EE 200 Signals, Systems & Networks — Assignment 1

1 You know that the signal in a conductor travels at a finite velocity less than that of light in vaccum. We call this the propogation velocity, v Let v for a given conductor be $0.4c$. As engineers, we accept that a long conductor can be considered a lumped element if the phase difference between the two ends is less than a milliradian.

(a) If we apply a sinusoid at 200 MHz, what is the maximum possible length of the conductor?

(b) If the conductor is $50km$ long, what is the highest frequency sinusoid we can apply?

(c) We join two equal lengths of different conductors with v of $0.4c$ and $0.25c$. Considering the length of the complete conductor, answer (a) and (b) above.

(d) A signal transmitted on a conductor is a complex signal with multiple Fourier components (harmonics) at $f, 2f, 3f, \ldots$ A ready example is a square wave. What criteria should be used to determine whether the conductor behaves as a lumped or distributed element?

2 In the circuit shown in Fig.2, let the current and voltage in branch $k : k = 1, 2, \ldots, 7$ be i_k and v_k respectively. Assume that the associated direction convention is followed to define branch voltage polarities. What is the minimum number of branch voltages you need to be given (and which ones) in order to find the rest using KVL? For the minimum number, is the set of branch voltages to be given unique? Or can there be multiple solutions?

3 A loop is any closed path without self intersections. A mesh is a closed path inside which no element/branches are present. List all meshes and loops in the graph of the previous problem.

4 A time-invariant inductor has an $i - \phi$ characteristic given by $i = \phi^2 \operatorname{sgn}(\phi)$.

(a) Sketch the characteristics.

(b) Is it active or passive? Linear or nonlinear?

(c) How would you assign L_{dc} at $\phi = 0$? What is L_{ac} at $\phi = 0$?

(d) Show that inverse of L_{ac} increases linearly as ϕ.

5 (a) Is the resistor in Fig.5 voltage or current controlled (or both or neither controlled?)

(b) Obtain the characteristics of the resistor which, when put in parallel with the given resistor will make the combination have a linear characteristic of 1Ω.

(c) Put this resistor in series with an ideal diode in the two configurations, (i) parallel, (ii) series and sketch the combined characteristic over $-4 < v < 4$. Next reverse the diode in the two configurations and repeat (sketch the combined characteristic).

6 A cylindrical core has an iron rod core that executes SHM $x(t) = \sin(100\pi t)$ along the coil axis. When rod is fully out (when $100\pi t = 2\pi n + 3\pi/2$), the coil inductance: $L_{min} = 0.5\,\mathrm{H}$ and when the rod is fully in (when $100\pi t = 2\pi n + \pi/2$), the coil inductance: $L_{max} = 2\,\mathrm{H}$.

(a) Find the coil terminal voltage when $i = 1\,\mathrm{A}$ dc.

(b) Find the coil terminal voltage when $i = 5\cos 240\pi t\,\mathrm{A}$.

(c) Find the coil terminal voltage if we set $i(t) = -L(t)\,\mathrm{A}$.

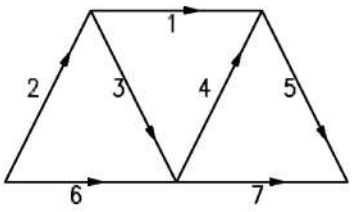

Fig.2

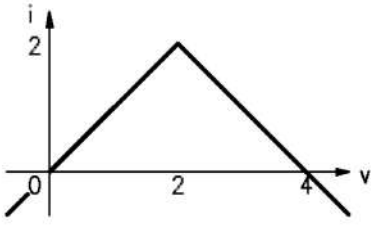

Fig.5