International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 4, April 2015

Design of Jig for Automated PCB Testimg

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***Abstract*— Paper includes hardware designing of PCB test jig using Raspberry Pi that will be used for automated testing of master card PCB used in X ray machines. Automated Test Euipment (ATE) will verify the PCB's functionality and its behavior. The test procedure includes sending of command frame from test jig to the DUT using Raspberry Pi controller and receiving the response frame from the DUT. The command frame and the response frame are then compared which determines the test to be pass or fail. The test procedures includes testing of digital inputs outputs of the DUT and also other functionalities of the master card. The test is usually performed according to the OEM test engineer, who defines the specifications and test procedures. The test is best at detecting wrong component values, functional failures and parametric failures.**

Keywords—Raspberry Pi; ATE; DUT; OEM.

I. INTRODUCTION

Automated Test Equipment (ATE) is an apparatus that is used to test device, known as the Device Under Test (DUT) or Unit Under Test (UUT). Using automation one can quickly perform measurements and evaluate the test results. An ATE is a simple computer controlled digital multimeter, or a complicated system containing many of complex test instruments capable of automatically testing and diagnosing faults in sophisticated PCBs.
The electronic manufacturing industry widely makes use of ATE to test electronic components and systems after being fabricated.

Wide range of electronic devices and systems, from simple components (resistors, capacitors, and inductors) to integrated circuits (ICs), printed circuit boards (PCBs), and complex, completely assembled electronic systems are tested using ATE. ATE reduces the time taken to test the device or to verify the device if it works as per the requirement and also ATE quickly finds the fault in the DUT if any before it goes to the consumers. There are several PCB test strategies to choose from including boundary scan and manufacturing defects analyzers.

II. WHY AUTOMATED TESTING?

Automatic test equipment enables printed circuit board test and equipment test to be undertaken very faster than if it were done manually. As time of production staff forms a major element of the overall production cost of an item of electronics equipment, it is necessary to reduce the production times as possible which can be achieved with the use of ATE, automatic test equipment.

ATE systems are designed to reduce the amount of test time needed to verify that a particular device works or to quickly find its faults before the part has a chance to be used in a final consumer product.
To reduce manufacturing costs and improve yield, semiconductor devices should be tested after being fabricated to prevent even a small number of defective devices ending up with consumer.

ATE architecture consists of master controller (usually a computer) that synchronizes one or more source and capture instruments. Historically, custom-designed controllers or relays were used by ATE systems. The Device Under Test (DUT) is physically connected to the ATE by another robotic machine called a Handler or Prober and through a customized Interface Test Adapter (ITA) or "fixture" that adapts the ATE's resources to the DUT[2].

ATE tests perform two basic functions. The first is to test whether or not the DUT is working correctly. The second is when the DUT is not working correctly, to diagnose the reason. The diagnostic portion can be the most difficult and costly portion of the test[1].

III. TEST PROCEDURE

General scheme to test inputs

1. Tester drives appropriate input DUT.
2. Tester sends command to DUT on UART to read the input
3. Upon reception of the command, the FPGA logic on DUT senses the input and reports the read value back to tester.

ISSN: 2278 – 909X

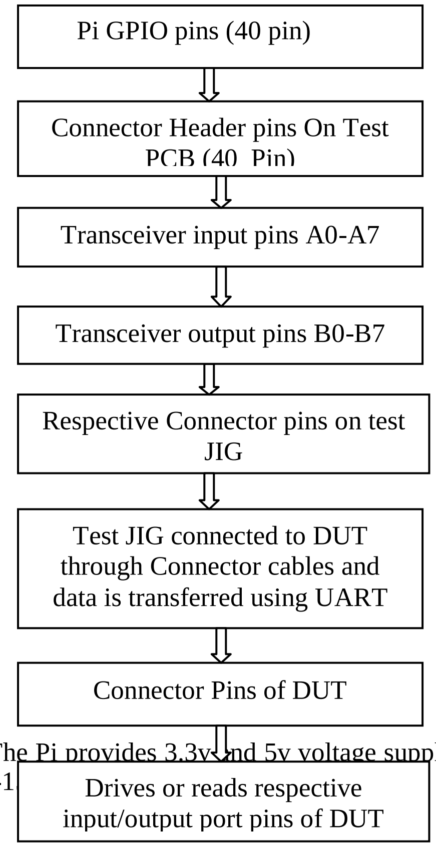
4. Tester compares the data sent by DUT with expected result and concludes on PASS or FAIL.

General scheme to test outputs

1. Tester sends command to DUT on UART with data to be driven on certain output pin.
2. Upon reception of the command, the FPGA logic on DUT drives the requested outputs and sends ACK to back to tester.
3. Tester senses the outputs on DUT connectors.
4. Tester compares the output values generated by DUT with expected result and concludes on PASS or FAIL.

IV. DESIGN OF JIG

The Jig comprises raspberry pi model B+ as the controller. The GPIO pins of the Pi are interfaced to the transceiver through a 40 pin header on the Jig. Setting the GPIO pins 1 and 3 enables the transreceiver pin OE and DIR signals. DIR signal is set to logic 1 so that data is transferred from the Jig to the DUT. Initially the transceiver sends the 8bit data parallely to the DUT. Output pins of the transceiver is connected to the connectors. The connectors on the Jig are used same as that on the DUT. The Jig and DUT are interfaced using these connectors. So the data sent from GPIO pins goes from transreceiver to the connectors of the jig to the connectors of the DUT and then to the respective input output pins of the DUT. The data is sent and received from DUT and Jig using UART communication. Electrostatic Diodes (ESD) are used in order to protect the transceiver and Pi if there are any voltage surges. The data flow chart is given below.



The Pi provides 3.3v and 5v voltage supply where as +15v and -1

The DUT is FPGA based and is programmed using Altera's USB blaster FPGA Programmer. First input port pins of DUT are driven by applying appropriate voltages, Logic 0 – 0v +/- 0.2v and Logic 1- 5v +/- 0.2v. Command frames (64 bits) are then sent from the Jig to the DUT to either drive the output or to read the input pins. The tester sends the command frame to DUT via UART to read the input ports.

A5	D1	C1	D1	Ignored	Ignored	Ignored	Ignored

The FPGA logic on DUT reads the input ports and sends back the acknowledge signal via response frame.

A5	C1	D1	D2	Data0	Data1	Data2	Data3

Data 0,1,2,3 are 8 bits each contains the information of input port pins. These data is then compared with the expected value which depend on what input was sent at earlier step, and concludes PASS or FAIL.

Similarly test Jig sends the command frame to drive the output port pins of the DUT via UART.

A5	C1	D1	D3	Data0	Data1	Data2	Data3

The FPGA logic on the DUT extracts the data frame, each data is 8 bits and drives the output pins on DUT. Later DUT sends back the acknowledgment signal to test Jig using response frame.

A5	A1	D1	AC	5A	5A	5A	5A

Tester reads the output available on the connector pins and compares the read value with expected value, which depend on what data was sent at earlier step and concludes PASS or FAIL.

Raspberry Pi over PIC controller

The advantages of using PI over PIC controller are as follows:

a) more number of GPIO pins compared to PIC controller.

b) can be easily configured as input or output pins where as in PIC controller setting up of registers are required inorder to use the output pins as by default pins are configured as input for PIC controller.

c) can be directly interfaced using jumper wires unlike in PIC controller which requires RS232 interfacing.

d) no need of interfacing protocols like I2C or SPI as required in PIC controller for connecting components.

e) Uart interfacing is much easier than in the PIC controller.

f) Interfacing Pi to PC is simple than PIC to PC which requires MAX 232 interfacing PI to PC required LAN port.

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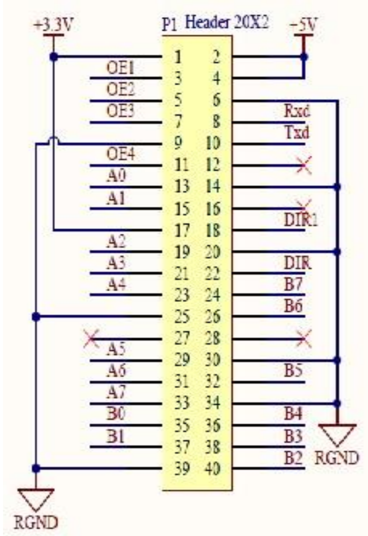
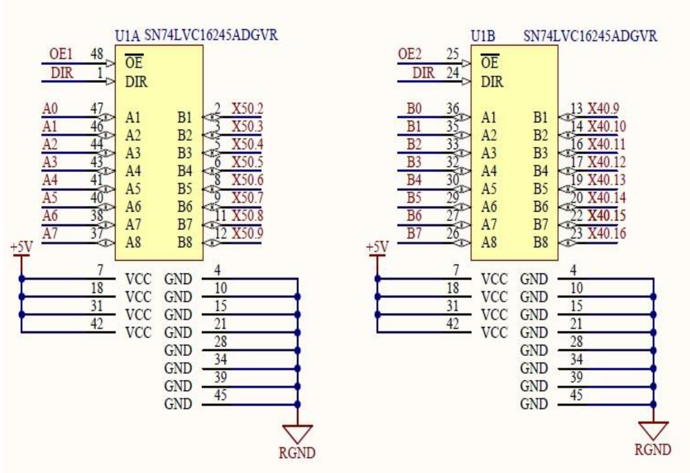


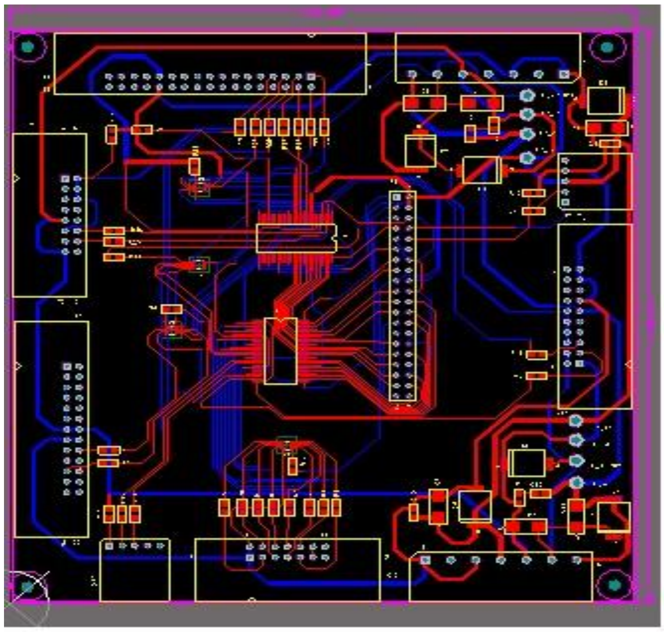


The 40 pin header is interfaced to the GPIO pins of Raspberry Pi B+ model. The pin 3 and 5 is connected to the transreceiver as shown in above schematics. OE1 and OE2 is set to logic 0 to enable transreceiver and DIR is set to 1 to direct the flow from jig to DUT. A1 to A8 are the inputs to the transreceiver which will carry data sent from the GPIO pins of the Pi. B1 to B8 are the outputs of the transreceiver which are connected to the connector pins of the Jig. The connectors of the test jig are then interfaced to the connectors of the DUT. And the connector pins of the DUT are then connected to the input output pins of the DUT. Hence the command frame data is sent from jig to the input output pins of the DUT. While receiving the Response frame from the DUT, the transreceiver pins B1 to B8 is the input to the transreceiver and A1 to A8 is the output of the transreceiver. This is done by setting the DIR signal to 0 in python code. So the response frame is transferred from the DUT to the Jig. The response frame data is available on the GPIO pins of the raspberry pi which can be read and compared with the data sent. If the response frame data and data sent are same then the test PCB or DUT is said to be 'Pass' else it is declared as 'Fail'. All the communication between the jig and DUT is done using the UART protocol.

V. RESULT

From the given test procedure, schematics were drawn using Altium tool designer and the schematics were extracted in the PCB layout. The components were placed one by one and were routed. Two test Jigs were designed to test input pins of the DUT and other to test output pins of the DUT. The final PCB test jig is shown below.

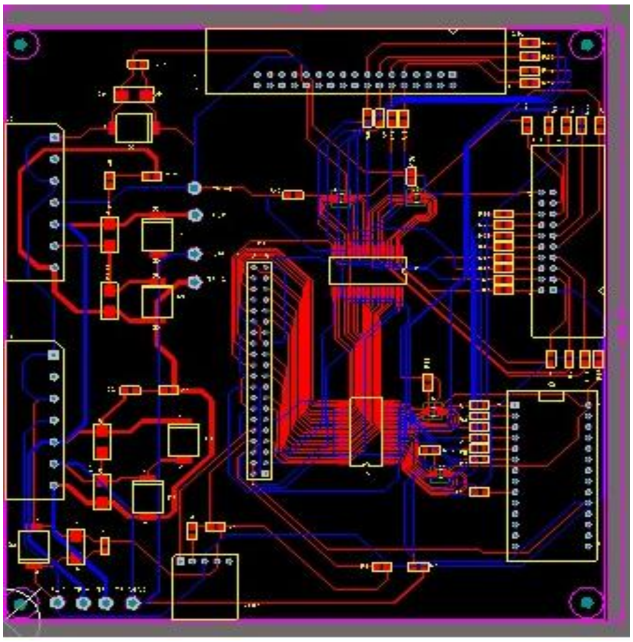
1) The test Jig to test input port pins of DUT.



ISSN: 2278 – 909X

International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 4, April 2015

2) The test Jig PCB est output port pins of DUT.



I) Decreased testing time.

- Automated testing can perform actions faster than humans can. The time it takes to run automated test is likely dramatically less than the time it would take a manual tester to perform those same actions.
- As the automated test suite is built, the time is invested in creating tests that can be run again and again. Whereas manual testing requires that a human tester put in work every single time a particular feature is to be tested, automated testing means devoting time once to write a test that can be run automatically countless times and be updated when needed.
- Automated testing performs parallel test runs. The response frame received is 64bit and each bit signifies the functionality of input/output pin, So it is possible to verify multiple functionality features simultaneously decreasing the overall testing time.

II) *Increased efficiency of testing process.*

- Single automated test can be reused on multiple features.
- Automating repetitive tasks frees up the testers to perform exploratory and manual testing on other parts of DUT that may not be suited to automation.
- Automated test can help to remove human error from testing process, providing you with consistent, reliable, repeatable tests and results.

III) Increased application quality.

- By running the automated tests regularly, tester can find bugs earlier in development process, leaving developers with time they need to resolve any issues prior to promotions.
- Automated testing lends itlsef to agile development and continuous integration practices. As new functionality is added to test PCB, we can run the relevant tests from the automated suite at the click of a button.
- Performing a combination of automated and exploratory testing of test PCB helps to discover “our-users-will-definitely-run-into-that” bugs and “discovered-completely-by-accident” bugs.

VI. CONCLUSION

Automated test jig is still in process of development as changes in test cases, test procedures to verify functionalities features other than input output pins and also how can these PCB design can be modified to test input output ports in one single jig instead of two. In this paper we have successfully investigated the automated testing of PCB is much faster, appropriate and human error free than manual testing. Test automation when carried out in a planned manner, offers great benefits and is therefore worth considering.

VII. REFERENCES

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[3] Adam Cort, “Functional testing of PCBs”, Assembly Magazine.

ISSN: 2278 – 909X