KEYENCE

ID CODE HANDBOOK

2D Code Implementation Guide Vol. 1

Getting Started

In order to begin using 2D codes, you need to use the following procedure:

[Flow of 2D code implementation]

STEP.1 Content and Size of the 2D Code to Print

Description

- Key points for data content when deciding the code size
- How to compute the module size

STEP.2 Materials to Print the 2D Code On

Description

- Key points when printing on different materials (labels, metals, plastic, etc.)
- Precautions about the printer and marker, etc.

STEP.3 Characteristics of Readers and Lighting

Description

- How the code appears to the reader
- Differences due to the color and shape of the lighting

This guide contains the details for STEP 1, above.

Table of Contents

1 What is a 2D code?

Barcodes have been used extensively all over the world in various fields, starting from POS systems in supermarkets and convenience stores, to production instruction systems in the manufacturing industry and ordering systems in enterprises. As barcodes became widespread, their convenience became widely recognized and the need for further functionality arose. Such needs included demands for a larger information capacity for storing all the relevant data in a barcode and also for a small barcode to use on electronic parts. The "2D code" was created to meet these demands. A 2D code has an information capacity up to several dozens times more than that of a barcode, while the size of a 2D code is over several dozens times smaller than that of a barcode. With these advantages, 2D codes are used increasingly more in various fields.

1-1 Features of 2D codes (how they differ from barcodes)

This section describes the main features of 2D codes and how they differ from barcodes.

Large data storage capacity

While barcodes can store information in only one direction, a 2D code can use both the horizontal and vertical directions for storing information. This means that a 2D code can encode several dozens to several hundreds of times more data than a barcode can.

[A 2D code containing 7089 digits of data]

High data density

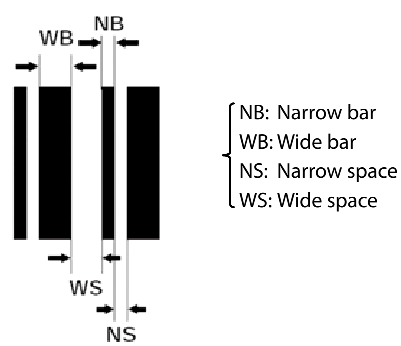
A 2D code can be much smaller than a barcode containing the same amount of data.

[A barcode and a 2D code containing all 26 letters of the alphabet]

* The narrow bar width of the barcode is the same as the size of the 2D code module.

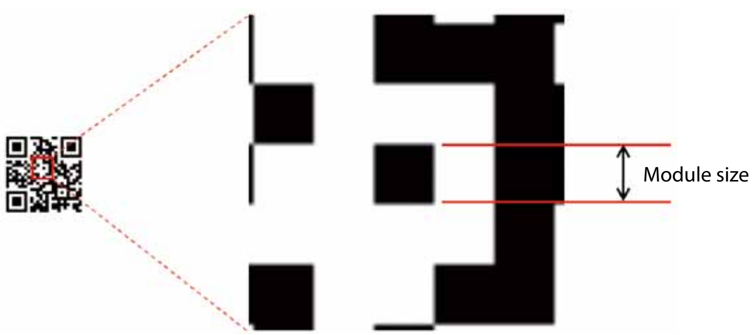
What is the narrow bar width?

The width of the narrowest bars comprising a barcode is called the narrow bar width. (Similarly, the width of the narrowest spaces is called the narrow space width. This is the same width as the narrow bar width.) The thick bars and spaces are called the wide bars and wide spaces.



What is the module size?

The smallest (black or white) square unit comprising a 2D code is called a module. The module size is the length of one of the sides of the module square.



Error correction (data restoration) capability

The 2D code has built-in error correction functionality for restoring the data from damage resulting from stains or tears. Data can be read-out normally even with damage affecting 10 to 30% of the code's area. The built-in error restoration method used in the 2D code is called the "Reed-Solomon method", a mathematical error detection and correction theory, which not only makes the 2D code capable of data restoration but also prevents read-out errors.

Stain Blot Tear

1-2 Typical 2D codes

QR code

QR code Micro QR code

The QR code (Quick Response code) is a matrix 2D code for high-speed reading developed by DENSO WAVE in 1994. It was registered as an ITS standard of the AIMI in 1997, and became an ISO/IEC standard in 2000. In addition, the Micro QR code was also standardized as JIS-X-0510 in 2004.

* Please refer to the "ID Code Handbook: 2-D Code Basic Guide" for details about the QR code.

DataMatrix ECC200

Square type Rectangular type

Data Matrix code is a matrix 2D code developed by ID Matrix in 1987. It was registered as an ISS standard of AIMI in 1996, and become an ISO/IEC standard in 2000. The older versions of Data Matrix code include ECC000, ECC050, ECC080, ECC100, and ECC140. There are also new versions that come in both the square type and the rectangular type.

* Please refer to "ID Code Handbook: 2-D Code Basic Guide" for details about the Data Matrix ECC200 code.

2 [Preparing for 2D Code Implementation] Deciding What Data to Print

The first step in introducing 2D codes is to decide what data to print as a 2D code. This section summarizes elements you need to consider, such as what kind of data to include in the code and what kind of format to use.

2-1 Summarizing the Data

First, you need to make clear how many data items you want to manage using the 2D code. For example, you might need data items such as the following:

Examples of data items

- Product number
- Lot number
- Serial number
- Manufacturing date
- Quantity
- Location number, etc.

Once you have a clear idea of what data items you want to manage (i.e., what data to include in the 2D code), you can then decide which data format to use.

2-2 Data Format

This subsection describes the important factors in deciding the data format. You need to consider these factors carefully because these factors affect the main application that is supposed to handle the data as well as the size of the 2D code.

- **Number of digits of each data item**

The data can be expressed either using "variable length" data, where the numbers of digits can vary among the data items, or using "fixed length" data, where all data items have the same number of digits. The choice of which of these two representations to use requires careful consideration, as it affects the method of data processing as well as the size and content of the 2D code.

How to delimit variable length data

If the number of digits is different for each data piece, you need to use a particular character (separator) that functions as a delimiter for variable length data when there is a sequence of variable length data pieces or when a variable length data piece is placed among fixed length data.

[No separator used]
(3 variable length data pieces: blue, red and green)

12345ABCD9876
963ZYX877123654

As there is no indication of where each data piece ends, the computer cannot tell how to delimit the digits.

[With separators]
(3 variable length data pieces: blue, red and green)

12345:ABCD:9876
963:ZYX877:123654

Here, the character ":" (colon) is used as separator. The computer can identify the three data pieces because the separators indicate where each piece ends and begins. (You need to set the computer in advance to process the separators appropriately.)

How variable length data affects the 2D code
Normally, 2D codes are created so that they are the smallest size possible. Therefore, if a 2D code contains variable length data, the size of the 2D code may vary depending on the contents of the variable length data. If the area available for printing the 2D code is limited, it is necessary to check the 2D code specification using the largest number of data digits possible.

- **When the 2D code contains data other than numerical values**
  2D code uses data compression to save the space it needs for printing. However, the compression methods used are different depending on the types, numbers and sequences of the characters. This means that the code size may vary even for data with the same number of digits.

Comparison of codes containing numbers and letters

Example 1 (same number of digits, some numbers replaced by letters)

Data content: all numbers, 41 digits

Data content: numbers 40 digits, letter 1 digit

Example 2 (same number of numbers and letters, in different orders)

Data content: the first 20 digits all numbers, the remaining 10 digits all letters, 30 digits in total

Data content: (numbers 2 digits, letter 1 digit) x 10 sets, 30 digits in total

4 character modes for building a 2D code

There are four different modes for representing characters available for the 2D code. Each of these modes has a different set of representable characters and a different compression rate. When creating a 2D code, these modes are used in combination so that the code size becomes as small as possible.

4 character modes

[Numeric mode]
Only numbers can be represented. This is effective when there is a sequence of numerical values 2 to 3 characters or more long. In numeric mode, the amount of per character information is small.

[Alphanumeric mode]
Numbers, letters and some symbols can be represented. The amount of information per character is more than in the case of numeric mode but less than in binary mode.

[Binary mode]
All half-width characters (including control sequences) can be represented. This mode has more information per character than in alphanumeric mode but this me used to represent control sequences.

[Kanji mode]
Full-width characters such as kanji can be represented. The amount of information per character is the largest among the 4 modes.

The amount of information per character

Numeric mode < **Alphanumeric mode** < **Binary mode** < **Kanji mode**

Given the above, please note the following:

- **Whether any variable length data will be included or not.**
  If the code will contain some variable length data, you need to consider how to delimit the data and the size of the code.

- **Whether the digits of the data are always numeric values or a mixture of numbers and letters.**
  This amounts to a change from numeric mode to alphanumeric mode and to an increase in the amount of space per character information, possibly resulting in a change to the code size. In such cases, you need to consider the code size using the data content that has the largest amount of information.

[Example]

12345 ↔ 123A5

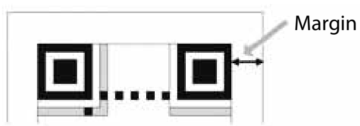
3 [Preparing for 2D Code Implementation] Module Size

What is as important as deciding the data contents is deciding the module size. The module size is an important factor directly influencing the operation as it relates to the read-out margin size, the choice of readers, and the choice of printers and markers.

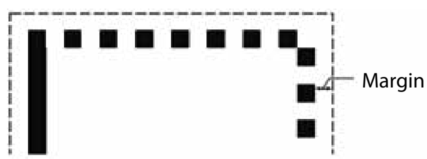
3-1 How to compute the module size

The two major factors that decide the module size are the following:

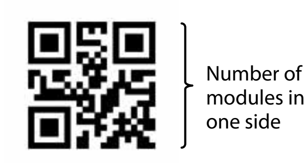
- **Margin**
  - QR code: four modules, Micro QR code: two modules



  - Data Matrix: one module



- **How many modules are placed in one side of the code** (this depends on the data mount)

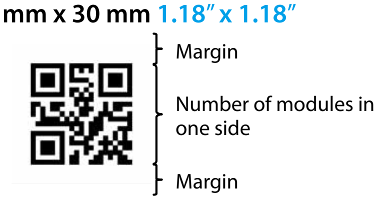


* Please refer to pages 11 and 12 for the size of each code and the corresponding maximum number of representable characters.
* QR codes with a larger version number can represent a greater number of characters.

If you have a certain fixed area ready for printing the 2D code, you can also use the formula given below to calculate the appropriate module size:

Example: when you have a printing area of 30 mm x 30 mm 1.18″ x 1.18″

If you are printing a QR code, you use the number of modules in one side and the 4 modules margin to compute the module size.



The number of modules in one direction =
the number of modules in one side + (margin x 2)

[In the case of Version 3]
29 modules (in one side) + 4 modules x 2 (margin x 2) = 37 modules
30 (mm) 1.18″ / 37 (modules) =/= 0.81 (mm 0.03″/module)

Once you have identified the data to print, the size of the code and the printing area, you can calculate the maximum module size you can print. Based on this module size value, you determine which reader, printer and marker to use.

4 Appendix (the maximum number of input characters)

Deciding the module size is as important as deciding the data contents.The module size is an important factor directly influencing the operation as it relates to the read-out margin size, the choice of readers, and the choice of printers and markers.

QR code (Model 2)

Version (module number)	Numeric				Alphanumeric				Binary				Kanji			
	L	M	Q	H	L	M	Q	H	L	M	Q	H	L	M	Q	H
1(21)	41	34	27	17	25	20	16	10	17	14	11	7	10	8	7	4
2(25)	77	63	48	34	47	38	29	20	32	26	20	14	20	16	12	8
3(29)	127	101	77	58	77	61	47	35	53	42	32	24	32	26	20	15
4(33)	187	149	111	82	114	90	67	50	78	62	46	34	48	38	28	21
5(37)	255	202	144	106	154	122	87	64	106	84	60	44	65	52	37	27
6(41)	322	255	178	139	195	154	108	84	134	106	74	58	82	65	45	36
7(45)	370	293	207	154	224	178	125	93	154	122	86	64	95	75	53	39
8(49)	461	365	259	202	279	221	157	122	192	152	108	84	118	93	66	52
9(53)	552	432	312	235	335	262	189	143	230	180	130	98	141	111	80	60
10(57)	652	513	364	288	395	311	221	174	271	213	151	119	167	131	93	74
11(61)	772	604	427	331	468	366	259	200	321	251	177	137	198	155	109	85
12(65)	883	691	489	374	535	419	296	227	367	287	203	155	226	177	125	96
13(69)	1,022	796	580	427	619	483	352	259	425	331	241	177	262	204	149	109
14(73)	1,101	871	621	468	667	528	376	283	458	362	258	194	282	223	159	120
15(77)	1,250	991	703	530	758	600	426	321	520	412	292	220	320	254	180	136
16(81)	1,408	1,082	775	602	854	656	470	365	586	450	322	250	361	277	198	154
17(85)	1,548	1,212	876	674	938	734	531	408	644	504	364	280	397	310	224	173
18(89)	1,725	1,346	948	746	1,046	816	574	452	718	560	394	310	442	345	243	191
19(93)	1,903	1,500	1,063	813	1,153	909	644	493	792	624	442	338	488	384	272	208
20(97)	2,061	1,600	1,159	919	1,249	970	702	557	858	666	482	382	528	410	297	235
21(101)	2,232	1,708	1,224	969	1,352	1,035	742	587	929	711	509	403	572	438	314	248
22(105)	2,409	1,872	1,358	1,056	1,460	1,134	823	640	1,003	779	565	439	618	480	348	270

Micro QR code

Version	Error correction	Numeric	Alphanumeric	Binary	Kanji
M1 (11)	Error detection	5	—	—	—
M2 (13)	L	10	6	—	—
	M	8	5	—	—
M3 (15)	L	23	14	9	6
	M	18	11	7	4
M4 (17)	L	35	21	15	9
	M	30	18	13	8
	Q	21	13	9	5

[Error correction level of the QR code and the Micro QR code]

Error correction level	Area ratio to the symbols
L	7%
M	15%
Q	25%
H	30%

Data Matrix ECC200 square type

Code size	Data capacity			Error correction capability
	Numeric	Alphanumeric	Binary	
10 x 10 modules	6	3	1	25%
12 x 12 modules	10	6	3	25%
14 x 14 modules	16	10	6	28 to 39%
16 x 16 modules	24	16	10	25 to 38%
18 x 18 modules	36	25	16	22 to 34%
20 x 20 modules	44	31	20	23 to 38%
22 x 22 modules	60	43	28	20 to 34%
24 x 24 modules	72	52	34	20 to 35%
26 x 26 modules	88	64	42	19 to 35%
32 x 32 modules	124	91	60	18 to 34%
36 x 36 modules	172	127	84	16 to 30%
40 x 40 modules	228	169	112	15 to 28%
44 x 44 modules	288	214	142	14 to 27%
48 x 48 modules	348	259	172	14 to 27%
52 x 52 modules	408	304	202	15 to 27%
64 x 64 modules	560	418	278	14 to 27%
72 x 72 modules	736	550	366	14 to 26%
80 x 80 modules	912	682	454	15 to 28%
88 x 88 modules	1152	862	574	14 to 27%
96 x 96 modules	1392	1042	694	14 to 27%
104 x 104 modules	1632	1222	814	15 to 28%
120 x 120 modules	2100	1573	1048	14 to 27%
132 x 132 modules	2608	1954	1302	14 to 26%
144 x 144 modules	3116	2335	1556	14 to 27%

Data Matrix ECC200 rectangular type

Symbol size	Data capacity			Error correction capability
	Numeric	Alphanumeric	Binary	
8 × 18 modules	10	6	3	25%
8 × 32 modules	20	13	8	24%
12 × 26 modules	32	22	14	23 to 37%
12 × 36 modules	44	31	20	23 to 38%
16 × 36 modules	64	46	30	21 to 38%
16 × 48 modules	98	72	47	18 to 33%

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Please read the instruction manual carefully in order to safely operate any KEYENCE product.

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