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Homework 2

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

$$λ=\frac{C\_{0}}{F}=\frac{3\*10^{8} m/s}{2\*10^{3} Hz}=150 Km$$

1. 200 kHz

$$λ=\frac{C\_{0}}{F}=\frac{3\*10^{8} m/s}{200\*10^{3} Hz}=1.5 Km$$

1. 20 MHz

$$λ=\frac{C\_{0}}{F}=\frac{3\*10^{8} m/s}{20\*10^{6} Hz}=15 m$$

1. 2GHz

$$λ=\frac{C\_{0}}{F}=\frac{3\*10^{8} m/s}{2\*10^{9} Hz}=150 mm$$

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

$$λ=\frac{C\_{0}}{F}=\frac{3\*10^{8} m/s}{80\*10^{3} Hz}=3.75 km$$

1. 8 MHz

$$λ=\frac{C\_{0}}{F}=\frac{3\*10^{8} m/s}{8\*10^{6} Hz}=37.5 m$$

1. 800 MHz

$$λ=\frac{C\_{0}}{F}=\frac{3\*10^{8} m/s}{800\*10^{6} Hz}=375 mm$$

1. 8 GHz

$$λ=\frac{C\_{0}}{F}=\frac{3\*10^{8} m/s}{8\*10^{9} Hz}=37.5 mm$$

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

$$λ=\frac{C\_{0}}{F}=\frac{186\*10^{3} m/s}{400 Hz}=465 mi$$

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

$$λ=\frac{C\_{0}}{F}=\frac{186\*10^{3} mi/s}{1.5 Hz}=124 mi$$

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

$$F=\frac{C\_{0}}{λ}=\frac{3\*10^{8} m/s}{80 m}=3.75 MHz$$

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

$$F=\frac{C\_{0}}{λ}=\frac{3\*10^{8} m/s}{6 m}=50 MHz$$

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

$$10\%=0.1$$

$$t\_{1}=0.1\*3 ns=300 ps$$

$$d=\left(3\*10^{8} ^{m}/\_{s}\right)\*\left(300 ps\right)=90 mm$$

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

$$d=0.2 m$$

$$t\_{1}=\frac{0.2 m}{\left(3\*10^{8} ^{m}/\_{s}\right)}=666.66 ps$$

$$Power\_{width}=\frac{666.66 ps}{0.1}=6.66 ns$$

* 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.

$$λ=\frac{C\_{0}}{F}=\frac{3\*10^{8} m/s}{800\*10^{6} Hz}=375 mm$$

* 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.

$$F=\frac{C\_{0}}{λ}=\frac{3\*10^{8} m/s}{0.5 m}=600 MHz$$

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

$$indunctance=\frac{flux}{current}=\frac{50 μWb}{100 mA}=500μH$$

* 1. A current 4 mA is flowing in a 20 $μH$ coil. Determine the magnetic flux.

$$Flux=inductance\*current=\left(20μH\right)\*\left(4mA\right)=80nWb$$

* 1. In a capacitor, a voltage of 20 V results in charge storage of 5 $μC$. Determine the Capacitance.

$$capacitance=\frac{charge}{voltage}=\frac{5μC}{20v}=250 nF$$

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

$$charge=capacitance\*voltage=40 μF\*12 v=480 μC$$

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

$$R\_{0}=\sqrt{\frac{L}{C}}=\sqrt{\frac{320 nH/m}{57 pF/m}}=74.926Ω$$

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

$$Ro=\sqrt{\frac{L}{C}}=\sqrt{\frac{1.2\frac{μH}{m}}{15\frac{pF}{m}}} =282.842 Ω$$

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

 $\in =\left(\in \_{r} \right)\left(\in \_{0}\right) \in \_{0}=8.842 x 10^{-12}^{F}/\_{m}$

$$\in =\left(6\right)\*\left(8.842 ^{pF}/\_{m}\right)= 53.052^{pF}/\_{m}$$

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

$$\in \_{r}=\frac{\in }{\in \_{0}}=\frac{14\_{ pF/m}}{8.842\_{ pF/m}}1.583$$

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

$$µ=µ\_{r}\*µ\_{0}= \left(800\right)\*( 4π\*10^{-7}^{H}/\_{m})=10.05^{mH}/\_{m}$$

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

$$µ\_{r}=\frac{µ}{µ\_{0}}=\frac{10^{-4} H/m}{4π\*10^{-7} H/m}=79.55$$

* 1. Determine the velocity of propagation of the transmission line of problem (1.15)

$$V=\sqrt{\frac{1}{L\*C}=}\sqrt{\frac{1}{(320 nH/m)\*(57 pf/m)}}=234.146\*10^{6} m/s$$

* 1. Determine the velocity of propagation of the transmission line of problem (1.16)

$$V=\sqrt{\frac{1}{L\*C}=}\sqrt{\frac{1}{\left(1.2 µH/m\right)\left(15 pF/m\right)}}=235.7 10^{6 }m/s$$

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

$$V=\frac{C}{√\in \_{r}}=\frac{3 X 10^{8 }m/s}{\sqrt{4.7}}=138.379 x 10^{6} m/s$$

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

$$V=\frac{C}{√\in \_{r}}=\frac{3 X 10^{8 }m/s}{\sqrt{3}}=173.2 x 10^{6} m/s$$

* 1. A coaxial cable has the following specification: $R\_{0}=73 Ω$, and velocity of propagation = $2.1\*10^{8} m/s$. Determine L and C

$$L=\frac{R\_{0}}{V}=\frac{73 Ω}{2.1\*10^{8} m/s}=347.62 nF$$

$$C=\frac{1}{R\_{0}\*V}=\frac{1}{\left(73 Ω\right)\*(2.1\*10^{8}\frac{m}{s})}=65.23 pF$$

* 1. A transmission line has the following specification: $R\_{0}=150 Ω$, and velocity factor = 0.8. Determine L and C

$$L=\frac{R\_{0}}{v}=\frac{150}{0.8\*(3 x 10^{8})}=650 mH$$

$$C=\frac{1}{R\_{0}\*V}=\frac{1}{\left(150\right)(240x 10^{8})}=27.77 pF$$

* 1. The lower end of the commercial amplitude-modulation (AM) band is about 550 kHz. AM stationary use “quarter-wave” vertical antennas whose lengths are $0.25λ$. Determine the length in meters of a vertical antenna operating at the lower end.

$$λ=\frac{c}{F}=\frac{3 x 10^{8}}{550khz}=545.45 m$$

$$0.25λ=0.25\*\left(545.45\right)=136.36 m$$

* 1. The upper end of the commercial AM band referred to in Problem (1.27) is about 1610 kHz. Determine the length in meters of a vertical antenna operating at the upper end.

$$λ=\frac{c}{F} =\frac{3 x 10^{8}}{1610khz}=186.335m$$

* 1. 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 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 88MHz.

$$λ=\frac{c}{F}=\frac{3 x 10^{8}}{88Mhz}=3.4090 m$$

$$0.5λ= 0.5\left(3.4090\right)=1.7045 m $$

$$1.7045 - (1.7045\*.05)] = 1.6197 m$$

* 1. Based on the discussion of Problem (1.29), determine the practical length in meter for a half-wave antenna to provide optimum reception, at the upper end of the FM band, which is about 108 MHz.

$$λ=\frac{c}{F} =\frac{3 x 10^{8}}{108Mhz}=2.77 m$$

$$0.5 λ= 0.5(2.77)=1.388 m$$

$$\left[1.388-\left(1.388\*0.005\right)\right]=1.3194 m$$