Lecture – 21

Date: 12.11.2014

- Vector Network Analyzer (VNA)

Introduction

Q: What is VNA?

Q: Why VNA?

Q: If not VNA, then what?

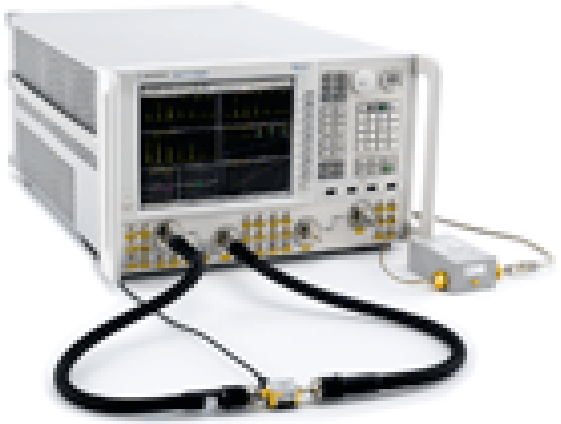
Simple answer could be:

- Another instrument (for high frequency measurement)
- Definitely to measure something that a simple low frequency instrument is not able to measure (S-parameter)
- Then a combination of instrument (such as power meter, phase meter, etc.)

Introduction (contd.)

Vector network analyzers are particularly useful items of RF test equipment. When used skilfully, they enable RF devices and networks to be characterised so that an RF design can be undertaken with a complete knowledge of the devices being used. This will provide a better understanding of how the circuit will operate. Vector network analyzers provide a much greater capability than their scalar counterparts, and as a result the vector network analyzers are more widely used, even though they tend to be more expensive.

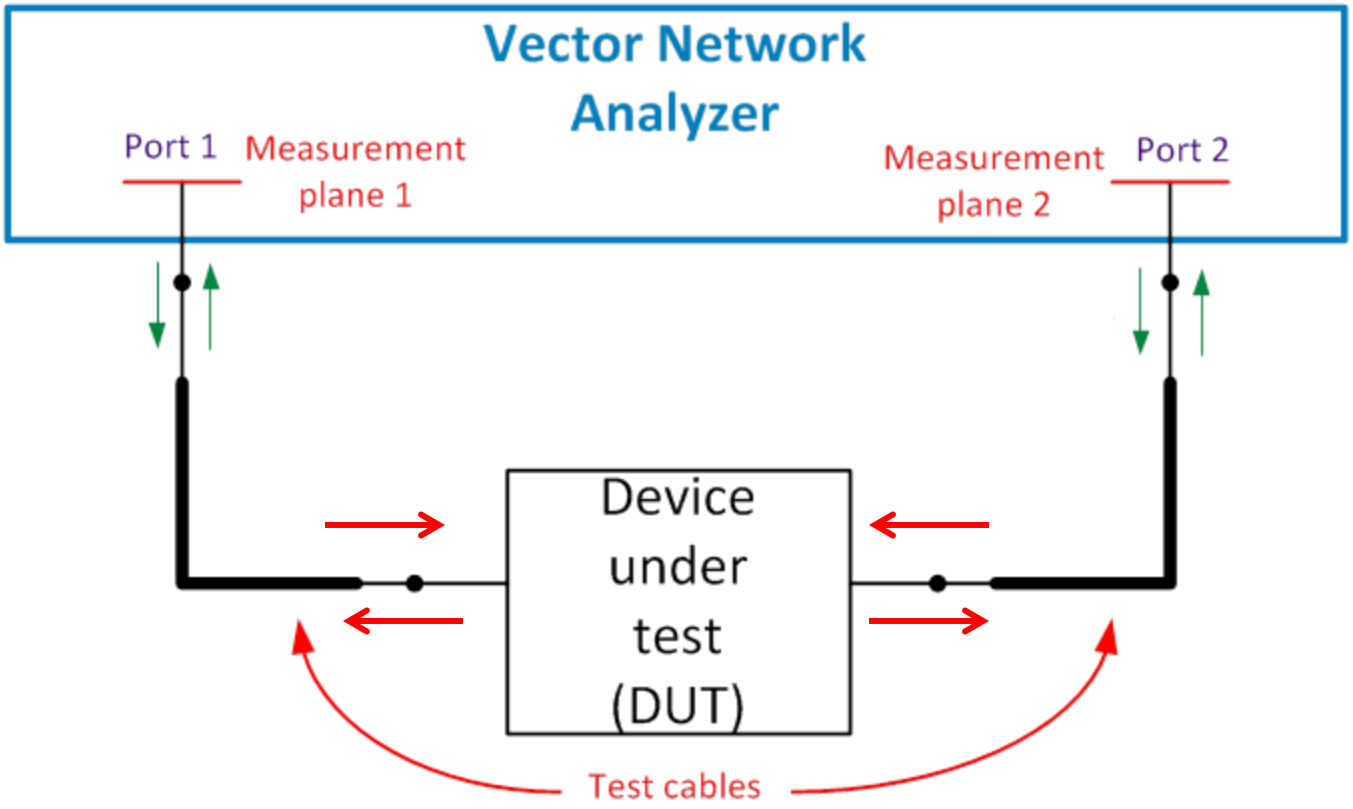
Introduction (contd.)



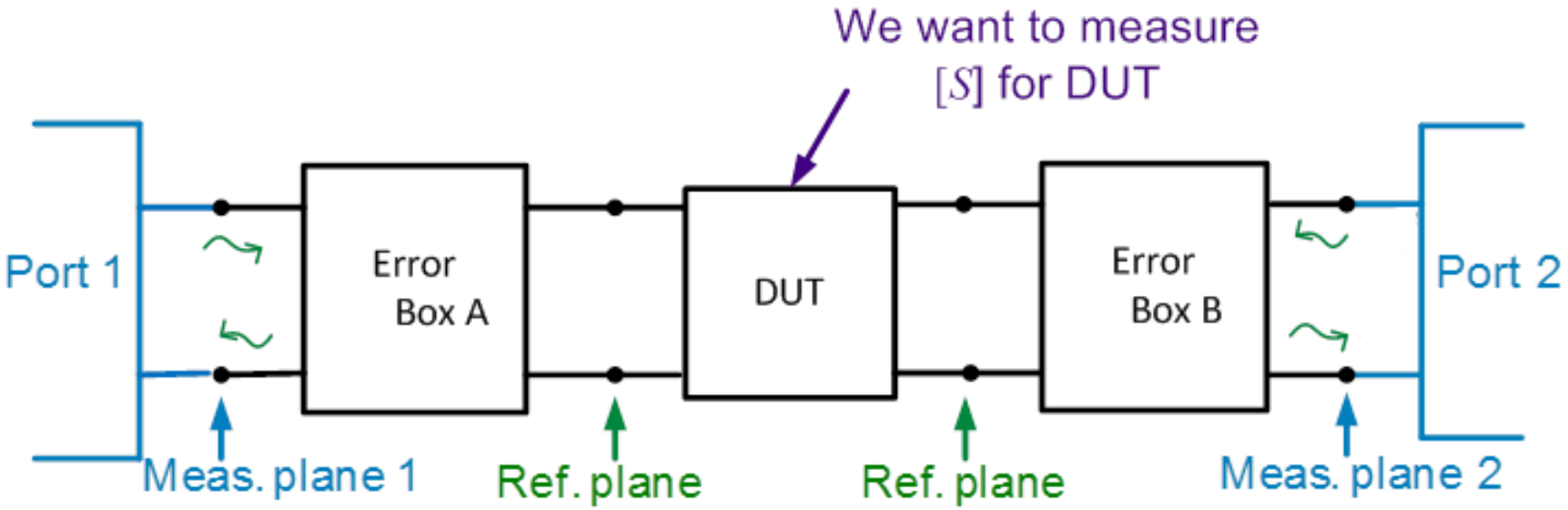
Vector Network Analyzer

VNA Experimental Setup

Vector Network Analyzer (contd.)



Vector Network Analyzer (contd.)

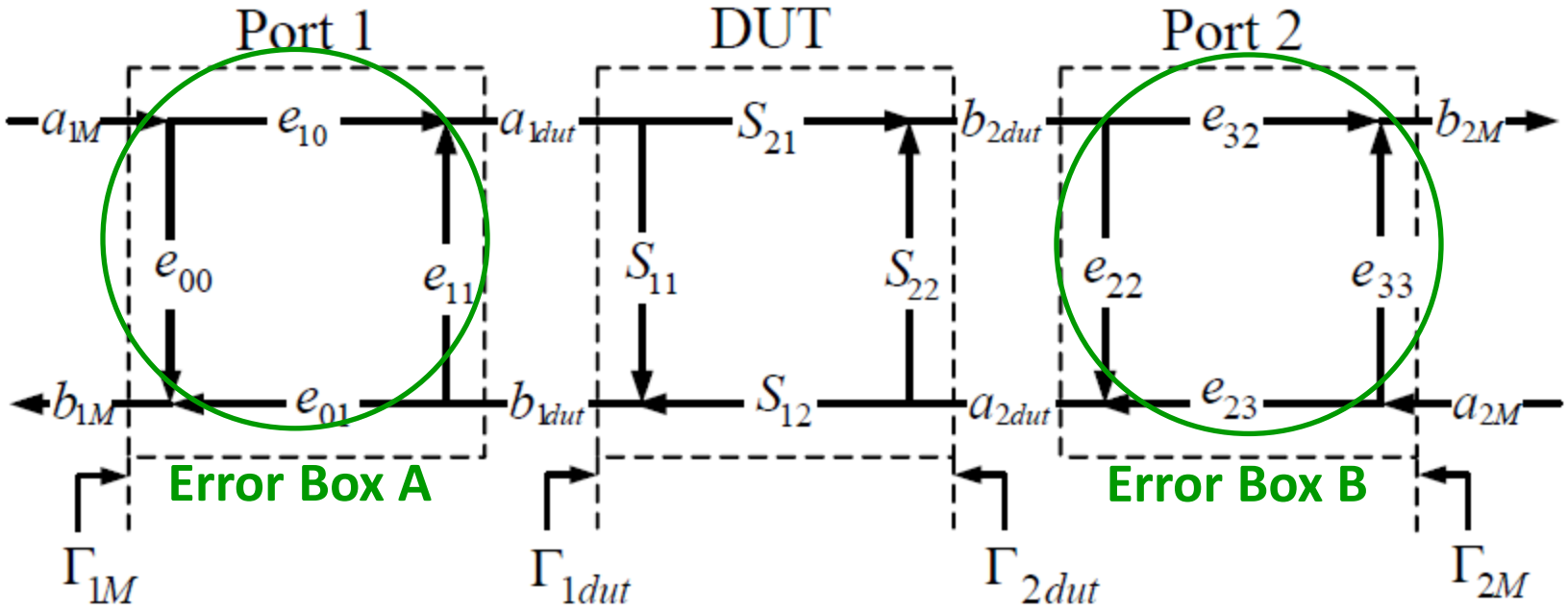


Errors Could be:

- System Error
- Random Error
- Drift Error

→ Necessitates Calibration

Vector Network Analyzer – Error Model



- **SFG Simplification:**

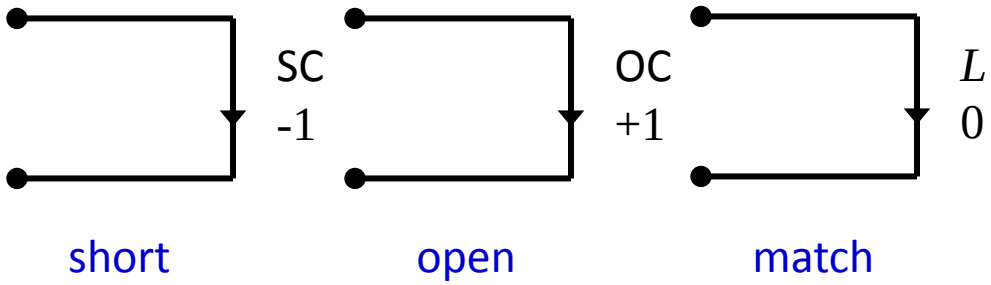
$$a_{1dut} = \left(\frac{e_{01}e_{10} - e_{00}e_{11}}{e_{01}}\right) a_{1M} + \left(\frac{e_{11}}{e_{01}}\right) b_{1M}$$

$$b_{1dut} = \left(\frac{-e_{00}}{e_{01}}\right) a_{1M} + \left(\frac{1}{e_{01}}\right) b_{1M}$$

Similarly for 2nd port

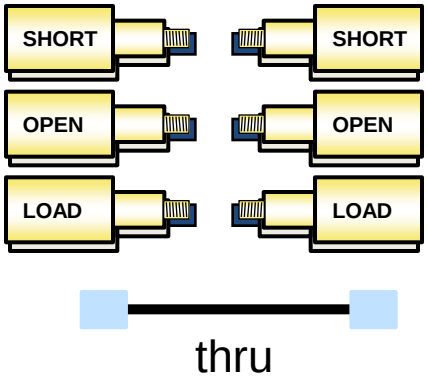
Vector Network Analyzer – Calibration

- It is apparent that you need to determine the error terms to get the traveling waves at the DUT ports.
- If you observe carefully, for 1-port error correction at port-1 only three terms ($e_{00}, e_{11}, e_{01}e_{10}$) need to be determined. Similarly for 1-port correction at port-2.
- For relating these error terms for 2-port measurements → carry out a THRU measurement between the two ports.



Vector Network Analyzer – Calibration

Calibration Standards



Vector Network Analyzer – Calibration

- The error terms e_{00}, e_{11}, and $e_{01}e_{10}$ can be determined from the first port measurement by connecting respective calibration standards and then relating the measured reflection coefficient to the reflection coefficient of the respective calibration standards.

$$\Gamma_{1M} = e_{00} + \frac{e_{01}e_{10}\Gamma_{1dut} + e_{00}}{1 - e_{11}\Gamma_{1dut}} = \frac{-\Delta e\Gamma_{1dut} + e_{00}}{-e_{11}\Gamma_{1dut} + 1} \quad \Leftarrow \quad \Delta e = \left(e_{00}e_{11} - e_{01}e_{10}\right)$$

$$\begin{bmatrix} e_{00} \\ e_{11} \\ \Delta e \end{bmatrix} = \begin{bmatrix} 1 & \Gamma_O\Gamma_{MO} & -\Gamma_O \\ 1 & \Gamma_S\Gamma_{MS} & -\Gamma_S \\ 1 & \Gamma_L\Gamma_{ML} & -\Gamma_L \end{bmatrix}^{-1} \times \begin{bmatrix} \Gamma_{MO} \\ \Gamma_{MS} \\ \Gamma_{ML} \end{bmatrix}$$

- Carry out similar measurements at port-2 and determine the error terms e_{22}, e_{33}, and $e_{23}e_{32}$.
- The perform THRU measurement to ideally determine the tracking errors between port-1 and port-2.