SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

OPTICAL AND MICROWAVE ENGINEERING

III YEAR/ VI SEMESTER

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UNIT 3 – MICROWAVE MEASUREMENTS

TOPIC – VSWR

DEFINITION

- VSWR stands for voltage standing wave ratio.

- The ratio of the reflected power to the incident power of standing waves created due to impedance mismatch between RF source and load.

- These standing waves are unwanted as the transmitted energy gets reflected, and travels back to the source it may damage the RF signal source.
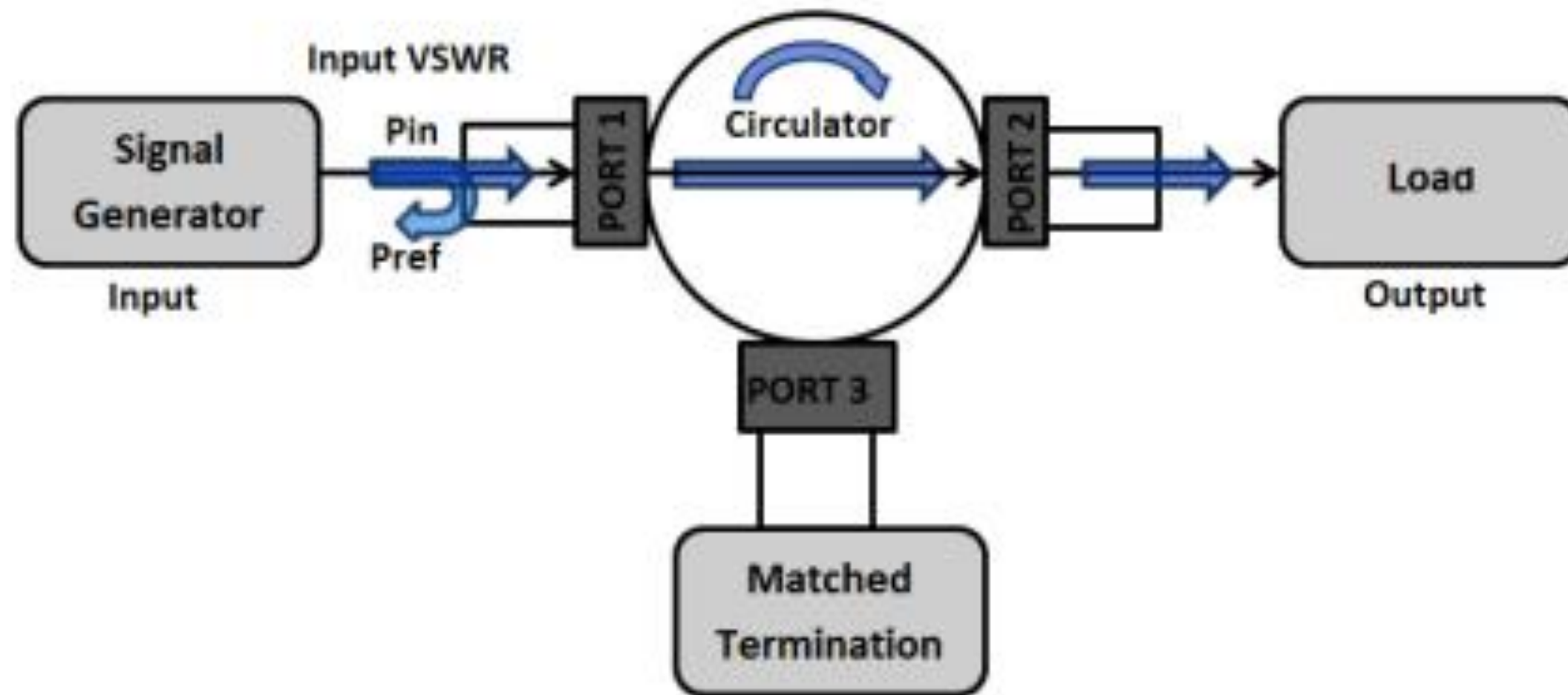
VSWR MEASUREMENT SETUP

Figure 1: VSWR Measurement

REFLECTION COEFFICIENT

Reflections occur as a result of discontinuities, such as imperfections in uniform transmission line, or when a transmission line is terminated with other than its characteristic impedance.

The reflection coefficient Γ is defined as a complex number that describes both the magnitude and the phase shift of the reflection.

The simplest cases, of reflection coefficient values are:

$\Gamma = -1$: maximum negative reflection, when the line is short-circuited

$\Gamma = 0$: no reflection, when the line is perfectly matched

$\Gamma = +1$: maximum positive reflection, when the line is open-circuited

The reflective property of a port is characterized by the reflection coefficient magnitude Γ

$|\Gamma| = \text{sqrt}[\text{Pref}]/\text{Pin}$ $|\Gamma| = V-/V+$ (Eq. 1)

Where Pref : reflected power [W]

Pin : incident power [W]

V- : reflected wave [V]

V+: incident wave. [V]

The resulting VSWR is given by: VSWR $= 1+|\Gamma| / 1-|\Gamma|$ (Eq. 2)

-The effective input VSWR of an Isolator will vary as a function of the load VSWR. If the output load mismatch is increased, more energy is reflected towards the termination port. After attenuated by the isolation it is then reflected back to the input. Due to which there is increase in total VSWR observed at the input. Therefore, a low VSWR specification is always desirable. VSWR is expressed in ratio form relative to 1

-Following are two special cases of VSWR:

-- VSWR of ∞:1 is obtained when the load is an open circuit

- - VSWR of 1:1 is obtained when the load is perfectly matched to source impedance

As shown in Figure 2 the reflection properties of Circulator can be described by S-parameters. An RF vector network analyzer (VNA) can be used to measure the reflection coefficients of the input port (S11) and the output port (S22).
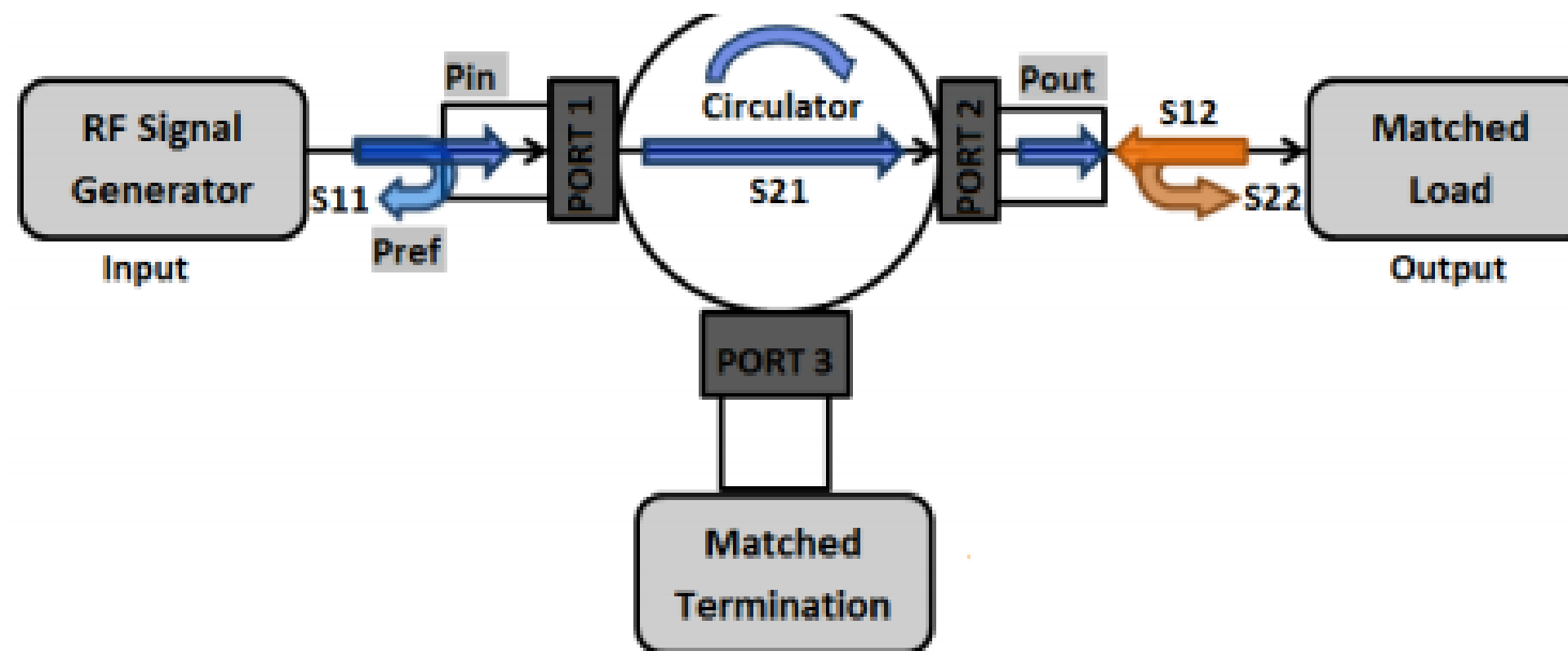

Figure 2: VSWR Measurement Principle

The return loss at the input and output ports can be calculated from the respective reflection coefficients as follows:

Input port return loss (RLIN) = $20\log10|S11|$ [dB] (Eq. 3)

Where, S11 : input port voltage reflection coefficient.

Output port return loss (RL_{OUT}) = $20\log_{10}|S_{22}|$ [dB] (Eq. 4)

Where, S_{22} : output port voltage reflection coefficient.

The reflection coefficient can also be expressed in terms of the characteristic impedance of the inner conductor and the matched load impedance as follows:

$$\Gamma = (Z_L - Z_O)/(Z_L + Z_O) \quad \text{(Eq. 5)}$$

Where Z_L is the matched load impedance.

Z_O is the characteristic impedance of the inner conductor.

Port return loss (R.L.) = $20\log_{10}|\Gamma|$

Substituting *(Eq.5)* into *(Eq.2)*, to obtain VSWR in terms of Z_L and Z_O:

$$VSWR = \frac{\left[1 + \left|\frac{ZL - ZO}{ZL + ZO}\right|\right]}{\left[1 - \left|\frac{ZL - ZO}{ZL + ZO}\right|\right]}$$

$$VSWR = \frac{[ZL + ZO + |ZL - ZO|]}{[ZL + ZO - |ZL - ZO|]} \qquad (Eq.6)$$

Solving *(Eq.6)* for,

Case 1: if $Z_L > Z_O$ then $|Z_L - Z_O| = Z_L - Z_O$

$$\therefore VSWR = \frac{[ZL + ZO + ZL - ZO]}{[ZL + ZO - ZL + ZO]}$$

$$\therefore VSWR = \frac{ZL}{ZO} \qquad (Eq.7)$$

Case 2: if $Z_L < Z_O$ then $|Z_L - Z_O| = Z_O - Z_L$

$$\therefore VSWR = \frac{[ZL + ZO + ZO - ZL]}{[ZL + ZO - ZO + ZL]}$$

$$\therefore VSWR = \frac{ZO}{ZL} \qquad (Eq.8)$$

REFERENCES

1. www.antenna-theory.com/definitions/vswr.php
2. https://www.microwaves101.com/.../voltage-standing-wave-ratio-vswr
3. https://www.maximintegrated.com/en/design/technical-documents

ASSESSMENT TIME

Think, Pair, Share

What's the issue / question / topic?	What do I think about it?	What does my partner think?	What will we share?

THANK YOU

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