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 TCET2220 Chapter 1

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

2 kHz

$$λ=\frac{c}{f}=\frac{3x10^{8}}{2x10^{3}}=150 Km $$

2000 kHz

$$λ=\frac{c}{f}=\frac{3x10^{8}}{200x10^{3}}=1.5 Km $$

20 MHz

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

 2 GHz

$$λ=\frac{c}{f}=\frac{3x10^{8}}{2x10^{9}}=150 mm $$

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

80 kHz

$$λ=\frac{c}{f}=\frac{3x10^{8}}{80x10^{3}}=3.75 Km $$

8 MHz

$$λ=\frac{c}{f}=\frac{3x10^{8}}{8x10^{36}}=37.5 m $$

800 MHz

$$λ=\frac{c}{f}=\frac{3x10^{8}}{8x10^{6}}=375 mm $$

8 GHz

$$λ=\frac{c}{f}=\frac{3x10^{8}}{800x10^{9}}=37.5 mm $$

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

$$λ=\frac{c}{f}=\frac{186x10^{3}}{400 }=465 mi $$

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

$$λ=\frac{c}{f}=\frac{186x10^{3}}{1.5 }=124 mi $$

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

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

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

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

7. 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 x 3 ns =300 ps

d= cx t 1 = (3 x 108 ) x (300 ps) = 9 cm

8. 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 =$\frac{.2}{3x10^{8}}$= 6.67 x10-10

pulse width= $\frac{6.67 x10^{-10}1}{.1}$= 6.67 x 109 s

9. 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.

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

10. 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.

$$f=\frac{c}{λ}=\frac{3x10^{8}}{.5 m}=600 MHz$$

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

$$Inductance=\frac{50x10 ^{-6}Wb}{100x10 ^{-3}A}=500x10 ^{-6}H$$

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

$Flux (Wb)$= Current x Inductance = (4 mA x20 $μ$H) = 8x 10-8 H

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

$$Capacitance=\frac{Charge}{Voltage}=\frac{5x10 ^{-6}C}{20v}=.25 x10 ^{-6}F$$

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

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

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

$$R\_{0}=\sqrt{\frac{L}{C}}=\sqrt{\frac{320 x10 ^{-9}}{57x10 ^{-12}}}=74.93Ω$$

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

$$R\_{0}=\sqrt{\frac{L}{C}}=\sqrt{\frac{1.2x10 ^{-6}}{1.5x10 ^{-12}}}=282.84Ω$$

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

ε=εrxε0= 6x8.842$x10 ^{-12}$ = 53.02 x10-12 F/m

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

εr =$\frac{ε}{ε0}$ =$\frac{14x10^{-12}}{8.842x10^{-12}}$ =1.58

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

$μ$**=**$μ\_{r}xμ$0

1.05 mH/m= (800x ($4π x10^{-7}$)

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

$μ\_{r}$**=**$\frac{μ}{μ0}$ **=** $\frac{10^{-4}}{4πx10^{-7}}$ **=79.58**

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

$V=\sqrt{\frac{1}{LC}}=\sqrt{\frac{1}{320 x10 ^{-9}x57x10 ^{-12}}}$ =2.34x108 m/s

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

$V=\sqrt{\frac{1}{LC}}=\sqrt{\frac{1}{1.2x10 ^{-6}x 15x10 ^{-12}}}$ =2.36x108m/s

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

**V**= $\frac{C}{√εr}$ =$\frac{3x10^{8}}{√4.7}$ =1.38 x 108 m/s

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

**V**= $\frac{C}{√εr}$ =$\frac{3x10^{8}}{√3}$ =1.73x 108 m/s

25. A coaxial cable has the following specifications: R0 = 73$Ω$, and velocity of propagation =2.1 x108 m/s. Determine L and C.

$L=\sqrt{\frac{R\_{0}}{V}}$ = $\sqrt{\frac{73}{2.1 x 10^{8}}}$ =347 x10-9

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

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

$L=\sqrt{\frac{R\_{0}}{Vc}}$ = $\sqrt{\frac{150}{.8(3x10^{8})}}$ =625 $x 10 ^{-9} H/m$

$C=\sqrt{\frac{1}{ VR\_{0}}}$ =$\sqrt{\frac{1}{73(2.4x10^{8})}}$ = 8$μF/m$

27. 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.

$λ=\frac{c}{f}=\frac{3x10^{8}}{550x10^{3}}$ =545.45

.25$λ$ =.25x545.45 = 136.36 m

28. 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.

$λ=\frac{c}{f}=\frac{3x10^{8}}{1610}$ =186.34 x 103 m

29. 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.

$λ=\frac{c}{f}=\frac{3x10^{8}}{88x10^{3}}$=3.409 m

.5x3.409 = 1.705 m

1.705-(1.7045x.05) =1.6193 m

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 108 MHz.

$λ=\frac{c}{f}=\frac{3x10^{8}}{108x10^{6}}$=2.78 m

.5x 2.78 = 1.4 m

1.4-(1.4x.05) =1.33 m