Transmission Lines

TECH 3812

Professor Kohn

THE UNIVERSITY OF MEMPHIS.

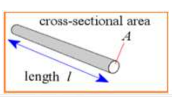
1

Resistance and Resistivity

For a wire of length l and cross-sectional area A the resistance R:

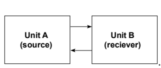
- ***Is proportional to l***
- ***And inversely proportional to A***
- ***The constant ρ (rho)***
- ***Is known as the resistivity.***

$$R = \rho \frac{l}{A}$$

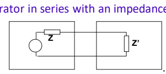


2

Characterize the signal transferred between two modules



Thevenin's theorem tells us that each unit can be modeled by voltage generator in series with an impedance



If we want to maximize the transfer of

Current → |Z'| << |Z|

Voltage→ |Z'| >> |Z|

Power→ |Z'| = |Z|

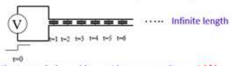
This is OK if the signals are slow and the system small

3

But with high speed signals

we have to consider the finite signal speed.

High speed signal lines are called transmission lines. They are often implemented as coaxial cables.



Each unit length **dx** of the transmission cable must have a capacitance **ΔC/dx**

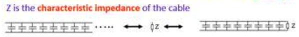
If we generate a **v** pulse at the time **t=0** it will propagate along the transmission line

Each unit time a capacitor is charged with the charge **Cv** (C=Q/V)

Thus we need a constant current **i= Cv /dt**

I.e. the transmission line behaves like an impedance with value **Z=dt/C**

Z is the **characteristic impedance** of the cable



This is called **terminating** the finite transmission line so that it behaves like it was infinite

4

Self Inductance

Self-inductance is usually just called inductance, symbolized by *L*.

Self-inductance is a measure of a coil's ability to establish an induced voltage as a result of a change in its current.

The induced voltage always opposes the change in current, which is basically a statement of Lenz's law.

The unit of inductance is the **henry** (**H**). One henry is the inductance of a coil when a current, changing at a rate of one ampere per second, induces one volt across the coil.

5

Lenz's Law

Recall Lenz's law states,

When the current through a coil *changes*, an induced voltage is created across the coil that always opposes the change in current.

In a practical circuit, the current can change because of a change in the load as shown in the following circuit example...

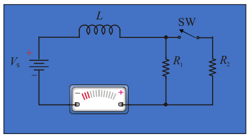
6

Summary

Lenz's law

A basic circuit to demonstrate Lenz's law is shown.

Initially, the SW is open and there is a small current in the circuit through L and R_1.



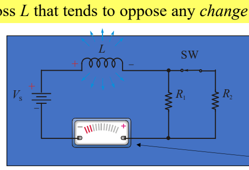
THE UNIVERSITY OF MEMPHIS.

7

Summary

Lenz's law

SW closes and immediately a voltage appears across L that tends to oppose any *change* in current.



Initially, the meter reads same current as before the switch was closed.

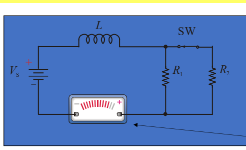
THE UNIVERSITY OF MEMPHIS.

8

Summary

Lenz's law

After a time, the current stabilizes at a higher level (due to I_2) as the voltage decays across the coil.

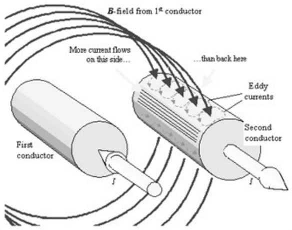


Later, the meter reads a higher current because of the load change.

THE UNIVERSITY OF MEMPHIS.

9

Proximity Effect via Eddy Current

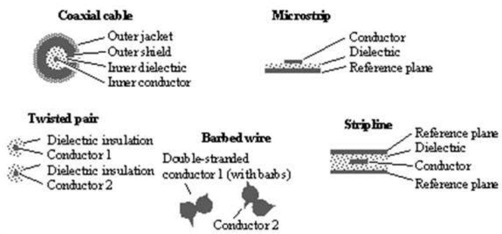


10

THE UNIVERSITY OF MEMPHIS

10

Transmission Line Structures

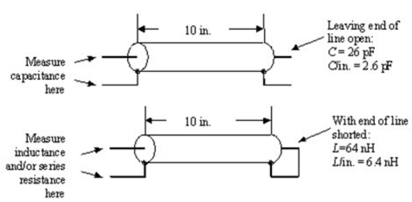


11

THE UNIVERSITY OF MEMPHIS

11

LC Measurement



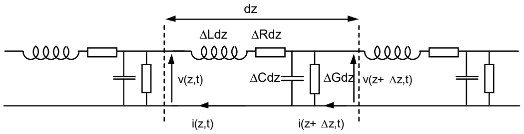
12

THE UNIVERSITY OF MEMPHIS

12

Model of a Transmission Line

Were we include the inductance and resistance along the cable and the conductance across.



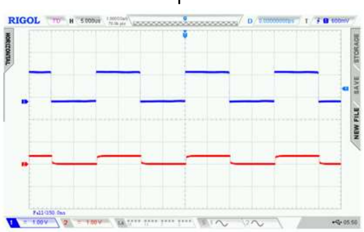
Model for transmission lines

13

Resistive Affect on a Square Wave

Input

Output

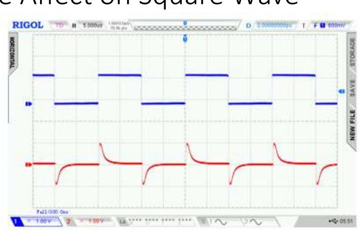


14

Inductive Affect on Square Wave

Input

Output

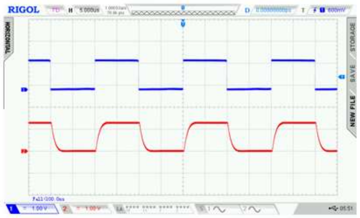


15

Capacitive Affects on a Square Wave

Input

Output



16

Lab Demo

- See Lab #1

17