Question Set 1:

1. A transmission line with characteristic resistance 50 ohms and speed of propagation $2x10^8$ m/s is driven by a step-function generator of zero internal resistance. The open-circuit voltage across the generator is zero volts for $t < 0$ and 10 volts for $t > 0$. The transmission line is 5 cm in length, and is terminated in an open circuit.
(i) Draw a bounce diagram for the transmission line from $t = 0$ to $t = 1.5$ ns.
(ii) Draw a graph of the voltage across the open-circuit load as a function of time for $0 < t < 1.5$ ns.

2. A pulse generator with internal resistance $R_s = 10$ ohms produces a pulse of voltage lasting 1 ns starting at $t = 0$. The open-circuit voltage has amplitude 10 Volts. The generator is connected to a load of $R_L = 50$ ohms by a 3 meter cable of characteristic resistance 70 ohms and speed of propagation $2.5x10^8$ m/s.
(i) Draw a "bounce diagram" for $0 < t < 65$ ns.
(ii) Plot the voltage across the generator $v_1(t)$ and the voltage across the load $v_2(t)$ for $0 < t < 65$ ns.

3. Repeat problem 2 if the generator produces a step function voltage. The generator's open-circuit voltage is equal to zero volts for $t < 0$ and 10 volts for $t > 0$.

Verify your answers with PSpice

Question Set 2:

1. A voltage source has internal resistance 10 ohms. It produces a pulse of 0.5 ns duration starting at $t = 0$. The open-circuit voltage is 5 volts. The generator is connected to a transmission line with characteristic resistance 50 ohms, and speed of propagation $2x10^8$ m/s. The length of the line is 1 cm. The line is terminated with a resistor R_L.
(a) Find the voltage across the load for R_L =50 ohms from $t = 0$ until $t = 0.65$ ns.
(b) If the termination is R_L =1000 ohms, then use a bounce diagram to find the voltage at the load for $t = 0$ until $t = 1.1$ ns. This is a lot of reflections back and forth, but is easy to calculate.
(c) The logic gate which is the load for this circuit samples the voltage at 0.18 ns to determine if it is a logical 0 or a logical 1. The input resistance to the chip is R_L =1000 ohms. A logical 0 is a voltage less than 1.2 volts; a logical 1 is a voltage greater than 3.8 volts. Is the sampled voltage a 0, or a 1, or indeterminate?
(d) Use PSpice to verify your solution.

2. A logic gate has an output resistance of 10 ohms and produces a step function voltage of 10 volts (open-circuit) starting at t=0. The gate is connected in series with two transmission lines, both having length 5 cm and speed of propagation $2x10^8$ m/s. The first line has characteristic resistance 50 ohms, and the second line has characteristic resistance 73 ohms. The load at the end of the second line is a 1000 ohm resistor. Plot the voltage at the junction and the voltage across the load for 0<t<1.1 ns. Use PSpice to verify your solution.

3. A logic gate has internal resistance 10 ohms and produces a 10 volt step function (open-circuit) starting at t=0. It is connected to transmission line #1, having length

0.4 cm. The end of line #1 branches into line #2 in parallel with line #3. Line #2 has length 1.5 cm and is terminated with a 50 ohm load. Line #3 has length 0.7 cm, and is terminated with a high-impedance logic gate of input resistance 1000 ohms.
The speed of propagation on all three lines is 2×10^8 m/s, and the characteristic resistance of all three lines is 50 ohms. Find the voltage across the 50 ohm load for $0<t<0.180$ ns. Use PSpice to verify your solution.

Question Set 3:

1. A wave travels in a material at 2.450 GHz. The relative permittivity of the material is $\varepsilon_r=15$ and the conductivity is $\sigma = 20$ mS/m. A plane wave propagates through the material in the z direction. The electric field is oriented parallel to the x axis. The amplitude of the electric field at $z = 0$ is 10 V/m.
(i) What is the value of the loss tangent?
(ii) What is the value of the propagation constant? What is the attenuation constant? What is the phase constant?
(iii) What is the penetration depth?
(iv) What is the intrinsic impedance?
(v) Write the vector-phasor for the electric field.
(vi) Write the vector-phasor for the magnetic field.
(vii) Write the electric field vector and the magnetic field vector in the time domain.
(viii) What is the amplitude of the electric field at $z = 2$ m?
(ix) What is the power density at $z = 0$ m? At $z = 2$? (Hint: evaluate the E and the H phasors at $z = 0$ and then evaluate the Poynting Vector. Then repeat with the E and H phasors evaluated at $z = 2$.)

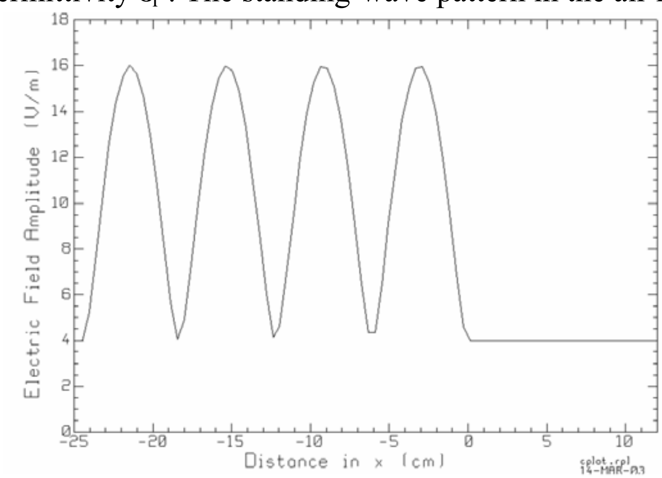
2. A plane wave propagates in air at 850 MHz. The plane wave travels in the + y direction and the electric field is oriented parallel to the z axis. At y =12.78 cm, the amplitude of the electric field is 6.23 V/m, and the phase of the electric field is 27 degrees.
(i) Write the vector-phasor for the electric field as a function of distance y. Give the numerical value of all the constants.
(ii) Use Maxwell's Equations to find the magnetic field "vector-phasor" by taking the curl of E .
(iii) What is the value of the Poynting vector?
(iv) What is the amplitude and phase of the electric field at point (x=37.2,y=63.8,z=49.4) m?

3. The electric field vector-phasor at 2.45 GHz is given by $\vec{E} = \hat{x}\left(10e^{-j\beta z} + 6e^{+j\beta z}\right)$
(i) Find the maximum value of the electric field, and the distances z where the field is a maximum.
(ii) Find the minimum value of the electric field, and the distances z where the field is a minimum.
(iii) Find the standing-wave ratio, which is defined as the largest electric field amplitude divided by the smallest electric field amplitude.

Question Set 4:

1. A plane wave at 850 MHz is normally incident on the surface of a half-space filled with brick material, which has ε_r =5.1 and σ =10 mS/m.
(i) Find the propagation constant in the air and in the brick.
(ii) What is the loss tangent of the brick? What is the penetration depth?
(iii) Find the intrinsic impedance of the brick.
(iv) Find the reflection coefficient and the transmission coefficient.
(v) If the incident wave has amplitude 3 V/m, then what is the amplitude of the field inside the brick at a depth of 1 meter from the surface?
(vi) In the air, what is the maximum value of the electric field? What is the minimum value of the electric field? What is the standing-wave ratio?
(vii) What is the distance of the first minimum in the standing-wave pattern in the air from the surface of the brick?

2. A plane wave in air is incident on the surface of a lossless dielectric of unknown permittivity ε_r . The standing-wave pattern in the air is measured, and is shown below.



The surface of the dielectric is at *x* = 0, with air for *x* < 0 and dielectric for *x* > 0. The largest electric field is 16 V/m, and the smallest is 4 V/m. There is a minimum in the standing-wave pattern at the surface of the dielectric, and another minimum at x=-6.1224 cm.
(i) What is the frequency?
(ii) What is the permittivity of the dielectric, ε_r?

3. A brick wall has ε_r =5.1 and σ =0. A plane wave in air at 2.450 GHz is normally incident on the surface of the brick, and is partially reflected by the wall and partially transmitted through the wall.
(i) If an electric field of 1 mV/m is normally incident on the surface of the wall, what is the transmitted field for a thickness of 22 cm?
(ii) How thick should be wall be for the reflection coefficient to be zero, so that there is perfect transmission through the wall?
Remark: In fact concrete has σ =60.1 mS/m at 850 MHz, but to keep this problem simple the conductivity is neglected.