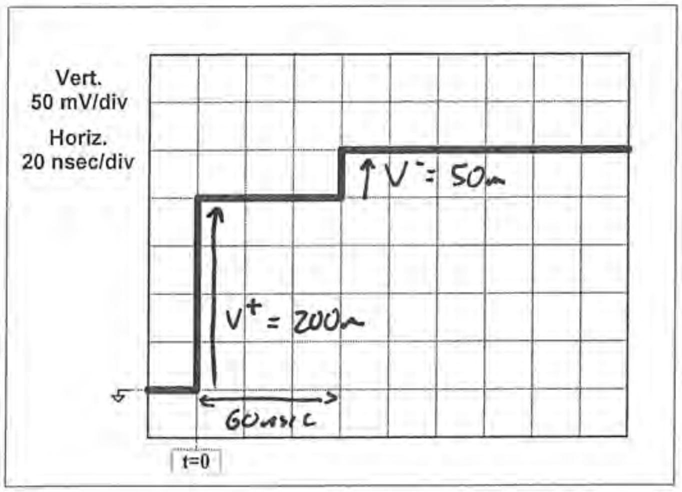
ECET 3410 – Spring 2016
High *f* Systems – Exam I **Print Name (Last Name First):** KEY

Instructions: Show all of your work, making sure your work in legible and that your reasoning can be followed. No credit will be given for illegible or illogical work, or for final answers that are not justified by the work shown. Place all final answers in the spaces provided. This exam is closed book, except for an 8.5"x11" sheet of handwritten notes, which may NOT contain any numerically-solved problems.

Coaxial Cables

RG #	AWG Material	Insulation	# Shields	Jacket	Nom. O.D. (inch)	Nom. Imp. (Ohms)	Nom. Vel. Of Prop.	Nom. Cap. (pF/ft.)	Nom. Attenuation per 100' MHz	dB	Standard Spool Lengths
14/U	20 Copper	Poly-ethylene	1	Black Vinyl	.420	95	66%	16.0	100 200 400	3.0 4.5 6.0	100, 500
14A/U	20 Copper	Poly-ethylene	1	Black Vinyl	.420	92	66%	16.0	100 200 400	3.5 5.0 7.0	100, 500
16A/U	18 Copper	Cellular Poly-ethylene	1	Black Vinyl	.195	50	78%	30.8	100 200 400	2.5 3.5 5.0	100,500 1000
18/U	18 Copper	Cellular Poly-ethylene	1	Black Vinyl	.280	75	78%	24	100 200 400	2.0 3.0 4.5	100,500 1000

Problem #1) A TDR test was performed on a piece of **RG 14A/U** cable of unknown length that is terminated with a purely resistive load. The results of the test are as follows:



Assuming that the cable is lossless, determine the **length** of the cable in meters and the **load impedance** in ohms.

$Z_o = 92\ \Omega$

$v = 0.66C = 1.98\times10^8$

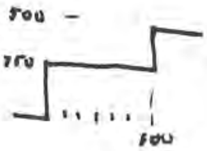
$\Gamma_R = \frac{V^-}{V^+} = \frac{50}{200} = \frac{1}{4}$ $Z_R = Z_o \frac{1+\Gamma_R}{1-\Gamma_R} = 92\left(\frac{1+1/4}{1-1/4}\right) = 92\left(\frac{5}{3}\right) = 153\ \Omega$

$\ell = \frac{v\cdot t}{2} = \frac{(1.98\times10^8)(60\times10^{-9})}{2} = 5.94$ meters

#2) $\hat{E}_s = 3.79\angle -30°$
$Z_{in} = 28.4 - j29.1$
$\lambda = 11.7$

#3)

#5)



#4) 13 dBm
20 mW

Length = 5.94 **(m)**

$Z_R =$ 153 Ω

Problem #2) A **5∠0° volt, 20MHz** incident waveform is applied to the input of a transmission line with characteristic impedance **Z_o = 75Ω** and propagation constant **γ = 0.01 Np/m + 0.537 rad/m** at the applied frequency. The line is terminated with a load impedance **Z_R = 300Ω.**

a) Determine the **actual steady-state voltage** (in polar form) **at the sending-end** of the line if the length of the line is **8 meters.**

b) Determine the **input impedance Z_{in}** (in rectangular form) of the line at this frequency.

c) Determine the **wavelength** of the waveform on the line.

$$\Gamma_R = \frac{Z_R - Z_o}{Z_R + Z_o} = \frac{300-75}{300+75} = \frac{225}{375} = 0.6 \qquad \bar{E}_o^+ = 5\angle 0$$

$$\tilde{E}_s = \tilde{E}_o^+ + \bar{E}_o^+ \Gamma_R e^{-2\gamma l} \qquad \gamma = 0.01 + j0.537 \qquad l = 8 ✓$$

$$E(l)^+ = E_o^+ e^{-\gamma l}$$

$$= 5\angle 0 + (5\angle 0)(0.6)\, e^{-2(0.01+j0.537)(8)} = \boxed{3.786\angle -30° \text{ volts}}$$

.61∠113.8°
4.61∠1.99rad

[illegible]

$$Z_{in} = Z_o \frac{\overset{1+0.5113\angle -132}{1+\Gamma_R e^{-2\gamma l}}}{\underset{1-0.5113\angle 132}{1-\Gamma_R e^{-2\gamma l}}} = \boxed{(28.4 - j29.1)\,\Omega} = 75\,\frac{0.757\angle -30°}{1.396\angle 15.7}$$

$$= 75(0.543\angle -45.0)$$

✓

$$\lambda = \frac{2\pi}{\beta} = \frac{2\pi}{0.537} = \boxed{11.7 \text{ meters}}$$

$$\Gamma_R e^{-2\gamma l} = (0.6)\left(0.852 \angle -132.3°\right)^{-2.3r}$$

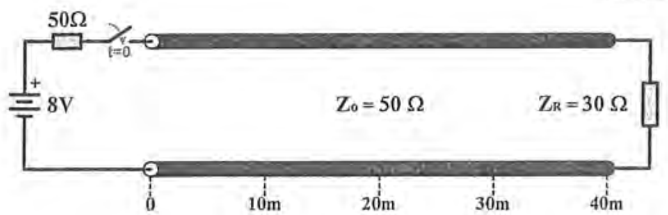
$$= 0.511\angle -132.3°$$

a) $\widetilde{E}_S$ = ______________________ **(V)**

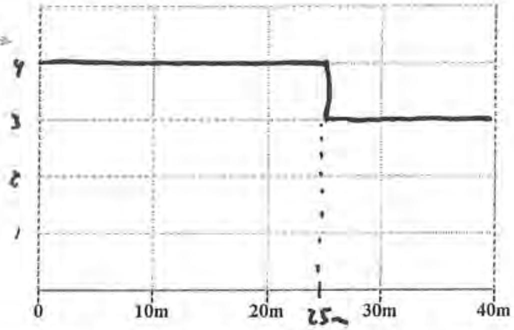
b) Z_{in} = ______________________ **(Ω)**

c) λ = ______________________ **(m)**

Problem #3) Given the system shown below containing a "**lossless**" line, the conductors of which are surrounded by Teflon insulation (**εr = 2.1**):

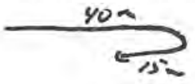


accurately label the voltage axis



Assuming that the switch closes at time t = 0, plot **voltage** as a function of position on the line at a time of **t = 266 nsec** after the switch closes. (Hint – use εr to determine velocity)

$v = \frac{c}{\sqrt{\epsilon_r}} = 2.07\times10^{8}$ $d = v\cdot t = v\cdot 266n = 55m$



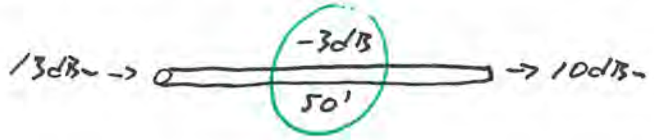
$E_0^+ = 4V$ $\Gamma_R = \frac{Z_R - Z_0}{Z_R + Z_0} + \frac{30-50}{30+50} = \frac{-20}{80} = -1/4$

$E_0^- = \Gamma_R \cdot E_0^+ = (-\frac{1}{4})(4) = -1V$ ✓

Problem #4) An r.f. power meter displays a **10dBm** signal power for a **400MHz** wave measured at the receiving-end of a **50 foot** section of **RG 14/U** cable. Assuming that the power meter's input impedance is matched to the line: 6dB/100' @ 400MHz

a) Determine the strength, in **dBm**, of the input signal applied to the **sending-end** of the line by the r.f. source.

b) Convert the sending-end (input) power in dBm to its equivalent **milliwatt** value.



$13 = 10\log_{10}\frac{P}{1m}$

$10^{1.3} = \frac{P}{1m} \rightarrow P = (1m)\cdot 10^{1.3} \approx 20mW$

a) P_{in} = 13 **(dBm)**

b) P_{in} = 20 **(mW)**

Problem #5) A **90 meter** section of **open-wire, lossless** transmission-line with a characteristic impedance of Z_o = **50Ω** is terminated with an "ideal" **open-circuit**.

Accurately sketch the plot (sending-end voltage vs. time) that would result from a **TDR** test being performed on the sending-end of the line if the TDR injects a **250mV** incident step-voltage (waveform) into the line.

(Note – assume that the TDR's source impedance is matched to the line)

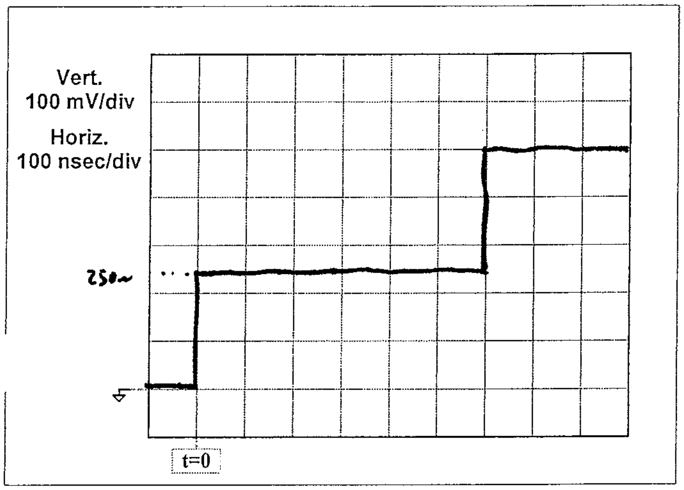
$v = 3\times10^8 \quad t = \frac{2l}{v} = \frac{180}{3\times10^8}$

$= 600\,nsec$

$E_o^+ = 250\,mV$

$Z_R = \infty \therefore \Gamma_R = 1$

$E_o^- = 250\,mV$



Problem #6) For each of the following, specify whether or not each of the responses is true by writing either **TRUE** or **FALSE** in the blank preceding each response.

FALSE The ***characteristic impedance*** of a coaxial cable can be increased by increasing the length of the cable.

FALSE If a line is terminated with an ideal "**short circuit**" then both the (actual) steady-state voltage and cu~~rre~~nt at the receiving-end of the line must be zero.

TRUE For normal coaxial transmission-lines, the **relative permeability** (μ_r) of the insulation that fills the space between the conductors is assumed to be **one**.

FALSE A transmission-line that is considered **lossless** will always have a propagation velocity of $3\text{x}10^8$ m/sec.

TRUE Given a source connected to a coaxial line; if the source frequency is increased then the **wavelength** of the wave on the line will decrease. $\lambda = v/f$

TRUE When expressed in terms of decibels, **attenuation** of a wave on a coaxial-cable is independent of the actual power of the wave (in mW) applied to the line's sending-end.

Do Not Write Below This Line

1) ______/15 2) ______/25 3) ______/20 4) ______/10 5) ______/15 6) ______/15 Total) ________/100