1. (30)

a) If a lossless transmission line is terminated in the characteristic impedance there are no standing waves. (True) or False.

b) What is the characteristic impedance of the coax transmission line in the large spools in the lab?

$Z_0 = 50\Omega$

c) Explain the difference between the input impedance and the characteristic impedance. A couple of sentences will do.

Characteristic impedance is the ratio of V^+/I^+ or $-\frac{V^-}{I^-}$.

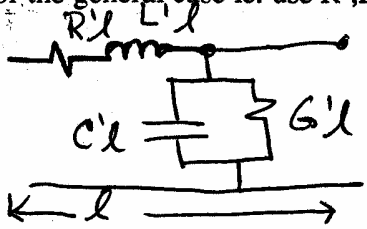
Input impedance is ratio of $\frac{V(z)}{I(z)}$ and due to waves on the line is a function of length or position

d) A wire in air is connecting a sinusoidal source to a load. Its length is 3 meters. At what frequency should we begin to apply transmission line theory? State assumptions.

If we assume that transmission line theory should be used when $l \geq 0.01\lambda$ then $\lambda \approx 300\,m$

$f = c/\lambda = \frac{3\times10^8}{3\times10^2} = 1\times10^6$ Hz and above.

e) Draw a lumped parameter circuit that represents a section of transmission line. Draw this for the general case ie. use R',L',C' and G'.



f) What is the characteristic impedance of a TV cable co-ax?

75Ω

g) Give a typical frequency for a cable TV channel?

250 MHz

2. (25) A lossless transmission line of electrical length $\ell = 0.35\lambda$ and characteristic impedance of 100 Ω is terminated in load impedance of $Z_L = 60 + j30\ \Omega$.

Find the reflection coefficient Γ

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{60+j30-100}{60+j30+100} = -0.208 + j0.226$$

$$= 0.307 \angle 132.61^\circ$$

Find the standing wave ratio

$$SWR = \frac{1+|\Gamma|}{1-|\Gamma|} = 1.887$$

Find the input impedance Z_0

$$\beta\ell = \frac{2\pi}{\lambda} \cdot 0.35\lambda = 0.7\pi$$

$$Z_{in} = Z_0\left(\frac{Z_L + jZ_0 \tan\beta\ell}{Z_0 + jZ_L \tan\beta\ell}\right) = 64.84 - j38.28$$

3. (25) A transmission line is 400 meters long and is short circuited at the load end. The source end is connected to a signal generator creating a single pulse of voltage of 100 Volts for 6 microseconds starting at t = 0. The internal resistance of the source is $R_G = 150\Omega$. The coax parameters are $C' = 100pF/m, L' = 0.25\mu H/m$.

Find the characteristic impedance, Z_0.

$$Z_0 = \sqrt{L'/C'} = 50\Omega$$

Find the velocity of propagation, v_p.

$$v_p = \frac{1}{\sqrt{L'C'}} = 2 \times 10^8 \text{ m/s}$$

Find the transit time, τ.

$$\tau = \frac{\ell}{v_p} = \frac{400}{2 \times 10^8} = 2\mu s$$

Find the reflection coefficient at the load, Γ_L.

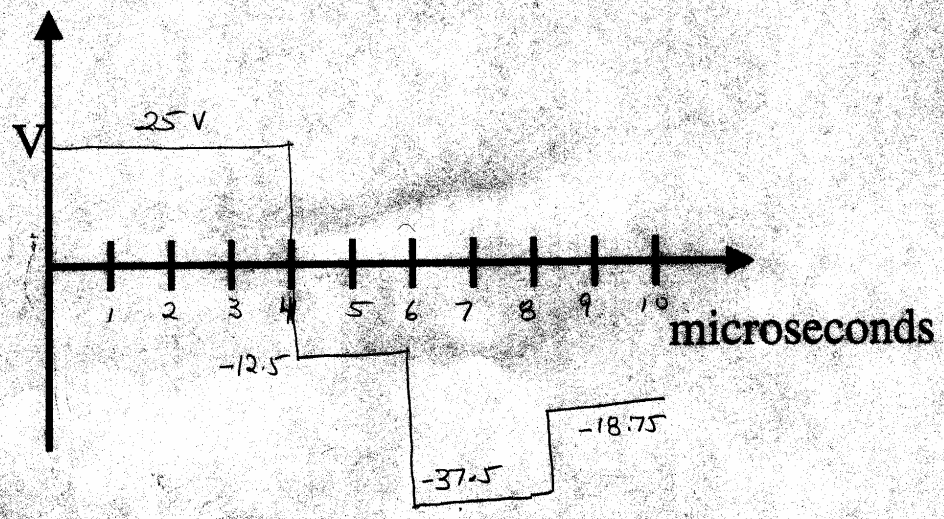
$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = -1$$

Find the reflection coefficient at the Source, Γ_G.

$$\Gamma_G = \frac{R_G - Z_0}{R_G + Z_0} = \frac{1}{2}$$

Plot the voltage at the generator end for 10 microseconds.

$$V^+ = \frac{Z_0}{R_G + Z_0} V_S = 25\,V$$



25 V wave in + direction

at 2 μsec we get a reflection of -25 V in - direction

at 4 μsec this wave hits the generator and is reflected as a -12.5 V wave in the + direction

at 6 μsec the pulse goes to zero and the +12.5 V wave is reflected at the load as 12.5 V in the - direction

at 8 μsec this wave is reflected as 6.25 V in + direction

4. (20)

i) Two waves have the same frequency wavelength and magnitude:

$f_1 = A\cos(kx - \omega t)$

$f_2 = A\cos(kx - \omega t + \phi)$

for $\phi = 90^0$ what is the magnitude of the combined wave $f_1 + f_2$?

a) $2A$

b) $\sqrt{2}A$

c) $4A$

d) $2A\cos(kx - \omega t + 45^0)$

ii) What value of ϕ will make the magnitude of the combined waves equal to A?

a) $\phi = 45^0$

b) $\phi = 90^0$

c) $\phi = 120^0$

d) $\phi = 215^0$

e) Not possible

iii) For the following expressions determine if the wave is traveling or standing. If traveling indicate the direction and velocity.

a) $\cos(\omega t + \phi)\cos(kz)$ standing

b) $\cos(5\omega t + ky)$ traveling in $-y$, $v_p = \frac{5\omega}{k}$

c) $\sin(1000t - 44z)$ traveling in $+z$, $v_p = \frac{1000}{44} = 22.727$

iiii) Find a time domain representation for $\tilde{V} = jA = Ae^{+j\pi/2}$

$V(t) = A\cos(\omega t + \pi/2)$

iiiii) Find a phasor for $V(t) = -6\cos(\omega t + 45^0)$

$\tilde{V} = -6e^{j\pi/4} = 6e^{j\pi}e^{j\pi/4} = 6e^{j\frac{5}{4}\pi}$