Coupled-Line Couplers

Two transmission lines in proximity to each other will couple power from one line into another.

This proximity will modify the electromagnetic fields (and thus modify voltages and currents) of the propagating wave, and therefore alter the characteristic impedance of the transmission line!

Generally, speaking, we find that this transmission lines are capacitively coupled (i.e., it appears that they are connected by a capacitor):

Figure 7.26 (p. 337)
Various coupled transmission line geometries. (a) Coupled stripline (planar, or edge-coupled). (b) Coupled stripline (stacked, or broadside-coupled). (c) Coupled microstrip.
If the two transmission lines are \textit{identical} (and they typically are), then $C_{11} = C_{22}$.

Likewise, if the two transmission lines are identical, then a \underline{plane of circuit symmetry} exists. As a result, we can analyze this circuit using \textit{odd/even mode} analysis!

Note we have divided the $C_{12}$ capacitor into \textbf{two series} capacitors, each with an \textbf{at value} $2C_{12}$.
**Odd Mode**

If the incident wave along the two transmission lines are **opposite** (i.e., equal magnitude but 180° out of phase), then a virtual **ground plane** is created at the plane of circuit symmetry.

Thus, the capacitance per unit length of each transmission line, in the **odd** mode, is thus:

\[ C_o = C_{11} + 2C_{12} = C_{22} + 2C_{12} \]

and thus its characteristic impedance is:

\[ Z_0^o = \sqrt{\frac{L}{C_o}} \]
**Even Mode**

If the incident wave along the two transmission lines are equal (i.e., equal magnitude and phase), then a virtual open plane is created at the plane of circuit symmetry.

Note the $2C_{12}$ capacitors have been “disconnected”, and thus the capacitance per unit length of each transmission line, in the even mode, is thus:

$$C_e = C_{11} = C_{22}$$

and thus its characteristic impedance is:

$$Z_0^e = \sqrt{\frac{L}{C_e}}$$