Linearity and Superposition

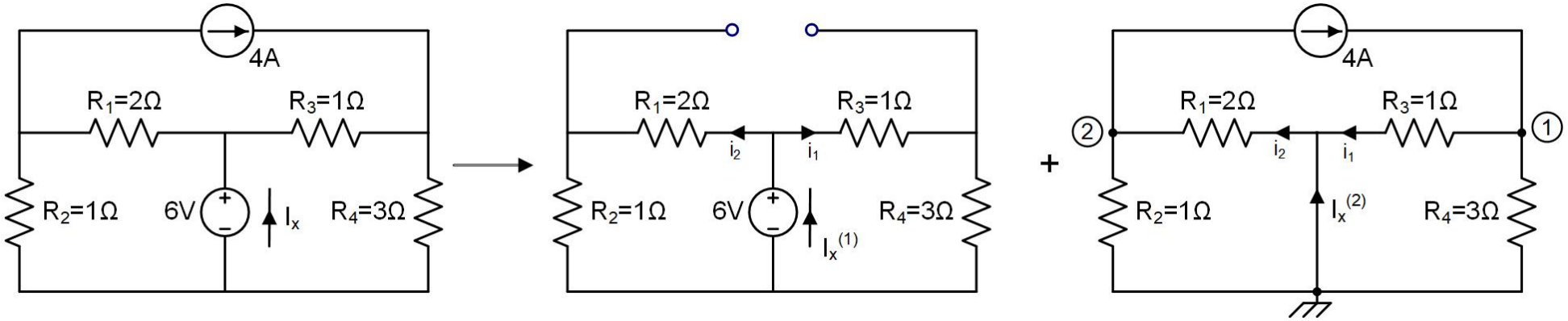
1. **The additive property:** In a circuit with two or more sources, each branch current and node voltage is the algebraic sum of the contributions from each source acting alone.
2. **The scaling (homogeneity) property:** The branch currents and node voltages resulting from a single source in the circuit are linearly proportional to the source. Multiplying the value of the source by a given constant multiplies all currents and voltages by the same amount.

The superposition principle: calculate the contributions from the individual sources acting alone and then superpose these contributions algebraically.

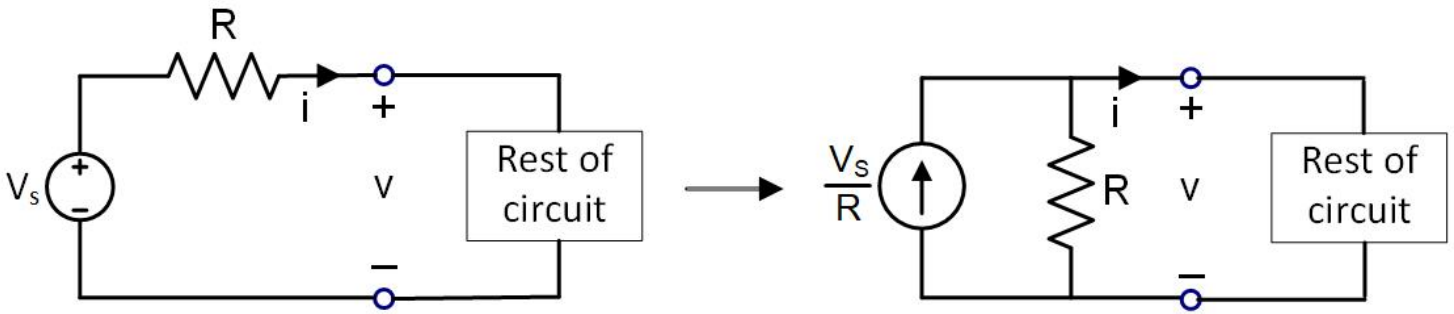
voltage source → short circuit

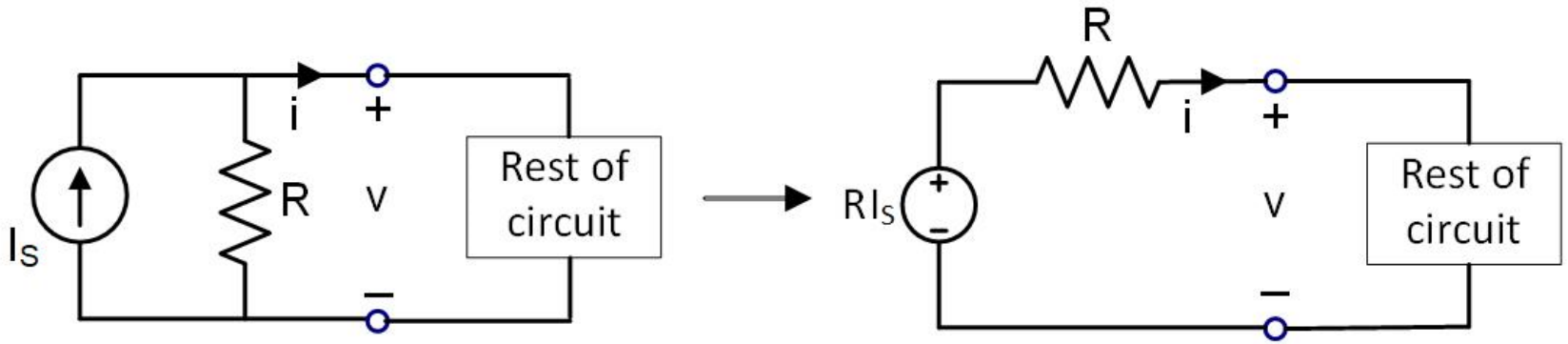
current source → open circuit

Example 7.1

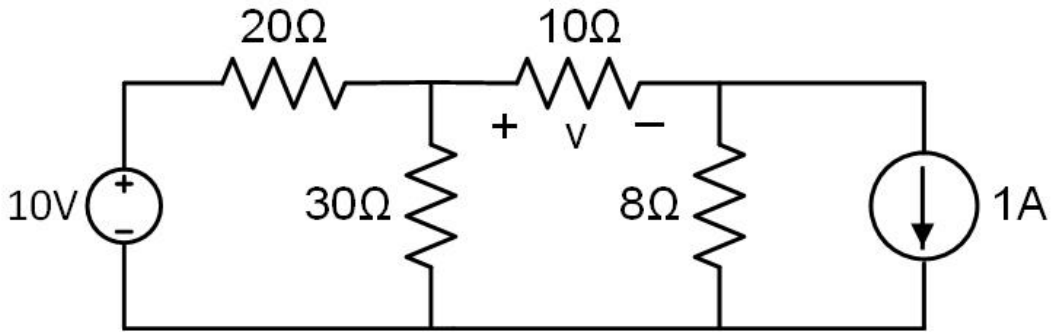


Source transformation





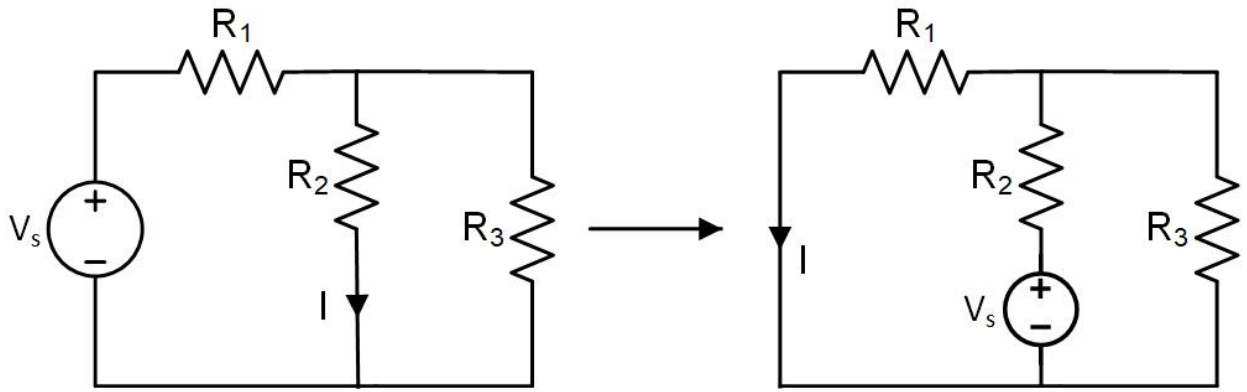
Example 7.2 Apply suitable voltage source transformations to the circuit shown below to find the voltage across the 10Ω resistance.



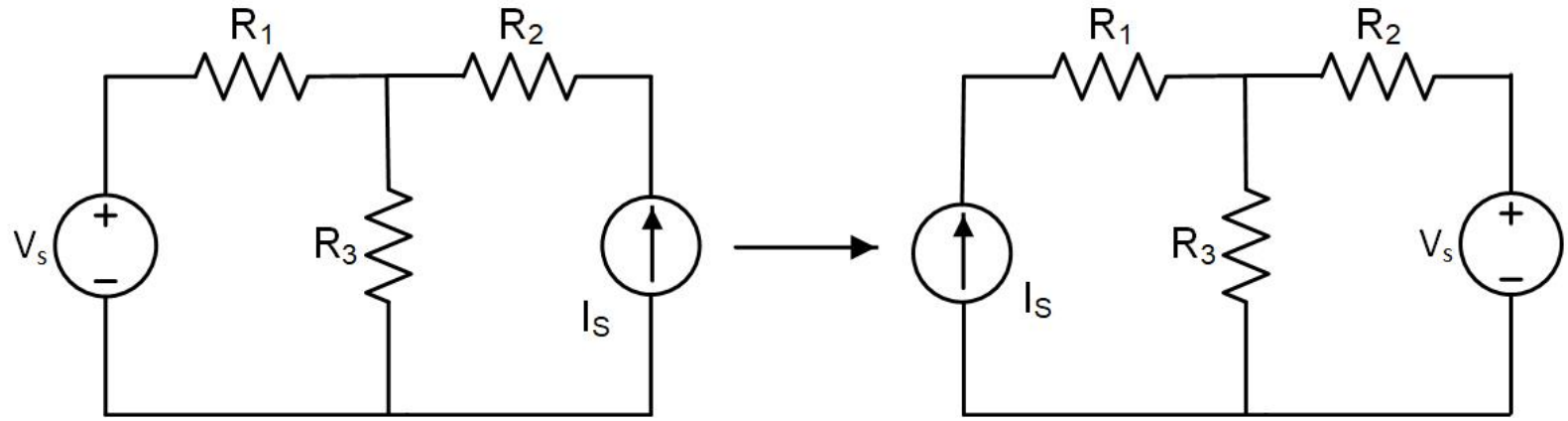
Reciprocity Theorem

A reciprocal circuit contains only linear time invariant two-terminal elements, coupled inductors and ideal transformers.

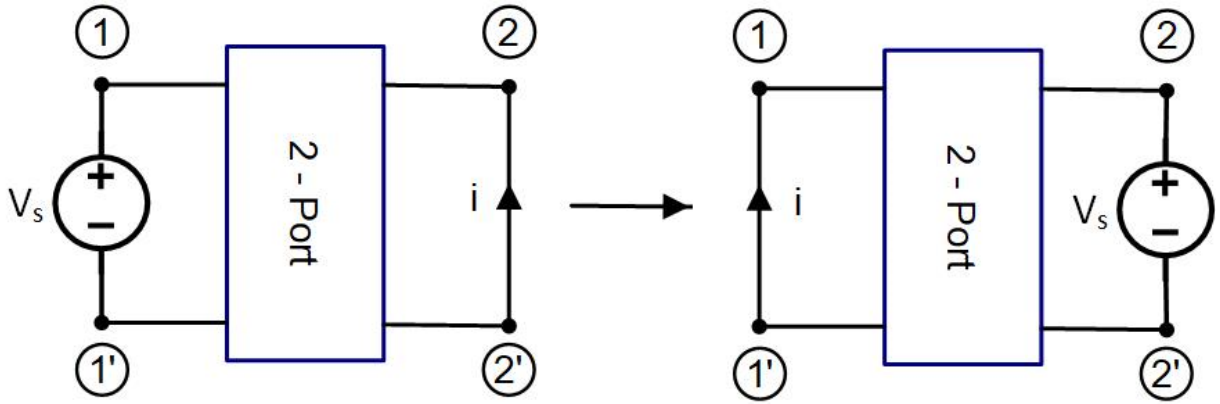
i) If a voltage source in one branch of a reciprocal network produces a current I in another, then if the voltage source is moved from the first to the second branch, it will cause the same current in the first branch, where the voltage source has been replaced by a short circuit.



ii) When the places of voltage and current source in any network are interchanged the amount or magnitude of current and voltage flowing in the circuit remains the same.



iii) Reciprocity in 2-ports



$i_1 = g_{11} V_1 + g_{12} V_2$ $\quad$ $i_2 = g_{21} V_s$ $\quad$ $i_1 = g_{12} V_s$

$i_2 = g_{21} V_1 + g_{22} V_2$ $\quad$ $\rightarrow g_{12} = g_{21}$

Reciprocity conditions for 2-ports:

$r_{12} = r_{21}$, $g_{12} = g_{21}$, $h_{12} = h_{21}$, $h'_{12} = h'_{21}$, $\det[T] = \det[T'] = 1$