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Information technology — Automatic identification and data capture techniques — Bar code symbology — QR Code

Technologies de l'information — Techniques d'identification automatique et de capture de données — Symboles de codes à barres — Code QR

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. 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 International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 18004 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*, in collaboration with AIM Inc.[1].

Annexes A to F form a normative part of this International Standard. Annexes G to M are for information only.

1) AIM Inc., 634 Alpha Drive, Pittsburgh, PA 15238-2802, U.S.A.

Introduction

QR Code is a matrix symbology consisting 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 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 1 is the original specification for QR Code; QR Code Model 2 is an enhanced form of the symbology with additional features and can be auto-discriminated from Model 1. Since Model 2 is the recommended model for new, open systems application of QR Code, this International Standard describes Model 2 fully, and specifies the features in which Model 1 QR Code differs from Model 2 in an annex.

Information technology — Automatic identification and data capture techniques — Bar code symbology — QR Code

1 Scope

This International Standard specifies the requirements for the symbology known as QR Code. It specifies the QR Code Model 2 symbology characteristics, data character encodation, symbol formats, dimensional characteristics, error correction rules, reference decoding algorithm, production quality requirements, and user-selectable application parameters, and defines in an annex the features of Model 1 symbols which differ from Model 2.

2 Conformance

QR Code symbols (and equipment designed to produce or read QR Code symbols) shall be considered as meeting this specification if they meet the requirements defined for either QR Code Model 2 or Model 1. It should be noted, however, that Model 2 is the form of the symbology recommended for new and open systems applications.

3 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC 15424, *Information technology — Automatic identification and data capture techniques — Data carrier/symbology identifiers.*

ISO/IEC 15416, *Information technology — Automatic identification and data capture techniques — Bar code print quality test specifications — Linear symbols.*

EN 1556, *Bar Coding — Terminology.*

JIS X 0201, *JIS 8-bit Character Set for Information Interchange.*

JIS X 0208-1997, *Japanese Graphic Character Set for Information Interchange.*

ANSI X3.4, *Coded Character Sets — 7-bit American National Standard Code for Information Interchange (7-bit ASCII).*

AIM International Technical Specification, *Extended Channel Interpretations: Part 1: Identification scheme and protocol* (referred to as "AIM ECI specification").

4 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in EN 1556 and the following apply.

4.1
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

4.2
Character Count Indicator
bit sequence which defines the data string length in a mode

4.3
ECI designator
six-digit number identifying a specific ECI assignment

4.4
encoding region
region of the symbol not occupied by function patterns and available for encodation of data and error correction codewords

4.5
Extended Channel Interpretation (ECI)
protocol used in some symbologies that allows the output data stream to have interpretations different from that of the default character set

4.6
Extension Pattern
in Model 1 symbols, a function pattern which does not encode data

4.7
Format Information
function pattern containing information on the error correction level applied to the symbol and on the masking pattern used, essential to enable the remainder of the encoding region to be decoded

4.8
function pattern
overhead component of the symbol required for location of the symbol or identification of its characteristics to assist in decoding

4.9
Mask Pattern Reference
three-bit identifier of the masking patterns applied to the symbol

4.10
masking
process of XORing the bit pattern in the encoding region with a masking 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

4.11
mode
method of representing a defined character set as a bit string

4.12
Mode Indicator
four-bit identifier indicating in which mode the next data sequence is encoded

4.13
Padding Bit
0 bit, not representing data, used to fill empty positions of the final codeword after the Terminator in a data bit string

4.14
Position Detection Pattern
one of three identical components of the Finder Pattern

4.15
Remainder Bit
0 bit, not representing data, used to fill empty positions of the symbol encoding region after the final symbol character, where the encoding region does not divide exactly into eight-bit symbol characters

4.16
Remainder Codeword
Pad Codeword 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

NOTE The Remainder codewords come after the error correction codewords.

4.17
segment
sequence of data encoded according to the rules of one ECI or encodation mode

4.18
Separator
function pattern of all light modules, one module wide, separating the Position Detection Patterns from the rest of the symbol

4.19
Terminator
bit pattern 0000 used to end the bit string representing data

4.20
Timing Pattern
alternating sequence of dark and light modules enabling module coordinates in the symbol to be determined

4.21
Version
size of the symbol represented in terms of its position in the sequence of permissible sizes from 21 × 21 modules (Version 1) to 177 × 177 (Version 40) modules

NOTE May also indicate the error correction level applied to the symbol.

4.22
Version Information
in Model 2 symbols, a function pattern containing information on the symbol version together with error correction bits for this data

5 Symbols (and abbreviated terms)

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

For the purposes of this specification, the mathematical operations which follow shall 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 ⊕.

6 Conventions

6.1 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.

6.2 Byte notation

Byte contents are shown as hexadecimal values.

6.3 Version references

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

7 Symbol description

The clauses and subclauses of this International Standard define the specifications applicable to Model 2 QR Code symbols. Unless indicated otherwise in Annex M they also apply to Model 1 symbols.

7.1 Basic characteristics

QR Code is a matrix symbology with the following characteristics:

a) 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) 8-bit byte data (JIS 8-bit character set (Latin and Kana) in accordance with JIS X 0201);

4) Kanji characters (Shift JIS character set in accordance with JIS X 0208 Annex 1 Shift Coded Representation. Note that Kanji characters in QR Code can have values 8140_{HEX} -$9FFC_{HEX}$ and $E040_{HEX}$ - $EBBF_{HEX}$, which can be compacted into 13 bits.)

b) Representation of data:

A dark module is a binary one and a light module is a binary zero.

c) Symbol size (not including quiet zone):

21 × 21 modules to 177 × 177 modules (Versions 1 to 40, increasing in steps of 4 modules per side)

d) Data characters per symbol (for maximum symbol size – Version 40-L):

   1) numeric data: 7 089 characters

   2) alphanumeric data: 4 296 characters

   3) 8-bit byte data: 2 953 characters

   4) Kanji data: 1 817 characters

e) Selectable error correction:

   Four levels of error correction allowing recovery of:

   L 7%

   M 15%

   Q 25%

   H 30%

   of the symbol codewords.

f) Code type:

   Matrix

g) Orientation independence:

   Yes

Figure 1 illustrates a Version 1 QR Code symbol.

Figure 1 — Example of QR Code symbol

7.2 Summary of additional features

The following additional features are either inherent or optional in QR Code:

a) *Structured append (optional)*

   This allows files of data to be represented logically and continuously in up to 16 QR Code symbols. These may be scanned in any sequence to enable the original data to be correctly reconstructed.

b) *Masking (inherent)*

This enables the ratio of dark to light modules in the symbol to be approximated to 1:1 whilst minimizing the occurrence of arrangements of adjoining modules which would impede efficient decoding.

c) *Extended Channel Interpretations (optional)*

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.

7.3 Symbol structure

Each QR Code symbol shall be constructed of nominally square modules set out in a regular square array and shall consist of a encoding region and function patterns, namely finder, separator, timing patterns, and alignment patterns. Function patterns shall not be used for the encodation of data. The symbol shall be surrounded on all four sides by a quiet zone border. Figure 2 illustrates the structure of a Version 7 QR Code symbol.

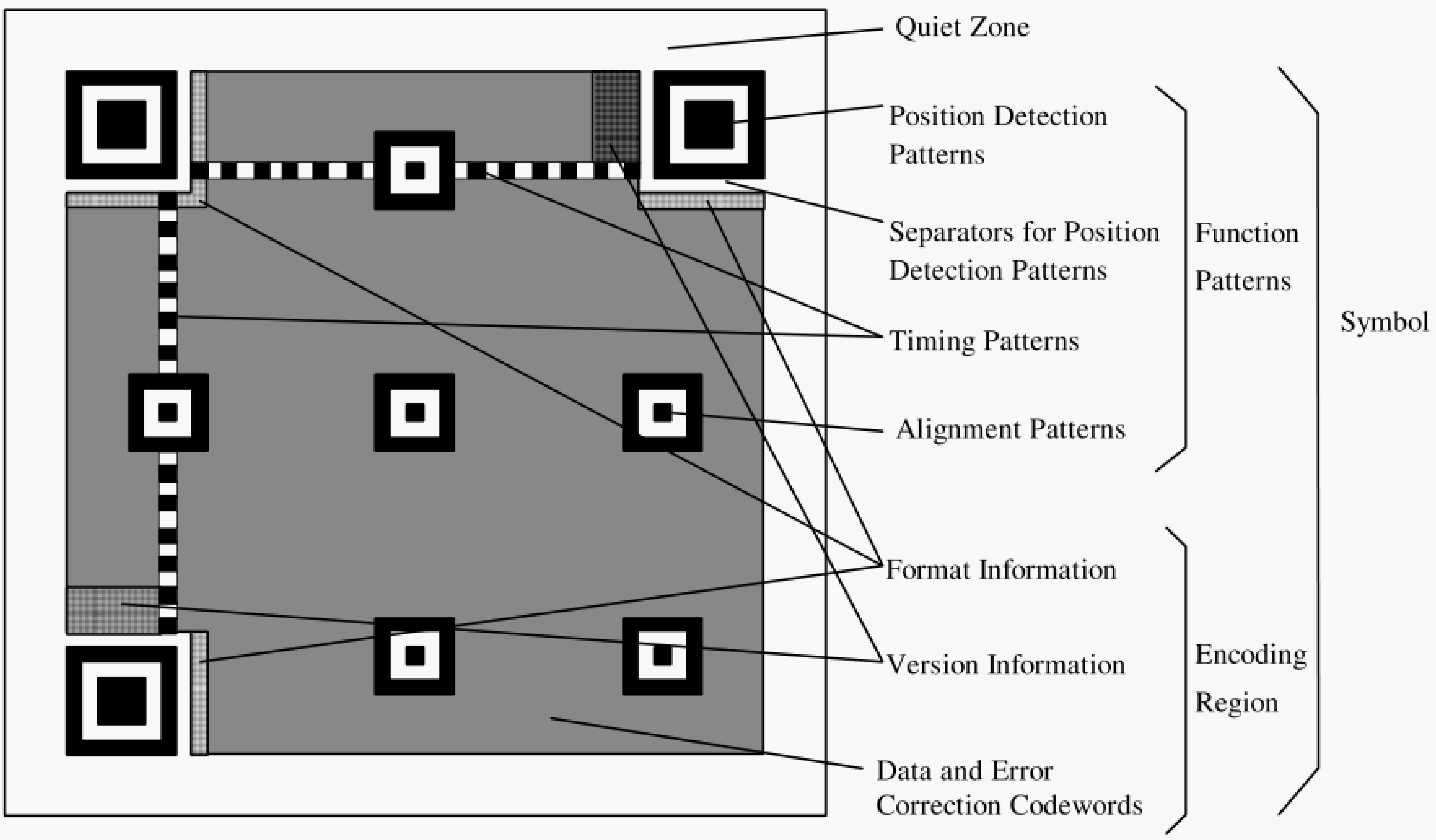

Figure 2 — Structure of a QR Code symbol

7.3.1 Symbol Versions and sizes

There are forty sizes of QR Code 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 3 to 8 illustrate the structure of Versions 1, 2, 6, 7, 14, 21 and 40.

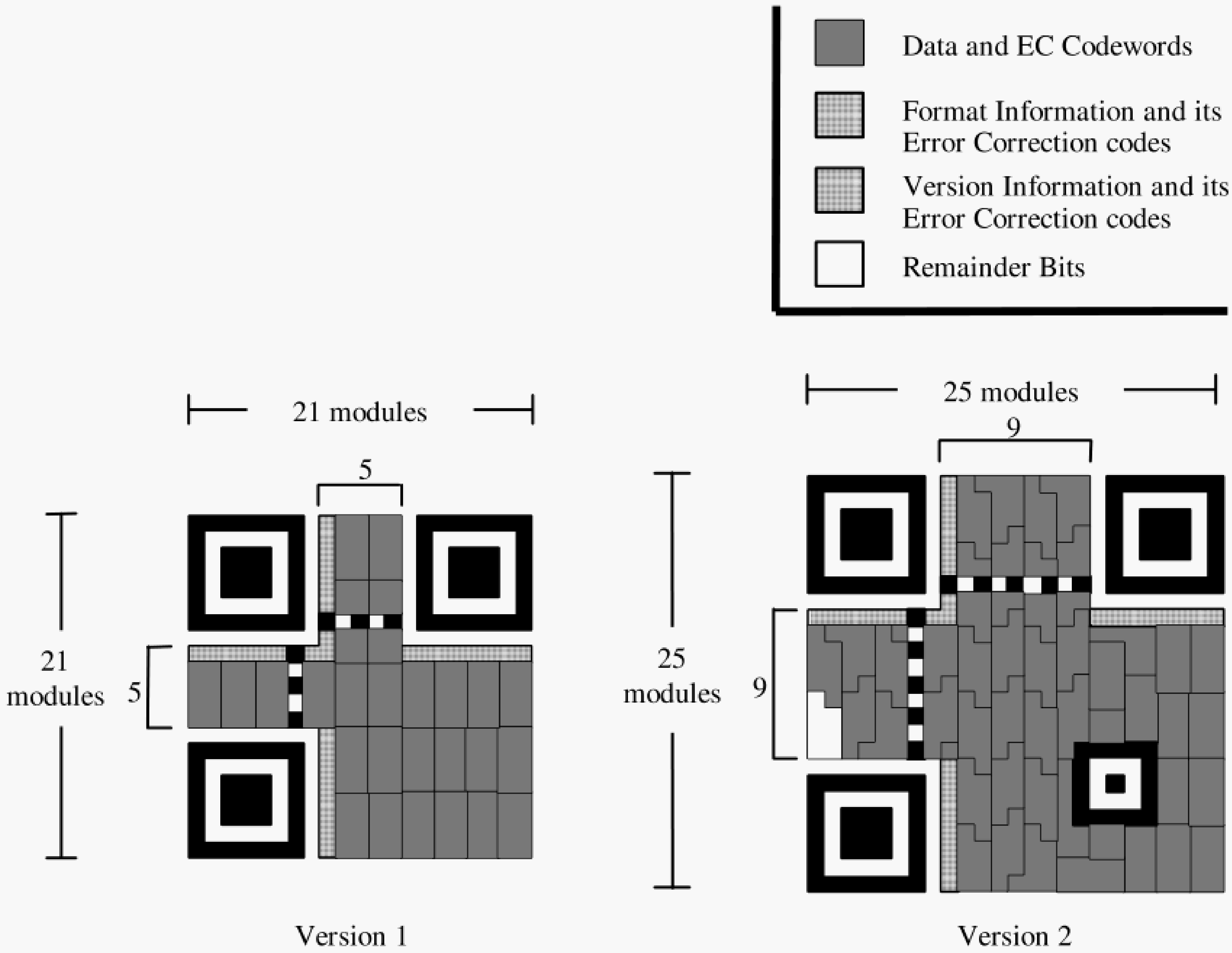

Figure 3 — Version 1 and 2 symbols

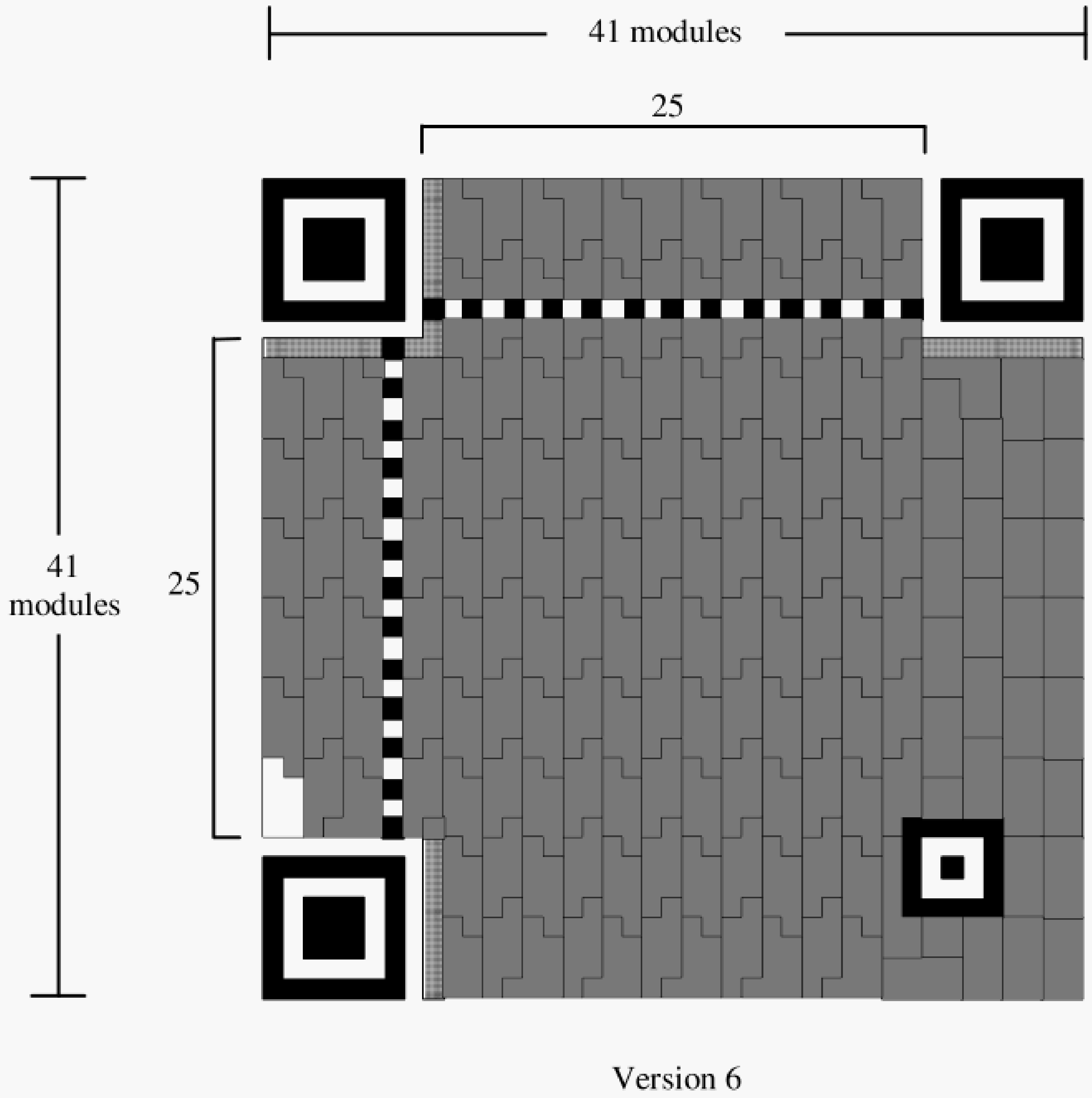

Figure 4 — Version 6 symbol

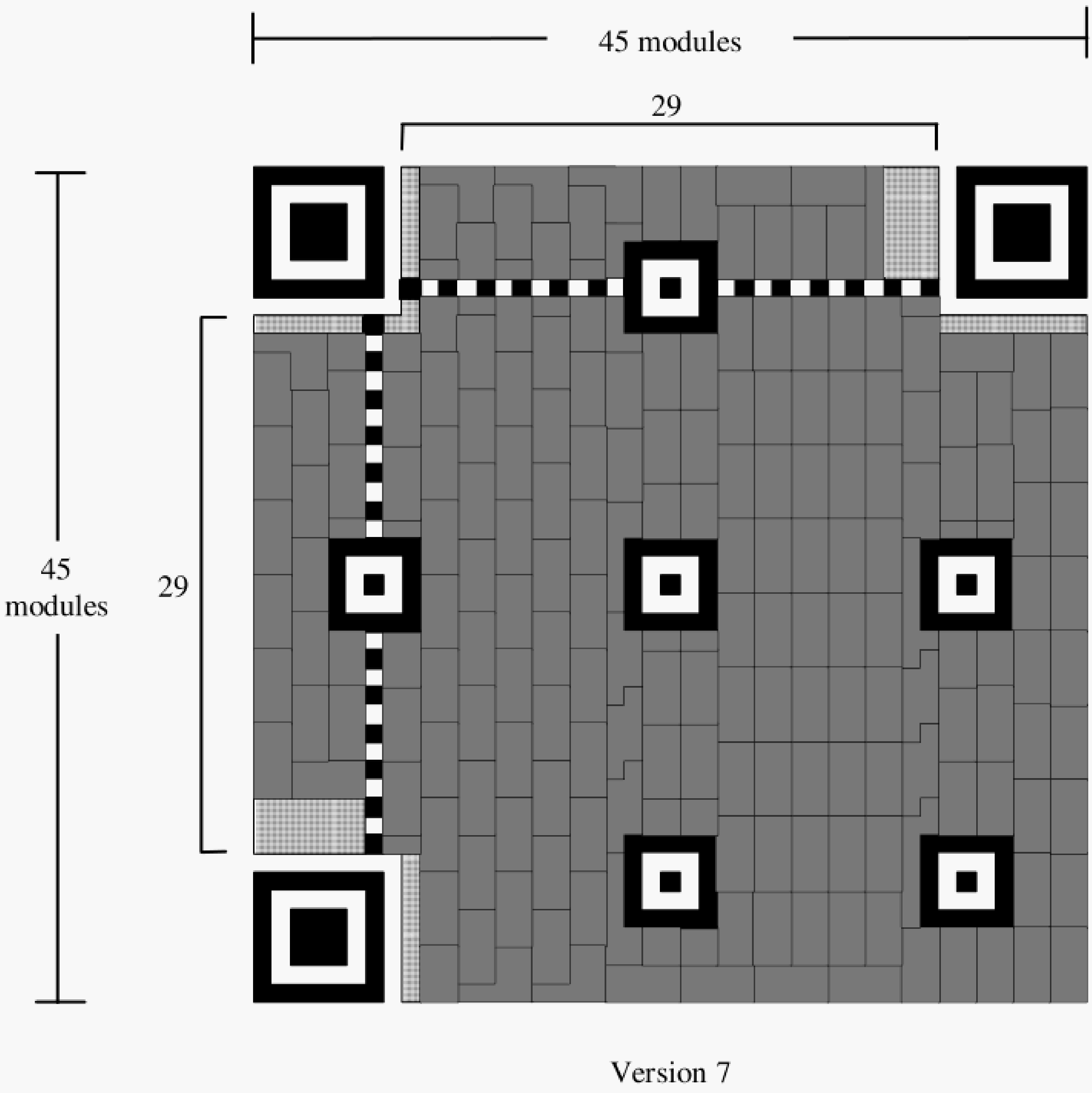

Figure 5 — Version 7 symbol

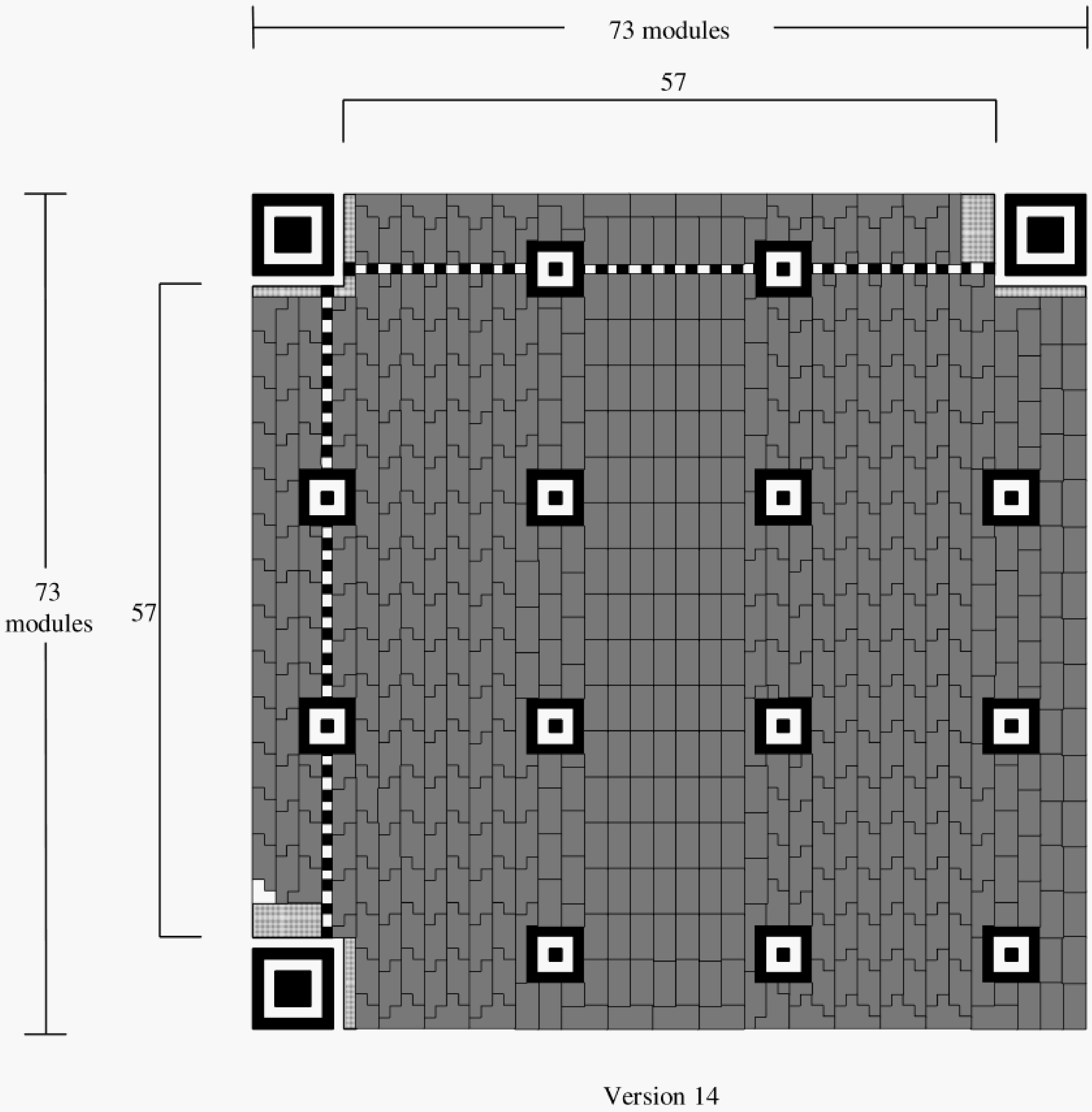

Figure 6 — Version 14 symbol

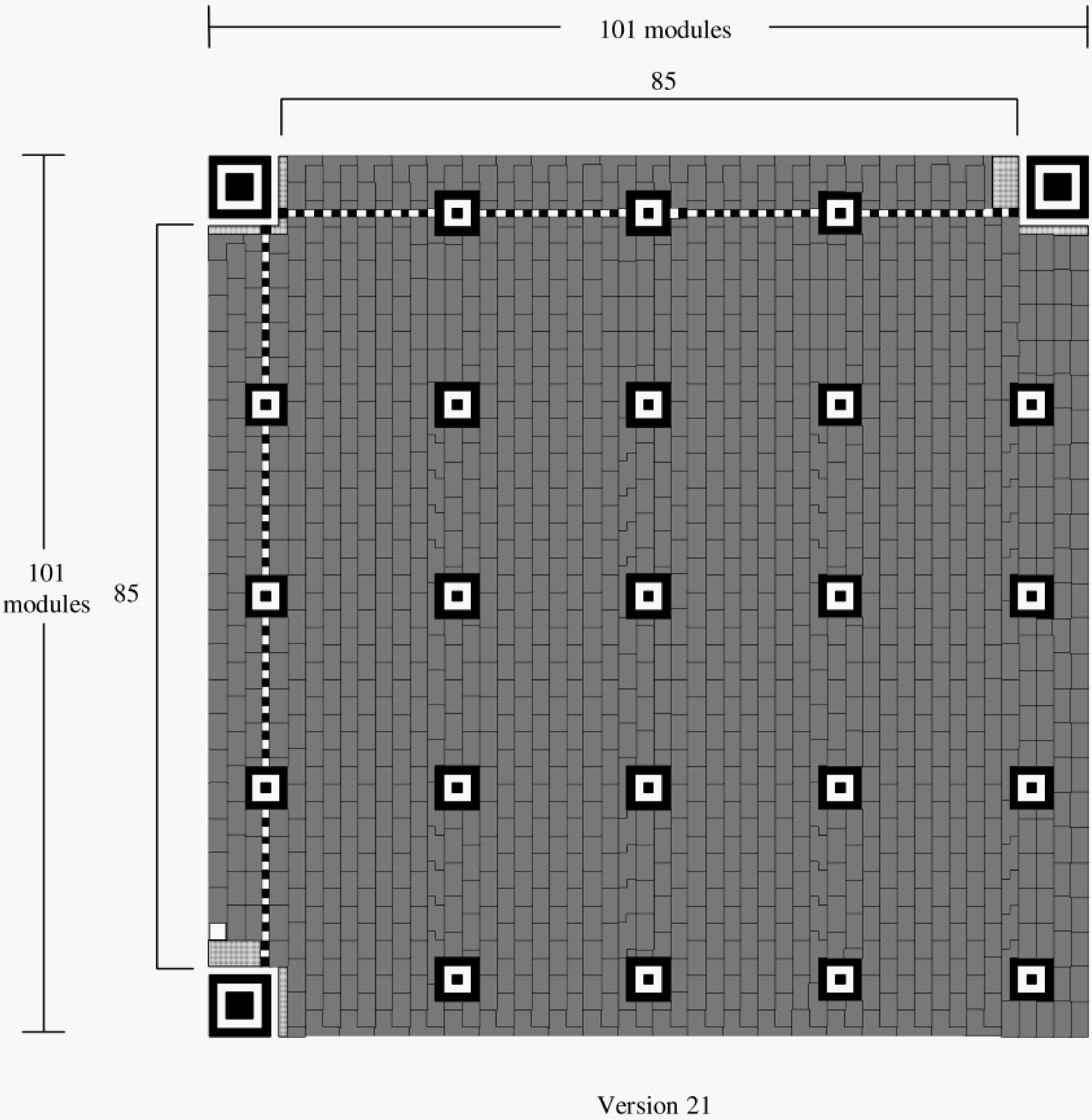

Figure 7 — Version 21 symbol

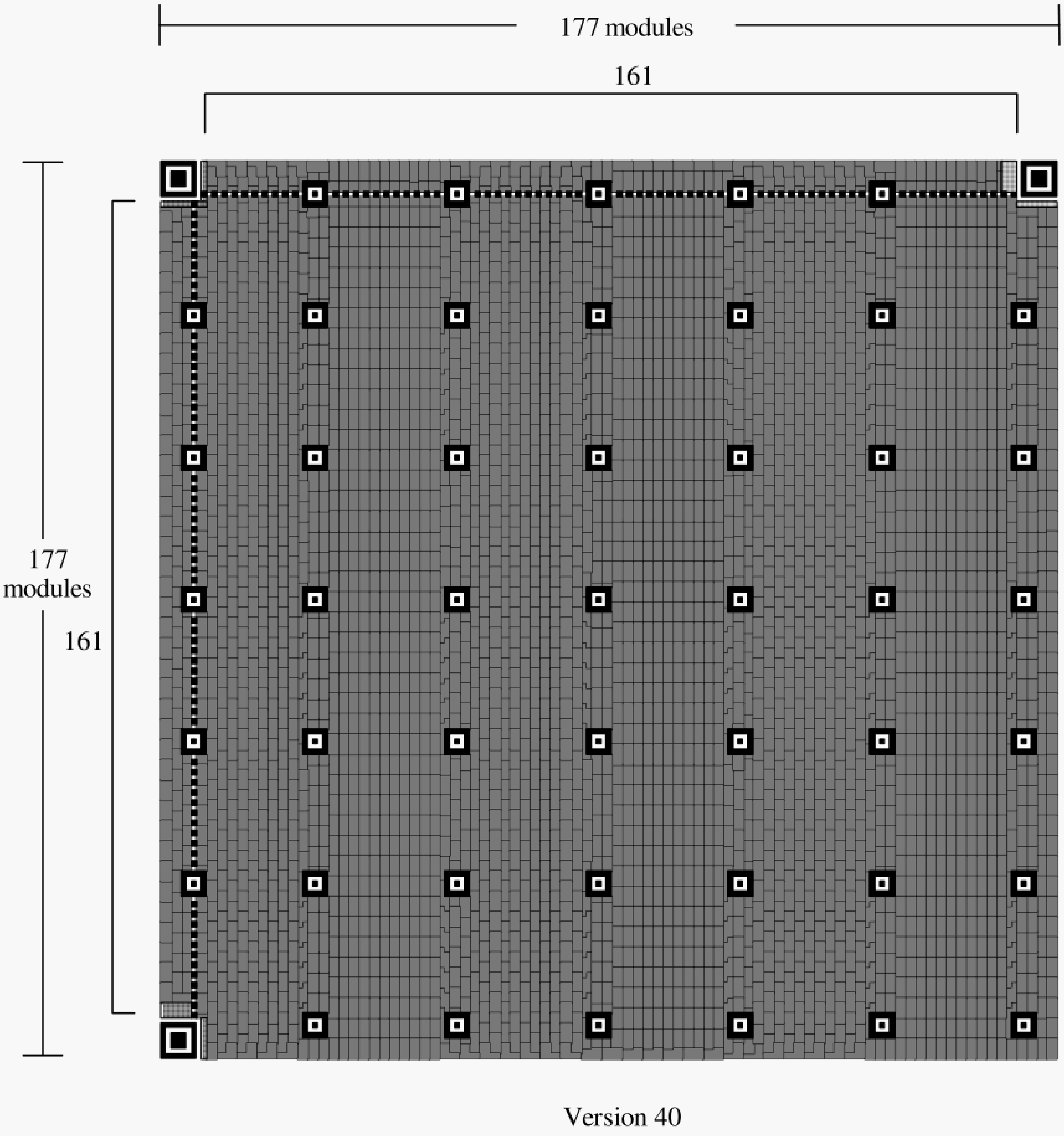

Figure 8 — Version 40 symbol

7.3.2 Finder pattern

The finder pattern shall consist of three identical Position Detection Patterns located at the upper left, upper right and lower left corners of the symbol respectively as illustrated in Figure 2. Each Position Detection 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 Position Detection Pattern is 1:1:3:1:1 as illustrated in Figure 9. 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. Identification of the three Position Detection Patterns comprising the finder pattern then unambiguously defines the location and orientation of the symbol in the field of view.

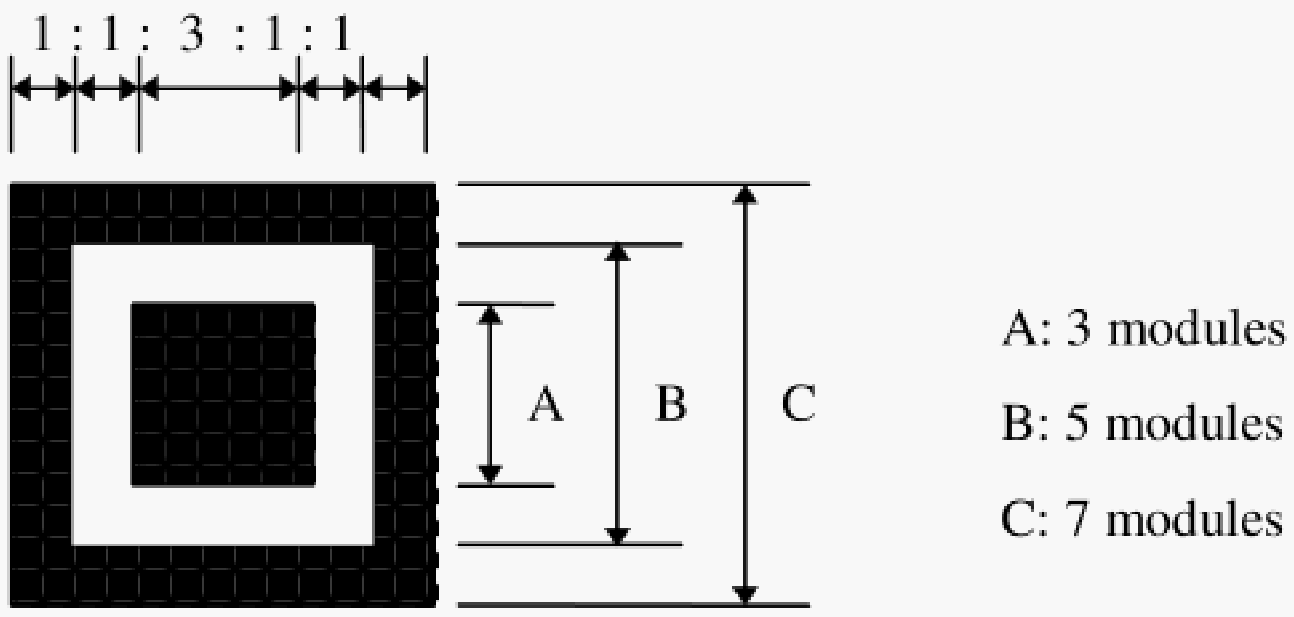

Figure 9 — Structure of Position Detection Pattern

7.3.3 Separators

A one-module wide Separator is placed between each Position Detection Pattern and Encoding Region, as illustrated in Figure 2, and is constructed of all light modules.

7.3.4 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. The horizontal Timing Pattern runs across row 6 of the symbol between the separators for the upper Position Detection Patterns; the vertical Timing Pattern similarly runs down column 6 of the symbol between the separators for the left-hand Position Detection Patterns. They enable the symbol density and version to be determined and provide datum positions for determining module coordinates.

7.3.5 Alignment Patterns

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 Model 2 symbols of Version 2 or larger in positions defined in Annex E.

7.3.6 Encoding region

This region shall contain the symbol characters representing data, those representing error correction codewords, the Version Information and Format Information. Refer to 8.7.1 for details of the symbol characters. Refer to 8.9 for details of the Format Information. Refer to 8.10 for details of the Version Information

7.3.7 Quiet zone

This is a region 4X wide 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.

8 Requirements

8.1 Encode procedure overview

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

Step 1 Data analysis

Analyze the input data stream to identify the variety of different characters to be encoded. QR Code supports the Extended Channel Interpretation feature, enabling data differing from the default character set to be encoded. QR Code includes several modes (see 8.3) 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 encodation

Convert the data characters into a bit stream in accordance with the rules for the mode in force, as defined in 8.4.1 to 8.4.5, 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 Tables 13 to 22) 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 8.6 (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 Alignment Patterns.

Step 6 Masking

Apply the 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 and (where applicable) Version Information and complete the symbol.

Table 1 — Data capacity of all versions of QR Code

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
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 shall be 8 bits in length.

8.2 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 8.4. 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. Guidance on this is given in Annex H. 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.

8.3 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, 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.

8.3.1 Extended Channel Interpretation (ECI) Mode

The Extended Channel Interpretation (ECI) protocol 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. Four broad types of interpretation are supported in QR Code:

a) international character sets (or code pages)

b) general purpose interpretations such as encryption or compaction

c) user-defined interpretations for closed systems.

d) control information for structured append in unbuffered mode

The ECI protocol is fully defined in the AIM ECI specification. The protocol provides a consistent method to specify particular interpretations of byte values before printing and after decoding.

The default interpretation for QR Code is ECI **000020** representing the JIS8 and Shift JIS character sets.

8.3.2 Numeric Mode

Numeric mode encodes data from the decimal digit set (**0 - 9**) (ASCII values 30_{HEX} to 39_{HEX}) at a normal density of 3 data characters per 10 bits.

8.3.3 Alphanumeric Mode

Alphanumeric Mode encodes data from a set of 45 characters, i.e. 10 numeric digits (**0 - 9**) (ASCII values 30_{HEX} to 39_{HEX}), 26 alphabetic characters (**A - Z**) (ASCII values 41_{HEX} to $5A_{HEX}$) , and 9 symbols (**SP**, **$**, **%**, *, **+**, **-**, **.**, /, **:**) (ASCII 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.

8.3.4 8-bit Byte Mode

The 8-bit byte mode handles the 8-bit Latin/Kana character set in accordance with JIS X 0201 (character values 00_{HEX} to FF_{HEX}). In this mode data is encoded at a density of 8 bits/character.

8.3.5 Kanji Mode

The Kanji mode handles 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. Refer to JIS X 0208 Annex 1 Shift Coded Representation for detail. Each two-byte character value is compacted to a 13 bit binary codeword.

8.3.6 Mixing modes

The QR Code symbol may contain sequences of data in a combination of any of the modes described in 8.3.1 to 8.3.5

Refer to Annex H for guidance on selecting the most efficient way of representing a given input data string in Mixing Mode.

8.3.7 Structured Append Mode

Structured Append mode is used to split the encodation 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 9 for details of encodation in Structured Append mode.

8.3.8 FNC1 Mode

FNC1 mode is used for messages containing data formatted either in accordance with the UCC/EAN Application Identifiers standard or in accordance with a specific industry standard previously agreed with AIM International.

8.4 Data encodation

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

The ECI header (if present) shall comprise:

— ECI Mode Indicator (4 bits)

— ECI Designator (8, 16 or 24 bits)

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

— Mode Indicator (4 bits)

— Character Count Indicator

— Data bit stream.

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. 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 8.4.1 to 8.4.6 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

Mode	Indicator
ECI	**0111**
Numeric	**0001**
Alphanumeric	**0010**
8-bit Byte	**0100**
Kanji	**1000**
Structured Append	**0011**
FNC1	**0101** (First position) **1001** (Second position)
Terminator (End of Message)	**0000**

Table 3 — Number of bits in Character Count Indicator

Version	Numeric Mode	Alphanumeric Mode	8-bit Byte Mode	Kanji Mode
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 4 bit terminator **0000**, 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.

8.4.1 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.** There is no need to invoke the default Extended Channel Interpretation for QR Code (ECI 000020, corresponding to the JIS8/Shift JIS character sets) specifically at the beginning of any symbol.

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 8-bit 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 8.4.2) 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.

8.4.1.1 ECI Designator

Each Extended Channel Interpretation is designated by a six-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 encodation rules are defined in Table 4. The ECI Designator appears in the data to be encoded as ASCII/JIS8 character $5C_{HEX}$ (\ or backslash in ISO 646 IRV, ¥ or yen sign in JIS8) followed by the six digit assignment number. Where ASCII/JIS8 character $5C_{HEX}$ appears as true data it shall have been doubled in the data string before encoding in symbols to which the ECI protocol applies.

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 8859-7 (ECI 000009) in version 1-H symbol.

Data to be encoded: ΑΒΓΔΕ (character values $A1_{HEX}$, $A2_{HEX}$, $A3_{HEX}$, $A4_{HEX}$, $A5_{HEX}$)

Bit sequence in symbol:

ECI Mode Indicator **0111**

ECI Assignment number (000009) **00001001**

Mode indicator (8-bit 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 15.2 for example of transmission of this data following decoding.

8.4.1.2 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 non-character set ECI which may co-exist with the initial ECI, or the second ECI may have the effect of cancelling 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 8.4.1.1 and shall commence a new Mode segment.

8.4.1.3 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 (signaled 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.

8.4.2 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 Character Count Indicator in the Numeric Mode has 10, 12 or 14 bits as defined in Table 3. The number of input data characters is converted to its 10, 12 or 14 bit binary equivalent and added 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

<u>Example 2</u> (for Version 1-H 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 (10 bits for version 1-H):

   No. of input data characters: **16 → 0000010000**

5. Add Mode Indicator **0001** and Character Count Indicator to binary data:

   0001 0000010000 0000001100 0101011001 1010100110 1110000101 0011101010 0101

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

$$B = 4 + C + 10(D \text{ DIV } 3) + R$$

where:

B = number of bits in bit stream

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

8.4.3 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 to 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 to a 6-bit binary number. The binary data is then concatenated and prefixed with the Mode Indicator and the Character Count Indicator. The Character Count Indicator in the Alphanumeric Mode has 9, 11 or 13 bits as defined in Table 3. The number of input data characters is converted to its 9, 11 or 13 bit binary equivalent and added after the Mode Indicator and before the binary data sequence.

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)**

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:

$B = 4 + C + 11(D \text{ DIV } 2) + 6(D \text{ MOD } 2)$

where:

B = number of bits in bit stream

C = number of bits in Character Count Indicator (from Table 3)

D = number of input data characters

8.4.4 8-bit Byte Mode

In this mode, one 8 bit codeword directly represents the JIS8 character value of the input data character as shown in Table 6, i.e. a density of 8 bits/character. In ECIs other than the default ECI, it represents an 8-bit byte value directly.

Table 6 — Encoding/decoding table for JIS8 character set

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

NOTE 1 In the JIS8 character set 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 and may be used to distinguish between the JIS8 and Shift JIS character sets. Refer to JIS X 0208 Annex 1 Shift Coded Representation for detail.

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

The binary data is then concatenated and prefixed with the Mode Indicator and the Character Count Indicator. The Character Count Indicator in the 8-bit Byte Mode has 8 or 16 bits as defined in Table 3. The number of input data characters is converted to its 8 or 16 bit 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 8-bit Byte Mode is given by the following formula:

$B = 4 + C + 8D$ where:

B = number of bits in bit stream

C = number of bits in Character Count Indicator (from Table 3)

D = number of input data characters

8.4.5 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. Refer to JIS X 0208 Annex 1 Shift Coded Representation for detail. Input data characters in Kanji Mode are compacted to 13 bit binary codewords as defined below. The binary data is then concatenated and prefixed with the Mode Indicator and the Character Count Indicator. The Character Count Indicator in the Kanji Mode has 8, 10 or 12 bits as defined in Table 3. The number of input data characters is converted to its 8, 10 or 12 bit binary equivalent and added after the Mode Indicator and before the binary data sequence.

1. For characters with Shift JIS values from 8140_{HEX} to $9FFC_{HEX}$:

a) Subtract 8140_{HEX} from Shift JIS value;

b) Multiply most significant byte of result by $C0_{HEX}$;

c) Add least significant byte to product from b);

d) Convert result to a 13 bit binary string.

2. For characters with Shift JIS values from $E040_{HEX}$ to $EBBF_{HEX}$:

a) Subtract $C140_{HEX}$ from Shift JIS value;

b) Multiply most significant byte of result by $C0_{HEX}$;

c) Add least significant byte to product from b);

d) Convert result to a 13 bit binary string;

Examples

Input character	"点"	"茗"
(Shift JIS value):	**935F**	**E4AA**
1. Subtract 8140 or C140	**935F - 8140 = 121F**	**E4AA - C140 = 236A**
2. Multiply m.s.b. by C0	**12 × C0 = D80**	**23 × C0 = 1A40**
3. Add l.s.b.	**D80 + 1F = D9F**	**1A40 + 6A = 1AAA**
4. Convert to 13 bit binary	**0D9F → 0 1101 1001 1111**	**1AAA →1 1010 1010 1010**

3. <u>For all characters:</u>

e) Prefix binary sequence representing input data characters with Mode Indicator (**1000**) and Character Count Indicator binary equivalent (8, 10 or 12 bits);

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

$$B = 4 + C + 13D$$

where:

B = number of bits in bit stream

C = number of bits in Character Count Indicator (from Table 3)

D = number of input data characters

8.4.6 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 encodation. Refer to Annex H for guidance. Each segment of data is encoded in the appropriate mode as indicated in 8.4.1 to 8.4.5, with the basic structure Mode Indicator/Character Count Indicator/Data and followed immediately by the Mode Indicator commencing the next segment. Figure 10 illustrates the structure of data containing n segments.

Segment 1			Segment 2			……	Segment n		
Mode Indicator 1	Character Count Indicator	Data	Mode Indicator 2	Character Count Indicator	Data	……	Mode Indicator n	Character Count Indicator	Data

Figure 10 — Format of mixed mode data

8.4.7 FNC1 Modes

There are two Mode Indicators which are used cumulatively with those defined in 8.3.1 to 8.3.8 and 8.4.1 to 8.4.6 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 15.1 and Annex F.

8.4.7.1 FNC1 in first position

This Mode Indicator identifies symbols encoding data formatted according to the UCC/EAN Application Identifiers standard. For this purpose, it is only used once in a symbol and shall always be placed immediately before the first Mode Indicator used for efficient data encoding (Numeric, Alphanumeric, 8-bit byte or Kanji), and after any ECI or Structured Append header. Where the UCC/EAN specifications call for the FNC1 character (in other symbologies which use this special character) to be used as a data field separator (i.e. at the end of a variable-length data field), QR Code symbols shall use the **%** character in Alphanumeric Mode or character **GS** (ASCII/JIS8 value 29) in 8-bit Byte Mode to perform this function. If the **%** character occurs as part of the data it shall be encoded as **%%**. Decoders encountering **%** in these symbols shall transmit it as ASCII/JIS8 value 29, and if **%%** is encountered it shall be transmitted as a single **%** character.

<u>Examples</u>

Input data:

0104912345123459 (Application Identifier 01 = UCC/EAN article no., 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 15.1 and Annex F)

]Q301049123451234591597033130128**<ASCII 29>**10ABC123

Example of encoding/transmission of % character in data:

Input data: 123%

Encoded as: 123%%

Transmitted as: 123%

8.4.7.2 FNC1 in second position

This Mode Indicator identifies symbols formatted in accordance with specific industry or application specifications previously agreed with AIM International. 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 by AIM International. For this purpose, it is only used once in a symbol and shall always be placed immediately before the first Mode Indicator used for efficient data encoding (Numeric, Alphanumeric, 8-bit byte or Kanji), and after any ECI or structured Append header. An Application Indicator may take the form of any single Latin alphabetic character from the set {a - z, A - Z} (represented by the ASCII 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.

Example:

(Application Indicator 37 has not been assigned at the time of publication 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 2nd position)

00100101 (Application Indicator, 37)

0010 (Mode Indicator, Alphanumeric Mode)

000001100 (Character Count Indicator, 12)

<data bits for **AA1234BBB112**>

0100 (Mode Indicator, 8-bit Byte Mode)

00010100 (Character Count Indicator, 20)

<data bits for **text text text text<CR>** >

Transmitted data:

]Q537AA1234BBB112text text text text<CR>

8.4.8 Terminator

The end of data in the symbol is signalled by the Terminator sequence **0000**, appended to the data bit stream following the final mode segment. This may 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 4 bits.

8.4.9 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, unless the data bit stream completely fills the capacity of the symbol. The resulting message bit stream shall then be divided into codewords. All codewords are 8 bits in length. If the bit stream length is such that the final codeword is not exactly 8 bits in length, it shall be made 8 bits long by the addition of padding bits with binary value 0. Padding bits shall be added after the final bit (least significant bit) of the data stream. 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 Tables 7 to 11, by the addition of the Pad Codewords **11101100** and **00010001** alternately. The resulting series of codewords, the data codeword sequence, is then processed as described in 8.5 to add error correction codewords to the message. In certain versions of symbol, it may be necessary to add 3, 4 or 7 Remainder Bits (all zeros) to the end of the message in order exactly to fill the symbol capacity (see Table 1).

Table 7 — Number of symbol characters and input data capacity for versions 1 to 8

Version	Error correction level	Number of data codewords[a]	Number of data bits[b]	Data capacity			
				Numeric	Alphanumeric	8-bit Byte	Kanji
1	L	19	152	41	25	17	10
	M	16	128	34	20	14	8
	Q	13	104	27	16	11	7
	H	9	72	17	10	7	4
2	L	34	272	77	47	32	20
	M	28	224	63	38	26	16
	Q	22	176	48	29	20	12
	H	16	128	34	20	14	8
3	L	55	440	127	77	53	32
	M	44	352	101	61	42	26
	Q	34	272	77	47	32	20
	H	26	208	58	35	24	15
4	L	80	640	187	114	78	48
	M	64	512	149	90	62	38
	Q	48	384	111	67	46	28
	H	36	288	82	50	34	21
5	L	108	864	255	154	106	65
	M	86	688	202	122	84	52
	Q	62	496	144	87	60	37
	H	46	368	106	64	44	27
6	L	136	1 088	322	195	134	82
	M	108	864	255	154	106	65
	Q	76	608	178	108	74	45
	H	60	480	139	84	58	36
7	L	156	1 248	370	224	154	95
	M	124	992	293	178	122	75
	Q	88	704	207	125	86	53
	H	66	528	154	93	64	39
8	L	194	1 552	461	279	192	118
	M	154	1 232	365	221	152	93
	Q	110	880	259	157	108	66
	H	86	688	202	122	84	52

a All codewords shall be 8 bits in length.

b The number of Data Bits includes bits for Mode Indicator and Character Count Indicator.

Table 8 — Number of symbol characters and input data capacity for versions 9 to 16

Version	Error correction level	Number of data codewords[a]	Number of data bits[b]	Data capacity			
				Numeric	Alphanumeric	8-bit Byte	Kanji
9	L	232	1 856	552	335	230	141
	M	182	1 456	432	262	180	111
	Q	132	1 056	312	189	130	80
	H	100	800	235	143	98	60
10	L	274	2 192	652	395	271	167
	M	216	1 728	513	311	213	131
	Q	154	1 232	364	221	151	93
	H	122	976	288	174	119	74
11	L	324	2 592	772	468	321	198
	M	254	2 032	604	366	251	155
	Q	180	1 440	427	259	177	109
	H	140	1 120	331	200	137	85
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

[a] All codewords shall be 8 bits in length.

[b] The number of Data Bits includes bits for Mode Indicator and Character Count Indicator.

Table 9 — Number of symbol characters and input data capacity for versions 17 to 24

Version	Error correction level	Number of data codewords[a]	Number of data bits[b]	Data capacity			
				Numeric	Alphanumeric	8-bit Byte	Kanji
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

a All codewords shall be 8 bits in length.

b The number of Data Bits includes bits for Mode Indicator and Character Count Indicator.

Table 10 — Number of symbol characters and input data capacity for versions 25 to 32

Version	Error correction level	Number of data codewords[a]	Number of data bits[b]	Data capacity			
				Numeric	Alphanumeric	8-bit Byte	Kanji
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
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

[a] All codewords shall be 8 bits in length.

[b] The number of Data Bits includes bits for Mode Indicator and Character Count Indicator.

Table 11 — Number of symbol characters and input data capacity for versions 33 to 40

Version	Error correction level	Number of data codewords[a]	Number of data bits[b]	Data capacity			
				Numeric	Alphanumeric	8-bit Byte	Kanji
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

[a] All codewords shall be 8 bits in length.

[b] The number of Data Bits includes bits for Mode Indicator and Character Count Indicator.

8.5 Error correction

8.5.1 Error correction capacity

QR Code employs error correction to generate a series of error correction codewords 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 12, offering the capability of recovery from the following amounts of damage:

Table 12 — Error correction levels

Error Correction Level	Recovery Capacity % (approx.)
L	7
M	15
Q	25
H	30

Clause I.3 gives guidance on the appropriate level of error correction to be applied to a symbol.

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 the following formula:

$$e + 2t \leq d - p$$

where:

e = number of erasures

t = number of errors

d = number of error correction codewords

p = number of misdecode protection codewords

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 the formula above, $p = 3$ in version 1-L symbols, $p = 2$ in version 1-M and 2-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 must be less than $d/2$. In a Version 2-L symbol, for example, the total number of codewords is 44; of these, 34 are data codewords and 10 error correction codewords. From Table 13 it can be seen that the error correction capacity is 4 errors (where $e = 0$). Substituting in the formula above,

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

meaning that the correction of the 4 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 4 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. Tables 13 to 22 list, 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 13 — Error correction characteristics for versions 1 to 6

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of error correction blocks	Error correction code per block [a]
1	26	L	7	1	(26,19,2) [b]
		M	10	1	(26,16,4) [b]
		Q	13	1	(26,13,6) [b]
		H	17	1	(26,9,8) [b]
2	44	L	10	1	(44,34,4) [b]
		M	16	1	(44,28,8)
		Q	22	1	(44,22,11)
		H	28	1	(44,16,14)
3	70	L	15	1	(70,55,7) [b]
		M	26	1	(70,44,13)
		Q	36	2	(35,17,9)
		H	44	2	(35,13,11)
4	100	L	20	1	(100,80,10)
		M	36	2	(50,32,9)
		Q	52	2	(50,24,13)
		H	64	4	(25,9,8)
5	134	L	26	1	(134,108,13)
		M	48	2	(67,43,12)
		Q	72	2 2	(33,15,9) (34,16,9)
		H	88	2 2	(33,11,11) (34,12,11)
6	172	L	36	2	(86,68,9)
		M	64	4	(43,27,8)
		Q	96	4	(43,19,12)
		H	112	4	(43,15,14)

[a] (c, k, r): c = total number of codewords
k = number of data codewords
r = number of error correction capacity

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

Table 14 — Error correction characteristics for versions 7 to 10

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of error correction blocks	Error correction code per block [a]
7	196	L	40	2	(98,78,10)
		M	72	4	(49,31,9)
		Q	108	2 4	(32,14,9) (33,15,9)
		H	130	4 1	(39,13,13) (40,14,13)
8	242	L	48	2	(121,97,12)
		M	88	2 2	(60,38,11) (61,39,11)
		Q	132	4 2	(40,18,11) (41,19,11)
		H	156	4 2	(40,14,13) (41,15,13)
9	292	L	60	2	(146,116,15)
		M	110	3 2	(58,36,11) (59,37,11)
		Q	160	4 4	(36,16,10) (37,17,10)
		H	192	4 4	(36,12,12) (37,13,12)
10	346	L	72	2 2	(86,68,9) (87,69,9)
		M	130	4 1	(69,43,13) (70,44,13)
		Q	192	6 2	(43,19,12) (44,20,12)
		H	224	6 2	(43,15,14) (44,16,14)

[a] (c, k, r): c = total number of codewords
k = number of data codewords
r = number of error correction capacity

Table 15 — Error correction characteristics for Model 2, versions 11 to 14

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of error correction blocks	Error correction code per block [a]
11	404	L	80	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	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	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	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)

[a] (c, k, r): c = total number of codewords
k = number of data codewords
r = number of error correction capacity

Table 16 — Error correction characteristics for versions 15 to 18

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of error correction blocks	Error correction code per block [a]
15	655	L	132	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	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)
17	815	L	168	1 5	(135,107,14) (136,108,14)
		M	308	10 1	(74,46,14) (75,47,14)
		Q	448	1 15	(50,22,14) (51,23,14)
		H	532	2 17	(42,14,14) (43,15,14)
18	901	L	180	5 1	(150,120,15) (151,121,15)
		M	338	9 4	(69,43,13) (70,44,13)
		Q	504	17 1	(50,22,14) (51,23,14)
		H	588	2 19	(42,14,14) (43,15,14)

[a] (c, k, r): c = total number of codewords
k = number of data codewords
r = number of error correction capacity

Table 17 — Error correction characteristics for versions 19 to 22

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of error correction blocks	Error correction code per block [a]
19	991	L	196	3 4	(141,113,14) (142,114,14)
		M	364	3 11	(70,44,13) (71,45,13)
		Q	546	17 4	(47,21,13) (48,22,13)
		H	650	9 16	(39,13,13) (40,14,13)
20	1 085	L	224	3 5	(135,107,14) (136,108,14)
		M	416	3 13	(67,41,13) (68,42,13)
		Q	600	15 5	(54,24,15) (55,25,15)
		H	700	15 10	(43,15,14) (44,16,14)
21	1 156	L	224	4 4	(144,116,14) (145,117,14)
		M	442	17	(68,42,13)
		Q	644	17 6	(50,22,14) (51,23,14)
		H	750	19 6	(46,16,15) (47,17,15)
22	1 258	L	252	2 7	(139,111,14) (140,112,14)
		M	476	17	(74,46,14)
		Q	690	7 16	(54,24,15) (55,25,15)
		H	816	34	(37,13,12)

[a] (c, k, r): c = total number of codewords
k = number of data codewords
r = number of error correction capacity

Table 18 — Error correction characteristics for versions 23 to 26

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of error correction blocks	Error correction code per block [a]
23	1 364	L	270	4 5	(151,121,15) (152,122,15)
		M	504	4 14	(75,47,14) (76,48,14)
		Q	750	11 14	(54,24,15) (55,25,15)
		H	900	16 14	(45,15,15) (46,16,15)
24	1 474	L	300	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	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	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)

[a] (c, k, r): c = total number of codewords
k = number of data codewords
r = number of error correction capacity

Table 19 — Error correction characteristics for versions 27 to 30

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of error correction blocks	Error correction code per block [a]
27	1 828	L	360	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	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	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)
30	2 185	L	450	5 10	(145,115,15) (146,116,15)
		M	812	19 10	(75,47,14) (76,48,14)
		Q	1 200	15 25	(54,24,15) (55,25,15)
		H	1 440	23 25	(45,15,15) (46,16,15)

[a] (c, k, r): c = total number of codewords
k = number of data codewords
r = number of error correction capacity

Table 19 — Error correction characteristics for versions 27 to 30

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27	1 828	L	360	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	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)
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		M	812	19 10	(75,47,14) (76,48,14)
		Q	1 200	15 25	(54,24,15) (55,25,15)
		H	1 440	23 25	(45,15,15) (46,16,15)

[a] (c, k, r): c = total number of codewords
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28	1 921	L	390	3 10	(147,117,15) (148,118,15)
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[a] (c, k, r): c = total number of codewords
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28	1 921	L	390	3 10	(147,117,15) (148,118,15)
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		Q	1 200	15 25	(54,24,15) (55,25,15)
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[a] (c, k, r): c = total number of codewords
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		H	1 200	12 28	(45,15,15) (46,16,15)
28	1 921	L	390	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)
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[a] (c, k, r): c = total number of codewords
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		H	1 200	12 28	(45,15,15) (46,16,15)
28	1 921	L	390	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)
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		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	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	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)
30	2 185	L	450	5 10	(145,115,15) (146,116,15)
		M	812	19 10	(75,47,14) (76,48,14)
		Q	1 200	15 25	(54,24,15) (55,25,15)
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Table 19 — Error correction characteristics for versions 27 to 30

Version	Total number of codewords	Error correction level	Number of error correction codewords	Number of error correction blocks	Error correction code per block [a]
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