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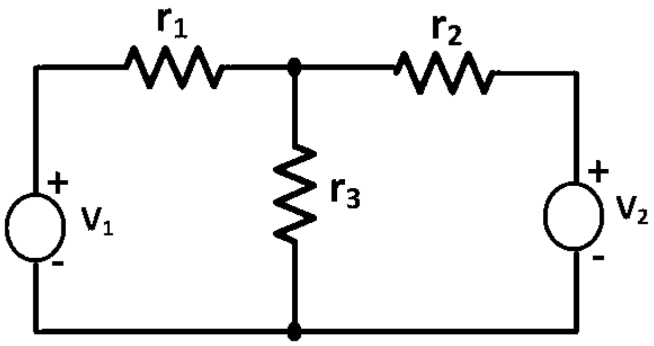
Experiment 1

Aim:

To verify Superposition Theorem.

Theory:

If a number of voltage or current source are acting simultaneously in a linear network, the resultant current in any branch is the algebraic sum of the currents that would be produced in it, when each source acts alone replacing all other independent sources by their internal resistances.



In the given figure apply superposition theorem,
Let us first take the sources V1 alone at first replacing V2 by short circuit. Here,

$$I_1' = \frac{V_1}{\frac{R_2 * R_3}{R_2 + R_3} + R_1}$$

$$I_2' = I_1' * \frac{R_3}{R_2 + R_3}$$

$$I_3' = I_1' - I_2'$$

Next, removing V1 by short circuit, let the circuit be energized by V2 only. Then,

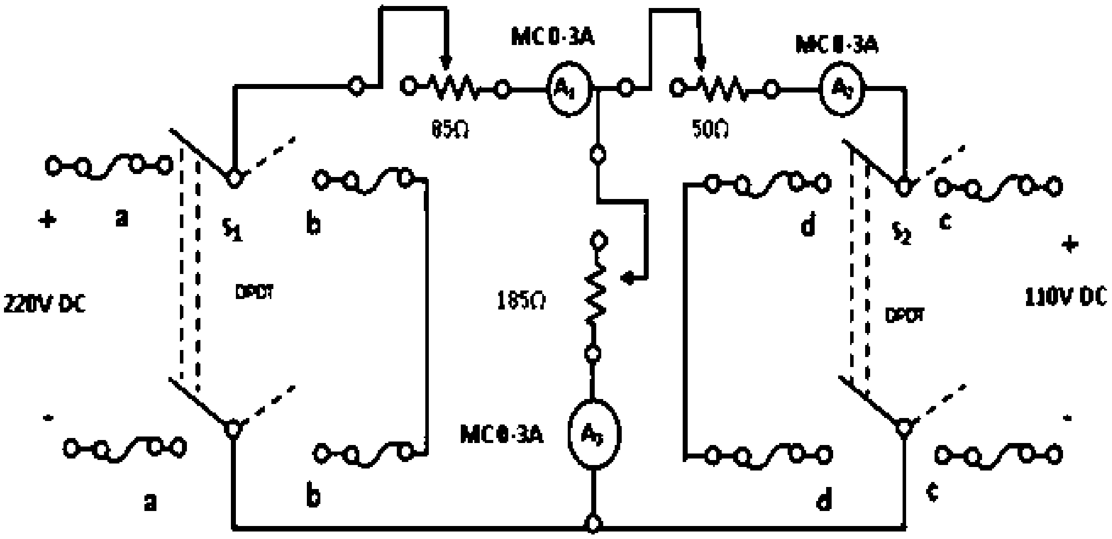
$$I_2'' = \frac{V_2}{\frac{R_1 * R_3}{R_1 + R_3} + R_2}$$

$$I_1'' = I_2'' * \frac{R_3}{R_1 + R_3}$$

$$I_3'' = I_2'' - I_1''$$

As per superposition theorem,
$I_3 = I_3' + I_3''$
$I_2 = I_2' + I_2''$
$I_1 = I_1' + I_1''$

Procedure:



1. Connect the circuit as shown in the diagram, keeping the switches open and resistance at their maximum positions.
2. Set S_1 to position "aa" and S_2 to position "cc" respectively which means both the sources are energized. Note down the current I_1, I_2 and I_3 from ammeter A_1, A_2 and A_3.
3. Set S_1 to positions "aa" and S_2 to position "dd" respectively which means the, only 220V source is energized and the terminals of S_2 are shorted. Note down current I_1', I_2' and I_3' from the ammeter A_1, A_2 and A_3.
4. Set S_1 to position "bb" and S_2 to position to "cc" respectively. Which means the, only 110V source is energized and the terminals of S_1 are shorted. Note down current I_1'', I_2'' and I_3'' from the ammeter A_1, A_2 and A_3.
5. Compare I_1, I_2 and I_3 with $I_1' + I_1''$, $I_2' + I_2''$ and $I_3' + I_3''$ taking care of signs properly of verify the theorem.
6. Repeat the step (2) to (6) for five different values of resistance for each three rheostats.

Observations:

Serial no. of Observation	In presence of both V_1 and V_2			In presence of V_1 only			In presence of V_2 only		
	Brach current I_1 (in amps)	Brach current I_2 (in amps)	Brach current I_3 (in amps)	Brach current I_1 (in amps)	Brach current I_2 (in amps)	Brach current I_3 (in amps)	Brach current I_1 (in amps)	Brach current I_2 (in amps)	Brach current I_3 (in amps)
1st	0.39032	-0.10645	0.28387	0.56774	-0.35484	0.21290	-0.17742	0.24839	0.070968
2nd	0.62857	-0.23571	0.39286	0.94286	-0.62857	0.31429	-0.31429	0.39286	0.078571
3rd	0.73333	-0.36667	0.36667	1.2222	-0.97778	0.24444	-0.48889	0.61111	0.12222
4th	1.1000	0.0000	1.1000	1.4667	-0.73333	0.73333	-0.36667	0.73333	0.36667
5th	0.21064	-0.046809	0.16383	0.37447	-0.32766	0.046809	-0.16383	0.28085	0.11702

Calculations:

For 1st Observations:

$$V_1 = 220V,\ V_2 = 110V\ , R_1 = 200\ ohm\ , R_2 = 300\ ohm\ , R_3 = 500\ ohm$$

Case I: When both sources are present, (Using Kirchhoff Voltage Law)

$$-V_1 + I_1R_1 - I_2R_2 + V_2 = 0 \ldots (i)$$
$$-V_1 + I_1R_1 + I_3R_3 = 0 \ldots (ii)$$
$$-V_2 + I_2R_2 + I_3R_3 = 0 \ldots (iii)$$

Solving (i),(ii) and (iii) and putting values we get,

$$I_1 = 0.3903225806\ A$$
$$I_2 = -0.1064516129\ A$$
$$I_3 = 0.2838709677\ A$$

Case II: When V_2 is short,

$$I_1' = \frac{V_1}{\frac{R_2 * R_3}{R_2 + R_3} + R_1} = \frac{220}{\frac{300 * 500}{300 + 500} + 200} = 0.5677419355\ A$$

$$I_2' = I_1' * \frac{R_3}{R_2 + R_3} = 0.5677419355 * \frac{500}{300 + 500} = 0.3548387097\ A\ (-ve\ direction)$$

$$I_3' = I_1' - I_2' = 0.5677419355 - 0.3548387097 = 0.2129032258\ A$$

Case III: When V_3 is short,

$$I_2'' = \frac{V_2}{\frac{R_1 * R_3}{R_1 + R_3} + R_2} = \frac{110}{\frac{200 * 500}{200 + 500} + 300} = 0.2483870968\ A$$

$$I_1'' = I_2'' * \frac{R_3}{R_1 + R_3} = 0.2483870968 * \frac{500}{200 + 500} = 0.1774193549\ A\ (-ve\ direction)$$

$$I_3'' = I_2'' - I_1'' = 0.2483870968 - 0.1774193549 = 0.0709677419\ A$$

According to Superposition Theorem,

$I_3 = I_3' + I_3''$
$I_2 = I_2' + I_2''$
$I_1 = I_1' + I_1''$

$I_1' + I_1'' = 0.5677419355 - 0.1774193549 = 0.3903225806\ A = I_1$
$I_2' + I_2'' = -0.3548387097 + 0.2483870968 = -0.1064516129\ A = I_2$
$I_3' + I_3'' = 0.2129032258 + 0.0709677419 = 0.2838709677\ A = I_3$

Superposition Theorem is verified in 1st observation.
1st observation is verified and similarly we can verify rest of the observations similar way,

2nd observation:

$I_1' + I_1'' = 0.94286 - 0.31429 = 0.62857\ A = I_1$

$I_2' + I_2'' = -0.62857 + 0.39286 = -0.23571\ A = I_2$

$I_3' + I_3'' = 0.31429 + 0.078571 = 0.39286\ A = I_3$

3rd observation:

$I_1' + I_1'' = 1.22222 - 0.48889 = 0.73333\ A = I_1$

$I_2' + I_2'' = -0.97778 + 0.61111 = -0.36667\ A = I_2$

$I_3' + I_3'' = 0.24444 + 0.12222 = 0.36667\ A = I_3$

4th observation:

$I_1' + I_1'' = 1.46667 - 0.36667 = 1.10000\ A = I_1$

$I_2' + I_2'' = -0.73333 + 0.73333 = 0.00000\ A = I_2$

$I_3' + I_3'' = 0.73333 + 0.36667 = 1.10000\ A = I_3$

5th observation:

$I_1' + I_1'' = 0.37447 - 0.16383 = 0.21064\ A = I_1$

$I_2' + I_2'' = -0.32766 + 0.28085 = -0.046809\ A = I_2$

$I_3' + I_3'' = 0.046809 + 0.11702 = 0.16383\ A = I_3$

Results:

We have successfully verified Superposition Theorem.

All of the observations are verified.