

Design of ATE Calibration Device Based on Microelectronic Reference Materials

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Abstract – Microelectronic Reference materials(RMs) are a good way to achieve microelectronic traceability. To achieve full calibration of Automated Test Equipment (ATE) , each test channel should be traced to calibration device of ATE based on RMs. This paper puts forward a design solution of calibration device of ATE based on RMs, which can realize the versatility and portability of calibration device, and realize automatic calibration progress.

Keywords –ATE, Calibration, Reference materials

I. INTRODUCTION

Microelectronic reference materials called as RMs for short, is a special circuit as a standard of dissemination, of which one or several parameters are certified. RMs has three notable characters. Firstly, it is for measurement. Secondly, it has the accurate certified values. Lastly, its value could be traced to the source^[1-8].

RMs are widely used in parameter alignment and calibration of Automated Test Equipment(ATE), which has many benefits such as simplification on ATE calibration, easy to take, adaptive for on-site calibration. Recently, development and application of RMs has become one of the main direction of microelectronics measurement. However, the pins of RMs are limited, which can't achieve full calibration of all channels of ATE. Therefore, in order to achieve the full calibration of ATE, it is necessary to design a calibration device of ATE based on RMs, which can disseminate the value of RMs to each channel of ATE.

This paper is organized as follows. In section 2 we describe the calibration principle of ATE with RMs. In section 3 we present the architecture design of calibration device. In section 4 we present the hardware composition of calibration device. In section 5 we draw conclusions.

II. THE CALIBRATION PRINCIPLE OF ATE WITH RM

ATE employs a number of stimulus and measurement instruments such as the Drivers, Comparators, Precision Measurement Unit(PMU), Device Power Supplies(DPS), AC subsection. Because of the complexity of ATE, which employs many instruments, and each instrument can have many ranges and modes, RMs used for ATE calibration should be a kind of integrated circuit(IC) with many programmable parameters, which can verify ATE and disseminate the value of quantity to ATE. Therefore, we choose the following parameters as the properties of RMs: Minimum Input high voltage(V_{IH}), Maximal Input low voltage(V_{IL}), Output high voltage(V_{OH}), Output low voltage(V_{OL}), Output high current(I_{OH}), Output low current(I_{OL}), Power Supply current(I_{DD}), Propagation delay L to H(t_{PLH}), Propagation delay H to L(t_{PHL}). The calibration principle of ATE with these parameters of RMs are as follows^[9].

A. The Calibration Principle of V_{IL}/V_{IH}

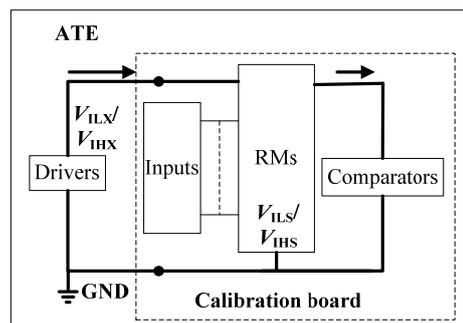


Fig.1. The calibration principle of V_{IL}/V_{IH}

Fig 1 shows the calibration principle of V_{IL}/V_{IH} . To perform a V_{IL}/V_{IH} calibration, the Driver is connected to the input pin under test, and the Comparator is connected to the output pin corresponding to the input pin. The voltage of the input is gradually increased from V_{SS} . Meanwhile execute functional test pattern and monitor the output signal. When the output state is changed, the input voltage is V_{ILX} , which is the measurement value of ATE. Calculate the error of V_{ILX} and V_{ILS} (standard value of RMs) by equation(1).

$$\Delta U = V_{ILX} - V_{ILS} \quad (1)$$

The calibration principle of V_{IH} is similar.

B. The Calibration Principle of V_{OL}/V_{OH}

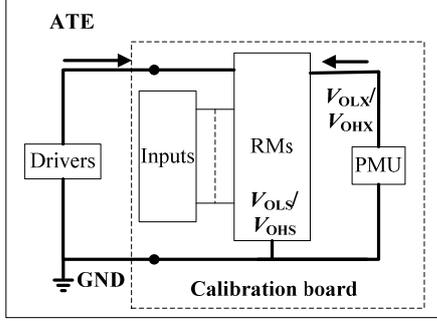


Fig.2. The calibration principle of V_{OL}/V_{OH}

Fig 2 shows the calibration principle of V_{OL}/V_{OH} . To perform a V_{OL} measurement, the device is preconditioned to set the output into the logic 0 state, the PMU is connected to the pin under test. The I_{OL} current is forced and the resultant voltage V_{OLX} is measured. Calculate the error of V_{OLX} and V_{OLS} (standard value of RMs) by equation(2).

$$\Delta U = V_{OLX} - V_{OLS} \quad (2)$$

The calibration principle of V_{OH} is similar.

C. The Calibration Principle of I_{OL}/I_{OH}

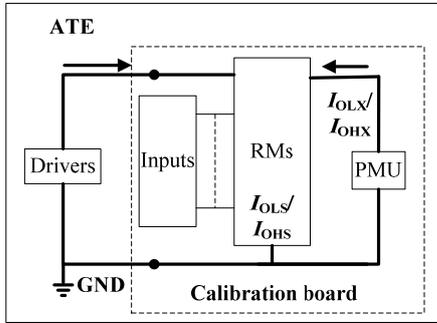


Fig.3. The calibration principle of I_{OL}/I_{OH}

Fig 3 shows the calibration principle of I_{OL}/I_{OH} . To perform a I_{OL} measurement, the device is preconditioned to set the output into the logic 0 state, the PMU is connected to the pin under test. The V_{OL} voltage is forced and the resultant current I_{OL} is measured. Calculate the error of I_{OLX} and I_{OLS} (standard value of RMs) by equation(3).

$$\Delta I = I_{OLX} - I_{OLS} \quad (3)$$

The calibration principle of I_{OH} is similar.

D. The Calibration Principle of I_{DD}

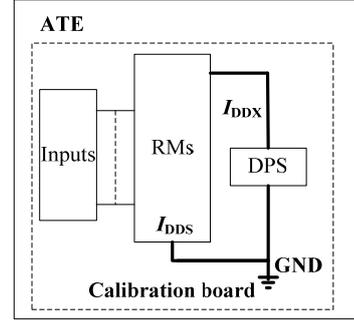


Fig.4. The calibration principle of I_{DD}

Fig 4 shows the calibration principle of I_{DD} . To perform a I_{DD} measurement, the device is held in a static condition state and the amount of current I_{DDX} flowing into the V_{DD} pin is measured. Calculate the error of I_{DDX} and I_{DDS} (standard value of RMs) by equation(4).

$$\Delta I = I_{DDX} - I_{DDS} \quad (4)$$

E. The Calibration Principle of t_{PLH}/t_{PHL}

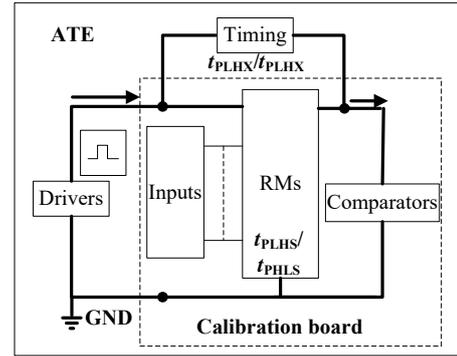


Fig.5. The calibration principle of t_{PLH}/t_{PHL}

Fig 5 shows the calibration principle of t_{PLH}/t_{PHL} . The t_{PLHX} measurement is made from an input signal to an output signal. This will fix the input signal and require a search on the output signal to find and measure their relative position. Calculate the error of t_{PLHX} and t_{PLHS} (standard value of RMs) by equation(5).

$$\Delta t = t_{PLHX} - t_{PLHS} \quad (5)$$

The calibration principle of t_{PHL} is similar.

III. THE ARCHITECTURE DESIGN OF CALIBRATION DEVICE

Through the use of virtual instrument technology, the calibration device of ATE based on RMs consists of RMs, PXI instruments, calibration software and calibration board. Compared to conventional special calibration device, which can't be used for calibrating different ATE due to the different hardware structure and programming language, the calibration device based on RMs has many benefits such as simplification and complete automation on ATE calibration, easy to take, adaptive for on-site calibration.

A. The Calibration Model of ATE Based on RMs

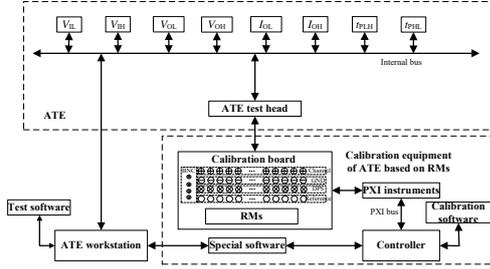


Fig.6. The structure of calibration device

Fig 6 shows the structure of calibration device based on RMs, which consists of RMs, PXI instruments, controller, special cables, calibration software and calibration board.

PXI instruments consist of SMU(Source Measure Unit), High Density Matrix Modules, RF Matrix Modules. SMU is used for supplying power to RMs. High Density Matrix Modules are used for the connection of RMs to ATE channels when DC parameters are calibrated. RF Matrix Modules are used for the connection of RMs to ATE channels when AC parameters are calibrated. All PXI instruments are interconnected to the controller via the bus, which establishes TCP/IP connection through the workstation of ATE to achieve the control signal synchronization and data transmission.

RMs are placed on the calibration board, which is placed on the test head of ATE during calibration of ATE. Matrix Modules are connected to the tested pins of RMs and digital channel interface via special cables. Through the switch of matrix RMs can be connected to each channel of ATE.

The working principle of calibration device is as follows. Through calibration board the connection is physically built between ATE and calibration device. Through the TCP/IP network protocol control signal and calibration data are successfully transited between ATE and calibration device. Finally, with the help of ATE program and calibration software, ATE can be fully calibrated after nine parameters of RMs(V_{IH} , V_{IL} , V_{OH} , V_{OL} , I_{OH} , I_{OL} , I_{DD} , t_{PLH} , t_{PHL}) are tested.

B. The Design of Calibration Software Based on Virtual Instrument

Virtual instrument technology is the new advanced technology in the field of test and measurement. With virtual instrument technology, it is easy to control different instruments, achieve signal acquisition and data processing, complete real-time process control and display. Virtual instrument that can greatly improve the flexibility and dynamic reconfiguration of the instrument, not only can achieve the test and measurement functions of traditional instrument, but also has lower price and the same measurement accuracy. Therefore, virtual instrument will

gradually become the mainstream of test and measurement technology^[10~13].

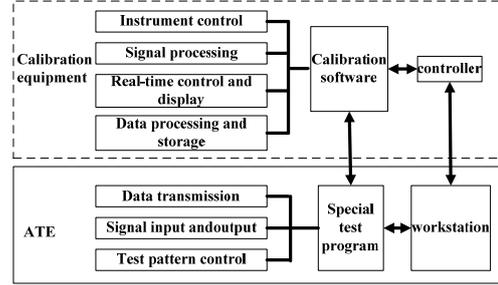


Fig.7. The function of calibration software

Fig 7 shows the function of calibration software, which consists of instrument control, signal processing, real-time control and display, data processing and storage. Meanwhile, ATE need to be calibrated with the help of special test program, which can control input and output signal to test RMs.

IV. THE HARDWARE COMPOSITION OF CALIBRATION DEVICE

Fig 8 shows the hardware composition of calibration device. The connection of hardware are as follows, SMU supplies power to RMs, High Density Matrix Modules are connected to ATE channels and RMs with the interface of IDC50, RF Matrix Modules are connected to ATE channels and RMs with the interface of SMA.

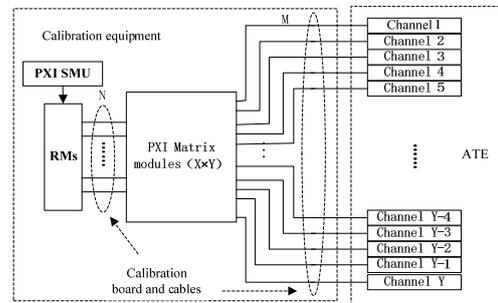


Fig.8. The hardware composition of calibration device

Fig 9 shows the composition of calibration board, which totally has four kinds of interfaces, including test fixture of RMs, test interface of RMs, interface of DC parameter, interface of AC parameter. IDC10 interface is adopted as test interface of RMs, one end of which is connected to the RMs via calibration board, the other end of which is connected to X end of High Density Matrix Modules via special cables. IDC50 interface is adopted as interface of DC parameters, one end of which is connected to test channels via calibration board, the other end of which is connected to Y end of High Density Matrix Modules via special cables. Every 32 test channels are connected to each IDC50 interface, numbers of which can fully connected to ATE. SMA interface is adopted as

interface of AC parameters, which is connected to test channel and pins of RMs via RF cables.

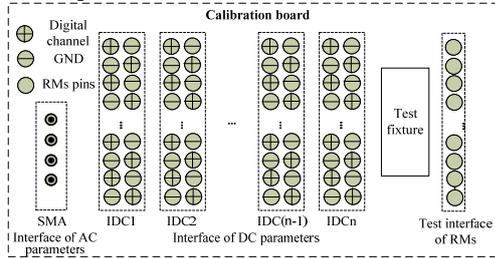


Fig.9. The composition of calibration board

The measurement loop between RMs and test channels of ATE will have a significant impact on the overall performance of calibration device. We will take the following approach to solve the problem. Firstly, the test channels are connected to IDC50 interface directly by all equal length lines. Secondly, in order to reduce the measurement error, we set the measurement interface to measure the loop resistance of any channel to RMs pins by calculating the compensation to the result. Finally, calibration board is guaranteed impedance matching of measurement loop. we measure the loop delays of any channel to RMs pins by calculating the compensation to the result.

V. CONCLUSIONS

ATE calibration with RMs is a new way, which have many benefits such as simplification on ATE calibration, easy to take, adaptive for on-site calibration. Based on the measurement characters of ATE, this paper proposes a calibration technique with microelectronic reference materials, which adopts the virtual instruments technique and develops an universal calibration device consists of PXI instruments modules, universal calibration software, special program for given ATE, RMs, as well as the calibration board. The calibration device based on RMs can be used to fully calibrate all kinds of ATE, which can greatly improve the calibration coverage of ATE.

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