ELL101: INTRODUCTION TO ELECTRICAL ENG.

Electrical Sources

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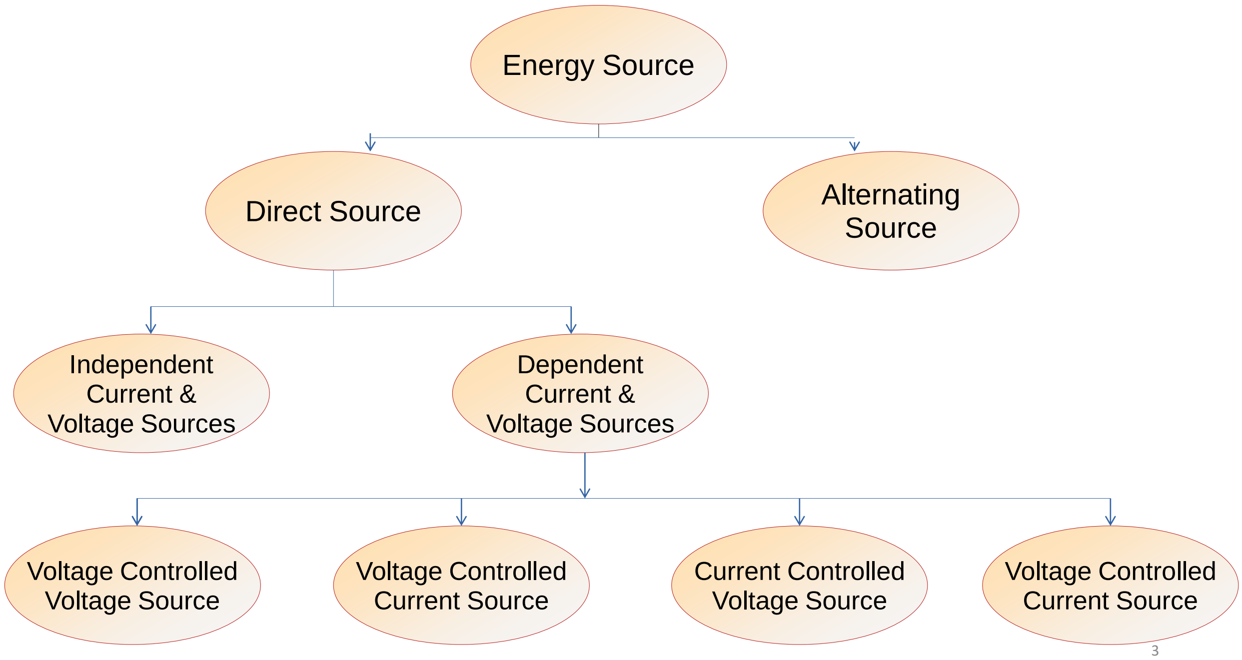
Electrical Sources

- The source which supplies the active power to the network is known as the electrical source. For e.g., battery, a generator, an operational amplifier
- There are two types of energy source direct sources and alternating sources
- <u>Direct Source</u> – The value of current or volatge remains constant with respect to time
- <u>Alternating Source</u> – The value of current or volatge is a function of time
- The direct source is further classified as independent voltage and current source and dependent voltage and the current source



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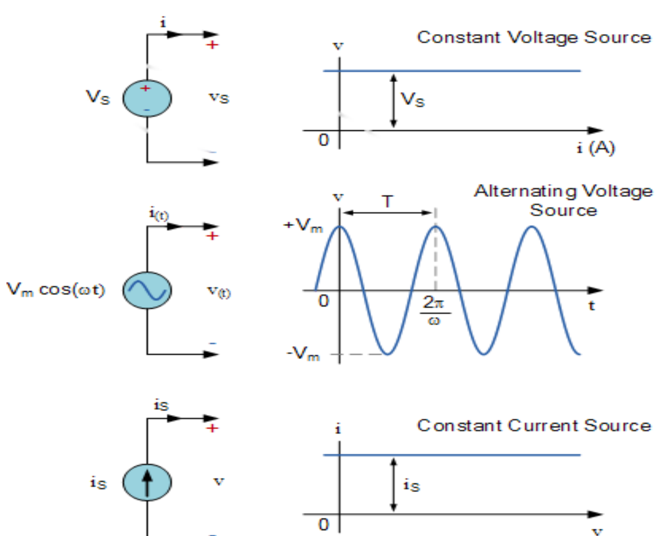
Electric Sources (contd.)



V_s-source voltage

V_m- maximum or peak voltage

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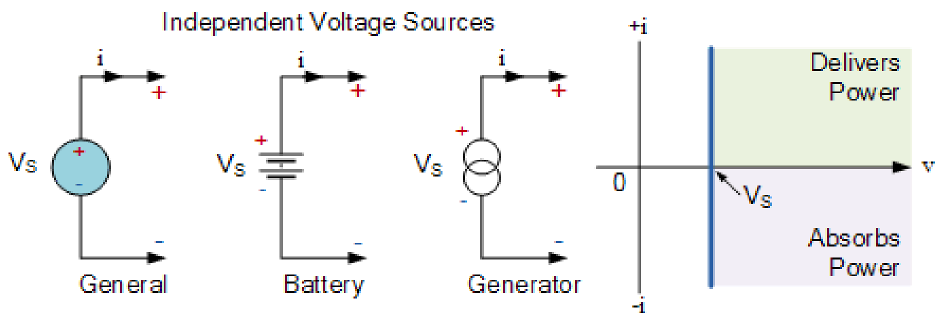
Independent Voltage Source

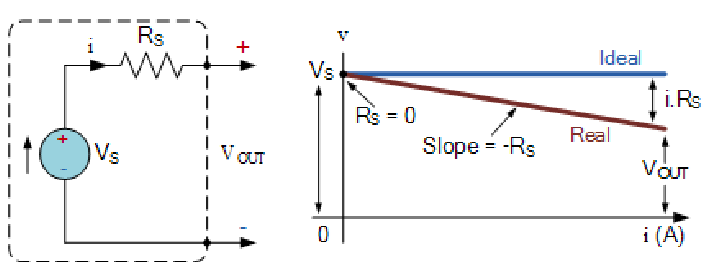
• It is defined as a two terminal active element that is capable of supplying and maintaining the same voltage (v) across its terminals regardless of the current, (i) flowing through it



Independent Voltage Source (contd.)

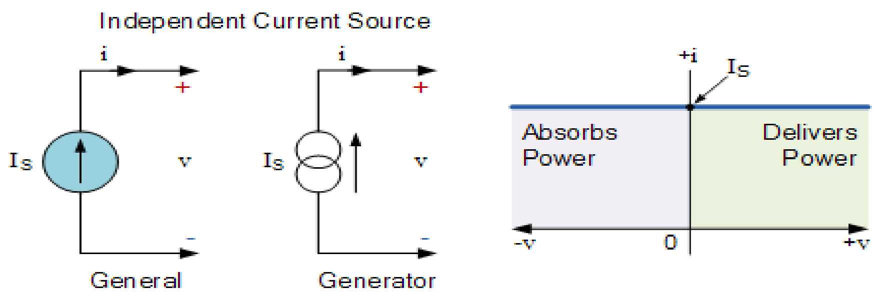
- All ideal voltage sources will have a straight line I-V characteristic but non-ideal or real practical voltage sources will not but instead will have an I-V characteristic that is slightly angled down by an amount equal to iR_s where R_s is the internal source resistance (or impedance)

Practical Voltage Source Characteristics



Independent Current Source

- It provides a constant steady state current independent of the load connected to it producing an I-V characteristic represented by a straight line



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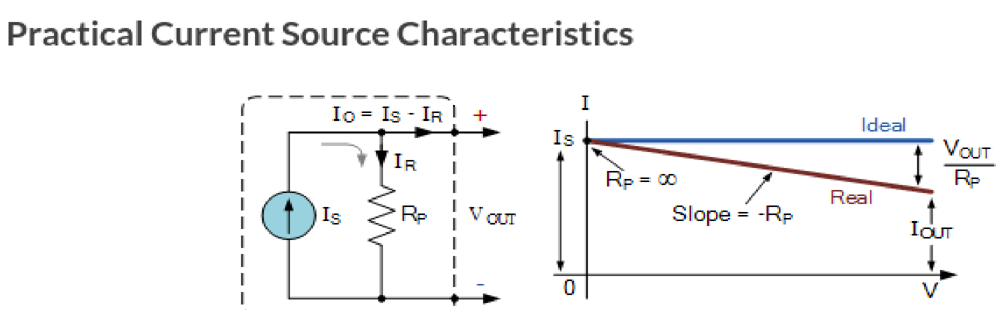
Independent Current Source (contd.)

- Non-ideal or real practical current sources will have an I-V characteristic that is slightly angled down by an amount equal to $\frac{V_{out}}{R_p}$ where V_{out} is the output voltage and R_p is the internal source resistance



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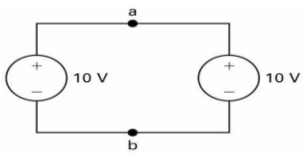
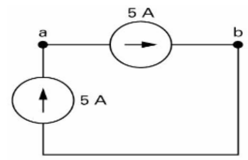
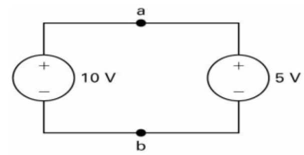
Example For each of the following connections, establish which interconnections are permissible and which violate the constrains by the ideal source



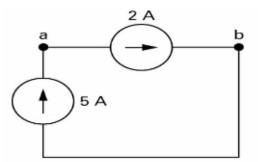
Connection is valid



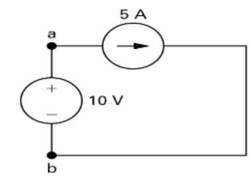
Connection is valid



Connection is not permissible



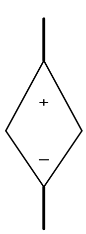
Connection is not permissible



Connection is valid

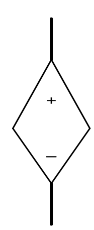
Dependent Voltage Source

- Dependent voltage sources behave similar to the electrical sources we have looked at so far, both practical and ideal (independent), the difference is that a dependent voltage source can be controlled by an input current or voltage.
- A voltage source that depends on a voltage input is generally referred to as a *Voltage Controlled Voltage Source* (VCVS). A voltage source that depends on a current input is referred too as a *Current Controlled Voltage Source* (CCVS).



V_x

VCVS

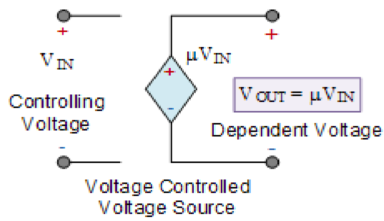


I_x

CCVS

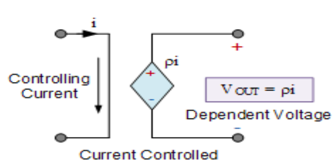
Voltage Controlled Voltage Source (VCVS)

- An ideal dependent voltage-controlled voltage source, VCVS, maintains an output voltage equal to some multiplying constant (basically an amplification factor) times the controlling voltage present elsewhere in the circuit.
- The VCVS output voltage is determined by equation: $V_{OUT} = \mu V_{IN}$. The multiplying constant μ is dimensionless as it is purely a scaling factor because $\mu = V_{OUT}/V_{IN}$.



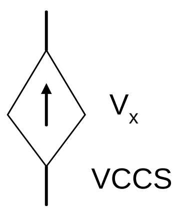
Current Controlled Voltage Source (CCVS)

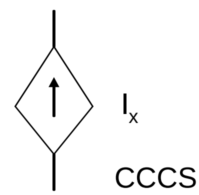
- An ideal dependent current-controlled voltage source, CCVS, maintains an output voltage equal to some multiplying constant (rho) times a controlling current input generated elsewhere within the connected circuit.
- As a controlling current, I_{IN} determines the magnitude of the output voltage, V_{OUT} times the magnification constant ρ, this allows us to model a current-controlled voltage source as a trans-resistance amplifier as the multiplying constant, ρ gives us the equation: $V_{OUT} = \rho I_{IN}$. This multiplying constant ρ has the units of Ohm's because $\rho = V_{OUT}/I_{IN}$, and its units will therefore be volts/amperes.



Dependent Current Source

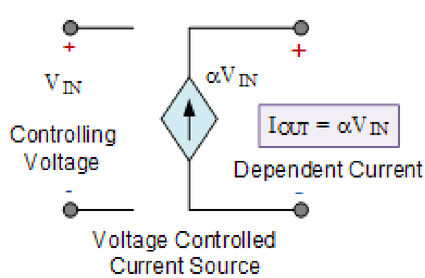
- Dependent current sources behave similar to the current sources we have looked at so far, both ideal (independent) and practical. The difference is that a dependent current source can be controlled by an input voltage or current.
- A current source that depends on a voltage input is generally referred to as a *Voltage Controlled Current Source* (VCCS). A current source that depends on a current input is generally referred too as a *Current Controlled Current Source* (CCCS).





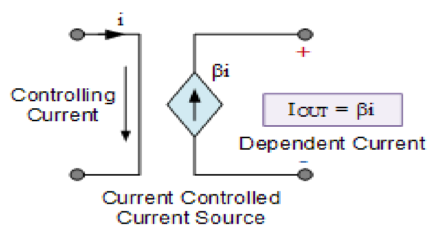
Voltage Controlled Current Source (VCCS)

- An ideal dependent voltage-controlled current source, VCCS, maintains an output current, I_{OUT} that is proportional to the controlling input voltage, V_{IN}.
- The VCCS output current is defined by the following equation: $I_{OUT} = \alpha V_{IN}$. This multiplying constant α has the SI units of mhos(℧) because $\alpha = I_{OUT}/V_{IN}$, and its units will therefore be amperes/volt.



Current Controlled Voltage Source (CCVS)

- An ideal dependent current-controlled current source, CCCS, maintains an output current that is proportional to a controlling input current.
- As a controlling current, I_{IN} determines the magnitude of the output current, I_{OUT} times the magnification constant β, the output current for a CCCS element is determined by equation: $I_{OUT} = \beta I_{IN}$. Note that the multiplying constant β is a dimensionless scaling factor as $\beta = I_{OUT}/I_{IN}$.



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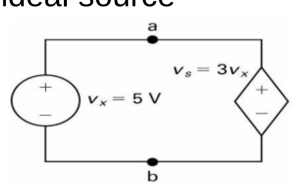
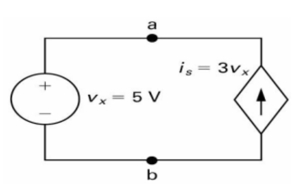
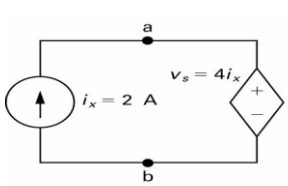
Example For each of the following connections establish which interconnections are permissible and which violate the constrains by the ideal source



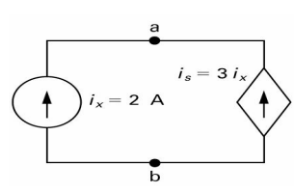
Connection is not permissible



Connection is valid



Connection is valid



Connection is not permissible

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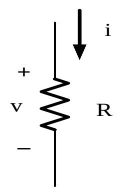
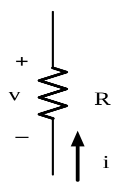
For purpose of circuit analysis, we must reference the current in the resistor to the terminal voltage. For the passive sign convention



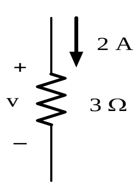
$v = Ri$

Otherwise we introduce a minus sign

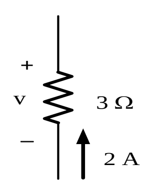


$v = -Ri$

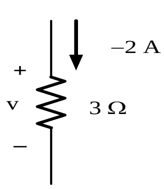
Example



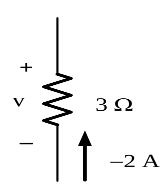
$v = (3)(2) = 6\ \text{V}$



$v = -(3)(2) = -6\ \text{V}$



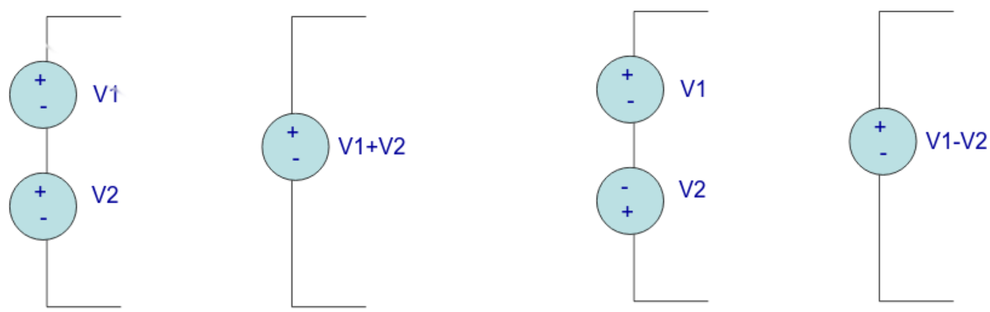
$v = (3)(-2) = -6\ \text{V}$



$v = -(3)(-2) = 6\ \text{V}$

Source Combinations

Voltage sources in series add algebraically. If same polarity is encountered then negative sign is introduced.



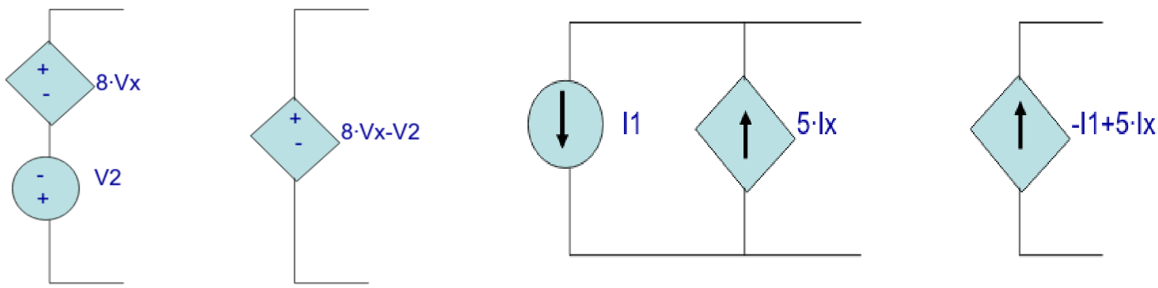
Source Combinations (contd.)

Current sources in parallel add algebraically

(a) (b)

Source Combinations (contd.)

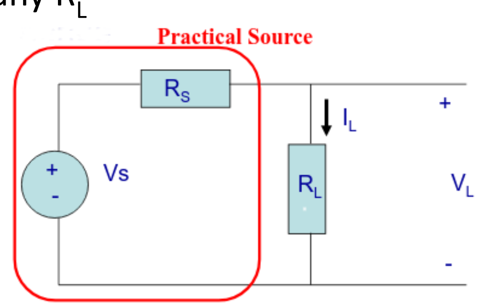
Example



(a) (b)

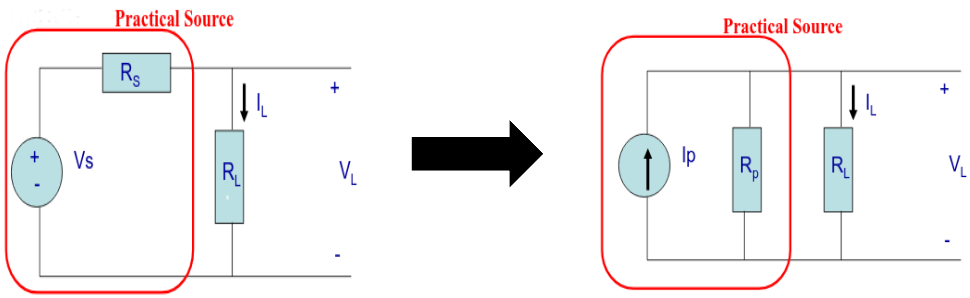
Source Transformation

- Practical voltage sources are current limited and we can model them by adding a resistor in series
- We want to create an equivalent using a current source and parallel resistance for any R_L



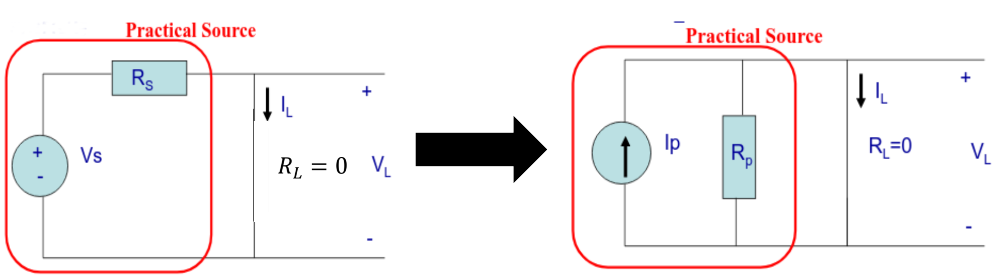
Source Transformation (contd.)

- V_L and I_L must be the same in both circuits for any R_L Practical Source



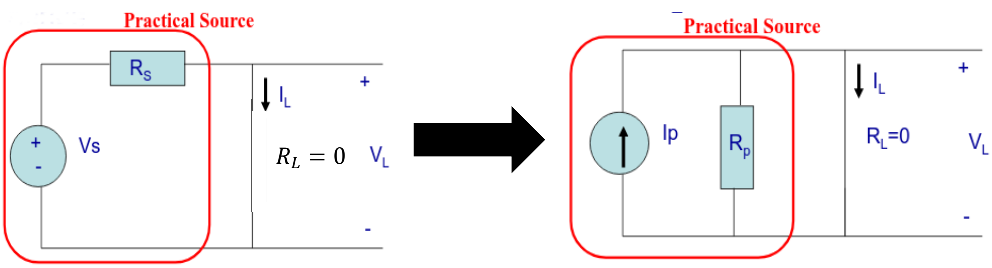
Source Transformation (contd.)

- V_L and I_L must be the same in both circuits for R_L= 0, or a short circuit
- I_p = I_L and V_L = 0



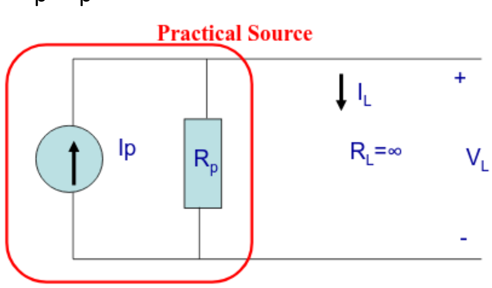
Source Transformation (contd.)

- Now look at the voltage source in series with the resistor with a short circuit
- $I_L = V_s/R_s$ and $V_L = 0$
- So, $I_p = V_s/R_s$



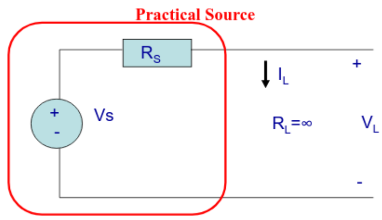
Source Transformation (contd.)

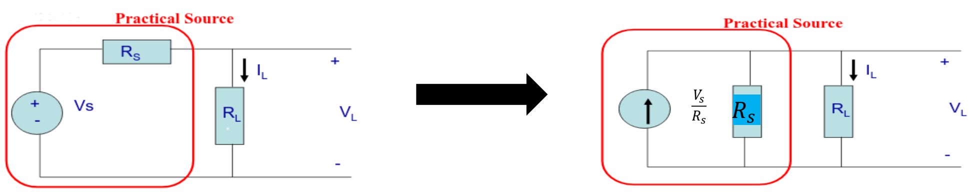
- V_L and I_L must also be the same in both circuits for $R_L = \infty$, or an open circuit
- $I_L = 0$ and $V_L = I_p \cdot R_p$



Source Transformation (contd.)

- Now look at the voltage source in series with the resistor with an open circuit
- $I_L = 0$ and $V_L = V_s$, so $V_s = I_p \cdot R_p$
- If $I_p = V_s/R_s$, then $R_p = R_s$





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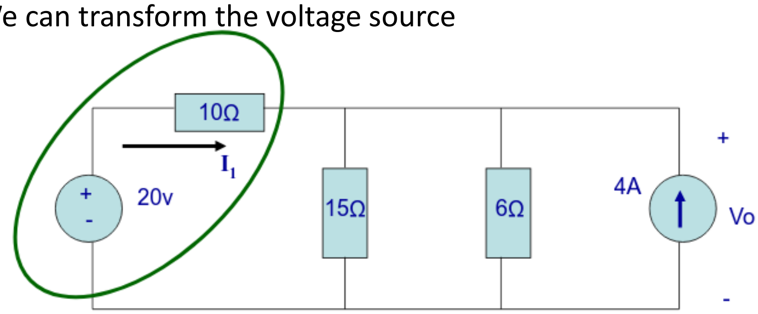
Source Transformation (contd.)

- **Example**

We can transform the voltage source



Why? Gets all components in parallel

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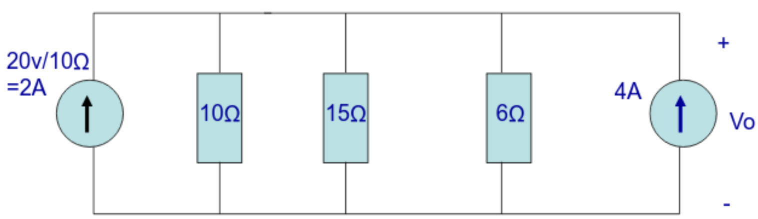
Source Transformation (contd.)

- Example (contd.)

We can combine sources and resistors



I_{eq} = 2A+4A = 6A, R_{eq} = 3Ω

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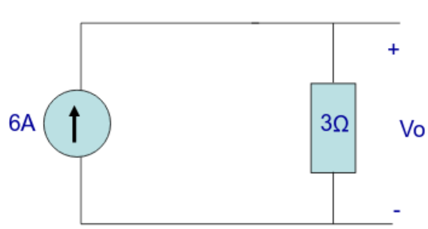
Source Transformation (contd.)

- Example (contd.)

Vo = 6A× 3Ω = 18 V



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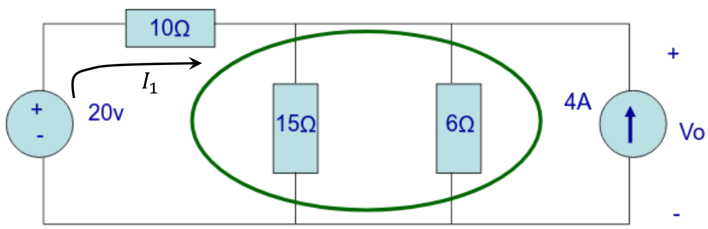
Source Transformation (contd.)

- Example (contd.): Method 2

We can transform the current source after first combining parallel resistances



Why? Gets all components in series

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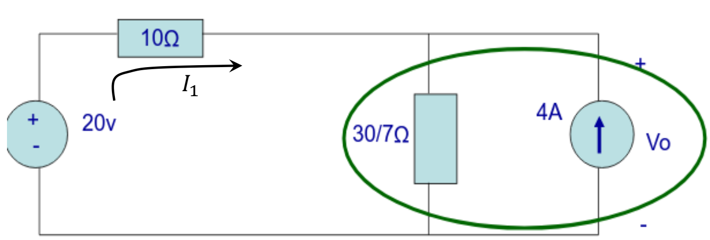
Source Transformation (contd.)

- Example (contd.): Method 2

We can transform the current source after first combining parallel resistances



R_{eq}=6x15/(6+15)=30/7 Ω

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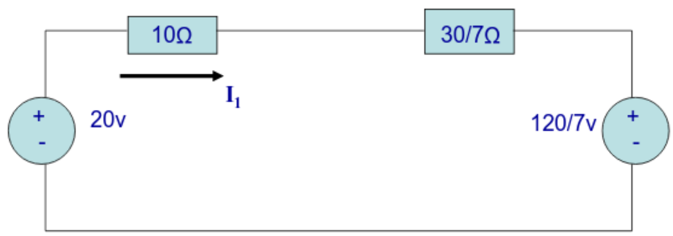
Source Transformation (contd.)

- Example (contd.): Method 2

We can now add the series voltage sources and resistances

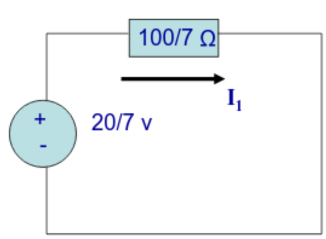


R_{total}=100/7 Ω and V_{total}=20/7 volts

Source Transformation (contd.)

- Example (contd.): Method 2

We can easily solve using KVL for I_1



I_1 = 20/7 ÷ 100/7 = 0.2 A