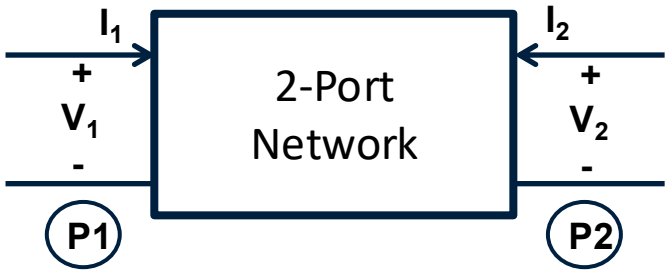
Lecture 3:
S-Parameters and Transmission-Lines Review

ELEC 404

Network Parameters @ Low Freq.



- **Z-parameters, Y-parameters**
  - **Z_{11} = Input impedance @ P1**

Apply current source I_1 and measure resultant volt@P1, with P2 open.

Network Parameters @ High Freq.

Measuring Z/Y parameters at high frequency:

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- **Active circuits may not work accurately if terminated into open/short**

Scattering Parameters (S-parameters)

- **A line terminated in its characteristic impedance gives rise to no reflections**
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Transmission Line

2-wire T-line Coaxial T-line

Voltages/currents are function of position & time.

$$V(x) = Ae^{-\gamma x} + Be^{+\gamma x}$$

$$I(x) = \frac{A}{Z_0}e^{-\gamma x} - \frac{B}{Z_0}e^{+\gamma x}$$

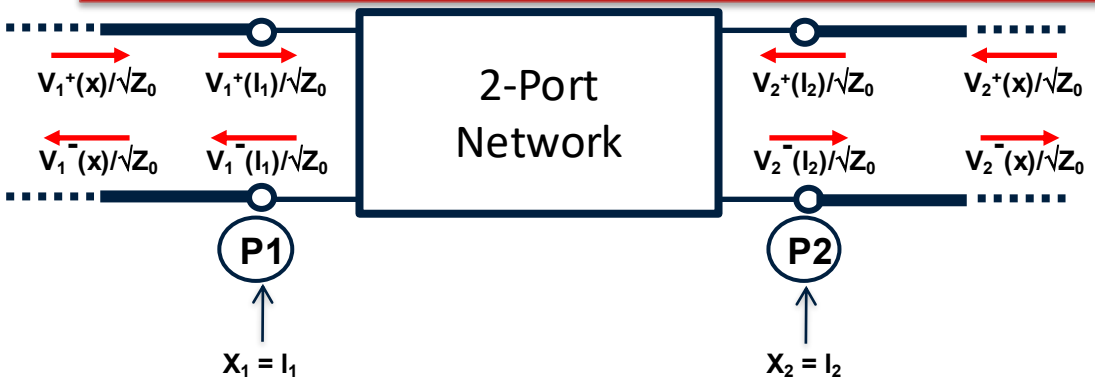
$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

$$\gamma = \sqrt{(R + j\omega L)(G + j\omega C)}$$

<u>Reflection coefficient</u> is defined as ratio of the incident to the reflected wave along a T-line. At a distance d = l - x from the load,

$\Gamma_{in}(d) = \Gamma_0 e^{-2\gamma d}$ **where** $\Gamma_0 = \frac{Z_L - Z_0}{Z_L + Z_0}$ **is** Γ **at d=0 (load)**

S-Parameters



Terminating a port with an impedance equal to the characteristic impedance of the T-line ($Z_L=Z_0 \rightarrow \Gamma=0$) produces $V_2^-(I_2)=0$.

$$S_{11} = \left.\frac{V_1^-(l_1)}{V_1^+(l_1)}\right]_{V_2^+(l_2)=0}$$ → **Input reflection coefficient with output properly terminated**

$$S_{22} = \left.\frac{V_2^-(l_2)}{V_2^+(l_2)}\right]_{V_1^+(l_1)=0}$$ → **Output reflection coefficient with input properly terminated**

$$S_{21} = \left.\frac{V_2^-(l_2)}{V_1^+(l_1)}\right]_{V_2^+(l_2)=0}$$ → **Forward transmission coefficient with output properly terminated**

$$S_{12} = \left.\frac{V_1^-(l_1)}{V_2^+(l_2)}\right]_{V_1^+(l_1)=0}$$ → **Reverse transmission coefficient with input properly terminated**