Symbology Comparison

Introduction

The subject of this document is “machine readable symbology,” the most common of which is the bar code. The types of machine-readable symbology are the following:

Linear (one-dimensional) bar codes: There are a number of such codes in the public domain. Code 39 is a popular example.

Stacked bar codes: An example is the Symbol Technologies’ Portable Data File 417 (PDF 417).

Two-dimensional (2D) or matrix codes: Examples include: Data Matrix, Maxicode, Quick Response (QR Code), and SignaKey™.

While this document primarily addresses the capabilities of 2D codes, PDF 417 is also presented for comparison. The key attribute of 2D codes is the large amount of information – up to 1000s of characters or bytes in a practical symbol – that can be represented in a given area. Because linear bar codes do not compare in this important area, (e.g. Code 39 is limited to about 25 characters) this document focuses on comparisons of 2D codes.

Listed below are the attributes of two-dimensional (2D) symbology that are used for comparison:

Data density: Data density refers to the number of bits or 8-bit bytes (characters) per unit area expressed in square inches. It is defined in terms of equivalent printer resolution of 300dpi and 600dpi for comparison, using a rectilinear form factor.

Sizing: Sizing refers to the physical size of a printed symbol in terms of user or variable data capacity, and degree of error correction. This ties directly with data density.

Geometry Constraints: This refers to the fact that due to the edge synchronization requirement of Data Matrix, it is constrained to a rectilinear aspect ratio. SignaKey™ has no such constraint and can be free form.

Error Detection and Correction: Type of error correction employed such as parity check, convolution, or Reed-Solomon.

Encryption Security: A method of encoding the original data which requires a key to recover the original data, such as AES or other methods.

Synchronization: This refers to symbol placement is recognized and decoding is performed. Synchronization is discussed in terms such as edge coding or self-clocking. For example, Data Matrix uses edge detection and edge coding whereby two adjacent edges intersecting at 90 degrees are used. By comparison, SignaKey™ uses an internal block structure combined with a self-clocking key symbols mark in a return-to-zero (RZ) code.

Quiet Zone: When required, this means that a symbol requires an uncluttered background surrounding it to accurately define the symbol boundaries and orientation.

Surface Geometry Constraints: This refers to constraints on the marking or printing surface such as curvature or other surface irregularities.

Imaging/Reading Constraints: This refers to the robustness of the image processing and decoding properties to be tolerant of poor external imaging conditions, such as low contrast, poor lighting, distortion, noise/clutter, glare, and reflection.

Embedding and Hiding: This refers to the physical appearance properties of the symbol and the ability to hide the symbol within other information for security reasons. This is a unique attribute of the SignaKey™ symbol since, when printed at high resolution, it appears as an unstructured shade of gray or color that can be blended with other information either as background or structure. In addition, the SignaKey™ symbol's capability to be printed in free form also enhances its ability to be hidden and thus not easily detected by shape recognition.

Comparisons

Comparison Table 1 below shows the relative comparison of SignaKey™ to two commonly used codes. With respect to the identified attributes most 2D codes compare favorably with Data Matrix.

Comparison Table 1

Attribute	**SignaKey**	**Data Matrix***	**PDF 417**
Data Density (Alpha-numeric character square inch)	600	1000	500
Sizing (Selectable)	1 mm to 20' square	1 mil to 14" square	¼" x 1.5"; 1x2"
Geometry Constraints	None, free-form OK	Rectilinear	Rectilinear
Error Correction/Detection	Parity/Reed-Solomon	Reed-Solomon	Unknown
Encryption Security	Uses AES 256 bit FIPS compliant	None. But could added as option.	None. But could be added as option.
Synchronization	Internal block structure	Edge	Edge
Quiet Zone	Not required	Required	Required
Surface Geometry	Severe curvature OK	Low tolerance	Low tolerance
Imaging/Reading Constraints	High tolerance	Low tolerance	Low tolerance
Embedding & Hiding	Excellent qualities	Not possible	Not possible

Comparison Table 2 below shows the relative comparison of SignaKey™ to three additional popular 2D codes.

Comparison Table 2

Attribute	Aztec	Maxicode	QR Code
Data Density (Alpha-numeric character square inch)	600	100	500
Sizing (Selectable)	½" to 10" square	1" fixed	½" to 20' square
Geometry Constraints	Square	Square	Square
Error Correction/Detection	Reed-Solomon	25% type unknown	3 levels
Synchronization	Internal targets	Center target	3 corner targets
Quiet Zone	Not required	Not required	Required on corners
Surface Geometry	Low tolerance	Low tolerance	Low tolerance
Imaging/Reading Constraints	Medium tolerance	Low tolerance	Low tolerance. Can be hacked/changed
Embedding & Hiding	Embedding OK; Hiding	Not good	Not good

Printed Codes

2D symbols were designed primarily to create a data storage mechanism, which could be carried on an item usually in the form of printing on a package or by use of tags and labels. Because they are often used for tracking and identification, they are expected to have a much longer and more useful life than the linear bar code. For this reason, they are usually designed to have a degree of durability in the form of error detection and correction to guard against physical damage to the printed symbol. All matrix codes compare favorably to one another in this regard.

SignaKey™ was designed specifically to expand the usefulness of 2D symbols to more difficult applications. These applications also include those with requirements for directly marking the symbol on the item to be identified with machine-readable data.

Direct Marking

Direct marking is not as controllable as marking on paper-based surfaces such as packaging, tags, or labels. Direct marking applications often encounter situations in which surfaces are curved, rough or irregular, or there are poor mark contrast conditions or limited marking areas. To expand the usefulness to these types of applications, SignaKey™ software has been designed to address these conditions.

Any machine-readable symbology system contains the following functional elements:

> ***Data Encoder***: This element converts human readable information, (e.g. keystroke entered data), into binary code suitable for printing or marking.
>
> ***Reader***: In the case of 2D symbols, the reader captures an image of the symbol and transfers it to a processor running data decoder software.
>
> ***Data Decoder***: The decoder converts the symbol image back to the original human readable data.

The SignaKey™ data encoder is designed to produce a symbol, which does not require edge detection, which in turn does not require a quiet zone around the symbol. In addition, it produces a return to zero (RZ) encoding scheme, which is self-clocking with internal synchronization. All of these allow the symbol to be free form and unconstrained by rectilinear geometry. This freedom of geometry is not offered by any other competing 2D symbology and is important when designing a symbol for direct unconstrained marking applications. As such, the symbol can be tailored to the item being marked and the space available for marking.

The decoder is designed with unique image processing capabilities to facilitate the accurate and reliable decoding of poor quality images, which are often encountered in direct marking applications. Selectable levels of error detection and correction are contained in the symbol at the encoding level and processed in the decoder to further enhance the ability to accurately decode even under severe symbol damage conditions. It is the decoding power that sets SignaKey™ apart from the competition.

Summary

As seen in the above tables, SignaKey™ compares favorably with all competing symbols for paper-based applications. For difficult direct marking conditions, however, extensive testing has shown that there is no other code available that can compete with the capabilities of the SignaKey™ technology.

SignaKey in Standards

IEC (International Electrotechnical Commission) is a global standard organization that covers 98% of the countries on this planet for electrical and electronic products. Only IEC and ISO are recognized by the WTO (World Trade Organization) as standards bodies that represent a global consensus on particular issues. Both IEC and ISO Standards are developed according to the principals agreed to by the WTO for fostering international trade - without creating unnecessary obstacles - which may result from policy makers creating their own "in-house" solutions.

It is especially significant then that in 2015, IEC published a new specification for e-Labelling based entirely on, and only on Signakey technology. This specification begins:

"e-Labelling may be affixed to or laser marked onto the surface of electronic devices or components"

"***Electronic Devices***" could include such things as Laptops, Smartphones. Actuators, PLC's or Sensors etc.

"***Components***" could include Discrete IC's PCB's or again Sensors.

Conclusion

Sensors play a key role in the IOT (Internet of Things). By 2020, a little more than three years from now there will be 25 Billion interconnected devices is a world - with a population just over 8 Billion. Both Cisco and GE agree that the IOT market will exceed 15 Trillion sensors by 2046 - if the current CAGR continues unabated - with a world population projected at with only 9 billion.

This proliferation of sensors will likely be focused on the developing world - because more people have access to 2 G cellular network coverage than they do to basic services such as electricity, sanitation and clean running water.

The World combined annual production of vehicles is 100 Million. Today, the average vehicle utilizes more than 200 sensors. By 2020, this will have risen to 350 sensors per vehicle. An autonomous vehicle would likely require more than 2,000 sensors.

Signakey could uniquely identify and track them all.

Identifying and tracking these sensors is an area in which only Signakey is currently capable and specified by a Global Standard Organization.