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Transmission Systems

Homework # 6

6-1. The voltage between two parallel plates separated by a distance of 5mm is 200 V. Determine the electric field intensity.

 $E=\frac{V}{d}$ 🡪 $E=\frac{200 V}{.005 m}$ 🡪=40 k v/m

6-2.This voltage between two parallel plates separated by a distance of 0.4 in is 60 V. Determine the electric field intensity.

 $E=\frac{v}{d}$ 🡪 $E=\frac{60 V}{.003 m}$ 🡪=20 k v/m

6-3.The electric field intensity in the region between two parallel plates separated by a distance of 4 cm is 2 kV/m. Determine the voltage between the plates.

 $E=\frac{v}{d}$ 🡪 $2000=\frac{v}{.04 m}$ 🡪 80 V

6-4.The electric field intensity in the region between parallel plates separated by a distance of 8 mm is 200 V/mm. Determine the voltage between the plates.

 $E=\frac{v}{d}$ 🡪 200 $V/mm=\frac{V}{8 mm}$ 🡪 160 V

6-5.A direct current of 5 A is flowing in a conductor. Determine the magnetic field intensity at a distance of 3 m from the conductor.

 $H=\frac{I}{2πd}$ = $\frac{5}{2\*π\*3}$ =.2653

6-6. A direct current of 40 mA is flowing in a conductor. Determine the magnetic field intensity at a distance of 5 ft from the conductor.

 $H=\frac{I}{2πd}$ = $\frac{40 mA}{2\*π\*(1.5)}$ = 4.24 mA/m

6-7. For the parallel plates of problem 6-3, determine the electric flux density if the dielectric is polyethylene (εr = 2.25).

 ε=εr\*ε0 =2.25 \*8.842\*10-12 =19.989 \* 10 -12

 D=ε \* E 🡪 19.989 \* 10 -12 \* 2000 = 39.78 \*10-9

6-8. For the parallel plates of problem 6-4, determine the electric flux density if the dielectric is air.

 D=ε \* E 🡪 8.842 \* 10 -12 F/m \* .2 m = 1.7684 \*10-12

6-9. For the current-carrying conductor of problem 6-5, determine the magnetic flux density at a distance of 3 m from the conductor if the medium is air.

 B=µ \* H= 1.257\*10-6 \*.26 A/ m =3.26 \* 10-7

6-10. For the current-carrying conductor of problem 6-6, determine the magnetic flux density at a distance of 5 ft from the conductor if the medium is air.

 B=µ \* H= 1.257\*10-6 \*4.24 mA/ m =5.33 \* 10-9

6-11. The electric flux density normal to a rectangular surface with dimensions 8 m x 75 cm is 4 *μ*C/m2. Determine the value of the electric flux across the area.

Ψ=D\*A= (4\*10-6) \*(8\*.75)= 24\*10-6 C

6-12. The electric flux density normal to a circular surface with a diameter of 3 m is 8 *μ*C/m2. Determine the value of the electric flux across the area.

 Ψ=D\*A= (8\*10-6) \*(π\*(1.5)2)= 57\*10-6 C

6-13. The magnetic flux density normal to a circular surface with a radius of 5 m is 4 nWb/m2. Determine the value of the magnetic flux across the area.

 Φ= B\*A=25 π \*4\*10-9 =3.14 \*10-7 Wb

6-14.The magnetic flux density normal to a rectangular surface with dimensions 30 cm x 60 cm is 12 Wb/m2. Determine the value of the magnetic flux across the area.

 Φ= B\*A= 18m \*12\*10-9 = .389 \*10-7 Wb

6-15. A current of 8 A is uniformly distributed over a rectangular conductor with dimensions 5 mm x 4 mm. Determine the current density.

 $J=\frac{I}{A}$ 🡪 $J=\frac{8 A}{.00002}$ 🡪400k A/m2

6-16. A current of 4 A is uniformly distributed over a circular conductor with a diameter of 3 cm. Determine the current density.

 $J=\frac{I}{A}$ 🡪 $J=\frac{4 A}{(π\*\left(1.5\right))^{2}}$ 🡪 .566 A/m2

6-17. Assume that the conductivity for the conductor of problem 6-15 is 5 MS/m. Determine the electric field intensity.

 $E=\frac{J}{σ}=\frac{400000}{5\*10^{6}}$ = .08

6-18. Assume that the conductivity for the conductor of problem 6-16 is 6 x 107 S/m. Determine the electric field intensity.

 $E=\frac{J}{σ}=\frac{.57}{6\*10^{7}}$ = 9.5 \*10-9

6-19. The rms magnitude of the magnetic field of a plane wave in air Hy =200 µA/m. Assuming that E in the positive x-direction, determine the following for a circular surface of diameter 50 m in the x-y plane over which the fields are constant:

1. Ex = Hy \*η =200\*10-6 \*377=7.54\*10-2
2. Pz= Ex \* Hy=(7.54\*10-2) \*(200\*10-6) = 1.508 \*10-5 W/ m2
3. total power transmitted through area

P= Pz \* A = (1.508 \*10-5 W/ m2) \* (π\*(25)2) =.02961 Watts

6-20. The rms magnitude of the electric field of a plane wave in sea water ( E­r =80 ) is Ex =3 V/m. Assuming that H is in the positive y-direction, determine the following for a square surface with sides of 15 m each in the x-y plane over which the fields are constant:

1. Hy= $\frac{Ex}{η }$=$ \frac{3}{377 }$ = 7.9 \* 10-3 A/m
2. Pz =$ $Ex \* Hy= 3\*(7.9\* 10-3 A/m) = .0237
3. total power transmitted through area

P= Pz \* A = (.0237) \* (225) = 5.30Watts

6-21. In a lossless dielectric medium, the rms electric and magnetic field intensities are E­­x = 18.97 mV/m and Hy= ­­­­­­­ 158.1 µA/m. Determine the following:

1. intrinsic impedance

η=$\frac{ Ex}{Hy}$ =$\frac{ 18.9 m/V}{158.1\*10^{-6}}$ = 119.98

1. power density

Pz =$ $Ex \* Hy = 18.97 mV/m \* 158.1 µA/m = 3 µW/m2

1. dielectric constant

 η=$\frac{ 377}{(120^{2})}$= 9.87

6-22. The power density of a plane wave propagating in free space is Pz =120 µW/m2. Determine the following:

1. Ex= Pz =$\frac{ Ex^{2}}{η}$ = Ex= $\sqrt{120\*10^{-6}\*377}$=.212697
2. Hy= Pz = $Hy^{2}\*$η =$\sqrt{\frac{120\*10^{-6}}{377}}$ = .564 mA/m

6-23. Using the values of εr =80 and σ =4 S/m for sea water in Example 6-13, determine the various quantities at a frequency of 10 MHz.

jωµ =j[2$π\left(10\*10^{6}\right)\*(4π\*10^{-7})]$

 = $8\*π^{2}$<$\frac{π}{2}$

 jωε=j[2$π\left(10\*10^{6}\right)\*80\*(8.842\*10^{-12})]$

 =0.04445<1.5708 =.04445j

 σ + jωε = 4+ j.04444 = 4.00025<.0111

1. Intrinsic impedance

$$η=\sqrt{\frac{8\*π^{2}<\frac{π}{2}}{.4.00025<.01111}}$$

$$=4.44<.7798=3.159+3.124j$$

1. Propagation constant

$γ=\sqrt{jωµ (}σ+jωε)$

$$γ=\sqrt{ 8\*π^{2}<\frac{π}{2}\*(}4.00025<.0111$$

$=17.77<.79$=12.497 + j12.64

1. Attenuation constant

$$α=12.49 Np/m$$

1. Velocity of propagation

$v=\frac{ω}{β}$ =$\frac{2π\left(10\*10^{6}\right)}{12.64}$ = 5 \* 106 m/s

6-24. Using the values of εr =80 and σ=4 S/m for sea water in Example 6-13, determine the various quantities at a frequency of 1 GHz.

jωµ =j[2$π\left(1\*10^{9}\right)\*(4π\*10^{-7})]$

 = 800\*$π^{2}$<$\frac{π}{2}$

 jωε=j[2$π\left(1\*10^{9}\right)\*80\*(8.842\*10^{-12})]$

 =4.4445<1.5708 =4.4445j

 σ + jωε = 4+ j4.4445 = 5.979<.83799

1. Intrinsic impedance

$$η=\sqrt{\frac{800\*π^{2}<\frac{π}{2}}{5.979<.83799}}$$

$=36.3384<.36$= 33.9263 +j33.93

1. Propagation constant

$γ=\sqrt{jωµ (}σ+jωε)$

$$γ=\sqrt{ 800\*π^{2}<\frac{π}{2}\*(}5.979<.83799)$$

$=217.282<1.204$=77.84 + j202.86

1. Attenuation constant

$$α=77.84 Np/m$$

1. Velocity of propagation

$v=\frac{ω}{β}$ =$\frac{2π\left(1\*10^{9}\right)}{202.86}$ = .3\* 106 m/s

6-25. Fresh water has typical values of dielectric constant and conductivity given by εr = 80 and σ =10-3 S/m. At a frequency of 100 MHz, determine the following quantities:

 jωµ =j[2$π\left(100\*10^{6}\right)\*(4π\*10^{-7})]$

 =j789.6= 789.6<1.5708

 jωε=j[2$π\left(100\*10^{6}\right)\*80\*(8.842\*10^{-12})]$

 =j0.4444=0.4444<1.5708

 σ + jωε = 10-3 + j0.4444 = .4444<1.569

1. Intrinsic impedance

$$η=\sqrt{\frac{789.6<1.5708}{.4444<1.569}}$$

$$=42.16<.0009$$

1. Propagation constant

$γ=\sqrt{jωµ (}σ+jωε)$

$$γ=\sqrt{ 789.6<1.5708\*(}.4444<1.569)$$

$=18.73<1.57$=.017 + j18.74

1. Attenuation constant

$$α=.017 Np/m$$

1. Velocity of propagation

$v=\frac{ω}{β}$ =$\frac{2π\left(100\*10^{6}\right)}{18.74}$ = .36 \* 106 m/s

6-26. Repeat the analysis of Problem 6-25 for fresh water at a frequency of 1 MHz

jωµ =j[2$π\left(1\*10^{6}\right)\*(4π\*10^{-7})]$

 = $\frac{4\*π^{2}}{5}$<$\frac{π}{2}$

 jωε=j[2$π\left(1\*10^{6}\right)\*80\*(8.842\*10^{-12})]$

 =0.004444<1.5708 =.004444j

 σ + jωε = 10-3 + j.004444 = .0046<1.35

1. Intrinsic impedance

$$η=\sqrt{\frac{\frac{4\*π^{2}}{5}<\frac{π}{2}}{.0046<1.35}}$$

$$=41.63<.111$$

1. Propagation constant

$γ=\sqrt{jωµ (}σ+jωε)$

$$γ=\sqrt{ \frac{4\*π^{2}}{5}<\frac{π}{2}\*(}.0046<1.35)$$

$=18.13<.841$=12.09 + j13.509

1. Attenuation constant

$$α=12.09 Np/m$$

1. Velocity of propagation

$v=\frac{ω}{β}$ =$\frac{2π\left(1\*10^{6}\right)}{13.51}$ = .46 \* 106 m/s