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**AMENDMENT 1**
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# Information technology — Security techniques — Encryption algorithms —

## Part 3:
## Block ciphers

## AMENDMENT 1: SM4

*Technologies de l'information — Techniques de sécurité — Algorithmes de chiffrement —*

*Partie 3: Chiffrement par blocs*

*AMENDEMENT 1: SM4*

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 27, *Information security, cybersecurity and privacy protection*.

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# Information technology — Security techniques — Encryption algorithms —

## Part 3:
## Block ciphers

## AMENDMENT 1: SM4

*Clause 1*

In the first paragraph, replace "seven different block ciphers" with "eight different block ciphers".

Replace Table 1 with the following:

| Block length | Algorithm name (see #) | Key length |
|---|---|---|
| 64 bits | TDEA (4.2) | 128 or 192 bits |
| | MISTY (4.3) | 128 bits |
| | CAST-128 (4.4) | |
| | HIGHT (4.5) | |
| 128 bits | AES (5.2) | 128, 192 or 256 bits |
| | Camellia (5.3) | |
| | SEED (5.4) | 128 bits |
| | SM4 (5.5) | |

*5.1*

Replace the sentence with the following:

In this clause, four 128-bit block ciphers are specified: AES in 5.2, Camellia in 5.3, SEED in 5.4, and SM4 in 5.5.

*5.5*

Add new subclause 5.5 as follows:

**5.5   SM4**

**5.5.1   The SM4 algorithm**

The SM4 algorithm is a symmetric block cipher that can process data blocks of 128 bits, using a cipher key with length of 128 bits under 32 rounds.

**5.5.2   SM4 encryption**

A 128-bit block $P$ is transformed into a 128-bit block $C$ using the following procedure, where for $i$ = 0, 1, 2, 3 the $X_i$ are 32-bit variables, and for $i$ = 0, 1, ..., 31 the $rk_i$ are 32-bit subkeys:

(1) $P = X_0 \| X_1 \| X_2 \| X_3$

(2) for $i$ = 0 to 31:

$$X_{i+4} = \mathrm{F}(X_i, X_{i+1}, X_{i+2}, X_{i+3}, rk_i)$$

(3) $C = X_{35} \| X_{34} \| X_{33} \| X_{32}$

### 5.5.3 SM4 decryption

The decryption operation is identical to the encryption operation, except that the rounds (and therefore the subkeys) are used in reverse order:

(1) $C = X_{35} \| X_{34} \| X_{33} \| X_{32}$

(2) for $i$ = 31 to 0:

$$X_i = \mathrm{F}(X_{i+4}, X_{i+1}, X_{i+2}, X_{i+3}, rk_i)$$

(3) $P = X_0 \| X_1 \| X_2 \| X_3$

### 5.5.4 SM4 functions

#### 5.5.4.1 Function F

The function F is used for both encryption and decryption. The function F is defined as follows:

$$\mathrm{F}(X_0, X_1, X_2, X_3, rk) = X_0 \oplus \mathrm{T}(X_1 \oplus X_2 \oplus X_3 \oplus rk)$$

where $X_i$ ($i$ = 0, 1, 2, 3) and $rk$ are bit strings of length 32, T is a permutation defined in 5.5.4.2.

#### 5.5.4.2 Permutation T and T'

##### 5.5.4.2.1 General

The permutation T is used both for encryption and decryption. T is a composition of a nonlinear transformation $\tau$ and a linear transformation L, that is $\mathrm{T}(\cdot) = \mathrm{L}(\tau(\cdot))$. The permutation T' is used for the key schedule. T' is a composition of the nonlinear transformation $\tau$ and a linear transformation L', that is $\mathrm{T}'(\cdot) = \mathrm{L}'(\tau(\cdot))$. T, T', L, L' and $\tau$ are all transformations on 32-bit strings.

##### 5.5.4.2.2 Nonlinear transformation $\tau$

The nonlinear transformation $\tau$ is defined as follows, where for $i$ = 0, 1, 2, 3 the $a_i$ are bytes and S is an S-box defined in 5.5.4.2.4:

$$\tau(a_0 \| a_1 \| a_2 \| a_3) = \mathrm{S}(a_0) \| \mathrm{S}(a_1) \| \mathrm{S}(a_2) \| \mathrm{S}(a_3).$$

##### 5.5.4.2.3 Linear transformation L and L'

The linear transformation L is defined as follows ($B$ is a 32-bit variable):

$$\mathrm{L}(B) = B \oplus (B{<<<}_2) \oplus (B{<<<}_{10}) \oplus (B{<<<}_{18}) \oplus (B{<<<}_{24}).$$

The linear transformation L' is defined as follows ($B$ is a 32-bit variable):

$$\mathrm{L}'(B) = B \oplus (B{<<<}_{13}) \oplus (B{<<<}_{23}).$$

##### 5.5.4.2.4 S-box S

The S-box S used in the transformation $\tau$ is presented in hexadecimal form in Table 17.

**Table 17 — SM4 S-box**

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | a | b | c | d | e | f |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | d6 | 90 | e9 | fe | cc | e1 | 3d | b7 | 16 | b6 | 14 | c2 | 28 | fb | 2c | 05 |
| **1** | 2b | 67 | 9a | 76 | 2a | be | 04 | c3 | aa | 44 | 13 | 26 | 49 | 86 | 06 | 99 |
| **2** | 9c | 42 | 50 | f4 | 91 | ef | 98 | 7a | 33 | 54 | 0b | 43 | ed | cf | ac | 62 |
| **3** | e4 | b3 | 1c | a9 | c9 | 08 | e8 | 95 | 80 | df | 94 | fa | 75 | 8f | 3f | a6 |
| **4** | 47 | 07 | a7 | fc | f3 | 73 | 17 | ba | 83 | 59 | 3c | 19 | e6 | 85 | 4f | a8 |
| **5** | 68 | 6b | 81 | b2 | 71 | 64 | da | 8b | f8 | eb | 0f | 4b | 70 | 56 | 9d | 35 |
| **6** | 1e | 24 | 0e | 5e | 63 | 58 | d1 | a2 | 25 | 22 | 7c | 3b | 01 | 21 | 78 | 87 |
| **7** | d4 | 00 | 46 | 57 | 9f | d3 | 27 | 52 | 4c | 36 | 02 | e7 | a0 | c4 | c8 | 9e |
| **8** | ea | bf | 8a | d2 | 40 | c7 | 38 | b5 | a3 | f7 | f2 | ce | f9 | 61 | 15 | a1 |
| **9** | e0 | ae | 5d | a4 | 9b | 34 | 1a | 55 | ad | 93 | 32 | 30 | f5 | 8c | b1 | e3 |
| **a** | 1d | f6 | e2 | 2e | 82 | 66 | ca | 60 | c0 | 29 | 23 | ab | 0d | 53 | 4e | 6f |
| **b** | d5 | db | 37 | 45 | de | fd | 8e | 2f | 03 | ff | 6a | 72 | 6d | 6c | 5b | 51 |
| **c** | 8d | 1b | af | 92 | bb | dd | bc | 7f | 11 | d9 | 5c | 41 | 1f | 10 | 5a | d8 |
| **d** | 0a | c1 | 31 | 88 | a5 | cd | 7b | bd | 2d | 74 | d0 | 12 | b8 | e5 | b4 | b0 |
| **e** | 89 | 69 | 97 | 4a | 0c | 96 | 77 | 7e | 65 | b9 | f1 | 09 | c5 | 6e | c6 | 84 |
| **f** | 18 | f0 | 7d | ec | 3a | dc | 4d | 20 | 79 | ee | 5f | 3e | d7 | cb | 39 | 48 |

### 5.5.5 SM4 key schedule

The key scheduling part accepts a 128-bit master key $MK = MK_0 \parallel MK_1 \parallel MK_2 \parallel MK_3$, and yields 32 subkeys, as shown below.

(1) $K_0 \parallel K_1 \parallel K_2 \parallel K_3 = (MK_0 \oplus FK_0) \parallel (MK_1 \oplus FK_1) \parallel (MK_2 \oplus FK_2) \parallel (MK_3 \oplus FK_3)$

(2) for $i$ = 0 to 31:

$$rk_i = K_{i+4} = K_i \oplus \text{T'}(K_{i+1} \oplus K_{i+2} \oplus K_{i+3} \oplus CK_i)$$

The constants $FK_i$ ($i$ = 0, 1, 2, 3) are as follows (in hexadecimal form):

$FK_0$ = a3b1bac6, $FK_1$ = 56aa3350, $FK_2$ = 677d9197, $FK_3$ = b27022dc.

The constants $CK_i$ ($i$ = 0, 1, …, 31) are defined as follows. Suppose $CK_i = ck_{i,0} \parallel ck_{i,1} \parallel ck_{i,2} \parallel ck_{i,3}$, where $ck_{i,j}$ are bytes, and $ck_{i,j} = (4i+j) \times 7$ (mod 256) ($i$ = 0, 1, …, 31, $j$ = 0, 1, 2, 3).

Thus, the values of $CK_i$ ($i$ = 0, 1, …, 31) are (in hexadecimal form):

```
00070e15,   1c232a31,   383f464d,   545b6269,
70777e85,   8c939aa1,   a8afb6bd,   c4cbd2d9,
e0e7eef5,   fc030a11,   181f262d,   343b4249,
50575e65,   6c737a81,   888f969d,   a4abb2b9,
c0c7ced5,   dce3eaf1,   f8ff060d,   141b2229,
30373e45,   4c535a61,   686f767d,   848b9299,
a0a7aeb5,   bcc3cad1,   d8dfe6ed,   f4fb0209,
10171e25,   2c333a41,   484f565d,   646b7279.
```

*Annex B*

Insert the following line after `id-bc128-seed`:

```
id-bc128-sm4 OID ::= {id-bc128 sm4(4)}
```

Replace{ OID id-bc128-seed PARMS KeyLength } , with the following:

```
{ OID id-bc128-seed PARMS KeyLength } |
{ OID id-bc128-sm4  PARMS KeyLength },
```

*Annex D*

Change the title to "Numerical examples".

Replace "test vectors" with "numerical examples".

*D.1*

Change the heading to "General".

Replace the text with the following :

This annex provides numerical examples for TDEA, MISTY1, CAST-128, HIGHT, AES, Camellia, SEED, and SM4 ciphers. In these examples, all data are expressed in hexadecimal.

*D.9*

Add new clause D.9 as follows:

**D.9   SM4 numerical examples**

**D.9.1   SM4 encryption**

Given inputs (plaintext and key), output (ciphertext and subkeys) and intermediate values are described.

Input plaintext: 01 23 45 67 89 ab cd ef fe dc ba 98 76 54 32 10.

Input key: 01 23 45 67 89 ab cd ef fe dc ba 98 76 54 32 10.

The subkeys and the values of the output of each round:

$rk_0$ = f12186f9          $X_4$ = 27fad345

$rk_1$ = 41662b61          $X_5$ = a18b4cb2

$rk_2$ = 5a6ab19a          $X_6$ = 11c1e22a

$rk_3$ = 7ba92077          $X_7$ = cc13e2ee

$rk_4$ = 367360f4          $X_8$ = f87c5bd5

$rk_5$ = 776a0c61          $X_9$ = 33220757

$rk_6$ = b6bb89b3          $X_{10}$ = 77f4c297

$rk_7$ = 24763151          $X_{11}$ = 7a96f2eb

$rk_8$ = a520307c          $X_{12}$ = 27dac07f

$rk_9$ = b7584dbd          $X_{13}$ = 42dd0f19

$rk_{10}$ = c30753ed          $X_{14}$ = b8a5da02

$rk_{11}$ = 7ee55b57          $X_{15}$ = 907127fa

$rk_{12}$ = 6988608c          $X_{16}$ = 8b952b83

$rk_{13}$ = 30d895b7          $X_{17}$ = d42b7c59

$rk_{14}$ = 44ba14af          $X_{18}$ = 2ffc5831

$rk_{15}$ = 104495a1          $X_{19}$ = f69e6888

$rk_{16}$ = d120b428          $X_{20}$ = af2432c4

$rk_{17}$ = 73b55fa3          $X_{21}$ = ed1ec85e

$rk_{18}$ = cc874966          $X_{22}$ = 55a3ba22

$rk_{19}$ = 92244439          $X_{23}$ = 124b18aa

$rk_{20}$ = e89e641f          $X_{24}$ = 6ae7725f

$rk_{21}$ = 98ca015a          $X_{25}$ = f4cba1f9

$rk_{22}$ = c7159060          $X_{26}$ = 1dcdfa10

$rk_{23}$ = 99e1fd2e          $X_{27}$ = 2ff60603

$rk_{24}$ = b79bd80c          $X_{28}$ = eff24fdc

$rk_{25}$ = 1d2115b0          $X_{29}$ = 6fe46b75

$rk_{26}$ = 0e228aeb          $X_{30}$ = 893450ad

$rk_{27}$ = f1780c81          $X_{31}$ = 7b938f4c

$rk_{28}$ = 428d3654          $X_{32}$ = 536e4246

$rk_{29}$ = 62293496          $X_{33}$ = 86b3e94f

$rk_{30}$ = 01cf72e5          $X_{34}$ = d206965e

$rk_{31}$ = 9124a012          $X_{35}$ = 681edf34

The output ciphertext: 68 1e df 34 d2 06 96 5e 86 b3 e9 4f 53 6e 42 46.

### D.9.2   SM4 encryption 1 000 000 times

Given inputs (plaintext and key), output (ciphertext) after encryption iteratively 1 000 000 times is described.

Input plaintext: 01 23 45 67 89 ab cd ef fe dc ba 98 76 54 32 10.