1.) Transmission lines, due to their long length, introduce an appreciable amount of phase shift in the electromagnetic waves. Hence, voltage and current signals obtained at the end of a big transmission line tend to be smaller in amplitude.

This is explained here -

An electromagnetic wave in power transmission lines can be expressed in the following form

$$V_s(z) = V_0^+ e^{-\gamma z} + V_0^- e^{\gamma z}$$

In time-domain form, $V(z,t) = Re\left[V_s(z) e^{j\omega t}\right]$

$$= Re\left[V_0^+ e^{j(\omega t - \gamma z)} + V_0^- e^{j(\omega t + \gamma z)}\right]$$

$$= V_0^+ e^{-\alpha z} \cos(\omega t - \beta z) \qquad \boxed{\gamma = \alpha + j\beta}$$

$$+ V_0^- e^{\alpha z} \cos(\omega t + \beta z).$$

Among these, $V_0^+ e^{-\alpha z}\cos(\omega t - \beta z)$ travels in the positive z-direction and $V_0^- e^{\alpha z} \cos(\omega t + \beta z)$ travels in the negative z-direction.

Taking the positive z-direction travelling wave,

considering lossless line, $\alpha = 0$.

$$VP = V_0^+ \cos(\omega t - \beta z)$$

$\beta = \frac{\omega}{v_p} \simeq \frac{\omega}{c}$ (If the medium is air).

$$= V_0^+ \cos\left(\omega t - \frac{\omega z}{c}\right).$$

Now considering length of a line, $(z = l)$.

$$VP(\text{at } z = l) = V_0^+ \cos\left(\omega t - \frac{2\pi}{\lambda} \cdot \frac{l}{c}\right).$$

$V^P(\text{at } z=l) = V_0^+ \cos\left(\frac{2\pi v}{\lambda} t - \frac{2\pi . l}{\lambda c}\right).$

Now, if the right hand term $\left(\frac{2\pi l}{\lambda c}\right)$ is appreciably high,

$V^P(\text{at } z=l)$ will be much lower than $V^P(\text{at } z=0)$.

$V^P(\text{at } z=0) = V_0^+ \cos\left(\frac{2\pi}{\lambda} . t\right).$

Hence, $\frac{2\pi l}{\lambda c}$ must be smaller for a wire not to show transmission line behaviour. Since, c (velocity of light) is constant, l/λ should be low enough.

A Thumb rule says that if $l/\lambda \gtrsim 0.01$, the wire shows transmission line behaviour.

(a) $l/\lambda = 0.01 \Rightarrow l = 0.01\lambda = 0.01 \frac{v}{f} = 0.01 . \frac{c}{f}$

$= 0.01 \times \frac{3 \times 10^8}{1.8 \times 10^9}$

$= 1.6667$ mm

b) ~~~~ If $l/\lambda = 0.0001$, the travelling wave doesnot behave like a transmission line at all.

$\therefore l = 0.0001\lambda = 0.0001(c/f) = 0.0001 \times \frac{3 \times 10^8}{1.8 \times 10^9}$

$\simeq 16.6667\,\mu m.$

2:)

(a) Transmission line parameters

resistance $R(\Omega/m) \Rightarrow$ It represents real power loss in conductors.

inductance $L(H/m) \Rightarrow$ Inductance in line conductors.

Conductance $G(S/m) \Rightarrow$ Power loss in lossy dielectrics.

Capacitance $C(F/m) \Rightarrow$ Capacitance formed between line conductors and ground (in insulators).

(b) For a lossless transmission line, resistance$(R) = 0$

For lossless dielectrics, conductance$(G) = 0$.

3:) Coaxial cable

Inner radius $(a) = 0.8\,mm$

Outer radius $(b) = 2.6\,mm$

$\sigma_c = 5.28 \times 10^7\, S/m$.

$\mu_c = \mu_0, \epsilon_c = \epsilon_0$.

Dielectric.

$\sigma = 10^{-5}\, S/m,\ \mu = \mu_0,\ \epsilon = 3.5\epsilon_0$

$f = 80\,MHz$.

$$\text{Skin Depth } (\delta) = \frac{1}{\sqrt{\pi f \mu_c \sigma_c}} = \frac{1}{\sqrt{\pi \times 80 \times 10^6 \times 4\pi \times 10^{-7} \times 5.28 \times 10^7}}$$

$$= 7.7438 \times 10^{-6}\, m.$$

Resistance (Ω/m)

$$= \frac{1}{2\pi\delta\sigma_c}\left(\frac{1}{a} + \frac{1}{b}\right) = \frac{1}{2\pi \times 7.74 \times 10^{-6} \times 5.28 \times 10^7}\left(\frac{1}{0.8 \times 10^{-3}} + \frac{1}{2.6 \times 10^{-3}}\right)$$

$$= 0.636\, \Omega/m.$$

Inductance $L(H/m) = \frac{\mu}{2\pi}\ln\frac{b}{a} = \frac{4\pi\times10^{-7}}{2\pi}\ln(2.6/0.8)$

$= 2.35\times10^{-7}$ H/m

$= 235.7$ nH/m.

Conductance $G(H/m) = \frac{2\pi\sigma}{\ln b/a}$

$= \frac{2\pi\times10^{-5}}{\ln(2.6/0.8)} = 5.33\times10^{-5}$ s/m

$= 53.30\ \mu s/m$.

Capacitance $C(F/m) = \frac{2\pi\epsilon}{\ln b/a} = \frac{2\pi\times3.5\times8.854\times10^{-12}}{\ln(2.6/0.8)}$

$= 1.65\times10^{-10}$ F/m

$= 165$ pF/m.

4.) $V_0 = 10V$.

A travelling transmission line wave can be expressed as →

$V(z,t) = V_0 e^{-\alpha z}\cos(\omega t - \beta z + \phi_p) + V_0\cos(\omega t - \beta z + \phi_n)e^{\alpha z}$

↓ Travelling in (+ve) z direction

↘ Travelling in (−ve) z direction.

$VP(z,t) = V_0 e^{-\alpha z}\cos(\omega t - \beta z)$ $[\because \phi p = 0]$

$\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \sqrt{(0.636 + j2\pi\times80\times10^{6}\times2.35\times10^{-7})(5.33\times10^{-5} + j2\pi\times80\times10^{6}\times1.65\times10^{-10})}$

$= \sqrt{(0.636 + j118.12)(5.33\times10^{-5} + j0.082)}$

$= \sqrt{9.68\angle179.654^\circ} = 3.111\angle89.827^\circ$

$\gamma = 3.111 \angle 89.827^\circ$

$= 9.39 \times 10^{-3} + j\, 3.1099.$

$\therefore \boxed{\begin{array}{l} \alpha = 9.39 \times 10^{-3} \\ \beta = 3.1099 \end{array}}$

$\therefore\ V_P(z,t) = 10\, e^{-0.00939 z} \cos(\omega t - 3.11 z).$