CLASS: B.E. E &TC SUBJECT: RMT

EXPT. NO.: 09 DATE:

Roll No. : 42428

TITLE: Study the network analyzer and carry out the measurements of s-parameters.

OBJECTIVE: 1. Study of front panel & rear panel controls, accessories, and calibration methods of R&S®ZVA Vector Network Analyzer.

THEORY:

A network analyzer is an instrument that measures the network parameters of electrical networks. Today, network analyzers commonly measure s–parameters because reflection and transmission of electrical networks are easy to measure at high frequencies, but there are other network parameter sets such as y-parameters, z-parameters, and h-parameters. Network analyzers are often used to characterize two-port networks such as amplifiers and filters, but they can be used on networks with an arbitrary number of ports.

Network analyzers are used mostly at high frequencies; operating frequencies can range from 9 kHz to 110 GHz. Special types of network analyzers can also cover lower frequency ranges down to 1 Hz. These network analyzers can be used for example for the stability analysis of open loops or for the measurement of audio and ultrasonic components.

The two main types of network analyzers are

* **Scalar Network Analyzer** (SNA) — measures amplitude properties

* **Vector Network Analyzer** (VNA) — measures both amplitude and phase properties

A VNA may also be called a gain-phase meter or an Automatic Network Analyzer. An SNA is functionally identical to a spectrum analyzer in combination with a tracking generator. The three biggest VNA manufacturers are Agilent, Anritsu, and Rohde & Schwarz.

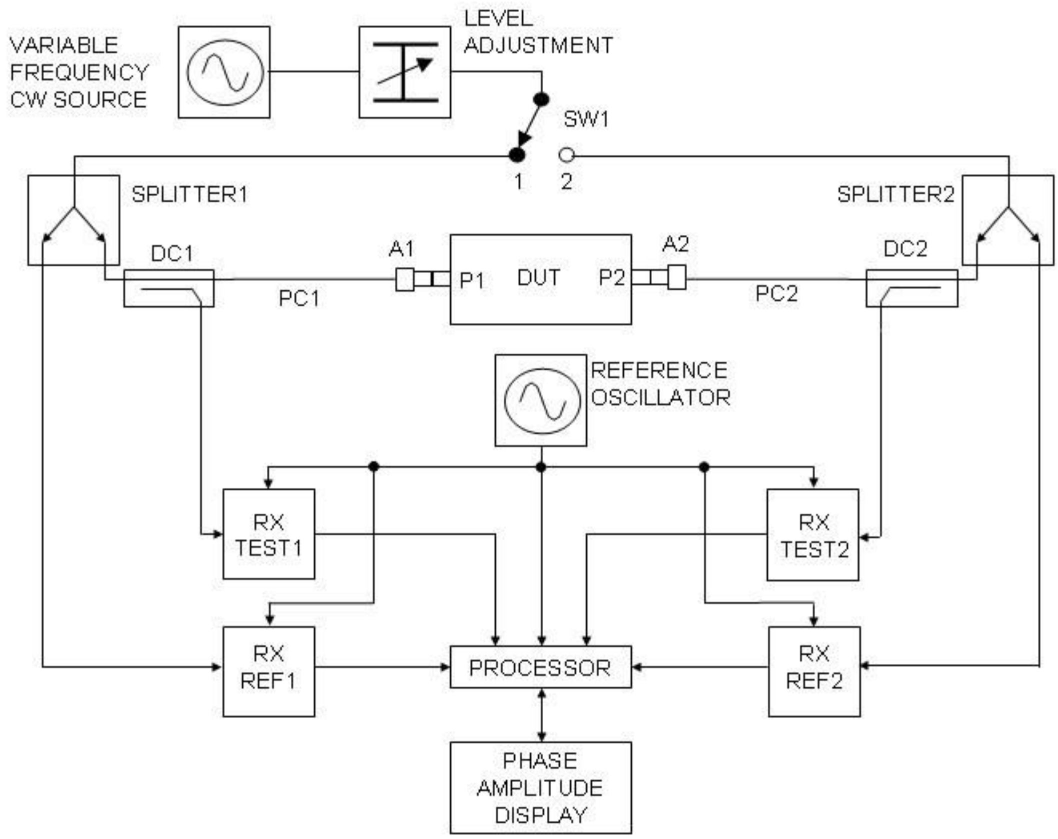


Fig1. Basic Parts of a Vector Network Analyser

Architecture

The basic architecture of a network analyzer involves a **signal generator, a test set, and one or more receivers**.

Signal generator

The network analyzer needs a test signal, and a signal generator or signal source will provide one. Older network analyzers did not have their own signal generator but had the ability to control a standalone signal generator using. Nearly all modern network analyzers have a built-in signal generator. High-performance network analyzers have two built-in sources. Two built-in sources are useful for applications such as mixer test, where one source provides the RF signal, another the LO, or amplifier intermodulation testing, where two tones are required for the test

Test set

The test set takes the signal generator output and routes it to the device under test, and it routes the signal to be measured to the receivers. It often splits off a reference channel for the incident wave. In a SNA, the reference channel may go to a diode detector (receiver) whose output is sent to the signal generator's automatic level control. The result is better control of the signal generator's output and better measurement accuracy. In a VNA, the reference channel goes to the receivers; it is needed to serve as a phase reference.

Receiver

The receivers make the measurements. A network analyzer will have one or more receivers connected to its test ports. The reference test port is usually labeled R, and the primary test ports are A, B, C,.... Some analyzers will dedicate a separate receiver to each test port, but others share one or two receivers among the ports. The R receiver may be less sensitive than the receivers used on the test ports.

For the SNA, the receiver only measures the magnitude of the signal. A receiver can be a detector diode that operates at the test frequency. The simplest SNA will have a single test port, but more accurate measurements are made when a reference port is also used. The reference port will compensate for amplitude variations in the test signal at the measurement plane. It is possible to share a single detector and use it for both the reference port and the test port by making two measurement passes.

For the VNA, the receiver measures both the magnitude and the phase of the signal. It needs a reference channel (R) to determine the phase, so a VNA needs at least two receivers. The usual method down converts the reference and test channels to make the measurements at a lower frequency. The phase may be measured with a quadrature detector. A VNA requires at least two receivers, but some will have three or four receivers to permit simultaneous measurement of different parameters.

Calibration

The accuracy and repeatability of measurements can be improved with calibration. Calibration involves measuring known standards and using those measurements to compensate for systematic errors. After making these measurements, the network analyzer can compute some correction values to produce the expected answer. For answers that are supposed to be zero, the analyzer can subtract the residual. For non-zero values, the analyzer could calculate complex factors that will compensate for both phase and amplitude errors. Calibrations can be simple (such as compensating for transmission line length) or involved methods that compensate for losses, mismatches, and feed through.

A network analyzer (or its test set) will have connectors on its front panel, but the measurements are seldom made at the front panel. Usually, some test cables will go from the front panel to the device under test (DUT) such as a two-port filter or amplifier. The length of those cables will introduce a time delay and corresponding phase shift (affecting VNA measurements); the cables may also introduce some attenuation (affecting SNA and VNA measurements).

S-parameter measurements have a notion of a reference plane. The goal is to refer all measurements to the reference plane.

Using ideal shorts, opens, and loads makes calibration easy, but ideal standards are difficult to make. Modern network analyzers will account for the imperfections in the standards.

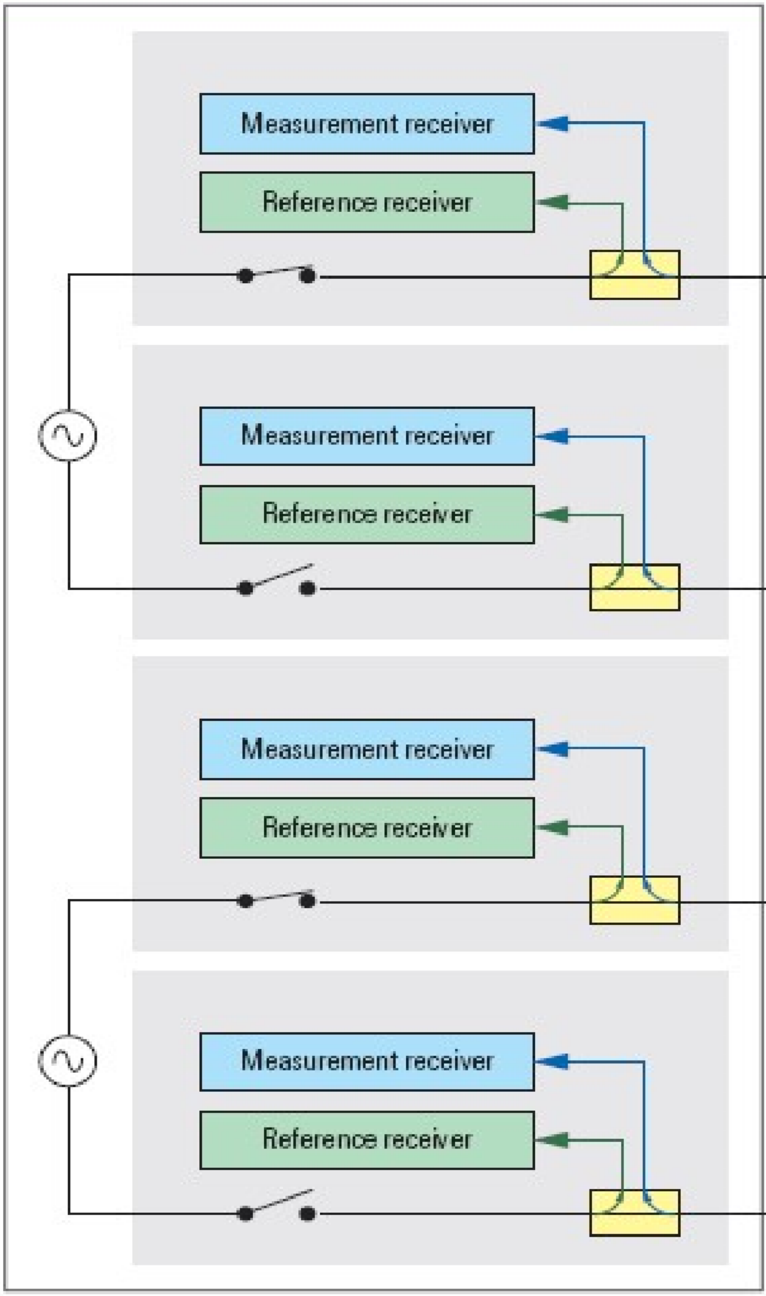
R&S®ZVA Vector Network Analyzer

Key features

- Linear and nonlinear amplifier and mixer measurements
- Noise figure measurements
- Pulse profile measurements with 12.5 ns resolution
- True differential measurements for reliable characterization of active devices with balanced ports
- High output power typ. > 15 dBm
- Wide dynamic range typ. > 140 dB
- High measurement speed < 3.5 µs per test point
- Wide IF bandwidth: 1/5/30 MHz
- Versatile calibration techniques: TOSM, TRL/LRL, TOM, TRM, TNA, UOSM
- Automatic calibration units
- Phase and group delay measurements on mixers with
- and without LO access
- Frequency range: 300 kHz to 8 GHz (R&S®ZVA8), 10 MHz to 24/40/50/67/80/110 GHz (R&S®ZVA24/40/50/67/80/110)

Test Port Cable: The **R&S®ZV-Z198** is a 1.00 mm female to 1.00 mm male cable of length 160 mm that has an operating frequency range from **0Hz to 110 GHz**

Block diagram of the R&S®ZVA8/24/40/50 four-port models



Calibration Features:

The R&S®ZVA not only offers classic TOSM calibration (Through, Open, Short, Match), but also a variety of other calibration techniques. Since each test port of the R&S®ZVA is equipped with a reference receiver of its own, modern seven-term calibration techniques can be used. These include TRL/LRL (Through, Reflect, Line/Line, Reflect, Line), TOM (Through, Open, Match), TNA (Through, Network, Attenuator), and TRM (Through, Reflect, Match), which are suitable for calibration in test fixtures or on wafers. Since calibration is performed directly on the DUT plane, any effects from the test fixture are eliminated.

Automatic calibration – fast, error-free, and with high precision

While all manual calibration techniques such as TOSM, TRM, and TRL can be used for multiport measurements, they are time-consuming, error-prone, and lead to excessive wear of the calibration standard. Rohde & Schwarz offers an automatic calibration unit for coaxial one-port and multiport calibration. The unit is ready to operate immediately after being connected and performs complete four-port calibration covering 201 test points in less than 30 seconds.

The R&S®ZVA allows for any combination between the analyzer ‘s test port connectors and the connectors of the calibration unit. The analyzer detects the connections automatically. Errors due to wrong connections are a thing of the past. The R&S®ZVA ‘s firmware also allows the characterization of calibration units by the user. Moreover, it is possible to characterize a calibration unit together with an adapter of any type. By treating the adapter as part of the calibration unit, the R&S®ZVA supports any combination of any connector types, which means that the calibration unit itself can be equipped with up to four different connectors. User-specific adapters can also be placed on the connectors of the calibration unit, which protects the connectors against wear.

OBSERVATIONS:-

For Rectangular Patch Antenna connected at Port 1 :

For Frequency = 2.315500 GHz

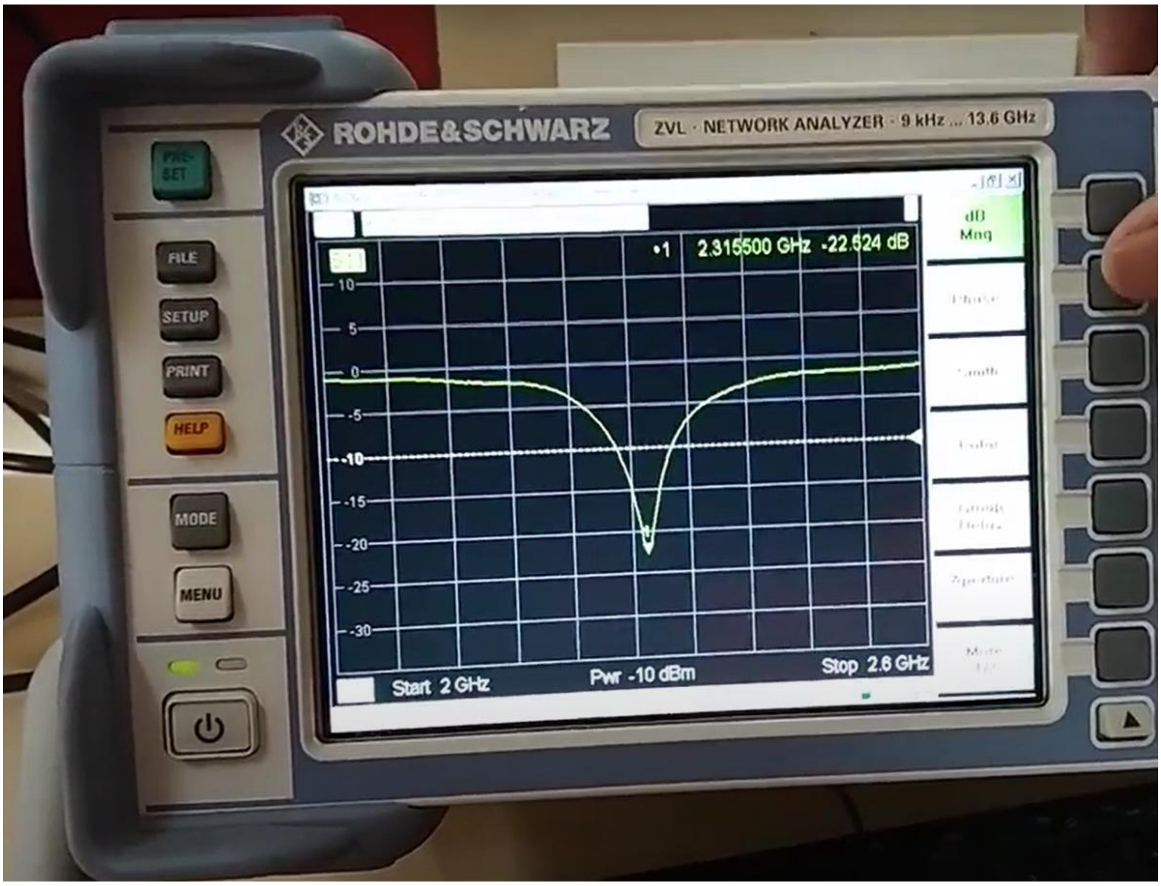
Return Loss(S11) = **-22.524** dB

VSWR = **1.160**

Impedance = **56.789 – j4.173** Ω

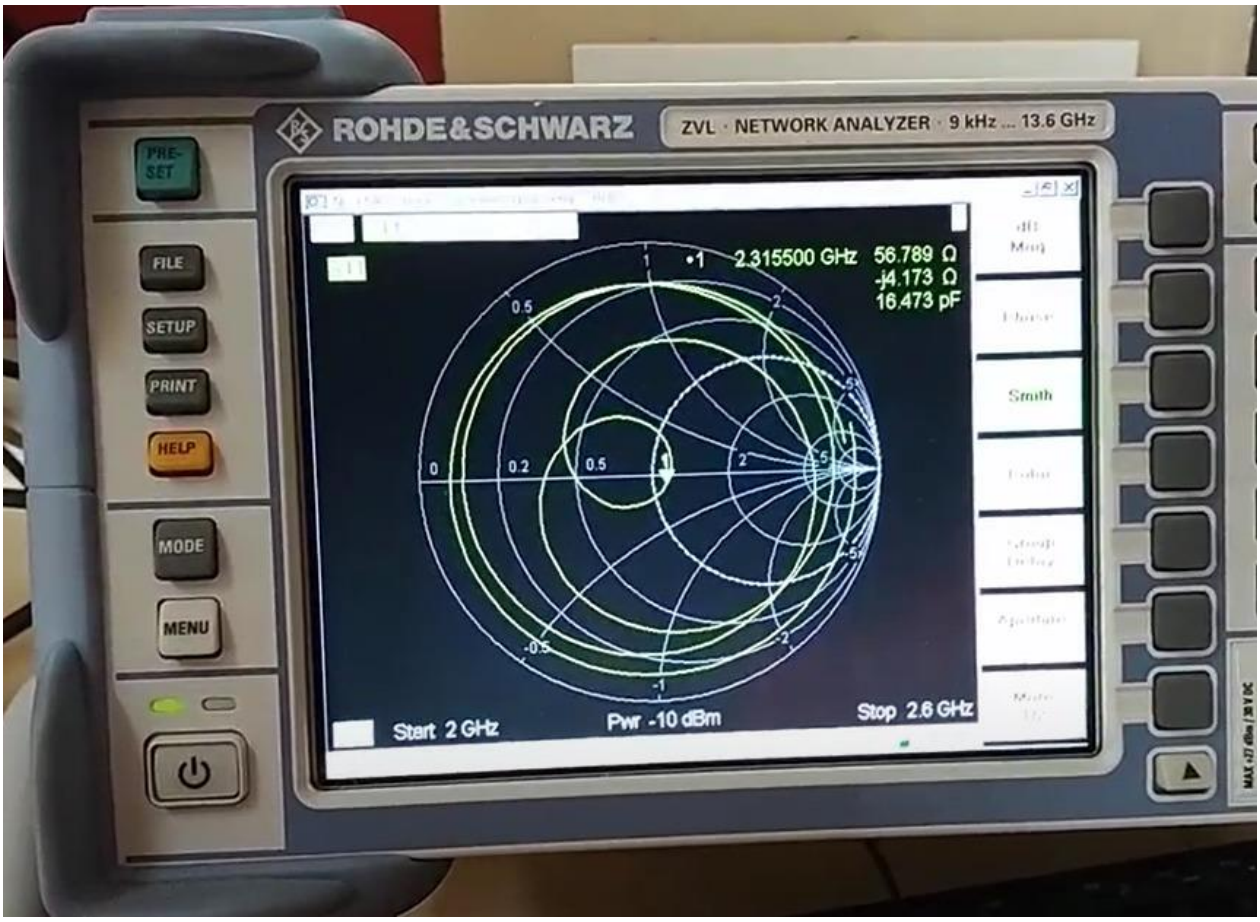
Phase = **-30.719º**

Return Loss(S11) Measurement :

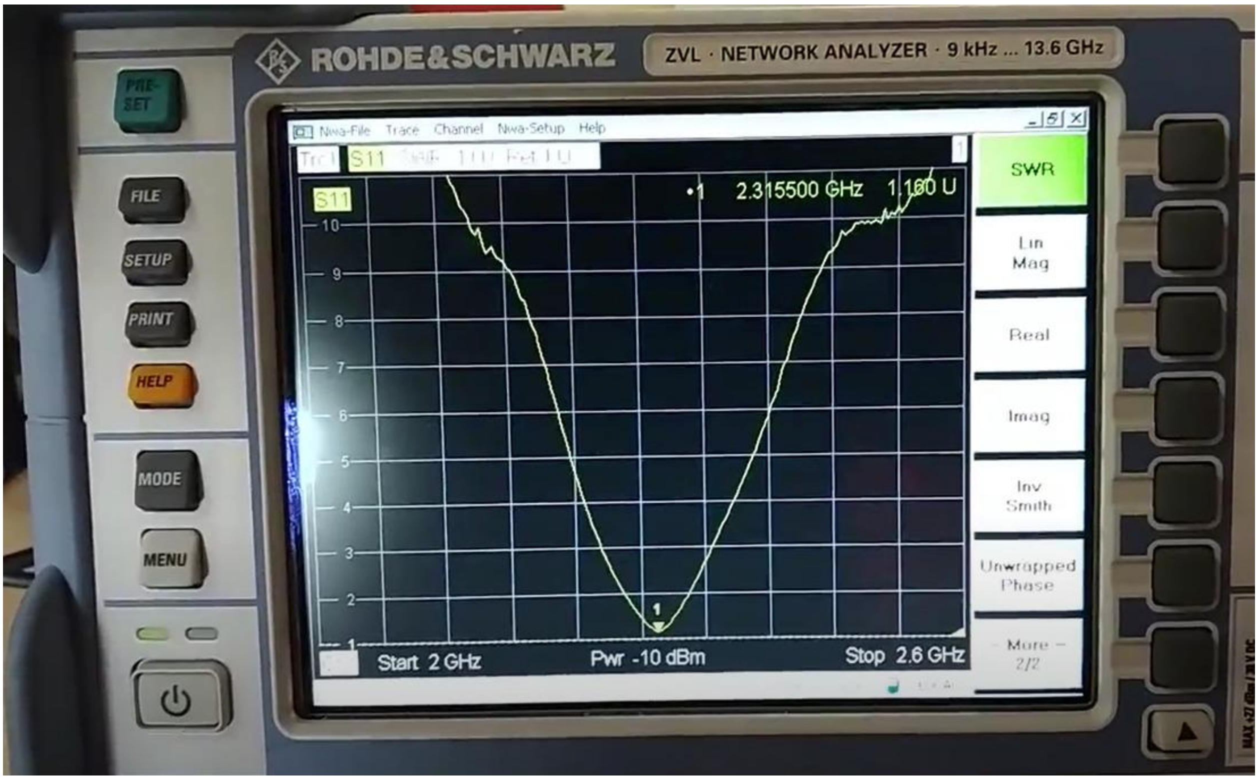


Phase Measurement :

Smith Chart :


ROHDE&SCHWARZ
ZVL · NETWORK ANALYZER · 9 kHz ... 13.6 GHz
PRE-SET
FILE
SETUP
PRINT
HELP
MODE
MENU
•1 2.315500 GHz 56.789 Ω
-j4.173 Ω
16.473 pF
Smith
Start 2 GHz
Pwr -10 dBm
Stop 2.6 GHz

VSWR Measurement :



CONCLUSION:-

In this experiment we studied about the Vector Network Analyzer, front panel & rear panel controls, accessories, and calibration methods of R&S®ZVA Vector Network Analyzer. We understood how we can access the functionality of VNA through the OS installed i.e., Windows XP. We understood and observed how we can measure different antenna parameters using the VNA and observed their respective plots on the screen. We also saw how we can observe multiple plots at a same time.

REFERENCES:-

1. R&S®ZVA Vector Network Analyzer Product Brochure, Datasheet
2. Network Analyzer Basics from Agilent.