SAVEETHA ENGINEERING COLLEGE

AUTONOMOUS

NAAC A GRADE

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION

19EC802-ELECTROMAGNETIC THEORY AND TRANSMISSION LINES

SKILL ASSESSMENT -II

Assignment Date: 30.10.2025
Submission Date: 15.11.2025

UNIT I **ELECTROSTATICS ANDMAGNETOSTATICS** Coulomb's law, Electric fieldintensity, Gauss law and its applications, Electric scalar potential,
Capacitance using Laplaceequation, Boundary conditions of conducting and dielectric medium, Biot -Savart Law, Magnetic fieldIntensity, Ampere Circuital Law, Scalar and Vector Magnetic potential, Magnetic boundary condition.

UNIT II **TIME VARYING FIELDS**

Differential form of Maxwell'sequations, Integral form of Maxwell's equations, Wave equations and their solutions, Poynting theorem, Propagation constant, Electromagnetic Spectrum.

UNIT III **IMPEDANCE MATCHING NETWORKS**

Lumped circuit model for transmission line, Reflection coefficient, standing wave ratio , transfer impedance Open circuited and short circuited lines, Impedance matching, stub matching using smith chart.

UNIT IV **PLANAR TRANSMISSION LINES**

Introduction to high frequency parameters, properties of scattering parameter, Formulation of multiport network, planar transmission lines, Strip lines ,Coplanar waveguide (CPW), Microstrip lines

UNIT V **WAVEGUIDES**

Transverse Magnetic waves, Transverse Electric and Transverse Electromagnetic waves between parallel plates, TE and TM waves in rectangular waveguides, Impossibility of TEM in rectangular waveguides, Circular waveguides.

Rubrics (Per Topic)

Topic is assignd for each learner from the above units and the relevant topic can be assessed using the following rubric breakdown.

Conceptual Understanding with real time example (50%)

- **Excellent** : Demonstrates clear and deep understanding; can explain principles and solve unfamiliar problems.
- **Good** : Understands most concepts and applies them correctly to standard problems.
- **Average**: Basic understanding; struggles with application.
- **Poor** : Major misunderstandings; cannot apply concepts.
- **Zero**: No relevant response.

2. Problem Solving:(30 %)

- **Excellent**: Accurate, well-structured solutions with correct methodology.
- **Good**: Minor errors; logical approach maintained.
- **Average**: Several errors, but shows understanding.
- **Poor**: Incorrect solutions or poor methodology.
- **Zero**: No attempt.

3. Clarity of Presentation (20%)

- **Clear steps**
- **Mostly clear**
- **Acceptable**
- **Unclear**
- **incomplete**

RUBRIC TEMPLATE

Criteria	Excellent (5)	Good (4)	Average (3)	Poor (2)	Very Poor (1)
Understanding of Concept	Deep insight	Good grasp	Basic grasp	minimal idea	No understanding
Mathematical Rigor	Accurate & neat	Minor errors	Some errors	Poor math	No math clarity
Clarity of Presentation	Very clear	Mostly clear	Acceptable	Unclear	Messy/incomplete

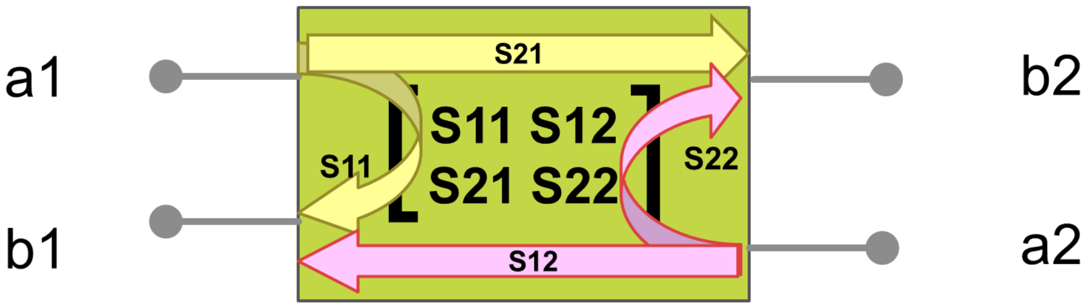
PROPERTIES OF S-PARAMETERS

Introduction:

- Scattering parameters (S-parameters) describe how RF/microwave networks respond to incident and reflected waves at each port.
- They are widely used because at high frequencies, measuring voltage and current directly becomes difficult.

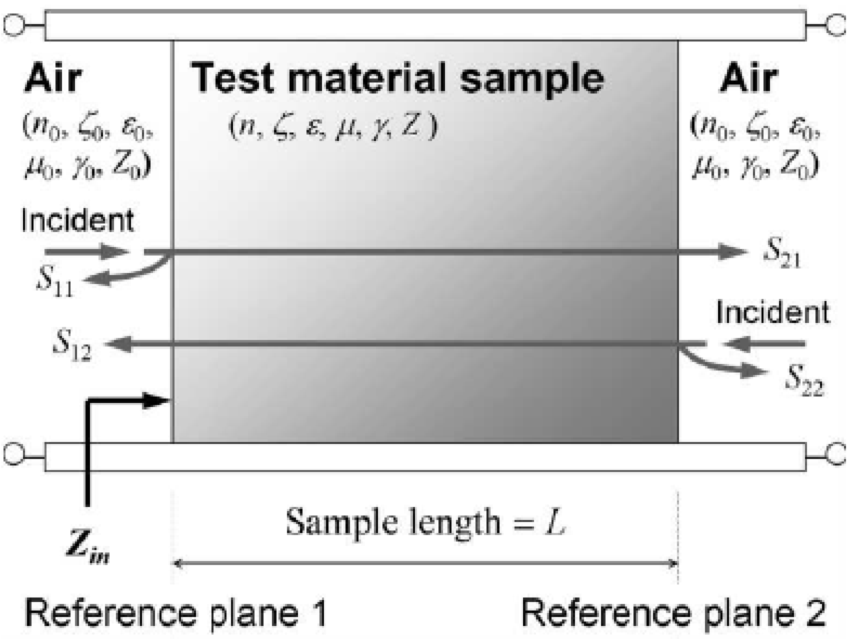
S-parameters:

S-parameters relate the traveling waves (incident and reflected) at the ports of a network[1]. Unlike Z (impedance) or Y(admittance) parameters, which use total voltages and currents, S-parameters are preferred at high frequencies because:



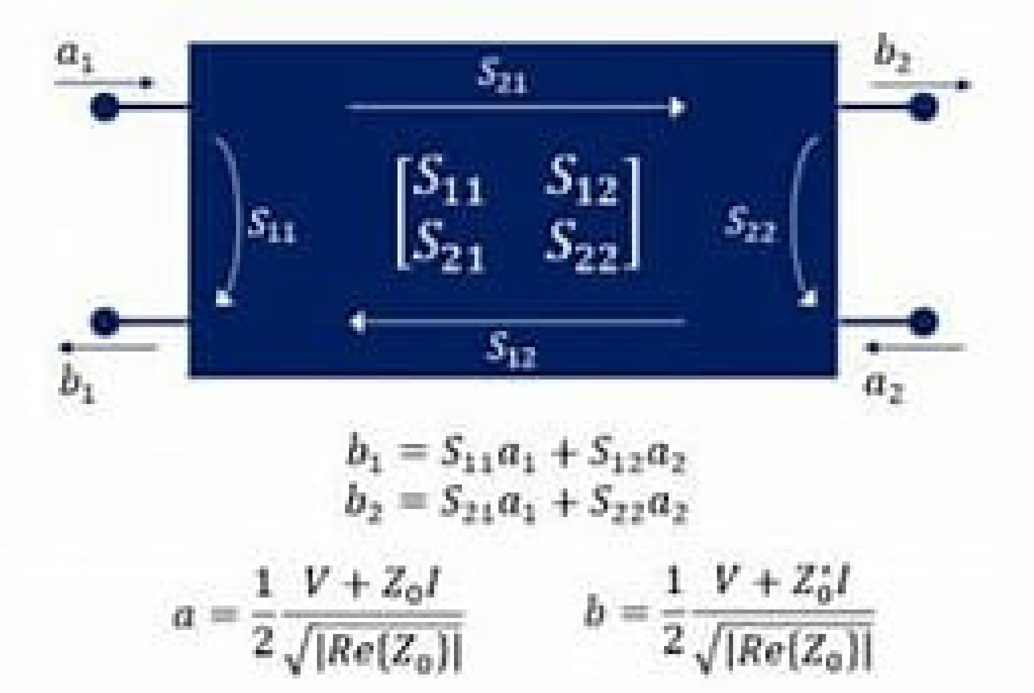
- **Impedance Measurement:**

  It's difficult to measure total voltage and current accurately at microwave frequencies.



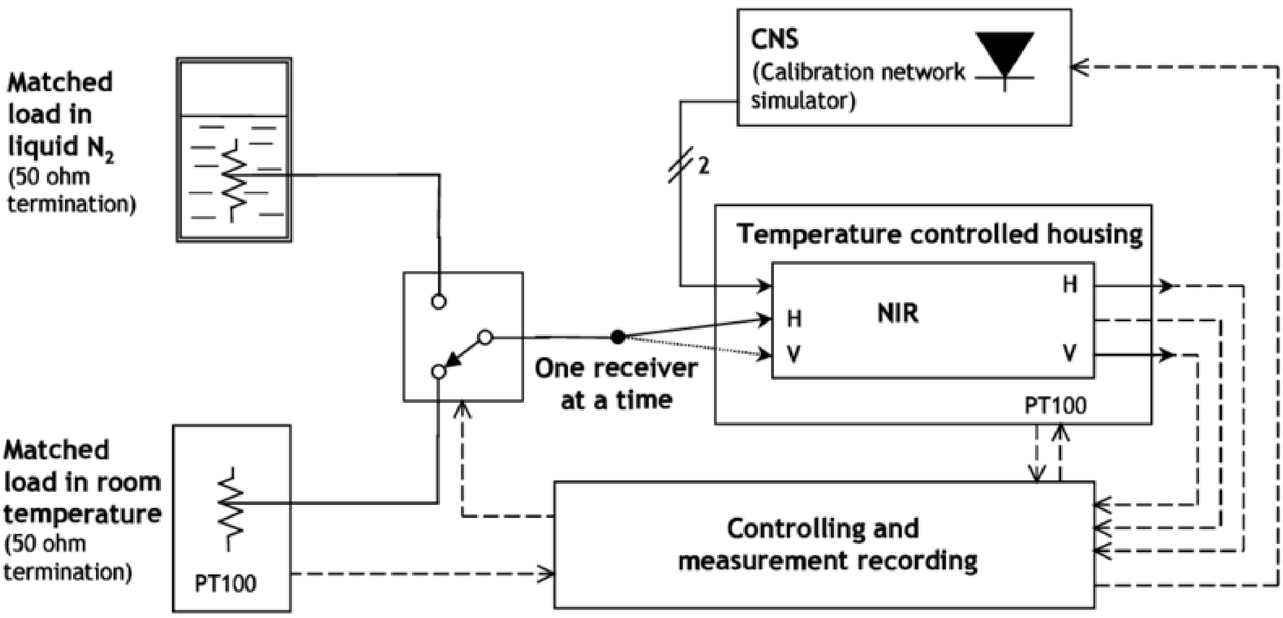
- **Open/Short Circuits:**

Performing open-circuit or short-circuit tests (required for Z and Y parameters) is impractical, as they often lead to oscillations or damage the device[3].



- **Matched Loads:**

S-parameters are measured using matched loads (usually 50 Ω), which is the standard operating condition for microwave devices, ensuring stable and repeatable results[4].



For an N-port network, the S-parameters form an $N \times N$ matrix, where the output b (reflected/outgoing wave) is related to the input a (incident/incoming wave) by the equation:

$$\mathbf{b} = \mathbf{S}\mathbf{a}$$

The element S_{ij} is defined as:

$$S_{ij} = \frac{\text{Reflected wave at port } i}{\text{Incident wave at port } j}\bigg|_{\text{All other ports matched}}$$

- S_{ii} **(Diagonal element): Input reflection coefficient** at port i when all other ports are terminated in matched loads. This measures how well port i is matched.
- S_{ji} **(Off-diagonal element, $j \neq i$): Forward transmission coefficient** from port j to port i. This measures the gain or loss through the network.

Key Properties of S-Parameters:

The properties simplify the S-matrix for different types of networks.it may involve deriving these properties or using them in problem-solving.

1. Reciprocal Network:

A network is reciprocal if the transmission from port i to port j is the same as the transmission from port j to port i. This is true for any network made of resistors, inductors, and capacitors.

- **Condition:** The S-matrix is symmetric.

$$S_{ij} = S_{ji}$$

2. Lossless Network:

A network is lossless if the total power entering the network is equal to the total power leaving the network (i.e., no power is dissipated internally).

- **Condition:** The S-matrix must be Unitary.
- Where [S*] is the complex conjugate transpose of [S], and [I] is the identity matrix.

$$[\mathbf{S}]^T[\mathbf{S}^*] = [\mathbf{I}]$$

3. Matched Network:

A network is matched if all its ports are perfectly matched to the characteristic impedance **Z**0.

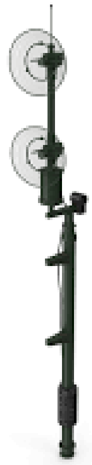
- Condition: The diagonal elements are zero.

$$S_{ii} = 0 \quad \text{for all } i$$

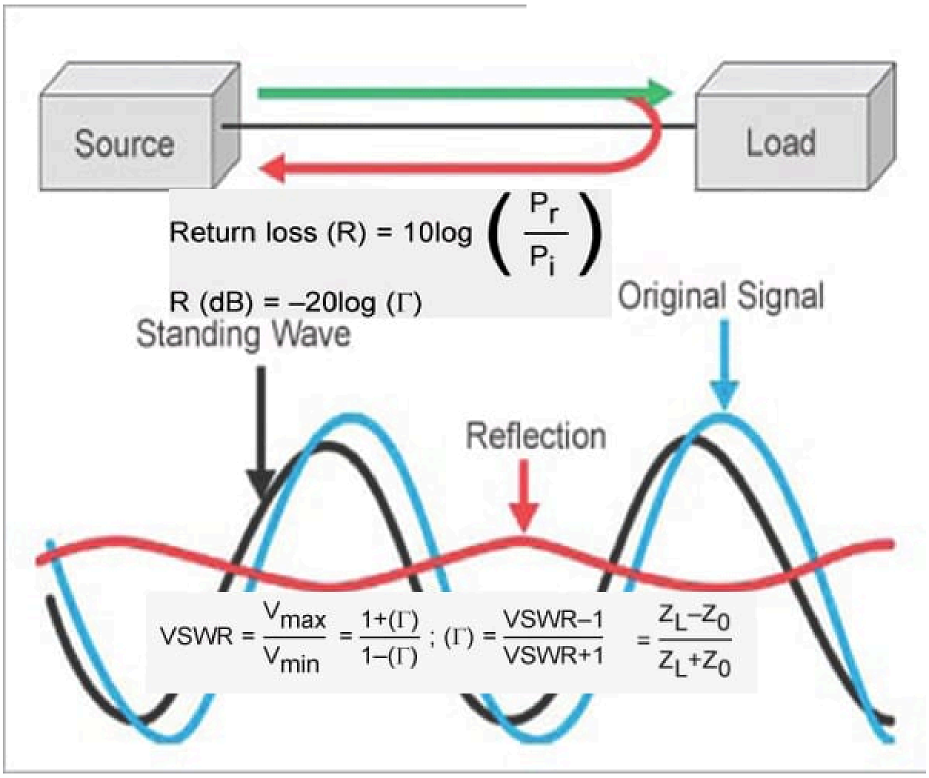
4. Zero S-Parameters:

If a network is ideal and matched, and it also blocks power transfer between all ports (like a perfect isolator), then all S-parameters are zero, and S = [0] (the null matrix).

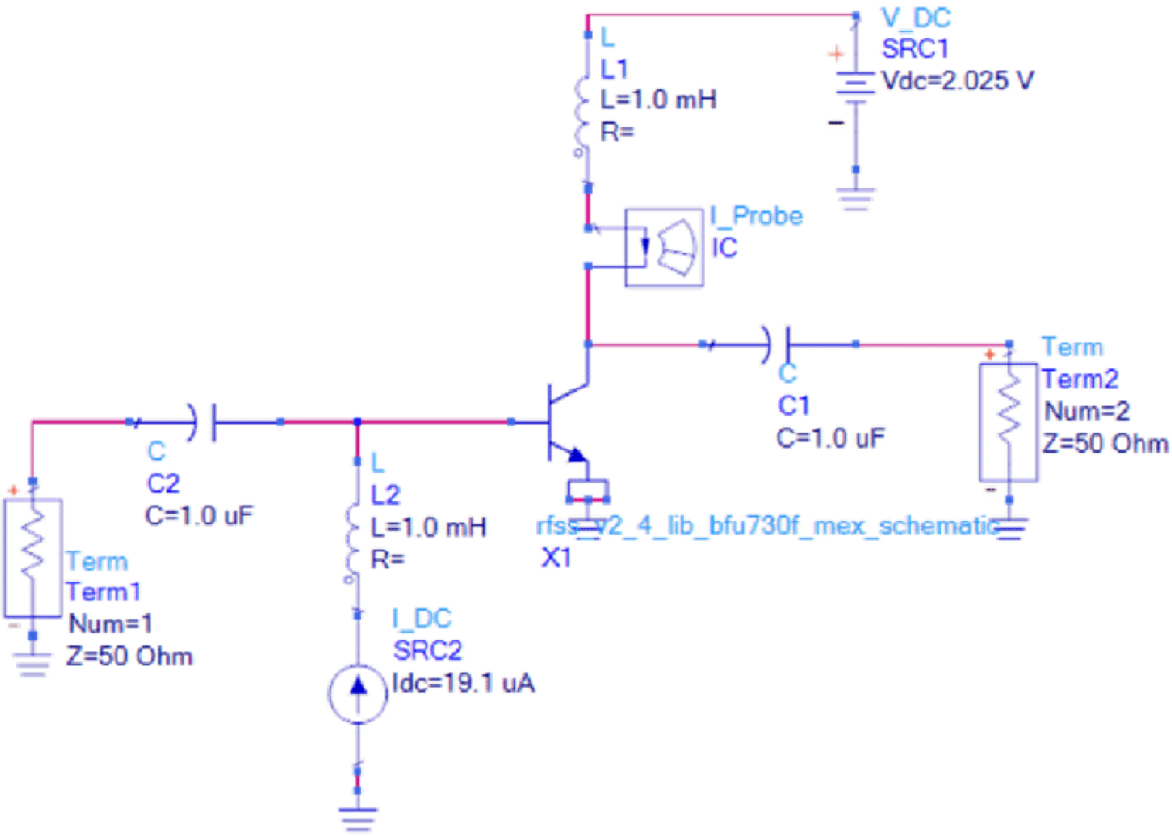
Real-Time Examples:



Example 1: Antenna Return Loss (S11)
An antenna with
S11=−20 dB
it reflects only 1% of power → good matching.



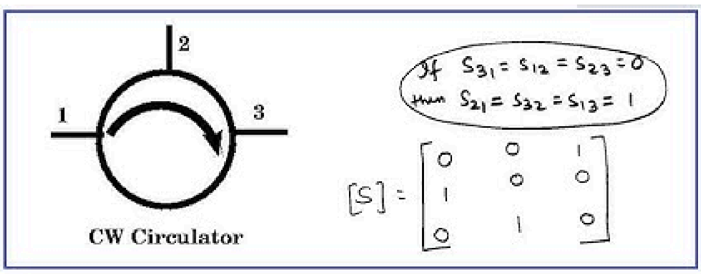
Example 2: RF Amplifier Gain (S21)
IS21=10 db
the amplifier gives 10 dB gain at that frequency.

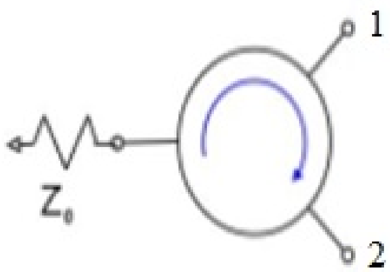


Example 3: Circulator and isolator

A circulator is non-reciprocal, so

$$S12 \neq S21$$





RF-Isolator

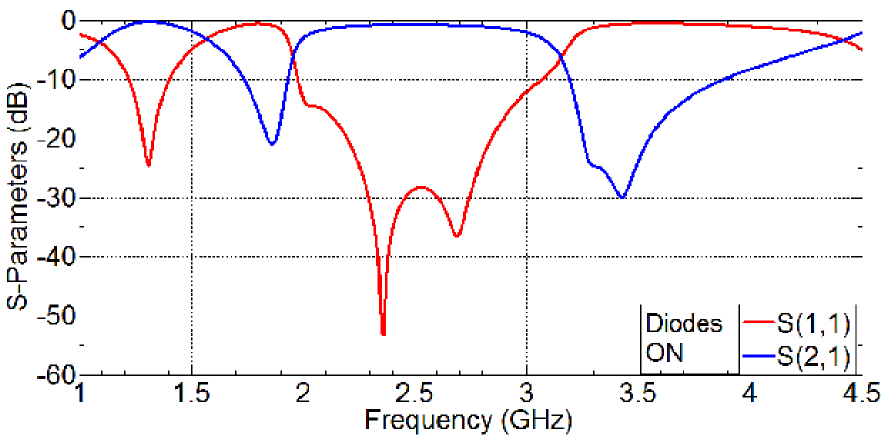
$$[s] = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}$$

Example 4: Band-pass filter

Passband → high S21

Stopband → low S21

Return loss → controlled through S11



Conclusion:

S-parameters are essential for RF, microwave, antenna, and high-frequency circuit design. Their properties such as reciprocity, losslessness, frequency-dependence, and measurability make them a powerful tool for characterizing multi-port networks.