T-2 9.4 THEVENIN'S THEOREM

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
B.E: Electronics & Communication Engineering / B.E: Electronics & Telecommunication Engineering
NEP, Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the academic year 2021 – 22)

IV Semester

Circuits & Controls			
Course Code	**21EC43**	CIE Marks	50
Teaching Hours/Week (L: T: P: S)	(3:0:2:0)	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 13 Lab slots	Total Marks	100
Credits	04	Exam Hours	03

Module-1	
Basic concepts and network theorems Types of Sources, Loop analysis, Nodal analysis with independent DC and AC Excitations. (Textbook 1: 2.3, 4.1, 4.2, 4.3, 4.4, 10.6) Super position theorem, Thevenin's theorem, Norton's Theorem, Maximum Power transfer Theorem. (Textbook 2: 9.2, 9.4, 9.5, 9.7)	
Teaching-Learning Process	Chalk and Talk, YouTube videos, Demonstrate the concepts using circuits **RBT Level:** L1, L2, L3

Module-2	
Two port networks: Short- circuit Admittance parameters, Open- circuit Impedance parameters, Transmission parameters, Hybrid parameters (Textbook 3: 11.1, 11.2, 11.3, 11.4, 11.5) **Laplace transform and its Applications**: Step Ramp, Impulse, Solution of networks using Laplace transform, Initial value and final value theorem (Textbook 3: 7.1, 7.2, 7.4, 7.7, 8.4)	
Teaching-Learning Process	Chalk and Talk **RBT Level:** L1, L2, L3
Module-3	
Basic Concepts and representation: Types of control systems, effect of feedback systems, differential equation of physical systems (only electrical systems), Introduction to block diagrams, transfer functions, Signal Flow Graphs (Textbook 4: Chapter 1.1, 2.2, 2.4, 2.5, 2.6)	
Teaching-Learning Process	Chalk and Talk, YouTube videos **RBT Level:** L1, L2, L3

Module-4	
Time Response analysis: Time response of first order systems. Time response of second order systems, time response specifications of second order systems (Textbook 4: Chapter 5.3, 5.4) **Stability Analysis:** Concepts of stability necessary condition for stability, Routh stability criterion, relative stability Analysis (Textbook 4: Chapter 5.3, 5.4, 6.1, 6.2, 6.4, 6.5)	
Teaching-Learning Process	Chalk and Talk, Any software tool to show time response **RBT Level:** L1, L2, L3

Module-5	
Root locus: Introduction the root locus concepts, construction of root loci (Textbook 4: 7.1, 7.2, 7.3) **Frequency Domain analysis and stability**: Correlation between time and frequency response and Bode plots (Textbook 4: 8.1, 8.2, 8.4) **State Variable Analysis:** Introduction to state variable analysis: Concepts of state, state variable and state models. State model for Linear continuous –Time systems, solution of state equations. (Textbook 4: 12.2, 12.3, 12.6)	
Teaching-Learning Process	Chalk and Talk, Any software tool to plot Root locus, Bode plot **RBT Level:** L1, L2, L3

Suggested Learning Resources:

Text Books

1. Engineering circuit analysis, William H Hayt, Jr, Jack E Kemmerly, Steven M Durbin, Mc Graw Hill Education, Indian Edition 8e.
2. Networks and Systems, D Roy Choudhury, New age international Publishers, second edition.
3. Network Analysis, M E Van Valkenburg, Pearson, 3e.
4. Control Systems Engineering, I J Nagrath, M. Gopal, New age international Publishers, Fifth edition.

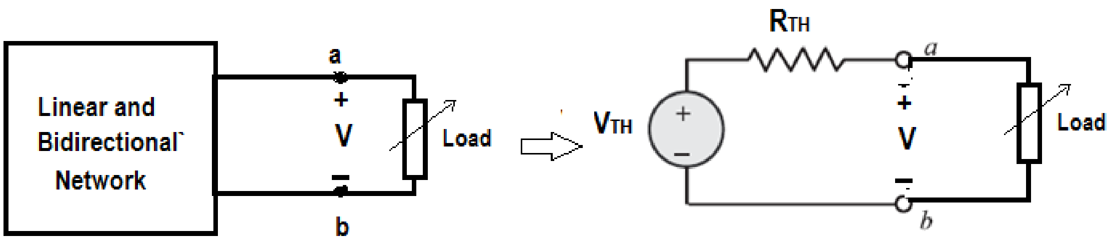
9.4 THEVENIN'S TEOREM

"A linear and bidirectional two- terminal network can be replaced by an equivalent network consisting of voltage source V_{TH} connected in series with a resistor R_{TH}"

V_{TH} ⟶ Open circuit voltage at the terminals

R_{TH} ⟶ Input / Equivalent resistance at the terminals

R_{TH} ⟶ *is the ratio of open–circuit voltage to the short–circuit current at the terminal pair.* $R_{TH} = \frac{v_{oc}}{i_{sc}}$



STEPS TO FIND V_{TH} AND R_{TH}

1) Remove the load resistor and mark the terminals

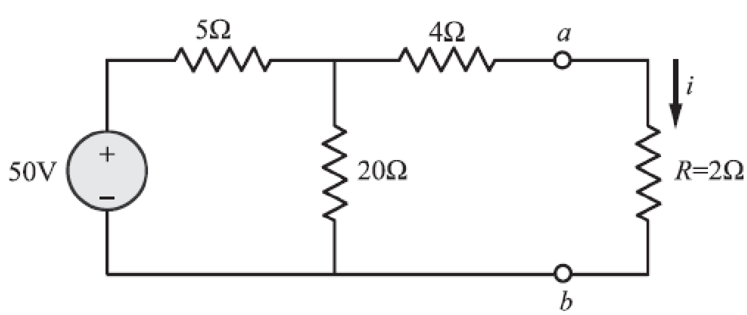
2) Find the open circuit voltage (V_{TH}) using KVL

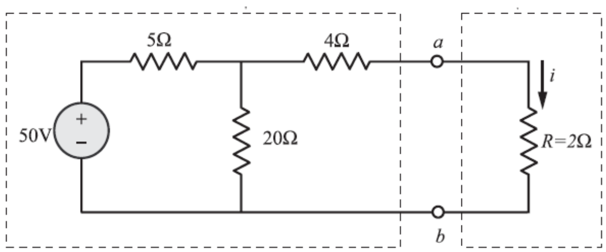
3) Deactivate all the independent sources and find R_{TH}

4) Produce the thevenin's equivalent circuit reconnecting the load resistor.

5) Find the current through the resistor.

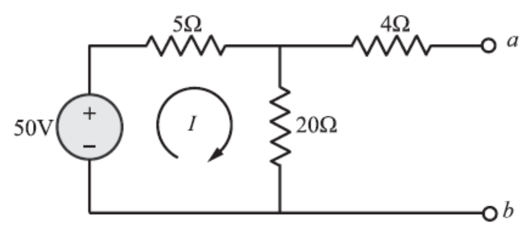
1) Using the Thevenin's theorem, find the current i through R = 2Ω. Refer Fig.



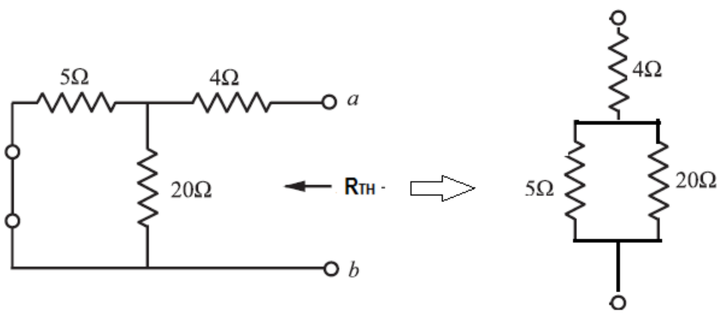


Load

After removing the load resistance the circuit is

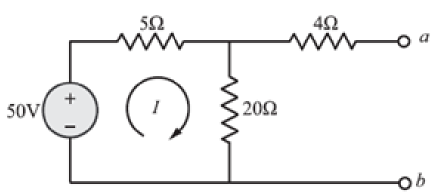


To find R_{TH} deactivate the independent voltage source.



$$R_{TH} = (5\ \Omega \| 20\ \Omega) + 4\ \Omega$$

$$= \frac{5 \times 20}{5 + 20} + 4 = 8\ \Omega$$



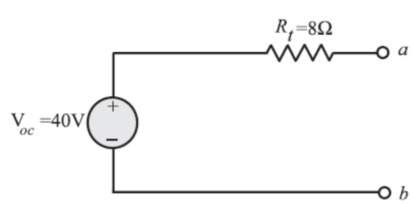
Apply KVL to the loop

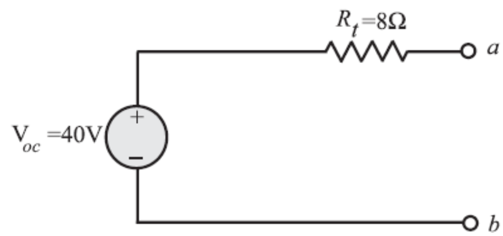
$$-50 + 25I = 0$$

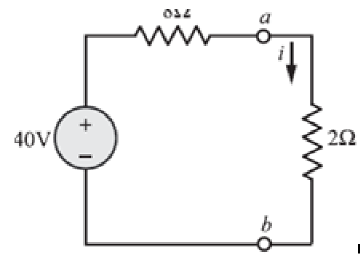
$$I = 2\text{A}$$

$$V_{ab} = V_{oc} = 20(I) = 40\text{V}$$

Thevenin's equivalent circuit which is as shown

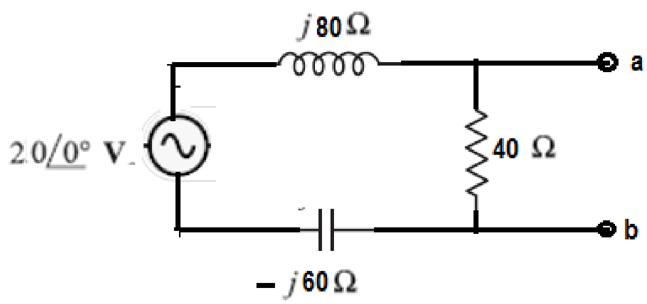


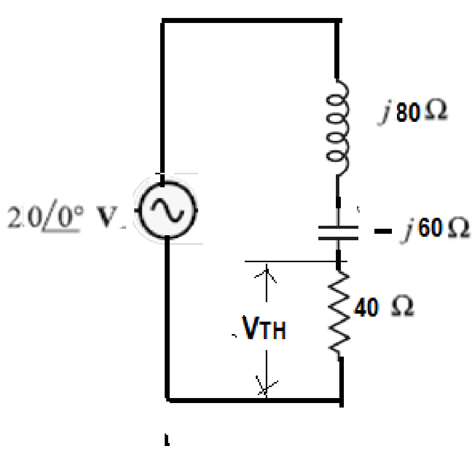




$$i = \frac{40}{2+8} = 4\text{A}$$

2) Find the thevenin Equivalent circuit





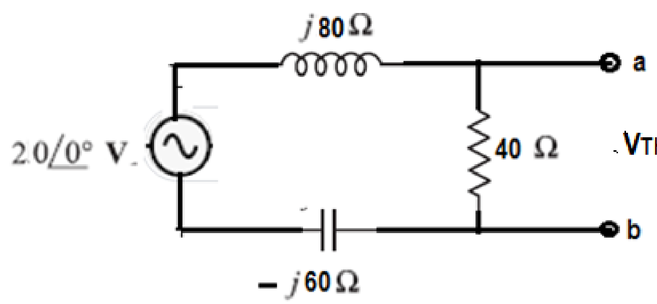
Apply voltage divider technic

$$V_{TH} = 20\angle 0^\circ \times \frac{40}{40 + j80 - j60}$$

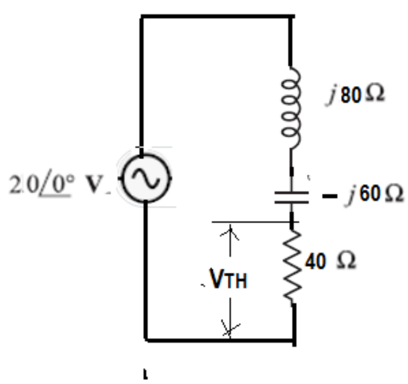
$$= 20\angle 0^\circ \times \frac{40}{40 + j20}$$

$$= 20\angle 0^\circ \times \frac{2}{(2 + j)}$$

$$V_{TH} = \frac{40\angle 0^\circ}{(2 + j)} = 17.9\angle 26.57 \text{ Volts}$$



$V_{TH} = 17.9\angle 26.57$ Volts



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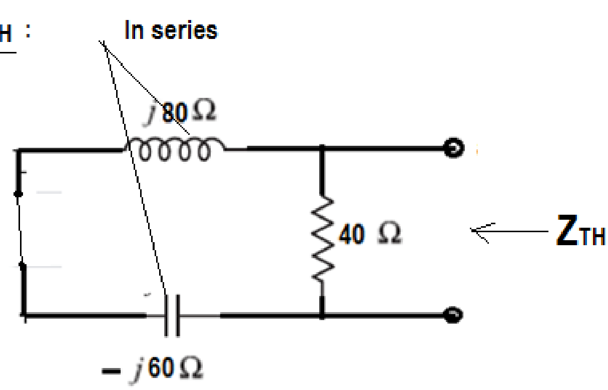
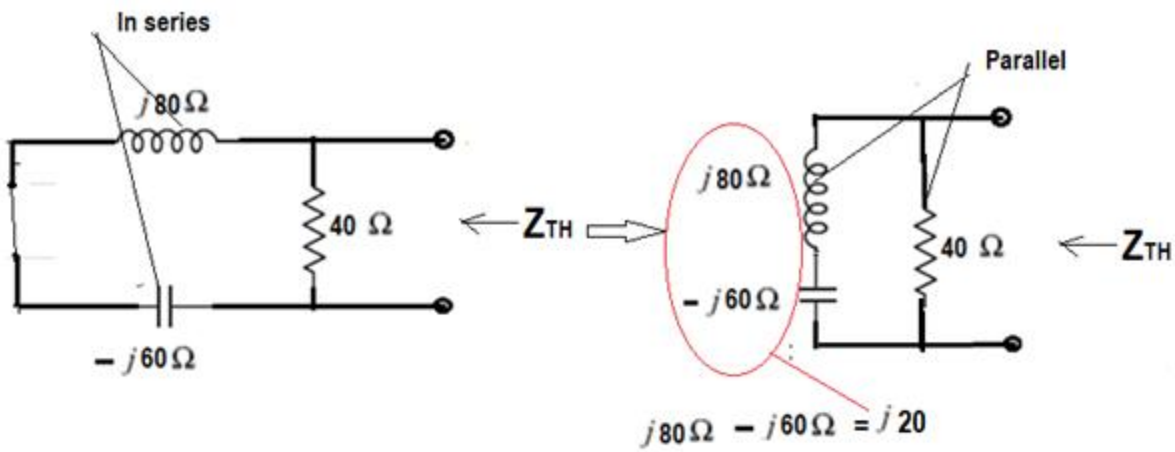
$$= 20\angle 0^\circ \times \frac{40}{40 + j20}$$

$$= 20\angle 0^\circ \times \frac{2}{(2 + j)}$$

$$= \frac{40\angle 0^\circ}{(2 + j)} = 17.9\angle 26.57 \text{ Volts}$$

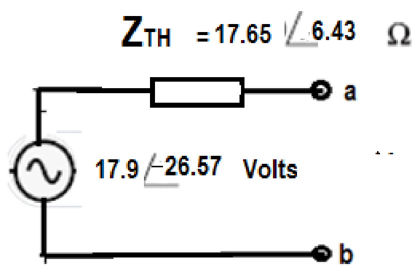
$\underline{Z_{TH}}$:



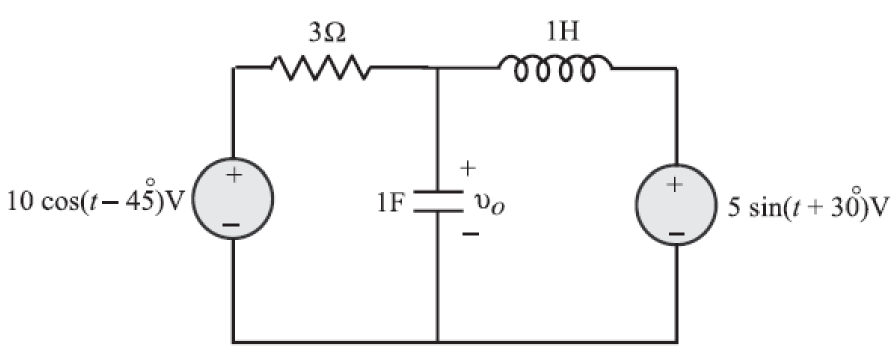


$$Z_{TH} = \frac{40 \times j20}{40 + j20} = 17.65 \angle 6.43 \ \Omega$$

Thevenin's equivalent circuit which is as shown



3) Find V0 using Thevenin's theorem. Refer to the circuit shown in Fig

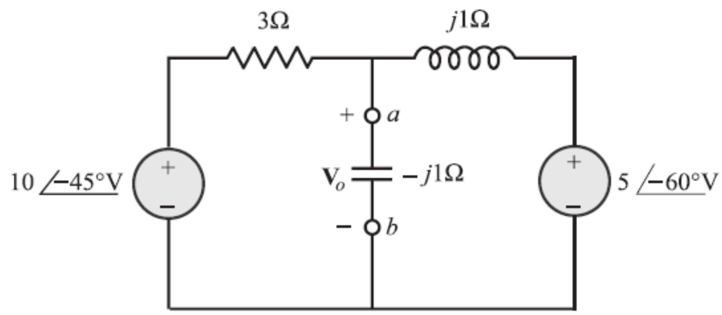


Convert the circuit given into a frequency domain equivalent or phasor circuit

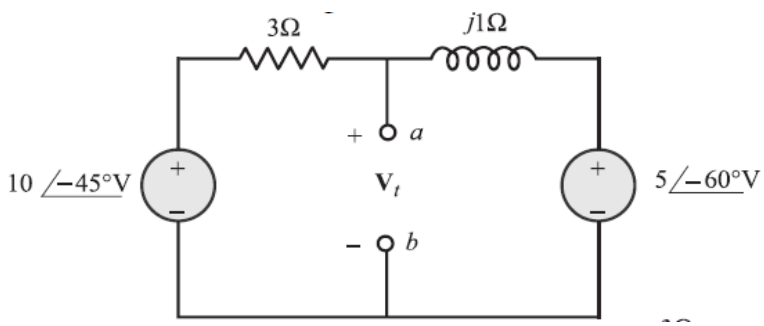
. $\omega = 1$

$$10\cos(t-45^\circ) \rightarrow 10\underline{/-45^\circ}\ \mathrm{V}$$
$$5\sin(t+30^\circ) = 5\cos(t-60^\circ) \rightarrow 5\underline{/-60^\circ}\ \mathrm{V}$$

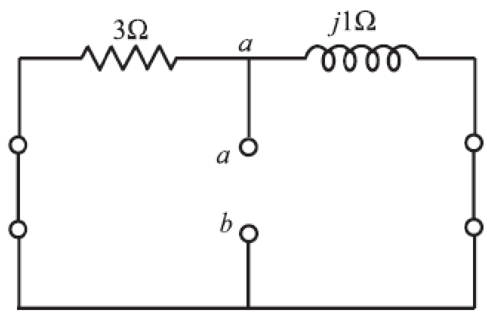
$$L = 1\mathrm{H} \rightarrow j\,\omega L = j\times 1\times 1 = j1\,\Omega$$
$$C = 1\mathrm{F} \rightarrow \frac{1}{j\,\omega C} = \frac{1}{j\times 1\times 1} = -j1\,\Omega$$



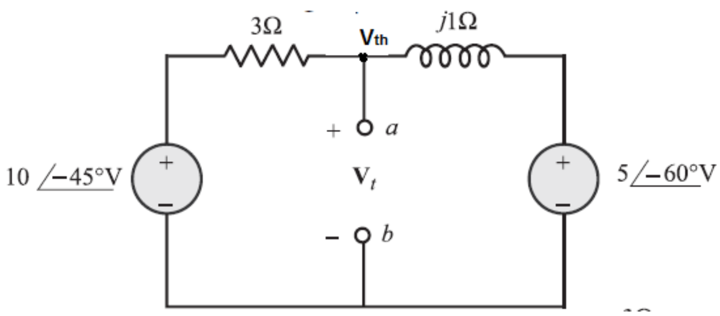
Disconnecting the capacitor from the original circuit,This circuit is used for finding V_{TH}



Deactivate the independent voltage sources

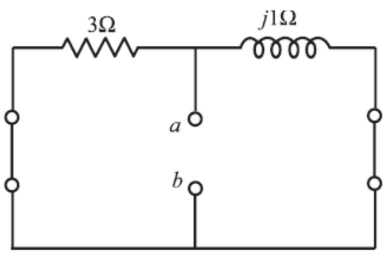


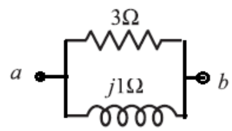
Apply KCL at the node a



$$\frac{\mathbf{V_{th}} - 10\,\underline{/-45^\circ}}{3} + \frac{\mathbf{V_{th}} - 5\,\underline{/-60^\circ}}{j1} = 0$$

$$\mathbf{V_{th}} = 4.97\,\underline{/-40.54^\circ}$$

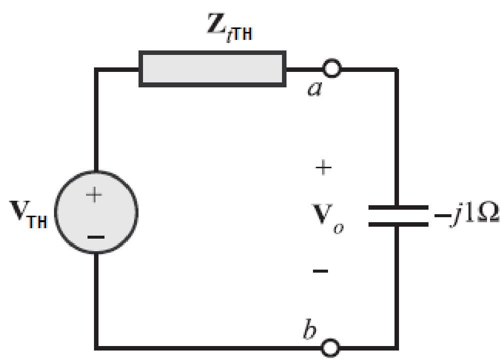




$$\mathbf{Z}_{TH} = \mathbf{Z}_{ab} = 3\Omega \| j1\ \Omega$$

$$= \frac{j3}{3+j} = \frac{3}{10}(1+j3)\ \Omega$$

Thevenin equivalent circuit along with the capacitor



Thevenin Equivalent ckt.

$$\mathbf{V}_o = \frac{\mathbf{V}_{TH}}{\mathbf{Z}_t - j1}(-j1)$$

$$= \frac{4.97\,\underline{/-40.54^\circ}}{0.3(1+j3) - j1}(-j1)$$

$$= 15.73\,\underline{/247.9^\circ}\ \ \text{V}$$

$$\text{Hence,}\quad v_o = 15.73\cos(t + 247.9^\circ)\ \text{V}$$

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