Bar Code Printing
With
DL Series 24-Wire Dot Matrix Printer

FUJITSU

REVISION RECORD

Edition	Date published	Revised contents
A	October, 1987	First edition

Specification No.: B-69310

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1. Scope

Some DL-series printers print bar code patterns when simple commands are entered in DPL24C and DPL24I emulation. This manual gives the specifications for bar code pattern printing features of DL-series printers. Check the user's manual to be sure that features are supported for your printer.

Bar codes enable characters to be mechanically read, and represent characters in patterns consisting of bars and spaces having different widths.

Specifications are summarized as follows:

The eight most popular coding systems are made available by using a single command:

- Codabar (nw-7)
- Code 3 of 9
- Industrial 2 of 5
- Interleaved 2 of 5
- Matrix 2 of 5
- EAN 13 (*1)
- EAN 8
- UPC Type A (*2)

*1 EAN: European Article Numbering
*2 UPC: Universal Product Code

A wide variety of bar code sizes is available:

- 0.6 inch wide and 0.13 inch high and up
- Up to 13 inches wide and 11 inches high
- Up to 0.015 inch the module density

OCR-B font data built into the printer enables the printing of characters for human-readable interpretation.

You can select from a wide variety of features to tailor your system to best meet your needs:

- Automatic addition of check digits to coding data
- Printing of characters for human-readable interpretation
- Positioning of the flag character for EAN and UPC coding

2. Bar Codes

2.1 Bar Code Configuration

Bar codes are machine-readable printed patterns that use the widths of printed bars, the widths of spaces between bars, and the relative positions of wide and narrow bars and spaces to encode a variety of information.

Typical bar codes consist of (1) start and stop margins, (2) start and stop characters, (3) information characters, (4) optional check digit, and (5) characters for human-readable interpretation (optional). See Figure 2.1.

Information characters (3)　　　　　　　Check digits (4)

Start character (2)　　　　　　　　　　Stop character (2)

ABC　　　　　　　　　　　　　　　　　DEF

Ordinary characters　　　　　　　　　Ordinary characters

* 1 2 3 4 5 F *

Start margin (1)　　　　　　　　　　　Stop margin (1)

Characters for human-readable interpretation (5)
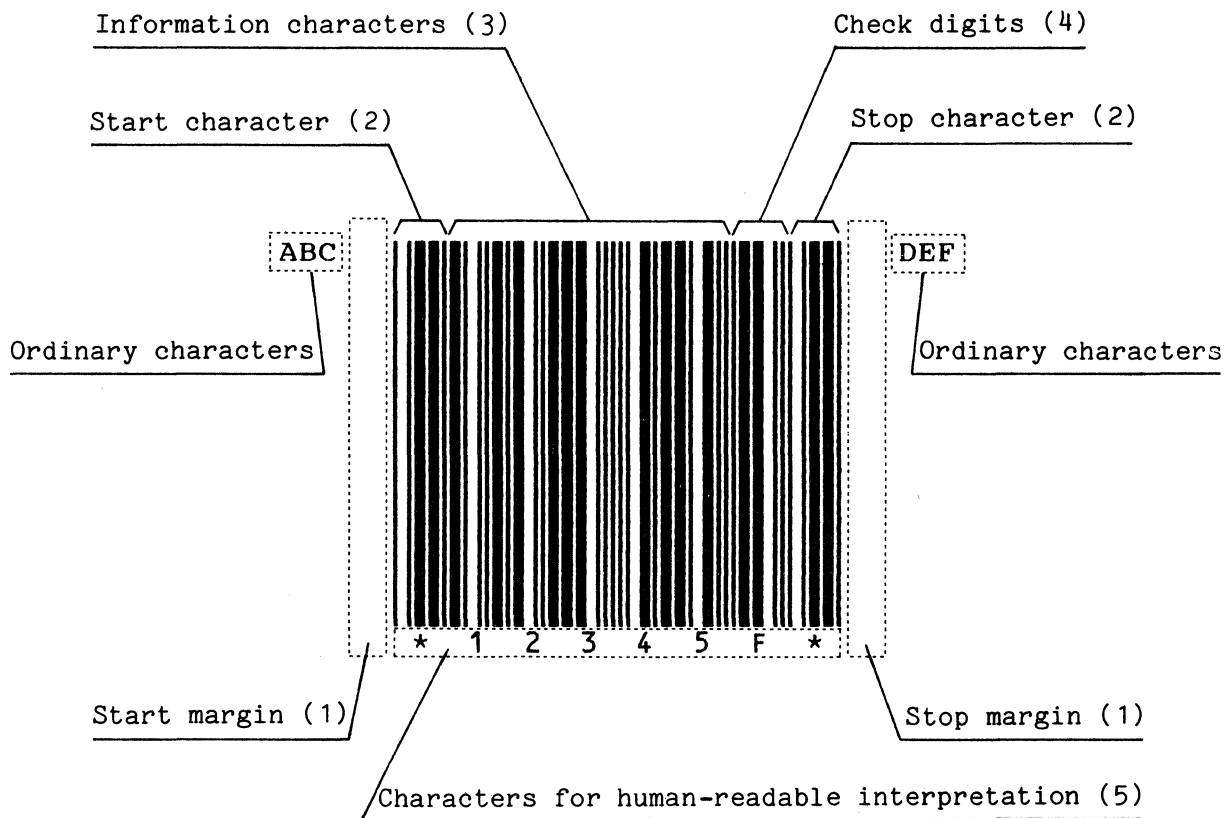
Figure 2.1　Bar code configuration

(1) Start and stop margins must be blank (white) for 0.4 inch or more from the first or the last bar. This area tells the bar code reader when to start reading, or when the end of the bar code is reached.

(2) The start character tells the reader the start of bar-coded information and enables it to distinguish between correct coded bars and random black and white pattern data. The stop character ends a bar code block. The start and stop characters are usually not symmetrical or the same pattern. This makes both forward and reverse scanning possible for most bar code readers.

(3) Information characters are data to be reported to the machine or system. The character set is limited by coding from ordinary ASCII characters. Generally, only numerals (0-9) can be used.

(4) Check digits are optional and help reduce read mistakes. Check digits are compared with the result of calculation predetermined for each coding system.

(5) Characters for human readable interpretation are optional and can be read by an operator the same way as information characters. An unrecoverable read error due, for example, to a stain or poor bar code contrast can be recovered when the operator manually enters characters for human-readable interpretation.

2.2 Bar Coding Classification

Bar coding is mainly classified into two-level coding (module-width encoding) and multiple-level coding (NRZ (non-return-to-zero) encoding).

In two-level coding, the narrow element (bar or space) corresponds to logical 0 and the wide one (bar or space) to logical 1. The wide element is usually two or three times wider than the narrow one. This coding includes the following:

- Codabar
- Code 3 of 9
- Industrial 2 of 5
- Interleaved 2 of 5
- Matrix 2 of 5

In multiple-level coding, the bar corresponds to logical 0 and the space to logical 1. The width of the bar or space is generally limited 1 to 4 times (an integer) of a unit width called a module. The reader must distinguish the difference between 1 to 4 times of bars and spaces, making the tolerance of the size error more severe than in two-level coding. This coding includes the following:

- EAN 13 (European Article Numbering)
- EAN 8 (European Article Numbering)
- UPC Type A (Universal Product Code)

Bar coding also features the following:

- Codable character sets
- Number of elements for each character

3. Bar Code Pattern Printing Command

3.1 Command Format

The command format for bar code pattern printing is as follows:

```
ASCII:        ESC DC4 (b) R (c)(w)(h)(a)(ch1)···(chn)
Decimal:       27  20 (b) 82 (c)(w)(h)(a)(ch1)···(chn)
Hexadecimal:   1B  14 (b) 52 (c)(w)(h)(a)(ch1)···(chn)
```

where lower case letters enclosed in parentheses, like (b), can be replaced with a single-byte parameter code specifying the bar code coding system.

Notes:

1. The most significant bits (MSB) of all parameters are ignored and data 80 (hex) to FF (hex) is treated as 00 (hex) to 7F (hex).

2. The command length varies and is specific by the (b) parameter.

3. R in the command is an identifier. For other than R, the number of bytes specified by (b) is skipped.

4. This command is used only in DPL24C and DPL24I emulation.

3.2 Parameters

3.2.1 Parameter (b) (byte count)

Parameter (b) specifies the number of subsequent bytes, including itself. For example, if n is 5 for (chn) in the command, (b) must be 11 (decimal) or 0B (hex).

3.2.2   Parameter (c) (coding system)

Parameter (c) specifies the type of bar code, i.e., the coding system, printed. See Table 3.1.

Table 3.1   Bar code types

Parameter value	Bar code type
1 (31 (hex))	Codabar (nw-7)
2 (32 (hex))	EAN 13
3 (33 (hex))	EAN 8
4 (34 (hex))	Code 3 of 9
5 (35 (hex))	Industrial 2 of 5
6 (36 (hex))	Interleaved 2 of 5
7 (37 (hex))	Matrix 2 of 5
A (41 (hex))	UPC Type A

When the specified parameter value is other than one given in Table 3.1, the number of bytes specified by (b) is skipped.

3.2.3   Parameter (w) (width of narrow bars)

Parameter (w) specifies the width of narrow bars, in units of 1/1440 inch but barcodes will be printed in units of 1/180 inch.

The printer selects the width closest to the specified width.

Table 3.2 shows the parameter values and corresponding number of dots in narrow bars.

Table 3.2   Number of dots in narrow bars

Parameter value (w) (decimal)	Number of dots (at 180 dpi)
0 to 19	2
20 to 27	3
28 to 127	4

3.2.4   Parameter (h) (bar height)

Parameter (h) specifies the height of bars with relation to the width of narrow bars (parameter (w), above).

Height H is determined as follows:

H = (w) x (h)   Unit: 1/1440 inch

When H is less than 192 (24 dots at 180 dpi), bar codes are printed using the default values (height) in Table 3.3.

Table 3.3   Default values (height)

Narrow bar width	EAN 13 UPC Type A	EAN 8	Other coding
2 dots	0.9 inch (162 dots)	0.7 inch (130 dots)	0.6 inch (108 dots)
3 dots	1.3 inch (234 dots)	1.0 inch (187 dots)	0.75 inch (135 dots)
4 dots	1.7 inch (312 dots)	1.4 inch (249 dots)	0.9 inch (162 dots)

3.2.5   Parameter (a) (bar code attributes)

Parameter (a) specifies items related to the check digit and characters for human-readable interpretation.

Table 3.4 shows items to be specified.   Undefined bits are ignored.

Table 3.4   Check digits

Bit	Specification item	Value	Set value
BIT0 (LSB)	Addition of check digits (*1)	0	Added
		1	Not added
BIT1	Printing of characters for human-readable interpretation (OCR-B)	0	Printed
		1	Not printed
BIT2	Printing position of the flag character (*2) for EAN and UPC coding	0	At the left of bar code
		1	Lower left of bar code

*1   The check digit is always added for EAN and UPC coding.   No check digit is added for Codabar coding regardless of the bit 0 value.
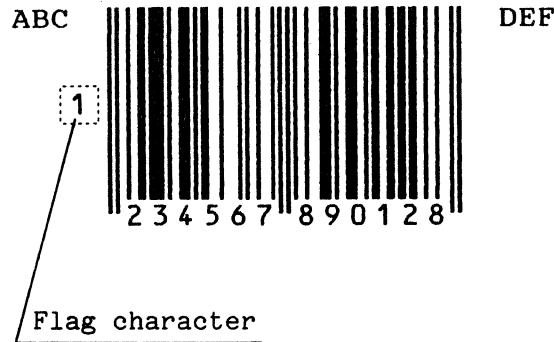*2   Figure 3.1 shows the flag character.

Figure 3.1   Flag character

Characters for human-readable interpretation need not be in a specific font.   Some standards, such as UPC and EAN, require that machine-readable OCR-B characters be used.   Printers described in this manual print characters for human-readable interpretation using the OCR-B font where standards require this.

3.3 Data Contents (ch1)···(chn)

Table 3.5 shows the number of data items and printed character sets.

Table 3.5   Data items and printed character set

Bar code type	Character set	Number of data items (n)
Codabar	Numeric: 0 to 9 Sign: +, -, ., \$, /, : Start/stop: A, a, B, b, C, c, D, d, T, t, N, n, *, E, e	$1 \leq n \leq 34$ including start/stop characters
EAN 13	Numeric: 0 to 9	$n = 12$
EAN 8	Numeric: 0 to 9	$n = 7$
Code 3 of 9	Numeric: 0 to 9 Alphabetic character: A to Z Special characters: +, -, /, %, \$, ., space Start/stop: *	Check-digit add mode $1 \leq n \leq 31$ Check-digit no-add mode $1 \leq n \leq 32$
Industrial 2 of 5	Numeric: 0 to 9	
Interleaved 2 of 5	Numeric: 0 to 9	
Matrix 2 of 5	Numeric: 0 to 9	
UPC Type A	Numeric: 0 to 9	$n = 11$

Data must be in the ASCII characters appropriate to the character set used by each type of bar code.

If a particular data item is to be processed or a character not in the character set is detected, the command is canceled and skipped.

Data contents have the following restrictions:

(1) Codabar

The start/stop code is not checked by the printer and the bar code is printed according to the input data. The user must select the start/stop code shown in Table 3.5 and input it as data. Both uppercase and lower case alphabetic characters can be used for the start/stop code. Characters for human-readable interpretation (OCR-B characters) are printed uppercase.

(2) Code 3 of 9

Only uppercase alphabetic characters can be used. The printer
automatically places the start/stop code (*) preceding and following
the input data. OCR-B characters are printed for the start/stop
code (*). An error occurs if the start/stop code (*) is detected in
the input data.

(3) Interleaved 2 of 5

The bar code composition requires that the number of data digits be
even. For an odd number of data items, the printer prints the bar
code with "0" preceding the input data; the OCR-B character for the
"0" is printed. The printer automatically places the start/stop
code.

3.4   Bar Code Printing

The bar code printing command is treated as a single vertically and
horizontally enlarged character in the printer in relation to other
commands or characters, and can be entered by the user at any point in
the text.

Figure 3.2 shows an example of command use.

EAN 8   1234567

ABC   ‖‖‖‖‖‖‖ ‖‖‖‖‖‖‖ ‖‖ ‖‖‖   DEF

1 2 3 4 5 6 7 0

Figure 3.2   Example of bar code printing command

Note that the bar code pattern is usually larger than ordinary characters
and there are some restrictions:

- If the bar code pattern width exceeds the right margin currently
  set, the bar code is not printed.
- The bar code pattern is printed from the current position even
  though the pattern extends beyond the bottom margin.
- The flag character for EAN and UPC bar coding is not printed if
  the bar code pattern is printed at the left margin without any
  spaces or characters.

Also note the following for printing:

- Selecting a printing color other than black by a command or control panel setting before printing prints the code in the specified color.
- Use a new ribbon to maintain a high contrast in the printed bar code.
- Higher-resolution bar codes printed by this printer may differ slightly from the specification of some standards because of limited printing resolution. Generally, the wider the bar code, the higher the readability ratio. Be sure to check readability with your bar code reader before actual use.

Figures 3.3 and 3.4 show samples of coding.

```
100 '********************************************
110 '*   Bar code print sample program 1        *
120 '*                                          *
130 '*       bar code spec.                     *
140 '*          bar code type  :  codabar       *
150 '*          narrow element :  3 dots        *
160 '*          bar height     :  1 [inch]      *
170 '*          OCR character  :  print         *
180 '*          start code     :  A             *
190 '*          data           :  1234567890    *
200 '*          stop code      :  B             *
210 '********************************************
220 '
230 '       prepare for bar code print
240 '
250 D$ = "A1234567890B"              'set bar code data & ST/SP
260 B = LEN(D$)+6                    'set command length
270 C$ = "1"                        'bar code type = codabar
280 W = 24                          'narrow element = 3 dots
290 HEIGHT = 1440                   'bar height = 1440/1440 [in.]
300 H = INT(HEIGHT/W)               '
310 A = &H0                         'OCR char. print mode = ON
320 '
330 '       print bar code type & data
340 '
350 LPRINT "Codabar",D$             '
360 '
370 '       send bar code command
380 '
390 LPRINT CHR$(&H1B);CHR$(&H14);   'Send ESC,DC4 code
400 LPRINT CHR$(B);                 'Send comman length
410 LPRINT "R";                     '
420 LPRINT C$;CHR$(W);              'Send C,W
430 LPRINT CHR$(H);CHR$(A);         'Send H,A
440 LPRINT D$;                      'Send bar code data
450 LPRINT CHR$(&HC);               'form feed
460 '
470 END
```

Codabar   A1234567890B

A 1 2 3 4 5 6 7 8 9 0 B

Figure 3.3   Sample, program 1

```
100 '*********************************************
110 '*   Bar code print sample program 2       *
120 '*                                          *
130 '*      bar code spec.                      *
140 '*         bar code type   :  EAN 13        *
150 '*         module width    :  3 dots        *
160 '*         bar height      :  1 [inch]      *
170 '*         OCR character   :  print         *
180 '*         data           :  123456789012   *
190 '*********************************************
200 '
210 '        prepare for bar code print
220 '
230 D$ = "123456789012"                    'set bar code data
240 B = LEN(D$)+6                          'set command length
250 C$ = "2"                               'bar code type = EAN 13
260 W = 24                                 'module width = 3 dots
270 HEIGHT = 1440                          'bar height = 1440/1440 [in.]
280 H = INT(HEIGHT/W)                      '
290 A = &H0                                'OCR char. print mode = ON
300 '
310 '        print bar code type & data
320 '
330 LPRINT "EAN 13",D$                     '
340 '
350 '        send bar code command
360 '
370 LPRINT "   ";                          'make space for Flag char.
380 LPRINT CHR$(&H1B);CHR$(&H14);          'Send ESC,DC4 code
390 LPRINT CHR$(B);                        'Send command length
400 LPRINT "R";                            '
410 LPRINT C$;CHR$(W);                     'Send C,W
420 LPRINT CHR$(H);CHR$(A);                'Send H,A
430 LPRINT D$;                             'Send bar code data
440 LPRINT CHR$(&HC);                      'form feed
450 '
460 END
```

EAN 13   123456789012

Figure 3.4   Sample, program 2

4. Module Width Encoding

Binary bar codes represent characters by using patterns of narrow and wide bars and spaces.

The width of narrow bars is specified by parameter (w) (width of the narrow bar) in units of 1/1440 inch. The printer converts this to the number of 1/180 inch dots, then prints the narrow bars. The number of dots in wide bars is three times that in narrow bars.

This type of encoding is used for the following:

- Codabar
- Code 3 of 9
- Industrial 2 of 5
- Interleaved 2 of 5
- Matrix 2 of 5

Specifications are given in the sections that follows.

4.1 Codabar


```
A 1 2 3 4 5 6 7 8 9 0 B
```
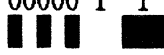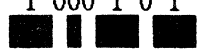
D1	D2	D3	...	Dn
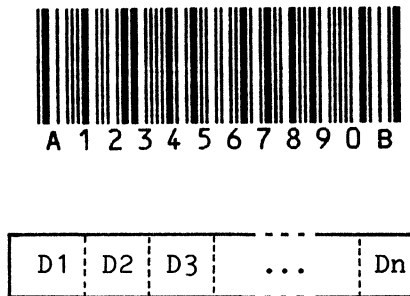
D1···Dn: Input data, (n: 1 to 34)
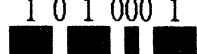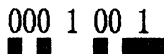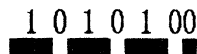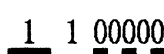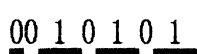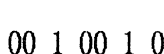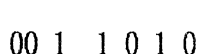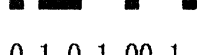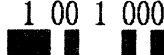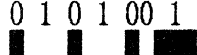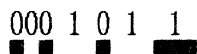
Figure 4.1 Codabar

Each character consists of four bars and three spaces. Characters are separated by narrow spaces.

A/T, B/N, C/* and D/E are start/stop characters, and can be used in any combination. The printer does not check start/stop characters because they are included in the input data. It prints them according to the input data.

Table 4.1 shows 7-bit codes and bar code patterns corresponding to each character.

Table 4.1   Codabar encoding

Character	7-bit code and bar code pattern	Character	7-bit code and bar code pattern
0	00000 1 1	:	1 000 1 0 1
1	0000 1 1 0	/	1 0 1 000 1
2	000 1 00 1	.	1 0 1 0 1 00
3	1 1 00000	+	00 1 0 1 0 1
4	00 1 00 1 0	A a	00 1 1 0 1 0
5	1 0000 1 0	B b	0 1 0 1 00 1
6	0 1 0000 1	C c	000 1 0 1 1
7	0 1 00 1 00	D d	000 1 1 1 0
8	0 1 1 0000	T t	00 1 1 0 1 0
9	1 00 1 000	N n	0 1 0 1 00 1
—	000 1 1 00	*	000 1 0 1 1
$	00 1 1 000	E e	000 1 1 1 0

```
*  1 2 3 4 5 F  *
```

*	D1	D2	D3	....	Dn	*
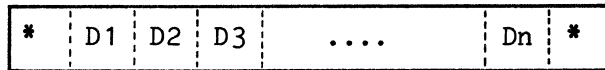
*:   Start/stop character
D1···Dn: Input data (n: 1 to 32)

or

*	D1	D2	D3	....	Dn	CD	*
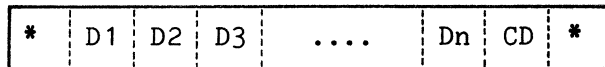
*:   Start/stop character
D1···Dn: Input data (n: 1 to 31)
CD: Check digit

Figure 4.2   Code 3 of 9

Each character consists of five bars and four spaces.   Characters are separated by narrow spaces.

Table 4.2 shows 7-bit codes and bar code patterns corresponding to each character.

Table 4.2   Encoding for Code 3 of 9

Character	9-bit code and bar code pattern	Character	9-bit code and bar code pattern
1	1 00 1 0000 1	C	1 0 1 00 1 000
2	00 1 1 0000 1	D	0000 1 1 00 1
3	1 0 1 1 00000	E	1 000 1 1 000
4	000 1 1 000 1	F	00 1 0 1 1 000
5	1 00 1 1 0000	G	00000 1 1 0 1
6	00 1 1 1 0000	H	1 0000 1 1 00
7	000 1 00 1 0 1	I	00 1 00 1 1 00
8	1 00 1 00 1 00	J	0000 1 1 1 00
9	00 1 1 00 1 00	K	1 000000 1 1
0	000 1 1 0 1 00	L	00 1 0000 1 1
A	1 0000 1 00 1	M	1 0 1 0000 1 0
B	00 1 00 1 00 1	N	0000 1 00 1 1

Table 4.2 - continued

Character	9-bit code and bar code pattern	Character	9-bit code and bar code pattern
O	1 000 1 00 1 0	Y	1 1 00 1 0000
P	00 1 0 1 00 1 0	Z	0 1 1 0 1 0000
Q	000000 1 1 1	—	0 1 0000 1 0 1
R	1 00000 1 1 0	.	1 1 0000 1 00
S	00 1 000 1 1 0	SPACE	0 1 1 000 1 00
T	0000 1 0 1 1 0	*	0 1 00 1 0 1 00
U	1 1 000000 1	$	0 1 0 1 0 1 000
V	0 1 1 00000 1	/	0 1 0 1 000 1 0
W	1 1 1 000000	+	0 1 000 1 0 1 0
X	0 1 00 1 000 1	%	000 1 0 1 0 1 0

The check digit (optional) is placed by the printer in check digit add mode. Start/stop characters (*) are also placed by the printer.

The check digit is calculated as follows:

(1) Determine the value of each character based on Table 4.3 and add them.

Table 4.3   Character values

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

(2) Divide the total by 43, and obtain the remainder.

(3) Find the character that corresponds to this remainder.

(4) That character is the check digit.
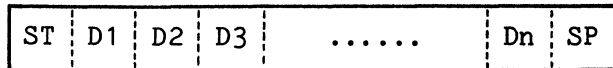
```
123457
```

```
| ST | D1 | D2 | D3 |   ......   | Dn | SP |
```

ST: Start character
D1···Dn: Input data (n: 1 to 32)
SP: Stop character

or

```
| ST | D1 | D2 | D3 |   ....   | Dn | CD | SP |
```
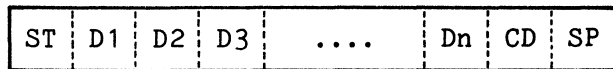
ST: Start character
D1···Dn: Input data (n: 1 to 31)
CD: Check digit
SP: Stop character

Figure 4.3   Industrial 2 of 5

Each character consists of five bars and four spaces and is represented by patterns of bars with different widths (the space has no meaning). Characters are separated by narrow spaces.

Tables 4.4 shows 5-bit codes and bar code patterns corresponding to each character.

Table 4.4   Encoding for Industrial 2 of 5

Char-acter	5-bit code and bar code pattern	Char-acter	5-bit code and bar code pattern
ST	1 1 0	4	0 0 1 0 1
SP	1 0 1	5	1 0 1 0 0
0	0 0 1 1 0	6	0 1 1 0 0
1	1 0 0 0 1	7	0 0 0 1 1
2	0 1 0 0 1	8	1 0 0 1 0
3	1 1 0 0 0	9	0 1 0 1 0

The check digit (optional) is placed by the printer in check digit add mode. For check digit calculation, see Section 4.6. Start/stop (ST/SP) characters are also placed by the printer.

0123456784


```
┌────┬────┬────┬────┬───────────────┬────┬────┐
│ ST │ D1 │ D2 │ D3 │     ......    │ Dn │ SP │
└────┴────┴────┴────┴───────────────┴────┴────┘
```

ST: Start character
D1···Dn: Input data (n: 1 to 32)
SP: Stop character

or

```
┌────┬────┬────┬────┬───────────┬────┬────┬────┐
│ ST │ D1 │ D2 │ D3 │    ....   │ Dn │ CD │ SP │
└────┴────┴────┴────┴───────────┴────┴────┴────┘
```
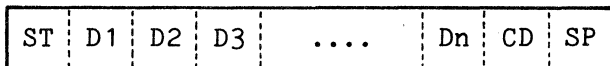
ST: Start character
D1···Dn: Input data (n: 1 to 31)
CD: Check digit
SP: Stop character

Figure 4.4   Interleaved 2 of 5

Odd-numbered characters are encoded by bar width and even-numbered characters are encoded by space width. See Figure 4.5.
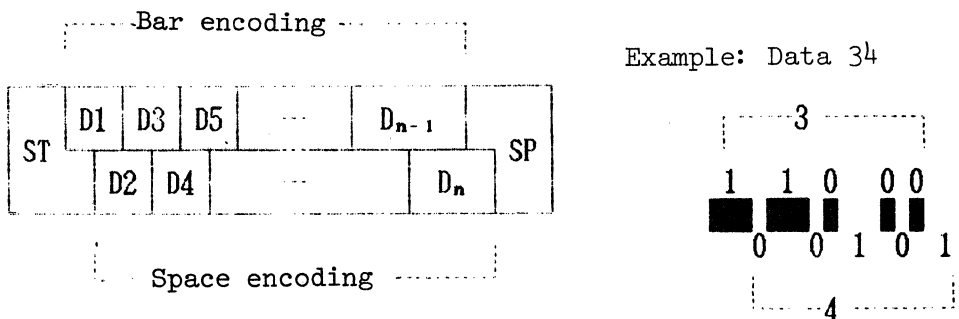
Figure 4.5   Example of bar and space encoding

There is no space between characters, and the number of data items must be even. For an odd number of input data characters and check digits (optional), the printer prints the bar code with "0" preceding the input data.

The check digit (optional) is placed by the printer in check digit add mode.

For check digit calculation, see Section 4.6.

Table 4.5   Encoding for Interleaved 2 of 5

	Odd-numbered character (bar-encoded)	Even-numbered character (space-encoded)
0	0 0 1 1 0	0 0 1 1 0
1	1 0 0 0 1	1 0 0 0 1
2	0 1 0 0 1	0 1 0 0 1
3	1 1 0 0 0	1 1 0 0 0
4	0 0 1 0 1	0 0 1 0 1
5	1 0 1 0 0	1 0 1 0 0
6	0 1 1 0 0	0 1 1 0 0
7	0 0 0 1 1	0 0 0 1 1
8	1 0 0 1 0	1 0 0 1 0
9	0 1 0 1 0	0 1 0 1 0
ST	0000	
SP	1 00	
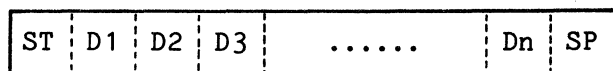
12345678905

ST	D1	D2	D3	......	Dn	SP

ST: Start character
D1···Dn: Input data (n: 1 to 32)
SP: Stop character

or

ST	D1	D2	D3	....	Dn	CD	SP
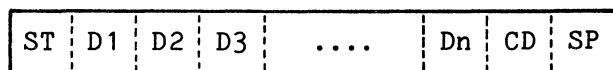
ST: Start character
D1···Dn: Input data (n: 1 to 31)
CD: Check digit
SP: Stop character

Figure 4.6   Matrix 2 of 5
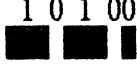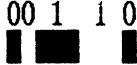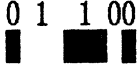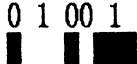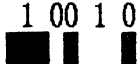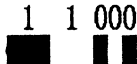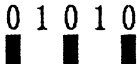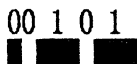
Each character consists of three bars and two spaces and is represented by the width of these bars and spaces.   Characters are separated by narrow spaces.
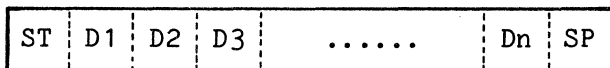Table 4.6 shows 5-bit codes and bar code patterns corresponding to each character.
Check digits (optional) are placed by the printer in check digit add mode. For check digit calculation, see Section 4.6.
Start/stop (ST/SP) characters are placed by the printer.

Table 4.6   Encoding for Matrix 2 of 5

Character	5-bit code and bar code pattern	Character	5-bit code and bar code pattern
ST/SP	1 0000 ▮ ▮ ▮	5	1 0 1 00 ▮ ▮ ▮
0	00 1 1 0 ▮ ▮ ▮	6	0 1 1 00 ▮ ▮ ▮
1	1 000 1 ▮ ▮ ▮	7	000 1 1 ▮▮ ▮
2	0 1 00 1 ▮ ▮ ▮	8	1 00 1 0 ▮ ▮ ▮
3	1 1 000 ▮ ▮▮	9	0 1 0 1 0 ▮ ▮ ▮
4	00 1 0 1 ▮ ▮ ▮		

4.6   Check Digit Calculation for Industrial 2 of 5, Interleaved 2 of 5,
      and Matrix 2 of 5

The check digit for Industrial 2 of 5, Interleaved 2 of 5, and Matrix 2
of 5 is calculated as follows:

Step 1:   Total the values of characters at odd-numbered
          positions.

Step 2:   Total the values of characters at even-numbered
          positions and multiply the total by three.

Step 3:   Add the results obtained in steps 1 and 2.

Step 4:   Find the multiple of 10 that is larger than and
          closest to the number obtained in step 3.   The
          difference between this multiple and the number
          obtained in step 3 is the value of the check
          digit.

	Data character										CD
Sample coding	0	1	2	3	4	5	6	7	8	9	5
Even-numbered position	/	1	+	3	+	5	+	7	+	9	
Odd-numbered position	0	+	2	+	4	+	6	+	8	/	

Step 1:   20
Step 2:   +) 25 x 3 = 75
Step 3:   95
Step 4:   100 - 95 = 5 --

Figure 4.7   Check digit calculation

4.7 Bar Code Printing
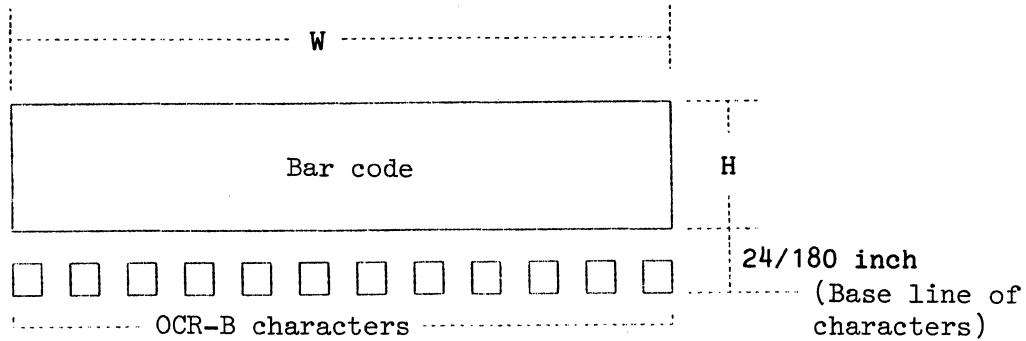
Figure 4.8   Bar code printing

Value W is given based on the type of bar code, width of module (narrow bar), and number of characters. See Table 4.7.

Table 4.7   Bar code width

Encoding	Width of bar code: W
Codabar	(M x 12 + 4) x n1 + (M x 14 + 4) x n2 - (M + 1)
Code 3 of 9	(M x 16 + 5) x (n + 2) - (M + 1)
Industrial 2 of 5	(M x 14 + 5) x n + (M x 19 + 5)
Interleaved 2 of 5	(M x 9 + 2.5) x n + (M x 9 + 3)
Matrix 2 of 5	(M x 10 + 3) x n + (M x 15 + 5)

M: Width of the narrow bar specified by parameter (w)

n: Number of characters without start/stop characters

n1 for Codabar: Number of numerals, "-", and "$" symbols

n2 for Codabar: Number of ":", "/", ".", "+", and start/stop characters

Value H is specified by parameters (w) and (h).

☐ indicates the printing position of OCR-B characters.

The center line of the OCR-B characters is generally aligned with the center line of the corresponding bar code.

5. NRZ Encoding

Four different widths of bars and spaces are used for NRZ (non-return-to-zero) encoding. EAN (European Article Numbering), UPC (Universal Product Code), and other codes use NRZ encoding. The minimum unit of bars and spaces is called a module. Parameter (w) (narrow bar width) specifies the width of the module. To ensure that reading is correct, note the following:

- The width of bars and spaces that have the same number of modules must be the same.
- The width of bars and spaces must be in proportion to the number of modules.

Table 5.1 shows the widths of modules and the number of print dots (360 dpi) for bars and spaces.

Table 5.1   Module width and print dots

	$1 \leq$ (w) $\leq$ 19	$20 \leq$ (w) $\leq$ 27	$28 \leq$ (w) $\leq$ 127
1-module width	5/360 inch	7/360 inch	9/360 inch
1-module bar	3 dots	5 dots	7 dots
2-module bar	8 dots	12 dots	16 dots
3-module bar	13 dots	19 dots	25 dots
4-module bar	18 dots	26 dots	34 dots
1-module space	7 dots	9 dots	11 dots
2-module space	12 dots	16 dots	20 dots
3-module space	17 dots	23 dots	29 dots
4-module space	22 dots	30 dots	38 dots

Dot pitch: 1/360 inch
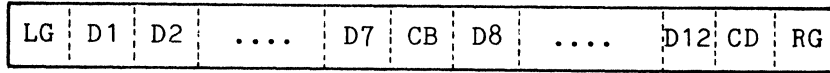
LG: Left guard bar
D1···D12: Input data
CB: Center bar
CD: Check digit
RG: Right guard bar
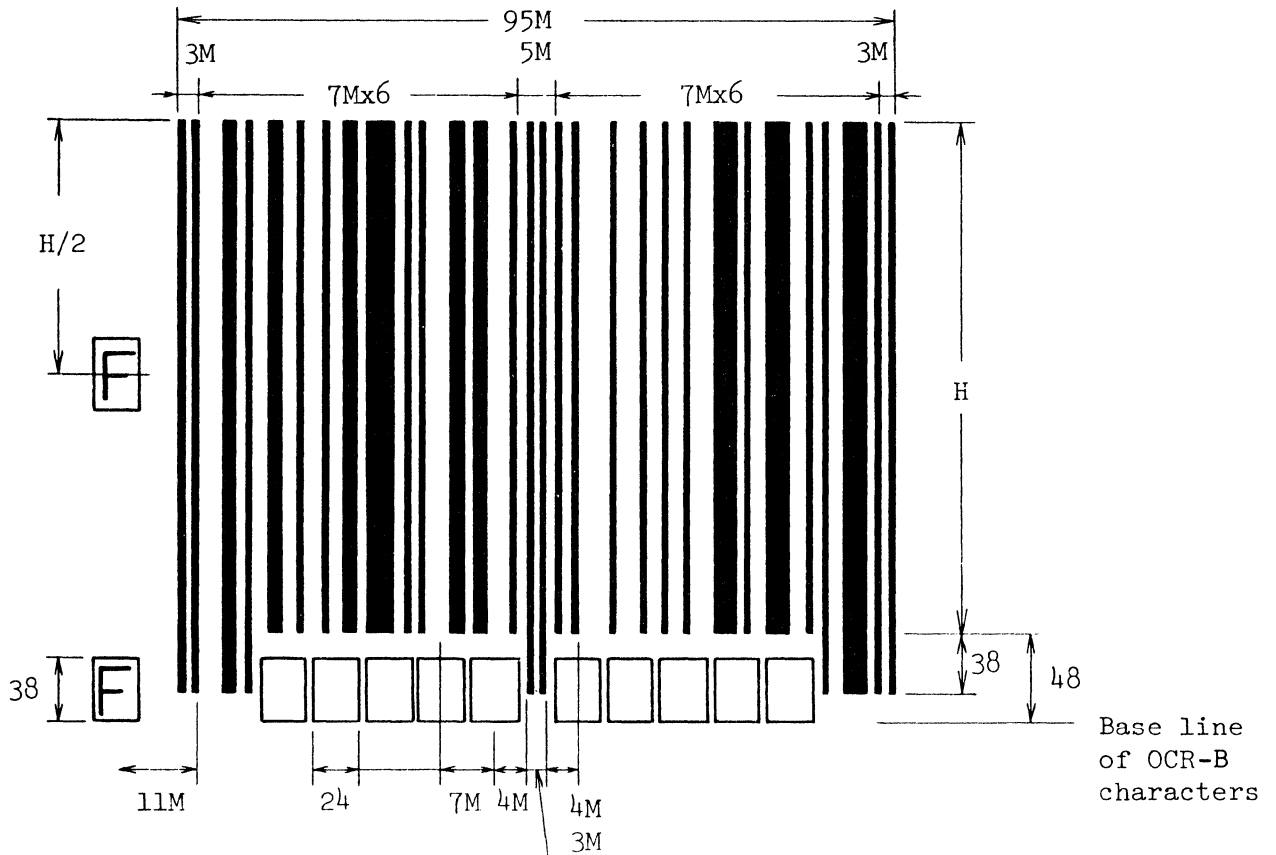
Notes:

1.   Unit: 1/360 inch
2.   M: 1 module wide (See Table 5.1.)
3.   H: Height of the bar code specified by parameter 3
4.   ☐ : Printing position of OCR-B characters
5.   F : Flag character selectable from two positions in the figure

Figure 5.1   Print size (EAN 13)

As shown in Figure 5.1, EAN 13 consists of the following (total bar code width: 95 modules):

- Left guard bar: 3 modules
- Left-side data characters (D2 to D7):   42 modules
- Center bar: 5 modules
- Right-side data characters (D8 to D12): 35 modules
- Check digit (CD):   7 modules
- Right guard bar: 3 modules

Input data D1 is represented as a flag character by the parity pattern of the left-side data characters (D2 to D7) (Table 5.2).

Input data D2 to D7 are represented by the left-side data characters. Input data D8 to D12 and the check digit (CD) are represented by the right-side data characters (Table 5.2).

When OCR-B characters are to be printed:

- Input data D1 is indicated by OCR-B characters at left center or lower left of the bar code which is called the flag character.
- Input data D1 to D12 and the check digit (CD) are indicated by OCR-B characters under the corresponding bar code.
- Guard bars extend down to approximately the middle of the OCR-B characters (Figure 5.1).
- If the printing position of the flag character is not within the specified printing area of the printer, the flag character is not printed.

(1) Left and right guard bars

The left and right guard bars consist of two bars and one space.
The bars and space are each one module wide.
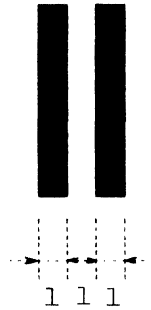
Figure 5.2   Left and right guard bars (EAN 13)

(2) Center guard bar

The center guard bar consists of two bars and three spaces. The
bars and spaces are each one module wide.
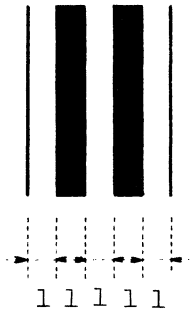
Figure 5.3   Center guard bar (EAN 13)

(3) Data characters

To encode D1=5, for example, "0 E E 0 0 E" is read out from column
for D1 and character 5 in the table. In obendience to this, D2 data
is coded with an odd parity and D3 data with an even parity. The D1
character is thus encoded by the bars for D2 to D7 data. Data for
D8 to D12 and CD is encoded as shown in Table 5.2.

Table 5.2   Data characters (EAN 13)

D1 ‖ D2 D3 D4 D5 D6 D7 ‖ D8 D9 D10 D11 D12 CD ‖

Character	Parity pattern according to D1 character value						Left-side data character		Right-side data character
	D2	D3	D4	D5	D6	D7	Odd number parity (O)	Even number parity (E)	Even number parity (E)
0	0	0	0	0	0	0	0001101	0100111	1110010
1	0	0	E	0	E	E	0011001	0110011	1100110
2	0	0	E	E	0	E	0010011	0011011	1101100
3	0	0	E	E	E	0	0111101	0100001	1000010
4	0	E	0	0	E	E	0100011	0011101	1011100
5	0	E	E	0	0	E	0110001	0111001	1001110
6	0	E	E	E	0	0	0101111	0000101	1010000
7	0	E	0	E	0	E	0111011	0010001	1000100
8	0	E	0	E	E	0	0110111	0001001	1001000
9	0	E	E	0	E	0	0001011	0010111	1110100

O: Odd parity
E: Even parity
0 (zero): Spaces 1 module wide
1: Bars 1 module wide

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The check digit for EAN 13 is calculated as follows:

Step 1: Total the values of characters at even-numbered positions (D2, D4, D6, D8, D10, D12) starting from the rightmost character and going left.

Step 2: Multiply the total obtained in step 1 by three.

Step 3: Total the values of characters at odd-numbered positions (D1, D3, D5, D7, D9, D11).

Step 4: Add the results obtained in steps 2 and 3.

Step 5: Find the multiple of 10 that is larger than and closest to the value obtained in step 4. The difference between this value and the value obtained in step 4 is the value of the check digit.

Character position	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	CD
Character number	13	12	11	10	9	8	7	6	5	4	3	2	1
Sample code	1	0	7	6	2	2	1	3	5	7	4	6	⑧
Even-numbered position		0	+	6	+	2	+	3	+	7	+	6	
Odd-numbered position	1	+	7	+	2	+	1	+	5	+	4		

```
        ┌────────┐      ┌────────┐
        │ Step 1 │      │ Step 2 ├ - - - - ┐
        └───┬────┘      └───┬────┘         │
            │               │              │
           24      x        3      =      72
┌────────┐
│ Step 3 ├ - - - - - - - - - - - - - - - +)  20
└────────┘                               ─────
        ┌────────┐
        │ Step 4 ├ - - - - - - - - - - - -  92
        └────────┘
┌────────┐
│ Step 5 ├ - - - - 100 - 92 = 8 - - - - - - - - -
└────────┘
```
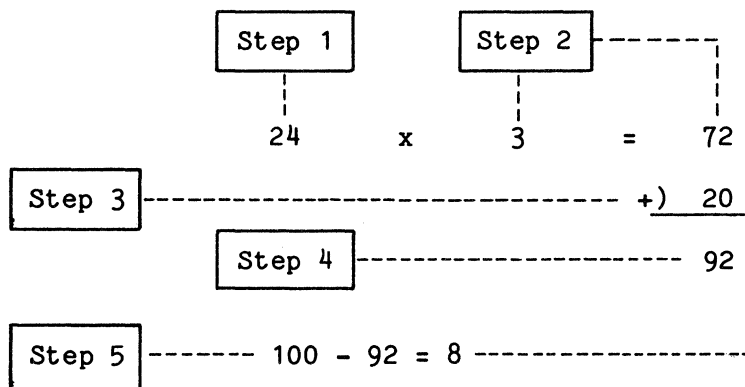
Figure 5.4   Check digit calculation (EAN 13)

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LG	D1	D2	D3	D4	CB	D5	D6	D7	CD	RG
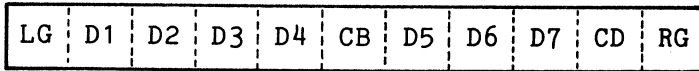
LG: Left guard bar
D1···D7: Input data
CB: Center bar
CD: Check digit
RG: Right guard bar
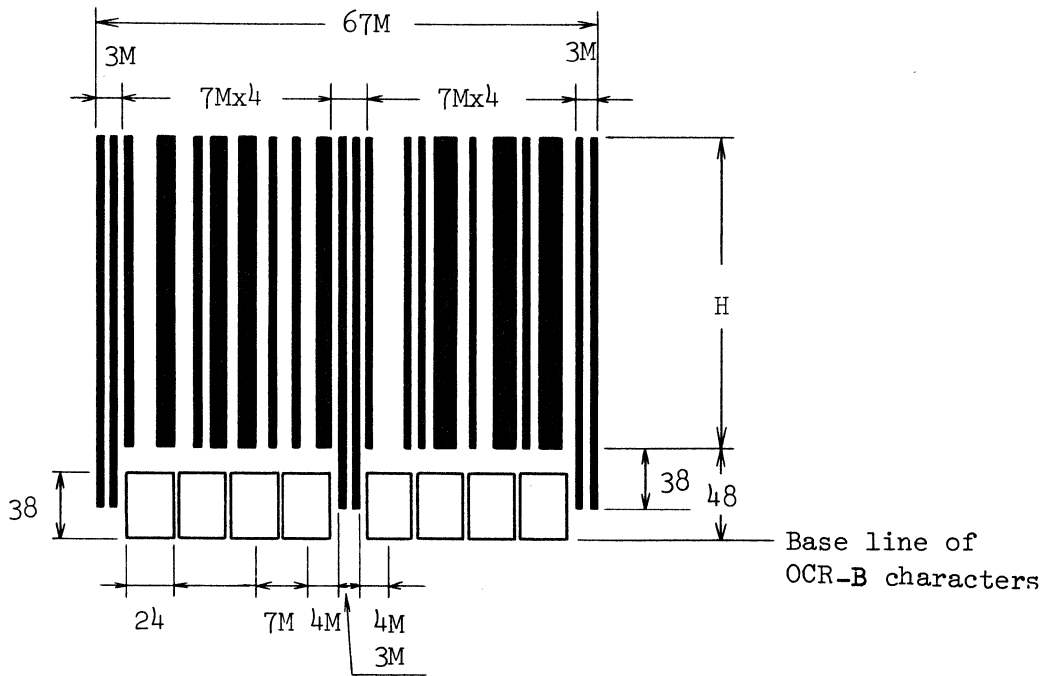
Notes:

1. Unit: 1/360 inch
2. M: 1 module wide (See Table 5.1.)
3. H: Height of the bar code specified by parameter 3
4. □ : Printing position of OCR-B characters

Figure 5.5   Print size (EAN 8)

As shown in Figure 5.5, EAN 8 consists of the following (total bar code width: 67 modules):

- Left guard bar: 3 modules
- Left-side data characters (D1 to D4):   28 modules
- Center bar: 5 modules
- Right-side data characters (D5 to D7):   21 modules
- Check digit (CD):   7 modules
- Right guard bar: 3 modules

Input data D1 to D4 are represented by the left-side data characters. Input data D5 to D7 and the check digit (CD) are represented by the right-side data characters (Table 5.3).

When OCR-B characters are to be printed:

- Input data D1 to D7 and the check digit (CD) are indicated by OCR-B characters under the corresponding bar code.
- Guard bars extend down to approximately the middle of the OCR-B characters (Figure 5.5).

(1)   Left and right guard bars

The left and right guard bars consist of two bars and one space. The bars and space are each one module wide.

1 1 1

Figure 5.6   Left and right guard bars (EAN 8)

(2) Center guard bar

The center guard bar consists of two bars and three spaces. The bars and spaces are each one module wide.
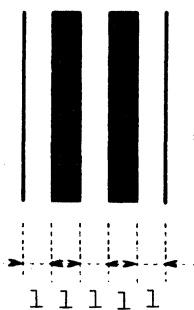
1 1 1 1 1

Figure 5.7   Center guard bar (EAN 8)

(3) Data characters

Table 5.3   Data characters (EAN 8)

‖ D1   D2   D3   D4 ‖ D5   D6   D7   CD ‖

Character	Left-side data character Odd number parity (O)	Right-side data character Even number parity (E)
0	0001101	1110010
1	0011001	1100110
2	0010011	1101100
3	0111101	1000010
4	0100011	1011100
5	0110001	1001110
6	0101111	1010000
7	0111011	1000100
8	0110111	1001000
9	0001011	1110100

O: Odd parity
E: Even parity
0 (zero): Spaces 1 module wide
1: Bars 1 module wide

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Check digit is calculated as follows:

Step 1: Total the values of characters at even-numbered positions (D1, D3, D5, D7) starting from the rightmost character and going left.

Step 2: Multiply the total obtained in step 1 by three.

Step 3: Total the values of characters at odd-numbered positions (D2, D4, D6).

Step 4: Add the total obtained in step 2 and that in step 3.

Step 5: Find the multiple of 10 that is larger than and closest to the value obtained in step 4. The difference between this multiple and the value obtained in step 4 is the value of the check digit.

Character position	D1	D2	D3	D4	D5	D6	D7	CD
Character number	8	7	6	5	4	3	2	1
Sample code	1	0	7	6	2	2	1	⑨
Even-numbered position	1	+	7	+	2	+	1	
Odd-numbered position		0	+	6	+	2		

Step 1   Step 2

11   x   3   =   33

Step 3 ------------------------------------ +)   8

Step 4 ------------------------------ 41

Step 5 -------- 50 - 41 = 9 --------------------------------
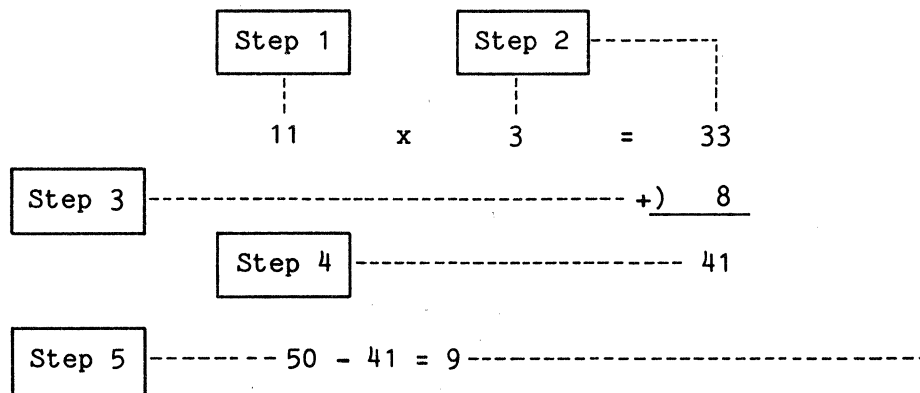
Figure 5.8   Check digit calculation (EAN 8)

5.3   UPC Type A


```
┌────┬────┬────┬────┬────┬────┬────┬────┬─────┬────┬────┐
│ LG │ D1 │ D2 │ .. │ D6 │ CB │ D7 │ .. │ D11 │ CD │ RG │
└────┴────┴────┴────┴────┴────┴────┴────┴─────┴────┴────┘
```
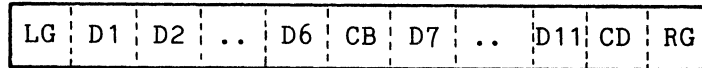
LG: Left guard bar
D1···D11:   Input data
CB: Center bar
CD: Check digit
RG: Right guard bar
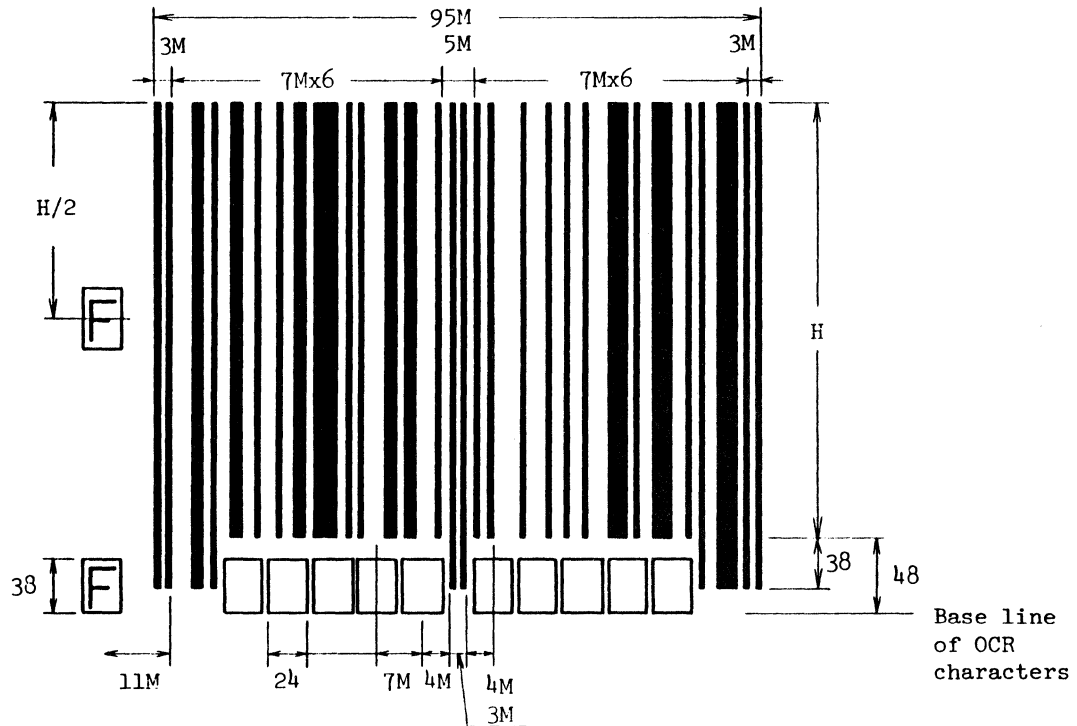
Notes:

1.   Unit: 1/360 inch
2.   M: 1 module wide (See Table 5.1.)
3.   H: Height of the bar code specified by parameter 3
4.   ☐ :   Printing position of OCR-B characters
5.   F :   Flag character selectable from two positions in the figure

Figure 5.9   Print size (UPC Type A)

As shown in Figure 5.9, UPC type A consists of the following (total bar code width: 95 modules):

- Left guard bar: 3 modules
- Left-side data characters (D1 to D6):   42 modules
- Center bar: 5 modules
- Right-side data characters (D7 to D11): 35 modules
- Check digit (CD):   7 modules
- Right guard bar: 3 modules

Input data D1 to D6 are represented by the left-side data characters. Input data D7 to D11 and the check digit (CD) are represented by the right-side data characters (Table 5.4).

When OCR-B characters are to be printed:

- Input data D1 is indicated by OCR-B characters at left center or lower left of the bar code which is called the flag character.
- Input data D1 to D11 and the check digit (CD) are indicated by OCR-B characters under the corresponding bar code.
- Guard bars and bar codes corresponding to D1 and CD extend down to approximately the middle of the OCR-B characters (Figure 5.9).
- If the printing position of the flag character is not within the specified printing area of the printer, the flag character is not printed.

(1) Left and right guard bars

The left and right guard bars consist of two bars and one space. The bars and spaces are each one module wide.
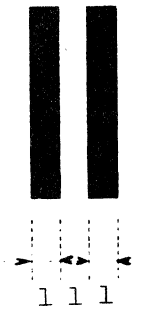
Figure 5.10   Left and right guard bars (UPC Type A)

(2) Center guard bar

The center guard bar consists of two bars and three spaces. The
bars and spaces are each one module wide.
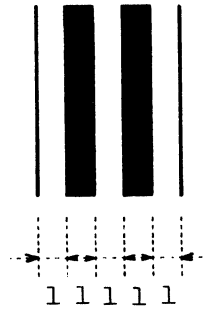
Figure 5.11   Center guard bar (UPC Type A)

(3) Data characters

Table 5.4 Data characters (UPC Type A)

‖ D1 D2 D3 D4 D5 D6 ‖ D7 D8 D9 D10 D11 CD ‖

Character	Left-side data character Odd number parity (O)	Right-side data character Even number parity (E)
0	0001101	1110010
1	0011001	1100110
2	0010011	1101100
3	0111101	1000010
4	0100011	1011100
5	0110001	1001110
6	0101111	1010000
7	0111011	1000100
8	0110111	1001000
9	0001011	1110100

O: Odd parity
E: Even parity
0: Spaces 1 module wide
1: Bars 1 module wide

The check digit for UPC Type A is calculated as follows:

Step 1: Total the values of characters at even-numbered positions (D1, D3, D5, D7, D9, D11) starting from the rightmost character and going left.

Step 2: Multiply the total obtained in step 1 by three.

Step 3: Total the values of characters at odd-numbered positions (D2, D4, D6, D8, D10).

Step 4: Add the results obtained in steps 2 and 3.

Step 5: Find the multiple of 10 that is larger than and closest to the value obtained in step 4. The difference between this value and the value obtained in step 4 is the value of the check digit.

Character position	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	CD
Character number	12	11	10	9	8	7	6	5	4	3	2	1
Sample code	1	0	7	6	2	2	1	3	5	7	6	⑥
Even-numbered position	1	+	7	+	2	+	1	+	5	+	6	
Odd-numbered position		0	+	6	+	2	+	3	+	7		

Step 1 ──── 22
Step 2 ──── x 3 = 66
Step 3 ────────────────────── +) 18
Step 4 ──────────────────── 84
Step 5 ──────── 90 − 84 = 6 ────────────────

Figure 5.12   Check digit calculation (UPC Type A)

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