**Homework 2**

1-1 Calculate the free-space wavelength in meters for the following frequencies:

1. 2KHz

$$λ=\frac{c}{f}=\frac{3x10^{8}m/s}{2x10^{3}Hz}=1.5x10^{5}m$$

1. 200KHz

$$λ=\frac{c}{f}=\frac{3x10^{8}m/s}{2x10^{5}Hz}=1.5x10^{3}m$$

1. 20MHz

$$λ=\frac{c}{f}=\frac{3x10^{8}m/s}{20x10^{6}Hz}=15m$$

1. 2GHz

$$λ=\frac{c}{f}=\frac{3x10^{8}m/s}{2x10^{9}Hz}=0.15m$$

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

1. 80KHz

$$λ=\frac{c}{f}=\frac{3x10^{8}m/s}{80x10^{3}Hz}=3750m$$

1. 8MHz

$$λ=\frac{c}{f}=\frac{3x10^{8}m/s}{8x10^{8}Hz}=37.5m$$

1. 800MHz

$$λ=\frac{c}{f}=\frac{3x10^{8}m/s}{800x10^{6}Hz}=0.375m$$

1. 8GHz

 $$λ=\frac{c}{f}=\frac{3x10^{8}m/s}{8x10^{9}Hz}=37.5x10^{-3}m$$

1-3 Calculate the free-space wavelength in miles for a frequency of 400 Hz

$$λ=\frac{c}{f}=\frac{186000mi/s}{400Hz}=465mi$$

1-4 Calculate the free-space wavelength in miles for a frequency of 1.5KHz

$$λ=\frac{c}{f}=\frac{186000mi/s}{1.5x10^{3}Hz}=124mi$$

1-5 A sinusoidal signal has a free-space wavelength of 80m. Calculate the frequency.

$$λ=\frac{c}{f} f=\frac{c}{λ}=\frac{3x10^{8}m/s}{80}=3.75KHz$$

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

$$λ=\frac{c}{f} f=\frac{c}{λ}=\frac{3x10^{8}m/s}{6}=50MHz$$

1-7 A digital signal utilizes pulses whose minimum widths are about 3ns. Assuming the speed of light, determine the longest lengths of wire-pairs that can be allowed based on the 10% rule.

$$t\_{1}=0.1 x 3ns=0.3ns$$

$$t\_{1}=\frac{d}{c}= d=t\_{1} x c=(3x10^{8}m/s)x (0.3x10^{-9}m/s)=0.09m$$

1-8 The longest connecting wires in a digital system are about 20cm. Assuming the speed of light, determine the shortest acceptable pulse width based on the 10% rule.

$$t\_{1}=\frac{d}{c}=\frac{0.2m}{3x10^{8}m/s}=66.6x10^{-8}s=66ns$$

$$t\_{1}=10\% x w= w=\frac{t\_{1}}{10\%}=\frac{66.6x10^{-8}s}{0.1}=666ns$$

1-9 A communication system operates at a frequency of 800MHz. 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.

$$λ=\frac{c}{f}=\frac{3x10^{8}m/s}{800x10^{6}Hz}=375mm$$

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

$$λ=\frac{c}{f} f=\frac{c}{λ}=\frac{3x10^{8}m/s}{0.5}=600MHz$$

1-11 In a coil, a current of 100mA results in a magnetic flux of 50μWb. Determine the inductance.

$$H=\frac{β}{I}=\frac{50μWb}{100mA}=\frac{50x10^{-6}Wb}{100x10^{-3}A}=0.5H$$

1-12 A current of 4mA is flowing in a 20μH coil. Determine the magnetic flux.

$$H=\frac{β}{I} β=HxI=\left(20x10^{-6}H\right)x\left(4x10^{-3}A\right)=80nWb $$

1-13 In a capacitor, a voltage of 20 V results in charges storages of 5μC. Determine the capacitance.

$$F=\frac{charge(c)}{voltage (V)}=\frac{5x10^{-6} Col}{20V}=250nF$$

1-14 A capacitance of 40μF is charged to a voltage of 12V. Determine the electric charge.

$$F=\frac{charge(c)}{voltage (V)} c=F x V=\left(40x10^{-6} F\right)x\left(12V\right)=48mCol$$

1-15 A lossless transmission line has an inductance of 320 nH/m and a capacitance of 57pF/m. Determine the characteristic impedance.

$$R\_{ο}=\sqrt{\frac{L}{C}}=\sqrt{\frac{320x10^{-9}H/m }{57x10^{-12} F/m}}=\sqrt{5614}=74.92Ω$$

1-16 A lossless transmission line has an inductance of 1.2 μH/m and a capacitance of 15pF/m. Determine the characteristic impedance.

$$R\_{ο}=\sqrt{\frac{L}{C}}=\sqrt{\frac{1.2x10^{-9}H/m }{57x10^{-12} F/m}}=\sqrt{80000}=282.84Ω$$

1-17 The dielectric constant of mica is 6. Determine the permittivity.

$$\in =\in \_{r}x \in \_{°}=6 x (8.842x10^{-12}F/m)=53.051 x10^{-2}F/m$$

1-18 The permittivity of a material is 14x10-12F/m. Determine the dielectric constant.

$$\in =\in \_{r}x \in \_{°} \in \_{r}=\frac{\in }{\in \_{°}}=\frac{14x10^{-12}F/m}{8.842x10^{-12}F/m} =1.35 $$

1-19 The relative permeability of nickel is 800. Determine the actual permeability.

$$μ=μ\_{r} x μ\_{ο}=800 x (4πx10^{-7}H/m)=1mH/m$$

1-20 The permeability of a ferromagnetic material is 10-4H/m. Determine the relative permeability.

$$μ=μ\_{r} x μ\_{ο} μ\_{r}=\frac{μ}{μ\_{°}}=\frac{10^{-4}H/m}{4πx10^{-7}H/m} =795.78 $$

1-21 Determine the velocity of propagation of the transmission line of Problem 1-15.

$$V=\frac{1}{\sqrt{LxC}}=\frac{1}{\sqrt{(320x10^{-9}H/m)x(57x10^{-12}F/m)}}=2.34x10^{8}m/s$$

1-22 Determine the velocity of propagation of the transmission line of Problem 1-16.

$$V=\frac{1}{\sqrt{LxC}}=\frac{1}{\sqrt{(1.2x10^{-6}H/m)x(15x10^{-12}F/m)}}=2.35x10^{8}m/s$$

1-23 The dielectric constant in a transmission line is 4.7, and μ=μo. Determine the velocity of propagation.

$$\in =\in \_{r}x \in \_{°}=4.7 x (8.842x10^{-12}F/m)=41.55 x10^{-2}F/m μ=μ\_{ο}= (4πx10^{-7}H/m)$$

$$V=\frac{1}{\sqrt{μxϵ}}=\frac{1}{\sqrt{(4πx10^{-7}H/m)x(41.55 x10^{-2}F/m)}}=\frac{1}{\sqrt{5.22 x10^{-17}}}=\frac{1}{7.22 x10^{-9}}=1.38x10^{8}m/s$$

1-24 The dielectric constant in a transmission line 3, and μ=μo. Determine the velocity of propagation.

$$\in =\in \_{r}x \in \_{°}=3 x (8.842x10^{-12}F/m)=26.52 x10^{-2}F/m μ=μ\_{ο}= (4πx10^{-7}H/m)$$

$$V=\frac{1}{\sqrt{μxϵ}}=\frac{1}{\sqrt{(4πx10^{-7}H/m)x(26.52 x10^{-2}F/m)}}=\frac{1}{\sqrt{3.33 x10^{-17}}}=\frac{1}{5.77 x10^{-9}}=1.73x10^{8}m/s$$

1-25 A coaxial cable has the following specifications: Ro=73Ω, and velocity of propagation is 2.1x108m/s. Determine L and C.

$$L=\frac{R\_{ο}}{V}=\frac{73Ω}{2.1 x10^{8}m/s}=3.47 x10^{-7}H/m$$

$$C=\frac{1}{R\_{ο}V}=\frac{1}{73Ω x (2.1 x10^{8}m/s)}=65.25 x10^{-12}F/m$$

1-26 A transmission line has the following specifications: Ro=150Ω, and velocity of propagation is 0.8. Determine L and C.

$$V\_{f}=\frac{V}{c} V=V\_{f} x c=0.8 x \left(3x10^{8}\right)=2.4x10^{8}m/s$$

$$L=\frac{R\_{ο}}{V}=\frac{150Ω}{2.4 x10^{8}m/s}=5.35 x10^{-7}H/m$$

$$C=\frac{1}{R\_{ο}V}=\frac{1}{150Ω x (2.4 x10^{8}m/s)}=27.75 x10^{-12}F/m$$

1-27 The lower end of the commercial amplitude-modulation (AM) band is about 550KHz. AM stations use "quarter-wave" vertical antennas whose lengths are 0.25λ. Determine the length in meters of a vertical antenna operating at the lower end.

$$λ=\frac{c}{f} 0.25λ=\frac{3x10^{8}m/s}{550x10^{3}Hz}=545.45m$$

$$0.25λ=545.45m λ=\frac{545.45m}{0.25}=2180m $$

1-28 The upper end of the commercial AM band referred to in Problem 1-27 is about 1610KHz. Determine the length in meters of a vertical antenna operating at the upper end.

$$λ=\frac{c}{f} 0.25λ=\frac{3x10^{8}m/s}{1610x10^{3}Hz}=186.3m$$

$$0.25λ=186.3m λ=\frac{186.3m}{0.25}=745m $$

1-29 One popular simple antenna is the "half-wave" horizontal antenna whose theoretical length is 0.5λ at the operating frequency. In practice, however, the antenna is usually shorted 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

$$λ=\frac{c}{f} λ=\frac{3x10^{8}m/s}{88x10^{3}Hz}=3.4m$$

$$0.5λ=186.3m λ=\frac{186.3m}{0.5}=372.6m $$

$$λ=3.4m x 0.05=0.17 λ=3.4m x 0.17=3.22m $$

1-30 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 108MHz.

$$λ=\frac{c}{f} λ=\frac{3x10^{8}m/s}{108x10^{3}Hz}=2.77m λ=\frac{2.77}{0.5}=5.55m $$

$$λ=5.55m x 0.05=0.27 λ=5.55m x 0.27=5.27m$$

1-31Show that the free-space velocity of light in feet/second is very close to c=982x106ft/s.

$$c=3x10^{8}m/s 1ft=m x 3.2808 ?ft=\frac{\frac{3x10^{8}m}{s}}{1m}=9.8425x10^{8}$$

1-32 Show that the free-space wavelength in feet can be expressed as

$$λ(ft)=\frac{c}{f}=\frac{982}{f(mHz)}$$

$$λ=\frac{c}{f}=\frac{984.25197x10^{6}ft}{f(Hz)}x\frac{10^{-6}}{10^{6}}=\frac{984.25ft}{f\left(Mz\right)}$$

You may use the result of Problem 1-31