MACHINE READABLE LABELS USING DATA MATRIX SYMBOLOGY

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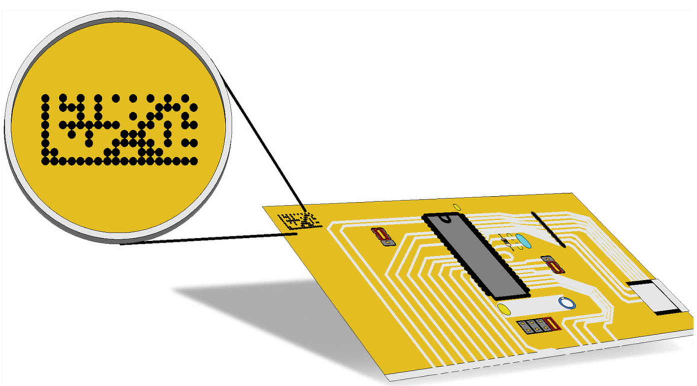
1. Introduction

As in practically all manufacturing processes, the question of unique product identification and tracking comes to light in the assembly of electronic circuit boards. The labels used are printed on automated systems. Until today, we have used barcodes like, Code 39 or 128 for this purpose. Today, the technical development and quality management requirements lead us to the points below:

a) The amount of data increases because more products with various assembly operations have to be tracked
b) The circuit boards get smaller and consequently the component density is higher
c) Real estate is an issue. Space at one's disposal for coding becomes smaller
d) The costs of the label have to be lowered

In particular, points a, b, and c necessitate a method of labeling with substantially higher information density. The development of two dimensional codes (2-D codes) which started at the end of the 1980s, created possibilities in this area which facilitated the fulfillment of all requirements.



2. Standards create clarity and reliability

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3. From bars to dots – the ECC200 standard

Today, one of the leading codes is definitely Data Matrix (ECC200). Today, this symbology is the first choice for the machine-readable label on small parts. In the meantime, diverse organizations have declared their recommendation of Data Matrix (Automotive Industry Action Group (AIAG), Electronics Industry Association (EIA), NASA, DoD, SEMI and EDIFICE).

The advantages of Data Matrix are clear:

- High data density ↔ smaller space
- Virtually any symbol size (scalability) allows adaptation for various uses
- Suitable for nearly all printing processes (from offset to thermal transfer) even direct marking by ink-jet or laser
- Readability even with low contrast
- Readability in 360 degree orientation without special equipment
- Alphanumeric and thus customer-specific data can encoded
- Possibility of electronic data transfer
- High reading reliability due to automatic error-detection and error-correction

It is especially this high flexibility combined with the extremely small space requirement which have attracted the interest of many electronics producers. In this field two processes compete with each other for the creation of the code, namely labeling and direct marking processes (with ink-jet and laser).

4. A question remains. Label or direct mark?

For a long time, the label was the code carrier to be used. However, the structure of the Data Matrix (i.e., individual cells that just need to be identifiably different from each other and are not relative to other cells in the symbol) also made the implementation of the direct marking process the obvious choice. The implementation of inscription with ink-jet printers and lasers engraving are examples of direct marking. Clearly, both processes have advantages and disadvantages.

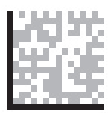
The substantial arguments have been listed in the following table. This table shows that the thermal transfer printing onto a label poses no direct problem; however, it does incur a larger space requirement and higher cost. With ink-jet direct printing and laser engraving, there are a lot of conditions to take into consideration that are paramount in the practical success or failure of the implementation.

	Thermal Transfer	Ink-jet on Part	Laser Marked
Printing Quality Symbol Proportion Contrast	 Good - Very Good Good - Very Good	 Limited Depends on Background	 Good Depends on Material
Durability	Poor - Fair	Poor - Fair	Good - Very Good
Flexibility	Flexible	Restricted	Restricted
Position	Flexible	Depends on Surface	Depends on Surface
Space Requirement	Depends on Label	Small	Small
Cost	Label Cost	Low	Low

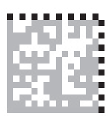
5. The "Norm" or not the "Norm"?

In its graphic depiction, the Data Matrix code is made from three parts, each of which has a specific function.

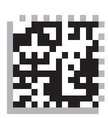
Finder Pattern
Defines the spatial position of the codes and the total size orientation, and permits the recognition of possible distortion.



Alternating Pattern
Defines the rows and columns and allows for adjustment of skew. Dictates the density of the data cells inside the matrix.



Data Region
Contains the data, provides a error correction process, which recognizes faults, within certain limitations, and corrects them.



The Finder Pattern and the Alternating Pattern are first and foremost determined by their function. If problems occur here, the code cannot be read. If one follows the standard requirements, the L-shape of the Finder must be made from two connected straight lines with well-defined edges and defined width. The Alternating Pattern should be made from discrete cells, which are arranged in the grid.

6. Minimum requirements. A guarantee for success.

Maintaining a minimum quality requirement for "printing" data matrix symbols is of great importance in enhancing the readability of the code. Deviations that can occur in practice are depicted in the following ink-jet printing example:

Disconnections in the Finder - edges are made from semicircular elements that do not lie on a straight line.

The individual dots create a wave in the alternating pattern. Some of the individual dots are completely missing.

The individual data cells clearly deviate from the center of the grid. There is no longer any logic to their arrangement in the positions exactly in the middle between two central points. This deviation initiates the error-correction capability of the code to correct these alignment issues.

7. Improved readability

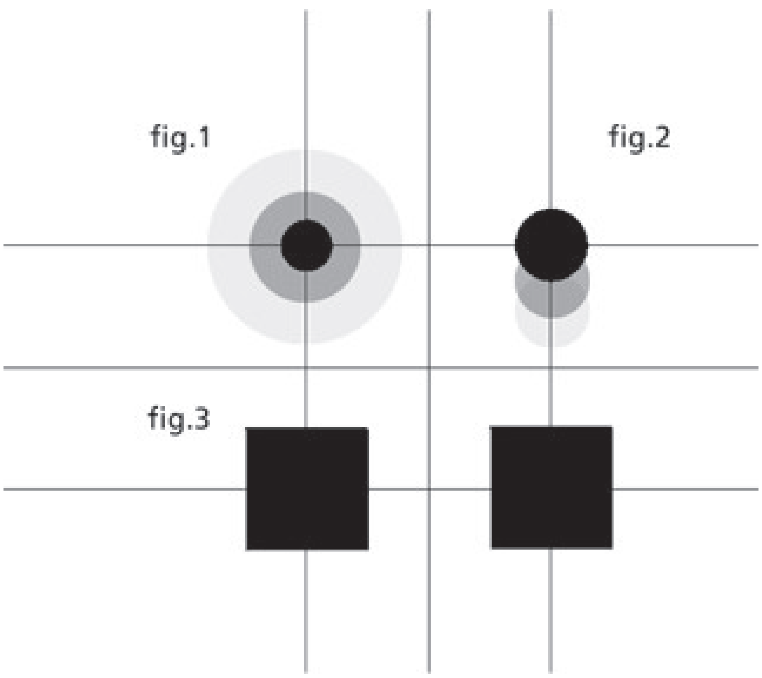
Improved decoding algorithms have ensured that Data Matrix symbols generated in such a way can be read. However, it is noteworthy that the redundant error-correction ensures readability and reading reliability even when the codes are impaired by unclear printing or are otherwise obscured. However, when counting on the redundancy feature, code readability from good printing technologies should take precedence over the occasional obscured code. That is why the minimum requirements, which assure readability, should be well defined.

The diagram below depicts the problem. It concerns the area that accommodates a cell. If this area is too small, it will fall short of the sensor detection. If it is too big, then a neighboring cell may be interpreted as “1”. In both cases, a substitution error occurs.

In Figure 2, we see the “migration” of a code dot from the center. In an extreme case, the point lies exactly in the middle between two centers. After this, it is no longer possible to arrange this dot logically in a specific position in the matrix. The quadratic cells as printed in Figure 3 are preferred and ideal. We take this model as a reference. If the cell appears as a dot instead of a square, then as a rule, the area is smaller. If the dots have a diameter the same as the length of the square’s edges, then the area is about 20% smaller. For most algorithms, this can be tolerated.

Finally, regarding the “migration” from the center, a maximum value of 25% should not be exceeded. After this, in view of all the other tolerances, a logically correct arrangement can no longer be assured.

The drawing up of Symbol Print Quality Guidelines may be found in the respective ISO documents.



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