Professor Viviana Bibin Koshy

Transmission Systems

Homework #1

* 1. Calculate the free-space wavelength in meters for the following frequencies:
1. 2 kHz

$$λ=\frac{c}{f}=\frac{3\*10^{8}}{2\*10^{3} }=150 Km $$

1. 2000 kHz

$$λ=\frac{c}{f}=\frac{3\*10^{8}}{200\*10^{3} }=1.5 Km $$

1. 20 MHz

$$λ=\frac{c}{f}=\frac{3\*10^{8}}{20\*10^{6} }=15 m $$

1. 2 GHz

$$λ=\frac{c}{f}=\frac{3\*10^{8}}{2\*10^{9}}=150 mm $$

* 1. Calculate the free-space wavelength in meters for the following frequencies:
1. 80 kHz

$$λ=\frac{c}{f}=\frac{3\*10^{8}}{80\*10^{3} }=3.75 Km $$

1. 8 MHz

$$λ=\frac{c}{f}=\frac{3\*10^{8}}{8\*10^{36} }=37.5 m $$

1. 800 MHz

$$λ=\frac{c}{f}=\frac{3\*10^{8}}{8\*10^{6} }=375 mm $$

1. 8 GHz

$$λ=\frac{c}{f}=\frac{3\*10^{8}}{800\*10^{9} }=37.5 mm $$

* 1. Calculate the free-space wavelength in miles for a frequency of 400 Hz.

$$λ=\frac{c}{f}=\frac{186\*10^{3}}{400 }=465 mi $$

* 1. Calculate the free-space wavelength in miles for a frequency of 1.5 kHz.

$$λ=\frac{c}{f}=\frac{186\*10^{3}}{1.5 }=124 mi $$

* 1. A sinusoidal signal has a free-space wavelength of 80 m. Calculate the frequency.

$$f=\frac{c}{λ}=\frac{3\*10^{8} }{80 m}=3.75 MHz$$

* 1. A sinusoidal signal has a free-space wavelength of 6 m. Calculate the frequency.

$$f=\frac{c}{λ}=\frac{3\*10^{8} }{6 m}=50 MHz$$

* 1. A digital signal utilizes pulse whose minimum widths are about 3 ns. Assuming the speed of light, determine the longest lengths of wire-pairs that can be allowed based on the 10% rule.

t = 0.1 \* 3 ns =300 ps

d= c\* t 1 = (3 \* 108 ) \* (300 ps) = 9 cm

* 1. The longest connecting wires in a digital system are about 20 cm. Assuming the speed of light, determine the shortest acceptable pulse width based on the 10% rule.

t =$\frac{.2}{3\*10^{8}}$= 6.67 \*10-10

pulse width= $\frac{6.67 \*10^{-10}1}{.1}$= 6.67 \* 109 s

* 1. A communication system operates at a frequency of 800 MHz. Assuming the speed of light, determine the length of connecting line that could be used without considering frequency-domain effects based on the 10% rule.

$$λ=\frac{c}{f}=\frac{3\*10^{8}}{800\*10^{6} }=375 mm $$

* 1. The length of a connecting cable between two points in a radio-frequency system is 50 cm. Assuming the speed of light, determine the highest operating frequency that should be used without considering frequency-domain effects based on the 10% rule.

$$f=\frac{c}{λ}=\frac{3\*10^{8} }{.5 m}=600 MHz$$

* 1. In a coil, a current of 100 mA results in a magnetic flux of 50$μWb.$ Determine the inductance.

$$Inductance=\frac{Flux (Wb)}{Current(A)}=\frac{50\*10 ^{-6}Wb}{100\*10 ^{-3}A}=500\*10 ^{-6}H$$

* 1. A current of 4 mA is flowing in a 20- $μ$H coil. Determine the magnetic flux.

$Flux (Wb)$= Current \* Inductance = (4 mA \*20 $μ$H) = 8\* 10-8 H

* 1. In a capacitor, a voltage of 20 V results in charge storage of 5 $μ$C. Determine the capacitance.

$$Capacitance=\frac{Charge}{Voltage}=\frac{5 \*10 ^{-6}C}{20 v}=.25 \*10 ^{-6}F$$

* 1. A capacitance of 40 $μ$F is charged to a voltage of 12 V. Determine the electric charge.

$$Charge=Capacitance\*Voltage=40\*10^{-6}\*12 v=480 \*10 ^{-6}C$$

* 1. A lossless transmission line has an inductance of 320 nH/m and a capacitance of 57 pF/m. Determine the characteristic impedance.

$$R\_{0}=\sqrt{\frac{L}{C}}=\sqrt{\frac{320 \*10 ^{-9}}{57\*10 ^{-12}}}=74.93 Ω$$

* 1. A lossless transmission line has an inductance of 1.2 $μ$ H/m and a capacitance of 15 pF/m. Determine the characteristic impedance.

$$R\_{0}=\sqrt{\frac{L}{C}}=\sqrt{\frac{1.2\*10 ^{-6}}{1.5\*10 ^{-12}}}=282.84Ω$$

* 1. The dielectric constant of mica is 6. Determine the permittivity.

ε=εr\*ε0= 6\*8.842$ \*10 ^{-12}$ = 53.02 \*10-12 F/m

* 1. The permittivity of a material is 14 \*10 -12 F/m. Determine the dielectric constant.

εr =$\frac{ε}{ε0}$ =$\frac{14\*10^{-12}}{8.842\*10^{-12}}$ =1.58

* 1. The relative permeability of nickel is 800. Determine the actual permeability.

$μ$ **=**$μ \_{r}$**\***$ μ$0

1.05 mH/m= (800\* ($4π\*10^{-7})]$)

* 1. The permeability of a ferromagnetic material is 10-4 H/m. Determine the relative permeability.

$μ \_{r}$**=**$\frac{μ }{μ0}$ **=** $\frac{10^{-4}}{4π\*10^{-7}}$ **=79.58**

* 1. Determine the velocity of propagation of the transmission line of Problem 1-15.

$V=\sqrt{\frac{1}{L\*C}}$ $=\sqrt{\frac{1}{320 \*10 ^{-9}\*57\*10 ^{-12}}}$ =2.34 \*108 m/s

* 1. Determine the velocity of propagation of the transmission line of Problem 1-16.

$V=\sqrt{\frac{1}{L\*C}}$ $=\sqrt{\frac{1}{1.2 \*10 ^{-6}\* 15\*10 ^{-12}}}$ =2.36 \*108 m/s

* 1. The dielectric constant in a transmission line is 4.7, and $μ$=$ μ$0. Determine the velocity of propagation.

**V**= $\frac{C}{√εr}$ =$\frac{3\*10^{8}}{√4.7}$ =1.38 \* 108 m/s

* 1. The dielectric constant in a certain transmission line is 3, and $μ$=$ μ$0.  Determine the velocity of propagation.

**V**= $\frac{C}{√εr}$ =$\frac{3\*10^{8}}{√3}$ =1.73\* 108 m/s

* 1. A coaxial cable has the following specifications: R0 = 73$Ω$, and velocity of propagation =2.1 \*108 m/s. Determine L and C.

$L=\sqrt{\frac{R\_{0}}{V}}$ = $\sqrt{\frac{73}{2.1 \*10^{8}}}$ =347 \*10-9

$C=\sqrt{\frac{1}{ V\* R\_{0}}}$ =$\sqrt{\frac{1}{2.1\*10 ^{8}\*73}}$ = $65.23\*10 ^{-12}$

* 1. A coaxial cable has the following specifications: R0 = 150$Ω$, and velocity factor =0.8. Determine L and C.

$L=\sqrt{\frac{R\_{0}}{V\*c}}$ = $\sqrt{\frac{150}{.8\*(3\*10^{8})}}$ =625 $\*10 ^{-9} H/m$

$C=\sqrt{\frac{1}{ V\* R\_{0}}}$ =$\sqrt{\frac{1}{73\*(2.4\*10^{8})}}$ = 8$ μF/m$

* 1. The lower end of the commercial amplitude-modulation (AM) band is about 550 kHz. AM stations use “ quarter-wave” vertical antennas whose lengths are .25$λ$. Determine he length in meters of a vertical antenna operating at the lower end.

$λ=\frac{c}{f}=\frac{3\*10^{8}}{550\*10^{3} }$ =545.45

.25$ λ$ =.25\*545.45 = 136.36 m

* 1. The upper end of a commercial AM band to in Problem 1-27 is about 1610 kHz. Determine the length in meters of a vertical antenna operating at the upper end.

$λ=\frac{c}{f}=\frac{3\*10^{8}}{1610 }$ =186.34 \* 103 m

* 1. One popular simple antenna is the “half-wave” horizontal antenna whose theoretical length is .5λ at the operating frequency. In practice, however, the antenna is usually shortened by about 5% due to end effects. Determine the practical length in meters for a half-wave antenna to provide optimum reception at the lower end of the commercial FM band, which is about 88 MHz.

$λ=\frac{c}{f}=\frac{3\*10^{8}}{ 88\*10^{3}}$=3.409 m

.5\*3.409 = 1.705 m

1.705-(1.7045\*.05) =1.6193 m

* 1. Based on the discussion of problem 1-29, determine the practical length in meters for a half-wave antenna to provide optimum reception at the upper end of the FM band, which is about 108 MHz.

$λ=\frac{c}{f}=\frac{3\*10^{8}}{ 108\*10^{6}}$=2.78 m

.5\*2.78 = 1.4 m

1.4-(1.4\*.05) =1.33 m

* 1. Show that the free-space velocity light in feet/second is very close to c=984 \*10­6 ft/s.
	2. Show that the free-space wavelength in feet can be expressed as

$$λ (ft)=\frac{982}{f(MHz)}$$

you may use the result of Problem 1-31.