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TCET-2220
Homework #2, Chapter 1
9/23/2013

1) **Calculate the free space wavelength in meter for the following frequencies:**
   a) **2kHz**
   b) **200kHz**
   c) **20 MHz**
   d) **2 GHz**

a) $\lambda = \frac{C}{f} = \frac{3X10^8}{2X10^3} = 150\ km$

b) $\lambda = \frac{C}{f} = \frac{3X10^8}{200X10^3} = 1.5\ km$

c) $\lambda = \frac{C}{f} = \frac{3X10^8}{20X10^6} = 15\ m$

d) $\lambda = \frac{C}{f} = \frac{3X10^8}{2X10^9} = 15\ cm$

2) **Calculate the free space wavelength in meter for the following frequencies:**
   a) **80 kHz**
   b) **8 MHz**
   c) **800 MHz**
   d) **8 GHz**

a) $\lambda = \frac{C}{f} = \frac{3X10^8}{80X10^3} = 3750\ m$

b) $\lambda = \frac{C}{f} = \frac{3X10^8}{8X10^6} = 37.5\ m$

c) $\lambda = \frac{C}{f} = \frac{3X10^8}{800X10^6} = 0.375\ m$

d) $\lambda = \frac{C}{f} = \frac{3X10^8}{8X10^9} = 3.75\ cm$

3) **Calculate the free space wavelength in miles for the frequency of 400 Hz.**

$$\lambda = \frac{C}{f} = \frac{3X10^8}{400} = 750\ Km = (750\ km)\left(\frac{1\ mile}{1.609\ km}\right) = 466\ miles$$

4) **Calculate the free space wavelength in miles for the frequency of 1.5 kHz.**

$$\lambda = \frac{C}{f} = \frac{3X10^8}{1.5X10^3} = 200\ Km = (200\ km)\left(\frac{1\ mile}{1.609\ km}\right) = 124\ miles$$

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

$$f = \frac{C}{\lambda} = \frac{3X10^8}{80} = 3.75\ MHz$$

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

$$f = \frac{C}{\lambda} = \frac{3X10^8}{80} = 50\ MHz$$

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

$$t_1 = (0.1)(3ns) = 0.3ns$$

$$d = ct_1 = (3X10^8)(0.3X10^{-9}) = 9\ cm$$

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.**

$$d = ct_1 \longrightarrow\ t_1 = \frac{d}{c} = \frac{20X10^{-2}}{3X10^8} = 0.67\ ns$$

$$Width = \frac{0.67X10^{-9}}{0.1} = 6.7\ ns$$

9) **A communication system operates 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.**

$$\lambda = \frac{C}{f} = \frac{3X10^8}{800X10^6} = 0.375\ m$$

$$d = (0.1)(0.373) = 3.75\ cm$$

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 high operating frequency that should be used without considering frequency domain effects based on the 10% rule.**

$$\lambda = \frac{d}{0.1} = \frac{50X10^{-2}}{0.1} = 5\ m$$

$$f = \frac{c}{\lambda} = \frac{3X10^8}{5} = 60\ MHz$$

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

$$Inductance = \frac{flux}{current} = \frac{50\ \mu Wb}{100\ mA} = 500\ \mu H$$

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

$$Inductance = \frac{flux}{current}$$

$$\longrightarrow flux = (current)(Inductance) = (4X10^{-3}A)(20X10^{-6}H) = 80\ nWb$$

13) In a capacitor, a voltage of 20V result in charge storage of 5 µC. determine the capacitance.

$$C = \frac{Charge}{voltage} = \frac{5X10^{-6}c}{20\ V} = 0.25\ \mu F$$

14) A capacitance of 40 µF is charged to a voltage of 12 V. determine the electric charge.

$$C = \frac{Charge}{voltage} \longrightarrow charge = (Capacitance)(voltage) = (40X10^{-6})(12\ V)$$

$$= 0.48mC$$

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

$$R_o = \sqrt{\frac{L}{C}} = \sqrt{\frac{320X10^{-9}\ H/m}{57X10^{-12}\ F/m}} = 74.93\Omega$$

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

$$R_o = \sqrt{\frac{L}{C}} = \sqrt{\frac{1.2X10^{-6}\ H/m}{15X10^{-12}\ F/m}} = 282.8\Omega$$

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

$$\epsilon = \epsilon_r \epsilon_o = (6)(8.84X10^{-12}\ F/m) = 5.3X10^{-11}\ F/m$$

18) The permittivity of a material is $14X10^{-12}$ F/m. determine the dielectric constant.

$$\epsilon = \epsilon_r \epsilon_o \longrightarrow \epsilon_r = \frac{\epsilon}{\epsilon_o} = \frac{14X10^{-12}\ F/m}{8.84X10^{-12}\ F/m} = 1.6$$

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

$$\mu = \mu_r \mu_0 = (800)(4\pi X10^{-7}\ H/m) = 1X10^{-3}\ F/m$$

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

$$\mu_r = \frac{\mu}{\mu_0} = \frac{10^{-4}\, H/m}{4\pi X 10^{-7}\, H/m} = 79.5$$

21) Determine the velocity of propagation of the transmission line of problem 15.

$$v = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(320X10^{-9}\, H/m)(57X10^{-12}\, F/m)}} = 2.34X10^{8}\, m/s$$

22) Determine the velocity of propagation of the transmission line of problem 16.

$$v = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(1.2X10^{-6}\, H/m)(15X10^{-12}\, F/m)}} = 2.36X10^{8}\, m/s$$

23) The dielectric constant in a transmission line is 4.7, and μ=$\boldsymbol{\mu_o}$. Determine the velocity of propagation.

$$v = \frac{c}{\sqrt{\epsilon_r}} = \frac{3X10^{8}}{\sqrt{(4.7)}} = 1.38X10^{8}\, m/s$$

24) The dielectric constant in a certain transmission line is 3, and μ=$\boldsymbol{\mu_o}$. Determine the velocity of propagation.

$$v = \frac{c}{\sqrt{\epsilon_r}} = \frac{3X10^{8}}{\sqrt{(3)}} = 1.73X10^{8}\, m/s$$

25) A coaxial cable has the following specification: $\boldsymbol{R_o = 73}$ Ω, and velocity of propagation = 2.1X10^{8} m/s. Determine L and C.

$$L = \frac{R_o}{v} = \frac{73}{2.1X10^{8}} = 347.6\, nH$$

$$C = \frac{1}{R_o v} = \frac{1}{(73)(2.1X10^{8})} = 65.2\, pF$$

26) A transmission line has the following specification:$\boldsymbol{R_o = 150}$ Ω, and velocity factor of 0.8. Determine L and C.

$$L = \frac{R_o}{0.8c} = \frac{150}{0.8(3X10^{8})} = 0.625\, \mu H$$

$$C = \frac{1}{0.8cR_o} = \frac{1}{(0.8)(3X10^{8})(150)} = 27.78\, pF$$

27) The lower end of a commercial AM band is about 550 KHz. AM station use "quarter wave" vertical antenna whose length are 0.25λ. Determine the length in meters of a vertical antenna operating at the lower end.

$$0.25\lambda = 0.25\frac{C}{f} = 0.25\frac{3X10^8}{550X10^3} = 1.36\,m$$

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

$$0.25\lambda = 0.25\frac{C}{f} = 0.25\frac{3X10^8}{1610X10^3} = 46.6\,m$$

29) One popular single 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 the end effect. 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.

$$0.5\lambda = 0.5\frac{C}{f} = 0.5\frac{3X10^8}{88X10^6} = 1.7\,m$$

$$Pactical\ length = 1.7(1 - 0.05) = 1.619\,m$$

30) Based on the discussion of problem 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 108 MHz.

$$0.5\lambda = 0.5\frac{C}{f} = 0.5\frac{3X10^8}{108X10^6} = 1.39\,m$$

$$Pactical\ length = 1.39(1 - 0.05) = 1.319\,m$$

31) Show that the free space velocity of light in feet/second is very closed to 982X10^6 ft/s.

$$c = 3X10^8\,{}^{m}/_{s} = (3X10^8\,{}^{m}/_{s})\left(3.28\,{}^{ft}/_{m}\right) = 984X10^6\,{}^{ft}/_{s}$$

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

$$\boldsymbol{\lambda(ft) = \frac{982}{f(MHz)}}$$

$$\lambda = \frac{c({}^{m}/_{s})}{f(Hz)} = \frac{(3X10^8\,{}^{m}/_{s})(3.28\,{}^{ft}/_{m})}{f(Hz)} = \frac{984X10^6\,{}^{ft}/_{s}}{f(Hz)} = \frac{984}{f(MHz)}$$