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TCET 2220

Homework 2

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* 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.**

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

$$0.5 λ= 0.5(2.77)=1.388 m$$

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

* 1. **Show that the free-space velocity of light in feet/second is very close to** $c=982\*10^{6} ft/s$**.**

$3 x 10^{8} m/s=982\* 10^{6} ft/s$

Therefore:

|  |  |
| --- | --- |
| 1 meter | 100 cm |
| 1 ft | 12 inch |
| 1 inch | 2.5 cm |
| 1 meter | 40 inches |
| 1 meter | 3.33 ft |

1 meter = 40 inches because in 1 cm there is 2.5 inches, if you divide 100 cm by 2.5 inches, It gives you 40 inches. In 12 inches, there is 1 ft. therefore in 40 inches there are 3.33 ft.

The speed of light is $3\*10^{8} m/s$. if we multiply that time 3.33 ft, we get $999\*10^{6} ft/s$. which is very close to the one above. ($982\* 10^{6} ft/s$).