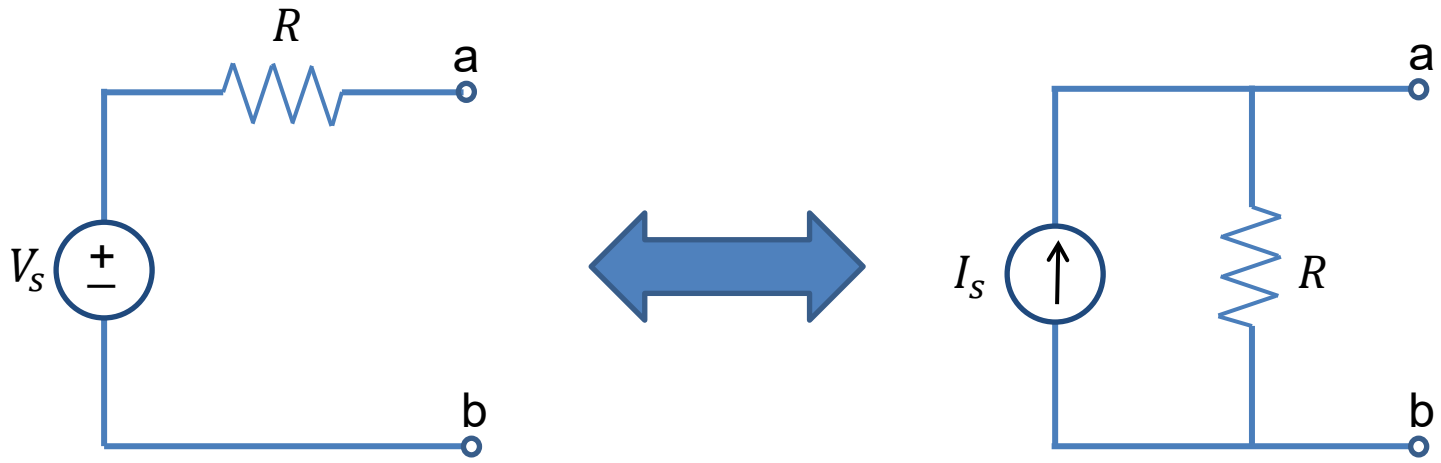
Source Transformations

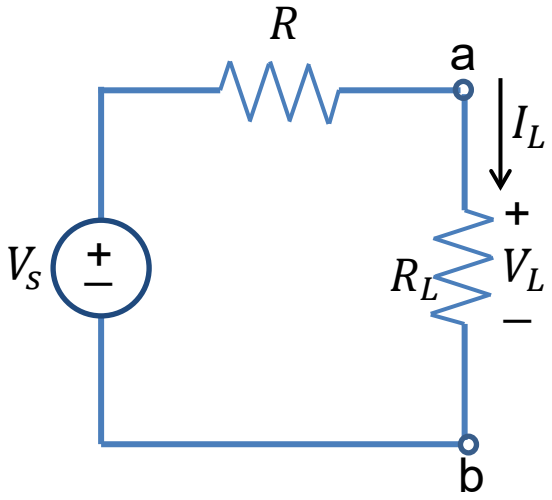
Often it is useful to transform a series combination of a voltage source and a resistor to an equivalent current source and a resistor (or vice versa) as shown below.

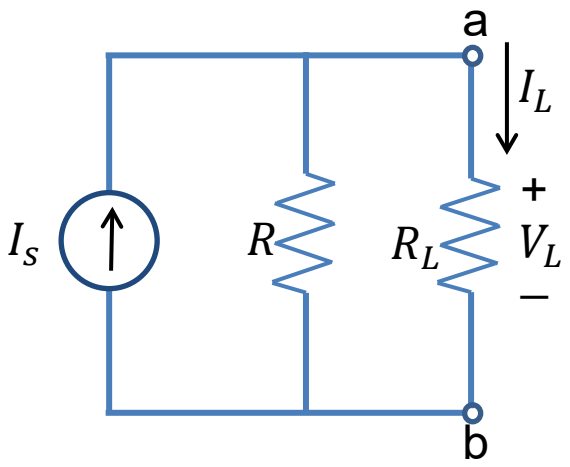


The equivalency is with respect to the behavior of any load we place across the terminals a-b.

In the next slide we examine the relationship that V_s and I_s must have in order for this equivalency to be valid.

Source Transformations





$$I_L = \frac{V_s}{R + R_L}, \quad V_L = V_s \frac{R_L}{R + R_L}$$

$$I_L = I_s \frac{R}{R + R_L}, \quad V_L = I_s \frac{R \cdot R_L}{R + R_L}$$

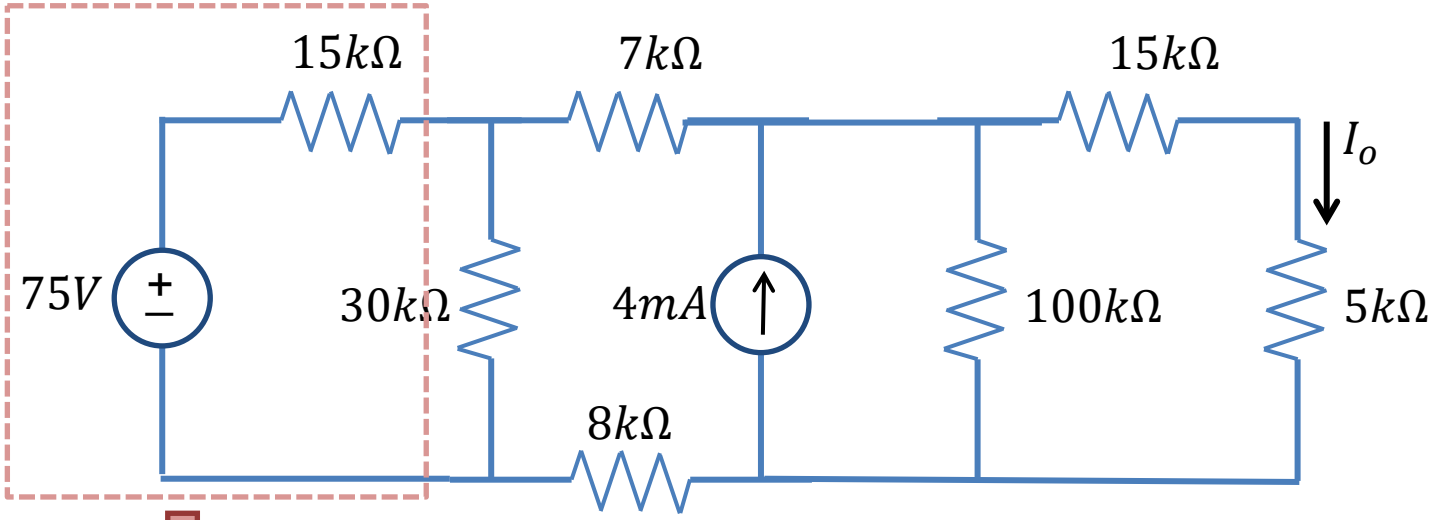
These equations (and hence the circuits) are equivalent if:

$$V_s = I_s \cdot R$$

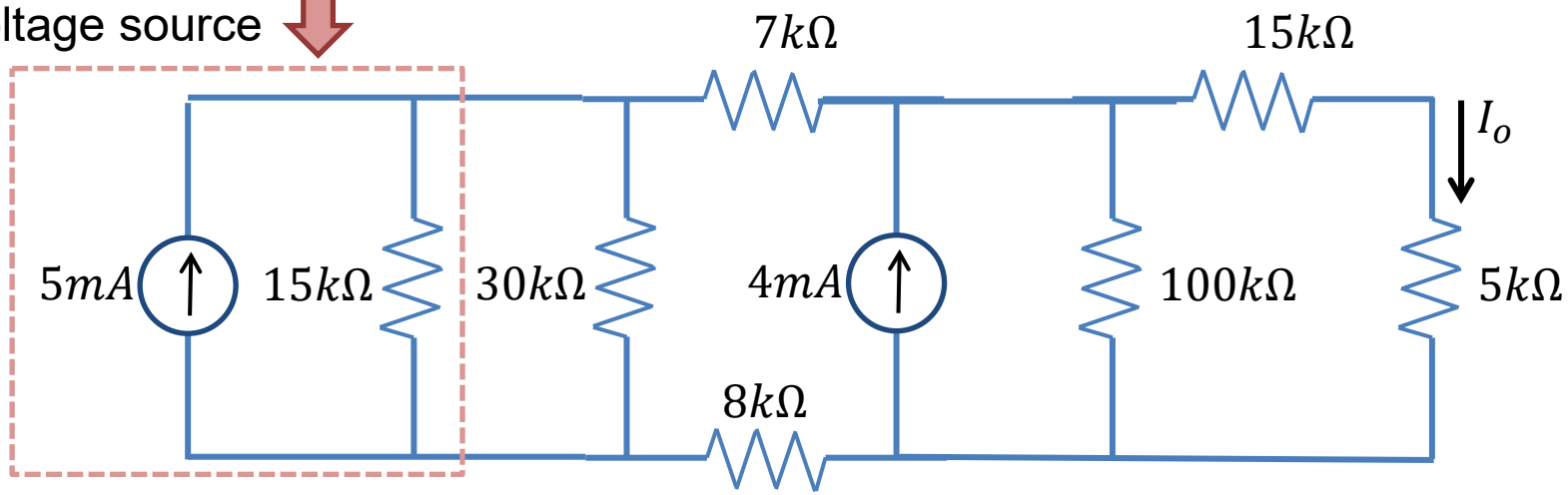
We can use this equivalency to simplify the analysis of many circuits.

Source Transformations

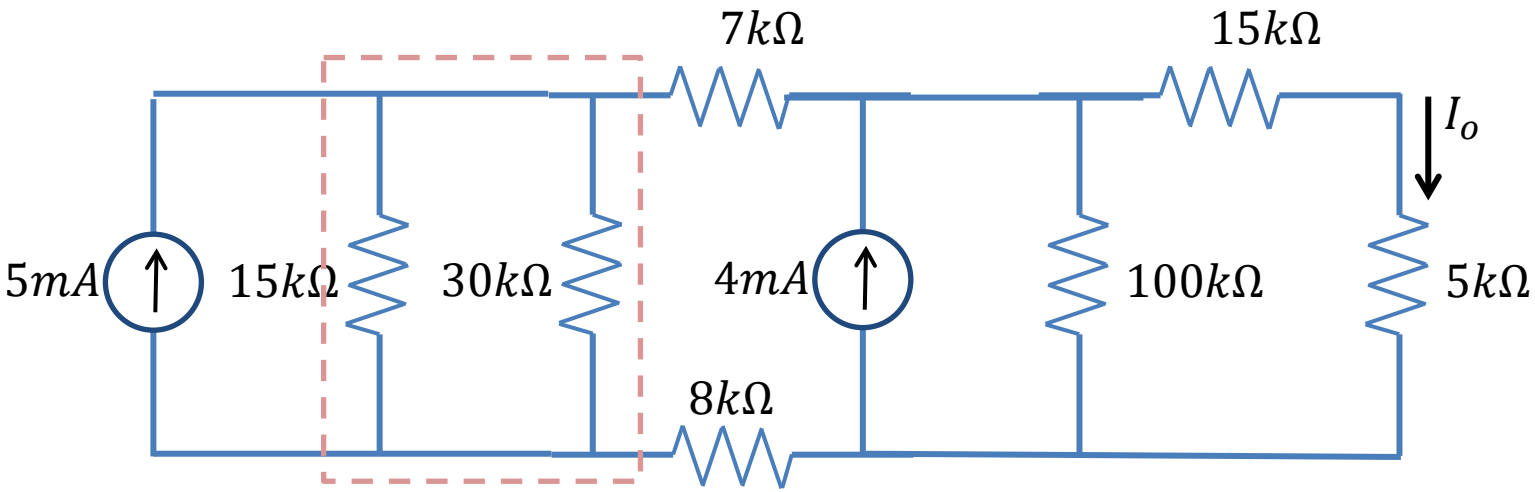
Example: Find the current, I_o, in the $5k\Omega$ resistor.



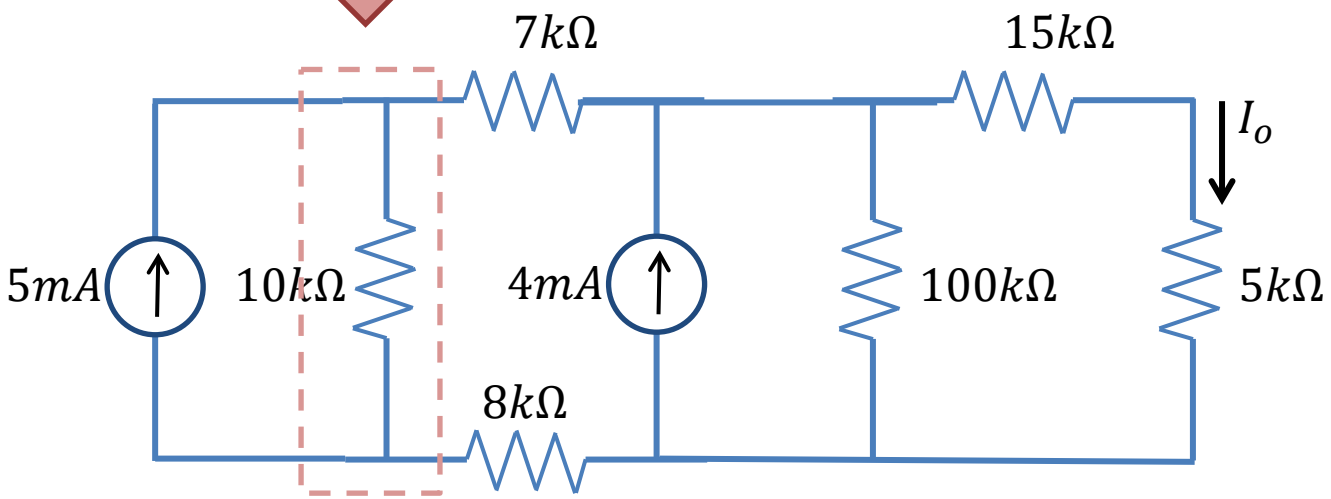
First, transform voltage source



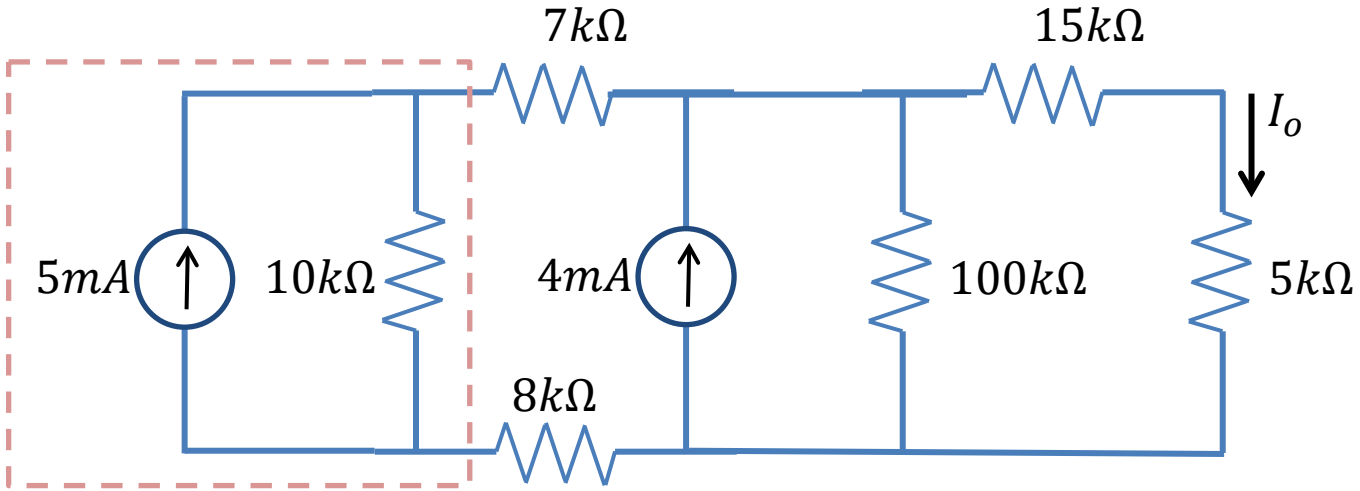
Source Transformations



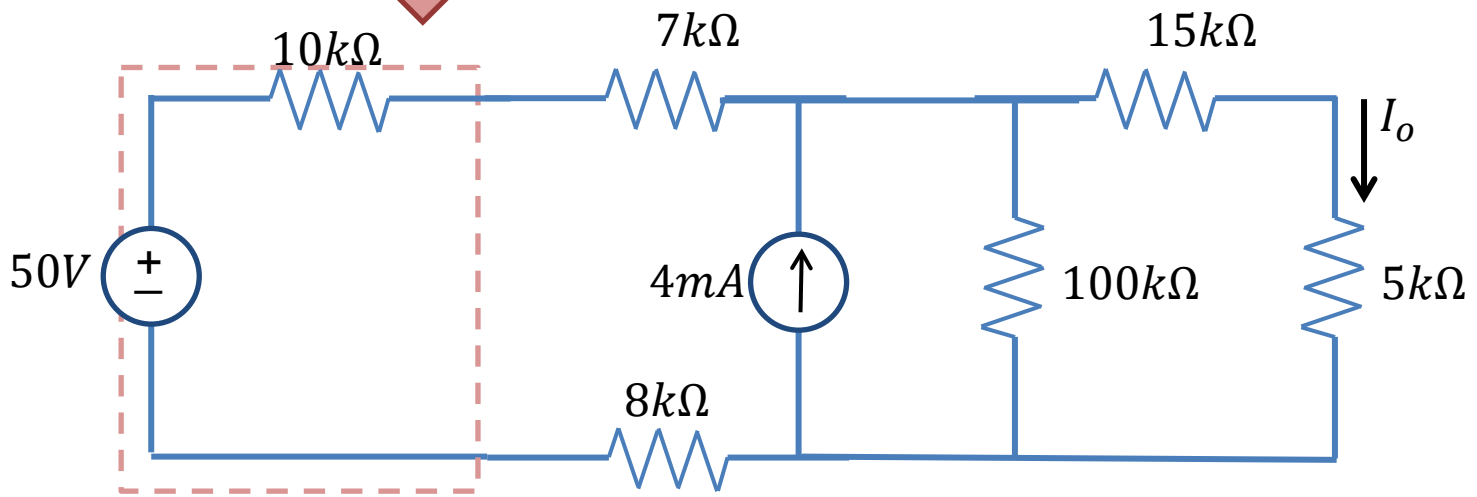
Combine parallel resistors



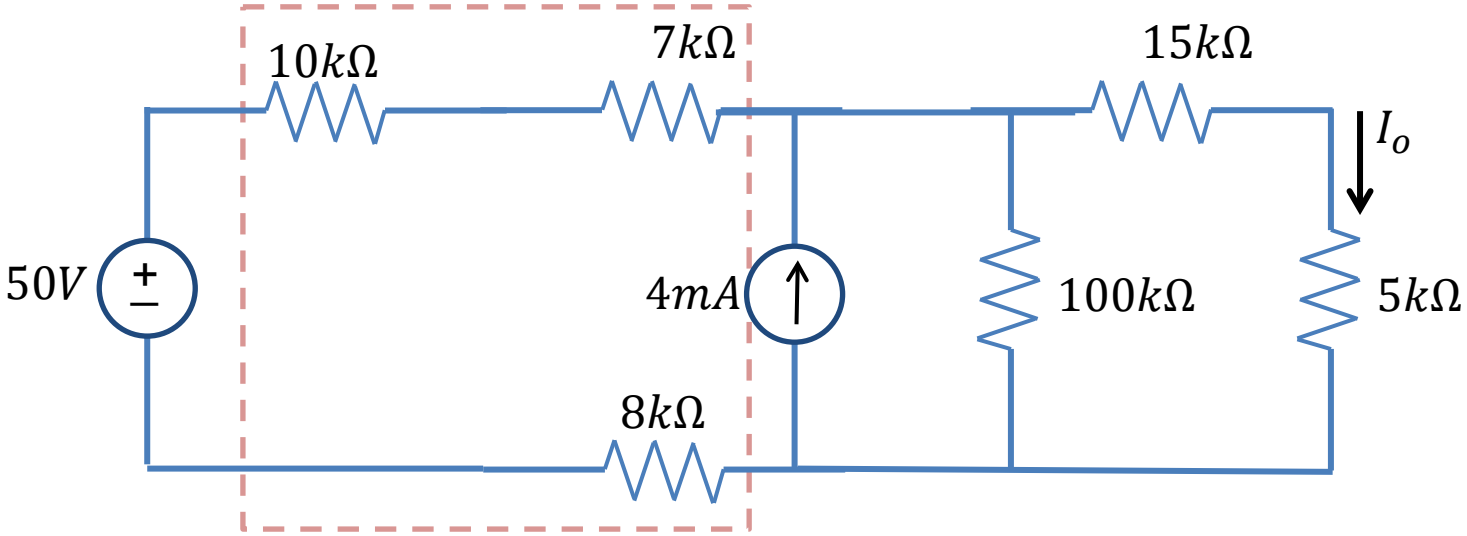
Source Transformations



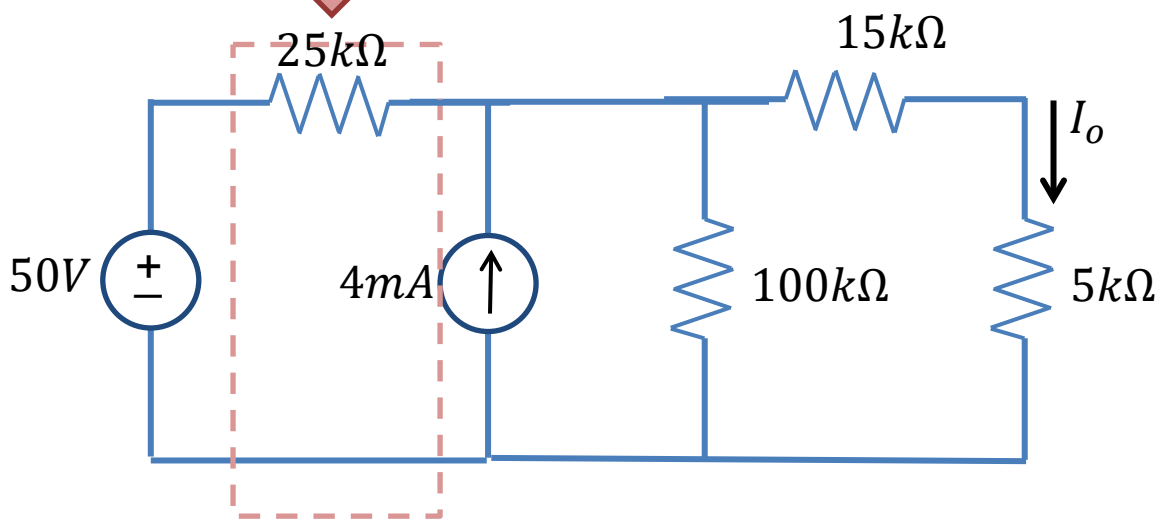
Transform current source



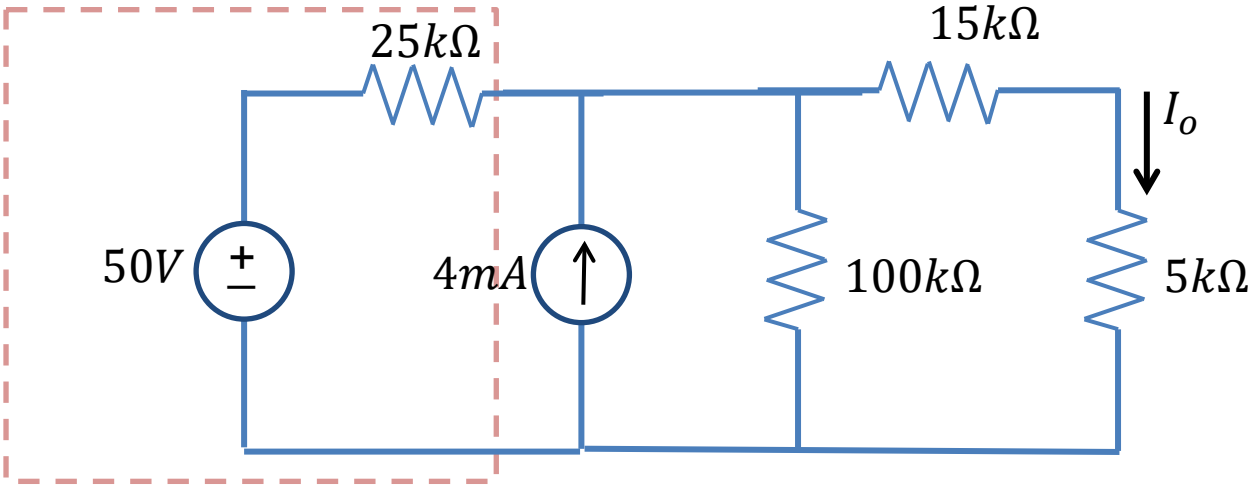
Source Transformations



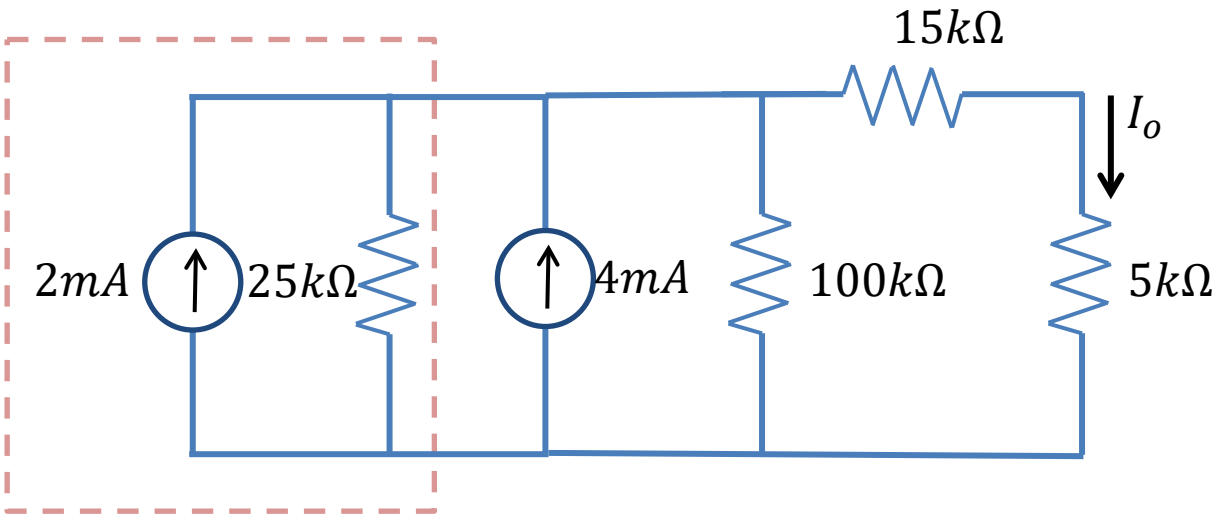
Combine series resistors



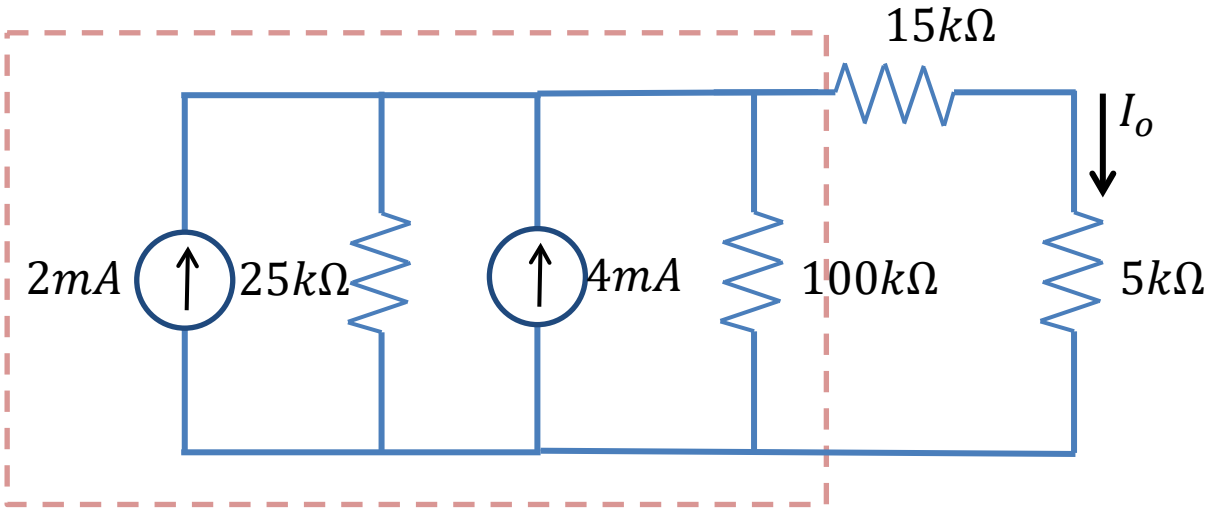
Source Transformations



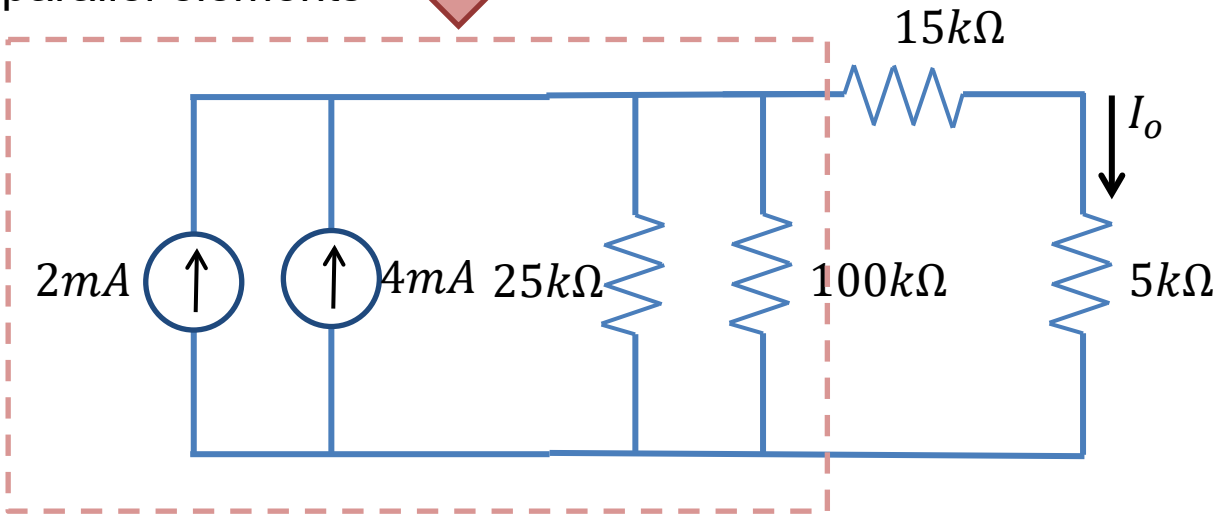
Transform voltage source



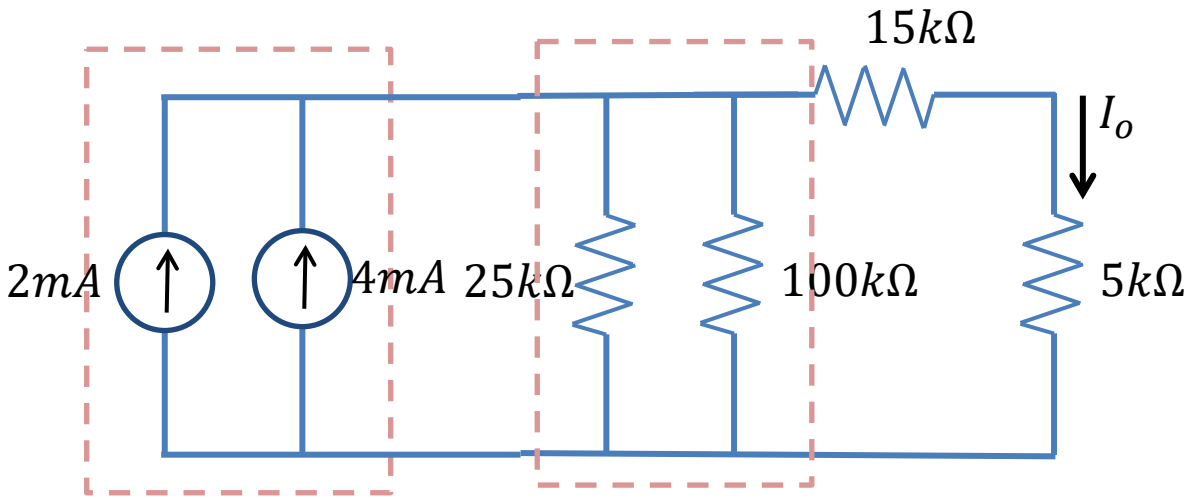
Source Transformations



Rearrange
parallel elements

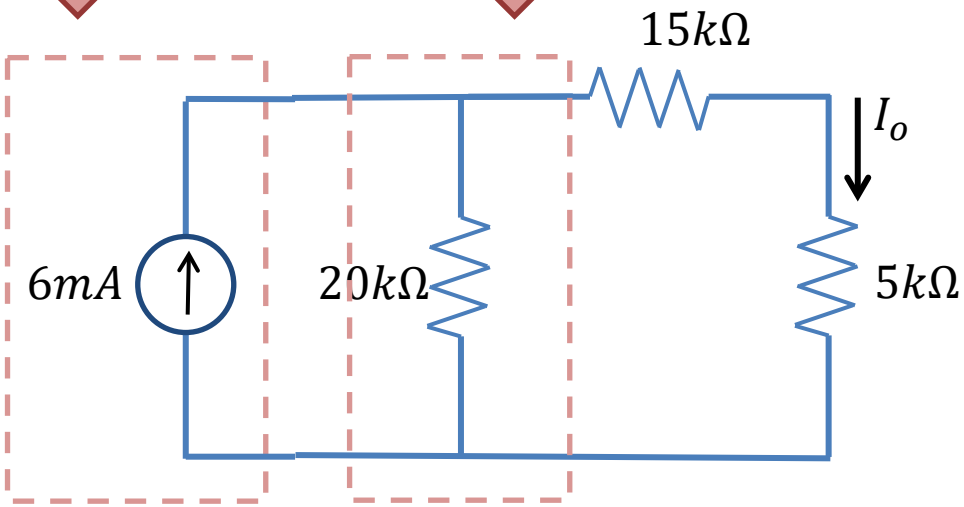


Source Transformations

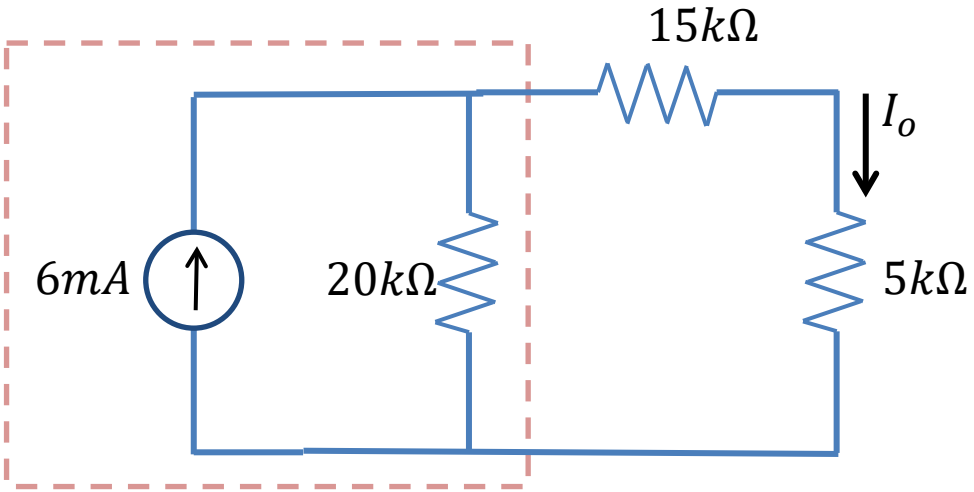


Combine parallel current sources

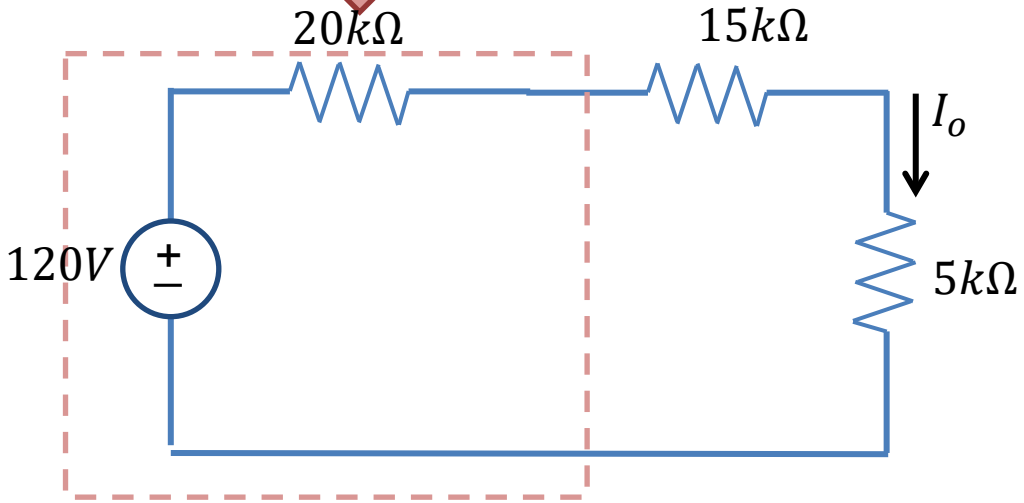
Combine parallel resistors



Source Transformations



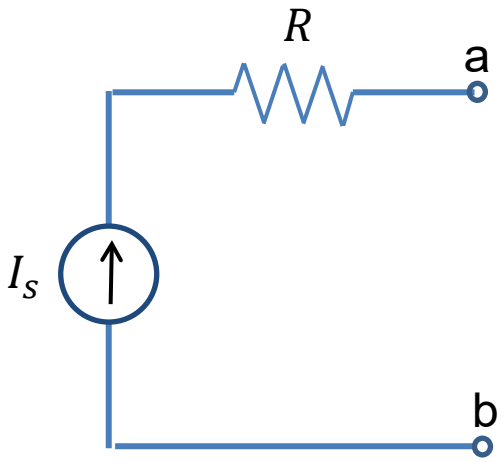
Transform current source

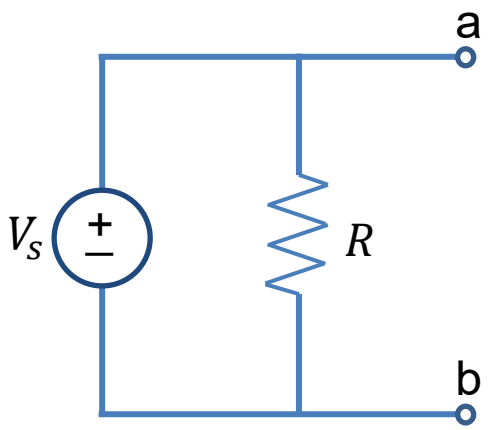


$$I_o = \frac{120V}{40k\Omega} = 3mA$$

Source Transformations

Before we present some examples, it is worth mentioning that we **DO NOT** use source transformations on the following circuits. **WHY NOT?**

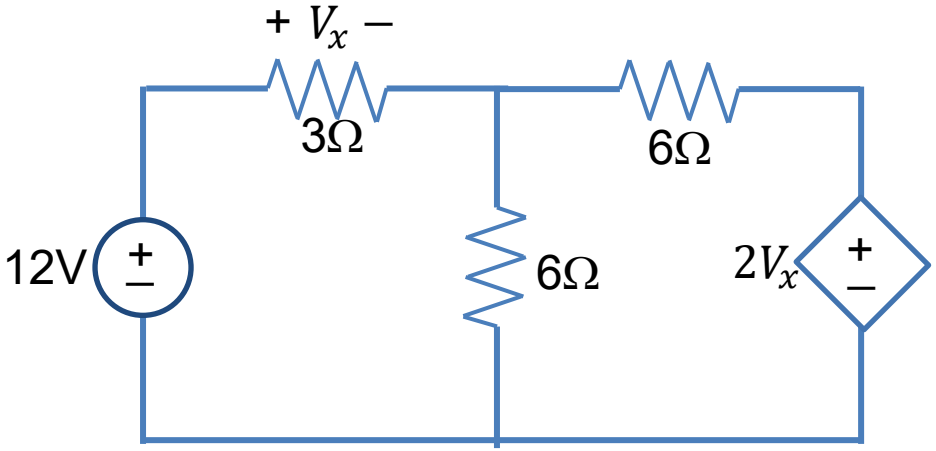




Q: What can we do with the above circuits to simplify them? **Hint:** What role does the resistor R play in each circuit above?

Example

Find V_x by applying a sequence of source transformations.



Note: If the circuit has dependent sources, we need to make sure to preserve the element with the control voltage/current.