Advanced Function Presentation Consortium

Bar Code Object Content Architecture

Frequently Asked Questions

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Implementation Tips for Producing Bar Codes with the Bar Code Object Content Architecture (BCOCA)

Editor:

David E. Stone, Ricoh Production Print Solutions

Contributing writers:

Edward F. Chatcavage, Ricoh Production Print Solutions
Don Maxwell, Crawford Technologies
David E. Stone, Ricoh Production Print Solutions

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Overview

Implementation Tips for Producing Bar Codes with the Bar Code Object Content Architecture

This document is a collection of information about AFP usage of bar codes intended to supplement the BCOCA Reference manual,AFPC-0005. It is assumed that the reader is familiar with basic bar code and BCOCA concepts; refer to the BCOCA Reference for a complete description of this architecture. The information in this document is intended for people using BCOCA objects to produce bar code symbols and for people implementing the BCOCA architecture within printers, transforms, or other products.

All of the bar codes supported by the BCOCA architecture are defined by Symbology Specifications provided by industry standards groups, such as GS1, Automatic Identification Manufacturers, Inc. (AIM), or postal organizations. A symbology sets the rules for a particular bar code type and defines how information is encoded into the physical attributes of bars, spaces, and two-dimensional modules.

Table of Contents

Bar Code Symbologies 4
Size of a Bar Code Symbol 8
Variations in Bar Code Symbol Width 10
Control of Symbol Width 11
Encrypting Bar Code Data 11
Aspect Ratio for PDF417 Symbols 12
FNC1 and Data Matrix Symbols 13
Recommended Module-Width-to-Pel Algorithm 15
BCOCA versus Fonts 16

Bar Code Symbologies

-- contributed by David E. Stone

What types of bar codes are supported within the BCOCA architecture?

A large variety of symbol types are supported; these can be classified into the following categories:

- Linear bar codes for numeric data
- Linear bar codes for alphanumeric data
- Postal bar codes
- Two-dimensional matrix bar codes
- Two-dimensional stacked bar codes

Linear bar codes for numeric data

UPC Version A
(encoding 01234567890)

UPC A + Two-digit Supplemental
(encoding 00633895260, supplemental = 24)

UPC A + Five-digit Supplemental
(encoding 09827721123, supplemental = 21826)

UPC Version E
(encoding 078349)

MSI - no check digit
(encoding 80523)

EAN 8
(encoding 2468123)

Codabar
(encoding A34698735B)

EAN 13
(encoding 041234567890)

EAN + 2 Digit Supplemental
(encoding 041234567890, supplemental = 99)

EAN + 5 Digit Supplemental
(encoding 041234567890, supplemental = 54321)

Industrial 2-of-5
(encoding 54321068)

Matrix 2-of-5
(encoding 54321068)

Interleaved 2-of-5
(encoding 54321068)

15400141288763

ITF-14 Symbol with Surrounding Bearer Bars

1234567895

Interleaved 2-of-5 Symbol
with Bearer Bars at Top and Bottom

(01)20012345678909

GS1 DataBar Omnidirectional
(encoding 20012345678909)

(01)20012345678909

GS1 DataBar Stacked Omnidirectional
(encoding 20012345678909)

(01)20012345678909

GS1 DataBar Stacked
(encoding 20012345678909)

(01)20012345678909

GS1 DataBar Truncated
(encoding 20012345678909)

(01)15012345678907

GS1 DataBar Limited
(encoding 15012345678907)

Linear bar codes for alphanumeric data

A B C 1 2 3 a b c @ 4 5 6

Code 128
(encoding ABC123abc@456)

00011111112222222229

UCC/EAN 128
(encoding FNC1 00011111112222222229)

39OR93W

Code 39 (3-of-9 Code)
(encoding 39OR93 with check character
yielding a 2.32 inch wide symbol)

□39OR93 □

Code 93
(encoding 39OR93
yielding a 1.82 inch wide symbol)

(01)98898765432106(3202)012345(15)991231

GS1 DataBar Expanded
(encoding 0198898765432106320201234515991231)

(01)98898765432106(3202)012345(15)991231

GS1 DataBar Expanded Stacked
(encoding 0198898765432106320201234515991231)

Postal bar codes

Australia Post Bar Code
Customer Barcode 2 using Table C
(encoding 56439111ABA 9)

Japan Postal Bar Code
Modifier X'00'
(encoding 15400233-16-4)

US POSTNET
Zip+4
(encoding 12345+6789)

PLANET Code
(encoding 00123456789)

Intelligent Mail Barcode
Modifier X’03’
(encoding 01 234 567094 987654321 01234567891)

USPS SCAN REQUIRED

99 M 123456 -----ABC1234

Intelligent Mail Container Barcode
Code 128, Modifier X’05’
(encoding 99M123456-----ABC1234)

Royal Mail (RM4SCC)
UK and Singapore version
(encoding SN34RD1A)

Royal Mail (RM4SCC)
Dutch KIX version
(encoding SN34RD1A)

Royal Mail RED TAG
(encoding 12345 67 2 2505 13 234567)

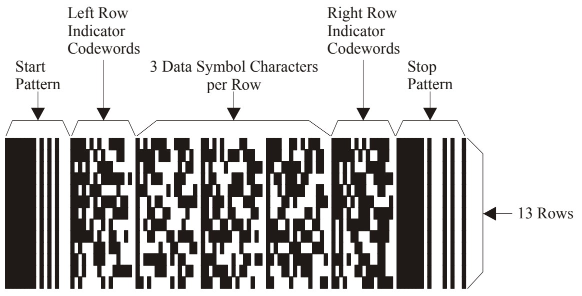
Two-dimensional matrix bar codes

Data Matrix 2D Symbol
(encoding A1B2C3D4E5F6G7H8I9J0K1L2)

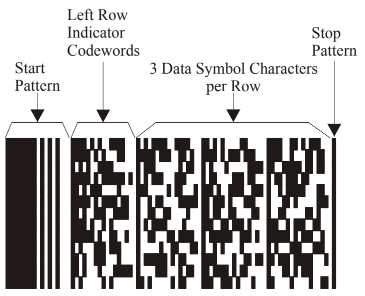
MaxiCode 2D Symbol

QR Code 2D Symbol

Two-dimensional stacked bar codes


Start Pattern
Left Row Indicator Codewords
3 Data Symbol Characters per Row
Right Row Indicator Codewords
Stop Pattern
13 Rows

PDF417


Start Pattern
Left Row Indicator Codewords
3 Data Symbol Characters per Row
Stop Pattern

Truncated PDF417

Size of a Bar Code Symbol

-- contributed by David E. Stone

What determines the size of a bar code symbol?

The height of a bar code symbol is controlled by the bar code symbology definition, by the amount of data to be encoded, and by various BCOCA parameters. The width of the symbol is usually dependent on the amount of data to be encoded and by choices made in various BCOCA parameters. Default values exist for most of the BCOCA parameters that can be used to produce minimal-size, scannable symbols; refer to your printer documentation for information about the specific default values used by BCOCA printers.

Linear Symbologies: The element-height and height-multiplier parameters specify the height of the symbol. For some bar code types, these parameters also include the height of the human-readable interpretation (HRI). Some bar code symbologies (Australia Post Bar Code, Intelligent Mail Barcode, Japan Postal Bar Code, POSTNET, RM4SCC, and Royal Mail RED TAG) explicitly specify the bar code symbol height; in this case, the element-height and height-multiplier parameters are ignored.

The height of GS1 DataBar symbols depends on the version of the symbol. Rules for GS1 DataBar symbol heights are as follows:

- GS1 DataBar Omnidirectional – The symbol height specified must be greater than or equal to 33 times the module width.
- GS1 DataBar Truncated – The symbol height specified must be greater than or equal to 13 times the module width.
- GS1 DataBar Stacked – The symbol height is fixed; the element height and height multiplier parameters are ignored.
- GS1 DataBar Stacked Omnidirectional – The row height specified must be greater than or equal to 33 times the module width; the symbol height includes both rows plus the height of the three-module-high separator pattern.
- GS1 DataBar Limited – The symbol height specified must be greater than or equal to 10 times the module width.
- GS1 DataBar Expanded – The symbol height specified must be greater than or equal to 34 times the module width.
- GS1 DataBar Expanded Stacked – The symbol height is fixed; the element height and height multiplier parameters are ignored.

Two-Dimensional Matrix Symbologies: The MaxiCode symbology specifies a fixed physical size, nominally 28.14 mm wide by 26.91 mm high; the module-width, element-height, and height-multiplier parameters are ignored for MaxiCode symbols.

Data Matrix symbols are rectangular and are made up of a pattern of light and dark squares (called modules). The size of each module is specified in the module-width parameter and the number of rows and columns of these modules is controlled by the desired-number-of-rows and desired-row-size parameters and the amount of data to be encoded. The element-height and height-multiplier parameters are ignored for Data Matrix symbols.

QR Code symbols are square and are made up of a pattern of light and dark squares (called modules). The size of each module is specified in the module-width parameter; the number of rows and columns of these modules is controlled by the version parameter, the error correction level selected, and the amount of data to be encoded. The element-height and height-multiplier parameters are ignored for QR Code symbols.

Two-Dimensional Stacked Symbologies: PDF417 symbols are rectangular and are made up of a pattern of light and dark rectangles (called modules). The size of each module is specified in the module-width, element-height, and height-multiplier parameters and the number of rows and columns of these modules is controlled by the data-symbols and rows parameters and the amount of data to be encoded. A PDF417 symbol must contain at least 3 rows.

Variations in Bar Code Symbol Width

-- contributed by David E. Stone

Why is a bar code symbol printed on a 240 pel printer sometimes wider than the same symbol printed on a 300 pel printer?

The width of a BCOCA bar code symbol depends on a variety of factors, including 1) amount and type of data to be encoded, 2) choices of BCOCA parameters (such as, module width, wide-to-narrow ratio, and bar code modifier), and 3) presentation device characteristics. It is the responsibility of the presentation device to produce bars and spaces that are as close to the user-specified module width and wide-to-narrow ratio as is practically possible. A difference in symbol length between different printers (given the same BCOCA object) is usually caused by device-implementation differences.

Typically, size differences are most noticeable in the width direction and this is due to how the module width parameter is handled by the implementation. Module width is specified in mils (1/1000th of an inch) and each printer must convert the specified module width to an integer number of printer pels; this conversion frequently cannot produce an exact measure and each implementer chooses an appropriate rounding or truncation method to yield acceptable results. This is made more difficult by device-specific characteristics, such as:

1) Size and positioning precision for each printer pel
2) The resolution of the print head (a good rounding/truncation choice made for a 300 pel/inch printer might be the wrong choice for a 480 pel/inch printer)
3) The ability of the print-head technology to produce precise and consistent pels. A laser printer is quite different from an ink jet or ribbon-based printer, a write-black technology is different from a write-white technology, etc.

The goal for each printer-development team is to produce bar widths that are as close to what the user specified as possible and still be within the tolerance defined in the symbology specification. Once a narrow-bar width in printer pels is generated, the printer lays out the sequence of bars and spaces that make up the symbol. If there is a slight difference between the theoretical module width (specified as a BCOCA parameter) and the resulting narrow-bar width in printer pels, this difference is multiplied by the number of bars (and spaces) in the symbol; the error gets worse when there are many bars and spaces in the symbol. Since there are real differences between printers (as described in the previous paragraph), there will be differences in symbol length between vendors and between printers with different resolutions.

The goal is defined by the BCOCA architecture, but the realization is up to the printer implementation. Most bar code symbologies specify a minimum recommended size for module width (for example, 7.5 mils is the minimum for a Code 39 symbol). Size problems are particularly noticeable when the module width is close to the minimum because some implementations round up to avoid producing a bar that is narrower than the minimum (other implementations don’t take this into consideration). Some printers provide options on the printer control panel to deal with this kind of boundary condition and to emulate the rounding/truncation algorithm used by other printers.

Since it uses a wide-to-narrow ratio, Code 39 symbols are also affected by the user choice for the wide-to-narrow ratio (WE:NE) parameter and by the ability of the printer to accurately generate the wide-bar that this symbology uses. The wide-to-narrow ratio specifies the module width of wide bars, using a ratio involving the narrow-bar width. If the narrow-bar width isn't exact, the wide-bar width will be affected, which can make the symbol width vary even more. Code 39 isn't the only bar code type for which this symbol-width problem exists, but it is often the most noticeable.

Control of Symbol Width

-- contributed by David E. Stone

How can I control the width of a bar code symbol?

The final width of a bar code symbol depends on several things: the amount of data to be encoded, module width, wide-to-narrow element ratio, error correction level, matrix row size, number of data symbol characters per row, security level, printer pel-rounding techniques, and so on. Determining the resulting symbol width from all these factors can be complicated and that often leads to trial-and-error techniques (adjusting the parameters to find a combination that produces a target symbol width). Worse yet, when the right combination is found for a given printer, that combination might produce a different size symbol on a different printer (one that has a different print head resolution, for example).

Many BCOCA implementations provide an easy way to specify a target symbol width that has a much better chance of producing the desired result. There are two things that can help:

1. Use the desired-symbol-width parameter (bytes 10-11 in the BSD). The BCOCA receiver will use the desired-symbol-width value to attempt to create the widest bar code symbol that fits within the desired symbol width. You will likely produce an acceptable symbol regardless of the print head resolution or printer technology.

2. For fixed-size symbols that explicitly specify the module width, use the module width parameter. These fixed-size symbols allow for a tolerance range in creating the symbol. Some BCOCA receivers can produce either an optimal-size symbol or a small-size symbol for these fixed-size bar codes. This is called “small-symbol support” and is controlled by the value of the module-width parameter. Refer to the “Sizing Targets for Fixed-Size Bar Code Types” table in the BCOCA Reference for more information about this option.

Encrypting Bar Code Data

-- contributed by David E. Stone

How can bar code data be protected by a key or password, so that the data can only be read by using the key or password?

It is possible to create a 2D bar code symbol whose data has been encrypted. Using this method, the customer would encrypt the data for the bar code using whatever encryption method and key the customer chooses, then the BCOCA bar code would contain the encrypted data (instead of the original data). Whenever the bar code is read by a scanning device, the output would be the encrypted data (and therefore not readable by an unauthorized person); the customer would have to decrypt the scanned output after the bar code has been read (this could be done by an application program whose input is from the scanner).

Using encrypted data is possible with BCOCA 2D bar codes because each of these bar code types (PDF417, Data Matrix, MaxiCode, and QR Code) can handle the full 256-byte ASCII and can handle binary data as input (so each input character can have any value and there is no need for the input to be readable by humans).

Aspect Ratio for PDF417 Symbols

-- contributed by David E. Stone

Why can't an aspect ratio (for example, a 2:1 ratio of columns to rows) be specified for BCOCA PDF417 symbol?

The BCOCA parameters for PDF417 are based on the PDF417 symbology definition, which defines the symbol in terms of a number of data symbol characters per row and a number of rows. When building a BCOCA PDF417 bar code, you must specify the number of data symbol characters per row. The actual symbol contains 4 more symbol characters (start pattern, stop pattern, left row indicator, and right row indicator); so what is specified is effectively the number of columns minus 4. For the number of rows, you have two choices:

1. Specify a number (that can be 1/2 the number of columns ... giving you a 2:1 ratio); the printer will pad if necessary to fill all of the requested rows
2. Specify X'FF', which tells the printer to use the minimum number of rows necessary to hold the data.

Some application programs allow a user to specify the relative size of a PDF417 symbol as an aspect ratio. When the BCOCA architecture was defined for PDF417, it was decided that having the printer figure out how to arrange the data into a particular aspect ratio was too time consuming at print time (particularly for printers running at greater than 1000 pages per minute). AFP data is usually generated as final form such that the generator makes the layout decisions (for example, the aspect ratio for a bar code). Defining the final-form data is pretty easy for most bar code generators, but it can be harder for a transform product that only has an aspect ratio as input.

FNC1 and Data Matrix Symbols

-- contributed by Edward F. Chatcavage

How are control characters, such as FNC1, used to produce the smallest Data Matrix symbol?

Background

Data Matrix is a two-dimensional matrix symbology that is made up of square modules arranged within a perimeter finder pattern. The specification for the symbology is published by AIM International, Inc. There are two types of symbols: ECC 000–140 with several available levels of convolutional error correction, and ECC 200, which uses the Reed-Solomon error correction. Since ECC 200 is the recommended type for all new applications, the BCOCA architecture uses only ECC 200.

The manner in which a user's data is converted to form an ECC 200 symbol is as follows:

1. Analyze the user's input data to identify the variety of different characters that will be encoded into the symbol. This is part of the Data Encodation step, where the data is efficiently converted into codewords using six different encodation schemes.

   Note: The user's input data may be supplemented with additional information obtained from the Data Matrix Special-Function Parameters as defined in the Bar Code Object Content Architecture Reference (AFPC-0005-08).

2. Generate the Reed-Solomon error correction codewords from step 1 above. These codewords will become part of the symbol.

3. Generate the symbol itself by converting the codewords into square modules for placement within the symbol.

Encoding the Data

During the encoding step, there are several special symbology control characters that get inserted as codewords for the symbol. These special control characters are used to instruct a bar code reader on how to interpret the data contained within the symbol. As an example, there are ***Latch Control Codewords*** to indicate switching between the different encodation schemes. Another special control character is **FNC1**, which is used as an *Alternate Data Type Identifier.*

As stated in section 6.2.4.6 of the AIM specification:

> *"To encode data to conform to specific industry standards as authorized by AIM International, a FNC1 character shall appear in the first or second symbol character position (or in the fifth or sixth data positions of the first symbol of Structured Append). FNC1 encoded in any other position is used as a field separator and shall be transmitted as GS control character (ASCII value 29)."*

The FNC1 character is inserted into the data when either one of the two Alternate Data Type identifiers is set in the Data Matrix Special-Function Parameters.

Problem Found While Encoding the Data

A problem was reported by a customer: Some implementations of the Data Matrix bar code are not producing the smallest size symbol for the given amount of input data. Different BCOCA implementations produced slightly different sized symbols. The problem was found to be caused by how the AIM Specification was interpreted by different people.

When the user's data is encoded for the symbol, it is desired that the smallest number of symbol codewords be inserted into the symbol. The AIM Specification has an Annex S (Informative) section describing an algorithm that will usually produce the shortest codeword stream. As part of this algorithm, there is a look-ahead test that scans the data to be encoded to find the best mode. The test basically wants to examine the next four data characters before determining a best mode. In the AIM Specification, part 'Q' of the look-ahead test read as follows:

"Q. Process the B256 count:

1. *If the character is a Function character (FNC1, Structured Append, Reader Program, or Code Page), add 4 to the B256 count.*
2. *Otherwise add 1 to the B256 count."*

Now, a FNC1 character could only be in the data when explicitly inserted by the BCOCA-implementation code when processing the Alternate Data Type identifiers parameters. So step 'Q' above should only recognize FNC1 characters that are inserted into the user's data. It so happens, that the codeword value for FNC1 is 232. Therefore, the user's data might contain this value as normal binary data. When this is the case, the look-ahead code should not treat the value 232 as an FNC1 character.

Note: The BCOCA implementation does not specify any means of inputting a FNC1 character as part of a user's data input.

Recommended Module-Width-to-Pel Algorithm

-- contributed by Don Maxwell and David E. Stone

How should a BCOCA receiver convert the module width value into device pels?

In the description of the Module Width parameter, the BCOCA Reference states that:

> "Presentation devices must map the module width specification (or recommendation) to an integer number of device pels. This mapping yields an approximation of the user request and can cause the actual width and height of a bar code symbol to be slightly different at different device resolutions."

The presentation device is required to closely approximate the specified width and to also obey the rules of the Symbology definition. Most symbologies require that each bar in the symbol be a multiple of the module width; so it is better to first round the module width to an integer number of pels and then use this value when calculating the width of each bar (trying to distribute fractional pels across the symbol will usually violate the Symbology rules).

For example, if a module width of 8 mils has been specified and the BCOCA presentation device has a resolution of 300 pels per inch, the presentation device has been asked to create a symbol using a narrow bar width of (8/1000)*300 = 2.4 device pels. It is recommended that the presentation device round this value to 2 pels (using the round-off algorithm, which rounds 2.x to 2 if x<5 and to 3 if x is 5 or greater). When applying the WE:NE parameter (or a simple multiple) to calculate the width of the wider bars of the symbol, the 2 pel narrow bar width is multiplied by the WE:NE or multiplier value.

For instance, here are two methods to create 1, 2, and 3 module-wide bars and to apply a WE:NE ratio of 2.25:

Incorrect:

2.4 * 1 = 2.4	(rounded to 2 pels, so the width of 1 bar is 2 pels)
2.4 * 2 = 4.8	(rounded to 5 pels, which is no longer twice the width of 1 bar)
2.4 * 3 = 7.2	(rounded to 7 pels, which is not 3 times the width of 1 bar)
2.4 * 2.25 = 5.4	(rounded to 5 pels)

Correct:

2 * 1 = 2	(rounded to 2 pels, so the width of 1 bar is 2 pels)
2 * 2 = 4	(rounded to 4 pels, which is twice the width of 1 bar)
2 * 3 = 6	(rounded to 6 pels, which is 3 times the width of 1 bar)
2 * 2.25 = 4.5	(rounded to 5 pels)

BCOCA versus Fonts

-- contributed by David E. Stone

When should a BCOCA object be used rather than drawing a bar code with some other method?

Bar codes are simply marks in a predefined pattern that could be created in many ways (fonts, images, graphics, text rules, etc.); but here are some reasons to prefer BCOCA to these other methods:

- A BCOCA bar code is self-identifying; anyone parsing the data stream will know that the object is intended to be a bar code and therefore must meet the rules of the symbology specification. There is no architected way to identify a bar code other than with BCOCA.
- BCOCA devices typically are very careful to take device characteristics (such as pel shape, toner spread, laser strength, write-black versus write-white technology, etc.) into account when producing bar code symbols.
- BCOCA objects are resolution independent; therefore the printer draws each bar code symbol based on the current print head resolution and any print quality tuning or other hardware adjustments that will be made to the final bitmap. Printers can also be aware of color management effects when a BCOCA object is processed. Some modern ink jet printers use an anamorphic resolution (different in the X versus Y directions) and have different spread characteristics in each direction.
- Fonts used to produce bar codes can produce different results on different devices. Sometimes, print server software substitutes fonts (for example, outline for raster, or 240 pel raster for 300 pel raster when the print head is 240 pel). Some bar codes are pretty easy to produce using a raster font, but others have to be tuned carefully (and therefore are affected by any under-the-covers substitution or resolution change). Using a font to produce a bar code symbol can be made to work on a specific printer, but might very well not work after a customer has upgraded to a newer printer or moved to another vendor's printer (or even tried to print a job on another printer because of workflow problems). Because bar codes made with fonts are device-specific, testing is essential when fonts are used, but not so critical with BCOCA.
- It is typically safer for data stream transform or conditioning software to modify BCOCA Bar Code data rather than text data (because you really have to use some kind of a convention to even find bar codes that are represented by text and sometimes text strings are used for multiple purposes ... so you might change more than is intended). Banks and other financial customers are often uncomfortable with software that alters text strings (but less concerned when the same software alters BCOCA object data).
- Almost every modern IPDS printer supports BCOCA (and most of the newer printers support most of the defined BCOCA function).
- The input needed to produce a BCOCA bar code is quite simple and consists of a few control parameters (most of which have reasonable defaults) and the actual data to be encoded; the user does not need to understand the bar code symbology definition (the printer does all of the difficult, technical work). In contrast, using a font requires the user to encode the symbol by translating the data characters into a binary sequence for encoding, create the bar and space pattern that represents each character, and format the individual characters into a completed bar code symbol (which can include calculating check digits and carefully adjusting the spacing to get around printer characteristics). This is quite easy for some symbologies, such as POSTNET, but difficult for 2D bar codes and most 4-state bar codes. Usually, you need both a specially designed font and some software to create the code point pattern needed to use the font.

In summary, AFP users can enjoy a better experience printing bar codes on their IPDS printers by simply using the capabilities of the BCOCA architecture rather than drawing pictures of bar codes using fonts, rules, or images. BCOCA is a proven technology that is used by many of the largest production print shops in the world today. The BCOCA architecture is an open standard maintained by the AFP Consortium. Symbologies, such as the Intelligent Mail Barcode, are monitored carefully by members of this international consortium to ensure that the architecture keeps up with changes made by the symbology owners.

Bar Code Object Content Architecture

Frequently Asked Questions

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