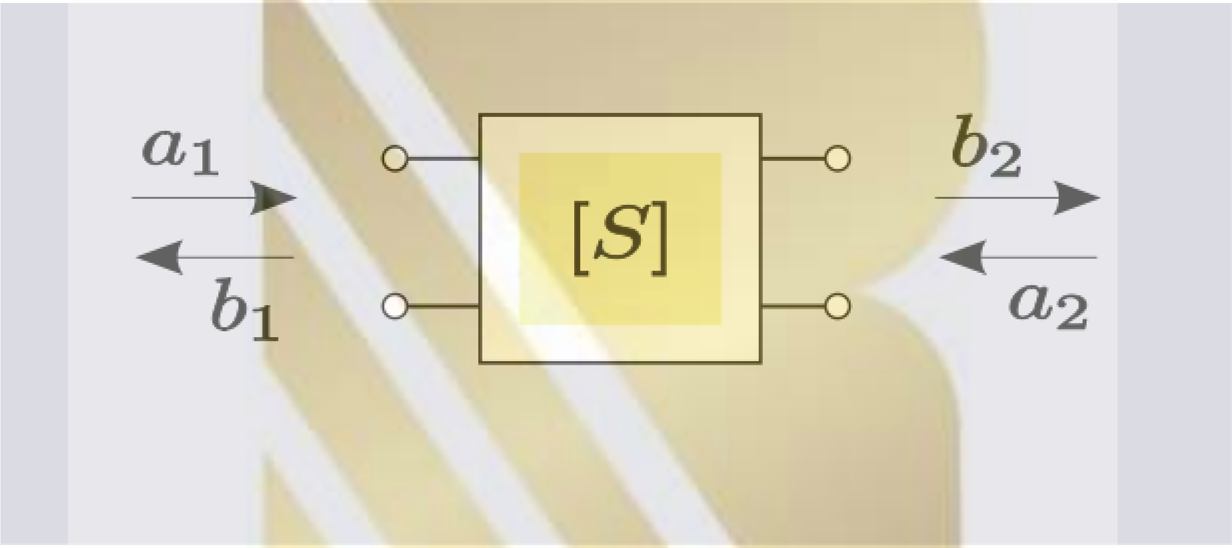


RF Components and Basic Concepts

1.18 - S-Parameters

Why we need S-parameters ?

- For high frequencies, it is convenient to describe a given network in terms of waves rather than voltages or currents. Microwave theory deals with **power quantities** rather than Voltage or current.

➢ Why ?

- Measurement of high-frequency voltages and currents in laboratory proves very difficult but measuring the average power is easier.

- Microwave theory models devices and circuits by parameters that can be obtain through the measurement of power quantities. These parameters are called scattering parameters or S-parameters.

Path Loss and Return Loss

- **Path loss** (or **path** attenuation) is the reduction in power density (attenuation) of an electromagnetic wave as it propagates through space.

- **Return loss** is the **loss** of power in the signal returned/reflected by a discontinuity in a transmission line.

S-parameters

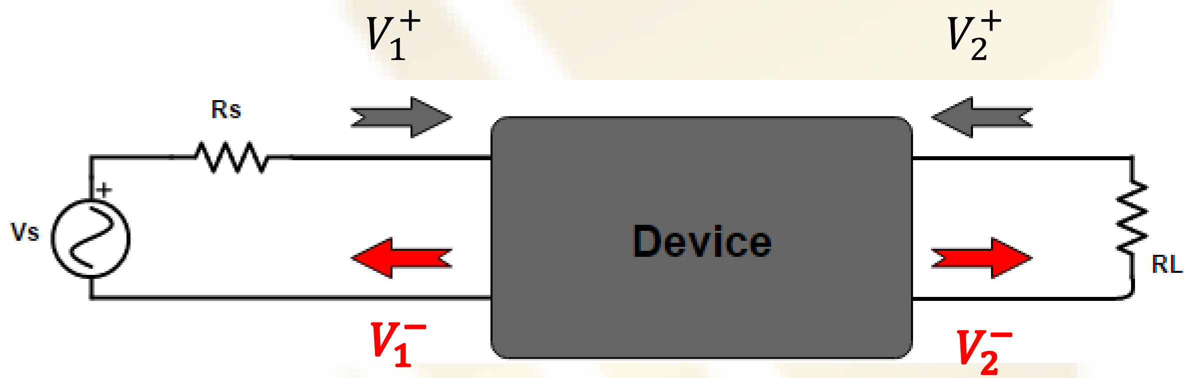
- We define S-Parameters for any two-port network.

- We have incident wave and reflected wave

At the input (V_1^+ and V_1^-)

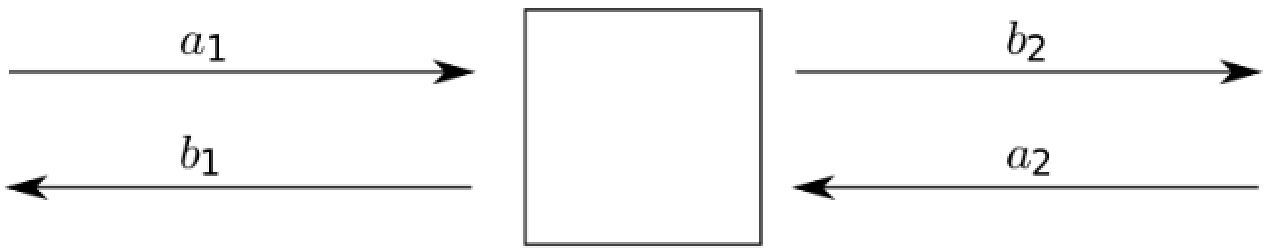
- We have incident wave and reflected wave

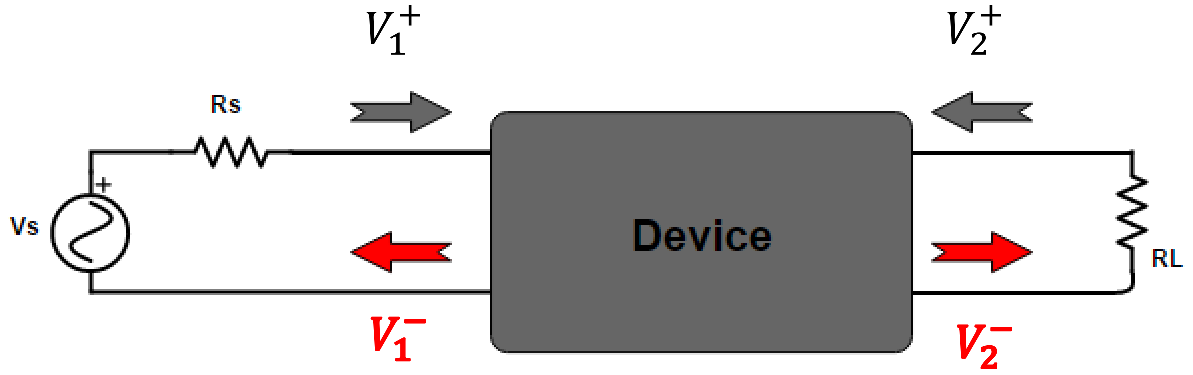
At the output (V_2^+ and V_2^-)



S-parameters

I. S11
II. S12
III. S21
IV. S22





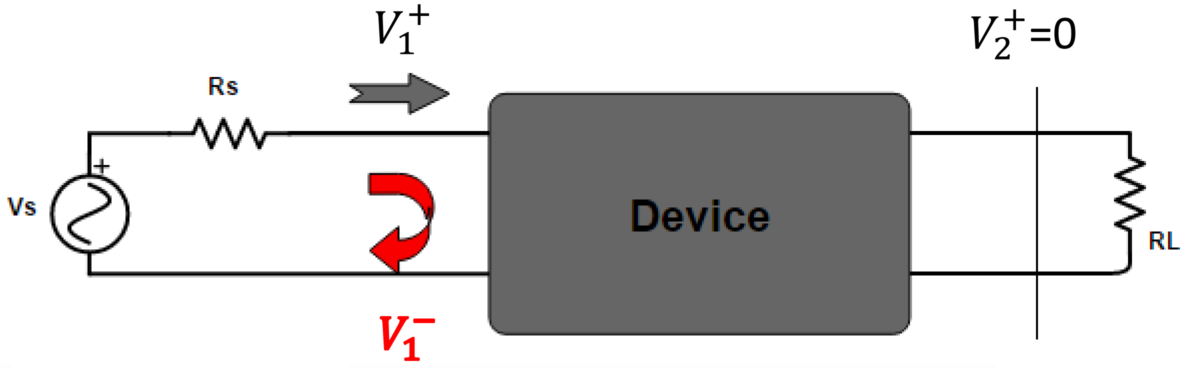
$$\begin{pmatrix} b_1 \\ b_2 \end{pmatrix} = \begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix} \begin{pmatrix} a_1 \\ a_2 \end{pmatrix} .$$

$$b_1 = S_{11} a_1 + S_{12} a_2 \quad b_2 = S_{21} a_1 + S_{22} a_2 \, .$$

S11

$$S_{11} = \frac{V_1^-}{V_1^+} \; (V_2^+ = 0)$$

S11 shows the accuracy of
Input matching.



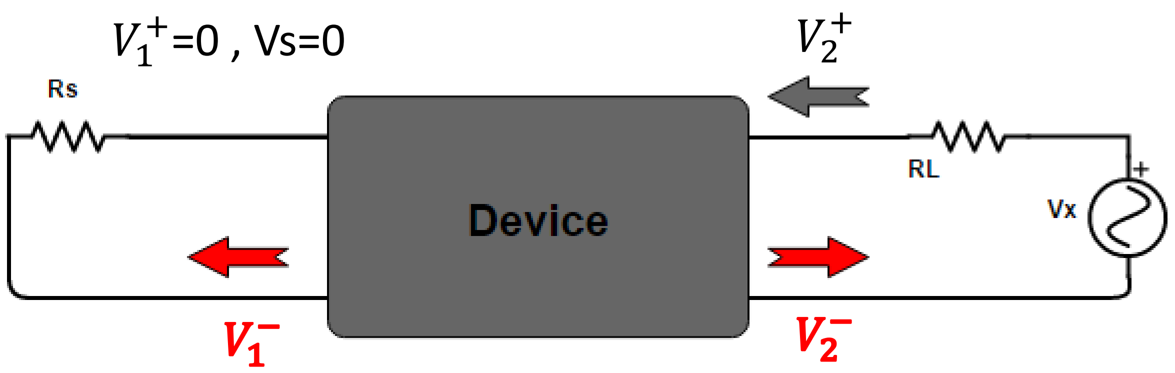
$$S_{11} = 10\log\left(\frac{V_1^-}{V_1^+}\right)$$

$$S_{11} \leq -15\ dB$$

S12

$$S_{12} = 10\log(\frac{V_1^-}{V_2^+})$$

$$S_{12} = \frac{V_1^-}{V_2^+}\ (V_1^+ = 0)$$



- S12 shows the reverse isolation
  Of the circuit.

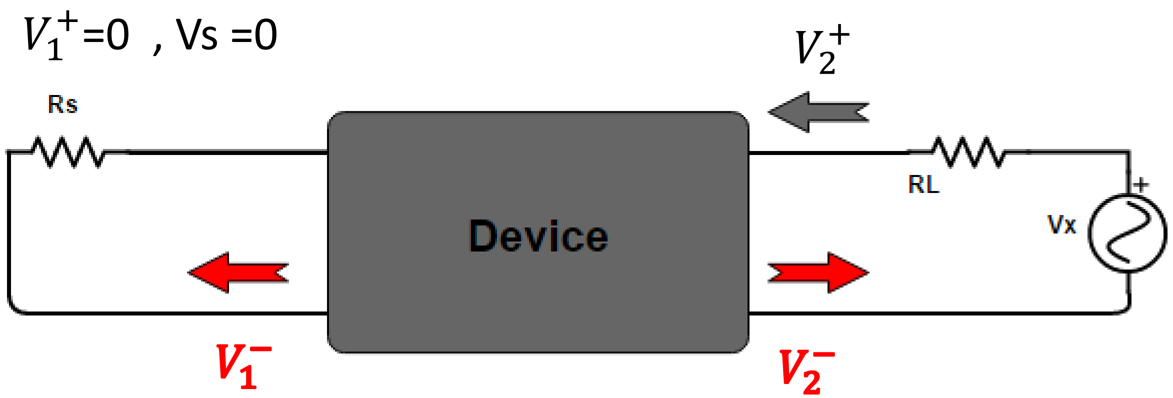
- Reverse isolation is a measure of how well a signal applied
  to the device output is "isolated" from its input.

- How much of the output signal couples to the input network.

S22

$$S_{22} = 10\log(\frac{V_2^-}{V_2^+})$$

$$S_{22} = \frac{V_2^-}{V_2^+}\ (V_1^+ = 0)$$



S22 shows the accuracy of
output matching.

$$S_{22} \leq -15\ dB$$

S21

$$S_{12} = 10\log\left(\frac{V_2^-}{V_1^+}\right)$$

$$S_{21} = \frac{V_2^-}{V_1^+} \; (V_2^+ = 0\,)$$

S21 shows the gain of the Circuit.