Department of Electrical Engineering
Assignment
Date: 17/04/2020

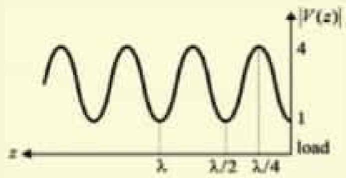
Course Details

Course Title:	Antennas & Wave Propagation	**Module:**	
Instructor:		**Total Marks:**	30

Student Details

Name:	Ibkar Ali	**Student ID:**	13008

Q1. (a) Voltage standing wave pattern in a lossless transmission line with characteristic impedance 50 Ω and resistive load is shown in the figure. — Marks 6, CLO 2



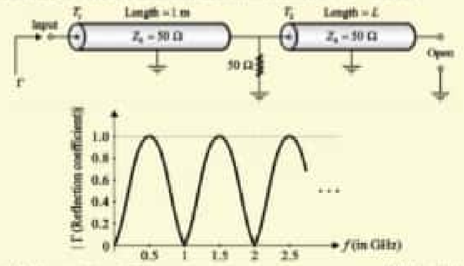
Qu. The value of the load resistance is

(A) 50 Ω (B) 200 Ω

(C) 12.5 Ω (D) 0

(b) Draw & Explain Equivalent circuit model of a Transmission line — Marks 4, CLO 1

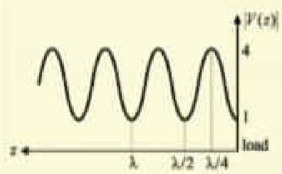
Q2. (a) A microwave circuit consisting of lossless transmission lines T_1 and T_2 is shown in the figure. The plot shows the magnitude of the input reflection coefficient Γ as a function of frequency f. The phase velocity of the signal in the transmission lines is 2×10^8 m/s. — Marks 6, CLO 2



The length L (in meters) of T_2 is ______. [Set - 02]

(b) Derive transmission line equation and describe what it says — Marks 4, CLO 1

Q3. (a) Voltage standing wave pattern in a lossless transmission line with characteristic impedance 50 Ω and resistive load is shown in the figure. — Marks 4, CLO 2



Qu. The reflection coefficient is given by

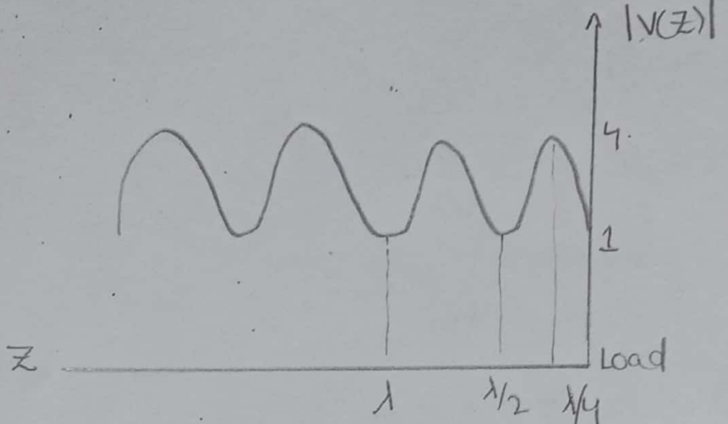
(A) −0.6 (B) −1

(C) 0.6 (D) 0.2

(b) Explain two Impedance Matching techniques in detail? — Marks 6, CLO 2

Q1)

(a) Voltage standing wave pattern in a lossless transmission line with characteristics impedance 50 Ω and resistive load as shown in figure.



Solution:

Given Data:

$Z_0 = 50\,\Omega$

$V_{max} = 4$

$V_{min} = 1$

Required Data:

$Z_L = ?$

S. wave ratio = ?

As we know that

$$\text{S. wave ratio} = \frac{V_{max}}{V_{min}} \quad \text{—(1)}$$

Putting values in eq (1)

$$= \frac{4}{1}$$

S. wave ratio = 4

Now find Z_L

$$\text{S. wave ratio} = \frac{Z_0}{Z_L}$$

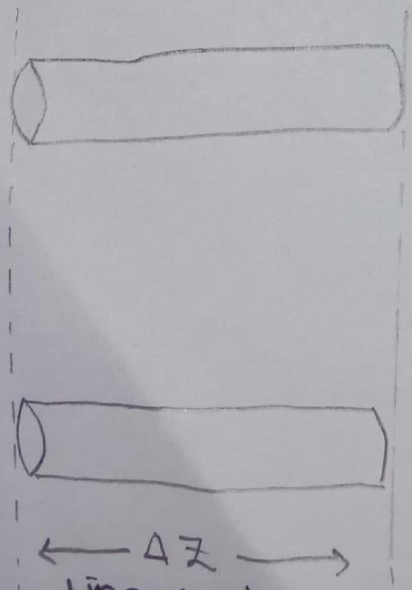
$$Z_L = \frac{Z_0}{\text{S. wave ratio}} \quad \text{—(2)}$$

Putting values in eq –(2)

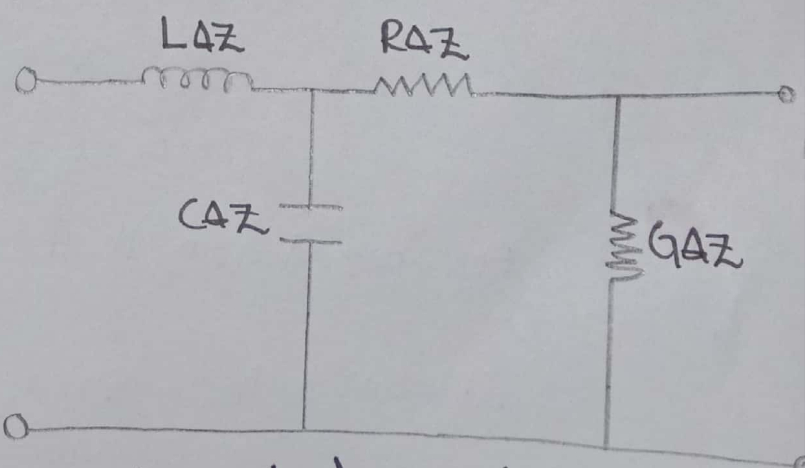
$$Z_L = \frac{50}{4}$$

$Z_L = 12.5\ \Omega$ Answer.

(b) Draw and explain Equivalent circuit model of a transmission line.

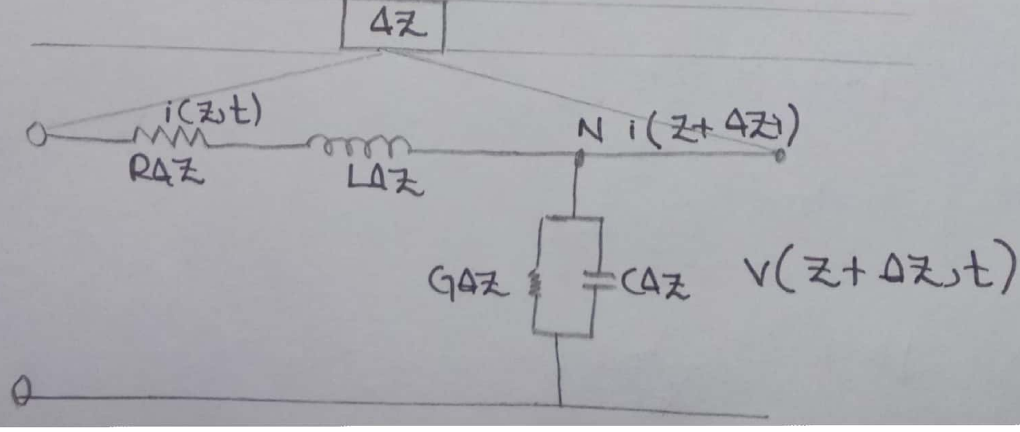


Line section



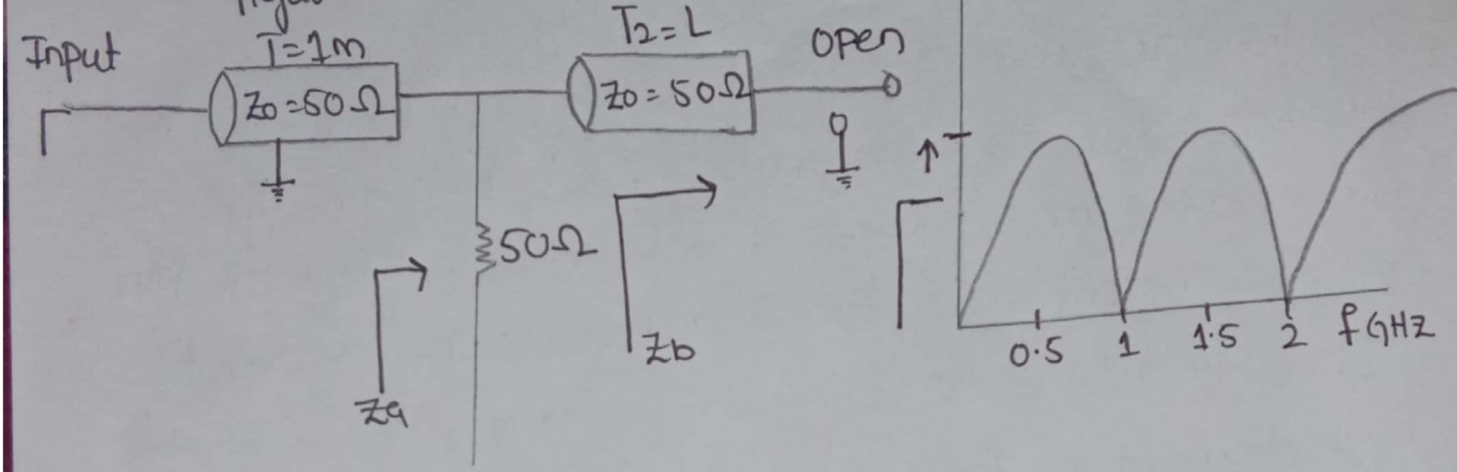
Equivalent circuit

R, L, G, C are primary line constants.
Since the voltage and current of a transmission line vary with position z (and time t). we have no characterize it by a "distributed" circuit model. consider an infinitesimal line of length Δz, the current set up magnetic field between the conductors (by Ampere's law) causing magnetic flux. When current are time-varying. so the magnetic flux and a voltage variation along the conductor electromotive force (emf) is induced in an attempt to derive the current oppositely. This behaviour can be modeled by a series inductor $\left[V = L\frac{d}{dt}i\right]$.
Mean while two seperated conductor form a capacitor. Since the upper and lower conductors of adjacent infinitesimal lines are connected respectively, the capacitive behaviour of an infinitesimal lines can be modeled by a shunt capacitor. In the presence of imperfect conducting and imperfect Insulating materials, voltage drop along the conducting line and leakage current between them exist, which can be modeled by a series resistor and a shunt conductor respectively.



Equivalent circuit

Q2) (a) A microwave circuit consisting of lossless transmission lines T_1 and T_2 is shown in figure....



solution :-

As we know that

$$\Gamma = \frac{Z_L - Z_o}{Z_L + Z_o}, \quad f = 1\,GHz$$

In this case $\Gamma = 0$

$Z_a = 50\,\Omega$

$Z_b = jZ_o \cot \beta L$

$Z_{eq} = Z_a \| Z_b = 50\,\Omega$

Here

$Z_b = \alpha$

so

$$Z_b = -jZ_o \cot \frac{2\pi}{\lambda} \cdot L$$

Putting values of Z_o

$$Z_b = -j50 \cot \frac{2\pi}{\lambda} \cdot L$$

if

$$\cot \frac{2\pi}{\lambda} \cdot L = \alpha$$

and if $L = \lambda/2$

so $\cot \frac{\cancel{2}\pi}{\cancel{\lambda}} \cdot \frac{\cancel{\lambda}}{\cancel{2}} = \alpha$

Now

$$L = \lambda/2$$

$$V_P = 2\times10^8$$

$$V_P = \omega/\beta$$

$$\frac{\omega}{\beta} = 2\times10^8$$

$$= \frac{\cancel{2}\pi f \times \lambda}{2\pi} = 2\times10^8$$

At $f = 1\,GHz$

$$\lambda = \frac{2\times10^8}{1\times10^9}$$

$$\lambda = 0.2m$$

Now

$$L = \lambda/2$$

$$= 0.2/2$$

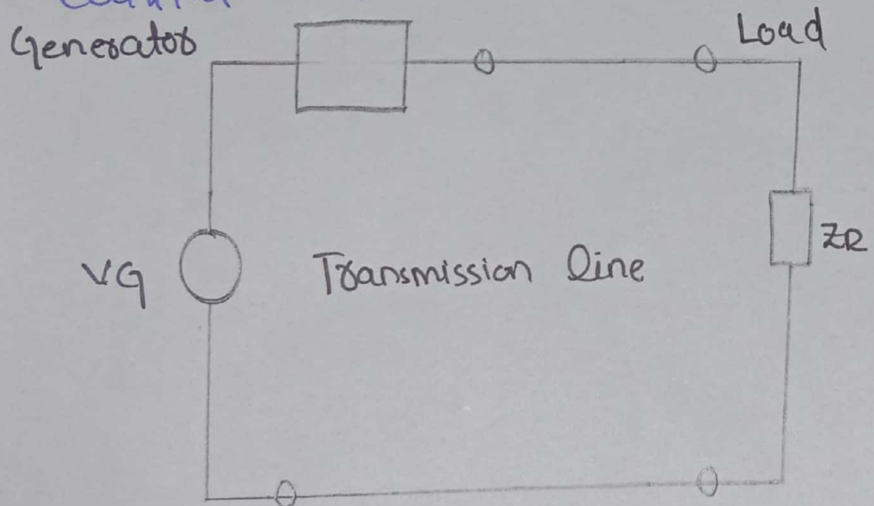
$$L = 0.1m \text{ Ans.}$$

(b) Derive transmission line equation and describe what it says?

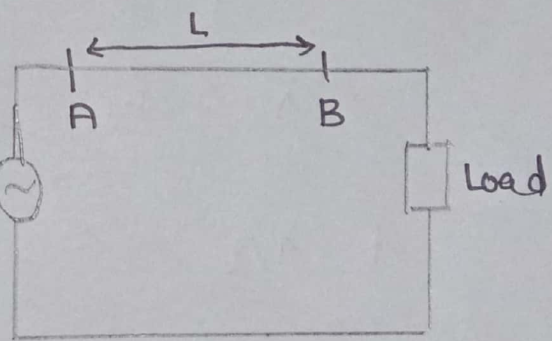
Ans)

Transmission line equation:

A Typical engineering Problem involves the transmission of a signal from a generator to a load. A transmission line is the part of the circuit that provides the direct link between generator and load. Transmission line can be realized in a number of ways. Common examples are parallel-wire line and the coaxial cables.



Transit Time effect:



$T >> t_r$

$T >> \frac{l}{v}$

$\frac{1}{f} >> \frac{l}{v}$

$\frac{v}{f} >> l$

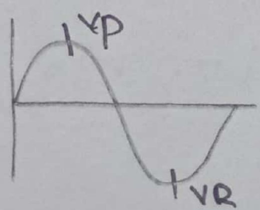
$\boxed{\lambda >> l}$

$t_r = \frac{l}{v}$

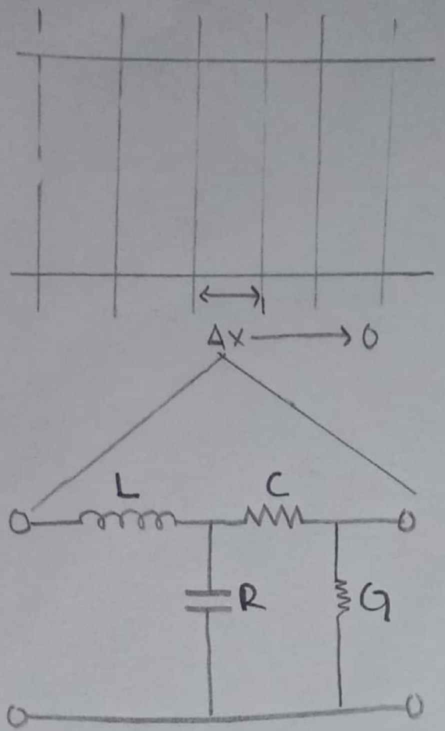
l = length

v = velocity

T = Time period of signal



Primary constant of Transmission line :



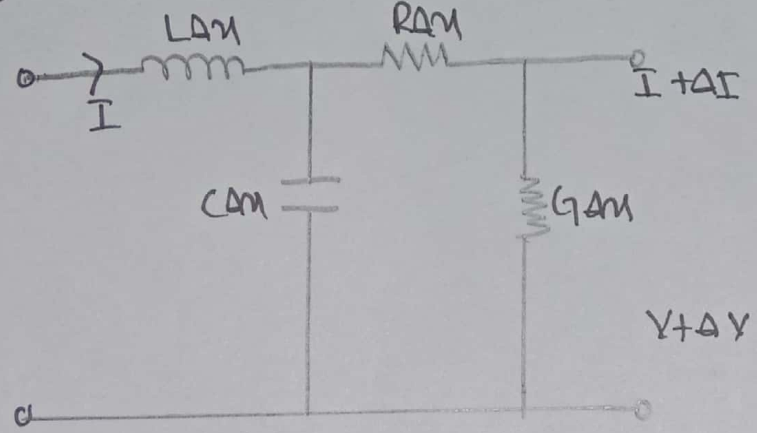
$L \to H/m$

$C \to F/m$

$R \to \Omega/m$

$G \to ℧/m$

Transmission line equation :



solution

$$\Delta I = -(G\Delta x + j\omega C\Delta x)V$$

$$\lim_{x \to 0} \frac{\Delta I}{\Delta x} = -(G + j\omega C)V$$

$$\frac{dI}{dx} = -(G + j\omega C)V \text{ —— (1)}$$

$$\Delta V = -(R\Delta x + j\omega L\Delta x)I$$

$$\lim_{\Delta x \to 0} \frac{\Delta V}{\Delta x} = -(R + j\omega L)I$$

$$\frac{dV}{dx} = -(R + j\omega L) I \quad \text{—— (2)}$$

again derivative:

$$\frac{d^2V}{dx^2} = -(R + j\omega L)\frac{dI}{dx}$$

$$\frac{d^2V}{dx^2} = (R + j\omega L)(G + j\omega C) V$$

As we know that

$$(R + j\omega L)(G + j\omega C) = \gamma^2$$

$$\boxed{\frac{d^2V}{dx^2} = \gamma^2 V}$$

Now

$$V(x,t) = (V^+ e^{-\gamma x} + V^- e^{+\gamma x}) e^{j\omega t}$$

$$= V^+ e^{-j\beta x} e^{j\omega t} + V^- e^{j\beta x} e^{j\omega t}$$

$$= V e^{+j(\omega t - \beta x)} + V e^{-j(\omega t + \beta x)}$$

Now we know that

$$\vec{E} = E_0 e^{-\alpha z} \cos(\omega t - \beta z)\hat{x}$$

$$\vec{E} = E_0 \cos(\omega t - \beta z)\hat{x} \quad \{\text{Loss less land}\}$$

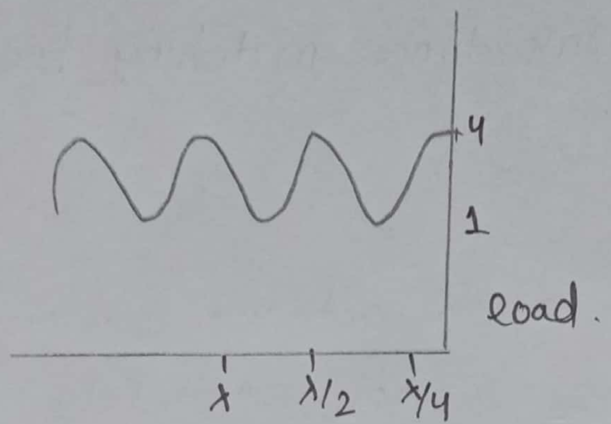
wave equation

$$V(x,t) = V^+ \cos(\omega t - \beta x) + V^- \cos(\omega t + \beta x)$$

travelling $+x$ direction — travelling $-x$ direction

Voltage & current in a transmission line behave like a wave.

Q3) (a) Voltage standing wave pattern in a lossless transmission line with characteristics impedance 50Ω and resistive load is shown in figure.



Solution:

Given data:

$Z_0 = 50\ \Omega$

$Z_L = 12.5\Omega$

Required = ?

Reflective-co-efficient = ?

So We know that

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} \quad -(1)$$

Putting values in eq (1)

$$\Gamma = \frac{12.5 - 50}{12.5 + 50}$$

$$= \frac{-37.5}{62.5}$$

$\Gamma = -0.6$ Ans.

(b) Explain two impedance matching techniques in detail =?

Ans) The operation of an antenna system over a frequency range is not completely dependent upon the frequency response of the antenna element it self but rather on the frequency characteristics of the transmission line - antenna element combination.

↳ In practice, the characteristics Impedance of the transmission line is usually real whereas that of the antenna element is complex. Also the variation of each as a function of frequency is not the same.

TYPES

1) stub Matching

2) Quarter - wavelength Transformer

1) stub Matching :-

Ideal matching at a given frequency can be accomplished by placing a short or open circuited shunt a distance from the transmission line antenna element connection.

↳ Assuming a real characteristics Impedance the length is controlled so as to make the real Part of the antenna element Impedance equal to the characteristics Impedance.

↳ A single stub with a variable length cannot always match all antenna (load). impedance. A double stub arrangment positioned a fixed distance from the load with the length of each stub variable and seperated by a constant length will match a greater range of antenna impedance.

2) Quarter-wavelength Transformer :-

1) single section

2) Multiple section

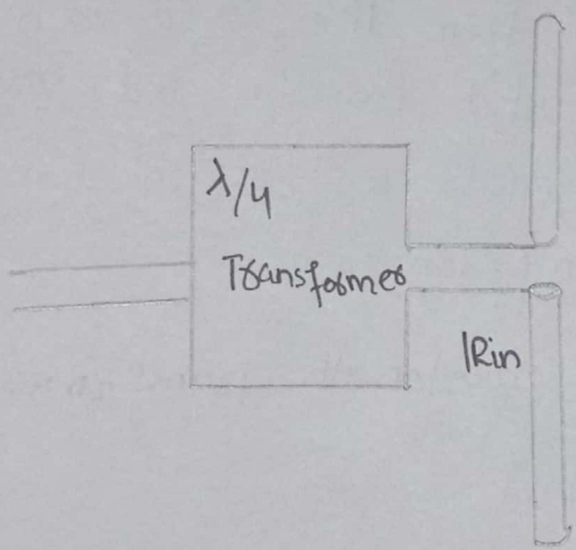
3) Binomial design.

1) single section:

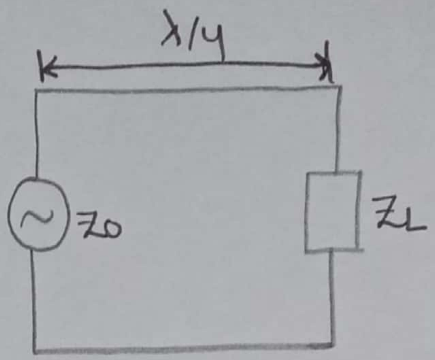
Another technique that can be used to match the antenna to the transmission line is to use a $\lambda/4$ transformer. If the impedance of the antenna is real, the transformer is attached directly to the load.

↳ However if the antenna impedance is complex the transformer is placed a distance away from the antenna. The distance is choosen so that input impedance towards the load is real and designated as R_{in}.

↳ The transformer is usually another transmission line with the desired characteristics impedance.



Input Impedance of $\lambda/4$ Length of transmission Line :



$$\beta l = \frac{2\pi}{\lambda} \times \frac{\lambda}{4}$$

$$= \pi/2$$

$$\boxed{Z_{in} = \frac{Z_0^2}{Z_L}}$$

$$Z_{in} = Z_0 \left\{ \frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l} \right\}$$

$$Z_{in} = Z_0 \frac{\cancel{\tan \beta l} \left\{ \overset{0}{\cancel{\frac{Z_L}{\tan \beta l}}} + jZ_0 \right\}}{\cancel{\tan \beta l} \left\{ \overset{0}{\cancel{\frac{Z_0}{\tan \beta l}}} + jZ_L \right\}}$$

$$Z_{in} = Z_0 \times \frac{jZ_0}{jZ_L} = \frac{Z_0^2}{Z_L}$$