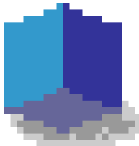
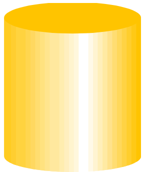
EEC 603
MICROWAVE ENGINEERING

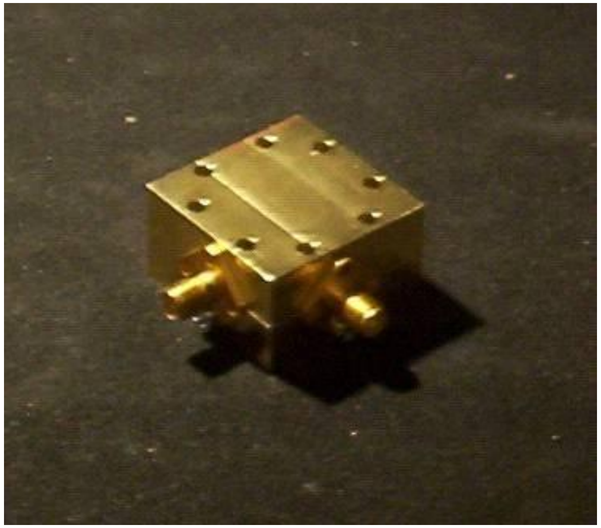
UNIT-1

Waveguide Cavities





- Cavities, or resonators, are used for storing energy
- Used in klystron tubes, band-pass filters and frequency meters
- It's equivalent to a RLC circuit at high frequency
- Their shape is that of a cavity, either cylindrical or cubical.



Cavity TM Mode to z

Solving by Separation of Variables :

$$E_z(x,y,z) = X(x)Y(y)Z(z)$$

from where we obtain :

$$X(x) = c_1 \cos k_x x + c_2 \sin k_x x$$

$$Y(y) = c_3 \cos k_y y + c_4 \sin k_y y$$

$$Z(z) = c_5 \cos k_z z + c_6 \sin k_z z$$

$$\textit{where} \quad k^2 = k_x^2 + k_y^2 + k_z{}^2$$

TM$_{mnp}$ Boundary Conditions

$$E_z = 0 \text{ at } y = 0, b$$

$$E_z = 0 \text{ at } x = 0, a$$

$$E_y = E_x = 0, \text{ at } z = 0, c$$

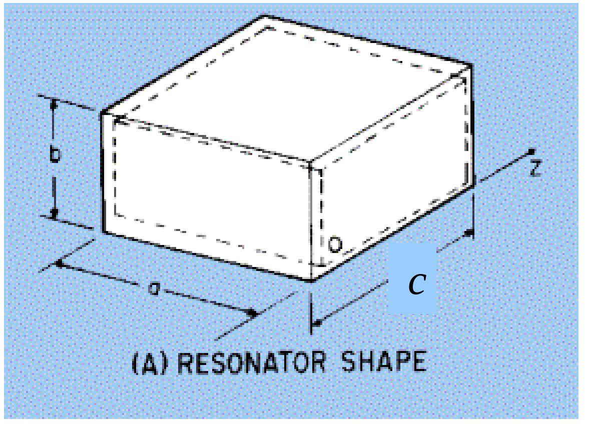
From these, we conclude:

$k_x = m\pi/a$

$k_y = n\pi/b$

$k_z = p\pi/c$

where <u>c is the dimension</u> in z-axis



$$E_z = E_o \sin\left(\frac{m\pi x}{a}\right)\sin\left(\frac{n\pi y}{b}\right)\sin\left(\frac{p\pi z}{c}\right)$$

where

$$k^2 = \left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 + \left(\frac{p\pi}{c}\right)^2 = \omega^2\mu\varepsilon$$

Resonant frequency

- The resonant frequency is the same for TM or TE modes, except that the lowest-order TM is TM_{111} and the lowest-order in TE is TE_{101}.

$$f_r = \frac{u'}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 + \left(\frac{p}{c}\right)^2}$$

Cavity TE Mode to z

Solving by Separation of Variables :

$$H_z(x, y, z) = X(x)Y(y)Z(z)$$

from where we obtain :

$$X(x) = c_1 \cos k_x x + c_2 \sin k_x x$$

$$Y(y) = c_3 \cos k_y y + c_4 \sin k_y y$$

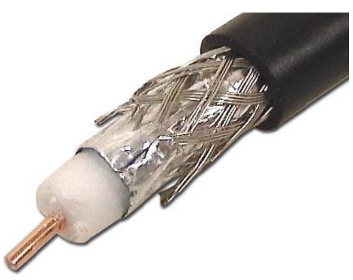
$$Z(z) = c_5 \cos k_z z + c_6 \sin k_z z$$

$$where \quad k^2 = k_x^2 + k_y^2 + k_z^{\ 2}$$

Transmission Line

Properties

- Has two conductors running parallel
- Can propagate a signal at any frequency (in theory)
- Becomes lossy at high frequency
- Can handle low or moderate amounts of power
- Does not have signal distortion, unless there is loss
- May or may not be immune to interference
- Does not have E_z or H_z components of the fields (TEM_z)

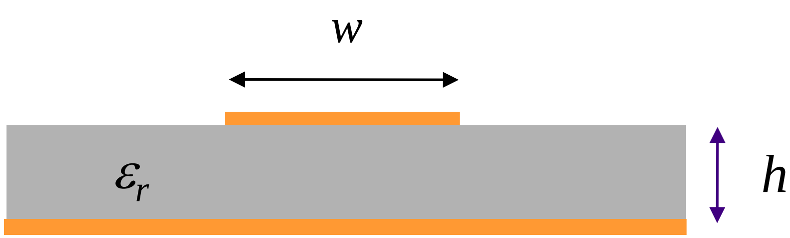


Coaxial cable (coax)

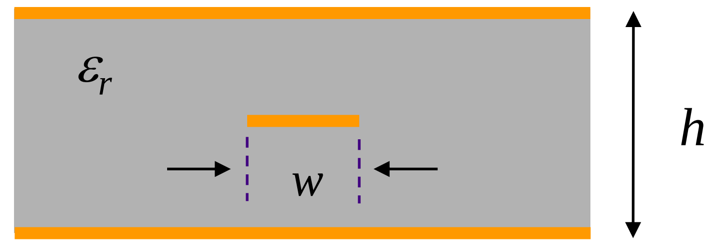
Twin lead
(shown connected to a 4:1 impedance-transforming balun)

Transmission Line (cont.)

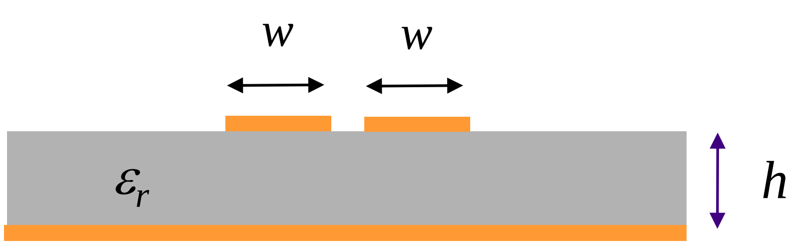
Transmission lines commonly met on printed-circuit boards



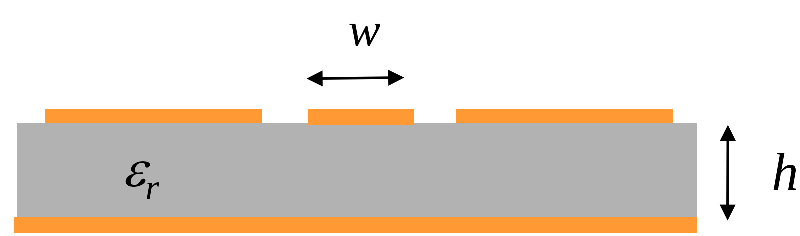
Microstrip



Stripline



Coplanar strips



Coplanar waveguide (CPW)

Transmission-Line Theory

- Lumped circuits: resistors, capacitors, inductors

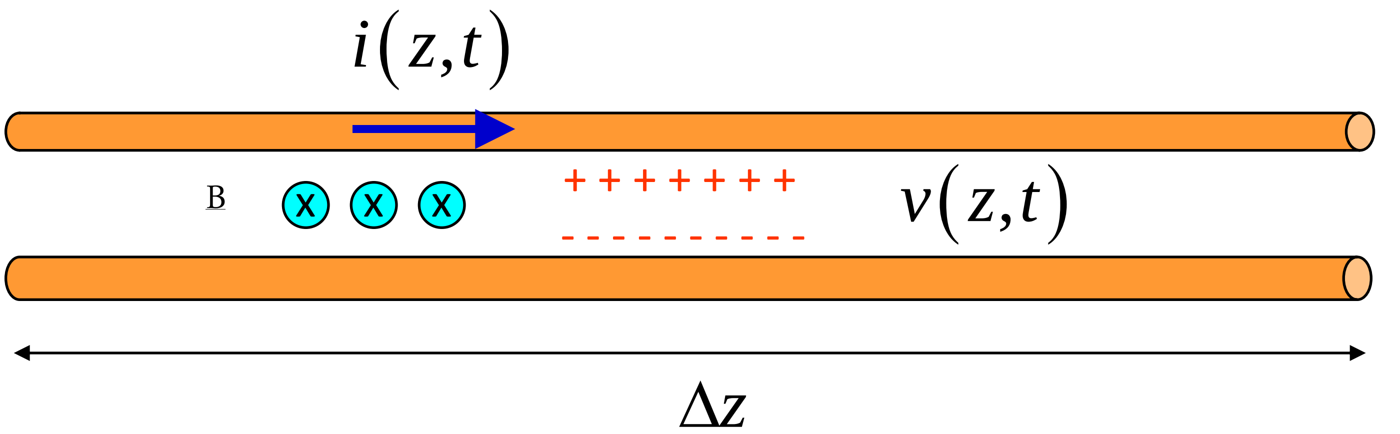
  neglect time delays (phase)

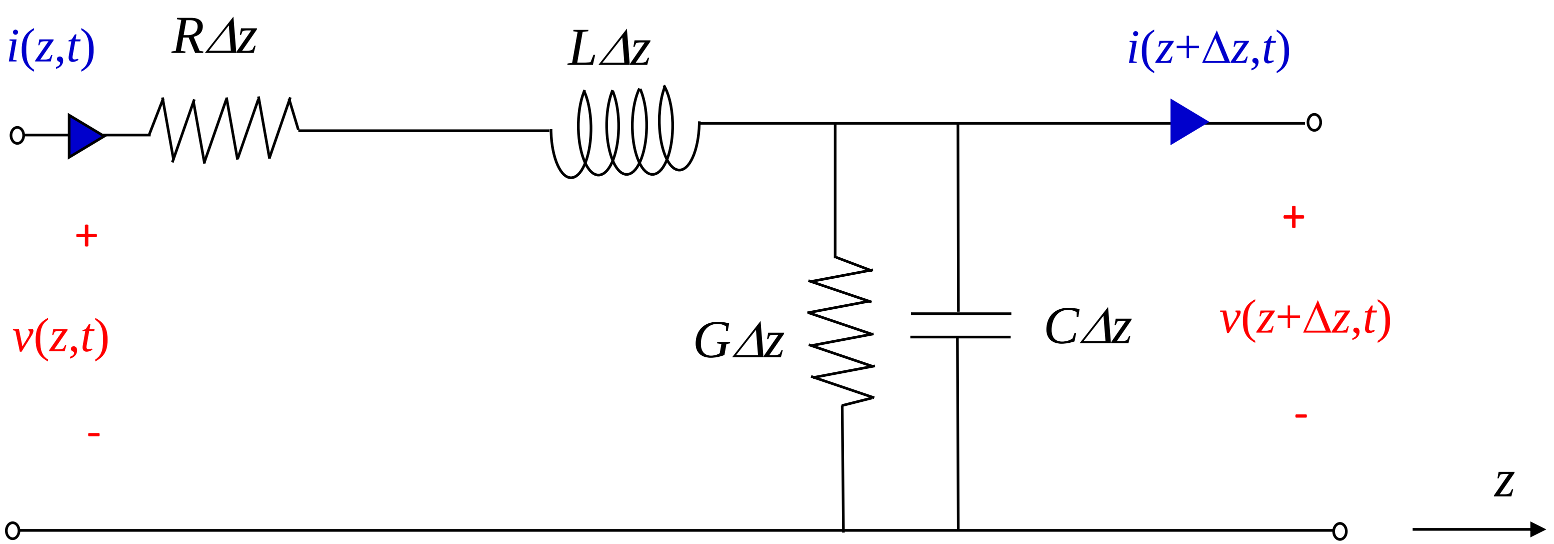
- Distributed circuit elements: transmission lines

  account for propagation and time delays (phase change)

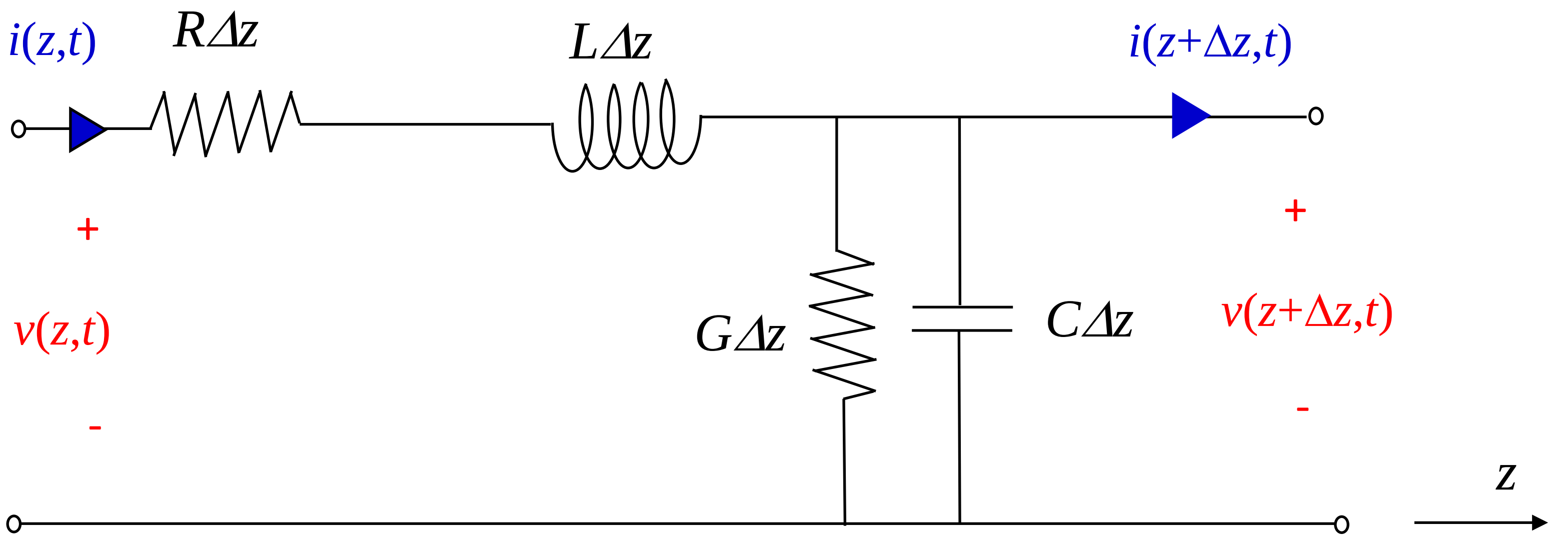
We need transmission-line theory whenever the length of a line is significant compared with a wavelength.

Transmission Line (cont.)





Transmission Line (cont.)



$$v(z,t) = v(z+\Delta z,t) + i(z,t)R\Delta z + L\Delta z\frac{\partial i(z,t)}{\partial t}$$

$$i(z,t) = i(z+\Delta z,t) + v(z+\Delta z,t)G\Delta z + C\Delta z\frac{\partial v(z+\Delta z,t)}{\partial t}$$