
**IT Security techniques — Hash-
functions —**

**Part 3:
Dedicated hash-functions**

*Techniques de sécurité IT — Fonctions de brouillage —
Partie 3: Fonctions de brouillage dédiées*



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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 27, *IT Security techniques*.

This fourth edition cancels and replaces the third edition (ISO/IEC 10118-3:2004), which has been technically revised. It also incorporates the Amendment ISO/IEC 10118-3:2004/Amd1:2006 and Technical Corrigendum ISO/IEC 10118-3:2004/Cor1:2011.

The main changes compared to the previous edition are as follows:

- SHA-3, STREEBOG and SM3 hash-functions have been included;
- SHA-3 extendable-output functions have been included;
- cautionary notes for hash-functions with short hash-codes have been added.

A list of all parts in the ISO/IEC 10118 series can be found on the ISO website.

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IT Security techniques — Hash-functions —

Part 3: Dedicated hash-functions

1 Scope

This document specifies dedicated hash-functions, i.e. specially designed hash-functions. The hash-functions in this document are based on the iterative use of a round-function. Distinct round-functions are specified, giving rise to distinct dedicated hash-functions.

The use of Dedicated Hash-Functions 1, 2 and 3 in new digital signature implementations is deprecated.

NOTE As a result of their short hash-code length and/or cryptanalytic results, Dedicated Hash-Functions 1, 2 and 3 do not provide a sufficient level of collision resistance for future digital signature applications and they are therefore, only usable for legacy applications. However, for applications where collision resistance is not required, such as in hash-functions as specified in ISO/IEC 9797-2, or in key derivation functions specified in ISO/IEC 11770-6, their use is not deprecated.

Numerical examples for dedicated hash-functions specified in this document are given in [Annex B](#) as additional information. For information purposes, SHA-3 extendable-output functions are specified in [Annex C](#).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 10118-1, *Information technology — Security techniques — Hash-functions — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 10118-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

block

bit string of length L_1 , i.e., the length of the first input to the round-function

3.2

word

string of bits

3.3

circulant matrix

matrix with the property that each row, apart from the first, consists of the right cyclic shift by one position of the row immediately above it

3.4

abelian group

group $(G, *)$ such that $a*b = b*a$ for every a and b in G

3.5

field

set of elements S and a pair of operations $(+, *)$ defined on S such that: (i) $a*(b + c) = a*b + a*c$ for every a, b and c in S , (ii) S together with $+$ forms an abelian group (with identity element 0) and (iii) S excluding 0 together with $*$ forms an abelian group

4 Symbols

4.1 Symbols specified in ISO/IEC 10118-1

B_i	byte
D	data
H	hash-code
IV	initializing value
L_1	length (in bits) of the first of the two input strings to the round-function Φ
L_2	length (in bits) of the second of the two input strings to the round-function Φ , of the output string from the round-function Φ and of the IV
L_X	length (in bits) of a bit string X
$X \oplus Y$	bitwise exclusive-or of bit strings X and Y (where $L_X = L_Y$)
$X Y$	concatenation of strings of bits X and Y in the indicated order
Φ	a round-function, i.e. if X, Y are bit strings of lengths L_1 and L_2 respectively, then $\Phi(X, Y)$ is the string obtained by applying Φ to X and Y

4.2 Symbols specific to this document

A^i	sequence of constant matrices used in the specification of the round-function defined in Clause 16
A^n	concatenation of n instances of the word A
a_i, a'_i	sequences of indices used in specifications of a round-function
C_i, C'_i	constant words used in the round-functions
C''	8×8 circulant matrix with entries chosen from $\text{GF}(2^8)$ used in the specification of the round-function in Clause 16
c_0	function taking a string of 64 elements of $\text{GF}(2^8)$ as input and giving an 8×8 matrix with entries from $\text{GF}(2^8)$ as output, used in specifying the round-function defined in Clause 16
c_1, c_2, c_3	functions taking an 8×8 matrix of elements of $\text{GF}(2^8)$ as input and giving an 8×8 matrix with entries from $\text{GF}(2^8)$ as output, used in the specification of the round-function defined in Clause 16

c_4	function taking two 8×8 matrices of elements of $\text{GF}(2^8)$ as input and giving an 8×8 matrix with entries from $\text{GF}(2^8)$ as output, used in the specification of the round-function defined in Clause 16
D_i	a block derived from the data string after the padding process
d_i, e_i, f_i, g_i	functions taking either one or three words as input and producing a single word as output, used in specifying round-functions
H_i	a string of L_2 bits which is used in the hashing operation to store an intermediate result
Int_n	an inverse mapping to the mapping Vec_n , i.e. $\text{Int}_n = \text{Vec}_n^{-1}$
$\text{GF}(2^8)$	a field defined as $\text{GF}(2)[x] / p_8(x)$ where $p_8(x) = x^8 + x^4 + x^3 + x^2 + 1$. The elements of the field are 8-bit strings
M	an 8×8 matrix whose entries are chosen from $\text{GF}(2^8)$
q	number of blocks in the data string after the padding and splitting processes
$R^n()$	operation of right shift by n bits, i.e. if A is a word and n is a non-negative integer then $R^n(A)$ denotes the word obtained by right-shifting the contents of A by n positions
$S^n()$	operation of “circular left shift” by n bit positions, i.e. if A is a word and n is a non-negative integer then $S^n(A)$ denotes the word obtained by left-shifting the contents of A by n places in a cyclic fashion
$S'^n()$	operation of “circular right shift” by n bit positions, i.e. if A is a word and n is a non-negative integer then $S'^n(A)$ denotes the word obtained by right-shifting the contents of A by n places in a cyclic fashion
s	a function, which replaces an element $x \in \text{GF}(2^8)$ with another element $s[x] \in \text{GF}(2^8)$
t_i, t'_i	shift-values used in specifying a round-function
Vec_n	a bijective mapping from $\mathbb{Z}_{2^n}$ to the set of n -bit words, which maps an integer from $\mathbb{Z}_{2^n}$ to its binary representation (i.e. for any integer $z = z_0 + 2z_1 + \dots + 2^{n-1}z_{n-1}$ of the set $\mathbb{Z}_{2^n}$, where $z_j \in \{0,1\}, j = 0, \dots, n-1$, by definition $\text{Vec}_n(z) = (z_{n-1} \parallel \dots \parallel z_1 \parallel z_0)$)
W, X_i, X'_i, Y_i, Z_i	words used to store the results of intermediate computations
W', X'', K_i, Y', Z'	matrices with entries chosen from $\text{GF}(2^8)$ used to store the results of intermediate computations
$\mathbb{Z}_{2^n}$	set of non-negative integers less than 2^n , together with the operations of addition and multiplication modulo 2^n
$\wedge$	bitwise logical AND operation on bit strings, i.e. if A, B are words then $A \wedge B$ is the word equal to bitwise logical AND of A and B
$\vee$	bitwise logical OR operation on bit strings, i.e. if A, B are words then $A \vee B$ is the word equal to bitwise logical OR of A and B
$\neg$	bitwise logical NOT operation on a bit string, i.e. if A is a word then $\neg A$ is the word equal to the bitwise logical NOT of A

- ⊕ addition modulo 2^w operation, where w is the number of bits in a word; i.e. if A and B are w -bit words, then $A \oplus B$ is the word obtained by treating A and B as the binary representations of integers and computing their sum modulo 2^w , where the result is constrained to lie between 0 and $2^w - 1$ inclusive. The value of w is 32 for Dedicated Hash-Functions 1 to 4, defined in [Clauses 7 to 10](#), 64 for Dedicated Hash-Functions 5 and 6, defined in [Clauses 11 and 12](#) and 512 for Dedicated Hash-Functions 11 and 12, defined in [Clauses 17 and 18](#)
- multiplication operation of 8×8 matrices with entries chosen from $\text{GF}(2^8)$; i.e. if A and B are such matrices, then $A \cdot B$ is the matrix obtained by multiplying A and B in the following way. Treat each entry of either A or B as the binary polynomial representation of an integer (for example, the binary polynomial representation of integer 89 (hexadecimal) is $x^7 + x^3 + 1$); treat the multiplication of two of the entries as the remainder when multiplication of the two polynomials is divided by a polynomial $p_8(x)$, where $p_8(x) = x^8 + x^4 + x^3 + x^2 + 1$; and treat the sum operation as the operation $\oplus$
- $:=$ a symbol denoting the “set equal to” operation used in procedural specifications of round-functions, where it indicates that the value of the variable (e.g. word or matrix) on the left side of the symbol should be set equal to the value of the expression on the right side of the symbol

5 Requirements

Users who wish to employ a hash-function from this document shall select

- one of the dedicated hash-functions specified below, and
- the length, L_H , of the hash-code H .

NOTE 1 All the hash-functions defined in this document take a bit string as input and give a bit string as output; this is independent of the internal byte ordering convention used within each hash-function.

NOTE 2 The choice of L_H affects the security of the hash-function. All of the hash-functions specified in this document are believed to be collision-resistant hash-functions in environments where performing $2^{L_H/2}$ hash-code computation is deemed to be computationally infeasible.

[Annex A](#) defines object identifiers that shall be used to identify the hash-functions specified in this document.

6 Models for dedicated hash-functions

6.1 Use of models

The 17 dedicated hash-functions specified in this document are defined using two different models. Dedicated Hash-Functions 1 to 12 and 17 are defined using the general round-function-based model defined in ISO/IEC 10118-1, which is further described in [6.2](#). Dedicated Hash-Functions 13 to 16 use the sponge construction model as defined in [6.3](#).

6.2 Round-function model

Dedicated Hash-Functions 1 to 12 and 17 specified in this document are based on the general model for hash-functions given in ISO/IEC 10118-1.

In the specifications of the hash-functions in this document, it is assumed that the padded data string input to the hash-function is in the form of a sequence of bytes. If the padded data string is in the form of a sequence of $8n$ bits, $x_0, x_1, \dots, x_{8n-1}$, then it shall be interpreted as a sequence of n bytes, $B_0, B_1, \dots, B_{n-1}$, in the following way. Each group of eight consecutive bits is considered as a byte, the first bit of a group being the most significant bit of that byte. Hence,

$$B_i = 2^7 x_{8i} + 2^6 x_{8i+1} + \dots + x_{8i+7}$$

for every i ($0 \leq i < n$).

The output transformation for the hash-functions specified in this document is defined so that the hash-code, H , is derived by taking the left-most L_H bits of the final L_2 -bit output string H_q .

Identifiers are defined for each of the 17 dedicated hash-functions specified in this document. The hash-function identifiers for the dedicated hash-functions specified in [Clauses 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22](#) and [23](#) are equal to 31, 32, 33, 34, 35, 36, 37, 38, 39, 3A, 3B, 3C, 3D, 3E, 3F, 40 and 11 (hexadecimal), respectively. Some hash-function identifiers are also used in the OSI object identifiers assigned in [Annex A](#).

6.3 Sponge model

In [6.3](#), a permutation-based hash-function with sponge construction is specified.

A permutation-based hash-function with sponge construction is defined by a padding method, a permutation and a set of parameters.

The sponge construction^[4] is a framework for specifying functions on a binary data with arbitrary output length. The construction employs the following three components:

- an underlying function on fixed-length strings, denoted by f ;
- a parameter called the rate, denoted by r ;
- a padding rule, denoted by pad .

The function that the construction produces from these components is called a sponge function, denoted by $\text{SPONGE}[f, \text{pad}, r]$. A sponge function takes two inputs, a bit string, N , and the bit length, d , of the output string, $\text{SPONGE}[f, \text{pad}, r](N, d)$.

NOTE For further details on the rationale of the sponge construction framework, see Reference [\[5\]](#).

The function, f , maps strings of a single, fixed length, b , to strings of the same length. b is called the width of f . When the underlying function, f , is invertible, i.e. a permutation, it is a permutation-based hash-function with sponge construction.

The rate, r , is a positive integer that is strictly less than the width b . The capacity, c , is the positive integer $b - r$. Thus, $r + c = b$.

In the padding rule, pad is a function that produces padding, i.e. a string with an appropriate length to append to another string. In general, given a positive integer x and a non-negative integer m , the output $\text{pad}(x, m)$ is a string with the property that $m + \text{len}[\text{pad}(x, m)]$ is a positive multiple of x . Within the sponge construction, $x = r$ and $m = \text{len}(N)$, so that the padded input string can be partitioned into a sequence of r -bit strings.

Given these three components, f , pad and r , as described above, the $\text{SPONGE}[f, \text{pad}, r]$ function on (N, d) is specified by $\text{SPONGE}[f, \text{pad}, r](N, d)$. The width b is determined by the choice of f .

$\text{SPONGE}[f, \text{pad}, r](N, d)$

Input: string N , non-negative integer d

Output: string Z , such that $\text{len}(Z) = d$

Steps:

- a) Let $P = N \parallel \text{pad}[r, \text{len}(N)]$.
- b) Let $q = \text{len}(P)/r$.

- c) Let $c = b - r$.
- d) Let $P_0, \dots, P_{q-1}$ be the unique sequence of strings of length r , such that $P = P_0 \parallel \dots \parallel P_{q-1}$.
- e) Let $S = 0^b$.
- f) For i from 0 to $q-1$, let $S = f[S \oplus (P_i \parallel 0^c)]$.
- g) Let Z be the empty string.
- h) Let $Z = Z \parallel \text{Trunc}_r(S)$.
- i) If $d \leq |Z|$, then return $\text{Trunc}_d(Z)$; else, continue.
- j) Let $S = f(S)$ and continue with step h).

Note that the input d determines the number of bits that $\text{SPONGE}[f, \text{pad}, r](N, d)$ returns, but it does not affect their values. In principle, the output can be regarded as an infinite string, whose computation, in practice, is halted after the desired number of output bits is produced.

The parameters of a sponge construction include:

- b , the width;
- r , the rate;
- c , the capacity, such that $b = r + c$; and
- d , the output length.

Here, if notations specified in ISO/IEC 10118-1:2016, Clause 3 are used, r can be considered as L_1 , which is the length of a block of input data (message), while b can be considered as L_2 , which is the output length of the function f . Furthermore, the relation between function f and the round-function Φ as defined in ISO/IEC 10118-1:2016, Clause 3 can be represented as $\Phi(P_i, S_{i-1}) = f[S_{i-1} \oplus (P_i \parallel 0^c)]$, where $P_i = D_i$ is the i th data block, while $S_{i-1} = H_{i-1}$ is the output of the previous execution. The squeezing stage is considered the output transformation.

7 Dedicated Hash-Function 1 (RIPEMD-160)

7.1 General

In [Clause 7](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 1. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{64}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 1 is equal to 31 (hexadecimal).

NOTE 1 Dedicated Hash-Function 1 defined in [Clause 7](#) is commonly called RIPEMD-160^[6].

NOTE 2 As a result of a short hash-code length and/or cryptanalytic results, Dedicated Hash-Function 1 does not provide a sufficient level of collision resistance for future digital signature applications and it is, therefore, only used for legacy applications. However, for applications where collision resistance is not required, such as in hash-functions as specified in the ISO/IEC 9797 series or in key derivation functions specified in ISO/IEC 11770-6, its use is not deprecated.

7.2 Parameters, functions and constants

7.2.1 Parameters

For this hash-function, $L_1 = 512$, $L_2 = 160$ and L_H is up to 160.

7.2.2 Byte ordering convention

In the specification of the round-function of [Clause 7](#), it is assumed that the block input to the round-function is in the form of a sequence of 32-bit words, each 512-bit block being made up of 16 such words. A sequence of 64 bytes, $B_0, B_1, \dots, B_{63}$, shall be interpreted as a sequence of 16 words, $Z_0, Z_1, \dots, Z_{15}$, in the following way. Each group of four consecutive bytes is considered as a word, the first byte of a word being the least significant byte of that word. Hence,

$$Z_i = 2^{24}B_{4i+3} + 2^{16}B_{4i+2} + 2^8B_{4i+1} + B_{4i}, \quad (0 \leq i \leq 15).$$

To convert the hash-code from a sequence of words to a byte-sequence, the inverse process shall be followed.

NOTE The byte-ordering specified here is different from that of [9.2.2](#).

7.2.3 Functions

To facilitate software implementation, the round-function Φ is described in terms of operations on 32-bit words. A sequence of functions $g_0, g_1, \dots, g_{79}$ is used in this round-function, where each function g_i , $0 \leq i \leq 79$, takes three words, X_0, X_1 and X_2 , as input and produces a single word as output.

The functions g_i are defined as follows:

$$\begin{aligned} g_i(X_0, X_1, X_2) &= X_0 \oplus X_1 \oplus X_2, & (0 \leq i \leq 15); \\ g_i(X_0, X_1, X_2) &= (X_0 \wedge X_1) \vee (\neg X_0 \wedge X_2), & (16 \leq i \leq 31); \\ g_i(X_0, X_1, X_2) &= (X_0 \vee \neg X_1) \oplus X_2, & (32 \leq i \leq 47); \\ g_i(X_0, X_1, X_2) &= (X_0 \wedge X_2) \vee (X_1 \wedge \neg X_2), & (48 \leq i \leq 63); \\ g_i(X_0, X_1, X_2) &= X_0 \oplus (X_1 \vee \neg X_2), & (64 \leq i \leq 79). \end{aligned}$$

7.2.4 Constants

Two sequences of constant words, $C_0, C_1, \dots, C_{79}$ and $C'_0, C'_1, \dots, C'_{79}$, are used in this round-function. In a hexadecimal representation (where the most significant bit corresponds to the left-most bit), these are defined as follows:

$$\begin{aligned} C_i &= 00000000, & (0 \leq i \leq 15); \\ C_i &= 5A827999, & (16 \leq i \leq 31); \\ C_i &= 6ED9EBA1, & (32 \leq i \leq 47); \\ C_i &= 8F1BBCDC, & (48 \leq i \leq 63); \\ C_i &= A953FD4E, & (64 \leq i \leq 79); \\ C'_i &= 50A28BE6, & (0 \leq i \leq 15); \\ C'_i &= 5C4DD124, & (16 \leq i \leq 31); \\ C'_i &= 6D703EF3, & (32 \leq i \leq 47); \\ C'_i &= 7A6D76E9, & (48 \leq i \leq 63); \\ C'_i &= 00000000, & (64 \leq i \leq 79). \end{aligned}$$

Two sequences of 80 shift-values are used in this round-function, where each shift-value is between 5 and 15. These sequences are denoted by $(t_0, t_1, \dots, t_{79})$ and $(t'_0, t'_1, \dots, t'_{79})$. Two additional sequences of 80 indices are used in this round-function, where each value in the sequence is between 0 and 15. These sequences are denoted as $(a_0, a_1, \dots, a_{79})$ and $(a'_0, a'_1, \dots, a'_{79})$. All four sequences are defined in [Table 1](#).

Table 1 — Sequences for Hash-Function 1

i	0	1	2	3	4	5	6	7
t_i	11	14	15	12	5	8	7	9
t'_i	8	9	9	11	13	15	15	5
a_i	0	1	2	3	4	5	6	7
a'_i	5	14	7	0	9	2	11	4

i	8	9	10	11	12	13	14	15
t_i	11	13	14	15	6	7	9	8
t'_i	7	7	8	11	14	14	12	6
a_i	8	9	10	11	12	13	14	15
a'_i	13	6	15	8	1	10	3	12

i	16	17	18	19	20	21	22	23
t_i	7	6	8	13	11	9	7	15
t'_i	9	13	15	7	12	8	9	11
a_i	7	4	13	1	10	6	15	3
a'_i	6	11	3	7	0	13	5	10

i	24	25	26	27	28	29	30	31
t_i	7	12	15	9	11	7	13	12
t'_i	7	7	12	7	6	15	13	11
a_i	12	0	9	5	2	14	11	8
a'_i	14	15	8	12	4	9	1	2

i	32	33	34	35	36	37	38	39
t_i	11	13	6	7	14	9	13	15
t'_i	9	7	15	11	8	6	6	14
a_i	3	10	14	4	9	15	8	1
a'_i	15	5	1	3	7	14	6	9

i	40	41	42	43	44	45	46	47
t_i	14	8	13	6	5	12	7	5
t'_i	12	13	5	14	13	13	7	5
a_i	2	7	0	6	13	11	5	12
a'_i	11	8	12	2	10	0	4	13

i	4 8	4 9	5 0	5 1	5 2	5 3	5 4	5 5
t_i	1 1	1 2	1 4	1 5	1 4	1 5	9	8
t'_i	1 5	5	8	1 1	1 4	1 4	6	1 4
a_i	1	9	1 1	1 0	0	8	1 2	4
a'_i	8	6	4	1	3	1 1	1 5	0

i	5 6	5 7	5 8	5 9	6 0	6 1	6 2	6 3
t_i	9	1 4	5	6	8	6	5	1 2
t'_i	6	9	1 2	9	1 2	5	1 5	8
a_i	1 3	3	7	1 5	1 4	5	6	2
a'_i	5	1 2	2	1 3	9	7	1 0	1 4

i	6 4	6 5	6 6	6 7	6 8	6 9	7 0	7 1
t_i	9	1 5	5	1 1	6	8	1 3	1 2
t'_i	8	5	1 2	9	1 2	5	1 4	6
a_i	4	0	5	9	7	1 2	2	1 0
a'_i	1 2	1 5	1 0	4	1	5	8	7

i	7 2	7 3	7 4	7 5	7 6	7 7	7 8	7 9
t_i	5	1 2	1 3	1 4	1 1	8	5	6
t'_i	8	1 3	6	5	1 5	1 3	1 1	1 1
a_i	1 4	1	3	8	1 1	6	1 5	1 3
a'_i	6	2	1 3	1 4	0	3	9	1 1

7.2.5 Initializing value

For this round-function, the initializing value, IV , shall always be the following 160-bit string, represented here as a sequence of five words, Y_0 , Y_1 , Y_2 , Y_3 and Y_4 , in a hexadecimal representation, where Y_0 represents the left-most 32 of the 160 bits:

$Y_0 = 67452301;$
 $Y_1 = \text{EFCDA}89;$
 $Y_2 = 98\text{BADCFE};$
 $Y_3 = 10325476;$
 $Y_4 = \text{C3D2E1F0}.$

7.3 Padding method

The data string, D , needs to be padded to make it contain a number of bits which is an integer multiple of 512. The padding procedure operates as follows.

- D is concatenated with a single "1" bit.
- The result of the previous step is concatenated with between zero and 511 "0" bits such that the length (in bits) of the resultant string is congruent to 448 modulo 512. More explicitly, if the original length of D is L_D and letting r be the remainder when L_D is divided by 512, then the number

of concatenated zeros is equal to either $447 - r$ (if $r \leq 447$) or $959 - r$ (if $r > 447$). The result will be a bit string whose length will be 64 bits short of an integer multiple of 512 bits.

- c) Divide the 64-bit binary representation of L_D into two 32-bit strings, one representing the “most significant half” of L_D and the other the “least significant half”. Now concatenate the string resulting from the previous step with these two 32-bit strings, with the “least significant half” preceding the “most significant half”.

In the description of the round-function which follows, each 512-bit data block D_i , $1 \leq i \leq q$, is treated as a sequence of 16 words, $Z_0, Z_1, \dots, Z_{15}$, where Z_0 corresponds to the left-most 32 bits of D_i .

NOTE The concatenation of the two 32-bit strings of L_D in step c) is such that these two 32-bit strings are used directly as the words Z_{14} and Z_{15} of the last data block; based on the byte ordering convention in 7.2.2, the least significant byte of L_D is the left-most byte and the most significant byte of L_D is the right-most byte.

7.4 Description of the round-function

The round-function, Φ , operates as follows.

NOTE In this description, the symbols $W, X_0, X_1, X_2, X_3, X_4, X'_0, X'_1, X'_2, X'_3$ and X'_4 are used to denote 11 distinct words which contain values required in the computations.

- a) Suppose the 512-bit (first) input to Φ is contained in $Z_0, Z_1, \dots, Z_{15}$, where Z_0 contains the left-most 32 of the 512 bits. Suppose also that the 160-bit (second) input to Φ is contained in five words, Y_0, Y_1, Y_2, Y_3 and Y_4 .
- b) Let $X_0 = Y_0, X_1 = Y_1, X_2 = Y_2, X_3 = Y_3$ and $X_4 = Y_4$.
- c) Let $X'_0 = Y_0, X'_1 = Y_1, X'_2 = Y_2, X'_3 = Y_3$ and $X'_4 = Y_4$.
- d) For $i = 0$ to 79, do the following four steps in the order specified:
- 1) $W = S^{t_i} [X_0 \cup g_i(X_1, X_2, X_3) \cup Z_{a_i} \cup C_i] \cup X_4$;
 - 2) $X_0 = X_4; X_4 = X_3; X_3 = S^{10}(X_2); X_2 = X_1; X_1 = W$;
 - 3) $W = S^{t'_i} [X'_0 \cup g_{79-i}(X'_1, X'_2, X'_3) \cup Z_{a'_i} \cup C'_i] \cup X'_4$;
 - 4) $X'_0 = X'_4; X'_4 = X'_3; X'_3 = S^{10}(X'_2); X'_2 = X'_1; X'_1 = W$.
- e) Let $W = Y_0, Y_0 = Y_1 \cup X_2 \cup X'_3, Y_1 = Y_2 \cup X_3 \cup X'_4, Y_2 = Y_3 \cup X_4 \cup X'_0, Y_3 = Y_4 \cup X_0 \cup X'_1$ and $Y_4 = W \cup X_1 \cup X'_2$.
- f) The five words, Y_0, Y_1, Y_2, Y_3 and Y_4 , represent the output of the round-function Φ . After the final iteration of the round-function, the five words, Y_0, Y_1, Y_2, Y_3 and Y_4 , shall be converted to a sequence of 20 bytes using the inverse of the procedure specified in 7.2.2 and where Y_0 shall yield the first four bytes, Y_1 the next four bytes and so on. Thus, the first (left-most) byte will correspond to the least significant byte of Y_0 and the 20th (right-most) byte will correspond to the most significant byte of Y_4 . The 20 bytes shall be converted to a string of 160 bits using the inverse of the procedure specified in Clause 6, i.e. the first (left-most) bit will correspond to the most significant bit of the first (left-most) byte and the 160th (right-most) bit will correspond to the least significant bit of the 20th (right-most) byte.

Figure 1 shows steps 1) and 2) of item d) of the round-function Φ in Dedicated Hash-Function 1 (RIPEMD-160) [the other half, i.e. steps 3) and 4) is similar]. In the round-function Φ , steps 1) to 4) of item d) are used 80 times ($i = 0, \dots, 79$).

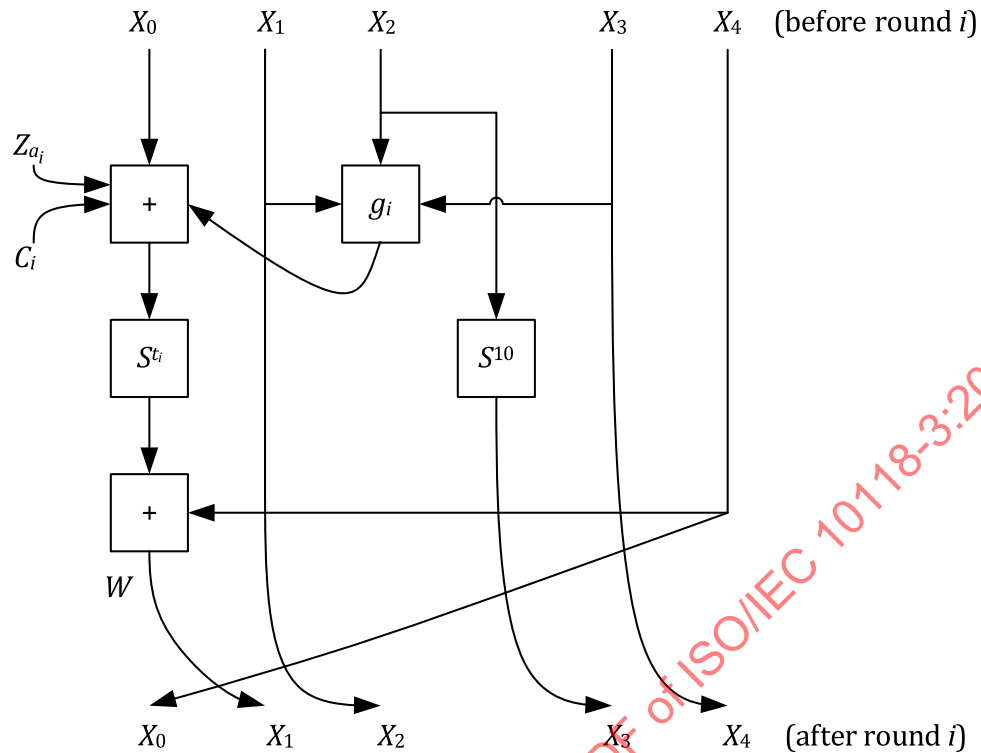


Figure 1 — Part of the round-function in Dedicated Hash-Function 1

8 Dedicated Hash-Function 2 (RIPEMD-128)

8.1 General

In [Clause 8](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 2. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{64}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 2 is equal to 32 (hexadecimal).

NOTE 1 Dedicated Hash-Function 2 defined in [Clause 8](#) is commonly called RIPEMD-128^[6]. This hash-function is only used in applications where a hash-code containing 128 bits or less is considered adequately secure.

NOTE 2 As a result of a short hash-code length and/or cryptanalytic results, Dedicated Hash-Function 2 does not provide a sufficient level of collision resistance for future digital signature applications and it is, therefore, only used for legacy applications. However, for applications where collision resistance is not required, such as in hash-functions as specified in the ISO/IEC 9797 series or in key derivation functions specified in ISO/IEC 11770-6, its use is not deprecated.

8.2 Parameters, functions and constants

8.2.1 Parameters

For this hash-function, $L_1 = 512$, $L_2 = 128$ and L_H is up to 128.

8.2.2 Byte ordering convention

The byte ordering convention for this hash-function is the same as that for the hash-function of [Clause 7](#).

8.2.3 Functions

To facilitate software implementation, the round-function, Φ , is described in terms of operations on 32-bit words. A sequence of functions, $g_0, g_1, \dots, g_{63}$, is used in this round-function, where each function g_i , $0 \leq i \leq 63$, takes three words, X_0, X_1 and X_2 , as input and produces a single word as output.

The functions g_i are defined to be the same as the first 64 of the functions defined in 7.2.3.

8.2.4 Constants

Two sequences of constant words, $C_0, C_1, \dots, C_{63}$ and $C'_0, C'_1, \dots, C'_{63}$, are used in this round-function. In a hexadecimal representation (where the most significant bit corresponds to the left-most bit), these are defined as follows:

$C_i = 00000000$,	$(0 \leq i \leq 15)$;
$C_i = 5A827999$,	$(16 \leq i \leq 31)$;
$C_i = 6ED9EBA1$,	$(32 \leq i \leq 47)$;
$C_i = 8F1BBCDC$,	$(48 \leq i \leq 63)$.
$C'_i = 50A28BE6$,	$(0 \leq i \leq 15)$;
$C'_i = 5C4DD124$,	$(16 \leq i \leq 31)$;
$C'_i = 6D703EF3$,	$(32 \leq i \leq 47)$;
$C'_i = 00000000$,	$(48 \leq i \leq 63)$.

Two sequences of 64 shift-values are also used in this round-function, where each shift-value is between 5 and 15. These sequences are denoted by $(t_0, t_1, \dots, t_{63})$ and $(t'_0, t'_1, \dots, t'_{63})$ and they are defined to be equal to the first 64 values of the corresponding sequences defined in 7.2.4.

Finally, two further sequences of 64 indices are used in this round-function, where each value in the sequence is between 0 and 15. These sequences are denoted by $(a_0, a_1, \dots, a_{63})$ and $(a'_0, a'_1, \dots, a'_{63})$ and they are defined to be equal to the first 64 values of the corresponding sequences defined in 7.2.4.

8.2.5 Initializing value

For this hash-function, the initializing value, IV , shall always be the following 128-bit string, represented here as a sequence of four words, Y_0, Y_1, Y_2 and Y_3 , in a hexadecimal representation, where Y_0 represents the left-most 32 of the 128 bits:

$Y_0 = 67452301$;
 $Y_1 = EFCDBA89$;
 $Y_2 = 98BADCFE$;
 $Y_3 = 10325476$.

8.3 Padding method

The padding method to be used with this hash-function shall be the same as the padding method defined in 7.3.

8.4 Description of the round-function

The round-function, Φ , operates as follows.

NOTE In this description, the symbols $W, X_0, X_1, X_2, X_3, X'_0, X'_1, X'_2$ and X'_3 are used to denote nine distinct words which contain values required in the computations.

- Suppose the 512-bit (first) input to Φ is contained in $Z_0, Z_1, \dots, Z_{15}$, where Z_0 contains the left-most 32 of the 512 bits. Suppose also that the 128-bit (second) input to Φ is contained in four words, Y_0, Y_1, Y_2 and Y_3 .
- Let $X_0 := Y_0, X_1 := Y_1, X_2 := Y_2$ and $X_3 := Y_3$.

- c) Let $X'_0 := Y_0$, $X'_1 := Y_1$, $X'_2 := Y_2$ and $X'_3 := Y_3$.
- d) For $i := 0$ to 63, do the following four steps in the order specified:
- 1) $W := S^{t_i} [X_0 \cup g_i(X_1, X_2, X_3) \cup Z_{a_i} \cup C_i]$;
 - 2) $X_0 := X_3$; $X_3 := X_2$; $X_2 := X_1$; $X_1 := W$;
 - 3) $W := S^{t'_i} [X'_0 \cup g_{63-i}(X'_1, X'_2, X'_3) \cup Z_{a'_i} \cup C'_i]$;
 - 4) $X'_0 := X'_3$; $X'_3 := X'_2$; $X'_2 := X'_1$; $X'_1 := W$.
- e) Let $W := Y_0$, $Y_0 := Y_1 \cup X_2 \cup X'_3$, $Y_1 := Y_2 \cup X_3 \cup X'_0$, $Y_2 := Y_3 \cup X_0 \cup X'_1$ and $Y_3 := W \cup X_1 \cup X'_2$.
- f) The four words, Y_0 , Y_1 , Y_2 and Y_3 , represent the output of the round-function Φ . After the final iteration of the round-function, the four words, Y_0 , Y_1 , Y_2 and Y_3 , shall be converted to a sequence of 16 bytes using the inverse of the procedure specified in 7.2.2 and where Y_0 shall yield the first four bytes, Y_1 the next four bytes and so on. Thus, the first (left-most) byte will correspond to the least significant byte of Y_0 and the 16th (right-most) byte will correspond to the most significant byte of Y_3 . The 16 bytes shall be converted to a string of 128 bits using the inverse of the procedure specified in Clause 6, i.e. the first (left-most) bit will correspond to the most significant bit of the first (left-most) byte and the 128th (right-most) bit will correspond to the least significant bit of the 16th (right-most) byte.

Figure 2 shows steps 1) and 2) of item d) of the round-function Φ in Dedicated Hash-Function 2 (RIPEMD-128) [the other half, i.e. steps 3) and 4) is similar]. In the round-function Φ , steps 1) to 4) of item d) are used 64 times ($i = 0, \dots, 63$).

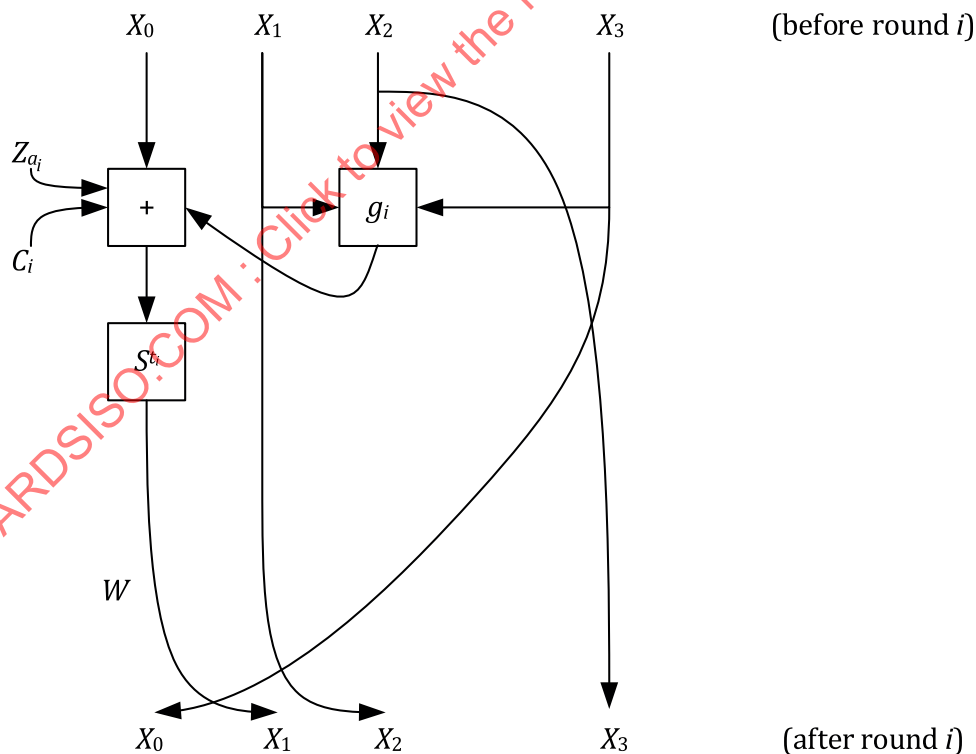


Figure 2 — Part of the round-function in Dedicated Hash-Function 2

9 Dedicated Hash-Function 3 (SHA-1)

9.1 General

In [Clause 9](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define the Dedicated Hash-Function 3. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{64}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 3 is equal to 33 (hexadecimal).

NOTE 1 Dedicated Hash-Function 3 defined in [Clause 9](#) is commonly called SHA-1^[1].

NOTE 2 As a result of a short hash-code length and/or cryptanalytic results, Dedicated Hash-Function 3 does not provide a sufficient level of collision resistance for future digital signature applications and it is, therefore, only used for legacy applications. However, for applications where collision resistance is not required, such as in hash-functions as specified in the ISO/IEC 9797 series or in key derivation functions specified in ISO/IEC 11770-6, its use is not deprecated.

9.2 Parameters, functions and constants

9.2.1 Parameters

For this hash-function, $L_1 = 512$, $L_2 = 160$ and L_H is up to 160.

9.2.2 Byte ordering convention

In the specification of the round-function of [Clause 9](#), it is assumed that the block input to the round-function is in the form of a sequence of 32-bit words, each 512-bit block made up of 16 such words. A sequence of 64 bytes, $B_0, B_1, \dots, B_{63}$, shall be interpreted as a sequence of 16 words, $Z_0, Z_1, \dots, Z_{15}$, in the following way, where each group of four consecutive bytes is considered as a word, the first byte of a word being the most significant byte of that word. Hence,

$$Z_i = 2^{24}B_{4i} + 2^{16}B_{4i+1} + 2^8B_{4i+2} + B_{4i+3}, \quad (0 \leq i \leq 15).$$

To convert the hash-code from a sequence of words to a sequence of bytes, the inverse process shall be followed.

NOTE The byte-ordering specified here is different from that of [7.2.2](#).

9.2.3 Functions

To facilitate software implementation, the round-function Φ is described in terms of operations on 32-bit words. A sequence of functions, $f_0, f_1, \dots, f_{79}$, is used in this round-function, where each function, f_i , $0 \leq i \leq 79$, takes three words, X_0, X_1 and X_2 , as input and produces a single word as output.

The functions f_i are defined as follows:

$$\begin{aligned} f_i(X_0, X_1, X_2) &= (X_0 \wedge X_1) \vee (\neg X_0 \wedge X_2), & (0 \leq i \leq 19); \\ f_i(X_0, X_1, X_2) &= X_0 \oplus X_1 \oplus X_2, & (20 \leq i \leq 39); \\ f_i(X_0, X_1, X_2) &= (X_0 \wedge X_1) \vee (X_0 \wedge X_2) \vee (X_1 \wedge X_2), & (40 \leq i \leq 59); \\ f_i(X_0, X_1, X_2) &= X_0 \oplus X_1 \oplus X_2, & (60 \leq i \leq 79). \end{aligned}$$

9.2.4 Constants

A sequence of constant words, $C_0, C_1, \dots, C_{79}$, is used in this round-function. In a hexadecimal representation (where the most significant bit corresponds to the left-most bit), these are defined as follows:

$$\begin{aligned}
C_i &= 5A827999, & (0 \leq i \leq 19); \\
C_i &= 6ED9EBA1, & (20 \leq i \leq 39); \\
C_i &= 8F1BBCDC, & (40 \leq i \leq 59); \\
C_i &= CA62C1D6, & (60 \leq i \leq 79).
\end{aligned}$$

9.2.5 Initializing value

For this round-function the initializing value, IV , shall always be the following 160-bit string, represented here as a sequence of five words, Y_0 , Y_1 , Y_2 , Y_3 and Y_4 , in a hexadecimal representation, where Y_0 represents the left-most 32 of the 160 bits:

$$\begin{aligned}
Y_0 &= 67452301; \\
Y_1 &= EFCDAB89; \\
Y_2 &= 98BADCFE; \\
Y_3 &= 10325476; \\
Y_4 &= C3D2E1F0.
\end{aligned}$$

9.3 Padding method

The data string, D , needs to be padded to make it contain a number of bits which is an integer multiple of 512. The padding procedure operates as follows.

- D is concatenated with a single “1” bit.
- The result of the previous step is concatenated with between zero and 511 “0” bits, such that the length (in bits) of the resultant string is congruent to 448 modulo 512. More explicitly, if the original length of D is L_D and letting r be the remainder when L_D is divided by 512, then the number of concatenated zeros is equal to either $447 - r$ (if $r \leq 447$) or $959 - r$ (if $r > 447$). The result will be a bit string whose length will be 64 bits short of an integer multiple of 512 bits.
- Concatenate the string resulting from the previous step with the 64-bit binary representation of L_D , most significant bit first.

In the description of the round-function which follows, each 512-bit data block D_i , $1 \leq i \leq q$, is treated as a sequence of 16 words, $Z_0, Z_1, \dots, Z_{15}$, where Z_0 corresponds to the left-most 32 bits of D_i .

NOTE The concatenation of the 64-bit string of L_D in step c) is such that the most significant 32-bit string and the least significant 32-bit string of L_D are used respectively as the words Z_{14} and Z_{15} of the last data block. Based on the byte ordering convention in 9.2.2, the most significant byte of L_D is the left-most byte and the least significant byte of L_D is the right-most byte.

9.4 Description of the round-function

The round-function, Φ , operates as follows.

NOTE In this description, the symbols $W, X_0, X_1, X_2, X_3, X_4, Z_0, Z_1, \dots, Z_{79}$ are used to denote 86 distinct words which contain values required in the computations.

- Suppose the 512-bit (first) input to Φ is contained in $Z_0, Z_1, \dots, Z_{15}$, where Z_0 contains the left-most 32 of the 512 bits. Suppose also that the 160-bit (second) input to Φ is contained in five words, Y_0, Y_1, Y_2, Y_3 and Y_4 .
- For $i = 16$ to 79, let $Z_i = S^1(Z_{i-3} \oplus Z_{i-8} \oplus Z_{i-14} \oplus Z_{i-16})$.
- Let $X_0 = Y_0, X_1 = Y_1, X_2 = Y_2, X_3 = Y_3$ and $X_4 = Y_4$.
- For $i = 0$ to 79, do the following two steps:
 - $W = S^5(X_0) \cup f_i(X_1, X_2, X_3) \cup X_4 \cup Z_i \cup C_i$

- 2) $X_4 := X_3$; $X_3 := X_2$; $X_2 := S^{30}(X_1)$; $X_1 := X_0$; $X_0 := W$.
- e) Let $Y_0 := Y_0 \cup X_0$, $Y_1 := Y_1 \cup X_1$, $Y_2 := Y_2 \cup X_2$, $Y_3 := Y_3 \cup X_3$ and $Y_4 := Y_4 \cup X_4$.
- f) The five words, Y_0 , Y_1 , Y_2 , Y_3 and Y_4 , represent the output of the round-function Φ . After the final iteration of the round-function, the five words, Y_0 , Y_1 , Y_2 , Y_3 and Y_4 , shall be converted to a sequence of 20 bytes using the inverse of the procedure specified in 9.2.2 and where Y_0 shall yield the first four bytes, Y_1 the next four bytes and so on. Thus, the first (left-most) byte will correspond to the most significant byte of Y_0 and the 20th (right-most) byte will correspond to the least significant byte of Y_4 . The 20 bytes shall be converted to a string of 160 bits using the inverse of the procedure specified in Clause 6, i.e. the first (left-most) bit will correspond to the most significant bit of the first (left-most) byte and the 160th (right-most) bit will correspond to the least significant bit of the 20th (right-most) byte.

Figure 3 shows steps 1) and 2) of item d) of the round-function Φ in Dedicated Hash-Function 3 (SHA-1). In the round-function Φ , steps 1) and 2) of item d) are used 80 times ($i = 0, \dots, 79$).

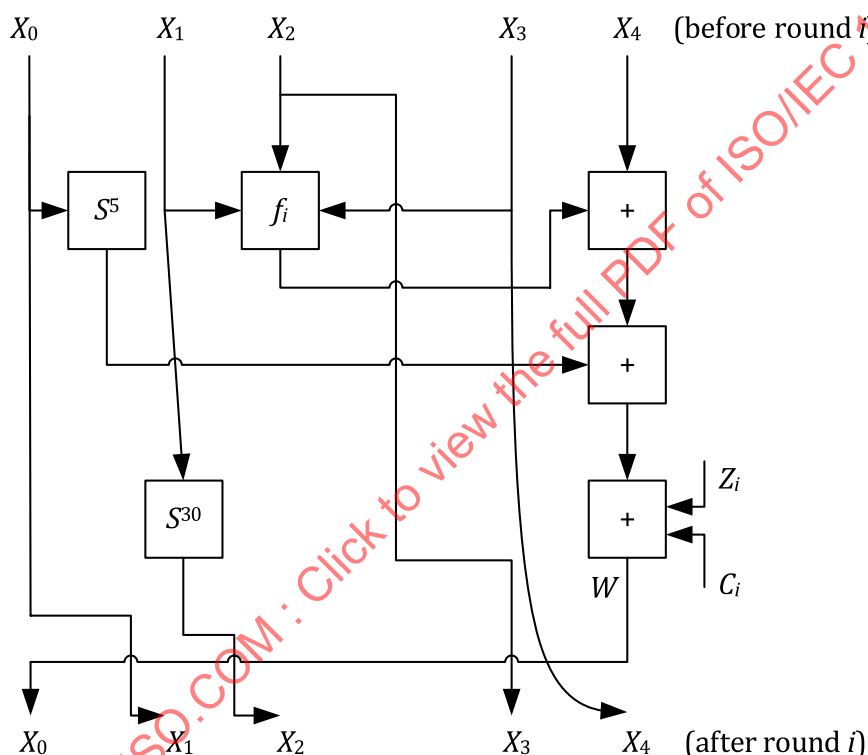


Figure 3 — Part of the round-function in Dedicated Hash-Function 3

10 Dedicated Hash-Function 4 (SHA-256)

10.1 General

In Clause 10, a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 4. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{64}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 4 is equal to 34 (hexadecimal).

NOTE Dedicated Hash-Function 4 defined in Clause 10 is commonly called SHA-256[1].

10.2 Parameters, functions and constants

10.2.1 Parameters

For this hash-function, $L_1 = 512$, $L_2 = 256$ and L_H is up to 256.

10.2.2 Byte ordering convention

The byte ordering convention to be used with this hash-function shall be the same as the byte ordering convention defined in 9.2.2.

10.2.3 Functions

To facilitate software implementation, the round-function Φ is described in terms of operations on 32-bit words. A sequence of functions, e_0 , e_1 , e_2 , e_3 , e_4 and e_5 , is used in this round-function, where e_0 and e_1 each takes three words, X_0 , X_1 and X_2 , as input; e_2 , e_3 , e_4 and e_5 each takes one word X_0 as input and each of these six functions produces a single 32-bit word as output.

The functions e_0 , e_1 , e_2 , e_3 , e_4 and e_5 are defined as follows:

$$\begin{aligned} e_0(X_0, X_1, X_2) &= (X_0 \wedge X_1) \oplus (\neg X_0 \wedge X_2); \\ e_1(X_0, X_1, X_2) &= (X_0 \wedge X_1) \oplus (X_0 \wedge X_2) \oplus (X_1 \wedge X_2); \\ e_2(X_0) &= S'^2(X_0) \oplus S'^{13}(X_0) \oplus S'^{22}(X_0); \\ e_3(X_0) &= S'^6(X_0) \oplus S'^{11}(X_0) \oplus S'^{25}(X_0); \\ e_4(X_0) &= S'^7(X_0) \oplus S'^{18}(X_0) \oplus R^3(X_0); \\ e_5(X_0) &= S'^{17}(X_0) \oplus S'^{19}(X_0) \oplus R^{10}(X_0). \end{aligned}$$

10.2.4 Constants

A sequence of constant words, C_0 , C_1 , ..., C_{63} , is used in this round-function. In a hexadecimal representation (where the most significant bit corresponds to the left-most bit), these are defined as follows, where the words are listed in the order C_0 , C_1 , ..., C_{63} .

428A2F98	71374491	B5C0FBCF	E9B5DBA5	3956C25B	59F111F1	923F82A4	AB1C5ED5
D807AA98	12835B01	243185BE	550C7DC3	72BE5D74	80DEB1FE	9BDC06A7	C19BF174
E49B69C1	EFBE4786	0FC19DC6	240CA1CC	2DE92C6F	4A7484AA	5CB0A9DC	76F988DA
983E5152	A831C66D	B00327C8	BF597FC7	C6E00BF3	D5A79147	06CA6351	14292967
27B70A85	2E1B2138	4D2C6DFC	53380D13	650A7354	766A0ABB	81C2C92E	92722C85
A2BFE8A1	A81A664B	C24B8B70	C76C51A3	D192E819	D6990624	F40E3585	106AA070
19A4C116	1E376C08	2748774C	34B0BCB5	391C0CB3	4ED8AA4A	5B9CCA4F	682E6FF3
748F82EE	78A5636F	84C87814	8CC70208	90BEFFFA	A4506CEB	BEF9A3F7	C67178F2

NOTE These values are the first 32 bits of the fractional parts of the cube roots of the first 64 primes.

10.2.5 Initializing value

For this round-function, the initializing value, IV , shall always be the following 256-bit string, represented here as a sequence of eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , in a hexadecimal representation, where Y_0 represents the left-most 32 of the 256 bits:

$$\begin{aligned} Y_0 &= 6A09E667; \\ Y_1 &= BB67AE85; \\ Y_2 &= 3C6EF372; \end{aligned}$$

$Y_3 = \text{A54FF53A};$
 $Y_4 = \text{510E527F};$
 $Y_5 = \text{9B05688C};$
 $Y_6 = \text{1F83D9AB};$
 $Y_7 = \text{5BE0CD19}.$

NOTE These values are obtained by taking the fractional parts of the square roots of the first eight primes.

10.3 Padding method

The padding method to be used with this hash-function shall be the same as the padding method defined in 9.3.

10.4 Description of the round-function

The round-function, Φ , operates as follows.

NOTE In this description, the symbols $W_1, W_2, X_0, X_1, X_2, X_3, X_4, X_5, X_6, X_7, Z_0, Z_1, \dots, Z_{63}$ are used to denote 74 distinct words which contain values required in the computations.

- a) Suppose the 512-bit (first) input to Φ is contained in $Z_0, Z_1, \dots, Z_{15}$, where Z_0 contains the left-most 32 of the 512 bits. Suppose also that the 256-bit (second) input to Φ is contained in eight words, $Y_0, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$ and Y_7 .
- b) For $i = 16$ to 63 , let $Z_i = e_5(Z_{i-2}) \cup Z_{i-7} \cup e_4(Z_{i-15}) \cup Z_{i-16}$.
- c) Let $X_0 = Y_0, X_1 = Y_1, X_2 = Y_2, X_3 = Y_3, X_4 = Y_4, X_5 = Y_5, X_6 = Y_6$ and $X_7 = Y_7$.
- d) For $i = 0$ to 63 , do the following three steps:
 - 1) $W_1 = X_7 \cup e_3(X_4) \cup e_0(X_4, X_5, X_6) \cup C_i \cup Z_i$;
 - 2) $W_2 = e_2(X_0) \cup e_1(X_0, X_1, X_2)$;
 - 3) $X_7 = X_6; X_6 = X_5; X_5 = X_4; X_4 = X_3 \cup W_1; X_3 = X_2; X_2 = X_1; X_1 = X_0; X_0 = W_1 \cup W_2$.
- e) Let $Y_0 = Y_0 \cup X_0, Y_1 = Y_1 \cup X_1, Y_2 = Y_2 \cup X_2, Y_3 = Y_3 \cup X_3, Y_4 = Y_4 \cup X_4, Y_5 = Y_5 \cup X_5, Y_6 = Y_6 \cup X_6$ and $Y_7 = Y_7 \cup X_7$.
- f) The eight words, $Y_0, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$ and Y_7 , represent the output of the round-function Φ . After the final iteration of the round-function, the eight words, $Y_0, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$ and Y_7 , shall be converted to a sequence of 32 bytes using the inverse of the procedure specified in 10.2.2 and where Y_0 shall yield the first four bytes, Y_1 the next four bytes and so on. Thus, the first (left-most) byte will correspond to the most significant byte of Y_0 and the 32nd (right-most) byte will correspond to the least significant byte of Y_7 . The 32 bytes shall be converted to a string of 256 bits using the inverse of the procedure specified in Clause 6, i.e. the first (left-most) bit will correspond to the most significant bit of the first (left-most) byte and the 256th (right-most) bit will correspond to the least significant bit of the 32nd (right-most) byte.

Figure 4 shows steps 1), 2) and 3) of item d) of the round-function Φ in Dedicated Hash-Function 4 (SHA-256). In the round-function Φ , steps 1), 2) and 3) of item d) are used 64 times ($i = 0, \dots, 63$).

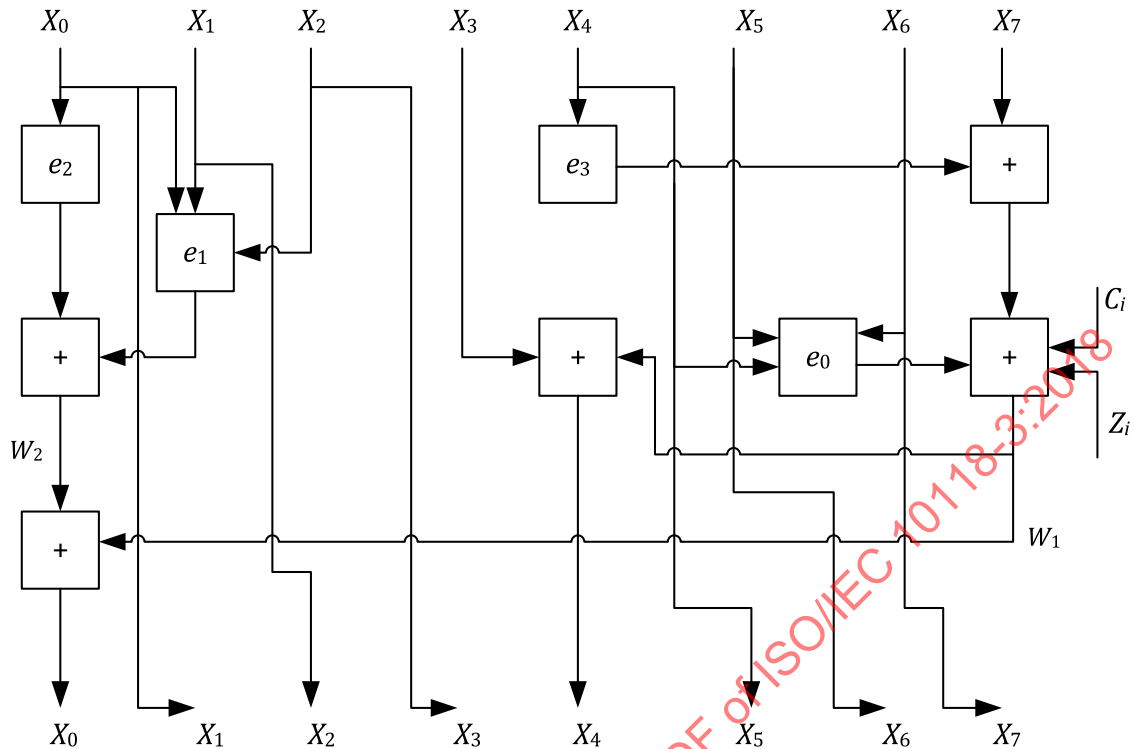


Figure 4 — Part of the round-function in Dedicated Hash-Function 4

11 Dedicated Hash-Function 5 (SHA-512)

11.1 General

In [Clause 11](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 5. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{128}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 5 is equal to 35 (hexadecimal).

NOTE Dedicated Hash-Function 5 defined in [Clause 11](#) is commonly called SHA-512[1].

11.2 Parameters, functions and constants

11.2.1 Parameters

For this hash-function, $L_1 = 1\,024$, $L_2 = 512$ and L_H is up to 512.

11.2.2 Byte ordering convention

In the specification of the round-function of [Clause 11](#), it is assumed that the block input to the round-function is in the form of a sequence of 64-bit words, each 1 024-bit block is made up of 16 such words. A sequence of 128 bytes, $B_0, B_1, \dots, B_{127}$, shall be interpreted as a sequence of 16 words, $Z_0, Z_1, \dots, Z_{15}$, in the following way. Each group of eight consecutive bytes is considered a word, where the first byte of a word is the most significant byte of that word. Hence,

$$Z_i = 2^{56}B_{8i} + 2^{48}B_{8i+1} + 2^{40}B_{8i+2} + 2^{32}B_{8i+3} + 2^{24}B_{8i+4} + 2^{16}B_{8i+5} + 2^8B_{8i+6} + B_{8i+7}, \quad (0 \leq i \leq 15).$$

To convert the hash-code from a sequence of words to a sequence of bytes, the inverse process shall be followed.

11.2.3 Functions

To facilitate software implementation, the round-function Φ is described in terms of operations on 64-bit words. A sequence of functions, d_0, d_1, d_2, d_3, d_4 and d_5 , is used in this round-function, where d_0 and d_1 each takes three 64-bit words, X_0, X_1 and X_2 , as input; d_2, d_3, d_4 and d_5 each takes one 64-bit word X_0 as input and each of these six functions produces a single 64-bit word as output.

The functions d_0, d_1, d_2, d_3, d_4 and d_5 are defined as follows:

$$\begin{aligned} d_0(X_0, X_1, X_2) &= (X_0 \wedge X_1) \oplus (\neg X_0 \wedge X_2); \\ d_1(X_0, X_1, X_2) &= (X_0 \wedge X_1) \oplus (X_0 \wedge X_2) \oplus (X_1 \wedge X_2); \\ d_2(X_0) &= S'^{28}(X_0) \oplus S'^{34}(X_0) \oplus S'^{39}(X_0); \\ d_3(X_0) &= S'^{14}(X_0) \oplus S'^{18}(X_0) \oplus S'^{41}(X_0); \\ d_4(X_0) &= S'^1(X_0) \oplus S'^8(X_0) \oplus R^7(X_0); \\ d_5(X_0) &= S'^{19}(X_0) \oplus S'^{61}(X_0) \oplus R^6(X_0). \end{aligned}$$

11.2.4 Constants

A sequence of constant words, $C_0, C_1, \dots, C_{79}$, is used in this round-function. In a hexadecimal representation (where the most significant bit corresponds to the left-most bit), these are defined as follows, where the words are listed in the order $C_0, C_1, \dots, C_{79}$.

428A2F98D728AE22	7137449123EF65CD	B5C0FBCEEC4D3B2F	E9B5DBA58189DBBC
3956C25BF348B538	59F111F1B605D019	923F82A4AF194F9B	AB1C5ED5DA6D8118
D807AA98A3030242	12835B0145706FBE	243185BE4EE4B28C	550C7DC3D5FFB4E2
72BE5D74F27B896F	80DEB1FE3B1696B1	9BDC06A725C71235	C19BF174CF692694
E49B69C19EF14AD2	EFBE4786384F25E3	0FC19DC68B8CD5B5	240CA1CC77AC9C65
2DE92C6F592B0275	4A7484AA6EA6E483	5CB0A9DCBD41FBD4	76F988DA831153B5
983E5152EE66DFAB	A831C66D2DB43210	B00327C898FB213F	BF597FC7BEEF0EE4
C6E00BF33DA88FC2	D5A79147930AA725	06CA6351E003826F	142929670A0E6E70
27B70A8546D22FFC	2E1B21385C26C926	4D2C6DFC5AC42AED	53380D139D95B3DF
650A73548BAF63DE	766A0ABB3C77B2A8	81C2C92E47EDAEE6	92722C851482353B
A2BFE8A14CF10364	A81A664BBC423001	C24B8B70D0F89791	C76C51A30654BE30
D192E819D6EF5218	D69906245565A910	F40E35855771202A	106AA07032BBD1B8
19A4C116B8D2D0C8	1E376C085141AB53	2748774CDF8EEB99	34B0BCB5E19B48A8
391C0CB3C5C95A63	4ED8AA4AE3418ACB	5B9CCA4F7763E373	682E6FF3D6B2B8A3
748F82EE5DEFB2FC	78A5636F43172F60	84C87814A1F0AB72	8CC702081A6439EC
90BEFFFA23631E28	A4506CEBDE82BDE9	BEF9A3F7B2C67915	C67178F2E372532B
CA273ECEEA26619C	D186B8C721C0C207	EADA7DD6CDE0EB1E	F57D4F7FEE6ED178

06F067AA72176FBA	0A637DC5A2C898A6	113F9804BEF90DAE	1B710B35131C471B
28DB77F523047D84	32CAAB7B40C72493	3C9EBE0A15C9BEBE	431D67C49C100D4C
4CC5D4BECB3E42B6	597F299CFC657E2A	5FCB6FAB3AD6FAEC	6C44198C4A475817

NOTE These values are the first 64 bits of the fractional parts of the cube roots of the first 80 primes.

11.2.5 Initializing value

For this round-function, the initializing value, IV , shall always be the following 512-bit string, represented here as a sequence of eight words, $Y_0, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$ and Y_7 , in a hexadecimal representation, where Y_0 represents the left-most 64 of the 512 bits:

$Y_0 = 6A09E667F3BCC908;$
 $Y_1 = BB67AE8584CAA73B;$
 $Y_2 = 3C6EF372FE94F82B;$
 $Y_3 = A54FF53A5F1D36F1;$
 $Y_4 = 510E527FADE682D1;$
 $Y_5 = 9B05688C2B3E6C1F;$
 $Y_6 = 1F83D9ABFB41BD6B;$
 $Y_7 = 5BE0CD19137E2179.$

NOTE These values are obtained by taking the fractional parts of the square roots of the first eight primes.

11.3 Padding method

The data string, D , needs to be padded to make it contain a number of bits which is an integer multiple of 1 024. The padding procedure is as follows.

- D is concatenated with a single “1” bit.
- The result of the previous step is concatenated with between zero and 1 023 “0” bits, such that the length (in bits) of the resultant string is congruent to 896 modulo 1 024. More explicitly, if the original length of D is L_D , and letting r be the remainder when L_D is divided by 1 024, then the number of concatenated zeros is equal to either $895 - r$ (if $r \leq 895$) or $1\,919 - r$ (if $r > 895$). The result will be a bit string whose length will be 128 bits short of an integer multiple of 1 024 bits.
- Concatenate the string resulting from the previous step with the 128-bit binary representation of L_D , most significant bit first.

In the description of the round-function which follows, each 1 024-bit data block D_i , $1 \leq i \leq q$, is treated as a sequence of 16 words, $Z_0, Z_1, \dots, Z_{15}$, where Z_0 corresponds to the left-most 64 bits of D_i .

NOTE The concatenation of the 128-bit string of L_D in step c) is such that the most significant 64-bit string and the least significant 64-bit string of L_D are used respectively as the words Z_{14} and Z_{15} of the last data block. Based on the byte ordering convention in 11.2.2, the most significant byte of L_D is the left-most byte and the least significant byte of L_D is the right-most byte.

11.4 Description of the round-function

The round-function, Φ , operates as follows.

NOTE In this description, the symbols $W_1, W_2, X_0, X_1, X_2, X_3, X_4, X_5, X_6, X_7, Z_0, Z_1, \dots, Z_{79}$ are used to denote 90 distinct words which contain values required in the computations.

- Suppose the 1 024-bit (first) input to Φ is contained in $Z_0, Z_1, \dots, Z_{15}$, where Z_0 contains the left-most 64 of the 1 024 bits. Suppose also that the 512-bit (second) input to Φ is contained in eight words, $Y_0, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$ and Y_7 .
- For $i = 16$ to 79, let $Z_i = d_5(Z_{i-2}) \cup Z_{i-7} \cup d_4(Z_{i-15}) \cup Z_{i-16}$.

- c) Let $X_0 := Y_0, X_1 := Y_1, X_2 := Y_2, X_3 := Y_3, X_4 := Y_4, X_5 := Y_5, X_6 := Y_6$ and $X_7 := Y_7$.
- d) For $i = 0$ to 79, do the following three steps:
- 1) $W_1 := X_7 \oplus d_3(X_4) \oplus d_0(X_4, X_5, X_6) \oplus C_i \oplus Z_i$;
 - 2) $W_2 := d_2(X_0) \oplus d_1(X_0, X_1, X_2)$;
 - 3) $X_7 := X_6; X_6 := X_5; X_5 := X_4; X_4 := X_3 \oplus W_1; X_3 := X_2; X_2 := X_1; X_1 := X_0; X_0 := W_1 \oplus W_2$.
- e) Let $Y_0 := Y_0 \oplus X_0, Y_1 := Y_1 \oplus X_1, Y_2 := Y_2 \oplus X_2, Y_3 := Y_3 \oplus X_3, Y_4 := Y_4 \oplus X_4, Y_5 := Y_5 \oplus X_5, Y_6 := Y_6 \oplus X_6$ and $Y_7 := Y_7 \oplus X_7$.
- f) The eight words, $Y_0, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$ and Y_7 , represent the output of the round-function Φ . After the final iteration of the round-function, the eight words, $Y_0, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$ and Y_7 shall be converted to a sequence of 64 bytes using the inverse of the procedure specified in 11.2.2 and where Y_0 shall yield the first eight bytes, Y_1 the next eight bytes and so on. Thus, the first (left-most) byte will correspond to the most significant byte of Y_0 and the 64th (right-most) byte will correspond to the least significant byte of Y_7 . The 64 bytes shall be converted to a string of 512 bits using the inverse of the procedure specified in Clause 6, i.e. the first (left-most) bit will correspond to the most significant bit of the first (left-most) byte and the 512th (right-most) bit will correspond to the least significant bit of the 64th (right-most) byte.

Figure 5 shows steps 1), 2) and 3) of item d) of the round-function Φ in Dedicated Hash-Function 5 (SHA-512). In the round-function Φ , steps 1), 2) and 3) of item d) are used 80 times ($i = 0, \dots, 79$).

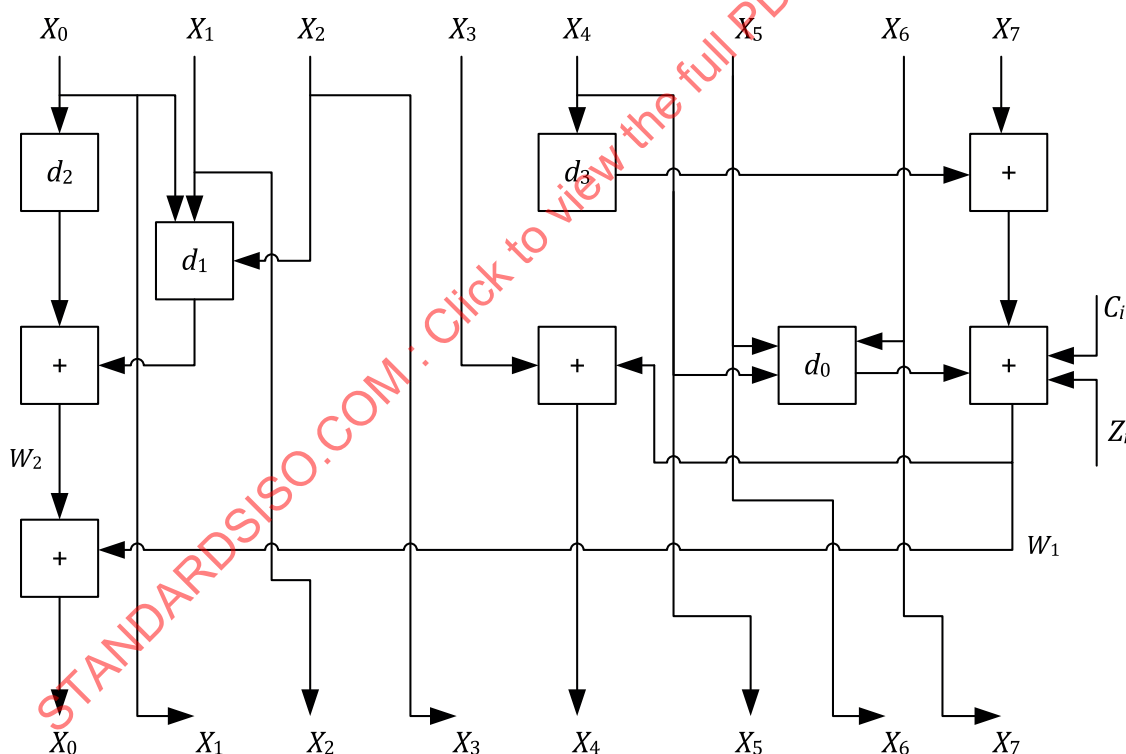


Figure 5 — Part of the round-function in Dedicated Hash-Function 5

12 Dedicated Hash-Function 6 (SHA-384)

12.1 General

In Clause 12, a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value

and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 6. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{128}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 6 is equal to 36 (hexadecimal).

NOTE Dedicated Hash-Function 6 defined in [Clause 12](#) is commonly called SHA-384[4].

12.2 Parameters, functions and constants

12.2.1 Parameters

For this hash-function, $L_1 = 1\,024$, $L_2 = 512$ and $L_H = 384$.

12.2.2 Byte ordering convention

The byte ordering convention for this hash-function is the same as that for the hash-function of [Clause 11](#).

12.2.3 Functions

The functions for this hash-function are the same as that for the hash-function of [Clause 11](#).

12.2.4 Constants

The constants for this hash-function are the same as that for the hash-function of [Clause 11](#).

12.2.5 Initializing value

For this round-function, the initializing value, IV , shall always be the following 512-bit string, represented here as a sequence of eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , in a hexadecimal representation, where Y_0 represents the left-most 64 of the 512 bits:

$Y_0 = \text{CBBB9D5DC1059ED8};$
 $Y_1 = \text{629A292A367CD507};$
 $Y_2 = \text{9159015A3070DD17};$
 $Y_3 = \text{152FEC8F70E5939};$
 $Y_4 = \text{67332667FFC00B31};$
 $Y_5 = \text{8EB44A8768581511};$
 $Y_6 = \text{DB0C2E0D64F98FA7};$
 $Y_7 = \text{47B5481DBEFA4FA4}.$

NOTE These values are obtained by taking the fractional parts of the square roots of the 9th to the 16th primes.

12.3 Padding method

The padding method to be used with this hash-function shall be the same as the padding method defined in [Clause 11](#).

12.4 Description of the round-function

The round-function to be used with this hash-function shall be the same as the round-function defined in [Clause 11](#).

The final 384-bit hash is obtained by truncating the SHA-512-based hash output to its left-most 384 bits.

13 Dedicated Hash-Function 7 (WHIRLPOOL)

13.1 General

In [Clause 13](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 7. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{256}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 7 is equal to 37 (hexadecimal).

NOTE Dedicated Hash-Function 7 defined in [Clause 13](#) is commonly called WHIRLPOOL^[3].

13.2 Parameters, functions and constants

13.2.1 Parameters

For this hash-function, $L_1 = 512$, $L_2 = 512$ and L_H is up to 512.

13.2.2 Byte ordering convention

In the specification of the round-function of [Clause 13](#), it is assumed that the block input to the round-function is in the form of a matrix M [where all matrices here are 8×8 matrices with entries chosen from $\text{GF}(2^8)$], each 512-bit block being made up of such a matrix. A sequence of 64 bytes, $B = (B_0, B_1, \dots, B_{63})$, shall be interpreted as a matrix M in the following way. The entry in the first row and the first column of the matrix shall be the left-most byte (where the left-most byte corresponds to the most significant byte) of the sequence B (i.e. B_0), the entry in the first row and the second column of the matrix shall be the second left-most byte of B (i.e. B_1), ..., and the entry in the eighth row and the eighth column of the matrix shall be the right-most byte of B (i.e. B_{63}). This is performed using function c_0 specified in [13.2.3](#).

To convert the hash-code from such a matrix to a sequence of bytes, the inverse process of the function c_0 shall be followed.

13.2.3 Functions

To facilitate software implementation, the round-function Φ is described in terms of operations on a matrix M . A sequence of functions, c_0 , c_1 , c_2 , c_3 and c_4 , is used in this round-function. They are defined as follows.

- a) Function c_0 takes a 64-byte sequence, $B = (B_0, B_1, \dots, B_{63})$ as input and produces a matrix $Z' = (z'_{ij})$ as output where:

$$z'_{ij} = B_{8i+j} \quad (0 \leq i, j \leq 7).$$

This means that $Z' = c_0(B)$, if and only if, $z'_{ij} = B_{8i+j}$ ($0 \leq i, j \leq 7$).

- b) Function c_1 takes a matrix $X'' = (x''_{ij})$ as input and produces another matrix $W' = (w'_{ij})$ as output where:

$$w'_{ij} = s[x''_{ij}], \quad (0 \leq i, j \leq 7),$$

and where s is a function defined below. This means $W' = c_1(X'')$, if and only if, $w'_{ij} = s[x''_{ij}]$ ($0 \leq i, j \leq 7$).

The function s replaces an element $x \in \text{GF}(2^8)$ with another element $s[x] \in \text{GF}(2^8)$. As specified in [Table 2](#), the elements in the first column are the “most significant half” of x and the elements in the first row are the “least significant half” of x . For instance, if $x = 01010110 = 56$ (hexadecimal), $s[x] = 49$ (hexadecimal) = 01001001.

Table 2 — Values of the s-box

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	18	23	C6	E8	87	B8	01	4F	36	A6	D2	F5	79	6F	91	52
1	60	BC	9B	8E	A3	0C	7B	35	1D	E0	D7	C2	2E	4B	FE	57
2	15	77	37	E5	9F	F0	4A	DA	58	C9	29	0A	B1	A0	6B	85
3	BD	5D	10	F4	CB	3E	05	67	E4	27	41	8B	A7	7D	95	D8
4	FB	EE	7C	66	DD	17	47	9E	CA	2D	BF	07	AD	5A	83	33
5	63	02	AA	71	C8	19	49	D9	F2	E3	5B	88	9A	26	32	B0
6	E9	0F	D5	80	BE	CD	34	48	FF	7A	90	5F	20	68	1A	AE
7	B4	54	93	22	64	F1	73	12	40	08	C3	EC	DB	A1	8D	3D
8	97	00	CF	2B	76	82	D6	1B	B5	AF	6A	50	45	F3	30	EF
9	3F	55	A2	EA	65	BA	2F	C0	DE	1C	FD	4D	92	75	06	8A
A	B2	E6	0E	1F	62	D4	A8	96	F9	C5	25	59	84	72	39	4C
B	5E	78	38	8C	D1	A5	E2	61	B3	21	9C	1E	43	C7	FC	04
C	51	99	6d	0D	FA	DF	7E	24	3B	AB	CE	11	8F	4E	B7	EB
D	3C	81	94	F7	B9	13	2C	D3	E7	6E	C4	03	56	44	7F	A9
E	2A	BB	C1	53	DC	0B	9D	6C	31	74	F6	46	AC	89	14	E1
F	16	3A	69	09	70	B6	D0	ED	CC	42	98	A4	28	5C	F8	86

- c) Function c_2 takes a matrix $X'' = (x''_{ij})$ as input and produces another matrix $W' = (w'_{ij})$ as output where:

$$w'_{ij} = x''_{(i-j) \bmod 8, j}, \quad (0 \leq i, j \leq 7).$$

This means that $W' = c_2(X'')$, if and only if, $w'_{ij} = x''_{(i-j) \bmod 8, j} \ (0 \leq i, j \leq 7)$.

- d) Function c_3 takes a matrix X'' as input and produces another matrix W' as output where:

$$W' = X'' \cdot C'',$$

and where C'' is an 8×8 circulant matrix with entries chosen from $\text{GF}(2^8)$, as specified below:

$$C'' = \begin{bmatrix} 01 & 01 & 04 & 01 & 08 & 05 & 02 & 09 \\ 09 & 01 & 01 & 04 & 01 & 08 & 05 & 02 \\ 02 & 09 & 01 & 01 & 04 & 01 & 08 & 05 \\ 05 & 02 & 09 & 01 & 01 & 04 & 01 & 08 \\ 08 & 05 & 02 & 09 & 01 & 01 & 04 & 01 \\ 01 & 08 & 05 & 02 & 09 & 01 & 01 & 04 \\ 04 & 01 & 08 & 05 & 02 & 09 & 01 & 01 \\ 01 & 04 & 01 & 08 & 05 & 02 & 09 & 01 \end{bmatrix}$$

This means that $W' = c_3(X'')$ if and only if $W' = X'' \cdot C''$.

- e) Function c_4 takes two matrices $X'' = (x''_{ij})$ and $Y' = (y'_{ij})$ as input and produces a single matrix $W' = (w'_{ij})$ as output where:

$$w'_{ij} = x''_{ij} \oplus y'_{ij}, \quad (0 \leq i, j \leq 7).$$

This means that $W' = c_4(X'', Y')$, if and only if, $w'_{ij} = x''_{ij} \oplus y'_{ij} \ (0 \leq i, j \leq 7)$.

13.2.4 Constants

A sequence of constant matrices, $A^r = (A_{ij}^r)$ ($0 < r \leq 10$), is used in this round-function. The round constant for the r th round is a matrix, defined as:

$$\begin{aligned} A_{0j}^r &= s[8(r-1) + j], & (0 \leq j \leq 7), \\ A_{ij}^r &= 0, & (1 \leq i \leq 7, 0 \leq j \leq 7). \end{aligned}$$

13.2.5 Initializing value

The initializing value, IV , is a string of 512 “0” bits.

NOTE 512 “0” bits for the initial value is represented by a matrix Y' with entries in $GF(2^8)$.

13.3 Padding method

The data string, D , needs to be padded to make it contain a number of bits which is an integer multiple of 512. The padding procedure is as follows.

- D is concatenated with a single “1” bit.
- The result of the previous step is concatenated with between zero and 511 “0” bits, such that the length (in bits) of the resultant string is an odd multiple of 256.
- If the original length of D is L_D , concatenate the string resulting from the previous step with the 256-bit binary representation of L_D , most significant bit first.

In the description of the round-function which follows, each 512-bit data block D_i , $1 \leq i \leq q$, is treated as a matrix $Z' = (z'_{ij})$ ($0 \leq i, j \leq 7$), as specified in 13.2.3, where z'_{00} corresponds to the left-most 8 bits of D_i and z'_{77} corresponds to the right-most 8 bits of D_i .

NOTE The concatenation of the 256-bit string of L_D in step c) is such that the 256-bit string is used directly as the second half of the last data matrix. Based on the byte ordering convention in 13.2.2, the most significant byte of L_D is the entry in the fifth row and the first column and the least significant byte of L_D is the entry in the eighth row and the eighth column.

13.4 Description of the round-function

The round-function Φ operates as follows.

NOTE In this description, the symbols $W', X'', K_0, K_1, \dots, K_{10}$ are used to denote 13 distinct matrices, each with entries chosen from $GF(2^8)$, which contain values required in the computations.

- Suppose the 512-bit (first) input to Φ is contained in a matrix Z' with entries chosen from $GF(2^8)$ which is formed by using the byte ordering convention specified in 13.2.2. Suppose also that the 512-bit (second) input to Φ is contained in a matrix Y' with entries chosen from $GF(2^8)$.
- Let $K_0 := Y'$ and for $i = 1$ to 10, let $K_i := c_4(c_3(c_2(c_1(K_{i-1}))), A^i)$.

NOTE This step expands the matrix Y' onto a sequence of round keys $K_0, \dots, K_{10}$.

- Let $X'' := c_4(Z', K_0)$ and for $j = 1$ to 10, do the following two steps:
 - $W' := c_4(c_3(c_2(c_1(X''))), K_j)$;
 - $X'' := W'$.
- Let $Y' := W' \oplus K_0 \oplus Z'$.

The matrix Y' represents the output of the round-function Φ . After the final iteration of the round-function, the matrix Y' shall be converted to a sequence of 64 bytes using the inverse of the procedure

specified in 16.2.2 and where the entry in the first row and the first column of the matrix shall yield the first byte, the entry in the first row and the second column of the matrix the next byte, ..., the entry in the eighth row and the eighth column of the matrix the last byte. The 64 bytes shall be converted to a string of 512 bits using the inverse of the procedure specified in Clause 6, i.e. the first (left-most) bit will correspond to the most significant bit of the first (left-most) byte and the 512th (right-most) bit will correspond to the least significant bit of the 64th (right-most) byte.

Figure 6 shows steps 1) and 2) of item c) of the round-function Φ in Dedicated Hash-Function 7 (WHIRLPOOL). In the round-function Φ , the steps shown in Figure 6 are used 10 times ($j = 1, \dots, 10$).

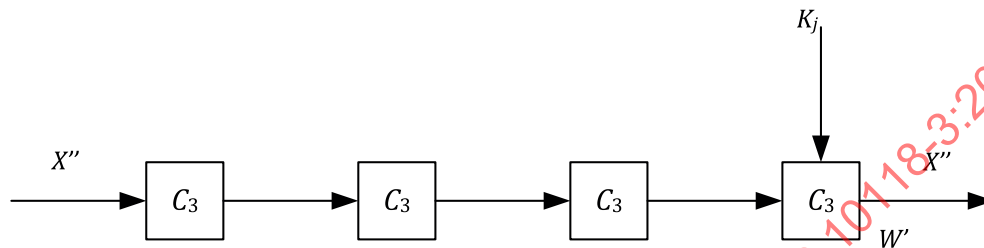


Figure 6 — Part of the round-function in Dedicated Hash-Function 7

14 Dedicated Hash-Function 8 (SHA-224)

14.1 General

In Clause 14, a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 8. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{64}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 8 is equal to 38 (hexadecimal).

NOTE Dedicated Hash-Function 8 defined in Clause 14 is commonly called SHA-224[1].

14.2 Parameters, functions and constants

14.2.1 Parameters

For this hash-function, $L_1 = 512$, $L_2 = 256$ and $L_H = 224$.

14.2.2 Byte ordering convention

The byte ordering convention for this hash-function is the same as that for the hash-function of Clause 10.

14.2.3 Functions

The functions for this hash-function are the same as those for the hash-function of Clause 10.

14.2.4 Constants

The constants for this hash-function are the same as those for the hash-function of Clause 10.

14.2.5 Initializing value

For this round-function, the initializing value, IV , shall always be the following 256-bit string, represented here as a sequence of eight words, $Y_0, Y_1, Y_2, Y_3, Y_4, Y_5, Y_6$ and Y_7 , in a hexadecimal representation, where Y_0 represents the left-most 32 of the 256 bits:

$Y_0 = \text{C1059ED8};$
 $Y_1 = \text{367CD507};$
 $Y_2 = \text{3070DD17};$
 $Y_3 = \text{F70E5939};$
 $Y_4 = \text{FFC00B31};$
 $Y_5 = \text{68581511};$
 $Y_6 = \text{64F98FA7};$
 $Y_7 = \text{BEFA4FA4}.$

NOTE These values are the low order 32 bits of the values specified in [12.2.5](#).

14.3 Padding method

The padding method to be used with this hash-function shall be the same as the padding method defined in [10.3](#).

14.4 Description of the round-function

The round-function to be used with this hash-function shall be the same as the round-function defined in [10.4](#).

The final 224-bit hash is obtained by truncating the SHA-256-based hash output to its left-most 224 bits.

15 Dedicated Hash-Function 9 (SHA-512/224)

15.1 General

In [Clause 15](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 9. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{128}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 9 is equal to 39 (hexadecimal).

NOTE Dedicated Hash-Function 9 defined in [Clause 15](#) is commonly called SHA-512/224[1].

15.2 Parameters, functions and constants

15.2.1 Parameters

For this hash-function, $L_1 = 1\,024$, $L_2 = 512$ and L_H is up to 224.

15.2.2 Byte ordering convention

The byte ordering convention for this hash-function is the same as that for the hash-function of [Clause 11](#).

15.2.3 Functions

The functions for this hash-function are the same as that for the hash-function of [Clause 11](#).

15.2.4 Constants

The constants for this hash-function are the same as that for the hash-function of [Clause 11](#).

15.2.5 Initializing value

For this round-function, the initializing value, IV , shall always be the following 512-bit string, represented here as a sequence of eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , in a hexadecimal representation, where Y_0 represents the left-most 64 of the 512 bits:

```

 $Y_0 = 8C3D37C819544DA2;$ 
 $Y_1 = 73E1996689DCD4D6;$ 
 $Y_2 = 1DFAB7AE32FF9C82;$ 
 $Y_3 = 679DD514582F9FCF;$ 
 $Y_4 = 0F6D2B697BD44DA8;$ 
 $Y_5 = 77E36F7304C48942;$ 
 $Y_6 = 3F9D85A86A1D36C8;$ 
 $Y_7 = 1112E6AD91D692A1.$ 

```

15.3 Padding method

The padding method to be used with this hash-function shall be the same as the padding method defined in [Clause 11](#).

15.4 Description of the round-function

The round-function to be used with this hash-function shall be the same as the round-function defined in [Clause 11](#). The final 224-bit hash is obtained by truncating the SHA-512-based hash output to its left-most 224 bits.

16 Dedicated Hash-Function 10 (SHA-512/256)

16.1 General

In [Clause 16](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 10. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{128}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 10 is equal to 3A (hexadecimal).

NOTE Dedicated Hash-Function 10 defined in [Clause 16](#) is commonly called SHA-512/256^[1].

16.2 Parameters, functions and constants

16.2.1 Parameters

For this hash-function, $L_1 = 1\,024$, $L_2 = 512$ and L_H is up to 256.

16.2.2 Byte ordering convention

The byte ordering convention for this hash-function is the same as that for the hash-function of [Clause 11](#).

16.2.3 Functions

The functions for this hash-function are the same as that for the hash-function of [Clause 11](#).

16.2.4 Constants

The constants for this hash-function are the same as that for the hash-function of [Clause 11](#).

16.2.5 Initializing value

For this round-function the initializing value, IV , shall always be the following 512-bit string, represented here as a sequence of eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , in a hexadecimal representation, where Y_0 represents the left-most 64 of the 512 bits:

$Y_0 = 22312194FC2BF72C;$
 $Y_1 = 9F555FA3C84C64C2;$
 $Y_2 = 2393B86B6F53B151;$
 $Y_3 = 963877195940EABD;$
 $Y_4 = 96283EE2A88EFFE3;$
 $Y_5 = BE5E1E2553863992;$
 $Y_6 = 2B0199FC2C85B8AA;$
 $Y_7 = 0EB72DDC81C52CA2.$

16.3 Padding method

The padding method to be used with this hash-function shall be the same as the padding method defined in [Clause 11](#).

16.4 Description of the round-function

The round-function to be used with this hash-function shall be the same as the round-function defined in [Clause 11](#). The final 256-bit hash is obtained by truncating the SHA-512-based hash output to its left-most 256 bits.

17 Dedicated Hash-Function 11 (STREEBOG-512)

17.1 General

In [Clause 17](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated Hash-Function 11. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{512}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 11 is equal to 3B (hexadecimal).

NOTE Dedicated Hash-Function 11 defined in [Clause 17](#) is one of the functions specified in GOST R 34.11-2012, the national standard of the Russian Federation, commonly called STREEBOG^[2].

17.2 Parameters, functions and constants

17.2.1 Parameters

For this hash-function, $L_1 = 512$, $L_2 = 512$ and $L_H = 512$.

17.2.2 Byte ordering convention

In the specification of the round-function of [Clause 17](#), it is assumed that the block input to the round-function is in the form of a sequence of 512 bits. A sequence of 64 bytes, $B_0, \dots, B_{63}$, shall be interpreted as a sequence of consecutive bits in the following way. Each byte is considered as an 8-bit sequence, the most significant bit of the byte shall be the first bit of the sequence. Each 512-bit block is treated as a number in the following format:

$$Z = B_0 + B_1 2^8 + \dots + B_{63} 2^{504}.$$

To convert the hash-code from a sequence of bits to a sequence of bytes, the inverse process shall be followed.

17.2.3 Functions

17.2.3.1 General

To calculate the hash-code H of the data string D , functions X, S, P, L and MSB_n are used. They are defined in [17.2.3.2](#) to [17.2.3.6](#).

17.2.3.2 Function X

Function $X[k]$ takes a 512-bit word as input and for the given 512-bit word, produces a 512-bit word as output, where $X[k](a) = k \oplus a$.

17.2.3.3 Function S

Function S takes a 512-bit word as input, produces a 512-bit word as output and is defined as:

$$S(a) = S(a_{63} \parallel \dots \parallel a_0) = \pi(a_{63}) \parallel \dots \parallel \pi(a_0),$$

where $a = a_{63} \parallel \dots \parallel a_0$, a_i , $i = 0, \dots, 63$, are 8-bit words and π denotes a function from the set of octet strings to itself. π is defined as:

$$\pi = \text{Vec}_8 \pi' \text{Int}_8,$$

where $\pi': \mathbb{Z}_{28} \rightarrow \mathbb{Z}_{28}$.

The function π' is defined by the array $\pi' = [\pi'(0), \pi'(1), \dots, \pi'(255)]$:

$\pi' = (252, 238, 221, 17, 207, 110, 49, 22, 251, 196, 250, 218, 35, 197, 4, 77, 233, 119, 240, 219, 147, 46, 153, 186, 23, 54, 241, 187, 20, 205, 95, 193, 249, 24, 101, 90, 226, 92, 239, 33, 129, 28, 60, 66, 139, 1, 142, 79, 5, 132, 2, 174, 227, 106, 143, 160, 6, 11, 237, 152, 127, 212, 211, 31, 235, 52, 44, 81, 234, 200, 72, 171, 242, 42, 104, 162, 253, 58, 206, 204, 181, 112, 14, 86, 8, 12, 118, 18, 191, 114, 19, 71, 156, 183, 93, 135, 21, 161, 150, 41, 16, 123, 154, 199, 243, 145, 120, 111, 157, 158, 178, 177, 50, 117, 25, 61, 255, 53, 138, 126, 109, 84, 198, 128, 195, 189, 13, 87, 223, 245, 36, 169, 62, 168, 67, 201, 215, 121, 214, 246, 124, 34, 185, 3, 224, 15, 236, 222, 122, 148, 176, 188, 220, 232, 40, 80, 78, 51, 10, 74, 167, 151, 96, 115, 30, 0, 98, 68, 26, 184, 56, 130, 100, 159, 38, 65, 173, 69, 70, 146, 39, 94, 85, 47, 140, 163, 165, 125, 105, 213, 149, 59, 7, 88, 179, 64, 134, 172, 29, 247, 48, 55, 107, 228, 136, 217, 231, 137, 225, 27, 131, 73, 76, 63, 248, 254, 141, 83, 170, 144, 202, 216, 133, 97, 32, 113, 103, 164, 45, 43, 9, 91, 203, 155, 37, 208, 190, 229, 108, 82, 89, 166, 116, 210, 230, 244, 180, 192, 209, 102, 175, 194, 57, 75, 99, 182).$

17.2.3.4 Function P

Function P takes a 512-bit word as input, produces a 512-bit word as output and is defined as:

$$P(a) = P(a_{63} \parallel \dots \parallel a_0) = a_{\tau(63)} \parallel \dots \parallel a_{\tau(0)},$$

where $a = a_{63} \parallel \dots \parallel a_0$, a_i , $i = 0, \dots, 63$, are 8-bit words and τ is a permutation of the set $\{0, 1, \dots, 63\}$ given by the array $\tau = (\tau(0), \tau(1), \dots, \tau(63))$:

$\tau = (0, 8, 16, 24, 32, 40, 48, 56, 1, 9, 17, 25, 33, 41, 49, 57, 2, 10, 18, 26, 34, 42, 50, 58, 3, 11, 19, 27, 35, 43, 51, 59, 4, 12, 20, 28, 36, 44, 52, 60, 5, 13, 21, 29, 37, 45, 53, 61, 6, 14, 22, 30, 38, 46, 54, 62, 7, 15, 23, 31, 39, 47, 55, 63)$.

17.2.3.5 Function L

Function L takes a 512-bit word as input, produces a 512-bit word as output and is defined as:

$$L(a) = L(a_7 \parallel \dots \parallel a_0) = l(a_7) \parallel \dots \parallel l(a_0),$$

where $a = a_7 \parallel \dots \parallel a_0$, a_i , $i = 0, \dots, 7$, are 64-bit words and l is a function equal to right multiplication by the matrix A , given below, over the field $\text{GF}(2)$. The matrix rows are expressed sequentially in hexadecimal notation. The row with number j , $j = 0, \dots, 63$, (specified in the form $a_{j,15}, \dots, a_{j,0}$, where $a_{j,i} \in \mathbb{F}_{16}$, $i = 0, \dots, 15$), is $\text{Vec}_4(a_{j,15}) \parallel \dots \parallel \text{Vec}_4(a_{j,0})$.

8E20FAA72BA0B470	47107DDD9B505A38	AD08B0E0C3282D1C	D8045870EF14980E
6C022C38F90A4C07	3601161CF205268D	1B8E0B0E798C13C8	83478B07B2468764
A011D380818E8F40	5086E740CE47C920	2843FD2067ADEA10	14AEF010BDD87508
0AD97808D06CB404	05E23C0468365A02	8C711E02341B2D01	46B60F011A83988E
90DAB52A387AE76F	486DD4151C3DFDB9	24B86A840E90F0D2	125C354207487869
092E94218D243CBA	8A174A9EC8121E5D	4585254F64090FA0	ACCC9CA9328A8950
9D4DF05D5F661451	C0A878A0A1330AA6	60543C50DE970553	302A1E286FC58CA7
18150F14B9EC46DD	0C84890AD27623E0	0642CA05693B9F70	0321658CBA93C138
86275DF09CE8AAA8	439DA0784E745554	AFC0503C273AA42A	D960281E9D1D5215
E230140FC0802984	71180A8960409A42	B60C05CA30204D21	5B068C651810A89E
456C34887A3805B9	AC361A443D1C8CD2	561B0D22900E4669	2B838811480723BA
9BCF4486248D9F5D	C3E9224312C8C1A0	EFFA11AF0964EE50	F97D86D98A327728
E4FA2054A80B329C	727D102A548B194E	39B008152ACB8227	9258048415EB419D
492C024284FBAEC0	AA16012142F35760	550B8E9E21F7A530	A48B474F9EF5DC18
70A6A56E2440598E	3853DC371220A247	1CA76E95091051AD	0EDD37C48A08A6D8
07E095624504536C	8D70C431AC02A736	C83862965601DD1B	641C314B2B8EE083

Each row of the given table contains four rows of the matrix A . So, the line with number i , $i = 0, \dots, 15$, specifies the rows of the matrix A with numbers $4i + j$, $j = 0, \dots, 3$, in the following left-to-right order: $4i + 0, 4i + 1, 4i + 2, 4i + 3$.

The product of the 64-bit word $b = b_{63}, \dots, b_0$ and the matrix A is a 64-bit word c :

$$c = b_{63}(\text{Vec}_4(a_{0,15}) \parallel \dots \parallel \text{Vec}_4(a_{0,0})) \oplus \dots \oplus b_0(\text{Vec}_4(a_{63,15}) \parallel \dots \parallel \text{Vec}_4(a_{63,0})),$$

where

$$b_i (\text{Vec}_4(a_{63-i,15}) \parallel \dots \parallel \text{Vec}_4(a_{63-i,0})) = \begin{cases} 0^{64}, & \text{if } b_i = 0, \\ (\text{Vec}_4(a_{63-i,15}) \parallel \dots \parallel \text{Vec}_4(a_{63-i,0})), & \text{if } b_i = 1, \end{cases}$$

for all $i = 0, \dots, 63$.

17.2.3.6 Truncation function

Function MSB_n maps the word $z_{k-1} \parallel \dots \parallel z_1 \parallel z_0$, $k \geq n$ to the word $z_{k-1} \parallel \dots \parallel z_{k-n+1} \parallel z_{k-n}$.

17.2.4 Constants

Round constants are expressed in hexadecimal notation. The constant value specified in the form $a_{127}, \dots, a_0$ (where $a_i \in \mathbb{F}_{16}$, $i = 0, \dots, 127$) is $\text{Vec}_4(a_{127}) \parallel \dots \parallel \text{Vec}_4(a_0)$:

C_1 = B1085BDA1ECADAE9EBCB2F81C0657C1F2F6A76432E45D016714EB88D7585C4FC
 4B7CE09192676901A2422A08A460D31505767436CC744D23DD806559F2A64507;

C_2 = 6FA3B58AA99D2F1A4FE39D460F70B5D7F3FEEA720A232B9861D55E0F16B50131
 9AB5176B12D699585CB561C2DB0AA7CA55DDA21BD7CBCD56E679047021B19BB7;

C_3 = F574DCAC2BCE2FC70A39FC286A3D843506F15E5F529C1F8BF2EA7514B1297B7B
 D3E20FE490359EB1C1C93A376062DB09C2B6F443867ADB31991E96F50ABA0AB2;

C_4 = EF1FDFB3E81566D2F948E1A05D71E4DD488E857E335C3C7D9D721CAD685E353F
 A9D72C82ED03D675D8B71333935203BE3453EAA193E837F1220CBEB8C84E3D12E;

C_5 = 4BEA6BACAD4747999A3F410C6CA923637F151C1F1686104A359E35D7800FFFBD
 BFCD1747253AF5A3DFFF00B723271A167A56A27EA9EA63F5601758FD7C6CFE57;

C_6 = AE4FAEAE1D3AD3D96FA4C33B7A3039C02D66C4F95142A46C187F9AB49AF08EC6
 CFFAA6B71C9AB7B40AF21F66C2BEC6B6BF71C57236904F35FA68407A46647D6E;

C_7 = F4C70E16EEAAC5EC51AC86FEBF240954399EC6C7E6BF87C9D3473E33197A93C9
 0992ABC52D822C3706476983284A05043517454CA23C4AF38886564D3A14D493;

C_8 = 9B1F5B424D93C9A703E7AA020C6E41414EB7F8719C36DE1E89B4443B4DDBC49A
 F4892BCB929B069069D18D2BD1A5C42F36ACC2355951A8D9A47F0DD4BF02E71E;

C_9 = 378F5A541631229B944C9AD8EC165FDE3A7D3A1B258942243CD955B7E00D0984
 800A440BDBB2CEB17B2B8A9AA6079C540E38DC92CB1F2A607261445183235ADB;

C_{10} = ABBEDEA680056F52382AE548B2E4F3F38941E71CFF8A78DB1FFFE18A1B336103
 9FE76702AF69334B7A1E6C303B7652F43698FAD1153BB6C374B4C7FB98459CED;

C_{11} = 7BCD9ED0EFC889FB3002C6CD635AFE94D8FA6BBEBAB07612001802114846679
 8A1D71EFEA48B9CAEFBACD1D7D476E98DEA2594AC06FD85D6BCAA4CD81F32D1B;

C_{12} = 378EE767F11631BAD21380B00449B17ACDA43C32BCDF1D77F82012D430219F9B
 5D80EF9D1891CC86E71DA4AA88E12852FAF417D5D9B21B9948BC924AF11BD720.

17.2.5 Initializing value

The initializing value, IV , is equal to 0^{512} .

17.3 Padding method

The data string, D , needs to be padded to make it contain a number of bits which is an integer multiple of 512. The padding procedure is as follows:

- D is concatenated with a single “1” bit (bit placed to the left).
- The result of the previous step is concatenated with between zero and 511 “0” bits (placed to the left) such that the length (in bits) of the resultant string is a multiple of 512.
- If the original length of D is L_D , concatenate the string resulting from the previous step with the 512-bit binary representation of L_D .
- If the data after step b) of padding could be expressed in the form $D_0, D_1, \dots, D_k$, where D_i are 512-bit words and k is a positive integer, calculate the value $\Sigma = D_0 \oplus D_1 \oplus \dots \oplus D_k$ and concatenate the string resulting from the previous step with value Σ .

17.4 Description of the round-function

The round-function Φ operates as follows. Note that in [Clause 17](#), the symbols h , m and N are used to denote three distinct 512-bit words which contain values required in the computations. The hash-code value of the data string D is calculated using an iterative procedure. Each iteration is performed using a round-function that transforms two 512-bit words to a 512-bit word and is calculated as:

$$\Phi(m, h) = g_N(h, m) = E(LPS(h \oplus N), m) \oplus h \oplus m,$$

where $E(K, m) = X[K_{13}]LPSX[K_{12}]...LPSX[K_2]LPSX[K_1](m)$ and where N denotes a 512-bit word calculated during the iterative procedure.

The values $K_i \in V_{512}$, $i = 1, \dots, 13$ are calculated as follows:

$$K_1 = K;$$

$$K_i = LPS(K_{i-1} \oplus C_{i-1}), i = 2, \dots, 13.$$

For brevity, instead of $g_{0^{512}}$, the notation g_0 is used.

The hash-function operates as follows. The input for calculating the hash-code is the data string, D (to be hashed), and the initializing value, IV .

The padding method described in [17.3](#) is accomplished within the algorithm that follows, i.e. that the padding does not actually have to be done prior to running the algorithm.

The algorithm for calculating the hash-code consists of the following stages.

a) Stage 1

Assign initial values to the following variables:

- 1) $h := IV$;
- 2) $N := 0^{512}$;
- 3) $\Sigma := 0^{512}$;
- 4) Go to Stage 2.

b) Stage 2

- 1) Check the condition: $L_D < 512$.

If it is true, then go to Stage 3.

Else, perform the following calculations:

- i) Let m be the right-most 512 bits of the message D (so that $D = D' \parallel m$). Then perform the following calculations:

- $h := g_N(h, m)$;
- $N := \text{Vec}_{512}(\text{Int}_{512}(N) \cup 512)$;
- $\Sigma := \text{Vec}_{512}(\text{Int}_{512}(\Sigma) \cup \text{Int}_{512}(m))$;
- $D := D'$.

- ii) Go to b)1).

c) Stage 3

- 1) $m := 0^{511-L_D} \parallel 1 \parallel D$.

- 2) $h := g_N(h, m)$.
- 3) $N := \text{Vec}_{512}(\text{Int}_{512}(N) \cup L_D)$.
- 4) $\Sigma := \text{Vec}_{512}(\text{Int}_{512}(\Sigma) \cup \text{Int}_{512}(m))$.
- 5) $h := g_0(h, N)$.
- 6) $h := g_0(h, \Sigma)$.
- 7) End of the algorithm.

The value of the variable h [obtained in step 6)] is the hash-code H .

18 Dedicated Hash-Function 12 (STREEBOG-256)

18.1 General

In [Clause 18](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define the Dedicated Hash-Function 12. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{512}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 12 is equal to 3C (hexadecimal).

NOTE Dedicated Hash-Function 12 defined in [Clause 18](#) is one of the functions specified in GOST R 34.11-2012, the national standard of the Russian Federation, commonly called STREEBOG^[2].

18.2 Parameters, functions and constants

18.2.1 Parameters

For this hash-function, $L_1 = 512$, $L_2 = 512$ and $L_H = 256$.

18.2.2 Byte ordering convention

The byte ordering convention for this hash-function is the same as that for the hash-function of [Clause 17](#).

18.2.3 Functions

The functions for this hash-function are the same as those for the hash-function of [Clause 17](#).

18.2.4 Constants

The constants for this hash-function are the same as those for the hash-function of [Clause 17](#).

18.2.5 Initializing value

The initializing value, IV , equals $(000\ 000\ 01)^{64}$.

18.3 Padding method

The padding method to be used with this hash-function shall be the same as the padding method defined in [Clause 17](#).

18.4 Description of the round-function

The round-function to be used with this hash-function shall be the same as the round-function defined in [Clause 17](#). The final 256-bit hash is obtained by truncating the STREEBOG-512-based hash output to its most significant 256 bits.

19 Dedicated Hash-Function 13 (SHA3-224)

19.1 General

In [Clause 19](#), a permutation-based hash-function with sponge construction SHA-224 is specified. The ISO/IEC hash-function identifier for Dedicated Hash-Function 13 is equal to 3D (hexadecimal).

19.2 Parameters, functions and constants

19.2.1 Parameters

For this hash-function, $L_1 = r = 1\,152$, $L_2 = b = 1\,600$, $c = b - r = 448$, $d = 224$, L_H is up to 224.

19.2.2 Byte ordering convention

Each data input D to the round-function Φ is a block of 1 152 bits that is XORed into the part of the state. The permutation f is then applied to the state. Because the step mappings that comprise the permutation are defined on the array form of the state, it is convenient to regard D as a sequence of 64-bit words that are XORed directly into the state array. For this purpose, when D is represented as a sequence of 144 bytes, $B_0, B_1, \dots, B_{143}$, then D shall be interpreted as a sequence of 18 lane words, $Z_0, Z_1, \dots, Z_{17}$, as follows:

$$Z_i = 2^{56}B_{8i+7} + 2^{48}B_{8i+6} + 2^{40}B_{8i+5} + 2^{32}B_{8i+4} + 2^{24}B_{8i+3} + 2^{16}B_{8i+2} + 2^8B_{8i+1} + B_{8i},$$

for $0 \leq i \leq 17$.

Hence, each group of eight consecutive bytes is a word and the bytes of the word are arranged in increasing order of significance, so that the first byte in the group becomes the least significant byte of the word.

For dedicated hash-function 13, the function is defined on a $5 \times 5 \times w$ state array. For each array six sub-arrays are defined for step-mappings. Lane is one of the subarrays and defined in [19.2.3.3](#). Under this interpretation, D is XORed with the state array as follows:

If j and k are the elements of $\{0, 1, 2, 3, 4\}$ such that (j, k) is the unique pair for which $i = 5k + j$, then for $0 \leq i \leq 17$, $\text{Lane}'(j, k) = Z_i \oplus \text{Lane}(j, k)$, where $\text{Lane}'(j, k)$ is the updated value of the lane.

19.2.3 Functions

19.2.3.1 General

In [19.2.3.8](#), the KECCAK- p permutations are specified. A KECCAK- p permutation is determined by two parameters. First, the fixed length of the strings that are permuted, called the *width* of the permutation, is denoted as b . Second, the number of iterations of an internal transformation, called a *round*, is denoted as n_r . For the Dedicated Hash-Functions 13, 14, 15 and 16, $b = 1\,600$ and $n_r = 24$. However, in some of the examples, in particular when a figure is used to illustrate the operations, smaller values of b are used.

A round of a KECCAK- p permutation, denoted by Rnd , consists of a sequence of five transformations called *step mappings*. The permutation is specified in terms of an array of values for b ($= 1\,600$) bits that is repeatedly updated, called the *state*. The state is initially set to the input values of the permutation.

NOTE The term round is used differently from the term specified in ISO/IEC 10118-1, where a round is a function used to process one single input data block to the hash-function. For the Dedicated Hash-Functions 13, 14, 15 and 16, to process one single data block, the round-function is iterated n_r ($= 24$) times. That is, each execution of round-function Φ , as it is named in ISO/IEC 10118-1, iterates Rnd 24 times.

The notation and terminology for the state are described in 19.2.3.2 to 19.2.3.6. The step mappings are specified in 19.2.3.7. The KECCAK- p permutations, including the round-function Rnd , are specified in 19.2.3.8.

19.2.3.2 State

The input and output states of the permutation are comprised of b bit strings. To represent the step mappings, a state is represented as a $5 \times 5 \times w$ array of bits, where $w = b/25$. For $b = 1\,600$, $w = 64$. If S denotes a string that represents the state, then its bits are indexed from 0 to $b-1$, so that

$$S = S[0] \parallel S[1] \parallel \dots \parallel S[b-2] \parallel S[b-1].$$

If $\mathbf{A}$ denotes a $5 \times 5 \times w$ array of bits that represents the state, then its indices are the integer triples (x, y, z) for which $0 \leq x < 5$, $0 \leq y < 5$ and $0 \leq z < w$. The bit that corresponds to (x, y, z) is denoted by $\mathbf{A}[x, y, z]$. A *state array* is a representation of the state by a three-dimensional array that is indexed in this manner.

19.2.3.3 Parts of the state array

The two-dimensional sub-arrays are called *sheets*, *planes* and *slices*; and the single-dimensional sub-arrays are called *rows*, *columns* and *lanes*.

The algebraic definitions of these sub-arrays are as follows.

Column For a state array, a sub-array of 5 bits with constant x and z coordinates.

Lane For a state array of a KECCAK- p permutation with width b , a sub-array of $b/25$ bits with constant x and y coordinates.

Plane For a state array of a KECCAK- p permutation with width b , a sub-array of $b/5$ bits with constant y coordinate.

Row For a state array, a sub-array of 5 bits with constant y and z coordinates.

Sheet For a state array of a KECCAK- p permutation with width b , a sub-array of $b/5$ bits with a constant x coordinate.

Slice For a state array, a sub-array of 25 bits with a constant z coordinate.

19.2.3.4 Converting strings to state arrays

Let S denote a string of b bits that represents the state for the KECCAK- p permutation. The corresponding state array, denoted by $\mathbf{A}$, is defined as follows.

For all triples (x, y, z) , such that $0 \leq x < 5$, $0 \leq y < 5$ and $0 \leq z < w$,

$$\mathbf{A}[x, y, z] = S[w(5y + x) + z].$$

For $b = 1\,600$ and $w = 64$,

$A[0, 0, 0] = S[0]$	$A[1, 0, 0] = S[64]$	$A[4, 0, 0] = S[256]$
$A[0, 0, 1] = S[1]$	$A[1, 0, 1] = S[65]$	$A[4, 0, 1] = S[257]$
$A[0, 0, 2] = S[2]$	$A[1, 0, 2] = S[66]$	$A[4, 0, 2] = S[258]$
$\vdots$	$\vdots$	$\vdots$
$A[0, 0, 61] = S[61]$	$A[1, 0, 61] = S[125]$	$A[4, 0, 61] = S[317]$
$A[0, 0, 62] = S[62]$	$A[1, 0, 62] = S[126]$	$A[4, 0, 62] = S[318]$
$A[0, 0, 63] = S[63]$	$A[1, 0, 63] = S[127]$	$A[4, 0, 63] = S[319]$

and

$A[0, 1, 0] = S[320]$	$A[1, 1, 0] = S[384]$	$A[4, 1, 0] = S[576]$
$A[0, 1, 1] = S[321]$	$A[1, 1, 1] = S[385]$	$A[4, 1, 1] = S[577]$
$A[0, 1, 2] = S[322]$	$A[1, 1, 2] = S[386]$	$A[4, 1, 2] = S[578]$
$\vdots$	$\vdots$	$\vdots$
$A[0, 1, 61] = S[381]$	$A[1, 1, 61] = S[445]$	$A[4, 1, 61] = S[637]$
$A[0, 1, 62] = S[382]$	$A[1, 1, 62] = S[446]$	$A[4, 1, 62] = S[638]$
$A[0, 1, 63] = S[383]$	$A[1, 1, 63] = S[447]$	$A[4, 1, 63] = S[639]$

and

$A[0, 2, 0] = S[640]$	$A[1, 2, 0] = S[704]$	$A[4, 2, 0] = S[896]$
$A[0, 2, 1] = S[641]$	$A[1, 2, 1] = S[705]$	$A[4, 2, 1] = S[897]$
$A[0, 2, 2] = S[642]$	$A[1, 2, 2] = S[706]$	$A[4, 2, 2] = S[898]$
$\vdots$	$\vdots$	$\vdots$
$A[0, 2, 61] = S[701]$	$A[1, 2, 61] = S[765]$	$A[4, 2, 61] = S[957]$
$A[0, 2, 62] = S[702]$	$A[1, 2, 62] = S[766]$	$A[4, 2, 62] = S[958]$
$A[0, 2, 63] = S[703]$	$A[1, 2, 63] = S[767]$	$A[4, 2, 63] = S[959]$

etc.

19.2.3.5 Converting state arrays to strings

Let $\mathbf{A}$ denote a state array. The corresponding string representation, denoted by S , can be constructed from the lanes and planes of $\mathbf{A}$, as follows:

For each pair of integers (i, j) , such that $0 \leq i < 5$ and $0 \leq j < 5$, define the string *Lane* (i, j) by using

$$\text{Lane}(i, j) = A[i, j, 0] \parallel A[i, j, 1] \parallel A[i, j, 2] \parallel \dots \parallel A[i, j, w-2] \parallel A[i, j, w-1].$$

For $b = 1\ 600$ and $w = 64$,

$$\text{Lane}(0, 0) = A[0, 0, 0] \parallel A[0, 0, 1] \parallel A[0, 0, 2] \parallel \dots \parallel A[0, 0, 62] \parallel A[0, 0, 63]$$

$$\text{Lane}(1, 0) = A[1, 0, 0] \parallel A[1, 0, 1] \parallel A[1, 0, 2] \parallel \dots \parallel A[1, 0, 62] \parallel A[1, 0, 63]$$

$$\text{Lane}(2, 0) = A[2, 0, 0] \parallel A[2, 0, 1] \parallel A[2, 0, 2] \parallel \dots \parallel A[2, 0, 62] \parallel A[2, 0, 63]$$

etc.

For each integer, j , such that $0 \leq j < 5$, define the string *Plane* (j) by using

$$\text{Plane}(j) = \text{Lane}(0, j) \parallel \text{Lane}(1, j) \parallel \text{Lane}(2, j) \parallel \text{Lane}(3, j) \parallel \text{Lane}(4, j).$$

Then,

$$S = \text{Plane}(0) \parallel \text{Plane}(1) \parallel \text{Plane}(2) \parallel \text{Plane}(3) \parallel \text{Plane}(4).$$

For $b = 1\ 600$ and $w = 64$,

$$\begin{aligned} S = & \mathbf{A}[0, 0, 0] \parallel \mathbf{A}[0, 0, 1] \parallel \mathbf{A}[0, 0, 2] \parallel \dots \parallel \mathbf{A}[0, 0, 62] \parallel \mathbf{A}[0, 0, 63] \\ & \parallel \mathbf{A}[1, 0, 0] \parallel \mathbf{A}[1, 0, 1] \parallel \mathbf{A}[1, 0, 2] \parallel \dots \parallel \mathbf{A}[1, 0, 62] \parallel \mathbf{A}[1, 0, 63] \\ & \parallel \mathbf{A}[2, 0, 0] \parallel \mathbf{A}[2, 0, 1] \parallel \mathbf{A}[2, 0, 2] \parallel \dots \parallel \mathbf{A}[2, 0, 62] \parallel \mathbf{A}[2, 0, 63] \\ & \parallel \mathbf{A}[3, 0, 0] \parallel \mathbf{A}[3, 0, 1] \parallel \mathbf{A}[3, 0, 2] \parallel \dots \parallel \mathbf{A}[3, 0, 62] \parallel \mathbf{A}[3, 0, 63] \\ & \parallel \mathbf{A}[4, 0, 0] \parallel \mathbf{A}[4, 0, 1] \parallel \mathbf{A}[4, 0, 2] \parallel \dots \parallel \mathbf{A}[4, 0, 62] \parallel \mathbf{A}[4, 0, 63] \\ & \parallel \mathbf{A}[0, 1, 0] \parallel \mathbf{A}[0, 1, 1] \parallel \mathbf{A}[0, 1, 2] \parallel \dots \parallel \mathbf{A}[0, 1, 62] \parallel \mathbf{A}[0, 1, 63] \\ & \parallel \mathbf{A}[1, 1, 0] \parallel \mathbf{A}[1, 1, 1] \parallel \mathbf{A}[1, 1, 2] \parallel \dots \parallel \mathbf{A}[1, 1, 62] \parallel \mathbf{A}[1, 1, 63] \\ & \parallel \mathbf{A}[2, 1, 0] \parallel \mathbf{A}[2, 1, 1] \parallel \mathbf{A}[2, 1, 2] \parallel \dots \parallel \mathbf{A}[2, 1, 62] \parallel \mathbf{A}[2, 1, 63] \\ & \parallel \mathbf{A}[3, 1, 0] \parallel \mathbf{A}[3, 1, 1] \parallel \mathbf{A}[3, 1, 2] \parallel \dots \parallel \mathbf{A}[3, 1, 62] \parallel \mathbf{A}[3, 1, 63] \\ & \parallel \mathbf{A}[4, 1, 0] \parallel \mathbf{A}[4, 1, 1] \parallel \mathbf{A}[4, 1, 2] \parallel \dots \parallel \mathbf{A}[4, 1, 62] \parallel \mathbf{A}[4, 1, 63] \\ & \parallel \mathbf{A}[0, 4, 0] \parallel \mathbf{A}[0, 4, 1] \parallel \mathbf{A}[0, 4, 2] \parallel \dots \parallel \mathbf{A}[0, 4, 62] \parallel \mathbf{A}[0, 4, 63] \\ & \parallel \mathbf{A}[1, 4, 0] \parallel \mathbf{A}[1, 4, 1] \parallel \mathbf{A}[1, 4, 2] \parallel \dots \parallel \mathbf{A}[1, 4, 62] \parallel \mathbf{A}[1, 4, 63] \\ & \parallel \mathbf{A}[2, 4, 0] \parallel \mathbf{A}[2, 4, 1] \parallel \mathbf{A}[2, 4, 2] \parallel \dots \parallel \mathbf{A}[2, 4, 62] \parallel \mathbf{A}[2, 4, 63] \\ & \parallel \mathbf{A}[3, 4, 0] \parallel \mathbf{A}[3, 4, 1] \parallel \mathbf{A}[3, 4, 2] \parallel \dots \parallel \mathbf{A}[3, 4, 62] \parallel \mathbf{A}[3, 4, 63] \\ & \parallel \mathbf{A}[4, 4, 0] \parallel \mathbf{A}[4, 4, 1] \parallel \mathbf{A}[4, 4, 2] \parallel \dots \parallel \mathbf{A}[4, 4, 62] \parallel \mathbf{A}[4, 4, 63]. \end{aligned}$$

19.2.3.6 Labelling convention for the state array

In the diagrams of the state that accompany the specifications of the step mappings, the lane that corresponds to the coordinates $(x, y) = (0, 0)$ is depicted at the centre of the slices.

19.2.3.7 Step mappings

19.2.3.7.1 General

The five step mappings that comprise a round of KECCAK- p are denoted by θ , ρ , π , χ and ι . Specifications for these functions are given in [19.2.3.7.2](#) to [19.2.3.7.6](#).

The algorithm for each step mapping takes a state array, denoted by $\mathbf{A}$, as an input and returns an updated state array, denoted by $\mathbf{A}'$, as the output.

The ι mapping has a second input: an integer called the *round index*, denoted by i_r , which is defined within Algorithm 5 for KECCAK- p , in [19.2.3.7.6](#). The other step mappings do not depend on the *round index*.

19.2.3.7.2 Specification of θ

Algorithm 1: $\theta(\mathbf{A})$

Input: state array **A**

Output: state array **A'**

Steps:

- a) For all pairs (x, z) , such that $0 \leq x < 5$ and $0 \leq z < w$, let

$$C[x, z] = A[x, 0, z] \oplus A[x, 1, z] \oplus A[x, 2, z] \oplus A[x, 3, z] \oplus A[x, 4, z].$$
- b) For all pairs (x, z) , such that $0 \leq x < 5$ and $0 \leq z < w$ let

$$D[x, z] = C[(x-1) \bmod 5, z] \oplus C[(x+1) \bmod 5, (z-1) \bmod w].$$
- c) For all triples (x, y, z) , such that $0 \leq x < 5$, $0 \leq y < 5$ and $0 \leq z < w$, let

$$A'[x, y, z] = A[x, y, z] \oplus D[x, z].$$

The effect of θ is to XOR each bit in the state with the parities of two columns in the array. In particular, for the bit $A[x_0, y_0, z_0]$, the x -coordinate of one of the columns is $(x_0 - 1) \bmod 5$, with the same z -coordinate, z_0 , while the x -coordinate of the other column is $(x_0 + 1) \bmod 5$, with z -coordinate $(z_0 - 1) \bmod w$.

19.2.3.7.3 Specification of ρ

Algorithm 2: $\rho(A)$

Input: state array **A**

Output: state array **A'**

Steps:

- a) For all z such that $0 \leq z < w$, let $A'[0, 0, z] = A[0, 0, z]$.
- b) Let $(x, y) = (1, 0)$.
- c) For t from 0 to 23:
 - 1) for all z such that $0 \leq z < w$, let $A'[x, y, z] = A\{x, y, [z - (t+1)(t+2)/2] \bmod w\}$;
 - 2) let $(x, y) = [y, (2x+3y) \bmod 5]$.
- d) Return **A'**.

19.2.3.7.4 Specification of π

Algorithm 3: $\pi(A)$

Input: state array **A**

Output: state array **A'**

Steps:

- a) For all triples (x, y, z) such that $0 \leq x < 5$, $0 \leq y < 5$ and $0 \leq z < w$, let

$$A'[x, y, z] = A[(x+3y) \bmod 5, x, z].$$
- b) Return **A'**.

19.2.3.7.5 Specification of χ

Algorithm 4: $\chi(A)$

Input: state array $\mathbf{A}$

Output: state array $\mathbf{A}'$

Steps:

- a) For all triples (x, y, z) such that $0 \leq x < 5$, $0 \leq y < 5$ and $0 \leq z < w$, let

$$\mathbf{A}'[x, y, z] = \mathbf{A}[x, y, z] \oplus \langle \mathbf{A}[(x+1) \bmod 5, y, z] \oplus 1 \rangle \wedge \mathbf{A}[(x+2) \bmod 5, y, z].$$
- b) Return $\mathbf{A}'$.

The notation $\wedge$ in the right side of the assignment for step a) is Boolean “AND” operation.

19.2.3.7.6 Specification of ι

The ι mapping is parameterized by the round index, i_r , whose values are specified in step b) of Algorithm 7 for computing KECCAK- p , in 19.2.3.8. Within the specification of ι in Algorithm 6, this parameter determines $l + 1$ bits of a lane value called the *round constant*, denoted by RC , where $l = \log(w)$. When $w = 64$, $l = 6$. Each of these 7 bits is generated by a function that is based on a linear feedback shift register. This function, denoted by rc , is specified in Algorithm 5.

Algorithm 5: $rc(t)$

Input: integer t

Output: bit $rc(t)$

Steps:

- a) If $t \bmod 255 = 0$, return 1.
- b) Let $R = 10\,000\,000$.
- c) For i from 1 to $t \bmod 255$, let:
 - 1) $R = 0 \parallel R$;
 - 2) $R[0] = R[0] \oplus R[8]$;
 - 3) $R[6] = R[6] \oplus R[8]$;
 - 4) $R[3] = R[3] \oplus R[8]$;
 - 5) $R[2] = R[2] \oplus R[8]$;
 - 6) $R = \text{Trunc}_8[R]$.
- d) Return $R[0]$.

In Algorithm 6, RC is a w -bit binary string and denoted as $RC[0], RC[1], \dots, RC[w-1]$.

Algorithm 6: $\iota(\mathbf{A}, i_r)$

Input: state array $\mathbf{A}$; round index i_r

Output: state array $\mathbf{A}'$

Steps:

- a) For all triples (x, y, z) , such that $0 \leq x < 5$, $0 \leq y < 5$ and $0 \leq z < w$, let $\mathbf{A}'[x, y, z] = \mathbf{A}[x, y, z]$.
- b) Let $RC = 0^w$.
- c) For j from 0 to 6, let $RC[2j - 1] = rc(j + 7i_r)$.

- d) For all z , such that $0 \leq z < w$, let $\mathbf{A}'[0, 0, z] = \mathbf{A}'[0, 0, z] \oplus RC[z]$.
- e) Return $\mathbf{A}'$.

The effect of ι is to modify some of the bits of *Lane* (0, 0) in a manner that depends on the round index i_r . The other 24 lanes are not affected by ι .

19.2.3.8 KECCAK- p

Given a state array $\mathbf{A}$ and a round index i_r , the round-function Rnd is the transformation that results from applying the step mappings θ , ρ , π , χ and ι , in that order, i.e.:

$$Rnd(\mathbf{A}, i_r) = \iota(\chi(\pi(\rho[\theta(\mathbf{A})])), i_r).$$

The KECCAK- p permutation consists of 24 iterations of Rnd , as specified in Algorithm 7.

Algorithm 7: KECCAK- p (S)

Input: string S of length 1 600 bits

Output: string S of length 1 600 bits

Steps:

- a) Convert S into a state array, $\mathbf{A}$, as described in [19.2.3.4](#).
- b) For i_r from 0 to 23, let $\mathbf{A} = Rnd(\mathbf{A}, i_r)$.
- c) Convert $\mathbf{A}$ into a string, S' of length b , as described in [19.2.3.5](#).
- d) Return S' .

19.3 Padding method

The data, a binary string M , will be padded with “01” before applying the padding method $\text{pad}_{10^*1}(x, m)$, specified below with $x = 1\ 152$.

$\text{pad}_{10^*1}(x, m)$

Input: positive integer x ; non-negative integer m

Output: string P , such that $m + \text{len}(P)$ is a positive multiple of x

Steps:

- a) Let $j = (-m - 2) \bmod x$.
- b) Return $P = 1 \parallel 0_j \parallel 1$.

Thus, the asterisk in “ pad_{10^*1} ” indicates that the “0” bit is either omitted or repeated as necessary, in order to produce an output string of the desired length.

That is, the padded data is $P = M \parallel 01 \parallel 10^*1$, such that the length of P is a multiple of 1 152.

19.4 Description of a round-function

The round-function for Dedicated Hash-Function 13 is the permutation KECCAK- p specified in [19.2.3.8](#). Notice that KECCAK- p is considered as Φ as defined in ISO/IEC 10118-1. However, for each execution of KECCAK- p , it iterates the Rnd function 24 times. That is, it executes

$$Rnd(\mathbf{A}, i_r) = \iota(\chi(\pi(\rho[\theta(\mathbf{A})])), i_r),$$

for $i_r = 0, 1, \dots, 23$.

19.5 Output transformation

In step h) of SPONGE[f , pad, r](N , d), $f = \text{KECCAK-}p$, because $r = 1\,152$, $d = 224$ and $r > d$, the $\text{Trunc}_r(S)$ will be further truncated to d bits.

20 Dedicated Hash-Function 14 (SHA3-256)

20.1 General

In [Clause 20](#), a permutation-based hash-function with sponge construction SHA3-256 is specified. The description of permutation-based hash-function with sponge construction is given in [Clause 19](#).

The ISO/IEC hash-function identifier for Dedicated Hash-Function 14 is equal to 3E (hexadecimal).

20.2 Parameters, functions and constants

20.2.1 Parameters

For this hash-function, $L_1 = r = 1\,088$, $L_2 = b = 1\,600$, $c = b - r = 512$, $d = 256$, L_H is up to 256.

20.2.2 Byte ordering convention

Each data input D to the round-function Φ is a block of 1 088 bits that is XORed into the part of the state. The permutation f is then applied to the state. Because the step mappings that comprise the permutation are defined on the array form of the state, it is convenient to regard D as a sequence of 64-bit words that are XORed directly into the state array. For this purpose, when D is represented as a sequence of 136 bytes, $B_0, B_1, \dots, B_{135}$, then D shall be interpreted as a sequence of 17 lane words, $Z_0, Z_1, \dots, Z_{16}$, as follows:

$$Z_i = 2^{56}B_{8i+7} + 2^{48}B_{8i+6} + 2^{40}B_{8i+5} + 2^{32}B_{8i+4} + 2^{24}B_{8i+3} + 2^{16}B_{8i+2} + 2^8B_{8i+1} + B_{8i},$$

for $0 \leq i \leq 16$.

Hence, each group of eight consecutive bytes is a word and the bytes of the word are arranged in increasing order of significance, so that the first byte in the group becomes the least significant byte of the word.

For dedicated hash-function 14, the function is defined on a $5 \times 5 \times w$ state array. For each array six sub-arrays are defined for step-mappings. Lane is one of the subarrays and defined in [19.2.3.3](#). Under this interpretation, D is XORed with the state array as follows.

If j and k are the elements of $\{0, 1, 2, 3, 4\}$ such that (j, k) is the unique pair for which $i = 5k + j$, then for $0 \leq i \leq 16$, $\text{Lane}'(j, k) = Z_i \oplus \text{Lane}(j, k)$, where $\text{Lane}'(j, k)$ is the updated value of the lane.

20.2.3 Functions

The functions, including the function Rnd and step mappings, for the Dedicated Hash-Function 14 are the same as Dedicated Hash-Function 13 and is specified in [Clause 19](#).

20.2.4 Constants

The constants used for the mapping ρ are the offsets defined in [Clause 19](#).

20.2.5 Initializing value

The initializing value is a 1 600-bit all-zero string.

20.3 Padding method

The data M will be padded with “01” before applying the padding method $\text{pad}_{10^*1}(x, m)$ specified in [Clause 19](#), with $x = 1\ 088$.

That is, the padded data is $P = M \parallel 01 \parallel 10^*1$, such that the length of P is a multiple of $1\ 088$.

20.4 Description of round-function

The round-function for Dedicated Hash-Function 14 is the permutation KECCAK- p specified in [Clause 19](#). Notice that KECCAK- p is considered as Φ as defined in ISO/IEC 10118-1. However, for each execution of KECCAK- p , it iterates the Rnd function 24 times. That is, it executes

$$Rnd(A, i_r) = \iota(\chi < \pi[\rho[\theta(A)]] >, i_r),$$

for $i_r = 0, 1, \dots, 23$.

20.5 Output transformation

In step h) of SPONGE[f, pad, r](N, d), specified in [Clause 19](#), $f = \text{KECCAK-}p$ because $r = 1\ 088$, $d = 256$ and $r > d$, the $\text{Trunc}_r(S)$ will be further truncated to d bits.

21 Dedicated Hash-Function 15 (SHA3-384)

21.1 General

In [Clause 21](#), a permutation-based hash-function with sponge construction SHA3-384 is specified. The description of permutation-based hash-function with sponge construction is given in [Clause 19](#).

The ISO/IEC hash-function identifier for Dedicated Hash-Function 15 is equal to 3F (hexadecimal).

21.2 Parameters, functions and constants

21.2.1 Parameters

For this hash-function, $L_1 = r = 832$, $L_2 = b = 1\ 600$, $c = b - r = 768$, $d = 384$, L_H is up to 384.

21.2.2 Byte ordering convention

Each data input D to the round-function Φ is a block of 832 bits that is XORed into the part of the state; the permutation f is then applied to the state. Because the step mappings that comprise the permutation are defined on the array form of the state, it is convenient to regard D as a sequence of 64-bit words that are XORed directly into the state array. For this purpose, when D is represented as a sequence of 104 bytes, $B_0, B_1, \dots, B_{103}$, then D shall be interpreted as a sequence of 13 lane words, $Z_0, Z_1, \dots, Z_{12}$, as follows:

$$Z_i = 2^{56}B_{8i+7} + 2^{48}B_{8i+6} + 2^{40}B_{8i+5} + 2^{32}B_{8i+4} + 2^{24}B_{8i+3} + 2^{16}B_{8i+2} + 2^8B_{8i+1} + B_{8i},$$

for $0 \leq i \leq 12$.

Hence, each group of eight consecutive bytes is a word and the bytes of the word are arranged in increasing order of significance, so that the first byte in the group becomes the least significant byte of the word.

For dedicated hash-function 14, the function is defined on a $5 \times 5 \times w$ state array. For each array six sub-arrays are defined for step-mappings. Lane is one of the subarrays and defined in [19.2.3.3](#). Under this interpretation, D is XORed with the state array as follows.

If j and k are the elements of $\{0, 1, 2, 3, 4\}$ such that (j, k) is the unique pair for which $i = 5k + j$, then for $0 \leq i \leq 12$, $\text{Lane}'(j, k) = Z_i \oplus \text{Lane}(j, k)$, where $\text{Lane}'(j, k)$ is the updated value of the lane.

21.2.3 Functions

The functions, including the function *Rnd* and step mappings, for the Dedicated Hash-Function 15 are the same as Dedicated Hash-Function 13 and is specified in [Clause 19](#).

21.2.4 Constants

The constants used for the mapping ρ are the offsets defined in [Clause 19](#).

21.2.5 Initializing value

The initializing value is a 1 600-bit all-zero string.

21.3 Padding method

The data M will be padded with “01” before applying the padding method $\text{pad}_{10^*1}(x, m)$ specified in [Clause 19](#), with $x = 832$.

That is, the padded data is $P = M \parallel 01 \parallel 10^*1$, such that the length of P is a multiple of 832.

21.4 Description of round-function

The round-function for Dedicated Hash-Function 15 is the permutation $\text{KECCAK-}p$ specified in [Clause 19](#). Notice that $\text{KECCAK-}p$ is considered as Φ as defined in ISO/IEC 10118-1. However, for each execution of $\text{KECCAK-}p$, it iterates the *Rnd* function 24 times. That is, it executes

$$\text{Rnd}(\mathbf{A}, i_r) = \iota(\chi < \pi\{\rho[\theta(\mathbf{A})]\} >, i_r),$$

for $i_r = 0, 1, \dots, 23$.

21.5 Output transformation

In step h) of $\text{SPONGE}[f, \text{pad}, r](N, d)$ specified in [Clause 19](#), because $r = 832$, $d = 384$ and $r > d$, the $\text{Trunc}_r(S)$ will be further truncated to d bits.

22 Dedicated Hash-Function 16 (SHA3-512)

22.1 General

In [Clause 22](#), a permutation-based hash-function with sponge construction SHA3-512 is specified. The description of permutation-based hash-function with sponge construction is given in [Clause 19](#).

The ISO/IEC hash-function identifier for Dedicated Hash-Function 16 is equal to 40 (hexadecimal).

22.2 Parameters, functions and constants

22.2.1 Parameters

For this hash-function, $L_1 = r = 576$, $L_2 = b = 1\,600$, $c = b - r = 1\,024$, $d = 512$, L_H is up to 512.

22.2.2 Byte ordering convention

Each data input D to the round-function Φ is a block of 576 bits that is XORed into the part of the state. The permutation f is then applied to the state. Because the step mappings that comprise the permutation are defined on the array form of the state, it is convenient to regard D as a sequence of 64-bit words that are XORed directly into the state array. For this purpose, when D is represented as a sequence of 72 bytes, $B_0, B_1, \dots, B_{71}$, then D shall be interpreted as a sequence of 9 lane words, $Z_0, Z_1, \dots, Z_8$, as follows:

$$Z_i = 2^{56}B_{8i+7} + 2^{48}B_{8i+6} + 2^{40}B_{8i+5} + 2^{32}B_{8i+4} + 2^{24}B_{8i+3} + 2^{16}B_{8i+2} + 2^8B_{8i+1} + B_{8i},$$

for $0 \leq i \leq 8$.

Hence, each group of eight consecutive bytes is a word and the bytes of the word are arranged in increasing order of significance, so that the first byte in the group becomes the least significant byte of the word.

For dedicated hash-function 14, the function is defined on a $5 \times 5 \times w$ state array. For each array six sub-arrays are defined for step-mappings. Lane is one of the subarrays and defined in [19.2.3.3](#). Under this interpretation, D is XORed with the state array as follows.

If j and k are the elements of $\{0, 1, 2, 3, 4\}$ such that (j, k) is the unique pair for which $i = 5k + j$, then for $0 \leq i \leq 8$, $Lane'(j, k) = Z_i \oplus Lane(j, k)$, where $Lane'(j, k)$ is the updated value of the lane.

22.2.3 Functions

The functions, including the function Rnd and step mappings, for the Dedicated Hash-Function 16 are the same as Dedicated Hash-Function 13 and is specified in [Clause 19](#).

22.2.4 Constants

The constants used for the mapping ρ are the offsets defined in [Clause 19](#).

22.2.5 Initializing value

The initializing value is a 1 600-bit all-zero string.

22.3 Padding method

The data M will be padded with “01” before applying the padding method $\text{pad}_{10^*1}(x, m)$ specified in [Clause 19](#), with $x = 576$.

That is, the padded data is $P = M \parallel 01 \parallel 10^*1$, such that the length of P is a multiple of 576.

22.4 Description of round-function

The round-function for Dedicated Hash-Function 16 is the permutation KECCAK- p specified in [Clause 19](#). Notice that KECCAK- p is considered as ϕ as defined in ISO/IEC 10118-1. However, for each execution of KECCAK- p , it iterates the Rnd function 24 times. That is, it executes

$$Rnd(\mathbf{A}, i_r) = \iota(\chi < \pi\{\rho[\theta(\mathbf{A})]\} >, i_r),$$

for $i_r = 0, 1, \dots, 23$.

22.5 Output transformation

In step h) of SPONGE[f , pad, r](N, d) specified in [Clause 19](#), $f = \text{KECCAK-}p$, because $r = 576$, $d = 512$ and $r > d$, the $\text{Trunc}_r(S)$ will be further truncated to d bits.

23 Dedicated Hash-Function 17 (SM3)

23.1 General

In [Clause 23](#), a padding method, an initializing value and a round-function for use in the general model for hash-functions described in ISO/IEC 10118-1 are specified. The padding method, initializing value and round-function specified here, when used in the above general model, together define Dedicated

Hash-Function 17. This dedicated hash-function can be applied to all data strings, D , containing at most $2^{64}-1$ bits.

The ISO/IEC hash-function identifier for Dedicated Hash-Function 17 is equal to 11 (hexadecimal).

NOTE Dedicated Hash-Function 17 defined in [Clause 23](#) is commonly called SM3[7][8].

23.2 Parameters, functions and constants

23.2.1 Parameters

For this hash-function, $L_1 = 512$, $L_2 = 256$ and L_H is up to 256.

23.2.2 Byte ordering convention

The byte ordering convention to be used with this hash-function shall be the same as the byte ordering convention defined in [9.2.2](#).

23.2.3 Functions

To facilitate software implementation, the round-function Φ is described in terms of operations on 32-bit words.

Two sequences of functions $b_0, b_1, \dots, b_{63}$ and $b'_0, b'_1, \dots, b'_{63}$ are used in this round-function, where each takes three words, X_0, X_1 and X_2 , as input and produces a single word as output. Two functions, P_0 and P_1 , are also used in this round-function, where each takes one word, X_0 , as input and produces a single word as output.

The functions $b_0, b_1, \dots, b_{63}, b'_0, b'_1, \dots, b'_{63}, P_0, P_1$ are defined as follows:

$$\begin{aligned}
 b_i(X_0, X_1, X_2) &= \begin{cases} X_0 \oplus X_1 \oplus X_2, & 0 \leq i \leq 15, \\ (X_0 \wedge X_1) \vee (X_0 \wedge X_2) \vee (X_1 \wedge X_2), & 16 \leq i \leq 63, \end{cases} \\
 b'_i(X_0, X_1, X_2) &= \begin{cases} X_0 \oplus X_1 \oplus X_2, & 0 \leq i \leq 15, \\ (X_0 \wedge X_1) \vee (\neg X_0 \wedge X_2), & 16 \leq i \leq 63, \end{cases} \\
 P_0(X_0) &= X_0 \oplus S^9(X_0) \oplus S^{17}(X_0), \\
 P_1(X_0) &= X_0 \oplus S^{15}(X_0) \oplus S^{23}(X_0).
 \end{aligned}$$

23.2.4 Constants

A sequence of constant words, $C_0, C_1, \dots, C_{63}$, is used in this round-function. In a hexadecimal representation (the most significant bit corresponds to the left-most bit), these are defined as follows:

$$C_i = \begin{cases} 79CC4519 & 0 \leq i \leq 15, \\ 7A879D8A & 16 \leq i \leq 63. \end{cases}$$

23.2.5 Initializing value

For this round-function the initializing value, IV , shall always be the following 256-bit string, represented here as a sequence of eight words, $Y_0, Y_1, \dots, Y_7$, in a hexadecimal representation, where Y_0 represents the left-most 32 of the 256 bits.

$$\begin{aligned}
 Y_0 &= 7380166F; \\
 Y_1 &= 4914B2B9;
 \end{aligned}$$

$Y_2 = 172442D7;$
 $Y_3 = DA8A0600;$
 $Y_4 = A96F30BC;$
 $Y_5 = 163138AA;$
 $Y_6 = E38DEE4D;$
 $Y_7 = B0FB0E4E.$

23.3 Padding method

The padding method to be used with this hash-function shall be the same as the padding method defined in [9.3](#).

23.4 Description of the round-function

The round-function, Φ , operates as follows.

NOTE In this description, the symbols $W_1, W_2, W_3, W_4, X_0, X_1, X_2, X_3, X_4, X_5, X_6, X_7, Z_0, Z_1, \dots, Z_{67}, Z'_0, Z'_1, \dots, Z'_{63}$ are used to denote 144 distinct words which contain values required in the computations.

- a) Suppose the 512-bit (first) input to Φ is contained in $Z_0, Z_1, \dots, Z_{15}$, where Z_0 contains the left-most 32 of the 512 bits. Suppose also that the 256-bit (second) input to Φ is contained in eight words, $Y_0, Y_1, \dots, Y_7$.
- b) For $i = 16$ to 67 , let $Z_i := P_1[Z_{i-16} \oplus Z_{i-9} \oplus S^{15}(Z_{i-3})] \oplus S^7(Z_{i-13}) \oplus Z_{i-6}$.
- c) For $i = 0$ to 63 , let $Z'_i := Z_i \oplus Z_{i+4}$.
- d) Let $X_0 := Y_0, X_1 := Y_1, X_2 := Y_2, X_3 := Y_3, X_4 := Y_4, X_5 := Y_5, X_6 := Y_6, X_7 := Y_7$.
- e) For $i = 0$ to 63 , do the following five steps:
 - 1) $W_1 := S^7[S^{12}(X_0) \cup X_4 \cup S^i(C_i)];$
 - 2) $W_2 := W_1 \oplus S^{12}(X_0);$
 - 3) $W_3 := b_i(X_0, X_1, X_2) \cup X_3 \cup W_2 \cup Z_i;$
 - 4) $W_4 := b'_i(X_4, X_5, X_6) \cup X_7 \cup W_1 \cup Z_i;$
 - 5) $X_7 := X_6, X_6 := S^{19}(X_5), X_5 := X_4, X_4 := P_0(W_4), X_3 := X_2, X_2 := S^9(X_1), X_1 := X_0, X_0 := W_3;$
- f) Let $Y_0 := Y_0 \oplus X_0, Y_1 := Y_1 \oplus X_1, Y_2 := Y_2 \oplus X_2, Y_3 := Y_3 \oplus X_3, Y_4 := Y_4 \oplus X_4, Y_5 := Y_5 \oplus X_5, Y_6 := Y_6 \oplus X_6$ and $Y_7 := Y_7 \oplus X_7$.
- g) The eight words, $Y_0, Y_1, \dots, Y_7$, represent the output of the round-function Φ . After the final iteration of the round-function, the eight words, $Y_0, Y_1, \dots, Y_7$, shall be converted to a sequence of 32 bytes using the inverse of the procedure specified in [Clause 9](#), where Y_0 shall yield the first four bytes, Y_1 the next four bytes and so on. Thus, the first (left-most) byte will correspond to the most significant byte of Y_0 and the 32nd (right-most) byte will correspond to the least significant byte of Y_7 . The 32 bytes shall be converted to a string of 256 bits using the inverse of the procedure specified in [Clause 6](#), i.e. the first (left-most) bit will correspond to the most significant bit of the first (left-most) byte and the 256th (right-most) bit will correspond to the least significant bit of the 32nd (right-most) byte.

[Figure 7](#) shows steps 1), 2), 3), 4) and 5) of item e) of the round-function Φ in SM3. In the round-function Φ , steps 1), 2), 3), 4) and 5) of item e) are used 64 times ($i = 0, 1, \dots, 63$).

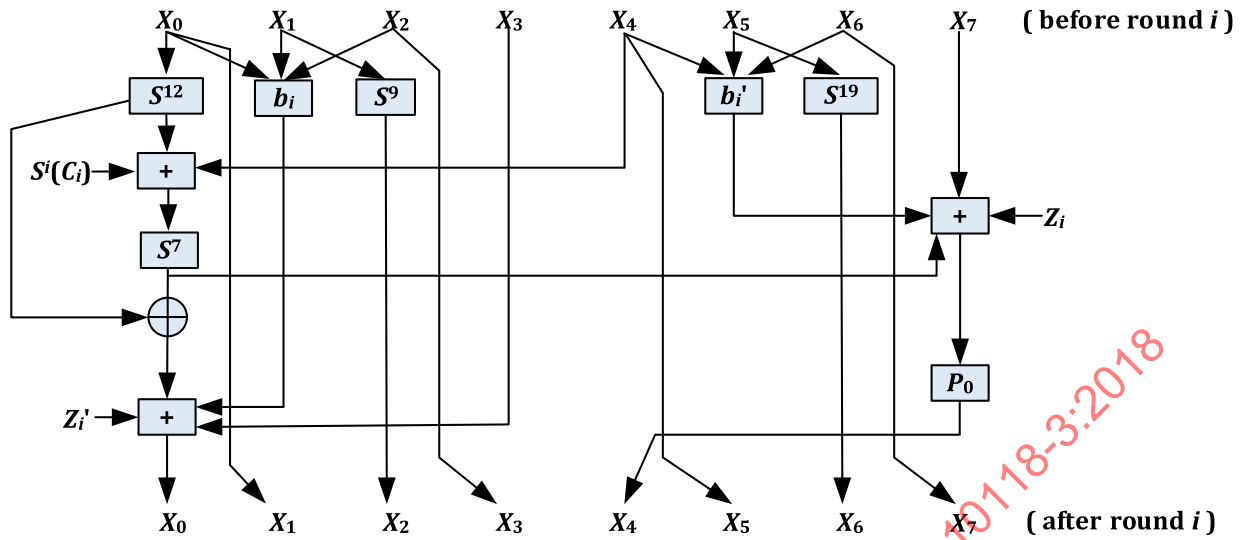


Figure 7 — Part of the round-function in Dedicated Hash-Function 17

Annex A (normative)

Object identifiers

Annex A lists the object identifiers assigned to the dedicated hash-functions specified in this document.

```
--
-- Draft object identifiers of ISO/IEC 10118-3
-- Based on ISO/IEC JTC 1/SC 27 N XXXX XXXX-XX-XX
--

DedicatedHashFunctions {
iso(1) standard(0) hash-functions(10118) part3(3)
asn1-module(1) dedicated-hash-functions(0) }
DEFINITIONS EXPLICIT TAGS ::= BEGIN

-- EXPORTS All; --

-- IMPORTS None; --

OID ::= OBJECT IDENTIFIER -- alias

-- Synonyms --

id-dhf OID ::= {
iso(1) standard(0) hash-functions(10118) part3(3) algorithm(0) }

-- Assignments --

id-dhf-ripemd160 OID ::= { id-dhf ripemd160 (49) }
id-dhf-ripemd128 OID ::= { id-dhf ripemd128 (50) }
id-dhf-whirlpool OID ::= { id-dhf whirlpool (55) }
id-dhf-streebog512 OID ::= { id-dhf streebog512 (59) }
id-dhf-streebog256 OID ::= { id-dhf streebog256 (60) }
id-dhf-SM3 OID ::= { id-dhf sm3 (65) }

-- note: assign any new OIDs above 68

-- FIPS 180-4 and FIPS 202 Secure Hash Algorithm --

id-sha1 OID ::= {
iso(1) identified-organization(3) oiw(14) secsig(3)
algorithm(2) 26
}

sha2Algorithm OID ::= {
joint-iso-itu-t(2) country(16) us(840) organization(1) gov(101)
csor(3) nistAlgorithm(4) hashAlgs(2)
}

id-sha256 OID ::= { sha2Algorithm sha256(1) }
id-sha384 OID ::= { sha2Algorithm sha384(2) }
id-sha512 OID ::= { sha2Algorithm sha512(3) }
id-sha224 OID ::= { sha2Algorithm sha224(4) }
```

```

id-sha512-224 OID ::= { sha2Algorithm sha512-224(5) }
id-sha512-256 OID ::= { sha2Algorithm sha512-256(6) }
id-sha3-224 OID ::= { sha2Algorithm sha3-224(7) }
id-sha3-256 OID ::= { sha2Algorithm sha3-256(8) }
id-sha3-384 OID ::= { sha2Algorithm sha3-384(9) }
id-sha3-512 OID ::= { sha2Algorithm sha3-512(10) }
id-shake128 OID ::= { sha2Algorithm shake128(11) }
id-shake256 OID ::= { sha2Algorithm shake256(12) }

HashFunctions ::= SEQUENCE {
  algorithm ALGORITHM.&id({HashFunctionAlgs}),
  parameters ALGORITHM.&Type({HashFunctionAlgs}{@algorithm}) OPTIONAL
}

HashFunctionAlgs ALGORITHM ::= {
  dhf-ripemd160 |
  dhf-ripemd128 |
  dhf-whirlpool |
  dhf-streebog256 |
  dhf-streebog512 |
  sha3-224 |
  sha3-256 |
  sha3-384 |
  sha3-512 |
  dhf-sm3 |
  shake128 |
  shake256 |
  SHA-Algorithms,

  ... -- Expect additional algorithms --
}

dhf-ripemd160 ALGORITHM ::= {
  OID id-dhf-ripemd160 PARMS NullParms
}

dhf-ripemd128 ALGORITHM ::= {
  OID id-dhf-ripemd128 PARMS NullParms
}

dhf-whirlpool ALGORITHM ::= {
  OID id-dhf-whirlpool PARMS NullParms
}

dhf-streebog256 ALGORITHM ::= {
  OID id-dhf-streebog256 PARMS NullParms
}

dhf-streebog512 ALGORITHM ::= {
  OID id-dhf-streebog512 PARMS NullParms
}

sha3-224 ALGORITHM ::= {
  OID id-sha3-224 PARMS NullParms
}

sha3-256 ALGORITHM ::= {
  OID id-sha3-256 PARMS NullParms
}

sha3-384 ALGORITHM ::= {
  OID id-sha3-384 PARMS NullParms
}

```

```

sha3-512 ALGORITHM ::= {
OID id-sha3-512 PARMS NullParms
}

dhf-SM3 ALGORITHM ::= {
OID id-dhf-sm3 PARMS NullParms
}

shake128 ALGORITHM ::= {
OID id-shake128 PARMS NullParms
}

shake256 ALGORITHM ::= {
OID id-shake256 PARMS NullParms
}

SHA-Algorithms ALGORITHM ::= {

-- The parameters associated with id-sha1, id-sha256, id-sha384, --
-- id-sha512, id-sha224, id-sha512-224 and id-sha512-256 should --
-- be omitted, but if present, should have --
-- a value of ASN.1 type NULL. This is to align with the original --
-- NIST definitions (which did not have parameters) and certain --
-- existing implementations (which have them). For these SHA --
-- algorithms, implementations should accept AlgorithmIdentifier --
-- values with NULL parameters and with the optional parameters --
-- component not present. --

sha-1      |
sha-256    |
sha-384    |
sha-512    |
sha-224    |
sha-512-224 |
sha-512-256,

... -- Expect additional algorithms --
}

sha-1 ALGORITHM ::= {
OID id-sha1 PARMS NullParms
}

sha-256 ALGORITHM ::= {
OID id-sha256 PARMS NullParms
}

sha-384 ALGORITHM ::= {
OID id-sha384 PARMS NullParms
}

sha-512 ALGORITHM ::= {
OID id-sha512 PARMS NullParms
}

sha-224 ALGORITHM ::= {
OID id-sha224 PARMS NullParms
}

sha-512-224 ALGORITHM ::= {
OID id-sha512-224 PARMS NullParms
}

sha-512-256 ALGORITHM ::= {
OID id-sha512-256 PARMS NullParms
}

NullParms ::= NULL

-- Cryptographic algorithm identification --

```

```
ALGORITHM ::= CLASS {  
  &id      OBJECT IDENTIFIER  UNIQUE,  
  &Type    OPTIONAL  
}  
WITH SYNTAX { OID &id [PARMS &Type] }  
  
END -- DedicatedHashFunctions --
```

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Annex B (informative)

Numerical examples

B.1 General

This annex gives numerical examples for the computation of Dedicated Hash-Functions 1 to 17. For each of the hash-functions, intermediate values derived during the hash-function's operation are given for some examples.

Throughout this annex, it is referred to as ASCII coding of data strings, which is equivalent to coding using ISO/IEC 646.

B.2 Dedicated Hash-Function 1 (RIPEMD-160)

NOTE Reference [4] contains a pseudocode description of Dedicated Hash-Function 1.

B.2.1 Example 1

In this example, the data string is the empty string, i.e., the string of length zero.

The hash-code is the following 160-bit string.

9C 11 85 A5 C5 E9 FC 54 61 28 08 97 7E E8 F5 48 B2 25 8D 31

B.2.2 Example 2

In this example, the data string consists of a single byte, namely the ASCII-coded version of the letter "a".

The hash-code is the following 160-bit string.

0B DC 9D 2D 25 6B 3E E9 DA AE 34 7B E6 F4 DC 83 5A 46 7F FE

B.2.3 Example 3

In this example, the data string is the 3-byte string consisting of the ASCII-coded version of "abc". This is equivalent to the bit string "01100001 01100010 01100011".

After the padding process, the single 16-word block derived from the data string is as follows.

80 63 62 61	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000018	00000000

The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X_4, X'_0, X'_1, X'_2, X'_3$ and X'_4 .

67452301,	EFCDA889,	98BADCFE,	10325476,	C3D2E1F0,	67452301,	EFCDA889,	98BADCFE,	10325476,	C3D2E1F0
C3D2E1F0,	3115FC67,	EFCDA889,	EB73FA62,	10325476,	C3D2E1F0,	DDD63FB8,	EFCDA889,	EB73FA62,	10325476
10325476,	B41192D5,	3115FC67,	36AE27BF,	EB73FA62,	10325476,	322E7AE3,	DDD63FB8,	36AE27BF,	EB73FA62
EB73FA62,	3A35DC50,	B41192D5,	57F19CC4,	36AE27BF,	EB73FA62,	883EE903,	322E7AE3,	58FEE377,	36AE27BF
36AE27BF,	D3786413,	3A35DC50,	464B56D0,	57F19CC4,	36AE27BF,	92B2B79B,	883EE903,	B9EB8CC8,	58FEE377
57F19CC4,	0E946720,	D3786413,	D77140E8,	464B56D0,	58FEE377,	F9091FF2,	92B2B79B,	FBA40E20,	B9EB8CC8

464B56D0,	D52BF632,	0E946720,	E1904F4D,	D77140E8,	B9EB8CC8,	E5B09992,	F9091FF2,	CADE6E4A,	FBA40E20
D77140E8,	150BD8A8,	D52BF632,	519C803A,	E1904F4D,	FBA40E20,	8B2D9FB3,	E5B09992,	247FCBE4,	CADE6E4A
E1904F4D,	3D6F601F,	150BD8A8,	AFD8CB54,	519C803A,	CADE6E4A,	E755F422,	8B2D9FB3,	C2664B96,	247FCBE4
519C803A,	B7B60384,	3D6F601F,	2F62A054,	AFD8CB54,	247FCBE4,	5922D09E,	E755F422,	B67ECE2C,	C2664B96
AFD8CB54,	B85A0A3F,	B7B60384,	BD807CF5,	2F62A054,	C2664B96,	CF24E72C,	5922D09E,	57D08B9D,	B67ECE2C
2F62A054,	7F8B38E5,	B85A0A3F,	D80E12DE,	BD807CF5,	B67ECE2C,	CA6A1C75,	CF24E72C,	8B427964,	57D08B9D
BD807CF5,	9DACA495,	7F8B38E5,	6828FEE1,	D80E12DE,	57D08B9D,	227F6D84,	CA6A1C75,	939CB33C,	8B427964
D80E12DE,	BC05F46F,	9DACA495,	2CE395FE,	6828FEE1,	8B427964,	5D801685,	227F6D84,	A871D729,	939CB33C
6828FEE1,	1494F053,	BC05F46F,	B2925676,	2CE395FE,	939CB33C,	B3C3F4D5,	5D801685,	FDB61089,	A871D729
2CE395FE,	85861D02,	1494F053,	17D1BEF0,	B2925676,	A871D729,	3D16242D,	B3C3F4D5,	005A1576,	FDB61089
B2925676,	597BF629,	85861D02,	53C14C52,	17D1BEF0,	FDB61089,	FF459078,	3D16242D,	0FD356CF,	005A1576
17D1BEF0,	6347EF78,	597BF629,	18740A16,	53C14C52,	005A1576,	927E40A8,	FF459078,	5890B4F4,	0FD356CF
53C14C52,	45C8FA44,	6347EF78,	EFD8A565,	18740A16,	0FD356CF,	ACBB994E,	927E40A8,	1641E3FD,	5890B4F4
18740A16,	AD2956AF,	45C8FA44,	1FBDE18D,	EFD8A565,	5890B4F4,	AD30AD24,	ACBB994E,	F902A249,	1641E3FD
EFD8A565,	5EAF16B7,	AD2956AF,	23E91117,	1FBDE18D,	1641E3FD,	6261732E,	AD30AD24,	EE653AB2,	F902A249
1FBDE18D,	41730D4B,	5EAF16B7,	A55ABEB4,	23E91117,	F902A249,	45ED27AF,	6261732E,	C2B492B4,	EE653AB2
23E91117,	FC0CCBD3,	41730D4B,	BC5ADD7A,	A55ABEB4,	EE653AB2,	243C5668,	45ED27AF,	85CCB989,	C2B492B4
A55ABEB4,	042ECC93,	FC0CCBD3,	CC352D05,	BC5ADD7A,	C2B492B4,	82F89BD1,	243C5668,	B49EBD17,	85CCB989
BC5ADD7A,	4D4D4377,	042ECC93,	332F4FF0,	CC352D05,	85CCB989,	5FC74686,	82F89BD1,	F159A090,	B49EBD17
CC352D05,	5207002B,	4D4D4377,	BB324C10,	332F4FF0,	B49EBD17,	B2720031,	5FC74686,	E26F460B,	F159A090
332F4FF0,	388278F5,	5207002B,	350DDD35,	BB324C10,	F159A090,	58A100F8,	B2720031,	1D1A197F,	E26F460B
BB324C10,	62879D70,	388278F5,	1C00AD48,	350DDD35,	E26F460B,	5992068B,	58A100F8,	C800C6C9,	1D1A197F
350DDD35,	A30A1FD9,	62879D70,	09E3D4E2,	1C00AD48,	1D1A197F,	CC290DCA,	5992068B,	8403E162,	C800C6C9
1C00AD48,	BDA2B31B,	A30A1FD9,	1E75C18A,	09E3D4E2,	C800C6C9,	863D625E,	CC290DCA,	481A2D66,	8403E162
09E3D4E2,	F7211DEE,	BDA2B31B,	287F668C,	1E75C18A,	8403E162,	6061B5A5,	863D625E,	A4372B30,	481A2D66
1E75C18A,	B6A665C6,	F7211DEE,	8ACC6EF6,	287F668C,	481A2D66,	AA98ADB5,	6061B5A5,	F5897A18,	A4372B30
287F668C,	2D30FA02,	B6A665C6,	8477BBDC,	8ACC6EF6,	A4372B30,	2999255A,	AA98ADB5,	86D69581,	F5897A18
8ACC6EF6,	C76D12F9,	2D30FA02,	99971ADA,	8477BBDC,	F5897A18,	98237631,	2999255A,	62B6D6AA,	86D69581
8477BBDC,	516F84DF,	C76D12F9,	C3E808B4,	99971ADA,	86D69581,	6C472A90,	98237631,	649568A6,	62B6D6AA
99971ADA,	F3FA5B05,	516F84DF,	B44BE71D,	C3E808B4,	62B6D6AA,	2EAD5672,	6C472A90,	8DD8C660,	649568A6
C3E808B4,	D539625E,	F3FA5B05,	BE137D45,	B44BE71D,	649568A6,	C5CB48BA,	2EAD5672,	1CAA41B1,	8DD8C660
B44BE71D,	D8500C99,	D539625E,	E96C17CF,	BE137D45,	8DD8C660,	05286DFB,	C5CB48BA,	B559C8BA,	1CAA41B1
BE137D45,	7ECDE5B2,	D8500C99,	E5897B54,	E96C17CF,	1CAA41B1,	88396DD2,	05286DFB,	2D22EB17,	B559C8BA
E96C17CF,	681D30B9,	7ECDE5B2,	40326761,	E5897B54,	B559C8BA,	333F2212,	88396DD2,	A1B7EC14,	2D22EB17
E5897B54,	960F7BFD,	681D30B9,	3796C9FB,	40326761,	2D22EB17,	C699295B,	333F2212,	E5B74A20,	A1B7EC14
40326761,	6770E498,	960F7BFD,	74C2E5A0,	3796C9FB,	A1B7EC14,	BFD68874,	C699295B,	FC8848CC,	E5B74A20
3796C9FB,	75EB06C5,	6770E498,	3DEFF658,	74C2E5A0,	E5B74A20,	BDDF3474,	BFD68874,	64A56F1A,	FC8848CC
74C2E5A0,	14FA827A,	75EB06C5,	C392619D,	3DEFF658,	FC8848CC,	8CBC87E9,	BDDF3474,	5A21D2FF,	64A56F1A
3DEFF658,	804B0068,	14FA827A,	AC1B15D7,	C392619D,	64A56F1A,	CDDA6EBF,	8CBC87E9,	7CD1D2F7,	5A21D2FF
C392619D,	475BA81B,	804B0068,	EA09E853,	AC1B15D7,	5A21D2FF,	656C7DA3,	CDDA6EBF,	F21FA632,	7CD1D2F7
AC1B15D7,	D26BC25D,	475BA81B,	2C01A201,	EA09E853,	7CD1D2F7,	76D66CA3,	656C7DA3,	69BAFF37,	F21FA632
EA09E853,	DBC5A2CB,	D26BC25D,	6EA06D1D,	2C01A201,	F21FA632,	C9B17F72,	76D66CA3,	B1F68D95,	69BAFF37
2C01A201,	77367F5E,	DBC5A2CB,	AF097749,	6EA06D1D,	69BAFF37,	65A60151,	C9B17F72,	59B28DDDB,	B1F68D95
6EA06D1D,	8155A6B4,	77367F5E,	168B2F6F,	AF097749,	B1F68D95,	33F3AC81,	65A60151,	C5FDCB26,	59B28DDDB
AF097749,	C90C4D38,	8155A6B4,	D9FD79DC,	168B2F6F,	59B28DDDB,	9BFB827D,	33F3AC81,	98054596,	C5FDCB26
168B2F6F,	9762713B,	C90C4D38,	569AD205,	D9FD79DC,	C5FDCB26,	DDC8130E,	9BFB827D,	CEB204CF,	98054596
D9FD79DC,	7EBF9C32,	9762713B,	3134E324,	569AD205,	98054596,	C24C2C79,	DDC8130E,	EE09F66F,	CEB204CF
569AD205,	20EFFA01,	7EBF9C32,	89C4EE5D,	3134E324,	CEB204CF,	F255847E,	C24C2C79,	204C3B77,	EE09F66F
3134E324,	75B7117F,	20EFFA01,	FE70C9FA,	89C4EE5D,	EE09F66F,	DCD63949,	F255847E,	30B1E709,	204C3B77
89C4EE5D,	A96BE4C7,	75B7117F,	BFE80483,	FE70C9FA,	204C3B77,	5B99238D,	DCD63949,	5611FBC9,	30B1E709
FE70C9FA,	5E3201FC,	A96BE4C7,	DC45FDD6,	BFE80483,	30B1E709,	B43484F4,	5B99238D,	58E52773,	5611FBC9
BFE80483,	2CF95A98,	5E3201FC,	AF931EA5,	DC45FDD6,	5611FBC9,	52325A09,	B43484F4,	648E356E,	58E52773
DC45FDD6,	1393F0C3,	2CF95A98,	C807F178,	AF931EA5,	58E52773,	D015577D,	52325A09,	D213D2D0,	648E356E

AF931EA5, BB49CCF7, 1393F0C3, E56A60B3, C807F178, 648E356E, BB9C87C4, D015577D, C9682548, D213D2D0
 C807F178, 6A330EB4, BB49CCF7, 4FC30C4E, E56A60B3, D213D2D0, B1BB1A2E, BB9C87C4, 555DF740, C9682548
 E56A60B3, 14E58204, 6A330EB4, 2733DEED, 4FC30C4E, C9682548, AC77F96D, B1BB1A2E, 721F12EE, 555DF740
 4FC30C4E, 79AAF53E, 14E58204, CC3AD1A8, 2733DEED, 555DF740, 1774D326, AC77F96D, EC68BAC6, 721F12EE
 2733DEED, 210769B3, 79AAF53E, 96081053, CC3AD1A8, 721F12EE, A625F112, 1774D326, DFE5B6B1, EC68BAC6
 CC3AD1A8, F44B53A7, 210769B3, ABD4F9E6, 96081053, EC68BAC6, 5DCA4D12, A625F112, D34C985D, DFE5B6B1
 96081053, 7C1E3640, F44B53A7, 1DA6CC84, ABD4F9E6, DFE5B6B1, EBC4D9C6, 5DCA4D12, 97C44A98, D34C985D
 ABD4F9E6, 06B59EE8, 7C1E3640, 2D4E9FD1, 1DA6CC84, D34C985D, 095F37FD, EBC4D9C6, 29344977, 97C44A98
 1DA6CC84, C422C3CD, 06B59EE8, 78D901F0, 2D4E9FD1, 97C44A98, 5BBEE487, 095F37FD, 13671BAF, 29344977
 2D4E9FD1, AD864025, C422C3CD, D67BA01A, 78D901F0, 29344977, BF5B2529, 5BBEE487, 7CDFF425, 13671BAF
 78D901F0, 29A83BB5, AD864025, 8B0F3710, D67BA01A, 13671BAF, FB5747C5, BF5B2529, FB921D6E, 7CDFF425
 D67BA01A, 626E3910, 29A83BB5, 190096B6, 8B0F3710, 7CDFF425, DD935A5F, FB5747C5, 6C94A6FD, FB921D6E
 8B0F3710, A719D8BC, 626E3910, A0EED4A6, 190096B6, FB921D6E, 27754F3A, DD935A5F, 5D1F17ED, 6C94A6FD
 190096B6, BA84C782, A719D8BC, B8E44189, A0EED4A6, 6C94A6FD, 4F5CA4A5, 27754F3A, 4D697F76, 5D1F17ED
 A0EED4A6, 9F6887A9, BA84C782, 6762F29C, B8E44189, 5D1F17ED, 325AFE7E, 4F5CA4A5, D53CE89D, 4D697F76
 B8E44189, 3A88288C, 9F6887A9, 131E0AEA, 6762F29C, 4D697F76, 86AFE021, 325AFE7E, 7292953D, D53CE89D
 6762F29C, AB23F78F, 3A88288C, A21EA67D, 131E0AEA, D53CE89D, C97F9EA1, 86AFE021, 6BF9F8C9, 7292953D
 131E0AEA, 7299044A, AB23F78F, 20A230EA, A21EA67D, 7292953D, 9F60751C, C97F9EA1, BF80861A, 6BF9F8C9
 A21EA67D, 6A3F10CF, 7299044A, 8FDE3EAC, 20A230EA, 6BF9F8C9, 1E9CE713, 9F60751C, FE7A8725, BF80861A
 20A230EA, 1A1B904D, 6A3F10CF, 641129CA, 8FDE3EAC, BF80861A, C13F038A, 1E9CE713, 81D4727D, FE7A8725
 8FDE3EAC, 0B2CDC01, 1A1B904D, FC433DA8, 641129CA, FE7A8725, BF627814, C13F038A, 739C4C7A, 81D4727D
 641129CA, D563BFDC, 0B2CDC01, 6E413468, FC433DA8, 81D4727D, 5ECCBADE, BF627814, FC0E2B04, 739C4C7A

The hash-code is the following 160-bit string.

8E B2 08 F7 E0 5D 98 7A 9B 04 4A 8E 98 C6 B0 87 F1 5A 0B FC

B.2.4 Example 4

In this example, the data string is the 14-byte string consisting of the ASCII-coded version of

“message digest”

The hash-code is the following 160-bit string.

5D 06 89 EF 49 D2 FA E5 72 B8 81 B1 23 A8 5F FA 21 59 5F 36

B.2.5 Example 5

In this example, the data string is the 26-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz”

The hash-code is the following 160-bit string.

F7 1C 27 10 9C 69 2C 1B 56 BB DC EB 5B 9D 28 65 B3 70 8D BC

B.2.6 Example 6

In this example, the data string is the 62-byte string consisting of the ASCII-coded version of

“ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789”

The hash-code is the following 160-bit string.

B0 E2 0B 6E 31 16 64 02 86 ED 3A 87 A5 71 30 79 B2 1F 51 89

B.2.7 Example 7

In this example, the data string is the 80-byte string consisting of the ASCII-coded version of eight repetitions of

“1234567890”

The hash-code is the following 160-bit string.

9B 75 2E 45 57 3D 4B 39 F4 DB D3 32 3C AB 82 BF 63 32 6B FB

B.2.8 Example 8

In this example, the data string is the 56-byte string consisting of the ASCII-coded version of

“abcdcbcdcedefdefgfehgfhghighijhijkijklklmklmnlmnomnopnopq”

After the padding process, the two 16-word blocks derived from the data string are as follows.

64636261	65646362	66656463	67666564	68676665	69686766	6A696867	6B6A6968
6C6B6A69	6D6C6B6A	6E6D6C6B	6F6E6D6C	706F6E6D	71706F6E	00000080	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	000001C0	00000000

The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X_4, X'_0, X'_1, X'_2, X'_3$ and X'_4 , obtained during the processing of the first block.

67452301,	EFCDAB89,	98BADCFE,	10325476,	C3D2E1F0,	67452301,	EFCDAB89,	98BADCFE,	10325476,	C3D2E1F0
C3D2E1F0,	3115FB87,	EFCDAB89,	EB73FA62,	10325476,	C3D2E1F0,	463DA521,	EFCDAB89,	EB73FA62,	10325476
10325476,	CC21EC2E,	3115FB87,	36AE27BF,	EB73FA62,	10325476,	DB247A12,	463DA521,	36AE27BF,	EB73FA62
EB73FA62,	DFEB9B7A,	CC21EC2E,	57EE1CC4,	36AE27BF,	EB73FA62,	1D166A23,	DB247A12,	F6948518,	36AE27BF
36AE27BF,	2363912E,	DFEB9B7A,	87B0BB30,	57EE1CC4,	36AE27BF,	CE7A12F6,	1D166A23,	91E84B6C,	F6948518
57EE1CC4,	A1B60DC7,	2363912E,	AE6DEB7F,	87B0BB30,	F6948518,	57FF19DD,	CE7A12F6,	59A88C74,	91E84B6C
87B0BB30,	96AC7C1E,	A1B60DC7,	8E44B88D,	AE6DEB7F,	91E84B6C,	01A9FEFA,	57FF19DD,	E84BDB39,	59A88C74
AE6DEB7F,	6AE46154,	96AC7C1E,	D8371E86,	8E44B88D,	59A88C74,	5D9A609C,	01A9FEFA,	FC67755F,	E84BDB39
8E44B88D,	3CF61F09,	6AE46154,	B1F07A5A,	D8371E86,	E84BDB39,	030F7FE7,	5D9A609C,	A7FBE806,	FC67755F
D8371E86,	696F0D9A,	3CF61F09,	918551AB,	B1F07A5A,	FC67755F,	7456C8E3,	030F7FE7,	69827176,	A7FBE806
B1F07A5A,	AB957B91,	696F0D9A,	D87C24F3,	918551AB,	A7FBE806,	F64C4453,	7456C8E3,	3DFF9C0C,	69827176
918551AB,	9FF4A064,	AB957B91,	BC3669A5,	D87C24F3,	69827176,	22A5FE6E,	F64C4453,	5B238DD1,	3DFF9C0C
D87C24F3,	912FE998,	9FF4A064,	55EE46AE,	BC3669A5,	3DFF9C0C,	8D7E53E4,	22A5FE6E,	31114FD9,	5B238DD1
BC3669A5,	C45F164E,	912FE998,	D281927F,	55EE46AE,	5B238DD1,	695B23B7,	8D7E53E4,	97F9B88A,	31114FD9
55EE46AE,	2211A508,	C45F164E,	BFA66244,	D281927F,	31114FD9,	6FAA776F,	695B23B7,	F94F9235,	97F9B88A
D281927F,	80B1F3DE,	2211A508,	7C593B11,	BFA66244,	97F9B88A,	4D94F720,	6FAA776F,	6C8EDDA5,	F94F9235
BFA66244,	3AA6A8F5,	80B1F3DE,	46942088,	7C593B11,	F94F9235,	D81C6137,	4D94F720,	A9DDBDBE,	6C8EDDA5
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The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X_4, X'_0, X'_1, X'_2, X'_3$ and X'_4 , obtained during the processing of the second block.

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1C648795,	2FE154B4,	FA97F1BB,	3FEF9DE2,	FBEF1BA3,	F91B9A57,	CA3DDAC0,	860F8E32,	4C0B51A0,	5760C92D
FBEF1BA3,	D884695B,	2FE154B4,	5FC6EFEA,	3FEF9DE2,	5760C92D,	7E790793,	CA3DDAC0,	3E38CA18,	4C0B51A0
3FEF9DE2,	A09357E9,	D884695B,	8552D0BF,	5FC6EFEA,	4C0B51A0,	4E0DF927,	7E790793,	F76B0328,	3E38CA18
5FC6EFEA,	019B9791,	A09357E9,	11A56F62,	8552D0BF,	3E38CA18,	311DFB90,	4E0DF927,	E41E4DF9,	F76B0328
8552D0BF,	70DB6FDF,	019B9791,	4D5FA682,	11A56F62,	F76B0328,	24FA9DC7,	311DFB90,	37E49D38,	E41E4DF9
11A56F62,	82F104B4,	70DB6FDF,	6E5E4406,	4D5FA682,	E41E4DF9,	CE45E142,	24FA9DC7,	77EE40C4,	37E49D38
4D5FA682,	BFAB29F8,	82F104B4,	6DBF7DC3,	6E5E4406,	37E49D38,	9C4F267F,	CE45E142,	EA771C93,	77EE40C4
6E5E4406,	880198A9,	BFAB29F8,	C412D20B,	6DBF7DC3,	77EE40C4,	06880805,	9C4F267F,	17850B39,	EA771C93
6DBF7DC3,	917C197C,	880198A9,	ACA7E2FE,	C412D20B,	EA771C93,	7625BD09,	06880805,	3C99FE71,	17850B39
C412D20B,	03E7992A,	917C197C,	0662A620,	ACA7E2FE,	17850B39,	8720C8E7,	7625BD09,	2020141A,	3C99FE71
ACA7E2FE,	824CEF7A,	03E7992A,	F065F245,	0662A620,	3C99FE71,	CBB7DA7A,	8720C8E7,	96F425D8,	2020141A
0662A620,	AF16F218,	824CEF7A,	9E64A80F,	F065F245,	2020141A,	88851068,	CBB7DA7A,	83239E1C,	96F425D8
F065F245,	EFC8943D,	AF16F218,	33BDEA09,	9E64A80F,	96F425D8,	C85C4EB8,	88851068,	DF69EB2E,	83239E1C
9E64A80F,	C80FF53B,	EFC8943D,	5BC862BC,	33BDEA09,	83239E1C,	57BF18E2,	C85C4EB8,	1441A222,	DF69EB2E
33BDEA09,	28DF9E36,	C80FF53B,	2250F7BF,	5BC862BC,	DF69EB2E,	48932C1A,	57BF18E2,	713AE321,	1441A222
5BC862BC,	6E1D8950,	28DF9E36,	3FD4EF20,	2250F7BF,	1441A222,	15C7B0BD,	48932C1A,	FC63895E,	713AE321
2250F7BF,	21EEE621,	6E1D8950,	7E78D8A3,	3FD4EF20,	713AE321,	FCBC9E78,	15C7B0BD,	4CB06922,	FC63895E
3FD4EF20,	561379BA,	21EEE621,	762541B8,	7E78D8A3,	FC63895E,	DD28EA60,	FCBC9E78,	1EC2F457,	4CB06922
7E78D8A3,	4D0255C5,	561379BA,	BB988487,	762541B8,	4CB06922,	CF1BB810,	DD28EA60,	F279E3F2,	1EC2F457
762541B8,	966845EC,	4D0255C5,	4DE6E958,	BB988487,	1EC2F457,	5D899D62,	CF1BB810,	A3A98374,	F279E3F2
BB988487,	D922DEB8,	966845EC,	09571534,	4DE6E958,	F279E3F2,	F1144141,	5D899D62,	6EE0433C,	A3A98374
4DE6E958,	B919B2A3,	D922DEB8,	A117B259,	09571534,	A3A98374,	940BBA12,	F1144141,	26758976,	6EE0433C
09571534,	D3CF80F9,	B919B2A3,	8B7AE364,	A117B259,	6EE0433C,	33DDA9B5,	940BBA12,	510507C4,	26758976
A117B259,	F548EA98,	D3CF80F9,	66CA8EE4,	8B7AE364,	26758976,	DCE0B562,	33DDA9B5,	2EE84A50,	510507C4
8B7AE364,	A1D3372D,	F548EA98,	3E03E74F,	66CA8EE4,	510507C4,	C103FBE9,	DCE0B562,	76A6D4CF,	2EE84A50
66CA8EE4,	6578D66C,	A1D3372D,	23AA63D5,	3E03E74F,	2EE84A50,	832961D9,	C103FBE9,	82D58B73,	76A6D4CF
3E03E74F,	57C29604,	6578D66C,	4CDCB687,	23AA63D5,	76A6D4CF,	B183744E,	832961D9,	0FEFA704,	82D58B73
23AA63D5,	27F5E937,	57C29604,	E359B195,	4CDCB687,	82D58B73,	E710A112,	B183744E,	A587660C,	0FEFA704

The hash-code is the following 160-bit string.

12 A0 53 38 4A 9C 0C 88 E4 05 A0 6C 27 DC F4 9A DA 62 EB 2B

B.2.9 Example 9

In this example, the data string is the 1 000 000-byte string consisting of the ASCII-coded version of “a” repeated 10^6 times.

The hash-code is the following 160-bit string.

52 78 32 43 C1 69 7B DB E1 6D 37 F9 7F 68 F0 83 25 DC 15 28

B.2.10 Example 10

In this example, the data string is the 112-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz
abcdefghijklmnopqrstuvwxyz”

(with no line break after the first n).

The hash-code is the following 160-bit string.

6F 3F A3 9B 6B 50 3C 38 4F 91 9A 49 A7 AA 5C 2C 08 BD FB 45

B.2.11 Example 11

In this example, the data string is the 32-byte string consisting of the ASCII-coded version of

“abcdbcdecdefdefgefghfghighijhijk”

The hash-code is the following 160-bit string.

94 C2 64 11 54 04 E6 33 79 0D FC C8 7B 58 7D 36 77 06 7D 9F

B.3 Dedicated Hash-Function 2 (RIPEMD-128)

B.3.1 Example 1

In this example, the data string is the empty string, i.e., the string of length zero.

The hash-code is the following 128-bit string.

CD F2 62 13 A1 50 DC 3E CB 61 0F 18 F6 B3 8B 46

B.3.2 Example 2

In this example, the data string consists of a single byte, namely the ASCII-coded version of the letter “a”.

The hash-code is the following 128-bit string.

86 BE 7A FA 33 9D 0F C7 CF C7 85 E7 2F 57 8D 33

B.3.3 Example 3

In this example, the data string is the 3-byte string consisting of the ASCII-coded version of “abc”. This is equivalent to the bit string “01100001 01100010 01100011”.

After the padding process, the single 16-word block derived from the data string is as follows.

80636261 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000018 00000000

The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X'_0, X'_1, X'_2$ and X'_3 .

67452301, EFCDAB89, 98BADCFE, 10325476, 67452301, EFCDAB89, 98BADCFE, 10325476
10325476, 6D431A77, EFCDAB89, 98BADCFE, 10325476, 70376F40, EFCDAB89, 98BADCFE
98BADCFE, B05D8A99, 6D431A77, EFCDAB89, 98BADCFE, 989F6BB0, 70376F40, EFCDAB89
EFCDAB89, 0C32E5C7, B05D8A99, 6D431A77, EFCDAB89, 39B14904, 989F6BB0, 70376F40
6D431A77, A20B2C0F, 0C32E5C7, B05D8A99, 70376F40, 671C03CC, 39B14904, 989F6BB0
B05D8A99, 74EBB911, A20B2C0F, 0C32E5C7, 989F6BB0, BFD55C42, 671C03CC, 39B14904
0C32E5C7, 2FFB728B, 74EBB911, A20B2C0F, 39B14904, A12F346F, BFD55C42, 671C03CC
A20B2C0F, A766AE02, 2FFB728B, 74EBB911, 671C03CC, 989C2210, A12F346F, BFD55C42
74EBB911, 03234F3D, A766AE02, 2FFB728B, BFD55C42, 0F95FBEA, 989C2210, A12F346F
2FFB728B, 52662805, 03234F3D, A766AE02, A12F346F, 068D5115, 0F95FBEA, 989C2210
A766AE02, E778A4C3, 52662805, 03234F3D, 989C2210, AFCD27FC, 068D5115, 0F95FBEA
03234F3D, 1C7F5769, E778A4C3, 52662805, 0F95FBEA, CBD1F3F8, AFCD27FC, 068D5115
52662805, 95765642, 1C7F5769, E778A4C3, 068D5115, CFFE405F, CBD1F3F8, AFCD27FC
E778A4C3, 35F37B70, 95765642, 1C7F5769, AFCD27FC, 2B55C9C3, CFFE405F, CBD1F3F8
1C7F5769, 398F8F52, 35F37B70, 95765642, CBD1F3F8, DD6A43FB, 2B55C9C3, CFFE405F
95765642, 13F3C36B, 398F8F52, 35F37B70, CFFE405F, 049B909E, DD6A43FB, 2B55C9C3

35F37B70, 058D8BB5, 13F3C36B, 398F8F52, 2B55C9C3, 3713BFFD, 049B909E, DD6A43FB
 398F8F52, FCBE3664, 058D8BB5, 13F3C36B, DD6A43FB, 82ADDB53, 3713BFFD, 049B909E
 13F3C36B, F7F306A6, FCBE3664, 058D8BB5, 049B909E, CC1D8105, 82ADDB53, 3713BFFD
 058D8BB5, 34CC3963, F7F306A6, FCBE3664, 3713BFFD, BE09159A, CC1D8105, 82ADDB53
 FCBE3664, 416E8BA0, 34CC3963, F7F306A6, 82ADDB53, 541AE568, BE09159A, CC1D8105
 F7F306A6, EDE91870, 416E8BA0, 34CC3963, CC1D8105, 27D40F94, 541AE568, BE09159A
 34CC3963, C352C547, EDE91870, 416E8BA0, BE09159A, 675C363A, 27D40F94, 541AE568
 416E8BA0, 5D5EEE28, C352C547, EDE91870, 541AE568, 77F3A38B, 675C363A, 27D40F94
 EDE91870, 6CC4BEF2, 5D5EEE28, C352C547, 27D40F94, 84D73C44, 77F3A38B, 675C363A
 C352C547, E140970B, 6CC4BEF2, 5D5EEE28, 675C363A, D2958F37, 84D73C44, 77F3A38B
 5D5EEE28, 79F631A9, E140970B, 6CC4BEF2, 77F3A38B, FC39C927, D2958F37, 84D73C44
 6CC4BEF2, 038E0E91, 79F631A9, E140970B, 84D73C44, E3A5A4DE, FC39C927, D2958F37
 E140970B, 1B942D52, 038E0E91, 79F631A9, D2958F37, 4BA3A889, E3A5A4DE, FC39C927
 79F631A9, 496AECFD, 1B942D52, 038E0E91, FC39C927, A964BA74, 4BA3A889, E3A5A4DE
 038E0E91, FE6CD56F, 496AECFD, 1B942D52, E3A5A4DE, 7AF9DBB0, A964BA74, 4BA3A889
 1B942D52, 2E94F501, FE6CD56F, 496AECFD, 4BA3A889, 7DA68EA9, 7AF9DBB0, A964BA74
 496AECFD, 584E8E58, 2E94F501, FE6CD56F, A964BA74, 9C7247E5, 7DA68EA9, 7AF9DBB0
 FE6CD56F, 41A17EFA, 584E8E58, 2E94F501, 7AF9DBB0, 0130312B, 9C7247E5, 7DA68EA9
 2E94F501, 8981C6CD, 41A17EFA, 584E8E58, 7DA68EA9, 90552232, 0130312B, 9C7247E5
 584E8E58, 400A93E1, 8981C6CD, 41A17EFA, 9C7247E5, 99C1FBA4, 90552232, 0130312B
 41A17EFA, 841F817F, 400A93E1, 8981C6CD, 0130312B, 9D481CD2, 99C1FBA4, 90552232
 8981C6CD, 659379BE, 841F817F, 400A93E1, 90552232, F5AABE07, 9D481CD2, 99C1FBA4
 400A93E1, AB3D9A70, 659379BE, 841F817F, 99C1FBA4, C3AFB7E6, F5AABE07, 9D481CD2
 841F817F, D3D21DC8, AB3D9A70, 659379BE, 9D481CD2, 473E2B79, C3AFB7E6, F5AABE07
 659379BE, 38C8D29D, D3D21DC8, AB3D9A70, F5AABE07, C4CAFF99, 473E2B79, C3AFB7E6
 AB3D9A70, 738B9B0F, 38C8D29D, D3D21DC8, C3AFB7E6, A2879AA4, C4CAFF99, 473E2B79
 D3D21DC8, 8528B83E, 738B9B0F, 38C8D29D, 473E2B79, 56565EDB, A2879AA4, C4CAFF99
 38C8D29D, 7345AF18, 8528B83E, 738B9B0F, C4CAFF99, E7A4BD86, 56565EDB, A2879AA4
 738B9B0F, FFCC52B, 7345AF18, 8528B83E, A2879AA4, 974B9E10, E7A4BD86, 56565EDB
 8528B83E, A77E902B, FFCC52B, 7345AF18, 56565EDB, 96CC5AE1, 974B9E10, E7A4BD86
 7345AF18, CB9C6C83, A77E902B, FFCC52B, E7A4BD86, 57E6A772, 96CC5AE1, 974B9E10
 FFCC52B, 38A2DA83, CB9C6C83, A77E902B, 974B9E10, F10B6CF5, 57E6A772, 96CC5AE1
 A77E902B, 487F9401, 38A2DA83, CB9C6C83, 96CC5AE1, 90426E6B, F10B6CF5, 57E6A772
 CB9C6C83, C7184576, 487F9401, 38A2DA83, 57E6A772, 0066E6BE, 90426E6B, F10B6CF5
 38A2DA83, 56D619B1, C7184576, 487F9401, F10B6CF5, 22D17257, 0066E6BE, 90426E6B
 487F9401, 3A35A3C5, 56D619B1, C7184576, 90426E6B, 016777A4, 22D17257, 0066E6BE
 C7184576, B5517538, 3A35A3C5, 56D619B1, 0066E6BE, 9A8DC5A0, 016777A4, 22D17257
 56D619B1, 4609C4C2, B5517538, 3A35A3C5, 22D17257, A9C46E68, 9A8DC5A0, 016777A4
 3A35A3C5, D5C2B699, 4609C4C2, B5517538, 016777A4, 13B0D540, A9C46E68, 9A8DC5A0
 B5517538, 342AF741, D5C2B699, 4609C4C2, 9A8DC5A0, 983D8B08, 13B0D540, A9C46E68
 4609C4C2, 38286DDA, 342AF741, D5C2B699, A9C46E68, 96084F4E, 983D8B08, 13B0D540
 D5C2B699, 9BCCEC0A, 38286DDA, 342AF741, 13B0D540, D25FDBB1, 96084F4E, 983D8B08
 342AF741, 5803DF3A, 9BCCEC0A, 38286DDA, 983D8B08, 35EA6FE0, D25FDBB1, 96084F4E
 38286DDA, E1B026EB, 5803DF3A, 9BCCEC0A, 96084F4E, B862709F, 35EA6FE0, D25FDBB1
 9BCCEC0A, 31587C22, E1B026EB, 5803DF3A, D25FDBB1, C02839EB, B862709F, 35EA6FE0
 5803DF3A, 9B25E1DC, 31587C22, E1B026EB, 35EA6FE0, 00245200, C02839EB, B862709F
 E1B026EB, 2205379E, 9B25E1DC, 31587C22, B862709F, CB116A95, 00245200, C02839EB
 31587C22, 5E3334A3, 2205379E, 9B25E1DC, C02839EB, B90EE1BF, CB116A95, 00245200
 9B25E1DC, 56F80FA9, 5E3334A3, 2205379E, 00245200, 64132D32, B90EE1BF, CB116A95

The hash-code is the following 128-bit string.

C1 4A 12 19 9C 66 E4 BA 84 63 6B 0F 69 14 4C 77

B.3.4 Example 4

In this example, the data string is the 14-byte string consisting of the ASCII-coded version of

“message digest”

The hash-code is the following 128-bit string.

9E 32 7B 3D 6E 52 30 62 AF C1 13 2D 7D F9 D1 B8

B.3.5 Example 5

In this example, the data string is the 26-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz”

The hash-code is the following 128-bit string.

FD 2A A6 07 F7 1D C8 F5 10 71 49 22 B3 71 83 4E

B.3.6 Example 6

In this example, the data string is the 62-byte string consisting of the ASCII-coded version of

“ABCDEFGHJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789”

The hash-code is the following 128-bit string.

D1 E9 59 EB 17 9C 91 1F AE A4 62 4C 60 C5 C7 02

B.3.7 Example 7

In this example, the data string is the 80-byte string consisting of the ASCII-coded version of eight repetitions of

“1234567890”

The hash-code is the following 128-bit string.

3F 45 EF 19 47 32 C2 DB B2 C4 A2 C7 69 79 5F A3

B.3.8 Example 8

In this example, the data string is the 56-byte string consisting of the ASCII-coded version of

“abcdcbcdcedefdefghfghghighijhijkijklklmklmnlmnomnopnopq”

After the padding process, the two 16-word blocks derived from the data string are as follows.

64636261	65646362	66656463	67666564	68676665	69686766	6A696867	6B6A6968
6C6B6A69	6D6C6B6A	6E6D6C6B	6F6E6D6C	706F6E6D	71706F6E	00000080	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	000001C0	00000000

The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X'_0, X'_1, X'_2$ and X'_3 obtained during the processing of the first block.

67452301, EFCDAB89, 98BADCFE, 10325476, 67452301, EFCDAB89, 98BADCFE, 10325476
 10325476, 6D431997, EFCDAB89, 98BADCFE, 10325476, D89ED5A9, EFCDAB89, 98BADCFE
 98BADCFE, C9AE23F2, 6D431997, EFCDAB89, 98BADCFE, 69B10AC1, D89ED5A9, EFCDAB89
 EFCDAB89, 69A6A520, C9AE23F2, 6D431997, EFCDAB89, B661DB9C, 69B10AC1, D89ED5A9
 6D431997, FB032247, 69A6A520, C9AE23F2, D89ED5A9, ABACC2AF, B661DB9C, 69B10AC1
 C9AE23F2, 16C49226, FB032247, 69A6A520, 69B10AC1, D412CAD1, ABACC2AF, B661DB9C
 69A6A520, 77A099B7, 16C49226, FB032247, B661DB9C, E2DEDF22, D412CAD1, ABACC2AF
 FB032247, 3B9BAEB7, 77A099B7, 16C49226, ABACC2AF, CFB03688, E2DEDF22, D412CAD1
 16C49226, DA61AB82, 3B9BAEB7, 77A099B7, D412CAD1, 72599389, CFB03688, E2DEDF22
 77A099B7, 54C888CC, DA61AB82, 3B9BAEB7, E2DEDF22, CF3CD682, 72599389, CFB03688
 3B9BAEB7, F2635347, 54C888CC, DA61AB82, CFB03688, B235784E, CF3CD682, 72599389
 DA61AB82, E2CAC9B4, F2635347, 54C888CC, 72599389, 881678DF, B235784E, CF3CD682
 54C888CC, 9596C718, E2CAC9B4, F2635347, CF3CD682, E815373B, 881678DF, B235784E
 F2635347, 9DD54912, 9596C718, E2CAC9B4, B235784E, BD994B56, E815373B, 881678DF
 E2CAC9B4, 2E8539A7, 9DD54912, 9596C718, 881678DF, B0055655, BD994B56, E815373B
 9596C718, 2303C213, 2E8539A7, 9DD54912, E815373B, CC87EF5A, B0055655, BD994B56
 9DD54912, EA79BE25, 2303C213, 2E8539A7, BD994B56, 6B24384D, CC87EF5A, B0055655
 2E8539A7, 23D7CB45, EA79BE25, 2303C213, B0055655, 93E7329F, 6B24384D, CC87EF5A
 2303C213, F028EF04, 23D7CB45, EA79BE25, CC87EF5A, 35B95AE7, 93E7329F, 6B24384D
 EA79BE25, 48863F19, F028EF04, 23D7CB45, 6B24384D, 06C6536D, 35B95AE7, 93E7329F
 23D7CB45, 514C81B6, 48863F19, F028EF04, 93E7329F, FF1C5DC7, 06C6536D, 35B95AE7
 F028EF04, 6102CE67, 514C81B6, 48863F19, 35B95AE7, D0D541F1, FF1C5DC7, 06C6536D
 48863F19, 330485FD, 6102CE67, 514C81B6, 06C6536D, A94C0DD9, D0D541F1, FF1C5DC7
 514C81B6, 289E8C82, 330485FD, 6102CE67, FF1C5DC7, DEDC1E39, A94C0DD9, D0D541F1
 6102CE67, 13CC3A1D, 289E8C82, 330485FD, D0D541F1, 12D926C0, DEDC1E39, A94C0DD9
 330485FD, 40A226A6, 13CC3A1D, 289E8C82, A94C0DD9, ED7EDA63, 12D926C0, DEDC1E39
 289E8C82, 70BFB1A8, 40A226A6, 13CC3A1D, DEDC1E39, 9E52219C, ED7EDA63, 12D926C0
 13CC3A1D, CE1D1A37, 70BFB1A8, 40A226A6, 12D926C0, F5D22339, 9E52219C, ED7EDA63
 40A226A6, EC9F7830, CE1D1A37, 70BFB1A8, ED7EDA63, 0BC5B4FC, F5D22339, 9E52219C
 70BFB1A8, 3CF2D6EE, EC9F7830, CE1D1A37, 9E52219C, FCFBD391, 0BC5B4FC, F5D22339
 CE1D1A37, F0C1F95C, 3CF2D6EE, EC9F7830, F5D22339, 2B6A389B, FCFBD391, 0BC5B4FC
 EC9F7830, 9A351A9D, F0C1F95C, 3CF2D6EE, 0BC5B4FC, FBF85B05, 2B6A389B, FCFBD391
 3CF2D6EE, 138B0685, 9A351A9D, F0C1F95C, FCFBD391, F7BBBE8B, FBF85B05, 2B6A389B
 F0C1F95C, EA3574D1, 138B0685, 9A351A9D, 2B6A389B, C8592ACC, F7BBBE8B, FBF85B05
 9A351A9D, 4719C849, EA3574D1, 138B0685, FBF85B05, FE2D3EFA, C8592ACC, F7BBBE8B
 138B0685, 57F52A13, 4719C849, EA3574D1, F7BBBE8B, 5411CC34, FE2D3EFA, C8592ACC
 EA3574D1, 4751F880, 57F52A13, 4719C849, C8592ACC, DC8ED546, 5411CC34, FE2D3EFA
 4719C849, 80605BAF, 4751F880, 57F52A13, FE2D3EFA, 55C1E317, DC8ED546, 5411CC34
 57F52A13, 1E53AD4A, 80605BAF, 4751F880, 5411CC34, 0B92E4F0, 55C1E317, DC8ED546
 4751F880, 1ABEED79, 1E53AD4A, 80605BAF, DC8ED546, 5E192900, 0B92E4F0, 55C1E317
 80605BAF, 75EACBB7, 1ABEED79, 1E53AD4A, 55C1E317, 186EB0CF, 5E192900, 0B92E4F0
 1E53AD4A, 08AC1056, 75EACBB7, 1ABEED79, 0B92E4F0, 8F3A64E3, 186EB0CF, 5E192900
 1ABEED79, 9BDB7A88, 08AC1056, 75EACBB7, 5E192900, 3701E7B3, 8F3A64E3, 186EB0CF
 75EACBB7, ADF32F05, 9BDB7A88, 08AC1056, 186EB0CF, 6CE969E9, 3701E7B3, 8F3A64E3
 08AC1056, 2277B80D, ADF32F05, 9BDB7A88, 8F3A64E3, EE7224D5, 6CE969E9, 3701E7B3
 9BDB7A88, 535DBB9A, 2277B80D, ADF32F05, 3701E7B3, 3E849D0F, EE7224D5, 6CE969E9
 ADF32F05, 2A494EC5, 535DBB9A, 2277B80D, 6CE969E9, DDBD8EE7, 3E849D0F, EE7224D5
 2277B80D, 693C7A09, 2A494EC5, 535DBB9A, EE7224D5, C3DDAC40, DDBD8EE7, 3E849D0F
 535DBB9A, 148A5796, 693C7A09, 2A494EC5, 3E849D0F, 5E0E10B9, C3DDAC40, DDBD8EE7

2A494EC5, D2932448, 148A5796, 693C7A09, DDBD8EE7, 1CCB75AF, 5E0E10B9, C3DDAC40
693C7A09, 39CA97B6, D2932448, 148A5796, C3DDAC40, 27F81499, 1CCB75AF, 5E0E10B9
148A5796, 770BCE98, 39CA97B6, D2932448, 5E0E10B9, 82843491, 27F81499, 1CCB75AF
D2932448, 8C4DC6AF, 770BCE98, 39CA97B6, 1CCB75AF, 4E4E13E9, 82843491, 27F81499
39CA97B6, 048CC517, 8C4DC6AF, 770BCE98, 27F81499, 03BD1BD9, 4E4E13E9, 82843491
770BCE98, 419960CF, 048CC517, 8C4DC6AF, 82843491, 6FA999B7, 03BD1BD9, 4E4E13E9
8C4DC6AF, 407700EE, 419960CF, 048CC517, 4E4E13E9, 37B18629, 6FA999B7, 03BD1BD9
048CC517, E60ABEC4, 407700EE, 419960CF, 03BD1BD9, 9EA44395, 37B18629, 6FA999B7
419960CF, 0E248A8B, E60ABEC4, 407700EE, 6FA999B7, F877D28C, 9EA44395, 37B18629
407700EE, 10667792, 0E248A8B, E60ABEC4, 37B18629, F63EA862, F877D28C, 9EA44395
E60ABEC4, 646BB7A8, 10667792, 0E248A8B, 9EA44395, 424072F0, F63EA862, F877D28C
0E248A8B, 625CCE22, 646BB7A8, 10667792, F877D28C, 3B7642B8, 424072F0, F63EA862
10667792, 8E0E1101, 625CCE22, 646BB7A8, F63EA862, CD620F4E, 3B7642B8, 424072F0
646BB7A8, C23D3583, 8E0E1101, 625CCE22, 424072F0, BFAA1A02, CD620F4E, 3B7642B8
625CCE22, 81DE3DC5, C23D3583, 8E0E1101, 3B7642B8, 1BA7FD36, BFAA1A02, CD620F4E
8E0E1101, D24E4181, 81DE3DC5, C23D3583, CD620F4E, E62B2A4, 1BA7FD36, BFAA1A02

The following are (hexadecimal representations of) the successive values of the variables X_0, X_1, X_2, X_3 , X'_0, X'_1, X'_2 and X'_3 obtained during the processing of the second block.

31560350, 285A21CF, 846C181B, 553B61B8, 31560350, 285A21CF, 846C181B, 553B61B8
553B61B8, 1ADDE153, 285A21CF, 846C181B, 553B61B8, 56C8C102, 285A21CF, 846C181B
846C181B, CE8FC309, 1ADDE153, 285A21CF, 846C181B, 702249A4, 56C8C102, 285A21CF
285A21CF, 0DD8403A, CE8FC309, 1ADDE153, 285A21CF, 22CB0A97, 702249A4, 56C8C102
1ADDE153, 4842F01E, 0DD8403A, CE8FC309, 56C8C102, 35B2DCDF, 22CB0A97, 702249A4
CE8FC309, BE6A9014, 4842F01E, 0DD8403A, 702249A4, D2EFFB4A, 35B2DCDF, 22CB0A97
0DD8403A, 7FE339CA, BE6A9014, 4842F01E, 22CB0A97, 59EA6C60, D2EFFB4A, 35B2DCDF
4842F01E, D1CCFD4B, 7FE339CA, BE6A9014, 35B2DCDF, 82DEA3AE, 59EA6C60, D2EFFB4A
BE6A9014, 108966B1, D1CCFD4B, 7FE339CA, D2EFFB4A, 4481FDE2, 82DEA3AE, 59EA6C60
7FE339CA, 899223E8, 108966B1, D1CCFD4B, 59EA6C60, 13BB8F73, 4481FDE2, 82DEA3AE
D1CCFD4B, 5E3B9917, 899223E8, 108966B1, 82DEA3AE, 946BD478, 13BB8F73, 4481FDE2
108966B1, 7666663B, 5E3B9917, 899223E8, 4481FDE2, BD0605EA, 946BD478, 13BB8F73
899223E8, A1BAD92C, 7666663B, 5E3B9917, 13BB8F73, 36F99153, BD0605EA, 946BD478
5E3B9917, DE527A04, A1BAD92C, 7666663B, 946BD478, EB4AE872, 36F99153, BD0605EA
7666663B, E52F1533, DE527A04, A1BAD92C, BD0605EA, 7C346442, EB4AE872, 36F99153
A1BAD92C, 5C3C2C22, E52F1533, DE527A04, 36F99153, AFA320AD, 7C346442, EB4AE872
DE527A04, FC1C4108, 5C3C2C22, E52F1533, EB4AE872, B4905651, AFA320AD, 7C346442
E52F1533, 0A03E84B, FC1C4108, 5C3C2C22, 7C346442, 02E94FA1, B4905651, AFA320AD
5C3C2C22, FB74BD26, 0A03E84B, FC1C4108, AFA320AD, E08D1799, 02E94FA1, B4905651
FC1C4108, C78DC5C4, FB74BD26, 0A03E84B, B4905651, 69AFAA80, E08D1799, 02E94FA1
0A03E84B, ACF60434, C78DC5C4, FB74BD26, 02E94FA1, FA665E46, 69AFAA80, E08D1799
FB74BD26, 58F751E0, ACF60434, C78DC5C4, E08D1799, 269AB7E3, FA665E46, 69AFAA80
C78DC5C4, EB75C7CB, 58F751E0, ACF60434, 69AFAA80, 0F06388B, 269AB7E3, FA665E46
ACF60434, 83C0A8B7, EB75C7CB, 58F751E0, FA665E46, FD44FBD5, 0F06388B, 269AB7E3
58F751E0, 27C87178, 83C0A8B7, EB75C7CB, 269AB7E3, DBBC0190, FD44FBD5, 0F06388B
EB75C7CB, B7B9163F, 27C87178, 83C0A8B7, 0F06388B, D0E3FC2B, DBBC0190, FD44FBD5
83C0A8B7, 0FA1C6DC, B7B9163F, 27C87178, FD44FBD5, 7D87B4BA, D0E3FC2B, DBBC0190
27C87178, 2CC60316, 0FA1C6DC, B7B9163F, DBBC0190, 68367FDB, 7D87B4BA, D0E3FC2B
B7B9163F, 08029C44, 2CC60316, 0FA1C6DC, D0E3FC2B, 53AB5439, 68367FDB, 7D87B4BA
0FA1C6DC, F693A10E, 08029C44, 2CC60316, 7D87B4BA, E78B75B5, 53AB5439, 68367FDB
2CC60316, 356224B9, F693A10E, 08029C44, 68367FDB, 830530DF, E78B75B5, 53AB5439

08029C44,	669F7869,	356224B9,	F693A10E,	53AB5439,	67FCB1AC,	830530DF,	E78B75B5
F693A10E,	7B70C168,	669F7869,	356224B9,	E78B75B5,	757BB243,	67FCB1AC,	830530DF
356224B9,	037FB19C,	7B70C168,	669F7869,	830530DF,	F0CA8878,	757BB243,	67FCB1AC
669F7869,	9B0A10B3,	037FB19C,	7B70C168,	67FCB1AC,	FA10CB33,	F0CA8878,	757BB243
7B70C168,	9D015956,	9B0A10B3,	037FB19C,	757BB243,	5487E56C,	FA10CB33,	F0CA8878
037FB19C,	6A7DE5F4,	9D015956,	9B0A10B3,	F0CA8878,	A5D33699,	5487E56C,	FA10CB33
9B0A10B3,	E522D913,	6A7DE5F4,	9D015956,	FA10CB33,	BEB495BC,	A5D33699,	5487E56C
9D015956,	0EFD42E5,	E522D913,	6A7DE5F4,	5487E56C,	05202F93,	BEB495BC,	A5D33699
6A7DE5F4,	7902100B,	0EFD42E5,	E522D913,	A5D33699,	BACE7DD9,	05202F93,	BEB495BC
E522D913,	1ACEFABC,	7902100B,	0EFD42E5,	BEB495BC,	08D045DD,	BACE7DD9,	05202F93
0EFD42E5,	E07378FF,	1ACEFABC,	7902100B,	05202F93,	5448A3A0,	08D045DD,	BACE7DD9
7902100B,	489C7A1A,	E07378FF,	1ACEFABC,	BACE7DD9,	D98BE3AA,	5448A3A0,	08D045DD
1ACEFABC,	C02A45A5,	489C7A1A,	E07378FF,	08D045DD,	12EC982F,	D98BE3AA,	5448A3A0
E07378FF,	3068DDE8,	C02A45A5,	489C7A1A,	5448A3A0,	4A1EB2B2,	12EC982F,	D98BE3AA
489C7A1A,	D5DD5018,	3068DDE8,	C02A45A5,	D98BE3AA,	D677AAA8,	4A1EB2B2,	12EC982F
C02A45A5,	B9D75D76,	D5DD5018,	3068DDE8,	12EC982F,	5AA89133,	D677AAA8,	4A1EB2B2
3068DDE8,	51A9B2DD,	B9D75D76,	D5DD5018,	4A1EB2B2,	49BCE169,	5AA89133,	D677AAA8
D5DD5018,	36F589C4,	51A9B2DD,	B9D75D76,	D677AAA8,	CF4FA8D2,	49BCE169,	5AA89133
B9D75D76,	B5C60EAF,	36F589C4,	51A9B2DD,	5AA89133,	C1985969,	CF4FA8D2,	49BCE169
51A9B2DD,	725DF80C,	B5C60EAF,	36F589C4,	49BCE169,	427440B4,	C1985969,	CF4FA8D2
36F589C4,	3F7A2507,	725DF80C,	B5C60EAF,	CF4FA8D2,	60927896,	427440B4,	C1985969
B5C60EAF,	9D539EB6,	3F7A2507,	725DF80C,	C1985969,	7050ED96,	60927896,	427440B4
725DF80C,	5A249895,	9D539EB6,	3F7A2507,	427440B4,	CBC74513,	7050ED96,	60927896
3F7A2507,	A7CECDCD,	5A249895,	9D539EB6,	60927896,	8431C75E,	CBC74513,	7050ED96
9D539EB6,	F8DCD12B,	A7CECDCD,	5A249895,	7050ED96,	0E3A1C68,	8431C75E,	CBC74513
5A249895,	3E30DB2A,	F8DCD12B,	A7CECDCD,	CBC74513,	62EEEC87,	0E3A1C68,	8431C75E
A7CECDCD,	A25D36CE,	3E30DB2A,	F8DCD12B,	8431C75E,	2B1F312D,	62EEEC87,	0E3A1C68
F8DCD12B,	A92CF759,	A25D36CE,	3E30DB2A,	0E3A1C68,	FB124197,	2B1F312D,	62EEEC87
3E30DB2A,	0CD0BA66,	A92CF759,	A25D36CE,	62EEEC87,	DB8A5C11,	FB124197,	2B1F312D
A25D36CE,	AF62D775,	0CD0BA66,	A92CF759,	2B1F312D,	EC3264DC,	DB8A5C11,	FB124197
A92CF759,	69D4E1DF,	AF62D775,	0CD0BA66,	FB124197,	9AA87F7C,	EC3264DC,	DB8A5C11
0CD0BA66,	0EE66339,	69D4E1DF,	AF62D775,	DB8A5C11,	04512915,	9AA87F7C,	EC3264DC
AF62D775,	5C5B5FBD,	0EE66339,	69D4E1DF,	EC3264DC,	C763272A,	04512915,	9AA87F7C
69D4E1DF,	0D80E8CF,	5C5B5FBD,	0EE66339,	9AA87F7C,	CCD7DF45,	C763272A,	04512915

The hash-code is the following 128-bit string.

A1 AA 06 89 D0 FA FA 2D DC 22 E8 8B 49 13 3A 06

B.3.9 Example 9

In this example, the data string is the 1 000 000-byte string consisting of the ASCII-coded version of “a” repeated 10^6 times.

The hash-code is the following 128-bit string.

4A 7F 57 23 F9 54 EB A1 21 6C 9D 8F 63 20 43 1F

B.3.10 Example 10

In this example, the data string is the 112-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz
abcdefghijklmnopqrstuvwxyz”

(with no line break after the first n).

The hash-code is the following 128-bit string.

D4 EC C9 13 E1 DF 77 6B F4 8D E9 D5 5B 1F 25 46

B.3.11 Example 11

In this example, the data string is the 32-byte string consisting of the ASCII-coded version of

“abcdbcdecdefdefgefghfghighijhijk”

The hash-code is the following 128-bit string.

13 FC 13 E8 EF FF 34 7D E1 93 FF 46 DB AC CF D4

B.4 Dedicated Hash-Function 3 (SHA-1)

B.4.1 Example 1

In this example, the data string is the empty string, i.e., the string of length zero.

The hash-code is the following 160-bit string.

DA 39 A3 EE 5E 6B 4B 0D 32 55 BF EF 95 60 18 90 AF D8 07 09

B.4.2 Example 2

In this example, the data string consists of a single byte, namely the ASCII-coded version of the letter “a”.

The hash-code is the following 160-bit string.

86 F7 E4 37 FA A5 A7 FC E1 5D 1D DC B9 EA EA EA 37 76 67 B8

B.4.3 Example 3

In this example, the data string is the 3-byte string consisting of the ASCII-coded version of “abc”. This is equivalent to the bit string “01100001 01100010 01100011”.

After the padding process, the single 16-word block derived from the data string is as follows.

61626380 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000018

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 and X_4 .

0116FC33, 67452301, 7BF36AE2, 98BADCFE, 10325476
8990536D, 0116FC33, 59D148C0, 7BF36AE2, 98BADCFE
A1390F08, 8990536D, C045BF0C, 59D148C0, 7BF36AE2
CDD8E11B, A1390F08, 626414DB, C045BF0C, 59D148C0
CFD499DE, CDD8E11B, 284E43C2, 626414DB, C045BF0C
3FC7CA40, CFD499DE, F3763846, 284E43C2, 626414DB
993E30C1, 3FC7CA40, B3F52677, F3763846, 284E43C2
9E8C07D4, 993E30C1, 0FF1F290, B3F52677, F3763846
4B6AE328, 9E8C07D4, 664F8C30, 0FF1F290, B3F52677
8351F929, 4B6AE328, 27A301F5, 664F8C30, 0FF1F290
FBDA9E89, 8351F929, 12DAB8CA, 27A301F5, 664F8C30

63188FE4, FBDA9E89, 60D47E4A, 12DAB8CA, 27A301F5
 4607B664, 63188FE4, 7EF6A7A2, 60D47E4A, 12DAB8CA
 9128F695, 4607B664, 18C623F9, 7EF6A7A2, 60D47E4A
 196BEE77, 9128F695, 1181ED99, 18C623F9, 7EF6A7A2
 20BDD62F, 196BEE77, 644A3DA5, 1181ED99, 18C623F9
 4E925823, 20BDD62F, C65AFB9D, 644A3DA5, 1181ED99
 82AA6728, 4E925823, C82F758B, C65AFB9D, 644A3DA5
 DC64901D, 82AA6728, D3A49608, C82F758B, C65AFB9D
 FD9E1D7D, DC64901D, 20AA99CA, D3A49608, C82F758B
 1A37B0CA, FD9E1D7D, 77192407, 20AA99CA, D3A49608
 33A23BFC, 1A37B0CA, 7F67875F, 77192407, 20AA99CA
 21283486, 33A23BFC, 868DEC32, 7F67875F, 77192407
 D541F12D, 21283486, 0CE88EFF, 868DEC32, 7F67875F
 C7567DC6, D541F12D, 884A0D21, 0CE88EFF, 868DEC32
 48413BA4, C7567DC6, 75507C4B, 884A0D21, 0CE88EFF
 BE35FBD5, 48413BA4, B1D59F71, 75507C4B, 884A0D21
 4AA84D97, BE35FBD5, 12104EE9, B1D59F71, 75507C4B
 8370B52E, 4AA84D97, 6F8D7EF5, 12104EE9, B1D59F71
 C5FBAF5D, 8370B52E, D2AA1365, 6F8D7EF5, 12104EE9
 1267B407, C5FBAF5D, A0DC2D4B, D2AA1365, 6F8D7EF5
 3B845D33, 1267B407, 717EEBD7, A0DC2D4B, D2AA1365
 046FAA0A, 3B845D33, C499ED01, 717EEBD7, A0DC2D4B
 2C0EBC11, 046FAA0A, CEE1174C, C499ED01, 717EEBD7
 21796AD4, 2C0EBC11, 811BEA82, CEE1174C, C499ED01
 DCBBB0CB, 21796AD4, 4B03AF04, 811BEA82, CEE1174C
 0F511FD8, DCBBB0CB, 085E5AB5, 4B03AF04, 811BEA82
 DC63973F, 0F511FD8, F72EEC32, 085E5AB5, 4B03AF04
 4C986405, DC63973F, 03D447F6, F72EEC32, 085E5AB5
 32DE1CBA, 4C986405, F718E5CF, 03D447F6, F72EEC32
 FC87DEDF, 32DE1CBA, 53261901, F718E5CF, 03D447F6
 970A0D5C, FC87DEDF, 8CB7872E, 53261901, F718E5CF
 7F193DC5, 970A0D5C, FF21F7B7, 8CB7872E, 53261901
 EE1B1AAF, 7F193DC5, 25C28357, FF21F7B7, 8CB7872E
 40F28E09, EE1B1AAF, 5FC64F71, 25C28357, FF21F7B7
 1C51E1F2, 40F28E09, FB86C6AB, 5FC64F71, 25C28357
 A01B846C, 1C51E1F2, 503CA382, FB86C6AB, 5FC64F71
 BEAD02CA, A01B846C, 8714787C, 503CA382, FB86C6AB
 BAF39337, BEAD02CA, 2806E11B, 8714787C, 503CA382
 120731C5, BAF39337, AFAB40B2, 2806E11B, 8714787C
 641DB2CE, 120731C5, EEBCE4CD, AFAB40B2, 2806E11B
 3847AD66, 641DB2CE, 4481CC71, EEBCE4CD, AFAB40B2
 E490436D, 3847AD66, 99076CB3, 4481CC71, EEBCE4CD
 27E9F1D8, E490436D, 8E11EB59, 99076CB3, 4481CC71
 7B71F76D, 27E9F1D8, 792410DB, 8E11EB59, 99076CB3
 5E6456AF, 7B71F76D, 09FA7C76, 792410DB, 8E11EB59
 C846093F, 5E6456AF, 5EDC7DDB, 09FA7C76, 792410DB
 D262FF50, C846093F, D79915AB, 5EDC7DDB, 09FA7C76
 09D785FD, D262FF50, F211824F, D79915AB, 5EDC7DDB
 3F52DE5A, 09D785FD, 3498BFD4, F211824F, D79915AB
 D756C147, 3F52DE5A, 4275E17F, 3498BFD4, F211824F
 548C9CB2, D756C147, 8FD4B796, 4275E17F, 3498BFD4

B66C020B, 548C9CB2, F5D5B051, 8FD4B796, 4275E17F
 6B61C9E1, B66C020B, 9523272C, F5D5B051, 8FD4B796
 19DFA7AC, 6B61C9E1, ED9B0082, 9523272C, F5D5B051
 101655F9, 19DFA7AC, 5AD87278, ED9B0082, 9523272C
 0C3DF2B4, 101655F9, 0677E9EB, 5AD87278, ED9B0082
 78DD4D2B, 0C3DF2B4, 4405957E, 0677E9EB, 5AD87278
 497093C0, 78DD4D2B, 030F7CAD, 4405957E, 0677E9EB
 3F2588C2, 497093C0, DE37534A, 030F7CAD, 4405957E
 C199F8C7, 3F2588C2, 125C24F0, DE37534A, 030F7CAD
 39859DE7, C199F8C7, 8FC96230, 125C24F0, DE37534A
 EDB42DE4, 39859DE7, F0667E31, 8FC96230, 125C24F0
 11793F6F, EDB42DE4, CE616779, F0667E31, 8FC96230
 5EE76897, 11793F6F, 3B6D0B79, CE616779, F0667E31
 63F7DAB7, 5EE76897, C45E4FDB, 3B6D0B79, CE616779
 A079B7D9, 63F7DAB7, D7B9DA25, C45E4FDB, 3B6D0B79
 860D21CC, A079B7D9, D8FDF6AD, D7B9DA25, C45E4FDB
 5738D5E1, 860D21CC, 681E6DF6, D8FDF6AD, D7B9DA25
 42541B35, 5738D5E1, 21834873, 681E6DF6, D8FDF6AD

The hash-code is the following 160-bit string.

A9 99 3E 36 47 06 81 6A BA 3E 25 71 78 50 C2 6C 9C D0 D8 9D

B.4.4 Example 4

In this example, the data string is the 14-byte string consisting of the ASCII-coded version of
 “message digest”

The hash-code is the following 160-bit string.

C1 22 52 CE DA 8B E8 99 4D 5F A0 29 0A 47 23 1C 1D 16 AA E3

B.4.5 Example 5

In this example, the data string is the 26-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxy”

The hash-code is the following 160-bit string.

32 D1 0C 7B 8C F9 65 70 CA 04 CE 37 F2 A1 9D 84 24 0D 3A 89

B.4.6 Example 6

In this example, the data string is the 62-byte string consisting of the ASCII-coded version of

“ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxy0123456789”

The hash-code is the following 160-bit string.

76 1C 45 7B F7 3B 14 D2 7E 9E 92 65 C4 6F 4B 4D DA 11 F9 40

B.4.7 Example 7

In this example, the data string is the 80-byte string consisting of the ASCII-coded version of eight repetitions of

“1234567890”

The hash-code is the following 160-bit string.

50 AB F5 70 6A 15 09 90 A0 8B 2C 5E A4 0F A0 E5 85 55 47 32

B.4.8 Example 8

In this example, the data string is the 56-byte string consisting of the ASCII-coded version of

“abcbcbcdcedefdefgefghghighijhijkijklklmklmnlmnomnopnopq”

After the padding process, the two 16-word blocks derived from the data string are as follows.

61626364	62636465	63646566	64656667	65666768	66676869	6768696A	68696A6B
696A6B6C	6A6B6C6D	6B6C6D6E	6C6D6E6F	6D6E6F70	6E6F7071	80000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
00000000	00000000	00000000	00000000	00000000	00000000	00000000	000001C0

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 and X_4 obtained during the processing of the first block.

0116FC17, 67452301, 7BF36AE2, 98BADCFE, 10325476
 EBF3B452, 0116FC17, 59D148C0, 7BF36AE2, 98BADCFE
 5109913A, EBF3B452, C045BF05, 59D148C0, 7BF36AE2
 2C4F6EAC, 5109913A, BAFCE14, C045BF05, 59D148C0
 33F4AE5B, 2C4F6EAC, 9442644E, BAFCE14, C045BF05
 96B85189, 33F4AE5B, 0B13DBAB, 9442644E, BAFCE14
 DB04CB58, 96B85189, CCFD2B96, 0B13DBAB, 9442644E
 45833F0F, DB04CB58, 65AE1462, CCFD2B96, 0B13DBAB
 C565C35E, 45833F0F, 36C132D6, 65AE1462, CCFD2B96
 6350AFDA, C565C35E, D160CFC3, 36C132D6, 65AE1462
 8993EA77, 6350AFDA, B15970D7, D160CFC3, 36C132D6
 E19ECAA2, 8993EA77, 98D42BF6, B15970D7, D160CFC3
 8603481E, E19ECAA2, E264FA9D, 98D42BF6, B15970D7
 32F94A85, 8603481E, B867B2A8, E264FA9D, 98D42BF6
 B2E7A8BE, 32F94A85, A180D207, B867B2A8, E264FA9D
 42637E39, B2E7A8BE, 4CBE52A1, A180D207, B867B2A8
 6B068048, 42637E39, ACB9EA2F, 4CBE52A1, A180D207
 426B9C35, 6B068048, 5098DF8E, ACB9EA2F, 4CBE52A1
 944B1BD1, 426B9C35, 1AC1A012, 5098DF8E, ACB9EA2F
 6C445652, 944B1BD1, 509AE70D, 1AC1A012, 5098DF8E
 95836DA5, 6C445652, 6512C6F4, 509AE70D, 1AC1A012
 09511177, 95836DA5, 9B111594, 6512C6F4, 509AE70D
 E2B92DC4, 09511177, 6560DB69, 9B111594, 6512C6F4
 FD224575, E2B92DC4, C254445D, 6560DB69, 9B111594
 EEB82D9A, FD224575, 38AE4B71, C254445D, 6560DB69
 5A142C1A, EEB82D9A, 7F48915D, 38AE4B71, C254445D
 2972F7C7, 5A142C1A, BBAE0B66, 7F48915D, 38AE4B71
 D526A644, 2972F7C7, 96850B06, BBAE0B66, 7F48915D

E1122421, D526A644, CA5CBDF1, 96850B06, BBAE0B66
 05B457B2, E1122421, 3549A991, CA5CBDF1, 96850B06
 A9C84BEC, 05B457B2, 78448908, 3549A991, CA5CBDF1
 52E31F60, A9C84BEC, 816D15EC, 78448908, 3549A991
 5AF3242C, 52E31F60, 2A7212FB, 816D15EC, 78448908
 31C756A9, 5AF3242C, 14B8C7D8, 2A7212FB, 816D15EC
 E9AC987C, 31C756A9, 16BCC90B, 14B8C7D8, 2A7212FB
 AB7C32EE, E9AC987C, 4C71D5AA, 16BCC90B, 14B8C7D8
 5933FC99, AB7C32EE, 3A6B261F, 4C71D5AA, 16BCC90B
 43F87AE9, 5933FC99, AADF0CBB, 3A6B261F, 4C71D5AA
 24957F22, 43F87AE9, 564CFF26, AADF0CBB, 3A6B261F
 ADEB7478, 24957F22, 50FE1EBA, 564CFF26, AADF0CBB
 D70E5010, ADEB7478, 89255FC8, 50FE1EBA, 564CFF26
 79BCFB08, D70E5010, 2B7ADD1E, 89255FC8, 50FE1EBA
 F9BCB8DE, 79BCFB08, 35C39404, 2B7ADD1E, 89255FC8
 633E9561, F9BCB8DE, 1E6F3EC2, 35C39404, 2B7ADD1E
 98C1EA64, 633E9561, BE6F2E37, 1E6F3EC2, 35C39404
 C6EA241E, 98C1EA64, 58CFA558, BE6F2E37, 1E6F3EC2
 A2AD4F02, C6EA241E, 26307A99, 58CFA558, BE6F2E37
 C8A69090, A2AD4F02, B1BA8907, 26307A99, 58CFA558
 88341600, C8A69090, A8AB53C0, B1BA8907, 26307A99
 7E846F58, 88341600, 3229A424, A8AB53C0, B1BA8907
 86E358BA, 7E846F58, 220D0580, 3229A424, A8AB53C0
 8D2E76C8, 86E358BA, 1FA11BD6, 220D0580, 3229A424
 CE892E10, 8D2E76C8, A1B8D62E, 1FA11BD6, 220D0580
 EDEA95B1, CE892E10, 234B9DB2, A1B8D62E, 1FA11BD6
 36D1230A, EDEA95B1, 33A24B84, 234B9DB2, A1B8D62E
 776C3910, 36D1230A, 7B7AA56C, 33A24B84, 234B9DB2
 A681B723, 776C3910, 8DB448C2, 7B7AA56C, 33A24B84
 AC0A794F, A681B723, 1DDB0E44, 8DB448C2, 7B7AA56C
 F03D3782, AC0A794F, E9A06DC8, 1DDB0E44, 8DB448C2
 9EF775C3, F03D3782, EB029E53, E9A06DC8, 1DDB0E44
 36254B13, 9EF775C3, BC0F4DE0, EB029E53, E9A06DC8
 4080D4DC, 36254B13, E7BDDD70, BC0F4DE0, EB029E53
 2BFAF7A8, 4080D4DC, CD8952C4, E7BDDD70, BC0F4DE0
 513F9CA0, 2BFAF7A8, 10203537, CD8952C4, E7BDDD70
 E5895C81, 513F9CA0, 0AFEBDEA, 10203537, CD8952C4
 1037D2D5, E5895C81, 144FE728, 0AFEBDEA, 10203537
 14A82DA9, 1037D2D5, 79625720, 144FE728, 0AFEBDEA
 6D17C9FD, 14A82DA9, 440DF4B5, 79625720, 144FE728
 2C7B07BD, 6D17C9FD, 452A0B6A, 440DF4B5, 79625720
 FDF6EFFF, 2C7B07BD, 5B45F27F, 452A0B6A, 440DF4B5
 112B96E3, FDF6EFFF, 4B1EC1EF, 5B45F27F, 452A0B6A
 84065712, 112B96E3, FF7DBBFF, 4B1EC1EF, 5B45F27F
 AB89FB71, 84065712, C44AE5B8, FF7DBBFF, 4B1EC1EF
 C5210E35, AB89FB71, A10195C4, C44AE5B8, FF7DBBFF
 352D9F4B, C5210E35, 6AE27EDC, A10195C4, C44AE5B8
 1A0E0E0A, 352D9F4B, 7148438D, 6AE27EDC, A10195C4
 D0D47349, 1A0E0E0A, CD4B67D2, 7148438D, 6AE27EDC

AD38620D, D0D47349, 86838382, CD4B67D2, 7148438D
 D3AD7C25, AD38620D, 74351CD2, 86838382, CD4B67D2
 8CE34517, D3AD7C25, 6B4E1883, 74351CD2, 86838382

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 and X_4 , obtained during the processing of the second block.

2DF257E9, F4286818, B0DEC9EB, 0408F581, 84677148
 4D3DC58F, 2DF257E9, 3D0A1A06, B0DEC9EB, 0408F581
 C352BB05, 4D3DC58F, 4B7C95FA, 3D0A1A06, B0DEC9EB
 EEF743C6, C352BB05, D34F7163, 4B7C95FA, 3D0A1A06
 41E34277, EEF743C6, 70D4AEC1, D34F7163, 4B7C95FA
 5443915C, 41E34277, BBBDD0F1, 70D4AEC1, D34F7163
 E7FA0377, 5443915C, D078D09D, BBBDD0F1, 70D4AEC1
 C6946813, E7FA0377, 1510E457, D078D09D, BBBDD0F1
 FDDE1DE1, C6946813, F9FE80DD, 1510E457, D078D09D
 B8538ACA, FDDE1DE1, F1A51A04, F9FE80DD, 1510E457
 6BA94F63, B8538ACA, 7F778778, F1A51A04, F9FE80DD
 43A2792F, 6BA94F63, AE14E2B2, 7F778778, F1A51A04
 FECD7BBF, 43A2792F, DAEA53D8, AE14E2B2, 7F778778
 A2604CA8, FECD7BBF, D0E89E4B, DAEA53D8, AE14E2B2
 258B0BAA, A2604CA8, FFB35EEF, D0E89E4B, DAEA53D8
 D9772360, 258B0BAA, 2898132A, FFB35EEF, D0E89E4B
 5507DB6E, D9772360, 8962C2EA, 2898132A, FFB35EEF
 A51B58BC, 5507DB6E, 365DC8D8, 8962C2EA, 2898132A
 C2EB709F, A51B58BC, 9541F6DB, 365DC8D8, 8962C2EA
 D8992153, C2EB709F, 2946D62F, 9541F6DB, 365DC8D8
 37482F5F, D8992153, F0BADC27, 2946D62F, 9541F6DB
 EE8700BD, 37482F5F, F6264854, F0BADC27, 2946D62F
 9AD594B9, EE8700BD, CDD20BD7, F6264854, F0BADC27
 8FBAA5B9, 9AD594B9, 7BA1C02F, CDD20BD7, F6264854
 88FB5867, 8FBAA5B9, 66B5652E, 7BA1C02F, CDD20BD7
 EEC50521, 88FB5867, 63EEA96E, 66B5652E, 7BA1C02F
 50BCE434, EEC50521, E23ED619, 63EEA96E, 66B5652E
 5C416DAF, 50BCE434, 7BB14148, E23ED619, 63EEA96E
 2429BE5F, 5C416DAF, 142F390D, 7BB14148, E23ED619
 0A2FB108, 2429BE5F, D7105B6B, 142F390D, 7BB14148
 17986223, 0A2FB108, C90A6F97, D7105B6B, 142F390D
 8A4AF384, 17986223, 028BEC42, C90A6F97, D7105B6B
 6B629993, 8A4AF384, C5E61888, 028BEC42, C90A6F97
 F15F04F3, 6B629993, 2292BCE1, C5E61888, 028BEC42
 295CC25B, F15F04F3, DAD8A664, 2292BCE1, C5E61888
 696DA404, 295CC25B, FC57C13C, DAD8A664, 2292BCE1
 CEF5AE12, 696DA404, CA573096, FC57C13C, DAD8A664
 87D5B80C, CEF5AE12, 1A5B6901, CA573096, FC57C13C
 84E2A5F2, 87D5B80C, B3BD6B84, 1A5B6901, CA573096
 03BB6310, 84E2A5F2, 21F56E03, B3BD6B84, 1A5B6901
 C2D8F75F, 03BB6310, A138A97C, 21F56E03, B3BD6B84
 BFB25768, C2D8F75F, 00EED8C4, A138A97C, 21F56E03
 28589152, BFB25768, F0B63DD7, 00EED8C4, A138A97C
 EC1D3D61, 28589152, 2FEC95DA, F0B63DD7, 00EED8C4
 3CAED7AF, EC1D3D61, 8A162454, 2FEC95DA, F0B63DD7

C3D033EA, 3CAED7AF, 7B074F58, 8A162454, 2FEC95DA
 7316056A, C3D033EA, CF2BB5EB, 7B074F58, 8A162454
 46F93B68, 7316056A, B0F40CFA, CF2BB5EB, 7B074F58
 DC8E7F26, 46F93B68, 9CC5815A, B0F40CFA, CF2BB5EB
 850D411C, DC8E7F26, 11BE4EDA, 9CC5815A, B0F40CFA
 7E4672C0, 850D411C, B7239FC9, 11BE4EDA, 9CC5815A
 89FBD41D, 7E4672C0, 21435047, B7239FC9, 11BE4EDA
 1797E228, 89FBD41D, 1F919CB0, 21435047, B7239FC9
 431D65BC, 1797E228, 627EF507, 1F919CB0, 21435047
 2BDBB8CB, 431D65BC, 05E5F88A, 627EF507, 1F919CB0
 6DA72E7F, 2BDBB8CB, 10C7596F, 05E5F88A, 627EF507
 A8495A9B, 6DA72E7F, CAF6EE32, 10C7596F, 05E5F88A
 E785655A, A8495A9B, DB69CB9F, CAF6EE32, 10C7596F
 5B086C42, E785655A, EA1256A6, DB69CB9F, CAF6EE32
 A65818F7, 5B086C42, B9E15956, EA1256A6, DB69CB9F
 7AAB101B, A65818F7, 96C21B10, B9E15956, EA1256A6
 93614C9C, 7AAB101B, E996063D, 96C21B10, B9E15956
 F66D9BF4, 93614C9C, DEAC406, E996063D, 96C21B10
 D504902B, F66D9BF4, 24D85327, DEAC406, E996063D
 60A9DA62, D504902B, 3D9B66FD, 24D85327, DEAC406
 8B687819, 60A9DA62, F541240A, 3D9B66FD, 24D85327
 083E90C3, 8B687819, 982A7698, F541240A, 3D9B66FD
 F6226BBF, 083E90C3, 62DA1E06, 982A7698, F541240A
 76C0563B, F6226BBF, C20FA430, 62DA1E06, 982A7698
 989DD165, 76C0563B, FD889AEF, C20FA430, 62DA1E06
 8B2C7573, 989DD165, DDB0158E, FD889AEF, C20FA430
 AE1B8E7B, 8B2C7573, 66277459, DDB0158E, FD889AEF
 CA1840DE, AE1B8E7B, E2CB1D5C, 66277459, DDB0158E
 16F3BABB, CA1840DE, EB86E39E, E2CB1D5C, 66277459
 D28D83AD, 16F3BABB, B2861037, EB86E39E, E2CB1D5C
 6BC02DFE, D28D83AD, C5BCEEAE, B2861037, EB86E39E
 D3A6E275, 6BC02DFE, 74A360EB, C5BCEEAE, B2861037
 DA955482, D3A6E275, 9AF00B7F, 74A360EB, C5BCEEAE
 58C0AAC0, DA955482, 74E9B89D, 9AF00B7F, 74A360EB
 906FD62C, 58C0AAC0, B6A55520, 74E9B89D, 9AF00B7F

The hash-code is the following 160-bit string.

84 98 3E 44 1C 3B D2 6E BA AE 4A A1 F9 51 29 E5 E5 46 70 F1

B.4.9 Example 9

In this example, the data string is the 1 000 000-byte string consisting of the ASCII-coded version of “a” repeated 10^6 times.

The hash-code is the following 160-bit string.

34 AA 97 3C D4 C4 DA A4 F6 1E EB 2B DB AD 27 31 65 34 01 6F

B.4.10 Example 10

In this example, the data string is the 112-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz
hijklmnopqrstuvwxyz”

(with no line break after the first n).

The hash-code is the following 160-bit string.

A4 9B 24 46 A0 2C 64 5B F4 19 F9 95 B6 70 91 25 3A 04 A2 59

B.4.11 Example 11

In this example, the data string is the 32-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz”

The hash-code is the following 160-bit string.

37 BC 52 21 AD E3 BC 09 CA D1 5E 47 84 F3 C7 05 14 54 B1 B3

B.5 Dedicated Hash-Function 4 (SHA-256)**B.5.1 Example 1**

In this example, the data string is the empty string, i.e., the string of length zero.

The hash-code is the following 256-bit string.

E3B0C442 98FC1C14 9AFBF4C8 996FB924 27AE41E4 649B934C A495991B 7852B855

B.5.2 Example 2

In this example, the data string consists of a single byte, namely the ASCII-coded version of the letter “a”.

The hash-code is the following 256-bit string.

CA978112 CA1BB9CA FAC231B3 9A23DC4D A786EFF8 147C4E72 B9807785 AFEE48BB

B.5.3 Example 3

In this example, the data string is the 3-byte string consisting of the ASCII-coded version of “abc”. This is equivalent to the bit string “01100001 01100010 01100011”.

After the padding process, the single 16-word block derived from the data string is as follows.

61626380 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000018

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 .

INIT: 6A09E667 BB67AE85 3C6EF372 A54FF53A 510E527F 9B05688C 1F83D9AB 5BE0CD19
0 5D6AEBCD 6A09E667 BB67AE85 3C6EF372 FA2A4622 510E527F 9B05688C 1F83D9AB
1 5A6AD9AD 5D6AEBCD 6A09E667 BB67AE85 78CE7989 FA2A4622 510E527F 9B05688C
2 C8C347A7 5A6AD9AD 5D6AEBCD 6A09E667 F92939EB 78CE7989 FA2A4622 510E527F
3 D550F666 C8C347A7 5A6AD9AD 5D6AEBCD 24E00850 F92939EB 78CE7989 FA2A4622

4 04409A6A D550F666 C8C347A7 5A6AD9AD 43ADA245 24E00850 F92939EB 78CE7989
 5 2B4209F5 04409A6A D550F666 C8C347A7 714260AD 43ADA245 24E00850 F92939EB
 6 E5030380 2B4209F5 04409A6A D550F666 9B27A401 714260AD 43ADA245 24E00850
 7 85A07B5F E5030380 2B4209F5 04409A6A 0C657A79 9B27A401 714260AD 43ADA245
 8 8E04ECB9 85A07B5F E5030380 2B4209F5 32CA2D8C 0C657A79 9B27A401 714260AD
 9 8C87346B 8E04ECB9 85A07B5F E5030380 1CC92596 32CA2D8C 0C657A79 9B27A401
 10 4798A3F4 8C87346B 8E04ECB9 85A07B5F 436B23E8 1CC92596 32CA2D8C 0C657A79
 11 F71FC5A9 4798A3F4 8C87346B 8E04ECB9 816FD6E9 436B23E8 1CC92596 32CA2D8C
 12 87912990 F71FC5A9 4798A3F4 8C87346B 1E578218 816FD6E9 436B23E8 1CC92596
 13 D932EB16 87912990 F71FC5A9 4798A3F4 745A48DE 1E578218 816FD6E9 436B23E8
 14 C0645FDE D932EB16 87912990 F71FC5A9 0B92F20C 745A48DE 1E578218 816FD6E9
 15 B0FA238E C0645FDE D932EB16 87912990 07590DCD 0B92F20C 745A48DE 1E578218
 16 21DA9A9B B0FA238E C0645FDE D932EB16 8034229C 07590DCD 0B92F20C 745A48DE
 17 C2FBD9D1 21DA9A9B B0FA238E C0645FDE 846EE454 8034229C 07590DCD 0B92F20C
 18 FE777BBF C2FBD9D1 21DA9A9B B0FA238E CC899961 846EE454 8034229C 07590DCD
 19 E1F20C33 FE777BBF C2FBD9D1 21DA9A9B B0638179 CC899961 846EE454 8034229C
 20 9DC68B63 E1F20C33 FE777BBF C2FBD9D1 8ADA8930 B0638179 CC899961 846EE454
 21 C2606D6D 9DC68B63 E1F20C33 FE777BBF E1257970 8ADA8930 B0638179 CC899961
 22 A7A3623F C2606D6D 9DC68B63 E1F20C33 49F5114A E1257970 8ADA8930 B0638179
 23 C5D53D8D A7A3623F C2606D6D 9DC68B63 AA47C347 49F5114A E1257970 8ADA8930
 24 1C2C2838 C5D53D8D A7A3623F C2606D6D 2823EF91 AA47C347 49F5114A E1257970
 25 CDE8037D 1C2C2838 C5D53D8D A7A3623F 14383D8E 2823EF91 AA47C347 49F5114A
 26 B62EC4BC CDE8037D 1C2C2838 C5D53D8D C74C6516 14383D8E 2823EF91 AA47C347
 27 77D37528 B62EC4BC CDE8037D 1C2C2838 EDFFBFF8 C74C6516 14383D8E 2823EF91
 28 363482C9 77D37528 B62EC4BC CDE8037D 6112A3B7 EDFFBFF8 C74C6516 14383D8E
 29 A0060B30 363482C9 77D37528 B62EC4BC ADE79437 6112A3B7 EDFFBFF8 C74C6516
 30 EA992A22 A0060B30 363482C9 77D37528 0109AB3A ADE79437 6112A3B7 EDFFBFF8
 31 73B33BF5 EA992A22 A0060B30 363482C9 BA591112 0109AB3A ADE79437 6112A3B7
 32 98E12507 73B33BF5 EA992A22 A0060B30 9CD9F5F6 BA591112 0109AB3A ADE79437
 33 FE604DF5 98E12507 73B33BF5 EA992A22 59249DD3 9CD9F5F6 BA591112 0109AB3A
 34 A9A7738C FE604DF5 98E12507 73B33BF5 085F3833 59249DD3 9CD9F5F6 BA591112
 35 65A0CFE4 A9A7738C FE604DF5 98E12507 F4B002D6 085F3833 59249DD3 9CD9F5F6
 36 41A65CB1 65A0CFE4 A9A7738C FE604DF5 0772A26B F4B002D6 085F3833 59249DD3
 37 34DF1604 41A65CB1 65A0CFE4 A9A7738C A507A53D 0772A26B F4B002D6 085F3833
 38 6DC57A8A 34DF1604 41A65CB1 65A0CFE4 F0781BC8 A507A53D 0772A26B F4B002D6
 39 79EA687A 6DC57A8A 34DF1604 41A65CB1 1EFBC0A0 F0781BC8 A507A53D 0772A26B
 40 D6670766 79EA687A 6DC57A8A 34DF1604 26352D63 1EFBC0A0 F0781BC8 A507A53D
 41 DF46652F D6670766 79EA687A 6DC57A8A 838B2711 26352D63 1EFBC0A0 F0781BC8
 42 17AA0DFE DF46652F D6670766 79EA687A DECD4715 838B2711 26352D63 1EFBC0A0
 43 9D4BAF93 17AA0DFE DF46652F D6670766 FDA24C2E DECD4715 838B2711 26352D63
 44 26628815 9D4BAF93 17AA0DFE DF46652F A80F11F0 FDA24C2E DECD4715 838B2711
 45 72AB4B91 26628815 9D4BAF93 17AA0DFE B7755DA1 A80F11F0 FDA24C2E DECD4715
 46 A14C14B0 72AB4B91 26628815 9D4BAF93 D57B94A9 B7755DA1 A80F11F0 FDA24C2E
 47 4172328D A14C14B0 72AB4B91 26628815 FECF0BC6 D57B94A9 B7755DA1 A80F11F0
 48 05757CEB 4172328D A14C14B0 72AB4B91 BD714038 FECF0BC6 D57B94A9 B7755DA1
 49 F11BFAA8 05757CEB 4172328D A14C14B0 6E5C390C BD714038 FECF0BC6 D57B94A9
 50 7A0508A1 F11BFAA8 05757CEB 4172328D 52F1CCF7 6E5C390C BD714038 FECF0BC6
 51 886E7A22 7A0508A1 F11BFAA8 05757CEB 49231C1E 52F1CCF7 6E5C390C BD714038

52 101FD28F 886E7A22 7A0508A1 F11BF8A8 529E7D00 49231C1E 52F1CCF7 6E5C390C
 53 F5702FDB 101FD28F 886E7A22 7A0508A1 9F4787C3 529E7D00 49231C1E 52F1CCF7
 54 3EC45CDB F5702FDB 101FD28F 886E7A22 E50E1B4F 9F4787C3 529E7D00 49231C1E
 55 38CC9913 3EC45CDB F5702FDB 101FD28F 54CB266B E50E1B4F 9F4787C3 529E7D00
 56 FCD1887B 38CC9913 3EC45CDB F5702FDB 9B5E906C 54CB266B E50E1B4F 9F4787C3
 57 C062D46F FCD1887B 38CC9913 3EC45CDB 7E44008E 9B5E906C 54CB266B E50E1B4F
 58 FFB70472 C062D46F FCD1887B 38CC9913 6D83BFC6 7E44008E 9B5E906C 54CB266B
 59 B6AE8FFF FFB70472 C062D46F FCD1887B B21BAD3D 6D83BFC6 7E44008E 9B5E906C
 60 B85E2CE9 B6AE8FFF FFB70472 C062D46F 961F4894 B21BAD3D 6D83BFC6 7E44008E
 61 04D24D6C B85E2CE9 B6AE8FFF FFB70472 948D25B6 961F4894 B21BAD3D 6D83BFC6
 62 D39A2165 04D24D6C B85E2CE9 B6AE8FFF FB121210 948D25B6 961F4894 B21BAD3D
 63 506E3058 D39A2165 04D24D6C B85E2CE9 5EF50F24 FB121210 948D25B6 961F4894

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

$Y_0 = 6A09E667 \cup 506E3058 = BA7816BF$
 $Y_1 = BB67AE85 \cup D39A2165 = 8F01CFEA$
 $Y_2 = 3C6EF372 \cup 04D24D6C = 414140DE$
 $Y_3 = A54FF53A \cup B85E2CE9 = 5DAE2223$
 $Y_4 = 510E527F \cup 5EF50F24 = B00361A3$
 $Y_5 = 9B05688C \cup FB121210 = 96177A9C$
 $Y_6 = 1F83D9AB \cup 948D25B6 = B410FF61$
 $Y_7 = 5BE0CD19 \cup 961F4894 = F20015AD$

The hash value is the following 256-bit string.

BA7816BF 8F01CFEA 414140DE 5DAE2223 B00361A3 96177A9C B410FF61 F20015AD

B.5.4 Example 4

In this example, the data string is the 14-byte string consisting of the ASCII-coded version of

“message digest”

The hash value is the following 256-bit string.

F7846F55 CF23E14E EBEAB5B4 E1550CAD 5B509E33 48FBC4EF A3A1413D 393CB650

B.5.5 Example 5

In this example, the data string is the 26-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz”

The hash value is the following 256-bit string.

71C480DF 93D6AE2F 1EFAD144 7C66C952 5E316218 CF51FC8D 9ED832F2 DAF18B73

B.5.6 Example 6

In this example, the data string is the 62-byte string consisting of the ASCII-coded version of

“ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789”

The hash value is the following 256-bit string.

DB4BFCBD 4DA0CD85 A60C3C37 D3FBD880 5C77F15F C6B1FDFF 614EE0A7 C8FDB4C0

B.5.7 Example 7

In this example, the data string is the 80-byte string consisting of the ASCII-coded version of eight repetitions of

“1234567890”

The hash-code is the following 256-bit string.

F371BC4A 311F2B00 9EEF952D D83CA80E 2B60026C 8E935592 D0F9C308 453C813E

B.5.8 Example 8

In this example, the data string is the 56-byte string consisting of the ASCII-coded version of

“abcdbcdecdefdefgfehgfhghijhijkijklklmklmnlnmnomnopnopq”

After the padding process, the following two 16-word blocks are derived from the data string.

61626364 62636465 63646566 64656667 65666768 66676869 6768696A 68696A6B
696A6B6C 6A6B6C6D 6B6C6D6E 6C6D6E6F 6D6E6F70 6E6F7071 80000000 00000000

00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 000001C0

The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X_4, X_5, X_6$ and X_7 in the first block process.

INIT: 6A09E667 BB67AE85 3C6EF372 A54FF53A 510E527F 9B05688C 1F83D9AB 5BE0CD19
0 5D6AEBB1 6A09E667 BB67AE85 3C6EF372 FA2A4606 510E527F 9B05688C 1F83D9AB
1 2F2D5FCF 5D6AEBB1 6A09E667 BB67AE85 4EB1CFCE FA2A4606 510E527F 9B05688C
2 97651825 2F2D5FCF 5D6AEBB1 6A09E667 62D5C49E 4EB1CFCE FA2A4606 510E527F
3 4A8D64D5 97651825 2F2D5FCF 5D6AEBB1 6494841B 62D5C49E 4EB1CFCE FA2A4606
4 F921C212 4A8D64D5 97651825 2F2D5FCF 05C4F88A 6494841B 62D5C49E 4EB1CFCE
5 55C8EF48 F921C212 4A8D64D5 97651825 7FF91C94 05C4F88A 6494841B 62D5C49E
6 485835B7 55C8EF48 F921C212 4A8D64D5 39A5B2CA 7FF91C94 05C4F88A 6494841B
7 D237E6DB 485835B7 55C8EF48 F921C212 A401D211 39A5B2CA 7FF91C94 05C4F88A
8 359F2BCE D237E6DB 485835B7 55C8EF48 C09FFEC4 A401D211 39A5B2CA 7FF91C94
9 3A474B2B 359F2BCE D237E6DB 485835B7 9037B3B8 C09FFEC4 A401D211 39A5B2CA
10 B8E2B4CB 3A474B2B 359F2BCE D237E6DB 443ED29E 9037B3B8 C09FFEC4 A401D211
11 1762215C B8E2B4CB 3A474B2B 359F2BCE EE1C97A8 443ED29E 9037B3B8 C09FFEC4
12 101A4861 1762215C B8E2B4CB 3A474B2B 839A0FC9 EE1C97A8 443ED29E 9037B3B8
13 D68E6457 101A4861 1762215C B8E2B4CB 9243F8AF 839A0FC9 EE1C97A8 443ED29E
14 DD16CBB3 D68E6457 101A4861 1762215C 9162ADED 9243F8AF 839A0FC9 EE1C97A8
15 C3486194 DD16CBB3 D68E6457 101A4861 1496A54F 9162ADED 9243F8AF 839A0FC9
16 B9DCACB1 C3486194 DD16CBB3 D68E6457 D4F64250 1496A54F 9162ADED 9243F8AF
17 046A193E B9DCACB1 C3486194 DD16CBB3 885370B6 D4F64250 1496A54F 9162ADED
18 F402F058 046A193E B9DCACB1 C3486194 6F433549 885370B6 D4F64250 1496A54F
19 2139187B F402F058 046A193E B9DCACB1 7C304206 6F433549 885370B6 D4F64250
20 D70AC17D 2139187B F402F058 046A193E 7CC6B262 7C304206 6F433549 885370B6
21 1B2B66B8 D70AC17D 2139187B F402F058 D560B028 7CC6B262 7C304206 6F433549
22 AE2E2D4F 1B2B66B8 D70AC17D 2139187B F074FC95 D560B028 7CC6B262 7C304206
23 59FCE6B9 AE2E2D4F 1B2B66B8 D70AC17D A2C7D51D F074FC95 D560B028 7CC6B262

24 4A885065 59FCE6B9 AE2E2D4F 1B2B66B8 763597FB A2C7D51D F074FC95 D560B028
 25 573221DA 4A885065 59FCE6B9 AE2E2D4F 36E74EB4 763597FB A2C7D51D F074FC95
 26 128661DA 573221DA 4A885065 59FCE6B9 1162D575 36E74EB4 763597FB A2C7D51D
 27 73F858AF 128661DA 573221DA 4A885065 E77C797F 1162D575 36E74EB4 763597FB
 28 74BCF468 73F858AF 128661DA 573221DA 72ABAECD E77C797F 1162D575 36E74EB4
 29 DF7151A0 74BCF468 73F858AF 128661DA 7629C961 72ABAECD E77C797F 1162D575
 30 EB43F3ED DF7151A0 74BCF468 73F858AF 0635D880 7629C961 72ABAECD E77C797F
 31 5581AB07 EB43F3ED DF7151A0 74BCF468 DF980085 0635D880 7629C961 72ABAECD
 32 9FC905C8 5581AB07 EB43F3ED DF7151A0 A94D2AF1 DF980085 0635D880 7629C961
 33 9CE5A62F 9FC905C8 5581AB07 EB43F3ED 6EF3B6BD A94D2AF1 DF980085 0635D880
 34 1DF8E885 9CE5A62F 9FC905C8 5581AB07 2A9E048E 6EF3B6BD A94D2AF1 DF980085
 35 0786DCE8 1DF8E885 9CE5A62F 9FC905C8 DE2A21D1 2A9E048E 6EF3B6BD A94D2AF1
 36 2C55D3A6 0786DCE8 1DF8E885 9CE5A62F B067C1AF DE2A21D1 2A9E048E 6EF3B6BD
 37 A985B4BE 2C55D3A6 0786DCE8 1DF8E885 F72BF353 B067C1AF DE2A21D1 2A9E048E
 38 91AC9D5D A985B4BE 2C55D3A6 0786DCE8 68D8D590 F72BF353 B067C1AF DE2A21D1
 39 7E4D30B8 91AC9D5D A985B4BE 2C55D3A6 9F5B9B6D 68D8D590 F72BF353 B067C1AF
 40 7E056794 7E4D30B8 91AC9D5D A985B4BE 423B26C0 9F5B9B6D 68D8D590 F72BF353
 41 508A16AB 7E056794 7E4D30B8 91AC9D5D 45459D97 423B26C0 9F5B9B6D 68D8D590
 42 B62C7013 508A16AB 7E056794 7E4D30B8 80A92A00 45459D97 423B26C0 9F5B9B6D
 43 167361DE B62C7013 508A16AB 7E056794 41DD3844 80A92A00 45459D97 423B26C0
 44 DE71E2F2 167361DE B62C7013 508A16AB FF61C636 41DD3844 80A92A00 45459D97
 45 18F0D19D DE71E2F2 167361DE B62C7013 6B88472C FF61C636 41DD3844 80A92A00
 46 165BE9CD 18F0D19D DE71E2F2 167361DE A483F080 6B88472C FF61C636 41DD3844
 47 13D82741 165BE9CD 18F0D19D DE71E2F2 A7802A4D A483F080 6B88472C FF61C636
 48 017B9D99 13D82741 165BE9CD 18F0D19D AEB10B60 A7802A4D A483F080 6B88472C
 49 543C99A1 017B9D99 13D82741 165BE9CD 16F134B6 AEB10B60 A7802A4D A483F080
 50 758CA97A 543C99A1 017B9D99 13D82741 100CF2EA 16F134B6 AEB10B60 A7802A4D
 51 81C1CDE0 758CA97A 543C99A1 017B9D99 5C47EB7B 100CF2EA 16F134B6 AEB10B60
 52 B8D55619 81C1CDE0 758CA97A 543C99A1 1C806A61 5C47EB7B 100CF2EA 16F134B6
 53 1D6DE87A B8D55619 81C1CDE0 758CA97A 3443BED4 1C806A61 5C47EB7B 100CF2EA
 54 F907B313 1D6DE87A B8D55619 81C1CDE0 61A41711 3443BED4 1C806A61 5C47EB7B
 55 9E57C4A0 F907B313 1D6DE87A B8D55619 EEC13548 61A41711 3443BED4 1C806A61
 56 71629856 9E57C4A0 F907B313 1D6DE87A 2F6C8C4E EEC13548 61A41711 3443BED4
 57 7C015A2C 71629856 9E57C4A0 F907B313 CB9D3DD0 2F6C8C4E EEC13548 61A41711
 58 921FCCB6 7C015A2C 71629856 9E57C4A0 43D8A034 CB9D3DD0 2F6C8C4E EEC13548
 59 E18F259A 921FCCB6 7C015A2C 71629856 51E15869 43D8A034 CB9D3DD0 2F6C8C4E
 60 BCFCE922 E18F259A 921FCCB6 7C015A2C 962D8621 51E15869 43D8A034 CB9D3DD0
 61 F6F443F8 BCFCE922 E18F259A 921FCCB6 ACC75916 962D8621 51E15869 43D8A034
 62 86126910 F6F443F8 BCFCE922 E18F259A 2FC08F85 ACC75916 962D8621 51E15869
 63 1BDC6F6F 86126910 F6F443F8 BCFCE922 25D2430A 2FC08F85 ACC75916 962D8621

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the round-function in the first block process.

$Y_0 = 6A09E667 \cup 1BDC6F6F = 85E655D6$
 $Y_1 = BB67AE85 \cup 86126910 = 417A1795$
 $Y_2 = 3C6EF372 \cup F6F443F8 = 3363376A$
 $Y_3 = A54FF53A \cup BCFCE922 = 624CDE5C$
 $Y_4 = 510E527F \cup 25D2430A = 76E09589$
 $Y_5 = 9B05688C \cup 2FC08F85 = CAC5F811$
 $Y_6 = 1F83D9AB \cup ACC75916 = CC4B32C1$
 $Y_7 = 5BE0CD19 \cup 962D8621 = F20E533A$

The following are (hexadecimal representations of) the successive values of the variables Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 in the second block process.

INIT: 85E655D6 417A1795 3363376A 624CDE5C 76E09589 CAC5F811 CC4B32C1 F20E533A

0	7C20C838	85E655D6	417A1795	3363376A	4670AE6E	76E09589	CAC5F811	CC4B32C1
1	7C3C0F86	7C20C838	85E655D6	417A1795	8C51BE64	4670AE6E	76E09589	CAC5F811
2	FD1EEBDC	7C3C0F86	7C20C838	85E655D6	AF71B9EA	8C51BE64	4670AE6E	76E09589
3	F268FAA9	FD1EEBDC	7C3C0F86	7C20C838	E20362EF	AF71B9EA	8C51BE64	4670AE6E
4	185A5D79	F268FAA9	FD1EEBDC	7C3C0F86	8DFF3001	E20362EF	AF71B9EA	8C51BE64
5	3EEB6C06	185A5D79	F268FAA9	FD1EEBDC	FE20CDA6	8DFF3001	E20362EF	AF71B9EA
6	89BBA3F1	3EEB6C06	185A5D79	F268FAA9	0A34DF03	FE20CDA6	8DFF3001	E20362EF
7	BF9A93A0	89BBA3F1	3EEB6C06	185A5D79	059ABDD1	0A34DF03	FE20CDA6	8DFF3001
8	2C096744	BF9A93A0	89BBA3F1	3EEB6C06	ABFA465B	059ABDD1	0A34DF03	FE20CDA6
9	2D964E86	2C096744	BF9A93A0	89BBA3F1	AA27ED82	ABFA465B	059ABDD1	0A34DF03
10	5B35025B	2D964E86	2C096744	BF9A93A0	10E77723	AA27ED82	ABFA465B	059ABDD1
11	5EB4EC40	5B35025B	2D964E86	2C096744	E11B4548	10E77723	AA27ED82	ABFA465B
12	35EE996D	5EB4EC40	5B35025B	2D964E86	5C24E2A2	E11B4548	10E77723	AA27ED82
13	D74080FA	35EE996D	5EB4EC40	5B35025B	68AA893F	5C24E2A2	E11B4548	10E77723
14	0CEA5CBC	D74080FA	35EE996D	5EB4EC40	60356548	68AA893F	5C24E2A2	E11B4548
15	16A8CC79	0CEA5CBC	D74080FA	35EE996D	0FCB1F6F	60356548	68AA893F	5C24E2A2
16	F16F634E	16A8CC79	0CEA5CBC	D74080FA	8B21CDC1	0FCB1F6F	60356548	68AA893F
17	23DCB6C2	F16F634E	16A8CC79	0CEA5CBC	CA9182D3	8B21CDC1	0FCB1F6F	60356548
18	DCFF40FD	23DCB6C2	F16F634E	16A8CC79	69BF7B95	CA9182D3	8B21CDC1	0FCB1F6F
19	76F1A2BC	DCFF40FD	23DCB6C2	F16F634E	0DC84BB1	69BF7B95	CA9182D3	8B21CDC1
20	20AAD899	76F1A2BC	DCFF40FD	23DCB6C2	CC4769F2	0DC84BB1	69BF7B95	CA9182D3
21	D44DC81A	20AAD899	76F1A2BC	DCFF40FD	5BACE62D	CC4769F2	0DC84BB1	69BF7B95
22	F13AE55B	D44DC81A	20AAD899	76F1A2BC	966AA287	5BACE62D	CC4769F2	0DC84BB1
23	A4195B91	F13AE55B	D44DC81A	20AAD899	EDDBD6ED	966AA287	5BACE62D	CC4769F2
24	4984FA79	A4195B91	F13AE55B	D44DC81A	A530D939	EDDBD6ED	966AA287	5BACE62D
25	AA6CB982	4984FA79	A4195B91	F13AE55B	0B5EEEE4	A530D939	EDDBD6ED	966AA287
26	9450FBBC	AA6CB982	4984FA79	A4195B91	09166DDA	0B5EEEE4	A530D939	EDDBD6ED
27	0D936BAB	9450FBBC	AA6CB982	4984FA79	6E495D4B	09166DDA	0B5EEEE4	A530D939
28	D958B529	0D936BAB	9450FBBC	AA6CB982	C2FA99B1	6E495D4B	09166DDA	0B5EEEE4
29	1CFA5EB0	D958B529	0D936BAB	9450FBBC	6C49DB9F	C2FA99B1	6E495D4B	09166DDA
30	02EF3A5F	1CFA5EB0	D958B529	0D936BAB	5DA10665	6C49DB9F	C2FA99B1	6E495D4B
31	B0EAB1C5	02EF3A5F	1CFA5EB0	D958B529	F6D93952	5DA10665	6C49DB9F	C2FA99B1
32	0BFBA73C	B0EAB1C5	02EF3A5F	1CFA5EB0	8B99E3A9	F6D93952	5DA10665	6C49DB9F
33	4BD1DF96	0BFBA73C	B0EAB1C5	02EF3A5F	905E44AC	8B99E3A9	F6D93952	5DA10665
34	9907F1B6	4BD1DF96	0BFBA73C	B0EAB1C5	66C3043D	905E44AC	8B99E3A9	F6D93952
35	ECDE4E0D	9907F1B6	4BD1DF96	0BFBA73C	5DC119E6	66C3043D	905E44AC	8B99E3A9

36 2F11C939 ECDE4E0D 9907F1B6 4BD1DF96 FED4CE1D 5DC119E6 66C3043D 905E44AC
 37 D949682B 2F11C939 ECDE4E0D 9907F1B6 32D99008 FED4CE1D 5DC119E6 66C3043D
 38 ADCA7A96 D949682B 2F11C939 ECDE4E0D C6CCE4FF 32D99008 FED4CE1D 5DC119E6
 39 221B8A5A ADCA7A96 D949682B 2F11C939 0B82C5EB C6CCE4FF 32D99008 FED4CE1D
 40 12D97845 221B8A5A ADCA7A96 D949682B E4213CA2 0B82C5EB C6CCE4FF 32D99008
 41 2C794876 12D97845 221B8A5A ADCA7A96 FF6759BA E4213CA2 0B82C5EB C6CCE4FF
 42 8300FCA2 2C794876 12D97845 221B8A5A E0E3457C FF6759BA E4213CA2 0B82C5EB
 43 F2AD6322 8300FCA2 2C794876 12D97845 CC48C7F3 E0E3457C FF6759BA E4213CA2
 44 0F154E11 F2AD6322 8300FCA2 2C794876 6F9517CB CC48C7F3 E0E3457C FF6759BA
 45 104A7DB4 0F154E11 F2AD6322 8300FCA2 5348E8F6 6F9517CB CC48C7F3 E0E3457C
 46 0B3303A7 104A7DB4 0F154E11 F2AD6322 BBE1C39A 5348E8F6 6F9517CB CC48C7F3
 47 D7354D5B 0B3303A7 104A7DB4 0F154E11 AAD55B6B BBE1C39A 5348E8F6 6F9517CB
 48 B736D7A6 D7354D5B 0B3303A7 104A7DB4 68F25260 AAD55B6B BBE1C39A 5348E8F6
 49 2748E5EC B736D7A6 D7354D5B 0B3303A7 D4B58576 68F25260 AAD55B6B BBE1C39A
 50 D8AABCF9 2748E5EC B736D7A6 D7354D5B 27844711 D4B58576 68F25260 AAD55B6B
 51 1A6BCF6A D8AABCF9 2748E5EC B736D7A6 FF5E99D0 27844711 D4B58576 68F25260
 52 4ECA6FA0 1A6BCF6A D8AABCF9 2748E5EC 989ED071 FF5E99D0 27844711 D4B58576
 53 EC02560A 4ECA6FA0 1A6BCF6A D8AABCF9 7151DF8E 989ED071 FF5E99D0 27844711
 54 D9F0C115 EC02560A 4ECA6FA0 1A6BCF6A 624150C4 7151DF8E 989ED071 FF5E99D0
 55 92952710 D9F0C115 EC02560A 4ECA6FA0 226806D6 624150C4 7151DF8E 989ED071
 56 20D4D0E4 92952710 D9F0C115 EC02560A 4E515A4D 226806D6 624150C4 7151DF8E
 57 4348EB1F 20D4D0E4 92952710 D9F0C115 C21EDDF9 4E515A4D 226806D6 624150C4
 58 286FE5F0 4348EB1F 20D4D0E4 92952710 54076664 C21EDDF9 4E515A4D 226806D6
 59 1C4CDD9 286FE5F0 4348EB1F 20D4D0E4 F487A853 54076664 C21EDDF9 4E515A4D
 60 A9F181DD 1C4CDD9 286FE5F0 4348EB1F 27CCB387 F487A853 54076664 C21EDDF9
 61 B25CEF29 A9F181DD 1C4CDD9 286FE5F0 2AA1BB13 27CCB387 F487A853 54076664
 62 908C2123 B25CEF29 A9F181DD 1C4CDD9 9A392956 2AA1BB13 27CCB387 F487A853
 63 9EA7148B 908C2123 B25CEF29 A9F181DD 2C5C4ED0 9A392956 2AA1BB13 27CCB387

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

$Y_0 = 85E655D6 \oplus 9EA7148B = 248D6A61$
 $Y_1 = 417A1795 \oplus 908C2123 = D20638B8$
 $Y_2 = 3363376A \oplus B25CEF29 = E5C02693$
 $Y_3 = 624CDE5C \oplus A9F181DD = 0C3E6039$
 $Y_4 = 76E09589 \oplus 2C5C4ED0 = A33CE459$
 $Y_5 = CAC5F811 \oplus 9A392956 = 64FF2167$
 $Y_6 = CC4B32C1 \oplus 2AA1BB13 = F6ECEDD4$
 $Y_7 = F20E533A \oplus 27CCB387 = 19DB06C1$

The hash value for this message is

248D6A61 D20638B8 E5C02693 0C3E6039 A33CE459 64FF2167 F6ECEDD4 19DB06C1

B.5.9 Example 9

In this example, the data string is the 1 000 000-byte string consisting of the ASCII-coded version of “a” repeated 10^6 times.

The hash-code is the following 256-bit string.

CDC76E5C 9914FB92 81A1C7E2 84D73E67 F1809A48 A497200E 046D39CC C7112CD0

B.5.10 Example 10

In this example, the data string is the 112-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz
hijklmnopqrstuvwxyz”

(with no line break after the first n).

The hash-code is the following 256-bit string.

CF5B16A7 78AF8380 036CE59E 7B049237 0B249B11 E8F07A51 AFAC4503 7AFEE9D1

B.5.11 Example 11

In this example, the data string is the 32-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz”

The hash-code is the following 256-bit string.

B09CBD26 3B043F00 0C5BEFCA A40BC2F5 5A4785E0 24E5DBE7 49B56061 EAFB65E9

B.6 Dedicated Hash-Function 5 (SHA-512)

B.6.1 Example 1

In this example, the data string is the empty string, i.e. the string of length zero.

The hash-code is the following 512-bit string.

CF83E1357EEFB8BD F1542850D66D8007 D620E4050B5715DC 83F4A921D36CE9CE
47D0D13C5D85F2B0 FF8318D2877EEC2F 63B931BD47417A81 A538327AF927DA3E

B.6.2 Example 2

In this example, the data string consists of a single byte, namely the ASCII-coded version of the letter “a”.

The hash-code is the following 512-bit string.

1F40FC92DA241694 750979EE6CF582F2 D5D7D28E18335DE0 5ABC54D0560E0F53
02860C652BF08D56 0252AA5E74210546 F369FBBBCE8C12CF C7957B2652FE9A75

B.6.3 Example 3

In this example, the data string is the 3-byte string consisting of the ASCII-coded version of “abc”. This is equivalent to the bit string “01100001 01100010 01100011”.

After the padding process, the single 16-word block derived from the data string is as follows.

61626380 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000018

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 .

INIT: 6A09E667F3BCC908 BB67AE8584CAA73B 3C6EF372FE94F82B A54FF53A5F1D36F1
 510E527FADE682D1 9B05688C2B3E6C1F 1F83D9ABFB41BD6B 5BE0CD19137E2179
 0 F6AFCEB8BCFCDDF5 6A09E667F3BCC908 BB67AE8584CAA73B 3C6EF372FE94F82B
 58CB02347AB51F91 510E527FADE682D1 9B05688C2B3E6C1F 1F83D9ABFB41BD6B
 1 1320F8C9FB872CC0 F6AFCEB8BCFCDDF5 6A09E667F3BCC908 BB67AE8584CAA73B
 C3D4EBFD48650FFA 58CB02347AB51F91 510E527FADE682D1 9B05688C2B3E6C1F
 2 EBCFFC07203D91F3 1320F8C9FB872CC0 F6AFCEB8BCFCDDF5 6A09E667F3BCC908
 DFA9B239F2697812 C3D4EBFD48650FFA 58CB02347AB51F91 510E527FADE682D1
 3 5A83CB3E80050E82 EBCFFC07203D91F3 1320F8C9FB872CC0 F6AFCEB8BCFCDDF5
 0B47B4BB1928990E DFA9B239F2697812 C3D4EBFD48650FFA 58CB02347AB51F91
 4 B680953951604860 5A83CB3E80050E82 EBCFFC07203D91F3 1320F8C9FB872CC0
 745ACA4A342ED2E2 0B47B4BB1928990E DFA9B239F2697812 C3D4EBFD48650FFA
 5 AF573B02403E89CD B680953951604860 5A83CB3E80050E82 EBCFFC07203D91F3
 96F60209B6DC35BA 745ACA4A342ED2E2 0B47B4BB1928990E DFA9B239F2697812
 6 C4875B0C7ABC076B AF573B02403E89CD B680953951604860 5A83CB3E80050E82
 5A6C781F54DCC00C 96F60209B6DC35BA 745ACA4A342ED2E2 0B47B4BB1928990E
 7 8093D195E0054FA3 C4875B0C7ABC076B AF573B02403E89CD B680953951604860
 86F67263A0F0EC0A 5A6C781F54DCC00C 96F60209B6DC35BA 745ACA4A342ED2E2
 8 F1ECA5544CB89225 8093D195E0054FA3 C4875B0C7ABC076B AF573B02403E89CD
 D0403C398FC40002 86F67263A0F0EC0A 5A6C781F54DCC00C 96F60209B6DC35BA
 9 81782D4A5DB48F03 F1ECA5544CB89225 8093D195E0054FA3 C4875B0C7ABC076B
 00091F460BE46C52 D0403C398FC40002 86F67263A0F0EC0A 5A6C781F54DCC00C
 10 69854C4AA0F25B59 81782D4A5DB48F03 F1ECA5544CB89225 8093D195E0054FA3
 D375471BDE1BA3F4 00091F460BE46C52 D0403C398FC40002 86F67263A0F0EC0A
 11 DB0A9963F80C2EAA 69854C4AA0F25B59 81782D4A5DB48F03 F1ECA5544CB89225
 475975B91A7A462C D375471BDE1BA3F4 00091F460BE46C52 D0403C398FC40002
 12 5E41214388186C14 DB0A9963F80C2EAA 69854C4AA0F25B59 81782D4A5DB48F03
 CDF3BFF2883FC9D9 475975B91A7A462C D375471BDE1BA3F4 00091F460BE46C52
 13 44249631255D2CA0 5E41214388186C14 DB0A9963F80C2EAA 69854C4AA0F25B59
 860ACF9EFFBA6F61 CDF3BFF2883FC9D9 475975B91A7A462C D375471BDE1BA3F4
 14 FA967EED85A08028 44249631255D2CA0 5E41214388186C14 DB0A9963F80C2EAA
 874BFE5F6AAE9F2F 860ACF9EFFBA6F61 CDF3BFF2883FC9D9 475975B91A7A462C
 15 0AE07C86B1181C75 FA967EED85A08028 44249631255D2CA0 5E41214388186C14
 A77B7C035DD4C161 874BFE5F6AAE9F2F 860ACF9EFFBA6F61 CDF3BFF2883FC9D9
 16 CAF81A425D800537 0AE07C86B1181C75 FA967EED85A08028 44249631255D2CA0
 2DEECC6B39D64D78 A77B7C035DD4C161 874BFE5F6AAE9F2F 860ACF9EFFBA6F61
 17 4725BE249AD19E6B CAF81A425D800537 0AE07C86B1181C75 FA967EED85A08028
 F47E8353F8047455 2DEECC6B39D64D78 A77B7C035DD4C161 874BFE5F6AAE9F2F
 18 3C4B4104168E3EDB 4725BE249AD19E6B CAF81A425D800537 0AE07C86B1181C75
 29695FD88D81DBD0 F47E8353F8047455 2DEECC6B39D64D78 A77B7C035DD4C161
 19 9A3FB4D38AB6CF06 3C4B4104168E3EDB 4725BE249AD19E6B CAF81A425D800537
 F14998DD5F70767E 29695FD88D81DBD0 F47E8353F8047455 2DEECC6B39D64D78
 20 8DC5AE65569D3855 9A3FB4D38AB6CF06 3C4B4104168E3EDB 4725BE249AD19E6B
 4BB9E66D1145BFDC F14998DD5F70767E 29695FD88D81DBD0 F47E8353F8047455
 21 DA34D6673D452DCF 8DC5AE65569D3855 9A3FB4D38AB6CF06 3C4B4104168E3EDB
 8E30FF09AD488753 4BB9E66D1145BFDC F14998DD5F70767E 29695FD88D81DBD0
 22 3E2644567B709A78 DA34D6673D452DCF 8DC5AE65569D3855 9A3FB4D38AB6CF06

0AC2B11DA8F571C6 8E30FF09AD488753 4BB9E66D1145BFDC F14998DD5F70767E
 23 4F6877B58FE55484 3E2644567B709A78 DA34D6673D452DCF 8DC5AE65569D3855
 C66005F87DB55233 0AC2B11DA8F571C6 8E30FF09AD488753 4BB9E66D1145BFDC
 24 9AFF71163FA3A940 4F6877B58FE55484 3E2644567B709A78 DA34D6673D452DCF
 D3ECF13769180E6F C66005F87DB55233 0AC2B11DA8F571C6 8E30FF09AD488753
 25 0BC5F791F8E6816B 9AFF71163FA3A940 4F6877B58FE55484 3E2644567B709A78
 6DDF1FD7EDCCE336 D3ECF13769180E6F C66005F87DB55233 0AC2B11DA8F571C6
 26 884C3BC27BC4F941 0BC5F791F8E6816B 9AFF71163FA3A940 4F6877B58FE55484
 E6E48C9A8E948365 6DDF1FD7EDCCE336 D3ECF13769180E6F C66005F87DB55233
 27 EAB4A9E5771B8D09 884C3BC27BC4F941 0BC5F791F8E6816B 9AFF71163FA3A940
 09068A4E255A0DAC E6E48C9A8E948365 6DDF1FD7EDCCE336 D3ECF13769180E6F
 28 E62349090F47D30A EAB4A9E5771B8D09 884C3BC27BC4F941 0BC5F791F8E6816B
 0FCDF99710F21584 09068A4E255A0DAC E6E48C9A8E948365 6DDF1FD7EDCCE336
 29 74BF40F869094C63 E62349090F47D30A EAB4A9E5771B8D09 884C3BC27BC4F941
 F0AEC2FE1437F085 0FCDF99710F21584 09068A4E255A0DAC E6E48C9A8E948365
 30 4C4FBBB75F1873A6 74BF40F869094C63 E62349090F47D30A EAB4A9E5771B8D09
 73E025D91B9EFA3 F0AEC2FE1437F085 0FCDF99710F21584 09068A4E255A0DAC
 31 FF4D3F1F0D46A736 4C4FBBB75F1873A6 74BF40F869094C63 E62349090F47D30A
 3CD388E119E8162E 73E025D91B9EFA3 F0AEC2FE1437F085 0FCDF99710F21584
 32 A0509015CA08C8D4 FF4D3F1F0D46A736 4C4FBBB75F1873A6 74BF40F869094C63
 E1034573654A106F 3CD388E119E8162E 73E025D91B9EFA3 F0AEC2FE1437F085
 33 60D4E6995ED91FE6 A0509015CA08C8D4 FF4D3F1F0D46A736 4C4FBBB75F1873A6
 EFABBD8BF47C041A E1034573654A106F 3CD388E119E8162E 73E025D91B9EFA3
 34 2C59EC7743632621 60D4E6995ED91FE6 A0509015CA08C8D4 FF4D3F1F0D46A736
 0FBAE670FA780FD3 EFABBD8BF47C041A E1034573654A106F 3CD388E119E8162E
 35 1A081AFC59FDBC2C 2C59EC7743632621 60D4E6995ED91FE6 A0509015CA08C8D4
 F098082F502B44CD 0FBAE670FA780FD3 EFABBD8BF47C041A E1034573654A106F
 36 88DF85B0BBE77514 1A081AFC59FDBC2C 2C59EC7743632621 60D4E6995ED91FE6
 8FBFD0162BBF4675 F098082F502B44CD 0FBAE670FA780FD3 EFABBD8BF47C041A
 37 002BB8E4CD989567 88DF85B0BBE77514 1A081AFC59FDBC2C 2C59EC7743632621
 66ADCFA249AC7BBD 8FBFD0162BBF4675 F098082F502B44CD 0FBAE670FA780FD3
 38 B3BB8542B3376DE5 002BB8E4CD989567 88DF85B0BBE77514 1A081AFC59FDBC2C
 B49596C20FEBA7DE 66ADCFA249AC7BBD 8FBFD0162BBF4675 F098082F502B44CD
 39 8E01E125B855D225 B3BB8542B3376DE5 002BB8E4CD989567 88DF85B0BBE77514
 0C710A47BA6A567B B49596C20FEBA7DE 66ADCFA249AC7BBD 8FBFD0162BBF4675
 40 B01521DD6A6BE12C 8E01E125B855D225 B3BB8542B3376DE5 002BB8E4CD989567
 169008B3A4BB170B 0C710A47BA6A567B B49596C20FEBA7DE 66ADCFA249AC7BBD
 41 E96F89DD48CBD851 B01521DD6A6BE12C 8E01E125B855D225 B3BB8542B3376DE5
 F0996439E7B50CB1 169008B3A4BB170B 0C710A47BA6A567B B49596C20FEBA7DE
 42 BC05BA8DE5D3C480 E96F89DD48CBD851 B01521DD6A6BE12C 8E01E125B855D225
 639CB938E14DC190 F0996439E7B50CB1 169008B3A4BB170B 0C710A47BA6A567B
 43 35D7E7F41DEFBBD5 BC05BA8DE5D3C480 E96F89DD48CBD851 B01521DD6A6BE12C
 CC5100997F5710F2 639CB938E14DC190 F0996439E7B50CB1 169008B3A4BB170B
 44 C47C9D5C7EA8A234 35D7E7F41DEFBBD5 BC05BA8DE5D3C480 E96F89DD48CBD851
 858D832AE0E8911C CC5100997F5710F2 639CB938E14DC190 F0996439E7B50CB1
 45 021FBADBABAB5AC6 C47C9D5C7EA8A234 35D7E7F41DEFBBD5 BC05BA8DE5D3C480
 E95C2A57572D64D9 858D832AE0E8911C CC5100997F5710F2 639CB938E14DC190
 46 F61E672694DE2D67 021FBADBABAB5AC6 C47C9D5C7EA8A234 35D7E7F41DEFBBD5
 C6BC35740D8DAA9A E95C2A57572D64D9 858D832AE0E8911C CC5100997F5710F2
 47 6B69FC1BB482FEAC F61E672694DE2D67 021FBADBABAB5AC6 C47C9D5C7EA8A234

35264334C03AC8AD C6BC35740D8DAA9A E95C2A57572D64D9 858D832AE0E8911C
48 571F323D96B3A047 6B69FC1BB482FEAC F61E672694DE2D67 021FBADBABAB5AC6
271580ED6C3E5650 35264334C03AC8AD C6BC35740D8DAA9A E95C2A57572D64D9
49 CA9BD862C5050918 571F323D96B3A047 6B69FC1BB482FEAC F61E672694DE2D67
DFE091DAB182E645 271580ED6C3E5650 35264334C03AC8AD C6BC35740D8DAA9A
50 813A43DD2C502043 CA9BD862C5050918 571F323D96B3A047 6B69FC1BB482FEAC
07A0D8EF821C5E1A DFE091DAB182E645 271580ED6C3E5650 35264334C03AC8AD
51 D43F83727325DD77 813A43DD2C502043 CA9BD862C5050918 571F323D96B3A047
483F80A82EAE23E 07A0D8EF821C5E1A DFE091DAB182E645 271580ED6C3E5650
52 03DF11B32D42E203 D43F83727325DD77 813A43DD2C502043 CA9BD862C5050918
504F94E40591CFFA 483F80A82EAE23E 07A0D8EF821C5E1A DFE091DAB182E645
53 D63F68037DDF06AA 03DF11B32D42E203 D43F83727325DD77 813A43DD2C502043
A6781EFE1AA1CE02 504F94E40591CFFA 483F80A82EAE23E 07A0D8EF821C5E1A
54 F650857B5BABDA4D D63F68037DDF06AA 03DF11B32D42E203 D43F83727325DD77
9CCFB31A86DF0F86 A6781EFE1AA1CE02 504F94E40591CFFA 483F80A82EAE23E
55 63B460E42748817E F650857B5BABDA4D D63F68037DDF06AA 03DF11B32D42E203
C6B4DD2A9931C509 9CCFB31A86DF0F86 A6781EFE1AA1CE02 504F94E40591CFFA
56 7A52912943D52B05 63B460E42748817E F650857B5BABDA4D D63F68037DDF06AA
D2E89BBD91E00BE0 C6B4DD2A9931C509 9CCFB31A86DF0F86 A6781EFE1AA1CE02
57 4B81C3AEC976EA4B 7A52912943D52B05 63B460E42748817E F650857B5BABDA4D
70505988124351AC D2E89BBD91E00BE0 C6B4DD2A9931C509 9CCFB31A86DF0F86
58 581ECB3355DCD9B8 4B81C3AEC976EA4B 7A52912943D52B05 63B460E42748817E
6A3C9B0F71C8BF36 70505988124351AC D2E89BBD91E00BE0 C6B4DD2A9931C509
59 2C074484EF1EAC8C 581ECB3355DCD9B8 4B81C3AEC976EA4B 7A52912943D52B05
4797CDE4ED370692 6A3C9B0F71C8BF36 70505988124351AC D2E89BBD91E00BE0
60 3857DFD2FC37D3BA 2C074484EF1EAC8C 581ECB3355DCD9B8 4B81C3AEC976EA4B
A6AF4E9C9F807E51 4797CDE4ED370692 6A3C9B0F71C8BF36 70505988124351AC
61 CFCD928C5424E2B6 3857DFD2FC37D3BA 2C074484EF1EAC8C 581ECB3355DCD9B8
09AEE5BDA1644DE5 A6AF4E9C9F807E51 4797CDE4ED370692 6A3C9B0F71C8BF36
62 A81DEDBB9F19E643 CFCD928C5424E2B6 3857DFD2FC37D3BA 2C074484EF1EAC8C
84058865D60A05FA 09AEE5BDA1644DE5 A6AF4E9C9F807E51 4797CDE4ED370692
63 AB44E86276478D85 A81DEDBB9F19E643 CFCD928C5424E2B6 3857DFD2FC37D3BA
CD881EE59CA6BC53 84058865D60A05FA 09AEE5BDA1644DE5 A6AF4E9C9F807E51
64 5A806D7E9821A501 AB44E86276478D85 A81DEDBB9F19E643 CFCD928C5424E2B6
AA84B086688A5C45 CD881EE59CA6BC53 84058865D60A05FA 09AEE5BDA1644DE5
65 EEB9C21BB0102598 5A806D7E9821A501 AB44E86276478D85 A81DEDBB9F19E643
3B5FED0D6A1F96E1 AA84B086688A5C45 CD881EE59CA6BC53 84058865D60A05FA
66 46C4210AB2CC155D EEB9C21BB0102598 5A806D7E9821A501 AB44E86276478D85
29FAB5A7BFF53366 3B5FED0D6A1F96E1 AA84B086688A5C45 CD881EE59CA6BC53
67 54BA35CF56A0340E 46C4210AB2CC155D EEB9C21BB0102598 5A806D7E9821A501
1C66F46D95690BCF 29FAB5A7BFF53366 3B5FED0D6A1F96E1 AA84B086688A5C45
68 181839D609C79748 54BA35CF56A0340E 46C4210AB2CC155D EEB9C21BB0102598
0ADA78BA2D446140 1C66F46D95690BCF 29FAB5A7BFF53366 3B5FED0D6A1F96E1
69 FB6AAAE5D0B6A447 181839D609C79748 54BA35CF56A0340E 46C4210AB2CC155D
E3711CB6564D112D 0ADA78BA2D446140 1C66F46D95690BCF 29FAB5A7BFF53366
70 7652C579CB60F19C FB6AAAE5D0B6A447 181839D609C79748 54BA35CF56A0340E
AFF62C9665FF80FA E3711CB6564D112D 0ADA78BA2D446140 1C66F46D95690BCF
71 F15E9664B2803575 7652C579CB60F19C FB6AAAE5D0B6A447 181839D609C79748
947C3DFAFEE570EF AFF62C9665FF80FA E3711CB6564D112D 0ADA78BA2D446140
72 358406D165AEE9AB F15E9664B2803575 7652C579CB60F19C FB6AAAE5D0B6A447

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8C7B5FD91A794CA0 947C3DFAFEE570EF AFF62C9665FF80FA E3711CB6564D112D
73 20878DCD29CDFAF5 358406D165AEE9AB F15E9664B2803575 7652C579CB60F19C
054D3536539948D0 8C7B5FD91A794CA0 947C3DFAFEE570EF AFF62C9665FF80FA
74 33D48DABB5521DE2 20878DCD29CDFAF5 358406D165AEE9AB F15E9664B2803575
2BA18245B50DE4CF 054D3536539948D0 8C7B5FD91A794CA0 947C3DFAFEE570EF
75 C8960E6BE864B916 33D48DABB5521DE2 20878DCD29CDFAF5 358406D165AEE9AB
995019A6FF3BA3DE 2BA18245B50DE4CF 054D3536539948D0 8C7B5FD91A794CA0
76 654EF9ABEC389CA9 C8960E6BE864B916 33D48DABB5521DE2 20878DCD29CDFAF5
CEB9FC3691CE8326 995019A6FF3BA3DE 2BA18245B50DE4CF 054D3536539948D0
77 D67806DB8B148677 654EF9ABEC389CA9 C8960E6BE864B916 33D48DABB5521DE2
25C96A7768FB2AA3 CEB9FC3691CE8326 995019A6FF3BA3DE 2BA18245B50DE4CF
78 10D9C4C4295599F6 D67806DB8B148677 654EF9ABEC389CA9 C8960E6BE864B916
9BB4D39778C07F9E 25C96A7768FB2AA3 CEB9FC3691CE8326 995019A6FF3BA3DE
79 73A54F399FA4B1B2 10D9C4C4295599F6 D67806DB8B148677 654EF9ABEC389CA9
D08446AA79693ED7 9BB4D39778C07F9E 25C96A7768FB2AA3 CEB9FC3691CE8326

```

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

```

Y0 = 6A09E667F3BCC908 ∪ 73A54F399FA4B1B2 = DDAF35A193617ABA
Y1 = BB67AE8584CAA73B ∪ 10D9C4C4295599F6 = CC417349AE204131
Y2 = 3C6EF372FE94F82B ∪ D67806DB8B148677 = 12E6FA4E89A97EA2
Y3 = A54FF53A5F1D36F1 ∪ 654EF9ABEC389CA9 = 0A9EEEE64B55D39A
Y4 = 510E527FADE682D1 ∪ D08446AA79693ED7 = 2192992A274FC1A8
Y5 = 9B05688C2B3E6C1F ∪ 9BB4D39778C07F9E = 36BA3C23A3FEEBBD
Y6 = 1F83D9ABFB41BD6B ∪ 25C96A7768FB2AA3 = 454D4423643CE80E
Y7 = 5BE0CD19137E2179 ∪ CEB9FC3691CE8326 = 2A9AC94FA54CA49F

```

The hash value is the following 512-bit string.

```

DDAF35A193617ABA CC417349AE204131 12E6FA4E89A97EA2 0A9EEEE64B55D39A
2192992A274FC1A8 36BA3C23A3FEEBBD 454D4423643CE80E 2A9AC94FA54CA49F

```

B.6.4 Example 4

In this example, the data string is the 14-byte string consisting of the ASCII-coded version of

“message digest”

The hash-code is the following 512-bit string.

```

107DBF389D9E9F71 A3A95F6C055B9251 BC5268C2BE16D6C1 3492EA45B0199F33
09E16455AB1E9611 8E8A905D5597B720 38DDB372A8982604 6DE66687BB420E7C

```

B.6.5 Example 5

In this example, the data string is the 26-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz”

The hash-code is the following 512-bit string.

```

4DBFF86CC2CA1BAE 1E16468A05CB9881 C97F1753BCE36190 34898FAA1AABE429
955A1BF8EC483D74 21FE3C1646613A59 ED5441FB0F321389 F77F48A879C7B1F1

```

"ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789"

1E07BE23C26A86EA 37EA810C8EC78093 52515A970E9253C2 6F536CFC7A9996C4
5C8370583E0A78FA 4A90041D71A4CEAB 7423F19C71B9D5A3 E01249F0BEBD5894

In this example, the data string is the 80-byte string consisting of the ASCII-coded version of eight repetitions of

“1234567890”

72EC1EF1124A45B0 47E8B7C75A932195 135BB61DE24EC0D1 914042246E0AEC3A
2354E093D76F3048 B456764346900CB1 30D2A4FD5DD16ABB 5E30BCB850DEE843

In this example, the data string is the 56-byte string consisting of the ASCII-coded version of

“abcd**bc**decdefdefgfgfghfghighijhijkijklklmnlmnomnopnopq”

The hash-code is the following 512-bit string.

204A8FC6DDA82F0A 0CED7BEB8E08A416 57C16EF468B228A8 279BE331A703C335
96FD15C13B1B07F9 AA1D3BEA57789CA0 31AD85C7A71DD703 54EC631238CA3445

In this example, the data string is the 1 000 000-byte string consisting of the ASCII-coded version of “a” repeated 10^6 times.

The hash-code is the following 512-bit string.

E718483D0CE76964 4E2E42C7BC15B463 8E1F98B13B204428 5632A803AFA973EB
DE0FF244877EA60A 4CB0432CE577C31B EB009C5C2C49AA2E 4EADB217AD8CC09B

In this example, the data string is the 112-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz
abcdefghijklmnopqrstuvwxyz”

(with no line break after the first n).

After the padding process, the following two 16-word blocks are derived from the data string.

```

61626364 65666768 62636465 66676869 63646566 6768696A 64656667 68696A6B
65666768 696A6B6C 66676869 6A6B6C6D 6768696A 6B6C6D6E 68696A6B 6C6D6E6F
696A6B6C 6D6E6F70 6A6B6C6D 6E6F7071 6B6C6D6E 6F707172 6C6D6E6F 70717273
6D6E6F70 71727374 6E6F7071 72737475 80000000 00000000 00000000 00000000

00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000080

```

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 in the first block process.

```

INIT: 6A09E667F3BCC908 BB67AE8584CAA73B 3C6EF372FE94F82B A54FF53A5F1D36F1
      510E527FADE682D1 9B05688C2B3E6C1F 1F83D9ABFB41BD6B 5BE0CD19137E2179
0  F6AFCE9D2263455D 6A09E667F3BCC908 BB67AE8584CAA73B 3C6EF372FE94F82B
      58CB0218E01B86F9 510E527FADE682D1 9B05688C2B3E6C1F 1F83D9ABFB41BD6B
1  0B7056A534AE5F62 F6AFCE9D2263455D 6A09E667F3BCC908 BB67AE8584CAA73B
      F8C7198FE39E4C8C 58CB0218E01B86F9 510E527FADE682D1 9B05688C2B3E6C1F
2  2CA82233760C9942 0B7056A534AE5F62 F6AFCE9D2263455D 6A09E667F3BCC908
      303ECCCCD65953DE F8C7198FE39E4C8C 58CB0218E01B86F9 510E527FADE682D1
3  A023F17CE52CDA7B 2CA82233760C9942 0B7056A534AE5F62 F6AFCE9D2263455D
      FFDEE5EEDCC9CA42 303ECCCCD65953DE F8C7198FE39E4C8C 58CB0218E01B86F9
4  8F0A67D9D591A1A7 A023F17CE52CDA7B 2CA82233760C9942 0B7056A534AE5F62
      CB4CFBB166505F2F FFDEE5EEDCC9CA42 303ECCCCD65953DE F8C7198FE39E4C8C
5  B466267371ACC493 8F0A67D9D591A1A7 A023F17CE52CDA7B 2CA82233760C9942
      73D6C84C54D399EE CB4CFBB166505F2F FFDEE5EEDCC9CA42 303ECCCCD65953DE
6  658269F1A312FCCD B466267371ACC493 8F0A67D9D591A1A7 A023F17CE52CDA7B
      CDC40314975FB275 73D6C84C54D399EE CB4CFBB166505F2F FFDEE5EEDCC9CA42
7  65E3519C5B88181B 658269F1A312FCCD B466267371ACC493 8F0A67D9D591A1A7
      A657850AB3970C5A CDC40314975FB275 73D6C84C54D399EE CB4CFBB166505F2F
8  56604FBB4B6393EC 65E3519C5B88181B 658269F1A312FCCD B466267371ACC493
      E8B3BE22FBE64DF7 A657850AB3970C5A CDC40314975FB275 73D6C84C54D399EE
9  C4562769A37D02C0 56604FBB4B6393EC 65E3519C5B88181B 658269F1A312FCCD
      0062E70A1EF705C1 E8B3BE22FBE64DF7 A657850AB3970C5A CDC40314975FB275
10 27C0B4C9186E1736 C4562769A37D02C0 56604FBB4B6393EC 65E3519C5B88181B
      BC9740477A18AE2D 0062E70A1EF705C1 E8B3BE22FBE64DF7 A657850AB3970C5A
11 F17F52FB02F4EB74 27C0B4C9186E1736 C4562769A37D02C0 56604FBB4B6393EC
      BE58522CB9590EE1 BC9740477A18AE2D 0062E70A1EF705C1 E8B3BE22FBE64DF7
12 F2C245AC903D4A35 F17F52FB02F4EB74 27C0B4C9186E1736 C4562769A37D02C0
      49D5FA3A16DCD502 BE58522CB9590EE1 BC9740477A18AE2D 0062E70A1EF705C1
13 9B04175EA8090DAA F2C245AC903D4A35 F17F52FB02F4EB74 27C0B4C9186E1736
      EC9C5E98FF98760D 49D5FA3A16DCD502 BE58522CB9590EE1 BC9740477A18AE2D
14 481B8A6EE5E07031 9B04175EA8090DAA F2C245AC903D4A35 F17F52FB02F4EB74
      E4D35B613A5AC420 EC9C5E98FF98760D 49D5FA3A16DCD502 BE58522CB9590EE1
15 9356AC3EC3E51459 481B8A6EE5E07031 9B04175EA8090DAA F2C245AC903D4A35
      701F17D27582443B E4D35B613A5AC420 EC9C5E98FF98760D 49D5FA3A16DCD502
16 B889ED34ABD7AA37 9356AC3EC3E51459 481B8A6EE5E07031 9B04175EA8090DAA

```


1D05D9BA779A1A78 701F17D27582443B E4D35B613A5AC420 EC9C5E98FF98760D
17 BF537B1F3EDC7381 B889ED34ABD7AA37 9356AC3EC3E51459 481B8A6EE5E07031
C362FF9CF932951D 1D05D9BA779A1A78 701F17D27582443B E4D35B613A5AC420
18 D4E44D54E8242AD8 BF537B1F3EDC7381 B889ED34ABD7AA37 9356AC3EC3E51459
459E4E6888919F36 C362FF9CF932951D 1D05D9BA779A1A78 701F17D27582443B
19 05F3FBA454E5DE3D D4E44D54E8242AD8 BF537B1F3EDC7381 B889ED34ABD7AA37
CAED4B5FA322B984 459E4E6888919F36 C362FF9CF932951D 1D05D9BA779A1A78
20 CDB73772DC0248BF 05F3FBA454E5DE3D D4E44D54E8242AD8 BF537B1F3EDC7381
DC8049AFA6ACD502 CAED4B5FA322B984 459E4E6888919F36 C362FF9CF932951D
21 1D47A3268FF677ED CDB73772DC0248BF 05F3FBA454E5DE3D D4E44D54E8242AD8
8407818E9B28CC12 DC8049AFA6ACD502 CAED4B5FA322B984 459E4E6888919F36
22 AF4E23EB622D0DF4 1D47A3268FF677ED CDB73772DC0248BF 05F3FBA454E5DE3D
64B5AE5424598428 8407818E9B28CC12 DC8049AFA6ACD502 CAED4B5FA322B984
23 BE50606778DE14A6 AF4E23EB622D0DF4 1D47A3268FF677ED CDB73772DC0248BF
0A5D727CC92E7ADB 64B5AE5424598428 8407818E9B28CC12 DC8049AFA6ACD502
24 821E44F6678AC478 BE50606778DE14A6 AF4E23EB622D0DF4 1D47A3268FF677ED
F367E596D0A038A5 0A5D727CC92E7ADB 64B5AE5424598428 8407818E9B28CC12
25 0C852B1359A77C18 821E44F6678AC478 BE50606778DE14A6 AF4E23EB622D0DF4
6DEC8A3396A80C3F F367E596D0A038A5 0A5D727CC92E7ADB 64B5AE5424598428
26 EBB574FAD4B7A7E4 0C852B1359A77C18 821E44F6678AC478 BE50606778DE14A6
A241E7EFC1EB6FF9 6DEC8A3396A80C3F F367E596D0A038A5 0A5D727CC92E7ADB
27 A092821C3CDF08DA EBB574FAD4B7A7E4 0C852B1359A77C18 821E44F6678AC478
C84E849917A7C08E A241E7EFC1EB6FF9 6DEC8A3396A80C3F F367E596D0A038A5
28 82BA2E1A2DF2A4F1 A092821C3CDF08DA EBB574FAD4B7A7E4 0C852B1359A77C18
61845F6924789851 C84E849917A7C08E A241E7EFC1EB6FF9 6DEC8A3396A80C3F
29 1959AD991C63D06A 82BA2E1A2DF2A4F1 A092821C3CDF08DA EBB574FAD4B7A7E4
231FAF24910A891A 61845F6924789851 C84E849917A7C08E A241E7EFC1EB6FF9
30 9B32D4CADC9A625B 1959AD991C63D06A 82BA2E1A2DF2A4F1 A092821C3CDF08DA
533066919D608799 231FAF24910A891A 61845F6924789851 C84E849917A7C08E
31 DC55339F4D841965 9B32D4CADC9A625B 1959AD991C63D06A 82BA2E1A2DF2A4F1
E2517F359998A58D 533066919D608799 231FAF24910A891A 61845F6924789851
32 FDEBB1283B12514F DC55339F4D841965 9B32D4CADC9A625B 1959AD991C63D06A
B1989170A183C661 E2517F359998A58D 533066919D608799 231FAF24910A891A
33 B44C7975A83E3334 FDEBB1283B12514F DC55339F4D841965 9B32D4CADC9A625B
009AD175B8D588A4 B1989170A183C661 E2517F359998A58D 533066919D608799
34 0BAC61BFC53D18B7 B44C7975A83E3334 FDEBB1283B12514F DC55339F4D841965
A7D5416D690557B8 009AD175B8D588A4 B1989170A183C661 E2517F359998A58D
35 392893C22E75856A 0BAC61BFC53D18B7 B44C7975A83E3334 FDEBB1283B12514F
7A7C9EB7BC813248 A7D5416D690557B8 009AD175B8D588A4 B1989170A183C661
36 824408631432E09B 392893C22E75856A 0BAC61BFC53D18B7 B44C7975A83E3334
5E696A9FDA56D6BF 7A7C9EB7BC813248 A7D5416D690557B8 009AD175B8D588A4
37 A64162F151A8C1CB 824408631432E09B 392893C22E75856A 0BAC61BFC53D18B7
0F57062401DC680B 5E696A9FDA56D6BF 7A7C9EB7BC813248 A7D5416D690557B8
38 922537ABAD1E95A1 A64162F151A8C1CB 824408631432E09B 392893C22E75856A
4F4C193D435FF721 0F57062401DC680B 5E696A9FDA56D6BF 7A7C9EB7BC813248
39 B80591F6FBFADCDE 922537ABAD1E95A1 A64162F151A8C1CB 824408631432E09B
00F4407C0F37237E 4F4C193D435FF721 0F57062401DC680B 5E696A9FDA56D6BF
40 08F151F4B8D0FA2E B80591F6FBFADCDE 922537ABAD1E95A1 A64162F151A8C1CB
EC8B96FE402094CD 00F4407C0F37237E 4F4C193D435FF721 0F57062401DC680B
41 12B5FCC2B68F65C0 08F151F4B8D0FA2E B80591F6FBFADCDE 922537ABAD1E95A1

D688101DFD24A148 EC8B96FE402094CD 00F4407C0F37237E 4F4C193D435FF721
 42 A71BF5BD64289948 12B5FCC2B68F65C0 08F151F4B8D0FA2E B80591F6FBFADCD E
 E052BFB7A6945939 D688101DFD24A148 EC8B96FE402094CD 00F4407C0F37237E
 43 890C2CD670C4AEA3 A71BF5BD64289948 12B5FCC2B68F65C0 08F151F4B8D0FA2E
 DD13E4EDEEFF00E7 E052BFB7A6945939 D688101DFD24A148 EC8B96FE402094CD
 44 CA61990B43297FFC 890C2CD670C4AEA3 A71BF5BD64289948 12B5FCC2B68F65C0
 139AA55C51D9EE5F DD13E4EDEEFF00E7 E052BFB7A6945939 D688101DFD24A148
 45 7196E8FA538BA4BF CA61990B43297FFC 890C2CD670C4AEA3 A71BF5BD64289948
 046735513CDD14D3 139AA55C51D9EE5F DD13E4EDEEFF00E7 E052BFB7A6945939
 46 1F0720944DBEB6A4 7196E8FA538BA4BF CA61990B43297FFC 890C2CD670C4AEA3
 A41EB7E5A27588E3 046735513CDD14D3 139AA55C51D9EE5F DD13E4EDEEFF00E7
 47 D6D4F8608B8AB199 1F0720944DBEB6A4 7196E8FA538BA4BF CA61990B43297FFC
 24B9C216F915DA60 A41EB7E5A27588E3 046735513CDD14D3 139AA55C51D9EE5F
 48 88761EB67845978E D6D4F8608B8AB199 1F0720944DBEB6A4 7196E8FA538BA4BF
 9FE22E39448D50ED 24B9C216F915DA60 A41EB7E5A27588E3 046735513CDD14D3
 49 7D40E6BE47D85702 88761EB67845978E D6D4F8608B8AB199 1F0720944DBEB6A4
 D9C900E01968C33E 9FE22E39448D50ED 24B9C216F915DA60 A41EB7E5A27588E3
 50 7D0D988DF5768598 7D40E6BE47D85702 88761EB67845978E D6D4F8608B8AB199
 2EC2E522A7C7D12C D9C900E01968C33E 9FE22E39448D50ED 24B9C216F915DA60
 51 48A8B60575B37F31 7D0D988DF5768598 7D40E6BE47D85702 88761EB67845978E
 7059F9BC8C88A373 2EC2E522A7C7D12C D9C900E01968C33E 9FE22E39448D50ED
 52 6BC425AF294BBF79 48A8B60575B37F31 7D0D988DF5768598 7D40E6BE47D85702
 6A8143B1716EE33D 7059F9BC8C88A373 2EC2E522A7C7D12C D9C900E01968C33E
 53 307A456158EE8849 6BC425AF294BBF79 48A8B60575B37F31 7D0D988DF5768598
 4372E85C16EE4440 6A8143B1716EE33D 7059F9BC8C88A373 2EC2E522A7C7D12C
 54 AF36382C8FD716BE 307A456158EE8849 6BC425AF294BBF79 48A8B60575B37F31
 A8F8B0033187A916 4372E85C16EE4440 6A8143B1716EE33D 7059F9BC8C88A373
 55 810EBEE951C64CA1 AF36382C8FD716BE 307A456158EE8849 6BC425AF294BBF79
 16A64F5997B9CCA6 A8F8B0033187A916 4372E85C16EE4440 6A8143B1716EE33D
 56 2DD7659F1B4D13CD 810EBEE951C64CA1 AF36382C8FD716BE 307A456158EE8849
 5DA6793BB7286A4B 16A64F5997B9CCA6 A8F8B0033187A916 4372E85C16EE4440
 57 5AC712ACFF4B98BE 2DD7659F1B4D13CD 810EBEE951C64CA1 AF36382C8FD716BE
 91F6395B301ADBFD 5DA6793BB7286A4B 16A64F5997B9CCA6 A8F8B0033187A916
 58 C1AF358833CB03C0 5AC712ACFF4B98BE 2DD7659F1B4D13CD 810EBEE951C64CA1
 D4883C0C21DDA190 91F6395B301ADBFD 5DA6793BB7286A4B 16A64F5997B9CCA6
 59 88A306074D388C7D C1AF358833CB03C0 5AC712ACFF4B98BE 2DD7659F1B4D13CD
 9FC52468B897F9C8 D4883C0C21DDA190 91F6395B301ADBFD 5DA6793BB7286A4B
 60 F11BFD0CF67D3040 88A306074D388C7D C1AF358833CB03C0 5AC712ACFF4B98BE
 47EFB6407F74D318 9FC52468B897F9C8 D4883C0C21DDA190 91F6395B301ADBFD
 61 1F065E7828ED4E1B F11BFD0CF67D3040 88A306074D388C7D C1AF358833CB03C0
 7481899904A4CE23 47EFB6407F74D318 9FC52468B897F9C8 D4883C0C21DDA190
 62 AEBDE39F2BC42EC1 1F065E7828ED4E1B F11BFD0CF67D3040 88A306074D388C7D
 62AB526FF177A988 7481899904A4CE23 47EFB6407F74D318 9FC52468B897F9C8
 63 D35A94706E3E5DF2 AEBDE39F2BC42EC1 1F065E7828ED4E1B F11BFD0CF67D3040
 53F92B648D5D815C 62AB526FF177A988 7481899904A4CE23 47EFB6407F74D318
 64 D72D727C53E09AB9 D35A94706E3E5DF2 AEBDE39F2BC42EC1 1F065E7828ED4E1B
 10746426BA9824F4 53F92B648D5D815C 62AB526FF177A988 7481899904A4CE23
 65 3A7235E5A4051D94 D72D727C53E09AB9 D35A94706E3E5DF2 AEBDE39F2BC42EC1
 AFE455DAEC5C2B00 10746426BA9824F4 53F92B648D5D815C 62AB526FF177A988
 66 F7F510FE73EF7E76 3A7235E5A4051D94 D72D727C53E09AB9 D35A94706E3E5DF2

F1202C0BB7C4583F AFE455DAEC5C2B00 10746426BA9824F4 53F92B648D5D815C
 67 23C2ACFB393523E9 F7F510FE73EF7E76 3A7235E5A4051D94 D72D727C53E09AB9
 A0BC2A61044AC12E F1202C0BB7C4583F AFE455DAEC5C2B00 10746426BA9824F4
 68 0307D241A1ED7121 23C2ACFB393523E9 F7F510FE73EF7E76 3A7235E5A4051D94
 FAD5F38F1E0AEA12 A0BC2A61044AC12E F1202C0BB7C4583F AFE455DAEC5C2B00
 69 191814D82F0A16FB 0307D241A1ED7121 23C2ACFB393523E9 F7F510FE73EF7E76
 39D325086E66E200 FAD5F38F1E0AEA12 A0BC2A61044AC12E F1202C0BB7C4583F
 70 0A1ED41B6DA18C01 191814D82F0A16FB 0307D241A1ED7121 23C2ACFB393523E9
 B3D3521E166E5DF1 39D325086E66E200 FAD5F38F1E0AEA12 A0BC2A61044AC12E
 71 8A3F07DB93F6C827 0A1ED41B6DA18C01 191814D82F0A16FB 0307D241A1ED7121
 6B370074BE040ED7 B3D3521E166E5DF1 39D325086E66E200 FAD5F38F1E0AEA12
 72 002744D87EF80D28 8A3F07DB93F6C827 0A1ED41B6DA18C01 191814D82F0A16FB
 8C5A245DE2D72FE6 6B370074BE040ED7 B3D3521E166E5DF1 39D325086E66E200
 73 778DC7880A4A2AA0 002744D87EF80D28 8A3F07DB93F6C827 0A1ED41B6DA18C01
 45A375B466E5E342 8C5A245DE2D72FE6 6B370074BE040ED7 B3D3521E166E5DF1
 74 A3F11DE5EDE05B11 778DC7880A4A2AA0 002744D87EF80D28 8A3F07DB93F6C827
 F5BBF52F1AB7CC05 45A375B466E5E342 8C5A245DE2D72FE6 6B370074BE040ED7
 75 629C8AE6ECD8AF4B A3F11DE5EDE05B11 778DC7880A4A2AA0 002744D87EF80D28
 5A8FE5919D3CF136 F5BBF52F1AB7CC05 45A375B466E5E342 8C5A245DE2D72FE6
 76 C9A8C1E2D063CE94 629C8AE6ECD8AF4B A3F11DE5EDE05B11 778DC7880A4A2AA0
 AACD089BFAE8FAF9 5A8FE5919D3CF136 F5BBF52F1AB7CC05 45A375B466E5E342
 77 C517CBA6A09BB26A C9A8C1E2D063CE94 629C8AE6ECD8AF4B A3F11DE5EDE05B11
 E1682BD33C8F8E23 AACD089BFAE8FAF9 5A8FE5919D3CF136 F5BBF52F1AB7CC05
 78 11E3570E06E3B74E C517CBA6A09BB26A C9A8C1E2D063CE94 629C8AE6ECD8AF4B
 075AABBADE34FD01 E1682BD33C8F8E23 AACD089BFAE8FAF9 5A8FE5919D3CF136
 79 D90F1B1237B3A561 11E3570E06E3B74E C517CBA6A09BB26A C9A8C1E2D063CE94
 867983F69D3A3AD1 075AABBADE34FD01 E1682BD33C8F8E23 AACD089BFAE8FAF9

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the round-function in the first block process.

$Y_0 = 6A09E667F3BCC908 \cup D90F1B1237B3A561 = 4319017A2B706E69$
 $Y_1 = BB67AE8554CAA73B \cup 11E3570E06E3B74E = CD4B05938BAE5E89$
 $Y_2 = 3C6EF372FE94F82B \cup C517CBA6A09BB26A = 0186BF199F30AA95$
 $Y_3 = A54FF53A5F1D36F1 \cup C9A8C1E2D063CE94 = 6EF8B71D2F810585$
 $Y_4 = 510E527FADE682D1 \cup 867983F69D3A3AD1 = D787D6764B20BDA2$
 $Y_5 = 9B05688C2B3E6C1F \cup 075AABBADE34FD01 = A260144709736920$
 $Y_6 = 1F83D9ABFB41BD6B \cup E1682BD33C8F8E23 = 00EC057F37D14B8E$
 $Y_7 = 5BE0CD19137E2179 \cup AACD089BFAE8FAF9 = 06ADD5B50E671C72$

The following are (hexadecimal representations of) the successive values of the variables Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 in the second block process.

INIT: 4319017A2B706E69 CD4B05938BAE5E89 0186BF199F30AA95 6EF8B71D2F810585
 D787D6764B20BDA2 A260144709736920 00EC057F37D14B8E 06ADD5B50E671C72
 0 B8FDB92BDFB187E8 4319017A2B706E69 CD4B05938BAE5E89 0186BF199F30AA95
 1D5F4D5AD031B8E6 D787D6764B20BDA2 A260144709736920 00EC057F37D14B8E
 1 6EB90718369C5CD7 B8FDB92BDFB187E8 4319017A2B706E69 CD4B05938BAE5E89
 4B9B4877D987B0FE 1D5F4D5AD031B8E6 D787D6764B20BDA2 A260144709736920
 2 C83451F2335D5144 6EB90718369C5CD7 B8FDB92BDFB187E8 4319017A2B706E69
 D6B67350E0781E99 4B9B4877D987B0FE 1D5F4D5AD031B8E6 D787D6764B20BDA2
 3 28EC1DEB2A9EE6E3 C83451F2335D5144 6EB90718369C5CD7 B8FDB92BDFB187E8
 25E3136BE5999B8C D6B67350E0781E99 4B9B4877D987B0FE 1D5F4D5AD031B8E6

4 806ABD86C0479E5B 28EC1DEB2A9EE6E3 C83451F2335D5144 6EB90718369C5CD7
1B8F7670EAB1CF89 25E3136BE5999B8C D6B67350E0781E99 4B9B4877D987B0FE

5 234788F8A54AED38 806ABD86C0479E5B 28EC1DEB2A9EE6E3 C83451F2335D5144
4FABE51C67D5D156 1B8F7670EAB1CF89 25E3136BE5999B8C D6B67350E0781E99

6 01264F18257B5E2C 234788F8A54AED38 806ABD86C0479E5B 28EC1DEB2A9EE6E3
1C3506096B99DE50 4FABE51C67D5D156 1B8F7670EAB1CF89 25E3136BE5999B8C

7 5B14F38104DDE991 01264F18257B5E2C 234788F8A54AED38 806ABD86C0479E5B
13F8BFDC4001C362 1C3506096B99DE50 4FABE51C67D5D156 1B8F7670EAB1CF89

8 F522574A41B2AAC6 5B14F38104DDE991 01264F18257B5E2C 234788F8A54AED38
63A5F09617622ED2 13F8BFDC4001C362 1C3506096B99DE50 4FABE51C67D5D156

9 6EC258B855AF5A5A F522574A41B2AAC6 5B14F38104DDE991 01264F18257B5E2C
211E271D92770B36 63A5F09617622ED2 13F8BFDC4001C362 1C3506096B99DE50

10 9364214BA48B416C 6EC258B855AF5A5A F522574A41B2AAC6 5B14F38104DDE991
D64DCB6EC0FE5BAC 211E271D92770B36 63A5F09617622ED2 13F8BFDC4001C362

11 082BA62147ECBBD5 9364214BA48B416C 6EC258B855AF5A5A F522574A41B2AAC6
34FE78473B61266E D64DCB6EC0FE5BAC 211E271D92770B36 63A5F09617622ED2

12 5790F6BA82BBA809 082BA62147ECBBD5 9364214BA48B416C 6EC258B855AF5A5A
D491E309141DCAA3 34FE78473B61266E D64DCB6EC0FE5BAC 211E271D92770B36

13 A6B8AEFD086D33CE 5790F6BA82BBA809 082BA62147ECBBD5 9364214BA48B416C
044943C2992CC0F0 D491E309141DCAA3 34FE78473B61266E D64DCB6EC0FE5BAC

14 BF2324A9A363ABE7 A6B8AEFD086D33CE 5790F6BA82BBA809 082BA62147ECBBD5
0CF5F4BDE5977C54 044943C2992CC0F0 D491E309141DCAA3 34FE78473B61266E

15 00E8E32076A61AFF BF2324A9A363ABE7 A6B8AEFD086D33CE 5790F6BA82BBA809
43BF4EB269A2650C 0CF5F4BDE5977C54 044943C2992CC0F0 D491E309141DCAA3

16 F0376DFF66FFF4A7 00E8E32076A61AFF BF2324A9A363ABE7 A6B8AEFD086D33CE
69FA5896969E85B8 43BF4EB269A2650C 0CF5F4BDE5977C54 044943C2992CC0F0

17 2FAD194272CDA857 F0376DFF66FFF4A7 00E8E32076A61AFF BF2324A9A363ABE7
DDB519D663B7B6EC 69FA5896969E85B8 43BF4EB269A2650C 0CF5F4BDE5977C54

18 9AE56936E95325AC 2FAD194272CDA857 F0376DFF66FFF4A7 00E8E32076A61AFF
04CEB04676619057 DDB519D663B7B6EC 69FA5896969E85B8 43BF4EB269A2650C

19 D94CCB853F53433B 9AE56936E95325AC 2FAD194272CDA857 F0376DFF66FFF4A7
DCDC0F45813FB5A2 04CEB04676619057 DDB519D663B7B6EC 69FA5896969E85B8

20 837F8075D2945995 D94CCB853F53433B 9AE56936E95325AC 2FAD194272CDA857
272B5F79A91419D8 DCDC0F45813FB5A2 04CEB04676619057 DDB519D663B7B6EC

21 786BDE689F7AA62D 837F8075D2945995 D94CCB853F53433B 9AE56936E95325AC
566586E69AD3F487 272B5F79A91419D8 DCDC0F45813FB5A2 04CEB04676619057

22 276457F01812AA6F 786BDE689F7AA62D 837F8075D2945995 D94CCB853F53433B
E78FB8B0DFBBC62F 566586E69AD3F487 272B5F79A91419D8 DCDC0F45813FB5A2

23 0DE519F5D6C2C298 276457F01812AA6F 786BDE689F7AA62D 837F8075D2945995
5CA3E5CD1A30B954 E78FB8B0DFBBC62F 566586E69AD3F487 272B5F79A91419D8

24 54314DFF825E2B22 0DE519F5D6C2C298 276457F01812AA6F 786BDE689F7AA62D
B81A51E0C96CCF77 5CA3E5CD1A30B954 E78FB8B0DFBBC62F 566586E69AD3F487

25 5D3F98DD7B29C363 54314DFF825E2B22 0DE519F5D6C2C298 276457F01812AA6F
95D49494F5A0D14A B81A51E0C96CCF77 5CA3E5CD1A30B954 E78FB8B0DFBBC62F

26 5E9DA426AA7D4A58 5D3F98DD7B29C363 54314DFF825E2B22 0DE519F5D6C2C298
D22CCCAD2E391CD4 95D49494F5A0D14A B81A51E0C96CCF77 5CA3E5CD1A30B954

27 3B62DD973298EA43 5E9DA426AA7D4A58 5D3F98DD7B29C363 54314DFF825E2B22
ACEB5D06101E514E D22CCCAD2E391CD4 95D49494F5A0D14A B81A51E0C96CCF77

28 FD258FF809B2253D 3B62DD973298EA43 5E9DA426AA7D4A58 5D3F98DD7B29C363
26C991E85352DA6F ACEB5D06101E514E D22CCCAD2E391CD4 95D49494F5A0D14A

29 B462A20846AF417D FD258FF809B2253D 3B62DD973298EA43 5E9DA426AA7D4A58
 291EEE54C034C326 26C991E85352DA6F ACEB5D06101E514E D22CCCAD2E391CD4
 30 D5471E3DC7171224 B462A20846AF417D FD258FF809B2253D 3B62DD973298EA43
 0AAF99C59E7FADBD 291EEE54C034C326 26C991E85352DA6F ACEB5D06101E514E
 31 9ACE856BA1290E6E D5471E3DC7171224 B462A20846AF417D FD258FF809B2253D
 658F0BEA63804D05 0AAF99C59E7FADBD 291EEE54C034C326 26C991E85352DA6F
 32 80A0D154506B37C4 9ACE856BA1290E6E D5471E3DC7171224 B462A20846AF417D
 BBE6E3B3BB7FEFAB 658F0BEA63804D05 0AAF99C59E7FADBD 291EEE54C034C326
 33 FB90A8A76DEA1BFE 80A0D154506B37C4 9ACE856BA1290E6E D5471E3DC7171224
 65234D5B5049E665 BBE6E3B3BB7FEFAB 658F0BEA63804D05 0AAF99C59E7FADBD
 34 F517B690D940A294 FB90A8A76DEA1BFE 80A0D154506B37C4 9ACE856BA1290E6E
 E4DD663F44D313BC 65234D5B5049E665 BBE6E3B3BB7FEFAB 658F0BEA63804D05
 35 B70883992932880D F517B690D940A294 FB90A8A76DEA1BFE 80A0D154506B37C4
 DC5DD7C12B1CB6E3 E4DD663F44D313BC 65234D5B5049E665 BBE6E3B3BB7FEFAB
 36 B2A2BE77B0FCF3BF B70883992932880D F517B690D940A294 FB90A8A76DEA1BFE
 50FCA57291E19874 DC5DD7C12B1CB6E3 E4DD663F44D313BC 65234D5B5049E665
 37 8575839B0F08472B B2A2BE77B0FCF3BF B70883992932880D F517B690D940A294
 BD7176BD099BB2F2 50FCA57291E19874 DC5DD7C12B1CB6E3 E4DD663F44D313BC
 38 4405D2765DE0ADFC 8575839B0F08472B B2A2BE77B0FCF3BF B70883992932880D
 7CA4916F2CD8DB10 BD7176BD099BB2F2 50FCA57291E19874 DC5DD7C12B1CB6E3
 39 EEC6FCA5AA657661 4405D2765DE0ADFC 8575839B0F08472B B2A2BE77B0FCF3BF
 7BE0B7E70BDABE53 7CA4916F2CD8DB10 BD7176BD099BB2F2 50FCA57291E19874
 40 BB3FCD7585B59E32 EEC6FCA5AA657661 4405D2765DE0ADFC 8575839B0F08472B
 2201C7CBD34E31FE 7BE0B7E70BDABE53 7CA4916F2CD8DB10 BD7176BD099BB2F2
 41 0E109EFC47927341 BB3FCD7585B59E32 EEC6FCA5AA657661 4405D2765DE0ADFC
 D43E5686506FA05D 2201C7CBD34E31FE 7BE0B7E70BDABE53 7CA4916F2CD8DB10
 42 55C0DBA83BCDC6E0 0E109EFC47927341 BB3FCD7585B59E32 EEC6FCA5AA657661
 5B634502F1671535 D43E5686506FA05D 2201C7CBD34E31FE 7BE0B7E70BDABE53
 43 F5756F847BFAEF67 55C0DBA83BCDC6E0 0E109EFC47927341 BB3FCD7585B59E32
 E2D307FD94F4818A 5B634502F1671535 D43E5686506FA05D 2201C7CBD34E31FE
 44 F1438C9CF271C06E F5756F847BFAEF67 55C0DBA83BCDC6E0 0E109EFC47927341
 AD8AC1ED966B2DC6 E2D307FD94F4818A 5B634502F1671535 D43E5686506FA05D
 45 A7DCAFFDBEFB9D4A F1438C9CF271C06E F5756F847BFAEF67 55C0DBA83BCDC6E0
 9E46E9F915099C34 AD8AC1ED966B2DC6 E2D307FD94F4818A 5B634502F1671535
 46 985BA373680B8E94 A7DCAFFDBEFB9D4A F1438C9CF271C06E F5756F847BFAEF67
 7D4C0ABC676B1A8B 9E46E9F915099C34 AD8AC1ED966B2DC6 E2D307FD94F4818A
 47 807F45784852303F 985BA373680B8E94 A7DCAFFDBEFB9D4A F1438C9CF271C06E
 082EE70D3F352AAC 7D4C0ABC676B1A8B 9E46E9F915099C34 AD8AC1ED966B2DC6
 48 D9C523173B1A1E05 807F45784852303F 985BA373680B8E94 A7DCAFFDBEFB9D4A
 E301DCA32C44CA05 082EE70D3F352AAC 7D4C0ABC676B1A8B 9E46E9F915099C34
 49 B6DF019CA515CAFB D9C523173B1A1E05 807F45784852303F 985BA373680B8E94
 754B3A461A665640 E301DCA32C44CA05 082EE70D3F352AAC 7D4C0ABC676B1A8B
 50 427A642921B2E645 B6DF019CA515CAFB D9C523173B1A1E05 807F45784852303F
 08A30FEFE981F2EC 754B3A461A665640 E301DCA32C44CA05 082EE70D3F352AAC
 51 7AAB58DBE1B9DF7B 427A642921B2E645 B6DF019CA515CAFB D9C523173B1A1E05
 2749C52D0B3D1225 08A30FEFE981F2EC 754B3A461A665640 E301DCA32C44CA05
 52 974DDD552AEC16CE 7AAB58DBE1B9DF7B 427A642921B2E645 B6DF019CA515CAFB
 A9E6CBFB416A591F 2749C52D0B3D1225 08A30FEFE981F2EC 754B3A461A665640
 53 55E0B99D4404F6CA 974DDD552AEC16CE 7AAB58DBE1B9DF7B 427A642921B2E645
 6C24AD697B41B1B9 A9E6CBFB416A591F 2749C52D0B3D1225 08A30FEFE981F2EC

54 901F632579EE1EEE 55E0B99D4404F6CA 974DDD552AEC16CE 7AAB58DBE1B9DF7B
 4EE99476DB1BB7A9 6C24AD697B41B1B9 A9E6CBFB416A591F 2749C52D0B3D1225
 55 F90DB9F292A60463 901F632579EE1EEE 55E0B99D4404F6CA 974DDD552AEC16CE
 5401644992A1F8B8 4EE99476DB1BB7A9 6C24AD697B41B1B9 A9E6CBFB416A591F
 56 9B906A7DF1007357 F90DB9F292A60463 901F632579EE1EEE 55E0B99D4404F6CA
 F5E402EE21DB8915 5401644992A1F8B8 4EE99476DB1BB7A9 6C24AD697B41B1B9
 57 71A0A998FB48C0FC 9B906A7DF1007357 F90DB9F292A60463 901F632579EE1EEE
 96BECE755CD203CB F5E402EE21DB8915 5401644992A1F8B8 4EE99476DB1BB7A9
 58 C25E798E50752535 71A0A998FB48C0FC 9B906A7DF1007357 F90DB9F292A60463
 9D548440D8E110F2 96BECE755CD203CB F5E402EE21DB8915 5401644992A1F8B8
 59 1CE4F2591812E6AE C25E798E50752535 71A0A998FB48C0FC 9B906A7DF1007357
 B27252537A83CF27 9D548440D8E110F2 96BECE755CD203CB F5E402EE21DB8915
 60 C1700E250DC6FFED 1CE4F2591812E6AE C25E798E50752535 71A0A998FB48C0FC
 970088839126BDA5 B27252537A83CF27 9D548440D8E110F2 96BECE755CD203CB
 61 F8E6924412FD0C64 C1700E250DC6FFED 1CE4F2591812E6AE C25E798E50752535
 D50CF4F73910E3EE 970088839126BDA5 B27252537A83CF27 9D548440D8E110F2
 62 D53E0A39EEE47528 F8E6924412FD0C64 C1700E250DC6FFED 1CE4F2591812E6AE
 1B6D7234ACE15D7D D50CF4F73910E3EE 970088839126BDA5 B27252537A83CF27
 63 3960545AB926C0D5 D53E0A39EEE47528 F8E6924412FD0C64 C1700E250DC6FFED
 9EABB5618B4FCD13 1B6D7234ACE15D7D D50CF4F73910E3EE 970088839126BDA5
 64 B2C164D71ABB92FE 3960545AB926C0D5 D53E0A39EEE47528 F8E6924412FD0C64
 F1736FBBFB6EBE72 9EABB5618B4FCD13 1B6D7234ACE15D7D D50CF4F73910E3EE
 65 4D979E985B067E75 B2C164D71ABB92FE 3960545AB926C0D5 D53E0A39EEE47528
 D1FB300F35992350 F1736FBBFB6EBE72 9EABB5618B4FCD13 1B6D7234ACE15D7D
 66 59D0238CE137ABD7 4D979E985B067E75 B2C164D71ABB92FE 3960545AB926C0D5
 5F3C64B7546E2CEC D1FB300F35992350 F1736FBBFB6EBE72 9EABB5618B4FCD13
 67 BF8D9453B9876B0A 59D0238CE137ABD7 4D979E985B067E75 B2C164D71ABB92FE
 6C27893A31B0E07E 5F3C64B7546E2CEC D1FB300F35992350 F1736FBBFB6EBE72
 68 C45DD4A2D2FEA059 BF8D9453B9876B0A 59D0238CE137ABD7 4D979E985B067E75
 48253E21B26D8CF9 6C27893A31B0E07E 5F3C64B7546E2CEC D1FB300F35992350
 69 E08471946C17B0B6 C45DD4A2D2FEA059 BF8D9453B9876B0A 59D0238CE137ABD7
 714E2ADF4E23FF24 48253E21B26D8CF9 6C27893A31B0E07E 5F3C64B7546E2CEC
 70 B4838C1C28FEE7BC E08471946C17B0B6 C45DD4A2D2FEA059 BF8D9453B9876B0A
 371F12F333F7E5B9 714E2ADF4E23FF24 48253E21B26D8CF9 6C27893A31B0E07E
 71 851CF60A77F6E6D1 B4838C1C28FEE7BC E08471946C17B0B6 C45DD4A2D2FEA059
 A2A475DEAC0E8B42 371F12F333F7E5B9 714E2ADF4E23FF24 48253E21B26D8CF9
 72 F53D23C50249AF2D 851CF60A77F6E6D1 B4838C1C28FEE7BC E08471946C17B0B6
 1E99CAE9D4CF0409 A2A475DEAC0E8B42 371F12F333F7E5B9 714E2ADF4E23FF24
 73 B81E85D427045550 F53D23C50249AF2D 851CF60A77F6E6D1 B4838C1C28FEE7BC
 F5794711FAA60F63 1E99CAE9D4CF0409 A2A475DEAC0E8B42 371F12F333F7E5B9
 74 AE70C7D11EA84A83 B81E85D427045550 F53D23C50249AF2D 851CF60A77F6E6D1
 DC0D633411C289B2 F5794711FAA60F63 1E99CAE9D4CF0409 A2A475DEAC0E8B42
 75 5C54592E13C76135 AE70C7D11EA84A83 B81E85D427045550 F53D23C50249AF2D
 1620DD5479E94B9B DC0D633411C289B2 F5794711FAA60F63 1E99CAE9D4CF0409
 76 03A0F79087078A93 5C54592E13C76135 AE70C7D11EA84A83 B81E85D427045550
 57E90FA678E4CC97 1620DD5479E94B9B DC0D633411C289B2 F5794711FAA60F63
 77 8DF0BAAD4C6ED50C 03A0F79087078A93 5C54592E13C76135 AE70C7D11EA84A83
 C6E7246F7F0BDAC6 57E90FA678E4CC97 1620DD5479E94B9B DC0D633411C289B2
 78 BFA9F194894DB5B6 8DF0BAAD4C6ED50C 03A0F79087078A93 5C54592E13C76135

90BB8597BB41DA1A C6E7246F7F0BDAC6 57E90FA678E4CC97 1620DD5479E94B9B
 79 4B7C99FBAF72A571 BFA9F194894DB5B6 8DF0BAAD4C6ED50C 03A0F79087078A93
 78955227FDE03A42 90BB8597BB41DA1A C6E7246F7F0BDAC6 57E90FA678E4CC97

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

Y_0 = 4319017A2B706E69 $\cup$ 4B7C99FBAF72A571 = 8E959B75DAE313DA
 Y_1 = CD4B05938BAE5E89 $\cup$ BFA9F194894DB5B6 = 8CF4F72814FC143F
 Y_2 = 0186BF199F30AA95 $\cup$ 8DF0BAAD4C6ED50C = 8F7779C6EB9F7FA1
 Y_3 = 6EF8B71D2F810585 $\cup$ 03A0F79087078A93 = 7299AEADB6889018
 Y_4 = D787D6764B20BDA2 $\cup$ 78955227FDE03A42 = 501D289E4900F7E4
 Y_5 = A260144709736920 $\cup$ 90BB8597BB41DA1A = 331B99DEC4B5433A
 Y_6 = 00EC057F37D14B8E $\cup$ C6E7246F7F0BDAC6 = C7D329EEB6DD2654
 Y_7 = 06ADD5B50E671C72 $\cup$ 57E90FA678E4CC97 = 5E96E55B874BE909

The following is the hash value for this message.

8E959B75DAE313DA 8CF4F72814FC143F 8F7779C6EB9F7FA1 7299AEADB6889018
 501D289E4900F7E4 331B99DEC4B5433A C7D329EEB6DD2654 5E96E55B874BE909

B.6.11 Example 11

In this example, the data string is the 32-byte string consisting of the ASCII-coded version of

“abcdbcdecdefdefgefgfghghighijhjk”

The hash-code is the following 512-bit string.

C50E7A500D4058BF 530EC603B66B032A 989A3E033A340090 DC51086CFD8CB222
 09027932EA830F9B 6BC09DAFE882F908 38C2C91018245904 828C1232FC0942EB

B.7 Dedicated Hash-Function 6 (SHA-384)

B.7.1 Example 1

In this example, the data string is the empty string, i.e. the string of length zero.

The hash-code is the following 384-bit string.

38B060A751AC9638 4CD9327EB1B1E36A 21FDB71114BE0743 4C0CC7BF63F6E1DA
 274EDEBFE76F65FB D51AD2F14898B95B

B.7.2 Example 2

In this example, the data string consists of a single byte, namely the ASCII-coded version of the letter “a”.

The hash-code is the following 384-bit string.

54A59B9F22B0B808 80D8427E548B7C23 ABD873486E1F035D CE9CD697E8517503
 3CAA88E6D57BC35E FAE0B5AFD3145F31

B.7.3 Example 3

In this example, the data string is the 3-byte string consisting of the ASCII-coded version of “abc”. This is equivalent to the bit string “01100001 01100010 01100011”.

After the padding process, the single 16-word block derived from the data string is as follows.

```
61626380 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000018
```

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 .

```
INIT: CBBB9D5DC1059ED8 629A292A367CD507 9159015A3070DD17 152FECD8F70E5939
      67332667FFC00B31 8EB44A8768581511 DB0C2E0D64F98FA7 47B5481DBEFA4FA4
0 470994AD30873F88 CBBB9D5DC1059ED8 629A292A367CD507 9159015A3070DD17
  BD03F724BE6075F9 67332667FFC00B31 8EB44A8768581511 DB0C2E0D64F98FA7
1 2E91230306A12AE0 470994AD30873F88 CBBB9D5DC1059ED8 629A292A367CD507
  5E1B4E1695372B9E BD03F724BE6075F9 67332667FFC00B31 8EB44A8768581511
2 EEBE5D379BE707AD 2E91230306A12AE0 470994AD30873F88 CBBB9D5DC1059ED8
  54074A65AEF34336 5E1B4E1695372B9E BD03F724BE6075F9 67332667FFC00B31
3 E308483153E15AD6 EEBE5D379BE707AD 2E91230306A12AE0 470994AD30873F88
  086C5B2D36A89178 54074A65AEF34336 5E1B4E1695372B9E BD03F724BE6075F9
4 3A7A023C593D8479 E308483153E15AD6 EEBE5D379BE707AD 2E91230306A12AE0
  8AA1144850633794 086C5B2D36A89178 54074A65AEF34336 5E1B4E1695372B9E
5 333199A85F92B052 3A7A023C593D8479 E308483153E15AD6 EEBE5D379BE707AD
  7A6316F0EF047CE7 8AA1144850633794 086C5B2D36A89178 54074A65AEF34336
6 76F0741213DD2EF6 333199A85F92B052 3A7A023C593D8479 E308483153E15AD6
  74063CBA385F0675 7A6316F0EF047CE7 8AA1144850633794 086C5B2D36A89178
7 02F2A04D3AAB1629 76F0741213DD2EF6 333199A85F92B052 3A7A023C593D8479
  1688B9BF14980FC0 74063CBA385F0675 7A6316F0EF047CE7 8AA1144850633794
8 73E5B2A1704A0349 02F2A04D3AAB1629 76F0741213DD2EF6 333199A85F92B052
  FD00139F705907D0 1688B9BF14980FC0 74063CBA385F0675 7A6316F0EF047CE7
9 BF3F67BA12882648 73E5B2A1704A0349 02F2A04D3AAB1629 76F0741213DD2EF6
  652E311D4F0A4257 FD00139F705907D0 1688B9BF14980FC0 74063CBA385F0675
10 33254508BB2EA48D BF3F67BA12882648 73E5B2A1704A0349 02F2A04D3AAB1629
  9E18991C4F39F0BA 652E311D4F0A4257 FD00139F705907D0 1688B9BF14980FC0
11 C1FDB2A0205EA0E5 33254508BB2EA48D BF3F67BA12882648 73E5B2A1704A0349
  04732E8BC4044582 9E18991C4F39F0BA 652E311D4F0A4257 FD00139F705907D0
12 185F9FF038A50F39 C1FDB2A0205EA0E5 33254508BB2EA48D BF3F67BA12882648
  8B4ACFC4D2B8AFE6 04732E8BC4044582 9E18991C4F39F0BA 652E311D4F0A4257
13 E5F06744C0D7563A 185F9FF038A50F39 C1FDB2A0205EA0E5 33254508BB2EA48D
  2FA93D1CE9523015 8B4ACFC4D2B8AFE6 04732E8BC4044582 9E18991C4F39F0BA
14 7E32DC0E9F414783 E5F06744C0D7563A 185F9FF038A50F39 C1FDB2A0205EA0E5
  3A9950AAA5E75884 2FA93D1CE9523015 8B4ACFC4D2B8AFE6 04732E8BC4044582
15 1EAB6159AE87EF6D 7E32DC0E9F414783 E5F06744C0D7563A 185F9FF038A50F39
  153B895CFBC436C5 3A9950AAA5E75884 2FA93D1CE9523015 8B4ACFC4D2B8AFE6
16 33EF2CEBBF1739AA 1EAB6159AE87EF6D 7E32DC0E9F414783 E5F06744C0D7563A
  9D1A64BAF1D366AA 153B895CFBC436C5 3A9950AAA5E75884 2FA93D1CE9523015
17 7DF1B65F1B87D6CA 33EF2CEBBF1739AA 1EAB6159AE87EF6D 7E32DC0E9F414783
  5B6E369D36E8E181 9D1A64BAF1D366AA 153B895CFBC436C5 3A9950AAA5E75884
18 63A24014A34BB0F6 7DF1B65F1B87D6CA 33EF2CEBBF1739AA 1EAB6159AE87EF6D
  E13E610EAE680D85 5B6E369D36E8E181 9D1A64BAF1D366AA 153B895CFBC436C5
19 F1AABD313309509B 63A24014A34BB0F6 7DF1B65F1B87D6CA 33EF2CEBBF1739AA
```

674385F0D87DB94F E13E610EAE680D85 5B6E369D36E8E181 9D1A64BAF1D366AA
20 9BA737AE88A72C64 F1AABD313309509B 63A24014A34BB0F6 7DF1B65F1B87D6CA
3FC2614C43906C0F 674385F0D87DB94F E13E610EAE680D85 5B6E369D36E8E181
21 042C2DC9A5BF558A 9BA737AE88A72C64 F1AABD313309509B 63A24014A34BB0F6
19316BEBC88E01F2 3FC2614C43906C0F 674385F0D87DB94F E13E610EAE680D85
22 7799C75ACC748C0F 042C2DC9A5BF558A 9BA737AE88A72C64 F1AABD313309509B
A7BBD65BF64F58C8 19316BEBC88E01F2 3FC2614C43906C0F 674385F0D87DB94F
23 CCF99A80F92BF002 7799C75ACC748C0F 042C2DC9A5BF558A 9BA737AE88A72C64
E52A24FAE4E8FC9B A7BBD65BF64F58C8 19316BEBC88E01F2 3FC2614C43906C0F
24 AE993474363EFE68 CCF99A80F92BF002 7799C75ACC748C0F 042C2DC9A5BF558A
587F308D58681928 E52A24FAE4E8FC9B A7BBD65BF64F58C8 19316BEBC88E01F2
25 335063D1A2AEC92F AE993474363EFE68 CCF99A80F92BF002 7799C75ACC748C0F
C2D6D65E38C6EA79 587F308D58681928 E52A24FAE4E8FC9B A7BBD65BF64F58C8
26 53A78B0CCA01BA37 335063D1A2AEC92F AE993474363EFE68 CCF99A80F92BF002
3B65A26C3C92C8F3 C2D6D65E38C6EA79 587F308D58681928 E52A24FAE4E8FC9B
27 AB7FFA529F622930 53A78B0CCA01BA37 335063D1A2AEC92F AE993474363EFE68
B9D8A2F2762901EA 3B65A26C3C92C8F3 C2D6D65E38C6EA79 587F308D58681928
28 E428BB43AFE3D63E AB7FFA529F622930 53A78B0CCA01BA37 335063D1A2AEC92F
6A8527525F898726 B9D8A2F2762901EA 3B65A26C3C92C8F3 C2D6D65E38C6EA79
29 BBED541A5128088C E428BB43AFE3D63E AB7FFA529F622930 53A78B0CCA01BA37
7973AADBDE294BE9 6A8527525F898726 B9D8A2F2762901EA 3B65A26C3C92C8F3
30 4C5C38DF7EC8BAF4 BBED541A5128088C E428BB43AFE3D63E AB7FFA529F622930
422CEEA0200E9EE4 7973AADBDE294BE9 6A8527525F898726 B9D8A2F2762901EA
31 4BA456EC244033ED 4C5C38DF7EC8BAF4 BBED541A5128088C E428BB43AFE3D63E
7CF40857056D86B0 422CEEA0200E9EE4 7973AADBDE294BE9 6A8527525F898726
32 AA4A6AB2AC5F5DD8 4BA456EC244033ED 4C5C38DF7EC8BAF4 BBED541A5128088C
AD2B1ECFB5BFC556 7CF40857056D86B0 422CEEA0200E9EE4 7973AADBDE294BE9
33 9CB941F2CED774B3 AA4A6AB2AC5F5DD8 4BA456EC244033ED 4C5C38DF7EC8BAF4
029F66C7B4569BF0 AD2B1ECFB5BFC556 7CF40857056D86B0 422CEEA0200E9EE4
34 39265F358594DE27 9CB941F2CED774B3 AA4A6AB2AC5F5DD8 4BA456EC244033ED
3F7B1C260C82E54F 029F66C7B4569BF0 AD2B1ECFB5BFC556 7CF40857056D86B0
35 09CCA487D39B02A1 39265F358594DE27 9CB941F2CED774B3 AA4A6AB2AC5F5DD8
4A22B37B58A5B1B0 3F7B1C260C82E54F 029F66C7B4569BF0 AD2B1ECFB5BFC556
36 D48D97CE438CF4F0 09CCA487D39B02A1 39265F358594DE27 9CB941F2CED774B3
A239E00B8BAA0410 4A22B37B58A5B1B0 3F7B1C260C82E54F 029F66C7B4569BF0
37 D6F41E25A8B634D6 D48D97CE438CF4F0 09CCA487D39B02A1 39265F358594DE27
25755CB8179DD0B0 A239E00B8BAA0410 4A22B37B58A5B1B0 3F7B1C260C82E54F
38 54078334358573B4 D6F41E25A8B634D6 D48D97CE438CF4F0 09CCA487D39B02A1
0E419FB0802B0EFC 25755CB8179DD0B0 A239E00B8BAA0410 4A22B37B58A5B1B0
39 DB24F9A03F4FFF6B 54078334358573B4 D6F41E25A8B634D6 D48D97CE438CF4F0
D30E99B4B394B090 0E419FB0802B0EFC 25755CB8179DD0B0 A239E00B8BAA0410
40 3604C53A845EFC37 DB24F9A03F4FFF6B 54078334358573B4 D6F41E25A8B634D6
791B2B4AF7338B99 D30E99B4B394B090 0E419FB0802B0EFC 25755CB8179DD0B0
41 F41B1C0EEE89BDC6 3604C53A845EFC37 DB24F9A03F4FFF6B 54078334358573B4
E319B77D9E4E87F9 791B2B4AF7338B99 D30E99B4B394B090 0E419FB0802B0EFC
42 36644AE374632E3A F41B1C0EEE89BDC6 3604C53A845EFC37 DB24F9A03F4FFF6B
458250878A3972B2 E319B77D9E4E87F9 791B2B4AF7338B99 D30E99B4B394B090
43 88806F6AE9FCD65B 36644AE374632E3A F41B1C0EEE89BDC6 3604C53A845EFC37
CFDE2E6EA54FA576 458250878A3972B2 E319B77D9E4E87F9 791B2B4AF7338B99
44 51DCAA36995C301D 88806F6AE9FCD65B 36644AE374632E3A F41B1C0EEE89BDC6

E37F778353998050 CFDE2E6EA54FA576 458250878A3972B2 E319B77D9E4E87F9
 45 EF5E3885A2F238DF 51DCAA36995C301D 88806F6AE9FCD65B 36644AE374632E3A
 740E347F24E18FDA E37F778353998050 CFDE2E6EA54FA576 458250878A3972B2
 46 EB3753F4283F4818 EF5E3885A2F238DF 51DCAA36995C301D 88806F6AE9FCD65B
 0AE48CF840BB8BE9 740E347F24E18FDA E37F778353998050 CFDE2E6EA54FA576
 47 A6998D63A5D09E04 EB3753F4283F4818 EF5E3885A2F238DF 51DCAA36995C301D
 E21095012EE0B72A 0AE48CF840BB8BE9 740E347F24E18FDA E37F778353998050
 48 D3698FB64DF175B0 A6998D63A5D09E04 EB3753F4283F4818 EF5E3885A2F238DF
 C2F0B90FFCE80739 E21095012EE0B72A 0AE48CF840BB8BE9 740E347F24E18FDA
 49 317A3B295B991914 D3698FB64DF175B0 A6998D63A5D09E04 EB3753F4283F4818
 1CADFF2E6CB5AA4D C2F0B90FFCE80739 E21095012EE0B72A 0AE48CF840BB8BE9
 50 0941DA08148BA463 317A3B295B991914 D3698FB64DF175B0 A6998D63A5D09E04
 833EB9A4BB5A073E 1CADFF2E6CB5AA4D C2F0B90FFCE80739 E21095012EE0B72A
 51 494AC238D68C3D0B 0941DA08148BA463 317A3B295B991914 D3698FB64DF175B0
 80C8FC138E645028 833EB9A4BB5A073E 1CADFF2E6CB5AA4D C2F0B90FFCE80739
 52 C87E9168DB9E97DE 494AC238D68C3D0B 0941DA08148BA463 317A3B295B991914
 65CF7F6A829ACA04 80C8FC138E645028 833EB9A4BB5A073E 1CADFF2E6CB5AA4D
 53 EDB4448879391DBB C87E9168DB9E97DE 494AC238D68C3D0B 0941DA08148BA463
 7729C85475DD318F 65CF7F6A829ACA04 80C8FC138E645028 833EB9A4BB5A073E
 54 073775C2456DC7DB EDB4448879391DBB C87E9168DB9E97DE 494AC238D68C3D0B
 A9CCA0B6266B1D77 7729C85475DD318F 65CF7F6A829ACA04 80C8FC138E645028
 55 54DE8857B24AFAF7 073775C2456DC7DB EDB4448879391DBB C87E9168DB9E97DE
 8DE51CFF2AE4B068 A9CCA0B6266B1D77 7729C85475DD318F 65CF7F6A829ACA04
 56 8A9CDD80F7F09C05 54DE8857B24AFAF7 073775C2456DC7DB EDB4448879391DBB
 A60BA5E9EBAEB96A 8DE51CFF2AE4B068 A9CCA0B6266B1D77 7729C85475DD318F
 57 3EEB22A7524D8D7F 8A9CDD80F7F09C05 54DE8857B24AFAF7 073775C2456DC7DB
 E2E6830B139DF58F A60BA5E9EBAEB96A 8DE51CFF2AE4B068 A9CCA0B6266B1D77
 58 0ED77C9CDE8883D3 3EEB22A7524D8D7F 8A9CDD80F7F09C05 54DE8857B24AFAF7
 38413A2052387A9E E2E6830B139DF58F A60BA5E9EBAEB96A 8DE51CFF2AE4B068
 59 E64E4135F9D30DBC 0ED77C9CDE8883D3 3EEB22A7524D8D7F 8A9CDD80F7F09C05
 45B640454C75C349 38413A2052387A9E E2E6830B139DF58F A60BA5E9EBAEB96A
 60 1CA93A293D544328 E64E4135F9D30DBC 0ED77C9CDE8883D3 3EEB22A7524D8D7F
 EFBEF83A35C0319E 45B640454C75C349 38413A2052387A9E E2E6830B139DF58F
 61 3DC764F89E54043A 1CA93A293D544328 E64E4135F9D30DBC 0ED77C9CDE8883D3
 A57784945550CF94 EFBEF83A35C0319E 45B640454C75C349 38413A2052387A9E
 62 56FB5883F1C87A05 3DC764F89E54043A 1CA93A293D544328 E64E4135F9D30DBC
 F5198A41EB80E022 A57784945550CF94 EFBEF83A35C0319E 45B640454C75C349
 63 24A1124262A331C7 56FB5883F1C87A05 3DC764F89E54043A 1CA93A293D544328
 06EDACAE6E7B54AD F5198A41EB80E022 A57784945550CF94 EFBEF83A35C0319E
 64 EB85D19201C89694 24A1124262A331C7 56FB5883F1C87A05 3DC764F89E54043A
 9CED24983EEC8723 06EDACAE6E7B54AD F5198A41EB80E022 A57784945550CF94
 65 CC981AB3A59C1DB4 EB85D19201C89694 24A1124262A331C7 56FB5883F1C87A05
 EAC5516336BC8882 9CED24983EEC8723 06EDACAE6E7B54AD F5198A41EB80E022
 66 CEEF5D997E148B44 CC981AB3A59C1DB4 EB85D19201C89694 24A1124262A331C7
 617BBF70BB165212 EAC5516336BC8882 9CED24983EEC8723 06EDACAE6E7B54AD
 67 689EDF608A8E3F14 CEEF5D997E148B44 CC981AB3A59C1DB4 EB85D19201C89694
 3280D88472C100FD 617BBF70BB165212 EAC5516336BC8882 9CED24983EEC8723
 68 1E6E0255AB88079F 689EDF608A8E3F14 CEEF5D997E148B44 CC981AB3A59C1DB4
 F2001138439902B1 3280D88472C100FD 617BBF70BB165212 EAC5516336BC8882
 69 8C5D3B7FDAD66E70 1E6E0255AB88079F 689EDF608A8E3F14 CEEF5D997E148B44

90D18EC8B69F0345 F2001138439902B1 3280D88472C100FD 617BBF70BB165212
70 32E5ED8655871E9B 8C5D3B7FDAD66E70 1E6E0255AB88079F 689EDF608A8E3F14
51105F6241313777 90D18EC8B69F0345 F2001138439902B1 3280D88472C100FD
71 BCD5061679BE7336 32E5ED8655871E9B 8C5D3B7FDAD66E70 1E6E0255AB88079F
454B99F654443AD0 51105F6241313777 90D18EC8B69F0345 F2001138439902B1
72 E7D913B6678E78EF BCD5061679BE7336 32E5ED8655871E9B 8C5D3B7FDAD66E70
1FF613B5AA63776E 454B99F654443AD0 51105F6241313777 90D18EC8B69F0345
73 E6B8CB8DFA3475AB E7D913B6678E78EF BCD5061679BE7336 32E5ED8655871E9B
2E75F34303D39BB0 1FF613B5AA63776E 454B99F654443AD0 51105F6241313777
74 FDD4A30E168C4AE5 E6B8CB8DFA3475AB E7D913B6678E78EF BCD5061679BE7336
83A35DBE2A64FC26 2E75F34303D39BB0 1FF613B5AA63776E 454B99F654443AD0
75 12AEB6268DFA3E14 FDD4A30E168C4AE5 E6B8CB8DFA3475AB E7D913B6678E78EF
F660943B276786F7 83A35DBE2A64FC26 2E75F34303D39BB0 1FF613B5AA63776E
76 055B73814CF102B4 12AEB6268DFA3E14 FDD4A30E168C4AE5 E6B8CB8DFA3475AB
C4B149710F5D6A71 F660943B276786F7 83A35DBE2A64FC26 2E75F34303D39BB0
77 95D33150DE6DF44C 055B73814CF102B4 12AEB6268DFA3E14 FDD4A30E168C4AE5
C7F7BFF08EBF0D30 C4B149710F5D6A71 F660943B276786F7 83A35DBE2A64FC26
78 5306143F64497B00 95D33150DE6DF44C 055B73814CF102B4 12AEB6268DFA3E14
CA06A219CC701096 C7F7BFF08EBF0D30 C4B149710F5D6A71 F660943B276786F7
79 FF44D7E1849DBFB3 5306143F64497B00 95D33150DE6DF44C 055B73814CF102B4
1952E0C3A227C0F2 CA06A219CC701096 C7F7BFF08EBF0D30 C4B149710F5D6A71

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

Y_0 = CBBB9D5DC1059ED8 $\cup$ FF44D7E1849DBFB3 = CB00753F45A35E8B
 Y_1 = 629A292A367CD507 $\cup$ 5306143F64497B00 = B5A03D699AC65007
 Y_2 = 9159015A3070DD17 $\cup$ 95D33150DE6DF44C = 272C32AB0EDED163
 Y_3 = 152FEC8F70E5939 $\cup$ 055B73814CF102B4 = 1A8B605A43FF5BED
 Y_4 = 67332667FFC00B31 $\cup$ 1952E0C3A227C0F2 = 8086072BA1E7CC23
 Y_5 = 8EB44A8768581511 $\cup$ CA06A219CC701096 = 58BAECA134C825A7
 Y_6 = DB0C2E0D64F98FA7 $\cup$ C7F7BFF08EBF0D30 = A303EDFDF3B89CD7
 Y_7 = 47B5481DBEFA4FA4 $\cup$ C4B149710F5D6A71 = 0C66918ECE57BA15

The hash value is the following 384-bit string.

CB00753F45A35E8B B5A03D699AC65007 272C32AB0EDED163 1A8B605A43FF5BED
8086072BA1E7CC23 58BAECA134C825A7

B.7.4 Example 4

In this example, the data string is the 14-byte string consisting of the ASCII-coded version of

“message digest”

The hash-code is the following 384-bit string.

473ED35167EC1F5D 8E550368A3DB39BE 54639F828868E945 4C239FC8B52E3C61
DBD0D8B4DE1390C2 56DCBB5D5FD99CD5

B.7.5 Example 5

In this example, the data string is the 26-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz”

After the padding process, the following two 16-word blocks are derived from the data string.

```

61626364 65666768 62636465 66676869 63646566 6768696A 64656667 68696A6B
65666768 696A6B6C 66676869 6A6B6C6D 6768696A 6B6C6D6E 68696A6B 6C6D6E6F
696A6B6C 6D6E6F70 6A6B6C6D 6E6F7071 6B6C6D6E 6F707172 6C6D6E6F 70717273
6D6E6F70 71727374 6E6F7071 72737475 80000000 00000000 00000000 00000000

00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000380

```

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 in the first block process.

```

INIT: CBBB9D5DC1059ED8 629A292A367CD507 9159015A3070DD17 152FEC8F70E5939
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0 4709949195EDA6F0 CBBB9D5DC1059ED8 629A292A367CD507 9159015A3070DD17
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1 78D3F8BC03A38303 4709949195EDA6F0 CBBB9D5DC1059ED8 629A292A367CD507
  AE067F071CD18A36 BD03F70923C6DD61 67332667FFC00B31 8EB44A8768581511
2 ED59D30BEFF95306 78D3F8BC03A38303 4709949195EDA6F0 CBBB9D5DC1059ED8
  C180C7A74ED5CF1F AE067F071CD18A36 BD03F70923C6DD61 67332667FFC00B31
3 8E7FE2ABA3168F2B ED59D30BEFF95306 78D3F8BC03A38303 4709949195EDA6F0
  D92D19667920B327 C180C7A74ED5CF1F AE067F071CD18A36 BD03F70923C6DD61
4 1174F9B374A9263A 8E7FE2ABA3168F2B ED59D30BEFF95306 78D3F8BC03A38303
  DD371F2D13661C52 D92D19667920B327 C180C7A74ED5CF1F AE067F071CD18A36
5 27AAAFB7FBEF806B 1174F9B374A9263A 8E7FE2ABA3168F2B ED59D30BEFF95306
  21AF3C6430A9AF9C DD371F2D13661C52 D92D19667920B327 C180C7A74ED5CF1F
6 B352D03A0BD34D65 27AAAFB7FBEF806B 1174F9B374A9263A 8E7FE2ABA3168F2B
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8 0F79040546E6EDF7 412DB7F990563D7C B352D03A0BD34D65 27AAAFB7FBEF806B
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  DAC695B91543AE80 6B6C511B25A6BDBC 5062FD5924E2B62E 69397DE9A30E1473
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12 E1041368D2FCA1A2 23D0A36B692118EB 97AA05D89B8DBE6D EBF02410F67B8EE7
  AE01675BFB003180 A5F6C5155E221E8C 83B8B72646C0B598 DAC695B91543AE80
13 45BD6F69EFEC540D E1041368D2FCA1A2 23D0A36B692118EB 97AA05D89B8DBE6D
  C35CC50C1CF7EF98 AE01675BFB003180 A5F6C5155E221E8C 83B8B72646C0B598
14 C237FA23ABB9BC16 45BD6F69EFEC540D E1041368D2FCA1A2 23D0A36B692118EB
  A16C4F134B28923E C35CC50C1CF7EF98 AE01675BFB003180 A5F6C5155E221E8C
15 B4092DF1C0F81853 C237FA23ABB9BC16 45BD6F69EFEC540D E1041368D2FCA1A2
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 74 500F7B61186F6C2E ABAB4B0CA75A17C7 D42C3A57CFA78513 9D38BDB9DF22B557
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 77 7001201948FB3D71 E1053FC85F9E56BE 4ABE0AF6A67DB2FE 500F7B61186F6C2E
 5CDF6C58FC052572 4779767CC2EC5321 14E986342DDCED0F 8347F5736531B3EC
 78 88146DA76FF6F23A 7001201948FB3D71 E1053FC85F9E56BE 4ABE0AF6A67DB2FE
 8901CFFE7A74DB98 5CDF6C58FC052572 4779767CC2EC5321 14E986342DDCED0F
 79 5EC3802B9ECFEF33 88146DA76FF6F23A 7001201948FB3D71 E1053FC85F9E56BE
 5F2EEAD69EFB4233 8901CFFE7A74DB98 5CDF6C58FC052572 4779767CC2EC5321

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the round-function in the first block process.

Y_0 = CBBB9D5DC1059ED8 $\cup$ 5EC3802B9ECFEF33 = 2A7F1D895FD58E0B
 Y_1 = 629A292A367CD507 $\cup$ 88146DA76FF6F23A = EAAE96D1A673C741
 Y_2 = 9159015A3070DD17 $\cup$ 7001201948FB3D71 = 015A2173796C1A88
 Y_3 = 152FECDD8F70E5939 $\cup$ E1053FC85F9E56BE = F6352CA156ACAFF7
 Y_4 = 67332667FFC00B31 $\cup$ 5F2EEAD69EFB4233 = C662113E9EBB4D64
 Y_5 = 8EB44A8768581511 $\cup$ 8901CFFE7A74DB98 = 17B61A85E2CCF0A9
 Y_6 = DB0C2E0D64F98FA7 $\cup$ 5CDF6C58FC052572 = 37EB9A6660FEB519
 Y_7 = 47B5481DBEFA4FA4 $\cup$ 4779767CC2EC5321 = 8F2EBE9A81E6A2C5

The following are (hexadecimal representations of) the successive values of the variables Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 in the second block process.

INIT: 2A7F1D895FD58E0B EAAE96D1A673C741 015A2173796C1A88 F6352CA156ACAFF7
 C662113E9EBB4D64 17B61A85E2CCF0A9 37EB9A6660FEB519 8F2EBE9A81E6A2C5
 0 657A3C2CA9639D40 2A7F1D895FD58E0B EAAE96D1A673C741 015A2173796C1A88
 791F2AD0055FDD62 C662113E9EBB4D64 17B61A85E2CCF0A9 37EB9A6660FEB519
 1 2A4AD5D9B9FD6D86 657A3C2CA9639D40 2A7F1D895FD58E0B EAAE96D1A673C741
 DBF2E656B5BE3F14 791F2AD0055FDD62 C662113E9EBB4D64 17B61A85E2CCF0A9
 2 F0AA6758653D1664 2A4AD5D9B9FD6D86 657A3C2CA9639D40 2A7F1D895FD58E0B
 6E0466C82F4FD35D DBF2E656B5BE3F14 791F2AD0055FDD62 C662113E9EBB4D64
 3 43A76F011A73D317 F0AA6758653D1664 2A4AD5D9B9FD6D86 657A3C2CA9639D40
 1367BD36D15E8B40 6E0466C82F4FD35D DBF2E656B5BE3F14 791F2AD0055FDD62

4 D802C2DFD7CC48F6 43A76F011A73D317 F0AA6758653D1664 2A4AD5D9B9FD6D86
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5 481208E5E8314602 D802C2DFD7CC48F6 43A76F011A73D317 F0AA6758653D1664
6B2271A46F14C843 F73D759B839A2A21 1367BD36D15E8B40 6E0466C82F4FD35D

6 AF9F8112DF35CF33 481208E5E8314602 D802C2DFD7CC48F6 43A76F011A73D317
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7 6730781342D1131B AF9F8112DF35CF33 481208E5E8314602 D802C2DFD7CC48F6
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8 82E64C677356A82E 6730781342D1131B AF9F8112DF35CF33 481208E5E8314602
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9 203578820A8F27D0 82E64C677356A82E 6730781342D1131B AF9F8112DF35CF33
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10 0BAC2A84C29A1E2B 203578820A8F27D0 82E64C677356A82E 6730781342D1131B
6AD288DAB3DE0D53 9937B3A0CB9248A1 10B62FDCE4EBAA51 81957AD408CEC995

11 DD3FF8A140485C25 0BAC2A84C29A1E2B 203578820A8F27D0 82E64C677356A82E
3149B728123C465E 6AD288DAB3DE0D53 9937B3A0CB9248A1 10B62FDCE4EBAA51

12 E826239F830C5346 DD3FF8A140485C25 0BAC2A84C29A1E2B 203578820A8F27D0
4BB7B199C4CED186 3149B728123C465E 6AD288DAB3DE0D53 9937B3A0CB9248A1

13 32215CE49AAE40F8 E826239F830C5346 DD3FF8A140485C25 0BAC2A84C29A1E2B
9A2872C72D790D49 4BB7B199C4CED186 3149B728123C465E 6AD288DAB3DE0D53

14 859533BAC457F94E 32215CE49AAE40F8 E826239F830C5346 DD3FF8A140485C25
539F225D25EBEB4C 9A2872C72D790D49 4BB7B199C4CED186 3149B728123C465E

15 A88704D9962849F3 859533BAC457F94E 32215CE49AAE40F8 E826239F830C5346
63BF0472EF24F7A5 539F225D25EBEB4C 9A2872C72D790D49 4BB7B199C4CED186

16 3AA5C566A6CFAD1C A88704D9962849F3 859533BAC457F94E 32215CE49AAE40F8
CE23F6380EAD33C2 63BF0472EF24F7A5 539F225D25EBEB4C 9A2872C72D790D49

17 2E9C483A7C08C9C1 3AA5C566A6CFAD1C A88704D9962849F3 859533BAC457F94E
B033F945F3E6B4A2 CE23F6380EAD33C2 63BF0472EF24F7A5 539F225D25EBEB4C

18 5A68585AE0835231 2E9C483A7C08C9C1 3AA5C566A6CFAD1C A88704D9962849F3
8A0187A9CE93D875 B033F945F3E6B4A2 CE23F6380EAD33C2 63BF0472EF24F7A5

19 CF9CD481E6407CED 5A68585AE0835231 2E9C483A7C08C9C1 3AA5C566A6CFAD1C
37A29FA30531BAC7 8A0187A9CE93D875 B033F945F3E6B4A2 CE23F6380EAD33C2

20 3F463F864F6474D9 CF9CD481E6407CED 5A68585AE0835231 2E9C483A7C08C9C1
0CF45BB3C07E847D 37A29FA30531BAC7 8A0187A9CE93D875 B033F945F3E6B4A2

21 CEA26288DFF931A5 3F463F864F6474D9 CF9CD481E6407CED 5A68585AE0835231
34F1B5F46BF48A73 0CF45BB3C07E847D 37A29FA30531BAC7 8A0187A9CE93D875

22 89634CD0F4F6C08A CEA26288DFF931A5 3F463F864F6474D9 CF9CD481E6407CED
3A728A543405A8E4 34F1B5F46BF48A73 0CF45BB3C07E847D 37A29FA30531BAC7

23 625FA38464E5C880 89634CD0F4F6C08A CEA26288DFF931A5 3F463F864F6474D9
CEE1B47A49B2FC42 3A728A543405A8E4 34F1B5F46BF48A73 0CF45BB3C07E847D

24 7DD21453A15A3B92 625FA38464E5C880 89634CD0F4F6C08A CEA26288DFF931A5
9308BFA1BE1F800B CEE1B47A49B2FC42 3A728A543405A8E4 34F1B5F46BF48A73

25 3D76277BC8CB0601 7DD21453A15A3B92 625FA38464E5C880 89634CD0F4F6C08A
480E017F5D1F0B1E 9308BFA1BE1F800B CEE1B47A49B2FC42 3A728A543405A8E4

26 C8D904196F5A1F54 3D76277BC8CB0601 7DD21453A15A3B92 625FA38464E5C880
4BD2F1F6E940C332 480E017F5D1F0B1E 9308BFA1BE1F800B CEE1B47A49B2FC42

27 B033139B58B6E423 C8D904196F5A1F54 3D76277BC8CB0601 7DD21453A15A3B92
F816EC1CBE0ADAFB 4BD2F1F6E940C332 480E017F5D1F0B1E 9308BFA1BE1F800B

28 097768182CB65F57 B033139B58B6E423 C8D904196F5A1F54 3D76277BC8CB0601
62E3DE54DCD8F974 F816EC1CBE0ADAFB 4BD2F1F6E940C332 480E017F5D1F0B1E

29 3196649AB5F5CC39 097768182CB65F57 B033139B58B6E423 C8D904196F5A1F54
F6887DE116D0BD8F 62E3DE54DCD8F974 F816EC1CBE0ADAFB 4BD2F1F6E940C332

30 F78D3D221D16965F 3196649AB5F5CC39 097768182CB65F57 B033139B58B6E423
C7E4859C2858ED3C F6887DE116D0BD8F 62E3DE54DCD8F974 F816EC1CBE0ADAFB

31 F58E9876B4984B51 F78D3D221D16965F 3196649AB5F5CC39 097768182CB65F57
621352B394B8CA02 C7E4859C2858ED3C F6887DE116D0BD8F 62E3DE54DCD8F974

32 38FBF0E726E04F78 F58E9876B4984B51 F78D3D221D16965F 3196649AB5F5CC39
4319856F17A0A430 621352B394B8CA02 C7E4859C2858ED3C F6887DE116D0BD8F

33 F4BE0B32A57597A2 38FBF0E726E04F78 F58E9876B4984B51 F78D3D221D16965F
C6D392A3B4EB0ED8 4319856F17A0A430 621352B394B8CA02 C7E4859C2858ED3C

34 F8A6B3FE2E4F0634 F4BE0B32A57597A2 38FBF0E726E04F78 F58E9876B4984B51
602663C0F34EFF33 C6D392A3B4EB0ED8 4319856F17A0A430 621352B394B8CA02

35 9BC3871BE8046113 F8A6B3FE2E4F0634 F4BE0B32A57597A2 38FBF0E726E04F78
05542ECD9883C6BA 602663C0F34EFF33 C6D392A3B4EB0ED8 4319856F17A0A430

36 F1BD2D46BE619585 9BC3871BE8046113 F8A6B3FE2E4F0634 F4BE0B32A57597A2
E47B9933BAFDC655 05542ECD9883C6BA 602663C0F34EFF33 C6D392A3B4EB0ED8

37 24C84B58D119AFFE F1BD2D46BE619585 9BC3871BE8046113 F8A6B3FE2E4F0634
5AE0B1175BEB5D2B E47B9933BAFDC655 05542ECD9883C6BA 602663C0F34EFF33

38 EC6D3ABC2B291FD3 24C84B58D119AFFE F1BD2D46BE619585 9BC3871BE8046113
9ECC381D277748A3 5AE0B1175BEB5D2B E47B9933BAFDC655 05542ECD9883C6BA

39 E266C1F77D5EE90E EC6D3ABC2B291FD3 24C84B58D119AFFE F1BD2D46BE619585
D92F34C110296B32 9ECC381D277748A3 5AE0B1175BEB5D2B E47B9933BAFDC655

40 5ADBAA463642B570 E266C1F77D5EE90E EC6D3ABC2B291FD3 24C84B58D119AFFE
83E8F410F859388E D92F34C110296B32 9ECC381D277748A3 5AE0B1175BEB5D2B

41 50FDB7BB2E499A34 5ADBAA463642B570 E266C1F77D5EE90E EC6D3ABC2B291FD3
257ED8EA645E933A 83E8F410F859388E D92F34C110296B32 9ECC381D277748A3

42 06514212BB7FA152 50FDB7BB2E499A34 5ADBAA463642B570 E266C1F77D5EE90E
466781DB35181ABE 257ED8EA645E933A 83E8F410F859388E D92F34C110296B32

43 673ED5A55FF2B07D 06514212BB7FA152 50FDB7BB2E499A34 5ADBAA463642B570
BA78F3545E7914F0 466781DB35181ABE 257ED8EA645E933A 83E8F410F859388E

44 125E2E5118393E2B 673ED5A55FF2B07D 06514212BB7FA152 50FDB7BB2E499A34
4453B23A3E13B090 BA78F3545E7914F0 466781DB35181ABE 257ED8EA645E933A

45 07EE813DF5910CEC 125E2E5118393E2B 673ED5A55FF2B07D 06514212BB7FA152
EAE013A0510D23CC 4453B23A3E13B090 BA78F3545E7914F0 466781DB35181ABE

46 0A0508F0A1D719C3 07EE813DF5910CEC 125E2E5118393E2B 673ED5A55FF2B07D
A93815EB58891016 EAE013A0510D23CC 4453B23A3E13B090 BA78F3545E7914F0

47 0FC8F3B3EFCB1B96 0A0508F0A1D719C3 07EE813DF5910CEC 125E2E5118393E2B
A071CC73B966E801 A93815EB58891016 EAE013A0510D23CC 4453B23A3E13B090

48 02AA5B28199F304A 0FC8F3B3EFCB1B96 0A0508F0A1D719C3 07EE813DF5910CEC
A49F1E14F8A2BE7A A071CC73B966E801 A93815EB58891016 EAE013A0510D23CC

49 9223E1B34382F104 02AA5B28199F304A 0FC8F3B3EFCB1B96 0A0508F0A1D719C3
BFE2106E512A7331 A49F1E14F8A2BE7A A071CC73B966E801 A93815EB58891016

50 E01A1E47EE8D5656 9223E1B34382F104 02AA5B28199F304A 0FC8F3B3EFCB1B96
592B899B35469A78 BFE2106E512A7331 A49F1E14F8A2BE7A A071CC73B966E801

51 FA7B17AAD857C2F4 E01A1E47EE8D5656 9223E1B34382F104 02AA5B28199F304A
EB6E85E4682C1671 592B899B35469A78 BFE2106E512A7331 A49F1E14F8A2BE7A

52 0C523B7A3C84AB77 FA7B17AAD857C2F4 E01A1E47EE8D5656 9223E1B34382F104
B5E80E871AC0C005 EB6E85E4682C1671 592B899B35469A78 BFE2106E512A7331

53 C773D8B69DA1FDE2 0C523B7A3C84AB77 FA7B17AAD857C2F4 E01A1E47EE8D5656
BE2B0602FC6F8F65 B5E80E871AC0C005 EB6E85E4682C1671 592B899B35469A78

54 C6B1BC79A4F23679 C773D8B69DA1FDE2 0C523B7A3C84AB77 FA7B17AAD857C2F4
C80BDC57F38A05E4 BE2B0602FC6F8F65 B5E80E871AC0C005 EB6E85E4682C1671

55 BEF9BB0FE467FD60 C6B1BC79A4F23679 C773D8B69DA1FDE2 0C523B7A3C84AB77
1DAB0BD116E434E5 C80BDC57F38A05E4 BE2B0602FC6F8F65 B5E80E871AC0C005

56 8E3DB3E380EC7F22 BEF9BB0FE467FD60 C6B1BC79A4F23679 C773D8B69DA1FDE2
32EF50751734FFEE 1DAB0BD116E434E5 C80BDC57F38A05E4 BE2B0602FC6F8F65

57 1003EC42412C7B7D 8E3DB3E380EC7F22 BEF9BB0FE467FD60 C6B1BC79A4F23679
1EC0D46F349FD058 32EF50751734FFEE 1DAB0BD116E434E5 C80BDC57F38A05E4

58 375FACC76291F85E 1003EC42412C7B7D 8E3DB3E380EC7F22 BEF9BB0FE467FD60
59C8BC0488F9768B 1EC0D46F349FD058 32EF50751734FFEE 1DAB0BD116E434E5

59 BD113D92E0354FB9 375FACC76291F85E 1003EC42412C7B7D 8E3DB3E380EC7F22
E66C73DB3FAD397D 59C8BC0488F9768B 1EC0D46F349FD058 32EF50751734FFEE

60 2F61D4FD8E36D9D4 BD113D92E0354FB9 375FACC76291F85E 1003EC42412C7B7D
E9F21933E1C02948 E66C73DB3FAD397D 59C8BC0488F9768B 1EC0D46F349FD058

61 1B1AD88B92701AE2 2F61D4FD8E36D9D4 BD113D92E0354FB9 375FACC76291F85E
6FD0C1719BCAC335 E9F21933E1C02948 E66C73DB3FAD397D 59C8BC0488F9768B

62 93D09FC06A19C5DA 1B1AD88B92701AE2 2F61D4FD8E36D9D4 BD113D92E0354FB9
B765273F571A571E 6FD0C1719BCAC335 E9F21933E1C02948 E66C73DB3FAD397D

63 04BEA2CE99CC3BF6 93D09FC06A19C5DA 1B1AD88B92701AE2 2F61D4FD8E36D9D4
6AB0E443C2F63714 B765273F571A571E 6FD0C1719BCAC335 E9F21933E1C02948

64 02EBFC0A13492F52 04BEA2CE99CC3BF6 93D09FC06A19C5DA 1B1AD88B92701AE2
77300C52E05AF415 6AB0E443C2F63714 B765273F571A571E 6FD0C1719BCAC335

65 1BF525ABCE8D6F04 02EBFC0A13492F52 04BEA2CE99CC3BF6 93D09FC06A19C5DA
8FAF12C33BB371B9 77300C52E05AF415 6AB0E443C2F63714 B765273F571A571E

66 B6A36A3431547328 1BF525ABCE8D6F04 02EBFC0A13492F52 04BEA2CE99CC3BF6
FA8BB40B4E08100F 8FAF12C33BB371B9 77300C52E05AF415 6AB0E443C2F63714

67 FFDAF83202AF0D72 B6A36A3431547328 1BF525ABCE8D6F04 02EBFC0A13492F52
8045A82F723A9B4E FA8BB40B4E08100F 8FAF12C33BB371B9 77300C52E05AF415

68 12737373D2985232 FFDAF83202AF0D72 B6A36A3431547328 1BF525ABCE8D6F04
870DBCE23BAD8988 8045A82F723A9B4E FA8BB40B4E08100F 8FAF12C33BB371B9

69 6189F68162B256B5 12737373D2985232 FFDAF83202AF0D72 B6A36A3431547328
8C059AF157146580 870DBCE23BAD8988 8045A82F723A9B4E FA8BB40B4E08100F

70 20B0A9A1D21C482D 6189F68162B256B5 12737373D2985232 FFDAF83202AF0D72
F22B874C96785EC8 8C059AF157146580 870DBCE23BAD8988 8045A82F723A9B4E

71 EF6D863C2127B394 20B0A9A1D21C482D 6189F68162B256B5 12737373D2985232
B7AEE28337D69DAB F22B874C96785EC8 8C059AF157146580 870DBCE23BAD8988

72 D3EFE8B442689074 EF6D863C2127B394 20B0A9A1D21C482D 6189F68162B256B5
22491AB9CDECB6B0 B7AEE28337D69DAB F22B874C96785EC8 8C059AF157146580

73 4694354944A9F487 D3EFE8B442689074 EF6D863C2127B394 20B0A9A1D21C482D
659890A5818D0C50 22491AB9CDECB6B0 B7AEE28337D69DAB F22B874C96785EC8

74 B93C2403773DD08C 4694354944A9F487 D3EFE8B442689074 EF6D863C2127B394
88C2C2AC52C4F679 659890A5818D0C50 22491AB9CDECB6B0 B7AEE28337D69DAB

75 025848E3AB6B69D3 B93C2403773DD08C 4694354944A9F487 D3EFE8B442689074
750DA3D4E16A1B64 88C2C2AC52C4F679 659890A5818D0C50 22491AB9CDECB6B0

76 396B53E58D04471B 025848E3AB6B69D3 B93C2403773DD08C 4694354944A9F487
700486BF252CBA75 750DA3D4E16A1B64 88C2C2AC52C4F679 659890A5818D0C50

77 51B6F9A3C1CEE4A 396B53E58D04471B 025848E3AB6B69D3 B93C2403773DD08C
E6B3850DE8AE6230 700486BF252CBA75 750DA3D4E16A1B64 88C2C2AC52C4F679

78 526A98F5DC595406 51B6F9A3C1CEE4A 396B53E58D04471B 025848E3AB6B69D3

4F0DCF74AEA76F90 E6B3850DE8AE6230 700486BF252CBA75 750DA3D4E16A1B64
 79 DEB3EEAA973BB9DD 526A98F5DC595406 51B6F9A3C1CEEB4A 396B53E58D04471B
 3665B5DBB6C2E055 4F0DCF74AEA76F90 E6B3850DE8AE6230 700486BF252CBA75

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

$Y_0 = 2A7F1D895FD58E0B \cup DEB3EEAA973BB9DD = 09330C33F71147E8$
 $Y_1 = EAAE96D1A673C741 \cup 526A98F5DC595406 = 3D192FC782CD1B47$
 $Y_2 = 015A2173796C1A88 \cup 51B6F9A3C1CEEB4A = 53111B173B3B05D2$
 $Y_3 = F6352CA156ACAFF7 \cup 396B53E58D04471B = 2FA08086E3B0F712$
 $Y_4 = C662113E9EBB4D64 \cup 3665B5DBB6C2E055 = FCC7C71A557E2DB9$
 $Y_5 = 17B61A85E2CCF0A9 \cup 4F0DCF74AEA76F90 = 66C3E9FA91746039$
 $Y_6 = 37EB9A6660FEB519 \cup E6B3850DE8AE6230 = 1E9F1F7449AD1749$
 $Y_7 = 8F2EBE9A81E6A2C5 \cup 700486BF252CBA75 = FF334559A7135D3A$

The following is the hash value for this message.

09330C33F71147E8 3D192FC782CD1B47 53111B173B3B05D2 2FA08086E3B0F712
 FCC7C71A557E2DB9 66C3E9FA91746039

B.7.11 Example 11

In this example, the data string is the 32-byte string consisting of the ASCII-coded version of

“abcdbcdecdefdefgefgfghghijhijk”

The hash-code is the following 384-bit string.

D4CC646A83A55044 DF94814DB93B6062 E656623DB0B9E2DA B8819174589BF0C9
 D7192B9799E30169 8B97ADAA3D82E20C

B.8 Dedicated Hash-Function 7 (WHIRLPOOL)

B.8.1 Example 1

In this example, the data string is the empty string, i.e. the string of length zero.

The hash-code is the following 512-bit string.

19FA61D75522A466 9B44E39C1D2E1726 C530232130D407F8 9AFEE0964997F7A7
 3E83BE698B288FEB CF88E3E03C4F0757 EA8964E59B63D937 08B138CC42A66EB3

B.8.2 Example 2

In this example, the data string consists of a single byte, namely the ASCII-coded version of the letter “a”.

The hash-code is the following 512-bit string.

8ACA2602792AEC6F 11A67206531FB7D7 F0DFF59413145E69 73C45001D0087B42
 D11BC645413AEFF6 3A42391A39145A59 1A92200D560195E5 3B478584FDAE231A

B.8.3 Example 3

In this example, the data string is the 3-byte string consisting of the ASCII-coded version of “abc”.

After the padding process, the 8×8 matrix Z' derived from the data string is as follows.

```

61 62 63 80 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 18

```

The K_0 matrix (from the initialization value, IV) and X'' matrix are as follows.

```

00 00 00 00 00 00 00 00    61 62 63 80 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 18

```

The following are (hexadecimal representations of) the successive values of the variables K_i for $i = 1$ to 10 and W' .

$i = 1:$

```

30 0B EE C0 AF 90 29 67    0F 34 9A FF 3F F3 2F E0
28 28 28 28 28 28 28 28    EB CD CD 13 CD 26 DE 87
28 28 28 28 28 28 28 28    2D 2C 98 98 5A 98 B4 C2
28 28 28 28 28 28 28 28    89 03 83 8F 8F 06 8F 0C
28 28 28 28 28 28 28 28    00 00 00 00 00 00 00 00
28 28 28 28 28 28 28 28    00 00 00 00 00 00 00 00
28 28 28 28 28 28 28 28    05 14 05 28 11 0A 2D 05
28 28 28 28 28 28 28 28    00 00 00 00 00 00 00 00

```

$i = 2:$

```

3B AB 89 F8 EA D1 AE 24    1D 0D 4C DA 43 F6 B0 98
44 45 45 66 45 E9 CB AF    E4 5E 3F B8 7B C7 AA 10
70 FE A4 A4 C5 A4 B2 89    C3 31 D1 56 FD E7 7B 8F
C5 FA A9 E1 E1 CC E1 A0    68 2F 47 A1 BE 4A 53 39
48 AC C0 5C FC FC B8 FC    B2 A2 B8 2F 20 72 F0 6C
8F F7 0E 26 90 8F 8F 69    03 D9 F4 6C 67 B1 79 72
96 79 14 07 D7 85 79 79    2C 67 87 6E FD 5C 25 F8
F8 A8 F8 68 B8 C8 78 F8    44 E6 4C 70 50 7C D8 26

```


$i = 3$:

D3 19 BF DB 30 46 70 58	EF ED 35 67 80 8E 8D 63
29 5B 23 D1 AF CF 37 DB	2F 03 49 91 5B 18 5C 24
01 2C 8A C2 8B 95 AC 98	77 96 F6 03 BF AA F8 E3
81 63 9E B1 C0 B2 06 A7	0A DC 04 7B 58 5A A5 A1
44 5E 60 7A B0 B2 09 DB	47 96 DA 7F 56 E4 CC 29
73 5B 2C CF BC 8C BC 71	20 70 D5 D8 50 01 C8 98
DC 67 09 24 EF ED DD D3	A7 4C 23 FA F6 81 49 A1
7B 8D 3B F0 D7 3B 7D 19	4A CE 46 7D 7D B0 73 A9

 $i = 4$:

38 BE AA C1 DE 11 65 86	95 BD DE 1E CA 0F CA 19
68 7C F3 D0 4A 87 33 7F	D3 C1 CF 6C A0 2E 41 E8
F3 37 FA DB 98 AD F0 57	74 C3 5C 63 15 C5 B9 8A
C5 E2 42 58 EE 35 8D BC	36 F0 4E 42 FE 2D D0 5E
11 09 F0 E8 99 6E 24 7E	0A 3C 50 76 A1 91 F8 EC
01 C5 D6 ED 10 B0 34 01	48 6B C7 3E 61 D2 A4 DC
FB C9 52 F1 7B 28 EC D3	ED B8 F0 C5 2C F0 5C 72
32 56 DC 0C C7 F1 27 40	FA 3D 00 D4 FB 9A 66 FF

 $i = 5$:

AF 25 A5 20 94 9B CF 14	06 A6 BA 18 05 54 8D 33
C1 36 26 A9 E3 C4 53 4D	84 55 FE C4 1F B2 0B 1C
E6 0F 7D 86 77 40 F9 E1	6E A2 93 49 3F 17 89 B7
91 5D E6 BB E2 6A 06 29	7D 02 C9 A0 52 85 BB EF
96 5A 54 CC 4C FE 5E 8D	AC 55 D7 A9 44 48 89 A9
EE E9 31 CB 62 32 3A A6	CB DE BE 43 AA 4D B5 A0
B1 7B 59 18 96 84 6A 47	60 A6 BA C0 25 D9 4F 8C
D4 F0 C9 36 27 59 AF 31	D7 E4 62 E5 D4 A8 CC C0

$i = 6$:

E2 F9 B5 C0 25 37 0B B0
39 2B CB A2 16 84 94 A5
60 8A F8 CE FA 34 8C 14
7A A5 37 64 41 8C 92 19
B3 F3 46 A1 FA 83 3F 89
97 49 3F 48 78 02 CF 7C
DC AD E8 BA 1E 00 8F 23
92 77 4F 49 ED B0 32 3D

DB 1D A8 4A 33 38 4D B3
97 4C 8E 1A 3E 51 F3 48
47 66 64 C2 33 F5 F2 A9
85 FD AA B1 D5 CB C3 6E
5D 89 59 F2 E1 F8 71 D4
8C 1F B9 78 8C 16 DD 05
62 AF 63 5F 6D EE D5 F4
D8 5B 74 35 5F 8A 98 47

$i = 7$:

75 41 63 82 77 4D FF 2F
FF FA 38 D0 55 03 46 00
BF 7D 02 49 3E 98 F3 61
F4 A8 60 C2 9A E5 CE 0B
C8 DF 5A 44 EE 5D 9D 27
23 F4 5A 55 04 75 00 A4
B0 16 10 12 02 F9 E2 8C
AC 30 CD 29 68 33 33 1D

59 3D 86 BD A8 CE 25 E5
BB 33 95 78 26 63 7D 82
EF 46 1D AE DC AD 0C 3C
AF A0 E2 86 5E 8B A3 F9
C8 8C 0B 43 27 84 31 F4
41 5F 51 64 4E 55 78 C2
F4 C7 C3 B5 EE A4 C5 86
49 F8 AB 68 4A 4C 96 B7

$i = 8$:

03 6B F1 82 68 84 AD 89
99 40 C6 62 D8 46 71 63
4C 43 3E 17 4B 19 C2 10
E2 9C CF D3 4C FF 86 C5
21 FF 11 A0 42 DF 26 53
1B 8E 00 CB 6C E4 4B 13
A6 12 3B F7 A3 47 B7 CE
D9 18 90 0E 3B 28 33 CA

9C 0D 38 97 73 B2 E4 35
4D 44 89 58 D4 59 27 E8
AD 59 2E B0 4C A3 63 32
E0 D4 70 F3 83 5A 15 59
9A 92 69 8C 76 40 A1 51
57 2E 81 EA CB A4 3C 36
5D 63 2F A7 36 BE 4B 61
40 0F DA CB 8B 9D E3 8A

$i = 9$:

D0 1C 67 7A 0A 9A 2C F9	4B F0 5E 9B 46 14 16 D0
2A 94 2F 53 4A 63 B6 B2	72 A8 C1 34 47 13 17 2D
88 42 22 46 FE AC A8 B4	17 33 2A 69 FB 34 98 98
47 4A 5C C7 3D 58 35 59	83 B1 EE 37 93 47 EC A0
74 A6 92 5D A5 5C 6F A1	3B 39 67 11 23 35 B5 78
77 17 E6 8C C4 73 5C 39	FC 78 3D 1F 9D 2F B6 AE
08 2A 3B 0B 53 EC 1A C6	3C F9 38 64 96 9B DE 6C
2A F6 58 EB 81 4D E7 62	42 5A D1 47 6C 0C 49 AE

$i = 10$:

48 95 48 B6 01 EE BC 3A	2F 46 2B 24 C6 F4 86 BB
A5 0D 6B C6 6B ED 8E 81	16 B6 56 2C 73 B4 02 0B
E0 CE 3D CF 88 26 5A 75	F3 04 3E 3A 73 1B CE 72
C2 8C 4A DB C0 F6 9C E9	1A E1 B3 03 D9 7E 6D 4C
54 B7 9C D5 7F 71 85 13	71 81 EE BD B6 C5 7E 27
43 41 4B 8A 97 7D 0B 7B	7D 0E 34 95 71 14 CB D6
63 19 35 BB DB F6 15 7A	C7 97 FC 9D 95 D8 B5 82
6A 7A 4E F6 37 01 82 27	D2 25 29 20 76 D4 EE ED

The value of Y' output from the round-function is as follows.

4E 24 48 A4 C6 F4 86 BB
16 B6 56 2C 73 B4 02 0B
F3 04 3E 3A 73 1B CE 72
1A E1 B3 03 D9 7E 6D 4C
71 81 EE BD B6 C5 7E 27
7D 0E 34 95 71 14 CB D6
C7 97 FC 9D 95 D8 B5 82
D2 25 29 20 76 D4 EE F5

The hash-code is the following 512-bit string.

4E2448A4C6F486BB 16B6562C73B4020B F3043E3A731BCE72 1AE1B303D97E6D4C
7181EEBDB6C57E27 7D0E34957114CBD6 C797FC9D95D8B582 D225292076D4EEF5

B.8.4 Example 4

In this example, the data string is the 14-byte string consisting of the ASCII-coded version of

“message digest”

The hash-code is the following 512-bit string.

378C84A4126E2DC6 E56DCC7458377AAC 838D00032230F53C E1F5700C0FFB4D3B
8421557659EF55C1 06B4B52AC5A4AAA6 92ED920052838F33 62E86DBD37A8903E

“abcdefghijklmnopqrstuvwxyz”

F1D754662636FFE9 2C82EBB9212A484A 8D38631EAD4238F5 442EE13B8054E41B
08BF2A9251C30B6A 0B8AAE86177AB4A6 F68F673E7207865D 5D9819A3DBA4EB3B

In this example, the data string is the 62-byte string consisting of the ASCII-coded version of

"ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789"

The hash-code is the following 512-bit string.

DC37E008CF9EE69B F11F00ED9ABA2690 1DD7C28CDEC066CC 6AF42E40F82F3A1E
08EBA26629129D8F B7CB57211B9281A6 5517CC879D7B9621 42C65F5A7AF01467

In this example, the data string is the 80-byte string consisting of the ASCII-coded version of eight repetitions of

“1234567890”

The hash-code is the following 512-bit string.

466EF18BABB0154D 25B9D38A6414F500 8784372BCCB204D6 549C4AFADB601429
4D5BD8DF2A6C44E5 38CD047B2681A51A 2C60481E88C5A20B 2C2A80CF3A9A0833

In this example, the data string is the 32-byte string consisting of the ASCII-coded version of

"abcbcdcedefdefgefghfghighijhiik"

After the padding process, the two 8×8 matrices derived from the data string are as follows.

61	62	63	64	62	63	64	65		00	00	00	00	00	00	00	00
63	64	65	66	64	65	66	67		00	00	00	00	00	00	00	00
65	66	67	68	66	67	68	69		00	00	00	00	00	00	00	00
67	68	69	6A	68	69	6A	6B		00	00	00	00	00	00	00	00
80	00	00	00	00	00	00	00		00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00		00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00		00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00		00	00	00	00	00	00	01	00

The first Z' matrix is as follows.

```

61 62 63 64 62 63 64 65
63 64 65 66 64 65 66 67
65 66 67 68 66 67 68 69
67 68 69 6A 68 69 6A 6B
80 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00

```

For the first Z' matrix, the K_0 matrix (from the initialization value, IV) and the X'' matrix are as follows.

```

00 00 00 00 00 00 00 00    61 62 63 64 62 63 64 65
00 00 00 00 00 00 00 00    63 64 65 66 64 65 66 67
00 00 00 00 00 00 00 00    65 66 67 68 66 67 68 69
00 00 00 00 00 00 00 00    67 68 69 6A 68 69 6A 6B
00 00 00 00 00 00 00 00    80 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00    00 00 00 00 00 00 00 00

```

The following are (hexadecimal representations of) the successive values of the variables K_i for $i = 1$ to 10 and W' .

$i = 1:$

```

30 0B EE C0 AF 90 29 67    86 B9 56 DD B4 BD 40 C2
28 28 28 28 28 28 28 28    0B 48 C1 2E 83 9C 2E 41
28 28 28 28 28 28 28 28    40 5E 0A ED 5C E9 42 E7
28 28 28 28 28 28 28 28    B2 1E 5B 93 43 07 7C 4D
28 28 28 28 28 28 28 28    19 04 67 A3 57 CF DA ED
28 28 28 28 28 28 28 28    59 36 7D 57 F8 E7 EA 60
28 28 28 28 28 28 28 28    98 D1 1B 6A C6 1C 4B CD
28 28 28 28 28 28 28 28    5E B9 76 56 F3 51 F4 43

```

$i = 2:$

```

3B AB 89 F8 EA D1 AE 24    10 54 A2 C2 9E 00 80 4F
44 45 45 66 45 E9 CB AF    6B C6 9F 0A 98 41 BA 45
70 FE A4 A4 C5 A4 B2 89    6B 0B DE 38 1B F6 5A 3F
C5 FA A9 E1 E1 CC E1 A0    34 F5 52 E4 38 30 DA 32
48 AC C0 5C FC FC B8 FC    A7 4E 3B C9 F2 58 65 5B
8F F7 0E 26 90 8F 8F 69    2C 84 5C F8 DE BA 57 52
96 79 14 07 D7 85 79 79    0B 0B CB 4F 5F 5F 13 10
F8 A8 F8 68 B8 C8 78 F8    B4 43 90 D6 92 4F 65 12

```

$i = 3$:

D3 19 BF DB 30 46 70 58	8F 55 E3 10 51 E9 E7 43
29 5B 23 D1 AF CF 37 DB	F3 AE 56 A1 2E 86 11 01
01 2C 8A C2 8B 95 AC 98	01 78 57 78 4C 25 EE 95
81 63 9E B1 C0 B2 06 A7	8B 13 D5 66 9A EA A5 53
44 5E 60 7A B0 B2 09 DB	55 E0 9A 46 78 79 57 56
73 5B 2C CF BC 8C BC 71	E2 3E F3 AF D4 5F 66 62
DC 67 09 24 EF ED DD D3	05 E9 CA 43 59 FC 08 53
7B 8D 3B F0 D7 3B 7D 19	6A 11 68 9A 3D 24 86 2C

 $i = 4$:

38 BE AA C1 DE 11 65 86	BD A3 5F AC C8 4B 7B 24
68 7C F3 D0 4A 87 33 7F	D4 D5 53 36 8A FA 90 C8
F3 37 FA DB 98 AD F0 57	7D 9A 3C 52 B5 B9 28 0B
C5 E2 42 58 EE 35 8D BC	FE CD D7 48 5D 98 AC 21
11 09 F0 E8 99 6E 24 7E	F6 D3 E3 F5 A1 C0 68 F0
01 C5 D6 ED 10 B0 34 01	D9 77 56 2D F1 C4 3C B6
FB C9 52 F1 7B 28 EC D3	C2 85 71 D3 B2 94 91 69
32 56 DC 0C C7 F1 27 40	E2 B9 81 C5 7C 60 42 23

 $i = 5$:

AF 25 A5 20 94 9B CF 14	15 03 B3 53 CF 70 04 4D
C1 36 26 A9 E3 C4 53 4D	D0 74 26 9B 60 EC 9B 92
E6 0F 7D 86 77 40 F9 E1	BE 22 90 B3 34 54 C2 84
91 5D E6 BB E2 6A 06 29	20 F3 7D 53 7D D1 C1 BA
96 5A 54 CC 4C FE 5E 8D	87 0E 9B F5 41 7C 2D 29
BE E9 31 CB 62 32 3A A6	A8 52 51 52 21 71 D5 9D
B1 7B 59 18 96 84 6A 47	96 9C 26 6D 4A B9 C6 AB
D4 F0 C9 36 27 59 AF 31	5A 2B DD 3C D9 8A D1 04

$i = 6$:

E2	F9	B5	C0	25	37	0B	B0	B1	44	C5	6B	09	97	59	91
39	2B	CB	A2	16	84	94	A5	CF	0D	2C	26	C0	C7	93	54
60	8A	F8	CE	FA	34	8C	14	18	D0	BE	9C	7A	35	09	8A
7A	A5	37	64	41	8C	92	19	32	8B	E8	B4	2C	B0	10	2A
B3	F3	46	A1	FA	83	3F	89	02	01	B5	CC	2C	68	E9	9C
97	49	3F	48	78	02	CF	7C	12	BF	E0	28	EB	7D	3F	F1
DC	AD	E8	BA	1E	00	8F	23	49	BD	0B	4E	55	81	21	AA
92	77	4F	49	ED	B0	32	3D	35	F4	59	17	F1	5C	49	DE

 $i = 7$:

75	41	63	82	77	4D	FF	2F	DD	D3	6C	6C	F0	7A	C1	16
FF	FA	38	D0	55	03	46	00	03	42	87	2D	A6	3A	4C	F4
BF	7D	02	49	3E	98	F3	61	5D	C0	C5	7D	6B	BC	49	81
F4	A8	60	C2	9A	E5	CE	0B	7C	12	58	40	F0	CD	DA	1E
C8	DF	5A	44	EE	5D	9D	27	46	AD	D5	C4	F9	77	40	C7
23	F4	5A	55	04	75	00	A4	FF	2E	7D	33	E9	7D	27	BA
B0	16	10	12	02	F9	E2	8C	2C	CC	DF	EF	3A	86	58	08
AC	30	CD	29	68	33	33	1D	FB	AC	B4	52	D2	63	9C	25

 $i = 8$:

03	6B	F1	82	68	84	AD	89	7B	3B	3C	7B	2D	73	FF	3C
99	40	C6	62	D8	46	71	63	32	7A	01	65	DD	7C	8C	7A
4C	43	3E	17	4B	19	C2	10	0F	70	81	E9	7B	A3	B6	80
E2	9C	CF	D3	4C	FF	86	C5	25	DF	D5	33	66	08	A2	55
21	FF	11	A0	42	DF	26	53	AB	95	54	FC	ED	D2	51	92
1B	8E	00	CB	6C	E4	4B	13	10	3A	15	9C	FE	CA	CF	6E
A6	12	3B	F7	A3	47	B7	CE	38	DA	67	14	8A	69	EB	B3
D9	18	90	0E	3B	28	33	CA	92	2A	69	0B	03	4B	46	69

$i = 9$:

D0 1C 67 7A 0A 9A 2C F9	56 21 86 2A 9C 0B D3 95
2A 94 2F 53 4A 63 B6 B2	D4 5A B8 28 42 F2 59 DC
88 42 22 46 FE AC A8 B4	B2 55 11 33 27 2D E8 43
47 4A 5C C7 3D 58 35 59	B7 2C 18 04 84 19 B2 C7
74 A6 92 5D A5 5C 6F A1	0A DD FF 03 52 91 16 83
77 17 E6 8C C4 73 5C 39	3E A7 8D 11 02 CF E8 C8
08 2A 3B 0B 53 EC 1A C6	A1 22 69 ED AD B3 2A B4
2A F6 58 EB 81 4D E7 62	BE 53 E9 F0 7C B0 79 E7

 $i = 10$:

48 95 48 B6 01 EE BC 3A	16 5A 82 D1 23 C3 52 8F
A5 0D 6B C6 6B ED 8E 81	26 E9 35 9E 6E C5 7A 23
E0 CE 3D CF 88 26 5A 75	17 EE A9 FF B7 C7 B4 99
C2 8C 4A DB C0 F6 9C E9	71 FD 96 BC 8F 74 63 4E
54 B7 9C D5 7F 71 85 13	B3 BE 30 9F 01 2A 59 09
43 41 4B 8A 97 7D 0B 7B	72 91 14 59 5F 08 6E 76
63 19 35 BB DB F6 15 7A	07 18 AF E3 65 BC 09 DE
6A 7A 4E F6 37 01 82 27	B6 AF A1 80 BC EC 2A 98

The value of Y' output from the round-function for the first Z' matrix is as follows.

77 38 E1 B5 41 A0 36 EA
45 8D 50 F8 0F A0 1C 44
72 88 CE 97 D1 A0 DC F0
16 95 FF D6 E7 1D 09 25
33 BE 30 9F 01 2A 59 09
72 91 14 59 5F 08 6E 76
07 18 AF E3 65 BC 09 DE
B6 AF A1 80 BC EC 2A 98

The second Z' matrix is as follows.

00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00
00 00 00 00 00 00 01 00

For the second Z' matrix, the K_0 matrix and the X'' matrix are as follows.

77 38 E1 B5 41 A0 36 EA	77 38 E1 B5 41 A0 36 EA
45 8D 50 F8 0F A0 1C 44	45 8D 50 F8 0F A0 1C 44
72 88 CE 97 D1 A0 DC F0	72 88 CE 97 D1 A0 DC F0
16 95 FF D6 E7 1D 09 25	16 95 FF D6 E7 1D 09 25
33 BE 30 9F 01 2A 59 09	33 BE 30 9F 01 2A 59 09
72 91 14 59 5F 08 6E 76	72 91 14 59 5F 08 6E 76
07 18 AF E3 65 BC 09 DE	07 18 AF E3 65 BC 09 DE
B6 AF A1 80 BC EC 2A 98	B6 AF A1 80 BC EC 2B 98

The following are (hexadecimal representations of) the successive values of the variables K_i for $i = 1$ to 10 and W' .

$i = 1:$

1A 78 4D 7D BD 4C 17 E6	18 23 C6 E8 87 B8 01 4F
27 31 10 AA 63 C5 9E 25	00 00 00 00 00 00 00 00
7A 2E B7 48 C4 5D E0 23	00 00 00 00 00 00 00 00
6D 0D 61 9F 6C 1D 80 AE	00 00 00 00 00 00 00 00
01 A2 D5 6E DB 41 D9 A0	00 00 00 00 00 00 00 00
E9 06 4C D1 27 95 FA 86	8C 23 05 AF 46 26 23 23
77 62 31 BC B4 4E C6 01	00 00 00 00 00 00 00 00
6F CD BC 98 10 78 6F EC	00 00 00 00 00 00 00 00

$i = 2:$

EB 0F 86 07 40 38 54 4F	DF 8A 74 7E 14 4C 22 D0
87 EF DC C8 FE 45 3D 83	2B 04 B7 AE 74 89 5A 13
99 0E F5 4E 73 1F C0 EA	2F FD BC A4 26 03 AD 74
EF E0 05 7F D2 C2 41 39	99 67 EA 50 34 08 BD B9
65 8F 5D 92 3E 9A AF 47	A8 7B 8E 1A 3B 56 CD 91
A9 1D 1C 13 BD 15 73 41	77 59 60 2D DD A2 4A 70
81 AD 80 BD 88 B3 B3 C3	03 43 90 91 2B DE 8E 37
16 26 63 99 AC 18 5D D0	48 6B C0 54 B9 C6 72 C9

$i = 3$:

7A A3 A3 3A 99 FD F6 5E
 E0 78 67 CD 3E 60 BF A7
 BC 06 8D 5D 98 70 34 84
 80 E8 69 7D 44 CF 6B E6
 7E 35 09 07 AF 76 70 C3
 3B 7E 15 0D CA 5E A9 0A
 8D 10 98 19 22 3B FC 57
 AB DE A9 DD D3 B6 68 14

6B 92 48 05 C3 F4 1A 6D
 45 20 59 41 0D 59 73 6D
 AF 72 CF 6A 4B B6 11 F4
 A2 6D AD C1 12 CC 43 6C
 95 8F C4 AE 60 94 74 74
 4B AB 72 C2 3E 2C BC 6D
 ED BF 23 B0 D6 82 B0 E8
 C0 4B 32 6B B5 14 B7 BB

 $i = 4$:

3D 21 15 88 E4 48 75 78
 47 BF 56 CC 8E D4 63 CA
 AE F0 D0 31 74 25 3C 4E
 08 F7 59 13 4F 6D DD 37
 C9 70 32 87 D8 F2 C1 E8
 90 E9 2D 7C AB A0 8E A7
 BF 22 A6 93 C1 6E 34 74
 58 40 F3 10 BF 03 3C 14

78 5A 13 A3 25 81 79 C9
 DC 69 90 E0 14 F2 39 AC
 89 5A 8F 66 7F F9 FC E3
 3B 5C C5 02 8C 4D 96 0A
 00 28 03 E7 DA 63 5E F5
 DA 35 A5 BF B6 AB C7 EA
 0D 5B 90 B8 88 56 C7 9F
 65 09 D2 D8 ED DA C6 B1

 $i = 5$:

AE 58 59 43 80 F4 F6 14
 14 5C 2E E0 5F B0 8E FD
 CF B7 1F C1 9A AC 6B 6A
 92 5C 25 E7 6C 28 7B 6B
 57 B5 8E 30 FB E4 61 9B
 38 5D B4 49 F9 44 F8 C9
 A5 EE 29 38 0C 2D A8 70
 45 8B FE 5E 05 C3 A6 89

6B 77 9A 58 6E 21 06 C1
 A7 2D B3 6D 1D AD 9E 3C
 32 CF E9 10 D3 AD CD EB
 EE 4B 44 77 56 BC BC 63
 41 05 39 5E 0B A3 8A 46
 07 B9 8B 76 67 41 AC BD
 E9 86 74 54 82 35 6F D9
 27 FB C9 68 EE 1E C7 57

i = 6:

B1 F3 E2 33 93 63 14 AC	53 41 C7 63 02 40 D8 3F
DD 80 87 12 BF E5 70 0E	7F D8 0D FB 5D 97 CF 7A
A5 F5 16 A8 2A 82 CC 76	52 47 5A 93 4A BC D9 84
8A F5 DD F3 5F B1 11 57	95 47 26 76 78 E9 10 42
62 34 D3 BC 57 72 C7 DC	E5 BA FB 23 2C 32 7B 6D
8D E2 8A 61 DC 88 CB 1A	62 CA FA 6D 35 F6 AA 13
53 35 F7 4C 99 ED 19 26	43 BF 3B F2 1B 0D B4 46
95 01 75 82 F7 A6 F7 2D	BC 1C 9F 38 97 77 17 5B

i = 7:

7E 42 E3 38 39 72 B7 82	61 E7 C2 37 B0 E6 F6 2B
79 B2 EA 12 B3 68 75 B0	46 FE 01 CA 0E 34 5A 26
D8 8D 5F 05 2F AA 73 D2	80 2E F8 49 0D 5F 17 60
90 FC 91 61 30 BB 7B 5C	89 D5 48 F0 59 6D 73 E8
5A 1B F6 C2 20 10 61 23	72 D8 71 5E 44 80 9B E3
E5 31 C5 68 BC 4F 85 F8	8C 90 07 54 63 6B 77 0D
60 72 0A BA A7 90 27 03	63 1B 4E CF D7 C6 5D B5
A7 FD 03 BB E3 E9 CA 19	91 92 11 87 0F FE EA AB

i = 8:

12 EF 8A A7 F3 B5 7E F6	42 C9 DC 71 10 DA FA 7C
E9 59 60 9F 18 84 D3 ED	02 5B 59 54 A2 45 83 20
93 3E 12 E9 EA 51 D7 C1	53 B6 C4 85 4D C3 52 A5
EF DA 8A 82 CB 14 13 93	3B 65 C0 24 87 E8 20 BD
4C F0 7B 81 0D 03 9C F3	C5 3C E3 C4 9C DE 93 9F
2F 40 9C A8 76 D4 7D A3	CD 47 4A B3 CB C3 69 1B
32 72 85 CE 7A BD 39 58	24 5E FB 0E 45 E6 7A 96
06 1A CE 00 E7 5F EC B5	2B 36 CC A8 8A 64 C1 40

$i = 9$:

7C D9 89 12 FC AB 39 B2	AC C3 BD D6 26 A6 41 F0
20 E1 E9 E6 79 8D 5E 4F	E7 D8 5F 60 03 D2 7B F8
99 70 2C 2A CA E1 07 48	3F 48 9A 48 16 88 0E 1D
A4 85 C1 1F 74 6C 23 DC	D9 C7 62 1D 42 6F 86 A4
CF C8 1D F4 64 41 C6 1B	AD A6 9F 9A 29 CC 8C 6D
7B 0D 6B 84 2A 58 16 40	14 63 22 F6 04 B0 94 F4
4F 0A 55 C3 38 6A 0C 2D	E9 1D 7D 05 0C A8 44 F4
E6 31 16 BA AE C9 AC EC	A7 B1 5B F5 48 C5 2E F7

 $i = 10$:

B4 74 E1 56 96 31 B9 6C	5D A0 9F 11 4E 31 46 8B
21 A1 B6 33 CC 89 68 1A	B0 5B A0 58 EE C4 53 0C
B1 97 25 86 7B 2B 3F 09	F8 F2 94 C5 0F 4E B9 92
4C 73 C7 62 93 A8 15 CF	11 50 9D 2F 6F F4 55 4C
55 15 C0 C0 9A 05 05 16	25 03 F8 9C 1A EF E7 12
23 44 8D 8D D3 5F B3 6E	09 05 62 60 A1 0D 65 20
7E 6C 2D 37 12 D0 F3 3E	94 83 05 43 C8 43 93 38
CE B8 04 F2 8D 9F C9 99	C2 F4 DA 98 A0 D7 C8 65

The value of Y' output from the round-function for the second Z' matrix is as follows.

2A 98 7E A4 0F 91 70 61
F5 D6 F0 A0 E4 64 4F 48
8A 7A 5A 52 DE EE 65 62
07 C5 62 F9 88 E9 5C 69
16 BD C8 03 1B C5 BE 1B
7B 94 76 39 FE 05 0B 56
93 9B AA A0 AD FF 9A E6
74 5B 7B 18 1C 3B E3 FD

The hash-code is the following 512-bit string.

2A987EA40F917061 F5D6F0A0E4644F48 8A7A5A52DEEE6562 07C562F988E95C69
16BDC8031BC5BE1B 7B947639FE050B56 939BAAA0ADFF9AE6 745B7B181C3BE3FD

B.8.9 Example 9

In this example, the data string is the 1 000 000-byte string consisting of the ASCII-coded version of “a” repeated 10^6 times.

The hash-code is the following 512-bit string.

0C99005BEB57EFF5 0A7CF005560DDF5D 29057FD86B20BFD6 2DECA0F1CCEA4AF5
1FC15490EDDC47AF 32BB2B66C34FF9AD 8C6008AD677F7712 6953B226E4ED8B01

B.9 Dedicated Hash-Function 8 (SHA-224)

B.9.1 Example 1

In this example, the data string is the empty string, i.e. the string of length zero.

The hash-code is the following 224-bit string.

D14A028C 2A3A2BC9 476102BB 288234C4 15A2B01F 828EA62A C5B3E42F

B.9.2 Example 2

In this example, the data string consists of a single byte, namely the ASCII-coded version of the letter “a”.

The hash-code is the following 224-bit string.

ABD37534 C7D9A2EF B9465DE9 31CD7055 FFDB8879 563AE980 78D6D6D5

B.9.3 Example 3

In this example, the data string is the 3-byte string consisting of the ASCII-coded version of “abc”. This is equivalent to the bit string “01100001 01100010 01100011”.

After the padding process, the single 16-word block derived from the data string is as follows.

61626380 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000018

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 .

INIT: C1059ED8 367CD507 3070DD17 F70E5939 FFC00B31 68581511 64F98FA7 BEFA4FA4
0 0E96B2DA C1059ED8 367CD507 3070DD17 0434225E FFC00B31 68581511 64F98FA7
1 C20DAB6B 0E96B2DA C1059ED8 367CD507 9CAB416F 0434225E FFC00B31 68581511
2 AB113B7A C20DAB6B 0E96B2DA C1059ED8 82177FE8 9CAB416F 0434225E FFC00B31
3 8253CC1A AB113B7A C20DAB6B 0E96B2DA 8346B27D 82177FE8 9CAB416F 0434225E
4 08A0DC0C 8253CC1A AB113B7A C20DAB6B 05B557DB 8346B27D 82177FE8 9CAB416F
5 B2CA3A91 08A0DC0C 8253CC1A AB113B7A 898DC7BB 05B557DB 8346B27D 82177FE8
6 0B6B9023 B2CA3A91 08A0DC0C 8253CC1A A2E49147 898DC7BB 05B557DB 8346B27D
7 F09D116D 0B6B9023 B2CA3A91 08A0DC0C 7A84120D A2E49147 898DC7BB 05B557DB
8 ED6FA633 F09D116D 0B6B9023 B2CA3A91 C037FAAD 7A84120D A2E49147 898DC7BB
9 55E6A367 ED6FA633 F09D116D 0B6B9023 AAE50091 C037FAAD 7A84120D A2E49147
10 0817E82B 55E6A367 ED6FA633 F09D116D C8C53A2C AAE50091 C037FAAD 7A84120D
11 17142334 0817E82B 55E6A367 ED6FA633 DD4C7BE9 C8C53A2C AAE50091 C037FAAD
12 FC4F023E 17142334 0817E82B 55E6A367 87BEA51A DD4C7BE9 C8C53A2C AAE50091
13 BE316902 FC4F023E 17142334 0817E82B 65141125 87BEA51A DD4C7BE9 C8C53A2C
14 1D80D178 BE316902 FC4F023E 17142334 4545F53A 65141125 87BEA51A DD4C7BE9
15 9F341A45 1D80D178 BE316902 FC4F023E 6A61C411 4545F53A 65141125 87BEA51A
16 0F324DB9 9F341A45 1D80D178 BE316902 06C80D6A 6A61C411 4545F53A 65141125
17 FFE7012B 0F324DB9 9F341A45 1D80D178 B7B601F4 06C80D6A 6A61C411 4545F53A
18 62932AB8 FFE7012B 0F324DB9 9F341A45 763B627A B7B601F4 06C80D6A 6A61C411
19 5207D867 62932AB8 FFE7012B 0F324DB9 7FBBA936 763B627A B7B601F4 06C80D6A
20 07D55CCB 5207D867 62932AB8 FFE7012B 9BA5A6EA 7FBBA936 763B627A B7B601F4
21 DECE98A4 07D55CCB 5207D867 62932AB8 293FFB5D 9BA5A6EA 7FBBA936 763B627A

22 E62A812E DECE98A4 07D55CCB 5207D867 28FE0FD9 293FFB5D 9BA5A6EA 7FBBA936
 23 57206FB8 E62A812E DECE98A4 07D55CCB C76084EA 28FE0FD9 293FFB5D 9BA5A6EA
 24 6A6ABCF0 57206FB8 E62A812E DECE98A4 B2614C5E C76084EA 28FE0FD9 293FFB5D
 25 937514F0 6A6ABCF0 57206FB8 E62A812E B42EC21C B2614C5E C76084EA 28FE0FD9
 26 82AF3FFB 937514F0 6A6ABCF0 57206FB8 BE6F6760 B42EC21C B2614C5E C76084EA
 27 ECA3BCD5 82AF3FFB 937514F0 6A6ABCF0 1DCCBB10 BE6F6760 B42EC21C B2614C5E
 28 2D1576C4 ECA3BCD5 82AF3FFB 937514F0 01641929 1DCCBB10 BE6F6760 B42EC21C
 29 FE3C8658 2D1576C4 ECA3BCD5 82AF3FFB FC4B36C5 01641929 1DCCBB10 BE6F6760
 30 0D7CCE07 FE3C8658 2D1576C4 ECA3BCD5 A4A4A3A4 FC4B36C5 01641929 1DCCBB10
 31 CCE1951D 0D7CCE07 FE3C8658 2D1576C4 4BE9475C A4A4A3A4 FC4B36C5 01641929
 32 09B76257 CCE1951D 0D7CCE07 FE3C8658 0CCDD86 4BE9475C A4A4A3A4 FC4B36C5
 33 F827767E 09B76257 CCE1951D 0D7CCE07 DB116DB7 0CCDD86 4BE9475C A4A4A3A4
 34 E4A0BB48 F827767E 09B76257 CCE1951D 994E2BAC DB116DB7 0CCDD86 4BE9475C
 35 D8BB1041 E4A0BB48 F827767E 09B76257 5B730ABB 994E2BAC DB116DB7 0CCDD86
 36 2A2E32F4 D8BB1041 E4A0BB48 F827767E 22E15C59 5B730ABB 994E2BAC DB116DB7
 37 0D275CA8 2A2E32F4 D8BB1041 E4A0BB48 F6C39382 22E15C59 5B730ABB 994E2BAC
 38 7902369C 0D275CA8 2A2E32F4 D8BB1041 D9F8C2E0 F6C39382 22E15C59 5B730ABB
 39 F3C80288 7902369C 0D275CA8 2A2E32F4 00E3A7BB D9F8C2E0 F6C39382 22E15C59
 40 483BBA4D F3C80288 7902369C 0D275CA8 F0A8198C 00E3A7BB D9F8C2E0 F6C39382
 41 D75D4D26 483BBA4D F3C80288 7902369C FCECD4 F0A8198C 00E3A7BB D9F8C2E0
 42 0744B618 D75D4D26 483BBA4D F3C80288 03186FAA FCECD4 F0A8198C 00E3A7BB
 43 9CCE9F01 0744B618 D75D4D26 483BBA4D A56F6BBF 03186FAA FCECD4 F0A8198C
 44 A3701BD9 9CCE9F01 0744B618 D75D4D26 AF1BEF5F A56F6BBF 03186FAA FCECD4
 45 131D4C09 A3701BD9 9CCE9F01 0744B618 ECB77E1B AF1BEF5F A56F6BBF 03186FAA
 46 FB3777D9 131D4C09 A3701BD9 9CCE9F01 1D601F44 ECB77E1B AF1BEF5F A56F6BBF
 47 847EA00E FB3777D9 131D4C09 A3701BD9 503A7B95 1D601F44 ECB77E1B AF1BEF5F
 48 AAA69347 847EA00E FB3777D9 131D4C09 5EEB9930 503A7B95 1D601F44 ECB77E1B
 49 505CAF28 AAA69347 847EA00E FB3777D9 CE695893 5EEB9930 503A7B95 1D601F44
 50 675E0B02 505CAF28 AAA69347 847EA00E C22DD75F CE695893 5EEB9930 503A7B95
 51 ABD26099 675E0B02 505CAF28 AAA69347 1409C3F8 C22DD75F CE695893 5EEB9930
 52 0DF9857A ABD26099 675E0B02 505CAF28 2D864D9F 1409C3F8 C22DD75F CE695893
 53 308B8799 0DF9857A ABD26099 675E0B02 02524F02 2D864D9F 1409C3F8 C22DD75F
 54 909CC059 308B8799 0DF9857A ABD26099 6F2A444A 02524F02 2D864D9F 1409C3F8
 55 8D25BD94 909CC059 308B8799 0DF9857A 1273C622 6F2A444A 02524F02 2D864D9F
 56 F32141DA 8D25BD94 909CC059 308B8799 1771ED3F 1273C622 6F2A444A 02524F02
 57 8CE24395 F32141DA 8D25BD94 909CC059 F52F66A6 1771ED3F 1273C622 6F2A444A
 58 07BCD846 8CE24395 F32141DA 8D25BD94 149DB547 F52F66A6 1771ED3F 1273C622
 59 622D5E5B 07BCD846 8CE24395 F32141DA B6F4C630 149DB547 F52F66A6 1771ED3F
 60 C693FC7A 622D5E5B 07BCD846 8CE24395 13DFB889 B6F4C630 149DB547 F52F66A6
 61 55D1C760 C693FC7A 622D5E5B 07BCD846 7E730E00 13DFB889 B6F4C630 149DB547
 62 FD89031B 55D1C760 C693FC7A 622D5E5B 55489EE6 7E730E00 13DFB889 B6F4C630
 63 6203DE4A FD89031B 55D1C760 C693FC7A 2AEDB1B3 55489EE6 7E730E00 13DFB889

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

```

 $Y_0$  = C1059ED8  $\cup$  6203DE4A = 23097D22
 $Y_1$  = 367CD507  $\cup$  FD89031B = 3405D822
 $Y_2$  = 3070DD17  $\cup$  55D1C760 = 8642A477
 $Y_3$  = F70E5939  $\cup$  C693FC7A = BDA255B3
 $Y_4$  = FFC00B31  $\cup$  2AEDB1B3 = 2AADBCE4
 $Y_5$  = 68581511  $\cup$  55489EE6 = BDA0B3F7
 $Y_6$  = 64F98FA7  $\cup$  7E730E00 = E36C9DA7
 $Y_7$  = BEFA4FA4  $\cup$  13DFB889 = AD25F72D

```

The hash value is the following 224-bit string.

```
23097D22 3405D822 8642A477 BDA255B3 2AADBCE4 BDA0B3F7 E36C9DA7
```

B.9.4 Example 4

In this example, the data string is the 14-byte string consisting of the ASCII-coded version of

“message digest”

The hash-code is the following 224-bit string.

```
2CB21C83 AE2F004D E7E81C3C 7019CBCB 65B71AB6 56B22D6D 0C39B8EB
```

B.9.5 Example 5

In this example, the data string is the 62-byte string consisting of the ASCII-coded version of

“ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789”

The hash-code is the following 224-bit string.

```
BFF72B4F CB7D75E5 632900AC 5F90D219 E05E97A7 BDE72E74 0DB393D9
```

B.9.6 Example 6

In this example, the data string is the 80-byte string consisting of the ASCII-coded version of eight repetitions of

“1234567890”

The hash-code is the following 224-bit string.

```
B50AECBE 4E9BB0B5 7BC5F3AE 760A8E01 DB24F203 FB3CDCD1 3148046E
```

B.9.7 Example 7

In this example, the data string is the 56-byte string consisting of the ASCII-coded version of

“abcdcbcdcedefdefgfhghighijhijkijklklmklmnlmnomnopnopq”

After the padding process, the following two 16-word blocks are derived from the data string.

```

61626364 62636465 63646566 64656667 65666768 66676869 6768696A 68696A6B
696A6B6C 6A6B6C6D 6B6C6D6E 6C6D6E6F 6D6E6F70 6E6F7071 80000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 000001C0

```

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 in the first block process.

```

INIT: C1059ED8 367CD507 3070DD17 F70E5939 FFC00B31 68581511 64F98FA7 BEFA4FA4
0 0E96B2BE C1059ED8 367CD507 3070DD17 04342242 FFC00B31 68581511 64F98FA7
1 51D17D7B 0E96B2BE C1059ED8 367CD507 2F8EA3D4 04342242 FFC00B31 68581511
2 FF1CBD7F 51D17D7B 0E96B2BE C1059ED8 79A896FA 2F8EA3D4 04342242 FFC00B31
3 24BCC047 FF1CBD7F 51D17D7B 0E96B2BE 1F60795A 79A896FA 2F8EA3D4 04342242
4 7D56A6AC 24BCC047 FF1CBD7F 51D17D7B DE395286 1F60795A 79A896FA 2F8EA3D4
5 745BEB11 7D56A6AC 24BCC047 FF1CBD7F D863D132 DE395286 1F60795A 79A896FA
6 0DD41573 745BEB11 7D56A6AC 24BCC047 2E60D323 D863D132 DE395286 1F60795A
7 9A2541FD 0DD41573 745BEB11 7D56A6AC 08D2B348 2E60D323 D863D132 DE395286
8 3140E909 9A2541FD 0DD41573 745BEB11 95DFD707 08D2B348 2E60D323 D863D132
9 B2954925 3140E909 9A2541FD 0DD41573 05EF5E3D 95DFD707 08D2B348 2E60D323
10 B2A874FB B2954925 3140E909 9A2541FD 9DCAF118 05EF5E3D 95DFD707 08D2B348
11 116CE44D B2A874FB B2954925 3140E909 0E6D566A 9DCAF118 05EF5E3D 95DFD707
12 5FF9349A 116CE44D B2A874FB B2954925 08EB3305 0E6D566A 9DCAF118 05EF5E3D
13 7FA9D65D 5FF9349A 116CE44D B2A874FB 4657CF17 08EB3305 0E6D566A 9DCAF118
14 006B1B16 7FA9D65D 5FF9349A 116CE44D 08D09E8D 4657CF17 08EB3305 0E6D566A
15 B301C98A 006B1B16 7FA9D65D 5FF9349A 6FBFA1D 08D09E8D 4657CF17 08EB3305
16 E623ECC0 B301C98A 006B1B16 7FA9D65D 2B3F859C 6FBFA1D 08D09E8D 4657CF17
17 D9244A78 E623ECC0 B301C98A 006B1B16 E66D8D9C 2B3F859C 6FBFA1D 08D09E8D
18 99C72726 D9244A78 E623ECC0 B301C98A B26A409C E66D8D9C 2B3F859C 6FBFA1D
19 AB0CBED2 99C72726 D9244A78 E623ECC0 010D7C65 B26A409C E66D8D9C 2B3F859C
20 78062878 AB0CBED2 99C72726 D9244A78 5678A949 010D7C65 B26A409C E66D8D9C
21 D7C5C5D5 78062878 AB0CBED2 99C72726 B280360C 5678A949 010D7C65 B26A409C
22 BAD2EE72 D7C5C5D5 78062878 AB0CBED2 0D4CD0C4 B280360C 5678A949 010D7C65
23 BCF47346 BAD2EE72 D7C5C5D5 78062878 D6A19DC8 0D4CD0C4 B280360C 5678A949
24 5ECC417B BCF47346 BAD2EE72 D7C5C5D5 3337A11C D6A19DC8 0D4CD0C4 B280360C
25 E15BFA57 5ECC417B BCF47346 BAD2EE72 0CE15173 3337A11C D6A19DC8 0D4CD0C4
26 FAE6167B E15BFA57 5ECC417B BCF47346 73DBE5C7 0CE15173 3337A11C D6A19DC8
27 991C3F99 FAE6167B E15BFA57 5ECC417B 8602A31F 73DBE5C7 0CE15173 3337A11C
28 7055843B 991C3F99 FAE6167B E15BFA57 EB4DE5F8 8602A31F 73DBE5C7 0CE15173
29 08DCFB6D 7055843B 991C3F99 FAE6167B 4606D126 EB4DE5F8 8602A31F 73DBE5C7
30 2964B340 08DCFB6D 7055843B 991C3F99 213B3E63 4606D126 EB4DE5F8 8602A31F
31 5B3677D0 2964B340 08DCFB6D 7055843B C9689CB0 213B3E63 4606D126 EB4DE5F8
32 1EE0FE7D 5B3677D0 2964B340 08DCFB6D 14318A4D C9689CB0 213B3E63 4606D126
33 6B918D6E 1EE0FE7D 5B3677D0 2964B340 216054A8 14318A4D C9689CB0 213B3E63
34 A6710D0D 6B918D6E 1EE0FE7D 5B3677D0 BC823A58 216054A8 14318A4D C9689CB0
35 5E198FED A6710D0D 6B918D6E 1EE0FE7D C49933FE BC823A58 216054A8 14318A4D
36 136C320A 5E198FED A6710D0D 6B918D6E 75687CCB C49933FE BC823A58 216054A8
37 40EE0C43 136C320A 5E198FED A6710D0D F1C2CAF6 75687CCB C49933FE BC823A58
38 AA96D78C 40EE0C43 136C320A 5E198FED F48B4CEB F1C2CAF6 75687CCB C49933FE
39 27C97B86 AA96D78C 40EE0C43 136C320A B556216A F48B4CEB F1C2CAF6 75687CCB
40 B07BD327 27C97B86 AA96D78C 40EE0C43 30EC2D76 B556216A F48B4CEB F1C2CAF6
41 D88D56BD B07BD327 27C97B86 AA96D78C DC2FA5A4 30EC2D76 B556216A F48B4CEB
42 5C775077 D88D56BD B07BD327 27C97B86 5FAD6DB5 DC2FA5A4 30EC2D76 B556216A
43 1526CCA3 5C775077 D88D56BD B07BD327 DA8A0B1C 5FAD6DB5 DC2FA5A4 30EC2D76
44 C09DDA14 1526CCA3 5C775077 D88D56BD D98EC23A DA8A0B1C 5FAD6DB5 DC2FA5A4

```

```

45 F885E124 C09DDA14 1526CCA3 5C775077 E4F23E41 D98EC23A DA8A0B1C 5FAD6DB5
46 5447F0AD F885E124 C09DDA14 1526CCA3 BFB7497C E4F23E41 D98EC23A DA8A0B1C
47 E6227061 5447F0AD F885E124 C09DDA14 5B09619B BFB7497C E4F23E41 D98EC23A
48 009CEBEA E6227061 5447F0AD F885E124 59ECAB46 5B09619B BFB7497C E4F23E41
49 92B0D169 009CEBEA E6227061 5447F0AD 9A572B85 59ECAB46 5B09619B BFB7497C
50 8D224E54 92B0D169 009CEBEA E6227061 32144602 9A572B85 59ECAB46 5B09619B
51 C1FCAC71 8D224E54 92B0D169 009CEBEA 4E98A8B7 32144602 9A572B85 59ECAB46
52 8E6CE843 C1FCAC71 8D224E54 92B0D169 2C1823BE 4E98A8B7 32144602 9A572B85
53 000F54DE 8E6CE843 C1FCAC71 8D224E54 F32CF2A8 2C1823BE 4E98A8B7 32144602
54 2FE2AF3A 000F54DE 8E6CE843 C1FCAC71 20F763EE F32CF2A8 2C1823BE 4E98A8B7
55 1FD539AF 2FE2AF3A 000F54DE 8E6CE843 5ACDBD62 20F763EE F32CF2A8 2C1823BE
56 7F86644E 1FD539AF 2FE2AF3A 000F54DE 9FC10216 5ACDBD62 20F763EE F32CF2A8
57 0E08DC77 7F86644E 1FD539AF 2FE2AF3A 2A4EA749 9FC10216 5ACDBD62 20F763EE
58 0B9F4851 0E08DC77 7F86644E 1FD539AF 18B1DFB9 2A4EA749 9FC10216 5ACDBD62
59 DBCE97C3 0B9F4851 0E08DC77 7F86644E 6EC6BA5B 18B1DFB9 2A4EA749 9FC10216
60 3CD78FE1 DBCE97C3 0B9F4851 0E08DC77 3E1CA2F1 6EC6BA5B 18B1DFB9 2A4EA749
61 35F4BF1C 3CD78FE1 DBCE97C3 0B9F4851 BA1A8A1B 3E1CA2F1 6EC6BA5B 18B1DFB9
62 86795A7D 35F4BF1C 3CD78FE1 DBCE97C3 2CE11258 BA1A8A1B 3E1CA2F1 6EC6BA5B
63 C14B4785 86795A7D 35F4BF1C 3CD78FE1 1108AC7F 2CE11258 BA1A8A1B 3E1CA2F1

```

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the round-function in the first block process.

```

 $Y_0 = C1059ED8 \cup C14B4785 = 8250E65D$ 
 $Y_1 = 367CD507 \cup 86795A7D = BCF62F84$ 
 $Y_2 = 3070DD17 \cup 35F4BF1C = 66659C33$ 
 $Y_3 = F70E5939 \cup 3CD78FE1 = 33E5E91A$ 
 $Y_4 = FFC00B31 \cup 1108AC7F = 10C8B7B0$ 
 $Y_5 = 68581511 \cup 2CE11258 = 95392769$ 
 $Y_6 = 64F98FA7 \cup BA1A8A1B = 1F1419C2$ 
 $Y_7 = BEFA4FA4 \cup 3E1CA2F1 = FD16F295$ 

```

The following are (hexadecimal representations of) the successive values of the variables Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 in the second block process.

```

INIT: 8250E65D BCF62F84 66659C33 33E5E91A 10C8B7B0 95392769 1F1419C2 FD16F295
0 692E407D 8250E65D BCF62F84 66659C33 E4BE1E69 10C8B7B0 95392769 1F1419C2
1 608D83E1 692E407D 8250E65D BCF62F84 3DDB8CEE E4BE1E69 10C8B7B0 95392769
2 09BFA89F 608D83E1 692E407D 8250E65D F5813490 3DDB8CEE E4BE1E69 10C8B7B0
3 2375FBC5 09BFA89F 608D83E1 692E407D C3E18529 F5813490 3DDB8CEE E4BE1E69
4 717E79E7 2375FBC5 09BFA89F 608D83E1 77D39CCC C3E18529 F5813490 3DDB8CEE
5 A9319748 717E79E7 2375FBC5 09BFA89F FDBB9913 77D39CCC C3E18529 F5813490
6 27A42F04 A9319748 717E79E7 2375FBC5 B999CCE4 FDBB9913 77D39CCC C3E18529
7 3419081E 27A42F04 A9319748 717E79E7 54E69E21 B999CCE4 FDBB9913 77D39CCC
8 0AB393C2 3419081E 27A42F04 A9319748 AD29647E 54E69E21 B999CCE4 FDBB9913
9 006784EB 0AB393C2 3419081E 27A42F04 AFF457E7 AD29647E 54E69E21 B999CCE4
10 ECD5C9DB 006784EB 0AB393C2 3419081E 9AF42A0E AFF457E7 AD29647E 54E69E21
11 4762E8F0 ECD5C9DB 006784EB 0AB393C2 8FB6F3D8 9AF42A0E AFF457E7 AD29647E
12 AF93B2A8 4762E8F0 ECD5C9DB 006784EB 97E63D39 8FB6F3D8 9AF42A0E AFF457E7
13 533C517C AF93B2A8 4762E8F0 ECD5C9DB 7364BAE6 97E63D39 8FB6F3D8 9AF42A0E
14 03C0A51B 533C517C AF93B2A8 4762E8F0 3AFB010D 7364BAE6 97E63D39 8FB6F3D8
15 5FD065BD 03C0A51B 533C517C AF93B2A8 B8E64229 3AFB010D 7364BAE6 97E63D39

```

16	18B268B5	5FD065BD	03C0A51B	533C517C	38EDA38D	B8E64229	3AFB010D	7364BAE6
17	B87D63B4	18B268B5	5FD065BD	03C0A51B	25C2C397	38EDA38D	B8E64229	3AFB010D
18	B1D846E0	B87D63B4	18B268B5	5FD065BD	D674405F	25C2C397	38EDA38D	B8E64229
19	8BA0AED6	B1D846E0	B87D63B4	18B268B5	B8109422	D674405F	25C2C397	38EDA38D
20	1485F843	8BA0AED6	B1D846E0	B87D63B4	1C58CD66	B8109422	D674405F	25C2C397
21	238F4CDA	1485F843	8BA0AED6	B1D846E0	39B2EB5F	1C58CD66	B8109422	D674405F
22	7031B061	238F4CDA	1485F843	8BA0AED6	4B8262AD	39B2EB5F	1C58CD66	B8109422
23	D4E7EC62	7031B061	238F4CDA	1485F843	163C3AA0	4B8262AD	39B2EB5F	1C58CD66
24	66582DF3	D4E7EC62	7031B061	238F4CDA	C0976260	163C3AA0	4B8262AD	39B2EB5F
25	DEDB8199	66582DF3	D4E7EC62	7031B061	B73E2DEC	C0976260	163C3AA0	4B8262AD
26	F8536917	DEDB8199	66582DF3	D4E7EC62	7C2AF9C4	B73E2DEC	C0976260	163C3AA0
27	D7333B8A	F8536917	DEDB8199	66582DF3	B2B0B71A	7C2AF9C4	B73E2DEC	C0976260
28	760847C1	D7333B8A	F8536917	DEDB8199	5898EFF2	B2B0B71A	7C2AF9C4	B73E2DEC
29	7EABC6D7	760847C1	D7333B8A	F8536917	24DD3883	5898EFF2	B2B0B71A	7C2AF9C4
30	90C49624	7EABC6D7	760847C1	D7333B8A	CCE25E67	24DD3883	5898EFF2	B2B0B71A
31	0B876264	90C49624	7EABC6D7	760847C1	E4E4A53B	CCE25E67	24DD3883	5898EFF2
32	04CB36C0	0B876264	90C49624	7EABC6D7	5403A391	E4E4A53B	CCE25E67	24DD3883
33	D58CC34A	04CB36C0	0B876264	90C49624	B78767C3	5403A391	E4E4A53B	CCE25E67
34	0ED14DD7	D58CC34A	04CB36C0	0B876264	FDCDC9D9	B78767C3	5403A391	E4E4A53B
35	5A89A942	0ED14DD7	D58CC34A	04CB36C0	790C4A20	FDCDC9D9	B78767C3	5403A391
36	4D30424C	5A89A942	0ED14DD7	D58CC34A	F95BF853	790C4A20	FDCDC9D9	B78767C3
37	47F58C5C	4D30424C	5A89A942	0ED14DD7	0EC9BE3B	F95BF853	790C4A20	FDCDC9D9
38	B5AD85D7	47F58C5C	4D30424C	5A89A942	CF9F1DBE	0EC9BE3B	F95BF853	790C4A20
39	762FECBC	B5AD85D7	47F58C5C	4D30424C	15427ED3	CF9F1DBE	0EC9BE3B	F95BF853
40	32ABE746	762FECBC	B5AD85D7	47F58C5C	4053E12E	15427ED3	CF9F1DBE	0EC9BE3B
41	84ADB2A0	32ABE746	762FECBC	B5AD85D7	7CECE4E2	4053E12E	15427ED3	CF9F1DBE
42	C6E1C5AF	84ADB2A0	32ABE746	762FECBC	42F9990B	7CECE4E2	4053E12E	15427ED3
43	35E14BFA	C6E1C5AF	84ADB2A0	32ABE746	C9965792	42F9990B	7CECE4E2	4053E12E
44	7410BFD8	35E14BFA	C6E1C5AF	84ADB2A0	CA54CE51	C9965792	42F9990B	7CECE4E2
45	3FE9E763	7410BFD8	35E14BFA	C6E1C5AF	AE7CDB66	CA54CE51	C9965792	42F9990B
46	853C3A00	3FE9E763	7410BFD8	35E14BFA	C2BE054D	AE7CDB66	CA54CE51	C9965792
47	F7D035E7	853C3A00	3FE9E763	7410BFD8	F6D59D2C	C2BE054D	AE7CDB66	CA54CE51
48	20BAE2B8	F7D035E7	853C3A00	3FE9E763	CAB73F06	F6D59D2C	C2BE054D	AE7CDB66
49	AE6BF667	20BAE2B8	F7D035E7	853C3A00	52384D2F	CAB73F06	F6D59D2C	C2BE054D
50	12E504E5	AE6BF667	20BAE2B8	F7D035E7	F9A8377F	52384D2F	CAB73F06	F6D59D2C
51	F3497054	12E504E5	AE6BF667	20BAE2B8	D0AB7CFC	F9A8377F	52384D2F	CAB73F06
52	9F166CDB	F3497054	12E504E5	AE6BF667	71B3459B	D0AB7CFC	F9A8377F	52384D2F
53	CCD8FA44	9F166CDB	F3497054	12E504E5	0F557DDD	71B3459B	D0AB7CFC	F9A8377F
54	F5E664BD	CCD8FA44	9F166CDB	F3497054	A679A5E9	0F557DDD	71B3459B	D0AB7CFC
55	D4EA8C7E	F5E664BD	CCD8FA44	9F166CDB	2958CE2A	A679A5E9	0F557DDD	71B3459B
56	E8C8FEC7	D4EA8C7E	F5E664BD	CCD8FA44	35F6800E	2958CE2A	A679A5E9	0F557DDD
57	882ED69E	E8C8FEC7	D4EA8C7E	F5E664BD	30267D8E	35F6800E	2958CE2A	A679A5E9
58	4EC725F6	882ED69E	E8C8FEC7	D4EA8C7E	CE1D1CE4	30267D8E	35F6800E	2958CE2A
59	5C9CFC69	4EC725F6	882ED69E	E8C8FEC7	C8242B92	CE1D1CE4	30267D8E	35F6800E
60	C9A31836	5C9CFC69	4EC725F6	882ED69E	9E40A370	C8242B92	CE1D1CE4	30267D8E
61	F754C16E	C9A31836	5C9CFC69	4EC725F6	333E0B63	9E40A370	C8242B92	CE1D1CE4
62	94314748	F754C16E	C9A31836	5C9CFC69	1FBC63B0	333E0B63	9E40A370	C8242B92
63	F2E7A4B9	94314748	F754C16E	C9A31836	9FFD8DAC	1FBC63B0	333E0B63	9E40A370

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

$Y_0 = 8250E65D \cup F2E7A4B9 = 75388B16$
 $Y_1 = BCF62F84 \cup 94314748 = 512776CC$
 $Y_2 = 66659C33 \cup F754C16E = 5DBA5DA1$
 $Y_3 = 33E5E91A \cup C9A31836 = FD890150$
 $Y_4 = 10C8B7B0 \cup 9FFD8DAC = B0C6455C$
 $Y_5 = 95392769 \cup 1FBC63B0 = B4F58B19$
 $Y_6 = 1F1419C2 \cup 333E0B63 = 52522525$
 $Y_7 = FD16F295 \cup 9E40A370 = 635651E5$

The hash value is the following 224-bit string.

75388B16 512776CC 5DBA5DA1 FD890150 B0C6455C B4F58B19 52522525

B.9.8 Example 8

In this example, the data string is the 1 000 000-byte string consisting of the ASCII-coded version of “a” repeated 10^6 times.

The hash-code is the following 224-bit string.

20794655 980C91D8 BBB4C1EA 97618A4B F03F425B 1948B2EE 4EE7AD67

B.9.9 Example 9

In this example, the data string consists of a single bit, namely 0.

The hash-code is the following 224-bit string.

D3FE57CB 76CDD24E 9EB23E7E 15684E03 9C75459B EAAE100F 89712E9D

B.9.10 Example 10

In this example, the data string consists of a single bit, namely 1.

The hash-code is the following 224-bit string.

0D05096B CA2A4A77 A2B47A05 A59618D0 1174B378 92376135 C1B6E957

B.9.11 Example 11

In this example, the data string consists of 101 bits, namely 1010101...01.

The hash-code is the following 224-bit string.

2B1D4A34 155C04D7 A51065D6 A4476203 9A38DFFD 73E76B17 B043555C

B.9.12 Example 12

In this example, the data string consists of 256 octets, namely 00 01 02 03 ... FE FF.

The hash-code is the following 224-bit string.

88702E63 237824C4 EB0D0FCF E41469A4 62493E8B EB2A75BB E5981734

B.9.13 Example 13

In this example, the data string is the H_0 consists of 224 0 bits. For $i = 1$ to 100 let H_i be the hash-code of H_{i-1} .

The hash-code H_{100} is the following 224-bit string.

A0884CC1 A335042B FE452BF4 6777ED20 217A3472 81DC389E 7B1FBFEE

B.10 Dedicated Hash-Function 9 (SHA-512/224)

B.10.1 Example 1

In this example, the input message is “abc”. The padded one block input (1 024 bits) is

$Z[0] = 6162638000000000$
 $Z[1] = 0000000000000000$
 $Z[2] = 0000000000000000$
 $Z[3] = 0000000000000000$
 $Z[4] = 0000000000000000$
 $Z[5] = 0000000000000000$
 $Z[6] = 0000000000000000$
 $Z[7] = 0000000000000000$
 $Z[8] = 0000000000000000$
 $Z[9] = 0000000000000000$
 $Z[10] = 0000000000000000$
 $Z[11] = 0000000000000000$
 $Z[12] = 0000000000000000$
 $Z[13] = 0000000000000000$
 $Z[14] = 0000000000000000$
 $Z[15] = 0000000000000018$

The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X_4, X_5, X_6$ and X_7 in each round.

$t=0$: 9F8617B9DCE5AAD2 8C3D37C819544DA2 73E1996689DCD4D6 1DFAB7AE32FF9C82
 E606D304F5742303 0F6D2B697BD44DA8 77E36F7304C48942 3F9D85A86A1D36C8
 $t=1$: 39EEF9EA0D97D0E7 9F8617B9DCE5AAD2 8C3D37C819544DA2 73E1996689DCD4D6
 ED6A8CE6AC02AE3B E606D304F5742303 0F6D2B697BD44DA8 77E36F7304C48942
 $t=2$: 9F956BCC32F99C4B 39EEF9EA0D97D0E7 9F8617B9DCE5AAD2 8C3D37C819544DA2
 E7C4F75F0018AB16 ED6A8CE6AC02AE3B E606D304F5742303 0F6D2B697BD44DA8
 $t=3$: 624C8289051D5B40 9F956BCC32F99C4B 39EEF9EA0D97D0E7 9F8617B9DCE5AAD2
 93C0EDD577EF4338 E7C4F75F0018AB16 ED6A8CE6AC02AE3B E606D304F5742303
 $t=4$: 8445DB53436C52F8 624C8289051D5B40 9F956BCC32F99C4B 39EEF9EA0D97D0E7
 E5662EE45E149450 93C0EDD577EF4338 E7C4F75F0018AB16 ED6A8CE6AC02AE3B
 $t=5$: 9873F29F683128C8 8445DB53436C52F8 624C8289051D5B40 9F956BCC32F99C4B
 0B843D2CDE075711 E5662EE45E149450 93C0EDD577EF4338 E7C4F75F0018AB16
 $t=6$: 134D4DD913EC29E7 9873F29F683128C8 8445DB53436C52F8 624C8289051D5B40
 CACE421FD59538B6 0B843D2CDE075711 E5662EE45E149450 93C0EDD577EF4338
 $t=7$: 6A01F4E5758D5A14 134D4DD913EC29E7 9873F29F683128C8 8445DB53436C52F8
 73EA4F37F91D77F0 CACE421FD59538B6 0B843D2CDE075711 E5662EE45E149450
 $t=8$: 0B9D8BDA33530FA3 6A01F4E5758D5A14 134D4DD913EC29E7 9873F29F683128C8
 A64384D872C70950 73EA4F37F91D77F0 CACE421FD59538B6 0B843D2CDE075711
 $t=9$: 2C961F00E387DF1D 0B9D8BDA33530FA3 6A01F4E5758D5A14 134D4DD913EC29E7
 AC79A3FFDAC317FC A64384D872C70950 73EA4F37F91D77F0 CACE421FD59538B6

t=10: 78953995DD54A904 2C961F00E387DF1D 0B9D8BDA33530FA3 6A01F4E5758D5A14
 5FF1DE02C59C17E6 AC79A3FFDAC317FC A64384D872C70950 73EA4F37F91D77F0
 t=11: 82A6A4ED5164390E 78953995DD54A904 2C961F00E387DF1D 0B9D8BDA33530FA3
 3A6E6AED341206D2 5FF1DE02C59C17E6 AC79A3FFDAC317FC A64384D872C70950
 t=12: 6528AFE0F531B8D9 82A6A4ED5164390E 78953995DD54A904 2C961F00E387DF1D
 AF77A75BBF7964C9 3A6E6AED341206D2 5FF1DE02C59C17E6 AC79A3FFDAC317FC
 t=13: 206C69B0295CAE2F 6528AFE0F531B8D9 82A6A4ED5164390E 78953995DD54A904
 3CA059F97E654F98 AF77A75BBF7964C9 3A6E6AED341206D2 5FF1DE02C59C17E6
 t=14: DB71F51BE96E76D1 206C69B0295CAE2F 6528AFE0F531B8D9 82A6A4ED5164390E
 340B10ABC4B10E09 3CA059F97E654F98 AF77A75BBF7964C9 3A6E6AED341206D2
 t=15: A69AF3FA50F71091 DB71F51BE96E76D1 206C69B0295CAE2F 6528AFE0F531B8D9
 6C6A7EF25668BBB4 340B10ABC4B10E09 3CA059F97E654F98 AF77A75BBF7964C9
 t=16: F57D3A111596E3F7 A69AF3FA50F71091 DB71F51BE96E76D1 206C69B0295CAE2F
 483FD5187E05AF83 6C6A7EF25668BBB4 340B10ABC4B10E09 3CA059F97E654F98
 t=17: 37F983BB8545A2F2 F57D3A111596E3F7 A69AF3FA50F71091 DB71F51BE96E76D1
 22CB500B1745C86F 483FD5187E05AF83 6C6A7EF25668BBB4 340B10ABC4B10E09
 t=18: 6AB7291DC27CE806 37F983BB8545A2F2 F57D3A111596E3F7 A69AF3FA50F71091
 CC2D9DA4800A1393 22CB500B1745C86F 483FD5187E05AF83 6C6A7EF25668BBB4
 t=19: 8E50B25D469759C2 6AB7291DC27CE806 37F983BB8545A2F2 F57D3A111596E3F7
 50193786D52F5194 CC2D9DA4800A1393 22CB500B1745C86F 483FD5187E05AF83
 t=20: 3041190F76AD53DF 8E50B25D469759C2 6AB7291DC27CE806 37F983BB8545A2F2
 746F4B17026AA6ED 50193786D52F5194 CC2D9DA4800A1393 22CB500B1745C86F
 t=21: D37D93454B59A769 3041190F76AD53DF 8E50B25D469759C2 6AB7291DC27CE806
 3792AA4013809C0F 746F4B17026AA6ED 50193786D52F5194 CC2D9DA4800A1393
 t=22: 28E37AB968D3F5E5 D37D93454B59A769 3041190F76AD53DF 8E50B25D469759C2
 936E64805412DE7D 3792AA4013809C0F 746F4B17026AA6ED 50193786D52F5194
 t=23: 05799053E5D280FD 28E37AB968D3F5E5 D37D93454B59A769 3041190F76AD53DF
 BD8F22E3B3312F05 936E64805412DE7D 3792AA4013809C0F 746F4B17026AA6ED
 t=24: A24BC13A743FCBCE 05799053E5D280FD 28E37AB968D3F5E5 D37D93454B59A769
 CD7C3D09944BE7B6 BD8F22E3B3312F05 936E64805412DE7D 3792AA4013809C0F
 t=25: 1EABC1C5C3A2CDEA A24BC13A743FCBCE 05799053E5D280FD 28E37AB968D3F5E5
 27A2534198BE3EFB CD7C3D09944BE7B6 BD8F22E3B3312F05 936E64805412DE7D
 t=26: 471543A4179B22FE 1EABC1C5C3A2CDEA A24BC13A743FCBCE 05799053E5D280FD
 A849D4C8E1909347 27A2534198BE3EFB CD7C3D09944BE7B6 BD8F22E3B3312F05
 t=27: 887298E1C82038F7 471543A4179B22FE 1EABC1C5C3A2CDEA A24BC13A743FCBCE
 536496733A17ADD7 A849D4C8E1909347 27A2534198BE3EFB CD7C3D09944BE7B6
 t=28: 42FE965258B7E0EC 887298E1C82038F7 471543A4179B22FE 1EABC1C5C3A2CDEA
 A37AD4727F2FB6A7 536496733A17ADD7 A849D4C8E1909347 27A2534198BE3EFB
 t=29: B251E1018FD0C473 42FE965258B7E0EC 887298E1C82038F7 471543A4179B22FE
 D4A476A812ED33C2 A37AD4727F2FB6A7 536496733A17ADD7 A849D4C8E1909347
 t=30: DDDD91CB1FDBFD41 B251E1018FD0C473 42FE965258B7E0EC 887298E1C82038F7
 04986D7E3FD773AE D4A476A812ED33C2 A37AD4727F2FB6A7 536496733A17ADD7
 t=31: 4AA9D15BECE3FB9F DDDD91CB1FDBFD41 B251E1018FD0C473 42FE965258B7E0EC
 53C83C436C1A8C55 04986D7E3FD773AE D4A476A812ED33C2 A37AD4727F2FB6A7
 t=32: 063BE3A3BA1F925C 4AA9D15BECE3FB9F DDDD91CB1FDBFD41 B251E1018FD0C473
 EB8227C63C6143AB 53C83C436C1A8C55 04986D7E3FD773AE D4A476A812ED33C2
 t=33: 0BA0D71206B4CE72 063BE3A3BA1F925C 4AA9D15BECE3FB9F DDDD91CB1FDBFD41
 672DE7D3FD6CE274 EB8227C63C6143AB 53C83C436C1A8C55 04986D7E3FD773AE
 t=34: 344234B9E239CFBD 0BA0D71206B4CE72 063BE3A3BA1F925C 4AA9D15BECE3FB9F
 38893650766BED56 672DE7D3FD6CE274 EB8227C63C6143AB 53C83C436C1A8C55

t=35: 8C098B89A7906A73 344234B9E239CFBD 0BA0D71206B4CE72 063BE3A3BA1F925C
 A7B9698E7EDB54BD 38893650766BED56 672DE7D3FD6CE274 EB8227C63C6143AB
 t=36: C5A836CC05300A0C 8C098B89A7906A73 344234B9E239CFBD 0BA0D71206B4CE72
 BC35E565541C0486 A7B9698E7EDB54BD 38893650766BED56 672DE7D3FD6CE274
 t=37: CDFE2808D45E7924 C5A836CC05300A0C 8C098B89A7906A73 344234B9E239CFBD
 8B500635C180CC3B BC35E565541C0486 A7B9698E7EDB54BD 38893650766BED56
 t=38: EDC87E1B480C8A77 CDFE2808D45E7924 C5A836CC05300A0C 8C098B89A7906A73
 F309D755002EF931 8B500635C180CC3B BC35E565541C0486 A7B9698E7EDB54BD
 t=39: 13D3A842A45159E7 EDC87E1B480C8A77 CDFE2808D45E7924 C5A836CC05300A0C
 6D9958CC3F974B68 F309D755002EF931 8B500635C180CC3B BC35E565541C0486
 t=40: 17AA585EACBB1D8C 13D3A842A45159E7 EDC87E1B480C8A77 CDFE2808D45E7924
 A62EFC64B5A504C7 6D9958CC3F974B68 F309D755002EF931 8B500635C180CC3B
 t=41: 7BCD6230B77F244A 17AA585EACBB1D8C 13D3A842A45159E7 EDC87E1B480C8A77
 543AA84578643C3A A62EFC64B5A504C7 6D9958CC3F974B68 F309D755002EF931
 t=42: BE63D26279808C58 7BCD6230B77F244A 17AA585EACBB1D8C 13D3A842A45159E7
 5D1D742D663F17BE 543AA84578643C3A A62EFC64B5A504C7 6D9958CC3F974B68
 t=43: C6F1FBBEDEA32F8E BE63D26279808C58 7BCD6230B77F244A 17AA585EACBB1D8C
 D83E6A094C606812 5D1D742D663F17BE 543AA84578643C3A A62EFC64B5A504C7
 t=44: 6346F580DD1CEC37 C6F1FBBEDEA32F8E BE63D26279808C58 7BCD6230B77F244A
 5BE7E65BC706B684 D83E6A094C606812 5D1D742D663F17BE 543AA84578643C3A
 t=45: 0C618B0042ADC22E 6346F580DD1CEC37 C6F1FBBEDEA32F8E BE63D26279808C58
 BA9737EA9A33D1D4 5BE7E65BC706B684 D83E6A094C606812 5D1D742D663F17BE
 t=46: BF9E3A882B0B4301 0C618B0042ADC22E 6346F580DD1CEC37 C6F1FBBEDEA32F8E
 FCAE077AACC5CF59 BA9737EA9A33D1D4 5BE7E65BC706B684 D83E6A094C606812
 t=47: 586A3D84D04FD482 BF9E3A882B0B4301 0C618B0042ADC22E 6346F580DD1CEC37
 45F48765CE6A2794 FCAE077AACC5CF59 BA9737EA9A33D1D4 5BE7E65BC706B684
 t=48: 5B2A6269DAF95602 586A3D84D04FD482 BF9E3A882B0B4301 0C618B0042ADC22E
 68B8F9BE61FCFCE0 45F48765CE6A2794 FCAE077AACC5CF59 BA9737EA9A33D1D4
 t=49: 5CF5F4502BB65B08 5B2A6269DAF95602 586A3D84D04FD482 BF9E3A882B0B4301
 038E7DBE733DDC71 68B8F9BE61FCFCE0 45F48765CE6A2794 FCAE077AACC5CF59
 t=50: DBB34340CCBA2D51 5CF5F4502BB65B08 5B2A6269DAF95602 586A3D84D04FD482
 3107BE9653EA4652 038E7DBE733DDC71 68B8F9BE61FCFCE0 45F48765CE6A2794
 t=51: 903B6E3D2CFDFA75 DBB34340CCBA2D51 5CF5F4502BB65B08 5B2A6269DAF95602
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The output is

$Y_0 = 8C3D37C819544DA2 \oplus B9F6EF4757271CB2 = 4634270F707B6A54$
 $Y_1 = 73E1996689DCD4D6 \oplus 66CCDBC9BC2B6E0C = DAAE7530460842E2$
 $Y_2 = 1DFAB7AE32FF9C82 \oplus F03D357829EF4D22 = 0E37ED265CEEE9A4$
 $Y_3 = 679DD514582F9FCF \oplus D6EB4F969D4CF40A = 3E8924AAF57C93D9$
 $Y_4 = 0F6D2B697BD44DA8 \oplus 12446E230B3B76AC = 21B1998C870FC454$
 $Y_5 = 77E36F7304C48942 \oplus B3953BA10977D31A = 2B78AB140E3C5C5C$
 $Y_6 = 3F9D85A86A1D36C8 \oplus FDDF88A8DFF1FD36 = 3D7D0E514A0F33FE$
 $Y_7 = 1112E6AD91D692A1 \oplus 054704D916035D9D = 1659EB86A7D9F03E$

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 t=68: CF675521103494C7 B93B21F8AEB8F329 A93AA5F85D1BCDEA 0F178025C27E422C
 9202AE67985172D8 1546C7737C00F978 DD8BDB1945B27133 E3065FF6F7ADDF6D
 t=69: 6BD1BCB0F69DEAB9 CF675521103494C7 B93B21F8AEB8F329 A93AA5F85D1BCDEA
 CC4A167A12B10D07 9202AE67985172D8 1546C7737C00F978 DD8BDB1945B27133
 t=70: 36FB6D38EC7A9F8F 6BD1BCB0F69DEAB9 CF675521103494C7 B93B21F8AEB8F329
 BF2DF292FDA17376 A167CC4A12B10D07 9202AE67985172D8 1546C7737C00F978
 t=71: B45C8408593C88F6 36FB6D38EC7A9F8F 6BD1BCB0F69DEAB9 CF675521103494C7
 70347EA05752DF76 BF2DF292FDA17376 A167CC4A12B10D07 9202AE67985172D8
 t=72: 0CA25CCF6FF6180E B45C8408593C88F6 36FB6D38EC7A9F8F 6BD1BCB0F69DEAB9
 0FFA31707E364987 70347EA05752DF76 BF2DF292FDA17376 A167CC4A12B10D07
 t=73: D49316BE5F130748 0CA25CCF6FF6180E B45C8408593C88F6 36FB6D38EC7A9F8F
 51269C93931E39F7 0FFA31707E364987 70347EA05752DF76 BF2DF292FDA17376
 t=74: 896EE1FEC0F16E4B D49316BE5F130748 0CA25CCF6FF6180E B45C8408593C88F6
 118DA75760797D25 51269C93931E39F7 0FFA31707E364987 70347EA05752DF76
 t=75: 22007C194C5B05AD 896EE1FEC0F16E4B D49316BE5F130748 0CA25CCF6FF6180E
 070F4D2C71FD0609 118DA75760797D25 51269C93931E39F7 0FFA31707E364987
 t=76: ED4C5451ED5670B7 22007C194C5B05AD 896EE1FEC0F16E4B D49316BE5F130748
 D5AE0EB0DE35A312 070F4D2C71FD0609 118DA75760797D25 51269C93931E39F7
 t=77: F61D35F056C47639 ED4C5451ED5670B7 22007C194C5B05AD 896EE1FEC0F16E4B
 137B9CA2A9375030 D5AE0EB0DE35A312 070F4D2C71FD0609 118DA75760797D25
 t=78: EC01C4BFEACC2519 F61D35F056C47639 ED4C5451ED5670B7 22007C194C5B05AD
 F6083B6FEFAEF695 137B9CA2A9375030 D5AE0EB0DE35A312 070F4D2C71FD0609
 t=79: 09C993659E2DEF45 EC01C4BFEACC2519 F61D35F056C47639 ED4C5451ED5670B7
 1617F9FA73004761 F6083B6FEFAEF695 137B9CA2A9375030 D5AE0EB0DE35A312

The output after processing the first block is

```

Y0 = 8C3D37C819544DA2 ⊕ 09C993659E2DEF45 = 9606CB2DB7823CE7
Y1 = 73E1996689DCD4D6 ⊕ EC01C4BFEACC2519 = 5FE35E2674A8F9EF
Y2 = 1DFAB7AE32FF9C82 ⊕ F61D35F056C47639 = 1417ED9E89C412BB
Y3 = 679DD514582F9FCF ⊕ ED4C5451ED5670B7 = 54EA296645861086
Y4 = 0F6D2B697BD44DA8 ⊕ 1617F9FA73004761 = 25852563EED49509
Y5 = 77E36F7304C48942 ⊕ F6083B6FEFAEF695 = 6DEBAAE2F4737FD7
Y6 = 3F9D85A86A1D36C8 ⊕ 137B9CA2A9375030 = 5319224B135486F8
Y7 = 1112E6AD91D692A1 ⊕ D5AE0EB0DE35A312 = E6C0F55E700C35B3

```

The second block input (1 024 bits) is

```

Z[ 0] = 0000000000000000
Z[ 1] = 0000000000000000
Z[ 2] = 0000000000000000
Z[ 3] = 0000000000000000
Z[ 4] = 0000000000000000
Z[ 5] = 0000000000000000
Z[ 6] = 0000000000000000
Z[ 7] = 0000000000000000
Z[ 8] = 0000000000000000
Z[ 9] = 0000000000000000
Z[10] = 0000000000000000
Z[11] = 0000000000000000
Z[12] = 0000000000000000
Z[13] = 0000000000000000
Z[14] = 0000000000000000
Z[15] = 0000000000000380

```

The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X_4, X_5, X_6$ and X_7 in each round when the second block is processed.

```

t= 0: C62A1109950BC4B0 9606CB2DB7823CE7 5FE35E2674A8F9EF 1417ED9E89C412BB
      B6602607DA508EC1 25852563EED49509 6DEBAAE2F4737FD7 5319224B135486F8
t= 1: 4A2EB8F6FF304F81 C62A1109950BC4B0 9606CB2DB7823CE7 5FE35E2674A8F9EF
      614F9DBEA0C1A45C B6602607DA508EC1 25852563EED49509 6DEBAAE2F4737FD7
t= 2: D708ED5418B1A603 4A2EB8F6FF304F81 C62A1109950BC4B0 9606CB2DB7823CE7
      CF8726E0E363D72E 614F9DBEA0C1A45C B6602607DA508EC1 25852563EED49509
t= 3: 44D5660E0E213AA5 D708ED5418B1A603 4A2EB8F6FF304F81 C62A1109950BC4B0
      EF8A0CF5A58EB13D CF8726E0E363D72E 614F9DBEA0C1A45C B6602607DA508EC1
t= 4: 957D13471214C5F4 44D5660E0E213AA5 D708ED5418B1A603 4A2EB8F6FF304F81
      981291723204C874 EF8A0CF5A58EB13D CF8726E0E363D72E 614F9DBEA0C1A45C
t= 5: 76E8C9D1C9DD8AB8 957D13471214C5F4 44D5660E0E213AA5 D708ED5418B1A603
      7FCCD3C31337A90E 981291723204C874 EF8A0CF5A58EB13D CF8726E0E363D72E
t= 6: 4B16F79453BE3727 76E8C9D1C9DD8AB8 957D13471214C5F4 44D5660E0E213AA5
      80E62F655E7ED37B 7FCCD3C31337A90E 981291723204C874 EF8A0CF5A58EB13D
t= 7: 5E63338FBE9889D9 4B16F79453BE3727 76E8C9D1C9DD8AB8 957D13471214C5F4
      441041F54BE0537B 80E62F655E7ED37B 7FCCD3C31337A90E 981291723204C874
t= 8: C7338364B83DF9C6 5E63338FBE9889D9 4B16F79453BE3727 76E8C9D1C9DD8AB8
      E4FA1425EB9F0182 441041F54BE0537B 80E62F655E7ED37B 7FCCD3C31337A90E
t= 9: 5ED78CF2D7AD0133 C7338364B83DF9C6 5E63338FBE9889D9 4B16F79453BE3727

```


21EC095197532090 E4FA1425EB9F0182 441041F54BE0537B 80E62F655E7ED37B
 t=10: 75C6A9870347B569 5ED78CF2D7AD0133 C7338364B83DF9C6 5E63338FBE9889D9
 37D613B93BD7DFB5 21EC095197532090 E4FA1425EB9F0182 441041F54BE0537B
 t=11: 2330FC9F6CEAC437 75C6A9870347B569 5ED78CF2D7AD0133 C7338364B83DF9C6
 2F1071A0C464DD6B 37D613B93BD7DFB5 21EC095197532090 E4FA1425EB9F0182
 t=12: B56EA6063E644DAF 2330FC9F6CEAC437 75C6A9870347B569 5ED78CF2D7AD0133
 D97C54DC192D2B1A 2F1071A0C464DD6B 37D613B93BD7DFB5 21EC095197532090
 t=13: F60601BFD3CE4BA2 B56EA6063E644DAF 2330FC9F6CEAC437 75C6A9870347B569
 B9D5E11F983972F8 D97C54DC192D2B1A 2F1071A0C464DD6B 37D613B93BD7DFB5
 t=14: FA6E99A8556DF258 F60601BFD3CE4BA2 B56EA6063E644DAF 2330FC9F6CEAC437
 015DEA3F41B9C289 B9D5E11F983972F8 D97C54DC192D2B1A 2F1071A0C464DD6B
 t=15: 38E5F661C3F1191B FA6E99A8556DF258 F60601BFD3CE4BA2 B56EA6063E644DAF
 5279EE55AFE8AFCC 015DEA3F41B9C289 B9D5E11F983972F8 D97C54DC192D2B1A
 t=16: ACDC1A5C38C85CD5 38E5F661C3F1191B FA6E99A8556DF258 F60601BFD3CE4BA2
 DB79F8F12D277F02 5279EE55AFE8AFCC 015DEA3F41B9C289 B9D5E11F983972F8
 t=17: 4B9240C9BA6F1B53 ACDC1A5C38C85CD5 38E5F661C3F1191B FA6E99A8556DF258
 4DE55D4B2EA4F33C DB79F8F12D277F02 5279EE55AFE8AFCC 015DEA3F41B9C289
 t=18: 4635F911BF4C6D0D 4B9240C9BA6F1B53 ACDC1A5C38C85CD5 38E5F661C3F1191B
 BCB192998C798DEA 4DE55D4B2EA4F33C DB79F8F12D277F02 5279EE55AFE8AFCC
 t=19: E586156D13060B8C 4635F911BF4C6D0D 4B9240C9BA6F1B53 ACDC1A5C38C85CD5
 176C6027F44C42A5 BCB192998C798DEA 4DE55D4B2EA4F33C DB79F8F12D277F02
 t=20: 65E9087A1372B7EE E586156D13060B8C 4635F911BF4C6D0D 4B9240C9BA6F1B53
 1CA79B5218212A16 176C6027F44C42A5 BCB192998C798DEA 4DE55D4B2EA4F33C
 t=21: 61D617FF18A51FA7 65E9087A1372B7EE E586156D13060B8C 4635F911BF4C6D0D
 FFF208DDA4ACF3BF 1CA79B5218212A16 176C6027F44C42A5 BCB192998C798DEA
 t=22: EAE30855B7D727BF 61D617FF18A51FA7 65E9087A1372B7EE E586156D13060B8C
 1908F447D8261EFD FFF208DDA4ACF3BF 1CA79B5218212A16 176C6027F44C42A5
 t=23: E17F4AA3CA31951F EAE30855B7D727BF 61D617FF18A51FA7 65E9087A1372B7EE
 A93A3B339DE2E79E 1908F447D8261EFD FFF208DDA4ACF3BF 1CA79B5218212A16
 t=24: CBDA7FD5D72B0448 E17F4AA3CA31951F EAE30855B7D727BF 61D617FF18A51FA7
 39CB25C47F7F1E76 A93A3B339DE2E79E 1908F447D8261EFD FFF208DDA4ACF3BF
 t=25: 875B7C8BD1FC6FFF CBDA7FD5D72B0448 E17F4AA3CA31951F EAE30855B7D727BF
 5061761EF4A7B430 39CB25C47F7F1E76 A93A3B339DE2E79E 1908F447D8261EFD
 t=26: 7493EB03CB083DCB 875B7C8BD1FC6FFF CBDA7FD5D72B0448 E17F4AA3CA31951F
 A00157FD4436BEC5 5061761EF4A7B430 39CB25C47F7F1E76 A93A3B339DE2E79E
 t=27: A2194EB42A179534 7493EB03CB083DCB 875B7C8BD1FC6FFF CBDA7FD5D72B0448
 75E556161E2D8F5E A00157FD4436BEC5 5061761EF4A7B430 39CB25C47F7F1E76
 t=28: 50120D72503F50A3 A2194EB42A179534 7493EB03CB083DCB 875B7C8BD1FC6FFF
 B2288596FBF78C7A 75E556161E2D8F5E A00157FD4436BEC5 5061761EF4A7B430
 t=29: 9388C45EF9BEDABA 50120D72503F50A3 A2194EB42A179534 7493EB03CB083DCB
 377650FBEE17C4B3 B2288596FBF78C7A 75E556161E2D8F5E A00157FD4436BEC5
 t=30: FA0D8AF6122631D1 9388C45EF9BEDABA 50120D72503F50A3 A2194EB42A179534
 4417C8D07BA5397A 377650FBEE17C4B3 B2288596FBF78C7A 75E556161E2D8F5E
 t=31: 9E234A4F427D2B06 FA0D8AF6122631D1 9388C45EF9BEDABA 50120D72503F50A3
 23652F849EA698BE 4417C8D07BA5397A 377650FBEE17C4B3 B2288596FBF78C7A
 t=32: 8D9DC47628B2D452 9E234A4F427D2B06 FA0D8AF6122631D1 9388C45EF9BEDABA
 D9DD068BDE33B870 23652F849EA698BE 4417C8D07BA5397A 377650FBEE17C4B3
 t=33: DBC5AB3931DBA353 8D9DC47628B2D452 9E234A4F427D2B06 FA0D8AF6122631D1
 E3F00F8D49C43EC4 D9DD068BDE33B870 23652F849EA698BE 4417C8D07BA5397A
 t=34: 90BBFAFE9E70D4DE DBC5AB3931DBA353 8D9DC47628B2D452 9E234A4F427D2B06

C79450C5A27F1152 E3F00F8D49C43EC4 D9DD068BDE33B870 23652F849EA698BE
 t=35: 0176074A50D737DC 90BBFAFE9E70D4DE DBC5AB3931DBA353 8D9DC47628B2D452
 484DCDA447B167ED C79450C5A27F1152 E3F00F8D49C43EC4 D9DD068BDE33B870
 t=36: 8A31589736A222D9 0176074A50D737DC 90BBFAFE9E70D4DE DBC5AB3931DBA353
 77F0533A9F4225D4 484DCDA447B167ED C79450C5A27F1152 E3F00F8D49C43EC4
 t=37: DB9603572C370B39 8A31589736A222D9 0176074A50D737DC 90BBFAFE9E70D4DE
 AD407246D492B9C9 77F0533A9F4225D4 484DCDA447B167ED C79450C5A27F1152
 t=38: A0BC2200492231A3 DB9603572C370B39 8A31589736A222D9 0176074A50D737DC
 001CFA61F6A94907 AD407246D492B9C9 77F0533A9F4225D4 484DCDA447B167ED
 t=39: D17150907EDA767B A0BC2200492231A3 DB9603572C370B39 8A31589736A222D9
 C7398391FEE339DE 001CFA61F6A94907 AD407246D492B9C9 77F0533A9F4225D4
 t=40: A3312953448FA7E1 D17150907EDA767B A0BC2200492231A3 DB9603572C370B39
 88C2310AFA13D7FD C7398391FEE339DE 001CFA61F6A94907 AD407246D492B9C9
 t=41: A1974BE1E531F375 A3312953448FA7E1 D17150907EDA767B A0BC2200492231A3
 9CABA67B2C460999 88C2310AFA13D7FD C7398391FEE339DE 001CFA61F6A94907
 t=42: 34BFABB3D67367DF A1974BE1E531F375 A3312953448FA7E1 D17150907EDA767B
 4AB15B8120A75FA0 9CABA67B2C460999 88C2310AFA13D7FD C7398391FEE339DE
 t=43: 47FB83EA0B09CFDF 34BFABB3D67367DF A1974BE1E531F375 A3312953448FA7E1
 82AF65BB8CF42FDF 4AB15B8120A75FA0 9CABA67B2C460999 88C2310AFA13D7FD
 t=44: BE123C3EE4765CED 47FB83EA0B09CFDF 34BFABB3D67367DF A1974BE1E531F375
 553B3C12510AF392 82AF65BB8CF42FDF 4AB15B8120A75FA0 9CABA67B2C460999
 t=45: 1BBD79A592A8BD47 BE123C3EE4765CED 47FB83EA0B09CFDF 34BFABB3D67367DF
 02E864735B8BF844 553B3C12510AF392 82AF65BB8CF42FDF 4AB15B8120A75FA0
 t=46: 0A8B7BECB393BFA4 1BBD79A592A8BD47 BE123C3EE4765CED 47FB83EA0B09CFDF
 1A8B439714CE8AF1 02E864735B8BF844 553B3C12510AF392 82AF65BB8CF42FDF
 t=47: 9510DFC044C38B79 0A8B7BECB393BFA4 1BBD79A592A8BD47 BE123C3EE4765CED
 F5B8B726BB1A26AC 1A8B439714CE8AF1 02E864735B8BF844 553B3C12510AF392
 t=48: 20C6FF36AAF2AFE6 9510DFC044C38B79 0A8B7BECB393BFA4 1BBD79A592A8BD47
 E5BDED3F35816323 F5B8B726BB1A26AC 1A8B439714CE8AF1 02E864735B8BF844
 t=49: 7FA16F7BA5EBE14C 20C6FF36AAF2AFE6 9510DFC044C38B79 0A8B7BECB393BFA4
 321838784DA12D56 E5BDED3F35816323 F5B8B726BB1A26AC 1A8B439714CE8AF1
 t=50: D2B84B6F18380735 7FA16F7BA5EBE14C 20C6FF36AAF2AFE6 9510DFC044C38B79
 67338C92A9E62CB3 321838784DA12D56 E5BDED3F35816323 F5B8B726BB1A26AC
 t=51: 9201269A2C54F51E D2B84B6F18380735 7FA16F7BA5EBE14C 20C6FF36AAF2AFE6
 18B3943C938E0477 67338C92A9E62CB3 321838784DA12D56 E5BDED3F35816323
 t=52: E5AA7485C1241AA4 9201269A2C54F51E D2B84B6F18380735 7FA16F7BA5EBE14C
 B9CD3EFC85E7C325 18B3943C938E0477 67338C92A9E62CB3 321838784DA12D56
 t=53: 5E3B46494F487A51 E5AA7485C1241AA4 9201269A2C54F51E D2B84B6F18380735
 A1A96A63C2F9C2D5 B9CD3EFC85E7C325 18B3943C938E0477 67338C92A9E62CB3
 t=54: 30F07AE985818A3F 5E3B46494F487A51 E5AA7485C1241AA4 9201269A2C54F51E
 F7B2345A39EE53D6 A1A96A63C2F9C2D5 B9CD3EFC85E7C325 18B3943C938E0477
 t=55: D5441CF2BBBF4247 30F07AE985818A3F 5E3B46494F487A51 E5AA7485C1241AA4
 08170A5A65B9CC59 F7B2345A39EE53D6 A1A96A63C2F9C2D5 B9CD3EFC85E7C325
 t=56: A028FDCCD5B3CD6C D5441CF2BBBF4247 30F07AE985818A3F 5E3B46494F487A51
 40F68900D8945D8B 08170A5A65B9CC59 F7B2345A39EE53D6 A1A96A63C2F9C2D5
 t=57: A7EC8B6433605C8D A028FDCCD5B3CD6C D5441CF2BBBF4247 30F07AE985818A3F
 5DCC12B8F92F5A2A 40F68900D8945D8B 08170A5A65B9CC59 F7B2345A39EE53D6
 t=58: E7440592C375CD18 A7EC8B6433605C8D A028FDCCD5B3CD6C D5441CF2BBBF4247
 800CC35788C7BD7E 5DCC12B8F92F5A2A 40F68900D8945D8B 08170A5A65B9CC59
 t=59: 8CFEBA0AA271D1E8 E7440592C375CD18 A7EC8B6433605C8D A028FDCCD5B3CD6C

18CEFFE60E5F76E0 800CC35788C7BD7E 5DCC12B8F92F5A2A 40F68900D8945D8B
 t=60: 47B9D567B722FB37 8CFEBA0AA271D1E8 E7440592C375CD18 A7EC8B6433605C8D
 A530BEE0AB96F7BF 18CEFFE60E5F76E0 800CC35788C7BD7E 5DCC12B8F92F5A2A
 t=61: A3C575002D2A90C4 47B9D567B722FB37 8CFEBA0AA271D1E8 E7440592C375CD18
 332C2311F81CC391 A530BEE0AB96F7BF 18CEFFE60E5F76E0 800CC35788C7BD7E
 t=62: F96FCB96DEB9E494 A3C575002D2A90C4 47B9D567B722FB37 8CFEBA0AA271D1E8
 7EFBDECC5D2B5820 332C2311F81CC391 A530BEE0AB96F7BF 18CEFFE60E5F76E0
 t=63: F363C8EC7B1A0888 F96FCB96DEB9E494 A3C575002D2A90C4 47B9D567B722FB37
 2AE76A4CDD0B55BD 7EFBDECC5D2B5820 332C2311F81CC391 A530BEE0AB96F7BF
 t=64: B80FA4876347AD57 F363C8EC7B1A0888 F96FCB96DEB9E494 A3C575002D2A90C4
 94D171AE802D6C9D 2AE76A4CDD0B55BD 7EFBDECC5D2B5820 332C2311F81CC391
 t=65: 96345101E32B060F B80FA4876347AD57 F363C8EC7B1A0888 F96FCB96DEB9E494
 5E1C4C06D3B02C21 94D171AE802D6C9D 2AE76A4CDD0B55BD 7EFBDECC5D2B5820
 t=66: 35C874D072FDC82C 96345101E32B060F B80FA4876347AD57 F363C8EC7B1A0888
 3353886B54C833B5 5E1C4C06D3B02C21 94D171AE802D6C9D 2AE76A4CDD0B55BD
 t=67: 401E4175643FC458 35C874D072FDC82C 96345101E32B060F B80FA4876347AD57
 EBEF8A88724B7FF7 3353886B54C833B5 5E1C4C06D3B02C21 94D171AE802D6C9D
 t=68: D58E109317C90113 401E4175643FC458 35C874D072FDC82C 96345101E32B060F
 894598AE776D2ED5 EBEF8A88724B7FF7 3353886B54C833B5 5E1C4C06D3B02C21
 t=69: 68A4AA1333AEA536 D58E109317C90113 401E4175643FC458 35C874D072FDC82C
 09FCE6C815B259F9 894598AE776D2ED5 EBEF8A88724B7FF7 3353886B54C833B5
 t=70: 8A0D8C01F5588CC1 68A4AA1333AEA536 D58E109317C90113 401E4175643FC458
 AEE1595DB3F40CF8 09FCE6C815B259F9 894598AE776D2ED5 EBEF8A88724B7FF7
 t=71: 6F485B267B52813E 8A0D8C01F5588CC1 68A4AA1333AEA536 D58E109317C90113
 BBA5B657667A087C AEE1595DB3F40CF8 09FCE6C815B259F9 894598AE776D2ED5
 t=72: CBF0FF8A3EB56D59 6F485B267B52813E 8A0D8C01F5588CC1 68A4AA1333AEA536
 D0686F6ECF9AB51E BBA5B657667A087C AEE1595DB3F40CF8 09FCE6C815B259F9
 t=73: AD1D1893EE86E3B6 CBF0FF8A3EB56D59 6F485B267B52813E 8A0D8C01F5588CC1
 D9F1FF942480D4D5 D0686F6ECF9AB51E BBA5B657667A087C AEE1595DB3F40CF8
 t=74: 1443D9D1606FF323 AD1D1893EE86E3B6 CBF0FF8A3EB56D59 6F485B267B52813E
 7AE67C10BF64A97B D9F1FF942480D4D5 D0686F6ECF9AB51E BBA5B657667A087C
 t=75: 9F07271D479F94DC 1443D9D1606FF323 AD1D1893EE86E3B6 CBF0FF8A3EB56D59
 84D997908D444616 7AE67C10BF64A97B D9F1FF942480D4D5 D0686F6ECF9AB51E
 t=76: 137D219301D78C4D 9F07271D479F94DC 1443D9D1606FF323 AD1D1893EE86E3B6
 2FD56FB46B6F4F93 84D997908D444616 7AE67C10BF64A97B D9F1FF942480D4D5
 t=77: 21BE76D4C61FFBB7 137D219301D78C4D 9F07271D479F94DC 1443D9D1606FF323
 BC85E4FC899BA009 2FD56FB46B6F4F93 84D997908D444616 7AE67C10BF64A97B
 t=78: D09E343D96634B44 21BE76D4C61FFBB7 137D219301D78C4D 9F07271D479F94DC
 D7AE6C10F1681576 BC85E4FC899BA009 2FD56FB46B6F4F93 84D997908D444616
 t=79: 8DF7FA8DDD53CE3C D09E343D96634B44 21BE76D4C61FFBB7 137D219301D78C4D
 A2C04D0AEA35A515 D7AE6C10F1681576 BC85E4FC899BA009 2FD56FB46B6F4F93

The output after processing the second block is

$Y_0 = 9606CB2DB7823CE7 \cup 8DF7FA8DDD53CE3C = 23FEC5BB94D60B23$
 $Y_1 = 5FE35E2674A8F9EF \cup D09E343D96634B44 = 308192640B0C4533$
 $Y_2 = 1417ED9E89C412BB \cup 21BE76D4C61FFBB7 = 35D664734FE40E72$
 $Y_3 = 54EA296645861086 \cup 137D219301D78C4D = 68674AF9475D9CD3$
 $Y_4 = 25852563EED49509 \cup A2C04D0AEA35A515 = C845726ED90A3A1E$
 $Y_5 = 6DEBAAE2F4737FD7 \cup D7AE6C10F1681576 = 459A16F3E5DB954D$
 $Y_6 = 5319224B135486F8 \cup BC85E4FC899BA009 = 0F9F07479CF02701$
 $Y_7 = E6C0F55E700C35B3 \cup 2FD56FB46B6F4F93 = 16966512DB7B8546$

The message digest is

23FEC5BB 94D60B23 30819264 0B0C4533 35D66473 4FE40E72 68674AF9

B.11 Dedicated Hash-Function 10 (SHA-512/256)

B.11.1 Example 1

In this example, the input message is “abc”. The padded one block input (1 024 bits) is

$Z[0] = 6162638000000000$
 $Z[1] = 0000000000000000$
 $Z[2] = 0000000000000000$
 $Z[3] = 0000000000000000$
 $Z[4] = 0000000000000000$
 $Z[5] = 0000000000000000$
 $Z[6] = 0000000000000000$
 $Z[7] = 0000000000000000$
 $Z[8] = 0000000000000000$
 $Z[9] = 0000000000000000$
 $Z[10] = 0000000000000000$
 $Z[11] = 0000000000000000$
 $Z[12] = 0000000000000000$
 $Z[13] = 0000000000000000$
 $Z[14] = 0000000000000000$
 $Z[15] = 0000000000000018$

The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X_4, X_5, X_6$ and X_7 in each round.

$t=0$: 9A2F6D11C39458FE 22312194FC2BF72C 9F555FA3C84C64C2 2393B86B6F53B151
 3908D19FBCAF1B12 96283EE2A88EFFE3 BE5E1E2553863992 2B0199FC2C85B8AA
 $t=1$: 9C465A16F85EBD68 9A2F6D11C39458FE 22312194FC2BF72C 9F555FA3C84C64C2
 BB7CF388A65CA549 3908D19FBCAF1B12 96283EE2A88EFFE3 BE5E1E2553863992
 $t=2$: D983D31C6CEA97C9 9C465A16F85EBD68 9A2F6D11C39458FE 22312194FC2BF72C
 C8A505020ACB43C1 BB7CF388A65CA549 3908D19FBCAF1B12 96283EE2A88EFFE3
 $t=3$: 1D4E8897FCFF509E D983D31C6CEA97C9 9C465A16F85EBD68 9A2F6D11C39458FE
 BA2E42D7925DE73B C8A505020ACB43C1 BB7CF388A65CA549 3908D19FBCAF1B12
 $t=4$: 47376B4548F81A5F 1D4E8897FCFF509E D983D31C6CEA97C9 9C465A16F85EBD68
 24ECDAD8A00C274A BA2E42D7925DE73B C8A505020ACB43C1 BB7CF388A65CA549
 $t=5$: AA7B88556927CE7D 47376B4548F81A5F 1D4E8897FCFF509E D983D31C6CEA97C9
 928BC3FFD85778B3 24ECDAD8A00C274A BA2E42D7925DE73B C8A505020ACB43C1
 $t=6$: B906B3DF822CF7C1 AA7B88556927CE7D 47376B4548F81A5F 1D4E8897FCFF509E
 2023A2CD4FA5A4D8 928BC3FFD85778B3 24ECDAD8A00C274A BA2E42D7925DE73B
 $t=7$: 2F839A3929F48358 B906B3DF822CF7C1 AA7B88556927CE7D 47376B4548F81A5F
 245A5F77616E5931 2023A2CD4FA5A4D8 928BC3FFD85778B3 24ECDAD8A00C274A
 $t=8$: 4B1B0E41FB81C46C 2F839A3929F48358 B906B3DF822CF7C1 AA7B88556927CE7D
 3FE7E2D7D7CED54A 245A5F77616E5931 2023A2CD4FA5A4D8 928BC3FFD85778B3
 $t=9$: C4F1C71E65B18C15 4B1B0E41FB81C46C 2F839A3929F48358 B906B3DF822CF7C1
 FF5E80C2A75481B7 3FE7E2D7D7CED54A 245A5F77616E5931 2023A2CD4FA5A4D8

t=10: 19D100CB5E1A3438 C4F1C71E65B18C15 4B1B0E41FB81C46C 2F839A3929F48358
 8484655060EBC3EE FF5E80C2A75481B7 3FE7E2D7D7CED54A 245A5F77616E5931
 t=11: 7AAB2807D4F3F022 19D100CB5E1A3438 C4F1C71E65B18C15 4B1B0E41FB81C46C
 BFC3C10D93FF00B8 8484655060EBC3EE FF5E80C2A75481B7 3FE7E2D7D7CED54A
 t=12: C9E2CB6D5D017BA7 7AAB2807D4F3F022 19D100CB5E1A3438 C4F1C71E65B18C15
 0662BFD092E26FB7 BFC3C10D93FF00B8 8484655060EBC3EE FF5E80C2A75481B7
 t=13: 8C4D8B98E0672988 C9E2CB6D5D017BA7 7AAB2807D4F3F022 19D100CB5E1A3438
 996E6405C63D83E3 0662BFD092E26FB7 BFC3C10D93FF00B8 8484655060EBC3EE
 t=14: 8D70D5EBDEA6724A 8C4D8B98E0672988 C9E2CB6D5D017BA7 7AAB2807D4F3F022
 CEAAAEFF7189EC61 996E6405C63D83E3 0662BFD092E26FB7 BFC3C10D93FF00B8
 t=15: 1EC6365704280063 8D70D5EBDEA6724A 8C4D8B98E0672988 C9E2CB6D5D017BA7
 419C9D961BA8EA8F CEAAAEFF7189EC61 996E6405C63D83E3 0662BFD092E26FB7
 t=16: 3AA569FFD0244EC4 1EC6365704280063 8D70D5EBDEA6724A 8C4D8B98E0672988
 4AC147677B104598 419C9D961BA8EA8F CEAAAEFF7189EC61 996E6405C63D83E3
 t=17: 2B6738209B26B728 3AA569FFD0244EC4 1EC6365704280063 8D70D5EBDEA6724A
 8EE2964A7ADF0F1D 4AC147677B104598 419C9D961BA8EA8F CEAAAEFF7189EC61
 t=18: 1FE6F882B4543504 2B6738209B26B728 3AA569FFD0244EC4 1EC6365704280063
 9CDC03D015DA1E7D 8EE2964A7ADF0F1D 4AC147677B104598 419C9D961BA8EA8F
 t=19: 73F4F92021784BB1 1FE6F882B4543504 2B6738209B26B728 3AA569FFD0244EC4
 6994C169A3D21916 9CDC03D015DA1E7D 8EE2964A7ADF0F1D 4AC147677B104598
 t=20: 4E8CA806D9319A74 73F4F92021784BB1 1FE6F882B4543504 2B6738209B26B728
 EDB2C079F68C6C60 6994C169A3D21916 9CDC03D015DA1E7D 8EE2964A7ADF0F1D
 t=21: 73214592D44C971F 4E8CA806D9319A74 73F4F92021784BB1 1FE6F882B4543504
 15BBE2C3AA0E7FD7 EDB2C079F68C6C60 6994C169A3D21916 9CDC03D015DA1E7D
 t=22: C56EBA713AEEA98F 73214592D44C971F 4E8CA806D9319A74 73F4F92021784BB1
 9D3DFCD24D8FF89C 15BBE2C3AA0E7FD7 EDB2C079F68C6C60 6994C169A3D21916
 t=23: 77F4BC54FFD4166B C56EBA713AEEA98F 73214592D44C971F 4E8CA806D9319A74
 A2981D9590A4F202 9D3DFCD24D8FF89C 15BBE2C3AA0E7FD7 EDB2C079F68C6C60
 t=24: B380E5F84D5DD65C 77F4BC54FFD4166B C56EBA713AEEA98F 73214592D44C971F
 1F5D06ACB369D69F A2981D9590A4F202 9D3DFCD24D8FF89C 15BBE2C3AA0E7FD7
 t=25: D8F368221281F96A B380E5F84D5DD65C 77F4BC54FFD4166B C56EBA713AEEA98F
 1E1F4553B9689309 1F5D06ACB369D69F A2981D9590A4F202 9D3DFCD24D8FF89C
 t=26: 73CE37ED59FC4595 D8F368221281F96A B380E5F84D5DD65C 77F4BC54FFD4166B
 5CB11AE8485959C1 1E1F4553B9689309 1F5D06ACB369D69F A2981D9590A4F202
 t=27: 2B79283E450B25D2 73CE37ED59FC4595 D8F368221281F96A B380E5F84D5DD65C
 9CA2CDF1A009F7A0 5CB11AE8485959C1 1E1F4553B9689309 1F5D06ACB369D69F
 t=28: 7C8479834A5D5E1C 2B79283E450B25D2 73CE37ED59FC4595 D8F368221281F96A
 F68FB52FAD1792EB 9CA2CDF1A009F7A0 5CB11AE8485959C1 1E1F4553B9689309
 t=29: 5623A1ED63ACFE9C 7C8479834A5D5E1C 2B79283E450B25D2 73CE37ED59FC4595
 4174C3633D3223CB F68FB52FAD1792EB 9CA2CDF1A009F7A0 5CB11AE8485959C1
 t=30: E0639E0746A1C4B9 5623A1ED63ACFE9C 7C8479834A5D5E1C 2B79283E450B25D2
 1D2D1CA60E71D9C4 4174C3633D3223CB F68FB52FAD1792EB 9CA2CDF1A009F7A0
 t=31: 0ECE8CB912DE792B E0639E0746A1C4B9 5623A1ED63ACFE9C 7C8479834A5D5E1C
 10EA82370759FF98 1D2D1CA60E71D9C4 4174C3633D3223CB F68FB52FAD1792EB
 t=32: 1011563D5CA6F21D 0ECE8CB912DE792B E0639E0746A1C4B9 5623A1ED63ACFE9C
 2ABC930AEB105DDA 10EA82370759FF98 1D2D1CA60E71D9C4 4174C3633D3223CB
 t=33: 001128D308744A0E 1011563D5CA6F21D 0ECE8CB912DE792B E0639E0746A1C4B9
 6DF15BD09649437B 2ABC930AEB105DDA 10EA82370759FF98 1D2D1CA60E71D9C4
 t=34: 785B23CDC94E4D47 001128D308744A0E 1011563D5CA6F21D 0ECE8CB912DE792B
 75645A2459E2B29C 6DF15BD09649437B 2ABC930AEB105DDA 10EA82370759FF98

t=35: 431A6F9571320866 785B23CDC94E4D47 001128D308744A0E 1011563D5CA6F21D
 C4B1FDB46655F51A 75645A2459E2B29C 6DF15BD09649437B 2ABC930AEB105DDA
 t=36: D9E89BCB3B3616FE 431A6F9571320866 785B23CDC94E4D47 001128D308744A0E
 445065C5E0806A68 C4B1FDB46655F51A 75645A2459E2B29C 6DF15BD09649437B
 t=37: 4C5C5085AFB86C02 D9E89BCB3B3616FE 431A6F9571320866 785B23CDC94E4D47
 0738C70B69B65E34 445065C5E0806A68 C4B1FDB46655F51A 75645A2459E2B29C
 t=38: 49F49406AA9C7915 4C5C5085AFB86C02 D9E89BCB3B3616FE 431A6F9571320866
 DDBFB052E66E151C 0738C70B69B65E34 445065C5E0806A68 C4B1FDB46655F51A
 t=39: D53B182812347708 49F49406AA9C7915 4C5C5085AFB86C02 D9E89BCB3B3616FE
 C0233F51F0027715 DDBFB052E66E151C 0738C70B69B65E34 445065C5E0806A68
 t=40: 6204009DBFD8D0DB D53B182812347708 49F49406AA9C7915 4C5C5085AFB86C02
 768286C2D8FD381E C0233F51F0027715 DDBFB052E66E151C 0738C70B69B65E34
 t=41: AF3049C09D76ABCE 6204009DBFD8D0DB D53B182812347708 49F49406AA9C7915
 11540218448DA4BA 768286C2D8FD381E C0233F51F0027715 DDBFB052E66E151C
 t=42: 6F48A93A6216BDFA AF3049C09D76ABCE 6204009DBFD8D0DB D53B182812347708
 60FF3969A7A7545B 11540218448DA4BA 768286C2D8FD381E C0233F51F0027715
 t=43: 163B797CD24C6D2E 6F48A93A6216BDFA AF3049C09D76ABCE 6204009DBFD8D0DB
 AF4C2A6889A401A2 60FF3969A7A7545B 11540218448DA4BA 768286C2D8FD381E
 t=44: 75B6F991523D6EBD 163B797CD24C6D2E 6F48A93A6216BDFA AF3049C09D76ABCE
 BE913F4585AA524A AF4C2A6889A401A2 60FF3969A7A7545B 11540218448DA4BA
 t=45: 807232323213D257 75B6F991523D6EBD 163B797CD24C6D2E 6F48A93A6216BDFA
 6269B8150084C5E5 BE913F4585AA524A AF4C2A6889A401A2 60FF3969A7A7545B
 t=46: 5A93EC3C573AB27A 807232323213D257 75B6F991523D6EBD 163B797CD24C6D2E
 EBCC25FD1EF4B66A 6269B8150084C5E5 BE913F4585AA524A AF4C2A6889A401A2
 t=47: 96F715647C35010B 5A93EC3C573AB27A 807232323213D257 75B6F991523D6EBD
 3DB3985131165CA8 EBCC25FD1EF4B66A 6269B8150084C5E5 BE913F4585AA524A
 t=48: A493F38FA8BD1B7A 96F715647C35010B 5A93EC3C573AB27A 807232323213D257
 72B27DF2E6E57AA8 3DB3985131165CA8 EBCC25FD1EF4B66A 6269B8150084C5E5
 t=49: D379E2742808F23F A493F38FA8BD1B7A 96F715647C35010B 5A93EC3C573AB27A
 3EA89437C88CCD1E 72B27DF2E6E57AA8 3DB3985131165CA8 EBCC25FD1EF4B66A
 t=50: 8C0C28392DFEEDF0 D379E2742808F23F A493F38FA8BD1B7A 96F715647C35010B
 ECCF127AA015E2F4 3EA89437C88CCD1E 72B27DF2E6E57AA8 3DB3985131165CA8
 t=51: 1D5955ABCFCADF0 8C0C28392DFEEDF0 D379E2742808F23F A493F38FA8BD1B7A
 496BCDAFE07B21B5 ECCF127AA015E2F4 3EA89437C88CCD1E 72B27DF2E6E57AA8
 t=52: 5799F02F81A7C51F 1D5955ABCFCADF0 8C0C28392DFEEDF0 D379E2742808F23F
 0532365FC98E332C 496BCDAFE07B21B5 ECCF127AA015E2F4 3EA89437C88CCD1E
 t=53: D09E98B45E7412B7 5799F02F81A7C51F 1D5955ABCFCADF0 8C0C28392DFEEDF0
 E1E81BC465A7CA13 0532365FC98E332C 496BCDAFE07B21B5 ECCF127AA015E2F4
 t=54: B404CE9F5B35EB6E D09E98B45E7412B7 5799F02F81A7C51F 1D5955ABCFCADF0
 52165E3326D1452E E1E81BC465A7CA13 0532365FC98E332C 496BCDAFE07B21B5
 t=55: 8FE543A7E1C7DE6B B404CE9F5B35EB6E D09E98B45E7412B7 5799F02F81A7C51F
 7D7C18AE2648F54D 52165E3326D1452E E1E81BC465A7CA13 0532365FC98E332C
 t=56: BF53B7992F425D82 8FE543A7E1C7DE6B B404CE9F5B35EB6E D09E98B45E7412B7
 D6993E728AC1A822 7D7C18AE2648F54D 52165E3326D1452E E1E81BC465A7CA13
 t=57: A7FC20CC2822A712 BF53B7992F425D82 8FE543A7E1C7DE6B B404CE9F5B35EB6E
 2BA925F0BBBDA744 D6993E728AC1A822 7D7C18AE2648F54D 52165E3326D1452E
 t=58: 1F5B9E4E9E470F85 A7FC20CC2822A712 BF53B7992F425D82 8FE543A7E1C7DE6B
 12F8ABBFDC71F41 2BA925F0BBBDA744 D6993E728AC1A822 7D7C18AE2648F54D
 t=59: 1F4AC7E8968E01F9 1F5B9E4E9E470F85 A7FC20CC2822A712 BF53B7992F425D82
 10F69F1491C21C9C 12F8ABBFDC71F41 2BA925F0BBBDA744 D6993E728AC1A822

t=60: 0B00107983688DDD 1F4AC7E8968E01F9 1F5B9E4E9E470F85 A7FC20CC2822A712
 0E8ABD59D36488D2 10F69F1491C21C9C 12F8ABBFDC71F41 2BA925F0BBBDA744
 t=61: 05774F6D8337D0DF 0B00107983688DDD 1F4AC7E8968E01F9 1F5B9E4E9E470F85
 E8D4AA14CC35666E 0E8ABD59D36488D2 10F69F1491C21C9C 12F8ABBFDC71F41
 t=62: 0E8748C473D5D319 05774F6D8337D0DF 0B00107983688DDD 1F4AC7E8968E01F9
 95EA094366CA9524 E8D4AA14CC35666E 0E8ABD59D36488D2 10F69F1491C21C9C
 t=63: 37313BCC31405DD8 0E8748C473D5D319 05774F6D8337D0DF 0B00107983688DDD
 9E24CC56AA903D0D 95EA094366CA9524 E8D4AA14CC35666E 0E8ABD59D36488D2
 t=64: 75CAD73882574762 37313BCC31405DD8 0E8748C473D5D319 05774F6D8337D0DF
 F95C519703B8731F 9E24CC56AA903D0D 95EA094366CA9524 E8D4AA14CC35666E
 t=65: 7D4BF508527DF4FA 75CAD73882574762 37313BCC31405DD8 0E8748C473D5D319
 D65ADF389D2C1A99 F95C519703B8731F 9E24CC56AA903D0D 95EA094366CA9524
 t=66: CEEFB640F1F288C3 7D4BF508527DF4FA 75CAD73882574762 37313BCC31405DD8
 44463E8C945BCBB5 D65ADF389D2C1A99 F95C519703B8731F 9E24CC56AA903D0D
 t=67: FC11CC97AE386106 CEEFB640F1F288C3 7D4BF508527DF4FA 75CAD73882574762
 12BF463D7223A309 44463E8C945BCBB5 D65ADF389D2C1A99 F95C519703B8731F
 t=68: DAF7189BF71319ED FC11CC97AE386106 CEEFB640F1F288C3 7D4BF508527DF4FA
 2D2182E71310E6C7 12BF463D7223A309 44463E8C945BCBB5 D65ADF389D2C1A99
 t=69: 51A81CBBFD3F7751 DAF7189BF71319ED FC11CC97AE386106 CEEFB640F1F288C3
 34E0F69B5611C0DC 2D2182E71310E6C7 12BF463D7223A309 44463E8C945BCBB5
 t=70: A26F13B306B9736B 51A81CBBFD3F7751 DAF7189BF71319ED FC11CC97AE386106
 3D6AD7280D27EE41 34E0F69B5611C0DC 2D2182E71310E6C7 12BF463D7223A309
 t=71: 93D2426FE4F65643 A26F13B306B9736B 51A81CBBFD3F7751 DAF7189BF71319ED
 F0C0DDC582C521E5 3D6AD7280D27EE41 34E0F69B5611C0DC 2D2182E71310E6C7
 t=72: AB4641C14C9D350B 93D2426FE4F65643 A26F13B306B9736B 51A81CBBFD3F7751
 88C22A9BFFF9C4D4 F0C0DDC582C521E5 3D6AD7280D27EE41 34E0F69B5611C0DC
 t=73: C7643EF265E0846D AB4641C14C9D350B 93D2426FE4F65643 A26F13B306B9736B
 5D58F038D47F838C 88C22A9BFFF9C4D4 F0C0DDC582C521E5 3D6AD7280D27EE41
 t=74: 0666E64633871262 C7643EF265E0846D AB4641C14C9D350B 93D2426FE4F65643
 01D41045F938489B 5D58F038D47F838C 88C22A9BFFF9C4D4 F0C0DDC582C521E5
 t=75: 126BCBCF100F86E6 0666E64633871262 C7643EF265E0846D AB4641C14C9D350B
 E5DFBAE06B85B880 01D41045F938489B 5D58F038D47F838C 88C22A9BFFF9C4D4
 t=76: 4AAA7A17AEA6C466 126BCBCF100F86E6 0666E64633871262 C7643EF265E0846D
 94AE3C3D5BB9D976 E5DFBAE06B85B880 01D41045F938489B 5D58F038D47F838C
 t=77: C12F185AC5A8BBF5 4AAA7A17AEA6C466 126BCBCF100F86E6 0666E64633871262
 578FB21004694EF1 94AE3C3D5BB9D976 E5DFBAE06B85B880 01D41045F938489B
 t=78: FBD8CA13A30018E9 C12F185AC5A8BBF5 4AAA7A17AEA6C466 126BCBCF100F86E6
 61A99523C8A086DB 578FB21004694EF1 94AE3C3D5BB9D976 E5DFBAE06B85B880
 t=79: 30D36C91856827CD FBD8CA13A30018E9 C12F185AC5A8BBF5 4AAA7A17AEA6C466
 780D55B8DD49F3A4 61A99523C8A086DB 578FB21004694EF1 94AE3C3D5BB9D976

The output is

$Y_0 = 22312194FC2BF72C \cup 30D36C91856827CD = 53048E2681941EF9$
 $Y_1 = 9F555FA3C84C64C2 \cup FBD8CA13A30018E9 = 9B2E29B76B4C7DAB$
 $Y_2 = 2393B86B6F53B151 \cup C12F185AC5A8BBF5 = E4C2D0C634FC6D46$
 $Y_3 = 963877195940EABD \cup 4AAA7A17AEA6C466 = E0E2F13107E7AF23$
 $Y_4 = 96283EE2A88EFFE3 \cup 780D55B8DD49F3A4 = 0E35949B85D8F387$
 $Y_5 = BE5E1E2553863992 \cup 61A99523C8A086DB = 2007B3491C26C06D$
 $Y_6 = 2B0199FC2C85B8AA \cup 578FB21004694EF1 = 82914C0C30EF079B$
 $Y_7 = 0EB72DDC81C52CA2 \cup 94AE3C3D5BB9D976 = A3656A19DD7F0618$

The message digest is

53048E26 81941EF9 9B2E29B7 6B4C7DAB E4C2D0C6 34FC6D46 E0E2F131 07E7AF23

B.11.2 Example 2

In this example, the input message is

"abcdefghijklmnoijklmnopqklmnopqklmnopqrsnmnopqrstnoprstu".

The padded message consists of two blocks.

The first block input (1 024 bits) is

Z[0] = 6162636465666768
 Z[1] = 6263646566676869
 Z[2] = 636465666768696A
 Z[3] = 6465666768696A6B
 Z[4] = 65666768696A6B6C
 Z[5] = 666768696A6B6C6D
 Z[6] = 6768696A6B6C6D6E
 Z[7] = 68696A6B6C6D6E6F
 Z[8] = 696A6B6C6D6E6F70
 Z[9] = 6A6B6C6D6E6F7071
 Z[10] = 6B6C6D6E6F707172
 Z[11] = 6C6D6E6F70717273
 Z[12] = 6D6E6F7071727374
 Z[13] = 6E6F707172737475
 Z[14] = 8000000000000000
 Z[15] = 0000000000000000

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 in each round when the first block is processed.

$t=0$: 9A2F6CF628FAC066 22312194FC2BF72C 9F555FA3C84C64C2 2393B86B6F53B151
 3908D1842215827A 96283EE2A88EFFE3 BE5E1E2553863992 2B0199FC2C85B8AA
 $t=1$: C45A73DC29847669 9A2F6CF628FAC066 22312194FC2BF72C 9F555FA3C84C64C2
 63F57A9FE723F8CE 3908D1842215827A 96283EE2A88EFFE3 BE5E1E2553863992
 $t=2$: 8C3630D3B59711CE C45A73DC29847669 9A2F6CF628FAC066 22312194FC2BF72C
 7EDABAB86DFF6A52 63F57A9FE723F8CE 3908D1842215827A 96283EE2A88EFFE3
 $t=3$: 17BDF848E242E2F 8C3630D3B59711CE C45A73DC29847669 9A2F6CF628FAC066
 9A30B98A6342E77F 7EDABAB86DFF6A52 63F57A9FE723F8CE 3908D1842215827A
 $t=4$: 81C23A1F69565E3C 17BDF848E242E2F 8C3630D3B59711CE C45A73DC29847669
 CEDB921A04ACEBDD 9A30B98A6342E77F 7EDABAB86DFF6A52 63F57A9FE723F8CE
 $t=5$: 6E79DFE5A559E037 81C23A1F69565E3C 17BDF848E242E2F 8C3630D3B59711CE
 3B3B402EDC778D6D CEDB921A04ACEBDD 9A30B98A6342E77F 7EDABAB86DFF6A52
 $t=6$: C39CC278160B5678 6E79DFE5A559E037 81C23A1F69565E3C 17BDF848E242E2F
 50562B0ACB6E7FEB 3B3B402EDC778D6D CEDB921A04ACEBDD 9A30B98A6342E77F
 $t=7$: 8A78B495684D9DD1 C39CC278160B5678 6E79DFE5A559E037 81C23A1F69565E3C
 494234DDD86A4729 50562B0ACB6E7FEB 3B3B402EDC778D6D CEDB921A04ACEBDD
 $t=8$: 24DF431236CE4D30 8A78B495684D9DD1 C39CC278160B5678 6E79DFE5A559E037

E80E84E515D941E1 494234DDD86A4729 50562B0ACB6E7FEB 3B3B402EDC778D6D
 t=9: 7E090CEB07F8BEE9 24DF431236CE4D30 8A78B495684D9DD1 C39CC278160B5678
 A46B4DEC5278E24F E80E84E515D941E1 494234DDD86A4729 50562B0ACB6E7FEB
 t=10: A755CCD779F18FA9 7E090CEB07F8BEE9 24DF431236CE4D30 8A78B495684D9DD1
 D41F5A6BFB41A89D A46B4DEC5278E24F E80E84E515D941E1 494234DDD86A4729
 t=11: CA6A3AEEEF5311EA A755CCD779F18FA9 7E090CEB07F8BEE9 24DF431236CE4D30
 3EEE2841CFE10A37 D41F5A6BFB41A89D A46B4DEC5278E24F E80E84E515D941E1
 t=12: 2885EE23B748F692 CA6A3AEEEF5311EA A755CCD779F18FA9 7E090CEB07F8BEE9
 CBE0A750BC77AFB9 3EEE2841CFE10A37 D41F5A6BFB41A89D A46B4DEC5278E24F
 t=13: 388A03C85D575053 2885EE23B748F692 CA6A3AEEEF5311EA A755CCD779F18FA9
 2E195C603FCFE523 CBE0A750BC77AFB9 3EEE2841CFE10A37 D41F5A6BFB41A89D
 t=14: E3E1C3D9B4C75FAB 388A03C85D575053 2885EE23B748F692 CA6A3AEEEF5311EA
 1012E63E4E71F612 2E195C603FCFE523 CBE0A750BC77AFB9 3EEE2841CFE10A37
 t=15: 4215C380CC7BA71B E3E1C3D9B4C75FAB 388A03C85D575053 2885EE23B748F692
 51D096BA7563D388 1012E63E4E71F612 2E195C603FCFE523 CBE0A750BC77AFB9
 t=16: D4B2ECE1F9EA4139 4215C380CC7BA71B E3E1C3D9B4C75FAB 388A03C85D575053
 A57AA8000D7E7D45 51D096BA7563D388 1012E63E4E71F612 2E195C603FCFE523
 t=17: A83038B321E1282C D4B2ECE1F9EA4139 4215C380CC7BA71B E3E1C3D9B4C75FAB
 FADB216834A22046 A57AA8000D7E7D45 51D096BA7563D388 1012E63E4E71F612
 t=18: 871C3F72FFF75168 A83038B321E1282C D4B2ECE1F9EA4139 4215C380CC7BA71B
 FAA41018DA73AA6B FADB216834A22046 A57AA8000D7E7D45 51D096BA7563D388
 t=19: 09CDADF5B09E542C 871C3F72FFF75168 A83038B321E1282C D4B2ECE1F9EA4139
 223C0812022BF992 FAA41018DA73AA6B FADB216834A22046 A57AA8000D7E7D45
 t=20: A70D03F8958F9BA4 09CDADF5B09E542C 871C3F72FFF75168 A83038B321E1282C
 63FFC78316C85D34 223C0812022BF992 FAA41018DA73AA6B FADB216834A22046
 t=21: EC07BC6D3DE528B1 A70D03F8958F9BA4 09CDADF5B09E542C 871C3F72FFF75168
 8079819B99C99A41 63FFC78316C85D34 223C0812022BF992 FAA41018DA73AA6B
 t=22: 8F21796FE4B51BD0 EC07BC6D3DE528B1 A70D03F8958F9BA4 09CDADF5B09E542C
 1DDFFF81567B2DE4 8079819B99C99A41 63FFC78316C85D34 223C0812022BF992
 t=23: 9F6F64FCB4C926E7 8F21796FE4B51BD0 EC07BC6D3DE528B1 A70D03F8958F9BA4
 8C8247B93F00D50C 1DDFFF81567B2DE4 8079819B99C99A41 63FFC78316C85D34
 t=24: D03596038CD63118 9F6F64FCB4C926E7 8F21796FE4B51BD0 EC07BC6D3DE528B1
 4F5168008F6D598E 8C8247B93F00D50C 1DDFFF81567B2DE4 8079819B99C99A41
 t=25: 338B31422B132F48 D03596038CD63118 9F6F64FCB4C926E7 8F21796FE4B51BD0
 571E4796BD2EB595 4F5168008F6D598E 8C8247B93F00D50C 1DDFFF81567B2DE4
 t=26: F13D1863C7906343 338B31422B132F48 D03596038CD63118 9F6F64FCB4C926E7
 2D8F44815B3B89BB 571E4796BD2EB595 4F5168008F6D598E 8C8247B93F00D50C
 t=27: 92FCCCA21D8FBBF2B F13D1863C7906343 338B31422B132F48 D03596038CD63118
 F1C21531DA4A08B6 2D8F44815B3B89BB 571E4796BD2EB595 4F5168008F6D598E
 t=28: 05F58CDABBF55813 92FCCCA21D8FBBF2B F13D1863C7906343 338B31422B132F48
 06CB086E9CE25950 F1C21531DA4A08B6 2D8F44815B3B89BB 571E4796BD2EB595
 t=29: 6EC03563D439AE54 05F58CDABBF55813 92FCCCA21D8FBBF2B F13D1863C7906343
 6B6E9C3EA7891D15 06CB086E9CE25950 F1C21531DA4A08B6 2D8F44815B3B89BB
 t=30: 2C5C8402B82F7480 6EC03563D439AE54 05F58CDABBF55813 92FCCCA21D8FBBF2B
 A56811F482933EA1 6B6E9C3EA7891D15 06CB086E9CE25950 F1C21531DA4A08B6
 t=31: 1A0CC3AD581C10FE 2C5C8402B82F7480 6EC03563D439AE54 05F58CDABBF55813
 56A84040EEE67BF6 A56811F482933EA1 6B6E9C3EA7891D15 06CB086E9CE25950
 t=32: A5F2FAA00D8A8747 1A0CC3AD581C10FE 2C5C8402B82F7480 6EC03563D439AE54
 F025CE5716C796CD 56A84040EEE67BF6 A56811F482933EA1 6B6E9C3EA7891D15
 t=33: AFB7E1D8C7F831C4 A5F2FAA00D8A8747 1A0CC3AD581C10FE 2C5C8402B82F7480

564993F74B0AD9F5 F025CE5716C796CD 56A84040EEE67BF6 A56811F482933EA1
 t=34: ABF4003C5B5F7017 AFB7E1D8C7F831C4 A5F2FAA00D8A8747 1A0CC3AD581C10FE
 28A6C03E6C2A4898 564993F74B0AD9F5 F025CE5716C796CD 56A84040EEE67BF6
 t=35: 4F2CB708B47DCE20 ABF4003C5B5F7017 AFB7E1D8C7F831C4 A5F2FAA00D8A8747
 DDAC365E41D4C20D 28A6C03E6C2A4898 564993F74B0AD9F5 F025CE5716C796CD
 t=36: EBA175A8080AA725 4F2CB708B47DCE20 ABF4003C5B5F7017 AFB7E1D8C7F831C4
 6634651E9C79BA41 DDAC365E41D4C20D 28A6C03E6C2A4898 564993F74B0AD9F5
 t=37: 27DD63A534C4822E EBA175A8080AA725 4F2CB708B47DCE20 ABF4003C5B5F7017
 1938417C593488CC 6634651E9C79BA41 DDAC365E41D4C20D 28A6C03E6C2A4898
 t=38: DC7BFE1851A2E81B 27DD63A534C4822E EBA175A8080AA725 4F2CB708B47DCE20
 CDB1FB3ED046F991 1938417C593488CC 6634651E9C79BA41 DDAC365E41D4C20D
 t=39: 6D07C2C7A947167B DC7BFE1851A2E81B 27DD63A534C4822E EBA175A8080AA725
 8D5583BD4628586D CDB1FB3ED046F991 1938417C593488CC 6634651E9C79BA41
 t=40: 8CC57E961CE1F956 6D07C2C7A947167B DC7BFE1851A2E81B 27DD63A534C4822E
 1994E5B3F53E4AF2 8D5583BD4628586D CDB1FB3ED046F991 1938417C593488CC
 t=41: 8C6947F81E1FD94A 8CC57E961CE1F956 6D07C2C7A947167B DC7BFE1851A2E81B
 82E08437768126E4 1994E5B3F53E4AF2 8D5583BD4628586D CDB1FB3ED046F991
 t=42: DDB8B34228A61CD0 8C6947F81E1FD94A 8CC57E961CE1F956 6D07C2C7A947167B
 17A90D3B6D6A2EA1 82E08437768126E4 1994E5B3F53E4AF2 8D5583BD4628586D
 t=43: 03BDE346FD50DCCD DDB8B34228A61CD0 8C6947F81E1FD94A 8CC57E961CE1F956
 5FC3283C3C91B062 17A90D3B6D6A2EA1 82E08437768126E4 1994E5B3F53E4AF2
 t=44: 80545AD9644D1756 03BDE346FD50DCCD DDB8B34228A61CD0 8C6947F81E1FD94A
 97BC9BD263E1FC6C 5FC3283C3C91B062 17A90D3B6D6A2EA1 82E08437768126E4
 t=45: EFD4BD2F26343181 80545AD9644D1756 03BDE346FD50DCCD DDB8B34228A61CD0
 4B766751CFBFDA62 97BC9BD263E1FC6C 5FC3283C3C91B062 17A90D3B6D6A2EA1
 t=46: 64624F7253A389BE EFD4BD2F26343181 80545AD9644D1756 03BDE346FD50DCCD
 C9C38B4792943C06 4B766751CFBFDA62 97BC9BD263E1FC6C 5FC3283C3C91B062
 t=47: 3E8CF0C51B035FE0 64624F7253A389BE EFD4BD2F26343181 80545AD9644D1756
 137F35F60E3A8AB0 C9C38B4792943C06 4B766751CFBFDA62 97BC9BD263E1FC6C
 t=48: C91687936637EB79 3E8CF0C51B035FE0 64624F7253A389BE EFD4BD2F26343181
 5DE2B5C19050BFAE 137F35F60E3A8AB0 C9C38B4792943C06 4B766751CFBFDA62
 t=49: 4A994A1444767A2C C91687936637EB79 3E8CF0C51B035FE0 64624F7253A389BE
 32281CDC06C6E9D8 5DE2B5C19050BFAE 137F35F60E3A8AB0 C9C38B4792943C06
 t=50: 7953E11357EBE4CF 4A994A1444767A2C C91687936637EB79 3E8CF0C51B035FE0
 14269D3481B031D0 32281CDC06C6E9D8 5DE2B5C19050BFAE 137F35F60E3A8AB0
 t=51: 4F16072F816AA7A1 7953E11357EBE4CF 4A994A1444767A2C C91687936637EB79
 B6A3D2D3805DCE61 14269D3481B031D0 32281CDC06C6E9D8 5DE2B5C19050BFAE
 t=52: A801F1AAC9415393 4F16072F816AA7A1 7953E11357EBE4CF 4A994A1444767A2C
 7C132F7309D27922 B6A3D2D3805DCE61 14269D3481B031D0 32281CDC06C6E9D8
 t=53: A223D983EBA809A8 A801F1AAC9415393 4F16072F816AA7A1 7953E11357EBE4CF
 0FD152F32163372C 7C132F7309D27922 B6A3D2D3805DCE61 14269D3481B031D0
 t=54: 080BBDDE727385E5 A223D983EBA809A8 A801F1AAC9415393 4F16072F816AA7A1
 8F9E0452A5063D26 0FD152F32163372C 7C132F7309D27922 B6A3D2D3805DCE61
 t=55: 03A460537E8B4F1E 080BBDDE727385E5 A223D983EBA809A8 A801F1AAC9415393
 A37615D60BEBFCF33 8F9E0452A5063D26 0FD152F32163372C 7C132F7309D27922
 t=56: 1BB7A154850F075F 03A460537E8B4F1E 080BBDDE727385E5 A223D983EBA809A8
 2FAA64724CFCF763 A37615D60BEBFCF33 8F9E0452A5063D26 0FD152F32163372C
 t=57: AB80BABC87BB7A16 1BB7A154850F075F 03A460537E8B4F1E 080BBDDE727385E5
 694348C139B7EA00 2FAA64724CFCF763 A37615D60BEBFCF33 8F9E0452A5063D26
 t=58: 8C0E0DB97B2D9C9F AB80BABC87BB7A16 1BB7A154850F075F 03A460537E8B4F1E

651F222826594F54 694348C139B7EA00 2FAA64724CFCF763 A37615D60BEBFCF33
t=59: 3A4EAE7FE4699540 8C0E0DB97B2D9C9F AB80BABC87BB7A16 1BB7A154850F075F
 13876F30BECA815D 651F222826594F54 694348C139B7EA00 2FAA64724CFCF763
t=60: BB7C0F789EA3699C 3A4EAE7FE4699540 8C0E0DB97B2D9C9F AB80BABC87BB7A16
 ECD91F96127B03A8 13876F30BECA815D 651F222826594F54 694348C139B7EA00
t=61: FE629FDEE04ED549 BB7C0F789EA3699C 3A4EAE7FE4699540 8C0E0DB97B2D9C9F
 B2F245A1C977A57A ECD91F96127B03A8 13876F30BECA815D 651F222826594F54
t=62: A419197F10A2F082 FE629FDEE04ED549 BB7C0F789EA3699C 3A4EAE7FE4699540
 747A1B529D1718B3 B2F245A1C977A57A ECD91F96127B03A8 13876F30BECA815D
t=63: 12D940B29B43FCAC A419197F10A2F082 FE629FDEE04ED549 BB7C0F789EA3699C
 5E88DDC8012ABCC8 747A1B529D1718B3 B2F245A1C977A57A ECD91F96127B03A8
t=64: 60F835EA7AE7A3B1 12D940B29B43FCAC A419197F10A2F082 FE629FDEE04ED549
 EE41795118402F41 5E88DDC8012ABCC8 747A1B529D1718B3 B2F245A1C977A57A
t=65: 5448E39ABC8584E0 60F835EA7AE7A3B1 12D940B29B43FCAC A419197F10A2F082
 4D9C54C24C73C5D3 EE41795118402F41 5E88DDC8012ABCC8 747A1B529D1718B3
t=66: 3FF824D6D11EDF6C 5448E39ABC8584E0 60F835EA7AE7A3B1 12D940B29B43FCAC
 4138B86695C59AC4 4D9C54C24C73C5D3 EE41795118402F41 5E88DDC8012ABCC8
t=67: 6E96137693191EDF 3FF824D6D11EDF6C 5448E39ABC8584E0 60F835EA7AE7A3B1
 046EB1A80DD1DF9A 4138B86695C59AC4 4D9C54C24C73C5D3 EE41795118402F41
t=68: EC2D31E61214BDF6 6E96137693191EDF 3FF824D6D11EDF6C 5448E39ABC8584E0
 55DBAB7D6FC52329 046EB1A80DD1DF9A 4138B86695C59AC4 4D9C54C24C73C5D3
t=69: 7E0F0C8461660735 EC2D31E61214BDF6 6E96137693191EDF 3FF824D6D11EDF6C
 F9B0E4BFF6CEE39C 55DBAB7D6FC52329 046EB1A80DD1DF9A 4138B86695C59AC4
t=70: D29A895ED31B66BB 7E0F0C8461660735 EC2D31E61214BDF6 6E96137693191EDF
 9D885DBABB9710B2 F9B0E4BFF6CEE39C 55DBAB7D6FC52329 046EB1A80DD1DF9A
t=71: AE123510491AC45C D29A895ED31B66BB 7E0F0C8461660735 EC2D31E61214BDF6
 E5C2B9E1DE72B8DC 9D885DBABB9710B2 F9B0E4BFF6CEE39C 55DBAB7D6FC52329
t=72: AABC342629053FFB AE123510491AC45C D29A895ED31B66BB 7E0F0C8461660735
 F55697A28603BF8A E5C2B9E1DE72B8DC 9D885DBABB9710B2 F9B0E4BFF6CEE39C
t=73: 0573072E1BF3F98C AABC342629053FFB AE123510491AC45C D29A895ED31B66BB
 82A724607E0562C3 F55697A28603BF8A E5C2B9E1DE72B8DC 9D885DBABB9710B2
t=74: 54404FE2C42230FE 0573072E1BF3F98C AABC342629053FFB AE123510491AC45C
 12B422CB3FC344B9 82A724607E0562C3 F55697A28603BF8A E5C2B9E1DE72B8DC
t=75: 71ADA568EFBA8B62 54404FE2C42230FE 0573072E1BF3F98C AABC342629053FFB
 E4AC0B9801F5A875 12B422CB3FC344B9 82A724607E0562C3 F55697A28603BF8A
t=76: FF078089585319D0 71ADA568EFBA8B62 54404FE2C42230FE 0573072E1BF3F98C
 42C94B5B6F533B3F E4AC0B9801F5A875 12B422CB3FC344B9 82A724607E0562C3
t=77: C555881BC0EDEBCD FF078089585319D0 71ADA568EFBA8B62 54404FE2C42230FE
 942D0C18A267E3B1 42C94B5B6F533B3F E4AC0B9801F5A875 12B422CB3FC344B9
t=78: 2C666488FF634DC6 C555881BC0EDEBCD FF078089585319D0 71ADA568EFBA8B62
 C23D16693B02AA5A 942D0C18A267E3B1 42C94B5B6F533B3F E4AC0B9801F5A875
t=79: 6BA87D1B8505285F 2C666488FF634DC6 C555881BC0EDEBCD FF078089585319D0
 17FBD871DB354C99 C23D16693B02AA5A 942D0C18A267E3B1 42C94B5B6F533B3F

The output after processing the first block is

```

Y0 = 22312194FC2BF72C ⊕ 6BA87D1B8505285F = 8DD99EB081311F8B
Y1 = 9F555FA3C84C64C2 ⊕ 2C666488FF634DC6 = CBBBC42CC7AFB288
Y2 = 2393B86B6F53B151 ⊕ C555881BC0EDEBCD = E8E9408730419D1E
Y3 = 963877195940EABD ⊕ FF078089585319D0 = 953FF7A2B194048D
Y4 = 96283EE2A88EFFE3 ⊕ 17FBD871DB354C99 = AE24175483C44C7C
Y5 = BE5E1E2553863992 ⊕ C23D16693B02AA5A = 809B348E8E88E3EC
Y6 = 2B0199FC2C85B8AA ⊕ 942D0C18A267E3B1 = BF2EA614CEED9C5B
Y7 = 0EB72DDC81C52CA2 ⊕ 42C94B5B6F533B3F = 51807937F11867E1

```

The second block input (1 024 bits) is

```

Z[0] = 0000000000000000
Z[1] = 0000000000000000
Z[2] = 0000000000000000
Z[3] = 0000000000000000
Z[4] = 0000000000000000
Z[5] = 0000000000000000
Z[6] = 0000000000000000
Z[7] = 0000000000000000
Z[8] = 0000000000000000
Z[9] = 0000000000000000
Z[10] = 0000000000000000
Z[11] = 0000000000000000
Z[12] = 0000000000000000
Z[13] = 0000000000000000
Z[14] = 0000000000000000
Z[15] = 0000000000000380

```

The following are (hexadecimal representations of) the successive values of the variables $X_0, X_1, X_2, X_3, X_4, X_5, X_6$ and X_7 in each round when the second block is processed.

```

t=0: CA1B701EA8D10380 8DD99EB081311F8B CBBBC42CC7AFB288 E8E9408730419D1E
    4301C5B7AF4F28EA AE24175483C44C7C 809B348E8E88E3EC BF2EA614CEED9C5B
t=1: 4B560A3D9D8BA236 CA1B701EA8D10380 8DD99EB081311F8B CBBBC42CC7AFB288
    4E2D9B9CB97640BF 4301C5B7AF4F28EA AE24175483C44C7C 809B348E8E88E3EC
t=2: 052AFD3A52839A12 4B560A3D9D8BA236 CA1B701EA8D10380 8DD99EB081311F8B
    40A7CA7D457EBBD6 4E2D9B9CB97640BF 4301C5B7AF4F28EA AE24175483C44C7C
t=3: 6D6469537181FB59 052AFD3A52839A12 4B560A3D9D8BA236 CA1B701EA8D10380
    E7E74F3462405FC1 40A7CA7D457EBBD6 4E2D9B9CB97640BF 4301C5B7AF4F28EA
t=4: 67D25B0D1D465E19 6D6469537181FB59 052AFD3A52839A12 4B560A3D9D8BA236
    81EA993A34CE5FD6 E7E74F3462405FC1 40A7CA7D457EBBD6 4E2D9B9CB97640BF
t=5: CE2D2DCA6276189B 67D25B0D1D465E19 6D6469537181FB59 052AFD3A52839A12
    2B11C440985F5E14 81EA993A34CE5FD6 E7E74F3462405FC1 40A7CA7D457EBBD6
t=6: C304AE7968FA6276 CE2D2DCA6276189B 67D25B0D1D465E19 6D6469537181FB59
    2D925EBD2371D4E0 2B11C440985F5E14 81EA993A34CE5FD6 E7E74F3462405FC1
t=7: A2F2F352C45E6B92 C304AE7968FA6276 CE2D2DCA6276189B 67D25B0D1D465E19
    2209E227605C477C 2D925EBD2371D4E0 2B11C440985F5E14 81EA993A34CE5FD6
t=8: B6408732E17EF2BF A2F2F352C45E6B92 C304AE7968FA6276 CE2D2DCA6276189B
    0A7493CBFB707A28 2209E227605C477C 2D925EBD2371D4E0 2B11C440985F5E14
t=9: E5A29310956CF4B0 B6408732E17EF2BF A2F2F352C45E6B92 C304AE7968FA6276

```

471CAEB6206FD6A9 0A7493CBFB707A28 2209E227605C477C 2D925EBD2371D4E0
t=10: 619A643B60A72678 E5A29310956CF4B0 B6408732E17EF2BF A2F2F352C45E6B92
2AFDCFD70197C551 471CAEB6206FD6A9 0A7493CBFB707A28 2209E227605C477C
t=11: 12E090BCE773988C 619A643B60A72678 E5A29310956CF4B0 B6408732E17EF2BF
2BB61C87D95F1EF6 2AFDCFD70197C551 471CAEB6206FD6A9 0A7493CBFB707A28
t=12: 844745BEB54BB38D 12E090BCE773988C 619A643B60A72678 E5A29310956CF4B0
A1B9B2E57ECE02D4 2BB61C87D95F1EF6 2AFDCFD70197C551 471CAEB6206FD6A9
t=13: 728E0FF0A633641C 844745BEB54BB38D 12E090BCE773988C 619A643B60A72678
D2EB1AE617CFA231 A1B9B2E57ECE02D4 2BB61C87D95F1EF6 2AFDCFD70197C551
t=14: 4294C9F0701FB711 728E0FF0A633641C 844745BEB54BB38D 12E090BCE773988C
E5722A671CACCC14 D2EB1AE617CFA231 A1B9B2E57ECE02D4 2BB61C87D95F1EF6
t=15: 1EB995845896146C 4294C9F0701FB711 728E0FF0A633641C 844745BEB54BB38D
F1F73492308170F3 E5722A671CACCC14 D2EB1AE617CFA231 A1B9B2E57ECE02D4
t=16: 2B4D4009404447A0 1EB995845896146C 4294C9F0701FB711 728E0FF0A633641C
C50207E5516E7902 F1F73492308170F3 E5722A671CACCC14 D2EB1AE617CFA231
t=17: 7EE24648DA164A4F 2B4D4009404447A0 1EB995845896146C 4294C9F0701FB711
9FFCB15331E1CD35 C50207E5516E7902 F1F73492308170F3 E5722A671CACCC14
t=18: 0D7915D334E98931 7EE24648DA164A4F 2B4D4009404447A0 1EB995845896146C
0ACF80CA9D91C843 9FFCB15331E1CD35 C50207E5516E7902 F1F73492308170F3
t=19: 7156E5D603D6D2C9 0D7915D334E98931 7EE24648DA164A4F 2B4D4009404447A0
3ADC14C21552B1A8 0ACF80CA9D91C843 9FFCB15331E1CD35 C50207E5516E7902
t=20: 1DA99E1A512119C7 7156E5D603D6D2C9 0D7915D334E98931 7EE24648DA164A4F
B9E562D0A2B54D40 3ADC14C21552B1A8 0ACF80CA9D91C843 9FFCB15331E1CD35
t=21: 1FB878880EF4B5E4 1DA99E1A512119C7 7156E5D603D6D2C9 0D7915D334E98931
CE2590CB43609153 B9E562D0A2B54D40 3ADC14C21552B1A8 0ACF80CA9D91C843
t=22: 3FDC41AC384A3129 1FB878880EF4B5E4 1DA99E1A512119C7 7156E5D603D6D2C9
32B0C09234E84242 CE2590CB43609153 B9E562D0A2B54D40 3ADC14C21552B1A8
t=23: B836D5F127D2FDB8 3FDC41AC384A3129 1FB878880EF4B5E4 1DA99E1A512119C7
3714588332FCEC71 32B0C09234E84242 CE2590CB43609153 B9E562D0A2B54D40
t=24: 2EC877975A9F8116 B836D5F127D2FDB8 3FDC41AC384A3129 1FB878880EF4B5E4
362102EAA0DD5D70 3714588332FCEC71 32B0C09234E84242 CE2590CB43609153
t=25: 565DBE48262353B9 2EC877975A9F8116 B836D5F127D2FDB8 3FDC41AC384A3129
E54F12F5AED463E6 362102EAA0DD5D70 3714588332FCEC71 32B0C09234E84242
t=26: 40C91B7364704A83 565DBE48262353B9 2EC877975A9F8116 B836D5F127D2FDB8
4656BB7233467988 E54F12F5AED463E6 362102EAA0DD5D70 3714588332FCEC71
t=27: 53CA178C6B368158 40C91B7364704A83 565DBE48262353B9 2EC877975A9F8116
4C67542852B3D7A1 4656BB7233467988 E54F12F5AED463E6 362102EAA0DD5D70
t=28: 15D0571DD1178764 53CA178C6B368158 40C91B7364704A83 565DBE48262353B9
405BD69B2C905BD7 4C67542852B3D7A1 4656BB7233467988 E54F12F5AED463E6
t=29: 264B6149F78D1035 15D0571DD1178764 53CA178C6B368158 40C91B7364704A83
CC414FDE2C1F1BFA 405BD69B2C905BD7 4C67542852B3D7A1 4656BB7233467988
t=30: 9A33B7A4623C0534 264B6149F78D1035 15D0571DD1178764 53CA178C6B368158
2C551E8A8C2C7434 CC414FDE2C1F1BFA 405BD69B2C905BD7 4C67542852B3D7A1
t=31: 3CCB61788641971E 9A33B7A4623C0534 264B6149F78D1035 15D0571DD1178764
06B6D7E811D72282 2C551E8A8C2C7434 CC414FDE2C1F1BFA 405BD69B2C905BD7
t=32: 73152319D664AB4D 3CCB61788641971E 9A33B7A4623C0534 264B6149F78D1035
961481C44171C469 06B6D7E811D72282 2C551E8A8C2C7434 CC414FDE2C1F1BFA
t=33: A13ED1EBC962EA7E 73152319D664AB4D 3CCB61788641971E 9A33B7A4623C0534
6CF7B8AA031A207A 961481C44171C469 06B6D7E811D72282 2C551E8A8C2C7434
t=34: 09F847AAB3E15178 A13ED1EBC962EA7E 73152319D664AB4D 3CCB61788641971E

BF27C53408DBD3E9 6CF7B8AA031A207A 961481C44171C469 06B6D7E811D72282
 t=35: 042BD9B3B1A3216D 09F847AAB3E15178 A13ED1EBC962EA7E 73152319D664AB4D
 58307603F69A3141 BF27C53408DBD3E9 6CF7B8AA031A207A 961481C44171C469
 t=36: C672CECB0E5C083C 042BD9B3B1A3216D 09F847AAB3E15178 A13ED1EBC962EA7E
 A713876F591E1729 58307603F69A3141 BF27C53408DBD3E9 6CF7B8AA031A207A
 t=37: 528D95291F5F694D C672CECB0E5C083C 042BD9B3B1A3216D 09F847AAB3E15178
 3F065D9605A497B0 A713876F591E1729 58307603F69A3141 BF27C53408DBD3E9
 t=38: D51413BD28942A19 528D95291F5F694D C672CECB0E5C083C 042BD9B3B1A3216D
 B8C08D67D6372533 3F065D9605A497B0 A713876F591E1729 58307603F69A3141
 t=39: D3E65D22ECE41799 D51413BD28942A19 528D95291F5F694D C672CECB0E5C083C
 48C71BDE787CF9CF B8C08D67D6372533 3F065D9605A497B0 A713876F591E1729
 t=40: 9DC023C14EC9FD06 D3E65D22ECE41799 D51413BD28942A19 528D95291F5F694D
 600D290EB716504D 48C71BDE787CF9CF B8C08D67D6372533 3F065D9605A497B0
 t=41: E201AB4097D56AD9 9DC023C14EC9FD06 D3E65D22ECE41799 D51413BD28942A19
 211AEFF5D426E06A 600D290EB716504D 48C71BDE787CF9CF B8C08D67D6372533
 t=42: D6E25625A771084A E201AB4097D56AD9 9DC023C14EC9FD06 D3E65D22ECE41799
 FEA9E0A415E0D53B 211AEFF5D426E06A 600D290EB716504D 48C71BDE787CF9CF
 t=43: BFEA46AB9859BFA1 D6E25625A771084A E201AB4097D56AD9 9DC023C14EC9FD06
 678E5BDDAF3C3B71 FEA9E0A415E0D53B 211AEFF5D426E06A 600D290EB716504D
 t=44: A16A621A085D68D6 BFEA46AB9859BFA1 D6E25625A771084A E201AB4097D56AD9
 138B192CEDB50B75 678E5BDDAF3C3B71 FEA9E0A415E0D53B 211AEFF5D426E06A
 t=45: 3476332E792C1C4B A16A621A085D68D6 BFEA46AB9859BFA1 D6E25625A771084A
 2ABC2AB574E9F080 138B192CEDB50B75 678E5BDDAF3C3B71 FEA9E0A415E0D53B
 t=46: 24F0545BB7DB3F19 3476332E792C1C4B A16A621A085D68D6 BFEA46AB9859BFA1
 F5EFACBE2AD8B856 2ABC2AB574E9F080 138B192CEDB50B75 678E5BDDAF3C3B71
 t=47: 06959C13A1020AF8 24F0545BB7DB3F19 3476332E792C1C4B A16A621A085D68D6
 7AE2E87ACB8DDE39 F5EFACBE2AD8B856 2ABC2AB574E9F080 138B192CEDB50B75
 t=48: FA114006862CF5D3 06959C13A1020AF8 24F0545BB7DB3F19 3476332E792C1C4B
 976564D9448EB34A 7AE2E87ACB8DDE39 F5EFACBE2AD8B856 2ABC2AB574E9F080
 t=49: 67B5638DBE2A3651 FA114006862CF5D3 06959C13A1020AF8 24F0545BB7DB3F19
 A752090797E79FDA 976564D9448EB34A 7AE2E87ACB8DDE39 F5EFACBE2AD8B856
 t=50: 884BDAE0CE147578 67B5638DBE2A3651 FA114006862CF5D3 06959C13A1020AF8
 B05132465F5172C1 A752090797E79FDA 976564D9448EB34A 7AE2E87ACB8DDE39
 t=51: 4EF7B5C89BCBC776 884BDAE0CE147578 67B5638DBE2A3651 FA114006862CF5D3
 581DAD1B56E18E1C B05132465F5172C1 A752090797E79FDA 976564D9448EB34A
 t=52: 820AD2EC649E6DCC 4EF7B5C89BCBC776 884BDAE0CE147578 67B5638DBE2A3651
 21AB0DF2BC658D9F 581DAD1B56E18E1C B05132465F5172C1 A752090797E79FDA
 t=53: 0563C5F2919ED596 820AD2EC649E6DCC 4EF7B5C89BCBC776 884BDAE0CE147578
 5AC4DB36E7FF1693 21AB0DF2BC658D9F 581DAD1B56E18E1C B05132465F5172C1
 t=54: CEBA54F000A09D5D 0563C5F2919ED596 820AD2EC649E6DCC 4EF7B5C89BCBC776
 F7F8883941A7E321 5AC4DB36E7FF1693 21AB0DF2BC658D9F 581DAD1B56E18E1C
 t=55: 40DEC62C74F632D5 CEBA54F000A09D5D 0563C5F2919ED596 820AD2EC649E6DCC
 1F8AF353EC8C6DDA F7F8883941A7E321 5AC4DB36E7FF1693 21AB0DF2BC658D9F
 t=56: 5F961EDFCB27CA82 40DEC62C74F632D5 CEBA54F000A09D5D 0563C5F2919ED596
 91EEDF5727B533B9 1F8AF353EC8C6DDA F7F8883941A7E321 5AC4DB36E7FF1693
 t=57: 0F6AA0004EB91943 5F961EDFCB27CA82 40DEC62C74F632D5 CEBA54F000A09D5D
 C70CF9E635760D8E 91EEDF5727B533B9 1F8AF353EC8C6DDA F7F8883941A7E321
 t=58: 547E34C8E16C8208 0F6AA0004EB91943 5F961EDFCB27CA82 40DEC62C74F632D5
 DAB76359DFE7875E C70CF9E635760D8E 91EEDF5727B533B9 1F8AF353EC8C6DDA
 t=59: 9AFF38B3BC64077D 547E34C8E16C8208 0F6AA0004EB91943 5F961EDFCB27CA82

BD0DF11423D8727B DAB76359DFE7875E C70CF9E635760D8E 91EEDF5727B533B9
 t=60: C1BB5920B7C5B67E 9AFF38B3BC64077D 547E34C8E16C8208 0F6AA0004EB91943
 B4B189776407C251 BD0DF11423D8727B DAB76359DFE7875E C70CF9E635760D8E
 t=61: 035C20D721BA914D C1BB5920B7C5B67E 9AFF38B3BC64077D 547E34C8E16C8208
 3102071764B6F123 B4B189776407C251 BD0DF11423D8727B DAB76359DFE7875E
 t=62: C32B2ED80EAB3663 035C20D721BA914D C1BB5920B7C5B67E 9AFF38B3BC64077D
 1625654B4B1F63E8 3102071764B6F123 B4B189776407C251 BD0DF11423D8727B
 t=63: 7E2893CE82EE6DDC C32B2ED80EAB3663 035C20D721BA914D C1BB5920B7C5B67E
 FCE7A5EA11A84E7F 1625654B4B1F63E8 3102071764B6F123 B4B189776407C251
 t=64: C5C6741A461B5C08 7E2893CE82EE6DDC C32B2ED80EAB3663 035C20D721BA914D
 31010FF1B53793FD FCE7A5EA11A84E7F 1625654B4B1F63E8 3102071764B6F123
 t=65: 250F7D7FC30C144F C5C6741A461B5C08 7E2893CE82EE6DDC C32B2ED80EAB3663
 9C824646617DD90A 31010FF1B53793FD FCE7A5EA11A84E7F 1625654B4B1F63E8
 t=66: 2985CBF9ADA94FEF 250F7D7FC30C144F C5C6741A461B5C08 7E2893CE82EE6DDC
 481E2BA9F24813AD 9C824646617DD90A 31010FF1B53793FD FCE7A5EA11A84E7F
 t=67: 7C3F7808EDDC4373 2985CBF9ADA94FEF 250F7D7FC30C144F C5C6741A461B5C08
 923A8EC51D528E0D 481E2BA9F24813AD 9C824646617DD90A 31010FF1B53793FD
 t=68: FC443DF03A273D02 7C3F7808EDDC4373 2985CBF9ADA94FEF 250F7D7FC30C144F
 9D92992298B6311F 923A8EC51D528E0D 481E2BA9F24813AD 9C824646617DD90A
 t=69: C1265539D2F29608 FC443DF03A273D02 7C3F7808EDDC4373 2985CBF9ADA94FEF
 1DA207AB69A702F0 9D92992298B6311F 923A8EC51D528E0D 481E2BA9F24813AD
 t=70: EFC50BC63BDB23A5 C1265539D2F29608 FC443DF03A273D02 7C3F7808EDDC4373
 F4F43A64BADFD219 1DA207AB69A702F0 9D92992298B6311F 923A8EC51D528E0D
 t=71: D2BEF501241BE22C EFC50BC63BDB23A5 C1265539D2F29608 FC443DF03A273D02
 A2870A290A867A1A F4F43A64BADFD219 1DA207AB69A702F0 9D92992298B6311F
 t=72: CA73C49DE77C7AC8 D2BEF501241BE22C EFC50BC63BDB23A5 C1265539D2F29608
 F820C00AA7E284E6 A2870A290A867A1A F4F43A64BADFD219 1DA207AB69A702F0
 t=73: 558A01B12EC35028 CA73C49DE77C7AC8 D2BEF501241BE22C EFC50BC63BDB23A5
 15E2469AD6262414 F820C00AA7E284E6 A2870A290A867A1A F4F43A64BADFD219
 t=74: 370DAFCBF2D25DA8 558A01B12EC35028 CA73C49DE77C7AC8 D2BEF501241BE22C
 8E3FA5D1EAE87FA8 15E2469AD6262414 F820C00AA7E284E6 A2870A290A867A1A
 t=75: B6FDAC1E04495875 370DAFCBF2D25DA8 558A01B12EC35028 CA73C49DE77C7AC8
 EC3C3233141B55E7 8E3FA5D1EAE87FA8 15E2469AD6262414 F820C00AA7E284E6
 t=76: DAAAD0BF300751AD B6FDAC1E04495875 370DAFCBF2D25DA8 558A01B12EC35028
 7401A3CB07B8228E EC3C3233141B55E7 8E3FA5D1EAE87FA8 15E2469AD6262414
 t=77: 7CE25CB7C7FD48F6 DAAAD0BF300751AD B6FDAC1E04495875 370DAFCBF2D25DA8
 69A9F1B43ECA54F4 7401A3CB07B8228E EC3C3233141B55E7 8E3FA5D1EAE87FA8
 t=78: 751E755B4A6D7F36 7CE25CB7C7FD48F6 DAAAD0BF300751AD B6FDAC1E04495875
 CB9D209C7B0DEB01 69A9F1B43ECA54F4 7401A3CB07B8228E EC3C3233141B55E7
 t=79: AB4F42D47A55716D 751E755B4A6D7F36 7CE25CB7C7FD48F6 DAAAD0BF300751AD
 22CA23DE9BE67C24 CB9D209C7B0DEB01 69A9F1B43ECA54F4 7401A3CB07B8228E

The output after processing the second block is

Y₀ = 8DD99EB081311F8B ⊕ AB4F42D47A55716D = 3928E184FB8690F8
 Y₁ = CBBBC42CC7AFB288 ⊕ 751E755B4A6D7F36 = 40DA3988121D31BE
 Y₂ = E8E9408730419D1E ⊕ 7CE25CB7C7FD48F6 = 65CB9D3EF83EE614
 Y₃ = 953FF7A2B194048D ⊕ DAAAD0BF300751AD = 6FEAC861E19B563A
 Y₄ = AE24175483C44C7C ⊕ 22CA23DE9BE67C24 = D0EE3B331FAAC8A0
 Y₅ = 809B348E8E88E3EC ⊕ CB9D209C7B0DEB01 = 4C38552B0996CEED
 Y₆ = BF2EA614CEED9C5B ⊕ 69A9F1B43ECA54F4 = 28D897C90DB7F14F
 Y₇ = 51807937F11867E1 ⊕ 7401A3CB07B8228E = C5821D02F8D08A6F

Iteration 1

$K_1 = \text{B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574}$
 $X[K_1](m) = \text{B2B1CD1EF7EC924286B7CF1CFFE49C4C84B5C91AFDE694448ABBCB18FBE09646}$
 $82B3C516F9E2904080B1CD1EF7EC924286B7CF1CFFE49C4C84B5C91AFDE69444,$
 $SX[K_1](m) = 4645D95FC0BEEC2C432F8914B62D4EFD3E5E37F14B097AEAD67DE417C220B048}$
 $2492AC996667E0EBDF45D95FC0BEEC2C432F8914B62D4EFD3E5E37F14B097AEA,$
 $PSX[K_1](m) = 46433ED624DF433E452F5E7D92452F5ED98937E4ACD989375F14F117995F14F1}$
 $C0B64BC266C0B64BBE2D092067BE2D09EC4E7AB0E0EC4E7A2CFDEA48EB2CFDEA,$
 $LPSX[K_1](m) = \text{E60059D4D8E0758024C73F6F3183653F56579189602AE4C21E7953EBC0E212A0}$
 $\text{CE78A8DF475C2FD4FC43FC4B71C01E35BE465FB20DAD2CF690CDF65028121BB9},$
 $K_1 \oplus C_1 = 028BA7F4D01E7F9D5848D3AF0EB1D96B9CE98A6DE0917562C2CD44A3BB516E88}$
 $\text{F8FF1CBF5CB3CC7511C1D6266AB47661B6F5881802A0E8576E0399773C72E073},$
 $S(K_1 \oplus C_1) = \text{DDF644E6E15F5733BFF249410445536F4E9BD69E200F3596B3D9FA737D70A1D7}$
 $\text{D1B6143B9C9288357758F8EF78278AA155F4D717DDA7CB12B211E87E7F19203D},$
 $PS(K_1 \oplus C_1) = \text{DDBF4EB3D17755B2F6F29BD9B658F4114449D6EA14F8D7E8E6419E733BEF177E}$
 $\text{E104207D9C78DD7F5F450F709227A719575335A1888ACB20336F96D735A1123D},$
 $LPS(K_1 \oplus C_1) = \text{D0B00807642FD78F13F2C3EBC774E80DE0E902D23AEF2EE9A73D010807DAE9C1}$
 $\text{88BE14F0B2DA27973569CD2BA051301036F728BD1D7EEC33F4D18AF70C46CF1E}.$

Iteration 2

$K_2 = \text{D0B00807642FD78F13F2C3EBC774E80DE0E902D23AEF2EE9A73D010807DAE9C1}$
 $\text{88BE14F0B2DA27973569CD2BA051301036F728BD1D7EEC33F4D18AF70C46CF1E},$
 $LPSX[K_2]LPSX[K_1](m) = 18E77571E703D19548075C574CE5E50E0480C9C5B9F21D45611AB86CF32}$
 $\text{E352AD91854EA7DF8F863D46333673F62FF2D3EFAE1CD966F8E2A74CE49902799AAD4}.$

Iteration 3

$K_3 = 9D4475C7899F2D0BB0E8B7DAC6EF6E6B44ECF66716D3A0F16681105E2D13712A}$
 $\text{1A9387ECC257930E2D61014A1B5C9FC9E24E7D636EB1607E816DBAF927B8FCA9},$
 $LPSX[K_3]...LPSX[K_1](m) = 03DC0A9C164D42543CCDB62960D58C17E0B5B805D08A07406ECE679D5F}$
 $\text{82B70FEA22A7EA56E21814619E8749B308214575489D4D465539852CD4B0CD3829BEF39}.$

Iteration 4

$K_4 = 5C283DABA5EC1F233B8C833C48E1C670DAE2E40CC4C3219C73E58856BD96A72F}$
 $\text{DF9F8055FEF3C004C8CDE3B8BF78F95F3370D0A3D6194AC5782487DEFD83CA0F},$
 $LPSX[K_4]...LPSX[K_1](m) = \text{DBEE312EA7301B0D6D13E43855E85DB81608C780C43675BC93CFD82C1}$
 $\text{B4933B3898A35B13E1878ABE119E4DFFB9DE4889738CA74D064CD9EB732078C1FB25E04}.$

Iteration 5

$K_5 = 109F33262731F9BD569CBC9317BAA551D4D2964FA18D42C41FAB4E37225292EC}$
 $\text{2FD97D7493784779046388469AE195C436FA7CBA93F8239CEB5FFC818826470C},$
 $LPSX[K_5]...LPSX[K_1](m) = 7FB3F15718D90E889F9FB7C38F527BEC861C298AFB9186934A93C9D96AD}$
 $\text{E20DF109379BB9C1A1FFD0AD81FCE7B45CCD54501E7D127E32874B5D7927B032DE7A1}.$

Iteration 6

$K_6 = \text{B32C9B02667911CF8F8A0877BE9A170757E25026CCF41E67C6B5DA70B1B87474}$
 $\text{3E1135CFBEFE244237555C676C153D99459BC382573AEE2D85D30D99F286C5E7},$
 $LPSX[K_6]...LPSX[K_1](m) = 95EFA4E104F235824BAE5030FE2D0F170A38DE3C9B8FC6D8FA1A9ADC2945C413389A12}$
 $\text{1501FA71A65067916B0C06F6B87CE18DE1A2A98E0A64670985F47D73F1}.$

The result of the transformation $g_0(h, N)$ is

h = 5C881FD924695CF196C2E4FEC20D14B642026F2A0B1716EBAABB7067D4D597523D2DB69D6D3794622147A14F19A66E7F9037E1D662D34501A8901A5DE7771D7C.

The result of the transformation $g_0(h, \Sigma)$ is

h = 486F64C1917879417FEF082B3381A4E211C324F074654C38823A/B76F830AD00FA1FBAE42B1285C0352F227524BC9AB16254288DD6863DCCD5B9F54A1AD0541B.

The hash-code of the message M_1 is the value:

H=486F64C1917879417FEF082B3381A4E211C324F074654C38823A7B76F830AD00FA1FBAE42B1285C0352F227524BC9AB16254288DD6863DCCD5B9F54A1AD0541B.

B.12.3 Example 2

In this example, the data string is given as a sequence of bytes (in hexadecimal notation):

$M_1 =$ D1 E5 20 E2 E5 F2 F0 E8 2C 20 D1 F2 F0 E8 E1 EE E6 E8 20 E2 ED F3 F6 E8 2C 20 E2 E5
FE F2 FA 20 F1 20 EC EE F0 FF 20 F1 F2 F0 E5 EB E0 EC E8 20 ED E0 20 F5 F0 E0 E1 F0 FB FF
20 EF EB FA EA FB 20 C8 E3 EE F0 E5 E2 FB.

Assign the following values to the variables:

$$h := IV = 0512;$$
$$N := 0512;$$
$$\Sigma := 0^{512}.$$

The length of the message is $L_{M_1} = 576 > 512$, so a part of this message is initially processed:

```
m := FBEAFAEBEF20FFFBF0E1F0F0F520E0ED20E8ECE0EBE5F0F2F120FFF0EEEC20F1
20FAF2FEE5E2202CE8F6F3E0E220E8E6EEE1E8F0F2D1202CE8F0F2E5E220E5D1.
```

Calculate $K := LPS(h \oplus N) = LPS(0512)$.

After the transformation S :

[illegible]

after the transformation P :

[illegible]

after the transformation L :

$$K = LPS(h \oplus N) = B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574 \\ B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574.$$

Then the transformation $E(K, m)$ is performed:

Iteration 1

$$\begin{aligned} K_1 &= \text{B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574} \\ &\quad \text{B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574B383FC2ECED4A574}, \\ X[K_1](m) &= 486906C521F45A8F43621CDE3BF44599936B10CE2531558642A303DE20388585 \\ &\quad 93790ED02B3685585B750FC32CF44D925D6214DE3C0585585B730ECB2CF440A5, \\ SX[K_1](m) &= \text{F29131AC18E613035196148598E6C8E8DE6FE9E75C840C432C731185F906A8A8} \\ &\quad \text{DE5404E1428FA8BF47354D408BE63AECB79693857F6EA8BF473D04E48BE6EB00}, \end{aligned}$$

$PSX[K_1](m) = \text{F251DE2CDE47B74791966F735435963D3114E911044D9304AC85E785E14085E4}$
 $18985CF9428B7F8BE6E684068FE66EE613C80CA8A83AA8EB03E843A8BFECBF00,$
 $LPSX[K_1](m) = 909AA733E1F52321A2FE35BFB8F67E92FBC70EF544709D5739D8FAACA4ACF126}$
 $E83E273745C25B7B8F4A83A7436F6353753CBBBE492262CD3A868EACE0104AF1,$
 $K_1 \oplus C_1 = 028BA7F4D01E7F9D5848D3AF0EB1D96B9CE98A6DE0917562C2CD44A3BB516188}$
 $F8FF1CBF5CB3CC7511C1D6266AB47661B6F5881802A0E8576E0399773C72E073,$
 $S(K_1 \oplus C_1) = \text{DDF644E6E15F5733BFF249410445536F4E9BD69E200F3596B3D9EA737D70A1D7}$
 $D1B6143B9C9288357758F8EF78278AA155F4D717DDA7CB12B211E87E7F19203D,$
 $PS(K_1 \oplus C_1) = \text{DDBF4EB3D17755B2F6F29BD9B658F4114449D6EA14F8D7E8E6419E733BEF177E}$
 $E104207D9C78DD7F5F450F709227A719575335A1888ACB20336F96D735A1123D,$
 $LPS(K_1 \oplus C_1) = \text{D0B00807642FD78F13F2C3EBC774E80DE0E902D23AEF2EE9A73D010807DAE9C1}$
 $88BE14F0B2DA27973569CD2BA051301036F728BD1D7EEC33F4D18AF70C46CF1E.$

Iteration 2

$K_2 = \text{D0B00807642FD78F13F2C3EBC774E80DE0E902D23AEF2EE9A73D010807DAE9C1}$
 $88BE14F0B2DA27973569CD2BA051301036F728BD1D7EEC33F4D18AF70C46CF1E,$
 $LPSX[K_2]LPSX[K_1](m) = 301AADD761D13DF0B473055B14A2F74A45F408022AECADD4D5F19CAB8228883A}$
 $021AC0B62600A495950C628354FFCE1161C68B7BE7E0C58AF090CE6B45E49F16.$

Iteration 3

$K_3 = 9D4475C7899F2D0BB0E8B7DAC6EF6E6B44ECF66716D3A0F16681105E2D13712A}$
 $1A9387ECC257930E2D61014A1B5C9FC9E24E7D636EB1607E816DBAF927B8FCA9,$
 $LPSX[K_3]...LPSX[K_1](m) = 9B83492B9860A93BCBA1C0D8E0CE59DB04E10500A6AC85D4103304974E78D322}$
 $59CEFF03FBB353147A9C948786582DF78A34C9BDE3F72B3CA41B9179C2CCEEF3.$

Iteration 4

$K_4 = 5C283DABA5EC1F233B8C833C48E1C670DAE2E40CC4C3219C73E58856BD96A72F}$
 $DF9F8055FFE3C004C8CDE3B8BF78F95F3370D0A3D6194AC5782487DEFD83CA0F,$
 $LPSX[K_4]...LPSX[K_1](m) = E638E0A1677CDEA107EC3402F70698A4038450DAB44AC7A447E10155AA33EF1B}$
 $DAF8F49DA7B66F3E05815045FBD39C991CB0DC536E09505FD62D3C2CD00B0F57.$

Iteration 5

$K_5 = 109F33262731F9BD569C9317BAA551D4D2964FA18D42C41FAB4E37225292EC}$
 $2FD97D7493784779046388469AE195C436FA7CBA93F8239CEB5FFC818826470C,$
 $LPSX[K_5]...LPSX[K_1](m) = 1C7C8E19B2BF443EB3ADC0C787A52A173821A97BC5A8EFEA58FB8B27861829F6}$
 $DD5FF9C97865E08C1AC66F47392B578E21266E323A0ACEDEEC3EF0314F517C6.$

Iteration 6

$K_6 = B32C9B02667911CF8F8A0877BE9A170757E25026CCF41E67C6B5DA70B1B87474}$
 $3E1135CFBEFE244237555C676C153D99459BC382573AEE2D85D30D99F286C5E7,$
 $LPSX[K_6]...LPSX[K_1](m) = 48FECFC5B3EB77998FB39BFCCCD128CD42FCCB714221BE1E675A1C6FDDE7E311}$
 $98B318622412AF7E999A3EFF45E6D61609A7F2AE5C2FF1AB7FF3B37BE7011BA2.$

Iteration 7

$K_7 = 8A13C1B195FD0886AC49989E7D84B08BC7B00E4F3F62765ECE6050FCBABDC234}$
 $6C8207594714E8E9C9C7AAD694EDC922D6B01E17285EB7E61502E634559E32F1,$
 $LPSX[K_7]...LPSX[K_1](m) = A48F8D781C2C5BE417AE644CC2E15A9F01FCEAD3232E5BD53F18A5AB875CCE1B}$
 $8A1A400CF48521C7CE27FB1E94452FB54DE23118F53B364EE633170A62F5A8A9.$

Iteration 8

$K_8 = 52CEC3B11448BB8617D0DDFBC926F2E88730CB9179D6DECEA5ACBFFD323EC376}$
 $4C47F7A9E13BB1DB56C342034773023D617FF01CC546728E71DFF8DE5D128CAC,$
 $LPSX[K_8]...LPSX[K_1](m) = E8A31B2E34BD2AE21B0ECF29CC4C37C75C4D11D9B82852517515C23E81E906A4}$
 $51B72779C3087141F1A15AB57F96D7DA6C7EE38ED25BEFBDEF631216356FF59C.$

The variables N and Σ change their values to:

[illegible]

The result of the transformation $g_0(h, N)$ is

h = 4DEB6649FFA5CAF4163D9D3F9967FBBD6EB3DA68F916B6A09F41F2518B81292B703DC5D74E1ACE5BCD3458AF43BB456E837326088F2B5DF14BF83997A0B1AD8D.

The result of the transformation $g_0(h, \Sigma)$ is

h = 28FBC9BADA033B1460642BDCDD90C3FB3E56C497CCD0F62B8A2AD4935E85F037613966DE4EE00531AE60F3B5A47F8DAE06915D5F2F194996FCABF2622E6881E.

The hash-code of the message M_2 is the value:

$H = 28\text{FBC9BADA033B1460642BDCDB90C3FB3E56C497CCD0F62B8A2AD4935E85F037613966DE4EE00531AE60F3B5A47F8DAE06915D5F2F194996FCABF2622E6881E}.$

B.13 Dedicated Hash-Function 12 (STREEBOG-256)

B.13.1 General

The binary words are expressed in hexadecimal notation. The $4n$ -bit word is given in the form $a_{n-1}, \dots, a_0$, where $a_i \in \mathbb{F}_{16}$, $i = 0, \dots, n-1$ is $\text{Vec}_4(a_{n-1}) \parallel \dots \parallel \text{Vec}_4(a_0)$.

It should be noted that in this set of examples all data strings treated in right-to-left order. Byte ordering convention holds.

B.13.2 Example 1

In this example, the data string is given as a sequence of bytes (in hexadecimal notation):

$M_1 =$ 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37
 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37 38 39 30 31 32 33 34 35 36 37
 38 39 30 31 32

Assign the following values to the variables:

$$h := IV = (000\ 000\ 01)^{64};$$
$$N := 0512;$$
$$\Sigma := 0^{512}.$$

The length of the message is $L_{M_1} = 504 < 512$, so the incomplete block is padded:

$$m := 0132313039383736353433323130393837363534333231303938373635343332$$

$$3130393837363534333231303938373635343332313039383736353433323130.$$

Calculate $K := LPS(h \oplus N) = LPS[(000\ 000\ 01)^{64}]$.

After the transformation S :

$$S(h \oplus N) =$$

Iteration 6

$K_6 = \text{F05772AE2CE7F025156C9A7FBCC6B8FDF1E735D613946E32922994E52820FFEA}$
 $62615D907EB0551AD170990A86602088AF98C83C22CDB0E2BE297C13C0F7A156,$

$LPSX[K_6] \dots LPSX[K_1](m) = 1BC204BF9506EE9B86BBCF82D254A112AEA6910B6DB3805E399CB718D1B33199$
 $64459516967CEE4E648E8CFBF81F56DC8DA6811C469091BE5123E6A1D5E28C73.$

Iteration 7

$K_7 = 5AD144C362546E4E46B3E7688829FBB77453E9C3211974330B2B8D0E6BE2B5AC$
 $C89EB6B35167F159B7B005A43E5959A651A9B18CFC8E4098FCF03D9B81CFBB8D,$

$LPSX[K_7] \dots LPSX[K_1](m) = \text{F30D791ED78BDEE819022A3D78182242124EFCDD54E203F23FB2DC7F94338FF9}$
 $55A5AFC15FFEF03165263C4FDB36933AA982016471FBAC9419F892551E9E568B.$

Iteration 8

$K_8 = 6A6CEC9A1BA20A8DB64FA840B934352B518C638ED530122A83332FE0B8EFDAC9$
 $018287E5A9F509C78D6C746ADCD5426FB0A0AD5790DFB73FC1F191A539016DAA,$

$LPSX[K_8] \dots LPSX[K_1](m) = 1FC20F1E91A1801A4293D3F3AA9E91560FCC3810BB15F3EE9741C9B87452519F$
 $67CB9145519884A24DE6DB736A5CB1430DA7458E5E51B80BE5204BA5E2800177.$

Iteration 9

$K_9 = 99217036737AA9B38A8D6643F705BD51F351531F948F0FC5E35FA35FEE9DD8BD$
 $BB4C9D580A224E9CD82E0E2069FC49ED367D5F94374435382B8FB6A8F5DD0409,$

$LPSX[K_9] \dots LPSX[K_1](m) = 1A52F09D1E81515A36171E0B1A2809C50359BED90F2E78CBD89B7D4AFA6D0466$
 $55C96BDAE6EE97055CC7E857267C2CCF28C8F5DD95ED58A9A68C12663BB28967.$

Iteration 10

$K_{10} = 906763C0FC89FA1AE69288D8EC9E9DDA9A7630E8BFD6C3FED703C35D2E62AEAF$
 $F0B35D80A7317A7F76F83022F2526791CA8FDF678FCB337BD74FE5393CCB05D2,$

$LPSX[K_{10}] \dots LPSX[K_1](m) = 764043744A0A93687E65ABA8CFC25EC8714FB8E1BDC9AE2271E7205EAAA577C1$
 $B3B83E7325E50A19BD2D56B061B5DE39235C9C9FD95E071A1A291A5F24E8C774.$

Iteration 11

$K_{11} = 88CE996C63618E6404A5C8E03EE433854E2AE3EEE68991BBBFF3C29D38DADB6E$
 $D6A1DAE9A6DC6DDF52CE34AF272F96D3159C8C624C3FE6E13D695C0BFC89ADD5,$

$LPSX[K_{11}] \dots LPSX[K_1](m) = 9B1CE8FF26B445CB288C0AECFF84658EEA91DBDF14828BF70110A5C9BD146CD9$
 $646350CFF4E90E7B63C5CC325E9B441081935F282D4648D9584F71860538F03B.$

Iteration 12

$K_{12} = 3E0A281EA9BD46063EEC550100576F3A506AA168CF82915776B978FCCAA32F38$
 $B55F30C79982CA45628E8365D8798477E75A49C68199112A1D7B5A0F7655F2DB,$

$LPSX[K_{12}] \dots LPSX[K_1](m) = 133AECEDE251EB81914B8BA48DCBC0B8A6FC63A292CC49043C3D3346B3F0829$
 $A9CB71ECFF25ED2A91BDCF8F649907C110CB76FF2E43100CDD4BA8A147A572F5.$

Iteration 13

$K_{13} = \text{F0B273409EB31AEBE432FBAE1867212262C848422B6A92F93F6CBAB54ED18B83}$
 $14B21CFFC51E3FA319FF433E76EF6ADB0EF9F5E03C907FA1FCF9ECA06500BF03,$

$LPSX[K_{13}] \dots LPSX[K_1](m) = \text{E3889D8E40960453FD26431450BB9D29E8A78E78024656697CAF698125EE83AA}$
 $BD796D133A3BD28988428CB112766D1A1E32831F12D36FAD21B2440122A5CDF6.$

The result of the transformation $g_N(h, m)$ is

$h = \text{E3BBADB7F8AF3264C9137127608AA510DE90BA4D3075665844965FB611DBB199}$
 $8D48552A0C0CE6BCBA71BC802A4F5B2D2A07B12C22E25794178570341096FDC7.$

The variables N and Σ change their values to:

[illegible]

The result of the transformation $g_0(h, N)$ is

h = 70F22BADA4CFE18A6A56EC4B3F328CD40DB8E1BF8A9D5F711D5EFAB11191279D715AAB7648D07EDDBF87DC79C80516E6FFCBCF5678B0AC29EA00FA85C8173CC6.

The result of the transformation $g_0(h, \Sigma)$ is

h = 00557BE5E584FD52A449B16B0251D05D27F94AB76CBAA6DA890B59D8EF1E159D2088E482E2ACF564E0E9795A51E4DD261F3F667985A2FCC40AC8631FAC41709A.

The hash-code of the message M_1 is the value:

$H = 00557BE5E584FD52A449B16B0251D05D27F94AB76CBAA6DA890B59D8EF1E159D.$

B.13.3 Example 2

In this example, the data string is given as a sequence of bytes (in hexadecimal notation):

$M_2 =$ D1 E5 20 E2 E5 F2 F0 E8 2C 20 D1 F2 F0 E8 E1 EE E6 E8 20 E2 ED F3 F6 E8 2C 20 E2 E5
FE F2 FA 20 F1 20 EC EE F0 FF 20 F1 F2 F0 E5 EB E0 EC E8 20 ED E0 20 F5 F0 E0 E1 F0 FB FF
20 EF EB FA EA FB 20 C8 E3 EE F0 E5 E2 FB.

Assign the following values to the variables:

$$h := IV = (000\ 000\ 01)^{64};$$
$$N := 0512;$$
$$\Sigma := 0512.$$

The length of the message is $L_{M_2} = 576 > 512$, so a part of this message is initially processed

```
m := FBEAFAEBBF20FFFBF0E1E0F0F520E0ED20E8ECE0EBE5F0F2F120FFF0EEEC20F1
20FAF2EEE5E2202CE8F6F3EDE220E8E6EEE1E8F0F2D1202CE8F0F2E5E220E5D1.
```

Calculate $K := LPS(h \oplus N) = LPS((000\ 000\ 01)^{64})$.

After the transformation S :

$$S(h \oplus N) =$$

after the transformation P :

$$PS(h \oplus N) =$$

after the transformation L :

$$K = LPS(h \oplus N) = 23C5EE40B07B5F1523C5EE40B07B5F1523C5EE40B07B5F1523C5EE40B07B5F15$$

$$23C5EE40B07B5F1523C5EE40B07B5F1523C5EE40B07B5F1523C5EE40B07B5F15.$$

Then the transformation $E(K, m)$ is performed:

Iteration 1

$K_1 = 23C5EE40B07B5F1523C5EE40B07B5F1523C5EE40B07B5F1523C5EE40B07B5F1523C5EE40B07B5F1523C5EE40B07B5F1523C5EE40B07B5F15,$
 $X[K_1](m) = D82F14AB5F5BA0EED3240EB0455BBFF8032D02A05B9EAFE7D2E511B05E977FE4033F1CBE55997F39CB331DAD525BB7F3CD2406B042AA7F39CB351CA5525BBAC4,$
 $SX[K_1](m) = 8D4F93828747A76C49E204ADC8473BD11101DDA7470A415B832B77AD5DBC572D111F14950CE8570BE4AEC9F0E472FD2D9E231AD2C38570BE46A14000E47A586,$
 $PSX[K_1](m) = 8D49118311E4D9E44FE2012B1FAEE26A9304DD7714CD311482ADA7AD959FAD0087C8475D0C0E2C0E47470ABCE8473847A73B4157572F57A56CD15B2D0BD20B86,$
 $LPSX[K_1](m) = A3A72A2E0FB5E6F812681222FEC037B0DB972086A395A387A6084508CAE13093AA71D352DCBCE288E9A39718A727F6FD4C5DA5D0BC10FAC3707CCD127FE45475,$
 $K_1 \oplus C_1 = 92CDB59AAEB185FCC80EC1C1701E230A0CAF98039E3E8F03528B56CDC5FE9BE968B90ED1221C36148187C448141B8C0026B39A767C0F1236FE458B1942DD1A12,$
 $S(K_1 \oplus C_1) = ECD95E282645A83930045858325F5AFA2341DC110AD303110EF676D9AC63509BF3A3041B65148F93F5C986F293BB7CFCE92288AC34DF08F63C8F6362CD8F1F0,$
 $PS(K_1 \oplus C_1) = EC30230EF3F5EF63D90441F6A3C992C85E58DC76048628F6285811D91BF28A3626320AAC6593C32C455FD36314BB4DD8A85A03508F7CF0F139FA119B93FC8FF0,$
 $LPS(K_1 \oplus C_1) = 18EE8F3176B2EBEA3BD6CB8233694CEA349769DF88BE26BF451CFAB6A904A549DA22DE93A66A66B19C7E6B5EEA633511E611D68C8401BFCD0C7D0CC39D4A5EB9.$

Iteration 2

$K_2 = 18EE8F3176B2EBEA3BD6CB8233694CEA349769DF88BE26BF451CFAB6A904A549DA22DE93A66A66B19C7E6B5EEA633511E611D68C8401BFCD0C7D0CC39D4A5EB9,$
 $LPSX[K_2]LPSX[K_1](m) = 9F50697B1D9CE23680DB1F4D35629778864C55780727AA79EB7BB7D648829CBA8674AFDAC5C62CA352D77556145CA7BC758679FBE1FBD32313CA8268A4A603F1.$

Iteration 3

$K_3 = AAA4CF31A265959157AEC8CE91E7FD46BF27DEE21164C5E3940BBA1A519E9D1FCE0913F1253E7757915000CD674BE12CC7F68E73BA26FB00FD74AF4101805F2D,$
 $LPSX[K_3]...LPSX[K_1](m) = 4183027975B257E9BC239B75C977ECC52DDAD82C091E694243C9143A945B4D853116EAE14FD81B14BB47F2C06FD283CB6C5E61924EDFAF971B78D771858D5310.$

Iteration 4

$K_4 = 61FE0A65CC177AF50235E2AFADDED326A5329A2236747BF8A54228AEC9C4585CD801EA9DD743A0D98D01EF0602B0E332067FB5DDD6AC1568200311920839286,$
 $LPSX[K_4]...LPSX[K_1](m) = 0368C884FCEE489207B5B97A133CE39A1EBFE5A3AE3CCCB3241DE1E7AD72857E76811D324F01FD7A75E0B669E8A22A4D056CE6AF3E876453A9C3C47C767E5712.$

Iteration 5

$K_5 = 9983685F4FD3636F1FD5ABB75FBF26A8E2934314AA2ECB3EE4693C86C06C7D4E169BD540AF75E1610A546ACD63D960BAD595394CC199BF6999A5D5309FE73D5A,$
 $LPSX[K_5]...LPSX[K_1](m) = C31433CEB8061E46440144E6553976512E5A9806AC9A2C771D5932D5F6508C5B78E406C4EFAB98AC5529BE0021B4D58FA26F01621EB10B43DE4C4C47B63F615.$

Iteration 6

$K_6 = F05772AE2CE7F025156C9A7FBCC6B8FDF1E735D613946E32922994E52820FFEA62615D907EB0551AD170990A86602088AF98C83C22CDB0E2BE297C13C0F7A156,$
 $LPSX[K_6]...LPSX[K_1](m) = 5D0AE97F252AD04534503FE5F52E9BD07F483EE3B3D206BEADC6E736C6E754BB713F97EA7339927893EACF2B474A482CADD9AC2E58F09BCB440CF36C2D14A9B6.$

The length of the rest of the message is less than 512, so the incomplete block is padded:

[illegible]

The result of the transformation $g_N(h, m)$ is

h = A69049E7BD076AB775BC2873AF26F098C538B17E39A5C027D532F0A2B3B56426
C96B285FA297B9D39AE6AFD8B9001D97BB718A65FCC53C41B4EBF4991A617227.

The variables N and Σ change their values to:

[illegible]

The result of the transformation $g_0(h, N)$ is

$h = \text{AEE3BD55EA6F387BCF28C6DCBDBBFB3DDACC67DCC13DBD8D548C6BF808111D4B75B8E74D2AFAE960835AE6A5F03575559C9FD839783FFCD5CF99BD61566B4818.}$

The result of the transformation $g_0(h, \Sigma)$ is

h = 508F7E553C06501D749A66FC28C6CAC0B005746D97537FA85D9E40904EFED29D
C345E53D7F84875D5068E4EB743F0793D673F09741F9578471FB2598CB35C230.

The hash-code of the message M_2 is the value:

$H = 508F7E553C06501D749A66FC28C6CAC0B005746D97537FA85D9E40904EFED29D.$

B.14 Dedicated Hash-Function 13 (SHA3-224)

NOTE 1 Data is presented in three different ways: bit strings, byte strings and w -length words (for the lanes).

NOTE 2 Bit strings are the sequence of bits from left to right.

NOTE 3 Byte strings are the bytes from left to right and the bits within the byte are right to left.

NOTE 4 Words are the integer representation of the values in the lanes.

The message as bit string

(empty message)

Round #0

After θ

```

06 00 00 00 00 00 00 00 07 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
0C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
07 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 0C 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 07 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
0C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
07 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
00 00 00 00 00 00 00 80 0C 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 07 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
0C 00 00 00 00 00 00 00 00

```

After p

```

06 00 00 00 00 00 00 00 0E 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 60 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 70 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 40 00 00 00 C0 00 00 00 00 00
00 00 00 00 00 00 00 00 00 1C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 01 00 00 00 00 00
00 00 00 00 00 06 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 E0 00 00 00 40 00 00 00 00 00 00
00 00 10 00 00 00 00 00 00 0C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 1C 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
00 00 03 00 00 00 00 00 00

```

After π

```

06 00 00 00 00 00 00 00 00 00 00 00 00 00 70 00 00
00 00 00 00 00 00 00 00 00 00 00 10 00 00 00 00 00
00 00 03 00 00 00 00 00 00 00 00 00 08 00 00 00 00
00 00 C0 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 E0 00 00 00 00 00 00 00 00 00 00 00
0E 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 01 00 00 00 00 00 00 0C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 60 00 00 00 00
00 00 00 00 00 00 00 00 00 00 1C 00 00 00 00 00 00
00 40 00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 40 00
00 00 00 00 00 06 00 00 00 00 00 00 00 00 00 00 00
1C 00 00 00 00 00 00 00 00

```

After χ

```

06 00 00 00 00 00 00 00 00 00 10 00 00 70 00 00
00 00 03 00 00 00 00 00 06 00 10 00 00 00 00 00
00 00 03 00 00 70 00 00 00 00 00 08 00 00 00 00
00 00 C0 00 00 E0 00 00 00 00 00 00 00 00 00 00
00 00 00 08 00 E0 00 00 00 00 C0 00 00 00 00 00
0E 00 00 01 00 00 00 00 00 0C 00 00 00 00 00 00
00 00 00 01 00 00 00 00 0E 0C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 1C 00 60 00 00 00 00
00 40 00 00 00 00 00 00 1C 00 00 00 00 00 80 00
00 40 00 60 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 06 00 00 00 00 00 00 00 00 40 00
1C 00 00 00 00 06 00 00 00 00 00 00 00 00 00 00
1C 00 00 00 00 00 00 40 00

```

After ι

```

07 00 00 00 00 00 00 00 00 00 10 00 00 70 00 00
00 00 03 00 00 00 00 00 06 00 10 00 00 00 00 00
00 00 03 00 00 70 00 00 00 00 00 08 00 00 00 00
00 00 C0 00 00 E0 00 00 00 00 00 00 00 00 00 00
00 00 00 08 00 E0 00 00 00 00 C0 00 00 00 00 00
0E 00 00 01 00 00 00 00 00 0C 00 00 00 00 00 00
00 00 00 01 00 00 00 00 0E 0C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 1C 00 60 00 00 00 00
00 40 00 00 00 00 00 00 00 1C 00 00 00 00 00 80 00
00 40 00 60 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 06 00 00 00 00 00 00 00 00 40 00
1C 00 00 00 00 06 00 00 00 00 00 00 00 00 00 00
1C 00 00 00 00 00 00 40 00

```

(Skip rounds 1 to 22)

Round #23

After θ

23 DE E9 70 36 66 D5 23 91 03 C3 F1 B6 6B 93 28
 69 4D 53 70 6B BA E5 B1 E5 9D C2 7E 0A 05 AD B2
 50 64 AE 08 3D B0 14 9C FB 89 A8 CE 9E BA 03 4F
 0F BB 2E E3 5E 01 F0 E2 4A AC FA E8 B0 11 19 00
 D8 15 A2 68 94 D3 D6 73 A3 57 6E 6C B4 F0 14 5C
 8B F5 47 AE E7 26 8B 54 6E E4 99 A0 C5 07 C8 83
 C1 F7 03 8E 6F 5D 36 A1 B7 B6 AD B9 10 2D E1 37
 A8 AD D4 4D DA BD 72 32 08 CF 7B 7F 6E A0 15 01
 51 8F EB C7 1E C0 B6 08 CF 77 B8 E7 0C BA 43 70
 BB 4E AB 4F 60 CA 82 5E 26 37 0A 73 AA C9 00 D9
 57 78 B9 E1 BC E9 EB 13 B9 98 DD 5A FB B1 60 18
 E9 0E 7E AC F3 3F F8 6C 5A 92 4F 9E FF FD 74 FF
 FD BB E9 E8 C4 A0 D4 D6

After ρ

23 DE E9 70 36 66 D5 23 22 07 86 E3 6D D7 26 51
 5A D3 14 DC 9A 6E 79 6C 50 D0 2A 5B DE 29 EC A7
 81 A5 E0 84 22 73 45 E8 EC A9 3B F0 B4 9F 88 EA
 32 EE 15 00 2F FE B0 BB 80 12 AB 3E 3A 6C 44 06
 0A 51 34 CA 69 EB 39 EC 4F C1 35 7A E5 C6 46 0B
 5A AC 3F 72 3D 37 59 A4 0F BA 91 67 82 16 1F 20
 70 7C EB B2 09 0D BE 1F 5A C2 6F 6E 6D 5B 73 21
 26 ED 5E 39 19 D4 56 EA FE DC 40 2B 02 10 9E F7
 FD D8 03 D8 16 21 EA 71 21 B8 E7 3B DC 73 06 DD
 59 D0 6B D7 69 F5 09 4C D9 26 37 0A 73 AA C9 00
 AF 4F 5C E1 E5 86 F3 A6 E4 62 76 6B ED C7 82 61
 DD C1 8F 75 FE 07 9F 2D 92 4F 9E FF FD 74 FF 5A
 B5 75 FF 6E 3A 3A 31 28

After π

23 DE E9 70 36 66 D5 23 32 EE 15 00 2F FE B0 EB
 70 7C EB B2 09 0D BE 1F 59 D0 6B D7 69 F5 09 4C
 B5 75 FF 6E 3A 3A 31 28 50 D0 2A 5B DE 29 EC A7
 4F C1 35 7A E5 C6 46 0B 5A AC 3F 72 3D 37 59 A4
 FD D8 03 D8 16 21 EA 71 DD C1 8F 75 FE 07 9F 2D
 22 07 86 E3 6D D7 26 51 80 12 AB 3E 3A 6C 44 06
 5A C2 6F 6E 6D 5B 73 21 D9 26 37 0A 73 AA C9 00
 AF 4F 5C E1 E5 86 F3 A6 81 A5 E0 84 22 73 45 E8
 EC A9 3B F0 B4 9F 88 EA 0F BA 91 67 82 16 1F 20
 21 B8 E7 3B DC 73 06 DD 92 4F 9E FF FD 74 FF 5A
 5A D3 14 DC 9A 6E 79 6C 0A 51 34 CA 69 EB 39 EC
 26 ED 5E 39 19 D4 56 EA FE DC 40 2B 02 10 9E F7
 E4 62 76 6B ED C7 82 61

After χ

63 CE 03 C2 36 67 DB 37 3B 6E 15 45 4F 0E B1 AB
 D4 59 7F 9A 1B 07 8E 3F 5B 5A 6B C7 6D B1 CD 4F
 A5 55 EB 6E 33 A2 11 E0 40 FC 20 5B C6 18 F5 03
 EA 91 35 F2 E7 C6 E4 5A 5A AD B3 57 D5 31 4C A8
 FD C8 23 D2 16 09 8A F3 D2 C0 9A 55 DF C1 9D 25
 78 C7 C2 A3 28 C4 15 70 01 36 BB 3E 28 CC CC 06
 7C 8B 27 8F E9 5F 41 87 D9 26 B5 08 7B FB CD 51
 2F 5F 75 FD F7 AE B3 A0 82 B7 60 83 20 73 52 E8
 CC A9 5D E8 E8 FE 88 37 9D FD 89 A3 A3 12 E6 22
 20 18 87 3B DE 70 06 7D FE 47 85 8F 69 F8 77 58
 7E 7F 5E ED 8A 7A 3F 6E D2 41 34 C8 6B EB B1 F9
 26 CF 68 79 F4 13 56 EA E4 4D 40 BF 10 38 E7 FB
 E4 62 56 69 8C 46 82 E1

After ι

6B 4E 03 42 36 67 DB B7 3B 6E 15 45 4F 0E B1 AB
 D4 59 7F 9A 1B 07 8E 3F 5B 5A 6B C7 6D B1 CD 4F
 A5 55 EB 6E 33 A2 11 E0 40 FC 20 5B C6 18 F5 03
 EA 91 35 F2 E7 C6 E4 5A 5A AD B3 57 D5 31 4C A8
 FD C8 23 D2 16 09 8A F3 D2 C0 9A 55 DF C1 9D 25
 78 C7 C2 A3 28 C4 15 70 01 36 BB 3E 28 CC CC 06
 7C 8B 27 8F E9 5F 41 87 D9 26 B5 08 7B FB CD 51
 2F 5F 75 FD F7 AE B3 A0 82 B7 60 83 20 73 52 E8
 CC A9 5D E8 E8 FE 88 37 9D FD 89 A3 A3 12 E6 22
 20 18 87 3B DE 70 06 7D FE 47 85 8F 69 F8 77 58
 7E 7F 5E ED 8A 7A 3F 6E D2 41 34 C8 6B EB B1 F9
 26 CF 68 79 F4 13 56 EA E4 4D 40 BF 10 38 E7 FB
 E4 62 56 69 8C 46 82 E1

After permutation

```

6B 4E 03 42 36 67 DB B7 3B 6E 15 45 4F 0E B1 AB
D4 59 7F 9A 1B 07 8E 3F 5B 5A 6B C7 6D B1 CD 4F
A5 55 EB 6E 33 A2 11 E0 40 FC 20 5B C6 18 F5 03
EA 91 35 F2 E7 C6 E4 5A 5A AD B3 57 D5 31 4C A8
FD C8 23 D2 16 09 8A F3 D2 C0 9A 55 DF C1 9D 25
78 C7 C2 A3 28 C4 15 70 01 36 BB 3E 28 CC CC 06
7C 8B 27 8F E9 5F 41 87 D9 26 B5 08 7B FB CD 51
2F 5F 75 FD F7 AE B3 A0 82 B7 60 83 20 73 52 E8
CC A9 5D E8 E8 FE 88 37 9D FD 89 A3 A3 12 E6 22
20 18 87 3B DE 70 06 7D FE 47 85 8F 69 F8 77 58
7E 7F 5E ED 8A 7A 3F 6E D2 41 34 C8 6B EB B1 F9
26 CF 68 79 F4 13 56 EA E4 4D 40 BF 10 38 E7 FB
E4 62 56 69 8C 46 82 E1

```

State (as lanes of integers)

```

[0, 0] = B7DB673642034E6B
[1, 0] = ABB10E4F45156E3B
[2, 0] = 3F8E071B9A7F59D4
[3, 0] = 4FCDB16DC76B5A5B
[4, 0] = E011A2336EEB55A5
[0, 1] = 03F518C65B20FC40
[1, 1] = 5AE4C6E7F23591EA
[2, 1] = A84C31D557B3AD5A
[3, 1] = F38A0916D223C8FD
[4, 1] = 259DC1DF559AC0D2
[0, 2] = 7015C428A3C2C778
[1, 2] = 06CCCC283EBB3601
[2, 2] = 87415FE98F278B7C
[3, 2] = 51CDFB7B08B526D9
[4, 2] = A0B3AEF7FD755F2F
[0, 3] = E85273208360B782
[1, 3] = 3788FEE8E85DA9CC
[2, 3] = 22E612A3A389FD9D
[3, 3] = 7D0670DE3B871820
[4, 3] = 5877F8698F8547FE
[0, 4] = 6E3F7A8AED5E7F7E
[1, 4] = F9B1EB6BC83441D2
[2, 4] = EA5613F47968CF26
[3, 4] = FBE73810BF404DE4
[4, 4] = E182468C695662E4

```

The hash value is

```

6B 4E 03 42 36 67 DB B7 3B 6E 15 45 4F 0E B1 AB
D4 59 7F 9A 1B 07 8E 3F 5B 5A 6B C7

```

The message as bit string

1 1 0 0 1

XORed state (in bytes)

```
D3 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

XORed state (as lanes of integers)

```
[0,0] = 0000000000000000D3
[1,0] = 000000000000000000
[2,0] = 000000000000000000
[3,0] = 000000000000000000
[4,0] = 000000000000000000
[0,1] = 000000000000000000
[1,1] = 000000000000000000
[2,1] = 000000000000000000
[3,1] = 000000000000000000
[4,1] = 000000000000000000
[0,2] = 000000000000000000
[1,2] = 000000000000000000
[2,2] = 000000000000000000
[3,2] = 000000000000000000
[4,2] = 000000000000000000
[0,3] = 000000000000000000
[1,3] = 000000000000000000
[2,3] = 800000000000000000
[3,3] = 000000000000000000
[4,3] = 000000000000000000
[0,4] = 000000000000000000
[1,4] = 000000000000000000
[2,4] = 000000000000000000
[3,4] = 000000000000000000
[4,4] = 000000000000000000
```

Round #0

After θ

```

D3 00 00 00 00 00 00 00 00 D2 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
A6 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00
D2 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 A6 01 00 00 00 00 00 00
00 00 00 00 00 00 00 00 D2 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
A6 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00
D2 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
00 00 00 00 00 00 00 80 A6 01 00 00 00 00 00 00
00 00 00 00 00 00 00 00 D2 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
A6 01 00 00 00 00 00 00

```

After ρ

```

D3 00 00 00 00 00 00 00 00 A4 01 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 08 00 00 00 00
00 00 00 30 0D 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 20 0D 00 00 00 00 00 00 00 00 00
00 00 00 00 00 40 00 00 00 60 1A 00 00 00 00 00
00 00 00 00 00 00 00 00 00 48 03 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 01 00 00 00 00
00 00 00 00 00 D3 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 40 1A 00 00 40 00 00 00 00 00 00
00 00 10 00 00 00 00 00 00 A6 01 00 00 00 00 00
00 00 00 00 00 00 00 00 48 03 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
00 80 69 00 00 00 00 00

```

After π

```

D3 00 00 00 00 00 00 00 00 00 00 00 00 20 0D 00
00 00 00 00 00 00 00 00 00 00 10 00 00 00 00 00
00 80 69 00 00 00 00 00 00 00 00 08 00 00 00 00
00 00 60 1A 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 40 1A 00 00 00 00 00 00 00 00 00
A4 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 01 00 00 00 00 00 A6 01 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 30 0D 00 00 00
00 00 00 00 00 00 00 00 00 48 03 00 00 00 00 00
00 40 00 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 00 00 00 00 00 00 00 00 40 00
00 00 00 00 00 D3 00 00 00 00 00 00 00 00 00 00
48 03 00 00 00 00 00 00

```

After χ

```

D3 00 00 00 00 00 00 00 00 00 00 10 00 00 20 0D 00
00 80 69 00 00 00 00 00 D3 00 10 00 00 00 00 00
00 80 69 00 00 20 0D 00 00 00 00 08 00 00 00 00
00 00 60 1A 00 40 1A 00 00 00 00 00 00 00 00 00
00 00 00 08 00 40 1A 00 00 00 60 12 00 00 00 00
A4 01 00 01 00 00 00 00 00 A6 01 00 00 00 00 00
00 00 00 01 00 00 00 00 A4 A7 01 00 00 00 00 00
00 00 00 00 00 00 00 00 00 48 03 30 0D 00 00 00
00 00 00 00 00 00 00 00 00 48 03 00 00 00 80 00
00 40 00 30 0D 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 D3 00 00 00 00 00 00 00 00 40 00
48 03 00 00 00 D3 00 00 00 00 00 00 00 00 00 00
48 03 00 00 00 00 00 40 00

```

After ι

```

D2 00 00 00 00 00 00 00 00 00 00 10 00 00 20 0D 00
00 80 69 00 00 00 00 00 D3 00 10 00 00 00 00 00
00 80 69 00 00 20 0D 00 00 00 00 08 00 00 00 00
00 00 60 1A 00 40 1A 00 00 00 00 00 00 00 00 00
00 00 00 08 00 40 1A 00 00 00 60 12 00 00 00 00
A4 01 00 01 00 00 00 00 00 A6 01 00 00 00 00 00
00 00 00 01 00 00 00 00 A4 A7 01 00 00 00 00 00
00 00 00 00 00 00 00 00 00 48 03 30 0D 00 00 00
00 00 00 00 00 00 00 00 00 48 03 00 00 00 80 00
00 40 00 30 0D 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 D3 00 00 00 00 00 00 00 00 40 00
48 03 00 00 00 D3 00 00 00 00 00 00 00 00 00 00
48 03 00 00 00 00 00 40 00

```

(Skip rounds 1 to 22)

Round #23

After θ

F1 B2 6C 63 94 B2 D4 96 0E 77 89 20 45 67 B5 7C
 54 76 53 B2 CE 42 7B 45 AE 9C D3 5B 7D 3F CF AE
 5B 7D 43 7B 5E D3 9D 8C F4 DB 13 5D 1B 41 E2 B6
 46 CE 85 7D 63 60 CC 3C C5 13 00 F1 9C 26 46 A3
 68 C9 F4 D7 8F 18 5A 2D 03 51 B3 76 FE 9A 0E 6D
 BF 8F A8 FD 7F D7 11 34 54 ED D4 9D 1F 53 45 90
 69 AC C0 01 37 37 47 30 30 86 B5 81 65 DB E4 45
 E0 E7 D6 4F 28 A3 E0 80 07 AA 7C B5 8D 7A 33 8F
 71 1B 55 70 8B 4C 36 EA 61 D3 13 EE B4 F3 C5 41
 40 86 6C 78 8D CD 22 A5 C3 9C 81 D4 B3 0A 5F AE
 1E 60 28 D1 E3 5A FD A4 F7 A3 3B 46 53 BE 04 26
 26 27 89 FB B3 CA 06 B9 A2 E1 6E 85 C6 1E BB 54
 7A 50 60 9F 7C 51 80 37

After p

F1 B2 6C 63 94 B2 D4 96 1C EE 12 41 8A CE 6A F9
 95 DD 94 AC B3 D0 5E 11 F7 F3 EC EA CA 39 BD D5
 9A EE 64 DC EA 1B DA F3 B5 11 24 6E 4B BF 3D D1
 D8 37 06 C6 CC 63 E4 5C 68 F1 04 40 3C A7 89 D1
 64 FA EB 47 0C AD 16 B4 E9 D0 36 10 35 6B E7 AF
 F9 7D 44 ED FF BB 8E A0 41 52 B5 53 77 7E 4C 15
 0E B8 B9 39 82 49 63 05 B6 C9 8B 60 0C 6B 03 CB
 27 94 51 70 40 F0 73 EB 6A 1B F5 66 1E 0F 54 F9
 0A 6E 91 C9 46 3D 6E A3 E2 A0 B0 E9 09 77 DA F9
 59 A4 14 C8 90 0D AF B1 AE C3 9C 81 D4 B3 0A 5F
 F5 93 7A 80 A1 44 8F 6B DC 8F EE 18 4D F9 12 98
 E4 24 71 7F 56 D9 20 D7 E1 6E 85 C6 1E BB 54 A2
 E0 8D 1E 14 D8 27 5F 14

After π

F1 B2 6C 63 94 B2 D4 96 D8 37 06 C6 CC 63 E4 5C
 0E B8 B9 39 82 49 63 05 59 A4 14 C8 90 0D AF B1
 E0 8D 1E 14 D8 27 5F 14 F7 F3 EC EA CA 39 BD D5
 E9 D0 36 10 35 6B E7 AF F9 7D 44 ED FF BB 8E A0
 0A 6E 91 C9 46 3D 6E A3 E4 24 71 7F 56 D9 20 D7
 1C EE 12 41 8A CE 6A F9 68 F1 04 40 3C A7 89 D1
 B6 C9 8B 60 0C 6B 03 CB AE C3 9C 81 D4 B3 0A 5F
 F5 93 7A 80 A1 44 8F 6B 9A EE 64 DC EA 1B DA F3
 B5 11 24 6E 4B BF 3D D1 41 52 B5 53 77 7E 4C 15
 E2 A0 B0 E9 09 77 DA F9 E1 6E 85 C6 1E BB 54 A2
 95 DD 94 AC B3 D0 5E 11 64 FA EB 47 0C AD 16 B4
 27 94 51 70 40 F0 73 EB 6A 1B F5 66 1E 0F 54 F9
 DC 8F EE 18 4D F9 12 98

After χ

```
F7 3A D5 5A 96 BA D7 97 89 33 02 06 DC 67 68 EC
AE B1 B3 2D CA 6B 33 01 48 96 74 AB 94 9D 2F 33
E8 88 1C 90 90 66 7F 5C E7 DE AC 07 00 A9 B5 D5
EB D2 A7 10 35 6F 87 AC 1D 7D 24 DB EF 7B 8E F4
19 BD 1D 49 CE 1D F3 A3 EC 24 63 6F 63 9B 62 FD
8A E6 99 61 8A 86 68 F3 60 F3 10 C1 EC 37 81 C5
E7 D9 E9 60 2D 2F 86 EB A6 AF 9C C0 DE 39 6A CF
95 82 7E 80 95 65 0E 6B DA AC F5 CD DE 5B 9A F7
17 B1 24 C6 43 BE AF 39 40 1C B0 55 61 F6 48 17
F8 20 D0 F1 E9 77 50 A8 C4 7F 85 E4 1F 1F 71 A2
96 D9 84 9C F3 80 3F 5A 2C F1 4F 41 12 A2 12 A4
B3 10 5B 68 01 00 71 EB 6B 4B E5 C2 AC 0F 18 F8
BC AD 85 5B 41 D4 12 3C
```

After ι

```
FF BA D5 DA 96 BA D7 17 89 33 02 06 DC 67 68 EC
AE B1 B3 2D CA 6B 33 01 48 96 74 AB 94 9D 2F 33
E8 88 1C 90 90 66 7F 5C E7 DE AC 07 00 A9 B5 D5
EB D2 A7 10 35 6F 87 AC 1D 7D 24 DB EF 7B 8E F4
19 BD 1D 49 CE 1D F3 A3 EC 24 63 6F 63 9B 62 FD
8A E6 99 61 8A 86 68 F3 60 F3 10 C1 EC 37 81 C5
E7 D9 E9 60 2D 2F 86 EB A6 AF 9C C0 DE 39 6A CF
95 82 7E 80 95 65 0E 6B DA AC F5 CD DE 5B 9A F7
17 B1 24 C6 43 BE AF 39 40 1C B0 55 61 F6 48 17
F8 20 D0 F1 E9 77 50 A8 C4 7F 85 E4 1F 1F 71 A2
96 D9 84 9C F3 80 3F 5A 2C F1 4F 41 12 A2 12 A4
B3 10 5B 68 01 00 71 EB 6B 4B E5 C2 AC 0F 18 F8
BC AD 85 5B 41 D4 12 3C
```

After permutation

```
FF BA D5 DA 96 BA D7 17 89 33 02 06 DC 67 68 EC
AE B1 B3 2D CA 6B 33 01 48 96 74 AB 94 9D 2F 33
E8 88 1C 90 90 66 7F 5C E7 DE AC 07 00 A9 B5 D5
EB D2 A7 10 35 6F 87 AC 1D 7D 24 DB EF 7B 8E F4
19 BD 1D 49 CE 1D F3 A3 EC 24 63 6F 63 9B 62 FD
8A E6 99 61 8A 86 68 F3 60 F3 10 C1 EC 37 81 C5
E7 D9 E9 60 2D 2F 86 EB A6 AF 9C C0 DE 39 6A CF
95 82 7E 80 95 65 0E 6B DA AC F5 CD DE 5B 9A F7
17 B1 24 C6 43 BE AF 39 40 1C B0 55 61 F6 48 17
F8 20 D0 F1 E9 77 50 A8 C4 7F 85 E4 1F 1F 71 A2
96 D9 84 9C F3 80 3F 5A 2C F1 4F 41 12 A2 12 A4
B3 10 5B 68 01 00 71 EB 6B 4B E5 C2 AC 0F 18 F8
BC AD 85 5B 41 D4 12 3C
```

State (as lanes of integers)

[0, 0] = 17D7BA96DAD5BAFF
 [1, 0] = EC6867DC06023389
 [2, 0] = 01336BCA2DB3B1AE
 [3, 0] = 332F9D94AB749648
 [4, 0] = 5C7F6690901C88E8
 [0, 1] = D5B5A90007ACDEE7
 [1, 1] = AC876F3510A7D2EB
 [2, 1] = F48E7BEFDB247D1D
 [3, 1] = A3F31DCE491DBD19
 [4, 1] = FD629B636F6324EC
 [0, 2] = F368868A6199E68A
 [1, 2] = C58137ECC110F360
 [2, 2] = EB862F2D60E9D9E7
 [3, 2] = CF6A39DEC09CAFA6
 [4, 2] = 6B0E6595807E8295
 [0, 3] = F79A5BDECDF5ACDA
 [1, 3] = 39AFBE43C624B117
 [2, 3] = 1748F66155B01C40
 [3, 3] = A85077E9F1D020F8
 [4, 3] = A2711F1FE4857FC4
 [0, 4] = 5A3F80F39C84D996
 [1, 4] = A412A212414FF12C
 [2, 4] = EB710001685B10B3
 [3, 4] = F8180FACC2E54B6B
 [4, 4] = 3C12D4415B85ADBC

The hash value is

FF BA D5 DA 96 BA D7 17 89 33 02 06 DC 67 68 EC
 AE B1 B3 2D CA 6B 33 01 48 96 74 AB

The message as bit string

110010100001101011011110100110

After θ

```

53 58 7B 99 01 00 00 00 52 58 7B 99 01 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
A6 B0 F6 32 03 00 00 00 00 00 00 00 00 00 00
52 58 7B 99 01 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 A6 B0 F6 32 03 00 00 00
00 00 00 00 00 00 00 00 52 58 7B 99 01 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
A6 B0 F6 32 03 00 00 00 00 00 00 00 00 00 00
52 58 7B 99 01 00 00 00 00 00 00 00 00 00 80
00 00 00 00 00 00 00 80 A6 B0 F6 32 03 00 00 00
00 00 00 00 00 00 00 00 52 58 7B 99 01 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
A6 B0 F6 32 03 00 00 00

```

After ρ

```

53 58 7B 99 01 00 00 00 A4 B0 F6 32 03 00 00 00
00 00 00 00 00 00 00 00 00 00 00 08 00 00 00
00 00 00 30 85 B5 97 19 00 00 00 00 00 00 00
97 19 00 00 00 20 85 B5 00 00 00 00 00 00 00
00 00 00 00 00 00 40 00 00 00 60 0A 6B 2F 33 00
00 00 00 00 00 00 00 00 00 48 61 ED 65 06 00 00
00 00 00 00 00 00 00 00 00 00 00 01 00 00 00
99 01 00 00 00 53 58 7B 00 00 00 00 00 00 00 00
2F 33 00 00 00 40 0A 6B 00 40 00 00 00 00 00 00
00 00 10 00 00 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 00 00 00 00 00 00 48 61 ED 65 06 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
00 80 29 AC BD CC 00 00

```

After π

```

53 58 7B 99 01 00 00 00 97 19 00 00 00 20 85 B5
00 00 00 00 00 00 00 00 00 00 10 00 00 00 00
00 80 29 AC BD CC 00 00 00 00 00 08 00 00 00
00 00 60 0A 6B 2F 33 00 00 00 00 00 00 00 00
2F 33 00 00 00 40 0A 6B 00 00 00 00 00 00 00
A4 B0 F6 32 03 00 00 00 00 00 00 00 00 00 00
00 00 00 01 00 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 00 00 00 00 00 00 00 00 30 85 B5 97 19
00 00 00 00 00 00 00 00 00 48 61 ED 65 06 00 00
00 40 00 00 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 00 00 00 00 00 00 00 00 40 00
99 01 00 00 00 53 58 7B 00 00 00 00 00 00 00 00
48 61 ED 65 06 00 00 00

```


After χ

```

53 58 7B 99 01 00 00 00 97 19 10 00 00 20 85 B5
00 80 29 AC BD CC 00 00 53 58 42 11 00 00 00 00
84 81 29 AC BD EC 85 B5 00 00 00 08 00 00 00 00
2F 33 60 0A 6B 6F 39 6B 00 00 00 00 00 00 00
2F 33 00 08 00 40 0A 6B 00 00 60 02 6B 2F 33 00
A4 B0 F6 33 03 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 00 01 00 00 00 00 A4 16 46 C4 31 03 00 00
00 00 00 00 00 00 00 00 00 48 61 DD E0 B3 97 19
00 00 00 00 00 00 00 00 00 48 61 ED 65 06 80 00
00 40 00 30 85 B5 17 19 00 00 00 00 00 00 80 00
99 01 00 00 00 53 18 7B 00 00 00 00 00 00 40 00
D1 60 ED 65 06 53 58 7B 00 00 00 00 00 00 00 00
48 61 ED 65 06 00 40 00

```

After ι

```

52 58 7B 99 01 00 00 00 97 19 10 00 00 20 85 B5
00 80 29 AC BD CC 00 00 53 58 42 11 00 00 00 00
84 81 29 AC BD EC 85 B5 00 00 00 08 00 00 00 00
2F 33 60 0A 6B 6F 39 6B 00 00 00 00 00 00 00
2F 33 00 08 00 40 0A 6B 00 00 60 02 6B 2F 33 00
A4 B0 F6 33 03 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 00 01 00 00 00 00 A4 16 46 C4 31 03 00 00
00 00 00 00 00 00 00 00 00 48 61 DD E0 B3 97 19
00 00 00 00 00 00 00 00 00 48 61 ED 65 06 80 00
00 40 00 30 85 B5 17 19 00 00 00 00 00 00 80 00
99 01 00 00 00 53 18 7B 00 00 00 00 00 00 40 00
D1 60 ED 65 06 53 58 7B 00 00 00 00 00 00 00 00
48 61 ED 65 06 00 40 00

```

(Skip rounds 1 to 22)

Round #23

After θ

CE E6 EC 95 C4 F1 D8 BE 89 31 6B F4 37 BB C3 10
 46 14 61 DF BC 87 EF 0F 7C 55 5A 24 86 54 37 D8
 E0 AC 13 D8 C4 E5 DC 0C BC DD EA C7 B1 17 C3 F5
 41 48 C6 E8 05 49 7A 33 D1 C3 AD 43 DF 01 5E E4
 AF EA B8 23 BA 81 44 F2 56 FF D3 33 B8 A2 FF 0D
 66 1F C1 21 27 77 E0 C1 ED D6 CD 84 64 57 02 47
 4F 6C 0F 52 20 B9 70 E3 95 51 E1 60 70 06 90 DD
 B2 8C 8D 91 20 D9 F9 1D 8A 76 62 3E 60 C1 97 44
 37 A2 56 38 9C 16 44 AE FD 9C 49 06 FA 9C 97 F4
 F7 3D FF 14 64 81 29 FA 0C 03 CB 10 7C 02 86 C2
 E6 06 57 D7 E2 04 71 0E 66 BA 6D 70 70 41 C2 7E
 40 7A 6A 65 1B F2 98 0C 22 EB 06 C8 20 08 1E B5
 76 CB 0C 95 A6 57 FB B1

After ρ

CE E6 EC 95 C4 F1 D8 BE 12 63 D6 E8 6F 76 87 21
 11 45 D8 37 EF E1 FB 83 48 75 83 CD 57 A5 45 62
 2E E7 66 00 67 9D C0 26 1C 7B 31 5C CF DB AD 7E
 8C 5E 90 A4 37 13 84 64 79 F4 70 EB D0 77 80 17
 75 DC 11 DD 40 22 F9 57 FA DF 60 F5 3F 3D 83 2B
 36 FB 08 0E 39 B9 03 0F 1C B5 5B 37 13 92 5D 09
 90 02 C9 85 1B 7F 62 7B 0C 20 BB 2B A3 C2 C1 E0
 48 90 EC FC 0E 59 C6 C6 7C C0 82 2F 89 14 ED C4
 0A 87 D3 82 C8 F5 46 D4 4B FA 7E CE 24 03 7D CE
 30 45 FF BE E7 9F 82 2C C2 0C 03 CB 10 7C 02 86
 C4 39 98 1B 5C 5D 8B 13 99 E9 B6 C1 C1 05 09 FB
 48 4F AD 6C 43 1E 93 01 EB 06 C8 20 08 1E B5 22
 7E AC DD 32 43 A5 E9 D5

After π

CE E6 EC 95 C4 F1 D8 BE 8C 5E 90 A4 37 13 84 64
 90 02 C9 85 1B 7F 62 7B 30 45 FF BE E7 9F 82 2C
 7E AC DD 32 43 A5 E9 D5 48 75 83 CD 57 A5 45 62
 FA DF 60 F5 3F 3D 83 2B 36 FB 08 0E 39 B9 03 0F
 0A 87 D3 82 C8 F5 46 D4 48 4F AD 6C 43 1E 93 01
 12 63 D6 E8 6F 76 87 21 79 F4 70 EB D0 77 80 17
 0C 20 BB 2B A3 C2 C1 E0 C2 0C 03 CB 10 7C 02 86
 C4 39 98 1B 5C 5D 8B 13 2E E7 66 00 67 9D C0 26
 1C 7B 31 5C CF DB AD 7E 1C B5 5B 37 13 92 5D 09
 4B FA 7E CE 24 03 7D CE EB 06 C8 20 08 1E B5 22
 11 45 D8 37 EF E1 FB 83 75 DC 11 DD 40 22 F9 57
 48 90 EC FC 0E 59 C6 C6 7C C0 82 2F 89 14 ED C4
 99 E9 B6 C1 C1 05 09 FB

After χ

```

DE E6 A5 94 CC 9D BA A5 AC 1B A6 9E D3 93 04 60
DE AA C9 85 1B 5F 0B AA B0 07 DF 3B 63 CF 92 06
7E B4 CD 12 70 A7 ED 95 4C 55 8B C7 57 25 45 66
F2 DB B3 75 FF 79 C7 FB 76 B3 24 62 3A B3 92 0E
0A B7 D1 03 DC 54 02 B6 FA C5 CD 5C 6B 06 11 08
16 63 5D E8 4C F6 C6 C1 BB F8 70 2B C0 4B 82 11
08 11 23 3B EF C3 48 F1 D0 4E 45 2B 33 5E 06 A6
AD AD B8 18 CC 5C 8B 05 2E 63 2C 23 77 9D 90 27
5F 31 15 94 EB DA 8D B8 BC B1 DB 17 1B 8E DD 29
4F 1B 58 CE 43 82 3D CA FB 1E D9 7C 80 5C 98 7A
19 45 34 17 E1 B8 FD 03 41 9C 13 DE C1 26 D0 57
C9 B9 D8 3C 4E 58 C6 FD 7C C4 CA 19 A7 F4 1F C4
FD 71 B7 09 C1 07 09 AF

```

After ι

```

D6 66 A5 14 CC 9D BA 25 AC 1B A6 9E D3 93 04 60
DE AA C9 85 1B 5F 0B AA B0 07 DF 3B 63 CF 92 06
7E B4 CD 12 70 A7 ED 95 4C 55 8B C7 57 25 45 66
F2 DB B3 75 FF 79 C7 FB 76 B3 24 62 3A B3 92 0E
0A B7 D1 03 DC 54 02 B6 FA C5 CD 5C 6B 06 11 08
16 63 5D E8 4C F6 C6 C1 BB F8 70 2B C0 4B 82 11
08 11 23 3B EF C3 48 F1 D0 4E 45 2B 33 5E 06 A6
AD AD B8 18 CC 5C 8B 05 2E 63 2C 23 77 9D 90 27
5F 31 15 94 EB DA 8D B8 BC B1 DB 17 1B 8E DD 29
4F 1B 58 CE 43 82 3D CA FB 1E D9 7C 80 5C 98 7A
19 45 34 17 E1 B8 FD 03 41 9C 13 DE C1 26 D0 57
C9 B9 D8 3C 4E 58 C6 FD 7C C4 CA 19 A7 F4 1F C4
FD 71 B7 09 C1 07 09 AF

```

After permutation

```

D6 66 A5 14 CC 9D BA 25 AC 1B A6 9E D3 93 04 60
DE AA C9 85 1B 5F 0B AA B0 07 DF 3B 63 CF 92 06
7E B4 CD 12 70 A7 ED 95 4C 55 8B C7 57 25 45 66
F2 DB B3 75 FF 79 C7 FB 76 B3 24 62 3A B3 92 0E
0A B7 D1 03 DC 54 02 B6 FA C5 CD 5C 6B 06 11 08
16 63 5D E8 4C F6 C6 C1 BB F8 70 2B C0 4B 82 11
08 11 23 3B EF C3 48 F1 D0 4E 45 2B 33 5E 06 A6
AD AD B8 18 CC 5C 8B 05 2E 63 2C 23 77 9D 90 27
5F 31 15 94 EB DA 8D B8 BC B1 DB 17 1B 8E DD 29
4F 1B 58 CE 43 82 3D CA FB 1E D9 7C 80 5C 98 7A
19 45 34 17 E1 B8 FD 03 41 9C 13 DE C1 26 D0 57
C9 B9 D8 3C 4E 58 C6 FD 7C C4 CA 19 A7 F4 1F C4
FD 71 B7 09 C1 07 09 AF

```

State (as lanes of integers)

[0, 0] = 25BA9DCC14A566D6
 [1, 0] = 600493D39EA61BAC
 [2, 0] = AA0B5F1B85C9AADE
 [3, 0] = 0692CF633BDF07B0
 [4, 0] = 95EDA77012CDB47E
 [0, 1] = 66452557C78B554C
 [1, 1] = FBC779FF75B3DBF2
 [2, 1] = 0E92B33A6224B376
 [3, 1] = B60254DC03D1B70A
 [4, 1] = 0811066B5CCDC5FA
 [0, 2] = C1C6F64CE85D6316
 [1, 2] = 11824BC02B70F8BB
 [2, 2] = F148C3EF3B231108
 [3, 2] = A6065E332B454ED0
 [4, 2] = 058B5CCC18B8ADAD
 [0, 3] = 27909D77232C632E
 [1, 3] = B88DDAEB9415315F
 [2, 3] = 29DD8E1B17DBB1BC
 [3, 3] = CA3D8243CE581B4F
 [4, 3] = 7A985C807CD91EFB
 [0, 4] = 03FDB8E117344519
 [1, 4] = 57D026C1DE139C41
 [2, 4] = FDC6584E3CD8B9C9
 [3, 4] = C41FF4A719CAC47C
 [4, 4] = AF0907C109B771FD

The hash value is

D6 66 A5 14 CC 9D BA 25 AC 1B A6 9E D3 93 04 60
 DE AA C9 85 1B 5F 0B AA B0 07 DF 3B

B.15 Dedicated Hash-Function 14 (SHA3-256)

NOTE 1 Data is presented in three different ways: bit strings, byte strings and w-length words (for the lanes).

NOTE 2 Bit strings are the sequence of bits from left to right.

NOTE 3 Byte strings are the bytes from left to right and the bits within the byte are right to left.

NOTE 4 Words are the integer representation of the values in the lanes.

The message as bit string

(empty message)

XORed state (in bytes)

[illegible]

XORed state (as lanes of integers)

[0, 0] = 000000000000000006
[1, 0] = 000000000000000000
[2, 0] = 000000000000000000
[3, 0] = 000000000000000000
[4, 0] = 000000000000000000
[0, 1] = 000000000000000000
[1, 1] = 000000000000000000
[2, 1] = 000000000000000000
[3, 1] = 000000000000000000
[4, 1] = 000000000000000000
[0, 2] = 000000000000000000
[1, 2] = 000000000000000000
[2, 2] = 000000000000000000
[3, 2] = 000000000000000000
[4, 2] = 000000000000000000
[0, 3] = 000000000000000000
[1, 3] = 800000000000000000
[2, 3] = 000000000000000000
[3, 3] = 000000000000000000
[4, 3] = 000000000000000000
[0, 4] = 000000000000000000
[1, 4] = 000000000000000000
[2, 4] = 000000000000000000
[3, 4] = 000000000000000000
[4, 4] = 000000000000000000

Round #0

After θ

```

07 00 00 00 00 00 00 00 06 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
0C 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00
06 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
00 00 00 00 00 00 00 00 0C 00 00 00 00 00 00 00
01 00 00 00 00 00 00 00 06 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
0C 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00
06 00 00 00 00 00 00 80 00 00 00 00 00 00 00 80
00 00 00 00 00 00 00 00 0C 00 00 00 00 00 00 00
01 00 00 00 00 00 00 00 06 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
0C 00 00 00 00 00 00 00 00 00 00 00 00 00 00

```

After ρ

```

07 00 00 00 00 00 00 00 0C 00 00 00 00 00 00 00
00 00 00 00 00 00 00 20 00 00 00 00 00 00 00 00
00 00 00 60 00 00 00 00 00 00 00 00 00 10 00 00
00 00 00 00 00 60 00 00 20 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
08 00 00 00 00 00 00 00 00 18 00 00 00 00 00 00
00 00 00 00 00 04 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 06 00 00 00 00 00 00 00 02 00 00
00 00 00 00 00 D0 00 00 00 40 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 0C 00 00 00 00 00 00
00 00 04 00 00 00 00 00 18 00 00 00 00 00 00 00
00 00 00 00 00 00 00 10 00 00 00 00 00 00 00 00
00 00 03 00 00 00 00 00 00

```

After π

```

07 00 00 00 00 00 00 00 00 00 00 00 00 60 00 00
00 00 00 00 00 04 00 00 00 00 00 00 00 00 00 00
00 00 03 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 C0 00 00 00 00 00 08 00 00 00 00 00 00 00
00 00 00 00 00 D0 00 00 00 00 00 00 00 00 10 00
0C 00 00 00 00 00 00 00 20 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 0C 00 00 00 00 00 00
00 00 04 00 00 00 00 00 00 00 00 60 00 00 00 00
00 00 00 00 10 00 00 00 00 18 00 00 00 00 00 00
00 40 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 20 00 00 00 00 00 00 00 00
00 00 00 00 00 06 00 00 00 00 00 00 00 02 00 00
18 00 00 00 00 00 00 00 00

```

After χ

```

07 00 00 00 00 04 00 00 00 00 00 00 00 60 00 00
00 00 03 00 00 04 00 00 07 00 00 00 00 00 00 00
00 00 03 00 00 60 00 00 08 00 00 00 00 00 00 00
00 00 C0 00 00 D0 00 00 08 00 00 00 00 00 00 10
00 00 00 00 00 D0 00 00 00 00 C0 00 00 00 00 10
0C 00 00 00 00 00 00 00 20 0C 00 00 00 00 00 00
00 00 04 00 00 00 00 00 0C 0C 00 00 00 00 00 00
20 00 04 00 00 00 00 00 00 18 00 60 00 00 00 00
00 40 00 00 10 00 00 00 00 18 00 00 00 00 00 00
00 40 00 60 00 00 00 00 00 00 00 00 10 00 00 00
00 00 00 00 00 06 00 20 00 00 00 00 00 00 00 00
18 00 00 00 00 06 00 00 00 00 00 00 00 02 00 20
18 00 00 00 00 00 00 00 00

```

After ι

```

06 00 00 00 00 04 00 00 00 00 00 00 00 60 00 00
00 00 03 00 00 04 00 00 07 00 00 00 00 00 00 00
00 00 03 00 00 60 00 00 08 00 00 00 00 00 00 00
00 00 C0 00 00 D0 00 00 08 00 00 00 00 00 00 10
00 00 00 00 00 D0 00 00 00 00 C0 00 00 00 00 10
0C 00 00 00 00 00 00 00 20 0C 00 00 00 00 00 00
00 00 04 00 00 00 00 00 0C 0C 00 00 00 00 00 00
20 00 04 00 00 00 00 00 00 18 00 60 00 00 00 00
00 40 00 00 10 00 00 00 00 18 00 00 00 00 00 00
00 40 00 60 00 00 00 00 00 00 00 00 10 00 00 00
00 00 00 00 00 06 00 20 00 00 00 00 00 00 00 00
18 00 00 00 00 06 00 00 00 00 00 00 00 02 00 20
18 00 00 00 00 00 00 00 00

```

(Skip rounds 1 to 22)

Round #23

After θ

0B 59 CE D1 EF 06 FE FE 38 5F F6 8E 93 9E 40 E5
 5C 66 DE 34 99 D3 D8 DF 14 D8 1D F8 4A 47 49 28
 15 4F 96 4D 0E 22 B1 D5 B4 62 AC E5 B1 0B AD 03
 0A 6D B6 05 78 44 B5 5A 5E 88 06 49 2D E1 CA CF
 17 B9 7C 0D 52 BF BE CA 53 F7 B5 93 4F 90 44 7B
 23 24 0F FF BE F7 13 6A 20 81 F5 70 53 F7 98 2E
 27 5F AB DE 54 A9 1F 3A 59 23 6F 17 94 8D 53 92
 B1 16 1C B0 07 E9 00 04 A9 4B 50 26 B1 5C D7 A3
 67 21 C4 76 20 9F C7 C0 55 30 C6 37 91 76 45 95
 5A 58 E2 7F B2 5A 0C 56 0A C2 D2 F7 03 FC DB 89
 6B BB A0 28 1A 30 B3 50 AB D5 DE D6 45 89 84 46
 03 A7 B8 A6 97 C5 08 C3 99 28 E1 5B 2E 90 19 BD
 FF CE D2 28 CF 8B 0B 98

After p

0B 59 CE D1 EF 06 FE FE 71 BE EC 1D 27 3D 81 CA
 97 99 37 4D E6 34 F6 37 74 94 84 42 81 DD 81 AF
 10 89 AD AE 78 B2 6C 72 1E BB D0 3A 40 2B C6 5A
 5B 80 47 54 AB A5 D0 66 B3 17 A2 41 52 4B B8 F2
 5C BE 06 A9 5F 5F E5 8B 49 B4 37 75 5F 3B F9 04
 1B 21 79 F8 F7 BD 9F 50 BA 80 04 D6 C3 4D DD 63
 F5 A6 4A FD D0 39 F9 5A 4B A7 24 B3 46 DE 2E 28
 D8 83 74 00 82 58 0B 0E 4C 62 B9 AE 47 53 97 A0
 D8 0E E4 F3 18 F8 2C 84 A2 CA 2A 18 E3 9B 48 BB
 8B C1 4A 0B 4B FC 4F 56 89 0A C2 D2 F7 03 FC DB
 CC 42 AD ED 82 A2 68 C0 AD 56 7B 5B 17 25 12 1A
 E0 14 D7 F4 B2 18 61 78 28 E1 5B 2E 90 19 BD 99
 02 E6 BF B3 34 CA F3 E2

After π

0B 59 CE D1 EF 06 FE FE 5B 80 47 54 AB A5 D0 66
 F5 A6 4A FD D0 39 F9 5A 8B C1 4A 0B 4B FC 4F 56
 02 E6 BF B3 34 CA F3 E2 74 94 84 42 81 DD 81 AF
 49 B4 37 75 5F 3B F9 04 1B 21 79 F8 F7 BD 9F 50
 D8 0E E4 F3 18 F8 2C 84 E0 14 D7 F4 B2 18 61 78
 71 BE EC 1D 27 3D 81 CA B3 17 A2 41 52 4B B8 F2
 1B A7 24 B3 46 DE 2E 28 89 0A C2 D2 F7 03 FC DB
 CC 42 AD ED 82 A2 68 C0 10 89 AD AE 78 B2 6C 72
 1E BB D0 3A 40 2B C6 5A BA 80 04 D6 C3 4D DD 63
 A2 CA 2A 18 E3 9B 48 BB 28 E1 5B 2E 90 19 BD 99
 97 99 37 4D E6 34 F6 37 5C BE 06 A9 5F 5F E5 8B
 D8 83 74 00 82 58 0B 0E 4C 62 B9 AE 47 53 97 A0
 AD 56 7B 5B 17 25 12 1A

After χ

```

AF 7F C6 78 BF 1E D7 E6 51 C1 47 56 A0 61 D6 62
F5 80 FF 4D E4 3B 49 FA 82 D8 0A 4B 80 F8 43 4A
52 66 BE B7 34 6B F3 E2 66 95 CC CA 21 59 87 FF
89 BA B3 76 57 7B D9 80 3B 31 6A FC 55 BD DE 28
CC 8E E4 F1 19 3D AC 03 E9 34 E4 C1 EC 3A 19 78
79 1E E8 AF 23 A9 87 C2 33 1F 60 01 E3 4A 68 21
5F E7 09 9E 46 7E 2E 28 B8 B6 82 C2 D2 1E 7D D1
4E 43 AF AD D2 E0 50 F0 B0 89 A9 6A FB F6 75 53
1E F1 FA 32 60 B9 C6 C2 B2 A1 55 F0 D3 4D 68 63
B2 C2 8E 98 8B 39 08 D9 26 D3 0B 3E 90 10 3F 91
17 98 47 4D 66 34 FC 33 58 DE 8F 07 1A 5C 71 2B
79 97 36 51 92 7C 0B 14 5E EB BD AA A7 43 73 85
E5 70 7B FB 0E 6E 13 92

```

After ι

```

A7 FF C6 F8 BF 1E D7 66 51 C1 47 56 A0 61 D6 62
F5 80 FF 4D E4 3B 49 FA 82 D8 0A 4B 80 F8 43 4A
52 66 BE B7 34 6B F3 E2 66 95 CC CA 21 59 87 FF
89 BA B3 76 57 7B D9 80 3B 31 6A FC 55 BD DE 28
CC 8E E4 F1 19 3D AC 03 E9 34 E4 C1 EC 3A 19 78
79 1E E8 AF 23 A9 87 C2 33 1F 60 01 E3 4A 68 21
5F E7 09 9E 46 7E 2E 28 B8 B6 82 C2 D2 1E 7D D1
4E 43 AF AD D2 E0 50 F0 B0 89 A9 6A FB F6 75 53
1E F1 FA 32 60 B9 C6 C2 B2 A1 55 F0 D3 4D 68 63
B2 C2 8E 98 8B 39 08 D9 26 D3 0B 3E 90 10 3F 91
17 98 47 4D 66 34 FC 33 58 DE 8F 07 1A 5C 71 2B
79 97 36 51 92 7C 0B 14 5E EB BD AA A7 43 73 85
E5 70 7B FB 0E 6E 13 92

```

After permutation

```

A7 FF C6 F8 BF 1E D7 66 51 C1 47 56 A0 61 D6 62
F5 80 FF 4D E4 3B 49 FA 82 D8 0A 4B 80 F8 43 4A
52 66 BE B7 34 6B F3 E2 66 95 CC CA 21 59 87 FF
89 BA B3 76 57 7B D9 80 3B 31 6A FC 55 BD DE 28
CC 8E E4 F1 19 3D AC 03 E9 34 E4 C1 EC 3A 19 78
79 1E E8 AF 23 A9 87 C2 33 1F 60 01 E3 4A 68 21
5F E7 09 9E 46 7E 2E 28 B8 B6 82 C2 D2 1E 7D D1
4E 43 AF AD D2 E0 50 F0 B0 89 A9 6A FB F6 75 53
1E F1 FA 32 60 B9 C6 C2 B2 A1 55 F0 D3 4D 68 63
B2 C2 8E 98 8B 39 08 D9 26 D3 0B 3E 90 10 3F 91
17 98 47 4D 66 34 FC 33 58 DE 8F 07 1A 5C 71 2B
79 97 36 51 92 7C 0B 14 5E EB BD AA A7 43 73 85
E5 70 7B FB 0E 6E 13 92

```

State (as lanes of integers)

[0, 0] = 66D71EBFF8C6FFA7
 [1, 0] = 62D661A05647C151
 [2, 0] = FA493BE44DFF80F5
 [3, 0] = 4A43F8804B0AD882
 [4, 0] = E2F36B34B7BE6652
 [0, 1] = FF875921CACC9566
 [1, 1] = 80D97B5776B3BA89
 [2, 1] = 28DEBD55FC6A313B
 [3, 1] = 03AC3D19F1E48ECC
 [4, 1] = 78193AECC1E434E9
 [0, 2] = C287A923AFE81E79
 [1, 2] = 21684AE301601F33
 [2, 2] = 282E7E469E09E75F
 [3, 2] = D17D1ED2C282B6B8
 [4, 2] = F050E0D2ADAF434E
 [0, 3] = 5375F6FB6AA989B0
 [1, 3] = C2C6B96032FAF11E
 [2, 3] = 63684DD3F055A1B2
 [3, 3] = D908398B988EC2B2
 [4, 3] = 913F10903E0BD326
 [0, 4] = 33FC34664D479817
 [1, 4] = 2B715C1A078FDE58
 [2, 4] = 140B7C9251369779
 [3, 4] = 857343A7AABDEB5E
 [4, 4] = 92136E0EFB7B70E5

The hash value is

A7 FF C6 F8 ... 80 F8 43 4A

The message as bit string

1 1 0 0 1

XORed state (in bytes)

[illegible]

XORed state (as lanes of integers)

```
[0, 0] = 00000000000000000000
[1, 0] = 00000000000000000000
[2, 0] = 00000000000000000000
[3, 0] = 00000000000000000000
[4, 0] = 00000000000000000000
[0, 1] = 00000000000000000000
[1, 1] = 00000000000000000000
[2, 1] = 00000000000000000000
[3, 1] = 00000000000000000000
[4, 1] = 00000000000000000000
[0, 2] = 00000000000000000000
[1, 2] = 00000000000000000000
[2, 2] = 00000000000000000000
[3, 2] = 00000000000000000000
[4, 2] = 00000000000000000000
[0, 3] = 00000000000000000000
[1, 3] = 80000000000000000000
[2, 3] = 00000000000000000000
[3, 3] = 00000000000000000000
[4, 3] = 00000000000000000000
[0, 4] = 00000000000000000000
[1, 4] = 00000000000000000000
[2, 4] = 00000000000000000000
[3, 4] = 00000000000000000000
[4, 4] = 00000000000000000000
```

Round #0

After θ

```

D2 00 00 00 00 00 00 00 00 D3 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
A6 01 00 00 00 00 00 00 01 00 00 00 00 00 00 00
D3 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
00 00 00 00 00 00 00 00 A6 01 00 00 00 00 00 00
01 00 00 00 00 00 00 00 D3 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
A6 01 00 00 00 00 00 00 01 00 00 00 00 00 00 00
D3 00 00 00 00 00 00 80 00 00 00 00 00 00 00 80
00 00 00 00 00 00 00 00 A6 01 00 00 00 00 00 00
01 00 00 00 00 00 00 00 D3 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
A6 01 00 00 00 00 00 00

```

After ρ

```

D2 00 00 00 00 00 00 00 A6 01 00 00 00 00 00 00
00 00 00 00 00 00 00 20 00 00 00 00 00 00 00 00
00 00 00 30 0D 00 00 00 00 00 00 00 00 10 00 00 00
00 00 00 00 00 30 0D 00 20 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 60 1A 00 00 00 00 00
08 00 00 00 00 00 00 00 00 4C 03 00 00 00 00 00
00 00 00 00 00 04 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 D3 00 00 00 00 00 00 00 02 00 00
00 00 00 00 00 70 1A 00 00 40 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 A6 01 00 00 00 00 00
00 00 04 00 00 00 00 00 4C 03 00 00 00 00 00 00
00 00 00 00 00 00 00 10 00 00 00 00 00 00 00 00
00 80 69 00 00 00 00 00

```

After π

```

D2 00 00 00 00 00 00 00 00 00 00 00 00 30 0D 00
00 00 00 00 00 04 00 00 00 00 00 00 00 00 00 00
00 80 69 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 60 1A 00 00 00 00 08 00 00 00 00 00 00 00
00 00 00 00 00 70 1A 00 00 00 00 00 00 00 00 10
A6 01 00 00 00 00 00 00 20 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 A6 01 00 00 00 00 00
00 00 04 00 00 00 00 00 00 00 30 0D 00 00 00
00 00 00 00 10 00 00 00 00 4C 03 00 00 00 00 00
00 40 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 20 00 00 00 00 00 00 00 00
00 00 00 00 00 D3 00 00 00 00 00 00 00 02 00 00
4C 03 00 00 00 00 00 00

```

After χ

```

D2 00 00 00 00 04 00 00 00 00 00 00 00 00 30 0D 00
00 80 69 00 00 04 00 00 D2 00 00 00 00 00 00 00 00
00 80 69 00 00 30 0D 00 08 00 00 00 00 00 00 00 00
00 00 60 1A 00 70 1A 00 08 00 00 00 00 00 00 00 10
00 00 00 00 00 70 1A 00 00 00 60 1A 00 00 00 00 10
A6 01 00 00 00 00 00 00 20 A6 01 00 00 00 00 00 00
00 00 04 00 00 00 00 00 A6 A7 01 00 00 00 00 00 00
00 00 04 00 00 00 00 00 00 4C 03 30 0D 00 00 00 00
00 00 00 00 10 00 00 00 00 4C 03 00 00 00 00 00 00
00 40 00 30 0D 00 00 00 00 00 00 00 00 10 00 00 00
00 00 00 00 00 D3 00 20 00 00 00 00 00 00 00 00 00
4C 03 00 00 00 D3 00 00 00 00 00 00 00 02 00 20
4C 03 00 00 00 00 00 00 00

```

After ι

```

D3 00 00 00 00 04 00 00 00 00 00 00 00 00 30 0D 00
00 80 69 00 00 04 00 00 D2 00 00 00 00 00 00 00 00
00 80 69 00 00 30 0D 00 08 00 00 00 00 00 00 00 00
00 00 60 1A 00 70 1A 00 08 00 00 00 00 00 00 00 10
00 00 00 00 00 70 1A 00 00 00 60 1A 00 00 00 00 10
A6 01 00 00 00 00 00 00 20 A6 01 00 00 00 00 00 00
00 00 04 00 00 00 00 00 A6 A7 01 00 00 00 00 00 00
00 00 04 00 00 00 00 00 00 4C 03 30 0D 00 00 00 00
00 00 00 00 10 00 00 00 00 4C 03 00 00 00 00 00 00
00 40 00 30 0D 00 00 00 00 00 00 00 00 10 00 00 00
00 00 00 00 00 D3 00 20 00 00 00 00 00 00 00 00 00
4C 03 00 00 00 D3 00 00 00 00 00 00 00 02 00 20
4C 03 00 00 00 00 00 00 00

```

(Skip rounds 1 to 22)

Round #23

After θ

7A C0 47 4F 5A 45 7C 12 42 CB B4 2E FF 7C AF 1E
 F9 70 2C D1 F8 A9 DE FA D1 44 4E E0 1F 81 9D 0C
 81 AA 52 B4 7E BF C1 1B 0D E4 68 B7 A9 C6 EB B5
 BC E6 66 DB F3 DF 5A AD 8F B8 18 FD 1A 68 07 B4
 D9 A1 B5 E4 D2 ED 8D A5 AF 1A 1A 58 DA C4 F4 03
 C7 78 B0 28 86 98 71 6A C8 4B AC EF E9 A2 D9 8C
 C8 C6 23 87 6A A6 01 12 06 EF 64 77 5F A0 70 79
 3F 1F C3 B3 68 88 AE 9A A3 82 63 1C 8B 11 6F BD
 A9 AD 0F A7 D9 91 1D CD B4 C3 93 CA 5F 50 57 A5
 3B AD CF FC FB 0D 0D 9A 9A 24 AE D5 6C 72 0C E7
 A3 2A 29 68 41 8B 00 C9 71 66 43 5D D7 29 F6 23
 60 99 F4 D9 38 70 BB E1 CE E8 1D 04 91 97 41 0D
 5A AE 78 3E 56 2D 77 83

After p

7A C0 47 4F 5A 45 7C 12 84 96 69 5D FE F9 5E 3D
 3E 1C 4B 34 7E AA B7 7E 11 D8 C9 10 4D E4 04 FE
 FB 0D DE 08 54 95 A2 F5 9B 6A BC 5E DB 40 8E 76
 B6 3D FF AD D5 CA 6B 6E ED 23 2E 46 BF 06 DA 01
 D0 5A 72 E9 F6 C6 D2 EC 4C 3F F0 AA A1 81 A5 4D
 3B C6 83 45 31 C4 8C 53 33 22 2F B1 BE A7 8B 66
 39 54 33 0D 90 40 36 1E 40 E1 F2 0C DE C9 EE BE
 59 34 44 57 CD 9F 8F E1 38 16 23 DE 7A 47 05 C7
 E1 34 3B B2 A3 39 B5 F5 AB 52 DA E1 49 E5 2F A8
 A1 41 73 A7 F5 99 7F BF E7 9A 24 AE D5 6C 72 0C
 02 24 8F AA A4 A0 05 2D C4 99 0D 75 5D A7 D8 8F
 2C 93 3E 1B 07 6E 37 1C E8 1D 04 91 97 41 0D CE
 DD A0 96 2B 9E 8F 55 CB

After π

7A C0 47 4F 5A 45 7C 12 B6 3D FF AD D5 CA 6B 6E
 39 54 33 0D 90 40 36 1E A1 41 73 A7 F5 99 7F BF
 DD A0 96 2B 9E 8F 55 CB 11 D8 C9 10 4D E4 04 FE
 4C 3F F0 AA A1 81 A5 4D 3B C6 83 45 31 C4 8C 53
 E1 34 3B B2 A3 39 B5 F5 2C 93 3E 1B 07 6E 37 1C
 84 96 69 5D FE F9 5E 3D ED 23 2E 46 BF 06 DA 01
 40 E1 F2 0C DE C9 EE BE E7 9A 24 AE D5 6C 72 0C
 02 24 8F AA A4 A0 05 2D FB 0D DE 08 54 95 A2 F5
 9B 6A BC 5E DB 40 8E 76 33 22 2F B1 BE A7 8B 66
 AB 52 DA E1 49 E5 2F A8 E8 1D 04 91 97 41 0D CE
 3E 1C 4B 34 7E AA B7 7E D0 5A 72 E9 F6 C6 D2 EC
 59 34 44 57 CD 9F 8F E1 38 16 23 DE 7A 47 05 C7
 C4 99 0D 75 5D A7 D8 8F

After χ

```

73 80 47 4F 5A 45 68 02 36 3C BF 0F B0 53 22 CF
65 F4 B7 05 9A 46 36 5E 83 01 32 E3 B5 D9 57 AF
59 9D 2E 8B 1B 05 56 A7 22 18 CA 55 5D A0 0C EC
8C 0F C8 18 23 B8 94 E9 37 45 87 4C 35 82 8E 5B
F0 7C FA B2 EB B9 B5 17 60 B4 0E B1 A7 6F 96 1D
84 56 B9 55 BE 30 7A 83 4A 39 2A E4 BE 22 CA 01
40 C5 79 0C FE 49 EB 9F 63 08 44 FB 8F 35 28 1C
6B 05 89 A8 A5 A6 85 2D DB 0D DD A9 70 32 A3 F5
13 3A 6C 1E 9A 00 AA FE 73 2F 2B A1 28 A7 8B 20
B8 52 00 E9 09 71 8D 99 E8 7F 24 C7 1C 01 01 CC
37 38 4F 22 77 B3 BA 7F F0 58 51 61 C4 86 D2 EA
9D BD 48 76 C8 3F 57 E9 02 12 61 DE 58 4F 22 B7
04 DB 3D BC DD E3 98 0F

```

After ι

```

7B 00 47 CF 5A 45 68 82 36 3C BF 0F B0 53 22 CF
65 F4 B7 05 9A 46 36 5E 83 01 32 E3 B5 D9 57 AF
59 9D 2E 8B 1B 05 56 A7 22 18 CA 55 5D A0 0C EC
8C 0F C8 18 23 B8 94 E9 37 45 87 4C 35 82 8E 5B
F0 7C FA B2 EB B9 B5 17 60 B4 0E B1 A7 6F 96 1D
84 56 B9 55 BE 30 7A 83 4A 39 2A E4 BE 22 CA 01
40 C5 79 0C FE 49 EB 9F 63 08 44 FB 8F 35 28 1C
6B 05 89 A8 A5 A6 85 2D DB 0D DD A9 70 32 A3 F5
13 3A 6C 1E 9A 00 AA FE 73 2F 2B A1 28 A7 8B 20
B8 52 00 E9 09 71 8D 99 E8 7F 24 C7 1C 01 01 CC
37 38 4F 22 77 B3 BA 7F F0 58 51 61 C4 86 D2 EA
9D BD 48 76 C8 3F 57 E9 02 12 61 DE 58 4F 22 B7
04 DB 3D BC DD E3 98 0F

```

After permutation

```

7B 00 47 CF 5A 45 68 82 36 3C BF 0F B0 53 22 CF
65 F4 B7 05 9A 46 36 5E 83 01 32 E3 B5 D9 57 AF
59 9D 2E 8B 1B 05 56 A7 22 18 CA 55 5D A0 0C EC
8C 0F C8 18 23 B8 94 E9 37 45 87 4C 35 82 8E 5B
F0 7C FA B2 EB B9 B5 17 60 B4 0E B1 A7 6F 96 1D
84 56 B9 55 BE 30 7A 83 4A 39 2A E4 BE 22 CA 01
40 C5 79 0C FE 49 EB 9F 63 08 44 FB 8F 35 28 1C
6B 05 89 A8 A5 A6 85 2D DB 0D DD A9 70 32 A3 F5
13 3A 6C 1E 9A 00 AA FE 73 2F 2B A1 28 A7 8B 20
B8 52 00 E9 09 71 8D 99 E8 7F 24 C7 1C 01 01 CC
37 38 4F 22 77 B3 BA 7F F0 58 51 61 C4 86 D2 EA
9D BD 48 76 C8 3F 57 E9 02 12 61 DE 58 4F 22 B7
04 DB 3D BC DD E3 98 0F

```

State (as lanes of integers)

[0, 0] = 8268455acf47007b
 [1, 0] = cf2253b00fbf3c36
 [2, 0] = 5e36469a05b7f465
 [3, 0] = af57d9b5e3320183
 [4, 0] = a756051b8b2e9d59
 [0, 1] = ec0ca05d55ca1822
 [1, 1] = e994b82318c80f8c
 [2, 1] = 5b8e82354c874537
 [3, 1] = 17b5b9ebb2fa7cf0
 [4, 1] = 1d966fa7b10eb460
 [0, 2] = 837a30be55b95684
 [1, 2] = 01ca22bee42a394a
 [2, 2] = 9feb49fe0c79c540
 [3, 2] = 1c28358ffb440863
 [4, 2] = 2d85a6a5a889056b
 [0, 3] = f5a33270a9dd0ddb
 [1, 3] = feaa009a1e6c3a13
 [2, 3] = 208ba728a12b2f73
 [3, 3] = 998d7109e90052b8
 [4, 3] = cc01011cc7247fe8
 [0, 4] = 7fbab377224f3837
 [1, 4] = ead286c4615158f0
 [2, 4] = e9573fc87648bd9d
 [3, 4] = b7224f58de611202
 [4, 4] = 0f98e3ddbc3ddb04

The hash value is

7B 00 47 CF 5A 45 68 82 36 3C BF 0F B0 53 22 CF
 65 E4 B7 05 9A 46 36 5E 83 01 32 E3 B5 D9 57 AF

The message as bit string

110010100001101011011110100110

XORed state (in bytes)

[illegible]

XORed state (as lanes of integers)

$[0, 0] = 000000001997B5853$
 $[1, 0] = 000000000000000000$
 $[2, 0] = 000000000000000000$
 $[3, 0] = 000000000000000000$
 $[4, 0] = 000000000000000000$
 $[0, 1] = 000000000000000000$
 $[1, 1] = 000000000000000000$
 $[2, 1] = 000000000000000000$
 $[3, 1] = 000000000000000000$
 $[4, 1] = 000000000000000000$
 $[0, 2] = 000000000000000000$
 $[1, 2] = 000000000000000000$
 $[2, 2] = 000000000000000000$
 $[3, 2] = 000000000000000000$
 $[4, 2] = 000000000000000000$
 $[0, 3] = 000000000000000000$
 $[1, 3] = 800000000000000000$
 $[2, 3] = 000000000000000000$
 $[3, 3] = 000000000000000000$
 $[4, 3] = 000000000000000000$
 $[0, 4] = 000000000000000000$
 $[1, 4] = 000000000000000000$
 $[2, 4] = 000000000000000000$
 $[3, 4] = 000000000000000000$
 $[4, 4] = 000000000000000000$

Round #0

After θ

```

52 58 7B 99 01 00 00 00 53 58 7B 99 01 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00
A6 B0 F6 32 03 00 00 00 01 00 00 00 00 00 00
53 58 7B 99 01 00 00 00 00 00 00 00 00 00 80
00 00 00 00 00 00 00 A6 B0 F6 32 03 00 00 00
01 00 00 00 00 00 00 53 58 7B 99 01 00 00 00
00 00 00 00 00 00 80 00 00 00 00 00 00 00
A6 B0 F6 32 03 00 00 00 01 00 00 00 00 00 00
53 58 7B 99 01 00 00 80 00 00 00 00 00 00 80
00 00 00 00 00 00 00 A6 B0 F6 32 03 00 00 00
01 00 00 00 00 00 00 53 58 7B 99 01 00 00 00
00 00 00 00 00 00 80 00 00 00 00 00 00 00
A6 B0 F6 32 03 00 00 00

```

After ρ

```

52 58 7B 99 01 00 00 00 A6 B0 F6 32 03 00 00 00
00 00 00 00 00 00 20 00 00 00 00 00 00 00 00
00 00 00 30 85 B5 97 19 00 00 00 00 10 00 00 00
97 19 00 00 00 30 85 B5 20 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 60 0A 6B 2F 33 00
08 00 00 00 00 00 00 00 4C 61 ED 65 06 00 00
00 00 00 00 04 00 00 00 00 00 00 00 00 00 00
99 01 00 00 00 53 58 7B 00 00 00 00 00 02 00 00
2F 33 00 00 00 70 0A 6B 00 40 00 00 00 00 00 00
00 00 00 00 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 04 00 00 00 00 00 4C 61 ED 65 06 00 00 00
00 00 00 00 00 00 10 00 00 00 00 00 00 00 00
00 80 29 AC BD CC 00 00

```

After π

```

52 58 7B 99 01 00 00 00 97 19 00 00 00 30 85 B5
00 00 00 00 00 04 00 00 00 00 00 00 00 00 00
00 80 29 AC BD CC 00 00 00 00 00 00 00 00 00
00 00 60 0A 6B 2F 33 00 08 00 00 00 00 00 00
2F 33 00 00 00 70 0A 6B 00 00 00 00 00 00 10
A6 B0 F6 32 03 00 00 00 20 00 00 00 00 00 00
00 00 00 00 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 04 00 00 00 00 00 00 00 30 85 B5 97 19
00 00 00 00 10 00 00 00 00 4C 61 ED 65 06 00 00
00 40 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 20 00 00 00 00 00 00 00 00
99 01 00 00 00 53 58 7B 00 00 00 00 00 02 00 00
4C 61 ED 65 06 00 00 00

```

After χ

```

52 58 7B 99 01 04 00 00 97 19 00 00 00 30 85 B5
00 80 29 AC BD C8 00 00 52 58 52 11 00 00 00 00
85 81 29 AC BD FC 85 B5 08 00 00 00 00 00 00 00
27 33 60 0A 6B 5F 39 6B 08 00 00 00 00 00 00 10
2F 33 00 00 00 70 0A 6B 00 00 60 0A 6B 2F 33 10
A6 B0 F6 32 03 00 00 00 20 A6 B0 F6 32 03 00 00
00 00 04 00 00 00 00 00 A6 16 42 C4 31 03 00 00
00 00 04 00 00 00 00 00 4C 61 DD E0 B3 97 19
00 00 00 00 10 00 00 00 00 4C 61 ED 65 06 00 00
00 40 00 30 85 B5 97 19 00 00 00 00 10 00 00 00
99 01 00 00 00 53 58 5B 00 00 00 00 00 00 00 00
D5 60 ED 65 06 53 58 7B 00 00 00 00 00 02 00 20
4C 61 ED 65 06 00 00 00

```

After ι

```

53 58 7B 99 01 04 00 00 97 19 00 00 00 30 85 B5
00 80 29 AC BD C8 00 00 52 58 52 11 00 00 00 00
85 81 29 AC BD FC 85 B5 08 00 00 00 00 00 00 00
27 33 60 0A 6B 5F 39 6B 08 00 00 00 00 00 00 10
2F 33 00 00 00 70 0A 6B 00 00 60 0A 6B 2F 33 10
A6 B0 F6 32 03 00 00 00 20 A6 B0 F6 32 03 00 00
00 00 04 00 00 00 00 00 A6 16 42 C4 31 03 00 00
00 00 04 00 00 00 00 00 4C 61 DD E0 B3 97 19
00 00 00 00 10 00 00 00 00 4C 61 ED 65 06 00 00
00 40 00 30 85 B5 97 19 00 00 00 00 10 00 00 00
99 01 00 00 00 53 58 5B 00 00 00 00 00 00 00 00
D5 60 ED 65 06 53 58 7B 00 00 00 00 00 02 00 20
4C 61 ED 65 06 00 00 00

```

(Skip rounds 1 to 22)

Round #23

After θ

E0 A8 3E 4F 51 BC 7A EA 31 43 F5 C3 14 A1 71 39
 1B 4F 50 1E 76 8B 79 7A F1 34 AF 61 D5 4D 3D 28
 6A 52 D5 36 62 0A 0C 4E 07 C1 3D 60 17 F4 CB 82
 7D 49 71 1D A3 AE E4 DC 6D E1 43 3A C0 1C D1 8B
 55 70 34 6E 5C F3 90 56 39 51 41 B7 2E F6 24 88
 EF 8A B3 ED 03 39 1B 7B 11 CD A4 A6 A4 A5 C5 F2
 8C 74 30 BE 27 43 64 F3 EB 76 40 BB 3E 2D 84 0D
 52 F5 75 CB 70 12 A0 7D DB 7F A6 74 94 69 27 4E
 C1 7A 29 C4 5D 0B AD 65 C3 DA 16 FE D6 B7 C2 8E
 E9 88 87 8F 87 3D 4D 17 1F 6E 56 FD F7 52 1B CE
 D7 77 A3 6C D4 A8 63 74 F3 43 7D FD 59 97 88 63
 B2 03 94 5E 27 59 2C 9B 91 64 2E 34 F7 7A 29 5F
 01 98 12 D4 FD 7E 2E 59

After p

E0 A8 3E 4F 51 BC 7A EA 62 86 EA 87 29 42 E3 72
 C6 13 94 87 DD 62 9E DE DD D4 83 12 4F F3 1A 56
 53 60 70 52 93 AA B6 11 76 41 BF 2C 78 10 DC 03
 D7 31 EA 4A CE DD 97 14 62 5B F8 90 0E 30 47 F4
 38 1A 37 AE 79 48 AB 2A 4F 82 98 13 15 74 EB 62
 7B 57 9C 6D 1F C8 D9 D8 CB 47 34 93 9A 92 96 16
 F1 3D 19 22 9B 67 A4 83 5A 08 1B D6 ED 80 76 7D
 65 38 09 D0 3E A9 FA BA E9 28 D3 4E 9C B6 FF 4C
 85 B8 6B A1 B5 2C 58 2F 61 C7 61 6D 0B 7F EB 5B
 A7 E9 22 1D F1 F0 F1 B0 CE 1F 6E 56 FD F7 52 1B
 8E D1 5D DF 8D B2 51 A3 CD 0F F5 F5 67 5D 22 8E
 76 80 D2 EB 24 8B 65 53 64 2E 34 F7 7A 29 5F 91
 4B 56 00 A6 04 75 BF 9F

After π

E0 A8 3E 4F 51 BC 7A EA D7 31 EA 4A CE DD 97 14
 F1 3D 19 22 9B 67 A4 83 A7 E9 22 1D F1 F0 F1 B0
 4B 56 00 A6 04 75 BF 9F DD D4 83 12 4F F3 1A 56
 4F 82 98 13 15 74 EB 62 7B 57 9C 6D 1F C8 D9 D8
 85 B8 6B A1 B5 2C 58 2F 76 80 D2 EB 24 8B 65 53
 62 86 EA 87 29 42 E3 72 62 5B F8 90 0E 30 47 F4
 5A 08 1B D6 ED 80 76 7D CE 1F 6E 56 FD F7 52 1B
 8E D1 5D DF 8D B2 51 A3 53 60 70 52 93 AA B6 11
 76 41 BF 2C 78 10 DC 03 CB 47 34 93 9A 92 96 16
 61 C7 61 6D 0B 7F EB 5B 64 2E 34 F7 7A 29 5F 91
 C6 13 94 87 DD 62 9E DE 38 1A 37 AE 79 48 AB 2A
 65 38 09 D0 3E A9 FA BA E9 28 D3 4E 9C B6 FF 4C
 CD 0F F5 F5 67 5D 22 8E

After χ

C0 A4 2F 6F 40 9E 5A 69 D1 F1 C8 57 AE 4D C6 24
 B9 2B 19 80 9F 62 AA 8C 07 41 1C 54 A0 78 B1 D0
 5C 47 C0 A6 8A 34 3A 8B ED 81 87 7E 45 7B 0A CE
 CB 2A FB 93 B5 50 EB 45 09 57 0C 27 1F 4B FC 88
 0C EC 6A B1 FE 5C 42 2B 74 82 CA EA 34 8F 84 73
 7A 86 E9 C1 C8 C2 D3 7B E6 4C 9C 90 1E 47 47 F6
 5A C8 0A 5F ED 80 77 DD AE 19 CC 56 DD B7 F0 4B
 8E 88 4D CF 8B 82 55 27 DA 66 70 C1 11 28 B4 05
 56 C1 FE 40 79 7D B5 4A CF 6F 20 01 EA 92 82 96
 72 87 21 6D 8A FD 4B 5B 40 2F BB DB 12 39 17 93
 83 33 9C D7 DB C3 CE 4E B0 1A E5 A0 F9 5E AE 6E
 61 3F 2D 61 5D E0 FA 38 EB 38 D3 4C 04 94 63 1C
 F5 07 D6 DD 47 55 03 AE

After ι

C8 24 2F EF 40 9E 5A E9 D1 F1 C8 57 AE 4D C6 24
 B9 2B 19 80 9F 62 AA 8C 07 41 1C 54 A0 78 B1 D0
 5C 47 C0 A6 8A 34 3A 8B ED 81 87 7E 45 7B 0A CE
 CB 2A FB 93 B5 50 EB 45 09 57 0C 27 1F 4B FC 88
 0C EC 6A B1 FE 5C 42 2B 74 82 CA EA 34 8F 84 73
 7A 86 E9 C1 C8 C2 D3 7B E6 4C 9C 90 1E 47 47 F6
 5A C8 0A 5F ED 80 77 DD AE 19 CC 56 DD B7 F0 4B
 8E 88 4D CF 8B 82 55 27 DA 66 70 C1 11 28 B4 05
 56 C1 FE 40 79 7D B5 4A CF 6F 20 01 EA 92 82 96
 72 87 21 6D 8A FD 4B 5B 40 2F BB DB 12 39 17 93
 83 33 9C D7 DB C3 CE 4E B0 1A E5 A0 F9 5E AE 6E
 61 3F 2D 61 5D E0 FA 38 EB 38 D3 4C 04 94 63 1C
 F5 07 D6 DD 47 55 03 AE

After permutation

C8 24 2F EF 40 9E 5A E9 D1 F1 C8 57 AE 4D C6 24
 B9 2B 19 80 9F 62 AA 8C 07 41 1C 54 A0 78 B1 D0
 5C 47 C0 A6 8A 34 3A 8B ED 81 87 7E 45 7B 0A CE
 CB 2A FB 93 B5 50 EB 45 09 57 0C 27 1F 4B FC 88
 0C EC 6A B1 FE 5C 42 2B 74 82 CA EA 34 8F 84 73
 7A 86 E9 C1 C8 C2 D3 7B E6 4C 9C 90 1E 47 47 F6
 5A C8 0A 5F ED 80 77 DD AE 19 CC 56 DD B7 F0 4B
 8E 88 4D CF 8B 82 55 27 DA 66 70 C1 11 28 B4 05
 56 C1 FE 40 79 7D B5 4A CF 6F 20 01 EA 92 82 96
 72 87 21 6D 8A FD 4B 5B 40 2F BB DB 12 39 17 93
 83 33 9C D7 DB C3 CE 4E B0 1A E5 A0 F9 5E AE 6E
 61 3F 2D 61 5D E0 FA 38 EB 38 D3 4C 04 94 63 1C
 F5 07 D6 DD 47 55 03 AE

State (as lanes of integers)

[0, 0] = E95A9E40EF2F24C8
 [1, 0] = 24C64DAE57C8F1D1
 [2, 0] = 8CAA629F80192BB9
 [3, 0] = D0B178A0541C4107
 [4, 0] = 8B3A348AA6C0475C
 [0, 1] = CE0A7B457E8781ED
 [1, 1] = 45EB50B593FB2ACB
 [2, 1] = 88FC4B1F270C5709
 [3, 1] = 2B425CFEB16AEC0C
 [4, 1] = 73848F34EACA8274
 [0, 2] = 7BD3C2C8C1E9867A
 [1, 2] = F647471E909C4CE6
 [2, 2] = DD7780ED5F0AC85A
 [3, 2] = 4BF0B7DD56CC19AE
 [4, 2] = 2755828BCF4D888E
 [0, 3] = 05B42811C17066DA
 [1, 3] = 4AB57D7940FEC156
 [2, 3] = 968292EA01206FCF
 [3, 3] = 5B4BFD8A6D218772
 [4, 3] = 93173912DBB2F40
 [0, 4] = 4ECEC3DED79C3383
 [1, 4] = 6EAE5FF9A0E51AB0
 [2, 4] = 38FAE05D612D3F61
 [3, 4] = 1C6394044CD338EB
 [4, 4] = AE035547DDD607F5

The hash value is

C8 24 2E EF 40 9E 5A E9 D1 F1 C8 57 AE 4D C6 24
 B9 C2 B 19 80 9F 62 AA 8C 07 41 1C 54 A0 78 B1 D0

B.16 Dedicated Hash-Function 15 (SHA3-384)

NOTE 1 Data is presented in three different ways: bit strings, byte strings and w-length words (for the lanes).

NOTE 2 Bit strings are the sequence of bits from left to right.

NOTE 3 Byte strings are the bytes from left to right and the bits within the byte are right to left.

NOTE 4 Words are the integer representation of the values in the lanes.

The message as bit string

(empty message)

XORed state (in bytes)

[illegible]

XORed state (as lanes of integers)

$[0, 0] = 00000000000000000000$
 $[1, 0] = 00000000000000000000$
 $[2, 0] = 00000000000000000000$
 $[3, 0] = 00000000000000000000$
 $[4, 0] = 00000000000000000000$
 $[0, 1] = 00000000000000000000$
 $[1, 1] = 00000000000000000000$
 $[2, 1] = 00000000000000000000$
 $[3, 1] = 00000000000000000000$
 $[4, 1] = 00000000000000000000$
 $[0, 2] = 00000000000000000000$
 $[1, 2] = 00000000000000000000$
 $[2, 2] = 80000000000000000000$
 $[3, 2] = 00000000000000000000$
 $[4, 2] = 00000000000000000000$
 $[0, 3] = 00000000000000000000$
 $[1, 3] = 00000000000000000000$
 $[2, 3] = 00000000000000000000$
 $[3, 3] = 00000000000000000000$
 $[4, 3] = 00000000000000000000$
 $[0, 4] = 00000000000000000000$
 $[1, 4] = 00000000000000000000$
 $[2, 4] = 00000000000000000000$
 $[3, 4] = 00000000000000000000$
 $[4, 4] = 00000000000000000000$

Round #0

After θ

```

06 00 00 00 00 00 00 00 07 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
0C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
07 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 0C 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 07 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 80
0C 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
07 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 0C 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 07 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
0C 00 00 00 00 00 00 00

```

After ρ

```

06 00 00 00 00 00 00 00 0E 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 08 00 00 00 00
00 00 00 60 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 70 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 40 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 1C 00 00 00 00 00
00 00 00 00 00 04 00 00 00 00 00 01 00 00 00 00
00 00 00 00 00 06 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 E0 00 00 00 00 00 00 00 00 00 00
00 00 10 00 00 00 00 00 00 00 0C 00 00 00 00 00
00 00 00 00 00 00 00 00 00 1C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
00 00 03 00 00 00 00 00

```

After π

```

06 00 00 00 00 00 00 00 00 00 00 00 00 70 00 00
00 00 00 00 00 04 00 00 00 00 10 00 00 00 00 00
00 00 03 00 00 00 00 00 00 00 00 08 00 00 00 00
00 00 C0 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 E0 00 00 00 00 00 00 00 00 00 00
0E 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 01 00 00 00 00 00 0C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 60 00 00 00 00
00 00 00 00 00 00 00 00 00 1C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 00 00 00 00 00 00 00 00 40 00
00 00 00 00 00 06 00 00 00 00 00 00 00 00 00 00
1C 00 00 00 00 00 00 00

```

After χ

```

06 00 00 00 00 04 00 00 00 00 10 00 00 70 00 00
00 00 03 00 00 04 00 00 06 00 10 00 00 00 00 00
00 00 03 00 00 70 00 00 00 00 00 08 00 00 00 00
00 00 C0 00 00 E0 00 00 00 00 00 00 00 00 00 00
00 00 00 08 00 E0 00 00 00 00 C0 00 00 00 00 00
0E 00 00 01 00 00 00 00 00 0C 00 00 00 00 00 00
00 00 00 01 00 00 00 00 0E 0C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 1C 00 60 00 00 00 00
00 00 00 00 00 00 00 00 00 1C 00 00 00 00 80 00
00 00 00 60 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 06 00 00 00 00 00 00 00 00 40 00
1C 00 00 00 00 06 00 00 00 00 00 00 00 00 00 00
      1C 00 00 00 00 00 40 00

```

After ι

```

07 00 00 00 00 04 00 00 00 00 10 00 00 70 00 00
00 00 03 00 00 04 00 00 06 00 10 00 00 00 00 00
00 00 03 00 00 70 00 00 00 00 00 08 00 00 00 00
00 00 C0 00 00 E0 00 00 00 00 00 00 00 00 00 00
00 00 00 08 00 E0 00 00 00 00 C0 00 00 00 00 00
0E 00 00 01 00 00 00 00 00 0C 00 00 00 00 00 00
00 00 00 01 00 00 00 00 0E 0C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 1C 00 60 00 00 00 00
00 00 00 00 00 00 00 00 00 1C 00 00 00 00 80 00
00 00 00 60 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 06 00 00 00 00 00 00 00 00 40 00
1C 00 00 00 00 06 00 00 00 00 00 00 00 00 00 00
      1C 00 00 00 00 00 40 00

```

(Skip rounds 1 to 22)

Round #23

After θ

82 C8 A7 F1 04 CC 56 DD 92 34 F3 C3 2B AC A0 86
 FD C0 AA 7F 37 23 13 EB 5A FF 0D 29 F9 3E 30 DF
 51 C0 BB 57 F0 50 5B 48 55 32 25 4A 13 39 94 30
 64 72 91 41 BD 4D AD 46 04 F5 B9 DE 62 D4 EC 57
 52 CD 17 96 D3 CC BA 6E 29 23 55 9F 09 26 7E 58
 26 CD F6 AD DD 05 DE DA D1 38 07 60 86 FF EA 16
 BA 87 E4 70 07 CA 55 D5 35 29 2F D3 CD A8 27 4C
 DF 50 FE 4B F8 EF B7 98 C5 2A 0F 3F C8 BB 69 92
 78 76 9E 56 EA AC B2 41 8A B0 9E E9 78 C2 9B C9
 DF 73 E7 F0 91 CD B4 B6 65 E2 04 F2 F3 CD CE 33
 5A B2 23 92 C4 CA 6C AB 5F 32 47 49 35 61 6F E7
 4E A1 F3 54 E7 7C F1 81 A0 45 75 8A E7 D5 D6 5A
 81 D5 30 29 ED 17 69 97

After p

82 C8 A7 F1 04 CC 56 DD 25 69 E6 87 57 58 41 0D
 3F B0 EA DF CD C8 C4 7A EF 03 F3 AD F5 DF 90 92
 87 DA 42 8A 02 DE BD 82 34 91 43 09 53 25 53 A2
 19 D4 DB D4 6A 44 26 17 15 41 7D AE B7 18 35 FB
 E6 0B CB 69 66 5D 37 A9 E2 87 95 32 52 F5 99 60
 36 69 B6 6F ED 2E F0 D6 5B 44 E3 1C 80 19 FE AB
 87 3B 50 AE AA D6 3D 24 51 4F 98 6A 52 5E A6 9B
 25 FC F7 5B CC 6F 28 FF 7E 90 77 D3 24 8B 55 1E
 D3 4A 9D 55 36 08 CF CE CD 64 45 58 CF 74 3C E1
 99 D6 F6 7B EE 1C 3E B2 33 65 E2 04 F2 F3 CD CE
 B3 AD 6A C9 8E 48 12 2B 7F C9 1C 25 D5 84 BD 9D
 29 74 9E EA 9C 2F 3E D0 45 75 8A E7 D5 D6 5A A0
 DA 65 60 35 4C 4A FB 45

After π

82 C8 A7 F1 04 CC 56 DD 19 D4 DB D4 6A 44 26 17
 87 3B 50 AE AA D6 3D 24 99 D6 F6 7B EE 1C 3E B2
 DA 65 60 35 4C 4A FB 45 EF 03 F3 AD F5 DF 90 92
 E2 87 95 32 52 F5 99 60 36 69 B6 6F ED 2E F0 D6
 D3 4A 9D 55 36 08 CF CE 29 74 9E EA 9C 2F 3E D0
 25 69 E6 87 57 58 41 0D 15 41 7D AE B7 18 35 FB
 51 4F 98 6A 52 5E A6 9B 33 65 E2 04 F2 F3 CD CE
 B3 AD 6A C9 8E 48 12 2B 87 DA 42 8A 02 DE BD 82
 34 91 43 09 53 25 53 A2 5B 44 E3 1C 80 19 FE AB
 CD 64 45 58 CF 74 3C E1 45 75 8A E7 D5 D6 5A A0
 3F B0 EA DF CD C8 C4 7A E6 0B CB 69 66 5D 37 A9
 25 FC F7 5B CC 6F 28 FF 7E 90 77 D3 24 8B 55 1E
 7F C9 1C 25 D5 84 BD 9D

After χ

```

04 E3 A7 DB 84 5E 4F FD 01 10 7D 85 2E 4C 24 85
C5 1A 50 AA AA 94 FC 61 99 5E 71 BB EE 98 3A 2A
C3 71 38 31 26 4A DB 47 FB 6B D1 E0 58 D5 F0 04
23 85 9C 22 40 F5 96 68 1E 5D B4 C5 65 09 C0 C6
15 49 FC 50 57 D8 4F CC 29 F0 9A F8 9E 0F 37 B0
65 67 66 C7 17 1E C3 0D 37 61 1F AA 17 B9 7C BF
D1 C7 90 A3 5E 56 B4 BA 37 25 66 02 A3 E3 8C CA
A3 AD 73 E1 2E 48 26 D9 CC 9E E2 9E 82 C6 11 8B
B0 B1 47 49 1C 41 53 E2 5B 55 69 BB 90 9B BC AB
4F EE 05 50 CD 7C 99 E3 75 74 8B E6 84 F7 18 80
3E 44 DE CD 45 EA CC 2C BC 0B CB E9 46 DD 62 A9
24 B5 FF 7F 1D 6B 80 7E 7E A0 95 09 2C C3 15 7C
      BF C2 1D 05 F7 91 8E 1C

```

After ι

```

0C 63 A7 5B 84 5E 4F 7D 01 10 7D 85 2E 4C 24 85
C5 1A 50 AA AA 94 FC 61 99 5E 71 BB EE 98 3A 2A
C3 71 38 31 26 4A DB 47 FB 6B D1 E0 58 D5 F0 04
23 85 9C 22 40 F5 96 68 1E 5D B4 C5 65 09 C0 C6
15 49 FC 50 57 D8 4F CC 29 F0 9A F8 9E 0F 37 B0
65 67 66 C7 17 1E C3 0D 37 61 1F AA 17 B9 7C BF
D1 C7 90 A3 5E 56 B4 BA 37 25 66 02 A3 E3 8C CA
A3 AD 73 E1 2E 48 26 D9 CC 9E E2 9E 82 C6 11 8B
B0 B1 47 49 1C 41 53 E2 5B 55 69 BB 90 9B BC AB
4F EE 05 50 CD 7C 99 E3 75 74 8B E6 84 F7 18 80
3E 44 DE CD 45 EA CC 2C BC 0B CB E9 46 DD 62 A9
24 B5 FF 7F 1D 6B 80 7E 7E A0 95 09 2C C3 15 7C
      BF C2 1D 05 F7 91 8E 1C

```

After permutation

```

0C 63 A7 5B 84 5E 4F 7D 01 10 7D 85 2E 4C 24 85
C5 1A 50 AA AA 94 FC 61 99 5E 71 BB EE 98 3A 2A
C3 71 38 31 26 4A DB 47 FB 6B D1 E0 58 D5 F0 04
23 85 9C 22 40 F5 96 68 1E 5D B4 C5 65 09 C0 C6
15 49 FC 50 57 D8 4F CC 29 F0 9A F8 9E 0F 37 B0
65 67 66 C7 17 1E C3 0D 37 61 1F AA 17 B9 7C BF
D1 C7 90 A3 5E 56 B4 BA 37 25 66 02 A3 E3 8C CA
A3 AD 73 E1 2E 48 26 D9 CC 9E E2 9E 82 C6 11 8B
B0 B1 47 49 1C 41 53 E2 5B 55 69 BB 90 9B BC AB
4F EE 05 50 CD 7C 99 E3 75 74 8B E6 84 F7 18 80
3E 44 DE CD 45 EA CC 2C BC 0B CB E9 46 DD 62 A9
24 B5 FF 7F 1D 6B 80 7E 7E A0 95 09 2C C3 15 7C
      BF C2 1D 05 F7 91 8E 1C

```

State (as lanes of integers)

[0, 0] = 7d4f5e845ba7630c
 [1, 0] = 85244c2e857d1001
 [2, 0] = 61fc94aaaa501ac5
 [3, 0] = 2a3a98eebb715e99
 [4, 0] = 47db4a26313871c3
 [0, 1] = 04f0d558e0d16bfb
 [1, 1] = 6896f540229c8523
 [2, 1] = c6c00965c5b45d1e
 [3, 1] = cc4fd85750fc4915
 [4, 1] = b0370f9ef89af029
 [0, 2] = 0dc31e17c7666765
 [1, 2] = bf7cb917aa1f6137
 [2, 2] = bab4565ea390c7d1
 [3, 2] = ca8ce3a302662537
 [4, 2] = d926482ee173ada3
 [0, 3] = 8b11c6829ee29ecc
 [1, 3] = e253411c4947b1b0
 [2, 3] = abbc9b90bb69555b
 [3, 3] = e3997ccd5005ee4f
 [4, 3] = 8018f784e68b7475
 [0, 4] = 2cccea45cddde443e
 [1, 4] = a962dd46e9cb0bbc
 [2, 4] = 7e806b1d7fffb524
 [3, 4] = 7c15c32c0995a07e
 [4, 4] = 1c8e91f7051dc2bf

The hash value is

0C 63 A7 5B 84 5E 4F 7D 01 10 7D 85 2E 4C 24 85
 C5 1A 50 AA AA 94 FC 61 99 5E 71 BB EE 98 3A 2A
 C3 71 38 31 26 4A DB 47 FB 6B D1 E0 58 D5 F0 04

The message as bit string

1 1 0 0 1

After θ

D3 00 00 00 00 00 00 00 00 D2 00 00 00 00 00 00 00
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
 A6 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 D2 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 00 00 00 00 00 00 00 80 A6 01 00 00 00 00 00 00
 00 00 00 00 00 00 00 00 D2 00 00 00 00 00 00 00
 00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 80
 A6 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 D2 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 00 00 00 00 00 00 00 80 A6 01 00 00 00 00 00 00
 00 00 00 00 00 00 00 00 D2 00 00 00 00 00 00 00
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
 A6 01 00 00 00 00 00 00

After ρ

D3 00 00 00 00 00 00 00 A4 01 00 00 00 00 00 00
 00 00 00 00 00 00 00 00 00 00 00 08 00 00 00 00
 00 00 00 30 0D 00 00 00 00 00 00 00 00 00 00 00
 00 00 00 00 00 20 0D 00 00 00 00 00 00 00 00 00
 00 00 00 00 00 00 40 00 00 00 60 1A 00 00 00 00
 00 00 00 00 00 00 00 00 00 48 03 00 00 00 00 00
 00 00 00 00 00 04 00 00 00 00 00 01 00 00 00 00
 00 00 00 00 00 D3 00 00 00 00 00 00 00 00 00 00
 00 00 00 00 00 40 1A 00 00 00 00 00 00 00 00 00
 00 00 10 00 00 00 00 00 00 A6 01 00 00 00 00 00
 00 00 00 00 00 00 00 00 48 03 00 00 00 00 00 00
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
 00 80 69 00 00 00 00 00

After π

D3 00 00 00 00 00 00 00 00 00 00 00 00 20 0D 00
 00 00 00 00 00 04 00 00 00 00 10 00 00 00 00 00
 00 80 69 00 00 00 00 00 00 00 00 08 00 00 00 00
 00 00 60 1A 00 00 00 00 00 00 00 00 00 00 00 00
 00 00 00 00 00 40 1A 00 00 00 00 00 00 00 00 00
 A4 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 00 00 00 01 00 00 00 00 00 A6 01 00 00 00 00 00
 00 00 00 00 00 00 00 00 00 00 00 30 0D 00 00 00
 00 00 00 00 00 00 00 00 00 48 03 00 00 00 00 00
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
 00 00 00 00 00 00 00 00 00 00 00 00 00 00 40 00
 00 00 00 00 00 D3 00 00 00 00 00 00 00 00 00 00
 48 03 00 00 00 00 00 00

After χ

```

D3 00 00 00 00 04 00 00 00 00 10 00 00 20 0D 00
00 80 69 00 00 04 00 00 D3 00 10 00 00 00 00 00
00 80 69 00 00 20 0D 00 00 00 00 08 00 00 00 00
00 00 60 1A 00 40 1A 00 00 00 00 00 00 00 00 00
00 00 00 08 00 40 1A 00 00 00 60 12 00 00 00 00
A4 01 00 01 00 00 00 00 00 00 A6 01 00 00 00 00 00
00 00 00 01 00 00 00 00 00 A4 A7 01 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 48 03 30 0D 00 00 00
00 00 00 00 00 00 00 00 00 00 48 03 00 00 00 80 00
00 00 00 30 0D 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 D3 00 00 00 00 00 00 00 00 00 40 00
48 03 00 00 00 D3 00 00 00 00 00 00 00 00 00 00 00
48 03 00 00 00 00 00 40 00

```

After ι

```

D2 00 00 00 00 04 00 00 00 00 10 00 00 20 0D 00
00 80 69 00 00 04 00 00 D3 00 10 00 00 00 00 00
00 80 69 00 00 20 0D 00 00 00 00 08 00 00 00 00
00 00 60 1A 00 40 1A 00 00 00 00 00 00 00 00 00
00 00 00 08 00 40 1A 00 00 00 60 12 00 00 00 00
A4 01 00 01 00 00 00 00 00 00 A6 01 00 00 00 00 00
00 00 00 01 00 00 00 00 00 A4 A7 01 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 48 03 30 0D 00 00 00
00 00 00 00 00 00 00 00 00 00 48 03 00 00 00 80 00
00 00 00 30 0D 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 D3 00 00 00 00 00 00 00 00 00 40 00
48 03 00 00 00 D3 00 00 00 00 00 00 00 00 00 00 00
48 03 00 00 00 00 00 40 00

```

(Skip rounds 1 to 22)

Round #23

After θ

F3 BD 8B A1 99 41 E9 3C 51 E0 3A E1 05 12 12 B9
 CD FF FD 9E 4D 58 D5 C5 3E D1 C3 D1 E7 7E A2 C7
 3D 80 9B EE FA E3 24 6B 49 51 2C 0C BF E2 5B 5E
 13 87 5E A5 D2 06 E9 27 ED 7A F5 BA 16 96 92 10
 73 95 55 13 68 DA D4 C6 0F 3E 1D 98 6D AA 95 8D
 B3 BB 77 B4 DA 14 AA A3 AB 8F A5 0D 74 0C E5 FC
 18 6C 98 39 8D 06 3D DC 75 83 32 99 36 C1 40 1F
 C6 A3 06 14 D0 38 AE C6 20 F0 90 21 1B 22 F1 AF
 FF 44 6D 00 E7 E6 88 FD 1B 5B 81 70 0F 98 F2 4F
 15 58 53 53 83 2A 5F 71 5F DB 3B 44 C6 DD 4D 00
 27 65 58 D0 56 40 0A 05 7A 42 58 B0 80 31 F5 75
 E5 AC 7A ED A8 33 5E 6C 41 D9 A9 82 7F A6 A8 6D
 E7 79 E7 17 2D 2E 46 A5

After p

F3 BD 8B A1 99 41 E9 3C A3 C0 75 C2 0B 24 24 72
 F3 7F BF 67 13 56 75 71 EE 27 7A EC 13 3D 1C 7D
 1F 27 59 EB 01 DC 74 D7 F0 2B BE E5 95 14 C5 C2
 55 2A 6D 90 7E 32 71 E8 44 BB 5E BD AE 85 A5 24
 CA AA 09 34 6D 6A E3 B9 5A D9 F8 E0 D3 81 D9 A6
 9D DD BD A3 D5 A6 50 1D F3 AF 3E 96 36 D0 31 94
 CC 69 34 E8 E1 C6 60 C3 82 81 3E EA 06 65 32 6D
 0A 68 1C 57 63 E3 51 03 43 36 44 E2 5F 41 E0 21
 0D E0 DC 1C B1 FF 9F A8 F9 A7 8D AD 40 B8 07 4C
 E5 2B AE 02 6B 6A 6A 50 00 5F DB 3B 44 C6 DD 4D
 29 14 9C 94 61 41 5B 01 E9 09 61 C1 02 C6 D4 D7
 9C 55 AF 1D 75 C6 8B AD D9 A9 82 7F A6 A8 6D 41
 51 E9 79 DE F9 45 8B 8B

After π

F3 BD 8B A1 99 41 E9 3C 55 2A 6D 90 7E 32 71 E8
 CC 69 34 E8 E1 C6 60 C3 E5 2B AE 02 6B 6A 6A 50
 51 E9 79 DE F9 45 8B 8B EE 27 7A EC 13 3D 1C 7D
 5A D9 F8 E0 D3 81 D9 A6 9D DD BD A3 D5 A6 50 1D
 0D E0 DC 1C B1 FF 9F A8 9C 55 AF 1D 75 C6 8B AD
 A3 C0 75 C2 0B 24 24 72 44 BB 5E BD AE 85 A5 24
 82 81 3E EA 06 65 32 6D 00 5F DB 3B 44 C6 DD 4D
 29 14 9C 94 61 41 5B 01 1F 27 59 EB 01 DC 74 D7
 F0 2B BE E5 95 14 C5 C2 F3 AF 3E 96 36 D0 31 94
 F9 A7 8D AD 40 B8 07 4C D9 A9 82 7F A6 A8 6D 41
 F3 7F BF 67 13 56 75 71 CA AA 09 34 6D 6A E3 B9
 0A 68 1C 57 63 E3 51 03 43 36 44 E2 5F 41 E0 21
 E9 09 61 C1 02 C6 D4 D7

After χ

```

7B FC 9B C9 18 85 E9 3F 74 28 E7 92 74 1A 7B F8
DC A9 65 34 71 C3 E1 48 47 3F 2C 23 6B 6A 0A 64
55 EB 1D CE 9F 77 9B 4B 6B 23 7F EF 17 1B 1C 64
5A F9 B8 FC F3 D8 56 06 0D C8 9E A2 91 A6 50 18
6F C2 8C FC B3 C6 8B F8 8C 8D 2F 1D B5 46 4A 2F
21 C0 55 80 0B 44 36 3B 44 E5 9F AC EE 07 68 24
AB 81 3A 6E 27 64 30 6D 82 9F BA 79 4E E2 F9 3F
6D 2F 96 A9 C5 C0 DA 05 1C A3 59 F9 23 1C 44 C3
F8 2B 3F CC D5 3C C3 8A F3 A7 3C C4 90 D0 59 95
FF A1 D4 2D 41 EC 17 DA 39 A1 24 7B 32 A8 EC 41
F3 3F AB 24 11 D7 65 73 8B BC 49 94 71 6A 43 99
A2 61 3D 56 63 65 45 D5 51 40 DA C4 4E 51 C1 01
E1 89 61 D1 6E EE 56 5F

```

After ι

```

73 7C 9B 49 18 85 E9 BF 74 28 E7 92 74 1A 7B F8
DC A9 65 34 71 C3 E1 48 47 3F 2C 23 6B 6A 0A 64
55 EB 1D CE 9F 77 9B 4B 6B 23 7F EF 17 1B 1C 64
5A F9 B8 FC F3 D8 56 06 0D C8 9E A2 91 A6 50 18
6F C2 8C FC B3 C6 8B F8 8C 8D 2F 1D B5 46 4A 2F
21 C0 55 80 0B 44 36 3B 44 E5 9F AC EE 07 68 24
AB 81 3A 6E 27 64 30 6D 82 9F BA 79 4E E2 F9 3F
6D 2F 96 A9 C5 C0 DA 05 1C A3 59 F9 23 1C 44 C3
F8 2B 3F CC D5 3C C3 8A F3 A7 3C C4 90 D0 59 95
FF A1 D4 2D 41 EC 17 DA 39 A1 24 7B 32 A8 EC 41
F3 3F AB 24 11 D7 65 73 8B BC 49 94 71 6A 43 99
A2 61 3D 56 63 65 45 D5 51 40 DA C4 4E 51 C1 01
E1 89 61 D1 6E EE 56 5F

```

After permutation

```

73 7C 9B 49 18 85 E9 BF 74 28 E7 92 74 1A 7B F8
DC A9 65 34 71 C3 E1 48 47 3F 2C 23 6B 6A 0A 64
55 EB 1D CE 9F 77 9B 4B 6B 23 7F EF 17 1B 1C 64
5A F9 B8 FC F3 D8 56 06 0D C8 9E A2 91 A6 50 18
6F C2 8C FC B3 C6 8B F8 8C 8D 2F 1D B5 46 4A 2F
21 C0 55 80 0B 44 36 3B 44 E5 9F AC EE 07 68 24
AB 81 3A 6E 27 64 30 6D 82 9F BA 79 4E E2 F9 3F
6D 2F 96 A9 C5 C0 DA 05 1C A3 59 F9 23 1C 44 C3
F8 2B 3F CC D5 3C C3 8A F3 A7 3C C4 90 D0 59 95
FF A1 D4 2D 41 EC 17 DA 39 A1 24 7B 32 A8 EC 41
F3 3F AB 24 11 D7 65 73 8B BC 49 94 71 6A 43 99
A2 61 3D 56 63 65 45 D5 51 40 DA C4 4E 51 C1 01
E1 89 61 D1 6E EE 56 5F

```

State (as lanes of integers)

[0, 0] = BFE98518499B7C73
 [1, 0] = F87B1A7492E72874
 [2, 0] = 48E1C3713465A9DC
 [3, 0] = 640A6A6B232C3F47
 [4, 0] = 4B9B779FCE1DEB55
 [0, 1] = 641C1B17EF7F236B
 [1, 1] = 0656D8F3FCB8F95A
 [2, 1] = 1850A691A29EC80D
 [3, 1] = F88BC6B3FC8CC26F
 [4, 1] = 2F4A46B51D2F8D8C
 [0, 2] = 3B36440B8055C021
 [1, 2] = 246807EEAC9FE544
 [2, 2] = 6D3064276E3A81AB
 [3, 2] = 3FF9E24E79BA9F82
 [4, 2] = 05DAC0C5A9962F6D
 [0, 3] = C3441C23F959A31C
 [1, 3] = 8AC33CD5CC3F2BF8
 [2, 3] = 9559D090C43CA7F3
 [3, 3] = DA17EC412DD4A1FF
 [4, 3] = 41ECA8327E24A139
 [0, 4] = 7365D71124AB3FF3
 [1, 4] = 99436A719449BC8B
 [2, 4] = D5456563563D61A2
 [3, 4] = 01C1514EC4DA4051
 [4, 4] = 5F56EE6ED16189E1

The hash value is

73 7C 9B 49 18 85 E9 BF 74 28 E7 92 74 1A 7B F8
 DC A9 65 34 71 C3 E1 48 47 3F 2C 23 6B 6A 0A 64
 55 EB 1D CE 9F 77 9B 4B 6B 23 7F EF 17 1B 1C 64

The message as bit string

110010100001101011011110100110

After θ

```

53 58 7B 99 01 00 00 00 52 58 7B 99 01 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
A6 B0 F6 32 03 00 00 00 00 00 00 00 00 00 00
52 58 7B 99 01 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 A6 B0 F6 32 03 00 00 00
00 00 00 00 00 00 00 00 52 58 7B 99 01 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 80
A6 B0 F6 32 03 00 00 00 00 00 00 00 00 00 00
52 58 7B 99 01 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 A6 B0 F6 32 03 00 00 00
00 00 00 00 00 00 00 00 52 58 7B 99 01 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80
A6 B0 F6 32 03 00 00 00

```

After ρ

```

53 58 7B 99 01 00 00 00 A4 B0 F6 32 03 00 00 00
00 00 00 00 00 00 00 00 00 00 00 08 00 00 00
00 00 00 30 85 B5 97 19 00 00 00 00 00 00 00
97 19 00 00 00 20 85 B5 00 00 00 00 00 00 00
00 00 00 00 00 00 40 00 00 00 60 0A 6B 2F 33 00
00 00 00 00 00 00 00 00 00 48 61 ED 65 06 00 00
00 00 00 00 00 04 00 00 00 00 00 01 00 00 00 00
99 01 00 00 00 53 58 7B 00 00 00 00 00 00 00 00
2F 33 00 00 00 40 0A 6B 00 00 00 00 00 00 00 00
00 00 10 00 00 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 00 00 00 00 00 00 48 61 ED 65 06 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
00 80 29 AC BD CC 00 00

```

After π

```

53 58 7B 99 01 00 00 00 97 19 00 00 00 20 85 B5
00 00 00 00 00 04 00 00 00 00 10 00 00 00 00 00
00 80 29 AC BD CC 00 00 00 00 00 08 00 00 00 00
00 00 60 0A 6B 2F 33 00 00 00 00 00 00 00 00 00
2F 33 00 00 00 40 0A 6B 00 00 00 00 00 00 00 00
A4 B0 F6 32 03 00 00 00 00 00 00 00 00 00 00 00
00 00 00 01 00 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 00 00 00 00 00 00 00 00 00 30 85 B5 97 19
00 00 00 00 00 00 00 00 00 48 61 ED 65 06 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 80 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 40 00
99 01 00 00 00 53 58 7B 00 00 00 00 00 00 00 00
48 61 ED 65 06 00 00 00

```

After χ

```

53 58 7B 99 01 04 00 00 97 19 10 00 00 20 85 B5
00 80 29 AC BD C8 00 00 53 58 42 11 00 00 00 00
84 81 29 AC BD EC 85 B5 00 00 00 08 00 00 00 00
2F 33 60 0A 6B 6F 39 6B 00 00 00 00 00 00 00 00
2F 33 00 08 00 40 0A 6B 00 00 60 02 6B 2F 33 00
A4 B0 F6 33 03 00 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 00 01 00 00 00 00 00 A4 16 46 C4 31 03 00 00
00 00 00 00 00 00 00 00 00 00 48 61 DD E0 B3 97 19
00 00 00 00 00 00 00 00 00 00 48 61 ED 65 06 80 00
00 00 00 30 85 B5 17 19 00 00 00 00 00 00 80 00
99 01 00 00 00 53 18 7B 00 00 00 00 00 00 40 00
D1 60 ED 65 06 53 58 7B 00 00 00 00 00 00 00 00
48 61 ED 65 06 00 40 00

```

After ι

```

52 58 7B 99 01 04 00 00 97 19 10 00 00 20 85 B5
00 80 29 AC BD C8 00 00 53 58 42 11 00 00 00 00
84 81 29 AC BD EC 85 B5 00 00 00 08 00 00 00 00
2F 33 60 0A 6B 6F 39 6B 00 00 00 00 00 00 00 00
2F 33 00 08 00 40 0A 6B 00 00 60 02 6B 2F 33 00
A4 B0 F6 33 03 00 00 00 00 00 A6 B0 F6 32 03 00 00
00 00 00 01 00 00 00 00 00 A4 16 46 C4 31 03 00 00
00 00 00 00 00 00 00 00 00 00 48 61 DD E0 B3 97 19
00 00 00 00 00 00 00 00 00 00 48 61 ED 65 06 80 00
00 00 00 30 85 B5 17 19 00 00 00 00 00 00 80 00
99 01 00 00 00 53 18 7B 00 00 00 00 00 00 40 00
D1 60 ED 65 06 53 58 7B 00 00 00 00 00 00 00 00
48 61 ED 65 06 00 40 00

```

(Skip rounds 1 to 22)

Round #23

After θ

BD 5B 7B D5 BE 03 9E 1B D9 A6 6A 12 CB 04 FC 5D
D0 76 3F A3 A9 F2 C4 09 73 F7 06 51 68 18 7E FD
7D 8C 28 76 AE 14 D1 94 95 CB 8C F2 5D 99 24 A7
1B E0 72 4D 86 3C F3 72 E0 77 86 C1 EB DE 56 02
53 F2 40 67 99 64 8E 5A 28 C2 52 4C 16 EA 6B E6
44 FC F9 BA AB 82 C3 68 60 00 F5 9D BB 09 26 A1
06 97 90 96 D8 D6 D6 25 8F 47 11 DB 72 4C A5 EA
57 AB F9 4C 32 96 3C C5 31 37 33 94 60 18 D5 F3
28 B3 7D E1 85 AE 9A 77 97 19 4B 51 B3 40 CB 7E
FA CB DB 12 56 A0 79 E2 58 E9 9B B9 02 03 F7 B2
64 6B 36 AE 0D 05 F9 33 A4 B7 F7 90 B3 01 A9 29
24 A7 43 A9 2D C2 F3 DE 9B 7B E1 63 BA 3D F4 70
B5 F3 BB A0 09 AC 14 1A

After ρ

BD 5B 7B D5 BE 03 9E 1B B2 4D D5 24 96 09 F8 BB
B4 DD CF 68 AA 3C 71 02 86 E1 D7 3F 77 6F 10 85
A5 88 A6 EC 63 44 B1 73 DF 95 49 72 5A B9 CC 28
D7 64 C8 33 2F B7 01 2E 00 F8 9D 61 F0 BA B7 95
79 A0 B3 4C 32 47 AD 29 BE 66 8E 22 2C C5 64 A1
23 E2 CF D7 5D 15 1C 46 84 82 01 D4 77 EE 26 98
B4 C4 B6 B6 2E 31 B8 84 98 4A D5 1F 8F 22 B6 E5
26 19 4B 9E E2 AB D5 7C 28 C1 30 AA E7 63 6E 66
2F BC D0 55 F3 0E 65 B6 65 BF CB 8C A5 A8 59 A0
34 4F 5C 7F 79 5B C2 0A B2 58 E9 9B B9 02 03 F7
E4 CF 90 AD D9 B8 36 14 90 DE DE 43 CE 06 A4 A6
E4 74 28 B5 45 78 DE 9B 7B E1 63 BA 3D F4 70 9B
85 46 ED FC 2E 68 02 2B

After π

BD 5B 7B D5 BE 03 9E 1B D7 64 C8 33 2F B7 01 2E
B4 C4 B6 B6 2E 31 B8 84 34 4F 5C 7F 79 5B C2 0A
85 46 ED FC 2E 68 02 2B 86 E1 D7 3F 77 6F 10 85
BE 66 8E 22 2C C5 64 A1 23 E2 CF D7 5D 15 1C 46
2F BC D0 55 F3 0E 65 B6 E4 74 28 B5 45 78 DE 9B
B2 4D D5 24 96 09 F8 BB 00 F8 9D 61 F0 BA B7 95
98 4A D5 1F 8F 22 B6 E5 B2 58 E9 9B B9 02 03 F7
E4 CF 90 AD D9 B8 36 14 A5 88 A6 EC 63 44 B1 73
DF 95 49 72 5A B9 CC 28 84 82 01 D4 77 EE 26 98
65 BF CB 8C A5 A8 59 A0 7B E1 63 BA 3D F4 70 9B
B4 DD CF 68 AA 3C 71 02 79 A0 B3 4C 32 47 AD 29
26 19 4B 9E E2 AB D5 7C 28 C1 30 AA E7 63 6E 66
90 DE DE 43 CE 06 A4 A6

After χ

```

9D DB 4D 51 BE 03 26 9B D7 6F 80 7A 7E FD 43 24
35 C4 17 36 28 11 B8 A5 0C 56 4E 7E E9 58 5E 1A
C7 62 6D DE 2F DC 03 0F 87 61 96 EA 26 7F 08 C3
B2 7A 9E 22 8E CF 05 11 E3 A2 E7 77 59 65 86 4F
2D 3D 07 5F C1 09 65 B2 DC 72 20 B5 4D F8 BA BB
2A 4F 95 3A 99 09 F8 DB 22 E8 B5 E1 C0 BA B6 87
DC CD C5 3B CF 9A 82 E5 A0 58 AC 9B BF 03 CB 5C
E4 7F 98 EC B9 0A 31 10 A5 8A A6 68 46 02 93 E3
BE A8 83 7A DA B9 95 08 9E C2 21 E6 6F BA 06 83
E1 B7 4F C8 E7 A8 D8 C0 21 F4 2A A8 25 4D 3C 93
B2 C4 87 FA 6A 94 21 56 71 60 83 6C 37 07 87 2B
B6 07 85 DF EA AF 55 FC 0C C0 31 82 C7 5B 3F 66
D9 FE EE 47 DE 45 28 8F

```

After ι

```

95 5B 4D D1 BE 03 26 1B D7 6F 80 7A 7E FD 43 24
35 C4 17 36 28 11 B8 A5 0C 56 4E 7E E9 58 5E 1A
C7 62 6D DE 2F DC 03 0F 87 61 96 EA 26 7F 08 C3
B2 7A 9E 22 8E CF 05 11 E3 A2 E7 77 59 65 86 4F
2D 3D 07 5F C1 09 65 B2 DC 72 20 B5 4D F8 BA BB
2A 4F 95 3A 99 09 F8 DB 22 E8 B5 E1 C0 BA B6 87
DC CD C5 3B CF 9A 82 E5 A0 58 AC 9B BF 03 CB 5C
E4 7F 98 EC B9 0A 31 10 A5 8A A6 68 46 02 93 E3
BE A8 83 7A DA B9 95 08 9E C2 21 E6 6F BA 06 83
E1 B7 4F C8 E7 A8 D8 C0 21 F4 2A A8 25 4D 3C 93
B2 C4 87 FA 6A 94 21 56 71 60 83 6C 37 07 87 2B
B6 07 85 DF EA AF 55 FC 0C C0 31 82 C7 5B 3F 66
D9 FE EE 47 DE 45 28 8F

```

After permutation

```

95 5B 4D D1 BE 03 26 1B D7 6F 80 7A 7E FD 43 24
35 C4 17 36 28 11 B8 A5 0C 56 4E 7E E9 58 5E 1A
C7 62 6D DE 2F DC 03 0F 87 61 96 EA 26 7F 08 C3
B2 7A 9E 22 8E CF 05 11 E3 A2 E7 77 59 65 86 4F
2D 3D 07 5F C1 09 65 B2 DC 72 20 B5 4D F8 BA BB
2A 4F 95 3A 99 09 F8 DB 22 E8 B5 E1 C0 BA B6 87
DC CD C5 3B CF 9A 82 E5 A0 58 AC 9B BF 03 CB 5C
E4 7F 98 EC B9 0A 31 10 A5 8A A6 68 46 02 93 E3
BE A8 83 7A DA B9 95 08 9E C2 21 E6 6F BA 06 83
E1 B7 4F C8 E7 A8 D8 C0 21 F4 2A A8 25 4D 3C 93
B2 C4 87 FA 6A 94 21 56 71 60 83 6C 37 07 87 2B
B6 07 85 DF EA AF 55 FC 0C C0 31 82 C7 5B 3F 66
D9 FE EE 47 DE 45 28 8F

```

State (as lanes of integers)

[0, 0] = 1B2603BED14D5B95
 [1, 0] = 2443FD7E7A806FD7
 [2, 0] = A5B811283617C435
 [3, 0] = 1A5E58E97E4E560C
 [4, 0] = 0F03DC2FDE6D62C7
 [0, 1] = C3087F26EA966187
 [1, 1] = 1105CF8E229E7AB2
 [2, 1] = 4F86655977E7A2E3
 [3, 1] = B26509C15F073D2D
 [4, 1] = BBBAF84DB52072DC
 [0, 2] = DBF809993A954F2A
 [1, 2] = 87B6BAC0E1B5E822
 [2, 2] = E5829ACF3BC5CDDC
 [3, 2] = 5CCB03BF9BAC58A0
 [4, 2] = 10310AB9EC987FE4
 [0, 3] = E393024668A68AA5
 [1, 3] = 0895B9DA7A83A8BE
 [2, 3] = 8306BA6FE621C29E
 [3, 3] = C0D8A8E7C84FB7E1
 [4, 3] = 933C4D25A82AF421
 [0, 4] = 5621946AFA87C4B2
 [1, 4] = 2B8707376C836071
 [2, 4] = FC55AFEADF8507B6
 [3, 4] = 663F5BC78231C00C
 [4, 4] = 8F2845DE47EEFED9

The hash value is

95 5B 4D D1 BE 03 26 1B D7 6F 80 7A 7E FD 43 24
 35 C4 17 36 28 11 B8 A5 0C 56 4E 7E E9 58 5E 1A
 C7 62 6D DE 2F DC 03 0F 87 61 96 EA 26 7F 08 C3

B.17 Dedicated Hash-Function 16 (SHA3-512)

NOTE 1 Data is presented in three different ways: bit strings, byte strings and w -length words (for the lanes).

NOTE 2 Bit strings are the sequence of bits from left to right.

NOTE 3 Byte strings are the bytes from left to right and the bits within the byte are right to left.

NOTE 4 Words are the integer representation of the values in the lanes.

The message as bit string

(empty message)

After θ

```

06 00 00 00 00 00 00 00 06 00 00 00 00 00 00 00
01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0C 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
06 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 0C 00 00 00 00 00 00 80
00 00 00 00 00 00 00 00 06 00 00 00 00 00 00 00
01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0C 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
06 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 0C 00 00 00 00 00 00 80
00 00 00 00 00 00 00 00 06 00 00 00 00 00 00 00
01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
0C 00 00 00 00 00 00 80

```

After ρ

```

06 00 00 00 00 00 00 00 0C 00 00 00 00 00 00 00
00 00 00 00 00 00 00 40 00 00 00 00 00 00 00 00
00 00 00 64 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 60 00 00 40 00 00 00 00 00 00 00
00 00 00 00 00 00 40 00 00 00 C8 00 00 00 00 00
00 00 00 00 00 00 00 00 00 18 00 00 00 00 00 00
00 00 00 00 00 08 00 00 60 00 00 00 00 00 00 00
00 00 00 00 40 06 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 C0 00 00 00 00 80 00 00 00 00 00
00 00 00 00 00 00 00 00 80 0C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 18 00 00 00 00 00 00 00
00 00 00 00 00 00 00 20 00 00 00 00 00 00 00 00
00 20 03 00 00 00 00 00 00

```

After π

```

06 00 00 00 00 00 00 00 00 00 00 00 00 60 00 00
00 00 00 00 00 08 00 00 00 00 00 00 00 00 00 00
00 20 03 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 C8 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 C0 00 00 00 00 00 00 00 00 00 20
0C 00 00 00 00 00 00 00 40 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 80 0C 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 64 00 00 00 00
00 00 00 00 00 00 00 00 00 18 00 00 00 00 00 00
00 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 40 00 00 00 00 00 00 40 00
00 00 00 00 40 06 00 00 00 00 00 00 00 00 00 00
18 00 00 00 00 00 00 00

```

After χ

```

06 00 00 00 00 08 00 00 00 00 00 00 00 60 00 00
00 20 03 00 00 08 00 00 06 00 00 00 00 00 00 00
00 20 03 00 00 60 00 00 00 00 00 00 00 00 00 00
00 00 c8 00 00 c0 00 00 00 00 00 00 00 00 00 20
00 00 00 00 00 c0 00 00 00 00 c8 00 00 00 00 20
0c 00 00 00 00 00 00 00 c0 0c 00 00 00 00 00 00
00 00 00 00 00 00 00 00 8c 0c 00 00 00 00 00 00
40 00 00 00 00 00 00 00 00 00 18 00 64 00 00 00
00 80 00 00 00 00 00 00 00 00 18 00 00 00 00 00
00 80 00 64 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 40 06 00 40 00 00 00 00 00 00 40 00
18 00 00 00 40 06 00 00 00 00 00 00 00 00 00 40
18 00 00 00 00 00 00 40 00

```

After ι

```

07 00 00 00 00 08 00 00 00 00 00 00 00 60 00 00
00 20 03 00 00 08 00 00 06 00 00 00 00 00 00 00
00 20 03 00 00 60 00 00 00 00 00 00 00 00 00 00
00 00 c8 00 00 c0 00 00 00 00 00 00 00 00 00 20
00 00 00 00 00 c0 00 00 00 00 c8 00 00 00 00 20
0c 00 00 00 00 00 00 00 c0 0c 00 00 00 00 00 00
00 00 00 00 00 00 00 00 8c 0c 00 00 00 00 00 00
40 00 00 00 00 00 00 00 00 00 18 00 64 00 00 00
00 80 00 00 00 00 00 00 00 00 18 00 00 00 00 00
00 80 00 64 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 40 06 00 40 00 00 00 00 00 00 40 00
18 00 00 00 40 06 00 00 00 00 00 00 00 00 00 40
18 00 00 00 00 00 00 40 00

```

(Skip rounds 1 to 22)

Round #23

After θ

AC 55 F3 6C 45 3B 9A 54 F3 B6 DB 13 0F 0F 54 16
 AA 2B 77 77 09 39 9A 23 C0 30 53 CE 15 21 F0 24
 AC 5F 9D 80 59 A4 0D 7B 08 65 07 88 55 78 03 79
 74 8F 0C 18 AA D5 85 E1 37 BF CF DB F9 A4 3E E5
 44 DE 1C E0 10 D0 A7 6D 51 2A 45 11 3C 32 8D 10
 38 FC F6 18 A4 21 AC 04 CD 6E 92 AC 91 33 D1 48
 88 28 43 70 19 90 E7 7C FC E9 C2 B5 B0 C0 6C 97
 DA A0 65 1D C0 BB 4C EF 48 C4 8C FB EF D1 B2 CD
 9D 20 37 49 6A D4 3D 7F A3 38 B2 81 F5 1A 4F FC
 29 1C B2 12 B4 45 A2 EC CC 35 72 2D 4D 4F CB 1B
 88 D9 B0 40 35 51 83 1E 34 52 E6 C0 03 FD 31 33
 09 AF BE 8D 62 DC 6C 1D 9E BC 42 EE 0B AC 4E AD
 68 AC A4 C7 72 12 57 48

After p

AC 55 F3 6C 45 3B 9A 54 E6 6D B7 27 1E 1E A8 2C
 EA CA DD 5D 42 8E E6 88 11 02 4F 02 0C 33 E5 5C
 22 6D D8 63 FD EA 04 CC 58 85 37 90 87 50 76 80
 80 A1 5A 5D 18 4E F7 C8 F9 CD EF F3 76 3E A9 4F
 6F 0E 70 08 E8 D3 36 22 D3 08 11 A5 52 14 C1 23
 C0 E1 B7 C7 20 0D 61 25 23 35 BB 49 B2 46 CE 44
 82 CB 80 3C E7 43 44 19 81 D9 2E F9 D3 85 6B 61
 0E E0 5D A6 77 6D D0 B2 F7 DF A3 65 9B 91 88 19
 26 49 8D BA E7 AF 13 E4 27 FE 51 1C D9 C0 7A 8D
 48 94 3D 85 43 56 82 B6 1B CC 35 72 2D 4D 4F CB
 0D 7A 20 66 C3 02 D5 44 D0 48 99 03 0F F4 C7 CC
 E1 D5 B7 51 8C 9B AD 23 BC 42 EE 0B AC 4E AD 9E
 15 12 1A 2B E9 B1 9C C4

After π

AC 55 F3 6C 45 3B 9A 54 80 A1 5A 5D 18 4E F7 C8
 82 CB 80 3C E7 43 44 19 48 94 3D 85 43 56 82 B6
 15 12 1A 2B E9 B1 9C C4 11 02 4F 02 0C 33 E5 5C
 D3 08 11 A5 52 14 C1 23 C0 E1 B7 C7 20 0D 61 25
 26 49 8D BA E7 AF 13 E4 E1 D5 B7 51 8C 9B AD 23
 E6 6D B7 27 1E 1E A8 2C F9 CD EF F3 76 3E A9 4F
 81 D9 2E F9 D3 85 6B 61 1B CC 35 72 2D 4D 4F CB
 0D 7A 20 66 C3 02 D5 44 22 6D D8 63 FD EA 04 CC
 58 85 37 90 87 50 76 80 23 35 BB 49 B2 46 CE 44
 27 FE 51 1C D9 C0 7A 8D BC 42 EE 0B AC 4E AD 9E
 EA CA DD 5D 42 8E E6 88 6F 0E 70 08 E8 D3 36 22
 0E E0 5D A6 77 6D D0 B2 F7 DF A3 65 9B 91 88 19
 D0 48 99 03 0F F4 C7 CC

After χ

AE 1F 73 4C A2 3A 9A 45 C8 B5 67 DC 18 5A 75 6E
 97 C9 82 16 4F E2 58 59 E0 D1 DC C1 47 5C 80 A6
 15 B2 12 3A F1 F5 F9 4C 11 E3 E9 40 2C 3A C5 58
 F5 00 19 9D 95 B6 D3 E3 01 75 85 86 28 1D CD 26
 36 4B C5 B8 E7 8F 53 B8 23 DD A7 F4 DE 9F AD 00
 E6 7D B7 2F 9F 9F EA 0C E3 C9 FE F1 5A 76 AD C5
 85 EB 2E FD 11 87 FB 65 F9 C9 A2 73 31 51 67 E3
 14 FA 68 B6 A3 22 D4 07 01 5D 50 2A CD EC 8C 88
 5C 4F 77 84 CE D0 46 09 BB 35 15 4A 96 48 4B 56
 25 D3 41 7C 88 60 7A CD E4 C2 C9 9B AE 5E DF 9E
 EA 2A D0 FB 55 A2 26 18 9E 11 D2 49 60 43 3E 2B
 0E E0 45 A4 73 09 97 76 DD 5D E7 39 DB 9B A8 19
 D5 4C B9 03 A7 A5 D7 EE

After ι

A6 9F 73 CC A2 3A 9A C5 C8 B5 67 DC 18 5A 75 6E
 97 C9 82 16 4F E2 58 59 E0 D1 DC C1 47 5C 80 A6
 15 B2 12 3A F1 F5 F9 4C 11 E3 E9 40 2C 3A C5 58
 F5 00 19 9D 95 B6 D3 E3 01 75 85 86 28 1D CD 26
 36 4B C5 B8 E7 8F 53 B8 23 DD A7 F4 DE 9F AD 00
 E6 7D B7 2F 9F 9F EA 0C E3 C9 FE F1 5A 76 AD C5
 85 EB 2E FD 11 87 FB 65 F9 C9 A2 73 31 51 67 E3
 14 FA 68 B6 A3 22 D4 07 01 5D 50 2A CD EC 8C 88
 5C 4F 77 84 CE D0 46 09 BB 35 15 4A 96 48 4B 56
 25 D3 41 7C 88 60 7A CD E4 C2 C9 9B AE 5E DF 9E
 EA 2A D0 FB 55 A2 26 18 9E 11 D2 49 60 43 3E 2B
 0E E0 45 A4 73 09 97 76 DD 5D E7 39 DB 9B A8 19
 D5 4C B9 03 A7 A5 D7 EE

After permutation

A6 9F 73 CC A2 3A 9A C5 C8 B5 67 DC 18 5A 75 6E
 97 C9 82 16 4F E2 58 59 E0 D1 DC C1 47 5C 80 A6
 15 B2 12 3A F1 F5 F9 4C 11 E3 E9 40 2C 3A C5 58
 F5 00 19 9D 95 B6 D3 E3 01 75 85 86 28 1D CD 26
 36 4B C5 B8 E7 8F 53 B8 23 DD A7 F4 DE 9F AD 00
 E6 7D B7 2F 9F 9F EA 0C E3 C9 FE F1 5A 76 AD C5
 85 EB 2E FD 11 87 FB 65 F9 C9 A2 73 31 51 67 E3
 14 FA 68 B6 A3 22 D4 07 01 5D 50 2A CD EC 8C 88
 5C 4F 77 84 CE D0 46 09 BB 35 15 4A 96 48 4B 56
 25 D3 41 7C 88 60 7A CD E4 C2 C9 9B AE 5E DF 9E
 EA 2A D0 FB 55 A2 26 18 9E 11 D2 49 60 43 3E 2B
 0E E0 45 A4 73 09 97 76 DD 5D E7 39 DB 9B A8 19
 D5 4C B9 03 A7 A5 D7 EE

State (as lanes of integers)

[0, 0] = C59A3AA2CC739FA6
 [1, 0] = 6E755A18DC67B5C8
 [2, 0] = 5958E24F1682C997
 [3, 0] = A6805C47C1DCD1E0
 [4, 0] = 4CF9F5F13A12B215
 [0, 1] = 58C53A2C40E9E311
 [1, 1] = E3D3B6959D1900F5
 [2, 1] = 26CD1D2886857501
 [3, 1] = B8538FE7B8C54B36
 [4, 1] = 00AD9FDEF4A7DD23
 [0, 2] = 0CEA9F9F2FB77DE6
 [1, 2] = C5AD765AF1FEC9E3
 [2, 2] = 65FB8711FD2EEB85
 [3, 2] = E367513173A2C9F9
 [4, 2] = 07D422A3B668FA14
 [0, 3] = 888CECCD2A505D01
 [1, 3] = 0946D0CE84774F5C
 [2, 3] = 564B48964A1535BB
 [3, 3] = CD7A60887C41D325
 [4, 3] = 9EDF5EAE9BC9C2E4
 [0, 4] = 1826A255FBD02AEA
 [1, 4] = 2B3E436049D2119E
 [2, 4] = 76970973A445E00E
 [3, 4] = 19A89BDB39E75DDD
 [4, 4] = EED7A5A703B94CD5

The hash value is

A6 9F 73 CC A2 3A 9A C5 C8 B5 67 DC 18 5A 75 6E
 97 C9 82 16 4F E2 58 59 E0 D1 DC C1 47 5C 80 A6
 15 B2 12 3A F1 F5 F9 4C 11 E3 E9 40 2C 3A C5 58
 F5 00 19 9D 95 B6 D3 E3 01 75 85 86 28 1D CD 26

The message as bit string

1 1 0 0 1

After θ

```

D3 00 00 00 00 00 00 00 00 D3 00 00 00 00 00 00 00
01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
A6 01 00 00 00 00 00 80 00 00 00 00 00 00 00 00
D3 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 A6 01 00 00 00 00 00 80
00 00 00 00 00 00 00 00 D3 00 00 00 00 00 00 00
01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
A6 01 00 00 00 00 00 80 00 00 00 00 00 00 00 00
D3 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 A6 01 00 00 00 00 00 80
00 00 00 00 00 00 00 00 D3 00 00 00 00 00 00 00
01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
A6 01 00 00 00 00 00 80

```

After ρ

```

D3 00 00 00 00 00 00 00 A6 01 00 00 00 00 00 00
00 00 00 00 00 00 00 40 00 00 00 00 00 00 00 00
00 00 00 34 0D 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 30 0D 00 40 00 00 00 00 00 00 00
00 00 00 00 00 00 40 00 00 00 68 1A 00 00 00 00
00 00 00 00 00 00 00 00 00 4C 03 00 00 00 00 00
00 00 00 00 00 08 00 00 00 00 00 00 00 00 00 00
00 00 00 00 40 D3 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 60 1A 00 00 80 00 00 00 00 00 00
00 00 00 00 00 00 00 00 80 A6 01 00 00 00 00 00
00 00 00 00 00 00 00 00 4C 03 00 00 00 00 00 00
00 00 00 00 00 00 00 20 00 00 00 00 00 00 00 00
00 A0 69 00 00 00 00 00 00

```

After π

```

D3 00 00 00 00 00 00 00 00 00 00 00 00 30 0D 00
00 00 00 00 00 08 00 00 00 00 00 00 00 00 00 00
00 A0 69 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 68 1A 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 60 1A 00 00 00 00 00 00 00 00 20
A6 01 00 00 00 00 00 00 40 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 80 A6 01 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 34 0D 00 00 00
00 00 00 00 00 00 00 00 00 00 4C 03 00 00 00 00
00 80 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 40 00 00 00 00 00 00 40 00
00 00 00 00 40 D3 00 00 00 00 00 00 00 00 00 00
4C 03 00 00 00 00 00 00

```

After χ

```

D3 00 00 00 00 08 00 00 00 00 00 00 00 00 30 0D 00
00 A0 69 00 00 08 00 00 D3 00 00 00 00 00 00 00 00
00 A0 69 00 00 30 0D 00 00 00 00 00 00 00 00 00 00
00 00 68 1A 00 60 1A 00 00 00 00 00 00 00 00 00 20
00 00 00 00 00 60 1A 00 00 00 68 1A 00 00 00 00 20
A6 01 00 00 00 00 00 00 C0 A6 01 00 00 00 00 00 00
00 00 00 00 00 00 00 00 26 A7 01 00 00 00 00 00 00
40 00 00 00 00 00 00 00 00 00 4C 03 34 0D 00 00 00
00 80 00 00 00 00 00 00 00 00 4C 03 00 00 00 00 00
00 80 00 34 0D 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 40 D3 00 40 00 00 00 00 00 00 00 40 00
4C 03 00 00 40 D3 00 00 00 00 00 00 00 00 00 00 40
4C 03 00 00 00 00 00 40 00

```

After ι

```

D2 00 00 00 00 08 00 00 00 00 00 00 00 00 30 0D 00
00 A0 69 00 00 08 00 00 D3 00 00 00 00 00 00 00 00
00 A0 69 00 00 30 0D 00 00 00 00 00 00 00 00 00 00
00 00 68 1A 00 60 1A 00 00 00 00 00 00 00 00 00 20
00 00 00 00 00 60 1A 00 00 00 68 1A 00 00 00 00 20
A6 01 00 00 00 00 00 00 C0 A6 01 00 00 00 00 00 00
00 00 00 00 00 00 00 00 26 A7 01 00 00 00 00 00 00
40 00 00 00 00 00 00 00 00 00 4C 03 34 0D 00 00 00
00 80 00 00 00 00 00 00 00 00 4C 03 00 00 00 00 00
00 80 00 34 0D 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 40 D3 00 40 00 00 00 00 00 00 00 40 00
4C 03 00 00 40 D3 00 00 00 00 00 00 00 00 00 00 40
4C 03 00 00 00 00 00 40 00

```

(Skip rounds 1 to 22)

Round #23

After θ

8C 3E 41 CB D0 65 FC 4C 7D 72 90 CA 3E 31 E5 16
 BF 34 08 00 48 62 98 BF F7 11 2F 6C BD 36 ED 59
 C3 26 A5 74 61 0B DF 40 80 43 3E 4A 07 80 B7 FD
 08 30 A2 25 D7 C2 8D C6 E9 93 68 6B 6B 56 35 C5
 7E DE A8 17 F1 8B 42 73 18 0C B8 DD 01 9B 77 E4
 D2 90 45 92 85 F5 E6 0F D5 F4 0F 1B A4 3B DA AF
 8F A7 AE 44 18 49 22 B3 09 A8 FD C7 C3 40 C0 D1
 E3 B2 55 35 3F E5 88 2E 20 8F 13 0A DE F6 23 51
 BE B7 81 D8 C4 87 AA C8 33 CA 45 F6 30 F5 40 38
 72 4D 2E F8 3B D1 92 3E 95 1E D9 29 82 D7 3B A1
 B9 3E B0 E5 2B 29 51 55 90 CA 7E 75 0C 69 34 81
 C2 3E 37 EE C2 E0 DB D6 91 C8 5D 11 B2 D4 9F 3B
 E0 54 36 27 2C FD 1B 30

After p

8C 3E 41 CB D0 65 FC 4C FA E4 20 95 7D 62 CA 2D
 2F 0D 02 00 92 18 E6 EF 6B D3 9E 75 1F F1 C2 D6
 5B F8 06 1A 36 29 A5 0B 74 00 78 DB 0F 38 E4 A3
 5A 72 2D DC 68 8C 00 23 71 FA 24 DA DA 9A 55 4D
 6F D4 8B F8 45 A1 39 3F 79 47 8E C1 80 DB 1D B0
 90 86 2C 92 2C AC 37 7F BE 56 D3 3F 6C 90 EE 68
 25 C2 48 12 99 7D 3C 75 81 80 A3 13 50 FB 8F 87
 9A 9F 72 44 97 71 D9 AA 14 BC ED 47 A2 40 1E 27
 10 9B F8 50 15 D9 F7 36 20 9C 19 E5 22 7B 98 7A
 5A D2 47 AE C9 05 7F 27 A1 95 1E D9 29 82 D7 3B
 44 55 E5 FA C0 96 AF A4 42 2A FB D5 31 A4 D1 04
 D8 E7 C6 5D 18 7C DB 5A C8 5D 11 B2 D4 9F 3B 91
 06 0C 38 95 CD 09 4B FF

After π

8C 3E 41 CB D0 65 FC 4C 5A 72 2D DC 68 8C 00 23
 25 C2 48 12 99 7D 3C 75 5A D2 47 AE C9 05 7F 27
 06 0C 38 95 CD 09 4B FF 6B D3 9E 75 1F F1 C2 D6
 79 47 8E C1 80 DB 1D B0 90 86 2C 92 2C AC 37 7F
 10 9B F8 50 15 D9 F7 36 D8 E7 C6 5D 18 7C DB 5A
 FA E4 20 95 7D 62 CA 2D 71 FA 24 DA DA 9A 55 4D
 81 80 A3 13 50 FB 8F 87 A1 95 1E D9 29 82 D7 3B
 44 55 E5 FA C0 96 AF A4 5B F8 06 1A 36 29 A5 0B
 74 00 78 DB 0F 38 E4 A3 BF 56 D3 3F 6C 90 EE 68
 20 9C 19 E5 22 7B 98 7A C8 5D 11 B2 D4 9F 3B 91
 2F 0D 02 00 92 18 E6 EF 6F D4 8B F8 45 A1 39 3F
 9A 9F 72 44 97 71 D9 AA 14 BC ED 47 A2 40 1E 27
 42 2A FB D5 31 A4 D1 04

After χ

A9 BE 01 C9 41 14 C0 18 00 62 2A 70 28 8C 43 21
 21 CE 70 03 9D 75 3C AD D2 E0 06 E4 D9 61 CB 27
 54 4C 14 81 E5 81 4B DC EB 53 BE 67 33 D5 E0 99
 79 5E 5E 81 91 8A DD B0 58 E2 2A 9F 24 88 3F 37
 33 8B E0 70 12 58 F7 B2 C8 E3 C6 DD 98 76 C6 7A
 7A E4 A3 94 7D 03 40 AF 51 EF 38 12 F3 9A 05 75
 C5 C0 42 31 90 EF A7 03 1B 35 1E DC 14 E2 97 32
 45 4F E1 B0 42 0E BA E4 D0 AE 85 3E 56 A9 AF 43
 74 88 70 1B 0D 53 F4 B1 77 17 D3 2D B8 14 CD E9
 33 3C 1F ED 00 5B 1C 70 EC 5D 69 73 DD 8F 7B 31
 BF 06 72 04 00 48 26 6F 6B F4 06 FB 65 A1 3F 3A
 D8 9D 60 D4 86 D5 18 AA 39 B9 ED 47 20 58 38 CC
 02 FA 72 2D 74 05 C8 14

After ι

A1 3E 01 49 41 14 C0 98 00 62 2A 70 28 8C 43 21
 21 CE 70 03 9D 75 3C AD D2 E0 06 E4 D9 61 CB 27
 54 4C 14 81 E5 81 4B DC EB 53 BE 67 33 D5 E0 99
 79 5E 5E 81 91 8A DD B0 58 E2 2A 9F 24 88 3F 37
 33 8B E0 70 12 58 F7 B2 C8 E3 C6 DD 98 76 C6 7A
 7A E4 A3 94 7D 03 40 AF 51 EF 38 12 F3 9A 05 75
 C5 C0 42 31 90 EF A7 03 1B 35 1E DC 14 E2 97 32
 45 4F E1 B0 42 0E BA E4 D0 AE 85 3E 56 A9 AF 43
 74 88 70 1B 0D 53 F4 B1 77 17 D3 2D B8 14 CD E9
 33 3C 1F ED 00 5B 1C 70 EC 5D 69 73 DD 8F 7B 31
 BF 06 72 04 00 48 26 6F 6B F4 06 FB 65 A1 3F 3A
 D8 9D 60 D4 86 D5 18 AA 39 B9 ED 47 20 58 38 CC
 02 FA 72 2D 74 05 C8 14

After permutation

A1 3E 01 49 41 14 C0 98 00 62 2A 70 28 8C 43 21
 21 CE 70 03 9D 75 3C AD D2 E0 06 E4 D9 61 CB 27
 54 4C 14 81 E5 81 4B DC EB 53 BE 67 33 D5 E0 99
 79 5E 5E 81 91 8A DD B0 58 E2 2A 9F 24 88 3F 37
 33 8B E0 70 12 58 F7 B2 C8 E3 C6 DD 98 76 C6 7A
 7A E4 A3 94 7D 03 40 AF 51 EF 38 12 F3 9A 05 75
 C5 C0 42 31 90 EF A7 03 1B 35 1E DC 14 E2 97 32
 45 4F E1 B0 42 0E BA E4 D0 AE 85 3E 56 A9 AF 43
 74 88 70 1B 0D 53 F4 B1 77 17 D3 2D B8 14 CD E9
 33 3C 1F ED 00 5B 1C 70 EC 5D 69 73 DD 8F 7B 31
 BF 06 72 04 00 48 26 6F 6B F4 06 FB 65 A1 3F 3A
 D8 9D 60 D4 86 D5 18 AA 39 B9 ED 47 20 58 38 CC
 02 FA 72 2D 74 05 C8 14

State (as lanes of integers)

[0, 0] = 98C0144149013EA1
 [1, 0] = 21438C28702A6200
 [2, 0] = AD3C759D0370CE21
 [3, 0] = 27CB61D9E406E0D2
 [4, 0] = DC4B81E581144C54
 [0, 1] = 99E0D53367BE53EB
 [1, 1] = B0DD8A91815E5E79
 [2, 1] = 373F88249F2AE258
 [3, 1] = B2F7581270E08B33
 [4, 1] = 7AC67698DDC6E3C8
 [0, 2] = AF40037D94A3E47A
 [1, 2] = 75059AF31238EF51
 [2, 2] = 03A7EF903142C0C5
 [3, 2] = 3297E214DC1E351B
 [4, 2] = E4BA0E42B0E14F45
 [0, 3] = 43AFA9563E85AED0
 [1, 3] = B1F4530D1B708874
 [2, 3] = E9CD14B82DD31777
 [3, 3] = 701C5B00ED1F3C33
 [4, 3] = 317B8FDD73695DEC
 [0, 4] = 6F264800047206BF
 [1, 4] = 3A3FA165FB06F46B
 [2, 4] = AA18D586D4609DD8
 [3, 4] = CC38582047EDB939
 [4, 4] = 14C805742D72FA02

The hash value is

A1 3E 01 49 41 14 C0 98 00 62 2A 70 28 8C 43 21
 21 CE 70 03 9D 75 3C AD D2 E0 06 E4 D9 61 CB 27
 54 4C 14 81 E5 81 4B DC EB 53 BE 67 33 D5 E0 99
 79 5E 5E 81 91 8A DD B0 58 E2 2A 9F 24 88 3F 37

The message as bit string

110010100001101011011110100110

After θ

```

53 58 7B 99 01 00 00 00 53 58 7B 99 01 00 00 00
01 00 00 00 00 00 00 00 00 00 00 00 00 00 00
A6 B0 F6 32 03 00 00 80 00 00 00 00 00 00 00
53 58 7B 99 01 00 00 00 01 00 00 00 00 00 00
00 00 00 00 00 00 00 80 A6 B0 F6 32 03 00 00 80
00 00 00 00 00 00 00 00 53 58 7B 99 01 00 00
01 00 00 00 00 00 00 00 00 00 00 00 00 00
A6 B0 F6 32 03 00 00 80 00 00 00 00 00 00 00
53 58 7B 99 01 00 00 00 01 00 00 00 00 00 00
00 00 00 00 00 00 00 00 A6 B0 F6 32 03 00 00 80
00 00 00 00 00 00 00 00 53 58 7B 99 01 00 00
01 00 00 00 00 00 00 00 00 00 00 00 00 00
A6 B0 F6 32 03 00 00 80

```

After ρ

```

53 58 7B 99 01 00 00 00 A6 B0 F6 32 03 00 00 00
00 00 00 00 00 00 00 40 00 00 00 00 00 00 00
00 00 00 34 85 B5 97 19 00 00 00 00 00 00 00
97 19 00 00 00 30 85 B5 40 00 00 00 00 00 00
00 00 00 00 00 00 40 00 00 00 68 0A 6B 2F 33 00
00 00 00 00 00 00 00 00 00 4C 61 ED 65 06 00 00
00 00 00 00 00 08 00 00 00 00 00 00 00 00 00
99 01 00 00 40 53 58 7B 00 00 00 00 00 00 00
2F 33 00 00 00 60 0A 6B 00 80 00 00 00 00 00
00 00 00 00 00 00 00 80 A6 B0 F6 32 03 00 00
00 00 00 00 00 00 00 00 4C 61 ED 65 06 00 00
00 00 00 00 00 00 00 20 00 00 00 00 00 00 00
00 A0 29 AC BD CC 00 00

```

After π

```

53 58 7B 99 01 00 00 00 97 19 00 00 00 30 85 B5
00 00 00 00 00 08 00 00 00 00 00 00 00 00 00
00 A0 29 AC BD CC 00 00 00 00 00 00 00 00 00
00 00 68 0A 6B 2F 33 00 00 00 00 00 00 00 00
2F 33 00 00 00 60 0A 6B 00 00 00 00 00 00 20
A6 B0 F6 32 03 00 00 00 40 00 00 00 00 00 00
00 00 00 00 00 00 00 00 80 A6 B0 F6 32 03 00 00
00 00 00 00 00 00 00 00 00 00 34 85 B5 97 19
00 00 00 00 00 00 00 00 00 4C 61 ED 65 06 00 00
00 80 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 40 00 00 00 00 00 00 40 00
99 01 00 00 40 53 58 7B 00 00 00 00 00 00 00
4C 61 ED 65 06 00 00 00

```


After χ

```

53 58 7B 99 01 08 00 00 97 19 00 00 00 30 85 B5
00 A0 29 AC BD C4 00 00 53 58 52 11 00 00 00 00
84 A1 29 AC BD FC 85 B5 00 00 00 00 00 00 00 00
2F 33 68 0A 6B 4F 39 6B 00 00 00 00 00 00 00 00
2F 33 00 00 00 60 0A 6B 00 00 68 0A 6B 2F 33 20
A6 B0 F6 32 03 00 00 00 C0 A6 B0 F6 32 03 00 00
00 00 00 00 00 00 00 00 26 16 46 C4 31 03 00 00
40 00 00 00 00 00 00 00 00 00 4C 61 D9 E0 B3 97 19
00 80 00 00 00 00 00 00 00 00 4C 61 ED 65 06 00 00
00 80 00 34 85 B5 97 19 00 00 00 00 00 00 00 00
99 01 00 00 40 53 18 3B 00 00 00 00 00 00 40 00
D5 60 ED 65 46 53 58 7B 00 00 00 00 00 00 00 40
4C 61 ED 65 06 00 40 00

```

After ι

```

52 58 7B 99 01 08 00 00 97 19 00 00 00 30 85 B5
00 A0 29 AC BD C4 00 00 53 58 52 11 00 00 00 00
84 A1 29 AC BD FC 85 B5 00 00 00 00 00 00 00 00
2F 33 68 0A 6B 4F 39 6B 00 00 00 00 00 00 00 00
2F 33 00 00 00 60 0A 6B 00 00 68 0A 6B 2F 33 20
A6 B0 F6 32 03 00 00 00 C0 A6 B0 F6 32 03 00 00
00 00 00 00 00 00 00 00 26 16 46 C4 31 03 00 00
40 00 00 00 00 00 00 00 00 00 4C 61 D9 E0 B3 97 19
00 80 00 00 00 00 00 00 00 00 4C 61 ED 65 06 00 00
00 80 00 34 85 B5 97 19 00 00 00 00 00 00 00 00
99 01 00 00 40 53 18 3B 00 00 00 00 00 00 40 00
D5 60 ED 65 46 53 58 7B 00 00 00 00 00 00 00 40
4C 61 ED 65 06 00 40 00

```

(Skip rounds 1 to 22)

Round #23

After θ

90 F6 4A 2B 92 8C C7 53 FB 93 74 1B F2 C9 3F DA
 5C CE AB BF CC 44 7B 46 A9 10 30 E8 9B 33 44 8A
 B0 63 1E 7F 5F 54 47 76 4D B7 91 25 DA 72 72 10
 D8 F6 AD 87 48 26 80 01 AB FE EA A9 2F 72 74 E0
 20 1E DE FE 0D 29 89 54 44 C7 D9 E3 9F C2 B7 55
 40 BB FA 09 2A E5 48 75 FA 43 A9 56 2A 7A E9 99
 4D CD 11 4B D9 31 7E B3 00 A1 4A 74 91 04 9D BB
 9D B6 4F FF F0 43 55 FE B2 69 27 A1 FB D7 83 E0
 12 54 52 B5 86 B0 BE 82 10 A5 27 6C CD 62 3A 4D
 E0 2A C0 16 4B C6 B7 D0 D6 B1 82 4F 04 ED 4D D1
 D9 CA D2 EC 3B 67 4F 5D 2B B1 7F 96 90 64 78 A3
 F2 F0 A1 C1 7B FB E3 09 89 72 89 B1 0D D4 0C 7B
 0B AA 42 6A 00 B4 C7 41

After p

90 F6 4A 2B 92 8C C7 53 F7 27 E9 36 E4 93 7F B4
 97 F3 EA 2F 33 D1 9E 11 39 43 A4 98 0A 01 83 BE
 A2 3A B2 83 1D F3 F8 FB A2 2D 27 07 D1 74 1B 59
 7A 88 64 02 18 80 6D DF F8 AA BF 7A EA 8B 1C 1D
 0F 6F FF 86 94 44 2A 10 7C 5B 45 74 9C 3D FE 29
 03 DA D5 4F 50 29 47 AA 67 EA 0F A5 5A A9 E8 A5
 58 CA 8E F1 9B 6D 6A 8E 09 3A 77 01 42 95 E8 22
 7F F8 A1 2A FF 4E DB A7 42 F7 AF 07 C1 65 D3 4E
 AA D6 10 D6 57 50 82 4A 9D 26 88 D2 13 B6 66 31
 F8 16 1A 5C 05 D8 62 C9 D1 D6 B1 82 4F 04 ED 4D
 3D 75 65 2B 4B B3 EF 9C AE C4 FE 59 42 92 E1 8D
 1E 3E 34 78 6F 7F 3C 41 72 89 B1 0D D4 0C 7B 89
 71 D0 82 AA 90 1A 00 ED

After π

90 F6 4A 2B 92 8C C7 53 7A 88 64 02 18 80 6D DF
 58 CA 8E F1 9B 6D 6A 8E F8 16 1A 5C 05 D8 62 C9
 71 D0 82 AA 90 1A 00 ED 39 43 A4 98 0A 01 83 BE
 7C 5B 45 74 9C 3D FE 29 03 DA D5 4F 50 29 47 AA
 AA D6 10 D6 57 50 82 4A 1E 3E 34 78 6F 7F 3C 41
 F7 27 E9 36 E4 93 7F B4 F8 AA BF 7A EA 8B 1C 1D
 09 3A 77 01 42 95 E8 22 D1 D6 B1 82 4F 04 ED 4D
 3D 75 65 2B 4B B3 EF 9C A2 3A B2 83 1D F3 F8 FB
 A2 2D 27 07 D1 74 1B 59 67 EA 0F A5 5A A9 E8 A5
 9D 26 88 D2 13 B6 66 31 72 89 B1 0D D4 0C 7B 89
 97 F3 EA 2F 33 D1 9E 11 0F 6F FF 86 94 44 2A 10
 7F F8 A1 2A FF 4E DB A7 42 F7 AF 07 C1 65 D3 4E
 AE C4 FE 59 42 92 E1 8D

After χ

90 B4 C0 DA 11 E1 C5 53 DA 9C 74 0E 1C 10 6D 9E
 59 0A 0E 53 0B 6F 6A AA 78 30 52 5D 07 5C A5 DB
 1B D8 A6 AA 98 1A 28 61 3A C3 34 93 4A 01 82 3C
 D4 5F 45 E4 9B 6D 7E 69 17 F2 F1 67 78 06 7B AB
 8B 97 90 56 57 50 01 F4 5A 26 75 1C FB 43 40 40
 F6 37 A9 37 E4 87 9F 96 28 6E 3F F8 E7 8B 19 50
 25 1B 33 28 42 26 EA B2 13 D4 39 96 EB 04 FD 6D
 35 FD 73 63 41 BB EF 95 E7 F8 BA 23 17 7A 18 5F
 3A 29 A7 55 D0 62 1D 49 05 63 3E A8 9E A1 F1 2D
 1D 14 8A 50 1A 45 E6 43 72 8C B4 09 14 08 78 89
 E7 63 EA 07 58 DB 4F B6 0F 68 F1 83 94 65 2A 58
 D3 F8 F1 72 FD DC FB 26 53 C4 AF 21 F0 24 CD 5E
 A6 C8 EB D9 C6 96 C1 8D

After ι

98 34 C0 5A 11 E1 C5 D3 DA 9C 74 0E 1C 10 6D 9E
 59 0A 0E 53 0B 6F 6A AA 78 30 52 5D 07 5C A5 DB
 1B D8 A6 AA 98 1A 28 61 3A C3 34 93 4A 01 82 3C
 D4 5F 45 E4 9B 6D 7E 69 17 F2 F1 67 78 06 7B AB
 8B 97 90 56 57 50 01 F4 5A 26 75 1C FB 43 40 40
 F6 37 A9 37 E4 87 9F 96 28 6E 3F F8 E7 8B 19 50
 25 1B 33 28 42 26 EA B2 13 D4 39 96 EB 04 FD 6D
 35 FD 73 63 41 BB EF 95 E7 F8 BA 23 17 7A 18 5F
 3A 29 A7 55 D0 62 1D 49 05 63 3E A8 9E A1 F1 2D
 1D 14 8A 50 1A 45 E6 43 72 8C B4 09 14 08 78 89
 E7 63 EA 07 58 DB 4F B6 0F 68 F1 83 94 65 2A 58
 D3 F8 F1 72 FD DC FB 26 53 C4 AF 21 F0 24 CD 5E
 A6 C8 EB D9 C6 96 C1 8D

After permutation

98 34 C0 5A 11 E1 C5 D3 DA 9C 74 0E 1C 10 6D 9E
 59 0A 0E 53 0B 6F 6A AA 78 30 52 5D 07 5C A5 DB
 1B D8 A6 AA 98 1A 28 61 3A C3 34 93 4A 01 82 3C
 D4 5F 45 E4 9B 6D 7E 69 17 F2 F1 67 78 06 7B AB
 8B 97 90 56 57 50 01 F4 5A 26 75 1C FB 43 40 40
 F6 37 A9 37 E4 87 9F 96 28 6E 3F F8 E7 8B 19 50
 25 1B 33 28 42 26 EA B2 13 D4 39 96 EB 04 FD 6D
 35 FD 73 63 41 BB EF 95 E7 F8 BA 23 17 7A 18 5F
 3A 29 A7 55 D0 62 1D 49 05 63 3E A8 9E A1 F1 2D
 1D 14 8A 50 1A 45 E6 43 72 8C B4 09 14 08 78 89
 E7 63 EA 07 58 DB 4F B6 0F 68 F1 83 94 65 2A 58
 D3 F8 F1 72 FD DC FB 26 53 C4 AF 21 F0 24 CD 5E
 A6 C8 EB D9 C6 96 C1 8D

State (as lanes of integers)

[0, 0] = D3C5E1115AC03498
 [1, 0] = 9E6D101C0E749CDA
 [2, 0] = AA6A6F0B530E0A59
 [3, 0] = DBA55C075D523078
 [4, 0] = 61281A98AAA6D81B
 [0, 1] = 3C82014A9334C33A
 [1, 1] = 697E6D9BE4455FD4
 [2, 1] = AB7B067867F1F217
 [3, 1] = F40150575690978B
 [4, 1] = 404043FB1C75265A
 [0, 2] = 969F87E437A937F6
 [1, 2] = 50198BE7F83F6E28
 [2, 2] = B2EA264228331B25
 [3, 2] = 6DFD04EB9639D413
 [4, 2] = 95EFBB416373FD35
 [0, 3] = 5F187A1723BAF8E7
 [1, 3] = 491D62D055A7293A
 [2, 3] = 2DF1A19EA83E6305
 [3, 3] = 43E6451A508A141D
 [4, 3] = 8978081409B48C72
 [0, 4] = B64FDB5807EA63E7
 [1, 4] = 582A659483F1680F
 [2, 4] = 26FEDCFD72F1F8D3
 [3, 4] = 5ECD24F021AFC453
 [4, 4] = 8DC196C6D9EBC8A6

The hash value is

98 34 C0 5A 11 E1 C5 D3 DA 9C 74 0E 1C 10 6D 9E
 59 0A 0E 53 0B 6F 6A AA 78 30 52 5D 07 5C A5 DB
 1B D8 A6 AA 98 1A 28 61 3A C3 34 93 4A 01 82 3C
 D4 5F 45 E4 9B 6D 7E 69 17 F2 F1 67 78 06 7B AB

B.18 Dedicated Hash-Function 17 (SM3)

B.18.1 Example 1

In this example, the data string is the empty string, i.e. the string of length zero.

The hash-code is the following 256-bit string.

1AB21D83 55CFA17F 8E611948 31E81A8F 22BEC8C7 28FEFB74 7ED035EB 5082AA2B

B.18.2 Example 2

In this example, the data string consists of a single byte, namely the ASCII-coded version of the letter “a”.

The hash-code is the following 256-bit string.

```
623476AC 18F65A29 09E43C7F EC61B49C 7E764A91 A18CCB82 F1917A29 C86C5E88
```

B.18.3 Example 3

In this example, the data string is the 3-byte string consisting of the ASCII-coded version of “abc”. This is equivalent to the bitstring “01100001 01100010 01100011”.

After the padding process, the single 16-word block derived from the data string is as follows.

```
61626380 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000018
```

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 .

```
INIT: 7380166F 4914B2B9 172442D7 DA8A0600 A96F30BC 163138AA E38DEE4D B0FB0E4E
0 B9EDC12B 7380166F 29657292 172442D7 B2AD29F4 A96F30BC C550B189 E38DEE4D
1 EA52428C B9EDC12B 002CDEE7 29657292 AC353A23 B2AD29F4 85E54B79 C550B189
2 609F2850 EA52428C DB825773 002CDEE7 D33AD5FB AC353A23 4FA59569 85E54B79
3 35037E59 609F2850 A48519D4 DB825773 B8204B5F D33AD5FB D11D61A9 4FA59569
4 1F995766 35037E59 3E50A0C1 A48519D4 8AD212EA B8204B5F AFDE99D6 D11D61A9
5 374A0CA7 1F995766 06FCB26A 3E50A0C1 ACF0F639 8AD212EA 5AFDC102 AFDE99D6
6 33130100 374A0CA7 32AECC3F 06FCB26A 3391EC8A ACF0F639 97545690 5AFDC102
7 1022AC97 33130100 94194E6E 32AECC3F 367250A1 3391EC8A B1CD6787 97545690
8 D47CAF4C 1022AC97 26020066 94194E6E 6AD473A4 367250A1 64519C8F B1CD6787
9 59C2744B D47CAF4C 45592E20 26020066 C6A3CEAE 6AD473A4 8509B392 64519C8F
10 481BA2A0 59C2744B F95E99A8 45592E20 02AFB727 C6A3CEAE 9D2356A3 8509B392
11 694A3D09 481BA2A0 84E896B3 F95E99A8 9DD1B58C 02AFB727 7576351E 9D2356A3
12 89CB5D58 694A3D09 37454090 84E896B3 6370DB62 9DD1B58C B938157D 7576351E
13 24C95ABC 89CB5D58 947A12D2 37454090 1A4A2554 6370DB62 AC64EE8D B938157D
14 7C529778 24C95ABC 979AB113 947A12D2 3EE95933 1A4A2554 DB131B86 AC64EE8D
15 34D1691E 7C529778 92B57849 979AB113 61F99646 3EE95933 2AA0D251 DB131B86
16 796AFAB1 34D1691E A52EF0F8 92B57849 067550F5 61F99646 C999F74A 2AA0D251
17 7D27CC0E 796AFAB1 A2D23C69 A52EF0F8 B3C8669B 067550F5 B2330FCC C999F74A
18 D7820AD1 7D27CC0E D5F562F2 A2D23C69 575C37D8 B3C8669B 87A833AA B2330FCC
19 F84FD372 D7820AD1 4F981CFA D5F562F2 A5DCEAF1 575C37D8 34DD9E43 87A833AA
20 02C57896 F84FD372 0415A3AF 4F981CFA 74576681 A5DCEAF1 BEC2BAE1 34DD9E43
21 4D0C2FCD 02C57896 9FA6E5F0 0415A3AF 576F1D09 74576681 578D2EE7 BEC2BAE1
22 EEEEC41A 4D0C2FCD 8AF12C05 9FA6E5F0 B5523911 576F1D09 340BA2BB 578D2EE7
23 F368DA78 EEEEC41A 185F9A9A 8AF12C05 6A879032 B5523911 E84ABB78 340BA2BB
24 15CE1286 F368DA78 DD8835DD 185F9A9A 62063354 6A879032 C88DAA91 E84ABB78
25 C3FD31C2 15CE1286 D1B4F1E6 DD8835DD 4DB58F43 62063354 8193543C C88DAA91
26 6243BE5E C3FD31C2 9C250C2B D1B4F1E6 131152FE 4DB58F43 9AA31031 8193543C
27 A549BEAA 6243BE5E FA638587 9C250C2B CF65E309 131152FE 7A1A6DAC 9AA31031
28 E11EB847 A549BEAA 877CBCC4 FA638587 E5B64E96 CF65E309 97F0988A 7A1A6DAC
29 FF9BAC9D E11EB847 937D554A 877CBCC4 9811B46D E5B64E96 184E7B2F 97F0988A
30 A5A4A2B3 FF9BAC9D 3D708FC2 937D554A E92DF4EA 9811B46D 74B72DB2 184E7B2F
31 89A13E59 A5A4A2B3 37593BFF 3D708FC2 0A1FF572 E92DF4EA A36CC08D 74B72DB2
32 3720BD4E 89A13E59 4945674B 37593BFF CF7D1683 0A1FF572 A757496F A36CC08D
```

33 9CCD089C 3720BD4E 427CB313 4945674B DA8C835F CF7D1683 AB9050FF A757496F
 34 C7A0744D 9CCD089C 417A9C6E 427CB313 0958FF1B DA8C835F B41E7BE8 AB9050FF
 35 D955C3ED C7A0744D 9A113939 417A9C6E C533F0FF 0958FF1B 1AFED464 B41E7BE8
 36 E142D72B D955C3ED 40E89B8F 9A113939 D4509586 C533F0FF F8D84AC7 1AFED464
 37 E7250598 E142D72B AB87DBB2 40E89B8F C7F93FD3 D4509586 87FE299F F8D84AC7
 38 2F13C4AD E7250598 85AE57C2 AB87DBB2 1A6CABC9 C7F93FD3 AC36A284 87FE299F
 39 19F363F9 2F13C4AD 4A0B31CE 85AE57C2 C302BADB 1A6CABC9 FE9E3FC9 AC36A284
 40 55E1DDE2 19F363F9 27895A5E 4A0B31CE 459DACCF C302BADB 5E48D365 FE9E3FC9
 41 D4F4EFE3 55E1DDE2 E6C7F233 27895A5E 5CFBA85A 459DACCF D6DE1815 5E48D365
 42 48DCBC62 D4F4EFE3 C3BBC4AB E6C7F233 6F49C7BB 5CFBA85A 667A2CED D6DE1815
 43 8237B8A0 48DCBC62 E9DFC7A9 C3BBC4AB D89D2711 6F49C7BB 42D2E7DD 667A2CED
 44 D8685939 8237B8A0 B978C491 E9DFC7A9 8EE87DF5 D89D2711 3DDB7A4E 42D2E7DD
 45 D2090A86 D8685939 6F714104 B978C491 2E533625 8EE87DF5 388EC4E9 3DDB7A4E
 46 E51076B3 D2090A86 D0B273B0 6F714104 D9F89E61 2E533625 EFAC7743 388EC4E9
 47 47C5BE50 E51076B3 12150DA4 D0B273B0 3567734E D9F89E61 B1297299 EFAC7743
 48 ABDDDBC8 47C5BE50 20ED67CA 12150DA4 3DFCDD11 3567734E F30ECFC4 B1297299
 49 BD708003 ABDDDBC8 8B7CA08F 20ED67CA 93494BC0 3DFCDD11 9A71AB3B F30ECFC4
 50 15E2F5D3 BD708003 BB7B9157 8B7CA08F C3956C3F 93494BC0 E889EFE6 9A71AB3B
 51 13826486 15E2F5D3 E100077A BB7B9157 CD09A51C C3956C3F 5E049A4A E889EFE6
 52 4A00ED2F 13826486 C5EBA62B E100077A 0741F675 CD09A51C 61FE1CAB 5E049A4A
 53 F4412E82 4A00ED2F 04C90C27 C5EBA62B 7429807C 0741F675 28E6684D 61FE1CAB
 54 549DB4B7 F4412E82 01DA5E94 04C90C27 F6BC15ED 7429807C B3A83A0F 28E6684D
 55 22A79585 549DB4B7 825D05E8 01DA5E94 9D4DB19A F6BC15ED 03E3A14C B3A83A0F
 56 30245B78 22A79585 3B696EA9 825D05E8 F6804C82 9D4DB19A AF6FB5E0 03E3A14C
 57 6598314F 30245B78 4F2B0A45 3B696EA9 F522ADB2 F6804C82 8CD4EA6D AF6FB5E0
 58 C3D629A9 6598314F 48B6F060 4F2B0A45 14FB0764 F522ADB2 6417B402 8CD4EA6D
 59 DDB0A26A C3D629A9 30629ECB 48B6F060 589F7D5C 14FB0764 6D97A915 6417B402
 60 71034D71 DDB0A26A AC535387 30629ECB 14D5C7F6 589F7D5C 3B20A7D8 6D97A915
 61 5E636B4B 71034D71 6144D5BB AC535387 09CCD95E 14D5C7F6 EAE2C4FB 3B20A7D8
 62 2BFA5F60 5E636B4B 069AE2E2 6144D5BB 4AC3CF08 09CCD95E 3FB0A6AE EAE2C4FB
 63 1547E69B 2BFA5F60 C6D696BC 069AE2E2 E808F43B 4AC3CF08 CAF04E66 3FB0A6AE

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

$Y_0 = 1547E69B \oplus 7380166F = 66C7F0F4$
 $Y_1 = 2BFA5F60 \oplus 4914B2B9 = 62EEEDD9$
 $Y_2 = C6D696BC \oplus 172442D7 = D1F2D46B$
 $Y_3 = 069AE2E2 \oplus DA8A0600 = DC10E4E2$
 $Y_4 = E808F43B \oplus A96F30BC = 4167C487$
 $Y_5 = 4AC3CF08 \oplus 163138AA = 5CF2F7A2$
 $Y_6 = CAF04E66 \oplus E38DEE4D = 297DA02B$
 $Y_7 = 3FB0A6AE \oplus B0FB0E4E = 8F4BA8E0$

The hash-code is the following 256-bit string.

66C7F0F4 62EEEDD9 D1F2D46B DC10E4E2 4167C487 5CF2F7A2 297DA02B 8F4BA8E0

B.18.4 Example 4

In this example, the data string is the 14-byte string consisting of the ASCII-coded version of
 “message digest”

The hash-code is the following 256-bit string.

C522A942 E89BD80D 97DD666E 7A5531B3 6188C981 7149E9B2 58DFE51E CE98ED77

B.18.5 Example 5

In this example, the data string is the 26-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz”

The hash-code is the following 256-bit string.

B80FE97A 4DA24AFC 277564F6 6A359EF4 40462AD2 8DCC6D63 ADB24D5C 20A61595

B.18.6 Example 6

In this example, the data string is the 62-byte string consisting of the ASCII-coded version of

“ABCDEFGHJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789”

The hash-code is the following 256-bit string.

2971D10C 8842B70C 979E5506 3480C50B ACFFD90E 98E2E60D 2512AB8A BFDFCEC5

B.18.7 Example 7

In this example, the data string is the 80-byte string consisting of the ASCII-coded version of eight repetitions of

“1234567890”

The hash-code is the following 256-bit string.

AD818053 21F3E69D 251235BF 886A5648 44873B56 DD7DDE40 0F055B7D DE39307A

B.18.8 Example 8

In this example, the data string is the 56-byte string consisting of the ASCII-coded version of

“abcdcbcdcedefdefgefghfghighijhijkijklklmklmnlmnomnopnopq”

After the padding process, the following two 16-word blocks are derived from the data string.

61626364 62636465 63646566 64656667 65666768 66676869 6768696A 68696A6B
696A6B6C 6A6B6C6D 6B6C6D6E 6C6D6E6F 6D6E6F70 6E6F7071 80000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 000001c0

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 in the first block process.

INIT: 7380166F 4914B2B9 172442D7 DA8A0600 A96F30BC 163138AA E38DEE4D B0FB0E4E
0 5C8F61B7 7380166F 29657292 172442D7 B2E561D0 A96F30BC C550B189 E38DEE4D
1 DC3DE4B3 5C8F61B7 002CDEE7 29657292 BA8630FD B2E561D0 85E54B79 C550B189
2 8D1A8984 DC3DE4B3 1EC36EB9 002CDEE7 C6F3AD94 BA8630FD 0E85972B 85E54B79
3 BBB4BF50 8D1A8984 7BC967B8 1EC36EB9 68627C7C C6F3AD94 87EDD431 0E85972B
4 3E50B8BC BBB4BF50 3513091A 7BC967B8 55AB956B 68627C7C 6CA6379D 87EDD431
5 8D4276DA 3E50B8BC 697EA177 3513091A AC958648 55AB956B E3E34313 6CA6379D
6 C8DA9226 8D4276DA A171787C 697EA177 68CEE8E5 AC958648 AB5AAD5C E3E34313

7 F33FBDEC C8DA9226 84EDB51A A171787C ABF9D51E 68CEE8E5 324564AC AB5AAD5C
 8 597E4171 F33FBDEC B5244D91 84EDB51A 970ACF5F ABF9D51E 472B4677 324564AC
 9 DA746360 597E4171 7F7BD9E6 B5244D91 87674D2F 970ACF5F A8F55FCE 472B4677
 10 BBD90A4E DA746360 FC82E2B2 7F7BD9E6 04B43D0B 87674D2F 7AFCB856 A8F55FCE
 11 D97774B7 BBD90A4E E8C6C1B4 FC82E2B2 121D28AC 04B43D0B 697C3B3A 7AFCB856
 12 78078302 D97774B7 B2149D77 E8C6C1B4 77C1DE3D 121D28AC E85825A1 697C3B3A
 13 C80F6D38 78078302 EEE96FB2 B2149D77 51D1B562 77C1DE3D 456090E9 E85825A1
 14 EACE16F6 C80F6D38 0F0604F0 EEE96FB2 6B06C8B2 51D1B562 F1EBBE0E 456090E9
 15 2128F407 EACE16F6 1EDA7190 0F0604F0 5107AFF4 6B06C8B2 AB128E8D F1EBBE0E
 16 93390D8D 2128F407 9C2DEDD5 1EDA7190 5EE90335 5107AFF4 45935836 AB128E8D
 17 B9DCAB4B 93390D8D 51E80E42 9C2DEDD5 E7081AB8 5EE90335 7FA2883D 45935836
 18 95473AFD B9DCAB4B 721B1B26 51E80E42 C12A2AF1 E7081AB8 19AAF748 7FA2883D
 19 E100DFDA 95473AFD B9569773 721B1B26 A2BB4ADD C12A2AF1 D5C73840 19AAF748
 20 2F9800CC E100DFDA 8E75FB2A B9569773 0838381E A2BB4ADD 578E0951 D5C73840
 21 1A113298 2F9800CC 01BFB5C2 8E75FB2A 41D4677B 0838381E 56ED15DA 578E0951
 22 7FEE2BD4 1A113298 3001985F 01BFB5C2 B77B5FEE 41D4677B C0F041C1 56ED15DA
 23 D615FE59 7FEE2BD4 22653034 3001985F C62C3A46 B77B5FEE 3BDA0EA3 C0F041C1
 24 A855127B D615FE59 DC57A8FF 22653034 C47ABE3F C62C3A46 FF75BBDA 3BDA0EA3
 25 A8E3132D A855127B 2BFCB3AC DC57A8FF 386D8373 C47ABE3F D2363161 FF75BBDA
 26 1A319D21 A8E3132D AA24F750 2BFCB3AC B4E3CC85 386D8373 F1FE23D5 D2363161
 27 B8C7870B 1A319D21 C6265B51 AA24F750 349AB542 B4E3CC85 1B99C36C F1FE23D5
 28 ED5910CB B8C7870B 633A4234 C6265B51 826818F2 349AB542 642DA71E 1B99C36C
 29 B7B7C514 ED5910CB 8F0E1771 633A4234 014D92BE 826818F2 AA11A4D5 642DA71E
 30 332D48CF B7B7C514 B22197DA 8F0E1771 67CC5228 014D92BE C7941340 AA11A4D5
 31 00B8692D 332D48CF 6F8A296F B22197DA BD8784C7 67CC5228 95F00A6C C7941340
 32 ED95F4E5 00B8692D 5A919E66 6F8A296F A9041B7A BD8784C7 91433E62 95F00A6C
 33 D7EC1070 ED95F4E5 70D25A01 5A919E66 FF634BF8 A9041B7A 263DEC3C 91433E62
 34 6D6DF2A0 D7EC1070 2BE9CBDB 70D25A01 208C87AC FF634BF8 DBD54820 263DEC3C
 35 342F3AD6 6D6DF2A0 D820E1AF 2BE9CBDB DA74F6BE 208C87AC 5FC7FB1A DBD54820
 36 822697C1 342F3AD6 DBE540DA D820E1AF A3C91873 DA74F6BE 3D610464 5FC7FB1A
 37 B75F5102 822697C1 5E75AC68 DBE540DA 058DD4EB A3C91873 B5F6D3A7 3D610464
 38 AB4D8A3D B75F5102 4D2F8304 5E75AC68 935C9926 058DD4EB C39D1E48 B5F6D3A7
 39 586F130A AB4D8A3D BEA2056E 4D2F8304 9D26A8A7 935C9926 A7582C6E C39D1E48
 40 2DBEEC34 586F130A 9B147B56 BEA2056E A104C193 9D26A8A7 C9349AE4 A7582C6E
 41 2CB7CD53 2DBEEC34 DE2614B0 9B147B56 BC21D865 A104C193 453CE935 C9349AE4
 42 A9DED8FE 2CB7CD53 7DD8685B DE2614B0 EFCD8176 BC21D865 0C9D0826 453CE935
 43 8F6EA284 A9DED8FE 6F9AA659 7DD8685B B0EF6305 EFCD8176 C32DE10E 0C9D0826
 44 4198155F 8F6EA284 BDB1FD53 6F9AA659 D1BF96EF B0EF6305 0BB77E6C C32DE10E
 45 FE0F20D1 4198155F DD45091E BDB1FD53 6D2B4951 D1BF96EF 182D877B 0BB77E6C
 46 939EAFE3 FE0F20D1 302ABE83 DD45091E F8DD3803 6D2B4951 B77E8DFC 182D877B
 47 12A2E11E 939EAFE3 1E41A3FC 302ABE83 B65B77A8 F8DD3803 4A8B695A B77E8DFC
 48 45F88856 12A2E11E 3D5FC727 1E41A3FC 1EAD7D75 B65B77A8 C01FC6E9 4A8B695A
 49 91D7D82C 45F88856 45C23C25 3D5FC727 C0016D52 1EAD7D75 BD45B2DB C01FC6E9
 50 287EF00E 91D7D82C F110AC8B 45C23C25 B8DF8FF0 C0016D52 EBA8F56B BD45B2DB
 51 3D6C1633 287EF00E AFB05923 F110AC8B 286928FC B8DF8FF0 6A96000B EBA8F56B
 52 D06316EC 3D6C1633 FDE01C50 AFB05923 77E4A5F5 286928FC 7F85C6FC 6A96000B
 53 5AF5093D D06316EC D82C667A FDE01C50 E56749BB 77E4A5F5 47E14349 7F85C6FC
 54 1658FDF5 5AF5093D C62DD9A0 D82C667A 9557584C E56749BB 2FABBF25 47E14349


```

55 52C7F5AC 1658FDF5 EA127AB5 C62DD9A0 109B96D2 9557584C 4DDF2B3A 2FABBF25
56 BE546CF1 52C7F5AC B1FBEA2C EA127AB5 E5AF8405 109B96D2 C264AABA 4DDF2B3A
57 731577CD BE546CF1 8FEB58A5 B1FBEA2C 2AFEB8A8C E5AF8405 B69084DC C264AABA
58 813558CC 731577CD A8D9E37C 8FEB58A5 8C01B50C 2AFEB8A8C 202F2D7C B69084DC
59 1986A1C9 813558CC 2AEF9AE6 A8D9E37C F217DF1C 8C01B50C D46157F5 202F2D7C
60 2D3B8ABC 1986A1C9 6AB19902 2AEF9AE6 EDDF3D93 F217DF1C A864600D D46157F5
61 C65C49EB 2D3B8ABC 0D439233 6AB19902 E50C2A6D EDDF3D93 F8E790BE A864600D
62 C3C11EE8 C65C49EB 7715785A 0D439233 AE18F3A1 E50C2A6D EC9F6EF9 F8E790BE
63 6ABB79FD C3C11EE8 B893D78C 7715785A B9DD7BBB AE18F3A1 536F2861 EC9F6EF9

```

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the round-function in the first block process.

```

 $Y_0 = 6ABB79FD \oplus 7380166F = 193B6F92$ 
 $Y_1 = C3C11EE8 \oplus 4914B2B9 = 8AD5AC51$ 
 $Y_2 = B893D78C \oplus 172442D7 = AFB7955B$ 
 $Y_3 = 7715785A \oplus DA8A0600 = AD9F7E5A$ 
 $Y_4 = B9DD7BBB \oplus A96F30BC = 10B24B07$ 
 $Y_5 = AE18F3A1 \oplus 163138AA = B829CB0B$ 
 $Y_6 = 536F2861 \oplus E38DEE4D = B0E2C62C$ 
 $Y_7 = EC9F6EF9 \oplus B0FB0E4E = 5C6460B7$ 

```

The following are (hexadecimal representations of) the successive values of the variables X_0 , X_1 , X_2 , X_3 , X_4 , X_5 , X_6 and X_7 in the second block process.

```

INIT: 193B6F92 8AD5AC51 AFB7955B AD9F7E5A 10B24B07 B829CB0B B0E2C62C 5C6460B7
0 F71ACD25 193B6F92 AB58A315 AFB7955B 5D580F7B 10B24B07 585DC14E B0E2C62C
1 42DF670C F71ACD25 76DF2432 AB58A315 301A33A1 5D580F7B 58388592 585DC14E
2 96EA0EDB 42DF670C 359A4BEE 76DF2432 FECE7B76 301A33A1 7BDAEAC0 58388592
3 0851B544 96EA0EDB BECE1885 359A4BEE 094B07B3 FECE7B76 9D0980D1 7BDAEAC0
4 00A8966D 0851B544 D41DB72D BECE1885 6CC097ED 094B07B3 DBB7F673 9D0980D1
5 ED15EFA6 00A8966D A36A8810 D41DB72D 519536E5 6CC097ED 3D984A58 DBB7F673
6 B1820DC8 ED15EFA6 512CDA01 A36A8810 8C851B7A 519536E5 BF6B6604 3D984A58
7 93EAECD0 B1820DC8 2BDF4DDA 512CDA01 422F81A2 8C851B7A B72A8CA9 BF6B6604
8 6903ACA3 93EAECD0 041B9163 2BDF4DDA F048BD9B 422F81A2 DBD46428 B72A8CA9
9 1F2BD8DB 6903ACA3 D5D9A127 041B9163 E5AE9D27 F048BD9B 0D12117C DBD46428
10 3DE4985A 1F2BD8DB 075946D2 D5D9A127 77AB882E E5AE9D27 ECDF8245 0D12117C
11 E0EDF809 3DE4985A 57B1B63E 075946D2 C2715679 77AB882E E93F2D74 ECDF8245
12 9058ACFC E0EDF809 C930B47B 57B1B63E 72B366DB C2715679 4173BD5C E93F2D74
13 AB17DC92 9058ACFC DBF013C1 C930B47B 3EDBFFA9 72B366DB B3CE138A 4173BD5C
14 32DDD4F1 AB17DC92 B159F920 DBF013C1 D5F4B6EA 3EDBFFA9 36DB959B B3CE138A
15 3990748B 32DDD4F1 2FB92556 B159F920 94FC9DF4 D5F4B6EA FD49F6DF 36DB959B
16 CDA22778 3990748B BBA9E265 2FB92556 5EDEEBF4 94FC9DF4 B756AFA5 FD49F6DF
17 0136EF6F CDA22778 20E91673 BBA9E265 B55FC7D9 5EDEEBF4 EFA4A7E4 B756AFA5
18 ECD46FAE 0136EF6F 444EF19B 20E91673 4B390AF7 B55FC7D9 5FA2F6F7 EFA4A7E4
19 6A5DF514 ECD46FAE 6DDEDE02 444EF19B 3BF2E429 4B390AF7 3ECDAAFE 5FA2F6F7
20 C3B5F0D2 6A5DF514 A8DF5DD9 6DDEDE02 BC4CA2BD 3BF2E429 57BA59C8 3ECDAAFE
21 645BAF5B C3B5F0D2 BBEA28D4 A8DF5DD9 E1A9773E BC4CA2BD 2149DF97 57BA59C8
22 B0ED09E5 645BAF5B 6BE1A587 BBEA28D4 37979EFC E1A9773E 15EDE265 2149DF97
23 85F08FB3 B0ED09E5 B75EB6C8 6BE1A587 DC23CE67 37979EFC B9F70D4B 15EDE265
24 CDEC3A25 85F08FB3 DA13CB61 B75EB6C8 C79B04E6 DC23CE67 F7E1BCBC B9F70D4B
25 5FE964F7 CDEC3A25 E11F670B DA13CB61 7233F530 C79B04E6 733EE11E F7E1BCBC

```

26 7F515284 5FE964F7 D8744B9B E11F670B DCE5766B 7233F530 27363CD8 733EE11E
 27 07628BE9 7F515284 D2C9EEBF D8744B9B C4C6EB17 DCE5766B A983919F 27363CD8
 28 EDFB1904 07628BE9 A2A508FE D2C9EEBF C1284E94 C4C6EB17 B35EE72B A983919F
 29 F07795D3 EDFB1904 C517D20E A2A508FE F8C23138 C1284E94 58BE2637 B35EE72B
 30 DAD7D8A8 F07795D3 F63209DB C517D20E 70D89EDF F8C23138 74A60942 58BE2637
 31 476692E1 DAD7D8A8 EF2BA7E0 F63209DB 428BACA3 70D89EDF 89C7C611 74A60942
 32 B1745ED9 476692E1 AFB151B5 EF2BA7E0 49A04792 428BACA3 F6FB86C4 89C7C611
 33 985F0EAE B1745ED9 CD25C28E AFB151B5 1C70F25B 49A04792 651A145D F6FB86C4
 34 A4EAC3C1 985F0EAE E8BDB362 CD25C28E BAEAFB1D 1C70F25B 3C924D02 651A145D
 35 94D3CC2E A4EAC3C1 BE1D5D30 E8BDB362 F772A4E5 BAEAFB1D 92D8E387 3C924D02
 36 AB64985E 94D3CC2E D5878349 BE1D5D30 CFD9ABF7 F772A4E5 D8EDD757 92D8E387
 37 EA650863 AB64985E A7985D29 D5878349 37D676A0 CFD9ABF7 272FBB95 D8EDD757
 38 7E9D76D0 EA650863 C930BD56 A7985D29 0E5B32C2 37D676A0 5FBE7ECD 272FBB95
 39 9C804F2F 7E9D76D0 CA10C7D4 C930BD56 B9883A18 0E5B32C2 B501BEB3 5FBE7ECD
 40 CC8BC84D 9C804F2F 3AEDA0FD CA10C7D4 89AF8633 B9883A18 961072D9 B501BEB3
 41 1E44D2CD CC8BC84D 009E5F39 3AEDA0FD D3FF5A20 89AF8633 D0C5CC41 961072D9
 42 9747774E 1E44D2CD 17909B99 009E5F39 94779237 D3FF5A20 319C4D7C D0C5CC41
 43 21E48A42 9747774E 89A59A3C 17909B99 319302A0 94779237 D1069FFA 319C4D7C
 44 4AA0D479 21E48A42 8EEE9D2E 89A59A3C 08A73B8F 319302A0 91BCA3BC D1069FFA
 45 C9A40B98 4AA0D479 C9148443 8EEE9D2E 4D7508FF 08A73B8F 15018C98 91BCA3BC
 46 050B4233 C9A40B98 41A8F295 C9148443 40C7B509 4D7508FF DC784539 15018C98
 47 270A62CB 050B4233 48173193 41A8F295 D06C4A51 40C7B509 47FA6BA8 DC784539
 48 7C3FCF98 270A62CB 1684660A 48173193 7ECBFA98 D06C4A51 A84A063D 47FA6BA8
 49 0BA56393 7C3FCF98 14C5964E 1684660A 02154736 7ECBFA98 528E8362 A84A063D
 50 27548370 0BA56393 7F9F30F8 14C5964E 6D3343B1 02154736 D4C3F65F 528E8362
 51 79AAEB0E 27548370 4AC72617 7F9F30F8 F2556152 6D3343B1 39B010AA D4C3F65F
 52 BD17409F 79AAEB0E A906E04E 4AC72617 1BDBA544 F2556152 1D8B699A 39B010AA
 53 5CEA4FAA BD17409F 55D61CF3 A906E04E 0958FC62 1BDBA544 0A9792AB 1D8B699A
 54 7FCE4D84 5CEA4FAA 2E813F7A 55D61CF3 B535CB5A 0958FC62 2A20DEDD 0A9792AB
 55 44232436 7FCE4D84 D49F54B9 2E813F7A EA59CC69 B535CB5A E3104AC7 2A20DEDD
 56 7FEDD3F5 44232436 9C9B08FF D49F54B9 CEE4B418 EA59CC69 5AD5A9AE E3104AC7
 57 3648449E 7FEDD3F5 46486C88 9C9B08FF B1AA5387 CEE4B418 634F52CE 5AD5A9AE
 58 4A8C2056 3648449E DBA7EAFB 46486C88 B1892488 B1AA5387 A0C67725 634F52CE
 59 C7FF81C0 4A8C2056 90893C6C DBA7EAFB AE0ADA7D B1892488 9C3D8D52 A0C67725
 60 D839686F C7FF81C0 1840AC95 90893C6C FD965E23 AE0ADA7D 24458C49 9C3D8D52
 61 64861392 D839686F FF03818F 1840AC95 D109486D FD965E23 D3ED7056 24458C49
 62 6C983266 64861392 72D0DFB0 FF03818F C7DF59B2 D109486D F11FECB2 D3ED7056
 63 7AA00357 6C983266 0C2724C9 72D0DFB0 1792E073 C7DF59B2 436E884A F11FECB2

The following eight words, Y_0 , Y_1 , Y_2 , Y_3 , Y_4 , Y_5 , Y_6 and Y_7 , represent the output of the final iteration of the round-function.

$$\begin{aligned} Y_0 &= 7AA00357 \oplus 193B6F92 = 639B6CC5 \\ Y_1 &= 6C983266 \oplus 4914B2B9 = E64D9E37 \\ Y_2 &= 0C2724C9 \oplus 172442D7 = A390B192 \\ Y_3 &= 72D0DFB0 \oplus DA8A0600 = DF4FA1EA \\ Y_4 &= 1792E073 \oplus A96F30BC = 0720AB74 \\ Y_5 &= C7DF59B2 \oplus 163138AA = 7FF692B9 \\ Y_6 &= 436E884A \oplus E38DEE4D = F38C4E66 \\ Y_7 &= F11FECB2 \oplus B0FB0E4E = AD7B8C05 \end{aligned}$$

The hash-code for this message is

639B6CC5 E64D9E37 A390B192 DF4FA1EA 0720AB74 7FF692B9 F38C4E66 AD7B8C05.

B.18.9 Example 9

In this example, the data string is the 1 000 000-byte string consisting of the ASCII-coded version of “a” repeated 10^6 times.

The hash-code is the following 256-bit string.

C8AAF894 29554029 E231941A 2ACC0AD6 1FF2A5AC D8FADD25 847A3A73 2B3B02C3

B.18.10 Example 10

In this example, the data string is the 112-byte string consisting of the ASCII-coded version of

“abcdefghijklm
 nijklmnopq
 rlmnopqrst
 uvwxyz”

(with no line break after the first n).

The hash-code is the following 256-bit string.

78BCFB58 6ACD983D 7FAE8E69 30157F15 62019E2C AF68F1C9 8A855F1A 95BB89BB

B.18.11 Example 11

In this example, the data string is the 32-byte string consisting of the ASCII-coded version of

“abcdefghijklmnopqrstuvwxyz”

The hash-code is the following 256-bit string.

F6556D8D B8BED431 81A678DA 7F6AFFE4 51DEBA50 115F3150 F19DEBB8 10B9958A

Annex C (informative)

SHA-3 Extendable-Output Functions

C.1 SHAKE-128

C.1.1 Parameters, functions and constants

C.1.1.1 Parameters

For SHAKE-128, $L_1 = r = 1\,344$, $L_2 = b = 1\,600$ and $c = b - r = 256$. For SHAKE-128, d is a variable to determine the output length.

C.1.1.2 Byte ordering convention

Each data input D to the round-function ϕ is a block of 1 344 bits that is XORed into the part of the state. The permutation f is then applied to the state. Because the step mappings that comprise the permutation are defined on the array form of the state, it is convenient to regard D as a sequence of 64-bit words that are XORed directly into the state array. For this purpose, when D is represented as a sequence of 168 bytes, $B_0, B_1, \dots, B_{167}$, then D should be interpreted as a sequence of 21 lane words, $Z_0, Z_1, \dots, Z_{20}$, as follows:

$$Z_i = 2^{56}B_{8i+7} + 2^{48}B_{8i+6} + 2^{40}B_{8i+5} + 2^{32}B_{8i+4} + 2^{24}B_{8i+3} + 2^{16}B_{8i+2} + 2^8B_{8i+1} + B_{8i},$$

for $0 \leq i \leq 20$.

Hence, each group of eight consecutive bytes is a word and the bytes of the word are arranged in increasing order of significance, so that the first byte in the group becomes the least significant byte of the word.

For dedicated hash-function 14, the function is defined on a $5 \times 5 \times w$ state array. For each array six sub-arrays are defined for step-mappings. Lane is one of the subarrays and defined in [19.2.3.3](#). Under this interpretation, D is XORed with the state array as follows.

If j and k are the elements of $\{0, 1, 2, 3, 4\}$, such that (j, k) is the unique pair for which $i = 5k + j$, then for $0 \leq i \leq 20$, $\text{Lane}'(j, k) = Z_i \oplus \text{Lane}(j, k)$, where $\text{Lane}'(j, k)$ is the updated value of the lane.

C.1.1.3 Functions

The functions, including the function Rnd and step mappings, for the dedicated SHAKE-128 are the same as Dedicated Hash-Function 13 and is specified in [Clause 19](#).

C.1.1.4 Constants

The constants used for the mapping are the offsets defined in [Clause 19](#).

C.1.1.5 Initializing value

The initializing value is a 1 600-bit all-zero string.

C.1.2 Padding method

The data M will be padded with “1111” before applying the padding method $\text{pad}_{10^*1}(x, m)$ specified in 19.2 with $x = 1\ 344$.

That is, the padded data is $P = M \parallel 1111 \parallel 10^*1$, such that the length of P is a multiple of 1 344.

C.1.3 Description of round-function

The round-function for SHAKE-128 is the permutation KECCAK- p specified in Clause 19. Notice that KECCAK- p is considered as defined in ISO/IEC 10118-1. However, for each execution of KECCAK- p , it iterates the Rnd function 24 times. That is, it executes

$$Rnd(\mathbf{A}, i_r) = \iota(\chi < \pi\{\rho[\theta(\mathbf{A})]\} >, i_r)$$

for $i_r = 0, 1, \dots, 23$.

C.1.4 Output transformation

In step h) of SPONGE[f , pad , r](N , d) specified in Clause 19, $f = \text{KECCAK-}p$, each execution of f in the squeezing stage for SHAKE-128 generates $r = 1\ 344$ bits. The output is concatenated until enough bits are generated to obtain d bits. That is, for a given d , after the last data block is inputted, it generates the first r bits of output.

Then, it executes the function $f[d/r] - 1$ times to generate a total of $[d/r] \cdot r$ output bits and then truncates to d bits.

C.1.5 Examples

NOTE 1 Data is presented in three different ways: bit strings, byte strings and w -length words (for the lanes).

NOTE 2 Bit strings are the sequence of bits from left to right.

NOTE 3 Byte strings are the bytes from left to right and the bits within the byte are right to left.

NOTE 4 Words are the integer representation of the values in the lanes.

SHAKE-128 sample to produce 4 096 bits of output

The message as bit string

(empty message)

about to call last of the absorb phase

XORed state (in bytes)

```

1F 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00

```

XORed state (as lanes of integers)

```

[0, 0] = 00000000000000001F
[1, 0] = 000000000000000000
[2, 0] = 000000000000000000
[3, 0] = 000000000000000000
[4, 0] = 000000000000000000
[0, 1] = 000000000000000000
[1, 1] = 000000000000000000
[2, 1] = 000000000000000000
[3, 1] = 000000000000000000
[4, 1] = 000000000000000000
[0, 2] = 000000000000000000
[1, 2] = 000000000000000000
[2, 2] = 000000000000000000
[3, 2] = 000000000000000000
[4, 2] = 000000000000000000
[0, 3] = 000000000000000000
[1, 3] = 000000000000000000
[2, 3] = 000000000000000000
[3, 3] = 000000000000000000
[4, 3] = 000000000000000000
[0, 4] = 800000000000000000
[1, 4] = 000000000000000000
[2, 4] = 000000000000000000
[3, 4] = 000000000000000000
[4, 4] = 000000000000000000

```

Round #0

After θ

```

1F 00 00 00 00 00 00 00 00 1F 00 00 00 00 00 00 80
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
3F 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
1F 00 00 00 00 00 00 00 80 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 3F 00 00 00 00 00 00
00 00 00 00 00 00 00 00 1F 00 00 00 00 00 00 80
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
3F 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
1F 00 00 00 00 00 00 00 80 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 3F 00 00 00 00 00 00
00 00 00 00 00 00 00 00 80 1F 00 00 00 00 00 80
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
3F 00 00 00 00 00 00 00 00

```

After ρ

```

1F 00 00 00 00 00 00 00 3F 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 F8 01 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 F8 01 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 F0 03 00 00 00 00
00 00 00 00 00 00 00 00 00 00 7E 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 80 1F 00 00 00 00 00 00 00 00 00
00 00 00 00 90 F0 03 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 3F 00 00 00 00 00
00 00 02 00 00 00 00 00 00 00 7E 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 C0 0F 00 00 00 00 00

```

After π

```

1F 00 00 00 00 00 00 00 00 00 00 00 00 F8 01 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 C0 0F 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 F0 03 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 F0 03 00 00 00 00 00 00 00 00
3F 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 3F 00 00 00 00 00
00 00 02 00 00 00 00 00 00 00 00 F8 01 00 00 00
00 00 00 00 00 00 00 00 00 00 7E 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 80 1F 00 00 00 00 00 00 00 00 00
7E 00 00 00 00 00 00 00

```

After χ

```

1F 00 00 00 00 00 00 00 00 00 00 00 00 00 F8 01 00
00 C0 0F 00 00 00 00 00 1F 00 00 00 00 00 00 00
00 C0 0F 00 00 F8 01 00 00 00 00 00 00 00 00 00
00 00 F0 03 00 F0 03 00 00 00 00 00 00 00 00 00
00 00 00 00 00 F0 03 00 00 00 F0 03 00 00 00 00
3F 00 00 00 00 00 00 00 00 00 3F 00 00 00 00 00
00 00 02 00 00 00 00 00 3F 3F 00 00 00 00 00 00
00 00 02 00 00 00 00 00 00 7E 00 F8 01 00 00 00
00 00 00 00 00 00 00 00 00 7E 00 00 00 00 00 00
00 00 00 F8 01 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 80 1F 00 00 00 00 00 00 00 00 00 00
7E 00 00 00 80 1F 00 00 00 00 00 00 00 00 00 00
      7E 00 00 00 00 00 00 00

```

After ι

```

1E 00 00 00 00 00 00 00 00 00 00 00 00 00 F8 01 00
00 C0 0F 00 00 00 00 00 1F 00 00 00 00 00 00 00
00 C0 0F 00 00 F8 01 00 00 00 00 00 00 00 00 00
00 00 F0 03 00 F0 03 00 00 00 00 00 00 00 00 00
00 00 00 00 00 F0 03 00 00 00 F0 03 00 00 00 00
3F 00 00 00 00 00 00 00 00 00 3F 00 00 00 00 00
00 00 02 00 00 00 00 00 3F 3F 00 00 00 00 00 00
00 00 02 00 00 00 00 00 00 7E 00 F8 01 00 00 00
00 00 00 00 00 00 00 00 00 7E 00 00 00 00 00 00
00 00 00 F8 01 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 80 1F 00 00 00 00 00 00 00 00 00 00
7E 00 00 00 80 1F 00 00 00 00 00 00 00 00 00 00
      7E 00 00 00 00 00 00 00

```

(Skip rounds 1 to 22)

Round #23

After θ

F5 86 2B A6 68 65 BA FC 10 4E F5 EE AA FB E0 C4
 33 8C FB C6 D3 83 A0 23 DB BC EE C7 0F 60 AD BF
 47 27 0B 74 8C A7 51 68 7D B6 65 F4 D1 54 62 D4
 60 CC 97 44 A6 82 E7 57 C9 7F A9 4D B1 05 A8 C2
 09 99 B6 5D 41 E7 9C 86 6A 84 85 BE B2 F6 54 C1
 6B 3D 70 76 CF AE CE DE 5F 9F 5D 03 93 F2 B3 CD
 9D 37 63 58 1F 40 58 FE 66 C7 E1 A8 11 DD 4F EB
 B1 A9 CB 54 8D A8 4B 33 AC A8 76 D1 29 4A CF 06
 61 54 AF E1 B5 72 C9 13 9F 5F E9 3A 08 3F 51 04
 53 D5 1C F8 52 52 E1 78 BF 91 01 1A BE D4 39 CF
 84 04 0B 06 B2 E7 23 7E FD 0F B0 4B CE 2A 1E 72
 BB 9F 26 93 52 D4 77 B1 EB 15 3A 7D 4F D1 8C E6
 BB C7 7B 02 3C 4C D2 44

After ρ

F5 86 2B A6 68 65 BA FC 21 9C EA DD 55 F7 C1 89
 0C E3 BE F1 F4 20 E8 C8 00 D6 FA BB CD EB 7E FC
 3C 8D 42 3B 3A 59 A0 63 1F 4D 25 46 DD 67 5B 46
 49 64 2A 78 7E 05 C6 7C 70 F2 5F 6A 53 6C 01 AA
 4C DB AE A0 73 4E C3 84 4F 15 AC 46 58 E8 2B 6B
 5E EB 81 B3 7B 76 75 F6 36 7F 7D 76 0D 4C CA CF
 C3 FA 00 C2 F2 EF BC 19 BA 9F D6 CD 8E C3 51 23
 AA 46 D4 A5 99 D8 D4 65 A2 53 94 9E 0D 58 51 ED
 35 BC 56 2E 79 22 8C EA 28 82 CF AF 74 1D 84 9F
 2A 1C 6F AA 9A 03 5F 4A CF BF 91 01 1A BE D4 39
 8F F8 11 12 2C 18 C8 9E F5 3F C0 2E 39 AB 78 C8
 F7 D3 64 52 8A FA 2E 76 15 3A 7D 4F D1 8C E6 EB
 34 D1 EE F1 9E 00 0F 93

After π

F5 86 2B A6 68 65 BA FC 49 64 2A 78 7E 05 C6 7C
 C3 FA 00 C2 F2 EF BC 19 2A 1C 6F AA 9A 03 5F 4A
 34 D1 EE F1 9E 00 0F 93 00 D6 FA BB CD EB 7E FC
 4F 15 AC 46 58 E8 2B 6B 5E EB 81 B3 7B 76 75 F6
 35 BC 56 2E 79 22 8C EA F7 D3 64 52 8A FA 2E 76
 21 9C EA DD 55 F7 C1 89 70 F2 5F 6A 53 6C 01 AA
 BA 9F D6 CD 8E C3 51 23 CF BF 91 01 1A BE D4 39
 8F F8 11 12 2C 18 C8 9E 3C 8D 42 3B 3A 59 A0 63
 1F 4D 25 46 DD 67 5B 46 36 7F 7D 76 0D 4C CA CF
 28 82 CF AF 74 1D 84 9F 15 3A 7D 4F D1 8C E6 EB
 0C E3 BE F1 F4 20 E8 C8 4C DB AE A0 73 4E C3 84
 AA 46 D4 A5 99 D8 D4 65 A2 53 94 9E 0D 58 51 ED
 F5 3F C0 2E 39 AB 78 C8

After χ

77 1C 2B 24 E8 8F 82 FD 61 60 45 50 76 05 85 3E
 D7 3B 80 93 F6 EF BC 88 EB 1A 6E AC FA 66 EF 26
 3C B1 EE A9 88 00 4B 93 10 3C FB 0A EE FD 2A 68
 6E 01 FA 4A 58 E8 A3 63 9C A8 A1 E3 F9 AE 57 E2
 35 B8 CC 87 3C 23 DC 62 B8 D2 60 16 9A FA 2F 75
 AB 91 6A 58 D9 74 91 88 35 D2 5E 6A 43 50 85 B2
 BA DF D6 DF AA C3 59 A5 EF BB 7B CC 4B 59 D5 38
 DF 9A 04 30 2E 10 C8 BC 1C BF 1A 0B 3A 51 20 EA
 17 CD A7 CF AD 76 5F 56 23 47 4D 36 8C CC A8 AF
 00 07 CD 9F 5E 4C 84 9F 16 7A 58 0B 14 AA BD EF
 AE E7 EE F4 7C B0 FC A9 4C CA AE BA 77 4E C2 0C
 FF 6A 94 85 A9 7B FC 65 AA 93 AA 4F C9 58 D1 ED
 B5 27 C0 2E 3A E5 7B CC

After ι

7F 9C 2B A4 E8 8F 82 7D 61 60 45 50 76 05 85 3E
 D7 3B 80 93 F6 EF BC 88 EB 1A 6E AC FA 66 EF 26
 3C B1 EE A9 88 00 4B 93 10 3C FB 0A EE FD 2A 68
 6E 01 FA 4A 58 E8 A3 63 9C A8 A1 E3 F9 AE 57 E2
 35 B8 CC 87 3C 23 DC 62 B8 D2 60 16 9A FA 2F 75
 AB 91 6A 58 D9 74 91 88 35 D2 5E 6A 43 50 85 B2
 BA DF D6 DF AA C3 59 A5 EF BB 7B CC 4B 59 D5 38
 DF 9A 04 30 2E 10 C8 BC 1C BF 1A 0B 3A 51 20 EA
 17 CD A7 CF AD 76 5F 56 23 47 4D 36 8C CC A8 AF
 00 07 CD 9F 5E 4C 84 9F 16 7A 58 0B 14 AA BD EF
 AE E7 EE F4 7C B0 FC A9 4C CA AE BA 77 4E C2 0C
 FF 6A 94 85 A9 7B FC 65 AA 93 AA 4F C9 58 D1 ED
 B5 27 C0 2E 3A E5 7B CC

After permutation

7F 9C 2B A4 E8 8F 82 7D 61 60 45 50 76 05 85 3E
 D7 3B 80 93 F6 EF BC 88 EB 1A 6E AC FA 66 EF 26
 3C B1 EE A9 88 00 4B 93 10 3C FB 0A EE FD 2A 68
 6E 01 FA 4A 58 E8 A3 63 9C A8 A1 E3 F9 AE 57 E2
 35 B8 CC 87 3C 23 DC 62 B8 D2 60 16 9A FA 2F 75
 AB 91 6A 58 D9 74 91 88 35 D2 5E 6A 43 50 85 B2
 BA DF D6 DF AA C3 59 A5 EF BB 7B CC 4B 59 D5 38
 DF 9A 04 30 2E 10 C8 BC 1C BF 1A 0B 3A 51 20 EA
 17 CD A7 CF AD 76 5F 56 23 47 4D 36 8C CC A8 AF
 00 07 CD 9F 5E 4C 84 9F 16 7A 58 0B 14 AA BD EF
 AE E7 EE F4 7C B0 FC A9 4C CA AE BA 77 4E C2 0C
 FF 6A 94 85 A9 7B FC 65 AA 93 AA 4F C9 58 D1 ED
 B5 27 C0 2E 3A E5 7B CC

State (as lanes of integers)

[0, 0] = 7D828FE8A42B9C7F
 [1, 0] = 3E85057650456061
 [2, 0] = 88BCEFF693803BD7
 [3, 0] = 26EF66FAAC6E1AEB
 [4, 0] = 934B0088A9EEB13C
 [0, 1] = 682AFDEE0AFB3C10
 [1, 1] = 63A3E8584AFA016E
 [2, 1] = E257AEF9E3A1A89C
 [3, 1] = 62DC233C87CCB835
 [4, 1] = 752FFA9A1660D2B8
 [0, 2] = 889174D9586A91AB
 [1, 2] = B28550436A5ED235
 [2, 2] = A559C3AADFD6DFBA
 [3, 2] = 38D5594BCC7BBBEF
 [4, 2] = BCC8102E30049ADF
 [0, 3] = EA20513A0B1ABF1C
 [1, 3] = 565F76ADCFA7CD17
 [2, 3] = AFA8CC8C364D4723
 [3, 3] = 9F844C5E9FCD0700
 [4, 3] = EFBDA1140B587A16
 [0, 4] = A9FCB07CF4EEE7AE
 [1, 4] = 0CC24E77BAAECA4C
 [2, 4] = 65FC7BA985946AFF
 [3, 4] = EDD158C94FAA93AA
 [4, 4] = CC7BE53A2EC027B5

About to call squeeze (again)

State before permutation

7F 9C 2B A4 E8 8F 82 7D 61 60 45 50 76 05 85 3E
 D7 3B 80 93 F6 EF BC 88 EB 1A 6E AC FA 66 EF 26
 3C B1 EE A9 88 00 4B 93 10 3C FB 0A EE FD 2A 68
 6E 01 FA 4A 58 E8 A3 63 9C A8 A1 E3 F9 AE 57 E2
 35 B8 CC 87 3C 23 DC 62 B8 D2 60 16 9A FA 2F 75
 AB 91 6A 58 D9 74 91 88 35 D2 5E 6A 43 50 85 B2
 BA DF D6 DF AA C3 59 A5 EF BB 7B CC 4B 59 D5 38
 DF 9A 04 30 2E 10 C8 BC 1C BF 1A 0B 3A 51 20 EA
 17 CD A7 CF AD 76 5F 56 23 47 4D 36 8C CC A8 AF
 00 07 CD 9F 5E 4C 84 9F 16 7A 58 0B 14 AA BD EF
 AE E7 EE F4 7C B0 FC A9 4C CA AE BA 77 4E C2 0C
 FF 6A 94 85 A9 7B FC 65 AA 93 AA 4F C9 58 D1 ED
 B5 27 C0 2E 3A E5 7B CC

State before permutation (as lanes of integers)

[0, 0] = 7D828FE8A42B9C7F
 [1, 0] = 3E85057650456061
 [2, 0] = 88BCEFF693803BD7
 [3, 0] = 26EF66FAAC6E1AEB
 [4, 0] = 934B0088A9EEB13C
 [0, 1] = 682AFDEE0AFB3C10
 [1, 1] = 63A3E8584AFA016E
 [2, 1] = E257AEF9E3A1A89C
 [3, 1] = 62DC233C87CCB835
 [4, 1] = 752FFA9A1660D2B8
 [0, 2] = 889174D9586A91AB
 [1, 2] = B28550436A5ED235
 [2, 2] = A559C3AADFD6DFBA
 [3, 2] = 38D5594BCC7BBBEF
 [4, 2] = BCC8102E30049ADF
 [0, 3] = EA20513A0B1ABF1C
 [1, 3] = 565F76ADCFA7CD17
 [2, 3] = AFA8CC8C364D4723
 [3, 3] = 9F844C5E9FCD0700
 [4, 3] = EFBDA140B587A16
 [0, 4] = A9FCB07CF4EEE7AE
 [1, 4] = 0CC24E77BAAECA4C
 [2, 4] = 65FC7BA985946AFF
 [3, 4] = EDD158C94FAA93AA
 [4, 4] = CC7BE53A2EC027B5

Round #0

After θ

44 50 E8 05 94 21 95 6E 4D CB 57 61 EF 89 AC EB
 80 94 15 F9 75 7A E4 20 36 32 65 E4 5F 19 DC D1
 4A EE CC 8C A0 C7 33 20 2B F0 38 AB 92 53 3D 7B
 42 AA E8 7B C1 64 8A B6 CB 07 34 89 7A 3B 0F 4A
 E8 90 C7 CF 99 5C EF 95 CE 8D 42 33 B2 3D 57 C6
 90 5D A9 F9 A5 DA 86 9B 19 79 4C 5B DA DC AC 67
 ED 70 43 B5 29 56 01 0D 32 93 70 84 EE 26 E6 CF
 A9 C5 26 15 06 D7 B0 0F 27 73 D9 AA 46 FF 37 F9
 3B 66 B5 FE 34 FA 76 83 74 E8 D8 5C 0F 59 F0 07
 DD 2F C6 D7 FB 33 B7 68 60 25 7A 2E 3C 6D C5 5C
 95 2B 2D 55 00 1E EB BA 60 61 BC 8B EE C2 EB D9
 A8 C5 01 EF 2A EE A4 CD 77 BB A1 07 6C 27 E2 1A
 C3 78 E2 0B 12 22 03 7F

After ρ

44 50 E8 05 94 21 95 6E 9B 96 AF C2 DE 13 59 D7
 20 65 45 7E 9D 1E 39 08 95 C1 1D 6D 23 53 46 FE
 3D 9E 01 51 72 67 66 04 2A 39 D5 B3 B7 02 8F B3
 BE 17 4C A6 68 2B A4 8A D2 F2 01 4D A2 DE CE 83
 C8 E3 E7 4C AE F7 4A 74 73 65 EC DC 28 34 23 DB
 84 EC 4A CD 2F D5 36 DC 9E 65 E4 31 6D 69 73 B3
 AA 4D B1 0A 68 68 87 1B 4D CC 9F 65 26 E1 08 DD
 0A 83 6B D8 87 D4 62 93 55 8D FE 6F F2 4F E6 B2
 D6 9F 46 DF 6E 70 C7 AC F8 03 3A 74 6C AE 87 2C
 E6 16 AD FB C5 F8 7A 7F 5C 60 25 7A 2E 3C 6D C5
 AC EB 56 AE B4 54 01 78 83 85 F1 2E BA 0B AF 67
 B5 38 E0 5D C5 9D B4 19 BB A1 07 6C 27 E2 1A 77
 C0 DF 30 9E F8 82 84 C8

After π

44 50 E8 05 94 21 95 6E BE 17 4C A6 68 2B A4 8A
 AA 4D B1 0A 68 68 87 1B E6 16 AD FB C5 F8 7A 7F
 C0 DF 30 9E F8 82 84 C8 95 C1 1D 6D 23 53 46 FE
 73 65 EC DC 28 34 23 DB 84 EC 4A CD 2F D5 36 DC
 D6 9F 46 DF 6E 70 C7 AC B5 38 E0 5D C5 9D B4 19
 9B 96 AF C2 DE 13 59 D7 D2 F2 01 4D A2 DE CE 83
 4D CC 9F 65 26 E1 08 DD 5C 60 25 7A 2E 3C 6D C5
 AC EB 56 AE B4 54 01 78 3D 9E 01 51 72 67 66 04
 2A 39 D5 B3 B7 02 8F B3 9E 65 E4 31 6D 69 73 B3
 F8 03 3A 74 6C AE 87 2C BB A1 07 6C 27 E2 1A 77
 20 65 45 7E 9D 1E 39 08 C8 E3 E7 4C AE F7 4A 74
 0A 83 6B D8 87 D4 62 93 55 8D FE 6F F2 4F E6 B2
 83 85 F1 2E BA 0B AF 67

After χ

44 18 59 0D 94 61 96 7F FA 05 40 57 ED BB DC EE
 AA 84 A1 0E 50 6A 03 9B E2 16 65 FA C1 D9 6B 59
 7A D8 34 3C 90 88 A4 48 11 49 1F 6C 24 92 52 FA
 21 76 E8 CE 68 14 E2 FB A5 CC EA CD AE 58 06 CD
 D6 5E 5B FF 4C 32 85 4A D7 1C 00 CD CD B9 95 18
 96 9A 31 E2 DA 32 59 8B C2 D2 21 57 AA C2 AB 83
 ED 47 CD E1 B6 A1 08 E5 4F 74 8C 3A 64 3F 35 42
 EC 8B 56 A3 94 98 87 78 A9 DA 21 51 3A 0E 16 04
 4A 3B CF F7 B7 84 0B BF 9D C5 E1 39 6E 29 6B E0
 FC 1D 3A 65 3C AB E3 2C B9 80 D3 CE A2 E2 93 C4
 22 65 4D EE 9C 1E 19 8B 9D EF 73 6B DE FC CE 54
 88 83 6A D8 8F D4 6B D6 75 ED FA 3F F7 5B F6 BA
 4B 07 53 2E 98 EA ED 13

After t

45 18 59 0D 94 61 96 7F FA 05 40 57 ED BB DC EE
AA 84 A1 0E 50 6A 03 9B E2 16 65 FA C1 D9 6B 59
7A D8 34 3C 90 88 A4 48 11 49 1F 6C 24 92 52 FA
21 76 E8 CE 68 14 E2 FB A5 CC EA CD AE 58 06 CD
D6 5E 5B FF 4C 32 85 4A D7 1C 00 CD CD B9 95 18
96 9A 31 E2 DA 32 59 8B C2 D2 21 57 AA C2 AB 83
ED 47 CD E1 B6 A1 08 E5 4F 74 8C 3A 64 3F 35 42
EC 8B 56 A3 94 98 87 78 A9 DA 21 51 3A 0E 16 04
4A 3B CF F7 B7 84 0B BF 9D C5 E1 39 6E 29 6B E0
FC 1D 3A 65 3C AB E3 2C B9 80 D3 CE A2 E2 93 C4
22 65 4D EE 9C 1E 19 8B 9D EF 73 6B DE FC CE 54
88 83 6A D8 8F D4 6B D6 75 ED FA 3F F7 5B F6 BA
4B 07 53 2E 98 EA ED 13

(Skip rounds 1 to 22)

Round #23

After θ

38 EB E3 7D 36 5C 29 FB B3 4A 0D 6A BC 96 62 80
A8 AE AB 8A 81 C2 F5 C6 6E A9 B2 90 4D 39 13 24
1C 38 32 7D 93 63 CC EF 72 3E 0E EF 7F C5 39 7C
B0 9C 84 F3 96 FB F9 70 7F 38 FD A8 E4 63 9A 41
74 F7 FA 60 97 0E D4 66 D5 49 8A 48 94 CC F6 C9
8E 33 8C 50 72 E6 8C 7A 75 51 1C 2D 3D 77 42 4C
39 B6 D5 EE 66 D0 F3 92 8C 0D BC ED 0D E3 40 52
A5 7D 92 41 35 0A 21 9D 5C 60 21 27 18 20 67 2C
B2 A7 72 50 8E 9A 47 D5 64 AD 4B 1D 66 DF FE 31
36 CE 9C 89 E7 3B CF 9A 15 E2 E0 AB F2 8C 59 69
3A F0 98 FA 59 9F 6B AA 77 0F B2 DF 43 39 07 F6
DC AA 81 F2 54 DB 92 E7 8F F1 7C 6C 29 40 9A 86
EF C9 88 30 89 D1 CB B8

After ρ

38 EB E3 7D 36 5C 29 FB 67 95 1A D4 78 2D C5 00
 AA EB AA 62 A0 70 BD 31 94 33 41 E2 96 2A 0B D9
 1C 63 7E E7 C0 91 E9 9B FE 57 9C C3 27 E7 E3 F0
 38 6F B9 9F 0F 07 CB 49 D0 1F 4E 3F 2A F9 98 66
 7B 7D B0 4B 07 6A 33 BA 6C 9F 5C 9D A4 88 44 C9
 73 9C 61 84 92 33 67 D4 31 D5 45 71 B4 F4 DC 09
 76 37 83 9E 97 CC B1 AD C6 81 A4 18 1B 78 DB 1B
 A0 1A 85 90 CE D2 3E C9 4E 30 40 CE 58 B8 C0 42
 0E CA 51 F3 A8 5A F6 54 FF 18 B2 D6 A5 0E B3 6F
 E7 59 D3 C6 99 33 F1 7C 69 15 E2 E0 AB F2 8C 59
 AE A9 EA C0 63 EA 67 7D DF 3D C8 7E 0F E5 1C D8
 5B 35 50 9E 6A 5B F2 9C F1 7C 6C 29 40 9A 86 8F
 32 EE 7B 32 22 4C 62 F4

After π

38 EB E3 7D 36 5C 29 FB 38 6F B9 9F 0F 07 CB 49
 76 37 83 9E 97 CC B1 AD E7 59 D3 C6 99 33 F1 7C
 32 EE 7B 32 22 4C 62 F4 94 33 41 E2 96 2A 0B D9
 6C 9F 5C 9D A4 88 44 C9 73 9C 61 84 92 33 67 D4
 0E CA 51 F3 A8 5A F6 54 5B 35 50 9E 6A 5B F2 9C
 67 95 1A D4 78 2D C5 00 D0 1F 4E 3F 2A F9 98 66
 C6 81 A4 18 1B 78 DB 1B 69 15 E2 E0 AB F2 8C 59
 AE A9 EA C0 63 EA 67 7D 1C 63 7E E7 C0 91 E9 9B
 FE 57 9C C3 27 E7 E3 F0 31 D5 45 71 B4 F4 DC 09
 FF 18 B2 D6 A5 0E B3 6F F1 7C 6C 29 40 9A 86 8F
 AA EB AA 62 A0 70 BD 31 7B 7D B0 4B 07 6A 33 BA
 A0 1A 85 90 CE D2 3E C9 4E 30 40 CE 58 B8 C0 42
 DF 3D C8 7E 0F E5 1C D8

After χ

7E FB E1 7D A6 94 19 5F B9 27 E9 DF 07 34 8B 19
 66 91 AB AE B5 80 B3 2D EF 58 53 8B 8D 23 F8 77
 32 EA 63 B0 2B 4F A0 F4 87 33 60 E2 84 19 28 CD
 60 DD 4C EE 8C C0 D4 C9 22 A9 61 88 D0 32 67 5C
 8A C8 50 93 3C 7A FF 15 33 B9 4C 83 4A DB B6 9C
 61 15 BA D4 69 2D 86 19 F9 0B 0C DF 8A 7B 9C 26
 40 29 AC 18 5B 70 B8 3F 28 01 F2 F4 B3 F7 0C 59
 3E A3 AE EB 61 3A 7F 1B 1D E3 3F D7 50 81 F5 92
 30 5F 2E 45 26 ED C0 96 31 B1 09 58 F4 64 D8 89
 F3 1B A0 10 25 0F DA 7F 13 68 EC 29 67 FC 84 EF
 2A E9 AF F2 68 E0 B1 70 35 5D F0 05 17 42 F3 B8
 31 17 0D A0 C9 97 22 51 6E F2 62 CE F8 A8 61 63
 8E 29 D8 77 08 EF 1E 52

After t

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76 7B E1 FD A6 94 19 DF B9 27 E9 DF 07 34 8B 19
66 91 AB AE B5 80 B3 2D EF 58 53 8B 8D 23 F8 77
32 EA 63 B0 2B 4F A0 F4 87 33 60 E2 84 19 28 CD
60 DD 4C EE 8C C0 D4 C9 22 A9 61 88 D0 32 67 5C
8A C8 50 93 3C 7A FF 15 33 B9 4C 83 4A DB B6 9C
61 15 BA D4 69 2D 86 19 F9 0B 0C DF 8A 7B 9C 26
40 29 AC 18 5B 70 B8 3F 28 01 F2 F4 B3 F7 0C 59
3E A3 AE EB 61 3A 7F 1B 1D E3 3F D7 50 81 F5 92
30 5F 2E 45 26 ED C0 96 31 B1 09 58 F4 64 D8 89
F3 1B A0 10 25 0F DA 7F 13 68 EC 29 67 FC 84 EF
2A E9 AF F2 68 E0 B1 70 35 5D F0 05 17 42 F3 B8
31 17 0D A0 C9 97 22 51 6E F2 62 CE F8 A8 61 63
      8E 29 D8 77 08 EF 1E 52

```

After permutation

```

76 7B E1 FD A6 94 19 DF B9 27 E9 DF 07 34 8B 19
66 91 AB AE B5 80 B3 2D EF 58 53 8B 8D 23 F8 77
32 EA 63 B0 2B 4F A0 F4 87 33 60 E2 84 19 28 CD
60 DD 4C EE 8C C0 D4 C9 22 A9 61 88 D0 32 67 5C
8A C8 50 93 3C 7A FF 15 33 B9 4C 83 4A DB B6 9C
61 15 BA D4 69 2D 86 19 F9 0B 0C DF 8A 7B 9C 26
40 29 AC 18 5B 70 B8 3F 28 01 F2 F4 B3 F7 0C 59
3E A3 AE EB 61 3A 7F 1B 1D E3 3F D7 50 81 F5 92
30 5F 2E 45 26 ED C0 96 31 B1 09 58 F4 64 D8 89
F3 1B A0 10 25 0F DA 7F 13 68 EC 29 67 FC 84 EF
2A E9 AF F2 68 E0 B1 70 35 5D F0 05 17 42 F3 B8
31 17 0D A0 C9 97 22 51 6E F2 62 CE F8 A8 61 63
      8E 29 D8 77 08 EF 1E 52

```


State (as lanes of integers)

[0,0] = DF1994A6FDE17B76
 [1,0] = 198B3407DFE927B9
 [2,0] = 2DB380B5AEAB9166
 [3,0] = 77F8238D8B5358EF
 [4,0] = F4A04F2BB063EA32
 [0,1] = CD281984E2603387
 [1,1] = C9D4C08CEE4CDD60
 [2,1] = 5C6732D08861A922
 [3,1] = 15FF7A3C9350C88A
 [4,1] = 9CB6DB4A834CB933
 [0,2] = 19862D69D4BA1561
 [1,2] = 269C7B8ADF0C0BF9
 [2,2] = 3FB8705B18AC2940
 [3,2] = 590CF7B3F4F20128
 [4,2] = 1B7F3A61EBAE33E
 [0,3] = 92F58150D73FE31D
 [1,3] = 96C0ED26452E5F30
 [2,3] = 89D864F45809B131
 [3,3] = 7FDA0F2510A01BF3
 [4,3] = EF84FC6729EC6813
 [0,4] = 70B1E068F2AFE92A
 [1,4] = B8F3421705F05D35
 [2,4] = 512297C9A00D1731
 [3,4] = 6361A8F8CE62F26E
 [4,4] = 521EEF0877D8298E

About to call squeeze (again)

State before permutation (in bytes)

76 7B E1 FD A6 94 19 DF B9 27 E9 DF 07 34 8B 19
 66 91 AB AE B5 80 B3 2D EF 58 53 8B 8D 23 F8 77
 32 EA 63 B0 2B 4F A0 F4 87 33 60 E2 84 19 28 CD
 60 DD 4C EE 8C C0 D4 C9 22 A9 61 88 D0 32 67 5C
 8A C8 50 93 3C 7A FF 15 33 B9 4C 83 4A DB B6 9C
 61 15 BA D4 69 2D 86 19 F9 0B 0C DF 8A 7B 9C 26
 40 29 AC 18 5B 70 B8 3F 28 01 F2 F4 B3 F7 0C 59
 3E A3 AE EB 61 3A 7F 1B 1D E3 3F D7 50 81 F5 92
 30 5F 2E 45 26 ED C0 96 31 B1 09 58 F4 64 D8 89
 F3 1B A0 10 25 0F DA 7F 13 68 EC 29 67 FC 84 EF
 2A E9 AF F2 68 E0 B1 70 35 5D F0 05 17 42 F3 B8
 31 17 0D A0 C9 97 22 51 6E F2 62 CE F8 A8 61 63
 8E 29 D8 77 08 EF 1E 52

State before permutation (as lanes of integers)

[0, 0] = DF1994A6FDE17B76
 [1, 0] = 198B3407DFE927B9
 [2, 0] = 2DB380B5AEAB9166
 [3, 0] = 77F8238D8B5358EF
 [4, 0] = F4A04F2BB063EA32
 [0, 1] = CD281984E2603387
 [1, 1] = C9D4C08CEE4CDD60
 [2, 1] = 5C6732D08861A922
 [3, 1] = 15FF7A3C9350C88A
 [4, 1] = 9CB6DB4A834CB933
 [0, 2] = 19862D69D4BA1561
 [1, 2] = 269C7B8ADF0C0BF9
 [2, 2] = 3FB8705B18AC2940
 [3, 2] = 590CF7B3F4F20128
 [4, 2] = 1B7F3A61EBAEA33E
 [0, 3] = 92F58150D73FE31D
 [1, 3] = 96C0ED26452E5F30
 [2, 3] = 89D864F45809B131
 [3, 3] = 7FDA0F2510A01BF3
 [4, 3] = EF84FC6729EC6813
 [0, 4] = 70B1E068F2AFE92A
 [1, 4] = B8F3421705F05D35
 [2, 4] = 512297C9A00D1731
 [3, 4] = 6361A8F8CE62F26E
 [4, 4] = 521EEF0877D8298E

Round #0

After θ

9F 2C BB 27 A8 69 0A A0 17 1E 87 BD 73 97 54 DD
 E3 93 BA 64 3B B3 23 BA AE 8C 5A 40 51 68 89 7C
 AD 3D 06 5F 13 C4 F7 00 6E 64 3A 38 8A E4 3B B2
 CE E4 22 8C F8 63 0B 0D A7 AB 70 42 5E 01 F7 CB
 CB 1C 59 58 E0 31 8E 1E AC 6E 29 6C 72 50 E1 68
 88 42 E0 0E 67 D0 95 66 57 32 62 BD FE D8 43 E2
 C5 2B BD D2 D5 43 28 A8 69 D5 FB 3F 6F BC 7D 52
 A1 74 CB 04 59 B1 28 EF F4 B4 65 0D 5E 7C E6 ED
 9E 66 40 27 52 4E 1F 52 B4 B3 18 92 7A 57 48 1E
 B2 CF A9 DB F9 44 AB 74 8C BF 89 C6 5F 77 D3 1B
 C3 BE F5 28 66 1D A2 0F 9B 64 9E 67 63 E1 2C 7C
 B4 15 1C 6A 47 A4 B2 C6 2F 26 6B 05 24 E3 10 68
 11 FE BD 98 30 64 49 A6

After ρ

9F 2C BB 27 A8 69 0A A0 2F 3C 0E 7B E7 2E A9 BA
 F8 A4 2E D9 CE EC 88 EE 85 96 C8 E7 CA A8 05 14
 20 BE 07 68 ED 31 F8 9A A3 48 BE 23 EB 46 A6 83
 C2 88 3F B6 D0 E0 4C 2E F2 E9 2A 9C 90 57 C0 FD
 8E 2C 2C F0 18 47 8F 65 15 8E C6 EA 96 C2 26 07
 43 14 02 77 38 83 AE 34 89 5F C9 88 F5 FA 63 0F
 95 AE 1E 42 41 2D 5E E9 78 FB A4 D2 AA F7 7F DE
 82 AC 58 94 F7 50 BA 65 1A BC F8 CC DB E9 69 CB
 E8 44 CA E9 43 CA D3 0C 24 0F DA 59 0C 49 BD 2B
 68 95 4E F6 39 75 3B 9F 1B 8C BF 89 C6 5F 77 D3
 88 3E 0C FB D6 A3 98 75 6D 92 79 9E 8D 85 B3 F0
 B6 82 43 ED 88 54 D6 98 26 6B 05 24 E3 10 68 2F
 92 69 84 7F 2F 26 0C 59

After π

9F 2C BB 27 A8 69 0A A0 C2 88 3F B6 D0 E0 4C 2E
 95 AE 1E 42 41 2D 5E E9 68 95 4E F6 39 75 3B 9F
 92 69 84 7F 2F 26 0C 59 85 96 C8 E7 CA A8 05 14
 15 8E C6 EA 96 C2 26 07 43 14 02 77 38 83 AE 34
 E8 44 CA E9 43 CA D3 0C B6 82 43 ED 88 54 D6 98
 2F 3C 0E 7B E7 2E A9 BA F2 E9 2A 9C 90 57 C0 FD
 78 FB A4 D2 AA F7 7F DE 1B 8C BF 89 C6 5F 77 D3
 88 3E 0C FB D6 A3 98 75 20 BE 07 68 ED 31 F8 9A
 A3 48 BE 23 EB 46 A6 83 89 5F C9 88 F5 FA 63 0F
 24 0F DA 59 0C 49 BD 2B 26 6B 05 24 E3 10 68 2F
 F8 A4 2E D9 CE EC 88 EE 8E 2C 2C F0 18 47 8F 65
 82 AC 58 94 F7 50 BA 65 1A BC F8 CC DB E9 69 CB
 6D 92 79 9E 8D 85 B3 F0

After χ

8A 0A BB 67 A9 64 18 61 AA 99 7F 02 E8 B0 6D 38
 07 C6 9E 4B 47 2F 5A A9 65 91 75 F6 B9 3C 39 3F
 D2 E9 80 EF 7F A6 48 57 C7 86 C8 F2 E2 A9 8D 24
 BD CE 0E 62 D5 8A 77 0F 55 96 03 73 B0 97 AA A4
 E9 50 42 EB 01 62 D2 08 A6 8A 45 E5 9C 16 F4 9B
 27 2E 8A 39 CD 8E 96 B8 F1 ED 31 95 D4 5F C0 FC
 F8 C9 A4 A0 BA 57 F7 FA 3C 8C BD 89 E7 53 56 59
 58 FF 2C 7F C6 F2 D8 30 28 A9 46 E0 F9 89 B9 96
 87 48 AC 72 E3 47 3A A3 8B 3F CC AC 16 EA 23 0B
 24 9B D8 11 00 68 2D BB A5 2B BD 27 E1 56 6E 2E
 F8 24 7E DD 29 FC B8 EE 96 3C 8C B8 10 EE CE EF
 E7 AE 59 86 F3 54 28 55 8A 98 FE 8D 99 81 61 C5
 6B 9A 79 BE 9D 86 B4 F1

After t

8B 0A BB 67 A9 64 18 61 AA 99 7F 02 E8 B0 6D 38
 07 C6 9E 4B 47 2F 5A A9 65 91 75 F6 B9 3C 39 3F
 D2 E9 80 EF 7F A6 48 57 C7 86 C8 F2 E2 A9 8D 24
 BD CE 0E 62 D5 8A 77 0F 55 96 03 73 B0 97 AA A4
 E9 50 42 EB 01 62 D2 08 A6 8A 45 E5 9C 16 F4 9B
 27 2E 8A 39 CD 8E 96 B8 F1 ED 31 95 D4 5F C0 FC
 F8 C9 A4 A0 BA 57 F7 FA 3C 8C BD 89 E7 53 56 59
 58 FF 2C 7F C6 F2 D8 30 28 A9 46 E0 F9 89 B9 96
 87 48 AC 72 E3 47 3A A3 8B 3F CC AC 16 EA 23 0B
 24 9B D8 11 00 68 2D BB A5 2B BD 27 E1 56 6E 2E
 F8 24 7E DD 29 FC B8 EE 96 3C 8C B8 10 EE CE EF
 E7 AE 59 86 F3 54 28 55 8A 98 FE 8D 99 81 61 C5
 6B 9A 79 BE 9D 86 B4 F1

(Skip rounds 1 to 22)

Round #23

After θ

24 F3 4C 0B 2B 53 2B E5 01 58 E8 86 76 54 27 BB
 E5 CB C8 81 CC B9 AC E4 E7 35 DC 86 4F 5D B1 57
 63 96 A9 1E E8 8B 43 5A AC 21 84 1F FE 01 8C A9
 CF 3E 10 19 17 03 6B E5 88 F0 B1 AA B6 3C AD 4F
 E7 B5 59 BA 83 7E 0B 57 C4 85 48 7C A2 1E E5 C7
 02 D1 1B 7B 79 0A 7B 03 47 86 2E 94 35 80 AF E5
 AA 5A CB A6 5B 31 93 6C 0B 8D A0 96 16 73 60 82
 D0 05 D4 79 71 59 70 81 8A 03 71 AB D6 C1 89 72
 A3 5F 4A 54 8E 95 3A EE 93 8B 08 B7 84 CA B1 E0
 90 6A E4 9A 38 12 09 72 DD 04 C3 7E 0B 12 60 ED
 44 1A CD AE A8 6A D3 2E E3 F4 95 B6 6B 53 43 4C
 DE 97 C5 E5 AE E6 E3 05 AA 64 4A 2C 9A 95 46 47
 B5 EA 07 D7 61 5F AD EA

After ρ

24 F3 4C 0B 2B 53 2B E5 03 B0 D0 0D ED A8 4E 76
 F9 32 72 20 73 2E 2B 79 D4 15 7B 75 5E C3 6D F8
 5F 1C D2 1A B3 4C F5 40 E1 1F C0 98 CA 1A 42 F8
 91 71 31 B0 56 FE EC 03 13 22 7C AC AA 2D 4F EB
 DA 2C DD 41 BF 85 AB F3 51 7E 4C 5C 88 C4 27 EA
 10 88 DE D8 CB 53 D8 1B 96 1F 19 BA 50 D6 00 BE
 36 DD 8A 99 64 53 D5 5A E6 C0 04 17 1A 41 2D 2D
 BC B8 2C B8 40 E8 02 EA 56 AD 83 13 E5 14 07 E2
 89 CA B1 52 C7 7D F4 4B 58 F0 C9 45 84 5B 42 E5
 22 41 0E 52 8D 5C 13 47 ED DD 04 C3 7E 0B 12 60
 4D BB 10 69 34 BB A2 AA 8D D3 57 DA AE 4D 0D 31
 FB B2 B8 DC D5 7C BC C0 64 4A 2C 9A 95 46 47 AA
 AB 7A AD FA C1 75 D8 57

After π

24 F3 4C 0B 2B 53 2B E5 91 71 31 B0 56 FE EC 03
 36 DD 8A 99 64 53 D5 5A 22 41 0E 52 8D 5C 13 47
 AB 7A AD FA C1 75 D8 57 D4 15 7B 75 5E C3 6D F8
 51 7E 4C 5C 88 C4 27 EA 10 88 DE D8 CB 53 D8 1B
 89 CA B1 52 C7 7D F4 4B 58 F0 C9 45 84 5B 42 E5
 03 B0 D0 0D ED A8 4E 76 13 22 7C AC AA 2D 4F EB
 E6 C0 04 17 1A 41 2D 2D ED DD 04 C3 7E 0B 12 60
 4D BB 10 69 34 BB A2 AA 5F 1C D2 1A B3 4C F5 40
 E1 1F C0 98 CA 1A 42 F8 96 1F 19 BA 50 D6 00 BE
 58 F0 C9 45 84 5B 42 E5 64 4A 2C 9A 95 46 47 AA
 F9 32 72 20 73 2E 2B 79 DA 2C DD 41 BF 85 AB F3
 BC B8 2C B8 40 E8 02 EA 56 AD 83 13 E5 14 07 E2
 8D D3 57 DA AE 4D 0D 31

After χ

02 7F C6 02 0B 52 3A BD 91 71 35 F2 DF F2 EE 06
 BF E7 2B 31 24 72 1D 4A 26 C0 4E 53 A7 5E 30 E7
 3A 7A 9C 4A 95 D9 1C 55 D4 95 E9 F5 1D D0 B5 E9
 D8 3C 6D 5E 8C E8 03 AA 62 B8 D6 54 DB 53 D0 9B
 8D CF F2 73 CD FE B5 73 FA D8 BC D4 55 78 BE C2
 E7 70 D0 1E FD E8 6E 72 1A 3F 7C 6C CE 27 5D AB
 E6 E2 14 3F 1A F1 8D A7 EF DD C4 C7 B7 0B 5E 34
 5D B9 3C C9 36 BE A3 23 49 1C CB 38 A3 88 F5 46
 A9 FF 00 DD 4E 13 00 B9 B2 15 3D 20 41 D2 05 B4
 43 E4 1B 45 A6 53 F2 A5 C4 49 2C 1A DD 54 45 12
 DD A2 52 98 33 46 2B 71 98 29 5E 42 1A 91 AE F3
 35 EA 78 70 4A A1 0A FB 26 8D A3 33 B4 36 25 AA
 8F DF DA 9B 22 CC 8D B3

After t

```

0A FF C6 82 0B 52 3A 3D 91 71 35 F2 DF F2 EE 06
BF E7 2B 31 24 72 1D 4A 26 C0 4E 53 A7 5E 30 E7
3A 7A 9C 4A 95 D9 1C 55 D4 95 E9 F5 1D D0 B5 E9
D8 3C 6D 5E 8C E8 03 AA 62 B8 D6 54 DB 53 D0 9B
8D CF F2 73 CD FE B5 73 FA D8 BC D4 55 78 BE C2
E7 70 D0 1E FD E8 6E 72 1A 3F 7C 6C CE 27 5D AB
E6 E2 14 3F 1A F1 8D A7 EF DD C4 C7 B7 0B 5E 34
5D B9 3C C9 36 BE A3 23 49 1C CB 38 A3 88 F5 46
A9 FF 00 DD 4E 13 00 B9 B2 15 3D 20 41 D2 05 B4
43 E4 1B 45 A6 53 F2 A5 C4 49 2C 1A DD 54 45 12
DD A2 52 98 33 46 2B 71 98 29 5E 42 1A 91 AE F3
35 EA 78 70 4A A1 0A FB 26 8D A3 33 B4 36 25 AA
      8F DF DA 9B 22 CC 8D B3

```

After permutation

```

0A FF C6 82 0B 52 3A 3D 91 71 35 F2 DF F2 EE 06
BF E7 2B 31 24 72 1D 4A 26 C0 4E 53 A7 5E 30 E7
3A 7A 9C 4A 95 D9 1C 55 D4 95 E9 F5 1D D0 B5 E9
D8 3C 6D 5E 8C E8 03 AA 62 B8 D6 54 DB 53 D0 9B
8D CF F2 73 CD FE B5 73 FA D8 BC D4 55 78 BE C2
E7 70 D0 1E FD E8 6E 72 1A 3F 7C 6C CE 27 5D AB
E6 E2 14 3F 1A F1 8D A7 EF DD C4 C7 B7 0B 5E 34
5D B9 3C C9 36 BE A3 23 49 1C CB 38 A3 88 F5 46
A9 FF 00 DD 4E 13 00 B9 B2 15 3D 20 41 D2 05 B4
43 E4 1B 45 A6 53 F2 A5 C4 49 2C 1A DD 54 45 12
DD A2 52 98 33 46 2B 71 98 29 5E 42 1A 91 AE F3
35 EA 78 70 4A A1 0A FB 26 8D A3 33 B4 36 25 AA
      8F DF DA 9B 22 CC 8D B3

```

State (as lanes of integers)

[0, 0] = 3D3A520B82C6FF0A
 [1, 0] = 06EEF2DFF2357191
 [2, 0] = 4A1D7224312BE7BF
 [3, 0] = E7305EA7534EC026
 [4, 0] = 551CD9954A9C7A3A
 [0, 1] = E9B5D01DF5E995D4
 [1, 1] = AA03E88C5E6D3CD8
 [2, 1] = 9BD053DB54D6B862
 [3, 1] = 73B5FECDD73F2CF8D
 [4, 1] = C2BE7855D4BCD8FA
 [0, 2] = 726EE8FD1ED070E7
 [1, 2] = AB5D27CE6C7C3F1A
 [2, 2] = A78DF11A3F14E2E6
 [3, 2] = 345E0BB7C7C4DDEF
 [4, 2] = 23A3BE36C93CB95D
 [0, 3] = 46F588A338CB1C49
 [1, 3] = B900134EDD00FFA9
 [2, 3] = B405D241203D15B2
 [3, 3] = A5F253A6451BE443
 [4, 3] = 124554DD1A2C49C4
 [0, 4] = 712B46339852A2DD
 [1, 4] = F3AE911A425E2998
 [2, 4] = FB0AA14A7078EA35
 [3, 4] = AA2536B433A38D26
 [4, 4] = B38DCC229BDADF8F

About to call squeeze (again)

State before permutation (in bytes)

0A FF C6 82 0B 52 3A 3D 91 71 35 F2 DF F2 EE 06
 BF E7 2B 31 24 72 1D 4A 26 C0 4E 53 A7 5E 30 E7
 3A 7A 9C 4A 95 D9 1C 55 D4 95 E9 F5 1D D0 B5 E9
 D8 3C 6D 5E 8C E8 03 AA 62 B8 D6 54 DB 53 D0 9B
 8D CF F2 73 CD FE B5 73 FA D8 BC D4 55 78 BE C2
 E7 70 D0 1E FD E8 6E 72 1A 3F 7C 6C CE 27 5D AB
 E6 E2 14 3F 1A F1 8D A7 EF DD C4 C7 B7 0B 5E 34
 5D B9 3C C9 36 BE A3 23 49 1C CB 38 A3 88 F5 46
 A9 FF 00 DD 4E 13 00 B9 B2 15 3D 20 41 D2 05 B4
 43 E4 1B 45 A6 53 F2 A5 C4 49 2C 1A DD 54 45 12
 DD A2 52 98 33 46 2B 71 98 29 5E 42 1A 91 AE F3
 35 EA 78 70 4A A1 0A FB 26 8D A3 33 B4 36 25 AA
 8F DF DA 9B 22 CC 8D B3

State before permutation (as lanes of integers)

[0, 0] = 3D3A520B82C6FF0A
 [1, 0] = 06EEF2DFF2357191
 [2, 0] = 4A1D7224312BE7BF
 [3, 0] = E7305EA7534EC026
 [4, 0] = 551CD9954A9C7A3A
 [0, 1] = E9B5D01DF5E995D4
 [1, 1] = AA03E88C5E6D3CD8
 [2, 1] = 9BD053DB54D6B862
 [3, 1] = 73B5FECD73F2CF8D
 [4, 1] = C2BE7855D4BCD8FA
 [0, 2] = 726EE8FD1ED070E7
 [1, 2] = AB5D27CE6C7C3F1A
 [2, 2] = A78DF11A3F14E2E6
 [3, 2] = 345E0BB7C7C4DDEF
 [4, 2] = 23A3BE36C93CB95D
 [0, 3] = 46F588A338CB1C49
 [1, 3] = B900134EDD00FFA9
 [2, 3] = B405D241203D15B2
 [3, 3] = A5F253A6451B5443
 [4, 3] = 124554DD1A2C49C4
 [0, 4] = 712B46339852A2DD
 [1, 4] = F3AE911A425E2998
 [2, 4] = FBDAA14A7078EA35
 [3, 4] = AA2536B433A38D26
 [4, 4] = B38DCC229BDADF8F

Round #0

After θ

18 3A D9 EA 90 AA CE B2 44 50 0B 2E 78 11 4E E5
 9E 35 D0 4D 72 50 1A 59 36 99 37 F4 5A F3 EC F5
 40 88 91 49 AD 5F 6F D8 C6 50 F6 9D 86 28 41 66
 0D 1D 53 82 2B 0B A3 49 43 6A 2D 28 8D 71 D7 88
 9D 96 8B D4 30 53 69 61 80 2A B1 D7 6D FE CD 4F
 F5 B5 CF 76 66 10 9A FD CF 1E 42 B0 69 C4 FD 48
 C7 30 EF 43 4C D3 8A B4 FF 84 BD 60 4A A6 82 26
 27 4B 31 CA 0E 38 D0 AE 5B D9 D4 50 38 70 01 C9
 7C DE 3E 01 E9 F0 A0 5A 93 C7 C6 5C 17 F0 02 A7
 53 BD 62 E2 5B FE 2E B7 BE BB 21 19 E5 D2 36 9F
 CF 67 4D F0 A8 BE DF FE 4D 08 60 9E BD 72 0E 10
 14 38 83 0C 1C 83 0D E8 36 D4 DA 94 49 9B F9 B8
 F5 2D D7 98 1A 4A FE 3E

After ρ

18 3A D9 EA 90 AA CE B2 89 A0 16 5C F0 22 9C CA
 67 0D 74 93 1C 94 46 96 35 CF 5E 6F 93 79 43 AF
 FD 7A C3 06 42 8C 4C 6A 69 88 12 64 66 0C 65 DF
 25 B8 B2 30 9A D4 D0 31 E2 90 5A 0B 4A 63 DC 35
 CB 45 6A 98 A9 B4 B0 4E DF FC 04 A8 12 7B DD E6
 AF AF 7D B6 33 83 D0 EC 23 3D 7B 08 C1 A6 11 F7
 1F 62 9A 56 A4 3D 86 79 4C 05 4D FE 09 7B C1 94
 65 07 1C 68 D7 93 A5 18 A1 70 E0 02 92 B7 B2 A9
 27 20 1D 1E 54 8B CF DB 81 D3 C9 63 63 AE 0B 78
 DF E5 76 AA 57 4C 7C CB 9F BE BB 21 19 E5 D2 36
 7E FB 3F 9F 35 C1 A3 FA 34 21 80 79 F6 CA 39 40
 02 67 90 81 63 B0 01 9D D4 DA 94 49 9B F9 B8 36
 BF 4F 7D CB 35 A6 86 92

After π

18 3A D9 EA 90 AA CE B2 25 B8 B2 30 9A D4 D0 31
 1F 62 9A 56 A4 3D 86 79 DF E5 76 AA 57 4C 7C CB
 BF 4F 7D CB 35 A6 86 92 35 CF 5E 6F 93 79 43 AF
 DF FC 04 A8 12 7B DD E6 AF AF 7D B6 33 83 D0 EC
 27 20 1D 1E 54 8B CF DB 02 67 90 81 63 B0 01 9D
 89 A0 16 5C F0 22 9C CA E2 90 5A 0B 4A 63 DC 35
 4C 05 4D FE 09 7B C1 94 9F BE BB 21 19 E5 D2 36
 7E FB 3F 9F 35 C1 A3 FA FD 7A C3 06 42 8C 4C 6A
 69 88 12 64 66 0C 65 DF 23 3D 7B 08 C1 A6 11 F7
 81 D3 C9 63 63 AE 0B 78 D4 DA 94 49 9B F9 B8 36
 67 0D 74 93 1C 94 46 96 CB 45 6A 98 A9 B4 B0 4E
 65 07 1C 68 D7 93 A5 18 A1 70 E0 02 92 B7 B2 A9
 34 21 80 79 F6 CA 39 40

After χ

02 78 D1 AC B4 83 C8 FA E5 3D D6 98 C9 94 A8 B3
 3F 68 93 17 84 9F 04 69 DF D5 F6 8A D7 44 34 EB
 9A CF 5F DB 3F F2 96 93 15 CC 27 79 B2 F9 43 A7
 DF FC 04 A0 56 73 D2 F5 AF E8 FD 37 10 B3 D0 E8
 12 A8 53 70 C4 C2 8D F9 C8 57 90 01 63 B2 9D DD
 85 A5 13 A8 F1 3A 9D 4A 71 2A E8 0A 5A E7 CE 17
 2C 44 49 60 2D 7B E0 5C 1E BE BB 61 D9 C7 CE 36
 1C EB 77 9C 3F 80 E3 CF FF 4F AA 0E C3 2E 5C 4A
 E9 4A 92 07 44 04 6F D7 77 35 6F 00 59 F7 A1 F1
 A8 F3 8A 65 23 AA 4F 30 D4 5A 84 29 BF F9 99 A3
 43 0F 60 F3 4A 97 43 86 4B 35 8A 9A A9 90 A2 EF
 71 06 1C 11 B3 DB AC 58 E2 7C 94 80 9A A3 F4 3F
 BC 61 8A 71 57 EA 89 08

After t

```

03 78 D1 AC B4 83 C8 FA E5 3D D6 98 C9 94 A8 B3
3F 68 93 17 84 9F 04 69 DF D5 F6 8A D7 44 34 EB
9A CF 5F DB 3F F2 96 93 15 CC 27 79 B2 F9 43 A7
DF FC 04 A0 56 73 D2 F5 AF E8 FD 37 10 B3 D0 E8
12 A8 53 70 C4 C2 8D F9 C8 57 90 01 63 B2 9D DD
85 A5 13 A8 F1 3A 9D 4A 71 2A E8 0A 5A E7 CE 17
2C 44 49 60 2D 7B E0 5C 1E BE BB 61 D9 C7 CE 36
1C EB 77 9C 3F 80 E3 CF FF 4F AA 0E C3 2E 5C 4A
E9 4A 92 07 44 04 6F D7 77 35 6F 00 59 F7 A1 F1
A8 F3 8A 65 23 AA 4F 30 D4 5A 84 29 BF F9 99 A3
43 0F 60 F3 4A 97 43 86 4B 35 8A 9A A9 90 A2 EF
71 06 1C 11 B3 DB AC 58 E2 7C 94 80 9A A3 F4 3F
BC 61 8A 71 57 EA 89 08

```

(Skip rounds 1 to 22)

Round #23

After θ

```

9F 9A 64 FF 91 6E D1 4E E0 09 19 1C 08 53 23 C9
05 F4 79 31 88 3D 47 ED B5 81 93 66 7C C3 CF F6
45 26 41 E5 63 41 BD 53 1A 1A 50 2B 22 D9 A9 34
5B E2 45 6C EF E9 02 8E 1E 94 C0 52 DF 97 85 ED
EC 5B BD DA 1F 0D 85 A9 07 E5 AF C8 B4 A0 65 9E
6D 68 DA 16 B7 76 85 2F FC CA A1 CF 21 76 A4 0A
CA 7B 74 0E 76 37 DD FE 30 67 35 85 78 58 DE 68
EF D6 98 47 0F 55 CB 85 1F 7A 33 E4 23 D9 21 29
8C 6D 66 BE 7D 07 0C 53 7B 76 B5 AC 0B F3 38 C8
1F 59 C5 71 43 C7 4C 2C E9 38 BC C0 33 C9 D2 68
9B 2D 28 8A 7F A4 9E 29 48 33 F4 1B 54 72 A7 68
0C 74 FD 1D E0 08 07 7A E2 F1 31 E9 B6 66 D2 9E
2E 9B 2C D8 E5 5E 5F 53

```

After ρ

9F 9A 64 FF 91 6E D1 4E C1 13 32 38 10 A6 46 92
 01 7D 5E 0C 62 CF 51 7B 37 FC 6C 5F 1B 38 69 C6
 0B EA 9D 2A 32 09 2A 1F 22 92 9D 4A A3 A1 01 B5
 C4 F6 9E 2E F0 B8 25 5E BB 07 25 B0 D4 F7 65 61
 AD 5E ED 8F 86 C2 54 F6 5A E6 79 50 FE 8A 4C 0B
 69 43 D3 B6 B8 B5 2B 7C 2A F0 2B 87 3E 87 D8 91
 73 B0 BB E9 F6 57 DE A3 B0 BC D1 60 CE 6A 0A F1
 A3 87 AA E5 C2 77 6B CC C8 47 B2 43 52 3E F4 66
 CC B7 EF 80 61 8A B1 CD 1C E4 3D BB 5A D6 85 79
 98 89 E5 23 AB 38 6E E8 68 E9 38 BC C0 33 C9 D2
 7A A6 6C B6 A0 28 FE 91 21 CD D0 6F 50 C9 9D A2
 81 AE BF 03 1C E1 40 8F F1 31 E9 B6 66 D2 9E E2
 D7 94 CB 26 0B 76 B9 D7

After π

9F 9A 64 FF 91 6E D1 4E C4 F6 9E 2E F0 B8 25 5E
 73 B0 BB E9 F6 57 DE A3 98 89 E5 23 AB 38 6E E8
 D7 94 CB 26 0B 76 B9 D7 37 FC 6C 5F 1B 38 69 C6
 5A E6 79 50 FE 8A 4C 0B 69 43 D3 B6 B8 B5 2B 7C
 CC B7 EF 80 61 8A B1 CD 81 AE BF 03 1C E1 40 8F
 C1 13 32 38 10 A6 46 92 BB 07 25 B0 D4 F7 65 61
 B0 BC D1 60 CE 6A 0A F1 68 E9 38 BC C0 33 C9 D2
 7A A6 6C B6 A0 28 FE 91 0B EA 9D 2A 32 09 2A 1F
 22 92 9D 4A A3 A1 01 B5 2A F0 2B 87 3E 87 D8 91
 1C E4 3D BB 5A D6 85 79 F1 31 E9 B6 66 D2 9E E2
 01 7D 5E 0C 62 CF 51 7B AD 5E ED 8F 86 C2 54 F6
 A3 87 AA E5 C2 77 6B CC C8 47 B2 43 52 3E F4 66
 21 CD D0 6F 50 C9 9D A2

After χ

AC 9A 45 3E 97 29 0B EF 4C FF DA 2C F9 90 05 16
 34 A4 B1 ED F6 11 4F B4 90 83 C1 FA 3B 30 2E E0
 97 F0 51 26 6B E6 9D C7 16 FD EE F9 1B 0D 4A B2
 DE 52 55 50 BF 80 DC 8A 68 4B C3 B5 A4 D4 6B 7E
 FA E7 AF DC 62 92 98 8D C9 AC AE 03 F8 63 44 86
 C1 AB E2 78 1A AE 4C 02 F3 46 0D 2C D4 E6 A4 63
 A2 BA 95 62 EE 62 3C F0 E9 F8 2A B4 D0 B5 C9 D0
 40 A2 69 36 64 79 DF F0 03 8A BF AF 2E 0F F2 1F
 36 96 89 72 E3 F1 04 DD CB E1 EB 83 1A 87 C2 13
 16 2E 29 B3 4A DF A5 64 D1 21 E9 F6 E7 72 9F 42
 03 FC 5C 6C 22 FA 7A 73 E5 1E FD 8D 96 CA C0 D4
 82 0F EA C9 C2 B6 62 4C C8 77 BC 43 70 38 B4 3F
 8D CF 71 EC D4 C9 99 26

After t

A4 1A 45 BE 97 29 0B 6F 4C FF DA 2C F9 90 05 16
 34 A4 B1 ED F6 11 4F B4 90 83 C1 FA 3B 30 2E E0
 97 F0 51 26 6B E6 9D C7 16 FD EE F9 1B 0D 4A B2
 DE 52 55 50 BF 80 DC 8A 68 4B C3 B5 A4 D4 6B 7E
 FA E7 AF DC 62 92 98 8D C9 AC AE 03 F8 63 44 86
 C1 AB E2 78 1A AE 4C 02 F3 46 0D 2C D4 E6 A4 63
 A2 BA 95 62 EE 62 3C F0 E9 F8 2A B4 D0 B5 C9 D0
 40 A2 69 36 64 79 DF F0 03 8A BF AF 2E 0F F2 1F
 36 96 89 72 E3 F1 04 DD CB E1 EB 83 1A 87 C2 13
 16 2E 29 B3 4A DF A5 64 D1 21 E9 F6 E7 72 9F 42
 03 FC 5C 6C 22 FA 7A 73 E5 1E FD 8D 96 CA C0 D4
 82 0F EA C9 C2 B6 62 4C C8 77 BC 43 70 38 B4 3F
 8D CF 71 EC D4 C9 99 26

After permutation

A4 1A 45 BE 97 29 0B 6F 4C FF DA 2C F9 90 05 16
 34 A4 B1 ED F6 11 4F B4 90 83 C1 FA 3B 30 2E E0
 97 F0 51 26 6B E6 9D C7 16 FD EE F9 1B 0D 4A B2
 DE 52 55 50 BF 80 DC 8A 68 4B C3 B5 A4 D4 6B 7E
 FA E7 AF DC 62 92 98 8D C9 AC AE 03 F8 63 44 86
 C1 AB E2 78 1A AE 4C 02 F3 46 0D 2C D4 E6 A4 63
 A2 BA 95 62 EE 62 3C F0 E9 F8 2A B4 D0 B5 C9 D0
 40 A2 69 36 64 79 DF F0 03 8A BF AF 2E 0F F2 1F
 36 96 89 72 E3 F1 04 DD CB E1 EB 83 1A 87 C2 13
 16 2E 29 B3 4A DF A5 64 D1 21 E9 F6 E7 72 9F 42
 03 FC 5C 6C 22 FA 7A 73 E5 1E FD 8D 96 CA C0 D4
 82 0F EA C9 C2 B6 62 4C C8 77 BC 43 70 38 B4 3F
 8D CF 71 EC D4 C9 99 26

State (as lanes of integers)

[0, 0] = 6F0B2997BE451AA4
 [1, 0] = 160590F92CDAFF4C
 [2, 0] = B44F11F6EDB1A434
 [3, 0] = E02E303BFAC18390
 [4, 0] = C79DE66B2651F097
 [0, 1] = B24A0D1BF9EEFD16
 [1, 1] = 8ADC80BF505552DE
 [2, 1] = 7E6BD4A4B5C34B68
 [3, 1] = 8D989262DCAFE7FA
 [4, 1] = 864463F803AEACC9
 [0, 2] = 024CAE1A78E2ABC1
 [1, 2] = 63A4E6D42C0D46F3
 [2, 2] = F03C62EE6295BAA2
 [3, 2] = D0C9B5D0B42AF8E9
 [4, 2] = F0DF79643669A240
 [0, 3] = 1FF20F2EAFBF8A03
 [1, 3] = DD04F1E372899636
 [2, 3] = 13C2871A83E8E1CB
 [3, 3] = 64A5DF4AB3292E16
 [4, 3] = 429F72E7F6E921D1
 [0, 4] = 737AFA226C5CFC03
 [1, 4] = D4C0CA968DFD1EE5
 [2, 4] = 4C62B6C2C9EA0F82
 [3, 4] = 3FB4387043BC77C8
 [4, 4] = 2699C9D4EC71CF8D

The hash value is

7F 9C 2B A4 E8 8F 82 7D 61 60 45 50 76 05 85 3E
D7 3B 80 93 F6 EF BC 88 EB 1A 6E AC FA 66 EF 26
3C B1 EE A9 88 00 4B 93 10 3C FB 0A EE FD 2A 68
6E 01 FA 4A 58 E8 A3 63 9C A8 A1 E3 F9 AE 57 E2
35 B8 CC 87 3C 23 DC 62 B8 D2 60 16 9A FA 2F 75
AB 91 6A 58 D9 74 91 88 35 D2 5E 6A 43 50 85 B2
BA DF D6 DF AA C3 59 A5 EF BB 7B CC 4B 59 D5 38
DF 9A 04 30 2E 10 C8 BC 1C BF 1A 0B 3A 51 20 EA
17 CD A7 CF AD 76 5F 56 23 47 4D 36 8C CC A8 AF
00 07 CD 9F 5E 4C 84 9F 16 7A 58 0B 14 AA BD EF
AE E7 EE F4 7C B0 FC A9 76 7B E1 FD A6 94 19 DF
B9 27 E9 DF 07 34 8B 19 66 91 AB AE B5 80 B3 2D
EF 58 53 8B 8D 23 F8 77 32 EA 63 B0 2B 4F A0 F4
87 33 60 E2 84 19 28 CD 60 DD 4C EE 8C C0 D4 C9
22 A9 61 88 D0 32 67 5C 8A C8 50 93 3C 7A FF 15
33 B9 4C 83 4A DB B6 9C 61 15 BA D4 69 2D 86 19
F9 0B 0C DF 8A 7B 9C 26 40 29 AC 18 5B 70 B8 3F
28 01 F2 F4 B3 F7 0C 59 3E A3 AE EB 61 3A 7F 1B
1D E3 3F D7 50 81 F5 92 30 5F 2E 45 26 ED C0 96
31 B1 09 58 F4 64 D8 89 F3 1B A0 10 25 0F DA 7F
13 68 EC 29 67 FC 84 EF 2A E9 AF F2 68 E0 B1 70
0A FF C6 82 0B 52 3A 3D 91 71 35 F2 DF F2 EE 06
BF E7 2B 31 24 72 1D 4A 26 C0 4E 53 A7 5E 30 E7
3A 7A 9C 4A 95 D9 1C 55 D4 95 E9 F5 1D D0 B5 E9
D8 3C 6D 5E 8C F8 03 AA 62 B8 D6 54 DB 53 D0 9B
8D CF F2 73 CD FE B5 73 FA D8 BC D4 55 78 BE C2
E7 70 D0 1E FD E8 6E 72 1A 3F 7C 6C CE 27 5D AB
E6 E2 14 3F 1A F1 8D A7 EF DD C4 C7 B7 0B 5E 34
5D B9 3C C9 36 BE A3 23 49 1C CB 38 A3 88 F5 46
A9 FF 00 DD 4E 13 00 B9 B2 15 3D 20 41 D2 05 B4
43 E4 1B 45 A6 53 F2 A5 C4 49 2C 1A DD 54 45 12
DD A2 52 98 33 46 2B 71 A4 1A 45 BE 97 29 0B 6F

SHAKE-128 sample to produce 4 096 bits of output

The message as a bit string

1 1 0 0 1

About to call last of the absorb phase

XORed state (in bytes)

F3	03	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	80	00	00	00	00	00	00	00	00
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
				00	00	00	00	00	00	00	00					

XORed state (as lanes of integers)

```
[0, 0] = 000000000000000003F3
[1, 0] = 00000000000000000000
[2, 0] = 00000000000000000000
[3, 0] = 00000000000000000000
[4, 0] = 00000000000000000000
[0, 1] = 00000000000000000000
[1, 1] = 00000000000000000000
[2, 1] = 00000000000000000000
[3, 1] = 00000000000000000000
[4, 1] = 00000000000000000000
[0, 2] = 00000000000000000000
[1, 2] = 00000000000000000000
[2, 2] = 00000000000000000000
[3, 2] = 00000000000000000000
[4, 2] = 00000000000000000000
[0, 3] = 00000000000000000000
[1, 3] = 00000000000000000000
[2, 3] = 00000000000000000000
[3, 3] = 00000000000000000000
[4, 3] = 00000000000000000000
[0, 4] = 80000000000000000000
[1, 4] = 00000000000000000000
[2, 4] = 00000000000000000000
[3, 4] = 00000000000000000000
[4, 4] = 00000000000000000000
```

Round #0

After θ

```

F3 03 00 00 00 00 00 00 00 F3 03 00 00 00 00 00 80
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
E7 07 00 00 00 00 00 00 00 00 00 00 00 00 00 00
F3 03 00 00 00 00 00 80 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 E7 07 00 00 00 00 00 00
00 00 00 00 00 00 00 00 F3 03 00 00 00 00 00 80
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
E7 07 00 00 00 00 00 00 00 00 00 00 00 00 00 00
F3 03 00 00 00 00 00 80 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 E7 07 00 00 00 00 00 00
00 00 00 00 00 00 00 80 F3 03 00 00 00 00 00 80
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
E7 07 00 00 00 00 00 00

```

After ρ

```

F3 03 00 00 00 00 00 00 E7 07 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 38 3F 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 38 3F 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 70 7E 00 00 00 00
00 00 00 00 00 00 00 00 00 CE 0F 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 80 F3 03 00 00 00 00 00 00 00 00 00
00 00 00 00 00 70 7E 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 E7 07 00 00 00 00 00 00
00 00 02 00 00 00 00 00 CE 0F 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 C0 F9 01 00 00 00 00

```

After π

```

F3 03 00 00 00 00 00 00 00 00 00 00 00 38 3F 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 C0 F9 01 00 00 00 00 00 00 00 00 00 00 00 00
00 00 70 7E 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 70 7E 00 00 00 00 00 00 00 00 00
E7 07 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 E7 07 00 00 00 00 00
00 00 02 00 00 00 00 00 00 00 00 38 3F 00 00 00
00 00 00 00 00 00 00 00 00 CE 0F 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 80 F3 03 00 00 00 00 00 00 00 00 00
CE 0F 00 00 00 00 00 00

```


After χ

```

F3 03 00 00 00 00 00 00 00 00 00 00 00 00 38 3F 00
00 C0 F9 01 00 00 00 00 F3 03 00 00 00 00 00 00 00
00 C0 F9 01 00 38 3F 00 00 00 00 00 00 00 00 00 00
00 00 70 7E 00 70 7E 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 70 7E 00 00 00 70 7E 00 00 00 00 00
E7 07 00 00 00 00 00 00 00 00 E7 07 00 00 00 00 00
00 00 00 00 00 00 00 00 E7 E0 07 00 00 00 00 00 00
00 00 02 00 00 00 00 00 00 CE 0F 38 3F 00 00 00
00 00 00 00 00 00 00 00 00 CE 0F 00 00 00 00 00 00
00 00 00 38 3F 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 80 F3 03 00 00 00 00 00 00 00 00 00 00
CE 0F 00 00 80 F3 03 00 00 00 00 00 00 00 00 00 00
CE 0F 00 00 00 00 00 00 00

```

After ι

```

F2 03 00 00 00 00 00 00 00 00 00 00 00 00 38 3F 00
00 C0 F9 01 00 00 00 00 F3 03 00 00 00 00 00 00 00
00 C0 F9 01 00 38 3F 00 00 00 00 00 00 00 00 00 00
00 00 70 7E 00 70 7E 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 70 7E 00 00 00 70 7E 00 00 00 00 00
E7 07 00 00 00 00 00 00 00 00 E7 07 00 00 00 00 00
00 00 00 00 00 00 00 00 E7 E0 07 00 00 00 00 00 00
00 00 02 00 00 00 00 00 00 CE 0F 38 3F 00 00 00
00 00 00 00 00 00 00 00 00 CE 0F 00 00 00 00 00 00
00 00 00 38 3F 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 80 F3 03 00 00 00 00 00 00 00 00 00 00
CE 0F 00 00 80 F3 03 00 00 00 00 00 00 00 00 00 00
CE 0F 00 00 00 00 00 00 00

```

(Skip rounds 1 to 22)

Round #23

After θ

22 B2 35 3A 97 67 32 8B 25 D8 47 EF FF E1 E6 1F
61 F2 2A F1 55 B6 A2 61 5B EF 58 FA 3C E5 7D 06
04 B6 51 87 0C 89 F8 9A 51 47 E1 4F 69 AA F7 A9
F6 DB BB 5C 44 76 AF 6E F8 D0 7A 6E 83 5C B3 AD
7F 82 9C 4E D6 60 8F FD 3E B1 1B B7 C6 E1 78 5D
FD 45 12 71 C0 DF EF 29 F8 7E F7 D2 F7 BA 4C BB
1C BD F7 09 4F F5 CA 6F 9E 65 00 E6 EB FD 11 00
23 C4 D2 83 D4 7C B0 C8 CA 4C 6C B0 A1 4A 79 B2
AA ED 13 4D 1B 0D CA 7B 81 78 5E 33 F7 B0 9C 7B
56 58 FF 75 56 B6 FB 5E 27 F1 CC F8 DD DC C2 EE
32 76 AE 9C D8 F8 7C BB D9 69 77 20 8C AF 2A 66
DB 44 C6 BF 3D 51 A1 79 9F 88 9C 53 5B 0C D7 A6
64 74 A5 78 C0 BF DF AF

After p

22 B2 35 3A 97 67 32 8B 4A B0 8F DE FF C3 CD 3F
98 BC 4A 7C 95 AD 68 58 53 DE 67 B0 F5 8E A5 CF
48 C4 D7 24 B0 8D 3A 64 94 A6 7A 9F 1A 75 14 FE
CB 45 64 F7 EA 66 BF BD 2B 3E B4 9E DB 20 D7 6C
41 4E 27 6B B0 C7 FE 3F 8E D7 E5 13 BB 71 6B 1C
E9 2F 92 88 03 FE 7E 4F ED E2 FB DD 4B DF EB 32
4F 78 AA 57 7E E3 E8 BD FB 23 00 3C CB 00 CC D7
41 6A 3E 58 E4 11 62 E9 60 43 95 F2 64 95 99 D8
A2 69 A3 41 79 4F B5 7D CE BD 40 3C AF 99 7B 58
76 DF CB 0A EB BF CE CA EE 27 F1 CC F8 DD DC C2
F3 ED CA D8 B9 72 62 E3 65 A7 DD 81 30 BE AA 98
9B C8 F8 B7 27 2A 34 6F 88 9C 53 5B 0C D7 A6 9F
F7 2B 19 5D 29 1E F0 EF

After π

22 B2 35 3A 97 67 32 8B CB 45 64 F7 EA 66 BF BD
4F 78 AA 57 7E E3 E8 BD 76 DF CB 0A EB BF CE CA
F7 2B 19 5D 29 1E F0 EF 53 DE 67 B0 F5 8E A5 CF
8E D7 E5 13 BB 71 6B 1C E9 2F 92 88 03 FE 7E 4F
A2 69 A3 41 79 4F B5 7D 9B C8 F8 B7 27 2A 34 6F
4A B0 8F DE FF C3 CD 3F 2B 3E B4 9E DB 20 D7 6C
FB 23 00 3C CB 00 CC D7 EE 27 F1 CC F8 DD DC C2
F3 ED CA D8 B9 72 62 E3 48 C4 D7 24 B0 8D 3A 64
94 A6 7A 9F 1A 75 14 FE ED E2 FB DD 4B DF EB 32
CE BD 40 3C AF 99 7B 58 88 9C 53 5B 0C D7 A6 9F
98 BC 4A 7C 95 AD 68 58 41 4E 27 6B B0 C7 FE 3F
41 6A 3E 58 E4 11 62 E9 60 43 95 F2 64 95 99 D8
65 A7 DD 81 30 BE AA 98

After χ

```

26 8A BF 3A 83 E6 72 8B FB C2 25 FF 6B 7A B9 FF
CE 58 BA 02 7E E3 D8 98 76 4F EF 28 7D DE CC CA
3E 6E 59 98 41 1E 7D DB 32 F6 75 38 F5 00 B1 8C
8C 97 C4 52 C3 70 EA 2C F0 AF CA 3E 05 DE 7E 4D
E2 7F A4 41 A9 CB 34 FD 17 C9 78 B4 2D 5B 7E 7F
9A B1 8F FE FF C3 C5 AC 2F 3A 45 5E EB FD C7 6C
EA EB 0A 2C CA 22 EE F6 E6 37 F4 CA BE 5C 51 DE
D2 E3 FA D8 B9 52 70 A3 21 84 56 64 F1 07 D1 64
96 BB 7A BF BE 75 04 B6 ED E2 E8 9E 4B 99 6F B5
8E FD C4 18 1F 91 63 38 1C BE 7B C0 06 A7 A2 05
98 9C 52 6C D1 BD 68 98 61 4F A6 C9 B0 43 67 2F
44 CE 76 59 F4 3B 40 E9 F8 5B 97 8E E1 94 D9 98
24 E5 F8 82 10 FC 3C BF

```

After ι

```

2E 0A BF BA 83 E6 72 0B FB C2 25 FF 6B 7A B9 FF
CE 58 BA 02 7E E3 D8 98 76 4F EF 28 7D DE CC CA
3E 6E 59 98 41 1E 7D DB 32 F6 75 38 F5 00 B1 8C
8C 97 C4 52 C3 70 EA 2C F0 AF CA 3E 05 DE 7E 4D
E2 7F A4 41 A9 CB 34 FD 17 C9 78 B4 2D 5B 7E 7F
9A B1 8F FE FF C3 C5 AC 2F 3A 45 5E EB FD C7 6C
EA EB 0A 2C CA 22 EE F6 E6 37 F4 CA BE 5C 51 DE
D2 E3 FA D8 B9 52 70 A3 21 84 56 64 F1 07 D1 64
96 BB 7A BF BE 75 04 B6 ED E2 E8 9E 4B 99 6F B5
8E FD C4 18 1F 91 63 38 1C BE 7B C0 06 A7 A2 05
98 9C 52 6C D1 BD 68 98 61 4F A6 C9 B0 43 67 2F
44 CE 76 59 F4 3B 40 E9 F8 5B 97 8E E1 94 D9 98
24 E5 F8 82 10 FC 3C BF

```

After permutation

```

2E 0A BF BA 83 E6 72 0B FB C2 25 FF 6B 7A B9 FF
CE 58 BA 02 7E E3 D8 98 76 4F EF 28 7D DE CC CA
3E 6E 59 98 41 1E 7D DB 32 F6 75 38 F5 00 B1 8C
8C 97 C4 52 C3 70 EA 2C F0 AF CA 3E 05 DE 7E 4D
E2 7F A4 41 A9 CB 34 FD 17 C9 78 B4 2D 5B 7E 7F
9A B1 8F FE FF C3 C5 AC 2F 3A 45 5E EB FD C7 6C
EA EB 0A 2C CA 22 EE F6 E6 37 F4 CA BE 5C 51 DE
D2 E3 FA D8 B9 52 70 A3 21 84 56 64 F1 07 D1 64
96 BB 7A BF BE 75 04 B6 ED E2 E8 9E 4B 99 6F B5
8E FD C4 18 1F 91 63 38 1C BE 7B C0 06 A7 A2 05
98 9C 52 6C D1 BD 68 98 61 4F A6 C9 B0 43 67 2F
44 CE 76 59 F4 3B 40 E9 F8 5B 97 8E E1 94 D9 98
24 E5 F8 82 10 FC 3C BF

```

State (as lanes of integers)

[0, 0] = 0B72E683BABF0A2E
 [1, 0] = FFB97A6BFF25C2FB
 [2, 0] = 98D8E37E02BA58CE
 [3, 0] = CACCDE7D28EF4F76
 [4, 0] = DB7D1E4198596E3E
 [0, 1] = 8CB100F53875F632
 [1, 1] = 2CEA70C352C4978C
 [2, 1] = 4D7EDE053ECAAFF0
 [3, 1] = FD34CBA941A47FE2
 [4, 1] = 7F7E5B2DB478C917
 [0, 2] = ACC5C3FFFE8FB19A
 [1, 2] = 6CC7FDEB5E453A2F
 [2, 2] = F6EE22CA2C0AEBEA
 [3, 2] = DE515CBEC4F437E6
 [4, 2] = A37052B9D8FAE3D2
 [0, 3] = 64D107F164568421
 [1, 3] = B60475BEBF7ABB96
 [2, 3] = B56F994B9EE8E2ED
 [3, 3] = 3863911F18C4FD8E
 [4, 3] = 05A2A706C07BBE1C
 [0, 4] = 9868BDD16C529C98
 [1, 4] = 2F6743E0C9A64F61
 [2, 4] = E9403BF45976CE44
 [3, 4] = 98D994E18E975BF8
 [4, 4] = BF3CFC1082F8E524

About to call squeeze (again)

State before permutation (in bytes)

2E 0A BF BA 83 E6 72 0B FB C2 25 FF 6B 7A B9 FF
 CE 58 BA 02 7E E3 D8 98 76 4F EF 28 7D DE CC CA
 3E 6E 59 98 41 1E 7D DB 32 F6 75 38 F5 00 B1 8C
 8C 97 C4 52 C3 70 EA 2C F0 AF CA 3E 05 DE 7E 4D
 E2 7F A4 41 A9 CB 34 FD 17 C9 78 B4 2D 5B 7E 7F
 9A B1 8F FE FF C3 C5 AC 2F 3A 45 5E EB FD C7 6C
 EA EB 0A 2C CA 22 EE F6 E6 37 F4 CA BE 5C 51 DE
 D2 E3 FA D8 B9 52 70 A3 21 84 56 64 F1 07 D1 64
 96 BB 7A BF BE 75 04 B6 ED E2 E8 9E 4B 99 6F B5
 8E FD C4 18 1F 91 63 38 1C BE 7B C0 06 A7 A2 05
 98 9C 52 6C D1 BD 68 98 61 4F A6 C9 B0 43 67 2F
 44 CE 76 59 F4 3B 40 E9 F8 5B 97 8E E1 94 D9 98
 24 E5 F8 82 10 FC 3C BF

State before permutation (as lanes of integers)

[0, 0] = 0B72E683BABF0A2E
 [1, 0] = FFB97A6BFF25C2FB
 [2, 0] = 98D8E37E02BA58CE
 [3, 0] = CACCDE7D28EF4F76
 [4, 0] = DB7D1E4198596E3E
 [0, 1] = 8CB100F53875F632
 [1, 1] = 2CEA70C352C4978C
 [2, 1] = 4D7EDE053ECAAFF0
 [3, 1] = FD34CBA941A47FE2
 [4, 1] = 7F7E5B2DB478C917
 [0, 2] = ACC5C3FFFE8FB19A
 [1, 2] = 6CC7FDEB5E453A2F
 [2, 2] = F6EE22CA2C0AEBEA
 [3, 2] = DE515CBEC4F437E6
 [4, 2] = A37052B9D8FAE3D2
 [0, 3] = 64D107F164568421
 [1, 3] = B60475BEBF7ABB96
 [2, 3] = B56F994B9EE8E2ED
 [3, 3] = 3863911F18C4FD8E
 [4, 3] = 05A2A706C07BBE1C
 [0, 4] = 9868BDD16C529C98
 [1, 4] = 2F6743B0C9A64F61
 [2, 4] = E9403BF45976CE44
 [3, 4] = 98D994E18E975BF8
 [4, 4] = BF3CFC1082F8E524

Round #0

After θ

B3 22 16 06 DB 28 70 FB 3E F7 AC 24 DF 9F C9 D6
 69 81 1B EC 1B BB 09 2C 8C 40 BB 93 F4 FA 71 CE
 45 65 37 45 87 6D 11 3D AF DE DC 84 AD CE B3 7C
 49 A2 4D 89 77 95 9A 05 57 76 6B D0 60 86 AF F9
 18 70 F0 FA 20 EF 89 F9 6C C2 16 69 EB 28 12 99
 07 99 26 42 A7 0D C7 5C EA 0F CC 85 5F 18 B7 45
 4D 32 AB C2 AF 7A 3F 42 1C 38 A0 71 37 78 EC DA
 A9 E8 94 05 7F 21 1C 45 BC AC FF D8 A9 C9 D3 94
 53 8E F3 64 0A 90 74 9F 4A 3B 49 70 2E C1 BE 01
 74 F2 90 A3 96 B5 DE 3C 67 B5 15 1D C0 D4 CE E3
 05 B4 FB D0 89 73 6A 68 A4 7A 2F 12 04 A6 17 06
 E3 17 D7 B7 91 63 91 5D 02 54 C3 35 68 B0 64 9C
 5F EE 96 5F D6 8F 50 59

After ρ

B3 22 16 06 DB 28 70 FB 7D EE 59 49 BE 3F 93 AD
 5A E0 06 FB C6 6E 02 4B AF 1F E7 CC 08 B4 3B 49
 6C 8B E8 29 2A BB 29 3A D8 EA 3C CB F7 EA CD 4D
 94 78 57 A9 59 90 24 DA FE 95 DD 1A 34 98 E1 6B
 38 78 7D 90 F7 C4 7C 0C 22 91 C9 26 6C 91 B6 8E
 3A C8 34 11 3A 6D 38 E6 16 A9 3F 30 17 7E 61 DC
 15 7E D5 FB 11 6A 92 59 F0 D8 B5 39 70 40 E3 6E
 82 BF 10 8E A2 54 74 CA B1 53 93 A7 29 79 59 FF
 9E 4C 01 92 EE 73 CA 71 DF 00 A5 9D 24 38 97 60
 D6 9B 87 4E 1E 72 D4 B2 E3 67 B5 15 1D C0 D4 CE
 A9 A1 15 D0 EE 43 27 CE 90 EA BD 48 10 98 5E 18
 FC E2 FA 36 72 2C B2 6B 54 C3 35 68 B0 64 9C 02
 54 D6 97 BB E5 97 F5 23

After π

B3 22 16 06 DB 28 70 FB 94 78 57 A9 59 90 24 DA
 15 7E D5 FB 11 6A 92 59 D6 9B 87 4E 1E 72 D4 B2
 54 D6 97 BB E5 97 F5 23 AF 1F E7 CC 08 B4 3B 49
 22 91 C9 26 6C 91 B6 8E 3A C8 34 11 3A 6D 38 E6
 9E 4C 01 92 EE 73 CA 71 FC E2 FA 36 72 2C B2 6B
 7D EE 59 49 BE 3F 93 AD FE 95 DD 1A 34 98 E1 6B
 F0 D8 B5 39 70 40 E3 6E E3 67 B5 15 1D C0 D4 CE
 A9 A1 15 D0 EE 43 27 CE 6C 8B E8 29 2A BB 29 3A
 D8 EA 3C CB F7 EA CD 4D 16 A9 3F 30 17 7E 61 DC
 DF 00 A5 9D 24 38 97 60 54 C3 35 68 B0 64 9C 02
 5A E0 06 FB C6 6E 02 4B 38 78 7D 90 F7 C4 7C 0C
 82 BF 10 8E A2 54 74 CA B1 53 93 A7 29 79 59 FF
 90 EA BD 48 10 98 5E 18

After χ

B2 24 96 54 DB 42 E2 FA 56 F9 55 AD 57 80 60 78
 15 3A C5 4A F0 EF B3 58 75 BB 87 4A 04 5A D4 6A
 50 8E D6 12 E5 07 F1 23 B7 57 D3 DD 1A D8 33 29
 A6 95 C8 A4 A8 83 74 9F 5A 6A CE 35 2A 61 08 EC
 9D 51 04 5A E6 E3 C3 71 FC 62 F2 14 16 2D 36 ED
 7D A6 79 68 FE 7F 91 A9 FD B2 DD 1E 39 18 F5 EB
 F8 58 B5 F9 92 43 C0 6E B7 29 FD 1C 0D FC 44 EF
 2B B0 91 C2 EE C3 47 8C 6A 8A EB 19 2A AF 09 AA
 11 EA BC 46 D7 EA 5B 6D 16 6A 2F 50 87 3A 69 DE
 F7 08 6D 9C 2E A3 B6 58 C4 A3 21 AA 65 24 58 47
 D8 67 06 F5 C6 7E 02 89 09 38 FE B1 FE ED 75 39
 82 17 3C C6 B2 D4 72 CA FB 53 91 14 EF 1F 59 BC
 B0 F2 C4 48 21 18 22 1C

After 1

B3 24 96 54 DB 42 E2 FA 56 F9 55 AD 57 80 60 78
 15 3A C5 4A F0 EF B3 58 75 BB 87 4A 04 5A D4 6A
 50 8E D6 12 E5 07 F1 23 B7 57 D3 DD 1A D8 33 29
 A6 95 C8 A4 A8 83 74 9F 5A 6A CE 35 2A 61 08 EC
 9D 51 04 5A E6 E3 C3 71 FC 62 F2 14 16 2D 36 ED
 7D A6 79 68 FE 7F 91 A9 FD B2 DD 1E 39 18 F5 EB
 F8 58 B5 F9 92 43 C0 6E B7 29 FD 1C 0D FC 44 EF
 2B B0 91 C2 EE C3 47 8C 6A 8A EB 19 2A AF 09 AA
 11 EA BC 46 D7 EA 5B 6D 16 6A 2F 50 87 3A 69 DE
 F7 08 6D 9C 2E A3 B6 58 C4 A3 21 AA 65 24 58 47
 D8 67 06 F5 C6 7E 02 89 09 38 FE B1 FE ED 75 39
 82 17 3C C6 B2 D4 72 CA FB 53 91 14 EF 1F 59 BC
 B0 F2 C4 48 21 18 22 1C

(Skip rounds 1 to 22)

Round #23

After 0

32 27 94 3E 45 37 CA 13 65 63 DD ED B3 8D FD BD
 95 B5 6A DE 6F F2 64 5A 62 74 F1 03 67 37 B9 09
 38 35 14 BD CB 14 70 24 AC 55 AB E9 DC CE 46 82
 5F 20 1D 30 D8 49 FD B6 04 31 0D 87 63 9F D0 CF
 FB 8C 9C 0A 10 AC 91 3E DD D8 C3 B6 1E F3 E0 02
 23 26 E6 37 3A 22 35 F1 0C 4D 27 AD 49 12 B4 3A
 76 3C AE A1 36 64 58 55 9A 7F 45 47 56 35 EA EB
 E8 57 49 8B C0 A4 28 8A A5 79 4F ED AB 43 0C E6
 95 DD 91 E4 86 6C 11 33 35 FE 10 3B 10 AA AA AD
 02 31 FE A2 18 27 9A 93 97 CA E2 AE 00 92 46 78
 FC A9 E2 65 1A 29 81 DD 02 98 AB A1 CB DB 32 AC
 BA 3E 81 B4 91 1F 07 D1 9F EB E7 1D F5 9A 44 B3
 47 FC 16 65 EC 11 97 45

After ρ

32 27 94 3E 45 37 CA 13 CB C6 BA DB 67 1B FB 7B
 65 AD 9A F7 9B 3C 99 56 76 93 9B 20 46 17 3F 70
 A6 80 23 C1 A9 A1 E8 5D CE ED 6C 24 C8 5A B5 9A
 01 83 9D D4 6F FB 05 D2 33 41 4C C3 E1 D8 27 F4
 46 4E 05 08 D6 48 9F 7D 0F 2E D0 8D 3D 6C EB 31
 1F 31 31 BF D1 11 A9 89 EA 30 34 9D B4 26 49 D0
 0D B5 21 C3 AA B2 E3 71 6A D4 D7 35 FF 8A 8E AC
 45 60 52 14 45 F4 AB A4 DA 57 87 18 CC 4B F3 9E
 92 DC 90 2D 62 A6 B2 3B D5 D6 1A 7F 88 1D 08 55
 44 73 52 20 C6 5F 14 E3 78 97 CA E2 AE 00 92 46
 04 76 F3 A7 8A 97 69 A4 0A 60 AE 86 2E 6F CB B0
 D7 27 90 36 F2 E3 20 5A EB E7 1D F5 9A 44 B3 9F
 65 D1 11 BF 45 19 7B C4

After π

32 27 94 3E 45 37 CA 13 01 83 9D D4 6F FB 05 D2
 0D B5 21 C3 AA B2 E3 71 44 73 52 20 C6 5F 14 E3
 65 D1 11 BF 45 19 7B C4 76 93 9B 20 46 17 3F 70
 0F 2E D0 8D 3D 6C EB 31 1F 31 31 BF D1 11 A9 89
 92 DC 90 2D 62 A6 B2 3B D7 27 90 36 F2 E3 20 5A
 CB C6 BA DB 67 1B FB 7B 33 41 4C C3 E1 D8 27 F4
 6A D4 D7 35 FF 8A 8E AC 78 97 CA E2 AE 00 92 46
 04 76 F3 A7 8A 97 69 A4 A6 80 23 C1 A9 A1 E8 5D
 CE ED 6C 24 C8 5A B5 9A EA 30 34 9D B4 26 49 D0
 D5 D6 1A 7F 88 1D 08 55 EB E7 1D F5 9A 44 B3 9F
 65 AD 9A F7 9B 3C 99 56 46 4E 05 08 D6 48 9F 7D
 45 60 52 14 45 F4 AB A4 DA 57 87 18 CC 4B F3 9E
 0A 60 AE 86 2E 6F CB B0

After χ

3E 13 B4 3D C5 37 28 32 41 C1 CF F4 2B B6 11 50
 2C 35 20 5C AB B2 88 75 56 55 D6 20 C6 79 94 F0
 64 51 18 7F 6F D1 7E 04 66 82 BA 12 86 06 3F F8
 8F E2 50 8D 1F CA F9 03 5A 12 31 AD 41 50 A9 C9
 B2 4C 9B 2D 66 B2 AD 1B DE 0B D0 BB CB 8B E0 5B
 83 52 29 EF 79 19 73 73 23 42 44 01 E1 D8 37 B6
 6E B4 E6 30 FF 1D E7 0C B3 17 C2 BA CB 08 00 1D
 34 77 B7 A7 0A 57 6D 20 86 90 33 58 9D 85 A0 1D
 DB 2B 66 46 C0 43 B5 9F C0 11 31 1D A6 66 FA 5A
 D1 D6 38 7F A9 BC 40 15 A3 8A 51 D1 DA 1E A6 1D
 64 8D C8 E3 9A 88 B9 D6 DC 59 80 00 5E 43 CF 67
 45 40 7A 92 67 D0 A3 84 BF DA 97 69 5D 5B E3 D8
 08 22 AB 8E 6A 2F CD 99

After t

36 93 B4 BD C5 37 28 B2 41 C1 CF F4 2B B6 11 50
 2C 35 20 5C AB B2 88 75 56 55 D6 20 C6 79 94 F0
 64 51 18 7F 6F D1 7E 04 66 82 BA 12 86 06 3F F8
 8F E2 50 8D 1F CA F9 03 5A 12 31 AD 41 50 A9 C9
 B2 4C 9B 2D 66 B2 AD 1B DE 0B D0 BB CB 8B E0 5B
 83 52 29 EF 79 19 73 73 23 42 44 01 E1 D8 37 B6
 6E B4 E6 30 FF 1D E7 0C B3 17 C2 BA CB 08 00 1D
 34 77 B7 A7 0A 57 6D 20 86 90 33 58 9D 85 A0 1D
 DB 2B 66 46 C0 43 B5 9F C0 11 31 1D A6 66 FA 5A
 D1 D6 38 7F A9 BC 40 15 A3 8A 51 D1 DA 1E A6 1D
 64 8D C8 E3 9A 88 B9 D6 DC 59 80 00 5E 43 CF 67
 45 40 7A 92 67 D0 A3 84 BF DA 97 69 5D 5B E3 D8
 08 22 AB 8E 6A 2F CD 99

After permutation

36 93 B4 BD C5 37 28 B2 41 C1 CF F4 2B B6 11 50
 2C 35 20 5C AB B2 88 75 56 55 D6 20 C6 79 94 F0
 64 51 18 7F 6F D1 7E 04 66 82 BA 12 86 06 3F F8
 8F E2 50 8D 1F CA F9 03 5A 12 31 AD 41 50 A9 C9
 B2 4C 9B 2D 66 B2 AD 1B DE 0B D0 BB CB 8B E0 5B
 83 52 29 EF 79 19 73 73 23 42 44 01 E1 D8 37 B6
 6E B4 E6 30 FF 1D E7 0C B3 17 C2 BA CB 08 00 1D
 34 77 B7 A7 0A 57 6D 20 86 90 33 58 9D 85 A0 1D
 DB 2B 66 46 C0 43 B5 9F C0 11 31 1D A6 66 FA 5A
 D1 D6 38 7F A9 BC 40 15 A3 8A 51 D1 DA 1E A6 1D
 64 8D C8 E3 9A 88 B9 D6 DC 59 80 00 5E 43 CF 67
 45 40 7A 92 67 D0 A3 84 BF DA 97 69 5D 5B E3 D8
 08 22 AB 8E 6A 2F CD 99

State (as lanes of integers)

[0, 0] = B22837C5BDB49336
 [1, 0] = 5011B62BF4CFC141
 [2, 0] = 7588B2AB5C20352C
 [3, 0] = F09479C620D65556
 [4, 0] = 047ED16F7F185164
 [0, 1] = F83F068612BA8266
 [1, 1] = 03F9CA1F8D50E28F
 [2, 1] = C9A95041AD31125A
 [3, 1] = 1BADB2662D9B4CB2
 [4, 1] = 5BE08BCBBBD00BDE
 [0, 2] = 73731979EF295283
 [1, 2] = B637D8E101444223
 [2, 2] = 0CE71DFF30E6B46E
 [3, 2] = 1D0008CBBAC217B3
 [4, 2] = 206D570AA7B77734
 [0, 3] = 1DA0859D58339086
 [1, 3] = 9FB543C046662BDB
 [2, 3] = 5AFA66A61D3111C0
 [3, 3] = 1540BCA97F38D6D1
 [4, 3] = 1DA61EDAD1518AA3
 [0, 4] = D6B9889AE3C88D64
 [1, 4] = 67CF435E008059DC
 [2, 4] = 84A3D067927A4045
 [3, 4] = D8E35B5D6997DABF
 [4, 4] = 99CD2F6A8EAB2208

About to call squeeze (again)

State before permutation (in bytes)

36 93 B4 BD C5 37 28 B2 41 C1 CF F4 2B B6 11 50
 2C 35 20 5C AB B2 88 75 56 55 D6 20 C6 79 94 F0
 64 51 18 7F 6F D1 7E 04 66 82 BA 12 86 06 3F F8
 8F E2 50 8D 1F CA F9 03 5A 12 31 AD 41 50 A9 C9
 B2 4C 9B 2D 66 B2 AD 1B DE 0B D0 BB CB 8B E0 5B
 83 52 29 EF 79 19 73 73 23 42 44 01 E1 D8 37 B6
 6E B4 E6 30 FF 1D E7 0C B3 17 C2 BA CB 08 00 1D
 34 77 B7 A7 0A 57 6D 20 86 90 33 58 9D 85 A0 1D
 DB 2B 66 46 C0 43 B5 9F C0 11 31 1D A6 66 FA 5A
 D1 D6 38 7F A9 BC 40 15 A3 8A 51 D1 DA 1E A6 1D
 64 8D C8 E3 9A 88 B9 D6 DC 59 80 00 5E 43 CF 67
 45 40 7A 92 67 D0 A3 84 BF DA 97 69 5D 5B E3 D8
 08 22 AB 8E 6A 2F CD 99

XState before permutation (as lanes of integers)

[0,0] = B22837C5BDB49336
 [1,0] = 5011B62BF4CFC141
 [2,0] = 7588B2AB5C20352C
 [3,0] = F09479C620D65556
 [4,0] = 047ED16F7F185164
 [0,1] = F83F068612BA8266
 [1,1] = 03F9CA1F8D50E28F
 [2,1] = C9A95041AD31125A
 [3,1] = 1BADB2662D9B4CB2
 [4,1] = 5BE08BCBBBD00BDE
 [0,2] = 73731979EF295283
 [1,2] = B637D8E101444223
 [2,2] = 0CE71DFF30E6B46E
 [3,2] = 1D0008CBBAC217B3
 [4,2] = 206D570AA7B77734
 [0,3] = 1DA0859D58339086
 [1,3] = 9FB543C046662BDB
 [2,3] = 5AFA66A61D3111C0
 [3,3] = 1540BCA97F38D6D1
 [4,3] = 1DA61EDAD1518AA3
 [0,4] = D6B9889AE3C88D64
 [1,4] = 67CF435E008059DC
 [2,4] = 84A3D067927A4045
 [3,4] = D8E35B5D6997DABF
 [4,4] = 99CD2F6A8EAB2208

Round #0

After θ

C7 31 4B FD 4D 43 FB 72 4A 1A 6A 92 BE 00 52 7F
 B4 22 5D 20 DF 5F 19 1F 80 9D 61 17 2E 48 3B 69
 3E EF 80 29 8B BF 1E DB 97 20 45 52 0E 72 EC 38
 84 39 F5 EB 8A 7C BA 2C C2 05 4C D1 35 BD 38 A3
 64 84 2C 1A 8E 83 02 82 84 B5 48 ED 2F E5 80 84
 72 F0 D6 AF F1 6D A0 B3 28 99 E1 67 74 6E 74 99
 F6 A3 9B 4C 8B F0 76 66 65 DF 75 8D 23 39 AF 84
 6E C9 2F F1 EE 39 0D FF 77 32 CC 18 15 F1 73 DD
 D0 F0 C3 20 55 F5 F6 B0 58 06 4C 61 D2 8B 6B 30
 07 1E 8F 48 41 8D EF 8C F9 34 C9 87 3E 70 C6 C2
 95 2F 37 A3 12 FC 6A 16 D7 82 25 66 CB F5 8C 48
 DD 57 07 EE 13 3D 32 EE 69 12 20 5E B5 6A 4C 41
 52 9C 33 D8 8E 41 AD 46

After ρ

C7 31 4B FD 4D 43 FB 72 94 34 D4 24 7D 01 A4 FE
 AD 48 17 C8 F7 57 C6 07 82 B4 93 06 D8 19 76 E1
 FC F5 D8 F6 79 07 4C 59 E5 20 C7 8E 73 09 52 24
 BF AE C8 A7 CB 42 98 53 A8 70 01 53 74 4D 2F CE
 42 16 0D C7 41 01 41 32 0E 48 48 58 8B D4 FE 52
 95 83 B7 7E 8D 6F 03 9D 65 A2 64 86 9F D1 B9 D1
 64 5A 84 B7 33 B3 1F DD 72 5E 09 CB BE EB 1A 47
 78 F7 9C 86 7F B7 E4 97 31 2A E2 E7 BA EF 64 98
 18 A4 AA DE 1E 16 1A 7E 35 18 2C 03 A6 30 E9 C5
 F1 9D F1 C0 E3 11 29 A8 C2 F9 34 C9 87 3E 70 C6
 AB 59 54 BE DC 8C 4A F0 5D 0B 96 98 2D D7 33 22
 FB EA C0 7D A2 47 C6 BD 12 20 5E B5 6A 4C 41 69
 AB 91 14 E7 0C B6 63 50

After π

C7 31 4B FD 4D 43 FB 72 BF AE C8 A7 CB 42 98 53
 64 5A 84 B7 33 B3 1F DD F1 9D F1 C0 E3 11 29 A8
 AB 91 14 E7 0C B6 63 50 82 B4 93 06 D8 19 76 E1
 0E 48 48 58 8B D4 FE 52 95 83 B7 7E 8D 6F 03 9D
 18 A4 AA DE 1E 16 1A 7E FB EA C0 7D A2 47 C6 BD
 94 34 D4 24 7D 01 A4 FE A8 70 01 53 74 4D 2F CE
 72 5E 09 CB BE EB 1A 47 C2 F9 34 C9 87 3E 70 C6
 AB 59 54 BE DC 8C 4A F0 FC F5 D8 F6 79 07 4C 59
 E5 20 C7 8E 73 09 52 24 65 A2 64 86 9F D1 B9 D1
 35 18 2C 03 A6 30 E9 C5 12 20 5E B5 6A 4C 41 69
 AD 48 17 C8 F7 57 C6 07 42 16 0D C7 41 01 41 32
 78 F7 9C 86 7F B7 E4 97 31 2A E2 E7 BA EF 64 98
 5D 0B 96 98 2D D7 33 22

After χ

87 61 4F ED 7D F2 FC FE 2E 2B B9 E7 0B 42 B8 73
 6E 5A 80 90 3F 15 5D 8D B5 BD BA D8 A2 50 B1 8A
 93 1F 94 E5 8E B6 63 51 13 37 24 20 DC 32 77 6C
 06 6C 40 D8 99 C4 E6 30 76 C9 F7 5F 2D 2E C7 1C
 18 B0 B9 DC 46 0E 2A 3E F7 A2 88 25 A1 83 4E AF
 C6 3A DC AC F7 A3 B4 FF 28 D1 35 53 75 59 4F 4E
 5B 5E 49 FD E6 6B 10 77 D6 DD B4 C9 A6 3F D4 C8
 83 19 55 ED DC C0 41 F0 FC 77 F8 F6 F5 D7 E5 88
 F5 38 CF 8F 53 29 12 20 67 82 36 32 D7 9D B9 F9
 D9 CD AC 41 B7 33 E5 D5 13 20 59 BD 68 44 53 4D
 95 A9 87 C8 C9 E1 62 82 43 1E 6F A6 C1 49 41 3A
 34 F6 88 9E 7A A7 F7 B5 91 6A E3 A7 68 EF A0 9D
 1F 1D 9E 9F 2D D7 32 12

After t

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86 61 4F ED 7D F2 FC FE 2E 2B B9 E7 0B 42 B8 73
6E 5A 80 90 3F 15 5D 8D B5 BD BA D8 A2 50 B1 8A
93 1F 94 E5 8E B6 63 51 13 37 24 20 DC 32 77 6C
06 6C 40 D8 99 C4 E6 30 76 C9 F7 5F 2D 2E C7 1C
18 B0 B9 DC 46 0E 2A 3E F7 A2 88 25 A1 83 4E AF
C6 3A DC AC F7 A3 B4 FF 28 D1 35 53 75 59 4F 4E
5B 5E 49 FD E6 6B 10 77 D6 DD B4 C9 A6 3F D4 C8
83 19 55 ED DC C0 41 F0 FC 77 F8 F6 F5 D7 E5 88
F5 38 CF 8F 53 29 12 20 67 82 36 32 D7 9D B9 F9
D9 CD AC 41 B7 33 E5 D5 13 20 59 BD 68 44 53 4D
95 A9 87 C8 C9 E1 62 82 43 1E 6F A6 C1 49 41 3A
34 F6 88 9E 7A A7 F7 B5 91 6A E3 A7 68 EF A0 9D
1F 1D 9E 9F 2D D7 32 12

```

(Skip rounds 1 to 22)

Round #23

After 0

```

7F B8 94 C4 39 9B 86 70 3B 89 48 FA 32 75 C3 E2
AE 9C 8E 91 39 CC 86 AF EF 55 83 9E CB BF 14 9F
A4 CA B3 FF ED BC BA 61 7A 8E 39 31 F8 6F DF C1
7C 13 22 A8 03 C0 9A A2 9B 4F 2C 70 28 7F E9 B1
D3 93 C4 9B C6 8D 29 FE 80 5A EB 0E 25 B2 C1 D5
BD F7 12 4D 48 A2 6A 36 FF 2E 6B CE 41 28 D8 4E
E6 6E E4 AA D6 EE A9 5C 07 01 C0 18 4E C2 EF 5A
23 BF 88 3F 02 E0 71 4C 66 D0 0C B6 55 FB B2 75
7A 4A 18 37 BE 9B 10 A0 EB E8 30 1D 07 93 4F B9
0E DD 19 67 64 9B 82 63 8C D9 19 58 5A F3 79 07
78 3C 6B 24 22 3C 24 90 F6 49 11 92 3F 53 A0 72
BC F4 74 C7 D5 E0 63 F5 40 25 4E 87 22 04 58 D7
37 17 4A B6 82 FC C4 DB

```

After ρ

7F B8 94 C4 39 9B 86 70 77 12 91 F4 65 EA 86 C5
 2B A7 63 64 0E B3 E1 AB FC 4B F1 F9 5B 35 E8 B9
 E7 D5 0D 23 55 9E FD 6F 83 FF F6 1D AC E7 98 13
 82 3A 00 AC 29 CA 37 21 EC E6 13 0B 1C CA 5F 7A
 49 E2 4D E3 C6 14 FF E9 1B 5C 0D A8 B5 EE 50 22
 E9 BD 97 68 42 12 55 B3 3B FD BB AC 39 07 A1 60
 57 B5 76 4F E5 32 77 23 84 DF B5 0E 02 80 31 9C
 1F 01 F0 38 A6 91 5F C4 6C AB F6 65 EB CC A0 19
 E3 C6 77 13 02 54 4F 09 A7 DC 75 74 98 8E 83 C9
 53 70 CC A1 3B E3 8C 6C 07 8C D9 19 58 5A F3 79
 90 40 E2 F1 AC 91 88 F0 D9 27 45 48 FE 4C 81 CA
 97 9E EE B8 1A 7C AC 9E 25 4E 87 22 04 58 D7 40
 F1 F6 CD 85 92 AD 20 3F

After π

7F B8 94 C4 39 9B 86 70 82 3A 00 AC 29 CA 37 21
 57 B5 76 4F E5 32 77 23 53 70 CC A1 3B E3 8C 6C
 F1 F6 CD 85 92 AD 20 3F FC 4B F1 F9 5B 35 E8 B9
 1B 5C 0D A8 B5 EE 50 22 E9 BD 97 68 42 12 55 B3
 E3 C6 77 13 02 54 4F 09 97 9E EE B8 1A 7C AC 9E
 77 12 91 F4 65 EA 86 C5 EC E6 13 0B 1C CA 5F 7A
 84 DF B5 0E 02 80 31 9C 07 8C D9 19 58 5A F3 79
 90 40 E2 F1 AC 91 88 F0 E7 D5 0D 23 55 9E FD 6F
 83 FF F6 1D AC E7 98 13 3B FD BB AC 39 07 A1 60
 A7 DC 75 74 98 8E 83 C9 25 4E 87 22 04 58 D7 40
 2B A7 63 64 0E B3 E1 AB 49 E2 4D E3 C6 14 FF E9
 1F 01 F0 38 A6 91 5F C4 6C AB F6 65 EB CC A0 19
 D9 27 45 48 FE 4C 81 CA

After χ

2A 3D E2 87 FD AB C6 72 82 7A 88 0C 33 0B BF 6D
 F7 33 77 4B 65 3E 57 30 5D 78 DC E1 12 F1 0A 2C
 71 F4 CD AD 92 ED 11 3E 1C EA 63 B9 19 25 ED 28
 19 1E 6D BB B5 AA 5A 2A FD A5 1F C0 5A 3A F5 25
 8B 87 66 52 43 55 0F 28 94 8A E2 B8 BE B6 BC 9C
 77 0B 35 F0 67 EA A6 41 EF E6 5B 1A 44 90 9D 1B
 14 9F 97 EE A6 01 39 1C 60 9E C8 1D 19 30 F5 7C
 18 A4 E0 FA B4 91 D1 CA DF D5 04 83 44 9E DC 0F
 07 FF B2 4D 2C 6F 9A 9A 3B FF 39 AE 3D 57 F5 60
 65 4D 7D 75 C9 08 AB E6 25 64 75 3E AC 39 D7 50
 3D A6 D3 7C 2E 32 E1 AF 29 48 4B A6 8F 58 5F F0
 8E 05 F1 30 B2 91 5E 06 4E 2B D4 41 EB 7F C0 38
 99 67 49 CB 3E 48 9F 8A

After t

22 BD E2 07 FD AB C6 F2 82 7A 88 0C 33 0B BF 6D
 F7 33 77 4B 65 3E 57 30 5D 78 DC E1 12 F1 0A 2C
 71 F4 CD AD 92 ED 11 3E 1C EA 63 B9 19 25 ED 28
 19 1E 6D BB B5 AA 5A 2A FD A5 1F C0 5A 3A F5 25
 8B 87 66 52 43 55 0F 28 94 8A E2 B8 BE B6 BC 9C
 77 0B 35 F0 67 EA A6 41 EF E6 5B 1A 44 90 9D 1B
 14 9F 97 EE A6 01 39 1C 60 9E C8 1D 19 30 F5 7C
 18 A4 E0 FA B4 91 D1 CA DF D5 04 83 44 9E DC 0F
 07 FF B2 4D 2C 6F 9A 9A 3B FF 39 AE 3D 57 F5 60
 65 4D 7D 75 C9 08 AB E6 25 64 75 3E AC 39 D7 50
 3D A6 D3 7C 2E 32 E1 AF 29 48 4B A6 8F 58 5F F0
 8E 05 F1 30 B2 91 5E 06 4E 2B D4 41 EB 7F C0 38
 99 67 49 CB 3E 48 9F 8A

After permutation

22 BD E2 07 FD AB C6 F2 82 7A 88 0C 33 0B BF 6D
 F7 33 77 4B 65 3E 57 30 5D 78 DC E1 12 F1 0A 2C
 71 F4 CD AD 92 ED 11 3E 1C EA 63 B9 19 25 ED 28
 19 1E 6D BB B5 AA 5A 2A FD A5 1F C0 5A 3A F5 25
 8B 87 66 52 43 55 0F 28 94 8A E2 B8 BE B6 BC 9C
 77 0B 35 F0 67 EA A6 41 EF E6 5B 1A 44 90 9D 1B
 14 9F 97 EE A6 01 39 1C 60 9E C8 1D 19 30 F5 7C
 18 A4 E0 FA B4 91 D1 CA DF D5 04 83 44 9E DC 0F
 07 FF B2 4D 2C 6F 9A 9A 3B FF 39 AE 3D 57 F5 60
 65 4D 7D 75 C9 08 AB E6 25 64 75 3E AC 39 D7 50
 3D A6 D3 7C 2E 32 E1 AF 29 48 4B A6 8F 58 5F F0
 8E 05 F1 30 B2 91 5E 06 4E 2B D4 41 EB 7F C0 38
 99 67 49 CB 3E 48 9F 8A

State (as lanes of integers)

[0, 0] = F2C6ABFD07E2BD22
 [1, 0] = 6DBF0B330C887A82
 [2, 0] = 30573E654B7733F7
 [3, 0] = 2C0AF112E1DC785D
 [4, 0] = 3E11ED92ADCDF471
 [0, 1] = 28ED2519B963EA1C
 [1, 1] = 2A5AAAB5BB6D1E19
 [2, 1] = 25F53A5AC01FA5FD
 [3, 1] = 280F55435266878B
 [4, 1] = 9CBCB6BEB8E28A94
 [0, 2] = 41A6EA67F0350B77
 [1, 2] = 1B9D90441A5BE6EF
 [2, 2] = 1C3901A6EE979F14
 [3, 2] = 7CF530191DC89E60
 [4, 2] = CAD191B4FAE0A418
 [0, 3] = 0FDC9E448304D5DF
 [1, 3] = 9A9A6F2C4DB2FF07
 [2, 3] = 60F5573DAE39FF3B
 [3, 3] = E6AB08C9757D4D65
 [4, 3] = 50D739AC3E756425
 [0, 4] = AFE1322E7CD3A63D
 [1, 4] = F05F588FA64B4829
 [2, 4] = 065E91B230F1058E
 [3, 4] = 38C07FEB41D42B4E
 [4, 4] = 8A9F483ECB496799

About to call squeeze (again)

State before permutation (in bytes)

22 BD E2 07 FD AB C6 F2 82 7A 88 0C 33 0B BF 6D
 F7 33 77 4B 65 3E 57 30 5D 78 DC E1 12 F1 0A 2C
 71 F4 CD AD 92 ED 11 3E 1C EA 63 B9 19 25 ED 28
 19 1E 6D BB B5 AA 5A 2A FD A5 1F C0 5A 3A F5 25
 8B 87 66 52 43 55 0F 28 94 8A E2 B8 BE B6 BC 9C
 77 0B 35 F0 67 EA A6 41 EF E6 5B 1A 44 90 9D 1B
 14 9F 97 EE A6 01 39 1C 60 9E C8 1D 19 30 F5 7C
 18 A4 E0 FA B4 91 D1 CA DF D5 04 83 44 9E DC 0F
 07 FF B2 4D 2C 6F 9A 9A 3B FF 39 AE 3D 57 F5 60
 65 4D 7D 75 C9 08 AB E6 25 64 75 3E AC 39 D7 50
 3D A6 D3 7C 2E 32 E1 AF 29 48 4B A6 8F 58 5F F0
 8E 05 F1 30 B2 91 5E 06 4E 2B D4 41 EB 7F C0 38
 99 67 49 CB 3E 48 9F 8A

State before permutation (as lanes of integers)

[0, 0] = F2C6ABFD07E2BD22
 [1, 0] = 6DBF0B330C887A82
 [2, 0] = 30573E654B7733F7
 [3, 0] = 2C0AF112E1DC785D
 [4, 0] = 3E11ED92ADCDF471
 [0, 1] = 28ED2519B963EA1C
 [1, 1] = 2A5AAAB5BB6D1E19
 [2, 1] = 25F53A5AC01FA5FD
 [3, 1] = 280F55435266878B
 [4, 1] = 9CBCB6BEB8E28A94
 [0, 2] = 41A6EA67F0350B77
 [1, 2] = 1B9D90441A5BE6EF
 [2, 2] = 1C3901A6EE979F14
 [3, 2] = 7CF530191DC89E60
 [4, 2] = CAD191B4FAE0A418
 [0, 3] = 0FDC9E448304D5DE
 [1, 3] = 9A9A6F2C4DB2FF07
 [2, 3] = 60F5573DAE39FF3B
 [3, 3] = E6AB08C9757D4D65
 [4, 3] = 50E739AC3E756425
 [0, 4] = AFE1322E7CD3A63D
 [1, 4] = F05F588FA64B4829
 [2, 4] = 065E91B230F1058E
 [3, 4] = 38C07FEB41D42B4E
 [4, 4] = 8A9F483ECB496799

Round #0

After θ

D7 0E 9F 91 35 1C 88 2D 7F B2 84 4B F7 45 6E 88
 96 09 86 38 D1 FE DD 4B 75 39 0C 2F 10 44 53 27
 BA AC D0 55 2B 9F EB EF E9 59 1E 2F D1 92 A3 F7
 E4 D6 61 FC 71 E4 8B CF 9C 9F EE B3 EE FA 7F 5E
 A3 C6 B6 9C 41 E0 56 23 5F D2 FF 40 07 C4 46 4D
 82 B8 48 66 AF 5D E8 9E 12 2E 57 5D 80 DE 4C FE
 75 A5 66 9D 12 C1 B3 67 48 DF 18 D3 1B 85 AC 77
 D3 FC FD 02 0D E3 2B 1B 2A 66 79 15 8C 29 92 D0
 FA 37 BE 0A E8 21 4B 7F 5A C5 C8 DD 89 97 7F 1B
 4D 0C AD BB CB BD F2 ED EE 3C 68 C6 15 4B 2D 81
 C8 15 AE EA E6 85 AF 70 D4 80 47 E1 4B 16 8E 15
 EF 3F 00 43 06 51 D4 7D 66 6A 04 8F E9 CA 99 33
 52 3F 54 33 87 3A 65 5B

After ρ

D7 0E 9F 91 35 1C 88 2D FF 64 09 97 EE 8B DC 10
 65 82 21 4E B4 7F F7 92 41 34 75 52 97 C3 F0 02
 F9 5C 7F D7 65 85 AE 5A 12 2D 39 7A 9F 9E E5 F1
 C6 1F 47 BE F8 4C 6E 1D 17 E7 A7 FB AC BB FE 9F
 63 5B CE 20 70 AB 91 51 6C D4 F4 25 FD 0F 74 40
 14 C4 45 32 7B ED 42 F7 F9 4B B8 5C 75 01 7A 33
 EB 94 08 9E 3D AB 2B 35 0A 59 EF 90 BE 31 A6 37
 81 86 F1 95 8D 69 FE 7E 2A 18 53 24 A1 55 CC F2
 57 01 3D 64 E9 4F FF C6 BF 0D AD 62 E4 EE C4 CB
 57 BE BD 89 A1 75 77 B9 81 EE 3C 68 C6 15 4B 2D
 BE C2 21 57 B8 AA 9B 17 50 03 1E 85 2F 59 38 56
 FD 07 60 C8 20 8A BA EF 6A 04 8F E9 CA 99 33 66
 D9 96 D4 0F D5 CC A1 4E

After π

D7 0E 9F 91 35 1C 88 2D C6 1F 47 BE F8 4C 6E 1D
 EB 94 08 9E 3D AB 2B 35 57 BE BD 89 A1 75 77 B9
 D9 96 D4 0F D5 CC A1 4E 41 34 75 52 97 C3 F0 02
 6C D4 F4 25 FD 0F 74 40 14 C4 45 32 7B ED 42 F7
 57 01 3D 64 E9 4F FF C6 FD 07 60 C8 20 8A BA EF
 FF 64 09 97 EE 8B DC 10 17 E7 A7 FB AC BB FE 9F
 0A 59 EF 90 BE 31 A6 37 81 EE 3C 68 C6 15 4B 2D
 BE C2 21 57 B8 AA 9B 17 F9 5C 7F D7 65 85 AE 5A
 12 2D 39 7A 9F 9E E5 F1 F9 4B B8 5C 75 01 7A 33
 BF 0D AD 62 E4 EE C4 CB 6A 04 8F E9 CA 99 33 66
 65 82 21 4E B4 7F F7 92 63 5B CE 20 70 AB 91 51
 81 86 F1 95 8D 69 FE 7E 2A 18 53 24 A1 55 CC F2
 50 03 1E 85 2F 59 38 56

After χ

FE 8E 97 91 30 BF 89 0D D2 35 F2 BF 78 18 3A 95
 63 94 48 98 69 23 AB 73 51 B6 B6 19 81 65 7F 98
 D9 87 94 21 1D 8C C7 5E 51 34 74 40 95 23 F2 B5
 2F D5 CC 61 7D 0D C9 40 BC C2 05 BA 7B 6D 42 DE
 57 31 28 76 7E 0E BF C6 D1 C7 E0 ED 48 86 BE AF
 F7 7C 41 97 FC 8B DC 30 96 41 B7 93 EC BF B7 97
 34 59 EE 87 86 9B 36 25 C0 CA 34 E8 80 14 0F 2D
 BE 41 87 3F B8 9A B9 98 10 1E FF D3 05 84 B4 58
 14 29 3C 58 1F 70 61 39 B9 4B BA D5 7F 10 49 17
 2E 55 DD 74 C1 EA 48 D3 68 25 8F C1 50 83 72 C7
 E5 06 10 DB 39 3F 99 BC 49 43 CC 00 50 BF 91 D1
 D1 85 FD 14 83 61 CE 7A 0F 98 72 6E 31 73 0B 72
 52 5A D0 A5 6F D9 38 17

After 1

```

FF 8E 97 91 30 BF 89 0D D2 35 F2 BF 78 18 3A 95
63 94 48 98 69 23 AB 73 51 B6 B6 19 81 65 7F 98
D9 87 94 21 1D 8C C7 5E 51 34 74 40 95 23 F2 B5
2F D5 CC 61 7D 0D C9 40 BC C2 05 BA 7B 6D 42 DE
57 31 28 76 7E 0E BF C6 D1 C7 E0 ED 48 86 BE AF
F7 7C 41 97 FC 8B DC 30 96 41 B7 93 EC BF B7 97
34 59 EE 87 86 9B 36 25 C0 CA 34 E8 80 14 0F 2D
BE 41 87 3F B8 9A B9 98 10 1E FF D3 05 84 B4 58
14 29 3C 58 1F 70 61 39 B9 4B BA D5 7F 10 49 17
2E 55 DD 74 C1 EA 48 D3 68 25 8F C1 50 83 72 C7
E5 06 10 DB 39 3F 99 BC 49 43 CC 00 50 BF 91 D1
D1 85 FD 14 83 61 CE 7A 0F 98 72 6E 31 73 0B 72
52 5A D0 A5 6F D9 38 17

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(Skip rounds 1 to 22)

Round #23

After 0

```

37 E8 EC 6A 7B 06 DA 58 CD F9 4D 54 60 33 DE 0F
0E 9D 66 56 32 64 53 73 0F A4 CA 2B 43 63 1C A7
E8 B3 06 EE F5 CA 0D 83 42 AD 23 B3 3A B8 5F E7
99 EB AB DF E1 6E 21 66 41 57 4A 94 20 47 29 06
36 0F 73 FE AF 49 5A 68 BE 60 D0 B4 B7 2C 98 0B
8C 86 9F C1 BF 2A C3 86 98 A9 EF FC 60 69 05 C4
F0 7B 93 6D 1C 8D 4E 5B 80 21 76 E4 EF CA 54 37
2A 09 9B 04 16 2E 65 6A D7 EE 90 D2 3C 62 6F C1
B4 E1 C8 B7 2B E9 E4 EF 03 35 0A 7C 6E 7F 0E 40
FE F9 A0 31 7A 7E BC 8B 46 68 9C 0E 43 96 BA 1E
A2 7A 2C 3B E9 E1 C7 A3 31 3B B1 00 C2 8C C8 4A
BE B9 41 20 3B 91 2D E0 40 15 75 78 DE BA 92 38
53 43 0B BF 4A 54 00 EB

```

After ρ

37 E8 EC 6A 7B 06 DA 58 9A F3 9B A8 C0 66 BC 1F
 43 A7 99 95 0C D9 D4 9C 34 C6 71 FA 40 AA BC 32
 57 6E 18 44 9F 35 70 AF AB 83 FB 75 2E D4 3A 32
 FA 1D EE 16 62 96 B9 BE 41 D0 95 12 25 C8 51 8A
 87 39 FF D7 24 2D 34 9B 82 B9 E0 0B 06 4D 7B CB
 64 34 FC 0C FE 55 19 36 10 63 A6 BE F3 83 A5 15
 6C E3 68 74 DA 82 DF 9B 95 A9 6E 00 43 EC C8 DF
 02 0B 97 32 35 95 84 4D A5 79 C4 DE 82 AF DD 21
 F9 76 25 9D FC 9D 36 1C 07 A0 81 1A 05 3E B7 3F
 8F 77 D1 3F 1F 34 46 CF 1E 46 68 9C 0E 43 96 BA
 1F 8F 8A EA B1 EC A4 87 C5 EC C4 02 08 33 22 2B
 37 37 08 64 27 B2 05 DC 15 75 78 DE BA 92 38 40
 C0 FA D4 D0 C2 AF 12 15

After π

37 E8 EC 6A 7B 06 DA 58 FA 1D EE 16 62 96 B9 BE
 6C E3 68 74 DA 82 DF 9B 8F 77 D1 3F 1F 34 46 CF
 C0 FA D4 D0 C2 AF 12 15 34 C6 71 FA 40 AA BC 32
 82 B9 E0 0B 06 4D 7B CB 64 34 FC 0C FE 55 19 36
 F9 76 25 9D FC 9D 36 1C 37 37 08 64 27 B2 05 DC
 9A F3 9B A8 C0 66 BC 1F 41 D0 95 12 25 C8 51 8A
 95 A9 6E 00 43 EC C8 DF 4E 46 68 9C 0E 43 96 BA
 1F 8F 8A EA B1 EC A4 87 57 6E 18 44 9F 35 70 AF
 AB 83 FB 75 2E D4 3A 32 10 63 A6 BE F3 83 A5 15
 07 A0 81 1A 05 3E B7 3F 15 75 78 DE BA 92 38 40
 43 A7 99 95 0C D9 D4 9C 87 39 FF D7 24 2D 34 9B
 02 0B 97 32 35 95 84 4D A5 79 C4 DE 82 AF DD 21
 C5 EC C4 02 08 33 22 2B

After χ

33 0A EC 0A E3 06 9C 59 79 09 7F 1D 67 A2 B9 FA
 2C 6B 6C B4 1A 09 CF 8B B8 77 F9 15 26 34 8E 87
 08 EF D6 C4 C2 3F 33 B3 50 C2 6D FE B8 BA BC 06
 1B FB E1 9A 06 C5 5D C3 62 35 F4 6C FD 77 18 F6
 F9 B6 54 07 BC 95 8E 3E B5 0E 88 65 21 F7 46 15
 0E DA F1 A8 82 42 34 4A 4B 96 95 8E 29 CB 47 AA
 94 20 EC 62 F2 40 E8 DA 9E 36 79 9C 4E 41 8E A2
 5E 8F 8E F8 94 64 E5 07 47 0E 1C CE 4E 36 F5 AA
 AC 03 FA 75 2A E8 28 18 00 36 DE 7A 49 03 AD 55
 45 AA 81 1A 00 1B F7 90 BD F4 9B EF 9A 52 32 50
 43 A5 99 B5 1D 49 54 D8 22 49 BF 1B A6 07 6D BB
 42 8F 97 32 3D 85 A6 47 A7 7A DD 4B 86 67 09 B5
 41 F4 A2 40 28 17 02 28

After t

```

3B 8A EC 8A E3 06 9C D9 79 09 7F 1D 67 A2 B9 FA
2C 6B 6C B4 1A 09 CF 8B B8 77 F9 15 26 34 8E 87
08 EF D6 C4 C2 3F 33 B3 50 C2 6D FE B8 BA BC 06
1B FB E1 9A 06 C5 5D C3 62 35 F4 6C FD 77 18 F6
F9 B6 54 07 BC 95 8E 3E B5 0E 88 65 21 F7 46 15
0E DA F1 A8 82 42 34 4A 4B 96 95 8E 29 CB 47 AA
94 20 EC 62 F2 40 E8 DA 9E 36 79 9C 4E 41 8E A2
5E 8F 8E F8 94 64 E5 07 47 0E 1C CE 4E 36 F5 AA
AC 03 FA 75 2A E8 28 18 00 36 DE 7A 49 03 AD 55
45 AA 81 1A 00 1B F7 90 BD F4 9B EF 9A 52 32 50
43 A5 99 B5 1D 49 54 D8 22 49 BF 1B A6 07 6D BB
42 8F 97 32 3D 85 A6 47 A7 7A DD 4B 86 67 09 B5
41 F4 A2 40 28 17 02 28

```

After permutation

```

3B 8A EC 8A E3 06 9C D9 79 09 7F 1D 67 A2 B9 FA
2C 6B 6C B4 1A 09 CF 8B B8 77 F9 15 26 34 8E 87
08 EF D6 C4 C2 3F 33 B3 50 C2 6D FE B8 BA BC 06
1B FB E1 9A 06 C5 5D C3 62 35 F4 6C FD 77 18 F6
F9 B6 54 07 BC 95 8E 3E B5 0E 88 65 21 F7 46 15
0E DA F1 A8 82 42 34 4A 4B 96 95 8E 29 CB 47 AA
94 20 EC 62 F2 40 E8 DA 9E 36 79 9C 4E 41 8E A2
5E 8F 8E F8 94 64 E5 07 47 0E 1C CE 4E 36 F5 AA
AC 03 FA 75 2A E8 28 18 00 36 DE 7A 49 03 AD 55
45 AA 81 1A 00 1B F7 90 BD F4 9B EF 9A 52 32 50
43 A5 99 B5 1D 49 54 D8 22 49 BF 1B A6 07 6D BB
42 8F 97 32 3D 85 A6 47 A7 7A DD 4B 86 67 09 B5
41 F4 A2 40 28 17 02 28

```

State (as lanes of integers)

[0, 0] = D99C06E38AEC8A3B
 [1, 0] = FAB9A2671D7F0979
 [2, 0] = 8BCF091AB46C6B2C
 [3, 0] = 878E342615F977B8
 [4, 0] = B3333FC2C4D6EF08
 [0, 1] = 06BCBAB8FE6DC250
 [1, 1] = C35DC5069AE1FB1B
 [2, 1] = F61877FD6CF43562
 [3, 1] = 3E8E95BC0754B6F9
 [4, 1] = 1546F72165880EB5
 [0, 2] = 4A344282A8F1DA0E
 [1, 2] = AA47CB298E95964B
 [2, 2] = DAE840F262EC2094
 [3, 2] = A28E414E9C79369E
 [4, 2] = 07E56494F88E8F5E
 [0, 3] = AAF5364ECE1C0E47
 [1, 3] = 1828E82A75FA03AC
 [2, 3] = 55AD03497ADE3600
 [3, 3] = 90F71B001A81AA45
 [4, 3] = 5032529AEF9BF4BD
 [0, 4] = D854491DB599A543
 [1, 4] = BB6D07A61BBF4922
 [2, 4] = 47A6853D32978F42
 [3, 4] = B50967864BDD7AA7
 [4, 4] = 2802172840A2F441

The hash value is

2E 0A BF BA 83 E6 72 0B FB C2 25 FF 6B 7A B9 FF
 CE 58 BA 02 7E E3 D8 98 76 4F EF 28 7D DE CC CA
 3E 6E 59 98 41 1E 7D DB 32 F6 75 38 F5 00 B1 8C
 8C 97 C4 52 C3 70 EA 2C F0 AF CA 3E 05 DE 7E 4D
 E2 7F A4 41 A9 CB 34 FD 17 C9 78 B4 2D 5B 7E 7F
 9A B1 8F FE FF C3 C5 AC 2F 3A 45 5E EB FD C7 6C
 EA EB 0A 2C CA 22 EE F6 E6 37 F4 CA BE 5C 51 DE
 D2 E3 FA D8 B9 52 70 A3 21 84 56 64 F1 07 D1 64
 96 BB 7A BF BE 75 04 B6 ED E2 E8 9E 4B 99 6F B5
 8E FD C4 18 1F 91 63 38 1C BE 7B C0 06 A7 A2 05
 98 9C 52 6C D1 BD 68 98 36 93 B4 BD C5 37 28 B2
 41 C1 CF F4 2B B6 11 50 2C 35 20 5C AB B2 88 75
 56 55 D6 20 C6 79 94 F0 64 51 18 7F 6F D1 7E 04
 66 82 BA 12 86 06 3F F8 8F E2 50 8D 1F CA F9 03
 5A 12 31 AD 41 50 A9 C9 B2 4C 9B 2D 66 B2 AD 1B
 DE 0B D0 BB CB 8B E0 5B 83 52 29 EF 79 19 73 73
 23 42 44 01 E1 D8 37 B6 6E B4 E6 30 FF 1D E7 0C
 B3 17 C2 BA CB 08 00 1D 34 77 B7 A7 0A 57 6D 20
 86 90 33 58 9D 85 A0 1D DE 2B 66 46 C0 43 B5 9F
 C0 11 31 1D A6 66 FA 5A D1 D6 38 7F A9 BC 40 15
 A3 8A 51 D1 DA 1E A6 1D 64 8D C8 E3 9A 88 B9 D6
 22 BD E2 07 FD AB C6 F2 82 7A 88 0C 33 0B BF 6D
 F7 33 77 4B 65 3E 57 30 5D 78 DC E1 12 F1 0A 2C
 71 F4 CD AD 92 ED 11 3E 1C EA 63 B9 19 25 ED 28
 19 1E 6D BB B5 AA 5A 2A FD A5 1F C0 5A 3A F5 25
 8B 87 66 52 43 55 0F 28 94 8A E2 B8 BE B6 BC 9C
 77 0B 35 F0 67 EA A6 41 EF E6 5B 1A 44 90 9D 1B
 14 9F 97 EE A6 01 39 1C 60 9E C8 1D 19 30 F5 7C
 18 A4 E0 FA B4 91 D1 CA DF D5 04 83 44 9E DC 0F
 07 FF B2 4D 2C 6F 9A 9A 3B FF 39 AE 3D 57 F5 60
 65 4D 7D 75 C9 08 AB E6 25 64 75 3E AC 39 D7 50
 3D A6 D3 7C 2E 32 E1 AF 3B 8A EC 8A E3 06 9C D9

SHAKE-128 sample to produce 4 096 bits of output

The message as a bit string

110010100001101011011110100110

About to call last of the absorb phase

XORed state (in bytes)

```

53 58 7B D9 07 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 80 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00

```

XORed state (as lanes of integers)

```

[0, 0] = 00000007D97B5853
[1, 0] = 0000000000000000
[2, 0] = 0000000000000000
[3, 0] = 0000000000000000
[4, 0] = 0000000000000000
[0, 1] = 0000000000000000
[1, 1] = 0000000000000000
[2, 1] = 0000000000000000
[3, 1] = 0000000000000000
[4, 1] = 0000000000000000
[0, 2] = 0000000000000000
[1, 2] = 0000000000000000
[2, 2] = 0000000000000000
[3, 2] = 0000000000000000
[4, 2] = 0000000000000000
[0, 3] = 0000000000000000
[1, 3] = 0000000000000000
[2, 3] = 0000000000000000
[3, 3] = 0000000000000000
[4, 3] = 0000000000000000
[0, 4] = 8000000000000000
[1, 4] = 0000000000000000
[2, 4] = 0000000000000000
[3, 4] = 0000000000000000
[4, 4] = 0000000000000000

```

Round #0

After θ

```

53 58 7B D9 07 00 00 00 53 58 7B D9 07 00 00 80
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
A7 B0 F6 B2 0F 00 00 00 00 00 00 00 00 00 00
53 58 7B D9 07 00 00 80 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 A7 B0 F6 B2 0F 00 00
00 00 00 00 00 00 00 00 53 58 7B D9 07 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00
A7 B0 F6 B2 0F 00 00 00 00 00 00 00 00 00 00
53 58 7B D9 07 00 00 80 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 A7 B0 F6 B2 0F 00 00
00 00 00 00 00 00 00 80 53 58 7B D9 07 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00
A7 B0 F6 B2 0F 00 00 00

```

After ρ

```

53 58 7B D9 07 00 00 00 A7 B0 F6 B2 0F 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 38 85 B5 97 7D 00 00 00 00 00 00 00
97 7D 00 00 00 38 85 B5 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 70 0A 6B 2F FB 00
00 00 00 00 00 00 00 00 00 4E 61 ED 65 1F 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00
D9 07 00 00 80 53 58 7B 00 00 00 00 00 00 00
2F FB 00 00 70 0A 6B 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 A7 B0 F6 B2 0F 00
00 00 02 00 00 00 00 00 4E 61 ED 65 1F 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 C0 29 AC BD EC 03 00

```

After π

```

53 58 7B D9 07 00 00 00 97 7D 00 00 00 38 85 B5
00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 C0 29 AC BD EC 03 00 00 00 00 00 00 00 00
00 00 70 0A 6B 2F FB 00 00 00 00 00 00 00 00
2F FB 00 00 00 70 0A 6B 00 00 00 00 00 00 00
A7 B0 F6 B2 0F 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 A7 B0 F6 B2 0F 00
00 00 02 00 00 00 00 00 00 00 38 85 B5 97 7D
00 00 00 00 00 00 00 00 00 4E 61 ED 65 1F 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00
D9 07 00 00 80 53 58 7B 00 00 00 00 00 00 00
4E 61 ED 65 1F 00 00 00

```

After χ

```

53 58 7B D9 07 00 00 00 97 7D 00 00 00 38 85 B5
00 C0 29 AC BD EC 03 00 53 18 52 51 02 00 00 00
84 E5 29 AC BD D4 86 B5 00 00 00 00 00 00 00 00
2F FB 70 0A 6B 5F F1 6B 00 00 00 00 00 00 00
2F FB 00 00 00 70 0A 6B 00 00 70 0A 6B 2F FB 00
A7 B0 F6 B2 0F 00 00 00 00 A7 B0 F6 B2 0F 00 00
00 00 02 00 00 00 00 00 00 A7 17 44 44 BD 0F 00 00
00 00 02 00 00 00 00 00 00 00 4E 61 D5 E0 AA 97 7D
00 00 00 00 00 00 00 00 00 00 4E 61 ED 65 1F 00 00
00 00 00 38 85 B5 97 7D 00 00 00 00 00 00 00 00
D9 07 00 00 80 53 58 7B 00 00 00 00 00 00 00 00
97 66 ED 65 9F 53 58 7B 00 00 00 00 00 00 00 00
4E 61 ED 65 1F 00 00 00

```

After ι

```

52 58 7B D9 07 00 00 00 97 7D 00 00 00 38 85 B5
00 C0 29 AC BD EC 03 00 53 18 52 51 02 00 00 00
84 E5 29 AC BD D4 86 B5 00 00 00 00 00 00 00 00
2F FB 70 0A 6B 5F F1 6B 00 00 00 00 00 00 00
2F FB 00 00 00 70 0A 6B 00 00 70 0A 6B 2F FB 00
A7 B0 F6 B2 0F 00 00 00 00 A7 B0 F6 B2 0F 00 00
00 00 02 00 00 00 00 00 00 A7 17 44 44 BD 0F 00 00
00 00 02 00 00 00 00 00 00 00 4E 61 D5 E0 AA 97 7D
00 00 00 00 00 00 00 00 00 00 4E 61 ED 65 1F 00 00
00 00 00 38 85 B5 97 7D 00 00 00 00 00 00 00 00
D9 07 00 00 80 53 58 7B 00 00 00 00 00 00 00 00
97 66 ED 65 9F 53 58 7B 00 00 00 00 00 00 00 00
4E 61 ED 65 1F 00 00 00

```

(Skip rounds 1 to 22)

Round #23

After θ

E5 C9 38 91 7E 2D CB B6 4A 58 42 73 14 82 E1 30
 C6 50 6D 1E 06 82 8D 5E 8B F9 05 58 45 03 D5 87
 8E 5B 12 B3 03 98 A7 EF A3 87 68 10 6A CF 6C B1
 4E 6B 71 A4 46 0A C2 25 DA DB 48 F1 BA 33 88 15
 3C 04 56 F1 82 E8 B3 83 7E D0 A1 5C 3A 51 4D 4B
 FB 44 D7 40 4E 41 AF AD 87 22 12 4D 83 EA 79 D4
 2A C6 4E D0 A7 90 BE 27 E7 B4 40 C6 63 09 3B 93
 36 ED 8D 06 58 2D 32 E0 26 54 B6 49 05 CD FC 47
 4F 83 EA 78 1E F1 51 EB 2F B3 24 89 85 66 CF B6
 B2 6B 35 F6 19 C3 E1 AC DF 6F 1B 5E E3 06 89 82
 27 71 C4 F3 B6 99 32 7C 4C 8E F3 6D 8D 18 5A 13
 60 56 56 76 79 A3 F4 B6 97 2F 9A CC 07 CF FB A1
 08 96 F2 AF 4E B2 8B 8F

After ρ

E5 C9 38 91 7E 2D CB B6 94 B0 84 E6 28 04 C3 61
 31 54 9B 87 81 60 A3 97 34 50 7D B8 98 5F 80 55
 C0 3C 7D 77 DC 92 98 1D A1 F6 CC 16 3B 7A 88 06
 47 6A A4 20 5C E2 B4 16 85 F6 36 52 BC EE 0C 62
 02 AB 78 41 F4 D9 41 1E D5 B4 E4 07 1D CA A5 13
 DD 27 BA 06 72 0A 7A 6D 51 1F 8A 48 34 0D AA E7
 82 3E 85 F4 3D 51 31 76 12 76 26 CF 69 81 8C C7
 03 AC 16 19 70 9B F6 46 93 0A 9A F9 8F 4C A8 6C
 1D CF 23 3E 6A FD 69 50 67 DB 97 59 92 C4 42 B3
 38 9C 55 76 AD C6 3E 63 82 DF 6F 1B 5E E3 06 89
 CA F0 9D C4 11 CF DB 66 30 39 CE B7 35 62 68 4D
 CC CA CA 2E 6F 94 DE 16 2F 9A CC 07 CF FB A1 97
 E2 23 82 A5 FC AB 93 EC

After π

E5 C9 38 91 7E 2D CB B6 47 6A A4 20 5C E2 B4 16
 82 3E 85 F4 3D 51 31 76 38 9C 55 76 AD C6 3E 63
 E2 23 82 A5 FC AB 93 EC 34 50 7D B8 98 5F 80 55
 D5 B4 E4 07 1D CA A5 13 DD 27 BA 06 72 0A 7A 6D
 1D CF 23 3E 6A FD 69 50 CC CA CA 2E 6F 94 DE 16
 94 B0 84 E6 28 04 C3 61 85 F6 36 52 BC EE 0C 62
 12 76 26 CF 69 81 8C C7 82 DF 6F 1B 5E E3 06 89
 CA F0 9D C4 11 CF DB 66 C0 3C 7D 77 DC 92 98 1D
 A1 F6 CC 16 3B 7A 88 06 51 1F 8A 48 34 0D AA E7
 67 DB 97 59 92 C4 42 B3 2F 9A CC 07 CF FB A1 97
 31 54 9B 87 81 60 A3 97 02 AB 78 41 F4 D9 41 1E
 03 AC 16 19 70 9B F6 46 93 0A 9A F9 8F 4C A8 6C
 30 39 CE B7 35 62 68 4D

After χ

65 DD 39 45 5F 3C CA D6 7F EA F4 22 DC 64 BA 17
 40 1D 07 75 6D 78 B0 FA 3D 54 6D 66 AF C2 76 71
 E0 01 06 85 FC 69 A7 EC 3C 53 67 B8 FA 5F DA 39
 D5 7C E5 3F 15 3F A4 03 1D 27 72 06 77 0A EC 6B
 2D DF 16 AE FA B6 69 11 0D 6E 4A 29 6A 14 FB 14
 86 B0 84 6B 69 05 43 E4 05 7F 7F 42 AA 8C 0E 6A
 5A 56 B6 0B 68 8D 55 A1 96 DF 6F 39 76 E3 06 88
 CB B6 AF D4 85 25 D7 64 90 35 7F 3F D8 97 BA FC
 87 36 D9 07 B9 BA C8 16 59 1F C2 4E 79 36 0B E3
 A7 FF A6 29 82 C4 5A BB 0E 58 4C 07 EC 93 A1 95
 30 50 9D 9F 81 62 15 D7 92 A9 F0 A1 7B 9D 49 36
 23 9D 52 1F 40 B9 B6 47 92 4E 8B F9 0F 4C 2B FE
 32 92 AE F7 41 FB 28 45

After ι

6D 5D 39 C5 5F 3C CA 56 7F EA F4 22 DC 64 BA 17
 40 1D 07 75 6D 78 B0 FA 3D 54 6D 66 AF C2 76 71
 E0 01 06 85 FC 69 A7 EC 3C 53 67 B8 FA 5F DA 39
 D5 7C E5 3F 15 3F A4 03 1D 27 72 06 77 0A EC 6B
 2D DF 16 AE FA B6 69 11 0D 6E 4A 29 6A 14 FB 14
 86 B0 84 6B 69 05 43 E4 05 7F 7F 42 AA 8C 0E 6A
 5A 56 B6 0B 68 8D 55 A1 96 DF 6F 39 76 E3 06 88
 CB B6 AF D4 85 25 D7 64 90 35 7F 3F D8 97 BA FC
 87 36 D9 07 B9 BA C8 16 59 1F C2 4E 79 36 0B E3
 A7 FF A6 29 82 C4 5A BB 0E 58 4C 07 EC 93 A1 95
 30 50 9D 9F 81 62 15 D7 92 A9 F0 A1 7B 9D 49 36
 23 9D 52 1F 40 B9 B6 47 92 4E 8B F9 0F 4C 2B FE
 32 92 AE F7 41 FB 28 45

After permutation

6D 5D 39 C5 5F 3C CA 56 7F EA F4 22 DC 64 BA 17
 40 1D 07 75 6D 78 B0 FA 3D 54 6D 66 AF C2 76 71
 E0 01 06 85 FC 69 A7 EC 3C 53 67 B8 FA 5F DA 39
 D5 7C E5 3F 15 3F A4 03 1D 27 72 06 77 0A EC 6B
 2D DF 16 AE FA B6 69 11 0D 6E 4A 29 6A 14 FB 14
 86 B0 84 6B 69 05 43 E4 05 7F 7F 42 AA 8C 0E 6A
 5A 56 B6 0B 68 8D 55 A1 96 DF 6F 39 76 E3 06 88
 CB B6 AF D4 85 25 D7 64 90 35 7F 3F D8 97 BA FC
 87 36 D9 07 B9 BA C8 16 59 1F C2 4E 79 36 0B E3
 A7 FF A6 29 82 C4 5A BB 0E 58 4C 07 EC 93 A1 95
 30 50 9D 9F 81 62 15 D7 92 A9 F0 A1 7B 9D 49 36
 23 9D 52 1F 40 B9 B6 47 92 4E 8B F9 0F 4C 2B FE
 32 92 AE F7 41 FB 28 45

State (as lanes of integers)

[0,0] = 56CA3C5FC5395D6D
 [1,0] = 17BA64DC22F4EA7F
 [2,0] = FAB0786D75071D40
 [3,0] = 7176C2AF666D543D
 [4,0] = ECA769FC850601E0
 [0,1] = 39DA5FFAB867533C
 [1,1] = 03A43F153FE57CD5
 [2,1] = 6BEC0A770672271D
 [3,1] = 1169B6FAAE16DF2D
 [4,1] = 14FB146A294A6E0D
 [0,2] = E44305696B84B086
 [1,2] = 6A0E8CAA427F7F05
 [2,2] = A1558D680BB6565A
 [3,2] = 8806E376396FDF96
 [4,2] = 64D72585D4AFB6CB
 [0,3] = FCBA97D83F7F3590
 [1,3] = 16C8BAB907D93687
 [2,3] = E30B36794EC21F59
 [3,3] = BB5AC48229A6FFA7
 [4,3] = 95A193EC074C580E
 [0,4] = D71562819F9D5030
 [1,4] = 36499D7BA1F0A992
 [2,4] = 47B6B9401F529D23
 [3,4] = FE2B4C0FF98B4E92
 [4,4] = 4528FB41F7AE9232

About to call squeeze (again)

State before permutation (in bytes)

6D 5D 39 C5 5F 3C CA 56 7F EA F4 22 DC 64 BA 17
 40 1D 07 75 6D 78 B0 FA 3D 54 6D 66 AF C2 76 71
 E0 01 06 85 FC 69 A7 EC 3C 53 67 B8 FA 5F DA 39
 D5 7C E5 3F 15 3F A4 03 1D 27 72 06 77 0A EC 6B
 2D DF 16 AE FA B6 69 11 0D 6E 4A 29 6A 14 FB 14
 86 B0 84 6B 69 05 43 E4 05 7F 7F 42 AA 8C 0E 6A
 5A 56 B6 0B 68 8D 55 A1 96 DF 6F 39 76 E3 06 88
 CB B6 AF D4 85 25 D7 64 90 35 7F 3F D8 97 BA FC
 87 36 D9 07 B9 BA C8 16 59 1F C2 4E 79 36 0B E3
 A7 FF A6 29 82 C4 5A BB 0E 58 4C 07 EC 93 A1 95
 30 50 9D 9F 81 62 15 D7 92 A9 F0 A1 7B 9D 49 36
 23 9D 52 1F 40 B9 B6 47 92 4E 8B F9 0F 4C 2B FE
 32 92 AE F7 41 FB 28 45

State before permutation (as lanes of integers)

[0, 0] = 56CA3C5FC5395D6D
 [1, 0] = 17BA64DC22F4EA7F
 [2, 0] = FAB0786D75071D40
 [3, 0] = 7176C2AF666D543D
 [4, 0] = ECA769FC850601E0
 [0, 1] = 39DA5FFAB867533C
 [1, 1] = 03A43F153FE57CD5
 [2, 1] = 6BEC0A770672271D
 [3, 1] = 1169B6FAAE16DF2D
 [4, 1] = 14FB146A294A6E0D
 [0, 2] = E44305696B84B086
 [1, 2] = 6A0E8CAA427F7F05
 [2, 2] = A1558D680BB6565A
 [3, 2] = 8806E376396FDF96
 [4, 2] = 64D72585D4AFB6CB
 [0, 3] = FCBA97D83F7F3590
 [1, 3] = 16C8BAB907D93687
 [2, 3] = E30B36794EC21F59
 [3, 3] = BB5AC48229A6FFA7
 [4, 3] = 95A193EC074C580E
 [0, 4] = D71562819F9D5030
 [1, 4] = 36499D7BA1F0A992
 [2, 4] = 47B6B9401F529D23
 [3, 4] = FE2B4C0FF98B4E92
 [4, 4] = 4528FB41F7AE9232

Round #0

After θ

03 A3 B6 BF A2 ED EB A7 F3 ED 6B C6 DF 17 2E 9E
 9D A0 33 CE 90 B7 F1 FE 74 9C 3C 5F 99 D3 C6 7D
 BC 52 4E C8 79 51 36 00 52 AD E8 C2 07 8E FB C8
 59 7B 7A DB 16 4C 30 8A C0 9A 46 BD 8A C5 AD 6F
 64 17 47 97 CC A7 D9 1D 51 3D 02 64 EF 2C 6A F8
 E8 4E 0B 11 94 D4 62 15 89 78 E0 A6 A9 FF 9A E3
 87 EB 82 B0 95 42 14 A5 DF 17 3E 00 40 F2 B6 84
 97 E5 E7 99 00 1D 46 88 FE CB F0 45 25 46 9B 0D
 0B 31 46 E3 BA C9 5C 9F 84 A2 F6 F5 84 F9 4A E7
 EE 37 F7 10 B4 D5 EA B7 52 0B 04 4A 69 AB 30 79
 5E AE 12 E5 7C B3 34 26 1E AE 6F 45 78 EE DD BF
 FE 20 66 A4 BD 76 F7 43 DB 86 DA C0 39 5D 9B F2
 6E C1 E6 BA C4 C3 B9 A9

After ρ

03 A3 B6 BF A2 ED EB A7 E7 DB D7 8C BF 2F 5C 3C
 27 E8 8C 33 E4 6D BC 7F 39 6D DC 47 C7 C9 F3 95
 8B B2 01 E0 95 72 42 CE 7C E0 B8 8F 2C D5 8A 2E
 B7 6D C1 04 A3 98 B5 A7 1B B0 A6 51 AF 62 71 EB
 8B A3 4B E6 D3 EC 0E B2 A2 86 1F D5 23 40 F6 CE
 40 77 5A 88 A0 A4 16 AB 8E 27 E2 81 9B A6 FE 6B
 84 AD 14 A2 28 3D 5C 17 E4 6D 09 BF 2F 7C 00 80
 4C 80 0E 23 C4 CB F2 F3 8B 4A 8C 36 1B FC 97 E1
 68 5C 37 99 EB 73 21 C6 A5 73 42 51 FB 7A C2 7C
 5A FD D6 FD E6 1E 82 B6 79 52 0B 04 4A 69 AB 30
 D2 98 78 B9 4A 94 F3 CD 7A B8 BE 15 E1 B9 77 FF
 1F C4 8C B4 D7 EE 7E C8 86 DA C0 39 5D 9B F2 DB
 6E AA 5B B0 B9 2E F1 70

After π

03 A3 B6 BF A2 ED EB A7 B7 6D C1 04 A3 98 B5 A7
 84 AD 14 A2 28 3D 5C 17 5A FD D6 FD E6 1E 82 B6
 6E AA 5B B0 B9 2E F1 70 39 6D DC 47 C7 C9 F3 95
 A2 86 1F D5 23 40 F6 CE 40 77 5A 88 A0 A4 16 AB
 68 5C 37 99 EB 73 21 C6 1F C4 8C B4 D7 EE 7E C8
 E7 DB D7 8C BF 2F 5C 3C 1B B0 A6 51 AF 62 71 EB
 E4 6D 09 BF 2F 7C 00 80 79 52 0B 04 4A 69 AB 30
 D2 98 78 B9 4A 94 F3 CD 8B B2 01 E0 95 72 42 CE
 7C E0 B8 8F 2C D5 8A 2E 8E 27 E2 81 9B A6 FE 6B
 A5 73 42 51 FB 7A C2 7C 86 DA C0 39 5D 9B F2 DB
 27 E8 8C 33 E4 6D BC 7F 8B A3 4B E6 D3 EC 0E B2
 4C 80 0E 23 C4 CB F2 F3 8B 4A 8C 36 1B FC 97 E1
 7A B8 BE 15 E1 B9 77 FF

After χ

03 23 A2 1D AA C8 A3 B7 ED 3D 03 59 65 9A 37 07
 A0 AF 1D A2 31 1D 2D 57 5B FC 72 F2 E4 DF 88 31
 DA E6 1A B0 B8 3E E5 70 79 1C 9C 4F 47 6D F3 B4
 8A 8E 3A C4 68 13 D7 8A 57 F7 D2 AC B4 28 48 A3
 48 75 67 DA EB 72 A0 D3 9D 46 8F 24 F7 EE 7A 82
 03 96 DE 22 BF 33 5C 3C 02 A2 A4 51 EF 63 DA DB
 66 E5 79 06 2F E8 50 4D 5C 11 8C 00 FF 42 A7 00
 CA B8 58 E8 4A D4 D2 0E 09 B5 43 E0 06 50 36 8F
 5D B0 B8 DF 4C 8D 8A 3A 8C AF 62 A9 9F 27 CE E8
 AC 53 43 91 7B 1A C2 78 F2 9A 78 36 75 1E 7A FB
 63 E8 88 32 E0 6E 4C 3E 08 E9 CB F2 C8 D8 0B B2
 3C 30 3C 22 24 CA 92 ED 8E 0A 8C 14 1F B8 1F E1
 F2 BB FD D1 F2 39 75 7F

After t

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02 23 A2 1D AA C8 A3 B7 ED 3D 03 59 65 9A 37 07
A0 AF 1D A2 31 1D 2D 57 5B FC 72 F2 E4 DF 88 31
DA E6 1A B0 B8 3E E5 70 79 1C 9C 4F 47 6D F3 B4
8A 8E 3A C4 68 13 D7 8A 57 F7 D2 AC B4 28 48 A3
48 75 67 DA EB 72 A0 D3 9D 46 8F 24 F7 EE 7A 82
03 96 DE 22 BF 33 5C 3C 02 A2 A4 51 EF 63 DA DB
66 E5 79 06 2F E8 50 4D 5C 11 8C 00 FF 42 A7 00
CA B8 58 E8 4A D4 D2 0E 09 B5 43 E0 06 50 36 8F
5D B0 B8 DF 4C 8D 8A 3A 8C AF 62 A9 9F 27 CE E8
AC 53 43 91 7B 1A C2 78 F2 9A 78 36 75 1E 7A FB
63 E8 88 32 E0 6E 4C 3E 08 E9 CB F2 C8 D8 0B B2
3C 30 3C 22 24 CA 92 ED 8E 0A 8C 14 1F B8 1F E1
F2 BB FD D1 F2 39 75 7F

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(Skip rounds 1 to 22)

Round #23

After θ

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09 F3 BB 3C 65 7E 82 3C EF 00 38 23 F6 8E C9 98
72 91 67 37 64 1A 04 F9 FB DB 6B 5A 79 80 81 4A
4B 51 05 7A 71 CC B6 8F 7D 28 B4 85 38 12 31 98
CC 6D 01 50 57 2F 91 49 F9 84 11 A9 73 A4 54 0F
DF A1 88 22 46 AF 38 AA E2 1D 4D 19 09 96 A0 D9
C6 4D 09 A8 4D 58 7A 20 F0 C3 EB 57 78 1A 3B D3
88 50 D7 04 63 E2 E6 54 BD 1B 7D FA 78 8A 4B CD
43 39 45 52 3B 7E D7 A2 55 17 A5 4D 10 CC 2E 39
50 AC CF F1 0E 03 0F 0E 58 7D 18 B1 BA A1 89 E0
24 ED 4C 92 92 90 6B 04 23 5F D5 EC E2 47 AD 9F
98 94 82 64 17 1C 1D FE 85 51 42 86 54 FC BD F3
21 2F EE F3 75 C6 67 DD 9F DB AB 48 97 89 3A 18
B7 2E B6 63 34 C7 DE 63

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After ρ

09 F3 BB 3C 65 7E 82 3C DF 01 70 46 EC 1D 93 31
 5C E4 D9 0D 99 06 41 BE 07 18 A8 B4 BF BD A6 95
 63 B6 7D 5C 8A 2A D0 8B 88 23 11 83 D9 87 42 5B
 00 75 F5 12 99 C4 DC 16 43 3E 61 44 EA 1C 29 D5
 50 44 11 A3 57 1C D5 EF 09 9A 2D DE D1 94 91 60
 31 6E 4A 40 6D C2 D2 03 4C C3 0F AF 5F E1 69 EC
 26 18 13 37 A7 42 84 BA 14 97 9A 7B 37 FA F4 F1
 A9 1D BF 6B D1 A1 9C 22 9B 20 98 5D 72 AA 2E 4A
 39 DE 61 E0 C1 01 8A F5 44 70 AC 3E 8C 58 DD D0
 72 8D 80 A4 9D 49 52 12 9F 23 5F D5 EC E2 47 AD
 74 F8 63 52 0A 92 5D 70 17 46 09 19 52 F1 F7 CE
 E4 C5 7D BE CE F8 AC 3B DB AB 48 97 89 3A 18 9F
 F7 D8 AD 8B ED 18 CD B1

After π

09 F3 BB 3C 65 7E 82 3C 00 75 F5 12 99 C4 DC 16
 26 18 13 37 A7 42 84 BA 72 8D 80 A4 9D 49 52 12
 F7 D8 AD 8B ED 18 CD B1 07 18 A8 B4 BF BD A6 95
 09 9A 2D DE D1 94 91 60 31 6E 4A 40 6D C2 D2 03
 39 DE 61 E0 C1 01 8A F5 44 70 AC 3E 8C 58 DD D0
 DF 01 70 46 EC 1D 93 31 43 3E 61 44 EA 1C 29 D5
 14 97 9A 7B 37 FA F4 F1 9F 23 5F D5 EC E2 47 AD
 74 F8 63 52 0A 92 5D 70 63 B6 7D 5C 8A 2A D0 8B
 88 23 11 83 D9 87 42 5B 4C C3 0F AF 5F E1 69 EC
 44 70 AC 3E 8C 58 DD D0 DB AB 48 97 89 3A 18 9F
 5C E4 D9 0D 99 06 41 BE 50 44 11 A3 57 1C D5 EF
 A9 1D BF 6B D1 A1 9C 22 9B 20 98 5D 72 AA 2E 4A
 17 46 09 19 52 F1 F7 CE

After χ

2F FB B9 19 43 7C 82 94 50 F0 75 92 81 CD 8E 16
 A3 48 3E 3C C7 52 09 1B 7A AE 92 90 9D 2F 50 1E
 F7 DC E9 89 75 98 91 B3 37 7C EA B4 93 FF E4 96
 01 0A 0C 7E 51 95 99 94 F5 6F 56 5E 63 3A F6 09
 3A C6 E1 E0 F0 04 88 71 EC 47 78 F4 8E F8 BD 5B
 CB 80 EA 7D F9 FF 47 11 C8 1E 24 C0 22 1C 2A D9
 74 4F BA 79 35 EA EC A1 14 22 4F D1 08 EF C5 AC
 74 C6 62 52 08 92 75 B4 27 76 73 70 8C 4A F9 2F
 88 13 B1 93 59 9F D6 4B D7 48 4F 2E 5E C3 69 E3
 64 64 99 76 8E 58 1D D0 53 AA 48 14 D8 BF 1A CF
 F5 FD 77 45 19 A7 49 BE 42 64 11 B7 75 16 F7 A7
 AD 5B BE 6B D1 F0 4D A6 D3 80 48 59 FB AC 2E 7A
 17 46 09 BB 14 E9 63 8F

After t

27 7B B9 99 43 7C 82 14 50 F0 75 92 81 CD 8E 16
A3 48 3E 3C C7 52 09 1B 7A AE 92 90 9D 2F 50 1E
F7 DC E9 89 75 98 91 B3 37 7C EA B4 93 FF E4 96
01 0A 0C 7E 51 95 99 94 F5 6F 56 5E 63 3A F6 09
3A C6 E1 E0 F0 04 88 71 EC 47 78 F4 8E F8 BD 5B
CB 80 EA 7D F9 FF 47 11 C8 1E 24 C0 22 1C 2A D9
74 4F BA 79 35 EA EC A1 14 22 4F D1 08 EF C5 AC
74 C6 62 52 08 92 75 B4 27 76 73 70 8C 4A F9 2F
88 13 B1 93 59 9F D6 4B D7 48 4F 2E 5E C3 69 E3
64 64 99 76 8E 58 1D D0 53 AA 48 14 D8 BF 1A CF
F5 FD 77 45 19 A7 49 BE 42 64 11 B7 75 16 F7 A7
AD 5B BE 6B D1 F0 4D A6 D3 80 48 59 FB AC 2E 7A
17 46 09 BB 14 E9 63 8F

After permutation

27 7B B9 99 43 7C 82 14 50 F0 75 92 81 CD 8E 16
A3 48 3E 3C C7 52 09 1B 7A AE 92 90 9D 2F 50 1E
F7 DC E9 89 75 98 91 B3 37 7C EA B4 93 FF E4 96
01 0A 0C 7E 51 95 99 94 F5 6F 56 5E 63 3A F6 09
3A C6 E1 E0 F0 04 88 71 EC 47 78 F4 8E F8 BD 5B
CB 80 EA 7D F9 FF 47 11 C8 1E 24 C0 22 1C 2A D9
74 4F BA 79 35 EA EC A1 14 22 4F D1 08 EF C5 AC
74 C6 62 52 08 92 75 B4 27 76 73 70 8C 4A F9 2F
88 13 B1 93 59 9F D6 4B D7 48 4F 2E 5E C3 69 E3
64 64 99 76 8E 58 1D D0 53 AA 48 14 D8 BF 1A CF
F5 FD 77 45 19 A7 49 BE 42 64 11 B7 75 16 F7 A7
AD 5B BE 6B D1 F0 4D A6 D3 80 48 59 FB AC 2E 7A
17 46 09 BB 14 E9 63 8F

State (as lanes of integers)

[0,0] = 14827C4399B97B27
 [1,0] = 168ECD819275F050
 [2,0] = 1B0952C73C3E48A3
 [3,0] = 1E502F9D9092AE7A
 [4,0] = B391987589E9DCF7
 [0,1] = 96E4FF93B4EA7C37
 [1,1] = 949995517E0C0A01
 [2,1] = 09F63A635E566FF5
 [3,1] = 718804F0E0E1C63A
 [4,1] = 5BBDF88EF47847EC
 [0,2] = 1147FFF97DEA80CB
 [1,2] = D92A1C22C0241EC8
 [2,2] = A1ECEA3579BA4F74
 [3,2] = ACC5EF08D14F2214
 [4,2] = B47592085262C674
 [0,3] = 2FF94A8C70737627
 [1,3] = 4BD69F5993B11388
 [2,3] = E369C35E2E4F48D7
 [3,3] = D01D588E76996464
 [4,3] = CF1AEFD81448AA53
 [0,4] = BE49A7194577FDF5
 [1,4] = A7F71675B7116442
 [2,4] = A64DF0D16BBE5BAD
 [3,4] = 7A2EACFB594880D3
 [4,4] = 8F63E914BB094617

About to call squeeze (again)

State before permutation (in bytes)

27 7B B9 99 43 7C 82 14 50 F0 75 92 81 CD 8E 16
 A3 48 3E 3C C7 52 09 1B 7A AE 92 90 9D 2F 50 1E
 F7 DC E9 89 75 98 91 B3 37 7C EA B4 93 FF E4 96
 01 0A 0C 7E 51 95 99 94 F5 6F 56 5E 63 3A F6 09
 3A C6 E1 E0 F0 04 88 71 EC 47 78 F4 8E F8 BD 5B
 CB 80 EA 7D F9 FF 47 11 C8 1E 24 C0 22 1C 2A D9
 74 4F BA 79 35 EA EC A1 14 22 4F D1 08 EF C5 AC
 74 C6 62 52 08 92 75 B4 27 76 73 70 8C 4A F9 2F
 88 13 B1 93 59 9F D6 4B D7 48 4F 2E 5E C3 69 E3
 64 64 99 76 8E 58 1D D0 53 AA 48 14 D8 BF 1A CF
 F5 FD 77 45 19 A7 49 BE 42 64 11 B7 75 16 F7 A7
 AD 5B BE 6B D1 F0 4D A6 D3 80 48 59 FB AC 2E 7A
 17 46 09 BB 14 E9 63 8F

State before permutation (as lanes of integers)

[0, 0] = 14827C4399B97B27
 [1, 0] = 168ECD819275F050
 [2, 0] = 1B0952C73C3E48A3
 [3, 0] = 1E502F9D9092AE7A
 [4, 0] = B391987589E9DCF7
 [0, 1] = 96E4FF93B4EA7C37
 [1, 1] = 949995517E0C0A01
 [2, 1] = 09F63A635E566FF5
 [3, 1] = 718804F0E0E1C63A
 [4, 1] = 5BBDF88EF47847EC
 [0, 2] = 1147FFF97DEA80CB
 [1, 2] = D92A1C22C0241EC8
 [2, 2] = A1ECEA3579BA4F74
 [3, 2] = ACC5EF08D14F2214
 [4, 2] = B47592085262C674
 [0, 3] = 2FF94A8C70737627
 [1, 3] = 4BD69F5993B11388
 [2, 3] = E369C35E2E4F48D7
 [3, 3] = D01D588E76996464
 [4, 3] = CF1ABFD81448AA53
 [0, 4] = BE49A7194577FDF5
 [1, 4] = A7F71675B7116442
 [2, 4] = A64DF0D16BBE5BAD
 [3, 4] = 7A2EACFB594880D3
 [4, 4] = 8F63E914BB094617

Round #0

After θ

AB EC F0 08 C0 43 9B 66 E8 0A 8E 4B 01 3E 70 F8
 36 86 18 29 38 FF 49 7E 74 B7 D4 CF FC D6 26 D0
 06 6A 7E CC 1D 8B 9C DF BB EB A3 25 10 C0 FD E4
 B9 F0 F7 A7 D1 66 67 7A 60 A1 70 4B 9C 97 B6 6C
 34 DF A7 BF 91 FD FE BF 1D F1 EF B1 E6 EB B0 37
 47 17 A3 EC 7A C0 5E 63 70 E4 DF 19 A2 EF D4 37
 E1 81 9C 6C CA 47 AC C4 1A 3B 09 8E 69 16 B3 62
 85 70 F5 17 60 81 78 D8 AB E1 3A E1 0F 75 E0 5D
 30 E9 4A 4A D9 6C 28 A5 42 86 69 3B A1 6E 29 86
 6A 7D DF 29 EF A1 6B 1E A2 1C DF 51 B0 AC 17 A3
 79 6A 3E D4 9A 98 50 CC FA 9E EA 6E F5 E5 09 49
 38 95 98 7E 2E 5D 0D C3 DD 99 0E 06 9A 55 58 B4
 E6 F0 9E FE 7C FA 6E E3

After ρ

AB EC F0 08 C0 43 9B 66 D1 15 1C 97 02 7C E0 F0
 8D 21 46 0A CE 7F 92 9F 6F 6D 02 4D 77 4B FD CC
 58 E4 FC 36 50 F3 63 EE 02 01 DC 4F BE BB 3E 5A
 7F 1A 6D 76 A6 97 0B 7F 1B 58 28 DC 12 E7 A5 2D
 EF D3 DF C8 7E FF 5F 9A 0E 7B D3 11 FF 1E 6B BE
 3B BA 18 65 D7 03 F6 1A DF C0 91 7F 67 88 BE 53
 64 53 3E 62 25 0E 0F E4 2C 66 C5 34 76 12 1C D3
 0B B0 40 3C EC 42 B8 FA C2 1F EA C0 BB 56 C3 75
 49 29 9B 0D A5 14 26 5D 14 43 21 C3 B4 9D 50 B7
 74 CD 43 AD EF 3B E5 3D A3 A2 1C DF 51 B0 AC 17
 42 31 E7 A9 F9 50 6B 62 E9 7B AA BB D5 97 27 24
 A7 12 D3 CF A5 AB 61 18 99 0E 06 9A 55 58 B4 DD
 DB B8 39 BC A7 3F 9F BE

After π

AB EC F0 08 C0 43 9B 66 7F 1A 6D 76 A6 97 0B 7F
 64 53 3E 62 25 0E 0F E4 74 CD 43 AD EF 3B E5 3D
 DB B8 39 BC A7 3F 9F BE 6F 6D 02 4D 77 4B FD CC
 0E 7B D3 11 FF 1E 6B BE 3E BA 18 65 D7 03 F6 1A
 49 29 9B 0D A5 14 26 5D A7 12 D3 CF A5 AB 61 18
 D1 15 1C 97 02 7C E0 F0 1B 58 28 DC 12 E7 A5 2D
 2C 66 C5 34 76 12 1C D3 A3 A2 1C DF 51 B0 AC 17
 42 31 E7 A9 F9 50 6B 62 58 E4 FC 36 50 F3 63 EE
 02 01 DC 4F BE BB 3E 5A DF C0 91 7F 67 88 BE 53
 14 43 21 C3 B4 9D 50 B7 99 0E 06 9A 55 58 B4 DD
 8D 21 46 0A CE 7F 92 9F EF D3 DF C8 7E FF 5F 9A
 0B B0 40 3C EC 42 B8 FA C2 1F EA C0 BB 56 C3 75
 E9 7B AA BB D5 97 27 24

After χ

AB AD E2 08 C1 4B 9F E6 6F 96 2C FB 6C A6 EB 66
 EF 63 06 72 25 0A 15 66 54 89 83 AD AF 7B E5 7D
 8F AA 34 CA 81 AB 9F A7 5E ED 0A 29 77 4A 69 CC
 4E 7A 50 19 DF 0A 6B FB 9D A8 58 A7 D7 A8 B7 1A
 01 44 9B 0D F7 54 BA 99 A7 00 02 DF 2D BF 63 2A
 F5 33 D9 B7 66 6C F8 22 98 D8 30 17 13 47 05 29
 6C 77 26 14 DE 52 5F B3 32 A6 04 C9 53 9C 2C 87
 48 79 C7 E1 E9 D3 6E 6F 85 24 FD 06 11 F3 E3 EF
 02 02 FC CF 2E AE 7E FE 56 CC 97 67 26 C8 1A 1B
 54 A3 D9 E7 B4 3E 13 95 9B 0F 06 D3 FB 50 A8 CD
 8D 01 46 3E 4E 7F 32 FF 2F DC 75 08 6D EB 1C 9F
 22 D0 40 07 A8 C3 9C FA C6 1F AE C0 B1 3E 53 EE
 8B A9 33 7B E5 17 6A 24

After t

AA AD E2 08 C1 4B 9F E6 6F 96 2C FB 6C A6 EB 66
 EF 63 06 72 25 0A 15 66 54 89 83 AD AF 7B E5 7D
 8F AA 34 CA 81 AB 9F A7 5E ED 0A 29 77 4A 69 CC
 4E 7A 50 19 DF 0A 6B FB 9D A8 58 A7 D7 A8 B7 1A
 01 44 9B 0D F7 54 BA 99 A7 00 02 DF 2D BF 63 2A
 F5 33 D9 B7 66 6C F8 22 98 D8 30 17 13 47 05 29
 6C 77 26 14 DE 52 5F B3 32 A6 04 C9 53 9C 2C 87
 48 79 C7 E1 E9 D3 6E 6F 85 24 FD 06 11 F3 E3 EF
 02 02 FC CF 2E AE 7E FE 56 CC 97 67 26 C8 1A 1B
 54 A3 D9 E7 B4 3E 13 95 9B 0F 06 D3 FB 50 A8 CD
 8D 01 46 3E 4E 7F 32 FF 2F DC 75 08 6D EB 1C 9F
 22 D0 40 07 A8 C3 9C FA C6 1F AE C0 B1 3E 53 EE
 8B A9 33 7B E5 17 6A 24

(Skip rounds 1 to 22)

Round #23

After 0

6E E1 47 C1 F8 67 26 A8 EA D9 BA EA 82 E2 64 DC
 15 5A 0C 64 0B 10 3F CA 05 64 49 91 73 CE 88 43
 09 1F 7C A5 A1 B6 3E 1E FD 70 27 85 1B 63 8B 44
 F5 0E F7 9F 6A 76 8F CE 9D CC F6 66 6A 4F 28 C2
 04 99 7D 3D 06 C9 AD 4B E7 EF 86 0A 91 1A 76 9F
 37 58 7F E7 98 74 3B 4B 27 53 05 7E AF EC 1C 78
 16 56 09 A2 C6 0C 74 D3 66 72 25 BE 53 A9 82 5A
 94 FB 83 EF D1 DC 63 8A E6 96 2A D7 E1 79 4A 75
 E4 A9 E7 E1 25 27 7A 79 6E EB 1F 39 F0 67 39 8B
 FD 13 06 B3 D0 6E A7 F1 DF 06 4A EA 4D 3C 0E 3F
 16 80 59 7C 83 4B 43 BB FD 13 03 C0 F8 BA 92 F4
 71 52 21 92 2F 61 23 F8 0B 4D C9 14 A4 0F CE E1
 F6 AF A3 8E A4 15 A5 B4

After ρ

6E E1 47 C1 F8 67 26 A8 D5 B3 75 D5 05 C5 C9 B8
 85 16 03 D9 02 C4 8F 72 E7 8C 38 54 40 96 14 39
 B5 F5 F1 48 F8 E0 2B 0D B8 31 B6 48 D4 0F 77 52
 FF A9 66 F7 E8 5C EF 70 70 27 B3 BD 99 DA 13 8A
 CC BE 1E 83 E4 D6 25 82 61 F7 79 FE 6E A8 10 A9
 BA C1 FA 3B C7 A4 DB 59 E0 9D 4C 15 F8 BD B2 73
 10 35 66 A0 9B B6 B0 4A 52 05 B5 CC E4 4A 7C A7
 F7 68 EE 31 45 CA FD C1 AE C3 F3 94 EA CC 2D 55
 3C BC E4 44 2F 8F 3C F5 9C 45 B7 F5 8F 1C F8 B3
 ED 34 BE 7F C2 7A 16 DA 3F DF 06 4A EA 4D 3C 0E
 0D ED 5A 00 66 F1 0D 2E F7 4F 0C 00 E3 EB 4A D2
 4E 2A 44 F2 25 6C 04 3F 4D C9 14 A4 0F CE E1 0B
 29 AD FD EB A8 23 69 45

After π

6E E1 47 C1 F8 67 26 A8 FF A9 66 F7 E8 5C EF 70
 10 35 66 A0 9B B6 B0 4A ED 34 BE 7F C2 7A 16 DA
 29 AD FD EB A8 23 69 45 E7 8C 38 54 40 96 14 39
 61 F7 79 FE 6E A8 10 A9 BA C1 FA 3B C7 A4 DB 59
 3C BC E4 44 2F 8F 3C F5 4E 2A 44 F2 25 6C 04 3F
 D5 B3 75 D5 05 C5 C9 B8 70 27 B3 BD 99 DA 13 8A
 52 05 B5 CC E4 4A 7C A7 3F DF 06 4A EA 4D 3C 0E
 0D ED 5A 00 66 F1 0D 2E B5 F5 F1 48 F8 E0 2B 0D
 B8 31 B6 48 D4 0F 77 52 E0 9D 4C 15 F8 BD B2 73
 9C 45 B7 F5 8F 1C F8 B3 4D C9 14 A4 0F CE E1 0B
 85 16 03 D9 02 C4 8F 72 CC BE 1E 83 E4 D6 25 82
 F7 68 EE 31 45 CA FD C1 AE C3 F3 94 EA CC 2D 55
 F7 4F 0C 00 E3 EB 4A D2

After χ

6E F5 47 C1 EB C5 36 A2 12 A9 FE A8 A8 14 E9 E0
 10 BC 27 20 B3 B7 D9 4F AB 74 BC 7F 92 3E 10 72
 B8 A5 DD DD A8 3B A0 15 7D 8C BA 55 C1 92 DF 69
 65 CB 7D BA 46 A3 34 0D F8 C3 FA 89 C7 C4 DB 53
 9D 38 DC 40 6F 1D 2C F5 4E 59 05 58 0B 44 04 BF
 D7 B3 71 95 61 C5 A5 9D 5D FD B1 BF 93 DF 13 82
 52 25 ED CC E0 FA 7D 87 EF CD 23 9F EB 49 FC 9E
 2D E9 D8 28 FE EB 1F 2C F5 79 B9 5D D0 50 AB 2C
 A4 71 05 A8 D3 0F 3F D2 A1 15 4C 15 F8 7F B3 7B
 2C 71 56 BD 7F 3C F2 B7 45 C9 12 A4 0B C1 B5 59
 B6 56 E3 E9 03 CC 57 33 C4 3D 0F 07 4E D2 25 96
 A6 64 E2 31 44 E9 BF 43 AE D3 F0 4D EA C8 A8 75
 BF E7 10 02 07 F9 6A 52

After t

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66 75 47 41 EB C5 36 22 12 A9 FE A8 A8 14 E9 E0
10 BC 27 20 B3 B7 D9 4F AB 74 BC 7F 92 3E 10 72
B8 A5 DD DD A8 3B A0 15 7D 8C BA 55 C1 92 DF 69
65 CB 7D BA 46 A3 34 0D F8 C3 FA 89 C7 C4 DB 53
9D 38 DC 40 6F 1D 2C F5 4E 59 05 58 0B 44 04 BF
D7 B3 71 95 61 C5 A5 9D 5D FD B1 BF 93 DF 13 82
52 25 ED CC E0 FA 7D 87 EF CD 23 9F EB 49 FC 9E
2D E9 D8 28 FE EB 1F 2C F5 79 B9 5D D0 50 AB 2C
A4 71 05 A8 D3 0F 3F D2 A1 15 4C 15 F8 7F B3 7B
2C 71 56 BD 7F 3C F2 B7 45 C9 12 A4 0B C1 B5 59
B6 56 E3 E9 03 CC 57 33 C4 3D 0F 07 4E D2 25 96
A6 64 E2 31 44 E9 BF 43 AE D3 F0 4D EA C8 A8 75
      BF E7 10 02 07 F9 6A 52

```

After permutation

```

66 75 47 41 EB C5 36 22 12 A9 FE A8 A8 14 E9 E0
10 BC 27 20 B3 B7 D9 4F AB 74 BC 7F 92 3E 10 72
B8 A5 DD DD A8 3B A0 15 7D 8C BA 55 C1 92 DF 69
65 CB 7D BA 46 A3 34 0D F8 C3 FA 89 C7 C4 DB 53
9D 38 DC 40 6F 1D 2C F5 4E 59 05 58 0B 44 04 BF
D7 B3 71 95 61 C5 A5 9D 5D FD B1 BF 93 DF 13 82
52 25 ED CC E0 FA 7D 87 EF CD 23 9F EB 49 FC 9E
2D E9 D8 28 FE EB 1F 2C F5 79 B9 5D D0 50 AB 2C
A4 71 05 A8 D3 0F 3F D2 A1 15 4C 15 F8 7F B3 7B
2C 71 56 BD 7F 3C F2 B7 45 C9 12 A4 0B C1 B5 59
B6 56 E3 E9 03 CC 57 33 C4 3D 0F 07 4E D2 25 96
A6 64 E2 31 44 E9 BF 43 AE D3 F0 4D EA C8 A8 75
      BF E7 10 02 07 F9 6A 52

```


State (as lanes of integers)

[0,0] = 2236C5EB41477566
 [1,0] = E0E914A8A8FEA912
 [2,0] = 4FD9B7B32027BC10
 [3,0] = 72103E927FBC74AB
 [4,0] = 15A03BA8DDDDA5B8
 [0,1] = 69DF92C155BA8C7D
 [1,1] = 0D34A346BA7DCB65
 [2,1] = 53DBC4C789FAC3F8
 [3,1] = F52C1D6F40DC389D
 [4,1] = BF04440B5805594E
 [0,2] = 9DA5C5619571B3D7
 [1,2] = 8213DF93BFB1FD5D
 [2,2] = 877DFAE0CCED2552
 [3,2] = 9EFC49EB9F23CDEF
 [4,2] = 2C1FEBFE28D8E92D
 [0,3] = 2CAB50D05DB979F5
 [1,3] = D23F0FD3A80571A4
 [2,3] = 7BB37FF8154C15A1
 [3,3] = B7F23C7FBD56712C
 [4,3] = 59B5C10BA412C945
 [0,4] = 3357CC03E9E356B6
 [1,4] = 9625D24E070F3DC4
 [2,4] = 43BFE94431E264A6
 [3,4] = 75A8C8EA4DF0D3AE
 [4,4] = 526AF9070210E7BF

About to call squeeze (again)

State before permutation (in bytes)

66 75 47 41 EB C5 36 22 12 A9 FE A8 A8 14 E9 E0
 10 BC 27 20 B3 B7 D9 4F AB 74 BC 7F 92 3E 10 72
 B8 A5 DD DD A8 3B A0 15 7D 8C BA 55 C1 92 DF 69
 65 CB 7D BA 46 A3 34 0D F8 C3 FA 89 C7 C4 DB 53
 9D 38 DC 40 6F 1D 2C F5 4E 59 05 58 0B 44 04 BF
 D7 B3 71 95 61 C5 A5 9D 5D FD B1 BF 93 DF 13 82
 52 25 ED CC E0 FA 7D 87 EF CD 23 9F EB 49 FC 9E
 2D E9 D8 28 FE EB 1F 2C F5 79 B9 5D D0 50 AB 2C
 A4 71 05 A8 D3 0F 3F D2 A1 15 4C 15 F8 7F B3 7B
 2C 71 56 BD 7F 3C F2 B7 45 C9 12 A4 0B C1 B5 59
 B6 56 E3 E9 03 CC 57 33 C4 3D 0F 07 4E D2 25 96
 A6 64 E2 31 44 E9 BF 43 AE D3 F0 4D EA C8 A8 75
 BF E7 10 02 07 F9 6A 52

State before permutation (as lanes of integers)

[0, 0] = 2236C5EB41477566
 [1, 0] = E0E914A8A8FEA912
 [2, 0] = 4FD9B7B32027BC10
 [3, 0] = 72103E927FBC74AB
 [4, 0] = 15A03BA8DDDDA5B8
 [0, 1] = 69DF92C155BA8C7D
 [1, 1] = 0D34A346BA7DCB65
 [2, 1] = 53DBC4C789FAC3F8
 [3, 1] = F52C1D6F40DC389D
 [4, 1] = BF04440B5805594E
 [0, 2] = 9DA5C5619571B3D7
 [1, 2] = 8213DF93BFB1FD5D
 [2, 2] = 877DFAE0CCED2552
 [3, 2] = 9EFC49EB9F23CDEF
 [4, 2] = 2C1FEBFE28D8E92D
 [0, 3] = 2CAB50D05DB979F5
 [1, 3] = D23F0FD3A80571A4
 [2, 3] = 7BB37FF8154C15A1
 [3, 3] = B7F23C7FBD56712C
 [4, 3] = 59B5C10BA412C945
 [0, 4] = 3357CC03E9E356B6
 [1, 4] = 9625D24E070F3DC4
 [2, 4] = 43BFE94431E264A6
 [3, 4] = 75A8C8EA4DF0D3AE
 [4, 4] = 526AF9070210E7BF

Round #0

After θ

D3 E8 34 4E 7A 02 FB F8 E6 9B 14 1E 60 24 BF 6F
 ED 29 D5 83 55 3F 38 D3 55 29 26 28 18 79 AA CB
 FC 4D 94 E6 1B B8 5A 5D C8 11 C9 5A 50 55 12 B3
 91 F9 97 0C 8E 93 62 82 05 56 08 2A 21 4C 3A CF
 63 65 46 17 E5 5A 96 4C 0A B1 4C 63 B8 C7 FE F7
 62 2E 02 9A F0 02 68 47 A9 CF 5B 09 5B EF 45 0D
 AF B0 1F 6F 06 72 9C 1B 11 90 B9 C8 61 0E 46 27
 69 01 91 13 4D 68 E5 64 40 E4 CA 52 41 97 66 F6
 50 43 EF 1E 1B 3F 69 5D 5C 80 BE B6 1E F7 52 E7
 D2 2C CC EA F5 7B 48 0E 01 21 5B 9F B8 42 4F 11
 03 CB 90 E6 92 0B 9A E9 30 0F E5 B1 86 E2 73 19
 5B F1 10 92 A2 61 5E DF 50 8E 6A 1A 60 8F 12 CC
 FB 0F 59 39 B4 7A 90 1A

After ρ

D3 E8 34 4E 7A 02 FB F8 CC 37 29 3C C0 48 7E DF
 7B 4A F5 60 D5 0F CE 74 91 A7 BA 5C 95 62 82 82
 C0 D5 EA E2 6F A2 34 DF 05 55 25 31 8B 1C 91 AC
 C9 E0 38 29 26 18 99 7F 73 81 15 82 4A 08 93 CE
 32 A3 8B 72 2D 4B A6 B1 EC 7F AF 10 CB 34 86 7B
 12 73 11 D0 84 17 40 3B 35 A4 3E 6F 25 6C BD 17
 78 33 90 E3 DC 78 85 FD 1C 8C 4E 22 20 73 91 C3
 89 26 B4 72 B2 B4 80 C8 A5 82 2E CD EC 81 C8 95
 DD 63 E3 27 AD 0B 6A E8 A9 73 2E 40 5F 5B 8F 7B
 0F C9 41 9A 85 59 BD 7E 11 01 21 5B 9F B8 42 4F
 68 A6 0F 2C 43 9A 4B 2E C0 3C 94 C7 1A 8A CF 65
 2B 1E 42 52 34 CC EB 7B 8E 6A 1A 60 8F 12 CC 50
 A4 C6 FE 43 56 0E AD 1E

After π

D3 E8 34 4E 7A 02 FB F8 C9 E0 38 29 26 18 99 7F
 78 33 90 E3 DC 78 85 FD 0F C9 41 9A 85 59 BD 7E
 A4 C6 FE 43 56 0E AD 1E 91 A7 BA 5C 95 62 82 82
 EC 7F AF 10 CB 34 86 7B 12 73 11 D0 84 17 40 3B
 DD 63 E3 27 AD 0B 6A E8 2B 1E 42 52 34 CC EB 7B
 CC 37 29 3C C0 48 7E DF 73 81 15 82 4A 08 93 CE
 1C 8C 4E 22 20 73 91 C3 11 01 21 5B 9F B8 42 4F
 68 A6 0F 2C 43 9A 4B 2E C0 D5 EA E2 6F A2 34 DF
 05 55 25 31 8B 1C 91 AC 35 A4 3E 6F 25 6C BD 17
 A9 73 2E 40 5F 5B 8F 7B 8E 6A 1A 60 8F 12 CC 50
 7B 4A F5 60 D5 0F CE 74 32 A3 8B 72 2D 4B A6 B1
 89 26 B4 72 B2 B4 80 C8 A5 82 2E CD EC 81 C8 95
 C0 3C 94 C7 1A 8A CF 65

After χ

E3 FB B4 8C A2 62 FF 78 CE 28 79 31 27 19 A1 7D
 D8 35 2E A2 8E 7E 85 FD 5C E1 41 96 AD 59 EF 9E
 AC C6 F6 62 52 16 AD 19 83 A7 AA 9C 91 61 C2 82
 21 7F 4D 37 E2 3C AC BB 30 6F 11 80 94 D3 C1 28
 4D C2 5B 2B 2C 29 6A 68 47 46 47 52 7E D8 EF 02
 C0 3B 63 1C E0 3B 7E DE 72 80 34 DB D5 80 D1 C2
 74 2A 40 06 60 71 98 E3 95 10 01 4B 1F F8 76 9E
 5B 26 1B AE 49 9A CA 2E F0 75 F0 AC 4B C2 18 CC
 8D 06 25 31 D1 0F 93 C4 33 AC 2E 4F A5 6C FD 17
 E9 E6 CE C2 3F FB BF F4 8B 6A 1F 71 0F 0E 4D 70
 F2 4E C1 60 47 BB CE 3C 16 23 81 FF 61 4A EE A4
 C9 1A 24 70 A0 BE 87 A8 9E C0 4F ED 29 84 C8 85
 C0 9D 9E D5 32 CA EF E4

After t

E2 FB B4 8C A2 62 FF 78 CE 28 79 31 27 19 A1 7D
D8 35 2E A2 8E 7E 85 FD 5C E1 41 96 AD 59 EF 9E
AC C6 F6 62 52 16 AD 19 83 A7 AA 9C 91 61 C2 82
21 7F 4D 37 E2 3C AC BB 30 6F 11 80 94 D3 C1 28
4D C2 5B 2B 2C 29 6A 68 47 46 47 52 7E D8 EF 02
C0 3B 63 1C E0 3B 7E DE 72 80 34 DB D5 80 D1 C2
74 2A 40 06 60 71 98 E3 95 10 01 4B 1F F8 76 9E
5B 26 1B AE 49 9A CA 2E F0 75 F0 AC 4B C2 18 CC
8D 06 25 31 D1 0F 93 C4 33 AC 2E 4F A5 6C FD 17
E9 E6 CE C2 3F FB BF F4 8B 6A 1F 71 0F 0E 4D 70
F2 4E C1 60 47 BB CE 3C 16 23 81 FF 61 4A EE A4
C9 1A 24 70 A0 BE 87 A8 9E C0 4F ED 29 84 C8 85
C0 9D 9E D5 32 CA EF E4

(Skip rounds 1 to 22)

Round #23

After θ

F9 F3 31 CD DE 7F AA 7C C7 29 EA 3A 25 16 46 21
D9 DC 2A 68 AB 06 96 C9 EA AE EB A0 89 44 A1 DF
FE A3 F1 85 FB 75 44 07 74 0E F5 B6 28 5C C2 D8
31 35 63 38 F6 C6 FE 3D 49 80 BE 20 6E EB 7A 7F
8D 5B 31 30 16 E5 3F 80 99 83 69 F0 DF D0 C1 32
C0 7C A7 42 18 2A 3E 57 DB 05 6F C2 91 67 0C 0A
D1 9D 32 23 6F 9E AF 67 28 4B 65 DC 19 C2 90 EC
08 4D 57 4A F3 90 A8 80 2E 3C 8C 93 E9 F6 8C 7D
3E 4B 4D CB 2C 79 65 62 51 1E E0 AC 22 DC B3 71
15 17 78 27 F0 30 55 4D 13 12 29 98 84 75 7D E5
83 00 8C 30 62 77 FB D5 E0 5C EA 1E 67 2D 74 A2
F0 51 87 FE C8 E8 5F BD 08 9D 84 2D 3A 0C BC 55
CE 9E EC 8C BE 08 98 D0

After ρ

F9 F3 31 CD DE 7F AA 7C 8E 53 D4 75 4A 2C 8C 42
 36 B7 0A DA AA 81 65 72 48 14 FA AD EE BA 0E 9A
 AF 23 3A F0 1F 8D 2F DC 8B C2 25 8C 4D B7 50 6F
 86 63 6F EC DF 13 53 33 5F 12 A0 2F 88 DB BA DE
 AD 18 18 8B F2 1F C0 C6 1D 2C 93 39 98 06 FF 0D
 02 E6 3B 15 C2 50 F1 B9 28 6C 17 BC 09 47 9E 31
 19 79 FB 7C 3D 8B EE 94 84 21 D9 51 96 CA B8 33
 A5 79 48 54 40 84 A6 2B 27 D3 ED 19 FB 5C 78 18
 69 99 25 AF 4C CC 67 A9 D9 B8 28 0F 70 56 11 EE
 A6 AA A9 E2 02 EF 04 1E E5 13 12 29 98 84 75 7D
 ED 57 0F 02 30 C2 88 DD 82 73 A9 7B 9C B5 D0 89
 3E EA D0 1F 19 FD AB 17 9D 84 2D 3A 0C BC 55 08
 26 B4 B3 27 3B A3 2F 02

After π

F9 F3 31 CD DE 7F AA 7C 86 63 6F EC DF 13 53 33
 19 79 FB 7C 3D 8B EE 94 A6 AA A9 E2 02 EF 04 1E
 26 B4 B3 27 3B A3 2F 02 48 14 FA AD EE BA 0E 9A
 1D 2C 93 39 98 06 FF 0D 02 E6 3B 15 C2 50 F1 B9
 69 99 25 AF 4C CC 67 A9 3E EA D0 1F 19 FD AB 17
 8E 53 D4 75 4A 2C 8C 42 5F 12 A0 2F 88 DB BA DE
 84 21 D9 51 96 CA B8 33 E5 13 12 29 98 84 75 7D
 ED 57 0F 02 30 C2 88 DD AF 23 3A F0 1F 8D 2F DC
 8B C2 25 8C 4D B7 50 6F 28 6C 17 BC 09 47 9E 31
 D9 B8 28 0F 70 56 11 EE 9D 84 2D 3A 0C BC 55 08
 36 B7 0A DA AA 81 65 72 AD 18 18 8B F2 1F C0 C6
 A5 79 48 54 40 84 A6 2B 27 D3 ED 19 FB 5C 78 18
 82 73 A9 7B 9C B5 D0 89

After χ

E0 EB A1 DD FE F7 06 F8 20 E1 6F 6E DD 77 53 39
 19 6D E9 79 04 8B C5 94 7F E9 A9 2A C6 B3 84 62
 20 B4 FD 07 3A A3 7E 01 4A D6 D2 A9 AC EA 0E 2A
 74 35 97 93 94 8A F9 0D 14 84 EB 05 D3 61 79 AF
 29 8D 0F 0F AA CE 63 21 2B C2 D1 0F 09 F9 5A 12
 0E 72 8D 25 5C 2C 8C 63 3E 00 A2 07 80 DF FF 92
 8C 65 D4 53 B6 88 30 B3 E7 13 C2 5C D2 A8 71 7F
 BC 57 2F 08 B0 11 BA 41 8F 0F 28 C0 1F CD A1 CC
 5A 52 0D 8F 3D A7 51 A1 2C 68 12 8C 05 EF DA 31
 FB 9B 3A CF 63 57 3B 3A 9D 44 28 36 4C 8E 05 2B
 36 D6 4A 8E AA 01 43 5B AF 9A BD 82 49 47 98 D6
 25 59 48 36 44 25 26 AA 13 57 EF 99 D9 5C 5D 6A
 0B 7B B9 7A CC AB 50 0D

After t

```

E8 6B A1 5D FE F7 06 78 20 E1 6F 6E DD 77 53 39
19 6D E9 79 04 8B C5 94 7F E9 A9 2A C6 B3 84 62
20 B4 FD 07 3A A3 7E 01 4A D6 D2 A9 AC EA 0E 2A
74 35 97 93 94 8A F9 0D 14 84 EB 05 D3 61 79 AF
29 8D 0F 0F AA CE 63 21 2B C2 D1 0F 09 F9 5A 12
0E 72 8D 25 5C 2C 8C 63 3E 00 A2 07 80 DF FF 92
8C 65 D4 53 B6 88 30 B3 E7 13 C2 5C D2 A8 71 7F
BC 57 2F 08 B0 11 BA 41 8F 0F 28 C0 1F CD A1 CC
5A 52 0D 8F 3D A7 51 A1 2C 68 12 8C 05 EF DA 31
FB 9B 3A CF 63 57 3B 3A 9D 44 28 36 4C 8E 05 2B
36 D6 4A 8E AA 01 43 5B AF 9A BD 82 49 47 98 D6
25 59 48 36 44 25 26 AA 13 57 EF 99 D9 5C 5D 6A
0B 7B B9 7A CC AB 50 0D

```

After permutation

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E8 6B A1 5D FE F7 06 78 20 E1 6F 6E DD 77 53 39
19 6D E9 79 04 8B C5 94 7F E9 A9 2A C6 B3 84 62
20 B4 FD 07 3A A3 7E 01 4A D6 D2 A9 AC EA 0E 2A
74 35 97 93 94 8A F9 0D 14 84 EB 05 D3 61 79 AF
29 8D 0F 0F AA CE 63 21 2B C2 D1 0F 09 F9 5A 12
0E 72 8D 25 5C 2C 8C 63 3E 00 A2 07 80 DF FF 92
8C 65 D4 53 B6 88 30 B3 E7 13 C2 5C D2 A8 71 7F
BC 57 2F 08 B0 11 BA 41 8F 0F 28 C0 1F CD A1 CC
5A 52 0D 8F 3D A7 51 A1 2C 68 12 8C 05 EF DA 31
FB 9B 3A CF 63 57 3B 3A 9D 44 28 36 4C 8E 05 2B
36 D6 4A 8E AA 01 43 5B AF 9A BD 82 49 47 98 D6
25 59 48 36 44 25 26 AA 13 57 EF 99 D9 5C 5D 6A
0B 7B B9 7A CC AB 50 0D

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