Code 128

Specification for Barcode Symbology

1.0 Introduction

USS-128 (nee Code 128) is a bar code symbology capable of encoding the full ASCII 128 character set, as well as four additional non-data function characters. It also allows numeric data to be represented in a compact double-density mode, two digits for every character.

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

Every USS-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. USS-128's characteristics are summarized in Table 1.

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—0.0075 inch (0.191mm)
Maximum Data Character Density—
- 24.24 Numeric Char./inch
- (9.54 Numeric Char./ cm)
- 12.12 Other ASCII Char./inch
- (4.77 Other ASCII Char./cm)

Non-Data Overhead—Equivalent of 3.18 Alphanumeric characters
Additional Features— Double Module Exterior Bars

Table 1
Characteristics of USS-128

2.0 Symbol Description

2.1 Symbol Structure

Each USS-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, the check character, and finally the unique stop character.

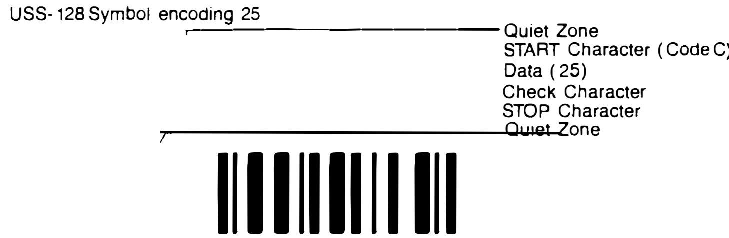

Figure 1 Symbol Structure

2.2 Character Encodation

Each USS-128 character consists of eleven modules. Each module, whose width is a dimension called X, can be either printed as a bar or part of a bar, or not printed and therefore represent a space or part of a space. Each character is comprised of three bars and three spaces, with each bar or space containing one to four modules. Character parity is defined by the sum of the printed modules in any character being even and the sum of the non-printed modules in any character being odd.

This definition applies to all USS-128 characters except the stop character, which differs with thirteen modules comprised of four bars and three spaces.

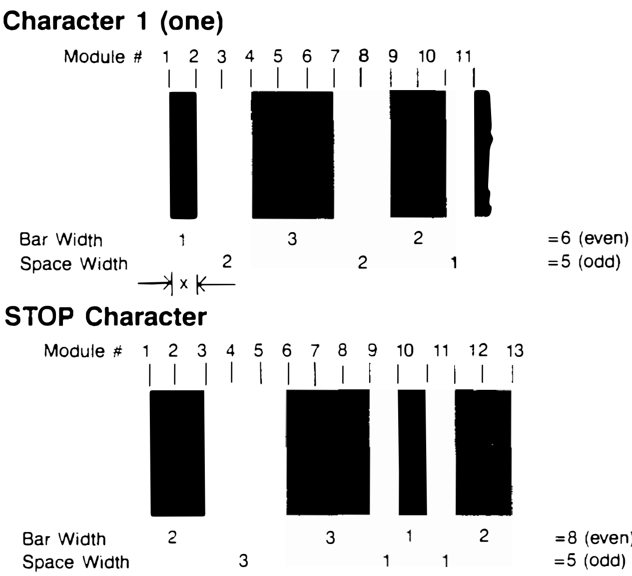

Figure 2 Character Structure

2.3 Code Structure

USS-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 USS-128 symbols, through the use of different combinations of start, code, and shift characters. Appendix G contains rules for generating the smallest symbol for given data.

CODE 128 (USD-6)

VALUE	CODE A	CODE B	CODE C	BAR PATTERN 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

VALUE	CODE A	CODE B	CODE C	BAR PATTERN B	S	B	S	B	S
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
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

VALUE		B	S	B	S	B	S
103	START (CODE A)	2	1	1	4	1	2
104	START (CODE B)	2	1	1	2	1	4
105	START (CODE C)	2	1	1	2	3	2

	B	S	B	S	B	S	B
STOP	2	3	3	1	1	1	2

TABLE 2

2.3.1 Code Subset A
Code Subset A includes all of the standard upper-case alpha-numeric 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 alpha-numeric 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 through 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. The code and shift special characters allow this type of change. 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
FNC 1 and FNC 4 are available for code reader specific definition.

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.

2.3.5 Value
Each character has an associated value listed in Table 2. This value is used in calculating the check character.

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 immediately precedes the stop character. Its value (value as shown in Table 2) is equal to the modulo 103 sum of the value of the start character and the weighted values of the data/special characters. The weights are one for the first data/special character and continuing with 2, 3, 4, etc. for the following data/special characters.

For example, in Figure 1 the value of the start character C is 105 and the data character for 25 is 25. The weight of the first data character is one, so the check character value is calculated as follows:

$105 + (25 \cdot 1) = 130$

where:

105 and 25 are the values and 1 is the weight

The checksum is equal to 130 modulo 103 (the remainder of 130 divided by 103):

$130/103 = 1$ **remainder 27**

Therefore the check character is equal to character value 27 (; in Code Set A).

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

3.0 Dimensions and Tolerances

3.1 Measurement Conditions
Implicit in the measurement of code element width is the measurement which locates the boundary between the light and dark elements of the code. In order to allow

for measurements to be made in the presence of edge roughness, spots and voids, the boundary is defined as the position of the center 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 by that aperture on the adjacent bar and space. X is the width of a narrow element.

3.2 Dimensions

USS-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 0.0075 inches (0.191 mm). (See Appendix F 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 shall be 10 times X or 0.10 inch (2.54 mm) in width, whichever is greater. For optimum hand scanning, the quiet zone should be at least 0.25 inch (6.35 mm) wide.

For general applications, the minimum bar height shall be 0.25 inches (6.25 mm) or 15 percent of the symbol's length, whichever is greater.

3.3 Symbol Length

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

L = ((5.5D + 11C + 35)X) + 2Q

where:

- **L = length**
- **D = number of digits in numeric fields (see Appendix G)**
- **C = number of ASCII characters not included in D, plus the number of function characters, plus the number of shift characters required**
- **X = X dimension**
- **Q = width of quiet zone**

3.4 Dimensional Tolerances

The various processes used to prepare 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. Appendix B describes the reference decode algorithm used in the derivation of the error tolerances given below.

The tolerances specify a minimum X dimension of 0.0075 inches (0.19 mm). This limit reflects the current technology for a range of standard scanning devices.

Three sets of measurements are required to determine the tolerances for every character (Figure 3).

The character to character tolerance, "p", is the maximum amount the total width of the character can vary from its nominal dimension.

The bar or space tolerance, "b", is the maximum amount any of the bar widths and space widths may vary from its nominal dimension.

The edge to edge tolerance, "e", is the maximum amount any of the four indicated dimensions may vary from its nominal dimension. These four 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.

The value of tolerances "b", "e", and "p" are defined as:

b = ± 0.40X − 0.0005 inches

or

b = ± 0.40X − 0.013 mm

e = ± 0.20X

p = ± 0.20X

where:

X is the nominal minimum dimension.

The 0.0005 inch (0.0127 mm) constant term is used in standard print densities. In special applications where the X dimension is less than 0.0075 inches (0.191 mm) b is defined as:

b = ± 0.33X (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.

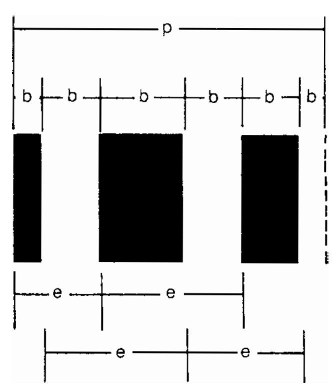

Figure 3 Tolerance Measurements

The following table lists the calculated tolerances for various densities.

(1) X	(2) numeric density	(3) character density	(4) b	(5) e	(6) p
7.5	24.24	12.12	2.50	1.50	1.50
8.0	22.73	11.35	2.70	1.60	1.60
9.0	20.20	10.10	3.10	1.80	1.80
10.0	18.18	9.09	3.50	2.00	2.00
12.0	15.15	7.57	4.30	2.40	2.40
14.0	12.99	6.49	5.10	2.80	2.80
17.0	10.70	5.35	6.30	3.40	3.40
20.0	9.09	4.55	7.50	4.00	4.00
30.0	6.06	3.03	11.50	6.00	6.00
40.0	4.55	2.27	15.50	8.00	8.00
50.0	3.64	1.82	19.50	10.00	10.00

(1) X is nominal module width in 0.001 inch (0.0254 mm)
(2) characters per inch in Code Set C
(3) characters per inch in Code Set A or B
(4) b is bar or space tolerance in ± mils
(5) e is edge to edge tolerance in ± mils
(6) p is character to character tolerance in ± mils

Table 3. Tolerance Values

These tolerances are represented graphically in Figure 4.

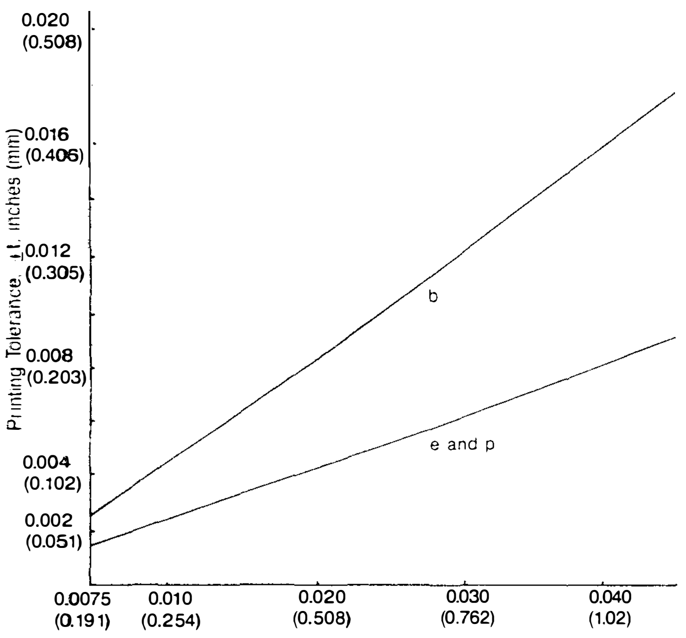

Figure 4 USS 128 Dimensional Tolerances

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 discernable difference in reflectance exists between spaces and bars. This difference must be at least 37.5 percentage points for symbols with an X dimension of less than 40 mils (1.02 mm) and at least 20 percentage points for symbols with an X dimension of 40 mils (1.02 mm) 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, that is, 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 limited to be no greater than one-quarter 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 can not vary any more than one-half 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 shall be made with a system having its peak response at 633 nanometres ±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, appropriate red LED's or alternatively the CIE Source A illuminant (incandescent source) along with an S-4 response photodetector and a Wratten 26 red filter.

Appendix F 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 to be the ratio of the diffusely reflected radiation from the surface to that reflected from a specially prepared Magnesium Oxide or Barium Sulfate 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, centered 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 the 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 be sampled adequately and that conditions under which an underlying dark surface or pattern may affect the symbol quality be included in the measurement process. The net effect of all noise contributing factors must not cause the symbol reflectance measurements to fall outside of 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. No reflectance measurements are made with the aperture positioned across the edge between a bar and space as defined in Section 3.1 above. 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.

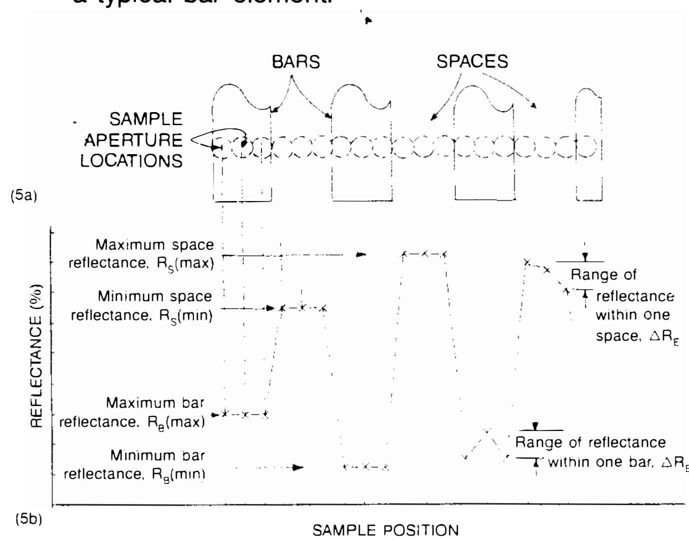

Figure 5. Bar Code Reflectance Measurements

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 percent

4.4.2 Minimum Space Reflectance (R_S)

R_S (MIN) > 25 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 ⩾ 37.5 percent for X < 0.040 inches (1.02 mm)
MRD ⩾ 20 percent for X ⩾ 0.040 inches (1.02 mm)

The special provisions for symbols with X ⩾ .040 inches (1.02 mm) have been made in order to accommodate the printing of lower density labels on darker backgrounds.

4.4.4 Element Uniformity

4.4.4.1 Maximum variation in reflectance of a single element, $\triangle R_E$ (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;

$\triangle R_E$(MAX) across one element $\leqslant$ 0.25 MRD

4.4.4.2 Maximum variation in reflectance of spaces across entire symbol, $\triangle R_S$ (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;

$\triangle R_S(MAX) = R_S(MAX) - R_S(MIN) \leqslant 0.5 MRD$

4.4.4.3 Maximum variation in the reflectance of bars across entire symbol, $\triangle R_B$ (MAX)

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

$\triangle R_B(MAX) = R_B(MAX) - R_B(MIN) \leqslant 0.5 MRD$

Appendix A

AIM Glossary of Terms

AIM—Automatic Identification Manufacturers, Inc. The publishers of this document.
Alphanumeric—The character set which contains letters, numbers and usually other characters such as punctuation marks.
Aperture—The opening in an optical system defined by a lens or baffle that establishes the field of view.
ASCII—The character set and code described in American National Standard Code for Information Interchange, ANSI X3.4-1977. Each ASCII character is encoded with 7-bits (8 bits including parity check). The ASCII character set is used for information interchange between data processing systems, communication systems and associated equipment. The ASCII set consists of both control and printing characters.
A.N.S.I.—The American National Standards Institute—nee United States of America Standards Institute (USASI)—is a non-governmental organization responsible for the development of manufacturing standards.
Background—The lighter portion of a bar code symbol, including the quiet zones.
Bar—The darker element of a printed bar code symbol.
Bar Code—An array of parallel rectangular bars and spaces that together represent data elements or characters in a particular symbology. The bars and spaces are arranged in a predetermined pattern following unambiguous rules defined by the symbology, e.g. USS-39.
Bar Code Character—A single group of bars and spaces which represent an individual number, letter, punctuation mark or other symbol.
Bar Code Symbol—See Symbol
Bar Code Density—The number of characters which can be represented in a linear unit of measure. Bar code density is often expressed in characters per inch.
Bar Code Reader—A device used to read a bar code symbol.
Bar Height—The dimension of a bar measured perpendicular to the bar width.
Bar Width—The thickness of a bar measured from the edge closest to the symbol start character to the trailing edge of the same bar.
Bidirectional—A bar code capable of being read successfully independent of scanning direction.
Binary—The number system that uses only 1's and 0's.
Bit—An abbreviation for "binary digit." A single element (0 or 1) in a binary number.
Character—1. A single group of bars and spaces which represent an individual number, letter, punctuation mark or other symbol. 2. A graphic shape representing a letter, numeral or symbol. 3. A letter, digit, or other symbol that is used as part of the organization, control, or representation of data.
Character Set—Those characters available for encodation in a particular bar code symbology.
Check Character—A character included within a symbol whose value is used for the purpose of performing a mathematical check to ensure the accuracy of the read.
Code—A set of unambiguous rules specifying the way in which data may be represented. (See "Bar Code".)
Continuous Code—A bar code symbol where all spaces within the symbol are parts of characters, e.g. USS-I 2/5. There is no intercharacter gap in a continuous code.
Diffuse Reflection—The component of reflected light which emanates in all directions from the reflecting surface.
Discrete Code—A bar code or symbol where the spaces between characters (intercharacter gaps) are not part of the code, e.g. USS-39.
EAN—European Article Numbering System, the international standard bar code for retail food packages.
Element—A single bar or space.
Font—A specific size and style of printer's type.
Helium Neon Laser—The type of laser commonly used in bar code scanners. It emits coherent red light at a wavelength of 633 nm.
Intercharacter Gap—The space between two adjacent bar code characters in a discrete code. For example, the clear space between two characters in AIM USS-39.
LED—Light emitting diode. A semiconductor that produces light at a frequency determined by its chemical composition. The light source commonly used in wand type readers.
Misread—A condition which occurs when the data output of a reader does not agree with the data encoded in the bar code symbol.
Module—The narrowest nominal unit of measure in a bar code.
Nanometre—A unit of measure used to define the wavelength of light. Equal to 10^{-9} metre.
Nominal—The exact (or ideal) intended value for a specified parameter. Tolerances are specified as positive and negative deviations from this value.
Non-Read—The absence of data at the reader's output after an attempted scan due to no code, defective code, reader failure or operator error.
Numeric—A character set that includes only numbers.
Opacity—The property of a substrate material that minimizes show-through from the back side or the next sheet. The ratio of the reflectance with a black backing to the reflectance with a white backing. Ink opacity is the property of an ink that prevents the substrate from showing through.
Orientation—The alignment of the symbol's scan path. Two possible orientations are horizontal with vertical bars and spaces (picket fence) and vertical with horizontal bars and spaces (ladder).
Overhead—The fixed number of characters required for start, stop and checking in a given symbol. For example,

a symbol requiring a start/stop and two check characters contains four characters of overhead. Thus, to encode three characters, seven characters are required.

Quiet Zone—A clear space, containing no dark marks, which precedes the start character of a symbol and follows the stop character.

Reflectance—The ratio of the amount of light of a specified wavelength or series of wavelengths reflected from a test surface to the amount of light reflected from a barium oxide or magnesium oxide standard.

Resolution—The narrowest element dimension which can be distinguished by a particular reading device or printed with a particular device or method.

Self-Checking—A bar code or symbol using a checking algorithm which can be independently applied to each character to guard against undetected errors.

Show-Through—The generally undesirable property of a substrate that permits underlying markings to be seen.

Space—The lighter element of a bar code usually formed by the background between bars.

Spectral Response—The variation in sensitivity of a reading device to light of different wavelengths.

Specular Reflection—The mirror-like reflection of light from a surface.

Spots—The undesirable presence of ink or dirt in a space.

Start-Stop Character or Pattern—A special bar code character that provides the scanner with start and stop reading instructions as well as scanning direction. The start character is normally at the left-hand end of a horizontally oriented symbol. The stop character is normally at the right-hand end of a horizontally oriented symbol.

Substrate—The surface on which a bar code symbol is printed.

Symbol—A combination of characters including start/stop characters, quiet zones, data characters, and check characters required by a particular symbology, which form a complete, scannable entity.

Symbol Length—The distance between the outside edges of the quiet zones.

UPC (Universal Product Code)—The standard bar code symbol for retail food packages in the United States.

USS—Uniform Symbology Specification of which this complete document is one. USS is used in the most recent of AIM symbology specifications.

Void(s)—The undesirable absence of ink in a bar.

Appendix B

Reference Decode Algorithm for USS-128

The allowable print tolerances for USS-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, 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 w, t1, t2, t3, t4, b1, b2, and b3 (Figure 6).

2. Convert measurements t1, t2, t3, and t4 to normalized values T1, T2, T3, and T4 which will represent the integral module width of these measurements. The following method is used for the i-th. value.

If $1.5w/11 < t_i < 2.5w/11$, then Ti is 2;
If $2.5w/11 < t_i < 3.5w/11$, then Ti is 3;
If $3.5w/11 < t_i < 4.5w/11$, then Ti is 4;
If $4.5w/11 < t_i < 5.5w/11$, then Ti is 5;
If $5.5w/11 < t_i < 5.5w/11$, then Ti is 5;

Otherwise the character is in error.

3. Lookup character in decode table using the four values, T1, T2, T3, and T4 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:

$$(V - 1.75)w/11 < (bi + b2 + b3) < (V+1.75)w/11,$$

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 character.

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.

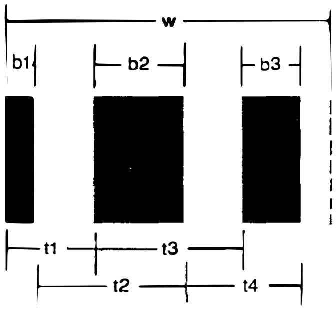

Figure 6 DECODE MEASUREMENTS

Appendix C

Optional Characteristics

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 characters 1 and 4 (FNC 1 and FNC 4) are not defined in the symbology and may be used for application specific purposes.

Appendix D

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.

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Figure 7

Appendix E

Auto-Discrimination Compatibility

USS-128 (Code 128) may be read by suitably programmed bar code readers that are designed to autodiscriminate this code from other symbologies. USS-128, in particular, compatible with:

USS-25
USS-39
USS-Codabar
USS-93
UPC Versions A and E
EAN-8 and EAN-13

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

Appendix F

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. But 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 0.0075 inches (0.191 mm). 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 0.25 inches (6.35 mm) 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 assure that the spectral response characteristics of the reading equipment is matched to the spectral reflectance characteristics of the printed symbols.

Other Considerations

Compliance with specifications is one key to assuring overall system success, but other considerations come into play which can influence performance as well. 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 which 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. Matte, non-glossy finishes minimize this effect.

In cases where specular reflective 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 assure that the optical properties are within specification over the entire range of read angles and distances required by the particular application.

Appendix G

Use of Start, Code, and Shift Characters

The same data may be represented by different USS-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:

1. Determine the start character:
   - 1a. If the data begins with 4 or more digits, use start Code C;
   - 1b. Otherwise, if a control character occurs in the data before any lower case character, use start Code A;
   - 1c. Otherwise, use start Code B.

2. When step 1a is followed with an odd number of digits starting the data, insert a Code A or Code B character before the last digit, following rules 1b and 1c to determine between Code A and Code B.

3. If 4 or more digits occur together when in Code A or Code B:
   - 3a. If there are an even number of digits, insert a Code C character before the first digit to change to Code C;
   - 3b. Otherwise, there are an odd number of digits, so insert a Code C character after the first digit to change to Code C.

4. When in Code B and a control character occurs in the data:
   - 4a. If that following that character, a lower case character occurs in the data before the occurrence of another 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.

ERRATA

Table 2 (page 4) of USS-128 should be corrected as follows. For Code A and B, the value 62 produces the ^ (carat) character. For Code B, the value 64 produces the ` (accent grave) character.

Appendix B (page 11) of USS-128 contains an error under item number 2. The last line was omitted in the document and the next-to-last line was incorrectly printed. The correct method for calculating the i-th value is:

If $1.5w/11 < t_i < 2.5w/11$, the Ti is 2;
If $2.5w/11 < t_i < 3.5w/11$, the Ti is 3;
If $3.5w/11 < t_i < 4.5w/11$, the Ti is 4;
If $4.5w/11 < t_i < 5.5w/11$, the Ti is 5;
If $5.5w/11 < t_i < 6.5w/11$, the Ti is 6;
If $6.5w/11 < t_i < 7.5w/11$, the Ti is 7;

UPDATE: UCC/EAN Use of Code 128

The use of the FNC1 character in the first position of a Code 128 symbol has been assigned to UCC/EAN as a "flag character" to indicate that the symbol complies with a UCC/EAN standard.

In UCC/EAN 128 applications, the Code Set C Start Character and FNC1 are called the Start Code. It should be noted that the UCC/EAN 128 check character is calculated in the same manner as outlined in this document, with the FNC1 character as the first data/special character, which receives a weight of 1 (one).

When determining the check character in Code Set C, remember to take the ***value*** of the ***two digit*** interpretation of the printed character.

UPDATE: Recommended HRI for FNC1

If there is a requirement to produce a human-recognizable character for the Function 1 (FNC1) character, the draft recommendation is to super-impose the Greater Than (>) symbol over the Less Than (<) symbol in order to create this "dingbat" ><