Final Exam Review

- \( \Gamma_L \), load voltage reflection coefficient
  - definition: \( \Gamma_L = \frac{V_0^-}{V_0^+} \)
  - also known by: \( \Gamma_L = \frac{(Z_L - Z_0)}{(Z_L + Z_0)} \)
    (Magnitude and phase angle of load reflection function of only \( Z_0 \) and \( Z_L \), just like before.)
  - in polar form: \( \Gamma_L = |\Gamma_L| e^{j\Theta_L} \); where \( |\Gamma_L| = \sqrt{r_e^2 + i m^2} \) and \( \Theta_L = \arctan\left(\frac{im}{r_e}\right) \)
  - we also see that: \( Z_L = Z_0 \left[\frac{(1 + \Gamma_L)}{(1 - \Gamma_L)}\right] \)

- Reflections from short, open and \( Z_0 \) terminated lines
  - Repetition period for standing waves is \( \lambda/2 \)
  - Voltage maximums coincide with current minimums
  - Voltage and current maximums and minimums are \( \lambda/4 \) apart
  - The standing wave does not move. Points of \( V_{\text{max}} \) and \( V_{\text{min}} \) are fixed.
  - \( |\Gamma_L| \) is 1 for short and open, 0 for \( Z_0 \) terminated lines
  - \( SWR = \frac{|V_{\text{max}}|}{|V_{\text{min}}|} = \frac{V^+(1 + |\Gamma_L|)}{V^+(1 - |\Gamma_L|)} \); ratio of min to max voltages on line
  - \( SWR \) varies from 1 to \( \infty \); \( SWR = 1 \) indicates maximum power transfer
  - An \( SWR \) of infinity indicates a completely reactive, shorted or open load, \( |\Gamma_L| = 1 \)
  - It then follows that: \( \Gamma_L = \frac{SWR - 1}{SWR + 1} \)

- Distances from load to voltage (or current) minimum and maximums \( z'_{\text{min}} \), \( z'_{\text{max}} \)
  - Voltage maximums are found: \( \beta z'_{\text{max}} = \frac{\Theta_L}{2} = n\pi \); \( n = 0, 1, 2... \)
  - Voltage minimums are found: \( \beta z'_{\text{min}} = \frac{\Theta_L}{2} = \frac{\pi}{2} + n\pi \); \( n = 0, 1, 2... \)
  - Observations
    * We find that the standing wave is offset (in \( z' \)) from the load by \( \frac{\Theta_L}{2} \);
    * For inductive loads, the voltage is rising as you move away from the load
    * For capacitive loads, the voltage is falling as you move away from the load
    * If \( z' \) comes out negative (beyond load), simply come out \( \lambda/2 \) back onto the line
Input impedance of open and short circuited lines

- Lossless: \( Z_{in}(z') = Z_0 \left[ \frac{Z_L + jZ_0 \tan(\beta z')}{Z_0 + jZ_L \tan(\beta z')} \right] \)

- Lossy: \( Z_{in}(z') = Z_0 \left[ \frac{Z_L + Z_0 \tanh(\gamma z')}{Z_0 + Z_L \tanh(\gamma z')} \right] \)

- \( Z_{in} \) is always totally reactive except at resonance \( \frac{\lambda}{4} \) or \( \frac{\lambda}{2} \)

- \( Z_{in} = Z_0 j \tan(\beta z') \implies \) Short circuited line

- \( Z_{in} = -Z_0 j \cot(\beta z') \implies \) Open circuited line

- Inductive reactance: \( X_L = 2\pi f L \)

- Capacitive reactance: \( X_C = \frac{1}{2\pi f C} \)

- Observations
  * Very short shorted lines look like inductors
  * Very short open lines look like capacitors

Smith Chart

- Prime center is totally resistive and equal to system impedance or admittance
- Middle horizontal line is the real (resistive) axis, no reactance
- Outer circle is totally reactive, no resistive component
- Impedance: Inductor upper half \((+j)\), Capacitor lower half \((-j)\), S.C. left, O.C. right
- Admittance: Capacitor upper half \((+j)\), Inductor lower half \((-j)\), O.C. left, S.C. right
• Stub matching
  - Normalize impedance or admittance
  - Rotate towards generator on constant $\Gamma$ circle to intersect with $R = 1$ or $G = 1$ circle
  - Here, $R = Z_0$ or $G = G_0$...but any reactance/susceptance still must be canceled
  - Cancellation is made with a $\pm X$ or $\pm B$
  - Cancellation can be done with either lumped element or transmission line
  - Tline used for cancellation can be at multiple locations
  - Tline used for cancellation can be either open or shorted at its end
  - Tline used for cancellation can be connected as series or shunt element

• Series Matching Stub
  - Use impedance chart
  - Find reactance that needs cancellation at the point where $R = Z_0$
  - Starting from S.C. (left) or O.C. (right), rotate towards generator till required reactance is reached on the outer circle (pure reactance).
  - Note rotation required in $\lambda$. This is your stub length.

• Shunt Matching Stub
  - Use admittance chart
  - Find susceptance that needs cancellation at the point where $G = Y_0$
  - Starting from S.C. (right) or O.C. (left), rotate towards generator till required susceptance is reached on the outer circle (pure susceptance).
  - Note rotation required in $\lambda$. This is your stub length.

• $\frac{\lambda}{4}$ line matching
  - Narrow bandwidths can be a problem, but multiple, stepped transformations can help
  - Can transform real resistances only with $Z_m = \sqrt{(Z_{in} \ast Z_{out})}$
  - Can be used in conjunction with a proper length of line to transform complex impedance
    * Using impedance chart, normalize load impedance
    * Rotate towards generator on constant $\Gamma$ circle to intersect with the axis of reals
    * Note distance in $\lambda$. This is the distance to the $\frac{\lambda}{4}$ line
    * Attach $\frac{\lambda}{4}$ line of impedance $Z_m = \sqrt{(Z_{in} \ast Z_{out})}$ to this point
    * Connect system impedance line from other end of $\frac{\lambda}{4}$ to generator