XX IMEKO World Congress
Metrology for Green Growth
September 9–14, 2012, Busan, Republic of Korea

THE DESIGN OF REFERENCE MATERIALS FOR AUTOMATED TEST EQUIPMENT(ATE) CALBRATION

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Abstract: Reference materials(RMs) are extremely useful in testing and benchmarking instrumentation. In this paper, a kind of IC RMs based on nine parameters is developed. It describes what parameters should be chosen as properties of IC RMs, and presents the circuit structure of RMs in detail. With these programmable parameters of IC RMs, ATE can be traced to national standards.

Keywords: reference materials, ATE calibration, programmable parameters

1. INTRODUCTION

Reference materials(RMs) are physical objects with one or more well established properties typically used to calibrate metrology instruments. RMs are also extremely useful in testing and benchmarking instrumentation. Automated Test Equipment(ATE) employs a number of stimulus and measurement instruments such as the Drivers, Comparators, Precision Measurement Unit(PMU), Device Power Supplies(DPS), AC subsection. These instruments require periodic calibration to ensure they are within tolerance. ATE calibration with RMs[1] is a new way, which have many benfits such as simplification on ATE calibration, easy to take, adaptive for on-site calibration. The US National Institute of Standards and Technology(NIST) is one of the internationally accepted national authorities of measurement science in the semiconductor industry. RMs used for ATE calibration should be traced to the NIST.

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. Meanwhile, IC RMs should be conveniently traced to the NIST[2].

This paper is organized as follows. In section 2 we describe the measurement principle of parameters of IC RMs chosen for ATE calibration. In section 3 we present the design of programmable parameters of IC RMs. In section 4 we present the traceability of IC RMs and how to use for ATE calibration. In section 5 we draw conclusions.

2. THE MEASUREMENT PRINCIPLE OF PARAMETERS OF IC RMs

The device specification defines the operational range for the various voltage, current, ac parameters associated with the operation of IC. Verifying voltages and currents requires the use of the DC subsection and Pin Electronics, which include the Drivers, Comparators, the PMU and DPS. Verifying AC parameters requires the use of the high speed section of the test system, including vector memory, signal formats, input timing control and output strobes. Therefore, we choose the following parameters as the properties of IC 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 measurement principle of these parameters are as follows[3].

2.1 The measurement principle of V_{IL}/ V_{IH}

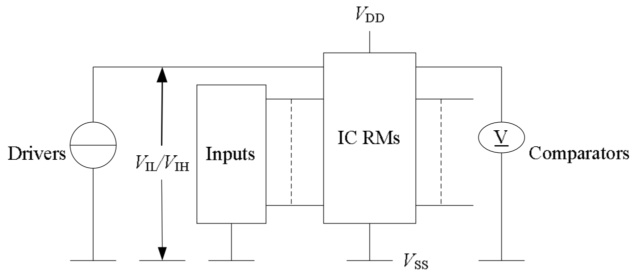

Fig.1 the measurement principle of V_{IL}/V_{IH}

Figure 1 shows the measurement principle of V_{IL}/V_{IH}. To perform a V_{IL}/V_{IH} measurement, 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_{IL}. Similarly the voltage of the input is gradually decreased from V_{DD}. When the output state is changed, the input voltage is V_{IH}.

It can be seen that the V_{IL}/V_{IH} parameters can reflect the accuracy of the Drivers.

2.2 The measurement principle of V_{OH}/I_{OH}

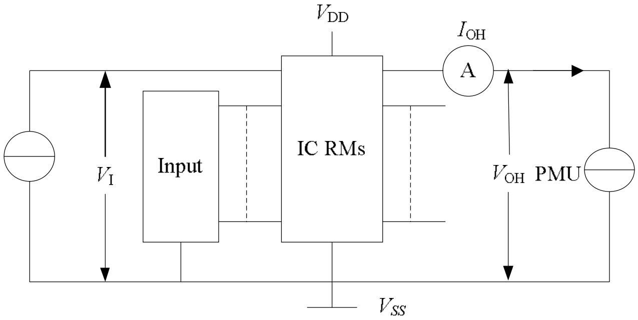

Fig.2 the measurement principle of V_{OH}/I_{OH}

Figure 2 shows the measurement principle of V_{OH}/I_{OH}. To perform a V_{OH}/I_{OH} measurement, the device is preconditioned to set the output into the logic 1 state, the PMU is connected to the pin under test. The I_{OH} current is forced and the resultant voltage V_{OH} is measured. The V_{OH} voltage is forced and the resultant current I_{OH} is measured.

It can be seen that the V_{OH}/I_{OH} parameters can reflect the accuracy of the PMU.

2.3 The measurement principle of V_{OL}/I_{OL}

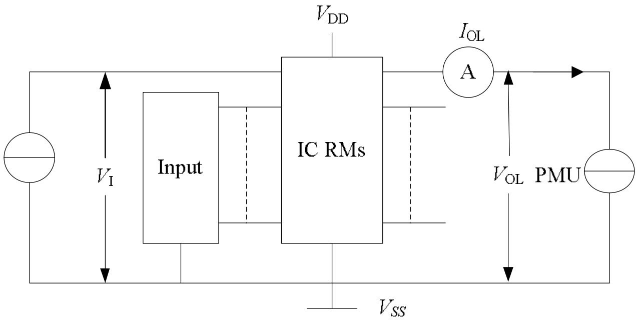

Fig.3 the measurement principle of V_{OL}/I_{OL}

Figure 3 shows the measurement principle of V_{OL}/I_{OL}. To perform a V_{OL}/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 I_{OL} current is forced and the resultant voltage V_{OL} is measured. The V_{OL} voltage is forced and the resultant current I_{OL} is measured.

It can be seen that the V_{OL}/I_{OL} parameters can reflect the accuracy of the PMU.

2.4 The measurement principle of I_{DD}

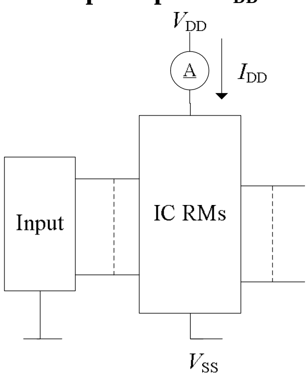

Fig.4 the measurement principle of I_{DD}

Figure 4 shows the measurement 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_{DD} flowing into the V_{DD} pin is measured.

It can be seen that the I_{DD} parameters can reflect the accuracy of the DPS.

2.5 The measurement principle of t_{PLH}/t_{PHL}

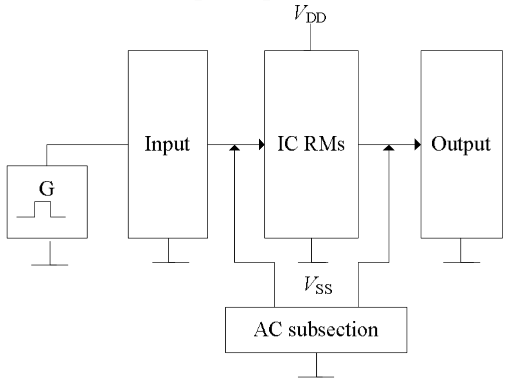

Fig.5 the measurement principle of t_{PLH}/t_{PHL}

Figure 5 shows the measurement principle of t_{PLH}/t_{PHL}. The t_{PLH}/t_{PHL} measurement is made from an input signal to an output signal. This will fix the input singal and require a search on the output signal to find and measure their relative position.

It can be seen that the t_{PLH}/t_{PHL} parameters can reflect the accuracy of the AC subsection.

In summary, IC RMs can fully calibrate the ATE with all nine parameters above.

3. THE DESIGN OF PROGRAMMABLE PARAMETERS OF IC RMs

IC RMs must have properties that remain stable during use. Both spatial and temporal variations in the certified material properties must be much smaller than the desired calibration uncertainty. At the same time, the entire range of ATE should be covered by IC RMs, which must be designed to be programmable. Based on the above analysis, the circuit structures of IC RMs are as follows.

3.1 The circuit structure of V_{IL}/ V_{IH} parameters

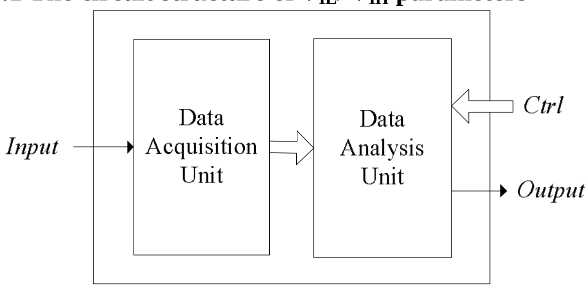

Fig.6 the circuit structure of V_{IL}/V_{IH} parameters

Figure 6 shows the circuit structure of V_{IL}/V_{IH} parameters. The circuit includes an power pin, an input pin, an output pin and a group of control pins. The circuit is mainly composed by analog to Data Acquisition Unit and Digital Analysis Unit. The Data Acquisition Unit converts the input signal into a group of digital signals, which are compared with the control signals. If the digital that is converted by the Data Acquisition Unit is less than the digital that the control pins input, the output pin occurs a low voltage. Otherwise the output pin occurs a high voltage. The control pins determine the value of programmable V_{IL}/ V_{IH} parameters.

3.2 The circuit structure of V_{OH}/I_{OH}, V_{OL}/I_{OL} and I_{DD} parameters

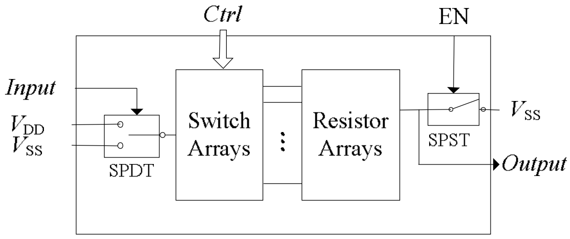

Fig.7 the circuit structure of V_{OH}/I_{OH}, V_{OL}/I_{OL} and I_{DD} parameters

Figure 7 shows the circuit structure of V_{OH}/I_{OH}, V_{OL}/I_{OL} and I_{DD} parameters. The circuit includes an power pin, an input pin, an output pin, an enable pin and a group of control pins. The circuit is mainly composed by analog switches, high precision thin film chip resistors. When the enable pin is preconditioned to logic 0, the SPST is turned off, then the measurement of V_{OH}/I_{OH} and V_{OL}/I_{OL} parameters have been taken. If the input pin is preconditioned to logic 0, the SPDT switches to V_{SS}, so the output pin, which is in the logic 0 state, is connected to V_{SS} through a resistor. Then the V_{OL}/I_{OL} parameters can be measured. Similarly the V_{OH}/I_{OH} parameters can be measured. When the enable pin and the input pin are both preconditioned to logic 1, the SPST is turned on, then the power pin is connected to V_{SS} through a resistor. Then the I_{DD} parameter can be measured. The control pins determine the value of programmable V_{OH}/I_{OH}, V_{OL}/I_{OL} and I_{DD} parameters.

3.3 The circuit structure of t_{PLH}/t_{PHL} parameters

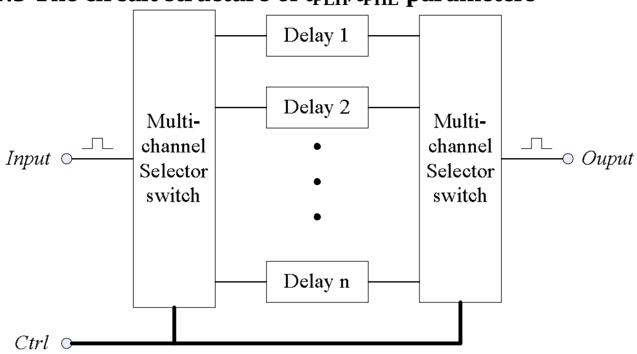

Fig.8 the circuit structure of t_{PLH}/t_{PHL} parameters

Figure 8 shows the circuit structure of t_{PLH}/t_{PHL} parameters. The circuit is composed by CPLD, which can achieve programmable delay line. The control pins determine the value of programmable t_{PLH}/t_{PHL} parameters.

4. THE TRACEABILITY OF IC RMs

For applications where accurate measurements are required, the parameters of IC RMs must be determined with an accuracy(including both bias and variability) better than 1/4 of the required final accuracy of the measurement for which it will be used. At the same time, measurement and certification of IC RMs must be carried out using standardized or well-documented test procedures. All of parameters of IC RMs should be traced to the NIST through high precision instrumentation, which should be with an better accuracy than ATE need to be calibrated.

5. CONCLUSION

ATE calibration with RMs is a new way, which have many benfits such as simplification on ATE calibration, easy to take, adaptive for on-site calibration. In this paper, a kind of IC RMs based on nine parameters are developed. With these programmable parameters, IC RMs can verify ATE fully and disseminate the value of quantity to ATE. The circuit of IC RMs is simple, and the final measurement uncertainty of IC RMs is less than the desired uncertainty of the final measurement. At the same time, IC RMs are easy to test on the ATE, and can be traced to the NIST through high precision instrumentation conveniently.

6. REFERENCES

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