International Journal of Early Childhood Special Education (INT-JECSE)
DOI:10.9756/INTJECSE/V14I5.78 ISSN: 1308-5581 Vol 14, Issue 05 2022

EMBEDDED BASED PCB – BARE BOARD TESTING MACHINE USING FLEXIBLE FLYING PROBE AND FUZZY PCA BASED IMAGE MATCHING

Dr.S. Kanimozhi
Assistant Professor,
Skrb0716@gmail.comz
Department of Electronics, PSG College of Arts and Science,
Coimbatore – 641014. Tamil Nadu, India
Dr.N.Sivanandan
AssistantProfessor,
sivanandan@psgcas.ac.in
Department of Electronics,PSG College of Arts and Science,
Coimbatore – 641014.Tamil Nadu, India

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 a 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

DOI:10.9756/INTJECSE/V14I5.78 ISSN: 1308-5581 Vol 14, Issue 05 2022

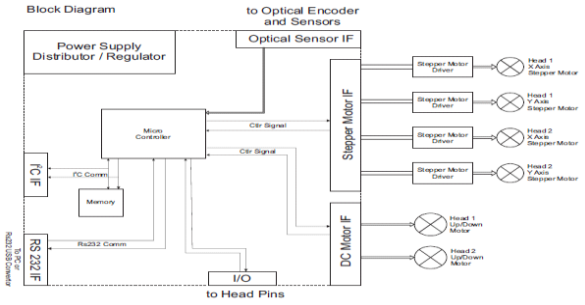
of defects on printed circuit boards (PCBs) have been done, but it is also crucial to classify these defects in order to analyze and identify the root cause of the defects. The research work presents an automated embedded based PCB defect detection and fuzzy PCA based matching algorithm.

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].



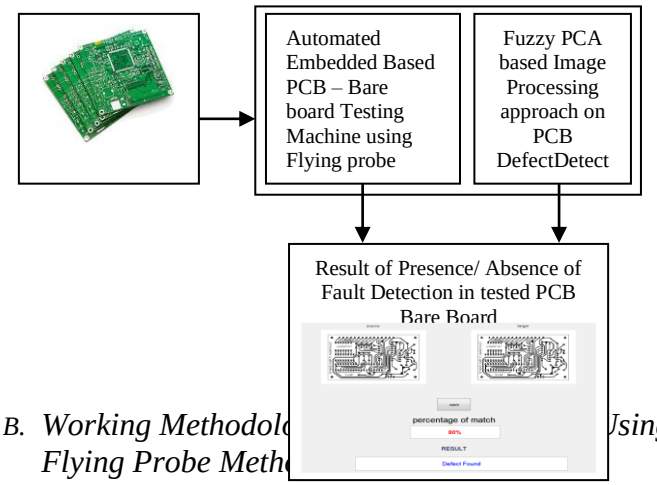
IV. Objective Of This Work

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 Methodol Using Flying Probe Meth

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 Detection rate	Time Taken
Smart Automated Embedded based PCB tester	92%	18%	13 mins
Jig board tester	78%	22%	45mins

FIGURE 3. PERFORMANCE COMPARISONS OF SMART AUTOMATED EMBEDDED BASED PCB TESTER AND JIG BOARD TESTER BASED ON ACCURACY AND FALSE DETECTION RATE

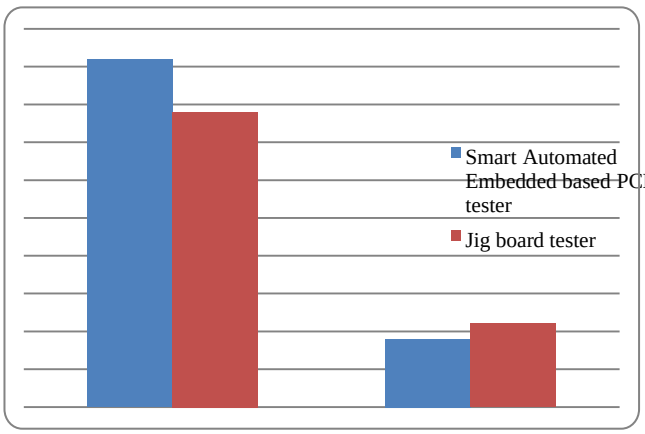
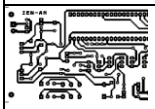
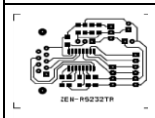


Fig. 3. The comparison shows in figure 3 & 4 that the SAEPCB tester contains 92% accuracy while the traditional jig board tester holds only 78%. The time taken is also very less while compared with the jig board tester shown in figure

FIGURE 4. PERFORMANCE COMPARISONS OF SMART AUTOMATED EMBEDDED BASED PCB TESTER AND JIG

PCB Boards	Name	Description	Board Area (cm2)	No of Net	No of Pin	No of Route	Tim N L Test
	H1-ENDO -02/06	Voltage Regulator	49.2	8	45	27	
	ZENAM	Auto Audio Mute Ctrl	62.2	34	165	92	1
	ZENRS232 TR	RS 232 Trans receiver	20.1	20	71	41	

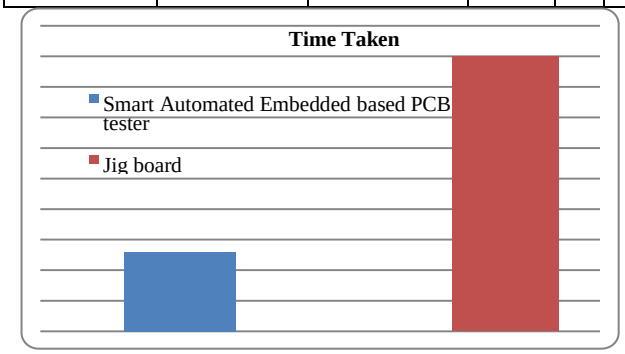


Fig. 4. The table 2 shows three different boards with their performance metric. The first board is H1-ENDO-02/06 and is a voltage regulator and its board area is 49.2cm2 and its number of net and number of pins are 8 and 45.The no of routes in this board is 27 and the time taken for net list test and route test is 45 and 155 seconds respectively.Second board is ZEN-AM is an auto audio mute control its board area is 62.2cm^2 and it no of net and no of pins are 34

and 165.The no of routes in this board is 92 and the time taken net list test and route test is 180 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 its number of net and number of pins are 20 and 71.The number of routes in this board is 41 and the time taken in net list test and route testis 70 and 220 seconds respectively.

TABLE2 PERFORMANCE OF SAEPCB TESTER FOR THREE DIFFERENT PCB BOARD

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 other jig method gives 60% accuracy of exact defect detection. 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.

References

[1] J. Hong, K. Park and K. Kim, Parallel processing machine vision system for bare PCB inspection, Proceedings of the 24th annual conference of the IEEE, Vol. No3 pp.1346-1350, 1998.

[2] Walter H. Schwartz, “Vision systems for PC board inspection", Assembly Engineering, Vol. No. 29, Issue No. 8, pp. 18-21, 1986.

[3] Frank J. Langley, Imaging systems for PCB Inspection", Circuits manufacturing, Vol. No 25, Issue No. 1, pp. 50-54, 1985.

[4] SyamsiahMashohor, Jonathan R. Evans and Ahmet T. Erdogan, Automatic hybrid Genetic algorithm based printed circuit board inspection, Proceedings of the first NASA/ESA conference on adaptive hardware and systems (AHS'06) , IEEE, 2006.

[5] Mauro HiromuTatibana, Roberto De AlencarLotufo, “Novel Automatic PCB Inspection Technique Based on Connectivity” IEEE, X Brazilian symposium on computer graphics and image processing, Campos do Jordao Brazil, Vol. No. 14, Issue No. 17, pp. 187 – 194 , 1997.

[6] Malge P.S, Nadaf R.S, “PCB defect detection, classification and localization using mathematical morphology and image processing tools”, International Journal of Computer Applications, ISSN No 0975 – 8887, Vol. No. 87, Issue No.9, February 2014.

[7] Jun-taoXiong, Jin-zhao Li, Bao-xia Sun, Jian-guo Chen, “Study of automatic PCB Jack center positioning system based on machine vision”, Published by Atlantis Press, Vol. No. 84, Issue No. 4, pp 942-949, 2013.

[8] S. BurakGöktürk, LaleAkarun and H. IşılBozma, “Automated Inspection of PCB’s using a novel approach”, Proceedings of the IEEE-EURASIP workshop on nonlinear signal and image processing (NSIP'99), pp 80-184, 1999.

[9] Zuwairie Ibrahim , Syed Abdul , Rahman Al-attas , ZulfakarAspar, “Model-based PCB inspection technique using wavelet transform”, Proceedings of the 4th Asian control conference, pp2026-2029, 2002.

[10] A. J. Crispin & V. Rankov ,“Automated inspection of PCB components using a genetic algorithm template-matching approach”, Springer International Journal of Advanced Manufacturing Technology, Vol. No. 35, Issue No 3, pp. 293-300, 2007.

[11] JoaquínSantoyo, J. Carlos Pedraza, L. Felipe Mejía, Alejandro Santoyo, “PCB inspection using image processing and wavelet transform”, MICAI 2007: Advances in Artificial Intelligence Lecture Notes in Computer Science Vol.No.4827,pp 634-639,2007.

[12] Chaitali R. Wagh , Vijay B. Baru, “Detection of faulty region on printed circuit board with IR Thermography”, International Journal of Scientific & Engineering Research, Vol. No. 4, Issue No. 11, pp 365- 369, 2013.

[13] M. Moganti, F. Ercal, C. H. Dagli and S. Tsunekawa, “Automatic PCB inspection algorithms: A survey, computer vision and image understanding”, Vol. No. 63, Issue No.2, pp.287-313, 1996.

[14] R. Heriansyah and S. A. R. Abu-Bakar (2004), “Defects classification on bare PCB using multiple learning vector quantization neural network paradigm”, International conference on computer graphics, imaging, and visualization (CGIV 2004), pp.50-53, 2004.

[15] D. Pugazhenthi, S. Arul Vallarasi,“Offline character recognition of printed tamil text using template matching method of baminitamil font”,Indian Journal of Science and Technology, Vol.No.8, Issue 35, pp 1-4, December 2015.

[16] G.J. Edwards, C.J. Taylor and T.F. Cootes, “Interpreting Face Images using Active Appearance Models”, Proceeding FG '98 Proceedings of the 3rd International Conference on Face & Gesture Recognition, IEEE Computer Society Washington, pp 300-306, 1998.

[17] A.JaffarSadiq Ali, G. P. Ramesh, “comparison of pi and PID controlled wind generator fed γ- z source based PMSM drives”,Indian Journal of Science and Technology, Vol. No 9, Issue No. 1, pp 1-6, 2016.

[18] Jana Selvaganesan, KannanNatarajan,“Robust face recognition from video based on extensive feature set and Fuzzy Batalgorithm”, Indian Journal of Science and Technology, Vol. No. 8, Issue No. 35, 2015.

[19] Zuwairie Ibrahim , Syed Abdul Rahman Al-Attas, “Wavelet-based printed circuit board inspection system”, International Journal of Signal Processing Vol.No.1 ,Issue No. 2, pp. 73-79, 2004.

[20] JoaquínSantoyo, J. Carlos Pedraza, L. Felipe Mejía, Alejandro Santoyo, “PCB inspection using image processing and wavelet transform”, MICAI 2007: Advances in artificial intelligence lecture notes in computer science Vol. No. 48 Issue No. 27, pp 634-639, 2007.