

## **Circuit Theory & Network**

**Code:** CS504A

**Contact:** 3L + 1T

**Credits:** 4

### **Module 1**

**a) Resonant Circuits:** Series and Parallel resonance [1L], (\*) ***Impedance and Admittance Characteristics, Quality Factor, Half Power Points, Bandwidth*** [2L], ***Phasor diagrams, Transform diagrams*** [1L],

***Practical resonant and series circuits, Solution of Problems*** [Tutorial - 1L].

**b) Mesh Current Network Analysis:** Kirchoff's Voltage law, Formulation of mesh equations [1L], Solution of mesh equations by Cramer's rule and matrix method [2L], Driving point impedance, Transfer impedance [1L], Solution of problems with DC and AC sources [1L].

### **Module 2**

**a) Node Voltage Network Analysis:** Kirchoff's Current law, Formulation of Node equations and solutions [2L], driving point admittance, transfer Admittance [1L], Solution of problems with DC and AC sources [1L].

**b) Network Theorems:** Definition and Implication of Superposition Theorem [1L], Thevenin's theorem, Norton's theorem [1L], Reciprocity theorem, Compensation theorem [1L], maximum Power Transfer theorem [1L], Millman's theorem, Star delta transformations [1L], Solutions and problems with DC and AC sources [1L].

### **Module 3**

**Graph of Network:** Concept of Tree and Branch [1L], tree link, junctions, (\*) ***Incident matrix, Tie set matrix*** [2L], ***Determination of loop current and node voltages*** [2L].

**Coupled Circuits:** Magnetic coupling, polarity of coils, polarity of induced voltage, concept of Self and mutual inductance, Coefficient of coupling, Solution of Problems.

**Circuit transients:** DC transients in R-L and R-C Circuits with and without initial charge, (\*) ***R-L-C Circuits, AC Transients in sinusoidal R-L, R-C and R-L-C Circuits, Solution of Problems*** [2L].

### **Module 4**

**Laplace transform:** Concept of Complex frequency [1L], transform of  $f(t)$  into  $F(s)$  [1L], transform of step, exponential, over damped surge, critically damped surge, damped and un-damped sine functions [2L], properties of Laplace transform [1L], linearity, real differentiation, real integration, initial value theorem and final value theorem [1L], inverse Laplace transform [1L], application in circuit analysis, Partial fraction expansion, Heaviside's expansion theorem, Solution of problems [1L].

(\*) ***Laplace transform and Inverse Laplace transform*** [2L].

**Two Port Networks:** Relationship of Two port network variables, short circuit admittance parameters, open circuit impedance parameters, transmission parameters, relationship between parameter sets, network functions for ladder network and general network.

**Tutorials: (\*)*Bold and Italics.***

Old module 9 viz. SPICE deleted for consideration in Sessional Subject.

### Problems for Module 1a:

**Ex. 1.** A parallel RLC Circuit has  $R = 100 \text{ K Ohms}$ ,  $L = 10 \text{ mH}$ ,  $C = 10 \text{ nF}$ . Find resonant frequency, bandwidth and Quality factor.

**Ex. 2.** Two coils one of  $R = 0.51 \text{ Ohms}$ ,  $L = 32 \text{ mH}$ , other of  $R = 1.3 \text{ Ohms}$ ,  $L = 15 \text{ mH}$ , and two capacitors of  $25 \text{ micro F}$  and  $62 \text{ micro F}$  are in series with a resistance of  $0.24 \text{ Ohms}$ . Determine resonance frequency and  $Q$  of each coil.

**Ex. 3.** In a series circuit with  $R = 50 \text{ Ohms}$ ,  $L = 0.05 \text{ Ohms}$  and  $C = 20 \text{ micro F}$ , frequency of the source is varied till the voltage across the capacitor is maximum. If the applied voltage is  $100 \text{ V}$ , find the maximum voltage across the capacitor and the frequency at which this occurs. Repeat the problem with  $R = 10 \text{ Ohms}$ .

### Problems for Module 1b and 2:

Examples for mesh current in networks like  $T$ ,  $\pi$ , bridged  $T$  and combination of  $T$  and  $\pi$ .

### Problems for Module- 2a:

**Ex.1.** The network of Fig.1 – Mod.4 is in the zero state until  $t = 0$  when switch is closed. Find the current  $i_1(t)$  in the resistor  $R_3$ .

Hints: the Fig.1 – Mod.4 shows the same network in terms of transform impedance with the Thevenin equivalent network.

**Ex.2.** Find the Norton's equivalent circuit for the circuit Fig.2 – Mod.4.

Hints: As a 1<sup>st</sup>. step, short the terminals  $ab$ . This results in the Circuit of Fig.2.(a). By applying KCL at node  $a$ , we have,  $(0-24)/4 + i_{sc} = 0$ ; i.e  $i_{sc} = 9 \text{ A}$ . To find out the equivalent Norton's impedance  $R_N$ , deactivate all the independent sources, resulting in a circuit of Fig.2.(b),  $R_N = (4 \times 12)/(4+12) = 3 \text{ Ohms}$ . Thus we obtain Norton equivalent circuit of Fig.2 (c).

### Problems for Module –2b:

**Ex.1.** Draw the graph, one tree and its co tree for the circuit shown in Fig.1 – mod.5.

Hints: In the circuit there are four nodes ( $N = 4$ ) and seven branches ( $B = 7$ ). The graph is so drawn and appears as in Fig. 1 (a).

Fig.1(b) shows one tree of graph shown in Fig. 1(a). The tree is made up of branches 2, 5 and 6. The co tree for the tree of Fig.1 (b) is shown in Fig. 1(c). The co tree has  $L = B - N + 1 = 7 - 4 + 1 = 4$  Links.

**Ex.2. (a).** For the circuit shown in Fig.2- Mod.5, construct a tree so that  $i_1$  is a link current. Assign a complete set of link currents and find  $i_1(t)$ .

**(b).** Construct another tree in which  $v_1$  is a tree branch voltage. Assign a complete set of tree branch voltages and  $v_1(t)$ .

Take  $i(t) = 25 \sin 1000t \text{ A}$ ,  $v(t) = 15 \cos 1000t$ .

# Annexure-1.

