International Standard

ISO/IEC 18004

Fourth edition
2024-08

Information technology — Automatic identification and data capture techniques — QR code bar code symbology specification

Technologies de l'information — Technologie d'identification automatique et de capture des données — Spécification de la symbologie de code à barres code QR

Reference number
ISO/IEC 18004:2024(en)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

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 or www.iec.ch/members_experts/refdocs).

ISO and IEC draw attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO and IEC take no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO and IEC had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents and https://patents.iec.ch. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This fourth edition cancels and replaces the third edition (ISO/IEC 18004:2015), which has been technically revised.

The main changes are as follows:

— continuous grading according to ISO/IEC 15415 has been adopted for grade fixed pattern damage;

— the reference decoding algorithm has been clarified.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

There are four technically different, but closely related members of the QR code family, which represent an evolutionary sequence.

— QR code model 1 is the original specification for QR code and is described in AIM ITS 97-001[21].

— QR code model 2 is an enhanced form of the symbology with additional features (primarily, the addition of alignment patterns to assist navigation in larger symbols) and is the basis of the first edition of this document (i.e. ISO/IEC 18004:2000).

— QR code [the basis of the second edition of this document (i.e. ISO/IEC 18004:2006)] is very similar to QR code model 2; its QR code format differs only in the addition of the facility for symbols to appear in a mirror image orientation for reflectance reversal (light symbols on dark backgrounds) and the option for specifying alternative character is set to the default.

— The micro QR code format [also specified in the second edition of this document (i.e. ISO/IEC 18004:2006)], is a variant of QR code with a reduced number of overhead modules and a restricted range of sizes, which enables small to moderate amount of data to be represented in a small symbol, particularly suited to direct marking on parts and components, and to applications where the space available for the symbol is severely restricted.

QR code is a matrix symbology. The symbols consist of an array of nominally square modules arranged in an overall square pattern, including a unique finder pattern located at three corners of the symbol (in micro QR code symbols, at a single corner) and intended to assist in easy location of its position, size and inclination. A wide range of sizes of symbol is provided for, together with four levels of error correction. Module dimensions are user-specific to enable symbol production by a wide variety of techniques.

QR code model 2 symbols are fully compatible with QR code reading systems.

QR code model 1 symbols are recommended only to be used in closed system applications. Equipment complying with this document are not required to support QR code model 1 symbols. Since QR code is the recommended model for new, open system application of QR code, this document describes QR code fully. This document also lists the features in which QR code model 1 differs from QR code in Annex N.

Information technology — Automatic identification and data capture techniques — QR code bar code symbology specification

1 Scope

This document specifies requirements for the symbology known as “QR code”. It specifies the QR code symbology characteristics, data character encoding methods, symbol formats, dimensional characteristics, error correction rules, reference decoding algorithm, production quality requirements and user-selectable application parameters.

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 15415, *Information technology — Automatic identification and data capture techniques — Bar code symbol print quality test specification — Two-dimensional symbols*

ISO/IEC 15424:—[1)], *Information technology — Automatic identification and data capture techniques — Data Carrier Identifiers (including Symbology Identifiers)*

ISO/IEC 19762, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
character count indicator
bit sequence which defines the data string length in a *mode* (3.10)

3.2
data masking
process of XORing the bit pattern in the *encoding region* (3.4) with a data mask pattern to provide a symbol with more evenly balanced numbers of dark and light modules, and reduced occurrence of patterns which would interfere with fast processing of the image

3.3
data mask pattern reference
3-bit identifier of the *data masking* (3.2) patterns applied to the symbol

1) Under preparation. Stage at the time of publication: ISO/IEC DIS 15424:2024.

3.4
encoding region
region of the symbol not occupied by *function patterns* (3.8) and available for encoding data and error correction codewords, and for *version* (3.20) and *format information* (3.7)

3.5
exclusive subset
subset of characters within the character set of a *mode* (3.10) which are not shared with the more restricted character set of another mode

3.6
extension pattern
function pattern (3.8) in model 1 symbols, which does not encode data

3.7
format information
encoded pattern containing information on symbol characteristics essential to enable the remainder of the *encoding region* (3.4) to be decoded

3.8
function pattern
overhead component of the symbol (finder, *separator* (3.16), *timing patterns* (3.19) and alignment patterns) required for location of the symbol or identification of its characteristics to assist in decoding

3.9
masking
process of XORing the bit pattern in an area of the symbol with a mask pattern to reduce the occurrence of patterns which would interfere with fast processing of the image

3.10
mode
method of representing a defined character set as a bit string

3.11
mode indicator
1-bit to 4-bit identifier (depending on symbol size) indicating in which *mode* (3.10) the following data sequence is encoded

3.12
padding bit
zero bit, not representing data, used to fill empty positions of the final codeword after the *terminator* (3.18) in a data bit string

3.13
remainder bit
zero bit, not representing data, used to fill empty positions of the symbol *encoding region* (3.4) after the final symbol character, where the area of the encoding region available for symbol characters does not divide exactly into 8-bit symbol characters

3.14
remainder codeword
pad codeword, placed after the error correction codewords, used to fill empty codeword positions to complete the symbol if the total number of data and error correction codewords does not exactly fill its nominal capacity

3.15
segment
sequence of data encoded according to the rules of one extended channel interpretation or encoding mode

3.16
separator
function pattern (3.8) of all light modules, one module wide, separating the finder patterns from the rest of the symbol

3.17
symbol number
3-bit field indicating the symbol *version* (3.20) and error correction level applied, used as part of the *format information* (3.7) in micro QR code symbols

3.18
terminator
bit pattern of defined number (depending on the symbol) of all zero bits used to end the bit string representing data

3.19
timing pattern
alternating sequence of dark and light modules enabling module coordinates in the symbol to be determined

3.20
version
size of the symbol represented in terms of its position in the sequence of permissible sizes for micro QR code symbols from 11 × 11 modules (version M1) to 17 × 17 modules (version M4) or, for QR code symbols, from 21 × 21 modules (version 1) to 177 × 177 (version 40) modules

Note 1 to entry: The error correction level applied to the symbol can be suffixed to the version designation, e.g. version 4-L or version M3-Q.

3.21
version information
encoded pattern in certain QR code symbols containing information on symbol *version* (3.20) together with error correction bits for this data

4 Mathematical and logical symbols, abbreviated terms and conventions

4.1 Mathematical and logical symbols

div integer division operator

mod integer remainder after division

XOR exclusive-or logic function whose output is one only when its two inputs are not equivalent

NOTE XOR is represented by the symbol ⊕.

4.2 Abbreviated terms

BCH Bose-Chaudhuri-Hocquenghem

DPM direct part mark

ECI extended channel interpretation

FNC1 function 1 symbol character

RS Reed-Solomon

4.3 Conventions

4.3.1 Module positions

For ease of reference, module positions are defined by their row and column coordinates in the symbol, in the form (*i, j*) where *i* designates the row (counting from the top downwards) and *j* the column (counting from left to right) in which the module is located, with counting commencing at 0. The module (0, 0) is therefore located at the upper left corner of the symbol.

4.3.2 Byte notation

Byte content is shown as a hex value.

4.3.3 Version references

For QR code symbols, symbol versions are referred to in the form version V-E where V identifies the version number (1 to 40) and E indicates the error correction level (L, M, Q, H).

For micro QR code symbols, symbol versions are referred to in the form version MV-E where the letter M indicates the micro QR code format, V identifies the version number (with a range of 1 to 4) and E indicates the error correction level (with values L, M and Q).

5 Symbol description

5.1 Basic characteristics

QR code is a matrix symbology with the following characteristics:

a) Formats:

   1) QR code, with full range of capabilities and maximum data capacity;

   2) micro QR code, with reduced overhead, some restrictions on capabilities and reduced data capacity (compared with QR code symbols).

b) Encodable character set:

   1) numeric data (digits 0 - 9);

   2) alphanumeric data (digits 0 - 9; upper case letters A - Z; nine other characters: space, $ % * + - . /:);

   3) byte data [default: ISO/IEC 8859-1; or other sets as otherwise defined (see 7.3.5)];

   4) Kanji characters (Kanji characters in QR code can be compacted into 13 bits).

c) Representation of data: a dark module is nominally a binary one and a light module is nominally a binary zero. However, see 5.2 for details of reflectance reversal.

d) Symbol size (not including quiet zone):

   1) for micro QR code symbols: 11 × 11 modules to 17 × 17 modules (versions M1 to M4, increasing in steps of two modules per side);

   2) for QR code symbols: 21 × 21 modules to 177 × 177 modules (versions 1 to 40, increasing in steps of four modules per side).

e) Data characters per symbol:

   1) maximum micro QR code symbol size, version M4-L:

      — numeric data: 35 characters;

- alphanumeric data: 21 characters;
- byte data: 15 characters;
- Kanji data: 9 characters;

2) maximum QR code symbol size, version 40-L:

- numeric data: 7 089 characters;
- alphanumeric data: 4 296 characters;
- byte data: 2 953 characters;
- Kanji data: 1 817 characters.

f) Selectable error correction: four levels of Reed-Solomon error correction (referred to as L, M, Q and H in increasing order of capacity) allowing the symbol codeword recovery of

- L: 7 %;
- M: 15 %;
- Q: 25 %;
- H: 30 %.

For micro QR code symbols, error correction level H is not available. For version M1 micro QR code symbols, the RS capacity is limited to error detection only.

g) Code type: matrix.

h) Orientation independence: yes (both rotation and reflection).

Figure 1 illustrates a version 1 QR code symbol in normal colour and with reflectance reversal (see 5.2), in both normal and mirror image orientations.

Figure 2 illustrates a version M2 micro QR code symbol in normal colour and with reflectance reversal (see 5.2), in both normal and mirror image orientations.

5.2 Summary of additional features

The use of the following additional features is optional in QR code.

- Structured append: This allows files of data to be represented logically and continuously in up to 16 QR code symbols. These can be scanned in any sequence to enable the original data to be correctly reconstructed. Structured append is not available with micro QR code symbols.
- Extended channel interpretations: This mechanism enables data using character sets other than the default encodable set (e.g. Arabic, Cyrillic, Greek) and other data interpretations (e.g. compacted data using defined compression schemes) or other industry-specific requirements to be encoded. ECIs other than the default interpretation are not available in micro QR code symbols.
- Reflectance reversal: Symbols are intended to be read when marked so that the image is either dark on light or light on dark (see Figures 1 and 2). The specifications in this document are based on dark images on a light background, therefore in the case of symbols produced with reflectance reversal references to dark or light modules should be taken as references to light or dark modules respectively.
- Mirror imaging: The arrangement of modules defined in this document represents the "normal" orientation of the symbol. It is, however, possible to achieve a valid decode of a symbol in which the arrangement of the modules has been laterally transposed. When viewed with the finder patterns in the top left, top right and bottom left corners of the symbol, mirror imaging interchanges the row and column positions of the modules.

a) Normal orientation and normal reflectance arrangement

b) Normal orientation and reversed reflectances

c) Mirror image orientation and normal reflectance arrangement

d) Mirror image orientation and reversed reflectances

NOTE The corner marks indicate the extent of the quiet zone.

Figure 1 — Examples of a QR code symbol encoding the text "QR code Symbol"

a) Normal orientation and normal reflectance arrangement

b) Normal orientation and reversed reflectances

c) Mirror image orientation and normal reflectance arrangement

d) Mirror image orientation and reversed reflectances

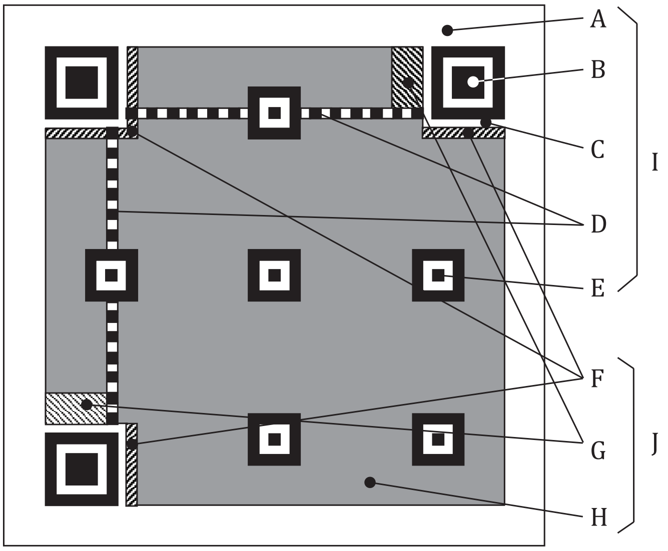
NOTE The corner marks indicate the extent of the quiet zone.

Figure 2 — Examples of a version M2 micro QR code symbol encoding the text "01234567"

5.3 Symbol structure

5.3.1 General

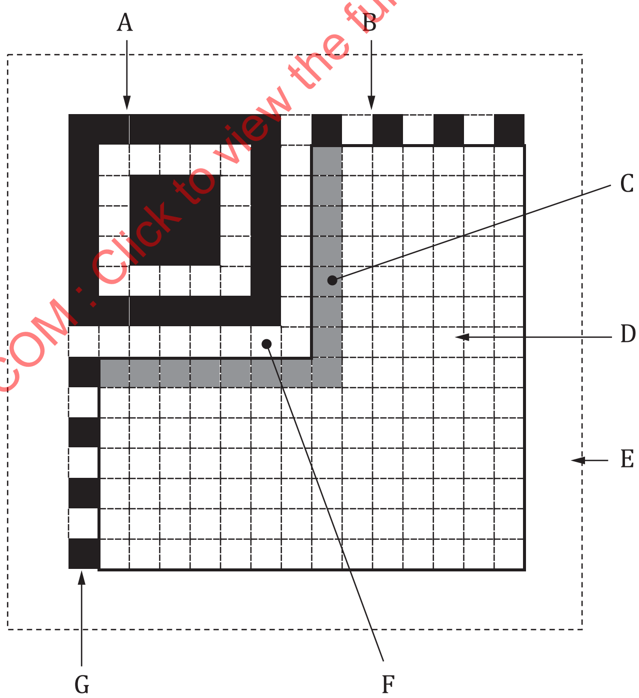
Each QR code symbol shall be constructed of nominally square modules set out in a regular square array and shall consist of an encoding region and function patterns, namely finder, separator, timing patterns and alignment patterns. Function patterns do not encode data. The symbol shall be surrounded on all four sides by a quiet zone border. Figure 3 illustrates the structure of a version 7 symbol. Figure 4 illustrates the structure of a version M3 symbol.



Key

A quiet zone
B finder pattern
C separator
D timing patterns
E alignment patterns
F format information
G version information
H data and error correction codewords
I function patterns
J encoding region

Figure 3 — Structure of a QR code symbol



Key

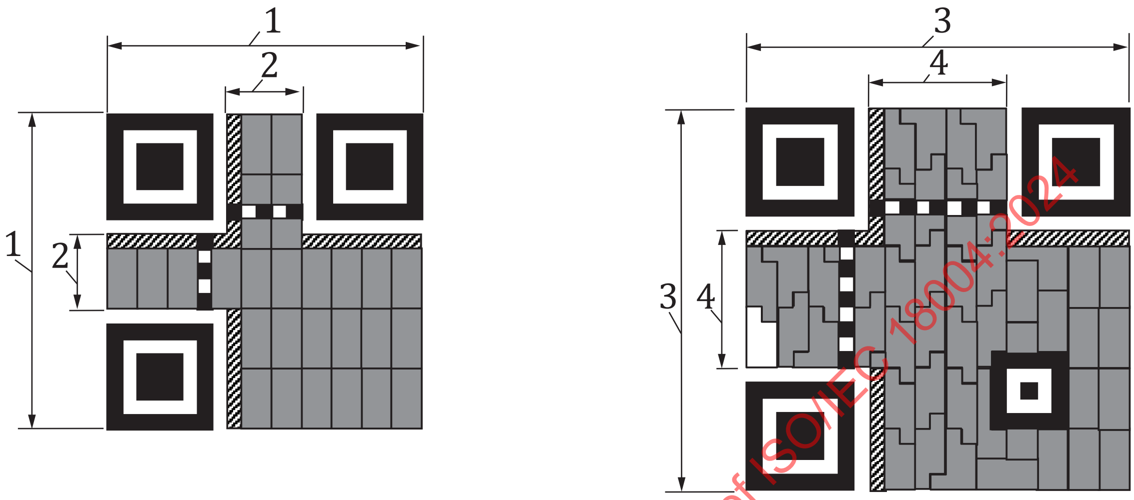
A finder pattern quiet zone
B timing patterns
C format information
D encoding region
E quiet zone
F separator
G timing pattern

Figure 4 — Structure of a version M3 micro QR code symbol

5.3.2 Symbol versions and sizes

5.3.2.1 QR code symbols

There are 40 sizes of QR code symbol referred to as version 1, version 2 ... version 40. Version 1 measures 21 × 21 modules, version 2 measures 25 × 25 modules and so on, increasing in steps of 4 modules per side up to version 40 which measures 177 × 177 modules. Figures 5 to 10 illustrate the structure of versions 1, 2, 6, 7, 14, 21 and 40.



a) Version 1

b) Version 2

Key

data and error correction codewords

format information and its error correction code

remainder bits

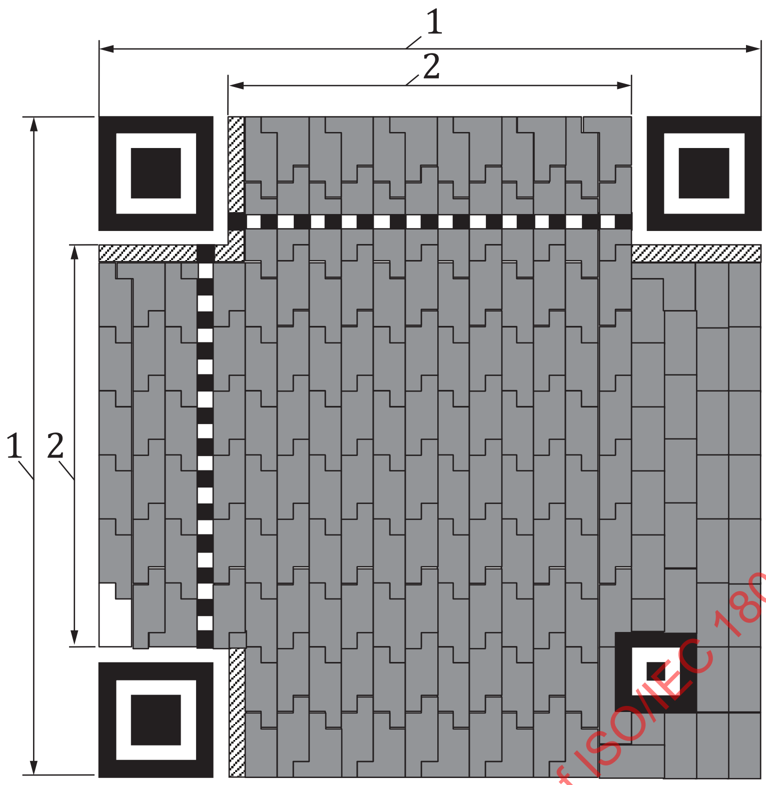
1 21 modules

2 5 modules

3 25 modules

4 9 modules

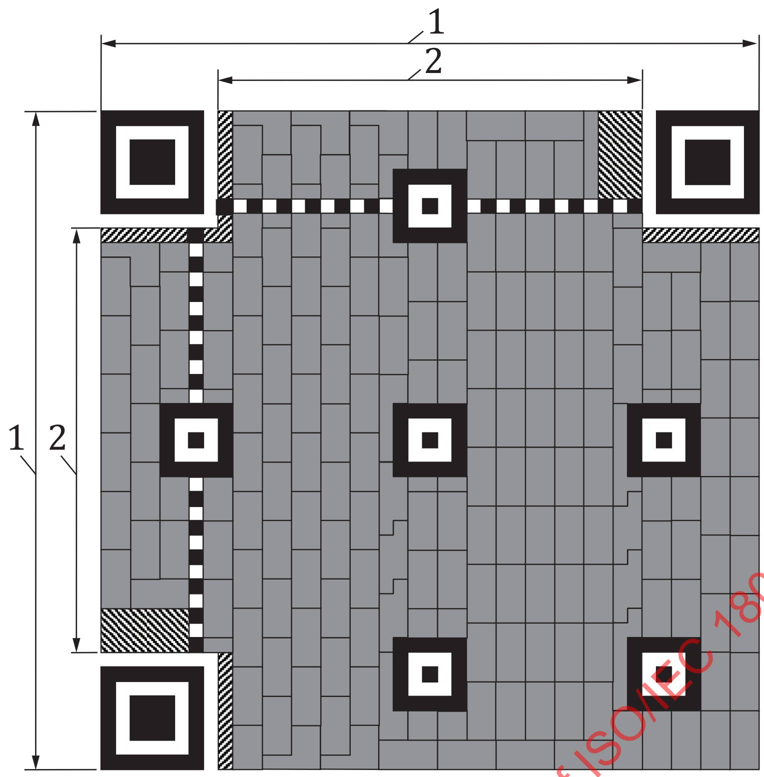
Figure 5 — Versions 1 and 2 symbols



Key

(grey)	data and error correction codewords	1	41 modules
(hatched)	format information and its error correction code	2	25 modules
(white)	remainder bits		

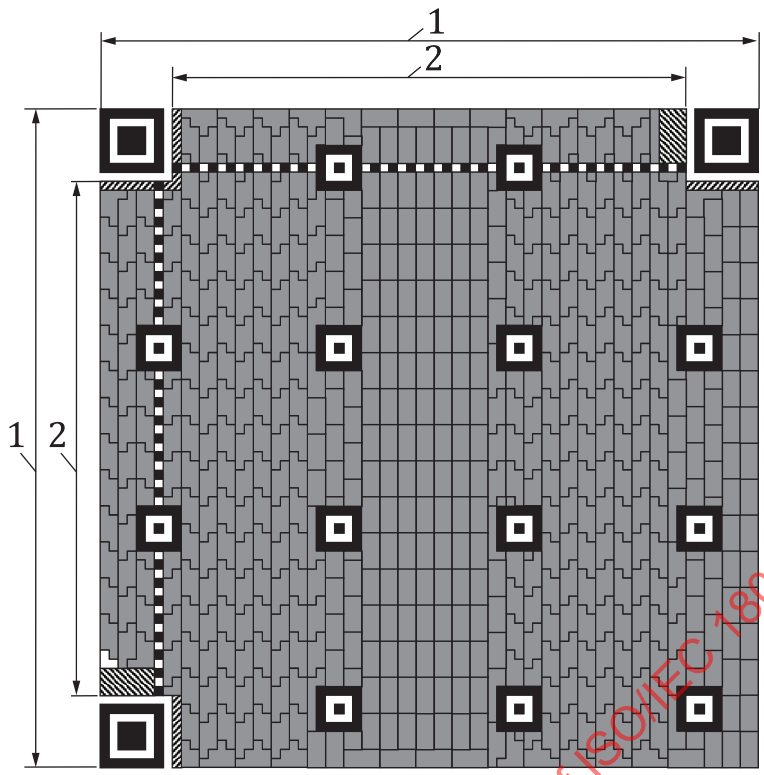
Figure 6 — Version 6 symbol



Key

(grey)	Da<ta and error correction codewords	1	45 modules
(hatched)	format information and its error correction code	2	29 modules
(cross-hatched)	version information and its error correction code		

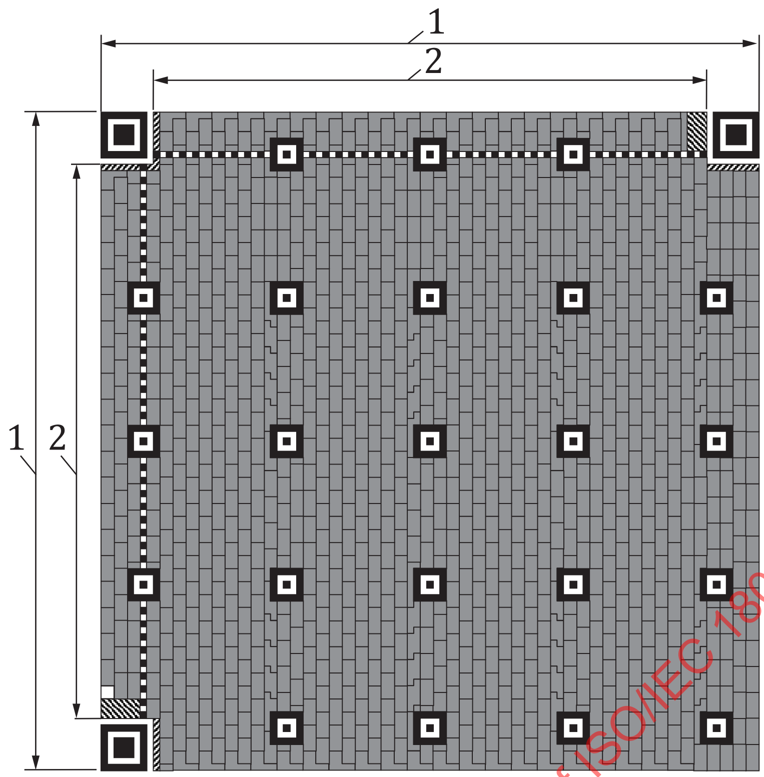
Figure 7 — Version 7 symbol



Key

[grey]	data and error correction codewords	1	73 modules
[hatched]	format information and its error correction code	2	57 modules
[hatched]	version information and its error correction code		
[white]	remainder bits		

Figure 8 — Version 14 symbol



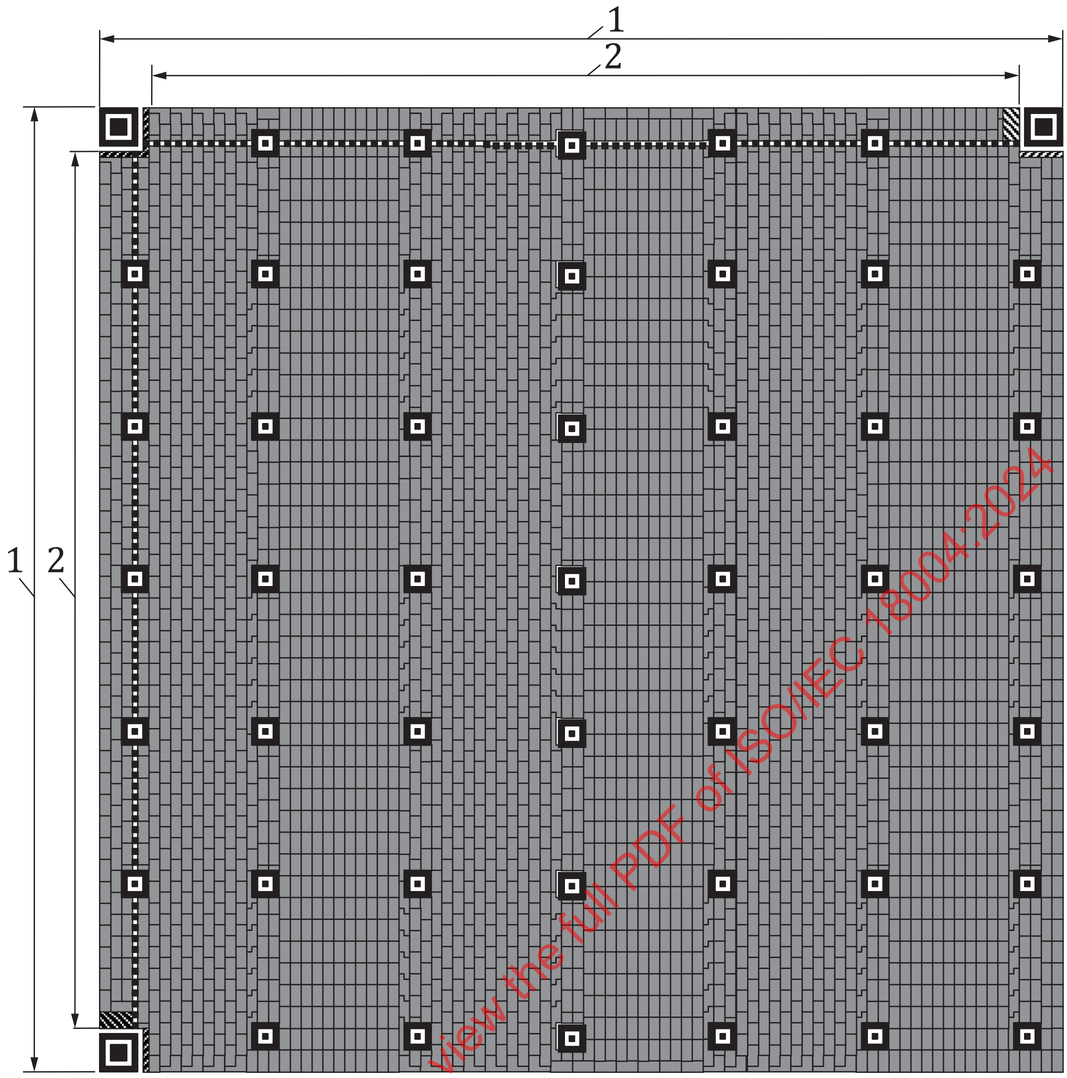
Key

(grey)	data and error correction codewords
(hatched)	format information and its error correction code
(cross-hatched)	version information and its error correction code
(white)	remainder bits

1 101 modules

2 85 modules

Figure 9 — Version 21 symbol



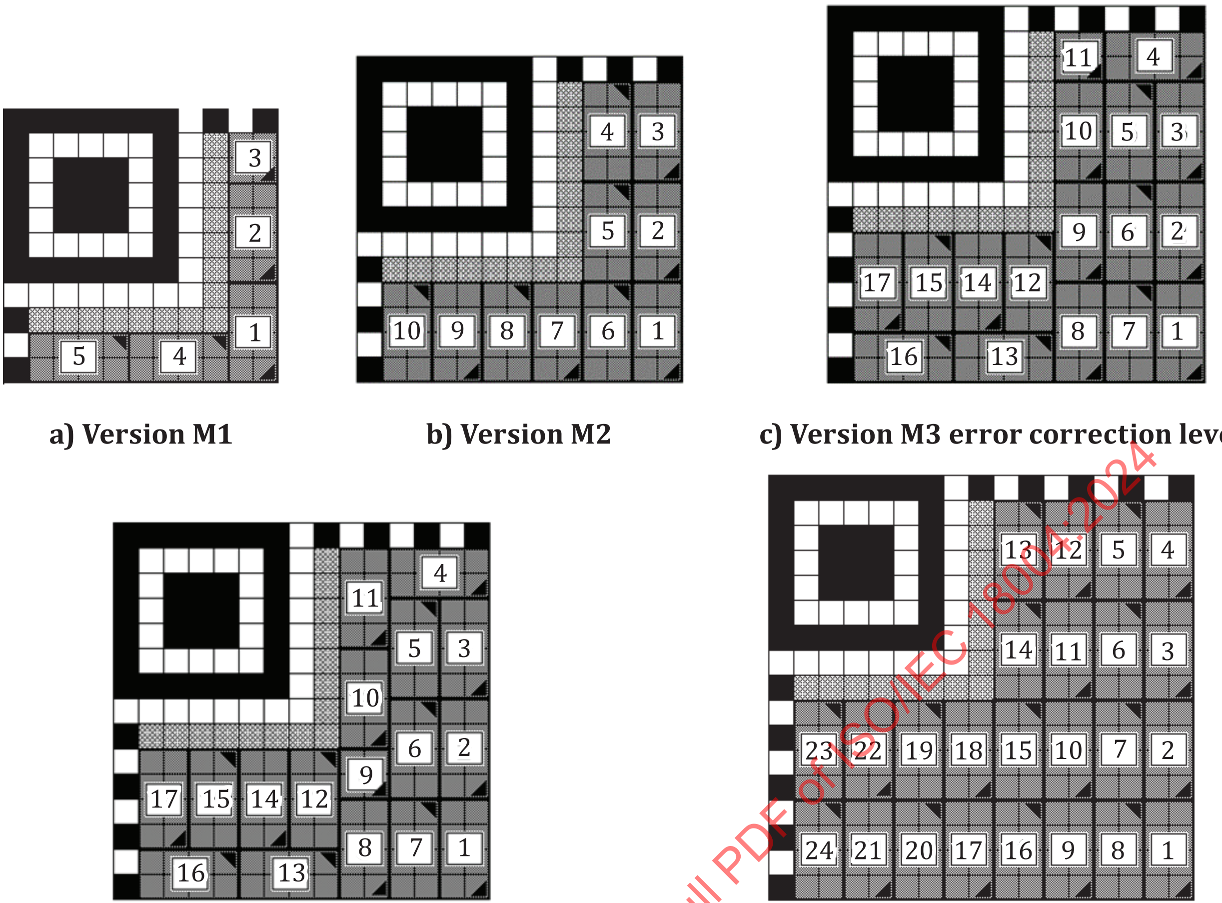
Key

(grey)	data and error correction codewords	1	177 modules
(hatched)	format information and its error correction code	2	161 modules
(cross-hatched)	version information and its error correction code		

Figure 10 — Version 40 symbol

5.3.2.2 Micro QR code symbols

There are four sizes of micro QR code symbol, referred to as versions M1 to M4. Version M1 measures 11 × 11 modules, version M2 measures 13 × 13 modules, version M3 measures 15 × 15 modules and version M4 measures 17 × 17 modules, i.e. increasing in steps of 2 modules per side. Figure 11 illustrates the structure of micro QR code versions M1 to M4.



a) Version M1 b) Version M2 c) Version M3 error correction level: L

d) Version M3 error correction level: M e) Version M4

NOTE Two formats of M3 symbol are shown, which differ only in the codeword placement according to the error correction level.

Figure 11 — Versions of a micro QR code symbol

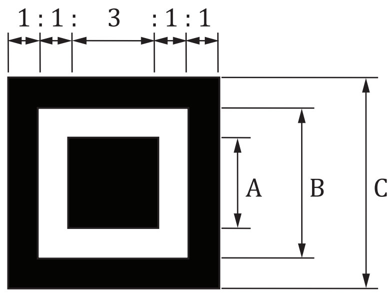
5.3.3 Finder pattern

5.3.3.1 QR code symbols

There are three identical finder patterns located at the upper left, upper right and lower left corners of the symbol respectively as illustrated in Figure 3. Each finder pattern may be viewed as three superimposed concentric squares and is constructed of 7 × 7 dark modules, 5 × 5 light modules and 3 × 3 dark modules. The ratio of module widths in each finder pattern is 1:1:3:1:1 as illustrated in Figure 12. The symbol is preferentially encoded so that similar patterns have a low probability of being encountered elsewhere in the symbol, enabling rapid identification of a possible QR code symbol in the field of view. The identification of the three finder patterns unambiguously defines the location and rotational orientation of the symbol in the field of view.

5.3.3.2 Micro QR code symbols

A single finder pattern, as defined in 5.3.3.1, is located at the upper left corner of the symbol as illustrated in Figure 4. Identification of the finder pattern together with the timing patterns unambiguously defines the size, location and rotational orientation of the symbol in the field of view.



Key

A 3 modules

B 5 modules

C 7 modules

Figure 12 — Structure of a finder pattern

5.3.4 Separator

A one-module wide separator, constructed of all light modules, is placed between each finder pattern and the encoding region, as illustrated in Figures 3 and 4.

5.3.5 Timing pattern

The horizontal and vertical timing patterns respectively consist of a one module wide row or column of alternating dark and light modules, commencing and ending with a dark module. They enable the symbol density and version to be determined and provide datum positions for determining module coordinates.

In QR code symbols, the horizontal timing pattern runs across row 6 of the symbol between the separators for the upper finder patterns; the vertical timing pattern similarly runs down column 6 of the symbol between the separators for the left-hand finder patterns. See Figure 3.

In micro QR code symbols, the horizontal timing pattern runs across row 0 of the symbol on the right side of the separator to the right-hand edge of the symbol; the vertical timing pattern similarly runs down column 0 of the symbol below the separator to the bottom edge of the symbol. See Figure 4.

5.3.6 Alignment patterns

Alignment patterns are present only in QR code symbols of version 2 or larger. Each alignment pattern may be viewed as three superimposed concentric squares and is constructed of 5 × 5 dark modules, 3 × 3 light modules and a single central dark module. The number of alignment patterns depends on the symbol version and they shall be placed in all symbols of version 2 or larger in positions defined in Annex E.

5.3.7 Encoding region

The encoding region shall contain the symbol characters representing data, those representing error correction codewords, the format information and, where appropriate, the version information. Refer to 7.7.1 for details on symbol characters. Refer to 7.9 for details on format information. Refer to 7.10 for details on version information.

5.3.8 Quiet zone

The quiet region which shall be free of all other markings, surrounding the symbol on all four sides. Its nominal reflectance value shall be equal to that of the light modules.

For QR code symbols, its width shall be 4X.

For micro QR code symbols, its width shall be 2X.

6 Conformance

QR code symbols (and equipment designed to produce or read QR code symbols) shall be considered as conforming with this document if they provide or support the features defined in this document.

Symbols complying with the requirements for QR code model 1, as described in the first edition of this document (i.e. ISO/IEC 18004:2000), can be unreadable with equipment complying with this document.

Symbols complying with the requirements for QR code model 2, as defined in the first edition of this document (i.e. ISO/IEC 18004:2000), are readable with equipment complying with this document.

Reading equipment complying with the first edition of this document (i.e. ISO/IEC 18004:2000) are not able to read all symbols complying with this document. Symbols that make use of the additional features of QR code are not readable by such equipment.

Printing equipment complying with the first edition of this document (i.e. ISO/IEC 18004:2000) are not able to print all symbols defined in this document. Symbols that make use of the additional features of QR code are not printable by such equipment.

It should be noted, however, that QR code model 2 and micro QR code are the form of the symbology recommended for new and open systems applications.

7 Requirements

7.1 Encode procedure overview

7.1.1 General

Subclause 7.1 provides an overview of the steps required to convert input data to a QR code symbol.

7.1.2 Step 1: Data analysis

Analyse the input data stream to identify the variety of different characters to be encoded. The QR code format (but not the micro QR code format) supports the ECI feature, enabling data differing from the default character set to be encoded. QR code includes several modes (see 7.3) to allow different sub-sets of characters to be converted into symbol characters in efficient ways. Switch between modes as necessary in order to achieve the most efficient conversion of data into a binary string. Select the required error detection and correction level. If the user has not specified the symbol version to be used, select the smallest version that will accommodate the data. A complete list of symbol versions and capacities is shown in Table 1.

7.1.3 Step 2: Data encoding

Convert the data characters into a bit stream in accordance with the rules for the mode in force, as defined in 7.4.3 to 7.4.7, inserting mode indicators as necessary to change modes at the beginning of each new mode segment, and a terminator at the end of the data sequence. Split the resulting bit stream into 8-bit codewords. Add pad characters as necessary to fill the number of data codewords required for the version.

7.1.4 Step 3: Error correction coding

Divide the codeword sequence into the required number of blocks (as defined in Table 9) to enable the error correction algorithms to be processed. Generate the error correction codewords for each block, appending the error correction codewords to the end of the data codeword sequence.

7.1.5 Step 4: Structure final message

Interleave the data and error correction codewords from each block as described in 7.6 c) and add remainder bits as necessary.

7.1.6 Step 5: Module placement in matrix

Place the codeword modules in the matrix together with the finder pattern, separators, timing pattern and, if required, alignment patterns.

7.1.7 Step 6: Data masking

Apply the data masking patterns in turn to the encoding region of the symbol. Evaluate the results and select the pattern which optimizes the dark/light module balance and minimizes the occurrence of undesirable patterns.

7.1.8 Step 7: Format and version information

Generate the format information and, where applicable, the version information. Complete the symbol.

Table 1 — Codeword capacity of all versions of QR code

Version	Number of modules per side *A*	Function pattern modules *B*	Format and version information modules *C*	Data modules except *D*[b]	Data capacity [codewords][a] *E*	Remainder bits
M1	11	70	15	36	5	0
M2	13	74	15	80	10	0
M3	15	78	15	132	17	0
M4	17	82	15	192	24	0
1	21	202	31	208	26	0
2	25	235	31	359	44	7
3	29	243	31	567	70	7
4	33	251	31	807	100	7
5	37	259	31	1 079	134	7
6	41	267	31	1 383	172	7
7	45	390	67	1 568	196	0
8	49	398	67	1 936	242	0
9	53	406	67	2 336	292	0
10	57	414	67	2 768	346	0
11	61	422	67	3 232	404	0
12	65	430	67	3 728	466	0
13	69	438	67	4 256	532	0
14	73	611	67	4 651	581	3
15	77	619	67	5 243	655	3
16	81	627	67	5 867	733	3
17	85	635	67	6 523	815	3
18	89	643	67	7 211	901	3
19	93	651	67	7 931	991	3
20	97	659	67	8 683	1 085	3
21	101	882	67	9 252	1 156	4
22	105	890	67	10 068	1 258	4
23	109	898	67	10 916	1 364	4
24	113	906	67	11 796	1 474	4
25	117	914	67	12 708	1 588	4
26	121	922	67	13 652	1 706	4
27	125	930	67	14 628	1 828	4
28	129	1 203	67	15 371	1 921	3

a All codewords are 8 bits in length, except in versions M1 and M3 where the final data codeword is 4 bits in length.

b $D = A^2 - B - C$

Table 1 *(continued)*

Version	Number of modules per side *A*	Function pattern modules *B*	Format and version information modules *C*	Data modules except *D*[b]	Data capacity [codewords][a] *E*	Remainder bits
29	133	1 211	67	16 411	2 051	3
30	137	1 219	67	17 483	2 185	3
31	141	1 227	67	18 587	2 323	3
32	145	1 235	67	19 723	2 465	3
33	149	1 243	67	20 891	2 611	3
34	153	1 251	67	22 091	2 761	3
35	157	1 574	67	23 008	2 876	0
36	161	1 582	67	24 272	3 034	0
37	165	1 590	67	25 568	3 196	0
38	169	1 598	67	26 896	3 362	0
39	173	1 606	67	28 256	3 532	0
40	177	1 614	67	29 648	3 706	0

a All codewords are 8 bits in length, except in versions M1 and M3 where the final data codeword is 4 bits in length.

b $D = A^2 - B - C$

7.2 Data analysis

Analyse the input data string to determine its content and select the default or other appropriate ECI and the appropriate mode to encode each sequence as described in 7.4. Each mode in sequence from numeric mode to Kanji mode progressively requires more bits per character. It is possible to switch from mode to mode within a symbol in order to minimize the bit stream length for data, parts of which can more efficiently be encoded in one mode than other parts, for example, numeric sequences followed by alphanumeric sequences. In theory, it is most efficient to encode data in the mode requiring the fewest bits per data character, but as there is some overhead in the form of mode indicator and character count indicator associated with each mode change, it does not always result in the shortest overall bit stream to change modes for a small number of characters. Also, as the capacity of symbols increases in discrete steps from one version to the next, it is not always necessary to achieve the maximum conversion efficiency in every case. Guidance on minimising the bit stream length is given in Annex J. In micro QR code symbols, there are restrictions on the modes available for smaller versions. Clause J.2 shows appropriate micro QR code symbol versions for various combinations of two modes.

7.3 Modes

7.3.1 General

The modes described in 7.3 are based on the character values and assignments associated with the default ECI. When any other ECI is in force (in QR code symbols only), the byte values rather than the specific character assignments shall be used to select the optimum data compaction mode. For example, the numeric mode would be appropriate if there is a sequence of data byte values within the range 30_{HEX} to 39_{HEX} inclusive. In this case, the compaction is carried out using the default numeric or alphabetic equivalents of the byte values.

7.3.2 Extended channel interpretation mode

The ECI protocol defined in Reference [21] allows the output data stream to have interpretations different from that of the default character set. The ECI protocol is defined consistently across many symbologies. The ECI protocol provides a consistent method to specify particular interpretations of byte values before printing and after decoding.

The ECI protocol is not supported in micro QR code symbols.

The default interpretation for QR code is ECI 000003 representing the ISO/IEC 8859-1 character set. International applications using other character sets should use the ECI protocol. For instance, the interpretation corresponding to the JIS8 (JIS X 0201, 7-bit and 8-bit coded character sets for information interchange) and shift JIS (JIS X 0208:1997, 7-bit and 8-bit double byte coded Kanji sets for information interchange) character sets is ECI 000020. The ECI mode causes the insertion of an ECI escape sequence at that point in the data. It is immediately followed by another mode indicator (e.g. for efficient data encoding) and remains in force until the end of the message or a subsequent ECI mode indicator.

7.3.3 Numeric mode

The numeric mode encodes data from the decimal digit set (0 - 9) (byte values 30_{HEX} to 39_{HEX}). Normally, three data characters are represented by 10 bits.

7.3.4 Alphanumeric mode

The alphanumeric mode encodes data from a set of 45 characters, i.e. 10 numeric digits (0 - 9) (byte values 30_{HEX} to 39_{HEX}), 26 alphabetic characters (A - Z) (byte values 41_{HEX} to $5A_{HEX}$) , and 9 symbols (SP, $, %, *, +, -, ., /,:) (byte values 20_{HEX}, 24_{HEX}, 25_{HEX}, $2A_{HEX}$, $2B_{HEX}$, 2D to $2F_{HEX}$, $3A_{HEX}$, respectively). Normally, two input characters are represented by 11 bits.

The alphanumeric mode is not available in version M1 micro QR code symbols.

7.3.5 Byte mode

In byte mode, data is encoded at 8 bits per character.

In closed-system national or application-specific implementations of QR code, an alternative 8-bit character set, for example as defined in an appropriate part of the ISO/IEC 8859 series, may be specified for byte mode. When an alternative character set is specified, however, the parties intending to read the QR code symbols require to be notified of the applicable character set in the application specification or by bilateral agreement.

Byte mode is not available in version M1 or M2 micro QR code symbols.

7.3.6 Kanji mode

The Kanji mode efficiently encodes Kanji characters according to the shift JIS system based on JIS X 0208. The shift JIS values are shifted from the JIS X 0208 values. JIS X 0208 gives details of the shift coded representation. Each two-byte character value is compacted to a 13-bit binary codeword.

When the character set specified for 8-bit byte mode makes use of byte values in the ranges of either 81_{HEX} to $9F_{HEX}$ or $E0_{HEX}$ to EB_{HEX}, or both, it is not always possible to use Kanji mode unambiguously, as reading systems will be unable to determine from the transmitted data whether such byte values are the lead byte of a double byte character. It can be possible to achieve a shorter bit stream by using the Kanji mode compaction rules when an appropriate sequence of byte values occurs in the data (i.e. lead bytes in the ranges of either 81_{HEX} to $9F_{HEX}$ or $E0_{HEX}$ to EB_{HEX}, or both, followed by trailer bytes in the range 40_{HEX} to FC_{HEX}, except $7F_{HEX}$, or EB_{HEX} followed by 40_{HEX} to BF_{HEX}). Figure H.1 shows the byte combinations graphically.

The Kanji mode is not available in version M1 or M2 micro QR code symbols.

7.3.7 Mixing modes

The QR code symbol can contain sequences of data in a combination of any of the modes described in 7.3.2 to 7.3.8. Micro QR code symbols may contain sequences of data in a combination of any of the modes available for the version of the symbol and described in 7.3.3 to 7.3.7.

Refer to Annex J for guidance to select the most efficient way of representing a given input data string in multiple modes in QR code symbols and Clause J.3 for the available versions of micro QR code symbols for given combinations of data in two modes.

7.3.8 Structured append mode

The structured append mode is used to split the encoding of the data from a message over a number of QR code symbols. All of the symbols require to be read and the data message can be reconstructed in the correct sequence. The structured append header is encoded in each symbol to identify the length of the sequence and the symbol's position in it, and verify that all the symbols read belong to the same message. Refer to Clause 8 for details of encoding in structured append mode.

The structured append mode is not available for micro QR code symbols.

7.4 Data encoding

7.4.1 FNC1 mode

FNC1 mode is used for messages containing specific data formats. In the "first position" it designates data formatted according to GS1 General Specifications. In the "second position", data shall be formatted in accordance with a specific industry application listed in ISO/IEC 15424:—, Annex E. FNC1 mode applies to the entire symbol and is not affected by subsequent mode indicators.

NOTE "First position" and "second position" do not refer to actual locations but are based on the positions of the character in Code 128 symbols, when used in an equivalent manner.

The FNC1 mode is not available for micro QR code symbols.

7.4.2 Sequence of data

Input data is converted into a bit stream consisting of one or more segments each in a separate mode. In the default ECI, the bit stream commences with the first mode indicator. If the initial ECI is other than the default ECI, the bit stream commences with an ECI header, followed by the first segment.

The ECI header (if present) shall comprise:

— an ECI mode indicator (4 bits);

— an ECI designator (8 bits, 16 bits or 24 bits).

The ECI header shall begin with the first (most significant) bit of the ECI mode indicator and end with the final (least significant) bit of the ECI designator.

The remainder of the bit stream is then made up of segments each comprising:

— a mode indicator;

— a character count indicator;

— a data bit stream.

Each mode segment shall begin with the first (most significant) bit of the mode indicator and end with the final (least significant) bit of the data bit stream. There shall be no explicit separator between segments as their length is defined unambiguously by the rules for the mode in force and the number of input data characters.

To encode a sequence of input data in a given mode, the steps described in 7.4.3 to 7.4.8 shall be followed. Table 2 defines the mode indicators for each mode. Table 3 defines the length of the character count indicator, which varies according to the mode and the symbol version in use.

Table 2 — Mode indicators for QR code

Mode	QR code symbols for all versions	Micro QR code symbols			
		Version M1	Version M2	Version M3	Version M4
Mode indicator length (bits)	4	0	1	2	3
ECI	0111	NA	NA	NA	NA
Numeric	0001	NA	0	00	000
Alphanumeric	0010	NA	1	01	001
Byte	0100	NA	NA	10	010
Kanji	1000	NA	NA	11	011
Structured append	0011	NA	NA	NA	NA
FNC1[a]	0101 (1st position) 1001 (2nd position)	NA	NA	NA	NA
Terminator (end of message)[b]	0000	000	00000	0000000	000000000

Key

NA not applicable

[a] See 7.4.9.2 and 7.4.9.3.

[b] The terminator is not a mode indicator as such.

Table 3 — Number of bits in the character count indicator for QR code

Version	Numeric mode	Alphanumeric mode	Byte mode	Kanji mode
M1	3	NA	NA	NA
M2	4	3	NA	NA
M3	5	4	4	3
M4	6	5	5	4
1 to 9	10	9	8	8
10 to 26	12	11	16	10
27 to 40	14	13	16	12

Key

NA not applicable

The end of the data in the complete symbol is indicated by a terminator consisting of between 3 and 9 zero bits (see Table 2), which is omitted or abbreviated if the remaining symbol capacity after the data bit stream is less than the required bit length of terminator. The terminator is not a mode indicator as such.

7.4.3 Extended channel interpretation mode

7.4.3.1 General

The ECI mode, used for encoding data subject to alternative interpretations of byte values (e.g. alternative character sets) according to the ECI protocol defined in Reference [21] which defines the pre-processing of this type of data, is invoked by the use of mode indicator 0111.

The ECI can only be used with readers enabled to transmit the symbology identifier. Readers that cannot transmit the symbology identifier cannot transmit the data from any symbol containing an ECI.

Input ECI data shall be handled by the encoding system as a series of byte values.

Data in an ECI sequence may be encoded in whatever mode or modes permit the most efficient encoding of the byte values of the data, irrespective of their significance. For example, a sequence of bytes in the range 30_{HEX} to 39_{HEX} can be encoded in numeric mode (see 7.4.4) as though it were a sequence of digits from 0 to 9, even though it does not necessarily represent numeric data. In order to determine the value of the character count indicator, the number of bytes (or, in Kanji mode, of byte pairs) shall be used.

7.4.3.2 ECI designator

Each extended channel interpretation is designated by a 6-digit assignment number which is encoded in the QR code symbol as the first one, two or three codewords following the ECI mode indicator. The encoding rules are defined in Table 4. The ECI designator appears in the data to be encoded as character $5C_{HEX}$ [\ or backslash (reverse solidus) in ISO/IEC 8859-1, ¥ or yen sign in JIS8] followed by the 6-digit assignment number. Where $5C_{HEX}$ appears as true data, it shall be doubled in the data string before encoding in symbols to which the ECI protocol applies.

When a single occurrence of $5C_{HEX}$ is encountered in the input to the decoder, an ECI mode indicator is inserted followed by the ECI designator. When a doubled $5C_{HEX}$ is encountered, it is encoded as two $5C_{HEX}$ bytes.

On decoding, the binary pattern of the first ECI Designator codeword (i.e. the codeword following the mode indicator in ECI mode), determines the length of the ECI Designator sequence. The number of 1 bits before the first 0 bit defines the number of additional codewords after the first used to represent the ECI assignment number. The bit sequence after the first 0 bit is the binary representation of the ECI assignment number. The lower numbered ECI assignments may be encoded in multiple ways, but the shortest way is preferred.

Table 4 — Encoding the ECI assignment number

ECI assignment value	Number of codewords	Codeword values[a]
000000 to 000127	1	0bbbbbbb
000000 to 016383	2	10bbbbbb bbbbbbbb
000000 to 999999	3	110bbbbb bbbbbbbb bbbbbbbb

[a] where b ... b is the binary value of the ECI assignment number.

EXAMPLE When encoding data in Greek using a character set ISO/IEC 8859-7 (ECI 000009) a in version 1-H symbol:

Data to be encoded:	\000009ΑΒΓΔΕ (character values $A1_{HEX}$, $A2_{HEX}$, $A3_{HEX}$, $A4_{HEX}$, $A5_{HEX}$)
Bit sequence in symbol:	
ECI mode indicator:	0111
ECI assignment number (000009):	0 0001001
Mode indicator (byte):	0100
Character count indicator (5):	00000101
Data:	10100001 10100010 10100011 10100100 10100101
Final bit string:	0111 00001001 0100 00000101 10100001 10100010 10100011 10100100 10100101

See 14.3 for an example of transmission of this data following decoding.

7.4.3.3 Multiple extended channel interpretations

Refer to the ECI protocol defined in Reference [21] defining the effect of a subsequent ECI designator in an ECI data segment. For example, data to which a character set ECI has been applied can also be subject to encryption or compaction using a transformation ECI which will co-exist with the initial ECI, or a second character set ECI will have the effect of terminating the first ECI and starting a new ECI segment. Where any ECI designator appears in the data, it shall be encoded in the QR code symbol in accordance with 7.4.3.2 and shall commence a new mode segment.

7.4.3.4 ECIs and structured append

Any ECI(s) invoked shall apply subject to the rules defined in 7.4.3.3 and in the ECI protocol defined Reference [21] until the end of the encoded data or a change of ECI (signalled by mode indicator 0111). If the encoded data in the ECI(s) extends through two or more symbols in the structured append mode, it is necessary to provide an ECI header consisting of ECI mode indicator and ECI designator number for each ECI in force, immediately following the structured append header, in subsequent symbols in which the ECI continues in force.

7.4.4 Numeric mode

The input data string is divided into groups of three digits, and each group is converted to its 10-bit binary equivalent. If the number of input digits is not an exact multiple of three, the final one or two digits are converted to 4 bits or 7 bits respectively. The binary data is then concatenated and prefixed with the mode indicator and the character count indicator. The mode indicator in the numeric mode has either 4 bits for QR code symbols or the number of bits defined in Table 2 for micro QR code symbols, and the character count indicator has the number of bits defined in Table 3. The number of input data characters is converted to its binary equivalent and added as the character count indicator after the mode indicator and before the binary data sequence.

EXAMPLE 1 For a version 1-H symbol:

Input data:	01234567
a) The input data is divided into groups of three digits:	012 345 67
b) Each group is converted to its binary equivalent:	012 → 0000001100
	345 → 0101011001
	67 → 1000011
c) The binary data is connected in sequence:	0000001100 0101011001 1000011
d) The character count indicator is converted to binary (10 bits for version 1-H):	
Number of input data characters:	8 → 0000001000
e) The mode indicator 0001 and character count indicator are added to binary data:	
0001 0000001000 0000001100 0101011001 1000011	

EXAMPLE 2 For a micro QR code version M3-M symbol:

Input data:	0123456789012345
a) The input data is divided into groups of three digits:	012 345 678 901 234 5
b) Each group is converted to its binary equivalent:	012 = 0000001100
	345 = 0101011001
	678 = 1010100110
	901 = 1110000101
	234 = 0011101010
	5 = 0101
c) The binary data is connected sequentially:	0000001100 0101011001 1010100110 1110000101 0011101010 0101
d) The character count indicator is converted to binary (5 bits for version M3-M):	
Number of input data characters:	16 = 10000
e) The mode indicator (00 for version M3-M) and character count indicator are added to binary data:	
00 10000 0000001100 0101011001 1010100110 1110000101 0011101010 0101	

For any number of data characters, the length of the bit stream in the numeric mode is given by Formula (1):

$$B = M + C + 10(D \operatorname{div} 3) + R \qquad (1)$$

where

B is the number of bits in bit stream;

M is the number of bits in mode indicator (4 for QR code symbols or as shown in Table 2 for micro QR code symbols);

C is the number of bits in character count indicator (from Table 3);

D is the number of input data characters;

R is 0 if (D mod 3) = 0, or is 4 if (D mod 3) = 1, or is 7 if (D mod 3) = 2.

7.4.5 Alphanumeric mode

Each input data character is assigned a character value *V* from 0 to 44 according to Table 5.

Table 5 — Encoding and decoding table for the alphanumeric mode

Char.	Value	Char.	Value	Char.	Value	Char.	Value	Char.	Value	Char.	Value	Char.	Value	Char.	Value
0	0	6	6	C	12	I	18	O	24	U	30	SP	36	.	42
1	1	7	7	D	13	J	19	P	25	V	31	$	37	/	43
2	2	8	8	E	14	K	20	Q	26	W	32	%	38	:	44
3	3	9	9	F	15	L	21	R	27	X	33	*	39		
4	4	A	10	G	16	M	22	S	28	Y	34	+	40		
5	5	B	11	H	17	N	23	T	29	Z	35	-	41		

Input data characters are divided into groups of two characters which are encoded as 11-bit binary codes. The character value of the first character is multiplied by 45 and the character value of the second digit is added to the product. The sum is then converted to an 11-bit binary number. If the number of input data characters is not a multiple of two, the character value of the final character is encoded as a 6-bit binary number. The binary data is then concatenated and prefixed with the mode indicator and the character count indicator. The mode indicator in the alphanumeric mode has either 4 bits for QR code symbols or the number of bits defined in Table 2 for micro QR code symbols, and the character count indicator has the number of bits defined in Table 3. The number of input data characters is converted to its binary equivalent and added as the character count indicator after the mode indicator and before the binary data sequence.

In FNC1 mode, separator characters can be required as data fields are concatenated. Refer to 7.4.9.2, 7.4.9.3 and 14.4 for details on encoding and transmission.

EXAMPLE For a version 1-H symbol:

Input data:	AC-42
a) Character values are determined according to Table 5:	AC-42 → (10,12,41,4,2)
b) The result is divided into groups of two decimal values:	(10,12) (41,4) (2)
c) Each group is converted to its 11-bit binary equivalent:	(10,12) 10*45+12 → 462 → 00111001110
	(41,4) 41*45+4 → 1849 → 11100111001
	(2) → 2 → 000010
d) The binary data is connected in sequence:	00111001110 11100111001 000010

e) The character count indicator is converted to binary (9 bits for version 1-H):

Number of input data characters:	5 → 000000101

f) The mode indicator 0010 and character count indicator are added to binary data:

0010 000000101 00111001110 11100111001 000010

For any number of data characters, the length of the bit stream in alphanumeric mode is given by the formula:

$$B = M + C + 11(D \text{ div } 2) + 6(D \text{ mod } 2)$$

where

B is the number of bits in bit stream;

M is the number of bits in mode indicator (4 for QR code symbols or as shown in Table 2 for micro QR code symbols);

C is the number of bits in character count indicator (from Table 3);

D is the number of input data characters.

7.4.6 Byte mode

In byte mode, one 8-bit codeword directly represents the byte value of the input data character, i.e. a density of 8 bits/character. Table 6 shall apply for encoding and decoding byte mode characters.

Table 6 — Encoding and decoding table for the byte mode character set

Byte		Char.	Byte		Char.	Byte		Char.	Byte		Char.	Byte		Char.	Byte		Char.	Byte		Char.	Byte		Char.
Dec	Hex		Dec	Hex		Dec	Hex		Dec	Hex		Dec	Hex		Dec	Hex		Dec	Hex		Dec	Hex	
0	00	NUL	32	20	space	64	40	@	96	60	`	128	80		160	A0	NBSP	192	C0	À	224	E0	à
1	01	SOH	33	21	!	65	41	A	97	61	a	129	81		161	A1	¡	193	C1	Á	225	E1	á
2	02	STX	34	22	"	66	42	B	98	62	b	130	82		162	A2	¢	194	C2	Â	226	E2	â
3	03	ETX	35	23	#	67	43	C	99	63	c	131	83		163	A3	£	195	C3	Ã	227	E3	ã
4	04	EOT	36	24	$	68	44	D	100	64	d	132	84		164	A4	¤	196	C4	Ä	228	E4	ä
5	05	ENQ	37	25	%	69	45	E	101	65	e	133	85		165	A5	¥	197	C5	Å	229	E5	å
6	06	ACK	38	26	&	70	46	F	102	66	f	134	86		166	A6	¦	198	C6	Æ	230	E6	æ
7	07	BEL	39	27	'	71	47	G	103	67	g	135	87		167	A7	§	199	C7	Ç	231	E7	ç
8	08	BS	40	28	(	72	48	H	104	68	h	136	88		168	A8	¨	200	C8	È	232	E8	è
9	09	HT	41	29	)	73	49	I	105	69	i	137	89		169	A9	©	201	C9	É	233	E9	é
10	0A	LF	42	2A	*	74	4A	J	106	6A	j	138	8A		170	AA	ª	202	CA	Ê	234	EA	ê
11	0B	VT	43	2B	+	75	4B	K	107	6B	k	139	8B		171	AB	«	203	CB	Ë	235	EB	ë
12	0C	FF	44	2C	,	76	4C	L	108	6C	l	140	8C		172	AC	¬	204	CC	Ì	236	EC	ì
13	0D	CR	45	2D	-	77	4D	M	109	6D	m	141	8D		173	AD	SHY	205	CD	Í	237	ED	í
14	0E	SO	46	2E	.	78	4E	N	110	6E	n	142	8E		174	AE	®	206	CE	Î	238	EE	î
15	0F	SI	47	2F	/	79	4F	O	111	6F	o	143	8F		175	AF	¯	207	CF	Ï	239	EF	ï
16	10	DLE	48	30	0	80	50	P	112	70	p	144	90		176	B0	°	208	D0	Ð	240	F0	ð
17	11	DC1	49	31	1	81	51	Q	113	71	q	145	91		177	B1	±	209	D1	Ñ	241	F1	ñ
18	12	DC2	50	32	2	82	52	R	114	72	r	146	92		178	B2	2	210	D2	Ò	242	F2	ò
19	13	DC3	51	33	3	83	53	S	115	73	s	147	93		179	B3	3	211	D3	Ó	243	F3	ó
20	14	DC4	52	34	4	84	54	T	116	74	t	148	94		180	B4	´	212	D4	Ô	244	F4	ô
21	15	NAK	53	35	5	85	55	U	117	75	u	149	95		181	B5	µ	213	D5	Õ	245	F5	õ
22	16	SYN	54	36	6	86	56	V	118	76	v	150	96		182	B6	¶	214	D6	Ö	246	F6	ö
23	17	ETB	55	37	7	87	57	W	119	77	w	151	97		183	B7	·	215	D7	×	247	F7	÷
24	18	CAN	56	38	8	88	58	X	120	78	x	152	98		184	B8	¸	216	D8	Ø	248	F8	ø
25	19	EM	57	39	9	89	59	Y	121	79	y	153	99		185	B9	1	217	D9	Ù	249	F9	ù
26	1A	SUB	58	3A	:	90	5A	Z	122	7A	z	154	9A		186	BA	º	218	DA	Ú	250	FA	ú
27	1B	ESC	59	3B	;	91	5B	[	123	7B	{	155	9B		187	BB	»	219	DB	Û	251	FB	û
28	1C	FS	60	3C	<	92	5C	\	124	7C			156	9C		188	BC	¼	220	DC	Ü	252	FC	ü
29	1D	GS	61	3D	=	93	5D	]	125	7D	}	157	9D		189	BD	½	221	DD	Ý	253	FD	ý
30	1E	RS	62	3E	>	94	5E	^	126	7E	~	158	9E		190	BE	¾	222	DE	Þ	254	FE	þ
31	1F	US	63	3F	?	95	5F	_	127	7F	DEL	159	9F		191	BF	¿	223	DF	ß	255	FF	ÿ

NOTE 1 In the JIS8 character set (see Table H.1), byte values 80_{HEX} to $9F_{HEX}$ and $E0_{HEX}$ to FF_{HEX} are not assigned but are reserved values. Some of those values are used as the first byte in the shift JIS character set (see Figure H.1) and can be used to distinguish between JIS8 and shift JIS character sets, or to enable Kanji mode compaction. JIS X 0208 gives details on shift coded representation.

NOTE 2 Byte values 00_{HEX} to $7F_{HEX}$ in the JIS8 character set correspond to ISO/IEC 8859-1 and ISO/IEC 646 IRV, except values $5C_{HEX}$ and $7E_{HEX}$.

NOTE 3 The set of characters shown in Table G.1 does not fully comply with ISO/IEC 8859-1. ISO/IEC 8859-1 contains only graphic characters with hexadecimal values 20-7E and A0-FF.

NOTE 4 The control functions given in Table G.1 in positions with decimal values 00-31 (hexadecimal values 00-1F) correspond to the C0 set of ISO/IEC 6429 where the characters with decimal values 28-31 (hexadecimal values 1C-1F) IS4, IS3, IS2, IS1 are replaced, respectively, by characters FS, GS, RS, US. The character DEL at the position with decimal value 127 (hexadecimal 7F) corresponds to the G0 set of ISO/IEC 646.

The binary data is then concatenated and prefixed with the mode indicator and the character count indicator. The mode indicator in the byte mode has either 4 bits for QR code symbols or the number of bits defined in Table 2 for micro QR code symbols, and the character count indicator has the number of bits defined in Table 3. The number of input data characters is converted to its binary equivalent and added after the mode indicator and before the binary data sequence.

For any number of data characters, the length of the bit stream in byte mode is given by Formula (2):

$$B = M + C + 8D \qquad (2)$$

where

B is the number of bits in bit stream;

M is the number of bits in mode indicator (4 for QR code symbols or as shown in Table 2 for micro QR code symbols);

C is the number of bits in character count indicator (from Table 3);

D is the number of input data characters.

7.4.7 Kanji mode

In the shift JIS system, Kanji characters are represented by a two-byte combination. These byte values are shifted from the JIS X 0208 values. JIS X 0208 gives details of the shift coded representation. Input data characters in Kanji mode are compacted to 13-bit binary codewords as defined in this subclause. The binary data is then concatenated and prefixed with the mode indicator and the character count indicator. The mode indicator in the numeric mode has either 4 bits for QR code symbols or the number of bits defined in Table 2 for micro QR code symbols, and the character count indicator has the number of bits defined in Table 3. The number of input data characters is converted to its binary equivalent and added as the character count indicator after the mode indicator and before the binary data sequence.

a) For characters with shift JIS values from 8140_{HEX} to $9FFC_{HEX}$

   1) subtract 8140_{HEX} from shift JIS value,

   2) multiply most significant byte of result by $C0_{HEX}$,

   3) add least significant byte to product from b), and

   4) convert result to a 13-bit binary string.

b) For characters with shift JIS values from $E040_{HEX}$ to $EBBF_{HEX}$

   1) subtract $C140_{HEX}$ from shift JIS value,

2) multiply most significant byte of result by $C0_{HEX}$,

3) add least significant byte to product from b), and

4) convert result to a 13-bit binary string.

EXAMPLE

Input character	“点”	“茗”
(Shift JIS value):	935F	E4AA
i) 8140 or C140 is subtracted:	935F - 8140 = 121F	E4AA - C140 = 236A
ii) The most significant byte is multiplied by C0:	12 × C0 = D80	23 × C0 = 1A40
iii) The least significant byte is added:	D80 + 1F = D9F	1A40 + 6A = 1AAA
iv) It is converted to 13-bit binary:	0D9F →0 1101 1001 1111	1AAA →1 1010 1010 1010

c) For all characters, prefix binary sequence representing input data characters with mode indicator (from Table 2) and character count indicator binary equivalent (number of bits defined in Table 3).

For any number of data characters, the length of the bit stream in Kanji mode is given by the formula:

$$B = M + C + 13D$$

where

B is the number of bits in bit stream;

M is the number of bits in mode indicator (4 for QR code symbols or as shown in Table 2 for micro QR code symbols);

C is the number of bits in character count indicator (from Table 3);

D is the number of input data characters.

7.4.8 Mixing modes

There is the option for a symbol to contain sequences of data in one mode and then to change modes if the data content requires it, or in order to increase the density of encoding. Refer to Annex J for guidance. Each segment of data is encoded in the appropriate mode as indicated in 7.4.3 to 7.4.7, with the basic structure mode indicator/character count indicator/data and followed immediately by the mode indicator commencing the next segment. Figure 13 illustrates the structure of data containing *n* segments.

Segment 1			Segment 2			. . .	Segment *n*			Terminator
mode indicator 1	character count indicator	Data	mode indicator 2	character count indicator	Data	. . .	mode indicator *n*	character count indicator	Data	

Figure 13 — Format of mixed mode data

7.4.9 FNC1 modes

7.4.9.1 General

In QR code symbols, there are two mode indicators which are used cumulatively with those defined in 7.3.2 to 7.3.8 and 7.4.3 to 7.4.8 to identify symbols encoding messages formatted according to specific predefined industry or application specifications. These (together with any associated parameter data) precede the mode indicator(s) used to encode the data efficiently. When these mode indicators are used, it is necessary for the decoder to transmit the symbology identifier as defined in 14.2 and Annex F.

7.4.9.2 FNC1 in first position

NOTE "First position" is not used in a literal sense but is a historical reference to the position of the FNC1 symbol character in Code 128 symbols.

This mode indicator identifies GS1 QR code symbols encoding data with GS1 application identifiers formatted according to the GS1 General Specifications. GS1 QR code symbology is a subset of QR code symbology. For this purpose, it shall only be used once in a symbol and shall be placed immediately before the first mode indicator used for efficient data encoding (numeric, alphanumeric, byte or Kanji), and after any ECI or structured append header. The FNC1 mode require the use of a separator character to distinguish concatenated data fields from each other. See 14.4 for the detail of transmission of the data field separator characters.

EXAMPLE 1

Input data:	0104912345123459 (application identifier 01 = GS1 article number, fixed length; data: 04912345123459)
	15970331 (application identifier 15 = "Best before" date YYMMDD, fixed length; data: 31 March 1997)
	30128 (application identifier 30 = quantity, variable length; data: 128) (requires separator character)
	10ABC123 (application identifier 10 = batch number, variable length; data: ABC123)
Data to be encoded:	01049123451234591597033130128%10ABC123
Bit sequence in symbol:	0101 (mode indicator, FNC1 implied in 1st position)
	0001 (mode indicator, numeric mode)
	0000011101 (character count indicator, 29)
	<data bits for 01049123451234591597033130128>
	0010 (mode indicator, alphanumeric mode)
	000001001 (character count indicator, 9)
	<data bits for %10ABC123>
Transmitted data (see 14.2 and Annex F):	]Q301049123451234591597033130128<1D$_{HEX}$>10ABC123

EXAMPLE 2 Encoding and transmission of percentage character in data:

Input data:	123 %
Encoded as:	123 %%
Transmitted as:	123 %

7.4.9.3 FNC1 in second position

NOTE 1 "Second position" is not used in a literal sense but is a historical reference to the position of the FNC1 symbol character in Code 128 symbols.

This mode indicator identifies symbols formatted according to a specific industry or application specification listed in ISO/IEC 15424:—, Annex E. It is immediately followed by a one-byte codeword the value of which is that of the application indicator assigned to identify the specification concerned.

For this purpose, it shall only be used once in a symbol and shall be placed immediately before the first mode indicator used for efficient data encoding (numeric, alphanumeric, byte or Kanji), and after any ECI or structured append header. An application indicator can take the form of any single Latin alphabetic character from the set {a - z, A - Z} (represented by the ISO/IEC 646 IRV value of the character plus 100) or a two-digit number (represented by its numeric value directly) and shall be transmitted by the decoder as the first one or two characters immediately preceding the data. The FNC1 mode and some other application specifications can require the use of a separator character to distinguish concatenated data fields from each other. See 14.4 for details on the transmission of data field separator characters.

NOTE 2 At the time of the publication of this document, application indicator 37 has not been assigned to any organisation and the data content of the example is purely arbitrary.

Application indicator:	37
Input data:	AA1234BBB112text text text text<CR>
Bit sequence in symbol:	1001 (mode indicator, FNC1 implied in 2^{nd} position)
	00100101 (application indicator 37)
	0010 (mode indicator, alphanumeric mode)
	000001100 (character count indicator 12)
	<data bits for AA1234BBB112>
	0100 (mode indicator, byte mode)
	00010100 (character count indicator 20)
	<data bits for text text text text<CR> >
Transmitted data:	]Q537AA1234BBB112text text text text<CR>

7.4.10 Terminator

The end of data in the symbol is signalled by the terminator sequence of 0 bits, as defined in Table 2, appended to the data bit stream following the final mode segment. The terminator shall be omitted if the data bit stream completely fills the capacity of the symbol or abbreviated if the remaining capacity of the symbol is less than the required bit length of terminator.

7.4.11 Bit stream to codeword conversion

The bit streams corresponding to each mode segment shall be connected in order. The terminator shall be appended to the complete bit stream as defined in 7.4.10. The resulting message bit stream shall then be divided into codewords. All codewords are 8 bits in length, except for the final data symbol character in micro QR code versions M1 and M3 symbols, which is 4 bits in length. If the bit stream length is such that it does not end at a codeword boundary, padding bits with binary value 0 shall be added after the final bit (least significant bit) of the data stream to extend it to the codeword boundary. The message bit stream shall then be extended to fill the data capacity of the symbol corresponding to the version and error correction level, as defined in Table 7, by adding the pad codewords 11101100 and 00010001 alternately. For micro QR code versions M1 and M3 symbols, the final data codeword is 4 bits long. The pad codeword used in the final data symbol character position in micro QR code versions M1 and M3 symbols shall be represented as 0000. The resulting series of codewords, the data codeword sequence, is then processed as described in 7.5 to add error correction codewords to the message. In certain versions of symbol, it can be necessary to add 3, 4 or 7 remainder bits (all zeros) to the end of the message, after the final error correction codeword, in order exactly to fill the symbol capacity (see Table 7).

Table 7 — Number of symbol characters and input data capacity for QR code

Version	Error correction level	Number of data codewords	Number of data bits	Data capacity			
				Numeric	Alphanumeric	Byte	Kanji
M1	Error detection only	3	20	5	—	—	—
M2	L M	5 4	40 32	10 8	6 5	— —	— —
M3	L M	11 9	84 68	23 18	14 11	9 7	6 4
M4	L M Q	16 14 10	128 112 80	35 30 21	21 18 13	15 13 9	9 8 5
1	L M Q H	19 16 13 9	152 128 104 72	41 34 27 17	25 20 16 10	17 14 11 7	10 8 7 4
2	L M Q H	34 28 22 16	272 224 176 128	77 63 48 34	47 38 29 20	32 26 20 14	20 16 12 8
3	L M Q H	55 44 34 26	440 352 272 208	127 101 77 58	77 61 47 35	53 42 32 24	32 26 20 15
4	L M Q H	80 64 48 36	640 512 384 288	187 149 111 82	114 90 67 50	78 62 46 34	48 38 28 21
5	L M Q H	108 86 62 46	864 688 496 368	255 202 144 106	154 122 87 64	106 84 60 44	65 52 37 27
6	L M Q H	136 108 76 60	1 088 864 608 480	322 255 178 139	195 154 108 84	134 106 74 58	82 65 45 36
7	L M Q H	156 124 88 66	1 248 992 704 528	370 293 207 154	224 178 125 93	154 122 86 64	95 75 53 39
8	L M Q H	194 154 110 86	1 552 1 232 880 688	461 365 259 202	279 221 157 122	192 152 108 84	118 93 66 52
9	L M Q H	232 182 132 100	1 856 1 456 1 056 800	552 432 312 235	335 262 189 143	230 180 130 98	141 111 80 60
10	L M Q H	274 216 154 122	2 192 1 728 1 232 976	652 513 364 288	395 311 221 174	271 213 151 119	167 131 93 74
11	L M Q H	324 254 180 140	2 592 2 032 1 440 1 120	772 604 427 331	468 366 259 200	321 251 177 137	198 155 109 85

Table 7 *(continued)*

Version	Error correction level	Number of data codewords	Number of data bits	Data capacity			
				Numeric	Alphanumeric	Byte	Kanji
12	L	370	2 960	883	535	367	226
	M	290	2 320	691	419	287	177
	Q	206	1 648	489	296	203	125
	H	158	1 264	374	227	155	96
13	L	428	3 424	1 022	619	425	262
	M	334	2 672	796	483	331	204
	Q	244	1 952	580	352	241	149
	H	180	1 440	427	259	177	109
14	L	461	3 688	1 101	667	458	282
	M	365	2 920	871	528	362	223
	Q	261	2 088	621	376	258	159
	H	197	1 576	468	283	194	120
15	L	523	4 184	1 250	758	520	320
	M	415	3 320	991	600	412	254
	Q	295	2 360	703	426	292	180
	H	223	1 784	530	321	220	136
16	L	589	4 712	1 408	854	586	361
	M	453	3 624	1 082	656	450	277
	Q	325	2 600	775	470	322	198
	H	253	2 024	602	365	250	154
17	L	647	5 176	1 548	938	644	397
	M	507	4 056	1 212	734	504	310
	Q	367	2 936	876	531	364	224
	H	283	2 264	674	408	280	173
18	L	721	5 768	1 725	1 046	718	442
	M	563	4 504	1 346	816	560	345
	Q	397	3 176	948	574	394	243
	H	313	2 504	746	452	310	191
19	L	795	6 360	1 903	1 153	792	488
	M	627	5 016	1 500	909	624	384
	Q	445	3 560	1 063	644	442	272
	H	341	2 728	813	493	338	208
20	L	861	6 888	2 061	1 249	858	528
	M	669	5 352	1 600	970	666	410
	Q	485	3 880	1 159	702	482	297
	H	385	3 080	919	557	382	235
21	L	932	7 456	2 232	1 352	929	572
	M	714	5 712	1 708	1 035	711	438
	Q	512	4 096	1 224	742	509	314
	H	406	3 248	969	587	403	248
22	L	1 006	8 048	2 409	1 460	1 003	618
	M	782	6 256	1 872	1 134	779	480
	Q	568	4 544	1 358	823	565	348
	H	442	3 536	1 056	640	439	270
23	L	1 094	8 752	2 620	1 588	1 091	672
	M	860	6 880	2 059	1 248	857	528
	Q	614	4 912	1 468	890	611	376
	H	464	3 712	1 108	672	461	284
24	L	1 174	9 392	2 812	1 704	1 171	721
	M	914	7 312	2 188	1 326	911	561
	Q	664	5 312	1 588	963	661	407
	H	514	4 112	1 228	744	511	315
25	L	1 276	10 208	3 057	1 853	1 273	784
	M	1 000	8 000	2 395	1 451	997	614
	Q	718	5 744	1 718	1 041	715	440
	H	538	4 304	1 286	779	535	330
26	L	1 370	10 960	3 283	1 990	1 367	842
	M	1 062	8 496	2 544	1 542	1 059	652
	Q	754	6 032	1 804	1 094	751	462
	H	596	4 768	1 425	864	593	365

Table 7 *(continued)*

Version	Error correction level	Number of data codewords	Number of data bits	Data capacity			
				Numeric	Alphanumeric	Byte	Kanji
27	L	1 468	11 744	3 517	2 132	1 465	902
	M	1 128	9 024	2 701	1 637	1 125	692
	Q	808	6 464	1 933	1 172	805	496
	H	628	5 024	1 501	910	625	385
28	L	1 531	12 248	3 669	2 223	1 528	940
	M	1 193	9 544	2 857	1 732	1 190	732
	Q	871	6 968	2 085	1 263	868	534
	H	661	5 288	1 581	958	658	405
29	L	1 631	13 048	3 909	2 369	1 628	1 002
	M	1 267	10 136	3 035	1 839	1 264	778
	Q	911	7 288	2 181	1 322	908	559
	H	701	5 608	1 677	1 016	698	430
30	L	1 735	13 880	4 158	2 520	1 732	1 066
	M	1 373	10 984	3 289	1 994	1 370	843
	Q	985	7 880	2 358	1 429	982	604
	H	745	5 960	1 782	1 080	742	457
31	L	1 843	14 744	4 417	2 677	1 840	1 132
	M	1 455	11 640	3 486	2 113	1 452	894
	Q	1 033	8 264	2 473	1 499	1 030	634
	H	793	6 344	1 897	1 150	790	486
32	L	1 955	15 640	4 686	2 840	1 952	1 201
	M	1 541	12 328	3 693	2 238	1 538	947
	Q	1 115	8 920	2 670	1 618	1 112	684
	H	845	6 760	2 022	1 226	842	518
33	L	2 071	16 568	4 965	3 009	2 068	1 273
	M	1 631	13 048	3 909	2 369	1 628	1 002
	Q	1 171	9 368	2 805	1 700	1 168	719
	H	901	7 208	2 157	1 307	898	553
34	L	2 191	17 528	5 253	3 183	2 188	1 347
	M	1 725	13 800	4 134	2 506	1 722	1 060
	Q	1 231	9 848	2 949	1 787	1 228	756
	H	961	7 688	2 301	1 394	958	590
35	L	2 306	18 448	5 529	3 351	2 303	1 417
	M	1 812	14 496	4 343	2 632	1 809	1 113
	Q	1 286	10 288	3 081	1 867	1 283	790
	H	986	7 888	2 361	1 431	983	605
36	L	2 434	19 472	5 836	3 537	2 431	1 496
	M	1 914	15 312	4 588	2 780	1 911	1 176
	Q	1 354	10 832	3 244	1 966	1 351	832
	H	1 054	8 432	2 524	1 530	1 051	647
37	L	2 566	20 528	6 153	3 729	2 563	1 577
	M	1 992	15 936	4 775	2 894	1 989	1 224
	Q	1 426	11 408	3 417	2 071	1 423	876
	H	1 096	8 768	2 625	1 591	1 093	673
38	L	2 702	21 616	6 479	3 927	2 699	1 661
	M	2 102	16 816	5 039	3 054	2 099	1 292
	Q	1 502	12 016	3 599	2 181	1 499	923
	H	1 142	9 136	2 735	1 658	1 139	701
39	L	2 812	22 496	6 743	4 087	2 809	1 729
	M	2 216	17 728	5 313	3 220	2 213	1 362
	Q	1 582	12 656	3 791	2 298	1 579	972
	H	1 222	9 776	2 927	1 774	1 219	750
40	L	2 956	23 648	7 089	4 296	2 953	1 817
	M	2 334	18 672	5 596	3 391	2 331	1 435
	Q	1 666	13 328	3 993	2 420	1 663	1 024
	H	1 276	10 208	3 057	1 852	1 273	784

All codewords shall be 8 bits in length, except for the final data codeword for versions M1 and M3 which is 4 bits long.

NOTE The number of data bits includes bits for the mode indicator and the character count indicator.

7.5 Error correction

7.5.1 Error correction capacity

QR code employs Reed-Solomon error control coding to detect and correct errors. A series of error correction codewords is generated, which are added to the data codeword sequence in order to enable the symbol to withstand damage without loss of data. There are four user-selectable levels of error correction, as shown in Table 8, offering the capability of recovery from the following amounts of damage.

Table 8 — Error correction levels

Error correction level	Approximate recovery capacity %
L	7
M	15
Q	25
H	30

Clause K.2 gives guidance on the appropriate level of error correction to be applied to a symbol.

The error correction level H is not available in micro QR code symbols.

The error correction codewords can correct two types of erroneous codewords, erasures (erroneous codewords at known locations) and errors (erroneous codewords at unknown locations). An erasure is an unscanned or undecodable symbol character. An error is a misdecoded symbol character. Since QR code is a matrix symbology, a defect converting a module from dark to light or vice versa will result in the affected symbol character misdecoding as an apparently valid but different codeword. Such an error causing a substitution error in the data requires two error correction codewords to correct it.

The number of erasures and errors correctable is given by Formula (3):

$$e + 2t \le d - p \tag{3}$$

where

e is the number of erasures;

t is the number of errors;

d is the number of error correction codewords;

p is the number of misdecoded protection codewords.

In the general case, $p = 0$. However, if most of the error correction capacity is used to correct erasures, the possibility of an undetected error is increased. Whenever the number of erasures is more than half the number of error correction codewords, $p = 3$. For small symbols with less than 8 error correction codewords, erasure correction should not be used ($e = 0$ and $p > 0$).

For example, in a version 6-H symbol there is a total of 172 codewords, of which 112 are error correction codewords (leaving 60 data codewords). The 112 error correction codewords can correct 56 misdecodes or substitution errors, i.e. 56/172 or 32,6 % of the symbol capacity.

In Formula (3), the following values should be assigned to *p*:

— *p* = 3 in version 1-L and M2-L symbols,

— *p* = 2 in version 1-M, 2-L, M1, M2-M, M3-L, and M4-L symbols,

— *p* = 1 in version 1-Q, 1-H and 3-L symbols,

— *p* = 0 in all other cases.

Where $p > 0$, there are *p* (i.e. 1, 2 or 3) codewords which act as error detection codewords and prevent transmission of data from symbols where the number of errors exceeds the error correction capacity, *e* is less than $d/2$. For example, in a version 2-L symbol, the total number of codewords is 44; of these, 34 are data codewords and 10 error correction codewords. From Table 9, the error correction capacity can be seen to be four errors (where $e = 0$). Substituting it in Formula (3)

$$0+(2\times 4)=10-2$$

meaning that the correction of the four errors requires only 8 error correction codewords; the remaining 2 error correction codewords can therefore detect (but not correct) any additional errors and the symbol would, if there were more than four errors, fail to decode.

Depending on the version and error correction level, the data codeword sequence shall be subdivided into one or more blocks, to each of which the error correction algorithm shall be applied separately. Table 9 lists, for each version and error correction level, the total number of codewords, the total number of error correction codewords, and the structure and number of error correction blocks.

If remainder bits are required to fill remaining modules in the symbol capacity for certain symbol versions, they shall all be 0 bits.

Table 9 — Error correction characteristics for QR code

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of misdecoded protection codewords *p*	Number of error correction blocks	Error correction code per block (*c*, *k*, *r*)
M1	5	Error detection only	2	2	1	(5,3,0)[a]
M2	10	L M	5 6	3 2	1 1	(10,5,1 [a] (10,4,2)[a]
M3	17	L M	6 8	2 0	1 1	(17,11,2)[a] (17,9,4)
M4	24	L M Q	8 10 14	2 0 0	1 1 1	(24,16,3)[a] (24,14,5) (24,10,7)
1	26	L M Q H	7 10 13 17	3 2 1 1	1 1 1 1	(26,19,2)[a] (26,16,4)[a] (26,13,6)[a] (26,9,8)[a]
2	44	L M Q H	10 16 22 28	2 0 0 0	1 1 1 1	(44,34,4)[a] (44,28,8) (44,22,11) (44,16,14)

Key

c total number of codewords

k number of data codewords

r error correction capacity

[a] The error correction capacity is less than half the number of error correction codewords to reduce the probability of misdecodes.

Table 9 *(continued)*

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of misdecoded protection codewords p	Number of error correction blocks	Error correction code per block (c, k, r)
3	70	L M Q H	15 26 36 44	1 0 0 0	1 1 2 2	(70,55,7)[a] (70,44,13) (35,17,9) (35,13,11)
4	100	L M Q H	20 36 52 64	0	1 2 2 4	(100,80,10) (50,32,9) (50,24,13) (25,9,8)
5	134	L M Q H	26 48 72 88	0	1 2 2 2 2 2	(134,108,13) (67,43,12) (33,15,9) (34,16,9) (33,11,11) (34,12,11)
6	172	L M Q H	36 64 96 112	0	2 4 4 4	(86,68,9) (43,27,8) (43,19,12) (43,15,14)
7	196	L M Q H	40 72 108 130	0	2 4 2 4 4 1	(98,78,10) (49,31,9) (32,14,9) (33,15,9) (39,13,13) (40,14,13)
8	242	L M Q H	48 88 132 156	0	2 2 2 4 2 4 2	(121,97,12) (60,38,11) (61,39,11) (40,18,11) (41,19,11) (40,14,13) (41,15,13)
9	292	L M Q H	60 110 160 192	0	2 3 2 4 4 4 4	(146,116,15) (58,36,11) (59,37,11) (36,16,10) (37,17,10) (36,12,12) (37,13,12)
10	346	L M Q H	72 130 192 224	0	2 2 4 1 6 2 6 2	(86,68,9) (87,69,9) (69,43,13) (70,44,13) (43,19,12) (44,20,12) (43,15,14) (44,16,14)

Key

c total number of codewords

k number of data codewords

r error correction capacity

[a] The error correction capacity is less than half the number of error correction codewords to reduce the probability of misdecodes.

Table 9 *(continued)*

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of misdecoded protection codewords p	Number of error correction blocks	Error correction code per block (c, k, r)
11	404	L	80	0	4	(101,81,10)
		M	150		1 4	(80,50,15) (81,51,15)
		Q	224		4 4	(50,22,14) (51,23,14)
		H	264		3 8	(36,12,12) (37,13,12
12	466	L	96	0	2 2	(116,92,12) (117,93,12)
		M	176		6 2	(58,36,11) (59,37,11)
		Q	260		4 6	(46,20,13) (47,21,13)
		H	308		7 4	(42,14,14) (43,15,14)
13	532	L	104	0	4	(133,107,13)
		M	198		8 1	(59,37,11) (60,38,11)
		Q	288		8 4	(44,20,12) (45,21,12)
		H	352		12 4	(33,11,11) (34,12,11)
14	581	L	120	0	3 1	(145,115,15) (146,116,15)
		M	216		4 5	(64,40,12) (65,41,12)
		Q	320		11 5	(36,16,10) (37,17,10)
		H	384		11 5	(36,12,12) (37,13,12)
15	655	L	132	0	5 1	(109,87,11) (110,88,11)
		M	240		5 5	(65,41,12) (66,42,12)
		Q	360		5 7	(54,24,15) (55,25,15)
		H	432		11 7	(36,12,12) (37,13,12)
16	733	L	144	0	5 1	(122,98,12) (123,99,12)
		M	280		7 3	(73,45,14) (74,46,14)
		Q	408		15 2	(43,19,12) (44,20,12)
		H	480		3 13	(45,15,15) (46,16,15)

Key

c total number of codewords

k number of data codewords

r error correction capacity

[a] The error correction capacity is less than half the number of error correction codewords to reduce the probability of misdecodes.

Table 9 *(continued)*

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of misdecoded protection codewords p	Number of error correction blocks	Error correction code per block (c, k, r)
17	815	L M Q H	168 308 448 532	0	1 5 10 1 1 15 2 17	(135,107,14) (136,108,14) (74,46,14) (75,47,14) (50,22,14) (51,23,14) (42,14,14) (43,15,14)
18	901	L M Q H	180 338 504 588	0	5 1 9 4 17 1 2 19	(150,120,15) (151,121,15) (69,43,13) (70,44,13) (50,22,14) (51,23,14) (42,14,14) (43,15,14)
19	991	L M Q H	196 364 546 650	0	3 4 3 11 17 4 9 16	(141,113,14) (142,114,14) (70,44,13) (71,45,13) (47,21,13) (48,22,13) (39,13,13) (40,14,13)
20	1 085	L M Q H	224 416 600 700	0	3 5 3 13 15 5 15 10	(135,107,14) (136,108,14) (67,41,13) (68,42,13) (54,24,15) (55,25,15) (43,15,14) (44,16,14)
21	1 156	L M Q H	224 442 644 750	0	4 4 17 17 6 19 6	(144,116,14) (145,117,14) (68,42,13) (50,22,14) (51,23,14) (46,16,15) (47,17,15)
22	1 258	L M Q H	252 476 690 816	0	2 7 17 7 16 34	(139,111,14) (140,112,14) (74,46,14) (54,24,15) (55,25,15) (37,13,12)
23	1 364	L M Q H	270 504 750 900	0	4 5 4 14 11 14 16 14	(151,121,15) (152,122,15) (75,47,14) (76,48,14) (54,24,15) (55,25,15) (45,15,15) (46,16,15)

Key

c total number of codewords

k number of data codewords

r error correction capacity

[a] The error correction capacity is less than half the number of error correction codewords to reduce the probability of misdecodes.

Table 9 *(continued)*

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of misdecoded protection codewords *p*	Number of error correction blocks	Error correction code per block (*c*, *k*, *r*)
24	1 474	L	300	0	6 4	(147,117,15) (148,118,15)
		M	560		6 14	(73,45,14) (74,46,14)
		Q	810		11 16	(54,24,15) (55,25,15)
		H	960		30 2	(46,16,15) (47,17,15)
25	1 588	L	312	0	8 4	(132,106,13) (133,107,13)
		M	588		8 13	(75,47,14) (76,48,14)
		Q	870		7 22	(54,24,15) (55,25,15)
		H	1050		22 13	(45,15,15) (46,16,15)
26	1 706	L	336	0	10 2	(142,114,14) (143,115,14)
		M	644		19 4	(74,46,14) (75,47,14)
		Q	952		28 6	(50,22,14) (51,23,14)
		H	1110		33 4	(46,16,15) (47,17,15)
27	1 828	L	360	0	8 4	(152,122,15) (153,123,15)
		M	700		22 3	(73,45,14) (74,46,14)
		Q	1 020		8 26	(53,23,15) (54,24,15)
		H	1 200		12 28	(45,15,15) (46,16,15)
28	1 921	L	390	0	3 10	(147,117,15) (148,118,15)
		M	728		3 23	(73,45,14) (74,46,14)
		Q	1 050		4 31	(54,24,15) (55,25,15)
		H	1 260		11 31	(45,15,15) (46,16,15)
29	2 051	L	420	0	7 7	(146,116,15) (147,117,15)
		M	784		21 7	(73,45,14) (74,46,14)
		Q	1 140		1 37	(53,23,15) (54,24,15)
		H	1 350		19 26	(45,15,15) (46,16,15)

Key

c total number of codewords

k number of data codewords

r error correction capacity

[a] The error correction capacity is less than half the number of error correction codewords to reduce the probability of misdecodes.

Table 9 *(continued)*

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of misdecoded protection codewords p	Number of error correction blocks	Error correction code per block (c, k, r)
30	2 185	L M Q H	450 812 1 200 1 440	0	5 10 19 10 15 25 23 25	(145,115,15) (146,116,15) (75,47,14) (76,48,14) (54,24,15) (55,25,15) (45,15,15) (46,16,15)
31	2 323	L M Q H	480 868 1 290 1 530	0	13 3 2 29 42 1 23 28	(145,115,15) (146,116,15) (74,46,14) (75,47,14) (54,24,15) (55,25,15) (45,15,15) (46,16,15)
32	2 465	L M Q H	510 924 1 350 1 620	0	17 10 23 10 35 19 35	(145,115,15) (74,46,14) (75,47,14) (54,24,15) (55,25,15) (45,15,15) (46,16,15)
33	2 611	L M Q H	540 980 1 440 1 710	0	17 1 14 21 29 19 11 46	(145,115,15) (146,116,15) (74,46,14) (75,47,14) (54,24,15) (55,25,15) (45,15,15) (46,16,15)
34	2 761	L M Q H	570 1 036 1 530 1 800	0	13 6 14 23 44 7 59 1	(145,115,15) (146,116,15) (74,46,14) (75,47,14) (54,24,15) (55,25,15) (46,16,15) (47,17,15)
35	2 876	L M Q H	570 1 064 1 590 1 890	0	12 7 12 26 39 14 22 41	(151,121,15) (152,122,15) (75,47,14) (76,48,14) (54,24,15) (55,25,15) (45,15,15) (46,16,15)

Key

c total number of codewords

k number of data codewords

r error correction capacity

[a] The error correction capacity is less than half the number of error correction codewords to reduce the probability of misdecodes.

Table 9 *(continued)*

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of misdecoded protection codewords p	Number of error correction blocks	Error correction code per block (c, k, r)
36	3 034	L	600	0	6 14	(151,121,15) (152,122,15)
		M	1 120		6 34	(75,47,14) (76,48,14)
		Q	1 680		46 10	(54,24,15) (55,25,15)
		H	1 980		2 64	(45,15,15) (46,16,15)
37	3 196	L	630	0	17 4	(152,122,15) (153,123,15)
		M	1 204		29 14	(74,46,14) (75,47,14)
		Q	1 770		49 10	(54,24,15) (55,25,15)
		H	2 100		24 46	(45,15,15) (46,16,15)
38	3 362	L	660	0	4 18	(152,122,15) (153,123,15)
		M	1 260		13 32	(74,46,14) (75,47,14)
		Q	1 860		48 14	(54,24,15) (55,25,15)
		H	2 220		42 32	(45,15,15) (46,16,15)
39	3 532	L	720	0	20 4	(147,117,15) (148,118,15)
		M	1 316		40 7	(75,47,14) (76,48,14)
		Q	1 950		43 22	(54,24,15) (55,25,15)
		H	2 310		10 67	(45,15,15) (46,16,15)
40	3 706	L	750	0	19 6	(148,118,15) (149,119,15)
		M	1 372		18 31	(75,47,14) (76,48,14)
		Q	2 040		34 34	(54,24,15) (55,25,15)
		H	2 430		20 61	(45,15,15) (46,16,15)

Key

c total number of codewords

k number of data codewords

r error correction capacity

[a] The error correction capacity is less than half the number of error correction codewords to reduce the probability of misdecodes.

7.5.2 Generating the error correction codewords

The data codewords including pad codewords as necessary shall be divided into the number of blocks shown in Table 9. The error correction codewords shall be calculated for each block and appended to the data codewords.

NOTE Micro QR code symbols consist of a single block.

The polynomial arithmetic for QR code shall be calculated using bit-wise modulo 2 arithmetic and byte-wise modulo 100011101 arithmetic. This is a Galois field of 2^8 with 100011101 representing the field's prime modulus polynomial $x^8 + x^4 + x^3 + x^2 + 1$.

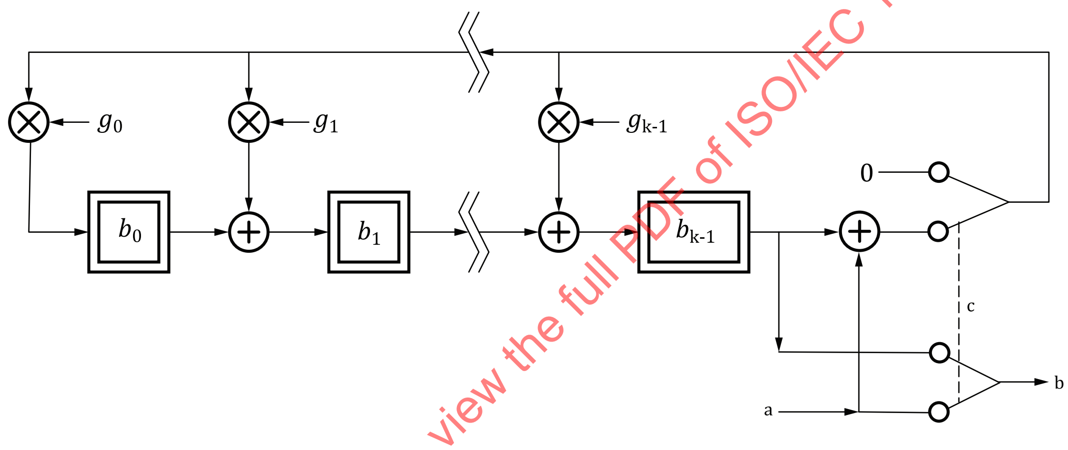
The data codewords are the coefficients of the terms of a polynomial with the coefficient of the highest term being the first data codeword and that of the lowest power term being the last data codeword before the first error correction codeword.

The error correction codewords are the remainder after dividing the data codewords by a polynomial $g(x)$ used for error correction codes (see Annex A). The highest order coefficient of the remainder is the first error correction codeword and the zero power coefficient is the last error correction codeword and the last codeword in the block.

If this calculation is performed by "long division" the symbol data polynomial shall first be multiplied by *x* ^{c-*k*}.

Thirty-six different generator polynomials in Annex A shall apply for generating the error correction codewords for QR code.

This can be implemented by using the division circuit as shown in Figure 14. The registers b_0 through b_{k-1} are initialized as zeros. There are two phases to generate the encoding. In the first phase, with the switch in the down position the data codewords are passed both to the output and the circuit. The first phase is complete after n clock pulses. In the second phase (n + 1 ... n + k clock pulses), with the switch in the up position, the error correction codewords ε_{k-1} ... ε_0 are generated by flushing the registers in order while keeping the data input at 0.



Key

⊕	GF(256) addition	⊗	GF(256) multiplication
a	Input.		
b	Output.		
c	Switch.		

Figure 14 — Error correction codeword encoding circuit

7.6 Constructing the final message codeword sequence

The total number of codewords in the message shall always be equal to the total number of codewords capable of being represented in the symbol, as shown in Tables 7 and 9.

The following steps shall be followed to construct the final sequence of codewords (data plus error correction codewords plus remainder codewords if necessary).

a) Divide the data codeword sequence into n blocks as defined in Table 9 in accordance with the version and error correction level (or a single block for micro QR code symbols).

b) For each data block, calculate a corresponding block of error correction codewords as defined in 7.5.2 and Annex A.

c) Assemble the final sequence by taking data and error correction codewords from each block in turn. For example, if there are four blocks the sequence would be: data block 1, codeword 1; data block 2, codeword 1; ...; data block 4, codeword 1; data block 1, codeword 2; ... and similarly to data block 3, final codeword; data block 4, final codeword; then, error correction block 1, codeword 1, error correction block 2, codeword 1, ... and similarly to error correction block 4, final codeword. QR code symbols contain data and error correction blocks which always exactly fill the symbol codeword capacity. In certain QR code versions, however, where the number of modules available for data and error correction codewords is not an exact multiple of 8, there can be a need for 3, 4 or 7 remainder bits to be appended to the final message bit stream in order to fill exactly the number of modules in the encoding region.

The shortest data block (or blocks) shall be placed first in the sequence and all the data codewords shall be placed in the symbol before the first error correction codeword. For example, the version 5-H symbol comprises four data and four error correction blocks, the first two of each of which contain 11 data and 22 error correction codewords respectively, while the third and fourth pairs of blocks contain 12 data and 22 error correction codewords respectively. In this symbol, the character arrangement can be depicted as shown in Figure 15. Each row of Figure 15 corresponds to one block of data codewords (shown as D_n) followed by the associated block of error correction codewords (shown as E_n). The sequence of character placement in the symbol is obtained by reading down each column of Figure 15.

	Data codewords					Error correction codewords			
Block 1	D_1	D_2	.....	D_{11}		E_1	E_2	.....	E_{22}
Block 2	D_{12}	D_{13}	.....	D_{22}		E_{23}	E_{24}	.....	E_{44}
Block 3	D_{23}	D_{24}	.....	D_{33}	D_{34}	E_{45}	E_{46}	.....	E_{66}
Block 4	D_{35}	D_{36}	.....	D_{45}	D_{46}	E_{67}	E_{68}	.....	E_{88}

Figure 15 — Construction of the final message codeword sequence

The final message codeword sequence for the version 5-H symbol is therefore:

$D_1, D_{12}, D_{23}, D_{35}, D_2, D_{13}, D_{24}, D_{36}, \ldots D_{11}, D_{22}, D_{33}, D_{45}, D_{34}, D_{46}, E_1, E_{23}, E_{45}, E_{67}, E_2, E_{24}, E_{46}, E_{68}, \ldots E_{22}, E_{44}, E_{66}, E_{88}$.

The symbol module capacity is filled by adding 7 remainder (0) bits as needed after the final codeword.

7.7 Codeword placement in matrix

7.7.1 Symbol character representation

There are two types of symbol character, regular and irregular, in the QR code symbol. Their use depends on their position in the symbol, relative to other symbol characters and function patterns.

Most codewords shall be represented in a regular 2 × 4 module block in the symbol. There are two ways of positioning these blocks, in a vertical arrangement (2 modules wide and 4 modules high) and, if necessary when placement changes direction, in a horizontal arrangement (4 modules wide and 2 modules high). Irregular symbol characters are used when changing direction or in the vicinity of alignment or other function patterns. Examples are shown in Figures 16, 17 and 18.

7.7.2 Function pattern placement

A square blank matrix shall be constructed with the number of modules horizontally and vertically corresponding to the version in use. Positions corresponding to the finder pattern, separator, timing pattern and alignment patterns shall be filled with either dark modules or light modules as appropriate. Module positions for the format information and version information shall be left temporarily blank. These blank positions are shown in Figures 19 and 20 and are common to all versions (although the version information is not present in version 1 to 6 symbols). The positioning of alignment patterns in Annex E shall apply.

7.7.3 Symbol character placement

In the encoding region of the QR code symbol, symbol characters are positioned in two-module wide columns commencing at the lower right corner of the symbol and running alternately upwards and downwards from the right to the left. The principles governing the placement of characters and of bits within the characters are given below. Figures 19 and 20 illustrate version 2 and version 7 symbols applying these principles.

a) The sequence of bit placement in the column shall be from right to left and either upwards or downwards in accordance with the direction of symbol character placement.

b) The most significant bit (shown as bit 7) of each codeword shall be placed in the first available module position. Subsequent bits shall be placed in the next module positions. The most significant bit therefore occupies the lower right module of a regular symbol character when the direction of placement is upwards, and the upper right module when the direction of placement is downwards. It may, however, occupy the lower left module of an irregular symbol character if the previous character has ended in the right-hand module column (see Figure 18).

a) Upwards direction **b) Downwards direction**

Figure 16 — Bit placement in a regular symbol character in upwards and downwards directions

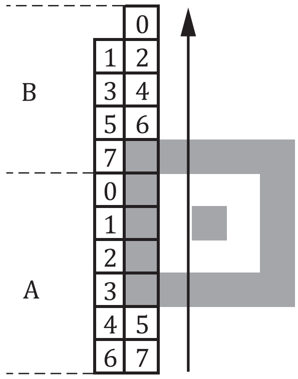
c) When a symbol character encounters the horizontal boundary of an alignment pattern or of the timing pattern in both module columns, it shall continue above or below the pattern as though the encoding region were continuous.

d) When the upper or lower boundary of the symbol character region is reached (i.e. the edge of the symbol, format information, version information, or separator) any remaining bits in the codeword shall be placed in the next column to the left. The direction of placement reverses.

a) Regular symbol characters **b) Irregular symbol characters when the placement direction changes**

Figure 17 — Example of a bit placement in upwards to downwards directions

e) When the right-hand module column of the symbol character column encounters an alignment pattern or an area occupied by version information, bits are placed to form an irregular symbol character, extending along the single module column adjacent to the alignment pattern or version information. If the character ends before two columns are available for the next symbol character, the most significant bit of the next character shall be placed in the single column.



Key

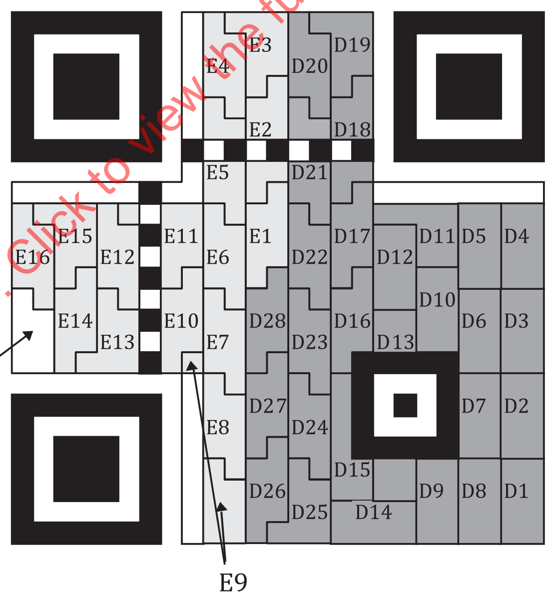
A character 1

B character 2

Figure 18 — Example of a bit placement adjacent to the alignment pattern in upwards direction

An alternative method for placement in the symbol, which yields the same result, is to regard the interleaved codeword sequence as a single bit stream, which is placed (starting with the most significant bit) in the two-module wide columns alternately upwards and downwards from the right to left of the symbol. In each column, the bits are placed alternately in the right and left modules, moving upwards or downwards according to the direction of placement and skipping areas occupied by function patterns, changing direction at the top or bottom of the column. Each bit shall always be placed in the first available module position.

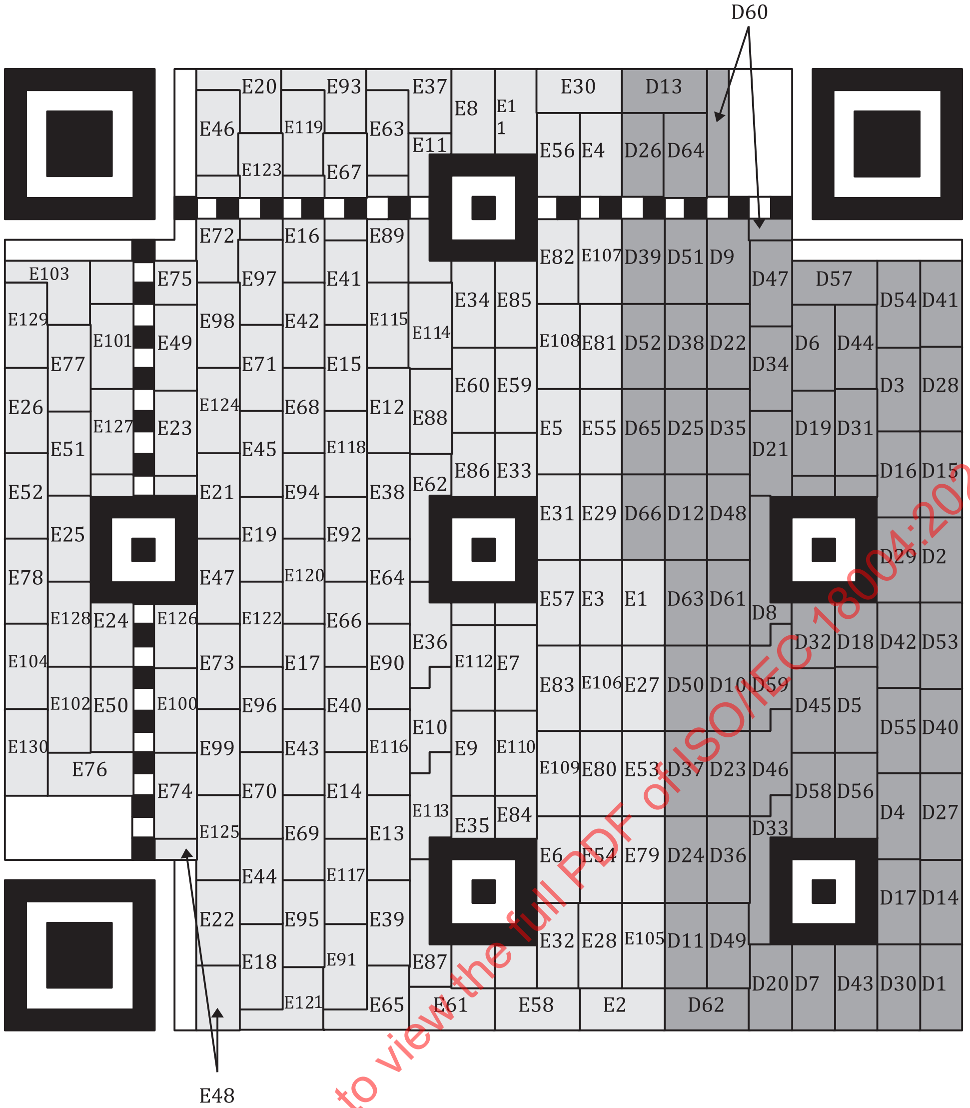
When the data capacity of the symbol is such that it does not divide exactly into a number of 8-bit symbol characters, the appropriate number of remainder bits (3, 4 or 7 as shown in Table 1) shall be used to fill the symbol capacity. These remainder bits shall always have the value 0 before data masking in accordance with 7.8.



Key

(light grey) data codewords	(dark grey) error correction codewords
A remainder bits	

Figure 19 — Symbol character arrangement in a version 2-M symbol



D1 - D13	DataBlock 1
D14 - D26	Data Block 2
D27 - D39	Data Block 3
D40 - D52	Data Block 4
D53 - D66	Data Block 5
E1 - E26	EC Block 1
E27 - E52	EC Block 2
E53 - E78	EC Block 3
E79 - E104	EC Block 4
E105 - E130	EC Block 5

Figure 20 — Symbol character arrangement in a version 7-H symbol

Exactly the same principles apply to a micro QR code symbol. There are no irregular symbol characters in these symbols and the sole exception is that D_3 in a version M1 symbol, D_{11} in a version M3-L symbol and D_9 in a version M3-M symbol is a 2 × 2 square 4-module block.

7.8 Data masking

7.8.1 General

For reliable QR code reading, it is preferable for dark and light modules to be arranged in a well-balanced manner in the symbol. The module pattern 1011101 particularly found in the finder pattern should be avoided in other areas of the symbol as much as possible. To meet the above conditions, data masking should be applied following the steps.

a) Do not apply data masking to function patterns.

b) Convert the given module pattern in the encoding region (excluding the format information and the version information) with multiple matrix patterns successively through the XOR operation. For the XOR operation, lay the module pattern over each of the data masking matrix patterns in turn and reverse the modules (from light to dark or vice versa) which correspond to dark modules of the data masking pattern.

c) Evaluate all the resulting converted patterns by charging penalties for undesirable features on each conversion result.

d) Select the pattern with the lowest penalty points score.

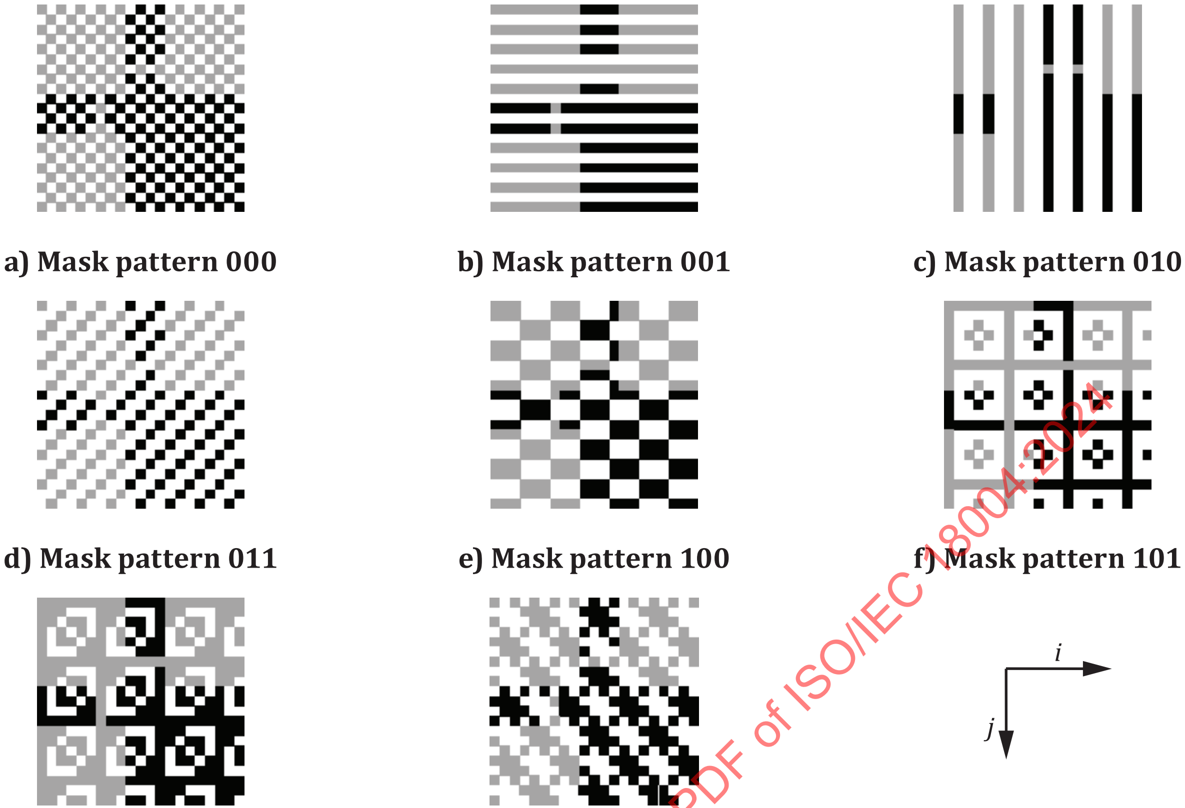
7.8.2 Data mask patterns

Table 10 shows the data mask pattern reference (binary reference for use in the format information) and the data mask pattern generation condition. The data mask pattern is generated by defining as dark any module in the encoding region (excluding the area reserved for format information and the version information) for which the condition is true; in the condition, *i* refers to the row position of the module in question and *j* to its column position, with (*i*, *j*) = (0, 0) for the top left module in the symbol.

Table 10 — Data mask pattern generation conditions

Data mask pattern reference for QR code symbols	Data mask pattern reference for micro QR code symbols	Condition
000		$(i + j) \bmod 2 = 0$
001	00	$i \bmod 2 = 0$
010		$j \bmod 3 = 0$
011		$(i + j) \bmod 3 = 0$
100	01	$((i \text{ div } 2) + (j \text{ div } 3)) \bmod 2 = 0$
101		$(i\, j) \bmod 2 + (i\, j) \bmod 3 = 0$
110	10	$((i\, j) \bmod 2 + (i\, j) \bmod 3) \bmod 2 = 0$
111	11	$((i+j) \bmod 2 + (i\, j) \bmod 3) \bmod 2 = 0$

Figure 21 shows all data mask patterns, illustrated in a version 1 symbol. Figure 23 simulates the effects of data masking using data mask pattern references 000 to 111.



a) Mask pattern 000

b) Mask pattern 001

c) Mask pattern 010

d) Mask pattern 011

e) Mask pattern 100

f) Mask pattern 101

g) Mask pattern 110

h) Mask pattern 111

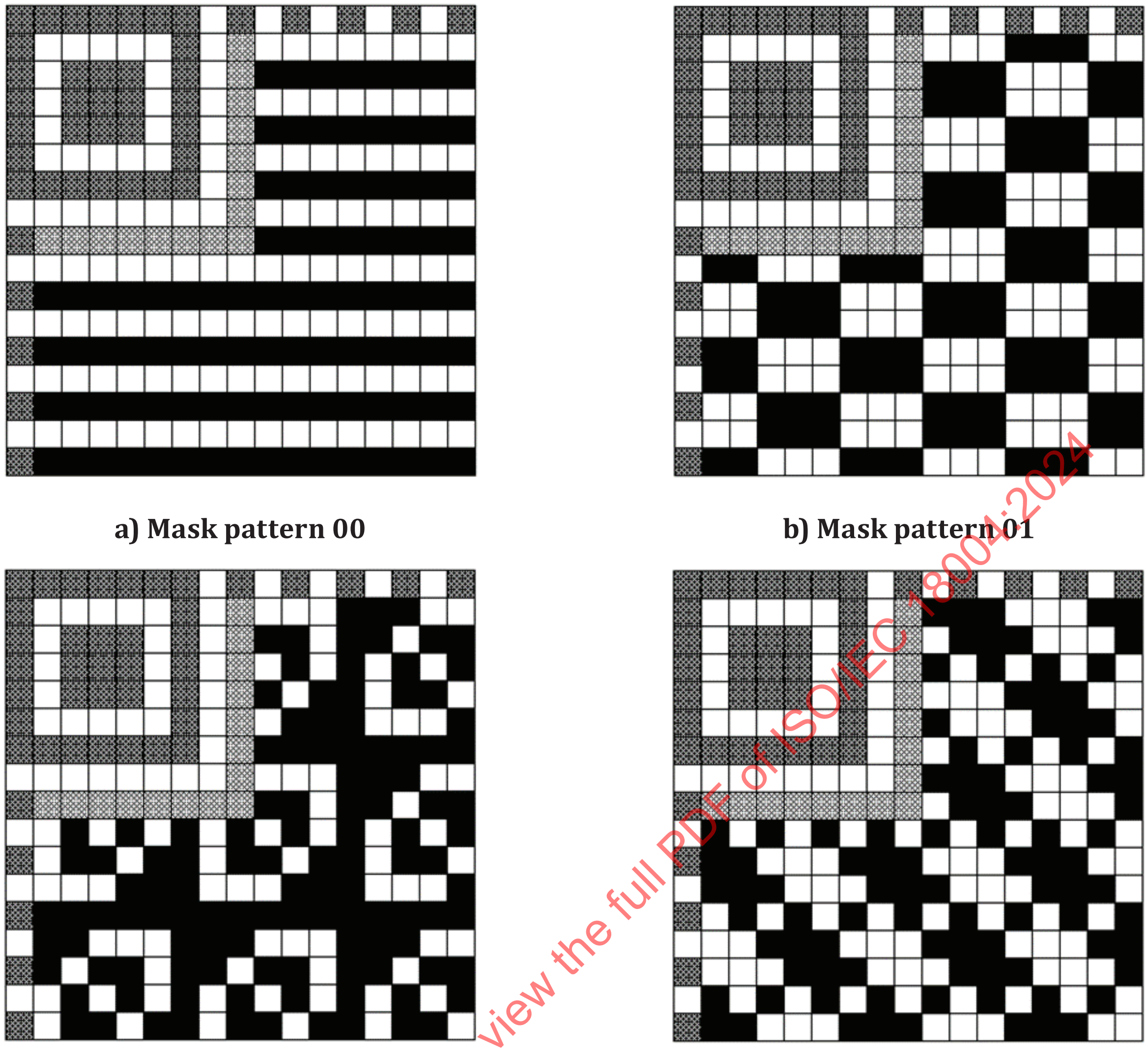
Key

function modules (grey square)

Figure 21 — Data mask patterns for a version 1 symbol

NOTE Masking is not applied to function modules.

Figure 22 shows the four available data masking patterns applied to a micro QR code version M-4 symbol.



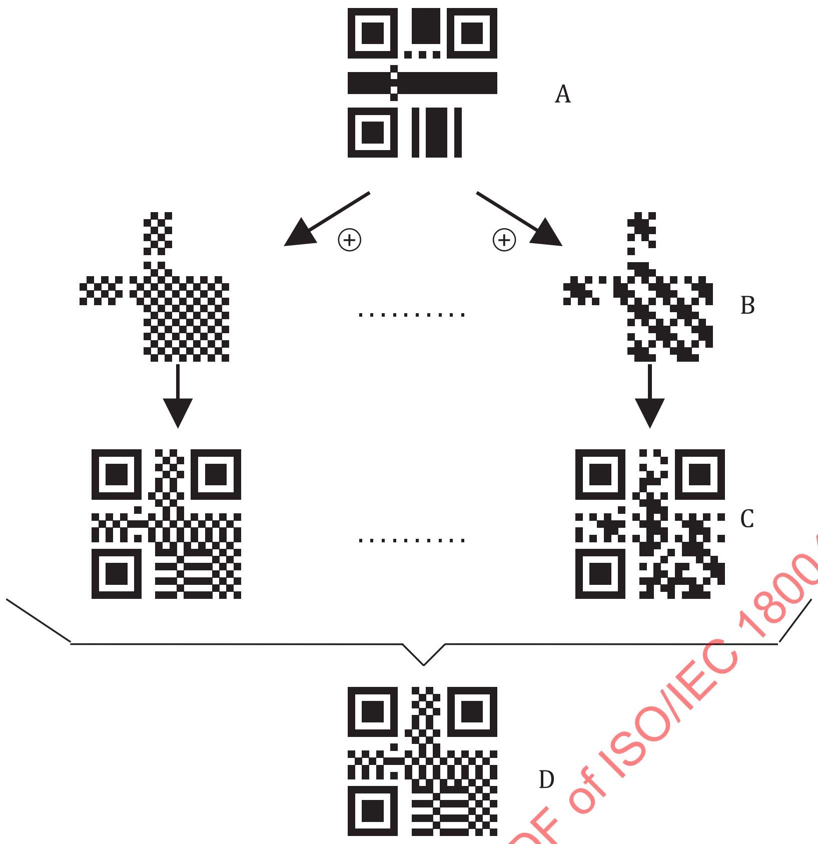
a) Mask pattern 00

b) Mask pattern 01

c) Mask pattern 10

d) Mask pattern 11

Figure 22 — Data mask patterns applied to a micro QR code version M4 symbol



Key

A unmasked symbol

B mask patterns 000 to 111

C masked symbol for evaluation

D selected result with lowest penalty score

Figure 23 — Data masking simulation in QR code symbols

7.8.3 Evaluation of data masking results

7.8.3.1 Evaluation of QR code symbols

After performing the data masking operation with each data mask pattern in turn, the results shall be evaluated by scoring penalty points for each occurrence of the following features. The higher the number of points, the less acceptable the result. In Table 11, the variables N_1 to N_4 represent weighted penalty scores for the undesirable features ($N_1 = 3$, $N_2 = 3$, $N_3 = 40$, $N_4 = 10$), i is the amount by which the number of adjacent modules of the same colour exceeds 5 and k is the rating of the deviation of the proportion of dark modules in the symbol from 50 % in steps of 5 %. Although the data masking operation is only performed on the encoding region of the symbol excluding the format information, the area to be evaluated is the complete symbol.

Table 11 — Scoring of data masking results

Feature	Evaluation condition	Points
Adjacent modules in a row or column in the same colour	Number of modules is: (5 + *i*)	$N_1 + i$
Block of modules in the same colour	Block size is: 2 × 2	N_2
1:1:3:1:1 ratio (dark:light:dark:light:dark) pattern in a row or column, preceded or followed by light area 4 modules wide	Existence of the pattern	N_3
Proportion of dark modules in entire symbol	50 × (5 × *k*) % to 50 × [5 × (*k* + 1)] %	$N_4 \times k$
NOTE 1 Adjacent modules in a row or column are in the same colour. The blocks consisting of light (white) or dark (black) modules of more than five in a row both laterally and vertically are checked for the evaluation of data masking results. The rule of this calculation is that three penalty points is added to each block of five consecutive modules, four penalty points for each block of six consecutive modules and so on, with scoring by one point each time the number of modules increases. For example, five penalty points are imposed on the block of "dark:dark:dark:dark:dark:dark:dark" module pattern, where a series of seven consecutive modules is counted as one block. However, do not double-count the point. The penalty point for a seven-module block, for example, is five, not the sum of the three (for a five-module block), four (for a six-module block) and five (for a seven-module block), equalling to 12. NOTE 2 Module blocks are in the same colour. The penalty point is equal to the number of blocks with 2 × 2 light or dark modules. For example, with a block consisting of 3 × 3 dark modules and considering that up to four 2 × 2 dark modules can be included in this block, the penalty applied to this block is calculated as 4 (blocks) × 3 (points) = 12 points. NOTE 3 1:1:3:1:1 ratio pattern are in a row or column. If the light area of more than four module width exists after or before a 1:1:3:1:1 ratio (dark:light:dark:light:dark) pattern, the imposed penalty is 40 points. NOTE 4 The proportion of dark modules is in the entire symbol. Ten points are added to a deviation of a 5 % increment or decrement in the proportion ratio of dark module from the referential 50 % (or 0 point) level. For example, 0 points are assigned as a penalty if the ratio of dark module is between 45 % and 55 %, or 10 points if the ratio of dark module is between 40 % and 60 %.		

The data mask pattern which results in the lowest penalty score shall be selected for the symbol.

7.8.3.2 Evaluation of micro QR code symbols

After performing the data masking operation on the encoding region of the symbol with each data mask pattern in turn, the results shall be evaluated by scoring points for the number of dark modules in each of the two edges which are not timing patterns. The lower the number of points, the less acceptable the result. In these symbols, it is desirable to have more dark modules in the edge, in order to differentiate a quiet zone from an encoding region more effectively.

For each data mask pattern in turn, count the number of dark modules in the right and lower edges of the symbol (excluding the final module of the timing pattern). The evaluation score is given by the following formulae:

— If $S_1 \leq S_2$:

$$E_s = S_1 \times 16 + S_2$$

— If $S_1 > S_2$:

$$E_s = S_2 \times 16 + S_1$$

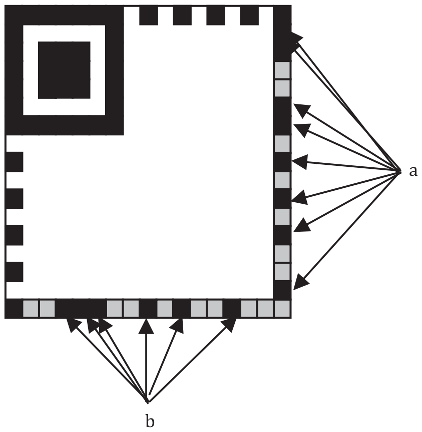
where

E_s is the evaluation score;

S_1 is the number of dark modules in the right side edge;

S_2 is the number of dark modules in the lower side edge.

Figure 24 shows an example of S_1 and S_2 in a micro QR code symbol.



Key

1 number of dark modules in right side edge: $S_1 = 8$

2 number of dark modules in lower side edge : $S_2 = 6$

Figure 24 — Example of S_1 and S_2 in a micro QR code symbol

The evaluation score in this case is:

$$S_1 > S_2$$

$$E_s = S_2 \times 16 + S_1$$

$$= (6 \times 16) + 8$$

$$= 104$$

The data mask pattern which results in the highest score shall be selected for the symbol.

7.9 Format information

7.9.1 QR code symbols

The format information is a 15-bit sequence containing 5 data bits, with 10 error correction bits calculated using the (15, 5) BCH code. The error correction calculation for the format information in Annex C shall apply. The first two data bits contain the error correction level of the symbol, indicated in Table 12.

Table 12 — Error correction level indicators for QR code symbols

Error correction level	Binary indicator
L	01
M	00
Q	11
H	10

The third to fifth data bits of the format information contain the data mask pattern reference from Table 10 for the pattern selected according to 7.8.3.

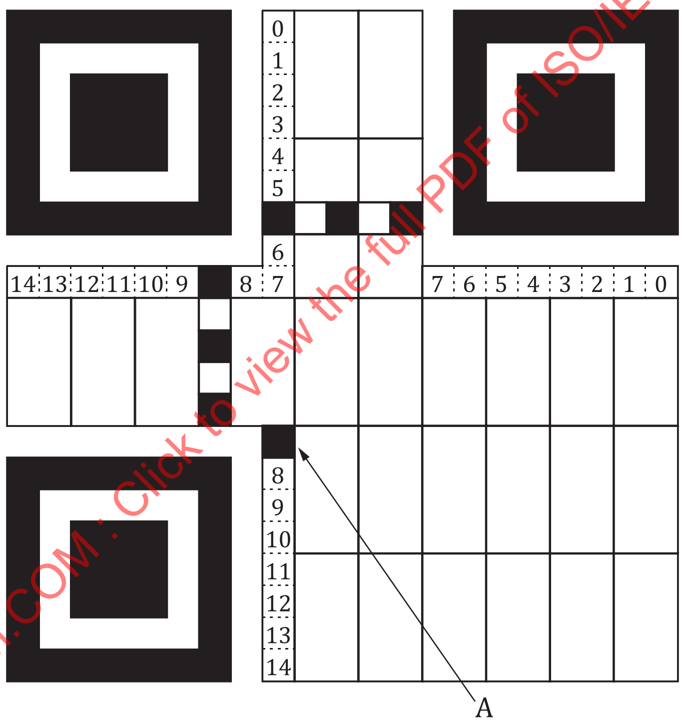
The 10 error correction bits shall be calculated as described in Annex C and appended to the 5 data bits.

The 15-bit error corrected format information shall then be XORed with the mask pattern 101010000010010, in order to ensure that no combination of error correction level and data mask pattern will result in an all-zero data string.

The resulting masked format information shall be mapped into the areas reserved for it in the symbol as shown in Figure 25. Note that the format information appears twice in the symbol in order to provide redundancy since its correct decoding is essential to the decoding of the complete symbol. The least significant bit of the format information is located in the modules numbered 0, and the most significant bit in the modules numbered 14 in Figure 25. The module in position (4 V + 9, 8) where V is the version number, shall always be dark and does not form part of the format information.

EXAMPLE

The error correction level M is assumed:	00
and data mask pattern reference:	101
Data:	00101
BCH bits:	0011011100
Unmasked bit sequence:	001010011011100
Mask pattern for XOR operation:	101010000010010
Format information module pattern:	100000011001110
	bit14 … bit0



Key

A dark module

Figure 25 — Format information positioning

7.9.2 Micro QR code symbols

The format information is a 15-bit sequence containing 5 data bits, with 10 error correction bits calculated using the (15, 5) BCH code. For details of the error correction calculation for the format information, refer to Annex C. The first three data bits contain the symbol number (in binary), which identifies the version and error correction level, as shown in Table 13.

Table 13 — Symbol numbers for micro QR code symbols

Symbol number	Version	Error correction level	Binary indicator
0	M1	Error detection only	000
1	M2	L	001
2	M2	M	010
3	M3	L	011
4	M3	M	100
5	M4	L	101
6	M4	M	110
7	M4	Q	111

The fourth and fifth data bits of the format information contain the data mask pattern reference shown in Table 10 for the pattern selected according to 7.8.3.

The 10 error correction bits shall be calculated as described in Annex C and appended to the 5 data bits.

The 15-bit error corrected format information shall then be XORed with the bit pattern 100010001000101, in order to ensure that no combination of symbol number and data mask pattern will result in an all-zero data string.

The resulting masked format information shall be mapped into the areas reserved for it in the symbol as shown in Figure 25 or 26, depending on the symbol type. The least significant bit of the format information is located in the module numbered 0, and the most significant bit in the module numbered 14 in Figures 24 and 25.

EXAMPLE

Symbol number 0:	000
Data mask pattern reference:	11
Data bits (symbol number, data mask pattern reference):	00011
BCH bits:	1101011001
Unmasked bit sequence:	000111101011001
Mask pattern for XOR operation:	100010001000101
Format information module pattern:	100101100011100
	bit14 … bit0

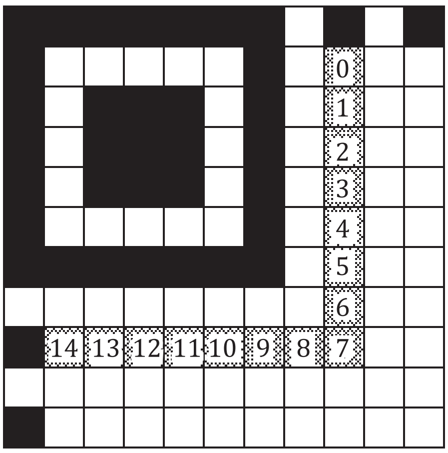


Figure 26 — Micro QR code symbol format information bit positions

7.10 Version information

The version information is included in QR code symbols of version 7 or larger. It consists of an 18-bit sequence containing 6 data bits, with 12 error correction bits calculated using the (18, 6) Golay code. For details of the error correction calculation for the version information, refer to Annex D. The six data bits contain the version of the symbol, most significant bit first.

The 12 error correction bits shall be calculated as described in Annex D and appended to the 6 data bits.

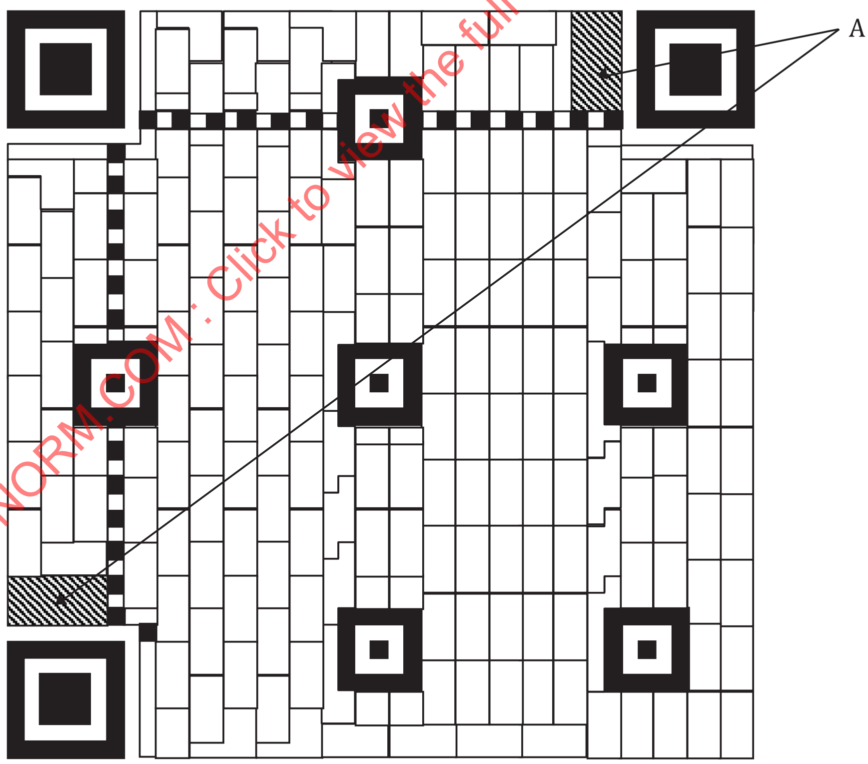
No version information will result in an all-zero data string since only versions 7 to 40 symbols contain the version information. Masking is not therefore applied to the version information.

The resulting version information shall be mapped into the areas reserved for it in the symbol as shown in Figure 27. Note that the version information appears twice in the symbol in order to provide redundancy since its correct decoding is essential to the decoding of the complete symbol. The least significant bit of the version information is located in the modules numbered 0, and the most significant bit in the modules numbered 17, in Figure 28.

EXAMPLE

Version number:	7
Data:	000111
BCH bits:	110010010100
Version information module pattern:	000111110010010100

The version information areas are the 6 × 3 module block above the timing pattern and immediately to the left of the top right finder pattern separator, and the 3 × 6 module block to the left of the timing pattern and immediately above the lower left finder pattern separator.



Key

A version information

Figure 27 — Version information positioning

0	3	6	9	12	15
1	4	7	10	13	16
2	5	8	11	14	17

a) Version information in lower left

0	1	2
3	4	5
6	7	8
9	10	11
12	13	14
15	16	17

b) Version information in upper right

Figure 28 — Module arrangement in version information

8 Structured append

8.1 Basic principles

Structured append is not available with micro QR code symbols.

Up to 16 QR code symbols can be appended in a structured format. If a symbol is part of a structured append message, it is indicated by a header block in the first two and a half symbol character positions.

The structured append mode indicator 0011 is placed in the four most significant bit positions in the first symbol character.

This is immediately followed by two structured append codewords, spread over the four least significant bits of the first symbol character, the second symbol character and the four most significant bits of the third symbol character. The first codeword is the symbol sequence indicator (see 7.2). The second codeword is the parity data (see 7.3) and is identical in all symbols in the message, enabling it to be verified that all symbols read form part of the same structured append message. This header is immediately followed by the data codewords for the symbol commencing with the first mode indicator. If one or more ECIs other than the default ECI is in force, an ECI header for each ECI, consisting of the ECI mode indicator and ECI designator, shall follow the structured append header.

The lower part of Figure 29 shows an example of four structured append symbols with the same data as that in the upper symbol.

Figure 29 — Single symbol (above) and structured append series of symbols (below) encoding the text "ABCDEFGHIJKLMNOPQRSTUVWXYZ 0123456789 ABCDEFGHIJKLMNOPQRSTUVWXYZ"

8.2 Symbol sequence indicator

This codeword indicates the position of the symbol within the set of (up to 16) QR code symbols in the structured append format (in the form *m* of *n* symbols). The first 4 bits of this codeword identify the position of the particular symbol. The last 4 bits identify the total number of symbols to be concatenated in the structured append format. The 4-bit patterns shall be the binary equivalents of (m − 1) and (n − 1) respectively.

EXAMPLE To indicate the third symbol of a set of 7, it is encoded as follows:

— third position: 0010

— total seven symbols: 0110

— bit pattern: 00100110

8.3 Parity data

The parity data shall be an 8-bit byte following the symbol sequence indicator. The parity data is a value obtained by XORing byte by byte the byte values of all the original input data before division into symbol blocks. Mode indicators, character count identifiers, padding bits, terminator and pad characters shall be excluded from the calculation. Input data is represented for this calculation by 2-byte Shift JIS values for Kanji (each byte being treated separately in the XOR calculation, most significant first) and 8-bit values as shown in Table 6 for other characters. In ECI mode, the byte values obtained after any encryption or compression of the data shall be used for the calculation.

For example, "0123456789日本" is divided into "0123", "4567" and "89日本" as follows:

— first symbol block ("0123"): hex values 30, 31, 32, 33

— second symbol block ("4567"): hex values 34, 35, 36, 37

— third symbol block ("89日本"): hex values 38, 39, 93FA, 967B

The parity data is calculated from "0123456789日本" by XORing the data successively, byte by byte.

$$30 \oplus 31 \oplus 32 \oplus 33 \oplus 34 \oplus 35 \oplus 36 \oplus 37 \oplus 38 \oplus 39 \oplus 93 \oplus \mathbf{FA} \oplus 96 \oplus \mathbf{7B} = \mathbf{85}$$

Note that the calculation of the parity data may be performed either before the data is sent to the printer or in the printer, based on the capabilities of the printer.

9 Symbol printing and marking

9.1 Dimensions

QR code symbols shall conform to the following dimensions:

— *X* dimension: the width of a module shall be specified by the application, taking into account the scanning technology to be used and the technology to produce the symbol;

— *Y* dimension: the height of a module shall be equal to the *X* dimension;

— minimum quiet zone: equal to 2*X* (for micro QR code symbols) or 4*X* (for QR code symbols) wide on all four sides.

9.2 Human-readable interpretation

As QR code symbols are capable of encoding thousands of characters, a human readable interpretation of the data characters is not always practical. As an alternative, descriptive text rather than literal text may accompany the symbol.

The character size and font are not specified, and the message may be printed anywhere in the area surrounding the symbol. The human readable interpretation should not interfere with the symbol itself nor the quiet zones.

9.3 Marking guidelines

QR code symbols can be printed or marked using a number of different techniques. Annex K provides user guidelines.

10 Symbol quality

10.1 Methodology

QR code symbols shall be assessed for quality using the 2D matrix bar code symbol print quality guidelines defined in ISO/IEC 15415, as augmented and modified in 10.2.

Some marking technologies can be unable to produce symbols conforming to this document without taking special precautions. Annex M gives additional guidance to help any printing system achieve valid QR code symbols.

Either directly marked symbols (DPM) or symbols printed with disconnected dots, or both, can be unable to pass this methodology and can be unreadable by QR code scanners. Application requiring such symbols should specify quality measurement methods, using ISO/IEC 29158, a quality extension of ISO/IEC 15415 and can require specialized DPM scanners.

10.2 Symbol quality parameters

10.2.1 Fixed pattern damage

The measurement and grading basis for fixed pattern damage in Annex G shall applied.

10.2.2 Scan grade and overall symbol grade

The symbol grade is determined using the method of ISO/IEC 15415 alone or with the DPM extension ISO/IEC 29158 depending on application demands.

10.2.3 Grid non-uniformity

The ideal grid is calculated by using the centre of the four outermost corner points of the symbol (top left of UL finder, etc.) and subdividing horizontally and vertically and connecting opposite points to form column and row lines which are or are not be parallel depending upon the actual location of these corner points. These points are previously determined by the reference decode algorithm (see Clause 12). In this way, the ideal grid is not prone to distortion from slight perspective and other optical effects.

10.2.4 Print growth

The print growth shall be graded using the method of ISO/IEC 15415. A linear bar code verifier capable of outputting direct measurements of bar and space patterns may be used for the assessment of print gain or loss in both horizontal and vertical axes, by measuring along two scan paths at right angles passing through a finder pattern and crossing the centre 3 × 3 block of modules. Analysis of the output should reveal an apparent bar/space/bar/space/bar pattern; the print gain (or loss) can be assessed by comparing the five measured element widths with the ideal 1:1:3:1:1 ratio of the widths.

10.3 Process control measurements

A variety of tools and methods can be used to perform useful measurements for monitoring and controlling the process of creating QR code symbols. These are described in Annex M. These techniques do not constitute a print quality check of the produced symbols (the method specified earlier in this clause and Annex G is the required method for assessing symbol print quality) but they individually and collectively yield good indications of whether the symbol print process is creating workable symbols.

11 Decoding procedure overview

The decoding steps from reading a QR code symbol to outputting data characters are the reverse of the encoding procedure. Figure 30 shows an outline of the process flow.

a) Locate and obtain an image of the symbol. Recognize dark and light modules as an array of “0” and “1” bits. Identify reflectance polarity from finder pattern module colouring.

b) Read the format information. Release the masking pattern and perform the error correction on the format information modules as necessary; if successful, symbol is in normal orientation, otherwise attempt mirror image decoding of the format information. Identify error correction level, either directly, in QR code symbols, or from micro QR code symbol number, and data mask pattern reference.

c) Read the version information (where applicable), then determine the version of the symbol (from the symbol number, in the case of micro QR code symbols).

d) Release the data masking by XORing the encoding region bit pattern with the data mask pattern the reference of which has been extracted from the format information.

e) Read the symbol characters in accordance with the placement rules for the model and restore the data and error correction codewords of the message.

f) Detect errors using the error correction codewords corresponding to the level information. If any error is detected, correct it.

g) Divide the data codewords into segments in accordance with the mode indicators and character count indicators.

h) Finally, decode the data characters in accordance with the mode(s) in use and output the result.

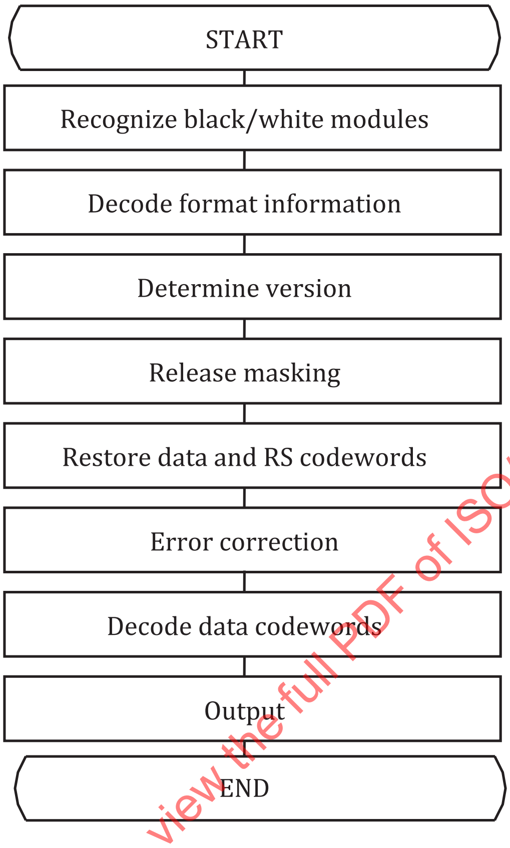


Figure 30 — QR code decoding steps

12 Reference decode algorithm for QR code

This reference decode algorithm finds the symbol in an image and decodes it. The decode algorithm refers to dark and light states in the image.

a) Determine a global threshold by taking a reflectance value midway between the maximum reflectance and minimum reflectance in the image. Convert the image to a set of dark and light pixels using the global threshold.

b) Locate the finder pattern. The finder pattern in QR code consists of three identical finder patterns located at three of the four corners of the symbol. The finder pattern in micro QR code is a single finder pattern. As described in 5.3.3, module widths in each finder pattern form a dark-light-dark-light-dark sequence the relative widths of each element of which are in the ratios 1:1:3:1:1. For the purposes of this algorithm, this finder pattern search find elements with edge-to-similar edge pairs of dark-light, light-dark, dark-light, light-dark sequence which are in the ratios 2:4:4:2 within 0,5 modules (i.e. a range of 1,5 to 2,5 for the 1:1 module pairs and 3,5 to 4,5 for 1:3 module pairs).

   1) When a candidate area is detected in the x axis note the position of the first and last points A and B respectively at which a line of pixels in the image encounters the outer edges of the finder pattern (see Figure 31). Repeat this for adjacent pixel lines in the image until all lines crossing the central box of the finder pattern in the x axis of the image have been identified.

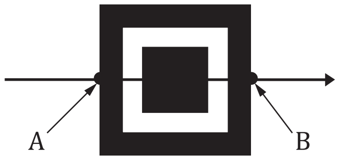


Figure 31 — Scan line in finder pattern

2) Repeat b) 1) for pixel columns crossing the central box of the finder pattern in the y axis of the image.

3) Locate the centre of the pattern. Construct a line through the midpoints between the points A and B on the outermost pixel lines crossing the central box of the finder pattern in the *x* axis. Construct a similar line through points A and B on the outermost pixel columns crossing the central box in the *y* axis. The centre of the pattern is located at the intersection of these two lines.

4) Repeat b) 1) to 3) to locate the centres of the two other finder patterns.

5) If no candidate areas are detected, reverse the colouring of the light and dark pixels and recommence at the beginning of b) to attempt to decode the symbol as a symbol with reflectance reversal.

6) If a single pattern is identified but two further finder patterns cannot be located, attempt to decode the symbol as a micro QR code symbol by jumping to the micro QR code symbols reference decode [from m)].

c) Determine the rotational orientation of the symbol by analysing the finder pattern centre coordinates to identify which pattern is the upper left pattern in the symbol and the angle of rotation of the symbol.

d) Determine

1) the distance D crossing the full width of the symbol between the centres of the upper left finder pattern and the upper right finder pattern, and

2) the width of the two patterns, $W_{\mathrm{UL}X}$ and $W_{\mathrm{UR}X}$ as shown in Figure 32.

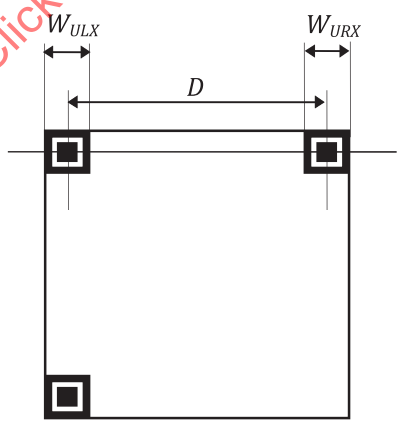


Figure 32 — Upper finder patterns

e) Calculate the nominal X dimension of the symbol.

$X = (W_{\mathrm{UL}X} + W_{\mathrm{UR}X})/12$

f) Provisionally determine the version V of the symbol.

$V = [(D / X) - 10] / 4$

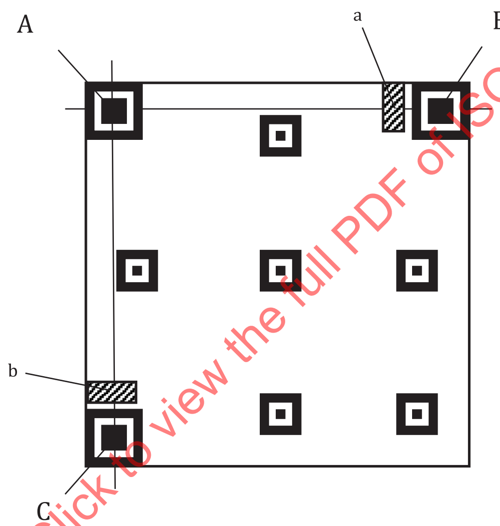
g) If the provisional symbol version is 6 or less, this information is specified as the defined version. If the provisional symbol version is 7 or more, the version information is decoded as follows.

1) Divide the width W_{URX} of the upper right finder pattern in the X direction by 6 to calculate the module size M_{URX}. In a similar manner, divide the width W_{URY} of the upper right finder pattern in the Y direction by six to calculate the module size M_{URY}.

$M_{URX} = W_{URX} / 6$

$M_{URY} = W_{URY} / 6$

2) Find the guide lines AC and AB from A, B and C, which pass through the centres of the three finder patterns, as shown in Figure 33. The sampling grid for each module centre in the version information 1 area is determined based on lines parallel to the guide lines, the central coordinates of the finder patterns, and the module size M_{URX} and M_{URY}. Binary values 0 and 1 are determined from the light or dark pattern on the sampling grid.



a Version information 1.

b Version information 2.

Figure 33 — Finder patterns and version information

3) Determine the version by detecting and correcting errors, if any, based on Table D.1.

4) If errors exceeding the error correction capacity are detected, calculate the pattern width W_{DLX} and W_{DLY} of the lower left finder pattern and follow a similar procedure to a), b) and c) to decode version information 2.

h) For version 1 symbols, redefine X and Y calculated them from the position of the centres of the finder patterns and the number of modules between those centres for a symbol of that size. Establish a sampling grid based on h) 1) the horizontal line through the upper side timing pattern with lines parallel to it at the vertical spacing of Y, comprising six lines above the horizontal reference line and as many lines below it as are required for the version of the symbol and h) 2) the vertical line passing through the left side timing pattern with lines parallel to it at the horizontal spacing of X, comprising six lines to the left of the vertical reference line and as many lines to the right of it as are required for the version of the symbol. For version 2 and larger symbols, determine the central coordinate of each alignment pattern from the coordinates defined in 5.3.6 and Annex E and construct the sampling grids with lines equidistantly spaced between these points.

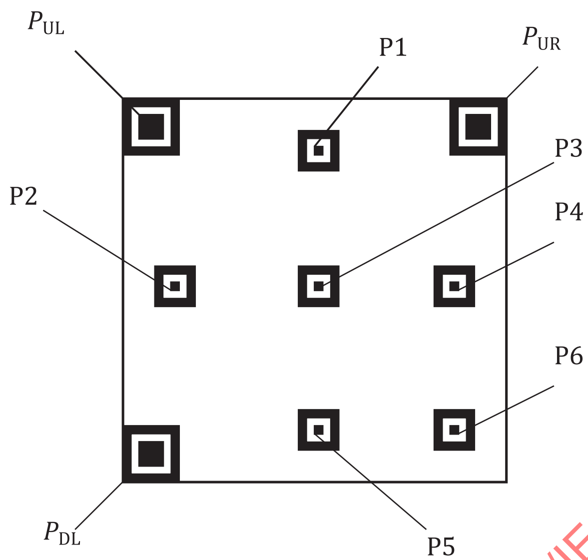


Figure 34 — Finder patterns and alignment patterns

1) Divide the pattern width W_{ULX} of the upper left finder pattern P_{UL} in the X direction by six to calculate the module size M_{ULX}. In a similar manner, divide the pattern width W_{ULY} of the upper left finder pattern P_{UL} in the Y direction by six to calculate the module size M_{ULY}.

   $M_{ULX} = W_{ULX} /6$

   $M_{ULY} = W_{ULY} /6$

2) Determine the provisional central coordinates of the alignment patterns P1 and P2 (see Figure 34), based on the coordinate of the centre A of the upper left finder pattern P_{UL}, lines parallel to the guide lines AB and AC obtained in g) 2), and the module size M_{ULX} and M_{ULY}.

3) Scan the outline of the white square in alignment pattern P1 and P2 starting from the pixel of the provisional central coordinate to find the actual central coordinates Xi and Yj (see Figure 35). Specifically, draw parallel lines to the lines AB and AC obtained in g) 2) from the pixel of the provisional central coordinate, find the edge where changes from light to dark and set the midpoint of the edge building as the actual central coordinates.

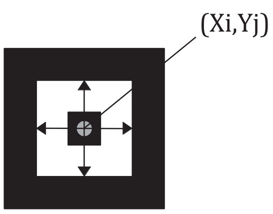


Figure 35 — Central coordinates of alignment pattern

4) Estimate the provisional central coordinate of the alignment pattern P3, based on parallel line of the lines AC obtained in g) 2) from the actual central coordinates of the alignment patterns P1 obtained in h) 3) and parallel line to the lines AB obtained in g) 2) from the actual central coordinates of the alignment patterns P2 obtained in h) 3).

5) Find the actual central coordinate of the alignment pattern P3 by following the same procedure inp h) 3).

6) Find L_x, which is the centre-to-centre distance of the alignment patterns P2 and P3, and L_y, which is the centre-to-centre distance of the alignment patterns P1 and P3. Divide L_x and L_y by the defined spacing of the alignment patterns to obtain the module pitches M_x in the lower side and M_y in the right side in the upper left area of the symbol (see Figure 36).

$M_x = L_x/N_{AP}$

$M_y = L_y/N_{AP}$

where N_{AP} is the spacing in modules of the alignment pattern centers (see Table E.1).

In the same fashion, find $L_{x'}$ which is the centre-to-centre distance of the upper left finder pattern P_{UL} and the module P1' whose row coordinate is equivalent to P_{UL} on the line passing through P1and P3 (specifically, the module where three modules (3*M_y) up from P1 on the line passing through P1and P3), and $L_{y'}$, which is the centre-to-centre distance of the upper left finder pattern P_{UL} and the module P2' whose column coordinate is equivalent to P_{UL} on the line passing through P2 and P3. Divide $L_{x'}$ and $L_{y'}$ by the formula below to obtain the module pitches $M_{x'}$ in the upper side and $M_{y'}$ in the left side in the upper left area of the symbol.

For the symbol version 2, 3, 4, 5 and 6 with a single alignment pattern, the module pitches $M_{x'}$ and $M_{y'}$ at the top and left sides of the symbol area are obtained from the centre-to-centre distance of each finder pattern.

The module pitch M_x at the bottom side of the symbol area is obtained from L_x which is the centre-to-centre distance of the alignment pattern and the module whose row coordinate is equivalent to the alignment pattern (3* $M_{y'}$ up from P_{DL}) on line AC, and the module pitch M_y at the right side of the symbol area is obtained in the same way.

$M_{x'} = L_{x'} / (C_{P1} - C_{PUL})$

where

C_{P1} is the column coordinate of the central module of the alignment pattern P1;

C_{PUL} is the column coordinate of the central module of the upper left finder pattern P_{UL}.

$M_{y'} = L_{y'} / (R_{P2} - R_{PUL})$

where

R_{P2} is the row coordinate of the central module of the alignment pattern P2;

R_{PUL} is the row coordinate of the central module of the upper left finder pattern P_{UL}.

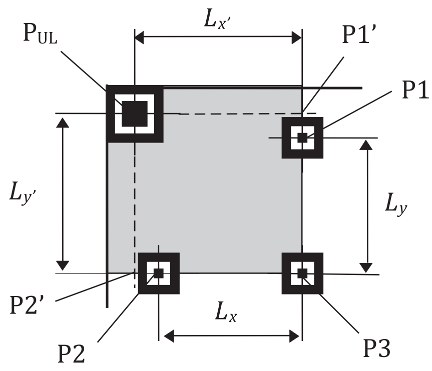


Figure 36 — Upper left area of symbol

7) Determine the sampling grid covering the upper left area of the symbol based on the module pitches M_x, $M_{x'}$, M_y and $M_{y'}$ representing each side. (Specifically, the grid is formed in the entire upper left area of the symbol based on the module centres of M_x intervals on a line passing through the alignment patterns P2 and P3, the module centres of $M_{x'}$ intervals on a line passing through the upper left finder pattern P_{UL} and P1′, the module centres of M_y intervals on a line passing through the alignment patterns P1 and P3, and the module centres of $M_{y'}$ intervals on a line passing through P_{UL} and P2′.)

8) In the same fashion determine the sampling grids for the upper right area (covered by the upper right finder pattern P_{UR}, alignment patterns P1, P3 and P4) and lower left area (covered by the lower left finder pattern P_{DL}, alignment patterns P2, P3 and P5) of the symbol.

9) For the alignment pattern P6 (see Figure 37), estimate its provisional central coordinate from the module pitches $M_{x'}$ and $M_{y'}$, the values of which are obtained from the spacings of alignment patterns P3, P4 and P5, guide lines passing through the centres of the alignment patterns P3 and P4, and P3 and P5 respectively, and the central coordinates of these patterns.

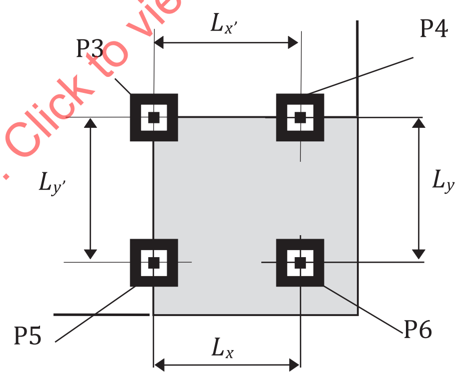


Figure 37 — Lower right area of symbol

10) Repeat 5) to 8) to determine the sampling grid for the lower right area of the symbol.

11) The same principles shall be applied to determine the sampling grids for any areas of the symbol not already covered.

i) Sample an area of each intersection of the grid lines and determine whether it is dark or light based on the global threshold. Construct a bit matrix mapping the dark modules as binary 1 and light modules as binary 0.

j) Decode the format information adjacent to the upper left finder pattern as described in Clause C.3 to yield the error correction level and the data mask pattern applied to the symbol. If errors exceeding the error correction capacity of the format information are detected, follow the same procedure to decode the format information adjacent to the upper right and lower left finder patterns.

k) If a valid format information bit string cannot be derived, determine whether it is a valid sequence if read in the reverse direction and if so attempt to continue decoding as a mirror image symbol with the image row and column coordinates transposed.

l) Go to y).

m) For micro QR code symbols, determine the possible angles of rotation of the symbol by analysing the angles of the lines from b) 3) relative to the imaging sensor axes, as ϑ (see Figure 38), ϑ + 90°, ϑ + 180° and ϑ + 270°.

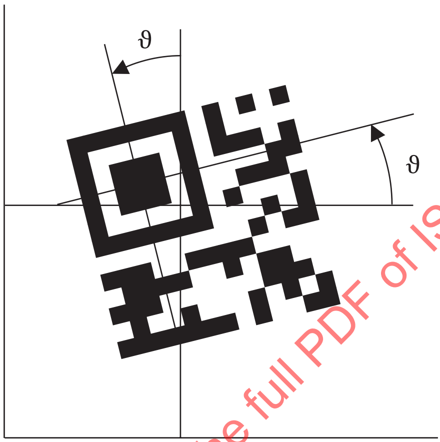


Figure 38 — Angle ϑ relative to the imaging sensor axes

n) Plot three lines parallel to each axis of the finder pattern and equally spaced across the pattern and measure the distances from point A to point B on each line. The spacing is not limited but three lines shall be in the finder pattern.

o) Calculate the provisional module dimension X of the symbol in each axis as one seventh of the mean of the three distances A to B from n).

p) Taking each side of the outer box of the finder pattern in turn, extend a line outward from the finder pattern in both directions, parallel to the edge and 0,5X in from the edge.

q) Search for the timing patterns:

1) Identify two edges of the finder pattern nominally perpendicular to each other, each of which has both

i) a clear area of at least 1,5X in one direction;

ii) alternating light and dark areas evenly spaced at 1X centres from the edge of the finder pattern and that is terminated by a clear area of at least 1,5X in the opposite direction (a candidate timing pattern);

2) Check that there is the same number of dark modules in each candidate timing pattern and that this number is between two and five.

r) Determine the provisional version of the symbol from the number of dark elements in the timing pattern.

— If there are two dark elements, the symbol version is M1.

— If there are three dark elements, the symbol version is M2.

— If there are four dark elements, the symbol version is M3.

— If there are five dark elements, the symbol version is M4.

s) From the centre of the first dark module in each side of the timing patterns extend a line parallel with the adjacent side of the finder pattern to intersect with the corresponding line from the other side and sample an area at 1*X* intervals along the line to determine the light or dark status of each module of the format information. Determine the format information bit string by taking the dark pixels as binary 1 and light pixels as binary 0.

t) Release masking of the format information by XORing the bit string with the pattern given in 7.9.2 and decode the format information (applying the error correction procedure given in Annex B if necessary) to yield the symbol number (and hence the version and error correction level of the symbol) and the data mask pattern applied to the symbol.

u) If the format information bit string is not a valid sequence, determine whether it is a valid sequence when read in the reverse direction, and if so, attempt to continue decoding as a mirror image symbol with the image row and column coordinates transposed. If no more than two bits differ from a valid sequence in Annex C substitute this sequence and decode the substituted format information to obtain the symbol number and the data mask pattern.

v) Confirm the module pitch *X* in each axis by dividing the overall width from the outer edge of the finder pattern adjacent to the quiet zone to the outer edge of the last dark module in the timing pattern by the number of modules corresponding to the symbol version.

w) Establish a sampling grid, corresponding to the version of the symbol, of lines spaced 1*X* apart in each axis, parallel to each other and to the side of the finder pattern, and running from the centres of the timing pattern modules and from similar positions in the finder pattern.

x) Sample an area on each intersection of the grid lines, and determine whether it is dark or light based on the global threshold. Construct a bit matrix mapping the dark modules as binary 1 and light modules as binary 0.

y) XOR the data mask pattern with the encoding region of the symbol to release the data masking and restore the symbol characters representing data and error correction codewords. This reverses the effect of the data masking process applied during the encoding procedure.

z) Determine the symbol codewords in accordance with the placement rules in 7.7.3.

   1) Rearrange the codeword sequence into blocks as required for the symbol version and error correction level, by reversing the interleaving process defined in 7.6 c).

   2) Follow the error detection and correction decoding procedure in Annex B to correct errors and erasures up to the maximum correction capacity for the symbol version and the error correction level.

   3) Restore the original message bit stream by assembling the data blocks in sequence.

   4) Subdivide the data bit stream into segments each commencing with a mode indicator and the length of which is determined by the character count indicator following the mode indicator.

   5) Decode each segment in accordance with the rules for the mode in force.

13 Autodiscrimination capability

QR code can be used in an autodiscrimination environment with a number of other symbologies (see Annex L). Although model 1 and QR code symbols can be autodiscriminated by analysis of the format information mask pattern, model 1 symbols should not be used in the same environment as QR code symbols.

14 Transmitted data

14.1 General principles

All encoded data characters shall be included in the data transmission. The function patterns, format and version information, error correction characters, pad and remainder characters shall not be transmitted. The default transmission mode for all data shall be as bytes.

The structured append header block shall not be transmitted by decoders operating in buffered mode which have reconstructed the complete message before transmission. If the decoder is operating in unbuffered mode, the structured append header shall be transmitted as the first 2 bytes of every symbol. More complex interpretations including the transmission of data in an extended channel interpretation, are addressed in 14.3.

14.2 Symbology identifier

ISO/IEC 15424 provides a standard procedure for reporting the symbology which has been read, together with options set in the decoder and any special features encountered in the symbol.

Once the structure of the data (including the use of any ECI) has been identified, the appropriate symbology identifier should be added by the decoder as a preamble to the transmitted data; if ECIs are used the symbology identifier is required. See Annex F for the symbology identifier and option values which apply to QR code.

14.3 Extended channel interpretations

In systems where the ECI protocol is supported, the transmission of the symbology identifier is required with every transmission. Whenever the ECI mode indicator is encountered, it shall be transmitted as the escape character $5C_{HEX}$, (which represents the backslash character "\" in ISO/IEC 8859-1 and in the ECI protocol defined in Reference [21], and maps to the character "¥" in JIS X 0201). The codeword(s) representing the ECI designator are converted into a 6-digit number by inverting the rules defined in Table 4. These six digits shall be transmitted as the corresponding 8-bit values in the range 30_{HEX} to 39_{HEX}, immediately following the escape character.

Application software recognizing \nnnnnn should interpret all subsequent characters as being from the ECI defined by the 6-digit designator. This interpretation remains in effect until:

— the end of the encoded data;

— a change to a new ECI signalled by mode indicator 0111, subject to rules defined in the AIM ECI specification.

When reverting to the default interpretation, the decoder shall output the appropriate escape sequence as prefix to the data.

If the character $5C_{HEX}$ needs to be used as encoded data, transmission shall be as follows: whenever the character $5C_{HEX}$ occurs as data, two bytes of the value shall be transmitted. Thus, a single occurrence is always an escape character and a double occurrence indicates true data.

EXAMPLE 1

a) Encoded data (hex):	41 42 43 5C 31 32 33 34
Transmitted data:	41 42 43 5C 5C 31 32 33 34
b) Encoded data:	ABC followed by <further data> encoded according to rules for ECI 123456.
Transmitted data:	41 42 43 5C 31 32 33 34 35 36 <further data>

EXAMPLE 2 Using data in 7.4.3.2, the message contains an ECI mode indicator/ECI designator/mode indicator/character count indicator/data in the form of

0111 00001001 0100 00000101 10100001 10100010 10100011 10100100 10100101

Symbology identifier	]Q2 (see Annex F) is added to the data transmission.
Transmission (hex values):	5D 51 32 5C 30 30 30 30 30 39 A1 A2 A3 A4 A5
Encoded data in ECI 000009:	ΑΒΓΔΕ

In structured append mode, when the ECI mode indicator is encountered at the beginning of the symbol, subsequent data characters shall be interpreted as being from the ECI(s) in force at the end of the preceding symbol.

NOTE $5C_{HEX}$ is equivalent to the backslash character "\" in ISO/IEC 8859-1 and to "¥" in JIS X 0201.

14.4 FNC1 mode

The FNC1 mode tells an application that a specific data structure is used in the code. In the modes with implied FNC1 in either first or second position, this implied character cannot be transmitted directly as there is no byte value corresponding to it. It is therefore necessary to indicate its presence in the first or second position by the transmission of the relevant symbology identifier (]Q3,]Q4,]Q5 or]Q6 defined in Annex F shall be used).

The FNC1 mode data structure can concatenate data fields. To distinguish data fields from each other they need to be separated by using separator characters. If a data field separator character is required in alphanumeric mode the % character shall be encoded. In byte mode the character GS (ISO/IEC 646 IRV value 29) shall be encoded. The decoder shall transmit in both cases always GS (ISO/IEC 646 IRV value 29). If, in symbols in FNC1 mode, the character **%** needs to be encoded as data while in alphanumeric mode, it shall be represented in the symbol by **%%**. If this is encountered, the decoder shall transmit a single **%** character.

NOTE When a FNC1 mode is not used, the % character is transmitted as it is.

Annex A
(normative)

Error detection and correction generator polynomials

The check character generation polynomial is used to divide the data codeword polynomial, where each codeword is the coefficient of the dividend polynomial in descending power order. The coefficients of the remainder of this division are the error correction codeword values.

Table A.1 shows the generator polynomials for the error correction codes which are used for each version and level, for all QR code symbols. The number of error correction codewords required for a particular version and error correction level can be obtained from Table 9. In Table A.1, α is the primitive element 2 under GF(2^8). Each generator polynomial is the product of first degree polynomials: $x - 2^0$, $x - 2^1$, ..., $x - 2^{n-1}$, where n is the degree of the generator polynomial.

Table A.1 — Generator polynomials for Reed-Solomon error correction codewords

Number of error correction codewords	Generator polynomials
2	$x^2 + \alpha^{25}x + \alpha$
5	$x^5 + \alpha^{113}x^4 + \alpha^{164}x^3 + \alpha^{166}x^2 + \alpha^{119}x + \alpha^{10}$
6	$x^6 + \alpha^{166}x^5 + x^4 + \alpha^{134}x^3 + \alpha^5x^2 + \alpha^{176}x + \alpha^{15}$
7	$x^7 + \alpha^{87}x^6 + \alpha^{229}x^5 + \alpha^{146}x^4 + \alpha^{149}x^3 + \alpha^{238}x^2 + \alpha^{102}x + \alpha^{21}$
8	$x^8 + \alpha^{175}x^7 + \alpha^{238}x^6 + \alpha^{208}x^5 + \alpha^{249}x^4 + \alpha^{215}x^3 + \alpha^{252}x^2 + \alpha^{196}x + \alpha^{28}$
10	$x^{10} + \alpha^{251}x^9 + \alpha^{67}x^8 + \alpha^{46}x^7 + \alpha^{61}x^6 + \alpha^{118}x^5 + \alpha^{70}x^4 + \alpha^{64}x^3 + \alpha^{94}x^2 + \alpha^{32}x + \alpha^{45}$
13	$x^{13} + \alpha^{74}x^{12} + \alpha^{152}x^{11} + \alpha^{176}x^{10} + \alpha^{100}x^9 + \alpha^{86}x^8 + \alpha^{100}x^7 + \alpha^{106}x^6 + \alpha^{104}x^5 + \alpha^{130}x^4 + \alpha^{218}x^3 + \alpha^{206}x^2 + \alpha^{140}x + \alpha^{78}$
14	$x^{14} + \alpha^{199}x^{13} + \alpha^{249}x^{12} + \alpha^{155}x^{11} + \alpha^{48}x^{10} + \alpha^{190}x^9 + \alpha^{124}x^8 + \alpha^{218}x^7 + \alpha^{137}x^6 + \alpha^{216}x^5 + \alpha^{87}x^4 + \alpha^{207}x^3 + \alpha^{59}x^2 + \alpha^{22}x + \alpha^{91}$
15	$x^{15} + \alpha^8x^{14} + \alpha^{183}x^{13} + \alpha^{61}x^{12} + \alpha^{91}x^{11} + \alpha^{202}x^{10} + \alpha^{37}x^9 + \alpha^{51}x^8 + \alpha^{58}x^7 + \alpha^{58}x^6 + \alpha^{237}x^5 + \alpha^{140}x^4 + \alpha^{124}x^3 + \alpha^5x^2 + \alpha^{99}x + \alpha^{105}$
16	$x^{16} + \alpha^{120}x^{15} + \alpha^{104}x^{14} + \alpha^{107}x^{13} + \alpha^{109}x^{12} + \alpha^{102}x^{11} + \alpha^{161}x^{10} + \alpha^{76}x^9 \ \alpha^3x^8 + \alpha^{91}x^7 + \alpha^{191}x^6 + \alpha^{147}x^5 + \alpha^{169}x{-}^{4}\alpha^{182}x^3 + \alpha^{194}x^2 + \alpha^{225}x + \alpha^{120}$
17	$x^{17} + \alpha^{43}x^{16} + \alpha^{139}x^{15} + \alpha^{206}x^{14} + \alpha^{78}x^{13} + \alpha^{43}x^{12} + \alpha^{239}x^{11} + \alpha^{123}x^{10} + \alpha^{206}x^9 + \alpha^{214}x^8 + \alpha^{147}x^7 + \alpha^{24}x^6 + \alpha^{99}x^5 + \alpha^{150}x^4 + \alpha^{39}x^3 + \alpha^{243}x^2 + \alpha^{163}x + \alpha^{136}$
18	$x^{18} + \alpha^{215}x^{17} + \alpha^{234}x^{16} + \alpha^{158}x^{15} + \alpha^{94}x^{14} + \alpha^{184}x^{13} + \alpha^{97}x^{12} + \alpha^{118}x^{11} + \alpha^{170}x^{10} + \alpha^{79}x^9 + \alpha^{187}x^8 + \alpha^{152}x^7 + \alpha^{148}x^6 + \alpha^{252}x^5 + \alpha^{179}x^4 + \alpha^5x^3 + \alpha^{98}x^2 + \alpha^{96}x + \alpha^{153}$
20	$x^{20} + \alpha^{17}x^{19} + \alpha^{60}x^{18} + \alpha^{79}x^{17} + \alpha^{50}x^{16} + \alpha^{61}x^{15} + \alpha^{163}x^{14} + \alpha^{26}x^{13} + \alpha^{187}x^{12} + \alpha^{202}x^{11} + \alpha^{180}x^{10} + \alpha^{221}x^9 + \alpha^{225}x^8 + \alpha^{83}x^7 + \alpha^{239}x^6 + \alpha^{156}x^5 + \alpha^{164}x^4 + \alpha^{212}x^3 + \alpha^{212}x^2 + \alpha^{188}x + \alpha^{190}$
22	$x^{22} + \alpha^{210}x^{21} + \alpha^{171}x^{20} + \alpha^{247}x^{19} + \alpha^{242}x^{18} + \alpha^{93}x^{17} + \alpha^{230}x^{16} + \alpha^{14}x^{15} + \alpha^{109}x^{14} + \alpha^{221}x^{13} + \alpha^{53}x^{12} + \alpha^{200}x^{11} + \alpha^{74}x^{10} + \alpha^8x^9 + \alpha^{172}x^8 + \alpha^{98}x^7 + \alpha^{80}x^6 + \alpha^{219}x^5 + \alpha^{134}x^4 + \alpha^{160}x^3 + \alpha^{105}x^2 + \alpha^{165}x + \alpha^{231}$
24	$x^{24} + \alpha^{229}x^{23} + \alpha^{121}x^{22} + \alpha^{135}x^{21} + \alpha^{48}x^{20} + \alpha^{211}x^{19} + \alpha^{117}x^{18} + \alpha^{251}x^{17} + \alpha^{126}x^{16} + \alpha^{159}x^{15} + \alpha^{180}x^{14} + \alpha^{169}x^{13} + \alpha^{152}x^{12} + \alpha^{192}x^{11} + \alpha^{226}x^{10} + \alpha^{228}x^9 + \alpha^{218}x^8 + \alpha^{111}x^7 + x^6 + \alpha^{117}x^5 + \alpha^{232}x^4 + \alpha^{87}x^3 + \alpha^{96}x^2 + \alpha^{227}x + \alpha^{21}$
26	$x^{26} + \alpha^{173}x^{25} + \alpha^{125}x^{24} + \alpha^{158}x^{23} + \alpha^2x^{22} + \alpha^{103}x^{21} + \alpha^{182}x^{20} + \alpha^{118}x^{19} + \alpha^{17}x^{18} + \alpha^{145}x^{17} + \alpha^{201}x^{16} + \alpha^{111}x^{15} + \alpha^{28}x^{14} + \alpha^{165}x^{13} + \alpha^{53}x^{12} + \alpha^{161}x^{11} + \alpha^{21}x^{10} + \alpha^{245}x^9 + \alpha^{142}x^8 + \alpha^{13}x^7 + \alpha^{102}x^6 + \alpha^{48}x^5 + \alpha^{227}x^4 + \alpha^{153}x^3 + \alpha^{145}x^2 + \alpha^{218}x + \alpha^{70}$
28	$x^{28} + \alpha^{168}x^{27} + \alpha^{223}x^{26} + \alpha^{200}x^{25} + \alpha^{104}x^{24} + \alpha^{224}x^{23} + \alpha^{234}x^{22} + \alpha^{108}x^{21} + \alpha^{180}x^{20} + \alpha^{110}x^{19} + \alpha^{190}x^{18} + \alpha^{195}x^{17} + \alpha^{147}x^{16} + \alpha^{205}x^{15} + \alpha^{27}x^{14} + \alpha^{232}x^{13} + \alpha^{201}x^{12} + \alpha^{21}x^{11} + \alpha^{43}x^{10} + \alpha^{245}x^9 + \alpha^{87}x^8 + \alpha^{42}x^7 + \alpha^{195}x^6 + \alpha^{212}x^5 + \alpha^{119}x^4 + \alpha^{242}x^3 + \alpha^{37}x^2 + \alpha^9x + \alpha^{123}$
30	$x^{30} + \alpha^{41}x^{29} + \alpha^{173}x^{28} + \alpha^{145}x^{27} + \alpha^{152}x^{26} + \alpha^{216}x^{25} + \alpha^{31}x^{24} + \alpha^{179}x^{23} + \alpha^{182}x^{22} + \alpha^{50}x^{21} + \alpha^{48}x^{20} + \alpha^{110}x^{19} + \alpha^{86}x^{18} + \alpha^{239}x^{17} + \alpha^{96}x^{16} + \alpha^{222}x^{15} + \alpha^{125}x^{14} + \alpha^{42}x^{13} + \alpha^{173}x^{12} + \alpha^{226}x^{11} + \alpha^{193}x^{10} + \alpha^{224}x^9 + \alpha^{130}x^8 + \alpha^{156}x^7 + \alpha^{37}x^6 + \alpha^{251}x^5 + \alpha^{216}x^4 + \alpha^{238}x^3 + \alpha^{40}x^2 + \alpha^{192}x + \alpha^{180}$
32	$x^{32}\alpha^{10}x^{31} + \alpha^6x^{30} + \alpha^{106}x^{29} + \alpha^{190}x^{28} + \alpha^{249}x^{27} + \alpha^{167}x^{26} + \alpha^4x^{25} + \alpha^{67}x^{24} + \alpha^{209}x^{23} + \alpha^{138}x^{22} + \alpha^{138}x^{21} + \alpha^{32}x^{20} + \alpha^{242}x^{19} + \alpha^{123}x^{18} + \alpha^{89}x^{17} + \alpha^{27}x^{16} + \alpha^{120}x^{15} + \alpha^{185}x^{14} + \alpha^{80}x^{13} + \alpha^{156}x^{12} + \alpha^{38}x^{11} + \alpha^{69}x^{10} + \alpha^{171}x^9 + \alpha^{60}x^8 + \alpha^{28}x^7 + \alpha^{222}x^6 + \alpha^{80}x^5 + \alpha^{52}x^4 + \alpha^{254}x^3 + \alpha^{185}x^2 + \alpha^{220}x + \alpha^{241}$
34	$x^{34} + \alpha^{111}x^{33} + \alpha^{77}x^{32} + \alpha^{146}x^{31} + \alpha^{94}x^{30} + \alpha^{26}x^{29} + \alpha^{21}x^{28} + \alpha^{108}x^{27} + \alpha^{19}x^{26} + \alpha^{105}x^{25} + \alpha^{94}x^{24} + \alpha^{113}x^{23} + \alpha^{193}x^{22} + \alpha^{86}x^{21} + \alpha^{140}x^{20} + \alpha^{163}x^{19} + \alpha^{125}x^{18} + \alpha^{58}x^{17} + \alpha^{158}x^{16} + \alpha^{229}x^{15} + \alpha^{239}x^{14} + \alpha^{218}x^{13} + \alpha^{103}x^{12} + \alpha^{56}x^{11} + \alpha^{70}x^{10} + \alpha^{114}x^9 + \alpha^{61}x^8 + \alpha^{183}x^7 + \alpha^{129}x^6 + \alpha^{167}x^5 + \alpha^{13}x^4 + \alpha^{98}x^3 + \alpha^{62}x^2 + \alpha^{129}x + \alpha^{51}$

Table A.1 *(continued)*

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

Table A.1 *(continued)*

Number of error correction codewords	Generator polynomials
68	$x^{68} + \alpha^{247}x^{67} + \alpha^{159}x^{66} + \alpha^{223}x^{65} + \alpha^{33}x^{64} + \alpha^{224}x^{63} + \alpha^{93}x^{62} + \alpha^{77}x^{61} + \alpha^{70}x^{60} + \alpha^{90}x^{59} + \alpha^{160}x^{58} + \alpha^{32}x^{57} + \alpha^{254}x^{56} + \alpha^{43}x^{55} + \alpha^{150}x^{54} + \alpha^{84}x^{53} + \alpha^{101}x^{52} + \alpha^{190}x^{51} + \alpha^{205}x^{50} + \alpha^{133}x^{49} + \alpha^{52}x^{48} + \alpha^{60}x^{47} + \alpha^{202}x^{46} + \alpha^{165}x^{45} + \alpha^{220}x^{44} + \alpha^{203}x^{43} + \alpha^{151}x^{42} + \alpha^{93}x^{41} + \alpha^{84}x^{40} + \alpha^{15}x^{39} + \alpha^{84}x^{38} + \alpha^{253}x^{37} + \alpha^{173}x^{36} + \alpha^{160}x^{35} + \alpha^{89}x^{34} + \alpha^{227}x^{33} + \alpha^{52}x^{32} + \alpha^{199}x^{31} + \alpha^{97}x^{30} + \alpha^{95}x^{29} + \alpha^{231}x^{28} + \alpha^{52}x^{27} + \alpha^{177}x^{26} + \alpha^{41}x^{25} + \alpha^{125}x^{24} + \alpha^{137}x^{23} + \alpha^{241}x^{22} + \alpha^{166}x^{21} + \alpha^{225}x^{20} + \alpha^{118}x^{19} + \alpha^{2}x^{18} + \alpha^{54}x^{17} + \alpha^{32}x^{16} + \alpha^{82}x^{15} + \alpha^{215}x^{14} + \alpha^{175}x^{13} + \alpha^{198}x^{12} + \alpha^{43}x^{11} + \alpha^{238}x^{10} + \alpha^{235}x^{9} + \alpha^{27}x^{8} + \alpha^{101}x^{7} + \alpha^{184}x^{6} + \alpha^{127}x^{5} + \alpha^{3}x^{4} + \alpha^{5}x^{3} + \alpha^{8}x^{2} + \alpha^{163}x + \alpha^{238}$

Annex B
(normative)

Error correction decoding steps

Take the version 1-M symbol as an example. For the symbol, the (26, 16, 4) Reed-Solomon code under GF(2^8) is used for error correction. Provided that the code after releasing data masking from the symbol is

$$R=(r_0,r_1,r_2,\ldots,r_{25})$$

that is,

$$R(x)=r_0+r_1x+r_2x^2+\ \ldots\ +r_{25}x^{25}$$

where r_i (i = 0 – 25) is an element of GF(2^8):

a) Calculate n syndromes where n is equal to the number of codewords available for error correction, given by (c – k – p) as shown in Table 9.

Find the syndrome S_i(i = 0 – (n – 1)) as shown in Formula (B.1):

$$\begin{aligned} S_0 &= R(1) = r_0+r_1+r_2+\ \ldots\ +r_{25} \\ S_1 &= R(\alpha) = r_0+r_1\alpha+r_2\alpha^2+\ \ldots\ +r_{25}\alpha^{25} \\ &\ldots \\ &\ldots \\ S_7 &= R\left(\alpha^7\right) = r_0+r_1\alpha^7+r_2\alpha^{14}+\ \ldots\ +r_{25}\alpha^{175} \end{aligned} \quad \text{(B.1)}$$

where α is the primitive element of GF(2^8).

b) Find the error positions:

$$\begin{aligned} S_0\sigma_4-S_1\sigma_3+S_2\sigma_2-S_3\sigma_1+S_4 &= 0 \\ S_1\sigma_4-S_2\sigma_3+S_3\sigma_2-S_4\sigma_1+S_5 &= 0 \\ S_2\sigma_4-S_3\sigma_3+S_4\sigma_2-S_5\sigma_1+S_6 &= 0 \\ S_3\sigma_4-S_4\sigma_3+S_5\sigma_2-S_6\sigma_1+S_7 &= 0 \end{aligned} \quad \text{(B.2)}$$

Find the variable σ_i(i = 1 – 4) for each error position using Formula (B.2). Then, substitute the variable for the following polynomial and substitute elements of GF(2^8) one by one in Formula (B.3).

$$\sigma(x) = \sigma_4+\sigma_3x+\sigma_2x^2+\sigma_1x^3+x^4 \quad \text{(B.3)}$$

Now, it is found that an error is on the j^{th} digit (counting from the 0^{th} digit) for the element αj which makes $\sigma(\alpha) = 0$.

c) Supposing that an error is on the j^1, j^2, j^4 digits in b), then find the size of the error.

$$\begin{aligned} Y_1 \alpha j^1 + Y_2 \alpha j^2 + Y_3 \alpha j^3 + Y_4 \alpha j^4 &= S_0 \\ Y_1 \alpha^2 j^1 + Y_2 \alpha^2 j^2 + Y_3 \alpha^2 j^3 + Y_4 \alpha^2 j^4 &= S_1 \\ Y_1 \alpha^3 j^1 + Y_2 \alpha^3 j^2 + Y_3 \alpha^3 j^3 + Y_4 \alpha^3 j^4 &= S_2 \\ Y_1 \alpha^4 j^1 + Y_2 \alpha^4 j^2 + Y_3 \alpha^4 j^3 + Y_4 \alpha^4 j^4 &= S_3 \end{aligned} \quad \text{(B.4)}$$

Solve Formula (B.4) to find the size of each error $Y_i (i = 1 - 4)$.

d) Correct the error by adding the complement of the error size value to each error position.

Annex C
(normative)

Format information

C.1 General

The format information consists of a 15-bit sequence comprising 5 data bits and 10 BCH error correction bits. This Annex describes the calculation of the error correction bits and the error correction decoding process.

C.2 Error correction bit calculation

The Bose-Chaudhuri-Hocquenghem (15,5) code shall be used for error correction. The polynomial whose coefficient is the data bit string shall be divided by the generator polynomial $G(x) = x^{10} + x^8 + x^5 + x^4 + x^2 + x + 1$. The coefficient string of the remainder polynomial shall be appended to the data bit string to form the (15,5) BCH code string. Finally, masking shall be applied by XORing the bit string with 101010000010010 (for QR code symbols) or 100010001000101 (for micro QR code symbols) to ensure that the format information bit pattern is not all zeroes for any combination of data mask pattern and error correction level.

EXAMPLE For the error correction level M; data mask pattern 101:

Binary string:	00101
Polynomial:	$x^2 + 1$
The power is raised to the (15 - 5)th:	$x^{12} + x^{10}$
And then divided by $G(x)$:	$= (x^{10} + x^8 + x^5 + x^4 + x^2 + x + 1)x^2 + (x^7 + x^6 + x^4 + x^3 + x^2)$

The coefficient string of the above remainder polynomial is added to the format information data string:

00100 + 0011011100 → 001010011011100

XOR with mask	101010000010010
Result:	100000011001110

Place these bits in the format information areas as described in 7.9.

C.3 Error correction decoding steps

Release the masking of the format information modules by XORing the bit sequence with the mask pattern 101010000010010 (for QR code symbols) or 100010001000101 (for micro QR code symbols).

The Hamming distance of the error correction code used in the format information is 7, which enables up to 3 bit errors to be corrected. There are 32 valid bit sequences for the format information, so decoding by using Table C.1 as a look-up table is efficient. Bit sequences read from the format information area of the symbol are compared with the 32 valid format information bit strings in Table C.1 on a bit by bit basis. The bit string from Table C.1 closest to the bit string read from the symbol is taken, provided the strings differ by 3 bits or less.

EXAMPLE For a QR code symbol:

Bit string read from format information area:	000011101001001
Closest bit string from table:	000111101011001

Since only 2 bits differ between the two bit strings, the comparison is successful and thus the symbol format is confirmed as utilising error correction level M with masking pattern 011.

Table C.1 — Valid format information bit sequences

Sequence before masking		Sequence after masking (QR code symbols)		Sequence after masking (micro QR code symbols)	
Data bits	Error correction bits	binary	hex	binary	hex
00000	0000000000	101010000010010	5412	100010001000101	4445
00001	0100110111	101000100100101	5125	100000101110010	4172
00010	1001101110	101111001111100	5E7C	100111000101011	4E2B
00011	1101011001	101101101001011	5B4B	100101100011100	4B1C
00100	0111101011	100010111111001	45F9	101010110101110	55AE
00101	0011011100	100000011001110	40CE	101000010011001	5099
00110	1110000101	100111110010111	4F97	101111111000000	5FC0
00111	1010110010	100101010100000	4AA0	101101011110111	5AF7
01000	1111010110	111011111000100	77C4	110011110010011	6793
01001	1011100001	111001011110011	72F3	110001010100100	62A4
01010	0110111000	111110110101010	7DAA	110110111111101	6DFD
01011	0010001111	111100010011101	789D	110100011001010	68CA
01100	1000111101	110011000101111	662F	111011001111000	7678
01101	1100001010	110001100011000	6318	111001101001111	734F
01110	0001010011	110110001000001	6C41	111110000010110	7C16
01111	0101100100	110100101110110	6976	111100100100001	7921
10000	1010011011	001011010001001	1689	000011011011110	06DE
10001	1110101100	001001110111110	13BE	000001111101001	03E9
10010	0011110101	001110011100111	1CE7	000110010110000	0CB0
10011	0111000010	001100111010000	19D0	000100110000111	0987
10100	1101110000	000011101100010	0762	001011100110101	1735
10101	1001000111	000001001010101	0255	001001000000010	1202
10110	0100011110	000110100001100	0D0C	001110101011011	1D5B
10111	0000101001	000100000111011	083B	001100001101100	186C
11000	0101001101	011010101011111	355F	010010100001000	2508
11001	0001111010	011000001101000	3068	010000000111111	203F
11010	1100100011	011111100110001	3F31	010111101100110	2F66
11011	1000010100	011101000000110	3A06	010101001010001	2A51
11100	0010100110	010010010110100	24B4	011010011100011	34E3
11101	0110010001	010000110000011	2183	011000111010100	31D4
11110	1011001000	010111011011010	2EDA	011111010001101	3E8D
11111	1111111111	010101111101101	2BED	011101110111010	3BBA

Annex D
(normative)

Version information

D.1 General

The version information consists of an 18-bit sequence comprising 6 data bits and 12 Golay error correction bits. This Annex describes the calculation of the error correction bits and the error correction decoding process.

D.2 Error correction bit calculation

The (18,6) Golay code shall be used for error correction. The polynomial whose coefficient is the data bit string shall be divided by the generator polynomial $G(x) = x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^5 + x^2 + 1$. The coefficient string of the remainder polynomial shall be appended to the data bit string to form the (18,6) Golay code string.

EXAMPLE

Version:	7
Binary string:	000111
Polynomial:	$x^2 + x + 1$
The power is raised to the (18 - 6)th:	$x^{14} + x^{13} + x^{12}$
And divided by $G(x)$:	$= (x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^5 + x^2 + 1)x^2 + (x^{11} + x^{10} + x^7 + x^4 + x^2)$

The coefficient string of above remainder polynomial is added to version information data string:

000111 + 110010010100 → 000111110010010100

These bits are placed in the version information areas as described in 7.10.

Table D.1 shows the full version information bit stream for each version.

D.3 Error correction decoding steps

The Hamming distance of the error correction code used in the version information is 8, which enables up to 3 bits of errors to be corrected. There are 34 valid bit sequences for the version information, so decoding by using Table D.1 as a look-up table is efficient. Bit sequences read from the version information area of the symbol are compared with the 34 valid version information bit strings in Table D.1 on a bit by bit basis. The bit string from Table D.1 is the closest to the bit string read from which the symbol is taken, provided the strings differ by 3 bits or less after the comparison.

EXAMPLE

Bit string read from version information area:	000111110110010100
Closest bit string from table:	000111110010010100

Since only 1 bit differs between the two bit strings, the comparison is successful, and thus the symbol version is confirmed as 7.

Table D.1 — Version information bit stream for each version

Version	Version information bit stream	Hex equivalent
7	00 0111 1100 1001 0100	07C94
8	00 1000 0101 1011 1100	085BC
9	00 1001 1010 1001 1001	09A99
10	00 1010 0100 1101 0011	0A4D3
11	00 1011 1011 1111 0110	0BBF6
12	00 1100 0111 0110 0010	0C762
13	00 1101 1000 0100 0111	0D847
14	00 1110 0110 0000 1101	0E60D
15	00 1111 1001 0010 1000	0F928
16	01 0000 1011 0111 1000	10B78
17	01 0001 0100 0101 1101	1145D
18	01 0010 1010 0001 0111	12A17
19	01 0011 0101 0011 0010	13532
20	01 0100 1001 1010 0110	149A6
21	01 0101 0110 1000 0011	15683
22	01 0110 1000 1100 1001	168C9
23	01 0111 0111 1110 1100	177EC
24	01 1000 1110 1100 0100	18EC4
25	01 1001 0001 1110 0001	191E1
26	01 1010 1111 1010 1011	1AFAB
27	01 1011 0000 1000 1110	1B08E
28	01 1100 1100 0001 1010	1CC1A
29	01 1101 0011 0011 1111	1D33F
30	01 1110 1101 0111 0101	1ED75
31	01 1111 0010 0101 0000	1F250
32	10 0000 1001 1101 0101	209D5
33	10 0001 0110 1111 0000	216F0
34	10 0010 1000 1011 1010	228BA
35	10 0011 0111 1001 1111	2379F
36	10 0100 1011 0000 1011	24B0B
37	10 0101 0100 0010 1110	2542E
38	10 0110 1010 0110 0100	26A64
39	10 0111 0101 0100 0001	27541
40	10 1000 1100 0110 1001	28C69

Annex E
(normative)

Position of alignment patterns

The alignment patterns are positioned symmetrically on either side of the diagonal running from the top left corner of the symbol to the bottom right corner. They are spaced as evenly as possible between the timing pattern and the opposite side of the symbol, any uneven spacing being accommodated between the timing pattern and the first alignment pattern in the symbol interior.

Table E.1 shows, for each version, the number of alignment patterns and the row or column coordinates of the centre module of each alignment pattern.

Table E.1 — Row or column coordinates of the centre module of alignment patterns

Version	Number of alignment patterns	Row or column coordinates of centre module						
1	0	—						
2	1	6	18					
3	1	6	22					
4	1	6	26					
5	1	6	30					
6	1	6	34					
7	6	6	22	38				
8	6	6	24	42				
9	6	6	26	46				
10	6	6	28	50				
11	6	6	30	54				
12	6	6	32	58				
13	6	6	34	62				
14	13	6	26	46	66			
15	13	6	26	48	70			
16	13	6	26	50	74			
17	13	6	30	54	78			
18	13	6	30	56	82			
19	13	6	30	58	86			
20	13	6	34	62	90			
21	22	6	28	50	72	94		
22	22	6	26	50	74	98		
23	22	6	30	54	78	102		
24	22	6	28	54	80	106		
25	22	6	32	58	84	110		
26	22	6	30	58	86	114		
27	22	6	34	62	90	118		
28	33	6	26	50	74	98	122	
29	33	6	30	54	78	102	126	
30	33	6	26	52	78	104	130	
31	33	6	30	56	82	108	134	
32	33	6	34	60	86	112	138	

Table E.1 *(continued)*

Version	Number of alignment patterns	Row or column coordinates of centre module						
33	33	6	30	58	86	114	142	
34	33	6	34	62	90	118	146	
35	46	6	30	54	78	102	126	150
36	46	6	24	50	76	102	128	154
37	46	6	28	54	80	106	132	158
38	46	6	32	58	84	110	136	162
39	46	6	26	54	82	110	138	166
40	46	6	30	58	86	114	142	170

For example, in a version 7 symbol, Table E.1 indicates values 6, 22 and 38. The alignment patterns, therefore, are to be centred on (row,column) positions (6,22), (22,6), (22,22), (22,38), (38,22), (38,38). Note that the coordinates (6,6), (6,38), (38,6) are occupied by finder patterns and are not therefore used for alignment patterns.

Annex F
(normative)

Symbology identifier

The symbology identifier assigned to QR code in ISO/IEC 15424, which should be added as a preamble to the decoded data by a suitably programmed decoder is:

]Qm

where

] is the symbology identifier flag (ASCII value 93);

Q is the code character for the QR code symbology;

m is the modifier character with one of the values defined in Table F.1.

The value of m shall always be 1 for micro QR code symbols.

NOTE The sign] is the character assigned to ASCII value 93 in the United States ASCII character set according to ISO/IEC 646.

Table F.1 — Symbology identifier options and modifier values

Modifier value	Option
0	QR code model 1 symbol (according to AIM ITS 97-001)
1	QR code symbol, ECI protocol not implemented
2	QR code symbol, ECI protocol implemented
3	QR code symbol, ECI protocol not implemented, FNC1 implied in first position
4	QR code symbol, ECI protocol implemented, FNC1 implied in first position
5	QR code symbol, ECI protocol not implemented, FNC1 implied in second position
6	QR code symbol, ECI protocol implemented, FNC1 implied in second position

The permissible values of m are: 0, 1, 2, 3, 4, 5, 6.

Annex G
(normative)

QR code print quality — Symbology-specific aspects

G.1 General

Due to the differences in symbology structures and reference decode algorithms, the effect of certain parameters on a symbol's reading performance can vary. ISO/IEC 15415 provides for symbology specifications to define the grading of certain symbology-specific attributes. This Annex therefore defines the method of grading fixed pattern damage and additional parameters (format information and version information) to be used in the application of ISO/IEC 15415 to QR code.

G.2 Fixed pattern damage

G.2.1 Features to be assessed

G.2.1.1 QR code symbols

The features to be assessed are:

— Three corner segments, each including:

 — the 7 × 7 finder pattern,

 — the 1X wide separators surrounding the two inner sides of the finder pattern,

 — part of the quiet zone of a minimum of four modules width (or more if specified by the application) extending for a length of 15 modules along the two outer sides of the finder pattern.

— The two timing patterns of alternating dark and light modules linking the inner corners of the finder patterns.

— The 5 × 5 alignment patterns (where present, in model 2 symbols of version 2 or larger).

The features listed above shall be assessed as six segments, namely:

— the three corner segments (finder patterns with their associated separators and part of the quiet zone) (segments A1, A2 and A3 respectively),

— the two timing patterns (segments B1 and B2 respectively),

— the single segment containing all the alignment patterns (segment C).

Where a timing pattern crosses an alignment pattern the five modules that coincide with the alignment pattern are assessed both as part of the timing pattern and of the alignment pattern.

For example, in a version 7 symbol (45 × 45 modules), each segment A occupies 168 modules, each segment B is 29 modules long and segment C occupies a total of 150 modules (i.e. 6 × 25).

These segments, in the case of a version 7 symbol, are illustrated in Figure G.1. A1, A2 and A3 indicate the three corner segments; B1 and B2 indicate the two timing pattern segments, and C indicates the single segment C (comprising the six alignment patterns).

For QR code symbols, its width of quiet zone shall be 4X. Figure G.1 shows segments that shall be checked with a fixed pattern print quality assessment. The remaining regions of quiet zones are not checked.

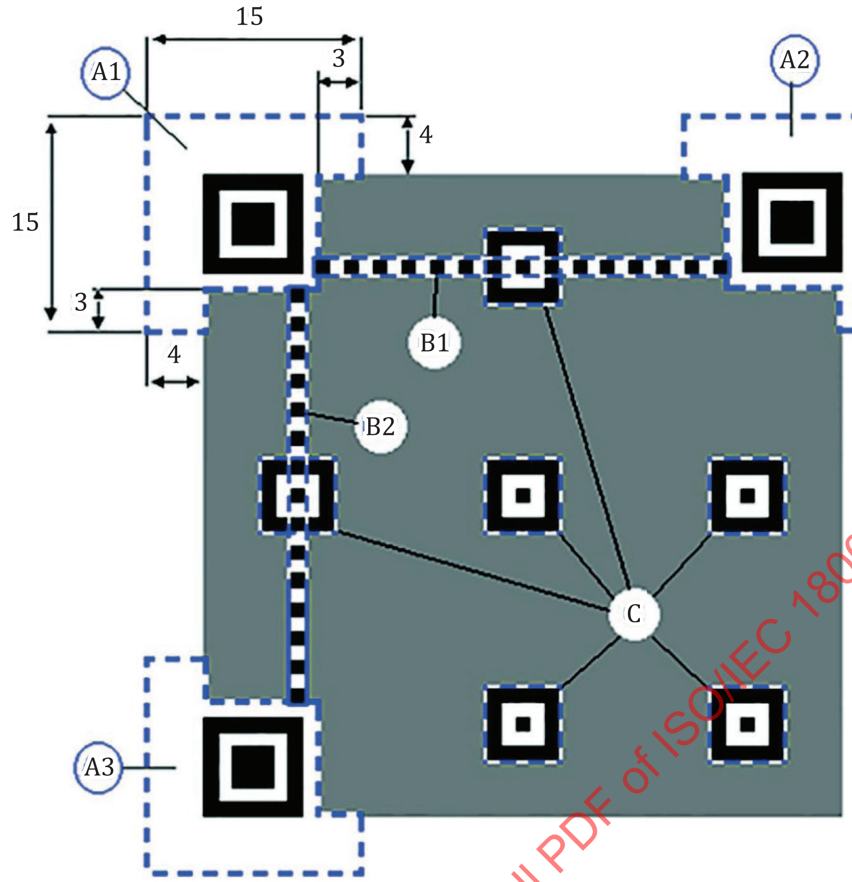


Figure G.1 — QR code fixed pattern segments

G.2.1.2 Micro QR code symbols

The features to be assessed are:

— the corner segment, including:

  — the finder pattern,

  — the 1X wide separators adjoining the two inner sides of the finder pattern,

  — part of the quiet zone of a minimum of two modules width (or more if specified by the application) extending for a length of 11 modules along the two outer sides of the finder pattern.

— The two timing patterns of alternating dark and light modules running along the top and left side of the symbol from the finder pattern.

The features listed above shall be assessed as three segments, namely:

— the corner segment (finder pattern with its associated separators and part of the quiet zone) (segment A), which occupies 104 modules,

— the two timing patterns (segments B1 and B2 respectively).

For example, in a version M4 symbol (17 × 17 modules), each segment B is 9 modules long. These segments are illustrated in Figure G.2. A indicates the corner segment, and B1 and B2 indicate the two timing pattern segments.

For micro QR code symbols, its width of quiet zone shall be 2X. Figure G.2 shows the segment that shall be checked during a fixed pattern print quality assessment. The remaining regions of quiet zones are not checked.

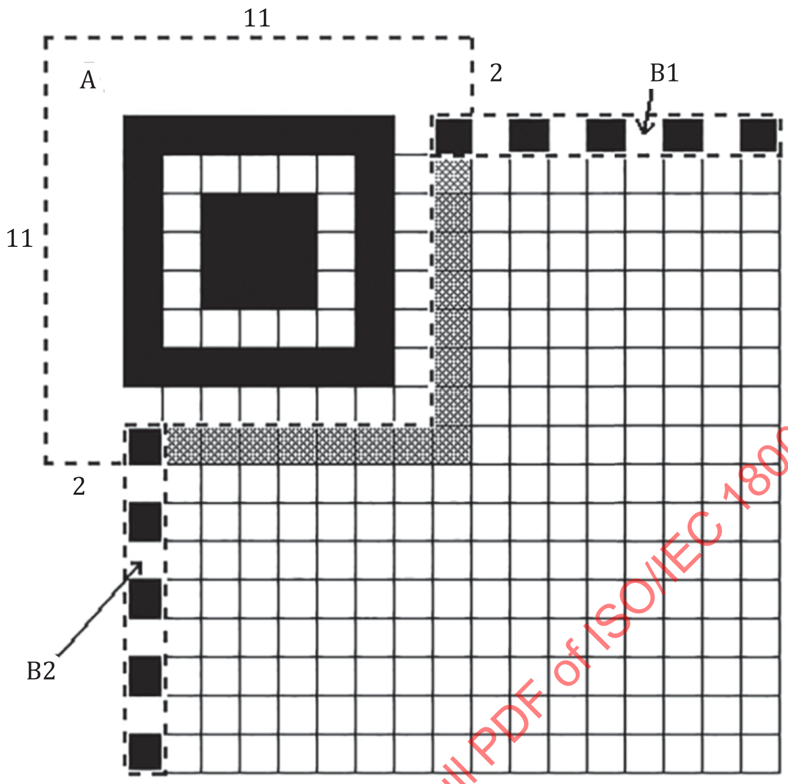


Figure G.2 — Micro QR code fixed pattern segments

G.2.2 Fixed pattern damage grading

Damage to each segment shall be graded based on the modulation of the individual modules that compose it.

The procedure described below shall be applied to each segment in turn.

a) From the reference grey-scale image of the symbol, find the modulation grade for each module based on the values in ISO/IEC 15415. Since the intended light or dark nature of the module is known, any module intended to be dark but the reflectance of which is above the global threshold, and any module intended to be light but the reflectance of which is below the global threshold shall be given modulation grade 0.

b) For each modulation grade level, assume that all modules not achieving that grade or a higher grade are module errors, and derive a notional damage grade based on the grade thresholds shown in Table G.1. Take the lower of the modulation grade level and the notional damage grade. The notional damage grade is determined as follows:

   1) For each of segments A1, A2, and A3, or segment A in micro QR code symbols, count the number of module errors.

   2) For segments B1 and B2, count the number of module errors. Express this number as a percentage of the total number of modules in the segment.

   3) For segments B1 and B2, taking groups of five adjacent modules and progressing along the segment in steps of one module, verify that in any group of five adjacent modules no more than two are damaged; if this test fails, the grade for the segment shall be 0. This test does not apply to micro QR code.

   4) For segment C (for QR code symbols only), count the number of alignment patterns containing a module error. Express this number as a percentage of the number of alignment patterns in the symbol.

5) Assign a notional damage grade to each segment based on the grade thresholds shown in Table G.1.

c) The fixed pattern damage grade for the segment shall be the highest resulting grade for all modulation grade levels.

The fixed pattern damage grade for the symbol shall be the lowest of the segment grades. The grade shall be computed as an interpolated value in steps of 1 to 10. Decimal points behind the first number are removed (no mathematical rounding applies).

Table G.1 — Grade thresholds for QR code fixed pattern damage

Segments A1, A2 and A3 (QR code), segment A (micro QR code)	Segments B1 and B2 (QR code)	Segments B1 and B2 (micro QR code)	Segment C (QR code)	Grade
Number of module errors	Percentage of total modules with module errors	Percentage of total modules with module errors	Percentage of alignment patterns with module errors	
0	0 %	0 %	0 %	4,0
1	≤7,0 % and >0 %	≤15,0 % and >0 %	≤10,0 % and >0 %	3,0 to 3,9
2	≤10,5 % and >7,0 %	≤30,0 % and >15,0 %	≤20,0 % and >10,0 %	2,0 to 2,9
3	≤14,0 % and >10,5 %	NA	≤30,0 % and >20,0 %	1,0 to 1,9
NA	≤17,5 % and >14,0 %	NA	NA	0,0 to 0 ,9
≥4	>17,5 %	>30,0 %	>30,0 %	0,0

Key

NA not applicable

G.3 Grading of additional parameters

G.3.1 General

QR code symbols contain a duplicated set of modules representing information that defines the format of the symbol, and symbols of version 7 to 40 also contain a duplicated set of modules representing information that defines the symbol size. Micro QR code symbols contain a single set of modules representing information that defines the format of the symbol. This data must be reliably detected at an early stage of the decoding procedure, and if it cannot be decoded, the remainder of the symbol cannot be decoded. For this reason, the format information and version information module blocks are graded separately (in a similar way to fixed pattern damage), and their grades are included in the overall symbol grade determination.

G.3.2 Grading of format information

For each block of format information, determine a grade for the block in accordance with the following method.

a) From the reference grey-scale image of the symbol, find the modulation grade for each module based on the values in ISO/IEC 15415. Since the intended light or dark nature of the module is known after decoding, any module intended to be dark but the reflectance of which is above the global threshold, and any module intended to be light but the reflectance of which is below the global threshold shall be given modulation grade 0. If the format information in the block cannot be decoded, the grade for the block shall be 0.

b) For each modulation grade level:

1) Assume that all modules not achieving that modulation grade or a higher grade are module errors, and derive a notional grade based on Table G.2.

Table G.2 — Format information notional grading

Number of module errors	Grade
0	4,0
1	3,0
2	2,0
3	1,0
≥4	0,0

2) Select the lower of the modulation grade and the notional grade at each level as the grade for that level, as illustrated in Table G.3.

3) The grade for the block shall be the highest resulting grade, as illustrated in Table G.3.

Table G.3 — Example of format information block grading

Modulation grade	Notional grade	Lower of grades
4,0	2	2
3,0	2	2
2,0	3	2
1,0	3	1
0,0	4	0
	Selected (highest) grade →	2

c) The format information grade shall be:

1) the average of the grades of the two format information blocks, rounded up if necessary to the next integer for QR code symbols;

2) the grade determined in step 2 c) for micro QR code symbols.

G.3.3 Grading of version information (QR code symbols)

For each block of version information, determine a grade for the block in accordance with the following method.

a) Find the modulation grade for each module based on the values in ISO/IEC 15415. Since the intended light or dark nature of the module is known after decode, any module intended to be dark but the reflectance of which is above the global threshold, and any module intended to be light but the reflectance of which is below the global threshold shall be given modulation grade 0. If the version information in the block cannot be decoded, the grade for the block shall be 0.

b) For each modulation grade level:

1) Assume that all modules not achieving that modulation grade or a higher grade are module errors, and derive a notional grade based on Table G.4.

Table G.4 — Version information notional grading

Number of module errors	Grade
0	4,0
1	3,0
2	2,0
3	1,0
≥4	0,0

2) Select the lower of the modulation grade and the notional grade at each level as the grade for that level, as illustrated in Table G.5.

3) The grade for the block shall be the highest resulting grade, as illustrated in Table G.5.

Table G.5 — Example of version information block grading

Modulation grade	Notional grade	Lower of grades
4,0	2	2
3,0	2	2
2,0	3	2
1,0	3	1
0,0	4	0
	Selected (highest) grade →	2

c) The version information grade shall be the average of the grades of the two version information blocks, rounded up if necessary to the next integer.

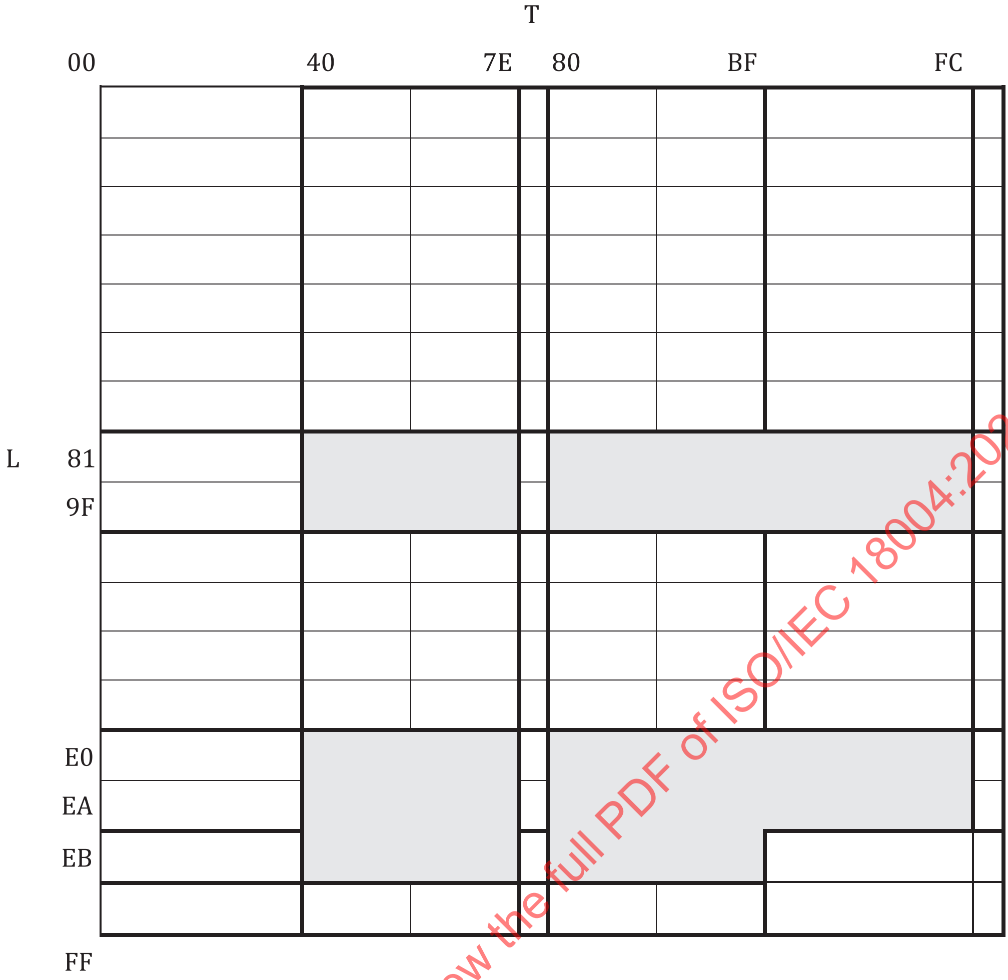
Annex H
(informative)

JIS8 and shift JIS character sets

Table H.1 — 8-bit character set for JIS X 0201 (JIS8)

Char.	Hex	Char.	Hex	Char.	Hex	Char.	Hex	Char.	Hex	Char.	Hex	Char.	Hex	Char.	Hex
NUL	00	SP	20	@	40	`	60		80		A0	ﾀ	C0		E0
SOH	01	!	21	A	41	a	61		81	｡	A1	ﾁ	C1		E1
STX	02	"	22	B	42	b	62		82	｢	A2	ﾂ	C2		E2
ETX	03	#	23	C	43	c	63		83	｣	A3	ﾃ	C3		E3
EOT	04	$	24	D	44	d	64		84	､	A4	ﾄ	C4		E4
ENQ	05	%	25	E	45	e	65		85	･	A5	ﾅ	C5		E5
ACK	06	&	26	F	46	f	66		86	ｦ	A6	ﾆ	C6		E6
BEL	07	'	27	G	47	g	67		87	ｧ	A7	ﾇ	C7		E7
BS	08	(	28	H	48	h	68		88	ｨ	A8	ﾈ	C8		E8
HT	09	)	29	I	49	i	69		89	ｩ	A9	ﾉ	C9		E9
LF	0A	*	2A	J	4A	j	6A		8A	ｪ	AA	ﾊ	CA		EA
VT	0B	+	2B	K	4B	k	6B		8B	ｫ	AB	ﾋ	CB		EB
FF	0C	,	2C	L	4C	l	6C		8C	ｬ	AC	ﾌ	CC		EC
CR	0D	-	2D	M	4D	m	6D		8D	ｭ	AD	ﾍ	CD		ED
SO	0E	.	2E	N	4E	n	6E		8E	ｮ	AE	ﾎ	CE		EE
SI	0F	/	2F	O	4F	o	6F		8F	ｯ	AF	ﾏ	CF		EF
DLE	10	0	30	P	50	p	70		90	ｰ	B0	ﾐ	D0		F0
DC1	11	1	31	Q	51	q	71		91	ｱ	B1	ﾑ	D1		F1
DC2	12	2	32	R	52	r	72		92	ｲ	B2	ﾒ	D2		F2
DC3	13	3	33	S	53	s	73		93	ｳ	B3	ﾓ	D3		F3
DC4	14	4	34	T	54	t	74		94	ｴ	B4	ﾔ	D4		F4
NAK	15	5	35	U	55	u	75		95	ｵ	B5	ﾕ	D5		F5
SYN	16	6	36	V	56	v	76		96	ｶ	B6	ﾖ	D6		F6
ETB	17	7	37	W	57	w	77		97	ｷ	B7	ﾗ	D7		F7
CAN	18	8	38	X	58	x	78		98	ｸ	B8	ﾘ	D8		F8
EM	19	9	39	Y	59	y	79		99	ｹ	B9	ﾙ	D9		F9
SUB	1A	:	3A	Z	5A	z	7A		9A	ｺ	BA	ﾚ	DA		FA
ESC	1B	;	3B	[	5B	{	7B		9B	ｻ	BB	ﾛ	DB		FB
FS	1C	<	3C	¥	5C	|	7C		9C	ｼ	BC	ﾜ	DC		FC
GS	1D	=	3D	]	5D	}	7D		9D	ｽ	BD	ﾝ	DD		FD
RS	1E	>	3E	^	5E	‾	7E		9E	ｾ	BE	ﾞ	DE		FE
US	1F	?	3F	_	5F	DEL	7F		9F	ｿ	BF	ﾟ	DF		FF

Figure H.1 shows the areas of the 256 × 256 code plane occupied by shift JIS double byte characters.



Key

T trailer bite

L leading bite

Figure H.1 — Shift JIS character values

According to JIS X 0208:1997, Annex 1, leading and trailing bytes within the ranges shown shaded are assigned to shift JIS Kanji characters. Any pairs of bytes within these ranges may be encoded using the Kanji mode compaction scheme.