ADVANTEST

High Accuracy S-Parameter Measurement on the ATE by calibrating at socket pin tip

Taro Osumi

Advantest

Introduction

Where to calibrate is one of important thing at S-Parameter measurement. This document introduces achieved S-Parameter measurement accuracy of T2000 with 12GHz Wideband Signal Generator/Analyzer Module (12GWSGA) by calibrating at socket pin tip with Calibration Kit made by Advantest.

Solution Overview of S-Parameter Measurement and Target Accuracy

The solution is measuring S-Parameter of DUT by using VNA function of 12GWSGA, which is one of T2000 module. Figure 1 shows the connection of the measurement setup. Target DUT is RF front-end device and it assumed that the size is comparatively small. Therefore normal handler could not convey the DUT to the socket and it is necessary to connect with rotary handler. As the result, long RF cables were used for connection between tester and handler. At the evaluation of the solution, 3m(10ft) cables were used as worst case. The effect of 3m(10ft) cables to the target S-Parameter measurement accuracy is not small and the calibration at the end of the socket pin tip is mandatory. Therefore Advantest designed Calibration Kit which can fit into the socket and evaluated the accuracy. At this time, we evaluated whether the capacitance calculated from measured S-Parameter was within 200fF +/- 100fF.

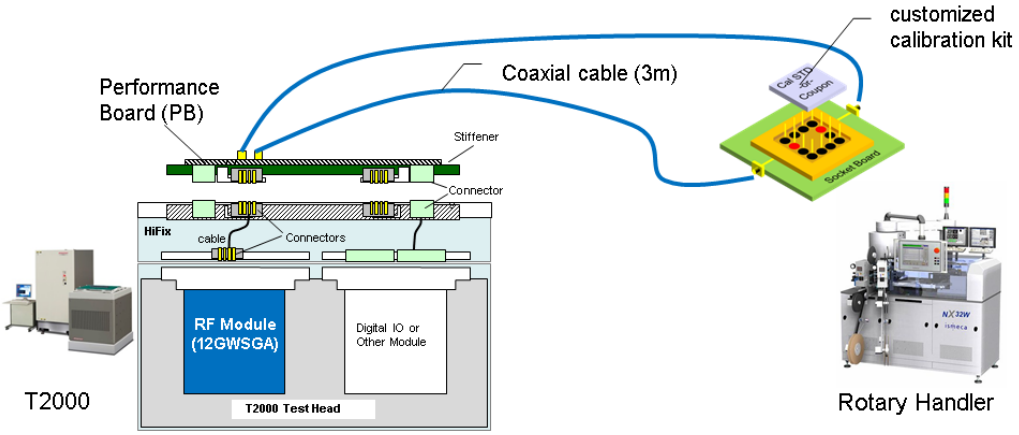


Figure 1. Solution Overview

Details of Solution

Tester is generally carried out AC Calibration before using tester. As the result, calibration plane is HiFix tip as shown in Figure 2. If the DUT is measured at this condition, the measurement result is affected by performance board, cable, socket board, and socket (pogo pin) characteristic and it makes the measurement difficult to achieve the desired accuracy. Therefore, it is necessary to move the calibration plane to the socket pin tip and necessary to create the Calibration Kit which can fit into socket.

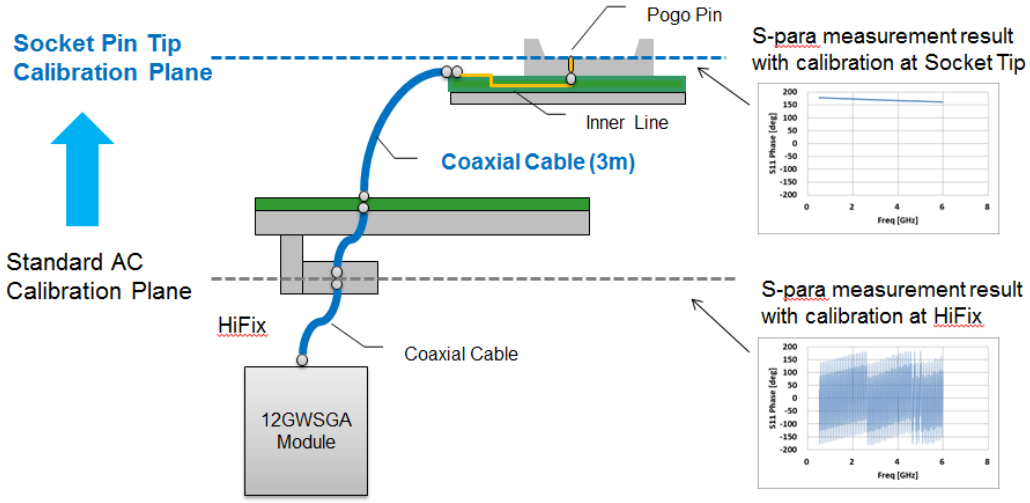


Figure 2. Move Calibration Plane to Socket Tip

There is also a Calibration Kit on the market certainly, however they are SMA type and probe type. It could not be adapted by calibration at socket pin tip. Therefore, we designed and created the Calibration Kit as shown in Figure 3 under consideration of target DUT RF port configuration. They are totally same shape as target DUT not only pin configuration but also thickness. When measuring different configuration DUT, it needs to create a Calibration Kit again. Figure 3 is the image of Calibration Kit Open/Short/Load/Thru which is made at this time.

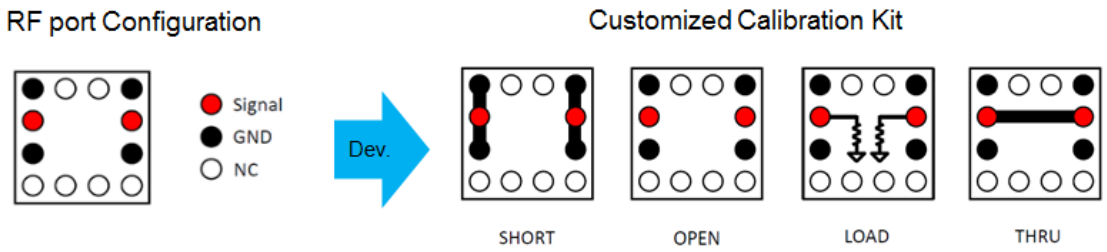


Figure 3. Develop Customized Calibration Kit

We used 3D simulator for high accuracy of Calibration Kit at design stage. However most important procedure for Calibration Kit production is the characterization of Calibration Kit, design by 3D simulator is also important, though. The characterization is to measure the S-Parameter of Calibration Kit itself and measured S-Parameter is used at T2000 Calibration formula.

[Tips]

The characterization is carried out by using proven VNA and probe station. However if you put the calibration kit on the probe station directly, characterization might be failed because the condition of Calibration Kit is different from actual usage, even proven measuring instrument is used. Therefore we created a board by using same material as socket lid and characterized on the board in order to reproduce the similar condition as socket inside.

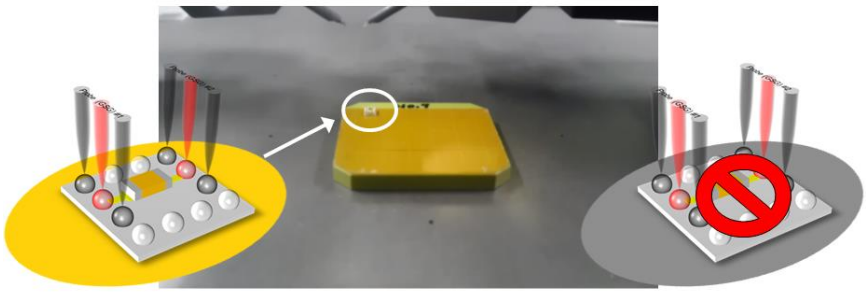


Figure 4. PAI(Polyamide Imide) Board for Accurate Measurement

Figure 5 shows characterization result. Left figure is from HFSS Simulator. Right graph is measurement result and it is sufficient accuracy for high-accuracy S-Parameter measurement.

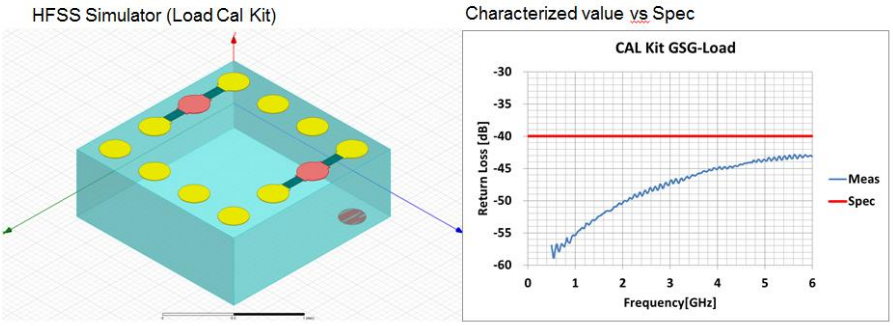


Figure 5. Characterization of Calibration Kit

Calibration software improvement is also applied. Conventional method acquires

calibration data of HiFix from AC calibration and calibration data of fixture from measurement and calculates DUT S-Parameter by using De-embedding function of tester. Improved software can acquire the calibration data of HiFix and fixture at one time and it is applied to T2000.

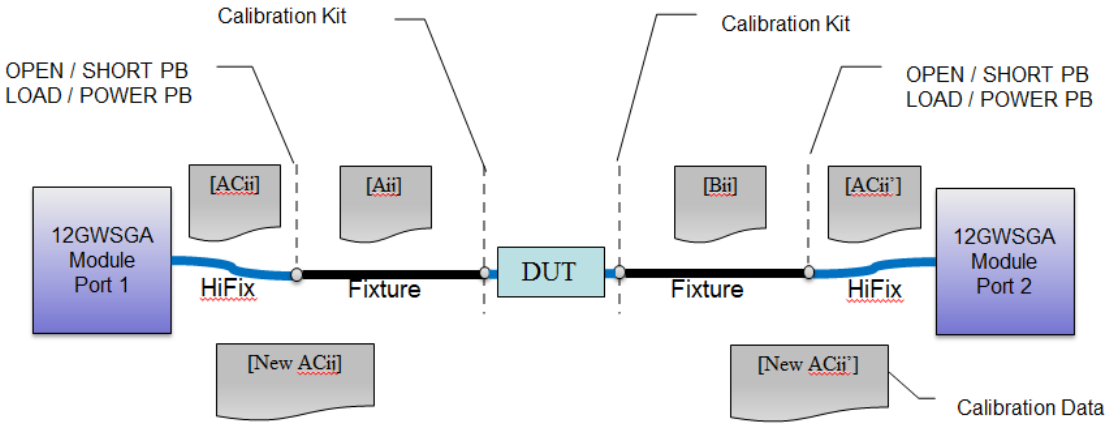


Figure 6. New Algorithm for Calibration Data

[Tips]

In addition to software improvement and calibration kit, 2 tips are applied to hardware in order to enhance the measurement accuracy.

1st tip is pattern layout. Normally RF pattern is layout at top or bottom layer. However inner layer was used for RF pattern in order to reduce the effect from socket di-electric constant at this time.

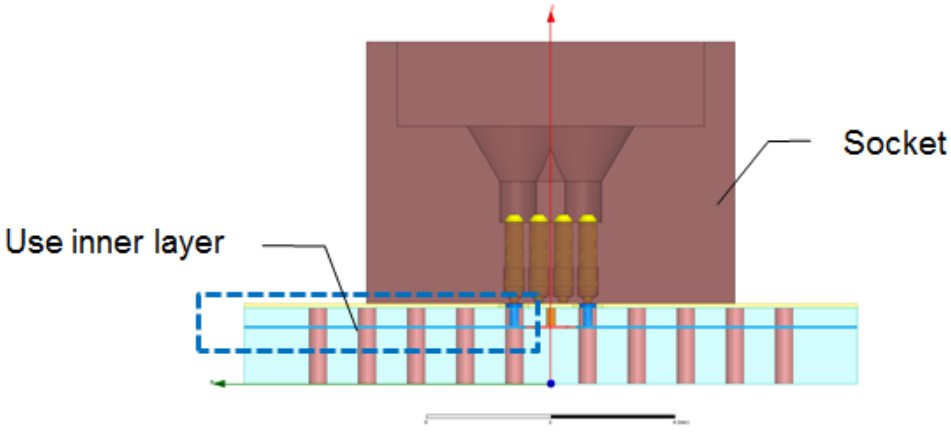


Figure 7. Socket Board Design

2nd tip is socket shape. In order to reproduce the same enviornment as characterization of Calibration Kit at probe station, a room was made at socket bottom as shown in

figure 8. This is the reason why the probe is surrounded by air.

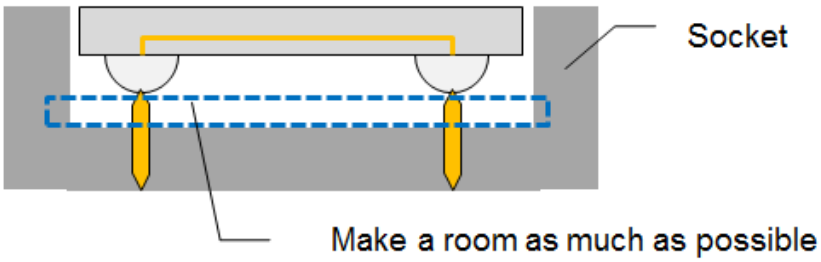


Figure 8. Socket Design

Evaluation Procedure

Evaluation of measurement accuracy is carried out by creating verification coupons of the same size as target DUT. Verification coupons are created by putting the device of 200fF - 1000fF in 200fF steps on the substrate likened to target DUT. We checked whether the difference of measured value of verification coupons by proven VNA with probe and by T2000 with socket was within +/-100fF.

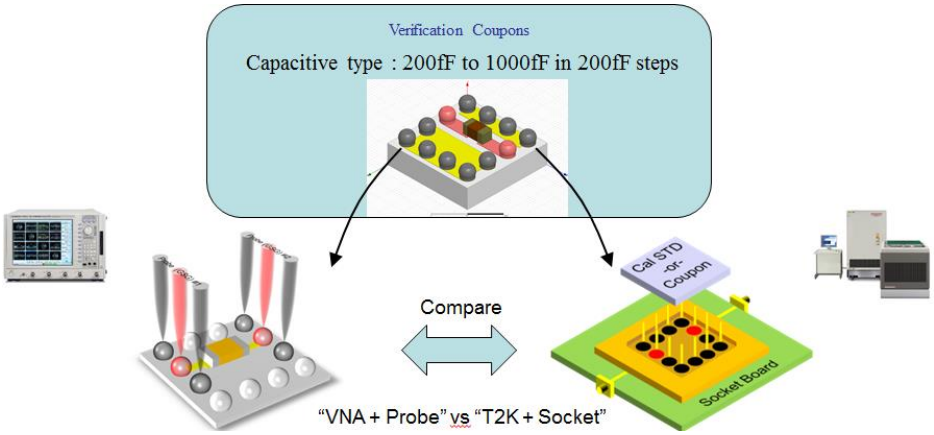
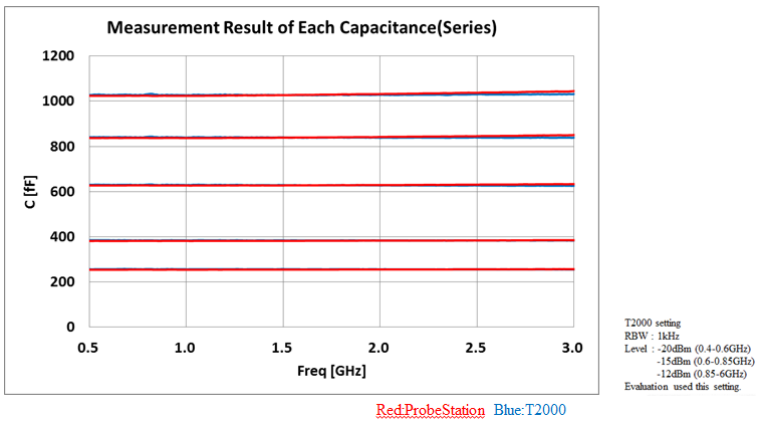


Figure 9. Verification Procedure

Measurement Accuracy

Figure 10 shows the measurement result of each verification coupons.



Red:ProbeStation Blue:T2000

Figure 10. Measurement Result

Measurement error is calculated by using variation of 100 times measurement and assumption of +/-5℃ temperature variation. Then measurement error of 200fF verification coupon is +/-19fF as shown in figure 11.

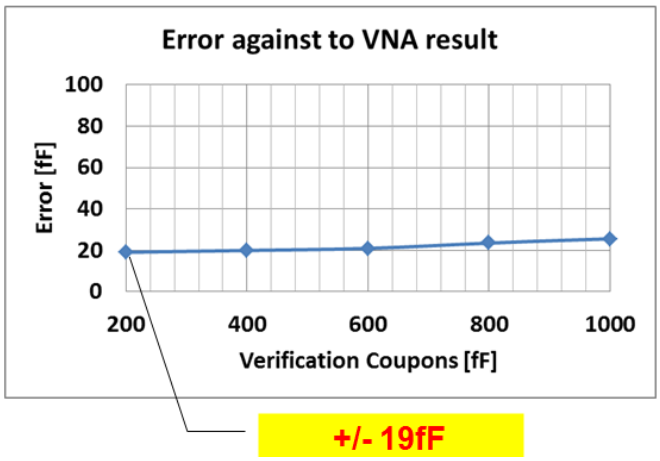


Figure 11. Achieved Accuracy

Summary

2-port full calibration at socket pin tip using the Calibration Kit designed by Advantest with T2000 12GWSGA shows high accuracy measurement results, +/-19fF, at verification upon evaluation over a wide frequency ranges. This solution can be applied for testing in production which needs precise S-parameter measurement.