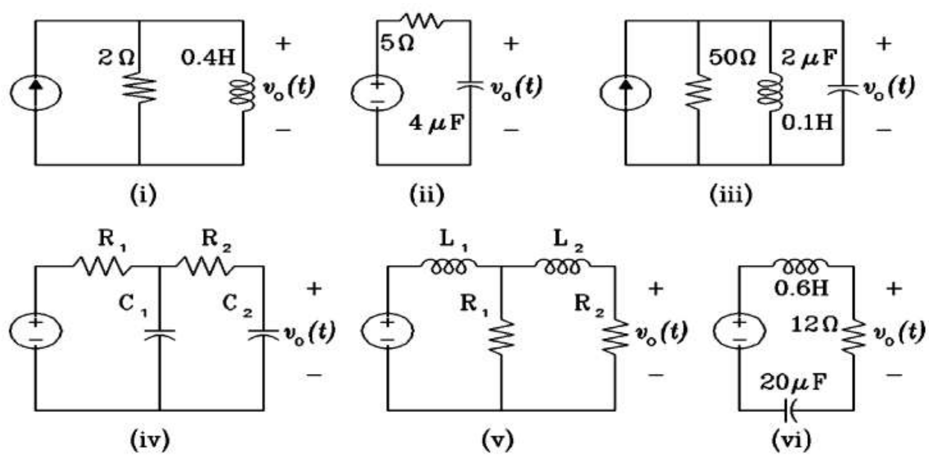
EE 200 2014 Signals, Systems & Networks

Assignment 2

1 Consider the following circuits (i) to (vi). In all cases, assume a switch in series with every voltage source, that is initially open, but closed at $t = 0$ and a switch across every current source that is initially closed, and opened at $t = 0$. For all 6 circuits, set up the KCL/KVL integrodifferential equation in terms of $v_o(t)$. Find the order of each circuit.



2 For (i), assume an initial inductor current of I flowing upwards through the inductor through a closed parallel switch across the inductor (not shown). The switch is also opened at $t = 0$ along with the switch across the 5A current source. For (ii), assume an initial capacitor voltage of V, positive above. Obtain the solution $v_o(t) = y(t)$, separating the respective transient and steady state components $y_T(t)$ and $y_S(t)$. Also separate $y(t)$ into the 'pure state' response $y_C(t)$ and the 'pure input' response $y_I(t)$. For this exercise, consider the inputs to be current source for (i) as $i(t) = I_s$; $t \geq 0$ and the voltage source for (ii) as $v(t) = V_s$; $t \geq 0$.

3 Now consider the previous question, Q.2 with the following changes.

(a) Current source for (i) is $i(t) = I_m \cos\omega t$; $t \geq 0$ and voltage source for (ii) is $v(t) = V_m \cos\omega t$; $t \geq 0$.

(b) Current source fror (i) is $i(t) = I_s + I_m \cos\omega t$; $t \geq 0$ and voltage source for (ii) is $v(t) = V_s + V_m \cos\omega t$; $t \geq 0$. Can you get this answer directly using the solutions of (a) above and of Q.2? Show how.

4 For circuits (iii) to (vi), for which the integrodifferential equations were formed in Q.1, differentiate throughout against time, if required, to obtain the pure differential equation, in homogeneous form (ignore the source) for $t \geq 0$. Next, write the characteristic equation, and solve it algebraically, to find the roots. Irrespective of the element values, what is the pattern observed with regard to the roots?

5 Whenever the total number of inductors + the total number of capacitors in the circuit is N, you would observe that we get an equation of corresponding order. For circuits (iii) to (vi), we thus get second order equations. Second order differential equations lead naturally to second degree characteristic algebraic equations whose roots we need to find. Consider the case when the roots are a conjugate pair of purely imaginary numbers. Find the form of the solution, and discuss what is unusual about it.

6 Among the circuits (iii) to (vi), find which exhibit the phenomenon of resonance, and which do not. Try to establish a connection between this and the answer to Q.6. Use your own definition of resonance based upon your past knowledge.