LET'S TALK SYMBOLOGY

A Guide to Decoding Barcodes

COGNEX

SYMBOLOGY IN BARCODES

Barcode technologies provide fast reliable data collection to ensure part or product traceability, error-proof assembly processes, and enhance customer service.

Barcodes are machine readable symbols that store identifying data about the part or product with which they are associated. These symbols, when read by a barcode scanner, are decoded, recorded, and processed to extract the data for a variety of uses (e.g., pricing, order fulfillment, traceability through production, sortation, shipping, etc.) Over the years, different forms of barcodes have been developed to help businesses around the world. These include:

1-D linear barcodes

A 1-D (one-dimensional) barcode is the typical style with which we are most familiar. All the information in the code is organized horizontally in bar and space widths and read left to right by a scanner. Several versions of 1-D codes store only numerical data while others can encode additional characters. The height of the code varies based on the space available on a product and the ability of a barcode reader to read a small or large sized barcode.

2-D matrix codes

In the 2-D (two-dimensional) matrix code type, the data is encoded as black and white ‘cells’ (small squares) arranged in either a square or rectangular pattern. As well as being able to encode huge amounts of data, the matrix code improves readability and resistance to poor printing. They also include redundant data so even if one or more cells are damaged, the code is still readable.

Postal codes

This type of barcode lies somewhere in between a 2-D and a 1-D linear barcode. Instead of encoding data in the black bar and white space widths, these primarily use the height of the bars. The majority of postal codes only use numbers, but a few are now starting to include letters as well.

Stacked linear barcodes

A stacked linear barcode is one of two types of 2-D barcodes. These simply consist of multiple linear barcodes that are layered on top of one another, allowing a greater amount information to be encoded. However, to fully decode the data, a barcode reader must be able to simultaneously read the code both horizontally and vertically.

DECODING A BARCODE

Let's take a closer look at the makeup of two of the most common barcode types:

Universal Product Code (UPC)

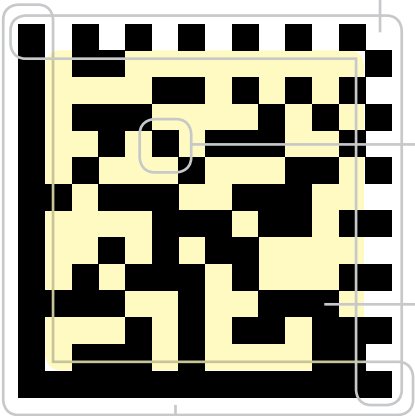
Check digit

Calculated by a formula using the other numbers in the code, it enables the barcode reader to determine if it scanned the number correctly.

Human Readable Code

The first six digits are the manufacturer identification number which they pay an annual fee for and the next five digits are an item number.

DataMatrix



Clocking Pattern

Provides a count of the number of rows and columns in the code.

Cell

Data Region

Can be text or numeric data up to 2,335 alphanumeric characters. Redundant data is often included so even if one or more cells are damaged, the code is still readable.

Finder or 'L' pattern

Helps a barcode reader locate and determine the orientation of the code.

BARCODES IN INDUSTRY

A brief history

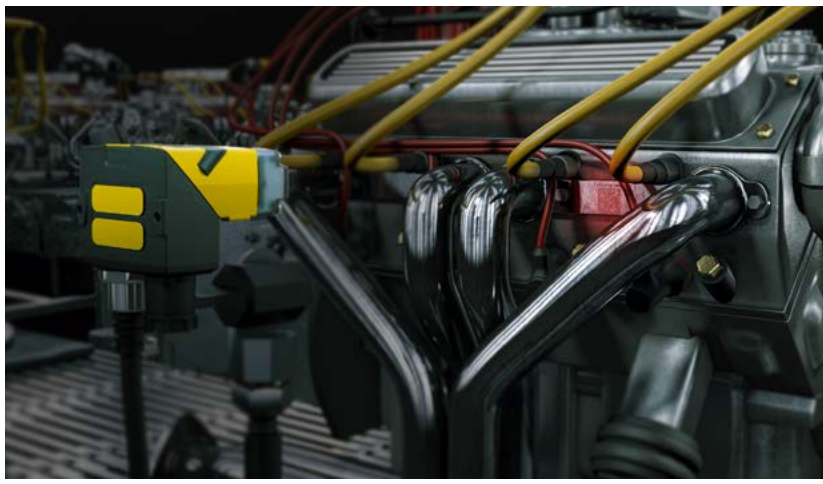
It might be hard to remember a time when barcodes were not part of our daily lives, but it was not until the 1970s that they first made an impact. Although the first patent was actually issued in 1952, it was still some time later that they were first commercially used to label railroad cars.

However, it took until June 1974 before the first scanner was installed at a Marsh's supermarket in Ohio, USA, allowing a product with a barcode attached to be read for the very first time. Unassumingly, this was just a simple packet of Wrigley's® chewing gum.

Today's application

Decades after that first scan, we can hardly imagine a world without barcodes. Available in various guises, barcodes continue to benefit industries that manufacture, buy, sell and distribute products. They help collect data faster and more reliably, improve decision making, eliminate the possibility of human error, reduce employee training time and track products throughout their lifecycle. They are also extremely versatile, inexpensive to design and print and ultimately reduce costs.

Quite simply they have changed the way businesses work across the globe.



Industry categories

It's not just the obvious usage in retail and logisitics that benefit from barcode solutions. Barcodes are now used in many different industries throughout the world including:

- Aerospace
- Automotive
- Beverage
- Consumer Products
- Document Handling
- Electronics
- Food
- Logistics
- Medical Devices
- Pharmaceutical
- Semiconductors
- Solar Wafers

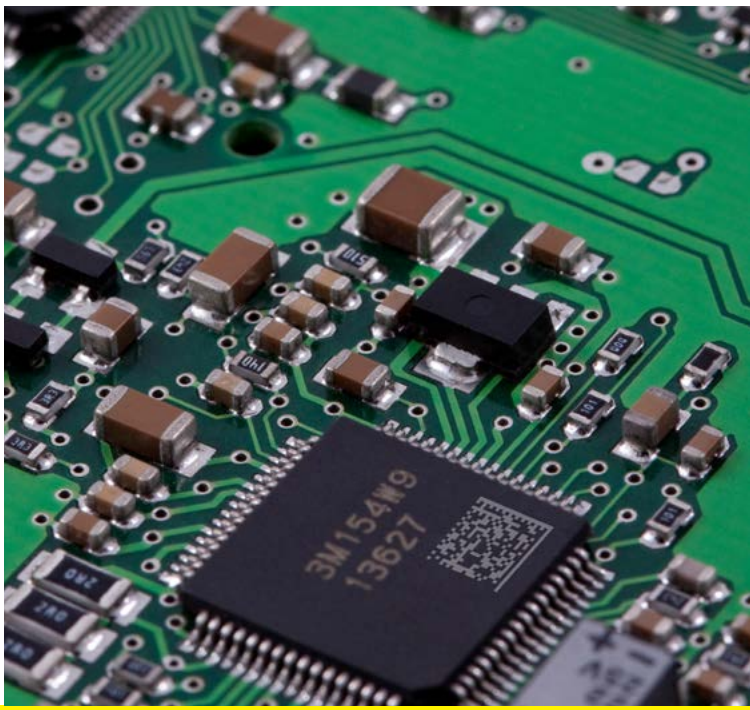
You could say that barcodes have earned their stripes. But that doesn't mean their work is done. As industries grow and technology develops at an ever increasing rate, it is more important than ever for barcodes to evolve too.

1-D Barcode Industry Standards

- GS1
- AIM-Global
- ISO/IEC
- MIL-STD-1189
- ANSI
- HIBCC
- US FDA

2-D Code Industry Standards

- AIM-DPM
- GS1
- ISO/IEC 16022
- AIAG
- US DoD
- ATA/IAQG
- MIL-STD



1-D LINEAR BARCODES

1-D linear barcodes are probably the most commonly recognized style of barcode used today.

The following selection of symbols help illustrate their multiple forms:

Code 128

Code 128 is a more recently introduced symbol and the most robust 1-D barcode type. The number 128 refers to the ability to hold any character of the ASCII 128 character set. That includes all digits, characters and punctuation marks. This makes it fairly compact and very powerful as it enables diverse storage of data.

Encoding Type: Alphanumeric ▪ Format: Multi-width ▪ Check Digit: Required

Typical Usage: Logistics

UPC-A*

By far the most common and well-known barcode used in the U.S., UPC-A encodes 12 digits of data. The first digit is the number system character followed by a five-digit manufacturer number, a five-digit product number and a final check digit. Due to its limited encoding, UPC-A is primarily used in retail.

Encoding Type: Numeric ▪ Format: Multi-width ▪ Check Digit: Required

Typical Usage:
Retail & Supermarkets
in United States

EAN-13*

EAN-13 is the European counterpart of the UPC-A symbol. The main difference between them is that the EAN-13 encodes an extra digit of data to make a total of 13. The first two digits of the barcode identify a specific country and the check digit is the last number of the second group of six digits.

Encoding Type: Numeric ▪ Format: Multi-width ▪ Check Digit: Required

Typical Usage:
Retail & Supermarkets
in Europe

UPC-E*

UPC-E is a condensed variation of a UPC-A barcode. The code is condensed as a result of eliminating ‘extra’ zeros from the digital data. Because the resulting barcode is about half the size of a UPC-A barcode, it is generally used on very small packaging where space is limited.

Encoding Type: Numeric ▪ Format: Multi-width ▪ Check Digit: Required

Typical Usage:
Small Retail Packages
in United States

EAN-8*

EAN-8 is the EAN equivalent of UPC-E in the sense that it provides a short barcode. Set in two groups of four numbers, it is composed of two flag digits, five data digits and one check digit. This is primarily used on small packaging where space is limited.

Encoding Type: Numeric ▪ Format: Multi-width ▪ Check Digit: Required

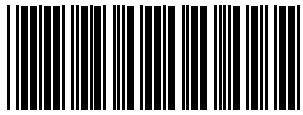
Typical Usage:
Small Retail Packages
in Europe

*Each of these requires registration to an association to assign unique serial data.

Code 39

Code 39, also known as '3 of 9 Code', was the first symbol to use numbers and letters. It is a variable-length barcode that is self-checking so a check digit normally isn't necessary, but is recommended. Its popularity is due to its ability to encode up to 43 numbers, letters and other characters. Code 39 is still widely used, especially in non-retail environments.

Encoding Type: Partial alphanumeric ▪ *Format: Wide/narrow* ▪ *Check Digit: Optional*



Typical Usage:
Military & Automotive

Extended Code 39

Extended Code 39 uses a combination of two standard Code 39 characters to encode every one of the 128 ASCII characters. It also allows for special characters, such as lowercase letters. Generally, the more special characters that are used, the longer the barcode will become. Most barcode readers will not automatically read Extended Code 39 without custom configuration.

Encoding Type: Partial alphanumeric ▪ *Format: Wide/narrow* ▪ *Check Digit: Optional*

Typical Usage:
Military & Automotive

Code 93

Code 93 was designed to encode data more compactly and with higher data redundancy than with older multi-length barcode types such as Code 39.

Encoding Type: Alphanumeric ▪ *Format: Multi-width* ▪ *Check Digit: Required*

Typical Usage:
Military, Automotive
& Healthcare

Codabar

Codabar is a discrete, self-checking barcode that allows encoding of up to 16 different characters, plus an additional four special start and stop characters, which include A, B, C and D.

Encoding Type: Numeric plus four alpha characters
Format: Wide/narrow ▪ *Check Digit: Optional*

Typical Usage:
U.S. Blood Banks, Photo Labs,
FedEx® Airbills and Libraries

Interleaved 2 of 5

Interleaved 2 of 5 encodes any even number of numeric characters. Unlike Standard 2 of 5 (a.k.a. Industrial 2 of 5), which only encodes information in the width of the bars, Interleaved 2 of 5 encodes data in the width of both the bars and spaces. This allows Interleaved 2 of 5 to achieve higher density encoding.

Encoding Type: Numeric ▪ *Format: Wide/narrow* ▪ *Check Digit: Optional*

Typical Usage:
Distribution & Warehousing

MSI/Plessey

MSI/Plessey, also known as Modified Plessey, is used primarily to mark supermarket shelves for inventory control. MSI is a continuous, non-self-checking barcode. While the barcode can be of any length, a given application usually implements a fixed-length barcode.

Encoding Type: Numeric ▪ *Format: Wide/narrow* ▪ *Check Digit: Required*

Typical Usage: Supermarkets

GS1 DataBar Omnidirectional

GS1 DataBar Omnidirectional barcodes are self-checking, high data density codes. Designed to hold the 14 digits of the GTIN (Global Trade Item Number), it is smaller than the UPC and EAN barcodes making it excellent for use on smaller items like produce. It can also be stacked or combined with other codes to create composite codes.

Encoding Type: Partial alphanumeric ▪ Format: Multi-width ▪ Check Digit: Required

Typical Usage: Retail & Supermarket Coupons

GS1 DataBar Expanded

GS1 DataBar Expanded barcodes were designed to encode Application Identifiers, allowing a greater range of data to be encoded such as expiry date, weight, and batch number. Again, these can also be stacked or combined with other codes to create composite ones.

Encoding Type: Partial alphanumeric ▪ Format: Multi-width ▪ Check Digit: Required

Typical Usage: Retail & Supermarket Coupons

POSTAL CODES

Over the years nearly every country in the world has developed their own postal codes to best suit their needs. However, in recent times there has been a move towards standardizing them.

POSTNET

The POSTNET (Postal Numeric Encoding Technique) barcode is used by the U.S. Postal Service to automatically sort mail. Unlike most other barcodes in which data is encoded in the width of the bars and spaces, POSTNET actually encodes data in the height of the bars.

Intelligent Mail Barcode

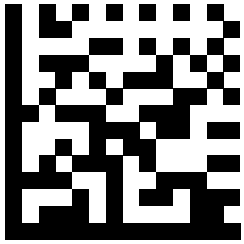
The IMB (Intelligent Mail Barcode) is a U.S. Postal Service barcode used to sort and track letters and flats. In addition to the ZIP code used to generate a POSTNET barcode, the IMB carries sender's information.

2-D MATRIX CODES

2-D symbologies are a more recent addition to the world of barcodes. By storing data both horizontally and vertically, significantly more can be encoded than is possible with a 1-D barcode. The following examples demonstrate the more popular ones available.

Data Matrix

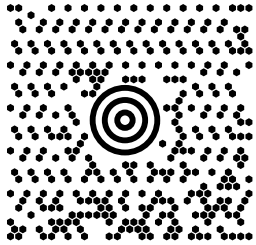
Data Matrix codes allow encoding of large amounts of data (up to 2,335 alphanumeric or 3,116 numerical characters) and use an error correction system to read codes that are as much as 40% damaged. They are made up of black and white cells in a square or rectangular pattern, a finder pattern and a timing pattern (see page three).



Typical Usage: Aerospace, Components, U.S. Mail, HIBC, Defense, & Printed Media

MaxiCode

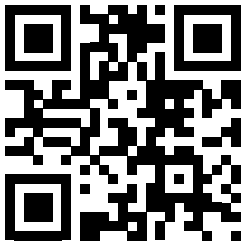
MaxiCode is a fixed-size code which holds up to 93 data characters. It is composed of a central bulls-eye locator and offset rows of hexagonal elements. It was created by United Parcel Service® to allow quick, automated scanning of packages on high-speed conveyor lines (high powered image-based barcode readers can read a MaxiCode on a carton traveling at up to 550 feet/minute or 168 meters/minute).



Typical Usage: Logistics

QR

QR (Quick Read) codes contain square blocks of black cells on a white background with finder patterns in the top left, top right, and bottom left corners. QR was developed with the intention of being used for tracking parts during vehicle assembly. However, it has grown in popularity since the introduction of readers on smartphones, and it is now commonly used in printed marketing materials.



Typical Usage: Automotive Parts & Commercial Marketing

Aztec

Named after the resemblance of the central finder pattern to an Aztec pyramid, the code is built on a square grid with a bulls-eye pattern at its center for locating the code. Data is encoded in concentric square rings around the bulls-eye pattern. Aztec codes have the potential to use less space than other matrix barcodes because they do not require a surrounding blank ‘quiet zone’.

Typical Usage: Travel Tickets & Car Registration Documents

STACKED LINEAR BARCODES

GS1 DataBar Stacked

GS1 DataBar Stacked barcodes are designed to condense the GTIN into a more compact and square barcode suitable for use on smaller packages (such as the label stickers on fresh produce).

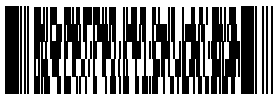
Encoding Type: ASCII characters ▪ *Format: Wide/narrow* ▪ *Check Digit: Required*

Typical Usage:
Supermarkets

PDF417

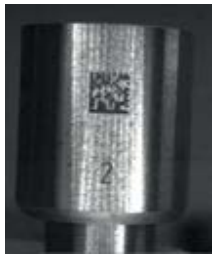
PDF417 barcodes can store up to 1,800 printable ASCII characters or 1,100 binary characters per symbol. It is also possible to break large amounts of data into several PDF417 codes which are linked together. In theory, there is no limit to the amount of data that can be stored in a group of PDF417 symbols.

Encoding Type: ASCII characters ▪ *Format: Wide/narrow* ▪ *Check Digit: Required*



Typical Usage:
U.S. Driver's Licenses
& Logistics

MARKING TYPES



Labels

The most cost-effective and simplest way to apply barcodes to an item is to use pre-printed labels, tags and stickers. However, this is not always the most flexible way as the data in the code has to be pre-determined.

Direct Part Marking

Direct Part Marking (DPM) is a process to permanently mark manufactured parts without labels or packaging. DPM is often used by automotive, aerospace, and electronic manufacturers to ensure reliable tracking of their parts throughout their lifecycle. The preferred codes for DPM are the Data Matrix and QR Code.

Typical methods for DPM include:

- Laser Printing
- Dot Peening
- Chemical Etching
- Casting
- Engraving

Without an advanced image-based reader, DPM codes are difficult to scan because the contrast between light and dark areas is very low.

READING BARCODES

There are many types of barcode scanners on the market that address the many applications that use barcodes. Decoding capability, performance reliability and communications are key to getting the data into the system.

Ranking barcode readers

The most important way to rank barcode reader performance is by its read rate. Read rate is the number of barcodes read divided by the number attempted. It's usually expressed as a percentage and the closer to 100%, the better. Read rate is the best measure of how reliable and robust the reader is to the barcodes seen on the factory floor.

Barcode quality feedback

In many production lines, it is important to maintain the barcode print quality at a high level to ensure that the code can be read by other readers in the product distribution chain. Image-based readers can provide this feedback on every code they read.

Extracting the data

After marking the part or product and reading the code, the data is stored or used within the plant or distribution center's MES (Manufacturing Execution System). If available, Ethernet communication is the fastest and most reliable method of data transfer.

Calculating Read Rate

If 9,900 barcodes are successfully read in 10,000 attempts, the read rate is calculated:
9,900 ÷ 10,000 = .99 or 99%.

Cognex barcode readers offer industry-leading 99.9% read rates, industrial connectivity, and reliable performance, and come in many shapes and sizes:

- Fixed-mount
- Handheld
- Mobile Terminals
- Verifiers

From the smallest and highest performing fixed-mount readers for direct part mark and high-speed code reading, to the widest range of handheld readers, Cognex has the solution for you.

Get more information about Cognex image-based barcode readers at:

www.cognex.com/barcodereaders

COGNEX BARCODE READERS: ANY CODE, EVERY TIME

Fixed-mount Barcode Readers

DataMan industrial fixed-mount barcode readers combine unmatched code reading performance and ease of use in an extremely small form factor. These fixed-mount readers offer best-in-class performance with patented Cognex 1-D barcode, 2-D matrix code, and direct part mark (DPM) reading software algorithms. The flexible optics, lighting options, easy setup and quick deployment make them ideal for the most demanding applications.

Handheld Barcode Readers

DataMan industrial handheld barcode readers provide unmatched performance for direct part marks (DPM) and label-based applications, where integration, ruggedness and the ability to read challenging marks quickly are essential to your success. These handheld readers have field interchangeable communication modules and each reader can be configured to meet specific communication needs.

Mobile Terminals

The MX-1000 series vision-enabled mobile terminals allow you to leverage the latest mobile device technology for your industrial barcode reading applications. The flexible design accepts a variety of both current and future generation mobile devices and augments their capability in a fully ruggedized housing tough enough to stand up to the most challenging environments.

2-D Data Matrix Verifiers

DataMan barcode verifiers ensure Data Matrix code quality and contract compliance. Easy-to-use and reliable, DataMan verifiers enable quality control solutions for applications that require the highest read rates for 2-D Data Matrix codes—critical to product traceability.

COGNEX

Companies around the world rely on Cognex vision and barcode reading solutions to optimize quality, drive down costs and control traceability.

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