Professor Viviana Biibin Koshy

TCET 2220

Chapter 3

3-1. A traveling wave of current in milliamperes is given by i=8 cos( 2π \*106t- 0.025x) with t in seconds and x in meters. Determine the following :

1. Direction of propagation:

Positive

1. Peak value

8

1. Angular frequency:

2\*π\*f= 2π\*106= 6.28 \*106

1. Phase constant:

β=.025

1. Cyclic frequency:

f=$\frac{ω}{2\*π}=\frac{6.28\*10^{6}}{2\*π}=$ 1\*106

1. Period:

T=$\frac{1}{f}$= $\frac{1}{10^{6}}$ =1\*10-6

1. Wavelength:

λ=$\frac{2π}{β}$=$\frac{2π}{.025}$ =251.327 m

1. Velocity of propagation:

V=f \*λ= 106 \*251.327 =2.51 \*108

3-2. A traveling wave of voltage in volts in given by v= 15 cos(108t+0.35x) with t in seconds and x in meters. Determine the following:

1. Direction of propagation:

Negative

1. Peak value:

15

1. Angular frequency:

108

1. Phase constant

β=.35

1. Cyclic frequency:

f=$\frac{ω}{2\*π}$=$\frac{10^{8}}{2\*π}$= 1.59 \*107

1. Period:

T=$\frac{1}{f}$= $\frac{1}{1.59 \*10^{7}}$ =6.289 \*10-8

1. Wavelength:

λ=$\frac{2π}{β}$ =$\frac{2π}{.35}$ =17.952

1. Velocity of propagation:

V=f \*λ= 1.59 \*107 \*17.952=2.86 \*108

3-3. A sinusoidal current with a peak value of 2 A and a frequency of 50 MHz is traveling in the positive x-direction with a velocity of 2 x 108 m/s. Determine the following:

1. Period

T=$\frac{1}{f}$=$\frac{1}{50\*10^{6}}$= $20 \*10^{-9}$

1. Angular frequency

ω= 2\*π\*f= 2\*π\*$50\*10^{6}$= 3.14 \*108

1. Phase constant

$β=\frac{ω}{v}$ =$\frac{3.14\*10^{8}}{ 2\*10^{8} }$= 1.57

1. Wavelength

λ=$\frac{2π}{β}$=$\frac{2π}{1.57}$=4.00203

1. An equation for the current

= 2\* cos (3.14 \*108 t-1.57x)

3-4. A sinusoidal voltage with a peak value of 25 V and a radian frequency of 20 Mrad/s is traveling in the negative x-direction with a velocity of 3 x 108 m/s. Determine the following:

1. Cylic frequency:

f=$\frac{ω}{2\*π}$ = $\frac{20\*10^{6}}{2\*π}$= 3.18 \*106

1. Period:

T=$\frac{1}{f}$=$\frac{1}{3.18\*10^{6}}$= 3.14 \*10-7

1. Phase constant:

$β=\frac{ω}{v}=\frac{20\*10^{6}}{3\*10^{8}}$ = .06667

1. Wavelength:

λ=$\frac{2π}{.06667}$ =94.2

1. An equation for the voltage:

= 25\*cos ($20\*10^{6}t+(.06667x)$)

3-5. Consider the current traveling wave of Problem 3-1. Determine the following:

 i=8 cos( 2π \*106t- 0.025x)

1. a fixed phasor representation in peak units as either $\overline{I}$+ or $\overline{I}$- ( You decide which label is appropriate.)

$\overline{I}$+ = 8 \*e0 = 8∠0

1. the corresponding distance-varying phasor $\overline{I}$(x) in peak units

$\overline{I}$(x) =$\overline{I}$+ = 8 \*e0 \*ejβx

=8 \*e0 \*ej-0.025

= (8∠0)\*(1∠-.0025x)

=(8∠-.0025x)

1. the value of the distance-varying phasor at x=100 m.

=(8∠-.0025x)

=(8∠-.0025\*100)

=8∠-2.5

3-6. Consider the voltage traveling wave of Problem 3-2. Determine the following:

15 cos(108t+0.35x)

1. a fixed phasor representation in peak units as either $\overline{V}$+ or $\overline{V}$- ( You decide which label is appropriate.)

$\overline{V}$- =15\*ej0 =15∠0

1. the corresponding distance-varying phasor $\overline{V}$(x) in peak units

$\overline{V}$(x)=$ \overline{V}$- \* ejβx

 =15\*ej0\* ej0.35

=15∠-0.35\*x

1. the value of the distance-varying phasor at x=4 m.

$\overline{V}$(4)= 15∠-0.35\*x

$\overline{V}$(4)= 15∠-0.35\*4

$\overline{V}$(4)= 15∠-1.20

3-7. Repeat the analysis of Problem 3-5 if the current of Problem 3-1 has a fixed phase shift such that it is described by

 i=8 cos( 2π \*106t- 0.025x +1.5)

1. $\overline{I}$+= 8\*e1.5 =8∠1.5
2. $\overline{I}$ = $\overline{I}$+ \* ej-0.025

 = 8\*e1.5 \* ej-0.025

= 8∠1.5-0.25\*x

1. $\overline{I} \left(100\right)=$8∠1.5-0.25\*100

 =8∠1.5-0.25\*100

 =8∠-1

3-8. Repeat the analysis of Problem 3-5 if the current of Problem 3-1 has a fixed phase shift such that it is described by

 v= 15 cos(108t+0.35x-$ \frac{π}{3}$)

a)$ \overline{V}$- =15 \*e j- $\frac{π}{3}$

b)$ \overline{V}$=15 \*e j- $\frac{π}{3}$\* ej0.35x

 =15∠- $\frac{π}{3}$ +0.35x

 c)$ \overline{V}$(4)= 15∠$-\frac{π}{3}$ + 0.35\*4

 =15∠-58.6

3-9. Redefine the fixed phasor of Problem 3-5 so that the phasor magnitude is expressed in rms units, and determine the average power dissipated in 50-Ω resistance.

 a)Irms=

 =$\frac{\overline{I}+ = 8 \*e^{j0}= 8∠0}{\sqrt{2}}$

 = 5.65

 b)Power dissipated= (I)2\* R= (5.65)2 \* 50 =1600 watts

3-10. Redefine the fixed phasor of Problem 3-6 so that the phasor magnitude is expressed in rms units, and determine the average power dissipated in75-Ω resistance.

 a)Vrms=

 =$\frac{\overline{V} ^{-}= 8 \*e^{j0}= 15∠0}{\sqrt{2}}$

 = 10.61$∠$0

 b)Power dissipated= $\frac{V^{2}}{R}$ =$\frac{(10.61)^{2}}{75}$ =1.501 watts

3-11. Redefine the fixed phasor of Problem 3-7 so that the phasor magnitude is expressed in rms units. Would the power dissipated in a 50-Ω resistance be the same as in Problem 3-9?

1. Irms=

 = $\frac{\overline{I}+ = 8 \*e^{j1.5}= 8∠1.5}{\sqrt{2}}$

=5.56<1.5

b) Power dissipated= (I)2\* R= (5.56)2 \* 75 =1600 watts

3-12. Redefine the fixed phasor of Problem 3-8 so that the phasor magnitude is expressed in rms units. Would the power dissipated in a 75-Ω resistance be the same as in Problem 3-10?

 a)Vrms=

 =$\frac{\overline{V} ^{-}= 15 \*e ^{j - \frac{π}{3}}= 15∠-\frac{π}{3}}{\sqrt{2}}$

 =10.61 $∠- \frac{π}{3}$

 b)Power dissipated= $\frac{V^{2}}{R}$ =$\frac{(10.61)^{2}}{75}$ =1.501 watts ; same as Problem 3-10

3-13. Under steady-state ac conditions, the forward current wave on a certain lossless 50-Ω line is $\overline{I}$+ =2$∠0$ A. Determine the voltage forward wave.

1. $\overline{I}$+ =2$∠0$ A.
2. $\overline{V}$ + = R0 \*$ \overline{I}$+

=2$∠0$ A \* 50

$\overline{V}$ + =100$∠$0

3-14. Under steady-state ac conditions, the forward voltage wave in a 300-Ω lossless line is $\overline{V}$+=15$∠3 $A. Determine the current forward wave.

 $\overline{I}$+ =$\frac{\overline{V} ^{+}}{ R0 }$ =$\frac{15∠3 }{300 }$ = .05$∠3 $A

3-15. Under steady-state ac conditions, the reverse voltage wave on a lossless 50-Ω line is $\overline{V}$- =200$∠0 $A. Determine the reverse current wave.

 $\overline{I}$- =$ -\frac{\overline{V} ^{-}}{ R0 }$ =$\frac{200∠0 }{-50 }$ = - 4$∠0 $A

3-16. Under steady-state ac conditions, the reverse current wave on a lossless 75-Ω line is $\overline{I}$- =.5$∠2 $. Determine the reverse voltage wave.

 $\overline{V} ^{-}$=$ R0$ \* $\overline{I}$- = -75 \*(.5$∠2 $A)= -37.5$∠$2

3-17. A table of specifications for one version of RG-8/U 50-Ω coaxial cable indicates that the attenuation per 100 ft at 50MHz is 1.2 dB. At this frequency, determine the following:

1. attenuation factor in decibels per foot.

α= $\frac{1.2 dB}{100 ft}$ =.012

1. attenuation factor in nepers per foot.

LNP =$\frac{.012 dB}{8.868 ft}$ =1.382\* 10-3

For a length of 300 ft, determine the following:

1. total attenuation in decibels.

300 ft \* .012 =3.6 dB

1. total attenuation in nepers

LNP = (1.382\* 10-3 )\* 300 =.4146

1. $\frac{V\_{2}}{V\_{1}}$ ratio using both decibels and nepers for a single wave

$\frac{V\_{2}}{V\_{1}}$= e-L = e –( 1.382 \* $10^{-3}$ ) =.999

$\frac{V\_{2}}{V\_{1}}=$10\*$\frac{-3.6}{20}$ =.661

3-18. A transmission line has an attenuation of 0.05 dB/m. Determine the following:

1. attenuation factor in nepers/m

For a length of 400 m, determine the following:

$\frac{L\frac{dB}{m}}{8.686}$= $\frac{.005}{8.686}$= 5.76 \*10-4

1. total attenuation in decibels.

Ldb =.05 \*400 =20

1. total attenuation in nepers

5.76 \* 10-3 \*400 =2.304

1. $\frac{V\_{2}}{V\_{1}}$ ratio using both decibels and nepers for a single wave.

$\frac{V\_{2}}{V\_{1}}=$10\*$\frac{-20}{20}$ =.1

3-19. A single frequency wave is propagating in one direction on a transmission line of length of 200 m. With an input rms voltage of 50 V, the output rms voltage is measured as 20 V. Determine the following:

1. total attenuation in decibels.
2. =20 log 10$ \frac{V\_{1}}{V\_{2}}$

8 Ldb =20 log 10 $( \frac{50}{20}$)

1. α $\frac{N\_{p}}{m}$ =$ \frac{Ldb}{8.686\*d}$=$\frac{8}{8.686\*200} $= .004511
2. αdb =8.686 \*.004511 =.039991
3. Ldb =.039991\*200= 7.9982
4. total attenuation in nepers.

LNP =α \*d = .004511 \*200 =.9022

1. attenuation factor in decibels/meter

αdb =8.686 \*.004511 =.039991

1. attenuation factor in nepers/meter

αNp =4.511 \* 10 -3  $\frac{N\_{p}}{m}$

3-20. A single frequency wave is propagating in one direction on a transmission line of length 400 m. The input power to the line is 40 W, and the output power is 12 W. Determine the following:

1. total attenuation in decibels.
2. Ldb =10 log 10 $( \frac{P\_{1}}{P\_{2}}$)

Ldb =10 log 10 $( \frac{40}{12}$) = 5.228

1. α $\frac{N\_{p}}{m}$ =$ \frac{Ldb}{8.686\*d}$=$\frac{5.228}{8.686\*200} $= .00334= 3.34 \*10-3 $\frac{N\_{p}}{m}$
2. αdb =8.686 \*.00334 =.029011
3. .029011 \*400=11.6044
4. total attenuation in nepers.

LNP=α \*d=.00334 \*400= 1.34

1. attenuation constant in decibels/meters

αdb =8.686 \*.004511 =.039991

1. attenuation factor in nepers/meter

α $\frac{N\_{p}}{m}$ =$ \frac{Ldb}{8.686\*d}$=$\frac{5.228}{8.686\*200} $= .00334= 3.34 \*10-3 $\frac{N\_{p}}{m}$

3-21. A transmission line has the following parameters at 50 MHz: L=1.2 μH/m, R= 15 Ω/m, C= 10 pF/m, and G= 4 μS/m. Determine the following:

1. Z =R +jωL= 15 + j (( 2\*π\*50\*106) \*1.2 \* 10-6))= 15 +j (376.991)

= 377 $∠1.5$

1. Y= G +jωC= 4\* 10 -6+ j (( 2\*π\*50\*106) \*10 \* 10-12))= .000004 +j (.003142)

 = .003142 $∠1.5$

1. γ,α, and β

γ =$ \sqrt{Z∠Y }$= $ \sqrt{\left(377∠1.5\right)\*(.00314∠1.57)}$ = .0223341 +j (1.08855)

$α$ =.0223341

β = 1.08855

1. attenuation in dB/m

αdb =8.686 \*.0223341 =.193994 $\frac{dB}{m}$

1. v=$\frac{ω}{β}$ = $\frac{2\*π\*50\*10^{6}}{1.08855}$= 2.885 \* 108  $\frac{m}{s}$
2. Z0 =$\sqrt{\frac{Z}{Y}}$ = $\sqrt{\frac{15 +j (376.991) }{.000004 +j (.003142)}}$ =346.46 –j(6.67) = 346.525 $∠$-.02

3-22. A lossy audio-frequency line has the following parameters at 2 kHz: L= 0.1 µH/ft, R= 0.2 Ω/ft, C= 2 pF/ft, and G is negligible. Determine the following:

1. Z = R +jωL= .2 +j((2\*π\*2000) \*.1 \* 10-6 = .2 +j(0.12566) = .200394 $∠$ .0627
2. Y= G +jωC= j (( 2\*π\*2000) \*2 \* 10-12))= j (2.513\*10-8)=

 = 2.513\*10-8$∠1.5$

1. γ,α, and β
2. γ,α, and β

γ =$ \sqrt{Z∠Y} $= $ \sqrt{\left(.2 +j(0.12566) \right)\*(. j (2.513\*10^{-8})}$ = .000049 +j (.000052)

$α$ =.000049

β = .000052

1. attenuation in dB/ft

αdb =8.686 \*.000049 =.000426 $\frac{dB}{ft}$

1. v=$\frac{ω}{β}=\frac{2\*π\*2000}{.000052}$= 2.42 \* 108  $\frac{m}{s}$
2. Z0$=\sqrt{\frac{Z}{Y}}$ = $\sqrt{\frac{.2 +j(0.12566) }{j (2.513\*10^{-8})}}$ = 2823.88 $∠$-.754

3-23. A coaxial cable has the following parameters at a frequency of 1 MHz:

 series resistance= 0.3 Ω/m

 series reactance = 2 Ω/m

 shunt conductance = 0.5 µS/m

 shunt susceptance =0.6 mS/m

Determine the following:

1. Z =R +jL= .3 + j 2= 2.022 $∠1.4$
2. Y= G +jC= .5\*10-6 + j (( .6\* 10-3))= . 5\*10-6  + j.0006

 = .0006$ ∠$1.57

1. γ,α, and β

γ =$ \sqrt{Z∠Y }$= $ \sqrt{2.022∠1.4\*(.0006 ∠1.57)}$ = .002985 +j (.034703)

$α$ =.002985

β = .034703

1. attenuation in dB/ft

αdb =8.686 \*.002985 =.025928 $\frac{dB}{m}$

1. v=$\frac{ω}{β}$ = $\frac{2\*π\*1\*10^{6}}{.034703}$= 1.81 \* 108  $\frac{m}{s}$
2. Z0= $\sqrt{\frac{Z}{Y}}$ = $\sqrt{\frac{.3 + j 2 }{.5\*10^{-6} + j.0006)}}$ =333.337 –j(490972) = 337.062 $∠$-.14

3-24. For the coaxial cable of Problem 3-23, repeat the analysis at 100 MHz if the series resistance increases to 1 Ω/m, but the shunt conductance remains essentially the same. ( *Note* : You must apply basic ac circuit theory to determine the new values for the reactance and susceptance.) (Not Answered)

3-25. For the circuit of Fig. P3-25, determine the following: 

α \*d =.001 \*150 =1.5

β\*d =.004 \*150=.6

1. input current $\overline{I}$1

$\overline{I}$1 =$\frac{E}{Z\_{1}+z\_{0}} $ =$\frac{50∠0}{300+290-j60} $= .799903+j.081066 = .084 $∠$.101

1. input voltage $\overline{V}$1

$\overline{V}$1 = $z\_{0}$ \* $\overline{I}$1 = (290-j60) \* (.799903+j.081066) =236.836-j24.485 = 238.098$∠$-.103

1. input power P1

P1 = ($\overline{I}$1)2 \*R0 = (.084)2 \*290=2.04 w

1. load current $\overline{I}$2

$\overline{I}$2 =$\overline{I}$1 \*e –α \*d \* e –jβ\*d = (.084 $∠$.101) \* e –1.5 \* e –j.6 = .01794 $∠$-.499

1. load voltage $\overline{V}$2

$\overline{V}$2 =$\overline{V}$1 \*e –α \*d \* e –jβ\*d = (238.098$∠$-.103) \* e –1.5 \* e –j.6 =555$∠$-.703

1. load power P2

P2 = ($\overline{I}$2)2 \*R0 = (.01794)2 \*290=.0933 w

1. line loss in dB

Ldb =10 log 10 $( \frac{P\_{1}}{P\_{2}}$) = 10 log 10 $( \frac{2.04}{.0933}$) =13.41

3-26. For the circuit of Fig. P3-26, determine the following: (Not sure )

α $\frac{N\_{p}}{mi}$ =$ \frac{Ldb}{8.686\*d}$=$\frac{4}{8.686\*6}$=.077

α \*d =.077 \*6 =.462

β\*d =.5\*6=.6

1. input current $\overline{I}$1

$\overline{I}$1 =$\frac{E}{Z\_{1}+z\_{0}} $ =$\frac{80∠0}{1216<.165} $= .0649- j.010806 =.0658$∠$-.165

1. input voltage $\overline{V}$1

$\overline{V}$1 = $z\_{0}$ \* $\overline{I}$1 = (600+j100) \*( .0649- j.010806) =606.484+j38.94= 607.732$∠$.064118

1. input power P1

l P1 = ($\overline{I}$1)2 \*R0 = (.0658)2 \*290=1.2556 w

1. load current $\overline{I}$2
2. load voltage $\overline{V}$2
3. load power P2
4. line loss in nepers

