Lecture Outline

• Why use impedance matching?
• Two element impedance matching
• Example 1
• Single stub impedance matching
• Example 2
Why use impedance matching?
Why use impedance matching?

- Maximum power delivered
- Improved SNR
- Reduce amplitude and phase errors in power distribution networks
- Consider factors such as complexity, frequencies of operation, ease of implementation, and behavior with variable loads.
Two Element Impedance Matching
Two-Element Matching

*L Network*

The most common impedance matching circuit is the *L* network.

1. \( Z_L \) inside \( 1 + jx \)

2. \( Z_L \) outside \( 1 + jx \)
Example 1
Example 1 – L Network Impedance Matching

Solution
1. Normalize load impedance

\[ z_L = \frac{Z_L}{Z_0} = 2 - j1 \Omega \]

\( z_L \) is located inside the \( 1 + jx \) circle, so option 1 is chosen.
Solution
3. The admittance of $z_L$ is

$$y_L = 0.4 - j0.2 \ \Omega$$

since the first element is in parallel, we move along the ADMITTANCE circle to intersect the $1 + jx$ circle. The element will be a shunt capacitor of value $jb = j0.29$
Solution
4. Now we move along the IMPEDANCE circle to the center of the chart. The element will be a series inductor of value $jx = +j1.23$
Solution

5. Now we obtain the values for the circuit elements:

\[ C = \frac{b}{2\pi f Z_0} = 0.923 \text{ pF} \]

\[ L = \frac{x Z_0}{2\pi f} = 39.15 \text{ nH} \]
Another Solution
1. We can also walk along the ADMITTANCE circles in the other direction to intersect the $1 + jx$ circle. This will yield a shunt inductor with $jb = -j0.69$.
Example 1 – Another Solution

2. Now we walk along the IMPEDANCE circle to the center of the chart. This will yield a series capacitor with $jx = -1.22$
Example 1 – Another Solution

3. Now we obtain the values for the circuit elements:

\[ C = \frac{-1}{2\pi f x Z_0} = 2.609 \text{ pF} \]

\[ L = -\frac{Z_0}{2\pi f b} = 46.13 \text{ nH} \]
Single Stub Impedance Matching
What is Stub Tuning? (1 of 6)

Power is reflected due to an impedance mismatch.

\[ \Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} \]
It is desired to add a short circuit stub to match the impedance.

\[ \Gamma = 0 \]
Back off from the load until the real part of the input admittance is \(1/Z_0\).

At this point, the real part of admittance is matched to the transmission line.
It is possible to perfectly match to this admittance by introducing a shunt element with the conjugate susceptance.

\[ Y_{in} = Z_0^{-1} \]

\[ Y_{SA} = -jB_A \]
To realize this shunt susceptance with a short-circuit stub, back off some distance $\ell_A$ from a short circuit load until the input admittance is $-jB_A$.

This is the stub.
Last, add the stub at position $d_A$ from the load to cancel the susceptance of the load.

The load is matched and there will be zero reflection!
Single-Stub Tuning

Example – Step 1

Problem:
A 50 Ω transmission line with an air-core operates at 100 MHz and is connected to a load impedance of $Z_L = 27.5 + j35$ Ω. Design a single-stub tuner.

Step 1 – Normalize impedance and calculate $\lambda$.

$$z_L = \frac{Z_L}{Z_0} = \frac{27.5 + j35 \, \Omega}{50 \, \Omega} = 0.55 + j0.7$$

$$\lambda = \frac{c_0}{nf} \approx \frac{3 \times 10^8 \, \text{m/s}}{(1.0)(100 \times 10^6 \, \text{Hz})} = 3 \, \text{m}$$
Single-Stub Tuning

Example – Step 2

Plot impedance and find admittance.

We read

\[ z_L = 0.55 + j0.7 \, \Omega \]
\[ y_L \approx 0.70 - j0.88 \, \Omega^{-1} \]
Walk CW around the constant VSWR circle until the $1 + jb$ circle intersects it.

We read

$y_A \approx 1 + j1.1$

$y_B \approx 1 - j1.1$

We will pick A because it leads to the shortest stub.
How far CW did we traverse to get to A?

\[0.416\lambda - 0.113\lambda = 0.303\lambda\]

\[d_A \approx 0.303\lambda\]

\[d_A \approx 90.9 \text{ cm}\]
Single-Stub Tuning

Example – Step 4

\( \gamma_A \) is the admittance where the stub is about to be placed. We chose point A.

\[ \gamma_A \approx 1 + j1.1 \]

\[ \gamma_{SA} = -j1.1 \]

We need to cancel the reactive component \( \chi_A \) of this.
Find the $-j\chi_A$ circle on the chart and follow it to the outside of the chart.

$\gamma_{SA} = -j1.1$

We are setting up to do an admittance transformation in the stub to realize a $-j1.1$ input admittance.
Start at the far left side of the chart and move CW to the point above (move away from short).

Here we are doing an admittance transformation to realize $-j1.1$. 
Determine the distance (in wavelengths) this represents. This is $l_A$.

$$l_A = 0.118\lambda$$

$$l_A = 0.118(3 \text{ m})$$

$$= 0.354 \text{ m} = \boxed{35.4 \text{ cm}}$$