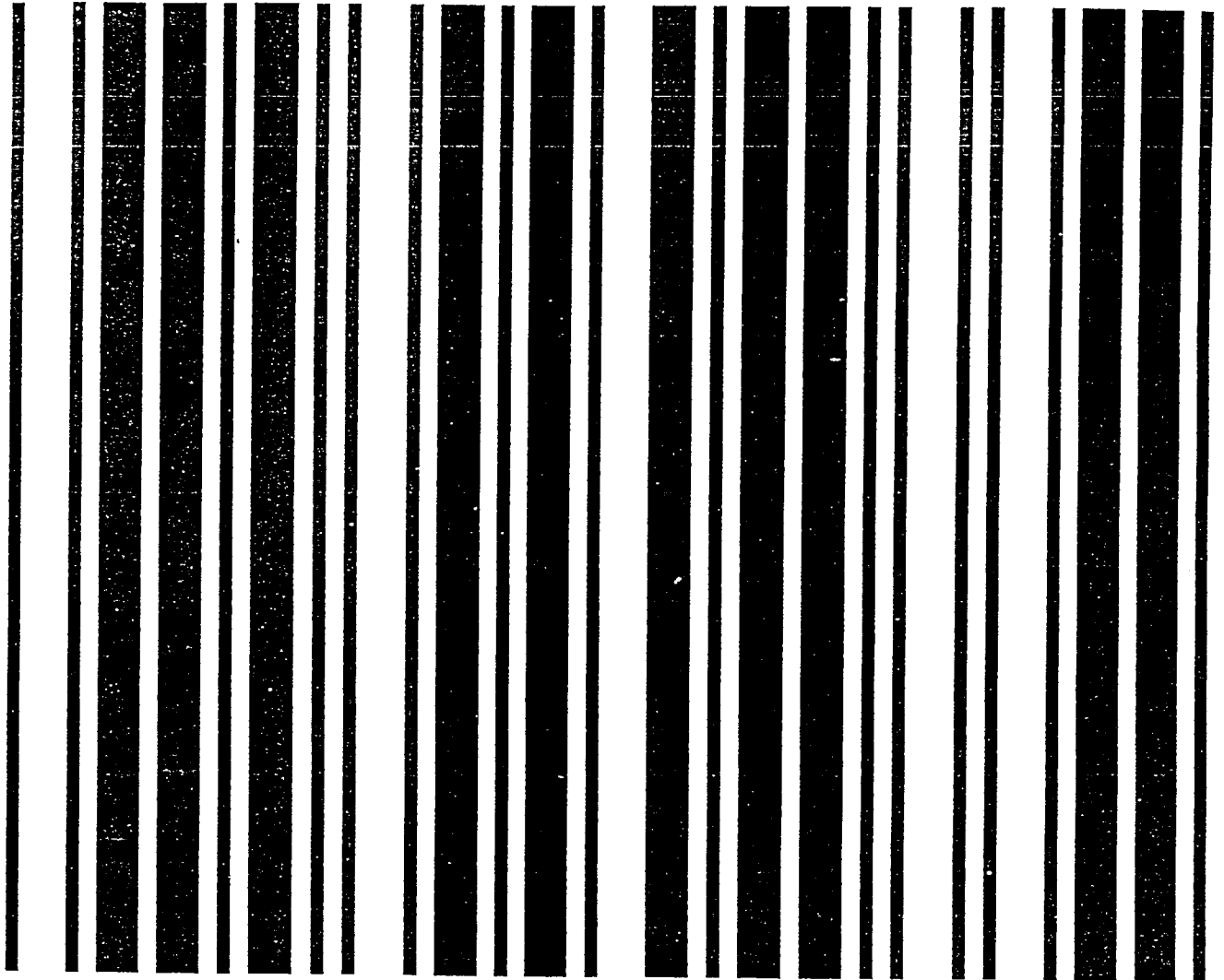




CODE 128

Uniform Symbology Specification

CAUTION: This Uniform Symbol Specification may be revised or withdrawn at any time. Work currently being undertaken by ANSI may require the revision of Section 4.0 Optical Specification. This edition was published in April 1989.

AIM Europe and AIM USA have made every effort to ensure that this Uniform Symbology Specification is correct, but no representation or warranty, express or implied, to that effect is made.

In addition no warranty or representation is made that this Specification will not require modification due to developments in technology.

NOTE: To utilize a bar code symbology in a scanning system it is always necessary—even in a closed system—to have an application standard which specifies the parameters (e.g. X dimension, wavelength, etc.) at which the system should operate. It is this application standard to which bar coding equipment and services should conform.

This Uniform Symbol Specification (USS) was developed by the AIM USA Technical Symbology Committee and revised for the European market by AIM Europe's Pan-European Technical Literature Committee. It is technically equivalent to the original USS specification.

The Uniform Symbol Specifications are intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of this USS does not in any respect preclude anyone from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the specification.

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1.0 Introduction

Code 128 is a bar code symbology with 106 symbol characters; precise rules enable the full ASCII 128 character set to be encoded. It also allows numeric data to be represented in a compact double-density mode, two digits for every character. There are four additional non-data function characters which have major significance with respect to systems applications. Function character 1 (FNC 1) is reserved exclusively for EAN/UCC use. By agreement between AIM and the EAN/UCC authorities in 1988 all other uses of function character 1 are prohibited, except in the specific instance where it is the symbol character corresponding with the calculated value of the symbol check character.

Every data character in Code 128 is constructed of eleven modules arranged into three bars and three spaces. In addition the bars always make up an even number of modules (even parity) in total, and the spaces make up an odd number of modules. The exterior bars of Code 128 symbols contain two modules, which facilitates the reading of high-density symbols by many readers.

Every Code 128 symbol uses two independent self-checking features: character self-checking via parity, and a modulo 103 check character. This minimizes the possibility of reader substitution errors. Code 128's characteristics are summarized in Table 1.

Table 1
Characteristics of Code 128

Encodable Character Set – All 128 ASCII Characters
4 Non-data Function Characters
4 Code Set Selection Characters
3 Start Characters
1 Stop Character
Code Type – Continuous
Character Self-checking – Yes
Symbol Length – Variable
Bidirectional Decoding – Yes
Number of Check Characters Required – 1
Smallest Nominal Element – 0.191 mm (0.0075 inch)
Maximum Data Character Density –
4.77 char./cm
(12.12 char./inch)
For double-density numeric mode:
9.54 numeric char./cm
(24.24 numeric char./inch)
Non-data Overhead – Equivalent of 3.18 alphanumeric characters
Additional Features – Double Module Exterior Bar Element

2.0 Symbol Description

2.1 Symbol Structure

Each Code 128 symbol consists of a series of bar coded characters framed by clear areas called quiet zones. The bar coded character series begins with a unique start character, followed by data and special characters with the most significant adjacent to the start character, then the check character, and finally the unique stop character.

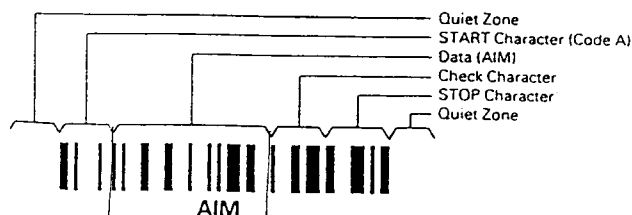


Figure 1. Code 128 symbol encoding AIM

Function character 1, reserved for EAN/UCC use, always appears immediately following the start character and preceding any data. The insertion of function character 1, immediately after the start character, creates a double character start pattern which signifies that this is an EAN/UPC usage of the code, known as EAN-128.

2.2 Character Encodation

Each Code 128 symbol character consists of eleven modules. The width of each module is a dimension called X. Each symbol character is represented by three bars and three spaces. Bars or spaces may be one to four modules wide. The character 'C', illustrated below, consists of a one-module bar followed by a three-module space, a one-module bar, a three-module space, a two-module bar, and finally a one-module space. The total character width is $1 + 3 + 1 + 3 + 2 + 1 = 11$ modules, as in all Code 128 characters except the stop character, which has 13 modules comprised of four bars and three spaces. Character parity is defined by the sum of the bar modules in any character being even and the sum of the space modules in any character being odd.

Module # 1 2 3 4 5 6 7 8 9 10 11



Bar Width 2 1 1 = 4 (even)
Space Width 1 4 2 = 7 (odd)

START Character A

Module # 1 2 3 4 5 6 7 8 9 10 11



Bar Width 1 1 2 = 4 (even)
Space Width 3 3 1 = 7 (odd)

Character C

Module # 1 2 3 4 5 6 7 8 9 10 11 12 13



Bar Width 2 3 1 2 = 8 (even)
Space Width 3 1 1 = 5 (odd)

STOP Character

Figure 2. Character Structure

Figure 2 illustrates that the start character begins with a double-module bar element. This feature is common to all three start characters. The illustration of the stop character also shows that this character ends with a double-module bar element. The stop character is 13 modules wide; the increased width is required to allow the character to end with a bar element, whereas all other Code 128 characters end with a space. The double-module bar element at the beginning of a start character and at the end of a stop character creates exterior elements which ensure that the scanner sees sufficient initial bar element to properly set the bar/space threshold; if the bar was only one module wide, it might not be sufficient.

2.3 Code Structure

Code 128 has three unique character subsets shown in Table 2 as Code A, B, and C. The bar and space patterns shown are applicable to their equivalent characters listed under columns for Code A, B, or C depending on which of the three unique start characters or preceding code character or shift character is used. If the symbol begins with start character A, then Code A subset is defined. Code

B or Code C subsets are similarly defined by beginning the symbol with start character B or C. The code subset can be redefined within the symbol by code characters A, B, or C, or the shift character.

The same data may be represented by different Code 128 symbols, through the use of different combinations of start, code, and shift characters. Appendix F contains rules for generating the smallest symbol for given data.

Table 2: Code 128

SYMBOL CHARACTER VALUE	DATA CHARACTER			SYMBOL CHARACTER STRUCTURE						SYMBOL CHARACTER PATTERN
	CODE A	CODE B	CODE C	B	S	B	S	B	S	
0	SP	SP	00	2	1	2	2	2	2	
1	!	!	01	2	2	2	1	2	2	
2	"	"	02	2	2	2	2	2	1	
3	#	#	03	1	2	1	2	2	3	
4	\$	\$	04	1	2	1	3	2	2	
5	%	%	05	1	3	1	2	2	2	
6	&	&	06	1	2	2	2	1	3	
7	'	'	07	1	2	2	3	1	2	
8	(	(	08	1	3	2	2	1	2	
9	)	)	09	2	2	1	2	1	3	
10	*	*	10	2	2	1	3	1	2	
11	+	+	11	2	3	1	2	1	2	
12	,	,	12	1	1	2	2	3	2	
13	-	-	13	1	2	2	1	3	2	
14	.	.	14	1	2	2	2	3	1	
15	/	/	15	1	1	3	2	2	2	
16	0	0	16	1	2	3	1	2	2	
17	1	1	17	1	2	3	2	2	1	
18	2	2	18	2	2	3	2	1	1	
19	3	3	19	2	2	1	1	3	2	
20	4	4	20	2	2	1	2	3	1	
21	5	5	21	2	1	3	2	1	2	
22	6	6	22	2	2	3	1	1	2	
23	7	7	23	3	1	2	1	3	1	
24	8	8	24	3	1	1	2	2	2	
25	9	9	25	3	2	1	1	2	2	
26	:	:	26	3	2	1	2	2	1	
27	;	;	27	3	1	2	2	1	2	
28	<	<	28	3	2	2	1	1	2	
29	=	=	29	3	2	2	2	1	1	
30	>	>	30	2	1	2	1	2	3	
31	?	?	31	2	1	2	3	2	1	
32	@	@	32	2	3	2	1	2	1	
33	A	A	33	1	1	1	3	2	3	
34	B	B	34	1	3	1	1	2	3	
35	C	C	35	1	3	1	3	2	1	
36	D	D	36	1	1	2	3	1	3	
37	E	E	37	1	3	2	1	1	3	
38	F	F	38	1	3	2	3	1	1	
39	G	G	39	2	1	1	3	1	3	
40	H	H	40	2	3	1	1	1	3	
41	I	I	41	2	3	1	3	1	1	
42	J	J	42	1	1	2	1	3	3	
43	K	K	43	1	1	2	3	3	1	
44	L	L	44	1	3	2	1	3	1	
45	M	M	45	1	1	3	1	2	3	
46	N	N	46	1	1	3	3	2	1	
47	O	O	47	1	3	3	1	2	1	
48	P	P	48	3	1	3	1	2	1	
49	Q	Q	49	2	1	1	3	3	1	
50	R	R	50	2	3	1	1	3	1	
51	S	S	51	2	1	3	1	1	3	
52	T	T	52	2	1	3	3	1	1	
53	U	U	53	2	1	3	1	3	1	
54	V	V	54	3	1	1	1	2	3	
55	W	W	55	3	1	1	3	2	1	
56	X	X	56	3	3	1	1	2	1	
57	Y	Y	57	3	1	2	1	1	3	
58	Z	Z	58	3	1	2	3	1	1	
59	[	[	59	3	3	2	1	1	1	
60	\	\	60	3	1	4	1	1	1	
61	]	]	61	2	2	1	4	1	1	
62	^	^	62	4	3	1	1	1	1	
63	_	_	63	1	1	1	2	2	4	

Table 2: Code 128

SYMBOL CHARACTER VALUE	CODE A	DATA CHARACTER			SYMBOL CHARACTER STRUCTURE						SYMBOL CHARACTER PATTERN
		CODE B	CODE C		B	S	B	S	B	S	
64	NUL	^	64		1	1	1	4	2	2	
65	SOH	a	65		1	2	1	1	2	4	
66	STX	b	66		1	2	1	4	2	1	
67	ETX	c	67		1	4	1	1	2	2	
68	EOT	d	68		1	4	1	2	2	1	
69	ENQ	e	69		1	1	2	2	1	4	
70	ACK	f	70		1	1	2	4	1	2	
71	BEL	g	71		1	2	2	1	1	4	
72	BS	h	72		1	2	2	4	1	1	
73	HT	i	73		1	4	2	1	1	2	
74	LF	j	74		1	4	2	2	1	1	
75	VT	k	75		2	4	1	2	1	1	
76	FF	l	76		2	2	1	1	1	4	
77	CR	m	77		4	1	3	1	1	1	
78	SO	n	78		2	4	1	1	1	2	
79	SI	o	79		1	3	4	1	1	1	
80	DLE	p	80		1	1	1	2	4	2	
81	DC1	q	81		1	2	1	1	4	2	
82	DC2	r	82		1	2	1	2	4	1	
83	DC3	s	83		1	1	4	2	1	2	
84	DC4	t	84		1	2	4	1	1	2	
85	NAK	u	85		1	2	4	2	1	1	
86	SYN	v	86		4	1	1	2	1	2	
87	ETB	w	87		4	2	1	1	1	2	
88	CAN	x	88		4	2	1	2	1	1	
89	EM	y	89		2	1	2	1	4	1	
90	SUB	z	90		2	1	4	1	2	1	
91	ESC	{	91		4	1	2	1	2	1	
92	FS		92		1	1	1	1	4	3	
93	GS	}	93		1	1	1	3	4	1	
94	RS	~	94		1	3	1	1	4	1	
95	US	DEL	95		1	1	4	1	1	3	
96	FNC 3	FNC 3	96		1	1	4	3	1	1	
97	FNC 2	FNC 2	97		4	1	1	1	1	3	
98	SHIFT	SHIFT	98		4	1	1	3	1	1	
99	CODE C	CODE C	99		1	1	3	1	4	1	
100	CODE B	FNC 4	CODE B		1	1	4	1	3	1	
101	FNC 4	CODE A	CODE A		3	1	1	1	4	1	
102	FNC 1	FNC 1	FNC 1		4	1	1	1	3	1	
103	START (CODE A)				B	S	B	S	B	S	
104	START (CODE B)				2	1	1	4	1	2	
105	START (CODE C)				2	1	1	2	1	4	
STOP					B	S	B	S	B	S	
					2	3	3	1	1	1	

Note: Each of the character encodings ends in a space which varies from one to four modules in width (except for the stop character, which ends in a two-module bar).

Technical Note:

Conversion rules between Symbol Character Value (S) and ASCII Decimal Value for Code A and Code B characters:

CODE A

If $S \leq 63$,
ASCII value = $S + 32$

If $64 \leq S \leq 95$,
ASCII value = $S - 64$

CODE B

If $S \leq 95$,
ASCII value = $S + 32$

2.3.1 Code Subset A

Code Subset A includes all of the standard upper case alphanumeric keyboard characters plus the control and the special characters.

2.3.2 Code Subset B

Code Subset B includes all of the standard upper case alphanumeric keyboard characters plus lower case alphabetic and the special characters.

2.3.3 Code Subset C

Code Subset C includes the set of 100 digit pairs from 00 to 99 inclusive, as well as special characters. This allows double-density numeric digits, two digits per bar coded character, to be defined.

2.3.4 Special Characters

The last seven characters of Code Subsets A and B and the last three characters of Code Subset C are special non-data characters that define special operations to the code reading device. These characters are never displayed or transmitted by the code reading device.

It is possible to change from one code subset to another within a symbol using the code or shift special

characters. The code characters allow a code subset change for all characters following it in the symbol. The shift character allows a code subset shift for one character only. Function Characters (FNC) define instructions to the code reading device to allow for special operations and applications.

2.3.4.1 Code Characters

Code A, B, or C characters change the symbol code subset from the subset defined previously to the new code subset defined by the code character. This change is applicable for all characters following the code character until either the end of the symbol or another code character is encountered.

2.3.4.2 Shift Character

The shift character changes the code subset from A to B or B to A for the single character following the shift character. Characters following the affected character revert to the Code Subset A or B that was defined previous to the shift character.

2.3.4.3 Function Characters

Function character 1 is reserved exclusively for EAN/UCC use. By agreement between AIM and the EAN/UCC authorities in 1988 all other uses of function character 1 are prohibited, except in the specific instance where it is the symbol character corresponding with the calculated value of the symbol check character.

FNC 2 (Message Append) instructs the code reader to temporarily store the data from the symbol containing the FNC 2 character and transmit it as a prefix to the next symbol data. This may be used to concatenate several symbols before transmission. This character can occur anywhere in the symbol.

FNC 3 (Initialize) instructs the code reader to interpret the data from the symbol containing the FNC 3 character as instructions for initialization or reinitialization of the code reader. The data from the symbol will not be transmitted by the code reader. This character can occur anywhere in the symbol.

FNC 4 is available for use in closed systems.

2.3.5 Symbol Character Value

Each symbol character has an associated value listed in Table 2. This value is used in calculating the check character. It can also be used to provide a conversion to and from ASCII decimal values (see technical note, Table 2).

2.4 Quiet Zones

The quiet zones are areas free and clear of all printing preceding the start character and following the stop character.

2.5 Check Character

The check character is an essential part of a Code 128 symbol and it immediately precedes the stop character. The encodation of the check character is determined by the following rules.

1. Each symbol character has a value (see Table 2).
2. Each symbol character position has a weighting. The start character is weighted 1. Then, beginning on the left with the first symbol character following the start character, the weights are 1, 2, 3, 4, ..., n , for all following symbol characters up to, but not including, the

check character itself; n represents the number of symbol characters representing data or special information in the symbol not counting the start/stop characters or check character. It should be stressed that both the start character and the first symbol character following the start character are both weighted '1'.

3. Each symbol character value is multiplied by its weighting.
4. The sum of the products of the calculation in step 3 is derived.
5. The sum of the products is divided by the modulo number 103.
6. The remainder deriving from the calculation in step 5 is the symbol character value of the check character.

For example, to calculate the check character for the data 'AIM':

Characters	Start	B	A	I	M
Character Values (Step 1)	104	33	41	45	
Weights (Step 2)	1	1	2	3	
Products (Step 3)	104	33	82	135	
Sum of Products (Step 4)			354		
Divide by modulo (Step 5)			$354 \div 103 = 3$		
Remainder = check character			45		

Note: The check character has no human-readable interpretation because its character value can correspond to different data depending on the code subset.

2.6 Transmitted Data

All data characters are included in the data transmission. Start and stop characters, shift characters, function characters, code characters and the check character are not transmitted.

3.0 Dimensions and Tolerances

3.1 Measurement Conditions

In order to measure code element width it is necessary to locate the boundary between the light and dark elements of the code. To enable measurements to be made in the presence of edge roughness, spots and voids, the boundary is defined as the position of the centre of a circular sample aperture no larger than 0.8X when the apparent reflectance of the sample viewed through the aperture is exactly half way between the maximum and minimum reflectance values obtained with that aperture on the adjacent bar and space. X is the width of a narrow element.

3.2 Dimensions

Code 128 may be printed at various densities to accommodate a variety of printing and scanning processes. The significant dimensional parameter is X, the nominal width of each narrow element. The X dimension must be constant throughout a given symbol.

The minimum standard X dimension is 0.191 mm (0.0075 inches). (See Appendix E for further discussion.)

The nominal width of each bar and space is determined by multiplying the X dimension by the module width of each bar or space (1, 2, 3, or 4).

The minimum quiet zone should be 10 times X or 2.54 mm (0.10 inch) in width, whichever is greater. For optimum hand scanning, the quiet zone should be at least 6.35 mm (0.25 inch) wide.

For general applications, the minimum bar height should be 6.35 mm (0.25 inch) or 15 percent of the symbol's length, whichever is greater.

3.3 Symbol Length

The minimum length of a Code 128 symbol may be calculated by:

$$L = 11X(C + D/2) + 2(Q + X)$$

Where: L = Symbol Length

D = Number of double-density numerics

C = Number of characters not in D , including function characters, start and stop characters, check character, code characters and shift characters.

Q = Width of quiet zone.

X = X Dimension.

3.4 Dimensional Tolerances

The various processes used to produce bar code symbols have a limited capacity to produce the bars and spaces with widths which precisely match the ideal symbol. Bar code reading systems are designed to read imperfect symbols to the extent that practical algorithms permit.

In order to quantify a bar code's required printing tolerances, it is necessary to identify an assumed decoding algorithm. Appendix A outlines the reference algorithm.

Using the decode algorithm described in Appendix A, there are three different tolerances that need to be considered when printing Code 128. These are illustrated in Figure 3 and are described as follows:

T_b is the tolerance on bar and space widths;

T_e is the tolerance on abutting bars and spaces within a character and illustrated as the four dimensions indicated (e) in Figure 3. These dimensions are measured from the leading edge of a bar to the leading edge of the following bar, or the trailing edge of a bar to the trailing edge of the following bar;

T_p is the tolerance applied to the total width of a character.

The value of tolerances " T_b ", " T_e ", and " T_p " are defined as:

$$T_b = \pm 0.40X - 0.013 \text{ mm (0.0005 inches)}$$

$$T_e = \pm 0.20X$$

$$T_p = \pm 0.20X$$

where X is the nominal minimum dimension.

The 0.013 mm (0.0005 inch) constant term is used in standard print densities. In special applications where the X dimension is less than 0.191 mm (0.0075 inches) T_b is defined as:

$$T_b = \pm 0.33X \text{ (for non-standard densities)}$$

The stop character should satisfy the tolerances as measured as a standard length character consisting of the first three bars and first three spaces. In addition it should satisfy the tolerances when viewed in reverse with the last three bars and the last three spaces in the symbol comprising a character.

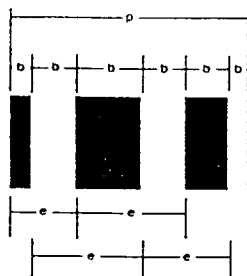


Figure 3 Tolerance Measurements

The following table lists the calculated tolerances for various densities.

Table 3: Tolerance Values

(1) X mm (inches)	(2) numeric density	(3) character density	(4) T_b mm (inches)	(5) T_e mm (inches)	(6) T_p mm (inches)
0.1905 (0.0075)	24.24	12.12	0.0635 (0.0025)	0.0381 (0.0015)	0.0381 (0.0015)
0.2032 (0.0080)	22.73	11.35	0.0686 (0.0027)	0.0406 (0.0016)	0.0406 (0.0016)
0.2286 (0.0090)	20.20	10.10	0.0787 (0.0031)	0.0457 (0.0018)	0.0457 (0.0018)
0.2540 (0.0100)	18.18	9.09	0.0889 (0.0035)	0.0508 (0.0020)	0.0508 (0.0020)
0.3048 (0.0120)	15.15	7.57	0.1092 (0.0043)	0.0610 (0.0024)	0.0610 (0.0024)
0.3302 (0.0130)	13.98	6.99	0.1193 (0.0047)	0.0660 (0.0026)	0.0660 (0.0026)
0.3556 (0.0140)	12.99	6.49	0.1295 (0.0051)	0.0711 (0.0028)	0.0711 (0.0028)
0.4318 (0.0170)	10.70	5.35	0.1600 (0.0063)	0.0864 (0.0034)	0.0864 (0.0034)
0.5080 (0.0200)	9.09	4.55	0.1905 (0.0075)	0.1016 (0.0040)	0.1016 (0.0040)
0.7620 (0.0300)	6.06	3.03	0.2921 (0.0115)	0.1524 (0.0060)	0.1524 (0.0060)
1.0160 (0.0400)	4.55	2.27	0.3937 (0.0155)	0.2032 (0.0080)	0.2032 (0.0080)
1.2700 (0.0500)	3.64	1.82	0.4953 (0.0195)	0.2540 (0.0100)	0.2540 (0.0100)

- (1) X is nominal module width in mm (inches)
(2) Characters per inch in Code Set C
(3) Characters per inch in Code Set A or B
(4) T_b is bar or space tolerance in mm (inches)
(5) T_e is edge to edge tolerance in mm (inches)
(6) T_p is character to character tolerance in mm (inches)

These tolerances are represented graphically in Figure 4.

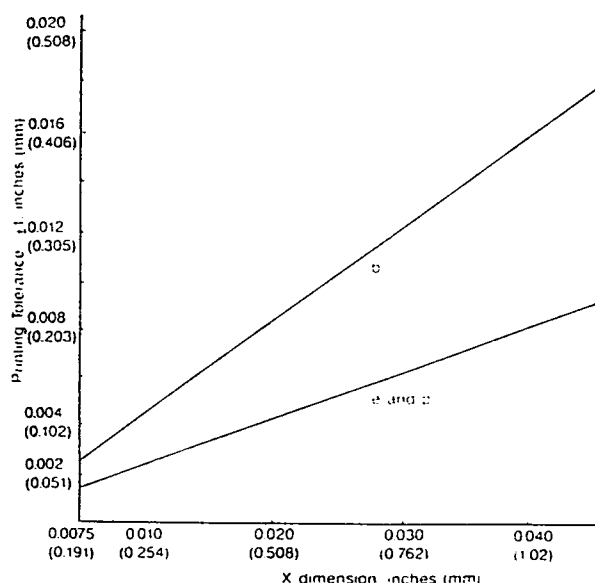


Figure 4 Code 128 Dimensional Tolerances

4.0 Optical Specification

4.1 Introduction and Summary

The optical characteristics of the printed bar code symbols can vary substantially because of the varied processes which may be used to produce them. It is necessary that certain optical properties be maintained within acceptable limits if the reading process is to be reliable. In particular, this specification describes the reflectance characteristics of the bar and space elements within the symbol and the spectral band to be used by the reflectance measurement equipment.

The reflectance specifications have been designed so that a sufficiently discernible difference in reflectance exists between spaces and bars. This difference must be at least 37.5 percent for symbols with an X dimension of less than

1.016 mm (0.040 inches) and at least 20 percent for symbols with an X dimension of 1.016 mm (0.040 inches) or larger. Bar reflectance must always be less than 30 percent and space reflectance more than 25 percent.

Finally, this specification limits the amount of noise, i.e. the reflectance variation, which can be tolerated within a bar or space and across the entire symbol. Noise can be caused by such printing defects as spots and voids, non-uniformity in the substrate material, or the show-through of patterns under a substrate which is not adequately opaque. Reflectance variation within bars or spaces must be no greater than one-quarter of the minimum reflectance difference between bars and spaces. In other words, the noise within one symbol element cannot exceed 25 percent of the minimum signal amplitude obtained between bars and spaces. Across an entire symbol, the reflectance of either the set of bars or the set of spaces cannot vary any more than one-half of the minimum reflectance difference between bars and spaces. The combined noise from all optical sources must not cause these limits to be exceeded.

A more detailed presentation of the optical specification is given in the sections which follow. Measurements have been defined in a manner which in many respects parallels the operation of most bar code reading systems.

4.2 Measurement Conditions

4.2.1 Spectral Band

All AIM USS symbols must satisfy the minimum reflectance specification cited below for the spectral band centered at 633 nanometres in the visible spectrum. Measurements should be made with a system having its peak response at 633 nanometres $\pm$ 5 percent and having a half-power band width no greater than 120 nanometres (in which there are no secondary peaks). Among possible source-filter-photodetector combinations which can be used are those employing a He-Ne laser, or alternatively the CIE Source A illuminant (incandescent source) along with an S-4 response photodetector and a Wratten 26 red filter, or appropriate red LED's.

Appendix E includes a discussion of systems which are designed to operate in spectral bands other than the 633 nanometre band.

4.2.2 Diffuse Reflectance Measurements of Bars and Spaces

The diffuse reflectance of a surface is defined as the ratio of the diffusely reflected radiation from the surface to that reflected from a specially prepared magnesium oxide or barium sulphate standard that is measured under the same illuminating and viewing conditions. Standard viewing conditions require the viewing and illuminating axes to be separated by 45 degrees, with one of the axes positioned normal to the sample surface. In order to reject specular reflections, the aperture of the viewing and illuminating system should subtend an angle no greater than 15 degrees measured from the sample surface.

Either the light source or the receiver must restrict the sample field to an area equal to a circle of diameter $0.8X$, where X is the width of a narrow element of the bar code, or as specified in an application standard. The other optical path must have a field of view on the sample large enough to include a circle of diameter $8X$ or more, centred on the $0.8X$ diameter circle defined above. The two alternatives represent either flood illumination with sample area viewing defined at the receiver, or illuminant sampling of the area as with a focused light source and wide area viewing.

4.3 Essential Bar Code Measurements

4.3.1 Measurement Conditions

The reflectance specifications given below are based upon signal-to-noise requirements for reliable decoding of a symbol by a bar code reader. The *signal* is the reflectance difference between a bar and a space. *Noise* is any variation in reflectance caused by gradations in the ink or substrate material. Spots and voids in the symbol and the *show-through* of a pattern underlying a label with low opacity can also contribute to noise in bar and space reflectance values. It is essential, therefore, that a symbol is sampled adequately and that conditions under which an underlying dark surface or pattern may affect the symbol quality are included in the measurement process. The net effect of all noise-contributing factors must not cause the symbol reflectance measurements to fall outside the stated specifications.

4.3.2 Reflectance Measurements

Figure 5 depicts the bar code reflectance measurement process and in graphical form shows the key measurement parameters required to describe the quality of the bar code symbol. Figure 5a indicates the position of the sample aperture on a bar code image in which reflectance measurements are made. Note that all sample reflectance measurements are made with the sampling aperture confined within the area of a space or bar. Measurements made with the aperture positioned across the edge between a bar and a space (as defined in Section 3.1 above) should not be taken into account. A plot of the reflectance measurements is shown in Figure 5b along with annotations describing the essential bar code reflectance parameters. On the left are indicated the maximum space reflectance $R_S(\max)$, the minimum space reflectance $R_S(\min)$, the maximum bar reflectance $R_B(\max)$, and the minimum bar reflectance $R_B(\min)$, obtained over all samples. On the right are indicated the ranges of reflectance ΔR_E obtained from a typical space and a typical bar element.

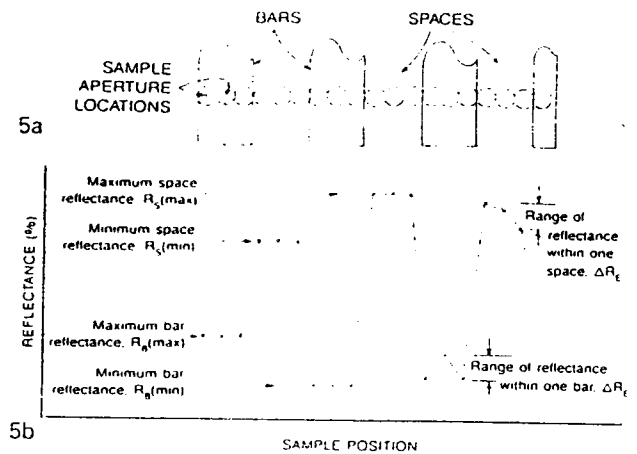


Figure 5. Bar Code Reflectance Measurements

4.4 Reflectance Specifications

The reflectance characteristics of AIM USS symbols must comply with the following specification:

4.4.1 Maximum Bar Reflectance (R_B)

$$R_B(\max) < 30 \text{ percent}$$

4.4.2 Minimum Space Reflectance (R_S)

$$R_S(\min) > 25 \text{ percent}$$

4.4.3 Minimum Bar-Space Reflectance Difference, MRD

The difference in reflectivity between the lightest bar and the darkest space is called MRD (Minimum Reflectance Difference). In other words, $MRD = R_S(\min) - R_B(\max)$.

The minimum value of MRD is:

$$MRD \geq 37.5 \text{ percent for } X < 1.016 \text{ mm (0.040 inches)}$$

$$MRD \geq 20 \text{ percent for } X \geq 1.016 \text{ mm (0.040 inches)}$$

The special provisions for symbols with $X \geq 1.016$ mm (0.040 inches) have been made in order to accommodate the printing of lower density labels on darker backgrounds.

4.4.4 Maximum variation in reflectance of a single element, $\Delta R_E(\max)$

The maximum permissible variation in the reflectance measurements made across one bar or space element cannot exceed one quarter of the MRD defined in 4.4.3:

$$\Delta R_E(\max) \text{ across one element} \leq 0.25 \text{ MRD}$$

4.4.5 Maximum variation in the reflectance of spaces across entire symbol, $\Delta R_S(\max)$

The maximum permissible variation in the reflectance across all spaces is one-half of the minimum bar-space reflectance difference as defined in 4.4.3:

$$\Delta R_S(\max) = R_S(\max) - R_S(\min) \leq 0.5 \text{ MRD}$$

4.4.6 Maximum variation in the reflectance of bars across entire symbol, $\Delta R_B(\max)$

The maximum permissible variation in the reflectance across all bars is one-half of the actual measured value of the minimum bar-space reflectance difference as defined in 4.4.3:

$$\Delta R_B(\max) = R_B(\max) - R_B(\min) \leq 0.5 \text{ MRD}$$

Appendix A

Reference Decode Algorithm for Code 128

The allowable print tolerances for Code 128 (see section 3) are derived from the characteristics of a reference decode algorithm, presented below.

In this algorithm the symbol is decoded using "edge to similar edge" measurements (e), plus an additional measurement of the sum of the three bar widths. The algorithm contains the following steps to decode each bar coded character:

1. Calculate eight width measurements p, e1, e2, e3, e4, b1, b2, and b3 (Figure 6).

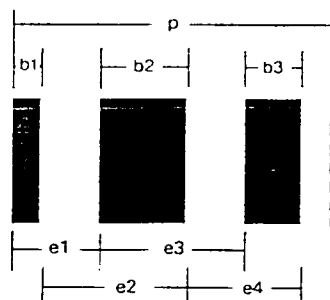


Figure 6 Decode Measurements

2. Convert measurements e1, e2, e3, and e4 to normalized values E1, E2, E3, and E4 which will represent the integral module width (Ei) of these measurements. The following method is used for the i-th value.

- If $1.5p/11 < e_i < 2.5p/11$, then Ei is 2.
- If $2.5p/11 < e_i < 3.5p/11$, then Ei is 3.
- If $3.5p/11 < e_i < 4.5p/11$, then Ei is 4.
- If $4.5p/11 < e_i < 5.5p/11$, then Ei is 5.
- If $5.5p/11 < e_i < 6.5p/11$, then Ei is 6.
- If $6.5p/11 < e_i < 7.5p/11$, then Ei is 7.

Otherwise the character is in error.

3. Look up character in decode table using the four values E1, E2, E3, and E4 as the key.

4. Retrieve character self-checking value V which is stored in the table with the character. The value V is equal to the sum of the modules for the bars as defined for that character.

5. Verify that:

$$(V - 1.75)p/11 < (b1 + b2 + b3) < (V + 1.75)p/11$$

Otherwise the character is in error.

This calculation indirectly uses character parity to detect all decode errors caused by single non-systematic one-module edge errors.

Using these five steps, decode the first character. If it is a start character, continue decoding the symbol in the normal forward direction. If it is not a start character, attempt to decode it and all subsequent characters in the reverse direction.

After all characters have been decoded, make sure there was a valid start character, a valid stop character, and that the check character calculated is correct.

Interpret the data characters according to the proper code Set A, B, or C according to the start character, code characters, and shift characters.

In addition, perform such other secondary checks on quiet zones, beam acceleration, absolute timing dimensions, etc., as are deemed prudent and appropriate considering the specific reading device and intended application environment.

Appendix B

Optional Characteristics

Function character 1 is reserved exclusively for EAN/UCC use. By agreement between AIM and the EAN/UCC authorities in 1988 all other uses of function character 1 are prohibited, except in the specific instance where it is the symbol character corresponding with the calculated value of the symbol check character.

The function character 3 (FNC 3) is reserved for code reader initialization. Symbols which contain FNC 3 will not be transmitted but interpreted by the code reader for its own purposes.

The function character 4 (FNC 4) is not defined in the symbology and may be used in closed systems.

Appendix C

Human-readable Interpretation

A human-readable representation of the data characters in the symbol (equivalent to the transmitted characters) may accompany the symbol. It should not interfere with the symbol itself nor the quiet zones.



Figure 7

Appendix D

Autodiscrimination Compatibility

Code 128 may be read by suitably programmed bar code readers that are designed to auto-discriminate it from other symbologies. The code is, in particular, fully distinguishable from and thus compatible with:

- Code 1 2/5
- Code 39
- Codabar
- Code 93
- EAN-8 and EAN-13
- UPC Versions A and E

It is advisable to limit the reader's valid set of symbologies to those needed by a given application to maximize reading security.

Appendix E

Systems Considerations

It is important that the various components (printers, labels, readers) making up a bar code installation operate together as a system. A failure in any component, or a mismatch between them, can compromise the performance of the overall system.

When both readers and printers are specified by a single user or by cooperative agreement (closed system), certain

specified values such as X dimensions and spectral band can be allowed to deviate from standard tolerances. However, the characteristics of the printer, symbol, and reader must be matched to achieve desired performance. Deviations should only be considered where standard specifications do not yield acceptable results, and where system component vendors and integrators take appropriate care to achieve required system matching.

X Dimension

In closed systems, the X dimension may be less than 0.191 mm (0.0075 inches). The user must exercise care in these systems to assure a match between the reader resolution and printed symbol X dimension.

Bar Height

In closed systems, bar-heights less than 6.35 mm (0.25 inches) may be printed.

Spectral Band

In closed systems, a reference spectral band other than 633 nanometres may be specified. In such systems, it is important to ensure that the spectral response characteristics of the reading equipment match the spectral reflectance characteristics of the printed symbols.

Other Considerations

Compliance with specifications is one key to assuring overall system success, but there are other considerations which can influence performance. The following guidelines suggest some factors to keep in mind when specifying or implementing bar code systems:

1. Choose a symbology and print density which yield tolerance values that can be achieved by the printing technology to be used.
2. Choose a reader with resolution suitable for the symbol density and quality produced by the printing technology.
3. Be certain that the printed symbol's optical properties are within specification for the spectral band employed by the reader.
4. Be sure to verify symbol specification compliance in the final label or package configuration. Overlays, show-through, and curved or irregular surfaces can all affect symbol readability.
5. Bar height should generally be set at the highest value that is practical given label, package, and printing technology constraints.

The effects of specular (mirror-like) reflections from shiny symbol surfaces must be considered. Standard reading systems are designed to detect variations in diffuse reflection between bars and spaces. At some reading angles, the specular component of the reflected light can greatly exceed the desired diffuse component, reducing read performances. Matt, non-glossy finishes minimize this effect.

In cases where specular reflection effects are used to achieve the desired contrasts (as in some forms of printing or etching directly onto metal), extreme care must be exercised to ensure that the optical properties are within specification over the entire range of read angles and distances required by the particular application.

Appendix F

Use of Start, Code, and Shift Characters

The same data may be represented by different Code 128 symbols through the use of different combinations of start, code and shift characters.

The following rules for the use of start, code and shift characters can be followed to minimize the symbol length:

Note: In these rules the term 'lower case' is used for convenience to mean precisely any set B character with values 64-95, i.e. all lower case alphabetic characters plus { } - DEL.

1. Determine the start character:
 - 1a. If the data begins with 4 or more digits, use start character C;
 - 1b. If an ASCII control character (e.g. NUL) occurs in the data before any lower case character, use start character A. (Control characters are those listed in Table 2 in character set A with values from 64 to 95.)
 - 1c. Otherwise, use start character B.
2. If start character C is used and an odd number of digits begins the data, insert a Code A or Code B character before the last digit, following rules 1b and 1c above to determine between character subsets Code A and Code B.
3. If 4 or more digits occur together when in character subsets Code A or Code B:
 - 3a. If there is an even number of digits, insert a Code C character before the first digit to change to character subset Code C;
 - 3b. If there is an odd number of digits, insert a Code C character immediately after the first digit to change to character subset Code C.
4. When in character subset Code B and an ASCII control character occurs in the data:
 - 4a. If there is a lower case character immediately following the control character, insert a shift character before the control character;
 - 4b. Otherwise, insert a Code A character before the control character to change to Code A.
5. When in Code A and a lower case character occurs in the data:
 - 5a. If following that character, a control character occurs in the data before the occurrence of another lower case character, insert a shift character before the lower case character;
 - 5b. Otherwise, insert a Code B character before the lower case character to change to Code B.
6. When in Code C and a non-numeric character occurs in the data, insert a Code A or Code B character before that character, following the rules 1b and 1c to determine between Code A or Code B.

A Glossary of Auto ID Terminology

AIM AIM International is a global affiliation of trade associations, comprising AIM USA, AIM Europe, AIM UK, AIM France, AIM Japan, and AIM Pacific, whose member companies are all involved with automatic identification. AIM stands for Automatic Identification Manufacturers, the original name for AIM USA.

alphanumeric (of a character set) Consisting of or representing both alphabetic and numeric characters (and usually other symbols such as punctuation marks).

ANSI American National Standards Institute, an organization responsible for the standardization of technical terminology, units of measurement, etc. in the USA.

aperture The opening in an optical device such as a scanner, photometer, or camera, which determines the size of the field of view. Most apertures are circular, but they may be rectangular or elliptical.

ASCII American Standard Code for Information Interchange: a computer code consisting of 128 alphanumeric and control characters, each encoded with 7 bits (8 including parity check), used for the exchange of information between computerized systems. It is described in the ANSI document X3.4-1977.

autodiscrimination The ability of a bar code reader to distinguish automatically between two or more symbologies (e.g. 12 of 5, Code 39).

automatic identification (Auto ID) A means of identifying an item by machine and entering the data automatically into a computer. The most widely used technology at present is bar code; others include optical character recognition (OCR), magnetic ink character recognition (MICR), and radio frequency (RF), machine vision, magnetic stripes and voice systems.

background The light area between and surrounding the bars of a printed bar code symbol. The background can be the substrate on which the bar code is printed or an over-printing of a suitable light colour.

bad read See *misread*.

bar Any of the dark lines in a printed bar code symbol.

bar code 1. An array of parallel rectangular bars and spaces arranged according to the encodation rules of a particular symbology in order to represent human-readable data in machine-readable form.

2. An automatic identification technology consisting of capturing data encoded in this way.

bar code character See *symbol character*.

bar code density (symbol density) The number of characters that can be represented by a bar code per linear unit of measure, usually expressed as characters per inch (cpi). The width of the narrowest bar or space and wide to narrow ratio are the controlling factors.

bar code reader A device used to capture the data encoded in a bar code symbol. It consists of two parts: the input device (scanner) which sends signals proportional to the reflectivity of each successive element of the bar code to the decoder, which examines the signals from the scanner and translates them into recognizable or computer-compatible data. The decoder itself is sometimes called a reader.

bar code symbol The combination of characters required by a particular symbology, including start/stop characters, quiet

zones, data characters, and check characters, which together form a complete scannable entity.

bar height (bar length) The length of the individual bars in a bar code measured along the axis of the bars. This measurement carries no information and the symbol is scanned at approximately 90 degrees to the bar height.

bar width The width (or thickness) of an individual bar in a bar code symbol. The number of possible width variations within a particular printed symbol depends on the symbology used.

bidirectional 1. Denoting a symbol that can be read successfully either forwards or backwards.

2. Denoting a scanner that can operate successfully either forwards or backwards.

binary Denoting a numbering system in which numbers are expressed as combinations of the digits 0 and 1, based on powers of 2. In computing these can be represented electrically by 'off' and 'on', or in bar codes by narrow and wide bars or spaces.

binary coded decimal A number in binary code written in groups of four bits, each group representing one digit of the number, for example 0010 0011 for 23. Some bar codes are based on the binary coded decimal numbering system.

bit Abbrev. for *binary digit*. 1. A single element (0 or 1) in a binary number.

2. A unit of information or information capacity in a binary storage device.

character 1. A graphic shape representing a letter, digit, punctuation mark, or other symbol, for example in an OCR font.

2. A symbol that is used in the organization, control, or presentation of data, for example a start or stop character in a bar code or a function code in an OCR string of data.

3. See *data character*.

4. See *symbol character*.

character set The total range of letters, numbers, and symbols that can be encoded in a particular bar code symbology or other automatic identification technology.

check character (check digit, checksum) A character included in a code in order to perform a mathematical check that when a machine reading or human operation is carried out the code is correct. Its value is calculated from the other characters in the code.

clear area See *quiet zone*.

Codabar A bar code symbology which encodes 16 data characters: 0-9, 6 special characters (— \$: / . +), and 4 unique start/stop characters (A, B, C & D). Each character has 7 elements (4 bars and 3 spaces). The USS Codabar symbology uses only two widths of element (wide or narrow). In USS Codabar, 12 characters (0-9 and — \$) have 2 wide elements, while the other characters have 3 wide elements; this means that USS Codabar characters have two different lengths. Traditional Codabar produces a constant length character, but requires the use of 18 different element widths. For decoding purposes, both versions are fully compatible when using the USS Codabar reference decode algorithm Codabar.

code 1. A set of specific rules according to which data can be represented.

2. A representation of information, such as a string of data, in symbol form. See *bar code*.

Code 39 (3 of 9) A bar code symbology which encodes 43 data characters: 0-9, A-Z, 7 special characters (— . Space \$ / + %), and a start/stop character (*). Each character has 9 elements (5 bars and 4 spaces), 3 of which are wide and 6 narrow. Code 39 is discrete (i.e. there is an intercharacter gap). Any length of data can be encoded.

Code 93 A bar code symbology which encodes 43 data characters: 0-9, A-Z, 7 special characters (— . Space \$ / + %), 4 control characters, and a unique start/stop character. The 4 control characters when combined with basic data characters enable the entire 128 ASCII character set to be encoded. Each character is made up of 9 modules, arranged into 3 bar elements and 3 adjacent space elements. Each element is from 1 to 4 modules wide (where the width of a module is X). Code 93 is a continuous code. Any length of data can be encoded.

Code 128 A bar code symbology which encodes the entire 128 ASCII character set, 4 non-data function characters, 4 Code Set selection characters, 3 start characters, and a stop character. Each of the 3 start characters identifies the code set being encoded; one allows all numeric data to be encoded at double density. Each character is made up of 11 modules arranged into 3 bar elements and 3 adjacent space elements. Each element is from 1 to 4 modules wide (where the width of a module is X). The entire ASCII character set is encodable by prefixing individual characters or blocks of characters with one of the Code Set selection characters. Code 128 is a *continuous code*. Any length of data can be encoded.

continuous code A bar code in which there is no *intercharacter gap*, i.e. all the elements carry binary data contiguously, for example USS 1 2/5. Compare *discrete code*.

cpi Characters per inch. See *bar code density*.

data character A letter, digit, or other symbol which is a member of the ASCII character set. Compare *symbol character*.

decoder An electronic assembly which translates the proportional electrical signals from a scanner into recognisable or computer-compatible data. The decoder performs checks on the electronic signal to validate it as meaningful (i.e. that quiet zones precede the signal representing the bar code), and processes the signal through a decode algorithm designed to detect errors in the signal. Depending on the equipment the decoder and scanner can be separate devices or be integral parts of the same device. In the former the output from the scanner is an electrical signal representing the reflectance of the bar code; in the second case the output from the integrated device is the decoded data.

Some decoders are microprocessor controlled and can carry out limited data processing operations of various types or store data for batch transmission.

A decoder is sometimes called a reader.

densitometer An instrument that measures the degree to which light is transmitted through or reflected from a material by illuminating the area to be measured with light at a known wavelength. A calibrated *photometer* receives the light and measures its value. Results of the measurement may be displayed as percentage reflectance or density.

depth of field The range of distances over which a scanner can reliably read a symbol.

diffuse reflection Reflection of light in all directions. Non-glossy surfaces reflect light in this way, whereas glossy surfaces produce *specular reflection*.

discrete code A bar code in which the spaces between characters (*intercharacter gaps*) are not part of the code as each character begins and ends with a bar. The spaces can therefore vary in width, within specified tolerances. An example is USS 39. Compare *continuous code*.

EAN 1. European Article Number. The international standard or system for applying unique article numbers and bar codes to products. The EAN bar code is a numeric only code, generally encoding 13 digits (known as EAN-13), though in specific circumstances shorter codes (EAN-8) and supplementary codes are used. The North American equivalent (now technically a subset of the EAN system) is the Uniform Product Code (UPC).
2. European Article Numbering Association, now the International Article Numbering Association. EAN is the international body responsible for administering the EAN system. National bodies include the CCG in West Germany, DCC in Japan, ANA in the United Kingdom. The North American body responsible for UPC coding is the Uniform Code Council.

element A single bar or space in a bar code symbol. For example, in a USS 39 character there are 9 elements (5 bars and 4 spaces, or 3 wide and 6 narrow). In a USS 93 character there are 6 elements (3 bars and 3 spaces). The width of individual elements is expressed in *modules*.

field of view The length of code that can be read in one scan. For wand scanners and others where the scanner beam has to be manually moved across the symbol, field of view is a function of the operator's ability to scan smoothly. For moving beam scanners and others where the scanner has depth of field, field of view is a function of the distance from the output of the

scanner, whereas for cameras the *aperture* determines the field of view.

flat bed scanner A fixed scanner (as widely used at supermarket checkouts) which can read bar code symbols at any angle in a plane parallel to or near parallel to the scanner window. Omnidirectional scanning of symbols is a property of this type of scanner. See also *slot scanner*.

font A set of characters of a specific style and size of graphic type.

guard bars The auxiliary characters at both ends and centre of EAN and UPC bar code symbols which provide reference points for scanning. In most cases the bars of these auxiliary characters are elongated. The guard bars function as *start/stop characters*; for omnidirectional scanning the centre guard bar (where present) acts as a stop character and the outer guard bars act as two separate start characters. There are no centre guard bars on UPC-E symbols (and other less common architectures).

helium neon laser (He Ne laser) A type of laser commonly used in bar code scanners. It emits visible coherent red light at a wavelength of 632.8 nanometers. Bars printed in red would therefore be indistinguishable from the background. In some specifications the wavelength of light is referred to as 'B633'.

human-readable character A letter, digit, or other symbol, which is a member of the ASCII character set, printed along with the bar code symbol. A human-readable character is generally associated with a specific symbol character, but in some symbologies more than one human-readable character can be encoded by a single *symbol character*, or more than one symbol character is required to encode a specific human-readable character.

intercharacter gap The space between the last bar of one character and the first bar of the next in a bar code symbology that does not utilize these spaces for the encodation of information. See *discrete code*, *continuous code*.

Interleaved 2 of 5 (I 2/5) A bar code symbology which encodes the numeric set (0-9), a unique start character, and a unique stop character. Each character has 5 elements (2 wide and 3 narrow). The characters are paired together using bars to represent the first digit and the spaces between them to represent the second digit; therefore, there must always be an even number of digits in this symbology. Interleaved 2 of 5 is a *continuous code*. Any length of data can be encoded but in a specific application there should be only one fixed length code. See also *ITF*.

ITF (Interleaved Two of Five) An abbreviation used in the International Article Numbering system (EAN) to identify its application of Interleaved 2 of 5 symbology. As with any application standard, parameters are set which make the symbology application-specific. For example, the most common reference in the EAN system is to ITF-14 symbols, which defines the number of digits encoded.

ladder See *orientation*.

laser (Light Amplification by the Stimulated Emission of Radiation) A device for producing an intense beam of monochromatic coherent light or other form of electromagnetic radiation. There are four basic types of laser, depending on the type of active material which converts energy into a laser beam: crystal lasers use a crystal such as a ruby; gas lasers use gases such as helium, neon, argon, carbon dioxide; liquid lasers use organic dyes such as rhodamine; and semiconductor lasers use material such as gallium arsenide.

Laser scanners for reading bar codes use a very low-energy laser beam as their light source, whereas lasers used for cutting and welding have outputs of up to thousands of watts.

Laser engravers use concentrated heat from a laser beam to engrave graphic images directly onto the item to be marked.

LED (Light Emitting Diode) A semiconductor that produces light at a wavelength determined by its chemical composition as a result of electrical stimulation. A range of devices is available, each having a single output over a restricted band of light, to operate at points in the spectrum between 600 (visible red) and 900 (infrared) nanometres. It is commonly used as a light source in wand type bar code readers.

light margin The EAN/UPC term equivalent to *quiet zone*.

light pen See *wand*.

misread (bad read) A disparity between the data encoded in a

bar code symbol and the data output from a bar code reader. The error passes tests established in the decode algorithm and the output data may be ambiguously equivalent to other valid data in the system. The term also applies in other Auto ID technologies. Compare *non-read*.

module The narrow nominal unit of measure in a bar code character. In certain symbologies, wider bars and spaces are often specified as multiples of one module. For example, bars and spaces in the EAN/UPC symbology and in USS 93 may be 1, 2, 3, or 4 modules wide. The character width is expressed in modules, e.g. EAN/UPC – 7 modules; USS 93 – 9 modules. Sometimes called: *X dimension*.

nanometre A unit of measure used to define the wavelength (and hence colour) of light. One nanometre is one thousand millionth of a metre (10^{-9} metres), or ten angstroms. Abbrev.: **nm**.

nominal Denoting the 'standard' or 'ideal' values of specified parameters of the elements which make up the characters of symbols. Maximum permitted deviations from these values are specified as the tolerances of the symbols. The nominal size of EAN and UPC bar code symbols can vary within a permitted range of magnification factors.

non-read (no-read, non-scan) Lack of data output when a bar code is scanned due to a defective code, incorrect orientation or speed of scan, scanner failure, or operator error. The decode algorithm succeeds in detecting the error and rejects the data 'observed' as invalid. The term can also be applied in other Auto ID technologies. Compare *misread*.

numeric Denoting a character set that includes only numbers. Compare *alphanumeric*.

omnidirectional 1. Denoting a bar code symbol that can be read in any orientation whenever the surface on which the symbol is printed is in a plane parallel or near parallel to the output part of the scanner. EAN and UPC symbols are capable of being read regardless of orientation to an omnidirectional scanner, as long as the bar code passes over the scanner window.

2. Denoting a scanner, such as a *flat bed scanner*, that can operate successfully whatever the orientation of the symbol in a plane parallel or near parallel to the output port of the scanner. Omnidirectional scanners employ multiple x-axis and y-axis scan patterns to achieve the omnidirectional capability.

opacity The property of a substance of preventing light from passing through it. *Substrate* opacity is concerned with the prevention of show-through from the reverse side of the substrate or any substance underneath it. Ink opacity is concerned with the ink coating preventing the reflectance showing through from the substrate.

optical throw The distance from the face of the reading device to the beginning of the *depth of field*.

orientation Positioning with respect to a specific direction or plane. Bar code symbols can be positioned so as to be scanned horizontally (vertical bars: 'picket fence' orientation) or vertically (horizontal bars: 'ladder' orientation). All scanners effectively scan at approximately 90 degrees rotation to the height of the bars.

overhead The part of a bar code symbol required in addition to the encoded data to give the symbol a valid structure. It consists of start and stop characters and (for certain symbologies) check characters, for example:
USS 39 – start and stop
USS 93 – start, stop, and 2 check characters
EAN/UPC: left and right guard bars (equivalent to start, stop) and centre pattern.

parity A system for encoding characters as 'odd' (having an odd number of binary ones in their structure) or 'even' (having an even number of binary ones in their structure), used as a self-checking mechanism in bar codes. A parity bit (parity bar or module) can be incorporated into an encoded character to make the sum of all the bits always odd or always even, which acts as a fundamental check.

photometer An instrument used to measure the intensity of light at specified wavelengths, as in measurements of

reflectance when verifying optical symbols of all types. See also *densitometer*.

picket fence See *orientation*.

print quality The degree to which a printed optical symbol complies with the requirements which are specified for it, such as dimensions, reflectance, edge roughness, spots, voids, etc., which will determine the performance of the scanner. See *verification*.

quiet zone (clear area, light margin) The area that must precede the start character and follow the stop character of a bar code symbol and surround OCR-A data, which contains no machine-readable markings or extraneous spots. It is 'quiet' in terms of scanning signals.

reader See *bar code reader, decoder*.

reflectance 1. The amount of light of a specified wavelength or range of wavelengths that is reflected from a substrate, ink, or other means to create the dark bars and light spaces of a bar code symbol and the printed characters and background of OCR data.

2. (Sometimes called **reflectance factor**) Reflectance is measured on a scale of 0 to 1, at a wavelength or bandwidth of light (spectral response) specified in the particular application specification. Barium sulphate or magnesium oxide are used as 'near perfect' reference white standards (a perfect standard of pure white would have a reflectance of 1.00 at any wavelength of light). The absence of any light in a vacuum is used as reference black standard. Samples (such as substrates, inks, etc.) are tested against the standards under similar illumination.

resolution 1. In a bar code system, the narrowest bar dimension that can be printed by a particular device or method, or scanned successfully by particular scanner.

2. The ability of an optical instrument to distinguish fine detail, or of photographic equipment to reproduce fine detail.

scanner An electronic device that converts optical information (e.g. a printed bar code or OCR symbol) into electrical signals for subsequent decoding and transmission to a computer. Originally used only for a laser scanner, the term is now used more generally for any optical code-reading device for all automatic identification technologies. See also *bar code reader, flat bed scanner, decoder*.

scanning window The whole area in front of the output port of a non-contact scanner in which symbols can be read. The scanning window increases in proportion to the distance from the output port, up to the maximum *depth of field* of the scanner.

self-checking Denoting a bar code or symbol using a checking algorithm which can be applied to each character in the code: *substitution errors* can then only occur if two or more separate printing defects occur within one character. Codes that are not self-checking usually have a check character added to the encoded data.

show-through The property of a substrate or packaging material to allow light to pass through, causing underlying markings or other matter to affect the reflectance of the substrate. The term *see-through* is sometimes used in OCR technology.

slot reader A bar code reading device which requires that the bar-coded material is drawn through a slot into which a near-contact bar code reader is built. The device requires that the bar code be in a fixed location relative to the edge of a thin substrate. See also *slot scanner*.

slot scanner 1. Another term for *flat bed scanner*. The name slot scanner derives from the plastic moulding over the output window of the scanner which has slots to enable the scanner beam to generate the scan pattern but which inhibits the entry of ambient light.

2. Another term for *slot reader*.

Note: Care should be exercised in the use of this term because of its ambiguity.

space Any of the light elements between the bars of a bar code, which may or may not carry encoded information. The space

may be formed by the substrate or by some light ink. Sometimes called *light bar*.

spectral response The sensitivity of a scanner or other device to light of different wavelengths. Bar code scanners and OCR readers operate in a specified but limited part of the visible or infrared spectrum, i.e. they can have different peak spectral responses, which affects the colours that can be used to print scannable bar code symbols and OCR data – even the suitability of some 'black' colours.

specular reflection Reflection of light from a surface at an angle equal but opposite to the angle of incidence, for example as from a mirror or glossy surface. Compare *diffuse reflection*.

spot An ink or dirt mark or other area of low reflectance relative to the background reflectance criteria within the space element of a bar code symbol or the background of OCR characters. Spots can abut the bar elements or OCR characters, distorting their shape, or they can be free standing. Distorted bar elements or OCR characters and large spots in the background might result in a misread or non-read. Compare *void*.

start/stop character A bar code character included in a symbol to indicate the beginning (start character) and end (stop character) of the code to the scanner and the direction in which it is being read. See also *guard bars*.

substitution error A character that is wrongly decoded when a bar code or other symbol is read. Compare *misread*, *non-read*.

substrate The material or medium upon which printed matter (such as a bar code symbol or OCR characters) or a coating is imposed.

symbol See *bar code symbol*.

symbol character (bar code character) A unique bar/space pattern which is defined for a particular symbology. There is not necessarily a one-to-one or unique correlation between symbol characters and data characters. Symbol characters may have a unique associated symbol value. See also *human-readable character*.

symbol density: See *bar code density*.

symbol length The total length of a bar code symbol including the *quiet zones* at the outside ends of the start and stop characters.

symbology Any of the standard systems of representing data in bar code form, each having its particular characteristics and rules of composition, such as USS 39, USS 1 2/5, USS 93, USS

128, USS Codabar, EAN/UPC. The symbology specifies the character set, start and stop codes, length, etc.

UCC (Uniform Code Council) (Previously the Uniform Product Code Council) the body that administers the UPC system in North America (Mexico, however, is a member of EAN).

UPC (Uniform Product Code) The North American standard or system for applying unique article numbers and bar codes to products. The UPC bar code is a numeric only code, generally encoding 12 digits (UPC-A), though in specific circumstances shorter symbols (UPC-E), supplementary codes, and longer symbol architecture (UPC-D) are used. The international equivalent (of which UPC is technically a subset) is the European Article Number (EAN) system.

USS (Uniform Symbology Specification) Any of the specifications published by AIM for encoding, printing and verifying bar code symbologies (currently Interleaved 2 of 5, Code 39, Code 128, Codabar and Code 93), in order to provide common standards for users in different applications. They replace the Uniform Symbol Descriptions (USDs).

verification The technical process by which a bar code symbol is measured to determine whether it meets the application specification for that symbol. Verification is usually accomplished with equipment which measures the elements with a microscope and establishes contrast by a densitometer.

verifier A device used to measure and analyse bar width dimensions, quiet zones, reflectance, and other print quality attributes of a bar code symbol against a standard to which the bar code symbol should conform.

void An area within a bar of a bar code symbol, or within an OCR character, which is of high reflectance relative to the dark reflectance criteria, i.e. the bar or character is poorly inked. Large voids might result in a non-read or misread. Compare *spot*.

wand (light pen) A bar code or OCR contact scanning device held in the operator's hand and moved across the symbol. Wands are contact or near-contact devices. The term 'light pen' is less frequently used now because it is easily confused with devices of this name which are used to control the cursor of CRT (cathode ray tube) terminals.

X dimension The desired dimension of the narrowest bar and narrowest space in a bar code symbol.