Fuzzy PCA based Image Matching and Flexible Flying Probe are Used in Embedded Based PCB Bare Board Testing Machine

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Abstract— In the conventional approach for test jig is equipped by mounting an insulation material pattern above the flexible conductive screen. This is done by maintaining small distance away from the PCB of same pattern in order to detect particular defect location. It is then done by scanning the pattern with help of the roller which forces these two patterns into making contact by passing current from the screen side to side in the wiring board at scan. Prerequisites are prepared to examine involuntarily X and Y coordinated positions of a fault spot into a register. But it has several disadvantages like incompatibility for different size boards, and multilayered testing is not possible, as testing procedure takes a lot of time. To overcome the above said problems the objective of this work is to design and develop an embedded based PCB bare board testing machine by using the flexible flying probe. It acts as a major replacement for the manual testing process conducted by the jig method. This machine is able to inspect multi-layered boards within a short period of time. The second work is the extension of the previous work. It performs the image comparison process using the fuzzy PCA algorithm which determines the presence of error in the testing of the PCB bare board image with already stored error free template image of PCB and it produces matching accuracy in percentage. If the result is 100% then the testing bare board is defect free, otherwise it is identified as a defected PCB.

Keywords— *Embedded system; flying probe; PCA Algorithm; Bare PCB board; Micro stepping motors.*

I.   INTRODUCTION

Bare Printed Circuit Board (PCB) is a PCB without any placement of electronic components [1]. Human operators monitor the results of the more than 50 process steps involved in fabrication of PCB. They are simply inspecting the work visually against prescribed standards. The decisions made by the mare often involve subjective judgments, in addition to being labor intensive [2] and therefore expensive, whereas automatic inspection systems remove the subjective aspects and provide fast, quantitative dimensional assessments. The increase in automated production line technology has rapidly initiated substitutes for human visual inspection. The systems have been produced with distinct and limited capabilities for covering the fault spectrum at each significant stage of PCB manufacture [3]. It is important to produce a zero-defect PCB, and to ensure a high-quality PCB that produces reliable and quality digital end products. Various concentrated work on detection of defects on printed circuit boards (PCBs) have been done, but it is also crucial to classify these defects in order to analyze and identify the root cause of the defects. The research work presents an automated embedded based PCB defect detection and fuzzy PCA based matching algorithm.

II. IMPORTANCE OF THIS PROPOSED SYSTEM

Automated visual inspection is required because of the following criteria as the research work reduce human inspection of the tiresome jobs concerned. Manual inspection is sluggish, expensive, leads to unnecessary scrap rates, and does not guarantee for high value output. Multi-layer boards are not appropriate for human eyes to examine, with the assist of an enlarging lens; the typical fault-finding rate of a human being is 90% while drop rate to 50%. Yet with fault free power and ground layers, the rate does not surpass 70%. High sampling inspection is

not applicable. Manual inspection is not feasible due to the higher production rates. Visual inspection is insufficient due to less tolerance's capability.

III. LITERATURE SURVEY

Syamsiah Mashohor et al [4] presents a novel integrated system in which a number of image processing algorithm are embedded within a Genetic Algorithm (GA) based framework was developed. In the paper [5] presented a novel technique for PCB inspection based on the comparison of the Connected Table of a Reference and a Test Image. The authors Malge and Nadaf [6] proposed a PCB defect detection and classification system using a morphological image segmentation algorithm and simple the image processing theories. The study done by authors [7] proposed Bwlabel algorithm, used to deal with the PCB images under the condition of backlighting. In the paper [8] represented a novel approach to the automated inspection of printed circuit boards. Zuwairie Ibrahim et al [9] proposed the goal in their technique is to enhance the performance of the image difference operation in term of computation time using wavelet transform. The paper [10] investigates methodologies for locating and identifying multiple objects in images used for surface mount device inspection. In the paper [11], a spatial filtering and wavelet-based automatic optical inspection system for detect PCB defects is presented. The paper [12] presented detection of faulty region of PCB by thermal image processing. In [13, 14] authors did improvement by classifying seven groups. This is done by combining image processing algorithm and the segmentation algorithm. In [15] the proposed Tamil character recognition of Bamini Tamil font using template matching method. The authors [16] have used Active Appearance Model (AAM) to find the appearance-based features in the face image. Jaffar Sadiq Ali and Ramesh [17] in their proposal has used Proportional Integral (PI) and Proportional Integral Derivative (PID) controller are worked to discover the reactions of the system by using the rectifier output voltage as feedback for closed loop operation. Image processing-based inspection with the aid of fuzzy controller has also developed by many researchers [18, 19, 20].

IV. OBJECTIVE OF THIS WORK

In conventional approach for test jig is equipped by mounting an insulation material pattern above the flexible conductive screen by maintaining a small distance away from the PCB of same pattern in order to detect particular defect location. It is done by scanning the pattern with help of the roller which forces these two patterns into make contact by passing current from the screen side to side in the wiring board at scan. Prerequisites are prepared to examine involuntarily X and Y coordinated positions of a fault spot into a register. But it has several disadvantages like incompatible for different size boards; multilayered testing is not possible, testing procedure takes lot of time. To overcome the above said problems the objective of this work is to design and develop an embedded based PCB bare board testing machine using flexible flying probe. It acts as a major replacement for manual testing process conducted by jig method. This machine is able to inspect multilayered boards within a short period of time. The second work is the extension of the previous work it performs image comparison process using fuzzy PCA algorithm which determines the presence of error in the testing PCB bare board image with already stored error free template image of PCB and produces matching accuracy in percentage. If the result is 100% then the testing bare board is a defect free, otherwise it is identified as defected PCB.

A. Proposed Work

FIGURE 1. OVERALL FRAMEWORK OF THE SYSTEM
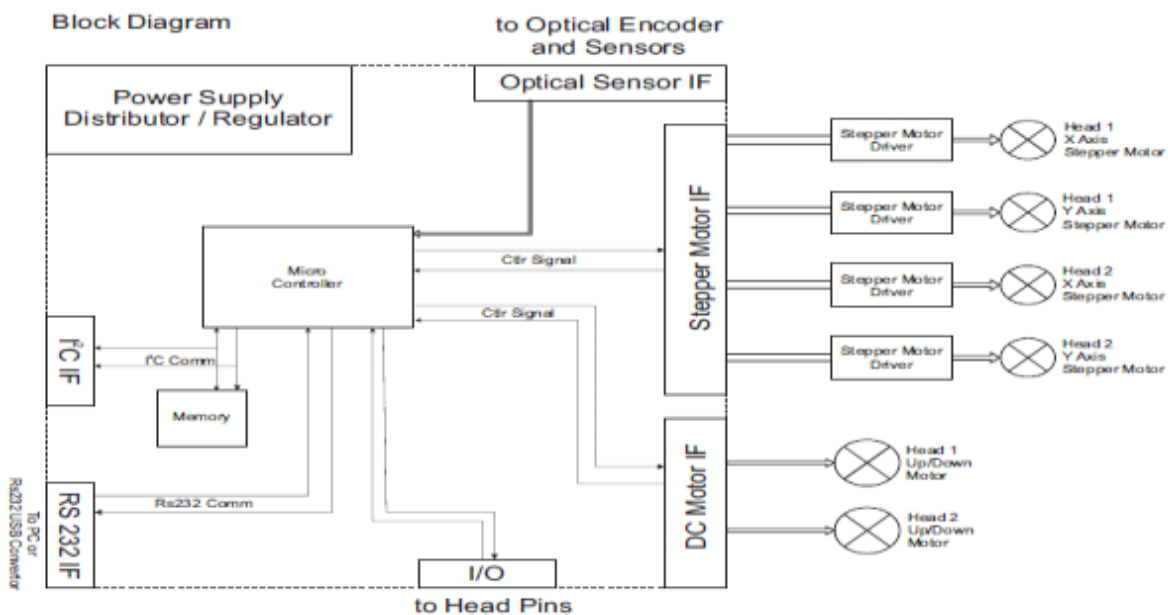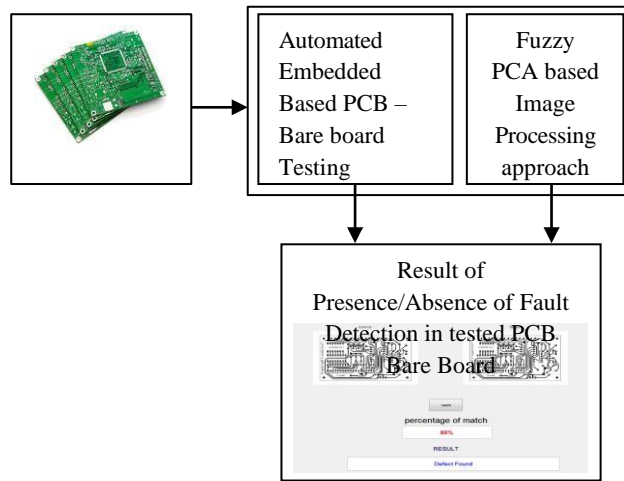
B. Working Methodology of Designed System Using Flying Probe Method

FIGURE 2. BLOCK DIAGRAM OF FLYING PROBE OF RS232 PIC MICROCONTROLLER

Fig. 2. Depicts the block diagram of the Flying probe method. In the designed system the bare PCB Board is tested with Gerber file using electrical test flying probe. The PIC Microcontroller board is used to position the test flying probe by four stepper motors. The main operation of the stepper motor is to move the two flying probes in X and Y directions simultaneously. A DC motor is used to place the probe into the board; an Optical sensor is used to place the probe exactly on the board as in the Gerber file. A system is developed which designs a PCB circuit using ORCAD software to generate a 2D drawing notations (use that is symbol here) Gerber file. The generated 2D drawing notations from Gerber file is transferred to the PIC Microcontroller present in the board through RS 232 communication, all the 2D drawing notations are stored in the memory of the PIC Microcontroller. According to the commends from PIC Microcontroller the stepper motor driver moves the flying probe in X and Y directions, meanwhile a DC motor which is connected in the developed machine to place the flying probe on hole and to

remove it. According to the Gerber file track order the probes are placed on the bare board tracks. Now the flying probe checks the continuity between the two ends of the each track. If there is continuity between the tracks it sends a data "0" to the PIC Microcontroller. Otherwise it sends a data "1". After checking the 1st track the PIC Microcontroller moves the flying probes to the next track according to the track information of the Gerber file. Likewise the entire PCB bare board is checked and the data (continuity details) of all the tracks are checked with the 2D drawing notations in the Gerber file, after the comparisons an error file is generated by the PIC Microcontroller and transferred to the PC, an error report is generated and displayed in the PC.

V. WORKING PRINCIPLE OF FUZZY PRINCIPAL COMPONENT ANALYSIS PCA BASED IMAGE PROCESSING APPROACH ON PCB DEFECT DETECTION

In the work image of the printed circuit board with no defects is loaded on to the computer as Master image (or) Template. The input image to be inspected is collected from the output generated by the flying probe. The template stored in the computer is compared with the testing image using mat lab software. The algorithm used for matching process is fuzzy PCA, Fuzzy PCA algorithm finds the dissimilarity between these two images and based on the Eigen value obtained using covariance matrix, the percentage of defects in the testing PCB is found out and displayed.

VI. EXPRIMENTAL RESULT

The proposed PCB Bare board tester is compared with the existing jig board and the result shows that the automated embedded based PCB tester produces more accuracy in the detection of the matching process than the traditional jig board. The table 1 shows the performance comparison of Smart Automated Embedded based PCB Tester and the Jig Board Tester based on accuracy, false detection rate and time taken for testing.

TABLE1 PERFORMACE COMPARISONS OF SMART AUTOMATED EMBEDDED BASED PCB TESTER AND JIG BOARD TESTER

Technique	Accuracy	False Detectionrate	Tim Taken
Smart Automated Embedded based PCB tester	92%	18%	13mins
Jig board tester	78%	22%	45mins

FIGURE3.Performance Comparisons of Smart Automated Embedded based PCB Tester and Jig Board Tester based on
ACCURACYANDFALSEDETECTIONRATE

•SmartAutomated Embeddedbased tester
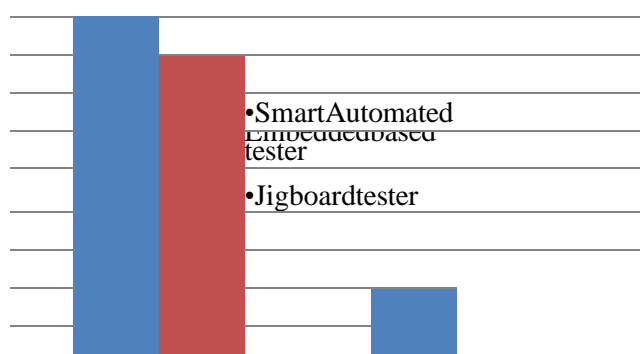
•Jigboardtester

Fig.4.The table 2 shows three different boards with their performance metric. The first board is H1-ENDO-02/06 and is a voltage regulator and its board area is 49.2cm2 and its number of net and number of pins are 8and 45.The no of routes in this board is 27 and the time taken for net list test and route test is 45 and 155 seconds respectively. Second board is ZEN-AM is an auto audio mute control its board area is62.2cm^2 and it no of net and no of pins are34 and 165.The no of routes in this board is92 and the time taken net list test and routetest is180 and 680 seconds respectively. The third board is ZEN-RS232TR is a RS 232 Trans receiver and is a voltage regulator and its board area is 20.1cm2 and itsnumberofnetandnumberofpinsare20and71.Thenumberofroutesinthis board is 41 and the time taken in net list test and route testis 70 and220 seconds respectively.

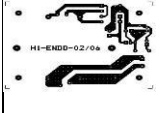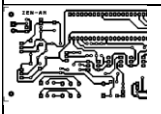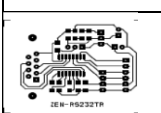TABLE2   PERFORMANCEOFSAEPCBTESTERFORTHREE DIFFERENT PCB BOARD

PCBBoards	Name	Description	BoardArea(cm2)	NoofNet	NoofPin	NoofRoute	TimetoNetList Test(Sec)	TimetoRoute Test(Sec)
	H1-ENDO-02/06	VoltageRegulator	49.2	8	45	27	45	155
	ZENAM	AutoAudioMuteCtrl	62.2	34	165	92	180	680
	ZENRS232TR	RS 232 Transreceiver	20.1	20	71	41	70	220

FIGURE 5.   PROPOSED FLEXIBLE FLYING BOARD MACHINE CONNECTED WITH THE PC

Fig.5.The figure 5 shows the original flexible embedded based flying probe machine connected with the pc. The input is collected from the gerber file which is stored in the hard disk of the pc and according to the prototype

the probe starts moving horizontally and vertically to scan and check the specified co-ordinates for each track. The final result of the testing board is then passed to the pc which displays the success or failure of the board design status.

VII. CONCLUSION

Tremendous advancement in the field of electronic industry leads to the demand of high quality and speedy inspection process for testing PCB bare board. In traditional testing the manual visual inspection is involved which often results in erroneous due to their tiresome work and lack of knowledge in understanding complexity of pattern details.In this work ten different PCB Bare board are tested with the proposed work and existing jig method approach, the experimental result shows that the proposed automated embedded flying probe produces 90% accuracy, while the otherjigmethodgives60%accuracyofexactdefectdetection. Fuzzy PCA based image processing technique for image matching process uses ten images for matching, it produced95% correct resultant thus it proves the enhanced in accurate testing on any kind of PCB bare board with low cost and less man power which increases the benefit of manufactures. The present research work can be extended in future by designing double sided PCB testing machine and the matching algorithms with error images can also be considered with the advancement in image enhancement process.

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