

## Different Types of Barcodes

A Barcode symbology defines the technical details of a particular type of barcode: the width of the bars, character set, method of encoding, checksum specifications, etc. Most users are more interested in the general capabilities of a particular symbology (how much and what kind of data can it hold, what are its common uses, etc) than in the excruciating technical details.

Want to compare barcodes side by side? Check out our Symbology Comparison Chart!

### Numeric-only barcodes

- [Codabar](#): Older code often used in library systems, sometimes in blood banks
- [Code 11](#): Used primarily for labeling telecommunications equipment
- [EAN-13](#): European Article Numbering international retail product code
- [EAN-8](#): Compressed version of EAN code for use on small products
- [Industrial 2 of 5](#): Older code not in common use
- [Interleaved 2 of 5](#): Compact numeric code, widely used in industry, air cargo
- [MSI](#): Variation of the Plessey code commonly used in USA
- [Plessey](#): Older code commonly used for retail shelf marking
- [Post Net](#): Used by U.S. Postal Service for automated mail sorting
- [UPC-A](#): Universal product code seen on almost all retail products in the USA and Canada
- [Standard 2 of 5](#): Older code not in common use
- [UPC-E](#): Compressed version of UPC code for use on small products

### Alpha-numeric barcodes

- [Code 128](#): Very capable code, excellent density, high reliability; in very wide use world-wide
- [Code 39](#): General-purpose code in very wide use world-wide
- [Code 93](#): Compact code similar to Code 39
- [LOGMARS](#): Same as Code 39, this is the U.S. Government specification
- [HIBC](#): Health Industry Barcode

### 2-Dimensional barcodes

- [PDF417](#): Excellent for encoding large amounts of data
- [DataMatrix](#): Can hold large amounts of data, especially suited for making very small codes
- [Maxicode](#): Fixed length, used by United Parcel Service for automated package sorting
- [QR Code](#): Used for material control and order confirmation
- Data Code
- Code 49
- 16K

## Industry Standards for Barcodes and Labels

- [Bookland](#) EAN encodes ISBN numbers, used internationally to mark books
- [ISSN](#) and the SISAC Barcode: International Standard Serial Numbering
- [OPC](#): Optical Industry Association barcode for marking retail optical products
- [UCC/EAN-128](#): Widely used data formatting model for Code 128
- [UPC Shipping Container Symbol](#): ITF-14
- [HIBC](#): Health Industry bar code

## Bookland EAN (for ISBN numbers)

The Bookland EAN barcode is used internationally to identify books as well as video and audio cassettes and software. The unique number assigned to each item is the International Standard Book Number (ISBN). If you are a new publisher and need one or more ISBNs, the agency responsible for assigning these numbers in the USA is:



*Bowker/Martindale-Hubbell*  
*121 Chanion Road*  
*New Providence, NJ 07974*  
*telephone: 908-665-6770 or 877-310-7333 (toll free)*  
*fax: 908-665-3502*  
[www.bowker.com](http://www.bowker.com)

The international agency is:

*International Standard Book Number Agency*  
*Staatsbibliothek Preussischer Kulturbesitz*  
*Posdamer Strasse 33*  
*D-1000 Berlin 30 Germany*  
*telephone: (49) 030-2661 (ext. 2338, 2498)*

An ISBN is a 10-digit number which is made up of:

1. Group identifier (1 digit, typically 0 or 1 for English-speaking countries)
2. Publisher identifier
3. Title identifier
4. Check digit

The total length of the publisher and the title identifier is 8 digits. When an identifier is assigned to a publisher, the ISBN agency takes into account the number of titles which the publisher believes will be needed. Larger publishers are given a shorter publisher identification number in order to make more digits available for title identification. Here is a sample ISBN from a publisher (ID number 55615) who has been assigned 3 digits for use as title identifiers:

ISBN 1-55615-678-2

ISBNs are printed on books using the EAN-13 barcode symbology. In normal use, the first two or three digits of an EAN-13 barcode identify the country of origin. The country prefixes 978 and 979 were set aside for 'Bookland' (only the 978 prefix is in current use). To print an ISBN as a Bookland EAN barcode, add the 978 prefix at the front of the ISBN and remove the ISBN check digit from the end; an EAN check digit will be added in its place. Thus the Bookland EAN code for the sample shown above would look like this (the ISBN check digit 2 is replaced by the EAN check digit 6):

The Bookland EAN barcode may be followed by a 5-digit add-on supplemental code which contains the suggested retail price. The first digit of the five indicates the currency: 0 for the British Pound and 5 for the US Dollar. Here is a sample with a suggested list price of \$18.95:

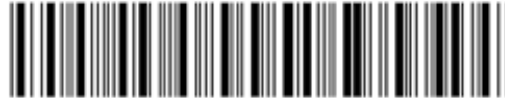


A supplemental code of 90000 indicates that the book has no suggested retail price. Supplemental numbers in the range 90001 to 98999 may be used by publishers for internal purposes. Complimentary copies of books are marked 99991. The National Association of College Stores uses 99990 to mark used books.

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123456789012



3 3191 00010 5864

## **Codabar (USD-4, NW-7, and 2of 7 code)**

Codabar can encode the digits 0 through 9, six symbols (-:.\$/+), and the start/stop characters A, B, C, D, E, \*, N, or T. The start/stop characters must be used in matching pairs and may not appear elsewhere in the barcode. Codabar is used in libraries, blood banks, the overnight package delivery industry, and a variety of other information processing applications.

There is no checksum defined as part of the Codabar standard, but some industries (libraries, for example) have adopted their own checksum standards. Many libraries use the following system which includes 13 digits plus a checksum; here is a description of the method used by Ameritech Library Services (Provo, Utah).

- Digit 1 indicates the type of barcode: 2 = patron, 3 = item (book)
- Digits 2-5 identify the institution
- The next 6 digits (00010 586) identify the individual patron or item
- Digit 14 is the checksum

To calculate the checksum, start with the total set to zero and scan the 13 digits from left to right:

1. If the digit is in an even-numbered position (2, 4, 6...) add it to the total.
2. If the digit is in an odd-numbered position (1, 3, 5...) multiply the digit by 2. If the product is equal to or greater than 10, subtract 9 from the product. Then add the product to the total.
3. After all digits have been processed, divide the total by 10 and take the remainder.
4. If the remainder = 0, that is the check digit. If the remainder is not zero, the check digit is 10 minus the remainder.

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## Code 11 (USD-8)

Code 11 is used primarily for labeling telecommunications equipment.

The character set includes the digits 0 through 9, a dash ( - ), and a start/stop code. Each character is encoded with three bars and two spaces. Of these five elements, there may be two wide and three narrow, or one wide and four narrow. Wide elements represent a binary 1 while narrow elements represent a binary 0.



Two check digits, named C and K, are used; often only the first check digit (C) is used when the length of the data is 10 characters or fewer. The check digits are the result of a Modulo 11 division of the sum of the products of each digit times a weight factor. The weights for the C check digit range from 1 to 10 while the weights for the K check digit range from 1 to 9. Weights start at the right end of the data and increment towards the left. The dash character has a value of 10 for purposes of check digit calculation.

1. Starting at the right end of the data, assign a weight to each character starting with 1 and incrementing to 10. If the data is longer than 10 characters, cycle back to 1 and continue.
2. Calculate the product of each data character times its weight. For the dash use a character value of 10.
3. Sum the products, divide by 11, and take the remainder
4. Append the result of Step 3 to the end of the data.
5. Starting at the right end of the data which now includes the C check digit, assign a weight to each character starting with 1 and incrementing to 9. If the data is longer than 9 characters, cycle back to 1 and continue.
6. Calculate the product of each data character times its weight.
7. Sum the products, divide by 11, and take the remainder.

Character	Bar	Space	Bar	Space	Bar
<b>0</b>	0	0	0	0	1
<b>1</b>	1	0	0	0	1
<b>2</b>	0	1	0	0	1
<b>3</b>	1	1	0	0	0
<b>4</b>	0	0	1	0	1
<b>5</b>	1	0	1	0	0
<b>6</b>	0	1	1	0	0
<b>7</b>	0	0	0	1	1
<b>8</b>	1	0	0	1	0
<b>9</b>	1	0	0	0	0
<b>-</b>	0	0	1	0	0
<b>S/S</b>	0	0	1	1	0

Format the complete barcode by concatenating a start character + data + C + K + stop character.

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## Code 128



ABCxyz#\$%15z



123456789012

Code 128 provides excellent density for all-numeric data and good density for alphanumeric data. It is often selected over Code 39 in new applications because of its density and because it offers a much larger selection of characters. The Code 128 standard is maintained by AIM (Automatic Identification Manufacturers).

The Code 128 character set includes the digits 0-9, the letters A-Z (upper and lower case), and all standard ASCII symbols and control codes. The codes are divided into three subsets A, B, and C. There are three separate start codes to indicate which subset will be used; in addition, each subset includes control characters to switch to another subset in the middle of a barcode. Subset A includes the standard ASCII symbols, digits, upper case letters, and control codes. Subset B includes standard ASCII symbols, digits, upper and lower case letters. Subset C compresses two numeric digits into each character, providing excellent density. Here is a sample that contains 12 digits; compare its size to the sample at the top of the page that contains 12 assorted characters:

Each character is 11 times the width of the narrowest bar; using a minimum bar width of 0.010" each character would be 0.11" wide. Using the 0.010" figure, 20 data characters plus start code, check digit, and stop code would measure 2.55" wide (the stop code is 13 times as wide as a narrow bar). Using Subset C with all-numeric data provides 2:1 compression of the data for a total width of 1.45".

Each character consists of 3 bars and 3 spaces, each of which may be 1, 2, or 3 elements wide (1 element = 1/11th of the character width). The bars always use an even number of elements and the spaces use an odd number. This provides the basis for a character-by-character consistency check during scanning. In addition, each Code 128 barcode includes a Modulo 103 checksum.

### The Checksum

Calculating the checksum can be a little tricky. Each Code 128 character has a numeric value from 0 to 102. In Subset A and B, the numeric value of a character is its ASCII code minus 32. For instance, a space (ASCII 32) has a value of 0, the exclamation point (ASCII 33) has a value of 1, etc.

Subset A permits printing of ASCII control characters, those with ASCII codes between 0 and 31. For these characters add 64 to the ASCII code to obtain the numeric value. For example, the value of NUL (ASCII 0) is 64, SOH (ASCII 1) is 65, STX (ASCII 2) is 66, etc.

Subset C prints numeric digits in pairs, and the value of the character for checksum purposes is the numeric value of the pair (00, 01, 02... 99).

To calculate the checksum, follow these steps:

1. Initialize the checksum variable with the value of the start character (103, 104, or 105 for Subsets A, B, or C, respectively).
2. Initialize a multiplier to 1.
3. Starting at the left end of the barcode data, add the numeric value of each character times the multiplier to the checksum. Increment the multiplier after each character.
4. Divide the result by 103. The remainder is the checksum.
5. Convert the numeric checksum into an ASCII character.

The details of converting the numeric checksum to an ASCII character may vary depending on the particular font being used. Special handling may be required in cases where the resulting ASCII character code equals zero or is above 95.

Generally speaking, in Subset A if the checksum is between 0 and 63 inclusive, add the checksum and the ASCII code for a space (32) to obtain the character code. If the checksum is 64 or higher, subtract 64 to obtain the character code. In Subset B, add the checksum and the ASCII code for a space (32). In Subset C, the checksum is the ASCII value of the character.

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## Code 39 (3 OF 9)

Code 39 is widely used in many industries and is the standard for many government barcode specifications, including the U.S. Department of Defense. Code 39 is



defined in American National Standards Institute (ANSI) standard MH10.8M-1983, and is also known as USD-3 and 3 of 9.

The Code 39 character set includes the digits 0-9, the letters A-Z (upper case only), and the following symbols: space, minus (-), plus (+), period (.), dollar sign (\$), slash (/), and percent (%). A special start/stop character is placed at the beginning and end of each barcode. The barcode may be of any length, although more than 25 characters really begins to push the bounds.

Each character consists of 9 elements: 5 bars and 4 spaces. Each character includes 3 wide and 6 narrow elements. Characters are separated by an inter-character gap which is the same width as a narrow bar. The ratio of wide:narrow bar width may be in the range of 1.8 to 3.4. Barcodes with a narrow bar width of less than 0.020 inches (0.508mm) should have a ratio of at least 2.5. A ratio of 3.0 is recommended. Every Code 39 barcode should be preceded and followed by a quiet zone the width of at least 10 narrow bars.

Code 39 does not require a checksum, although a modulo 43 check digit may be appended for increased data integrity (the Mod 43 checksum is seldom used). Code 39 is just about the only type of barcode in common use that does not require a checksum. This makes it especially attractive for applications where it is inconvenient, difficult, or impossible to perform calculations each time a barcode is printed. For example, when performing a word processor merge operation there is generally no easy way to calculate a checksum if one of the merge data fields is to be barcoded. With Code 39, however, no checksum is needed; the merge template document must simply add a fixed asterisk (\*) before and after the data and print the field using a Code 39 barcode font.

### Extended Code 39

Extended Code 39 was developed to provide a means of encoding additional characters that are not normally part of the Code 39 character set (lower case characters and symbols). Extended characters are encoded by a pair of normal Code 39 characters; for example, a lower case 'a' (not part of the standard Code 39 character set) can be encoded by the pair '+A'. A carriage return control code can be encoded by the pair '\$M'.

### *Tips...*

Code 39 can be read by just about every scanner on the market. It is widely used for in-house solutions; that is, applications where the barcodes will be used internally. It is also used for transferring data between companies. For example, the Automotive Industry

Action Group (AIAG) defines a set of labeling standards for marking inter-company shipments within the industry; these labels use Code 39.

When planning a system, a useful technique to help protect against errors is to include a prefix character in every barcode. For example, product identification numbers might begin with a "P" while quantities might begin with a "Q". If the operator is asked to scan a part number, the scanner can check for the presence of the "P" prefix and immediately reject the scan if it is not there.

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## Code 93 (USS-93)

Code 93 is a more compact version of Code 39. It encodes exactly the same characters as Code 39, but uses 9 barcode elements per character instead of 15. The Modulus 43 checksum is optional, just as with Code 39.



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## DataMatrix

DataMatrix is a two-dimensional barcode which can store from 1 to about 2,000 characters. The symbol is square and can range from 0.001 inch per up to 14 inches per side. As an example of density, 500 numeric only characters can be encoded in a 1-inch square using a 24-pin dot matrix printer. The sample shown above encodes 20 ASCII characters.



side

DataMatrix is being used to encode product and serial number information on electrical rating plates; to mark of surgical instruments in Japan; to identify lenses, circuit boards, and other items during manufacturing.

DataMatrix symbols require a 2-D scanner; they cannot be read using an ordinary linear barcode scanner. A number of scanners are on the market using both laser and CCD camera technologies. DataMatrix symbols can be printed using most professional-grade thermal transfer label printers on the market.

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## EAN-13

EAN-13 is used world-wide for marking retail goods.

The symbol encodes 13 characters: the first two or three are a country code which identify the country in which the manufacturer is registered (not necessarily where the product is actually made). The country code is followed by 9 or 10 data digits (depending on the length of the country code) and a single digit checksum. 2-digit and 5-digit supplemental barcodes may be added for a total of 14 or 17 data digits.



The Uniform Code Council (the organization which issues retail codes in the USA) has announced that January 1, 2005 will be the date by which all retail scanning systems in the USA must be able to accept the EAN-13 symbol as well as the standard UPC-A. This change will eliminate the need for manufacturers who export goods to the US and Canada to double-label their products.

The checksum is a Modulo 10 calculation:

1. Add the values of the digits in the even-numbered positions: 2, 4, 6, etc.
2. Multiply this result by 3.
3. Add the values of the digits in the odd-numbered positions: 1, 3, 5, etc.
4. Sum the results of steps 2 and 3.
5. The check character is the smallest number which, when added to the result in step 4, produces a multiple of 10.

Example: Assume the barcode data = 001234567890

1.  $0 + 2 + 4 + 6 + 8 + 0 = 20$
2.  $20 * 3 = 60$
3.  $0 + 1 + 3 + 5 + 7 + 9 = 25$
4.  $60 + 25 = 85$
5.  $85 + X = 90$  (nearest equal or higher multiple of 10), therefore  $X = 5$  (checksum)

Here is a sample Visual Basic function to calculate the checksum:

```
Function Append_EAN_Checksum (RawString as String)
```

```
Dim Position as Integer
```

```
Dim CheckSum as Integer
```

```
CheckSum = 0
```

```
For Position = 2 to 12 step 2
```

```
    Checksum = Checksum + Val(Mid$(RawString, Position, 1))
```

```
Next Position
```

```
CheckSum = CheckSum * 3
```

```
For Position = 1 to 11 Step 2
    CheckSum = CheckSum + Val(Mid$(RawString, Position, 1))
Next Position
CheckSum = CheckSum Mod 10
CheckSum = 10 - CheckSum
If CheckSum = 10 Then
    CheckSum = 0
End If
Append_Ean_Checksum = RawString & Format$(CheckSum, "0")
End Function
```

Many countries have EAN coding authorities which regulate the use of retail barcodes. For names, addresses, and telephone numbers, check our list of standards organizations. In the United States the UPC-A and UPC-E symbologies are used for marking retail products; the administering authority is the Uniform Code Council in Dayton, Ohio (tel. 937-435-3870).

The USA has begun the process of moving to the EAN-13 symbol, which will be known as the UPC-13 symbol in the USA. Existing UPC-A codes do not have to be changed, but new identification numbers issued will follow the UPC-13 format. This means that imported products labeled with EAN-13 codes do not have to be re-labeled for USA retail sale. All retail scanning systems must accept the EAN-13.

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## EAN-8

EAN-8 is a shortened version of the EAN-13 code. It includes a 2 or 3 digit country code, 4 or 5 data digits (depending on the length of the country code), and a checksum digit. While it is possible to add a 2-digit or 5-digit extension barcode, the primary purpose of the EAN-8 code is to use as little space as possible.



Unlike the UPC-E symbol, which compresses data that could also be printed as a full-size UPC-A symbol by squeezing out zeroes, the data digits in an EAN-8 symbol specifically identify a particular product and manufacturer. Since a limited number of EAN-8 codes are available in each country, they are issued only for products with insufficient space for a normal EAN-13 symbol. For example, a 2-digit country code permits a total of only 100,000 item numbers.

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## HIBC

The HIBC Barcode (Health Industry Bar Code) is created specially for the health industry. Healthcare products have special human safety requirements, are routinely monitored by government regulators, and are often “purchased” indirectly (through insurance claims) for patients in hospitals and other healthcare facilities. As a result, labels must be as error-free as possible, must contain additional information, and must satisfy greater needs than those commonly found in point-of-sale environments such as grocery check-out counters.

By utilizing the HIBC format, manufacturers and distributors are meeting these requirements while simultaneously using the system which best suits their own internal needs.



The data elements for encoding in Barcode:

ID mark for the HIBC Standard	the plus sign ( + )
Labeler/location identification code	4 digit a/n, issued by Ehibcc Product/article
code	variable 1 to 13 digit a/n, issued by the supplier
Unit of measure	1 digit numeric
Quantity	optional 2 or 5 digit numeric
Expiration date	different formats as Julian calendar, as YYMM, etc.
Charge/Serial number	variable 0 to 13 digit
Security elements:	
Check digit	1 digit Modulo 43
Link character	1 digit Modulo 43 for connecting separated primary and secondary code properly
Data concatenation	CODABLOCK structure to concatenate separated Barcode rows for space optimization reasons

The HIBC specification is available with the Ehibcc offices in Europe and with HINCC in the USA.

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## Industrial 2 of 5

Industrial 2 of 5 is a numeric-only barcode that has been in use a long time. Unlike Interleaved 2 of 5, all of the information is encoded in the bars; the spaces are fixed width and are used only to separate the bars. The code is self-checking and does not include a checksum.



1234

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## Interleaved 2 of 5 (Code 25, I2of5, ITF, I25)

Interleaved 2 of 5 is a numeric-only barcode widely used in warehouse and industrial applications. The data must consist of an even number of digits.



Each data character is composed of 5 elements, either 5 bars or 5 spaces. Of these 5 elements, two are wide and three are narrow. Adjacent characters are interleaved, alternating the spaces from one character with the bars of the other.

*Note on the "Code 25" name: Interleaved 2 of 5 is sometimes referred to as Code 25. This is not a precise term, as Code 25 is also sometimes used to mean Standard 2 of 5 or Industrial 2 of 5.*

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## ISSN and the SISAC Barcode (International Standard Serial Numbering)



The ISSN system is used for identifying serial publications (print and non-print); these are publications like magazines, newspapers, annual reports, etc. that are published at regular intervals. The standard that governs the ISSN is ISO 3297-1975/ANSI Z39.9-1979.

An ISSN uniquely identifies a title regardless of language or country of origin. The number is 8 digits long and looks like this:

**ISSN 1234-5679**

The first 7 digits identify the title; the last digit is a check digit. If the final digit computes to a 10, an X is used (Roman numeral 10). At the time an ISSN is registered the title is associated with it; if the title of the publication changes a new ISSN must be assigned.

The coordination of the ISSN is international, with registration initiated at the national level where serials are published. The National Serials Data Program (NSDP) within the Library of Congress is the U.S. Center of the ISSN Network. The ISSN International Centre located in Paris coordinates the network. NSDP is responsible for registering and providing ISSN for serials published in the United States and for promoting use of the ISSN.

For more details on the ISSN, visit the Library of Congress ISSN site at [www.lcweb.loc.gov/issn](http://www.lcweb.loc.gov/issn) or ISSN International Headquarters at [www.issn.org](http://www.issn.org). You can contact the Library of Congress at:

Library of Congress  
National Serials Data Program  
Washington, D.C. 20540-4160

Tel.: (202) 707-6452  
Fax: (202) 707-6333  
Email: [issn@loc.gov](mailto:issn@loc.gov)

The SISAC (Serials Industry Systems Advisory Committee) barcode symbol uses Code 128 to uniquely identify each issue of a serial publication using the ISSN, date of publication, and volume or issue number. The SISAC symbol is a barcode representation of the SICI code (Serial Item and Contribution Identifier), which is described in the ANSI/NISO Z39.56-1991 standard. Here is an example of a barcode with the SICI code underneath:



1144875X9031993307665201

1144-875X(199303)52;1-0

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## LOGMARS (Code39)

LOGMARS (Logistics Applications of Automated Marking and Reading Symbols) is a special application of Code 39 used by the U.S. Department of Defense and is governed by Military Standard MIL-STD-1189B. The Standard defines acceptable ranges for a number of variables, include density, ratio, bar height, and size of the human-readable interpretation line. The Modulus 43 check digit, optional with Code 39, is defined and recommended in the specification. While not required by the general specification, it may be required in specific Department of Defense applications. Be sure to check the requirements for your project or contract.



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## MaxiCode

MaxiCode is a fixed-size code which holds up to 93 data characters. The symbol is composed of a central bulls-eye locator and offset rows of hexagonal elements; the overall dimensions of the symbol are approximately 1.11 x 1.054 inches. Each element measures 0.035 x 0.041 inches.



Created by United Parcel Service, the MaxiCode symbol was designed for quick automated scanning of packages on high-speed conveyor lines (special cameras can read a MaxiCode on a carton travelling at up to 500 feet per minute). A 2-D scanner is required; MaxiCode cannot be read using an ordinary linear barcode scanner.

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## MSI Plessey

The MSI Plessey barcode is a variant of the Plessey barcode. It is a pulse-width modulated non-self checking code, and is used primarily in store shelf labeling. Each character consists of eight elements, four bars and four spaces. The character set includes the digits 0 through 9. A Modulo 10 checksum is appended to the end of the code.



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## PDF-417

PDF-417 is a two-dimensional barcode which can store up to about 1,800 printable ASCII characters or 1,100 binary characters per symbol. The symbol is rectangular; the shape of the symbol can be adjusted to some extent by setting the width and allowing the height to grow with the data. It is also possible to break large amounts of data into several PDF-417 symbols which are logically linked. There is no theoretical limit on the amount of data that can be stored in a group of PDF-417 symbols.



The capacity of PDF-417 can be helpful in applications where the data must travel with the labeled item, where a host database is not always available for quick look-up. PDF-417 is being used for hazardous materials labeling; storing technical specifications and calibration data on electronic instruments; encoding fingerprints and photographs on the backs of drivers' licenses.

The maximum data density is determined by the smallest elements which can be reliably printed and scanned. Using the smallest recommended element size of 0.0075 inch wide and 0.010 inch high, the maximum data density in the binary mode is 686 bytes per square inch (106.2 bytes per square centimeter). In the printable ASCII mode the density is 1,144 characters per square inch (177.2 characters per square centimeter).

PDF-417 symbols require a 2-D scanner; or a standard CCD or laser scanner and special decoding software (a wand scanner will not work). A number of scanners are on the market using both laser and CCD camera technologies. PDF-417 symbols can be printed using most professional-grade thermal transfer label printers on the market. The Barcode Software Center carries several label design and printing programs that can create PDF-417 symbols; we also have function libraries for programmers, programs for creating master artwork, and add-in hardware modules for Hewlett-Packard printers.

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## Optical Industry Association (OPC) Product Marking

The OPC code is used for marking retail optical products, much like the UPC code is used for marking general retail items. The code uses the Interleaved 2 of 5 barcode symbology.



Digits 1 through 5 identify the manufacturer of the item; this 5-digit number is assigned by the Optical Product Code Council, Inc. The next 4 digits are a product identification number assigned by the manufacturer to each product. The final digit is a check digit. In the example above, we have added dashes to the human-readable text below the bars to separate the data fields for clarity. The dashes are not included in the barcode itself, and they are not required in the readable text.

### Calculating the Checksum

The checksum uses the "212" variation of the Modulo-10 method. Please note that this is not a common technique, and most barcode labeling software and scanners do not support it directly. A check digit is optional with Interleaved 2 of 5, so standard software and scanners are happy to print and read the OPC barcode. However, creation and verification of the check digit will be the responsibility of the software that creates the product codes and processes scanner data.

Starting with the leftmost digit, multiply each digit by a weighting factor. The weighting factor follows a repeating 212 pattern. The first digit is multiplied by 2, the second digit by 1, the third digit by 2, the fourth digit by 1, and so on. Using our sample barcode above, we start with the number 020711721.

$$\begin{aligned}0 * 2 &= 0 \\2 * 1 &= 2 \\0 * 2 &= 0 \\7 * 1 &= 7 \\1 * 2 &= 2 \\1 * 1 &= 1 \\7 * 2 &= 14 \\2 * 1 &= 2 \\1 * 2 &= 2\end{aligned}$$

Now sum all of the products, treating 2-digit numbers as individual digits. In the above example, 14 would be treated as a 1 and a 4:

$$0 + 2 + 0 + 7 + 2 + 1 + 1 + 4 + 2 + 2 = 21$$

Divide the result by 10; in this example, 21 divided by 10 = 2 with a remainder of 1. Subtract the remainder from 10 to obtain the check digit; in this case, 10 - 1 = 9. If the result is 10 (in the case of 10 - 0 = 10) change the result to 0.

## **For more information**

For assignment of a manufacturer code, further details on the OPC code, and information about the Optical Industry's EDI system, contact:

Optical Product Code Council  
1700 Diagonal Road Suite 500  
Alexandria, VA 22314  
703.548.4560  
703.548.4580 fax  
[www.visionsite.org](http://www.visionsite.org)

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## Plessey Barcode

The Plessey code was originally developed in England and gave rise to several variations including the MSI, Anker, and Telxon codes. Of these, the MSI Plessey is still in use in the USA; it is used in libraries, and is often used for retail grocery shelf marking.



The MSI Plessey Code is a pulse-width modulated non-self checking code. Each character is represented by 4 bars; a narrow bar represents a binary 0 and a wide bar represents a binary 1. The bars have the binary weights 8-4-2-1. It is possible to encode the digits 0 through 9 and the letters A through F, although this code is most often used just for numeric information. The start character is a single wide bar, and the stop character is two narrow bars.

## The Modulo 10 Checksum

A MSI Plessey barcode always includes a Modulo 10 checksum, and may include a second checksum. The method for calculating the checksum is a bit unusual:

1. Form a new number using every other digit from the original number. If the original number contains an even number of digits, start with the second digit; if an odd number of digits, start with the first. For example, if the original number is 123456, the new number will be 246; if the original number is 12345, the new number will be 135. The last digit in the new number will always be the last digit in the original number.
2. Multiply the new number by 2. Using the original number 12345 as an example,  $135 \times 2 = 270$ .
3. Add up all the digits in the result. For example,  $2 + 7 + 0 = 9$ .
4. Add to this result all of the digits from the original number not used in step 1. So  $9 + 2 + 4 = 15$ .
5. Perform a Modulo 10 division on the result and subtract the result from 10. If the result is 10, change it to 0. Using our example...  $10 - (15 \text{ Modulo } 10) = 5$ . This is the checksum.

If a second checksum is required, append the first checksum to the original string and perform the calculation all over again including the first checksum. In our example, the checksum for 12345 would be 5. The second checksum would be calculated using 123455 as the original string.

## The Modulo 11 Checksum

Some applications may require a Modulo 11 checksum, and this is calculated in a very different way from the Modulo 10 checksum:

1. Assign a weight to each digit position of the original number. The weighting factors are 2, 3, 4, 5, 6, 7 starting with the rightmost character and working to the left. The rightmost character receives a weight of 2, the next to the left a weight of 3, and so on. After the weight of 7 is used, go back to 2 and repeat.

Original number: 9 4 3 4 5 7 8 4 2

Assigned weights: 4 3 2 7 6 5 4 3 2

2. Multiply each digit by its assigned weight and add the products:

$$(9 \times 4) + (4 \times 3) + (3 \times 2) + (4 \times 7) + (5 \times 6) + (7 \times 5) + (8 \times 4) + (4 \times 3) + (2 \times 2) = 195$$

3. Perform a Modulo 11 division and subtract the result from 11; if the result is 11, change it to 0:

$$195 \text{ Modulo } 11 = 8 \text{ (the remainder of } 195 / 11)$$

$$11 - 8 = 3$$

4. Append the checksum (3 in this case) to the end of the original number.

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## PostNet (3 of 5)

The PostNet barcode is used by the United States Postal Service to automatically sort mail. The



PostNet code consists of evenly spaced bars of two different heights. Each character is represented by five bars, two tall and three short. The character set includes the digits 0 through 9. The code begins and ends with a tall bar ('frame bar'), and may contain a 5-digit ZIP code, a 9-digit ZIP+4 code, or an 11-digit Delivery Point Code. A Modulo 10 check digit ('correction character') is inserted after the ZIP code and before the ending frame bar.

The check digit is calculated on the content of each ZIP code. The check digit is simply the number that, when added to the sum of the digits in the ZIP code, will produce an even multiple of 10.

Here is some sample 'C' code that will calculate the checksum. This function will work with any length of zip code (it will not generate an error if the zip code is an incorrect length), and it will automatically skip over any embedded dashes or other non-numeric characters. Note that dashes have to be removed before printing the barcode:

```
int checksum(char *zipcode)
{
    int tot;
    char *cp;

    tot = 0;
    cp = zipcode;
    while (*cp != 0) {
        if (*cp >= '0' && *cp <= '9')
            tot += *cp - '0';
        cp++;
    }
    return(10 - (tot % 10));
}
```

Here is a routine for FileMaker Pro. This function operates on a 9-digit zip code and assumes that there are no embedded dashes. CALCTOT adds up the digits and CHECKSUM calculates the check digit: ZIP Text

```
CALCTOT Calculation(Number) = TextToNum(Left(ZIP,1)) +
TextToNum(Middle(ZIP,2,1)) + TextToNum(Middle(ZIP,3,1)) +
TextToNum(Middle(ZIP,4,1)) + TextToNum(Middle(ZIP,5,1)) +
TextToNum(Middle(ZIP,6,1)) + TextToNum(Middle(ZIP,7,1)) +
TextToNum(Middle(ZIP,8,1)) + TextToNum(Middle(ZIP,9,1))

CHECKSUM Calculation(Number) = 10 - MOD(CALCTOT,10)
```

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## QR Code

The QR Code (Quick Response Code) is a 2-dimensional matrix code. It can encode up to 2509 numeric or 1520 alphanumeric characters and offers three levels of error detection. The smallest QR Code measures 21 X 21 cells (each cell encodes one bit) and can grow in increments of 4 cells to a maximum size of 105 X 105 cells. The squares in the bottom left, top left, and top right corners are locator patterns.



The QR Code was developed in Japan by the Nippondenso Company; it was introduced in 1994 at the Japan Scan-Tech show and was submitted to AIM for consideration as a standard in 1996.

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## Standard 2 of 5

Standard 2 of 5 is a self-checking numeric-only barcode. Unlike Interleaved 2 of 5, all of the information is encoded in the bars; the spaces are fixed width and are used only to separate the bars.

Standard 2 of 5 is used primarily for warehouse sorting, photo finishing, and airline ticket marking.



1234

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## UPC-A

UPC-A is used for marking products which are sold at retail in the USA. The barcode identifies the manufacturer and specific product so point-of-sale cash register systems can automatically look up the price. The UPC-A Code and the assignment of manufacturer ID numbers is controlled in the U.S.A. by the [Uniform Code Council](#) located in Dayton, Ohio. If you need a manufacturer ID number, call them at (937) 435-3870 and they will send you an application form. Their fax number is (937) 435-4749. The registration fee for a UPC is \$750 for companies whose annual sales are \$2 million or less. Fees rise proportionately for companies with annual sales greater than \$2 million.



### The UPC-E symbol for small items

*The UPC-E code is a compressed barcode which is intended for use on small items. Compression works by squeezing extra zeroes out of the barcode and then automatically re-inserting them at the scanner. Only barcodes containing zeroes are candidates for the UPC-E symbol. The Uniform Code Council is very stingy when it comes to handing out manufacturer ID numbers with extra zeroes; these are reserved for products which have a genuine need for the UPC-E symbol. If you need a small symbol, tell the UCC when you apply for a manufacturer's ID number and be prepared to substantiate your need.*

### USA retailers required to scan EAN-13 by 2005

*The [Uniform Code Council](#) has announced that January 1, 2005 will be the date by which all retail scanning systems in the USA must be able to accept the EAN-13 symbol as well as the standard UPC-A. This change will eliminate the need for manufacturers who export goods to the US and Canada to double-label their products.*

*Most scanners sold as early as 1985 can auto-discriminate between these two codes, so the hardware will generally not be an issue. The primary concern is that product databases used by retailers will need to store 13 digits to accommodate all EAN/UCC numbers; many database designs currently store only 11 digits (or 12 if the check digit is included). In order to guard against any confusion between an existing UPC code and a previously assigned EAN-13 code it is necessary to use all 13 digits as a lookup key. If you are importing items to the USA market and your retailers insist that you re-label with UPC-A barcodes, you might suggest to them that it would be a good idea to work towards accepting the EAN-13 code; they will have to be ready when 2005 arrives.*

*Existing US manufacturers will not have to obtain new numbers or redesign packaging. After the changeover date, manufacturers may mark products exported to the USA and Canada with their assigned EAN-13 numbers; there will be no requirement to obtain a separate UPC registration number.*

### Structure of the UPC-A Code



UPC-A encodes 12 numeric digits. The first digit identifies the numbering system being used:

- 0: regular UPC codes
- 1: reserved
- 2: random weight items marked at the store
- 3: National Drug Code and National Health Related Items code
- 4: no format restrictions, for in-store use on non-food items
- 5: for use on coupons
- 6: reserved
- 7: regular UPC codes
- 8: reserved
- 9: reserved

The next group of 5 digits identifies the manufacturer. This number is assigned by the Uniform Code Council (UCC). The next 5 digits identify the particular product and are assigned by the manufacturer. The last digit is a Modulo 10 checksum.

### Calculating the Checksum

The checksum is a Modulo 10 calculation.

1. Add the values of the digits in positions 1, 3, 5, 7, 9, and 11.
2. Multiply this result by 3.
3. Add the values of the digits in positions 2, 4, 6, 8, and 10.
4. Sum the results of steps 2 and 3.
5. The check character is the smallest number which, when added to the result in step 4, produces a multiple of 10.

Example: Assume the barcode data = 01234567890

1.  $0 + 2 + 4 + 6 + 8 + 0 = 20$
2.  $20 \times 3 = 60$
3.  $1 + 3 + 5 + 7 + 9 = 25$
4.  $60 + 25 = 85$
5.  $85 + X = 90$  (next highest multiple of 10), therefore  $X = 5$   
(checksum)

### 2-Digit Supplemental Codes for Periodicals

A UPC-A code may be augmented with a two-digit supplemental barcode to indicate the issue number for a periodical. Weekly publications are generally numbered 1-52, while semi-monthlies are numbered 1-24 and monthlies 1-12. Here is an example for issue No. 3:



### Audio and Video Recordings

Code	Audio Recordings	Video Recordings
------	------------------	------------------

Companies which produce recordings are assigned a 6-digit number. The final digit of the company identification also serves as the first digit of the selection number, and can be requested on the application to the Uniform Code Council. The next 4 digits encode the rest of the

0	n/a	n/a
1	12" LP or 12" single	12" CDV
2	CD, CD-ROM, CDI, VCD	n/a
3	n/a	VHS
4	Cassette, Maxi-Cassette, Cassette Single	n/a
5	DCC	BETA
6	n/a	Laserdisc
7	7" single	n/a
8	MiniDisc	8mm tape
9	DVD (all music formats)	DVD music video

selection number. The 11th digit indicates the type of recording medium; here are the codes recommended by RIAA ([www.riaa.org](http://www.riaa.org)).

Books are generally marked with Bookland EAN barcodes.

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## UPC-E

UPC-E is a variation of the UPC-A symbol that is used for number system 0. By suppressing zeroes, UPC-E codes can be printed in a very small space and are used for labeling small items.



In addition to the requirement that the first digit of the barcode (number system) must be zero, there are four rules that determine what UPC codes can be printed using the compressed UPC-E format:

- If the last 3 digits of the manufacturer's number are 000, 100, or 200, the valid product code numbers are 00000 - 00999 (1,000 numbers).
- If the last 3 digits of the manufacturer's number are 300, 400, 500, 600, 700, 800, or 900, the valid product code numbers are 00000 - 00099 (100 numbers).
- If the last 2 digits in the manufacturer's number are 10, 20, 30, 40, 50, 60, 70, 80, or 90, the valid product code numbers are 00000 - 00009 (10 numbers).
- If the manufacturer's number does not end in zero, the valid product code numbers are 00005 - 00009 (5 numbers).

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## UCC/EAN-128

UCC/EAN-128 uses normal Code 128 barcodes, but formats the data in a standardized way to identify the type of information contained in the barcode. Code 128 includes four special control codes named FNC1 through FNC4; by convention, the FNC1 code is used to identify barcodes that conform to the UCC/EAN-128 standard. A normal Code 128 barcode is constructed like this:

- start code
- data
- checksum
- stop code



A UCC/EAN-128 barcode is constructed like this:

- start code
- FNC1
- application identifier
- data
- checksum
- stop code

The Application Identifier is a 2, 3, or 4-digit number that identifies the type of data which follows. A list of many of the standard Application Identifiers appears at the end of this article. By convention, the Application Identifier is enclosed in parentheses when printed below the barcode (the parentheses are only for visual clarity, and are not encoded in the barcode). The FNC1 code is not represented in the readable text. For example, Application Identifier 420 indicates that the data contains the destination postal code, and you will often find this barcode on shipping labels. If the destination postal code (ZIP code in the USA) is 90210 the barcode would look like this:



When this barcode is scanned, software is alerted by the FNC1 code that this is a UCC/EAN-128 barcode and, since the Application Identifier is 420, it contains a destination postal code. For another example consider the tracking barcode that appears on most packages handled by freight carriers around the world. Application Identifier 00 indicates that the data contains a package serial number; this format is called the "UCC/EAN-128 Serialized Shipping Container Symbol". This type of barcode uniquely identifies every package currently in transit and makes global tracking systems possible:



- start code
- FNC1
- Application Identifier (00)
- Package Type (0 = carton)
- UCC/EAN number system/numbering authority
- Manufacturer's ID code
- Package serial number
- Check character for readable text
- Check character for entire barcode
- Stop code

A single barcode may contain more than one type of information. The beginning of each new piece of information is marked by a FNC1 character and an Application Identifier. For example, let's combine a Batch Number (Application Identifier 10) and a Sell By Date (Application Identifier 17):

- start code
- FNC1
- Application Identifier (10 = batch number)
- Batch Number
- FNC1
- Application Identifier (17 = sell by date)
- Sell By Date (YYMMDD)
- Checksum
- Stop Code

Here is an example for Batch Number 45566 with a Sell By Date of March 1, 2004:



Here is a list of Application Identifiers. New ones are added from time to time, so this list may not be complete. The full specification is available from the [Uniform Code Council](#).

<b>Code</b>	<b>Application</b>
00	Serial Shipping Container Code

01 Shipping Container Code  
10 Batch or Lot Number  
11 Production Date (YYMMDD)  
13 Packaging Date (YYMMDD)  
15 Best Before/Sell By Date (YYMMDD)  
17 Sell By/Expiration Date (YYMMDD)  
20 Product Variant  
21 Serial Number  
22 HIBCC; quantity, date, batch, and link  
23 Lot number  
240 Secondary product attributes  
250 Secondary Serial number  
30 Quantity each  
310 Net Weight, kilograms  
311 Length or first dimension, meters  
312 Width, diameter, or 2nd dimension, meters  
313 Depth, thickness, height, or 3rd dimension, meters  
314 Area, square meters  
315 Volume, liters  
316 Volume, cubic meters  
320 Net weight, pounds  
330 Gross weight, kilograms  
331 Length or first dimension, meters logistics  
332 Width, diameter, or 2nd dimension, meters logistics  
333 Depth, thickness, height, or 3rd dimension, meters logistics  
334 Area, square meters logistics  
335 Gross volume, liters logistics  
336 Gross volume, cubic meters logistics  
340 Gross weight, pounds  
400 Customer purchase order number  
410 Ship to location code (EAN-13 or DUNS)  
411 Bill to location code (EAN-13 or DUNS)  
412 Purchase from location code (EAN-13 or DUNS)  
420 Ship to postal code  
421 Ship to postal code with 3-digit ISO country code  
8001 Roll products: width, length, core diameter, direction, splices  
8002 Electronic serial number for cellular telephones  
90 FACT identifiers (internal applications)

- 91 Internal use (raw materials, packaging, components)
- 92 Internal use (raw materials, packaging, components)
- 93 Internal use (product manufacturers)
- 94 Internal use (product manufacturers)
- 95 SCAC+Carrier PRO number
- 96 SCAC+Carrier assigned container ID
- 97 Internal use (wholesalers)
- 98 Internal use (retailers)
- 99 Mutually defined text

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## UPC Shipping Container Symbol (ITF-14)

The UPC Shipping Container Symbol is used to mark cartons, cases, or pallets that contain products which have a UPC or EAN product identification number. The container symbols are used by manufacturers and distributors to take inventory or tally shipments quickly and accurately. The short-hand name for the symbol is "ITF-14," which is an acronym for "Interleaved 2 of 5" (the type of barcode used) and 14 digits (the length of the container symbol). The ITF-14 symbol contains the following information:



- Digit 1: Packaging indicator
- Digits 2-3: UPC numbering system or EAN prefix
- Digits 4-8: Manufacturer identification number
- Digits 9-13: Item identification number
- Digit 14: Check digit

The first digit describes the type of package. There are no official restrictions on values 1 through 7 other than the contents must have the same UPC indicated by the container symbol. The following codes are used by convention:

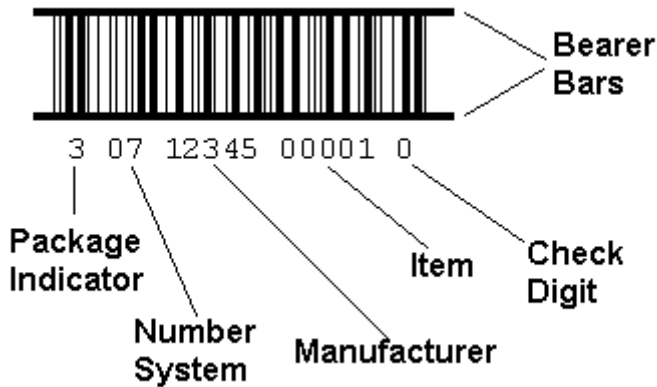
- 0. UPC code of contents differs from case code
- 1. More than each and below inner packs
- 2. Alternative for 1
- 3. Inner packs
- 4. Alternative for 3
- 5. Shipping containers (cartons)
- 6. Alternative for 5
- 7. Pallet
- 8. Reserved by Uniform Code Council for future use
- 9. Variable quantity content

Exactly how many units are inside any of these containers is established by each manufacturer and coordinated with their distributors and wholesalers. For example, the Acme Candy Company's popular Sticky Snakes Caramel Candy (4 ounce box) has a UPC code of 7-12345-00001-9 and is marked with a standard UPC-A barcode:



These items are packed in point of sale display cartons which Acme marks with an ITF-14 code. Acme informs all distributors and wholesalers that a level 3 package for this particular product contains 24 individual retail units:





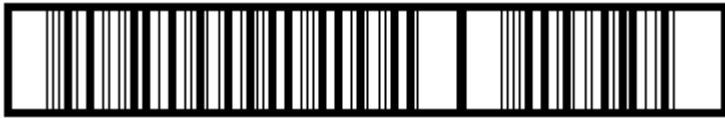
The lines at the top and the bottom of the barcode are called "bearer bars" and are used to prevent something called a "short scan." Because of the structure of the Interleaved 2 of 5 code, it is statistically possible in some situations for a scanner to cut diagonally through only part of the code and still think that it has read valid data. The bearer bars disrupt the scan and insure that only complete scans will return a valid read. The bearer bars have another advantage when using the flexographic process to print barcodes directly on cartons: they provide extra physical support for the ends of the bars on the flexographic plate. Using a complete box also provides support for the ends of the bearer bars:



When the above ITF-14 code is scanned, the grocer's software can automatically determine that a display box containing 24 retail boxes of Sticky Snakes Caramel Candy has been received. However, because of the popularity of Sticky Snakes Caramel Candy, the distributors and grocers need to work with larger quantities. Acme packages 12 of the display boxes into a shipping carton, a total of 288 retail boxes. Acme marks these shipping cartons as Level 5 and lets everyone know that they contain 288 retail boxes (packed in display boxes of 24 each):



This works well for normal distribution channels where everything moves in standard quantities. But Acme has some large customers who order in non-standard quantities. These customers have insisted that the shipping cartons be marked with the actual quantity of retail boxes inside each carton. A pack level code of 9 indicates that the carton contains a variable number of units. A second barcode indicates the actual number of units in the carton; this barcode includes a 5-digit quantity and a check digit. The two barcodes are separated by a space; in some cases a thick vertical bar is used to separate the two codes. The barcode below is used to mark cartons containing 196 each 4 ounce retail boxes of Sticky Snakes Caramel Candy:



9 07 12345 00001 2 00196 0

In their quest for increased sales, Acme's marketing department came up with the idea of selling Sticky Snakes Caramel Candy in 6-packs ("Den O' Snakes"). Test marketing was successful, and Acme made the 6-pack a standard retail product with its own UPC code. The next item number they had available was 00022, and they now use it to mark each Den O' Snakes 6-pack:



7 12345 00022 4

For this product, Acme selected a larger shipping carton and let distributors know that the Pack Level 5 ITF-14 code shown below marks cartons containing 50 each Den O' Snakes 6-packs:



5 07 12345 00022 9

Note that Pack Level 5 cartons may contain different amounts depending on the particular product. Item 00001 cases contain 288 each 4 ounce boxes of Sticky Snakes Caramel Candy packaged in display boxes of 24 units. Item 00022 cases contain 50 each Den O' Snakes 6-packs (a total of 300 each 4 ounce boxes).

If your carton graphic layout is being created electronically using publishing software, software can be used to create the master barcode artwork. The artwork can be pasted electronically or printed out on a laser printer or typesetter. When dealing with lower volumes, a complex mix of different products, or variable case quantities, it is often more efficient to print ITF-14 barcodes on demand using laser, inkjet, or thermal transfer printers.

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