EE101 Course Review Topics

Spring 2003

Units and prefixes

Charge: coulombs (C)
Current: amps (A) coulombs per second
Voltage: volts (V) energy per coulomb

Period: seconds (s)
Frequency: hertz (Hz)

Resistance: ohms (Ω) Capacitance: farads (F)

10^6: mega (M)
10^3: kilo (k)
10^{-3}: milli (m)
10^{-6}: micro (μ)
10^{-9}: nano (n)
10^{-12}: pico (p)

Ohm's Law V = I R

The voltage across a resistor is equal to the current multiplied by the resistance.
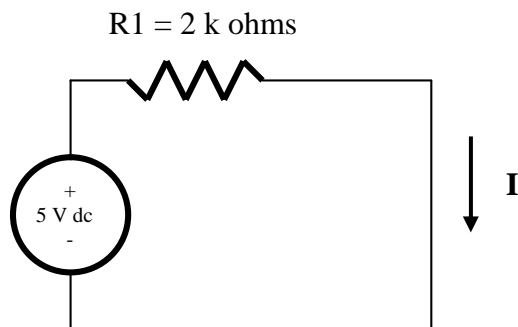
> *Example:*
> You measure 100 mA flowing through a 100 Ω resistor. What is the voltage across the resistor?
>
> $V = I R = (100 \text{ mA} \cdot 100 \ \Omega) = (0.1 \cdot 100) \text{ volts} = 10 \text{ volts}$
>
> *Example:*
> What is the current in the circuit below?
>
> The circuit has 5 volts across a 2 kΩ resistor, so $I = (5 \text{ volts} / 2 \text{ k}\Omega) = 2.5 \text{ mA}$

Period and Frequency

The *period* of a waveform is the duration of one cycle. Period is a time interval, so it is measured in *seconds*.

The *frequency* of a waveform is the number of cycles that occur in one second (cycles per second = hertz [Hz]).

Since the period is the duration of one cycle and frequency is the number of cycles per second, period and frequency are reciprocals: period = 1/frequency, and frequency = 1/period.

Nodes, Loops, and Branches

A *node* is a place in a circuit where two or more components come together. The node encompasses the entire portion of the circuit wiring that comprises the node. A circuit must have at least two nodes.

Example: 3 nodes
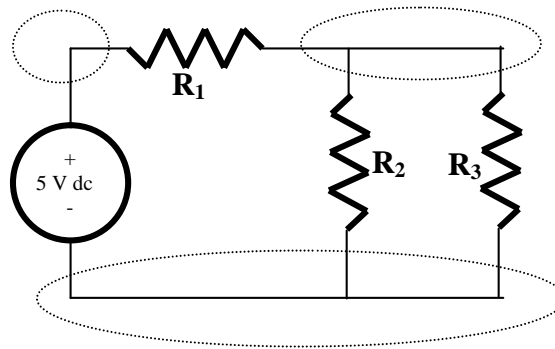
A *loop* is a connected path through a sequence of elements that starts and ends at the same node without crossing itself. A circuit must have at least one loop. If there is more than a single loop, the separate loops of a circuit generally partially overlap one another.

Example: 3 loops
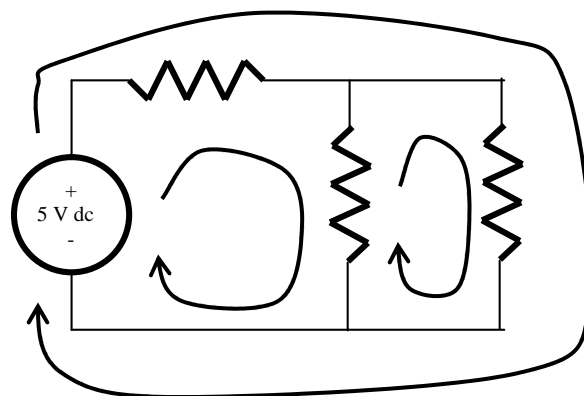
A *branch* is a path from one node to an adjacent node. A circuit branch contains one or more components (resistors, capacitor, etc.).

Kirchhoff's Voltage Law (KVL)

If we move from around a circuit loop, starting and ending at the same node, KVL states that the sum of the voltages around the loop must be zero.

> *Example:* Following arbitrary polarities for V1 and V2, a loop equation clockwise from upper left is

$$-V_1 + V_2 + 5 = 0$$
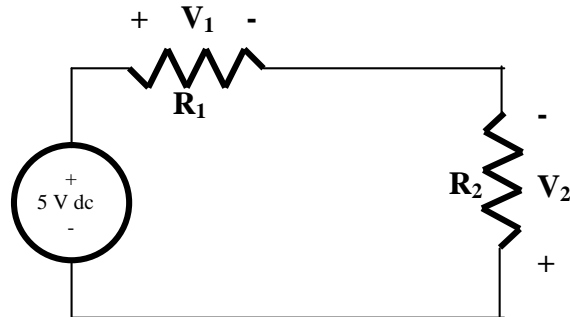
Kirchhoff's Current Law (KCL)

Since a node can neither create, store, nor destroy electric charge, the total current entering a node must equal the total current leaving that node. Put another way, the sum of the currents entering a node must be zero.

Voltage and Current Measurement

Voltage and current measurements have polarity: positive or negative.

The voltmeter will indicate a positive voltage if its "+" (red) input is connected to a higher voltage than its "-" (black) input. Voltage can be measured without having to change the circuit.

The ammeter will indicate a positive current if the circuit causes current to flow <u>into</u> the "+" (red) terminal of the meter, out the "-" (black) terminal, and back into the circuit. Current measurements require you to place the meter within the circuit—in series with the circuit branch you want to measure—so the circuit must be altered to insert the meter.

Series Resistance

If two or more resistors are connected in series (end to end), the total resistance is the *sum* of the individual resistances. The total series resistance is always larger than the largest resistor in the group, since the resistances are summed.

$$R_{series} = R_1 + R_2 + \ldots + R_N$$

Parallel Resistance

If two or more resistors are connected in parallel (side by side), the total resistance is the *reciprocal of the sum of the reciprocals*.

$$R_{parallel} = \frac{1}{\dfrac{1}{R_1} + \dfrac{1}{R_2} + ... + \dfrac{1}{R_N}}$$

Logic Functions

Several basic logic functions:

AND

A	B	OUT
0	0	0
0	1	0
1	0	0
1	1	1

OR

A	B	OUT
0	0	0
0	1	1
1	0	1
1	1	1

NAND

A	B	OUT
0	0	1
0	1	1
1	0	1
1	1	0

NOR

A	B	OUT
0	0	1
0	1	0
1	0	0
1	1	0

NOT

A	OUT
0	1
1	0

Voltage Gain

The voltage gain of an amplifier is the ratio of the output voltage to the input voltage.

> *Example:*
>> Output voltage 3 V peak-to-peak
>> Input voltage 1 V peak-to-peak
>> Voltage gain = V_o/V_{in} = 3

Capacitors and time constant

A capacitor is a charge storage element. It takes time for the capacitor to charge up, and the charging time depends on the amount of current in the capacitor: small current means a slow charge time, while a large current means a quicker charge time.

The charging time for a capacitor is often expressed in terms of a *time constant* given by $R \cdot C$ (resistance times capacitance). The RC time constant is proportional to the time required to charge the capacitor from zero to the applied voltage.

Diodes

A diode allows current to pass in one direction, but blocks current in the other direction. Semiconductor diodes show a *forward voltage* of 0.5 – 1.0 volt when current passes in the forward direction. Essentially no current passes in the reverse direction.

Lab instruments

Digital multimeter (DMM): measures voltage, current, or resistance.

Function generator (or signal generator): produces alternating voltage signals (such as sine waves) with a particular frequency and amplitude.

DC power supply (or bench supply): produces a constant voltage like a battery, except derived electronically from the 120V line voltage.

Oscilloscope: displays voltage vs. time for measurement of signal amplitude, period, and relative phase.