THE QUARTER WAVE LINE:

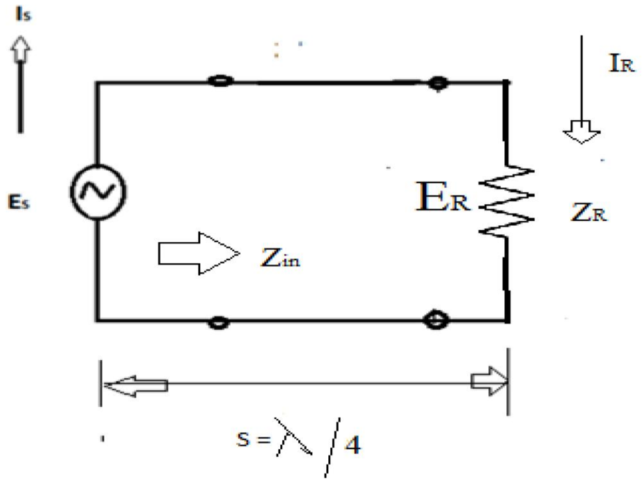

Fig: 3.1.2 Quarter wave section as a impedance inverter

Fig 3.1.2 shows the circuit diagram of a transmission line with finite length $\frac{\lambda}{4}$ the input voltage is E_s and current I_s.

The input impedance of the circuit is Z_{in}

The receiving end voltage and current is E_R and I_R.

The distance between sending and receiving end S = $\frac{\lambda}{4}$

We know, the input impedance of the lossless line is given by,

$$Z_{in} = \frac{E_S}{I_S} = R_O\left[\frac{Z_R + jR_O\tan\beta s}{R_O + jZ_R\tan\beta s}\right]$$

Sub, **S**= $\frac{\lambda}{4}$, $\beta = \frac{2\pi}{\lambda}$ in above equ,

$$Z_{in} = R_O\left[\frac{Z_R + jR_O\tan\left(\frac{2\pi}{\lambda}\right)\left(\frac{\lambda}{4}\right)}{R_O + jZ_R\tan\left(\frac{2\pi}{\lambda}\right)\left(\frac{\lambda}{4}\right)}\right]$$

$$Z_{in} = R_O\left[\frac{Z_R + jR_O\tan\left(\frac{\pi}{2}\right)}{R_O + jZ_R\tan\left(\frac{\pi}{2}\right)}\right]$$

$$Z_{in} = R_O\frac{\tan\left(\frac{\pi}{2}\right)}{\tan\left(\frac{\pi}{2}\right)}\left[\frac{\frac{Z_R}{\tan\left(\frac{\pi}{2}\right)} + jR_O}{\frac{R_O}{\tan\left(\frac{\pi}{2}\right)} + jZ_R}\right]$$

$$Z_{in} = R_O\left[\frac{\frac{1}{\infty} + jR_O}{\frac{1}{\infty} + jZ_R}\right]$$

$$Z_{in} = \frac{{R_O}^2}{Z_R}$$

The input impedance equation is similar to the equation of transformer.

Thus the quarter wave line can be used as a transformer for impedance matching to the load Z_R with input impedance z_{in}.

A quarter wave transformer can transfer low impedance into high impedance and vice versa.

So, it can be considered as impedance inverter. The short circuit quarter wave line behaves like a open circuit in the other end.

While, the open circuited quarter wave line will behave like short circuit in the other end.

APPLICATION:

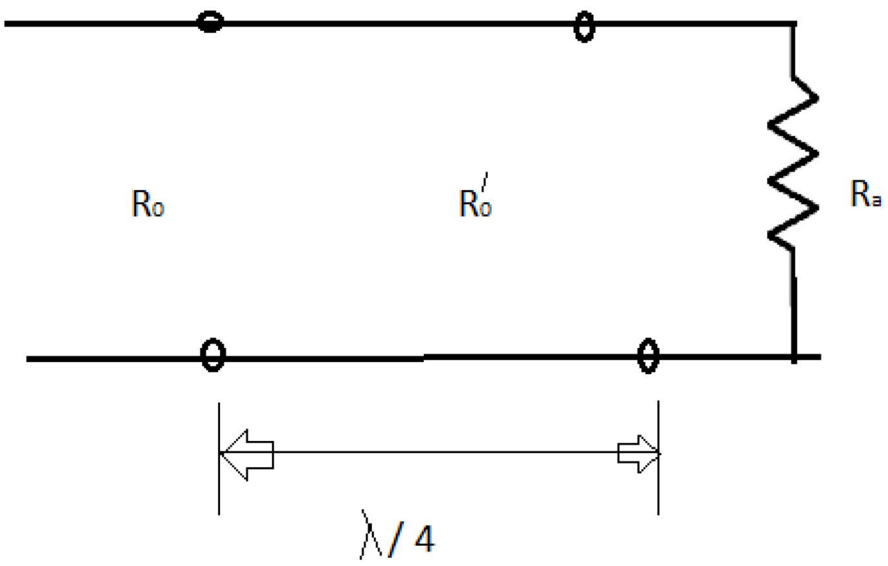

Fig: 3.1.3 Quarter wave line as-insulator

In Fig 3.1.3 the major application of $\frac{\lambda}{4}$ line is impedance transformer is coupling a transmission line to a resistive load such as an antenna. From the input impedance equation of $\frac{\lambda}{4}$ line.

$$Z_{in} = \frac{R_O^2}{Z_R}$$

If antenna is a load having a resistance of $\boldsymbol{R_a}$ the quarter wave section is designed such that its characteristic impedance $\boldsymbol{R'_O}$ transforms antenna resistance $\boldsymbol{R_a}$ to the characteristic impedance of the line $\boldsymbol{R_O}$.

$$\boldsymbol{R_O = \frac{R'^2_O}{R_a}}$$

$$\boldsymbol{R'^2_O = R_O R_a}$$

$$\boldsymbol{R'_O = \sqrt{R_O R_a}}$$