

03-Circuit Elements

Text: Chapter 1.6 – 1.9, 2.3

ECEGR 210

Electrical Circuits I



Overview

- Circuit Topology
- Series and Parallel Connections
- Sources



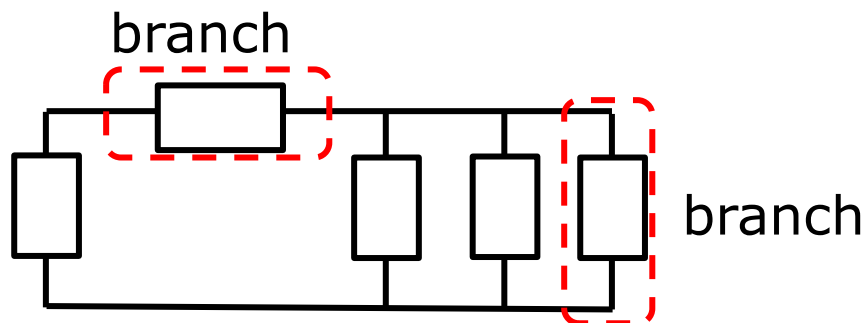
Circuit Topology

- Circuits are usually described graphically
- Need to be proficient in understanding basic circuit symbols
- Road map:
 - Circuit topology (branches, nodes, loops)
 - Active elements
 - Passive elements (later lectures)



Branch

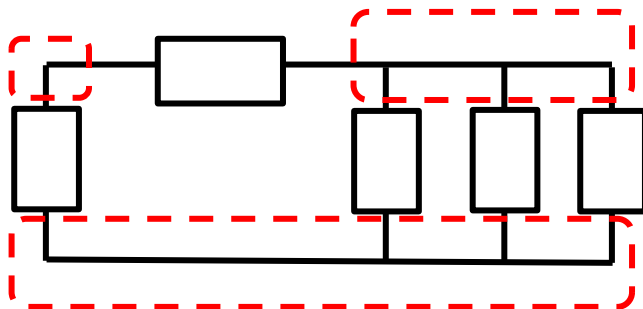
- Branch: a single element in a network
 - Examples: single voltage source, resistor
 - Orientation does not matter
 - Terminals are part of the branch
- Example below has five branches





Node

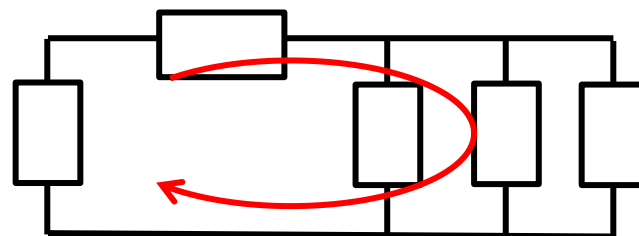
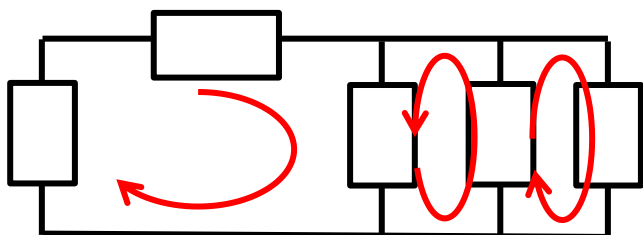
- Node: point of common connection between two or more branches
- Example below has three nodes





Loops

- Loop: any closed path in a network
- Start at a node, pass through at least one other node and return to the original node
 - Direction matters
- Independent loop: a loop that contains at least one branch not contained in another loop
 - Independent loops have independent equations





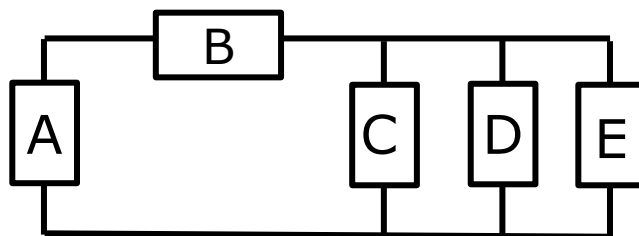
Topology Relations

- For all networks
 - $B = L + N - 1$
- Where
 - B = number of branches
 - L = number of loops
 - N = number of nodes



Series Connections

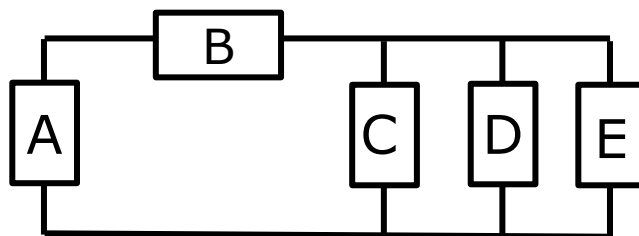
- Two branches (elements) are in series if they exclusively share a single node
- Same current flows through each element
- Network below:
 - A and B are in series
 - No other elements are in series





Parallel Connections

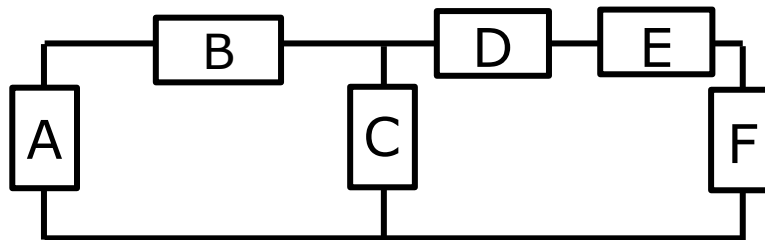
- Two branches (elements) are in series if they share both nodes
- Network below:
 - C, D, E are in parallel
- It is possible for two elements to not be in series or in parallel (e.g. B and C)





Example

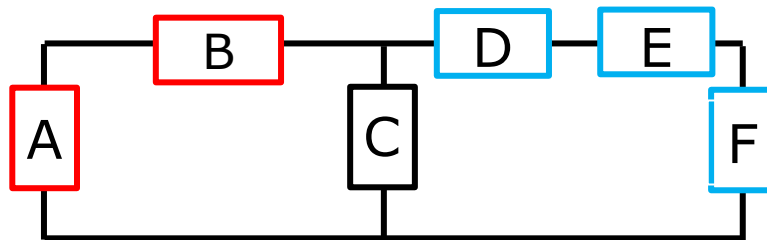
- Which elements are in series?





Example

- Which elements are in series?
 - A, B
 - D, E, F

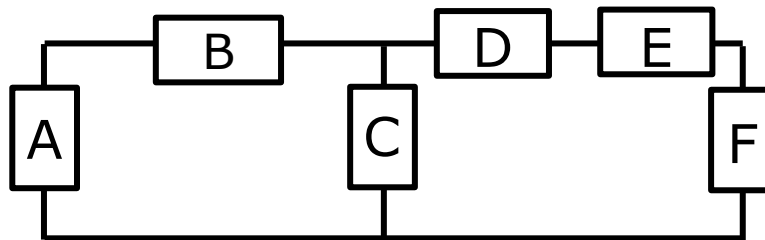


C prevents B and D from being in series



Example

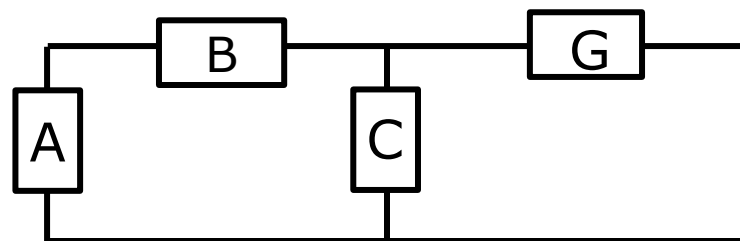
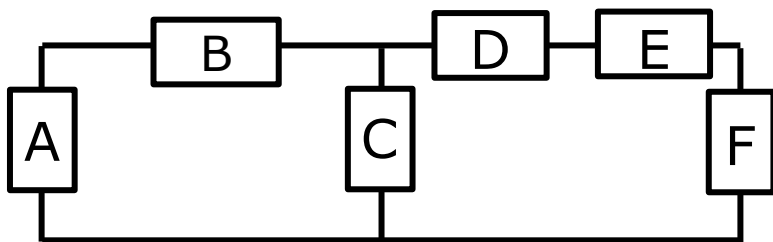
- Which elements are in parallel?





Example

- Which elements are in parallel?
 - None
 - But C is in parallel if D, E and F can be combined into a single element G (more on this later)





Circuit Elements

- Two types of elements:
 - Active: supplies energy
 - Batteries, generators, etc
 - Passive: cannot supply energy (may or may not consume energy)
 - Resistors, inductors, capacitors



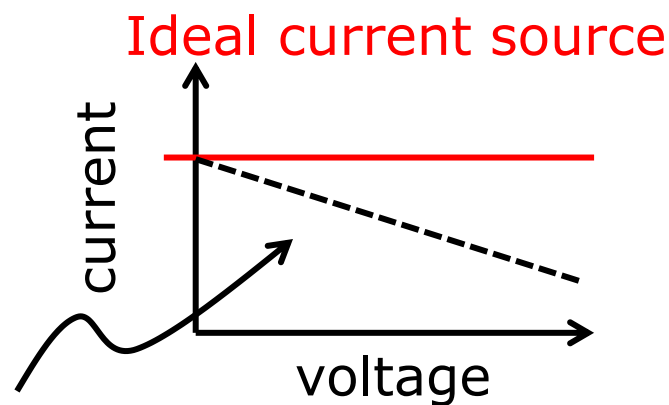
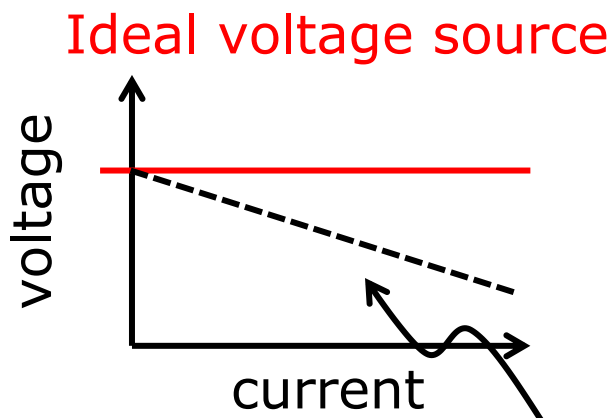
Voltage and Current Sources

- We are concerned with ideal voltage and current sources
- Voltage source: prescribed voltage, can supply infinite current with no loss
- Current source: prescribed current, can supply infinite voltage with no loss



Voltage and Current Sources

- V-I characteristics



Examples of non-ideal sources

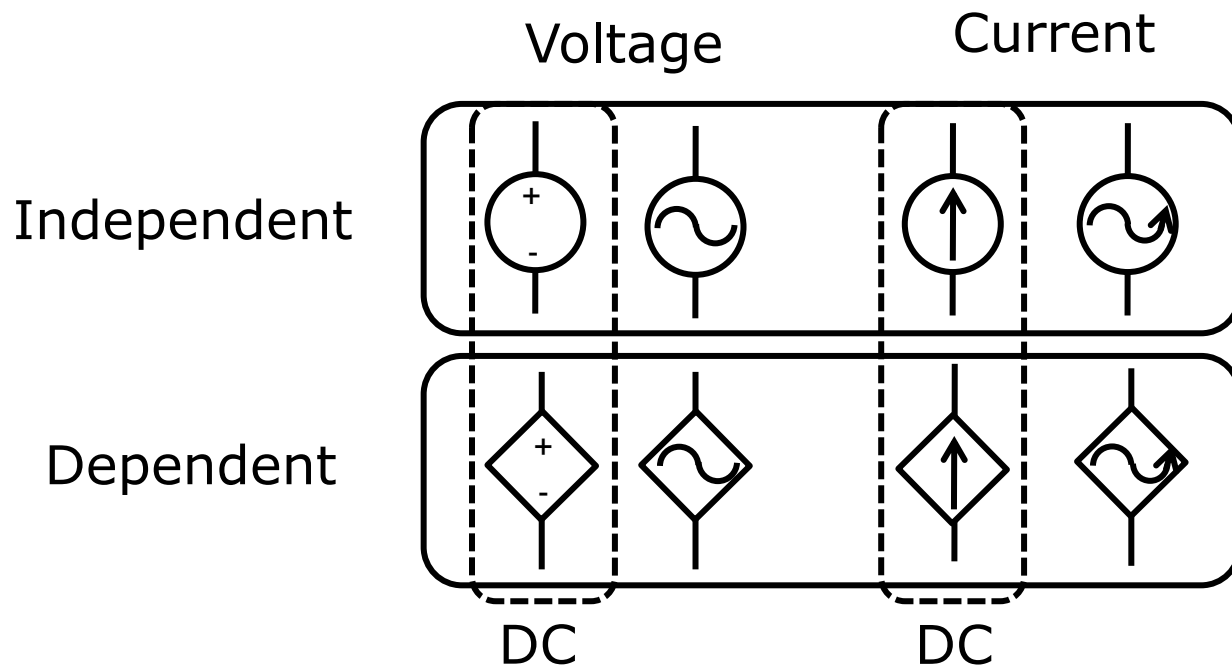


Voltage/Current Sources

- Current and voltage sources are active elements
- Two types:
 - Independent (I or V are independent from other circuit elements)
 - Dependent: (I or V depend on other circuit elements)



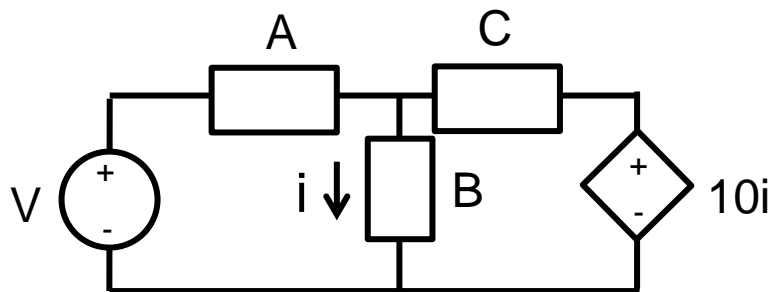
Independent/Dependent Sources





Dependent Sources

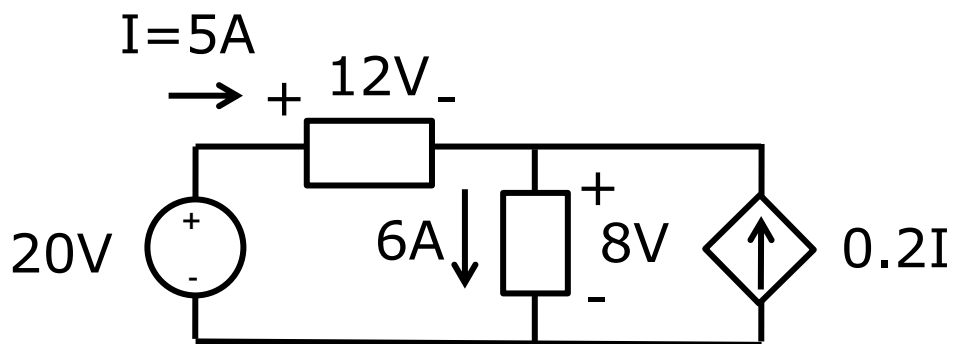
- Dependent Voltage Sources:
 - Often controlled by voltage or current in the circuit
 - Generators voltage controlled by rotational speed
- Dependent Current Sources:
 - Often controlled by voltage or current in the circuit





Example

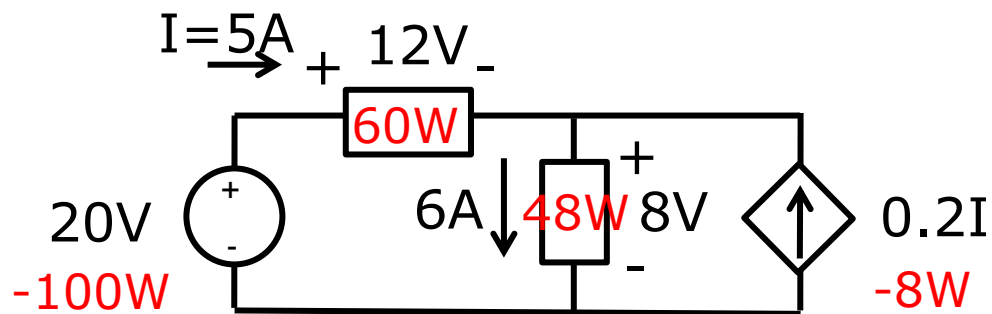
- Find the power consumed or supplied by each element





Example

- Find the power consumed or supplied by each element
 - $20 \times -5 = -100\text{W}$ (supply)
 - $12 \times 5 = 60\text{ W}$
 - $6 \times 8 = 48\text{W}$
 - $-0.2 \times 5 \times 8 = -8\text{ W}$ (supply)





Sources

- Voltage sources can be easily conceptualized as a battery
- What about current sources?
 - One example is in the internal model of a photovoltaic cell