BRITISH STANDARD

BS ISO/IEC 18004:2006

Incorporating corrigendum March 2009

Information technology — Automatic identification and data capture techniques — QR Code 2005 bar code symbology specification

ICS 01.080.50; 35.040

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National foreword

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The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by ISO/IEC corrigendum March 2009 is indicated in the text by AC AC.

The UK participation in its preparation was entrusted to Technical Committee IST/34, Automatic identification and data capture techniques.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2007

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ISBN 978 0 580 67368 9

Amendments/corrigenda issued since publication

Date	Comments
30 June 2009	Implementation of ISO/IEC corrigendum March 2009

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INTERNATIONAL STANDARD

ISO/IEC 18004

Second edition
2006-09-01

Information technology — Automatic identification and data capture techniques — QR Code 2005 bar code symbology specification

Technologies de l'information — Techniques d'identification automatique et de capture des données — Spécification de la symbologie de code à barres QR Code 2005

Reference number
ISO/IEC 18004:2006(E)

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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. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 18004 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This second edition cancels and replaces the first edition (ISO/IEC 18004:2000), which has been technically revised.

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Introduction

It is necessary to distinguish four technically different, but closely related members of the QR Code family, which represent an evolutionary sequence.

— QR Code Model 1 was the original specification for QR Code and is described in AIM International Symbology Specification 97-001.

— QR Code Model 2 was an enhanced form of the symbology with additional features (primarily the addition of alignment patterns to assist navigation in larger symbols), and was the basis of the first edition of ISO/IEC 18004.

— QR Code 2005 (the basis of this second edition of ISO/IEC 18004) is closely similar to QR Code Model 2 and, in 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 sets to the default.

— The Micro QR Code format (also specified in this International Standard), is a variant of QR Code 2005 with a reduced number of overhead modules and a restricted range of sizes, which enables small to moderate amounts 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 2005 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-specified to enable symbol production by a wide variety of techniques.

QR Code Model 2 symbols are fully compatible with QR Code 2005 reading systems.

Model 1 QR Code symbols are recommended only to be used in closed system applications and it is not a requirement that equipment complying with this International Standard should support Model 1. Since QR Code 2005 is the recommended model for new, open systems application of QR Code, this International Standard describes QR Code 2005 fully, and lists the features in which Model 1 QR Code differs from QR Code 2005 in Annex N.

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Information technology — Automatic identification and data capture techniques — QR Code 2005 bar code symbology specification

1 Scope

This International Standard defines the requirements for the symbology known as QR Code 2005. It specifies the QR Code 2005 symbology characteristics, data character encoding methods, symbol formats, dimensional characteristics, error correction rules, reference decoding algorithm, production quality requirements, and user-selectable application parameters, and lists in an informative annex the features of QR Code Model 1 symbols which differ from QR Code 2005.

2 Conformance

QR Code 2005 symbols (and equipment designed to produce or read QR Code 2005 symbols) shall be considered as conforming with this International Standard if they provide or support the features defined in this International Standard.

Symbols complying with the requirements for QR Code Model 1, as defined in ISO/IEC 18004:2000, may not be readable with equipment complying with this International Standard.

Symbols complying with the requirements for QR Code Model 2, as defined in ISO/IEC 18004:2000, are readable with equipment complying with this International Standard.

Reading equipment complying with ISO/IEC 18004:2000 will not be able to read all symbols complying with this International Standard. Symbols that make use of the additional features of QR Code 2005 will not be readable by such equipment.

Printing equipment complying with ISO/IEC 18004:2000 will not be able to print all symbols defined in this International Standard. Symbols that make use of the additional features of QR Code 2005 will not be printable by such equipment.

It should be noted, however, that QR Code 2005 is the form of the symbology recommended for new and open systems applications.

3 Normative references

The following referenced documents are indispensable for the application 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 8859-1:1998, *Information technology — 8-bit single-byte coded graphic character sets — Part 1: Latin alphabet No. 1*

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

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

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*

ISO/IEC 19762-2, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 2: Optically readable media (ORM)*

JIS X 0201, *7-bit and 8-bit coded character sets for information interchange*

JIS X 0208:1997, *7-bit and 8-bit double byte coded KANJI sets for information interchange*

AIM International Technical Specification, *Extended Channel Interpretations:*

— *Part 1, Identification Schemes and Protocols*
— *Part 2, Registration Procedure for Coded Character Sets and Other Data Formats*
— *Character Set Register*

AIM International Symbology Specification 97-001, *QR Code*

GS1 General Specifications, GS1

4 Terms and definitions, mathematical and logical symbols, abbreviations and conventions

4.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1 and 19762-2 and the following apply.

4.1.1
alignment pattern
fixed reference pattern in defined positions in a matrix symbology, which enables the decode software to re-synchronise the coordinate mapping of the image modules in the event of moderate amounts of distortion of the image

4.1.2
character count indicator
bit sequence which defines the data string length in a mode

4.1.3
data masking
process of XORing the bit pattern in the encoding region 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

4.1.4
data mask pattern reference
three-bit identifier of the data masking patterns applied to the symbol

4.1.5
encoding region
region of the symbol not occupied by function patterns and available for encoding of data and error correction codewords, and for Version and format information

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4.1.6
exclusive subset
subset of characters within the character set of a mode which are not shared with the more restricted character set of another mode

4.1.7
Extension Pattern
function pattern in Model 1 symbols, which does not encode data

4.1.8
format information
encoded pattern containing information on symbol characteristics essential to enable the remainder of the encoding region to be decoded

4.1.9
QR Code
pertaining to QR Code 2005 symbols identified as Versions 1 to 40, as distinct from Micro QR Code symbols

4.1.10
function pattern
overhead component of the symbol (finder, separator, timing patterns, and alignment patterns) required for location of the symbol or identification of its characteristics to assist in decoding

4.1.11
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

4.1.12
Micro
pertaining to QR Code 2005 symbols identified as Versions M1 to M4, as distinct from QR Code symbols

4.1.13
mode
method of representing a defined character set as a bit string

4.1.14
mode indicator
four-bit identifier indicating in which mode the following data sequence is encoded

4.1.15
Padding Bit
0 bit, not representing data, used to fill empty positions of the final codeword after the Terminator in a data bit string

4.1.16
finder pattern
one of three identical components of the finder pattern in QR Code symbols

4.1.17
Remainder Bit
0 bit, not representing data, used to fill empty positions of the symbol encoding region 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

4.1.18
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

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4.1.19
segment
sequence of data encoded according to the rules of one ECI or encoding mode

4.1.20
separator
function pattern of all light modules, one module wide, separating the finder patterns from the rest of the symbol

4.1.21
symbol number
three-bit field indicating the symbol version and error correction level applied, used as part of the Format Information in Micro QR Code symbols

4.1.22
Terminator
bit pattern of defined number (depending on symbol) of all zero bits used to end the bit string representing data

4.1.23
timing pattern
alternating sequence of dark and light modules enabling module coordinates in the symbol to be determined

4.1.24
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 The error correction level applied to the symbol may be suffixed to the version designation, e.g. Version 4-L or Version M3-Q.

4.1.25
version information
encoded pattern in certain QR Code 2005 symbols containing information on the symbol version together with error correction bits for this data

4.2 Mathematical and logical symbols

Mathematical symbols used in formulae and equations are defined after the formula or equation in which they appear.

For the purposes of this document, the following mathematical operations apply.

div is the integer division operator

mod is the integer remainder after division

XOR is the exclusive-or logic function whose output is one only when its two inputs are not equivalent. It is represented by the symbol ⊕.

4.3 Abbreviations

BCH Bose-Chaudhuri-Hocquenghem

ECI Extended Channel Interpretation

RS Reed-Solomon

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4.4 Conventions

4.4.1 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. Module (0, 0) is therefore located at the upper left corner of the symbol.

4.4.2 Byte notation

Byte contents are shown as hex values.

4.4.3 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 and V (with a range of 1 to 4) and E (with values L, M and Q) have the meanings defined above.

5 Symbol description

5.1 Basic characteristics

QR Code 2005 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 6.3.4));

4) Kanji characters. Kanji characters in QR Code 2005 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) Micro QR Code symbols: 11 × 11 modules to 17 × 17 modules (Versions M1 to M4, increasing in steps of two modules per side);

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2) 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 recovery of:

— L 7%

— M 15%

— Q 25%

— H 30%

of the symbol codewords.

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 2005 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.

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5.2 Summary of additional features

The use of the following additional features is optional in QR Code 2005:

— Structured append

This allows files of data to be represented logically and continuously in up to 16 QR Code 2005 symbols. These may 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. Extended Channel Interpretations 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 International Standard 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 International Standard 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 at the top left, top right and bottom left corners of the symbol, the effect of mirror imaging is to interchange the row and column positions of the modules.

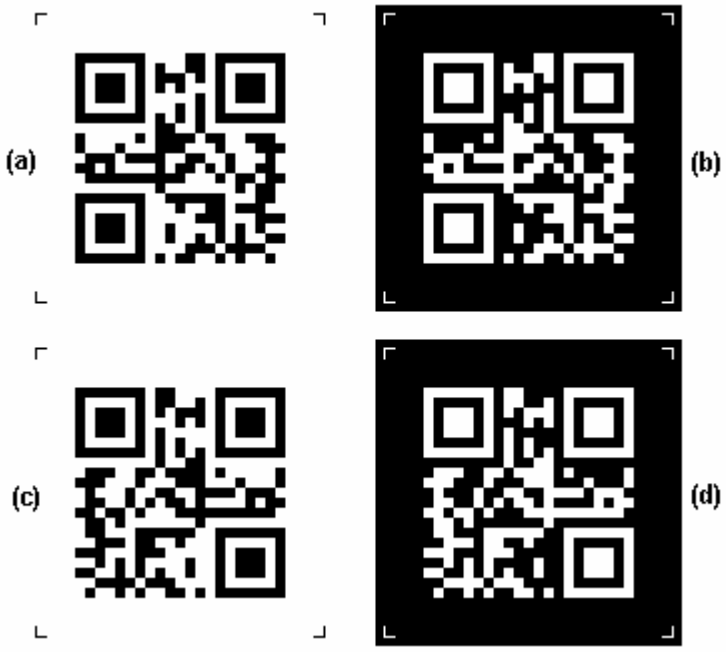

Figure 1 — Examples of QR Code 2005 symbol encoding the text "QR Code Symbol" – (a) normal orientation and normal reflectance arrangement; (b) normal orientation and reversed reflectances; (c) mirror image orientation and normal reflectance arrangement; (d) mirror image orientation and reversed reflectances

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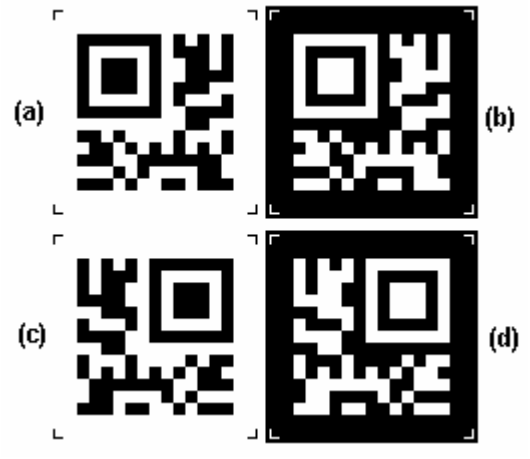

Figure 2 — Examples of Version M2 Micro QR Code symbol encoding the text "01234567" – (a) normal orientation and normal reflectance arrangement; (b) normal orientation and reversed reflectances; (c) mirror image orientation and normal reflectance arrangement; (d) mirror image orientation and reversed reflectances

NOTE The corner marks in Figures 1 and 2 indicate the extent of the quiet zone.

5.3 Symbol structure

Each QR Code 2005 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.

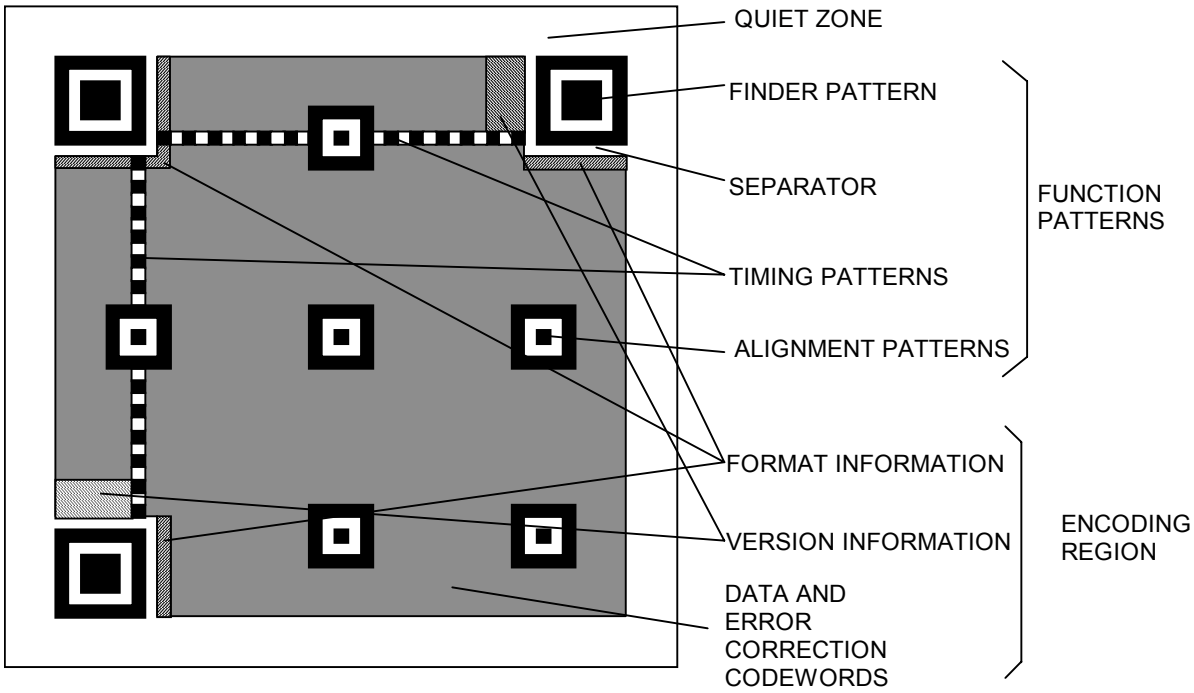

Figure 3 — Structure of a QR Code 2005 symbol

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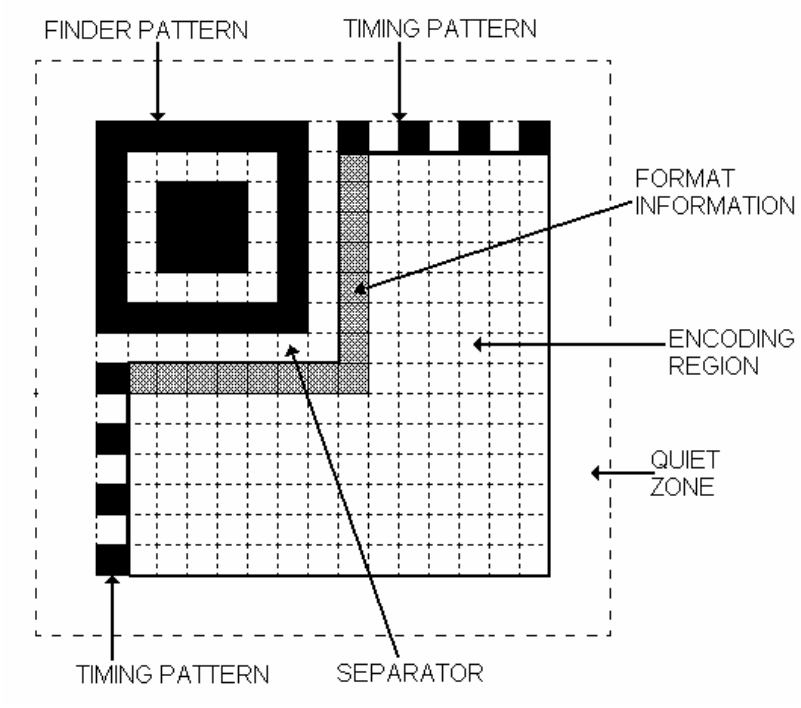

Figure 4 — Structure of Version M3 Micro QR Code symbol

5.3.1 Symbol Versions and sizes

5.3.1.1 QR Code symbols

There are forty sizes of QR Code 2005 symbol referred to as Version 1, Version 2 ... Version 40. Version 1 measures 21 modules × 21 modules, Version 2 measures 25 modules × 25 modules and so on increasing in steps of 4 modules per side up to Version 40 which measures 177 modules × 177 modules. Figures 5 to 10 illustrate the structure of Versions 1, 2, 6, 7, 14, 21 and 40.

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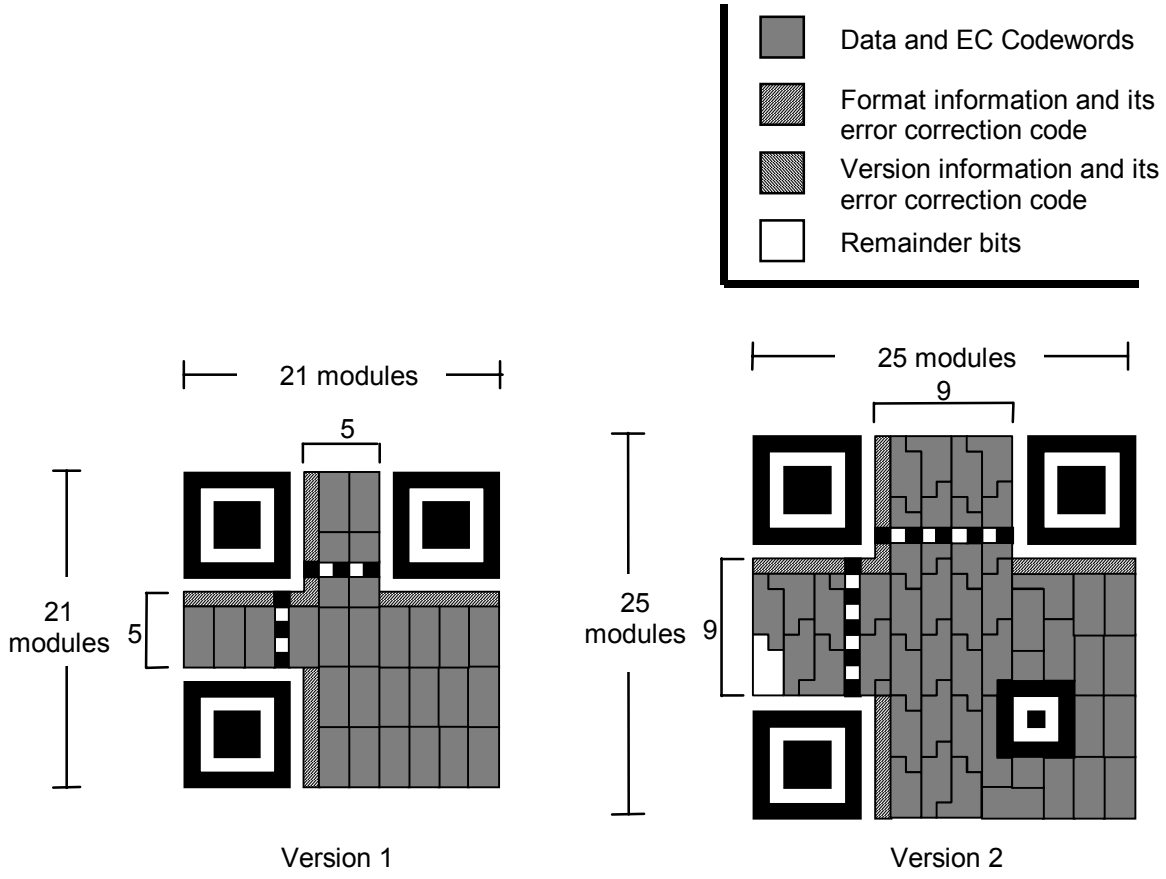

Figure 5 — Version 1 and 2 symbols

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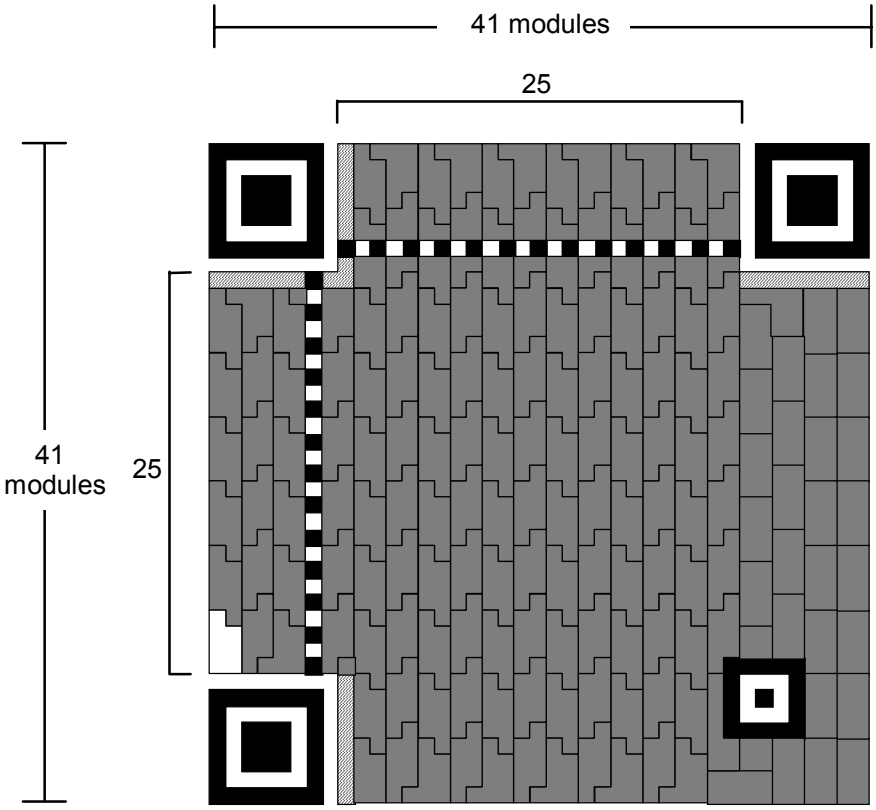

Version 6

Figure 6 — Version 6 symbol

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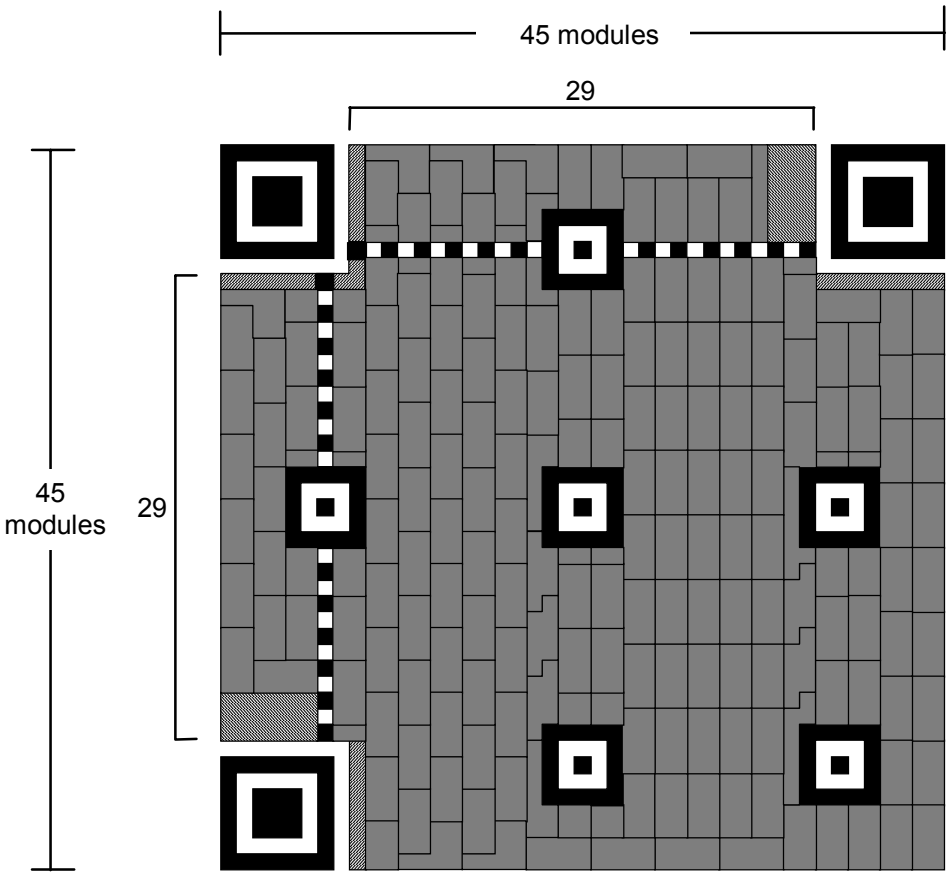

Version 7

Figure 7 — Version 7 symbol

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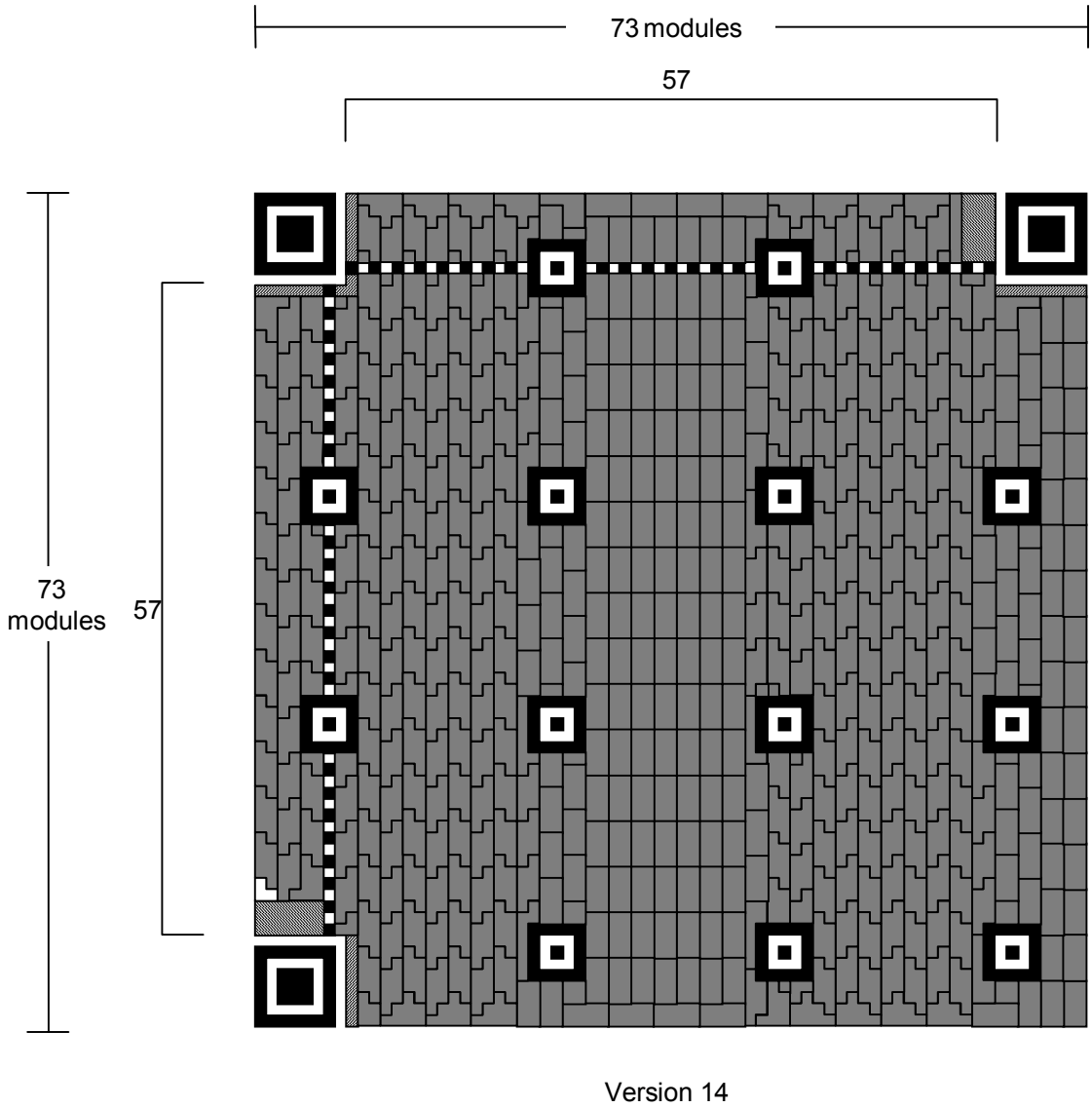

Figure 8 — Version 14 symbol

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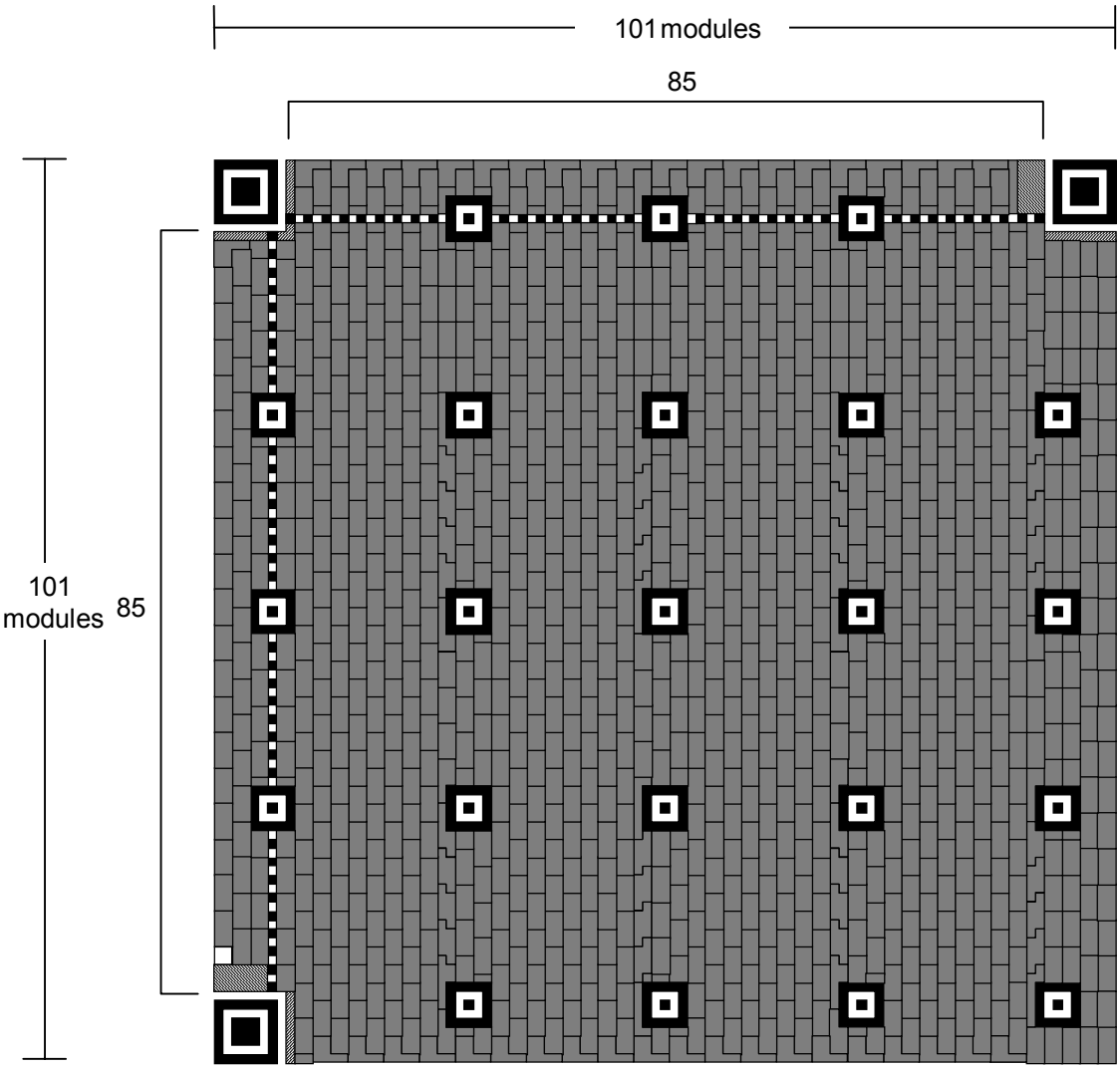

Version 21

Figure 9 — Version 21 symbol

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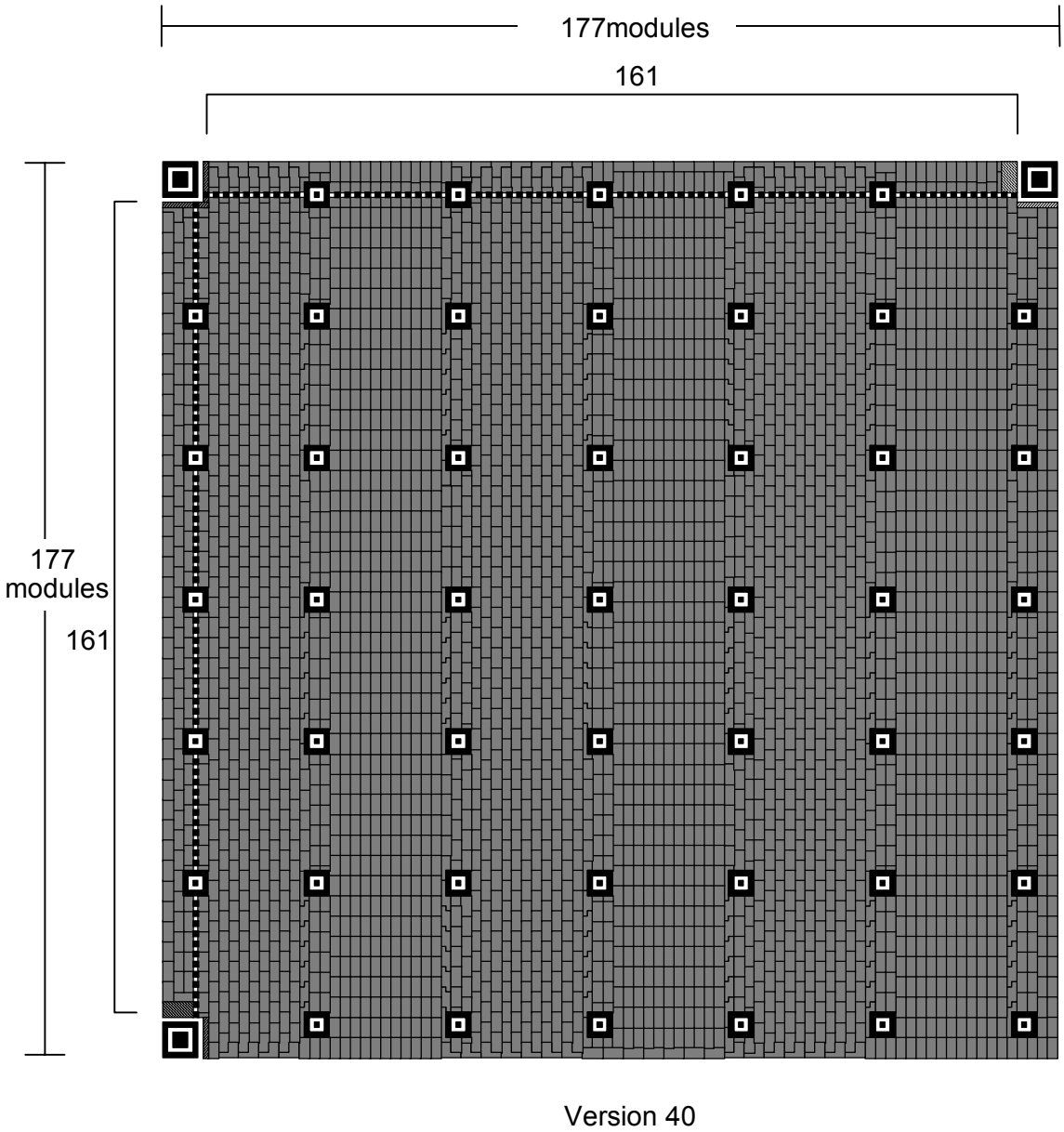

Figure 10 — Version 40 symbol

5.3.1.2 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 13 × 13 modules, Version M3 15 × 15 modules, and Version M4 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.

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

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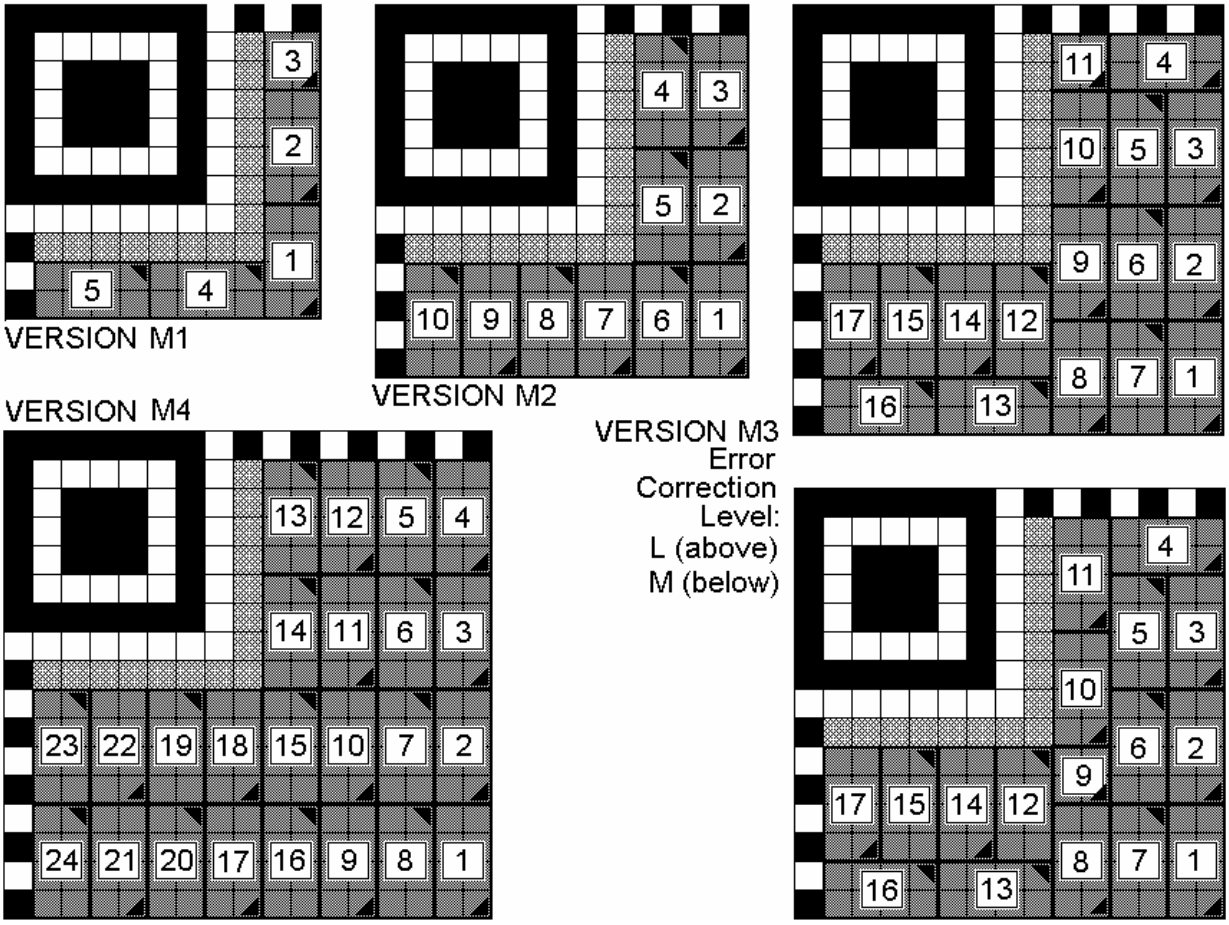

Figure 11 — Versions of Micro QR Code symbol

5.3.2 Finder pattern

5.3.2.1 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 dark 7 × 7 modules, light 5 × 5 modules and dark 3 × 3 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 2005 symbol in the field of view. Identification of the three finder patterns comprising the Finder Pattern then unambiguously defines the location and rotational orientation of the symbol in the field of view.

5.3.2.2 Micro QR Code symbols

A single finder pattern, as defined in 5.3.2.1, 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.

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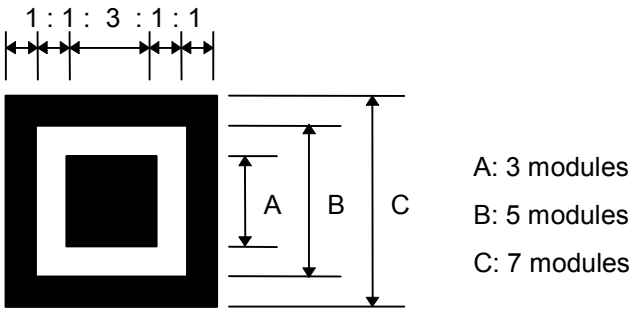

Figure 12 — Structure of finder pattern

5.3.3 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.

5.3.4 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.

5.3.5 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 dark 5×5 modules, light 3×3 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.

5.3.6 Encoding region

This region shall contain the symbol characters representing data, those representing error correction codewords, the format information and, where appropriate, the version information. Refer to 6.7.1 for details of the symbol characters. Refer to 6.9 for details of the format information. Refer to 6.10 for details of the version information.

5.3.7 Quiet zone

This is a 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.

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6 Requirements

6.1 Encode procedure overview

This section provides an overview of the steps required to convert input data to a QR Code 2005 symbol.

Step 1 Data analysis

Analyze 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 Extended Channel Interpretation feature, enabling data differing from the default character set to be encoded. QR Code 2005 includes several modes (see 6.3) 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.

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 6.4.2 to 6.4.6, 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.

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.

Step 4 Structure final message

Interleave the data and error correction codewords from each block as described in 6.6 (step 3) and add remainder bits as necessary.

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.

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.

Step 7 Format and version information

Generate the format information and (where applicable) the version information and complete the symbol.

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Table 1 — Codeword capacity of all versions of QR Code 2005

Version	No. of Modules/ side (A)	Function pattern modules (B)	Format and version information modules (C)	Data modules except (C) ($D=A^2-B-C$)	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
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

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6.2 Data analysis

Analyze 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 6.4. 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, e.g. numeric sequences followed by alphanumeric sequences. It is in theory 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 may not always result in the shortest overall bit stream to change modes for a small number of characters. Also, because the capacity of symbols increases in discrete steps from one version to the next, it may not always be 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 in the smaller versions. Annex J.2 shows the Micro QR Code symbol versions appropriate for various combinations of two modes.

6.3 Modes

The modes defined below 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, 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.

6.3.1 Extended Channel Interpretation (ECI) mode

The Extended Channel Interpretation (ECI) protocol defined in the AIM Inc. International Technical Specification *Extended Channel Interpretations*, allows the output data stream to have interpretations different from that of the default character set. The ECI protocol is defined consistently across a number of 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 2005 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 and Shift JIS character sets is ECI **000020**.

The effect of ECI mode is to insert 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.

6.3.2 Numeric mode

Numeric mode encodes data from the decimal digit set (**0 - 9**) (byte values 30_{HEX} to 39_{HEX}). Normally, 3 data characters are represented by 10 bits.

6.3.3 Alphanumeric mode

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.

Alphanumeric mode is not available in Version M1 Micro QR Code symbols.

6.3.4 Byte mode

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

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In closed-system national or application-specific implementations of QR Code 2005, an alternative 8-bit character set, for example as defined in an appropriate part of ISO/IEC 8859, may be specified for Byte mode. When an alternative character set is specified, however, the parties intending to read the QR Code 2005 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.

6.3.5 Kanji mode

The Kanji mode efficiently encodes Kanji characters in accordance with 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 81_{HEX} to $9F_{HEX}$ and/or $E0_{HEX}$ to EB_{HEX}, it may not be 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 may 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 81_{HEX} to $9F_{HEX}$ and/or $E0_{HEX}$ to EB_{HEX} 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.

Kanji mode is not available in version M1 or M2 Micro QR Code symbols.

6.3.6 Mixing modes

The QR Code 2005 symbol may contain sequences of data in a combination of any of the modes described in 6.3.1 to 6.3.8. 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 6.3.2 to 6.3.6.

Refer to Annex J for guidance on selecting the most efficient way of representing a given input data string in multiple modes in QR Code symbols, and to Annex J.3 for the available versions of Micro QR Code symbols for given combinations of data in two modes.

6.3.7 Structured Append mode

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 7 for details of encoding in Structured Append mode.

Structured Append mode is not available for Micro QR Code symbols.

6.3.8 FNC1 mode

FNC1 mode is used for messages containing specific data formats. In the "1st position" it designates data formatted in accordance with the GS1 General Specifications. In the "2nd position" it designates data formatted in accordance with a specific industry application previously agreed with AIM Inc. FNC1 mode applies to the entire symbol and is not affected by subsequent mode indicators.

NOTE "1st position" and 2nd 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.

FNC1 mode is not available for Micro QR Code symbols.

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6.4 Data encoding

6.4.1 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:

- ECI mode indicator (4 bits)
- ECI Designator (8, 16 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:

- Mode indicator
- Character count indicator
- 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 defined in sections 6.4.2 to 6.4.7 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 2005

Mode	**QR Code symbols**	**Micro QR Code symbols**			
Version	**all**	**M1**	**M2**	**M3**	**M4**
Mode indicator length (bits)	**4**	**0**	**1**	**2**	**3**
ECI	**0111**	n/a	n/a	n/a	n/a
Numeric	**0001**	n/a	**0**	**00**	**000**
Alphanumeric	**0010**	n/a	**1**	**01**	**001**
Byte	**0100**	n/a	n/a	**10**	**010**
Kanji	**1000**	n/a	n/a	**11**	**011**
Structured Append	**0011**	n/a	n/a	n/a	n/a
FNC1	**0101** (1st position) **1001** (2nd position)	n/a	n/a	n/a	n/a
Terminator (End of Message) [a]	**0000**	**000**	**00000**	**0000000**	**000000000**

[a] The Terminator is not a mode indicator as such

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Table 3 — Number of bits in character count indicator for QR Code 2005

Version	Numeric mode	Alphanumeric mode	byte mode	Kanji mode
M1	**3**	n/a	n/a	n/a
M2	**4**	**3**	n/a	n/a
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**

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 4 bits. The Terminator is not a mode indicator as such.

6.4.2 Extended Channel Interpretation (ECI) mode

This mode, used for encoding data subject to alternative interpretations of byte values (e.g. alternative character sets) in accordance with the AIM ECI specification which defines the pre-processing of this type of data, is invoked by the use of mode indicator **0111.**

The Extended Channel Interpretation 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} could be encoded in Numeric mode (see 6.4.3) as though it were a sequence of digits 0 – 9 even though it might not actually 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.

6.4.2.1 ECI Designator

Each Extended Channel Interpretation is designated by a six-digit assignment number which is encoded in the QR Code 2005 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 six 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.

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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 ECI Assignment Number

ECI Assignment Value	No. of Codewords	Codeword values
000000 to 000127	1	**0**bbbbbbb
000000 to 016383	2	**10**bbbbbb bbbbbbbb
000000 to 999999	3	**110**bbbbb bbbbbbbb bbbbbbbb
		where b ... b is the binary value of the ECI Assignment number

Example

Assume data to be encoded is in Greek, using character set ISO/IEC 8859-7 (ECI 000009) 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 13.3 for example of transmission of this data following decoding.

6.4.2.2 Multiple ECIs

Refer to the AIM ECI specification for the rules 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 may 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 2005 symbol in accordance with 6.4.2.1 and shall commence a new mode segment.

6.4.2.3 ECIs and Structured Append

Any ECI(s) invoked shall apply subject to the rules defined above and in the AIM ECI specification 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 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.

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6.4.3 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 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 Version 1-H symbol)

Input data: **01234567**

1. Divide into groups of three digits: **012 345 67**

2. Convert each group to its binary equivalent: **012 → 0000001100**

345 → 0101011001

67 → 1000011

3. Connect the binary data in sequence: **0000001100 0101011001 1000011**

4. Convert character count indicator to binary (10 bits for version 1-H):

No. of input data characters: **8 → 0000001000**

5. Add mode indicator **0001** and character count indicator to binary data:

0001 0000001000 0000001100 0101011001 1000011

EXAMPLE 2 (for Micro QR Code version M3-M symbol)

Input data: **0123456789012345**

1. Divide into groups of three digits: **012 345 678 901 234 5**

2. Convert each group to its binary equivalent: **012 = 0000001100**

345 = 0101011001

678 = 1010100110

901 = 1110000101

234 = 0011101010

5 = 0101

3. Connect the binary data in sequence:

0000001100 0101011001 1010100110 1110000101 0011101010 0101

4. Convert character count indicator to binary (5 bits for version M3-M):

No. of input data characters: **16 = 10000**

5. Add mode indicator (**00** for version M3-M) and character count indicator to binary data:

00 10000 0000001100 0101011001 1010100110 1110000101 0011101010 0101

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

$$B = M + C + 10(D \text{ DIV } 3) + R$$

where:

B = number of bits in bit stream

M = number of bits in mode indicator (4 for QR Code symbols, or as shown in Table 2 for Micro QR Code symbols)

C = number of bits in character count indicator (from Table 3)

D = number of input data characters

$R = 0$ if (D MOD 3) = 0

$R = 4$ if (D MOD 3) = 1

$R = 7$ if (D MOD 3) = 2

6.4.4 Alphanumeric mode

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

Table 5 — Encoding/decoding table for 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 symbols the **FNC1** character may occur in the data. It is represented in Alphanumeric mode by the character **%**. Refer to 6.4.8.1, 6.4.8.2 and 13.4 for details of the encoding and transmission of **FNC1** and **%**.

EXAMPLE (for Version 1-H symbol)

Input data: **AC-42**

1. Determine character values according to Table 5. **AC-42 → (10,12,41,4,2)**

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2. Divide the result into groups of two decimal values: **(10,12) (41,4) (2)**

3. Convert each group to its 11-bit binary equivalent: **(10,12) 10*45+12 → 462 → 00111001110**

   (41,4) 41*45+4 → 1849 → 11100111001

   (2) → 2 → 000010

4. Connect the binary data in sequence: **00111001110 11100111001 000010**

5. Convert character count indicator to binary (9 bits for version 1-H):

   No. of input data characters: **5 → 000000101**

6. Add mode indicator **0010** and character count indicator 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 following formula:

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

where:

B = number of bits in bit stream

M = number of bits in mode indicator (4 for QR Code symbols, or as shown in Table 2 for Micro QR Code symbols)

C = number of bits in character count indicator (from Table 3)

D = number of input data characters

6.4.5 Byte mode

In this mode, one 8-bit codeword directly represents the byte value of the input data character, i.e. a density of 8 bits/character.

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Table 6 — Encoding/decoding table for ISO/IEC 8859-1 character set

Byte	Char.	Byte	Char.	Byte	Char.	Byte	Char.	Byte	Char.	Byte	Char.	Byte	Char.	Byte	Char.
0	NUL	32	space	64	@	96	`	128		160	NBSP	192	À	224	à
1	SOH	33	!	65	A	97	a	129		161	¡	193	Á	225	á
2	STX	34	"	66	B	98	b	130		162	¢	194	Â	226	â
3	ETX	35	#	67	C	99	c	131		163	£	195	Ã	227	ã
4	EOT	36	$	68	D	100	d	132		164	¤	196	Ä	228	ä
5	ENQ	37	%	69	E	101	e	133		165	¥	197	Å	229	å
6	ACK	38	&	70	F	102	f	134		166	¦	198	Æ	230	æ
7	BEL	39	'	71	G	103	g	135		167	§	199	Ç	231	ç
8	BS	40	(	72	H	104	h	136		168	¨	200	È	232	è
9	HT	41	)	73	I	105	I	137		169	©	201	É	233	é
10	LF	42	*	74	J	106	j	138		170	ª	202	Ê	234	ê
11	VT	43	+	75	K	107	k	139		171	«	203	Ë	235	ë
12	FF	44	,	76	L	108	l	140		172	¬	204	Ì	236	ì
13	CR	45	-	77	M	109	m	141		173	SHY	205	Í	237	í
14	SO	46	.	78	N	110	n	142		174	®	206	Î	238	î
15	SI	47	/	79	O	111	o	143		175	¯	207	Ï	239	ï
16	DLE	48	0	80	P	112	p	144		176	°	208	Ð	240	ð
17	DC1	49	1	81	Q	113	q	145		177	±	209	Ñ	241	ñ
18	DC2	50	2	82	R	114	r	146		178	²	210	Ò	242	ò
19	DC3	51	3	83	S	115	s	147		179	³	211	Ó	243	ó
20	DC4	52	4	84	T	116	t	148		180	´	212	Ô	244	ô
21	NAK	53	5	85	U	117	u	149		181	µ	213	Õ	245	õ
22	SYN	54	6	86	V	118	v	150		182	¶	214	Ö	246	ö
23	ETB	55	7	87	W	119	w	151		183	·	215	×	247	÷
24	CAN	56	8	88	X	120	x	152		184	¸	216	Ø	248	ø
25	EM	57	9	89	Y	121	y	153		185	¹	217	Ù	249	ù
26	SUB	58	:	90	Z	122	z	154		186	º	218	Ú	250	ú
27	ESC	59	;	91	[	123	{	155		187	»	219	Û	251	û
28	FS	60	<	92	\	124	|	156		188	¼	220	Ü	252	ü
29	GS	61	=	93	]	125	}	157		189	½	221	Ý	253	ý
30	RS	62	>	94	^	126	~	158		190	¾	222	Þ	254	þ
31	US	63	?	95	_	127	DEL	159		191	¿	223	ß	255	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 Table H.2) and may be used to distinguish between the JIS8 and Shift JIS character sets, or to enable Kanji mode compaction to be carried out. JIS X 0208 gives details of the shift coded representation.

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