# Automated Traceability System in SMT Section

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**Abstract: -** The traceability system is very important for the manufacturing industries for control over the assembly process and materials used in assembly process. In this project a traceability system will be created in such a way that by scanning the QR code of PCB, entire database of the components used in PCB manufacturing can be generated. The component traceability provides us complete visibility of what components are available and used in manufacturing process, including components in reels and trays loaded on machines. In case of any failures, the data provides the strong degree of assurance in finding out the root cause of failure which is very important in maintaining customer relationship.

*Key Words:- Assembly process, Traceability.*

## I. INTRODUCTION

### A. Traceability

Traceability is the capability to trace something. In some cases, it is interpreted as the ability to verify the history, location, or application of an item by means of documented recorded identification. Components traceability manufacturing provides complete visibility of what components are available for use in manufacturing process including components on reels and trays loaded on machines.

### B. QR Code Technology

Quick Response(QR) technology which is being viewed as providing vision for the computers to gain management control and information updating. By scanning the QR code as shown in Figure 1 of PCB maintaining the component traceability throughout the SMT process can be achieved
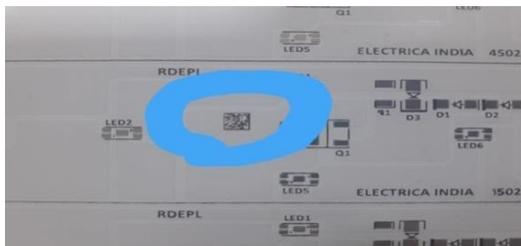


Figure.1. QR Code On PCB

### C. Surface Mount Technology

Surface Mount Technology(SMT) is a method for producing electronic circuits in which the components are mounted or placed directly onto the surface of printed circuit boards (PCBs). An electronic device so made is called a Surface Mount Device. By employing SMT, the production process speeds up, but the risk of defects also increases due to component miniaturization and to the denser packing of boards. In those conditions, detection of failures has become critical for any SMT manufacturing process. The main advantages of this technology are smaller components and much higher component density and many more connections per component. Look inside any piece of commercially made electronic equipment these days and it is filled with minute devices. Rather than using traditional components with wire leads like those that may be used for home construction and kits, these components are mounted onto the surface of the boards and many are minute in size.

### D. SMT Assembly Process

- SOLDER PASTE PRINTING OR DISPENSING
- COMPONENT PLACEMENT
- REFLOW
- INSPECTION
- REWORK/BACKLOAD & CLEANING

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### E.  Different Types of Barcodes

There are primarily two types of Barcodes: 1D and 2D. The kind of barcode you need to use depends on how much data you intend to store in the barcode.

*1D CODE:*

These codes, like the UPC code, are generally linear black and white spaces of varying widths as shown in Figure 2 They will have close to 12 characters13. Traditional barcodes systematically represent data by varying the widths and spacings of parallel lines, and may be referred to as linear or one-dimensional (1D). The disadvantage of the 1D code is that the more information you want to include, the longer the barcode will become.



Fig.2. 1D Code

*2D CODE:*

2D code, like QR codes and data matrix use squares, hexagon and other shapes to store data. It is read in 2 dimensions as data is arranged in both horizontal as well as vertical patterns as shown in Figure 3. It can be much smaller than the 1D code but can carry up to 100 characters, and thus hold much more information. Another advantage is that while 1D can carry only alpha numerics, 2D codes can carry other kinds of information like images, website address, voice, and other types of binary data. A barcode requires a specific type of scanner, called the "barcode scanner" to scanthis code. The scanned output is transmitted to the computer using this device. There are various types of barcode scanners available in the market.



Fig.3. 2D Code

### F.  QR Code Mapping in RDEPLI

Information which is to be added in the form of QR Code on PCB is as below-

- The maximum characters that can be used in QR Code is 4296 characters.
- The maximum characters that can be used in Data Matrix Code is 2335 characters.
- In our machine we can add upto 20 Digit information (Alphanumeric/Special Characters) as shown in Figure.4.
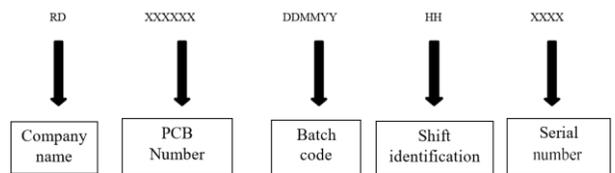


Fig.4. Details of QR Code

The first 2 digits of our QR code describes about the company name, the next 6 digits describes about the PCB number, the next 6 digits describes about the Batch Code, the next 2 digits explain about the Shift Identification and last 4 digits explain about the Serial number

## II.  BARCODE TECHNOLOGY IN AUTOMATED STORAGE

Barcode technology is being viewed as providing vision for the computers to gain management control and information updating. Barcode symbolizes which are being used widely have been explained with the aid of truth tables and examples in this paper. Applications for which barcodes in general and in Automated Storage & Retrieval Systems is discussed in detail as shown in Figure 5 Presently, barcode technology is being used to gain management control and information updating [7]. Barcode technology finds applications in inventory control like maintenance of stock items to be reordered, control on incoming goods and raw materials etc. Applications in production control includes information related to the material availability, shipping details etc.

Fig.5. Barcode labels showing the details of the components

### A. Industrial Matrix Codes

The Data Matrix Code (DMC) is a 2D matrix bar-code, the information to be encoded can be text or raw data and stores up to 2,335 alphanumeric characters. To use the code in industrial environment, the DMC can be marked directly onto industrial parts with various methods such as dot-marking or laser marking, giving a permanent mark which should last the lifetime of the industrial part [11]. The pattern of the DMC is a square and we know the estimated size of the pattern sides. The searched object must meet these conditions: all the sides of the pattern should be equal, the adjacent sides must be orthogonal and the length of the pattern side should be equal with the predicted value as shown in Figure.6.



Figure 6 Data Matrix Code

### B. Introduction to QR Code Technology

QR code is a 2D matrix code that is designed by keeping two points under consideration, i.e. it must store large amount of data as compared to 1D barcodes and it must be decoded at high speed. QR code provides high data storage capacity, fast scanning, omnidirectional readability, and many other advantages including, error- correction (so that damaged code can also be read successfully) and different type of versions. Different varieties of QR code symbols like logo QR code,

encrypted QR code, i.e, QR Code are also available so that user can choose among them according their need as shown in Figure 7 Now these days, a QR code is applied in different application streams related to marketing, security, academics etc. and gain popularity at a really high pace. Day by day more people are getting aware of this technology and use it accordingly [4]. The popularity of QR code grows rapidly with the growth of smartphone users and thus the QR code is rapidly arriving at high levels of acceptance worldwide. In this paper, we studied QR code technology, its benefits, application areas, and its impact on marketing and technological world. QR codes are developed and use for inventory tracking stuff. Adoption of the QR codes grows rapidly during past years and number of users increases exponentially, due to its features like high data storage capacity, fast scanning, error-correction, direct marking and ease of use [9]



Fig.7. QR Code Technology

### C. Understanding 2D-Bar Code Technology

The concept of barcodes appeared decades ago. Traditionally, the barcodes stored data in the form of parallel lines in different widths, and they are known as 1D barcodes, and could only encode numbers [8]. About 30 years ago, the first linear barcodes were used for railway transportation and tracking of the goods in USA. Since then, barcodes have been used almost everywhere, including manufacturing, postal, transportation, government, health care, retail business, trade show, and automotive business. Barcodes, as machine-readable representation of information in a visual format, can be easily stored, transferred, processed, and validated. A linear barcode refers a way of encoding numbers and letters in a sequence of varying width bar and spaces so that it can be read, retrieved, processed, and validated using a computer. Using barcodes provides a simple and inexpensive method of encoding text information that is easily read using electronic readers. Barcodes are used widely because barcode code technology and processing provide a fast and accurate tool to enter data without keyboard data entry. The research for storing more data in barcodes led to the development of 2D barcodes that can store large amount of data in a small Compared with 1D barcodes which hold vary limited

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information data, 2D barcodes has a much larger capacity to hold more information data. As shown in table 2, a QR code can holds up to 7,089 digits, 4296 letters, and 2953 binary data [3]. Selecting and using 2D barcodes must consider the following factors: a) the application usage, b) standard, c) implementation d) the data you need to encode in barcodes and d) how you wish to print the barcode.

D. Traceability System in Electronic Manufacturing System

Recording every aspect of the manufacturing process, from materials to production processes, whether at the board level or the entire system build, thus providing full product and process traceability, helps manufacturers to limit the scope of product recalls and reduces associated recall costs, while providing for compliance to a variety of environmental and safety regulations across all segments of the industry. The requirements of the Quality Assurance Systems in EMS and not only, has a continue demand for more information to be recorded onto the accompanying data storage vehicles that consist mainly of different types of labels in order to accomplished the traceability demand [2]. The compatibility of bar code and data matrix with the traceability demands of the EMS is an actual issue and the choice of one over the other an everyday question for the manufacturers. The paper is looking into this subject attempting to make a classification of the usage of data matrix and barcode systems and attempting a comparison of the two methods in accordance with the production requirements.

The barcode is a row of dark and light spaces in order to create different reflectance to an optical reader input. The electronic device converts the analogue signals in 1 and 0 logical values. The arrangement of the spaces is according to a certain symbology as shown in Figure.8. In the beginnings, the information was made up by the width of the dark and light spaces.
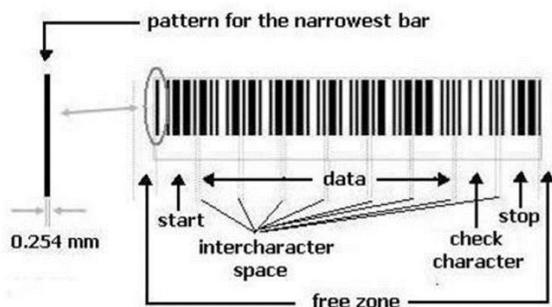


Fig.8. Barcode Structure

Modern test equipment's have the possibility to give the results of the measurements in a printable format. For this amount of data, the analogue 1D barcode is insufficient. Therefore, the technology moved towards digital 2D codes. Whilst there are many different 2D codes on the market the predominant market leader in the Western world is the Data matrix code. On the other hand, the Electronic Industries Alliance recommends using Data matrix for labeling small electronic components [4]. Some manufacturers are marking PCBs with 2D matrix code by laser.

A DMC is a unique digital 2D machine readable symbol that is capable of storing a large amount of information within a small physical size as shown in Figure 9.
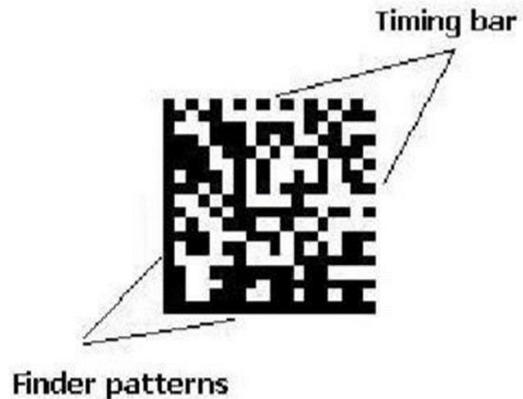


Fig.9. Dot matrix

A Data matrix is made up of a scalable number of rows and columns, consists of a locating bar (solid border), a timing bar (broken border) and a quiet zone.

E. Industrial Laser Machine

PCB Laser Marking Machine is designed for bar codes marking, 2D codes and characters, graphics and other information on any kinds of printed circuit board as shown in Figure 10. Laser technology offers various methods for permanent marking and thus can be used in more diverse applications than conventional lettering and labeling methods. Whether metals, plastics, wood, or ceramics, nearly any material can be lettered, marked, or engraved permanently with a laser, and there are many laser marking systems that can be used to create durable engravings.

Fig.10. laser marker

### F. QR/BAR Code Scanner

A Bar code reader (or bar code scanner) is an electronic device that can read and output printed barcodes to a computer as shown in Figure 11. It consists of a light source, a lens and a light sensor translating for optical impulses into electrical signals. Within the field of 3D object scanning, laser scanning (also known as lidar) combines controlled steering of laser beams with a laser rangefinder. By taking a distance measurement at every direction the scanner rapidly captures the surface shape of objects, buildings and landscapes. More specifically, the sensor in the barcode scanner detects the reflected light from the illumination system (the red light) and generates an analog signal that is sent to the decoder. The decoder interprets that signal, validates the barcode using the check digit, and converts it into text.



Fig.11. Laser Scanner

### G. Components Stored in Reel/Tape Form

Components Reel is used in feeders to facilitate automatic pick and place of components on PCB as shown in Figure.12.

It is committed to providing high-quality high-reliability surface-mount products. Nearly every product is offered in a surface mount package. Surface-mount products are tested through the same production flow as dual-in-line plastic devices and are tested to the same stringent electrical and visual AQL levels. Product qualification and reliability monitoring programs for DIP and surface-mount products are nearly identical. Surface-mount products are additionally subjected to preconditioning prior to many reliability tests. Refer to our product reliability report for details. Maxim surface-mount packages are shipped in antistatic plastic rails. For customers using automatic placement systems, parts also come mounted in pockets on embossed tape. The tape is wound and shipped on reels. The table and diagram on this page indicate the tape sizes used for various package types and the basic orientation convention used.
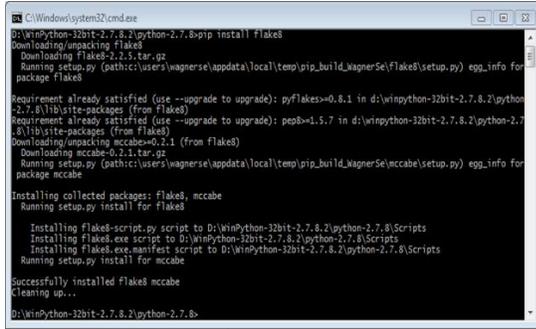


Fig.12. Components in Reel Form

*RIP*:

PIP is a Package-management system used to install and manage software packages written in Python. One major advantage of PIP is the ease of its command line interface, which makes installing Python software packages as easy as issuing a command. to start PIP, open a command prompt window and navigate to the folder containing get-pip.py. Then run python get-pip.py. This will install pip Verify a successful installation by opening a command prompt window and navigating.

## III. INSTALLING ADDITIONAL PACKAGES

Using the Winpython, Command Prompt you are able to use pip directly to install packages for example: "pip install openpyxl", "pip install flake8" as shown in Figure 13 to your Python installation's script directory.

Fig.12. Installing flake8 package through pip

### A. Open PYXL Module

Openpyxl is a Python library to read/write Excel 2010 xlsx/xlsm/xltx/xltm files. It was born from lack of existing library to read/write natively from the Python the Office Open XML format. Pyxl is an open source package that extends Python to support inline HTML However, a Python 3 fork is available. Excel is an application whereas Python is a programming language.

### B. Downloading OpenPYXL

- Below are the simple steps to install Openpyxl on Windows Operating System
- Download Openpyxl module from Openpyxl
- Extract the downloaded TAR file.
- Open command prompt or powershell on windows.
- Navigate to the folder that you extracted (TAR file). That folder contains setup.py file
- Type Python setup.py install and Enter 6.

## IV.   VISUAL BASIC FOR APPLICATIONS CODING

Visual Basic for Applications (VBA) is an implementation of Microsoft's event- driven programming language Visual Basic. Visual Basic Application enables building user-defined functions, automating processes and accessing Windows API and other low-level functionality through dynamic-link libraries. It can be used to control many aspects of the host application, including manipulating user interface features, such as menus and toolbars, and working with custom user forms or dialog boxes. As its name suggests, VBA is closely related to Visual Basic and uses the Visual Basic Runtime Library. However, VBA code normally can only run within a host application, rather than as a standalone program. VBA can, however, control one application from another  using

OLE Automation. For example, VBA can automatically create  a Microsoft  Word  report  from Microsoft Excel data that Excel collects automatically from polled sensors. VBA can use, but not create, ActiveX/COM DLLs, and later versions add support for class modules.

To save the data automatically we have to go with VBA. It consists of two steps first we have to write the code in general form as shown in Figure 13 and later we have to write it in workbook as shown in Figure 13. While writing VBA code make sure that the data sheet is in the correct form it must be in the form of XLSM. VBA is closely related to Visual Basic and uses the Visual Basic Runtime Library. However, VBA code normally can only run within a host application, rather than as a standalone program.

To save the data automatically we have to go with Visual Basic Application. It consists of two steps first we have to write the code in general form and later we have to write it in workbook. While writing VBA code make sure that the data sheet is in



Fig.13. General VBA Coding

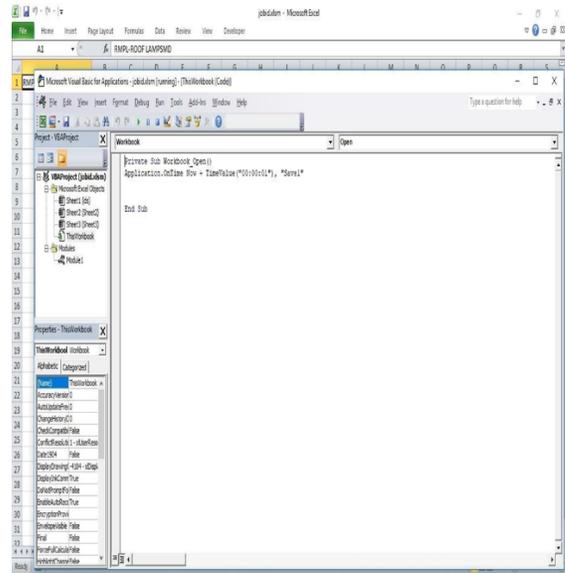the correct form it must be in the form of XLSM. VBA is closely related to Visual Basic and uses the Visual Basic Runtime Library. However, VBA code normally can only run within a host application, rather than as a standalone program. However, VBA code normally can only run within a host application, rather than as a standalone program. VBA can, however, control one application from another using OLE

Automation. For example, VBA can automatically create a Microsoft Word report from Microsoft Excel
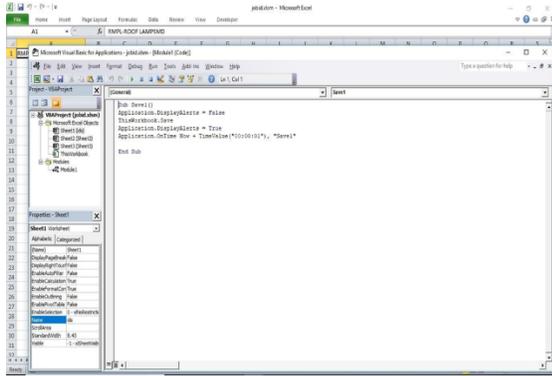


Fig.14. Workbook VBA coding

## V. AUTOMATED TRACEABILITY SYSTEM

Traceability is the capability to trace something. In some cases, it is interpreted as the ability to verify the history, location, or application of an item by means of documented recorded identification. Today‟s contract manufactures are more concern for traceability system for control over the assembly process and materials used in assembly process. The overview of the traceability system is shown in Figure. 15.

### A. Overview of The Project
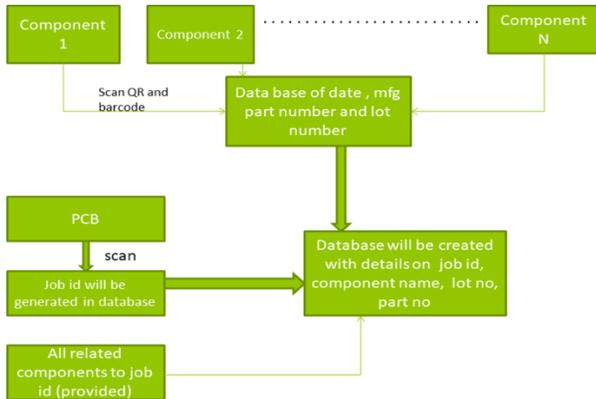


Fig.15. Block Diagram

### B. Creating Data Base of All the Components

By scanning the QR codes/Bar codes of the components using Laser Scanner we have to create a data base of all the components available in the store which are available in the form of Reels/Tapes as shown in Figure 16. All the details regarding Item name, Item code, Reference no, Part no, Bomb Quantity is stored in the data base. The inventory control system for components to be assembled on PCB is created. This gives us all the details of the components like quantity, its reference no, the part no, bomb quantity etc. which are available on the store.



Fig.16. Database of all the components

### C. Database of The Components Regarding Job ID'S

The database of the components which are available under all the specific job id's of all the PCBs is to be maintained. This will give us brief details about the components which are under the particular PCB through the unique job id as shown in Figure 17. We can verify the components which are under the PCB if any complaint is issued from the customers after delivery. This will be helpful to find the error in the PCB and to negotiate with the customer. Today‟s EMS industries are more concerned for traceability system to control over the assembly process and materials used in assembly process.

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Fig.17. Database of the components regarding job ID

### D. Database of The Components of PCB After Traceability

The python code is written such that the data base regarding the particular job id of the PCB is compared with database of all the components of the store and a new database is printed of all the details regarding them. By scanning the QR code of PCB maintaining the component traceability throughout the SMT process is done through this as shown in Figure 18. Some defects which are identified in test process & even after delivery such as field failures, in such issues the product traceability system data provides the strong degree of assurance and is essential for finding out the root cause of failure, in turn maintaining customer relationship management and maximum customer satisfaction.



Fig.18. Database of the details of the components after Traceability

## VI. RESULTS

### A. Output of Job ID and The Details of the Components Regarding the Job Id:

The Python code is written such that all the details of components regarding the specific job id of PCB is to be compared with database of all the components and the output is to be printed as shown in Figure 19 after their comparison with job id and the details regarding the components of the PCB.



Fig.19. Output of details of the components after Traceability

### B. Database of Job Id and The Details of The Components Regarding The Job Id After Traceability



Fig.20. Database of the details of the components after Traceability

The database after traceability and comparison of the databases available in the industry is as Figure.20.

## VII. CONCLUSION

Thus the project describes the Automated Traceability System in SMT section. Through this project we have also created the inventory control system of the components to be assembled on PCB. It is a design which is implemented by scanning the QR code of PCB and hence maintaining the component traceability. In case of any failures, it helps in finding out the root cause of the failures. By scanning the QR code of PCB maintaining the component traceability throughout the SMT process is done.

## VIII. FUTURE SCOPE

The traceability system can be made automatic by automatically scanning of the PCB in SMT section. A server can be created and all the data bases can be stored in the server. This Traceability System can be linked with existing ERP (Enterprise Resource Planning) system. The Traceability system can be implemented through GUI (Graphical User Interface).

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