Automation of Linear and Non- Linear Measurements for Dual TRM

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***Abstract* —Transmit/Receive Module (TRM) is the basic building block in any modern Active Phased Array radar system. TRM which is based on new Hybrid MIC (Microwave Integrated Circuit) / MMIC (Monolithic Microwave Integrated Circuit) technology comprises of RF Power devices, Digital control circuitry and Surface mount passive/active components.**

This paper describes Automated Test Measurement setup for measuring L and S-Band Dual TRM. Considering the large number of T/R modules in Phased array radar, this measurement automation gives the paramount advantage of very less testing time and high accuracy.

This automation includes linear and non- linear measurements such as O/P Power Level, instantaneous Phase and Attenuator, Harmonics, input/output VSWR, receiver Gain, Band Pass filter characteristics, Limiter switch isolation, switching time and Noise figure. The Graphical User Interface (GUI) designed using Agilent VEE Pro software, invokes test definition, sequencing, stimulus, timing and monitors status of power supply, temperature and forward power. It also facilitates storage, retrieval and report generation.

The technique presented this paper is extremely short test times for ensuring the high throughput required in production. In addition, it allows measurements to be flexibly configured for development. These capabilities help the manufacturer develop modules, reduce production cycles and make production more efficient.

***Key Words*— Active phased array, Transmit/Receive modules, Automated test measurement, Agilent VEE Pro software.**

I. INTRODUCTION

The Transmit/Receive Module based Active Antenna Array is a subsystem of Phased Array Radars. Antenna Array includes several radiating elements, feed networks, Solid State Active devices, Digital attenuators, Digital phase shifters, a controller card, beamsteering unit and power supply [1].

Dual T/R Modules(DTRM) consists of two identical T/R chain having two independent T_XOUT/R_X IN antenna connectors and a common T_X IN/R_XOUT connector. Each T/R Module consists of Transmit chain, Receive chain, circulator, digital controller and a power conditioning block. Input drive power to the Transmit chain and return signals from receive chains are through a power divider/combiner. The Digital Controller in the DTRM gets command modes for phase/attenuation and timing control from the Higher Level Controller unit in Low Voltage Differential Signaling (LVDS) levels.

Measurement of linear and non- linear parameters of DTRM is complex and time consuming issue as every radar uses from hundreds to thousands of DTRMs and each must be tested separately during development and production. To handle the large number of different measurements a high degree of automation is preferred. Automation helps simplify the complex testing procedure and helps shorten the testing time.

II. OVERVIEW OF THE DEVELOPED AUTOMATION

The Automated Graphical User Interface (GUI) is designed using Agilent Technologies VEE Pro software. The results are displayed in Excel with appropriate rectangular/polar plots. The interface invokes test definition, test sequencing, stimulus and response signals, magnitude, and timing constraints. The data at High Level Controller uses LVDS signaling standard. Therefore, an LVDS jig has been designed to aid conversion of RS-232 to LVDS and vice versa.

Most of the instruments employed in the design of Automated Measurement Setup are from Agilent Technologies. This automation setup includes the use of following instruments viz., DC Power Supplies, Synthesized Signal Source, Vector Signal Generator, Spectrum Analyzer, Vector Network Analyzer, RF Peak/Average Power Meter, Noise Figure Analyzer, Arbitrary Waveform Generator, Pulse/Pattern Generator, Controller/Desktop Computer, Digital Interface Card with full duplex LVDS and RS-232 ports and associated interfacing cables such as GPIB cables, probes and RF cables. The GUI of automation for linear and non- linear measurements of DTRMs is as shown in figure 2.1.

III. Details of Measurement Setup

The Automation Setup developed is capable of measuring and characterizing the following Digital and RF parameters of the Unit Under Test (UUT) viz., S and L-band Dual Transmit/Receive Module (DTRM). Both the Transmit Chain testing, Receive Chain testing is carried out using the same setup. It is also ensured that all measurement instruments are calibrated.

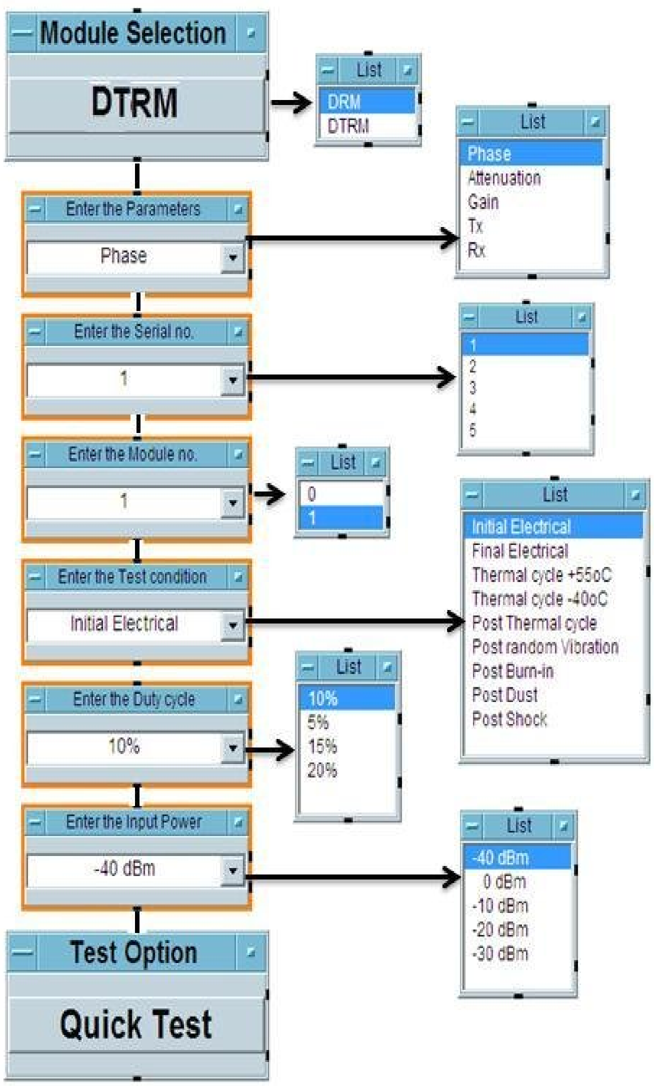

Figure 2.1 GUI Screenshot of Automated parameters

1. **Transmit Chain Test:** The Transmit Chain employs a common arm (6-bit Digital Phase Shifter,6-bit Digital Attenuator, T/R Switch), Driver amplifier and Power amplifier stages. The Transmit Chain measurement setup is as shown in the Figure 3.1.

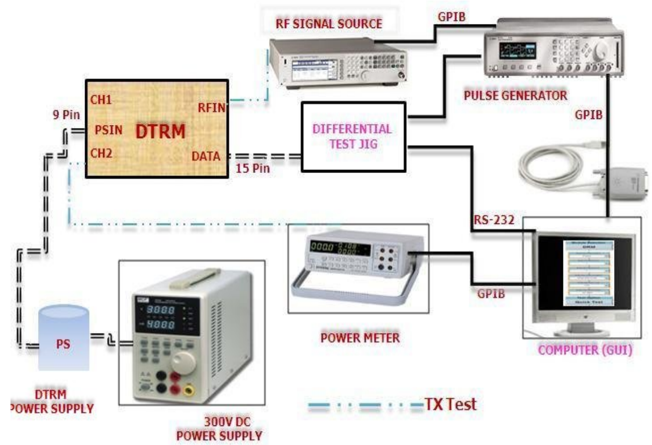

Figure 3.1 Transmit Chain Measurement Setup

2. **Receive Chain Test:** This setup includes the common arm, Blanking Switch Limiter, Low Noise Amplifier(LNA), Band Pass Filter (BPF).The resolution of phase shifter and attenuator is 5.625 degrees and 0.5dB respectively. By giving progressive resolution as input, the corresponding outputs can be plotted. The Receive Gain measurement setup is as shown inFigure-3.2.

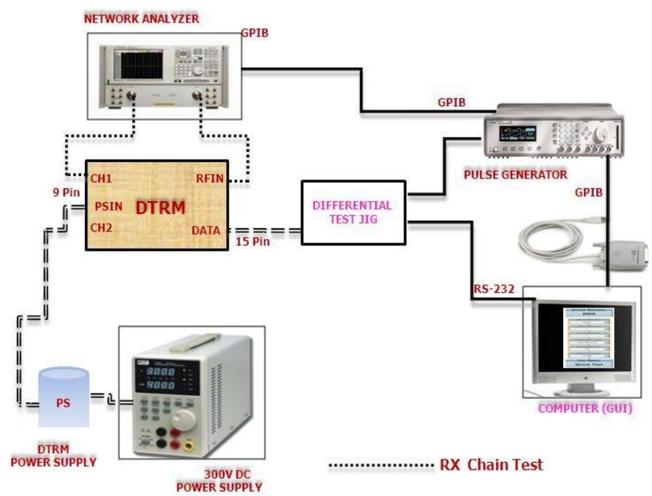

Figure 3.2 Receive Chain Measurement Setup

3. **Noise Figure Measurement Test:** The setup for Noise Figure Measurement is as shown in the figure 3.3. The measurement setup is capable of measuring Noise Figure at desired operating frequencywith100MHz steps.

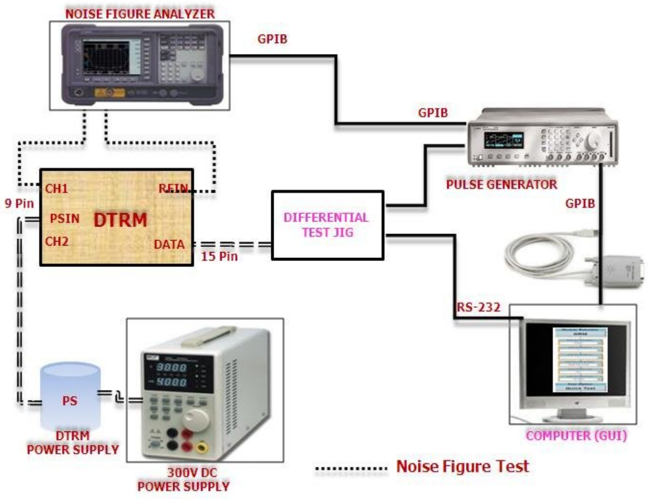

Figure3.3 Noise Figure Measurement Setup

IV. RESULTS

All the measurement data is conveniently arranged in Microsoft excel for easy understanding. Data thus obtained are then plotted as rectangular and polar graphs. Every individual DTRMs are characterized for all the 64 Attenuator and Phase States in Receive Mode. The Attenuation and Phase Data for the desired frequency are displayed in the measured result.

The Transmit Chain test plots shown in the figure 4.1 illustrate the variation in the output power vs. frequency and power droop vs. frequencyrespectively.

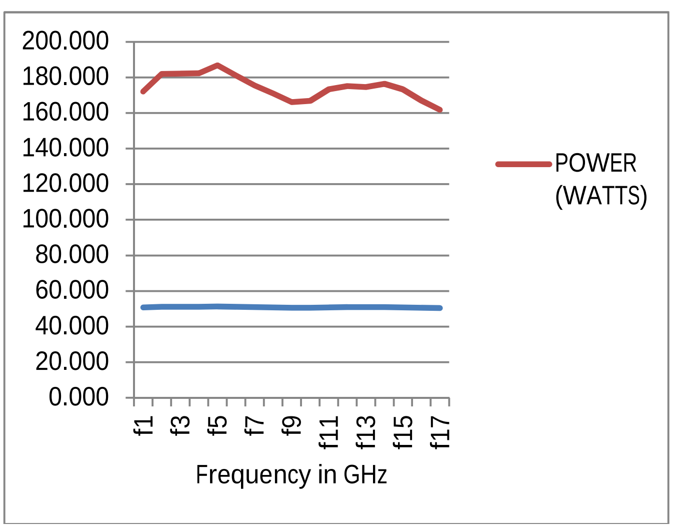

Figure 4.1 Transmit measurement plot

Receive Attenuation Measurement plot explains the variation in the attenuation with respect to frequency as shown in the figure 4.2.

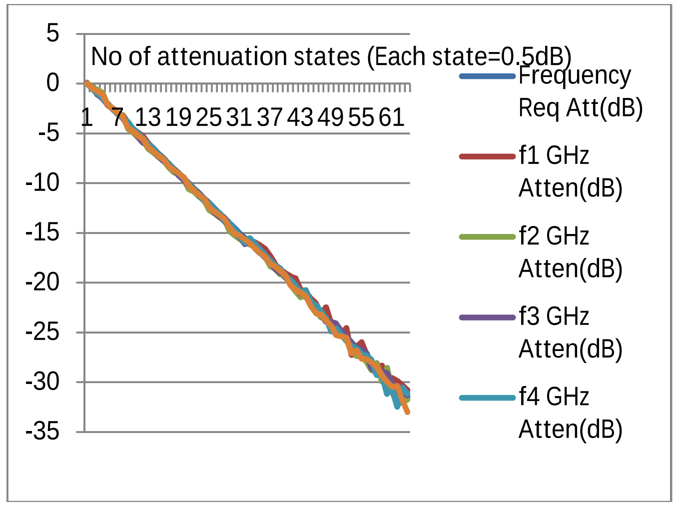

Figure 4.2 Receive Attenuation Measurement Plot

Receive phase shift measurement plot explains the variation in the Phase with respect to frequency as shown in the figure 4.3.

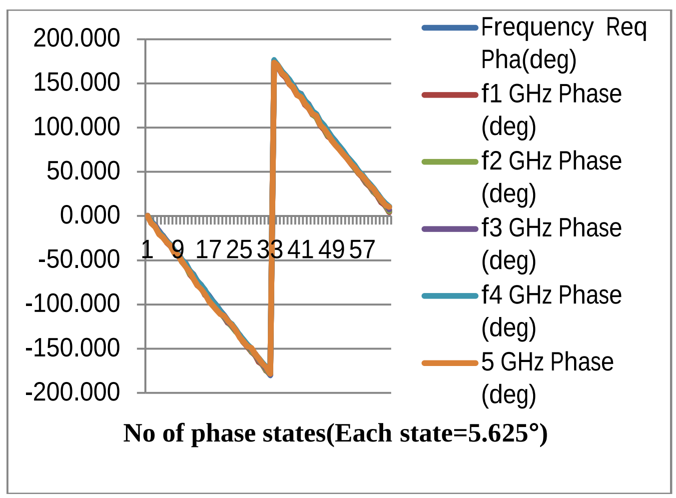

Figure 4.3 Receive phase shift measurement plot

Receive Gain v/s Frequency Measurement plot and Receive Gain v/s O/p P1dB Measurement plots as shown in the figure 4.4a and figure 4.4b respectively.

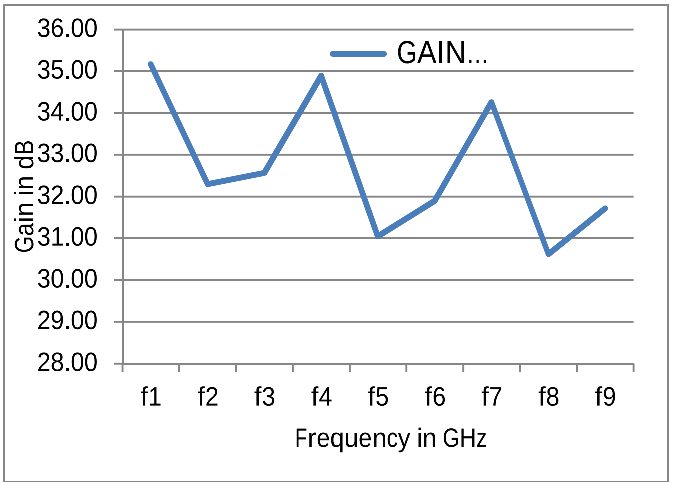

Figure4.4a Receive Gain v/s Frequency Measurement plot

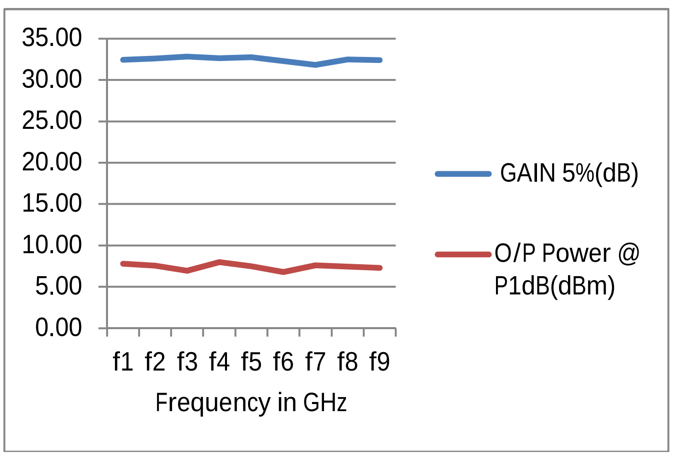

Figure 4.4b Receive Gain v/s O/p P1dB Measurement plot

Input/output VSWR v/s Frequency Measurement plot is as shown in the figure 4.5.

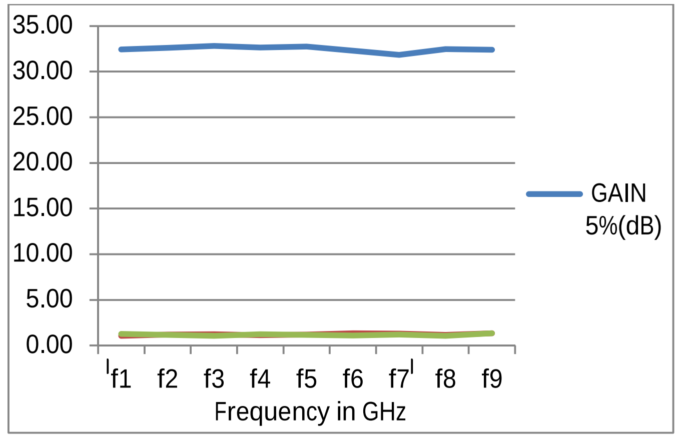

Figure 4.5 I/O VSWR v/s Frequency Measurement plot

Noise Figure plot shows the Receive Noise Figure variation with respect to frequency as shown in the figure 4.6.

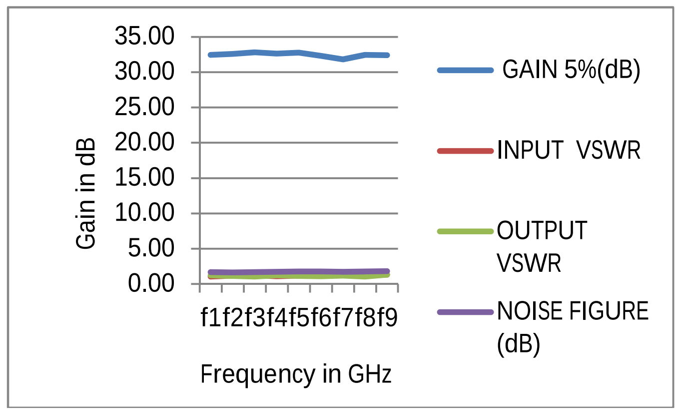

Figure 4.6 Noise Figure Measurement plot

VII. Conclusion

The Automated Graphical User Interface (GUI) is functioning as per the requirements and has been interfaced successfully with Unit Under Test (UUT). Employment of this setup reduces the T/R module testing time considerably without compromising measurement accuracy.

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SomsingRathod received his B.E degree in Electronics and Communication Engineering from Karnataka University, Dharwad in 1999 and he has completed M.Tech in Radio Frequency Design and Technology from Indian Institute Of Technology, Delhi. He is working as scientist in LRDE, Defence R&D Organization (DRDO), Bangalore since 2002. He has been working in the area of distributed beam steering controller for active phased array for airborne radar and his interest lies in design and implementation of digital systems using programmable logic devices.

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