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Lab 1 Superposition principle & Thevenin's theorem

1.1 Pre-Lab Assignment:

Reading "Fundamentals of Electric Circuits", Page 122-127,131-137
Author: Charles K. Alexander Matthew N.O. Sadiku

1.2 Theory

The superposition principle states that voltage across (or current through) an element in a linear circuit is the algebraic sum of the voltages across (or currents through) that element due to each independent source acting alone.

Thevenin's theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source V_{Th} in series with a resistor R_{Th}, where V_{Th} is the open-circuit voltage at the terminals and R_{Th} is the input or equivalent resistance at terminals when the independent sources are turned off.

1.3 Experiment

1.3.1 Part 1.

Steps:

1. Turn off all independent sources except one source. Find the output (voltage or current) due to that active source.
2. Repeat step 1 for each of the other independent sources.
3. Find the total contribution by adding algebraically all the contributions due to the independent source.

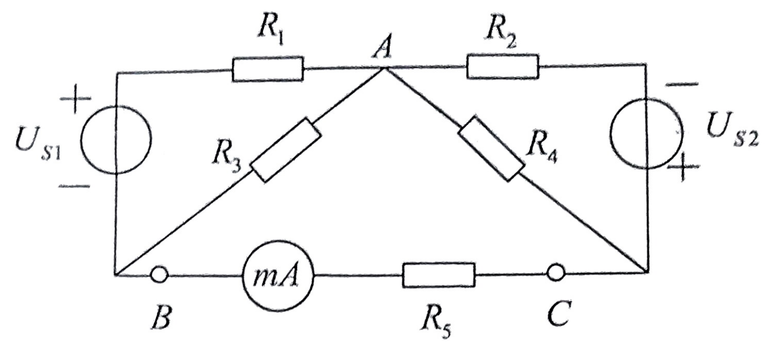


Fig. 1.1 Both voltage sources exist

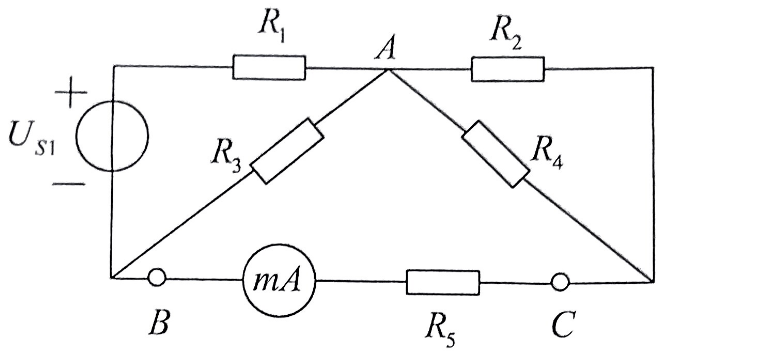


Fig. 1.2 only U_{s1}exists

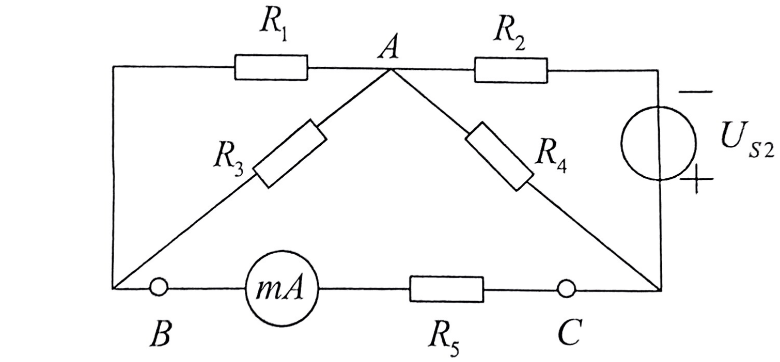


Fig. 1.3 only U_{s2}exists

Table 1 Superposition principle ($U_{s1} = 16V$,$U_{s2} = 10V$)

	$U_{AB}(V)$	$U_{AC}(V)$	$U_{BC}(V)$	$I_{BC}(mA)$
Only U_{s1} exists	+8.606 ~~0.8606~~ V	+1.821 V	-6.786V	-44
Only U_{s2} exists	-2.241 V	-6.742 V	-4.494V	-29
U_{s1}, U_{s2} both exist	+6.367V	-4.922V	-11.290V	- ~~[illegible]~~ 74
绝对 Error~~(%)~~ ~~(V)~~	0.002V	0.001V	0.010V	1mA
相对误差 (%)	0.031%	0.020%	0.088%	1.351%

(相对 both exist)

1.3.2 Part 2

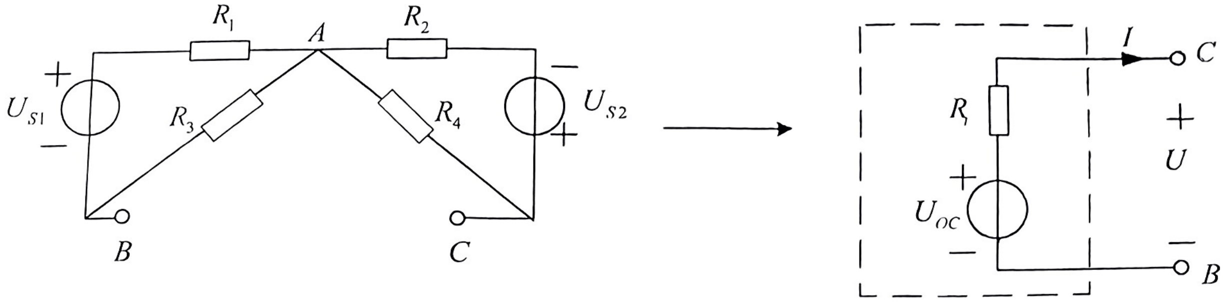


Fig. 1.4 Equivalent Thevenin circuit for a linear two-terminal circuit

(1) Measure U_{OC} = *19.74V that is U_{CB} when open circuit.

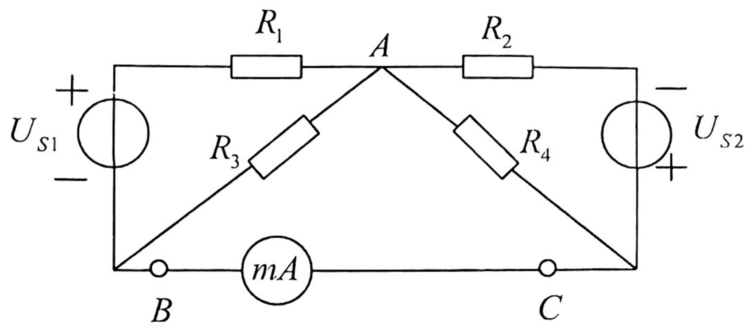


Fig. 1.5 Measure short-circuit current of a two-terminal circuit

(2) Measure I_{SC} = *171mA, that is I_{CB} when short circuit.

(3) $R_i = \frac{U_{OC}}{I_{SC}}$ = 115.44Ω, $R_{eq} = (R_1//R_3 + R_2//R_4)$ = 115.63Ω.

(4) The relation between U and I is ~~U=Uoc~~ $I = \frac{U_{oc}}{R_i}$ in Fig. 1.4

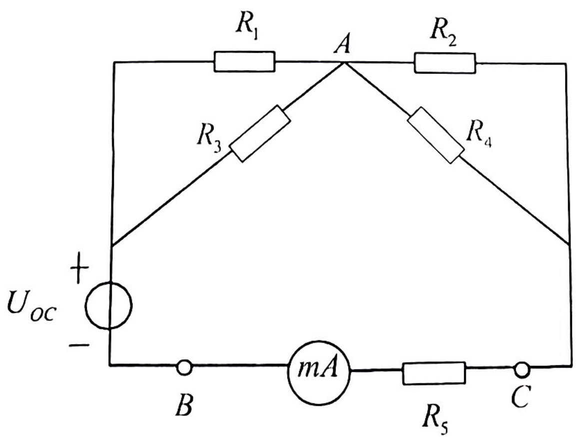


Fig. 1.6 Equivalent Thevenin's circuit

Table 2 Comparison I_{CB} of origin circuit vs. Thevenin's circuit

I_{CB} in Fig. 1.1	I_{CB} in Fig. 1.6	Error(mA)	Error(%)
74mA	74mA	0	0

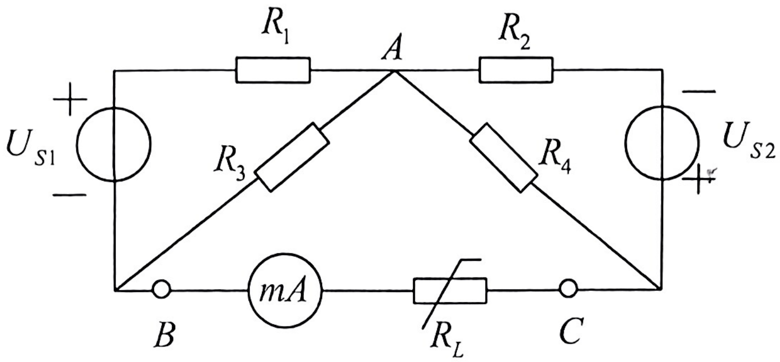
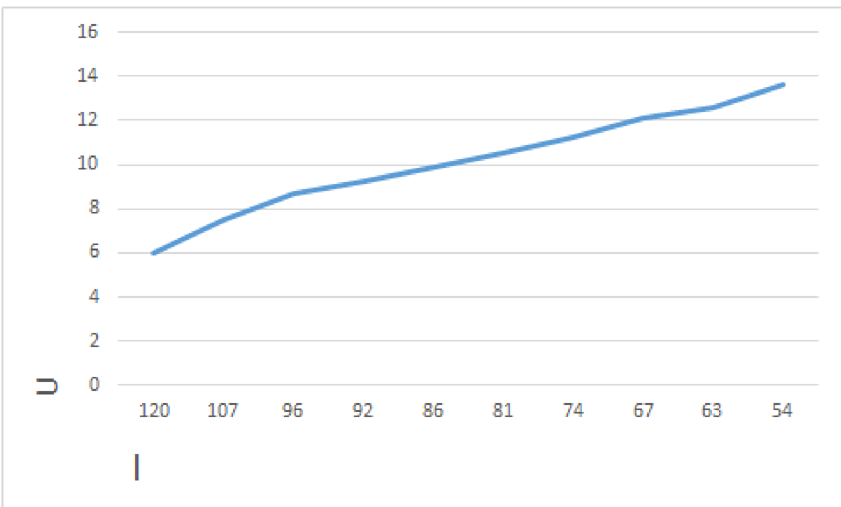


Fig. 1.7 Characteristics of a two-terminal network

Table 3 Output of Fig. 1.

$R_L(\Omega)$	50	70	90	100	R_i	130	150	180	200	250
$U_{CB}(V)$	6.015	7.505	8.713	9.220	9.922	10.532	11.239	12.120	12.616	13.616
$I_{CB}(mA)$	120	107	96	92	86	81	74	67	63	54
$P_{R_L}(W)$	0.722	0.803	0.836	0.848	0.853	0.852	0.832	0.812	0.794	0.735

(4) Draw a curve of U_{CB} vs. I_{CB} according to Table 3. On the same figure, draw a curve of U vs. I according to Fig. 1.4.



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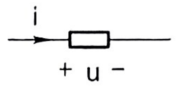
Lab 2 Tellegen Theorem & Reciprocity Theorem

1.Theory

2.1.1 Passive sign convention:

By the Passive sign convention, current enters through the positive polarity of the voltage.



2.1.2 Tellegen Theorem:

1. If there are b branches in a lumped circuit, and the voltage u_k, currenti_k of each branch apply passive sign convention, then

$$\sum_{k=1}^{b} u_k i_k = 0$$

2. If two lumped circuits have the same topological graph, and the voltage, current of each branch apply passive sign convention, then

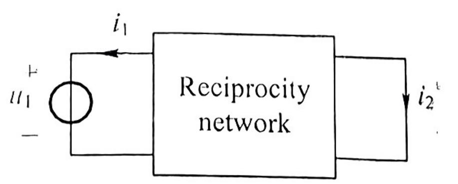
$$\sum_{k=1}^{b} u_k \widehat{i_k} = 0$$

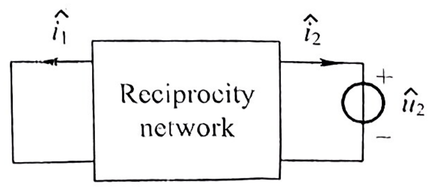
$$\sum_{k=1}^{b} \widehat{u_k}\ i_k = 0$$

2.1.3 Reciprocity Theorem

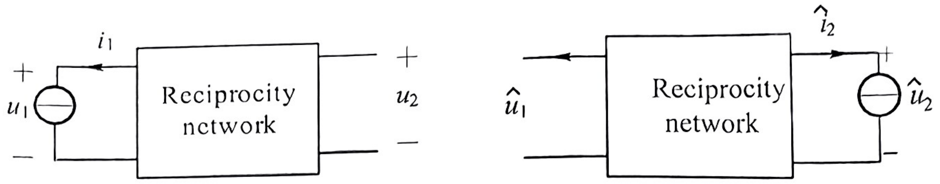
only applicable to reciprocity networks

Case 1: $\frac{i_2}{u_1} = \frac{\widehat{i_1}}{\widehat{u_2}}$

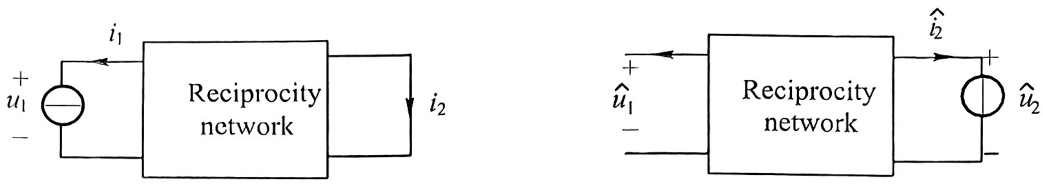




Case 2: $\frac{u_2}{i_1} = \frac{\widehat{u_1}}{\widehat{i_2}}$



Case 3: $\frac{i_2}{i_1} = \frac{\widehat{u_1}}{\widehat{u_2}}$



2.2 Experiment

2.2.1 Part 1

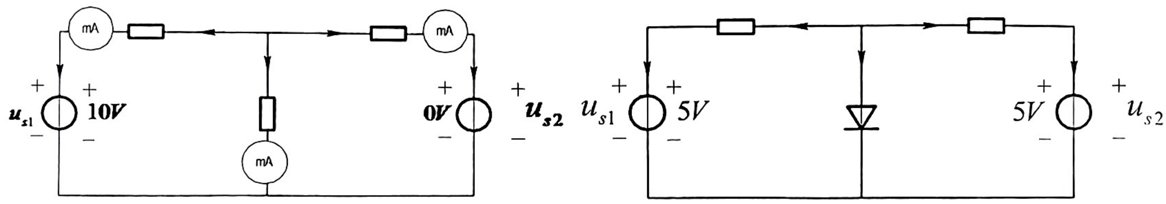


Table 1 Tellegen Theorem

		R_1	R_2 1.681	$R_3(D)$	U_{s1}	U_{s2}
Network 1	u_k (V)	-8.302 ~~-6.736~~	~~0.085~~ 0.851	1.680 ~~3.246~~	9.98V ~~10V~~	~~5.16~~ ~~0V~~ 0
	i_k (mA)	~~-44~~ -55	~~±~~ ~~55~~ 32	~~44~~ 22	~~-44~~ -55	~~±~~ 32
	$u_k i_k$	0.512 ~~0.296~~	~~0.000085~~ 0.054	0.037 ~~0.140~~	-0.549 ~~-0.439~~	0 ~~0.00316~~
Network 2	$\widehat{u_k}$ (V)	-4.237	-4.233	0.748	4.99	5.00
	$\widehat{i_k}$ (mA)	-27	-82	~~28~~ 110	-27	-82
	$\widehat{u_k} i_k$	0.233 ~~0.186~~	0.135 ~~0.00423~~	0.016 ~~0.0322~~	-0.274 ~~-0.220~~	0.16 ~~0.005~~
	$u_k \widehat{i_k}$	~~0.182~~	~~0.00693~~	~~0.094~~	~~-0.269~~	~~0.259~~

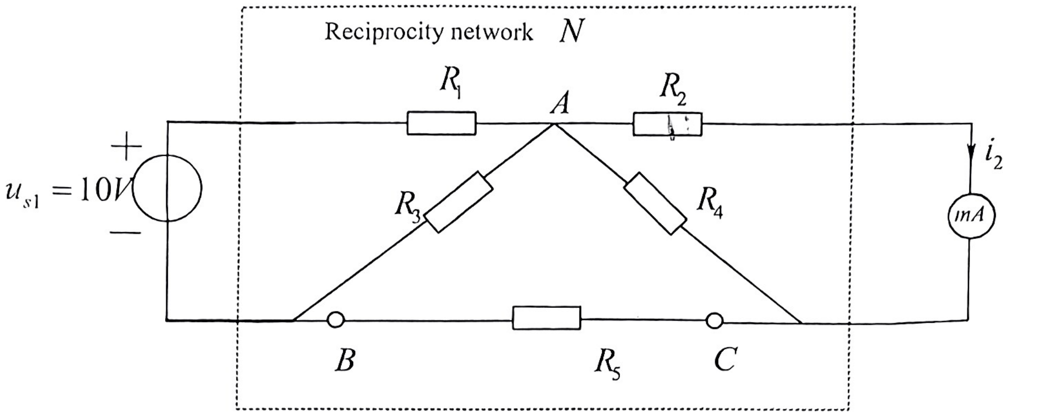
0.224 0.138 0.185 -0.269 0

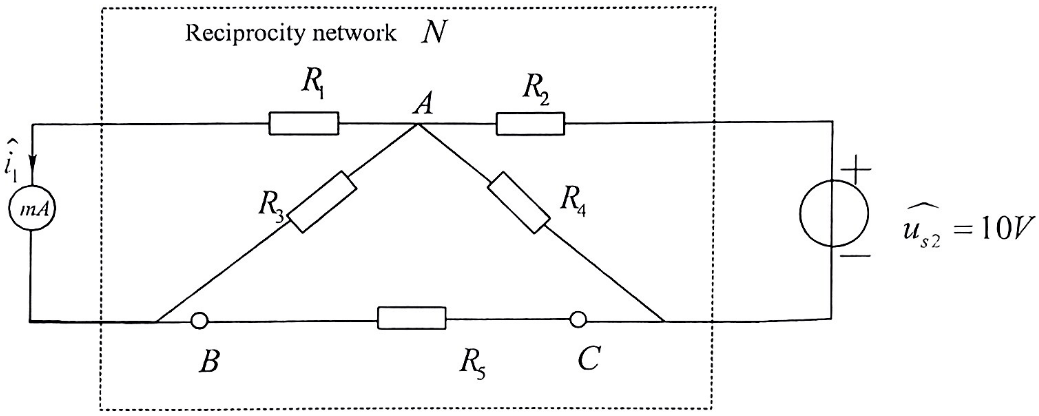
Calculate the sum of b branches :

$\sum_{k=1}^{b} u_k i_k =$ ~~0.000245~~ 0.054 $\sum_{k=1}^{b} u_k \widehat{i_k} =$ ~~0.205~~ 0.270 $\sum_{k=1}^{b} \widehat{u_k} i_k =$ ~~0.198~~ 0.278

2.2.2 Part 2

Case 1:

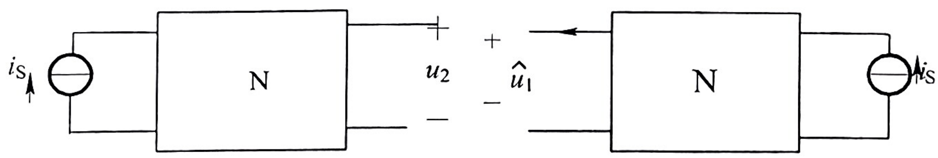




Measure the short currents i_2=~~-22mA~~ 22mA

$\hat{i}_1$=~~-22mA~~ 22mA

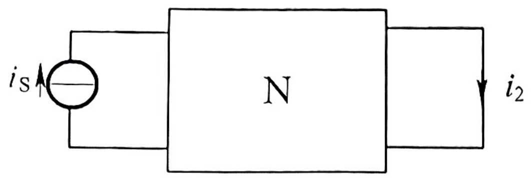
Case 2: use the same reciprocity network N, $i_s = 25mA$

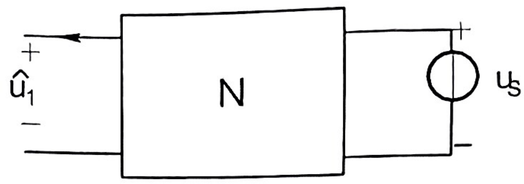


Measure the short currents u_2= 2.170 V

$\widehat{u_1}$= 2.171 V

Case 3: use the same reciprocity network N, ,$i_s = 25mA,\ u_s = 25V$





Measure the short currents i_2= 11 mA

$\widehat{u_1}$= 17.14 V