

Module 2 : Transmission Lines

Lecture 17 : Measurement of characteristics parameters of various lines

Objectives

In this course you will learn the following

- Practical measurement of transmission line parameters.
- Various types of transmission lines.
- Formulae for characteristic impedance of various transmission lines.

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Measurement of Line Parameters Z_0 and γ

- The transmission line calculations need two parameters γ and Z_0 . Although these parameters can be obtained from the primary constants of the line, it is rather difficult to measure the primary constants. We therefore directly measure the primary constants γ and Z_0 for a line. Here in general we assume that the line has a finite loss and therefore γ and Z_0 are complex.
- Take any arbitrary length of the line say, L , and measure the input impedance Z_{oc} and Z_{sc} (technique for measuring impedance has been described earlier) of the line with its other end open and short respectively.

$$\begin{aligned}Z_{oc} &= Z_0 \coth \gamma L \\Z_{sc} &= Z_0 \tanh \gamma L\end{aligned}$$

This gives

$$\begin{aligned}Z_0^2 &= Z_{sc} Z_{oc} \\ \Rightarrow Z_0 &= \sqrt{Z_{sc} Z_{oc}}\end{aligned}$$

and

$$\tanh \gamma L = \sqrt{\frac{Z_{sc}}{Z_{oc}}} \equiv A \text{ (say)}$$

Expanding $\tanh \gamma L$ we get

$$\begin{aligned}\frac{e^{\gamma L} - e^{-\gamma L}}{e^{\gamma L} + e^{-\gamma L}} &= A \\ \Rightarrow e^{2\gamma L} &= \frac{1+A}{1-A} \equiv R e^{j\theta} \text{ (say)} \\ \Rightarrow e^{2\alpha L} e^{j2\beta L} &= R e^{j(\theta \pm 2m\pi)}\end{aligned}$$

$$\begin{aligned}\alpha &= \frac{1}{2L} \ln R = \frac{1}{2L} \ln \left| \frac{1+A}{1-A} \right| \\ \beta &= \frac{1}{2L} (\theta \pm 2m\pi) = \frac{1}{2L} \left[\angle \left(\frac{1+A}{1-A} \right) \pm 2m\pi \right]\end{aligned}$$

The α has a unique value but there is ambiguity in the measurement of β

- The ambiguity in β can be resolved either by choosing a length L less than $\lambda/2$, or by multifrequency measurements. For the first choice, $L < \lambda/2$ and therefore $m = 0$ giving

$$\beta = \frac{1}{2L} \angle \left(\frac{1+A}{1-A} \right)$$

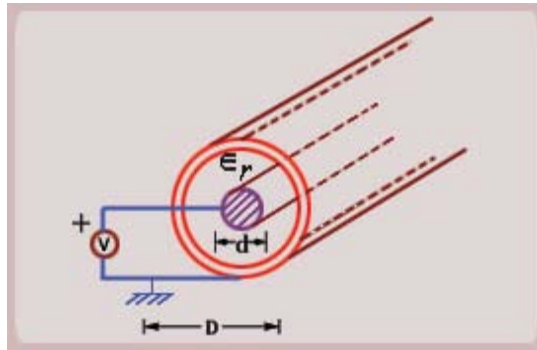
Note

- It should be noted however that due to short length the calculation of α becomes inaccurate for low loss lines.

Various Types of Transmission Lines

(A) Co-axial Cable

- The co-axial cable transmission line is as shown in Figure. The outer conductor is a hollow circular cylinder and the inner conductor is generally a circular rod. The volume between the two conductors is filled with a dielectric material like teflon or perspex etc.



- The characteristic impedance of a coaxial cable is given as

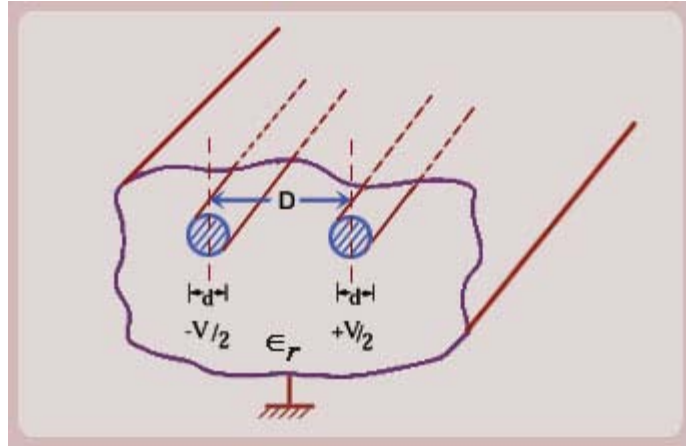
$$Z_0 = \frac{138}{\sqrt{\epsilon_r}} \log_{10} \left(\frac{D}{d} \right)$$

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(B) Parallel Wire Transmission Line

A parallel wire transmission line consists of two similar conducting circular rods separated by a dielectric (or air) as shown in Figure. The whole structure can be encapsulated in a plastic shell or can be kept open. Due to symmetry, the ground is floating for this configuration and one can assume the potential on the two conductors to be equal and opposite with respect to some hypothetical ground point.



The characteristic impedance for a parallel wire line is given by ($D \gg d$)

$$Z_0 = \frac{276}{\sqrt{\epsilon_r}} \log \frac{2D}{d}$$

Note

Since D is large compared to d , the characteristic impedance of this line is typically few hundred ohms. This line therefore finds application in those cases where high impedances are required.

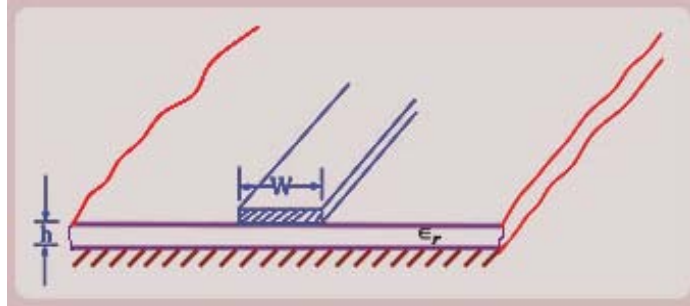
Two standard parallel wire lines of 300Ω and 600Ω are commonly used in telephone networks and antenna feeder systems.

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(C) Microstrip Transmission Line

- This transmission line consists of an infinitely large conducting plane and a flat metal strip placed at a distance from it (Figure). The region between the conducting plane and the strip may be filled with a dielectric.



- The characteristic impedance for this line is approximately given as

$$Z_0 \approx \frac{377}{\sqrt{\epsilon_r} [(W/h) + 2]}$$

- This type of transmission lines are encountered in high frequency printed circuits. The characteristic impedance generally lies in a range which is compatible with the co-axial cables.

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Recap

In this course you have learnt the following

- Practical measurement of transmission line parameters.
- Various types of transmission lines.
- Formulae for characteristic impedance of various transmission lines.

Congratulations! You have finished Module 2. To view the next Module select it from left hand side of the page.