Intro to electricity

September 6, 2023 10:05 AM

Static Electricity - imbalance of electrons between objects

- called static because the displaced electrons tend to remain stationary after being moved from one insulating material to another
- can cause damage to sensitive semiconductors in circuitry.

Grounding is how you can get rid of static electricity

Getting rid of static electricity

- ground yourself
- have clean air (air conditioning??)

Conductors vs Insulators

Conductor

- conductors allow electrons to move around freely
- some good conductors: copper, gold, iron, concrete, dirty water

Insulator

- insulators don't allow electrons to move around as freely
- insulators get hot from resistance
- some good insulators: glass, rubber, air, fibreglass, pure water

10 BASE T

10 mbps, baseband (as opposed to broadband), T - twisted pair

10 base 2

10 mbps, baseband, 200 meters

Electron Flow

- a controlled movement of electrons (rather than the typically random pattern of "free" electrons)
- this is what we call electricity or electrical current, could also be called dynamic electricity
- electrons require there to be a continuous path of conductive material to flow (closed circuit)
- needs a source & destination of power

Alternating vs Direct Current

Alternating

- flows in an alternating path (back and forth constantly)

Direct Current

- flows from source to destination, negative to positive

Electric Circuit

- a never ending loop that has a continuous flow of electrons

a continuous charge flow cannot occur **anywhere** in a broken circuit

Voltage and Current

voltage:

- what pushes the electrons, moves from point A to point B,
- the speed of electricity getting to you
- sources: batteries, solar cells, generators
- measured in volts (V)

current:
-
- how much electricity gets to you
- measured in amperes

polarity matters - also known as potential direction

resistance can be linked to size of cable

Ohm's Law
- discovered by George Simon Ohm

need to know voltage, current, and resistance
- conductors have low resistance, and insulators have high resistance

the amount of current in a circuit depends on the amount of voltage and the amount of resistance in the circuit to oppose current flow

current	I	amp	A
voltage	E or V	volt	V
resistance	R	Ohm	omega

conventional flow: positive to negative - this is what the OG scientists believed
electron flow: negative to positive - this is what happens in the real world

Safety
how to help someone that's been electrically shocked
- disconnect them from the source
- turn off the circuit (breaker) or hit them with an insulated stick
- give them medical attention
- heart troubles can continue after shock for hours

sources of hazard
- wet conditions increase the risk of electric shock by lowering skin resistance
- replace or repair damaged cables, the best way of preventing use is by cutting an end off.
- powerlines should be avoided - don't get out of your car, or hop on one foot

safe meter (tool) usage
- multimeter can check voltage, current, and resistance
- voltage is always relative between two points
- remember to set your tool to what you need (ac/dc, voltage/current/resistance)
- never try to read resistance or continuity with a multimeter on a circuit that is powered
- current measuring meters (ammeters) are always connected in a circuit

Series and Parallel circuits

September 11, 2023 3:28 PM

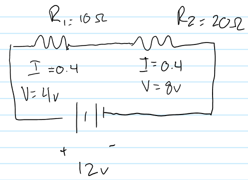
Series Circuit

- only one path for current to flow
- connected in a daisy-chain (end to end)

★ current: the amount of current is the same throughout any component in a series circuit

resistance: the total resistance of any series circuit is equal to the sum of individual resistances

voltage: the supply voltage in a series circuit is equal to the sum of the individual voltage drops



$R_T = 30\Omega$

$\frac{12v}{30\Omega} = 0.4A$

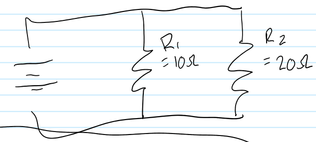
Parallel Circuit

- all components are connected between the same set of electrically common points
- all components are connected across each other's leads

★ voltage: voltage is equal across all components in a parallel circuit

current: the total circuit current is equal to the sum of the individual branch currents

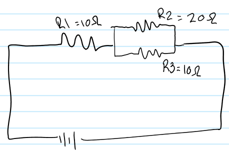
resistance: individual resistances diminish to equal a smaller total resistance rather than add to make the total



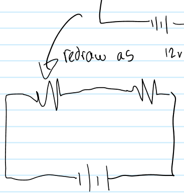
$\frac{1}{RT} = \frac{1}{R1} + \frac{1}{R2}$

$\frac{1}{RT} = \frac{1}{10} + \frac{1}{20} = \frac{2}{20} + \frac{1}{20} = \frac{3}{20} = 0.15 \rightarrow \frac{1}{0.15} = 6.67\Omega$

Ex



redraw as



$\frac{1}{R_t} = \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_t} = \frac{1}{20} + \frac{1}{10}$

$\frac{1}{R_t} = \frac{3}{20}$

$R_t = \frac{1}{\frac{3}{20}} = 6.67\Omega$

$R_T = 10\Omega + 6.67\Omega$

$R_T = 16.67\Omega$

$I_T = \frac{V}{R}$

$I_T = \frac{12v}{16.67\Omega}$

$I_T = 0.72A$

$I_{R1} = 0.72A$

$I_{R2/3} = 0.72A$

$V_{R1} = 10 \times 0.72$

$V_{R1} = 7.2v$

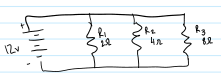
$V_{R2} = 6.67 \times 0.72$

$V_{R2} = 4.8v$

$I_{R2} = \frac{4.8v}{20\Omega} = 0.24A$

$I_{R3} = \frac{4.8v}{10\Omega} = 0.48A$

In class example



d) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_t} = \frac{1}{2} + \frac{1}{4} + \frac{1}{8}$

$\frac{1}{R_t} = \frac{7}{8}$ $\quad \frac{1}{0.875} = R_t = 1.14\Omega$

a) $I_{R_1} = \frac{12v}{2\Omega} = 6A$

b) 12v

c) $I_t = \frac{V}{R_t} = \frac{12v}{1.14\Omega} \therefore I_t = 10.53A$

d) 1.14Ω

e) 12v

f) $P_t = I_t V_t$ $\quad P_t = 10.53A \cdot 12v$ $\quad P_t = 126.36W$

g) $P_{R1} = I_{R1} V_{R1}$ $\quad P_{R1} = 6A \cdot 12v$ $\quad P_t = 72W$

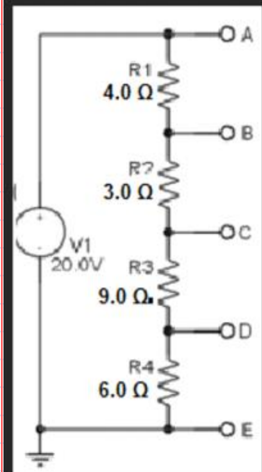
Power equations

$P = IE$ | $P = \frac{V^2}{R}$ | $P = I^2 R$

Class Activity #1

September 13, 2023 10:29 AM

Question 1



SERIES CIRCUIT

a) $R_T = \Sigma R \therefore R_T = 4.0 + 3.0 + 9.0 + 6.0$, $R_T = 22.0\Omega$

b) $I_T = \frac{V_T}{R_T} \therefore \frac{20v}{22.0\Omega}$, $I_T = 0.91A$

c) $V_T = V_1 + V_2 \cdots \therefore R_1 = 4.0\Omega \times 0.91A = 3.64v$, $R_2 = 2.73v$, $R_3 = 8.19v$, $R_4 = 5.46v$

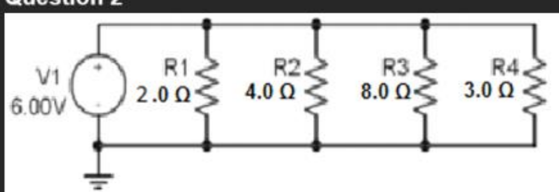
$V_T = \underbrace{3.64v}_{R_1} + \underbrace{2.73v}_{R_2} + \underbrace{8.19v}_{R_3} + \underbrace{5.46v}_{R_4} = 20.02v$

d) $A = 20.02v$, $B = 16.38v$, $C = 13.65v$, $D = 5.46v$, $E = 0v$

From the circuit above determine the following: (Show all working)

a. Determine the total resistance of the circuit.
b. Determine the circuit current.
c. Determine the voltage drops across each resistor.
d. Using the voltage drops, determine the voltage at each labelled node relative to ground.
e. Copy and paste simulation result here

Question 2



From the circuit above determine the following: (Show all working)

a. Determine the total resistance of the circuit.
b. Determine the total current supplied by the source.
c. Determine the current for each branch.
d. Determine the voltage drops across each resistor.
e. Copy and paste simulation result here

Parallel Circuit

a) $R_T = 1/(\frac{1}{R_1} + \frac{1}{R_2} \cdots)$

$R_T = 1/(\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{3})$

$R_T = 0.83v$

b) $I_T = \Sigma I \therefore R_1 = \frac{6.0v}{2.0\Omega} = 3A$, $R_2 = 1.5A$, $R_3 = 0.75A$, $R_4 = 2A$

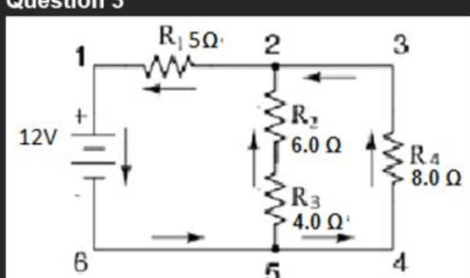
$I_T = 3A + 1.5A + 0.75A + 2A = 7.25A$

c) $R_1 = 3A$, $R_2 = 1.5A$, $R_3 = 0.75$, $R4 = 2A$

d) $V_T = V_1 = V_2 \cdots \therefore V_T = 6.0v$

$V = I \cdot R \therefore R_1 = 3A \cdot 2\Omega = 6.0v$

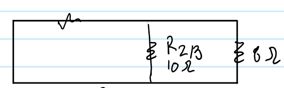
Question 3

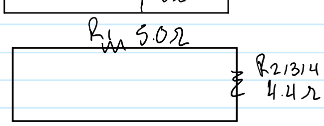


From the circuit above determine the following: (Show all working)

a. Determine the total resistance of the circuit.
b. Determine the total current supplied by the source.
c. Determine the current for each branch.
d. Determine the voltage drops across each resistor.

SERIES & PARALLEL CIRCUIT (need to squash)?



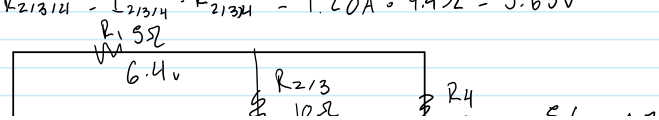


$RT = 9.4\Omega$

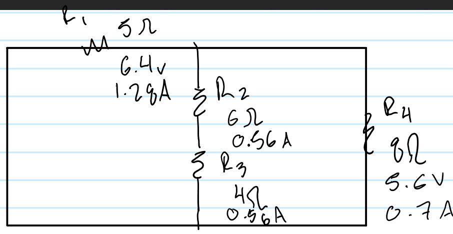
$I_T = \frac{V_T}{R_T}$ $I_T = \frac{12v}{9.4\Omega}$ $I_T = 1.28A$

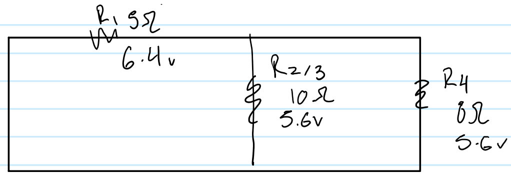
$V_{R_1} = I_1 \cdot R_1$ $R_1 = 1.28A \cdot 5.0\Omega = 6.4V$

$V_{R_{2/3/4}} = I_{2/3/4} \cdot R_{2/3/4} = 1.28A \cdot 4.4\Omega = 5.63V$



d. Determine the voltage drops across each resistor.





$\frac{5.6}{8\Omega} = 0.7A$

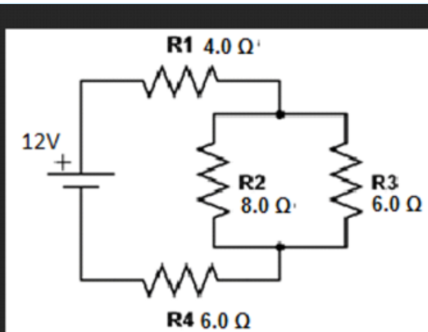
$1.28 - 0.7 = 0.56$

$\frac{5.6}{10\Omega} = 0.56$

$V_{R2} = I \cdot R = 6 \cdot 0.56 = 3.36$

$V_{R3} = I \cdot R = 4 \cdot 0.56 = 2.24$

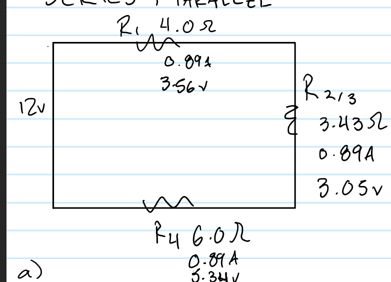
$+ = 5.6$



From the circuit above determine the following: (Show all working)

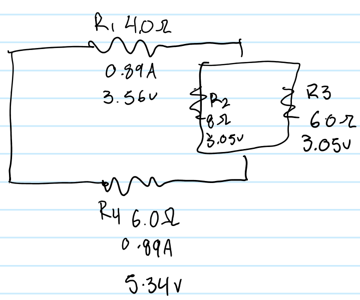
a. Determine the total resistance of the circuit.
b. Determine the total current supplied by the source.
c. Determine the current for each branch.
d. Determine the voltage drops across each resistor.

SERIES & PARALLEL



a) $R_T = 4.0 + 14.0 + 6.0 = 13.43\Omega$

b) $I_T = \frac{V_T}{R_T}$ $I_T = \frac{12v}{13.43}$ $I_T = 0.89A$



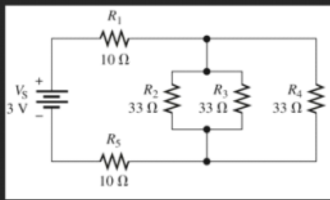
$R_3 \frac{3.05}{6.0\Omega} = 0.51A$

$+$

$R_2 = \frac{3.05}{8.0\Omega} = 0.38A$

$= 0.89A$ ✓

Question 5



From the circuit above determine the following: (Show all working)

a. Determine the total resistance of the circuit.
b. Determine the total current supplied by the source.
c. Determine the current for each branch.
d. Determine the voltage drops across each resistor.
e. Copy and paste simulation result here

Electrical Test Instruments

September 18, 2023 2:56 PM

Voltmeter (V)

- an instrument for measuring electrical potential difference (Volts) between two points in an electric circuit.
- **the voltmeter is connected in *parallel* or *across* the device being measured**
- needs a power supply to be on

Ammeter (A)

- an instrument for measuring current (electrons) in a circuit.
- **the ammeter is connected in *series* or *in-line* with the circuit so the current passes through the ammeter**
- remember to turn the probe into the current one

Ohmmeter (Ohms)

- an instrument for measuring the resistance placed between its leads.
- **an ohmmeter does not need a power supply connected**
- you can measure the resistance in parallel or in series.
- the resistance reading is indicated through a digital meter which operates on electric current
- this meter can be used to ensure the continuity of the circuit (sufficient flow of current)

a multimeter is the best of all of them
digital is king baby

Safety:

- don't touch bare probe tips while measuring voltage
- always check for both AC and DC voltage
- never try to read resistance or continuity with a multimeter on an energized circuit.

Lab 1 Calculations - Quinn

September 18, 2023 4:00 PM

$R_{R1} = 100\Omega$
$V_{R1} = 1.8v$
$I_{R1} = 0.018A$

$R_{R2} = 150\Omega$
$V_{R2} = 2.7v$
$I_{R2} = 0.018A$

$R_{R3} = 180\Omega$
$V_{R3} = 3.24v$
$I_{R3} = 0.018A$

$R_{R4} = 220\Omega$
$V_{R4} = 3.96v$
$I_{R4} = 0.018A$

$R_T = 650\Omega$
$V_T = 12v$
$I_T = 0.01846A = 0.018A$

Series circuit

a) $R_T = \sum R_n$
$R_T = R_1 + R_2 + R_3 + R_4$
$R_T = 100\Omega + 150\Omega + 180\Omega + 220\Omega$
$R_T = 650\Omega$

b) $I_T = \frac{V_T}{R_T}$

$I_T = \frac{12v}{650\Omega}$

$I_T = 0.01846A$

c) $V_{R1} = 0.018A \cdot 100\Omega$ | $V_{R1} = 1.8v$
$V_{R2} = 0.018A \cdot 150\Omega$ | $V_{R2} = 2.7v$
$V_{R3} = 0.018A \cdot 180\Omega$ | $V_{R3} = 3.24v$
$V_{R4} = 0.018A \cdot 220\Omega$ | $V_{R4} = 3.96v$

Lab 2 calculations - Quinn

September 22, 2023 12:25 PM

$V_{R_1} = 12v$
$R_{R_1} = 1.2k\Omega$
$I_{R_1} = 0.01A$

a) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_T} = \frac{1}{1200} + \frac{1}{1000} + \frac{1}{180}$

$\frac{1}{R_T} = 135.33\Omega$

$\frac{V}{I \mid R}$

$V_{R_2} = 12v$
$R_{R_2} = 1k\Omega$
$I_{R_2} = 0.012A$

b) $I_T = I_1 + I_2 + I_3$

$I_1 = \frac{V_1}{R_1} \therefore I_1 = \frac{12v}{1200\Omega} \therefore I_1 = 0.01A$

$I_2 = \frac{V_2}{R_2} \therefore I_2 = \frac{12v}{1000\Omega} \therefore I_2 = 0.012A$

$I_3 = \frac{V_3}{R_3} \therefore I_3 = \frac{12v}{180\Omega} \therefore I_3 = 0.0\bar{6}A$

$I_T = 0.01A + 0.012A + 0.0\bar{6}A \therefore I_T = 0.088\bar{6}A$

$V_{R_3} = 12v$
$R_{R_3} = 180\Omega$
$I_{R_3} = 0.0\bar{6}A$

c) as per parallel circuit rules,

$V_T = V_1 = V_2 = V_3 \ldots$

$V_1 = 12v$, $V_2 = 12v$, $V_3 = 12v$

$V_T = 12v$
$R_T = 135.33\Omega$
$I_T = 0.088\bar{6}A$

AC Power

September 29, 2023 12:12 PM

polarity changes rapidly on AC circuits

- this makes the polarity of devices connected irrelevant

the symbol for AC in a diagram is a circle with a wave in it
how to check if something is AC without knowing:

- use a multimeter

things that use AC

- homes, car alternators, radios, lots of electronics

AC advantages over DC

- generation / transmissions
- transformer voltage increase/decrease
- efficient power distribution and motors (compared to DC)

AC power is produced when the magnet is closest to the coils (this happens twice)

- the north pole = positive side of current generation

transformers use "mutual inductance" - which is when a coils changing magnetic field induces a voltage in another coil
(exchanging of energy from one coil to another)

^ very similar to a bike's gear system

step-down = high voltage / low current > high current / low voltage

step-up = high current / low voltage > high voltage / low current

transformers only work with AC

- done to step up or down voltage

low current - high voltage : can be used over thinner wires over long distance

- you then need to step the voltage down for more current

AC Waveform characteristics

- sine wave
- square wave
- triangular wave

Measuring AC

- **root mean square (RMS) - measuring AC to the equivalent in DC**
- 10v AC RMS = 10v DC
- 10v AC =/= 10v DC
- **RMS = 0.707**
- **$V_{RMS} = V_{peak}$ / root(2)**
- **$I_{RMS} = I_{peak}$/root(2)**
- **$V_{RMS} = V_{peak} * 0.707$**

- peak of a square wave lasts way longer than triangle or sign wave,
- so RMS measures the average heat of the wave

Q8 $I_{R_1} = 6A$
$V_{R_1} = 12v$
$R_{R_1} = 2\Omega$

$$\frac{V}{I \mid R}$$

$I_{R_2} = 3A$
$V_{R_2} = 12v$
$R_{R_2} = 4\Omega$

$I_{R_3} = 1.5A$
$V_{R_3} = 12v$
$R_{R_3} = 8\Omega$

$I_{total} = 10.5A$
$V_{total} = 12v$
$R_{total} = 1.142857143\Omega$

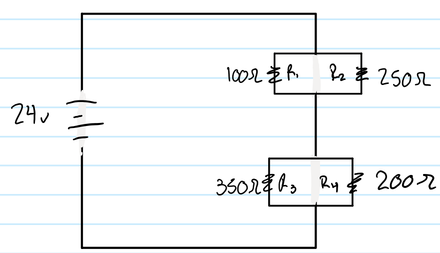
Q16 I_{R_1}
V_{R_1}
R_{R_1}

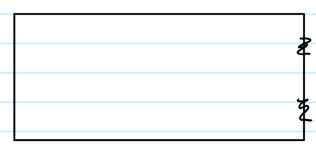
I_{R_2}
V_{R_2}
R_{R_2}

I_{R_3}
V_{R_3}
R_{R_3}

I_{R_4}
V_{R_4}
R_{R_4}

$I_{total} = 0.1207A$
$V_{total} = 24v$
$R_{total} = 198.7012987\Omega$





$R_1/R_2 = 71.428\Omega$

$R_3/R_4 = 127.2727\Omega$

$I_{total} = \frac{V_{total}}{R_{total}}$

$I_{total} = \frac{24}{198.\ldots}$

$I_{total} = 0.1207843137A$

$R_1/R_2 \cdot I_{total} = V_{R_1/R_2}$
$71.428\Omega \cdot 0.120784\ldots = 8.627450979v = V_{R_1} : V_{R_2}$

$R_3/R_4 \cdot I_{total} = V_{R_3/R_4} = 15.37254902v = V_{R_3} : V_{R_4}$

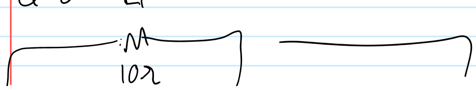
$R_1 = 100\Omega$
$8.6274\ldots v$
$\frac{8.6274}{100\Omega} = 0.086274A$

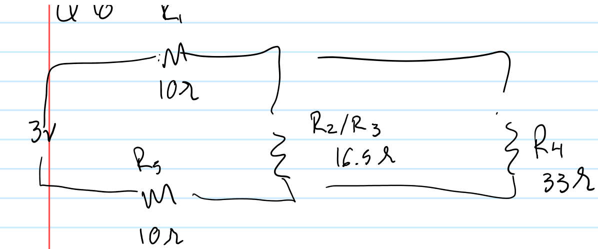
$R_2 = 250\Omega$
$8.6274\ldots v$
$\frac{8.6274}{250\Omega} = 0.0345096A$

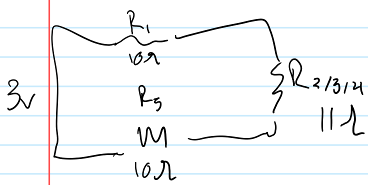
$R_3 = 350\Omega$
$15.37254902v$
$\frac{15.37254902v}{350\Omega} = 0.0439215\ldots A$

$R_4 = 200\Omega$
$15.3725\ldots v$
$\frac{15.37\ldots v}{200\Omega} = 0.076862\ldots A$

Q10







$R_{total} = 10 + 11 + 10 = 31\Omega$

$V_{total} = 3v$

$I_{total} = \frac{3v}{31\Omega} = 0.09677A$

$V_{R1} = 3v$

$I_{R1} = 0.09677A$

$R_{R1} = 10\Omega$

$V_{R2/3/4} = 3v$

$I_{R2/3/4} = 0.09677A$

$R_{R2/3/4} = 11\Omega$

$V_{R5} = 3v$

$I_{R5} = 0.09677A$

$R_{R5} = 10\Omega$

$V_{R4} = 3v$

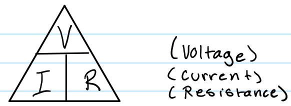
$I_{R4} = 0.090909A$

$R_{R4} = 33\Omega$

Formulas

September 13, 2023 10:03 AM

SERIES CIRCUITS



CURRENT : equal across all components (A)

$I_{total} = I_1 = I_2 \cdots$

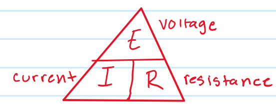
RESISTANCE : equal to sum of individual resistances (Ω)

$R_{total} = R_1 + R_2 + R_3 \cdots$

VOLTAGE : equal to sum of individual voltage drops (V)

$V_{total} = V_1 + V_2 + V_3 \cdots$

PARALLEL CIRCUITS



VOLTAGE : equal across all components (V)

$V_{total} = V_1 = V_2 \cdots$

CURRENT : equal to sum of individual branch currents (A)

$I_{total} = I_1 + I_2 \ldots$

RESISTANCE: diminish to equal smaller than added total resistance (Ω)

$R_{total} = 1 / (\frac{1}{R_1} + \frac{1}{R_2} \cdots)$

POWER EQUATIONS

$P = I \cdot V$ | $P = \frac{V^2}{R}$ | $P = I^2 R$

Manchester	0s = high to low
(SPLIT)	1s = low to high

Diff Manchester	0s = high to low
(SPLIT)	1s = swap each 1

NRZ-L	0s = low / below middle
(NON-SPLIT)	1s = high / above middle

NRZ-I	0s = same as the last voltage
(NON-SPLIT)	1s = swap directions / above or below

Return to Zero	0s = low to mid
(SPLIT)	1s = high to mid

Unipolar	0s = none (bottom/zero)
(NON-SPLIT)	1s = high (top/power)

Bipolar	0s = mid (zero)
(NON-SPLIT)	1s = swapping from high to low (positive to negative)

- **RMS = 0.707** – root mean square (aka equivalent to DC)
- **V_{RMS} = V_{peak} / root(2)**
- **I_{RMS} = I_{peak}/root(2)**
- **V_{RMS} = V_{peak} * 0.707**

$$V_{RMS} = \frac{V_{peak}}{\sqrt{2}}$$ (AC voltage equivalent to DC voltage)

$$I_{RMS} = \frac{I_{peak}}{\sqrt{2}}$$ (AC current equivalent to DC current)

$$V_{RMS} = V_{peak} \cdot 0.707$$

V1 = most significant bit

$V_{out} = -(V_1 + V_2/2 + V_3/4 \ldots)$

$V_n / 2^{n-1}$ is general formula

Electronics Quiz Friday

Wednesday, November 8, 2023 10:55 AM

List a few objects in a building that are considered to be an ideal area for good electrical grounding/bonding?

- Grounding wires, pipes (metal)
- Bus bar

Grounding :

Grounding points are good (?)

Transformer has more coils on one side than the other (small to large transformer - or something)

Transformers - high voltage over the power lines, low amperage - transformer makes this do it
It either steps up the voltage or steps down the voltage

Why was AC chosen to be the preferred choice for the Electrical PowerGrid?
Efficient for transmitting current over a longer distance
The ability to step up and step down current
Smaller wires can be used
AC Generator are consider to be more efficient than DC
All of the above -

Rectifier = AC>DC
Inverter = DC>AC

Online ups - constantly using the battery for power
Standby up - switches to battery power if it needs it

120AV uses 14 gauge wire

RMS - AC constantly changes - takes the average of AC power equivalent of dc power

What is peak voltage of 120V AC supply - 170V (know how to do these calculations)

difference between AC and DC
AC - current flows in one direction then another
- magnet surrounded by coils - generates power twice per rotation

DC - current flows in a single direction
- coil surrounded by magnets - generates power constantly while spinning

how is AC current generated
- A magnet is spun between two coils (creates current twice per 360 degree rotaion)
  - known as Faraday's law of electromagnetic induction

importance of stepping up/down AC current

- it is much easier to do with AC than DC
- can step voltage up so you can send it across thinner lines further distances (without having to worry about the resistance and thickness of wire like if you had high current)
-

AC current advantages over DC
- can be stepped up and down
- easier / cheaper to generate

how AC wave is produced
- usually expressed in SIN wave

mutual induction is produced by transformer (coil inducing another coil with voltage)

AC voltage / current is not stable - DC voltage / current is

10V AC RMS is equivalent to 10V DC - same amount of heat dissipation across a resistor
* - for sine wave it is about 0.707*peak

$P= E^2/R$ and $P = I^2/R$

RMS = "DC Equivalent" to any AC voltage or current

Rectifier = AC to DC power

Inverter = DC to AC power

Online UPS = constantly charging battery and using that as the power for the devices

Standby UPS = utility power is used until power outage is detected, then battery is used for power (a few milliseconds of AC output)


calligraphr
Include all those four markers
untrimmed on your photo or scan.
www.calligraphr.com


calligraphr
l m n o p q
l m n o p q
r s t u v w
r s t u v w
x y z
x y z
Include all those four markers untrimmed on your photo or scan.
www.calligraphr.com

Analog to Digital Conversion

November 13, 2023 3:16 PM

What is a signal - voltage that is changing over time
- analog can vary **infinitely**
- digital is on or off (think binary)

analog signal - like the real world, infinite gradient
- a time vs voltage graph would be **smooth** and **continuous**

digital signal - computers, set amount of data; can increase detail but will **never be** infinite
- a time vs voltage graph would be choppy based on how many bits it has
  (may look like a digital graph but it is made up of a ton of little steps)

- uses a binary system (0s and 1s) so it cannot take on fractional values

Digital to Analog Conversion (DAC)
DAC - Inputs a binary number and outputs an analog voltage/current signal
- weighted resistor DAC (r/2nr DAC)
- ladder DAC (?)

Operational Amplifier / op-amp
- **takes a small voltage and increases it**
- **takes two inputs and compares them**
- has 2 digital inputs (positive and negative), then needs power

Digital to Analog Conversion (DAC)

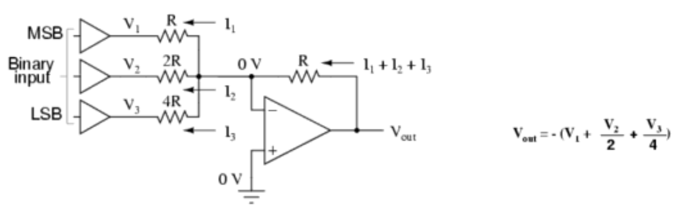


Figure illustrates a 3-bit binary weighted resistor DAC

V1 = most significant bit
$V_{out} = -(V_1 + V_2/2 + V_3/4 \ldots)$ - FORMULA FOR DAC - OUTPUT IN ANALOG

$V_n / 2^{n-1}$ is general formula

FLASH OPERATION:

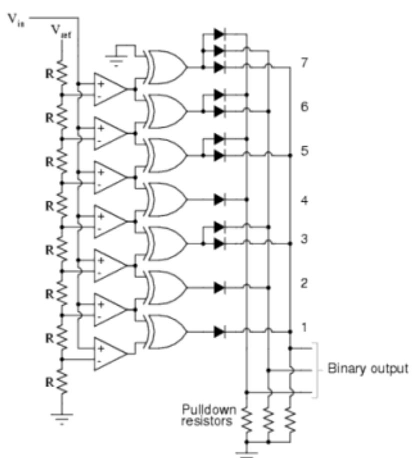
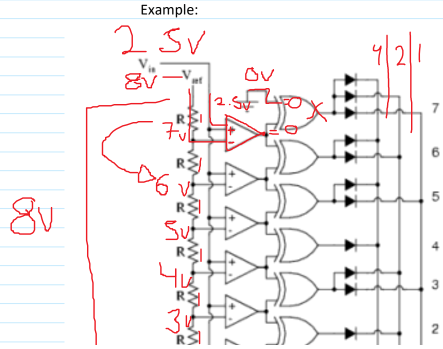


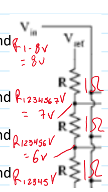
Figure illustrate a 3-Bit ADC

Example:



SERIES CIRCUIT If V_{ref} = 8V

8v from ground
7v from ground
6v from ground
5v from ground



The weird looking guys are **XOR gates**
ONLY ACTIVATE IF IT IS **(1 - 0) OR (0 - 1)**

Operational Amp
If you connect the positive to a ground, it is an amplifier

7v from ground

6v from ground

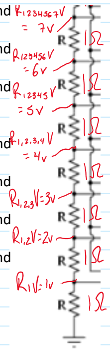
5v from ground

4v from ground

3v from ground

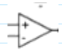
2v from ground

1v from ground

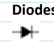


Operational Amp
If you connect the positive to a ground, it is an amplifier

If you connect the positive to a positive, it is a comparator (HOW IT WORKS HERE)
POSITIVE > NEGATIVE, OUTPUT = 1



Diodes, allow only one way power



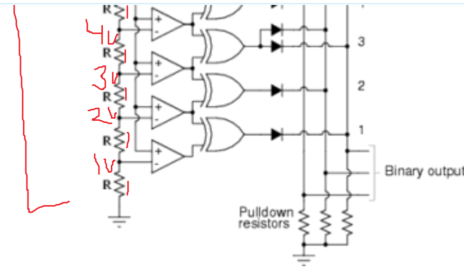


Figure illustrate a 3-Bit ADC

Analog/Digital Signal Processing

Monday, November 20, 2023 3:17 PM

Modulation: the process of varying one or more parameters of a carrier signal according to the values of the message signal. (think binary on and off for data)

Pulse Code Modulation: digital modulation technique - turns it into 1s and 0s (resembles binary)
Analog Modulation: (Amplitude Modulation (AM), Frequency Modulation (FM), Phase Modulation (M))

Basic Elements of PCM (pulse code modulation):
(transmitter)
Low Pass Filter: a filter to eliminate high frequency components in input analog signal which is greater than the highest frequency of message signal. (done to avoid aliasing)

Sampler: the process of measuring the values of continuous-time signal in a discrete form

Quanitzer: process of reducing the excessive bits and confining the data from analog to digital
- Rounds the sampled data to an approximate/near stabilized value

Encoder: the actual digitization of analog signal.
- Designates each quantized level by a binary code
- Sample-and-hold process
- LPF, Sampler, and Quantizer will act as an analog to digital converter

Both sampling and quantization loses information - difference of input and output value is called **quantization error**

Companding: mixture of compressing and expanding
- Non-linear technique used in PCM which compresses the data at the transmitter and expands the same data at the receiver
- Noise and crosstalk are reduced by using this technique

(receiver)
Regenerative Repeater Circuit: increases signal strength
- Output of the channel also has one regenerative repeater circuit to compensate signal loss and reconstruct signal / increase its strength

Decoder: decodes the pulse coded waveform to reproduce original signal - circuit acts as the demodulator

Reconstruction Filter: after digital-to-analog conversion (done by regenerative circuit and decoder) a low pass filter is employed, called a reconstruction filter to get back to the original signal

(2) Analog/Digital Signal Processing

Wednesday, November 22, 2023 10:09 AM

Data can be stored in either:
Analog - (hard drives, CDs)
Or Digital - (SSD, NVME, RAM)

Digital or Analog **data** can be converted into Digital **signal.** There are two ways of doing it:
Line Coding: necessary for all communications, stored as a series of 1s and 0s. Discreet signal
Block Coding: optional

Line Coding:
Three types:

- **Uni-Polar Encoding (unipolar-non-return-to-zero)** - use a single voltage level to represent data.

Uses a binary system: 1 = high voltage, 0 = no voltage

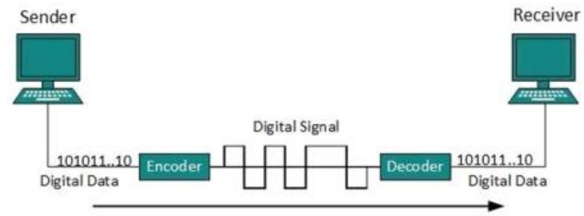


Figure illustrate Digital data being transmitted as a Digital Signal

On test, have to identify if it is digital to digital or not

- **Polar Encoding** - uses multiple voltage levels to represent binary values

Available in 4 types:

- **Polar Non-Return to Zero (Polar NRZ)** - two voltage levels to represent binary

Usually negative and positive, NOT ZERO.
NRZ-L - *1 is positive and 0 is negative*
NRZ-I - *swaps every time it sees a 1*

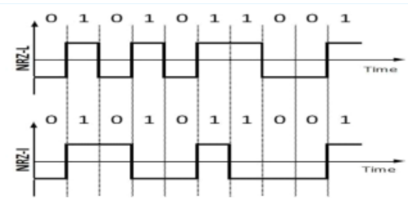


Figure illustrate NRZ-L & NRZ-I encoding scheme

NRZ-L vs NRZ-I

- **Return to Zero (RZ)** - uses THREE voltage levels. (signal is self-clocking)

+ = 1, - = 0, 0 = none
Goes to value then returns to zero before moving on

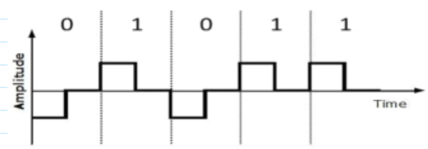


Figure illustrate RZ signal scheme

Return to Zero (RZ)

- **Manchester** - combination of RZ and NRZ-L, bit time is divided into two halves.

Left side positive is 0, right side positive is 1
0 is low to high, 1 is high to low

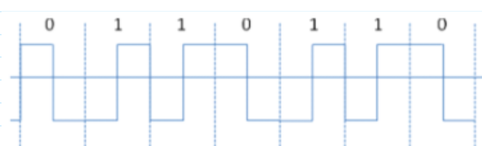


Figure illustrate Manchester encoding signal scheme

Manchester

- **Differential Manchester** - combination of RZ and NRZ-I, also transits in the middle, but changes phase only when a 1 is encountered.

Left side positive is 0 OR 1 if previous bit was a 1. Right side positive is 1.

1 starts **low to high**, then **swaps** to **high to low** each 1
0 is always **high to low**

Differential Manchester

- This encoding scheme is a combination of RZ and NRZ-I. It also transit at the middle of the bit but changes phase only when 1 is encountered.

Figure illustrate Differential Manchester encoding signal scheme

Differential Manchester

- **Bipolar Encoding** - uses THREE voltage levels.

Zero voltage represents 0

1 bit is represented by alternating positive and negative

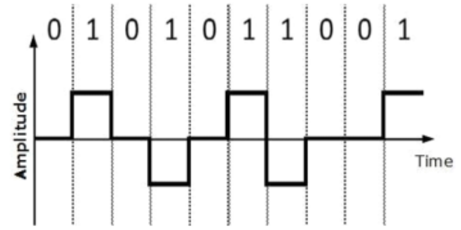


Figure illustrate Bipolar encoding signal scheme

Bipolar Encoding

Quiz notes

Friday, November 24, 2023 12:37 PM

Will for sure see Manchester and differential Manchester

RS232 to IC2
2 circuits - one for data and one for clock

Busses & Digital Communication

Monday, November 27, 2023 3:39 PM

Bus - two or more digital devices being connected together so that data can be communicated between them.

Fieldbus or Profibus - not just physical wiring of bus, also specify voltage levels for communication, timing sequence, connector pinout specs, and all other distinguishing features of the network.

Busses are the things that connect the wires and convert the language so that the two things can speak to each other.
- Ex. 2 CAN bus devices can communicate

Two types:

Short distance busses:
- Ex. PC/AT Bus - used in early IBM-compatible PCs to connect peripherals
- PCI - another bus MUCH faster than PC/AT - 100Mbytes/sec (32bit), 200Mbytes/sec (64bit)
- PCMCIA - bus designed for connecting peripherals to laptops
- SCSI - an alternative bus used for personal computer disk drives

Extended distance network:
- Ex. 20 mA current loop: digital communications network based on interrupting a 20 mA current loop to represent binary
- RS-232C: most common serial network used in computer systems - often for peripherals
- RS-422A/RS-485: better version of RS-232C - more range - less noise
- Ethernet (IEEE 802.3): ethernet
- Token ring: ethernet competitor way back in the day, allowed for more precise response times from individual network devices
- Modbus/Modbus plus: originally implemented by Modicon corporation, a large maker of PLCs (programmable logic controllers) fo linking remote I/O (input/output) racks with a PLC processor

Universal Serial Bus (USB) characteristics

Wednesday, November 29, 2023 10:30 AM

Intro to USB
USB was developed by Compaq, Intel, Microsoft and NEC, Hewlett-Packard, Lucent and Philips.
Was developed to find one connector - not a bunch like there was at the time.
Was designed to replace legacy connections, and be hot-pluggable

Data Speed
Three speeds (now there are 6?)

Low Speed	**1.5Mbit/s**
Full Speed	**12Mbit/s**
High Speed	**480Mbit/s**

USB 3.2 Gen 1 (SuperSpeed)	**5Gbit/s**
USB 3.2 Gen 2 (SuperSpeed 10Gbit/s)	**10Gbit/s**
USB 3.2 Gen 2 x 2 (SuperSpeed 20Gbit/s)	**20Gbit/s**

Architecture:
USB is based on "tiered star topology" - single host controller and (theoretically) up to **127 "slave" devices**
- Most hubs would run out of power way before 127, (7 bits, 0 is special and can't be used)

Host is the Master
All communications on this bus are initiated by the host
- The devices cannot intercommunicate with each other on the hub
- A device cannot initiate a transfer - must be prompted by user
- The only exception is when a device has been put into 'suspend' mode by the host (low power mode)

USB Electrical Characteristics
Contains 4 wires
- D+, D- (twisted pair for data, low speed may not be twisted) - (pins 1 and 2)
- VBUS - 5v power supply (pin 4)
- GND - ground wire (pin 3)

Power distribution
- A device (or hub) can only consume current from its upstream port.
- A "self-powered" device is one that provides its own power and does not draw power from the bus
- A "Bus-powered" device is one that needs extra power, it can pull **100mA or 500mA** if permitted by host.
- In "suspended" mode, must reduce its current consumption to 0.5mA (it needs this for getting woken up)

Device Powering
- Up to 5v is an attractive feature - this is usually what they use.
- Voltage can drop to 4.35V (?)
- No device is permitted to take more than 100mA before it has been **configured** by the host.
- The device must reduce its current consumption to 2.5mA whenever it is "suspended"
- The device may draw up to 500mA after it has been configured as a high power device
- A "self-powered" hub can provide 500mA

- Devices that draw more than 500mA need to be self-powered (using a Y splitter USB is not permitted and can easily damage ports.)

Hot-Pluggable devices

- If you pull a plug out while current is being drawn, it can cause an arc ("flyback") and cause damage / data loss.
- To be able to plug a device in and out of a running system rules have to be followed:

- Minimum of 1 micro F capacitor on VBUS and ground
- When you plug your device in with any capacitance between VBUS and ground will cause a dip in voltage across the other ports in the hub so:
- Maximum of 10 micro F capacitor on VBUS and ground

USB Data Flow

at any point in time only the host OR one device can be transmitting at a time
Works like a hub - blasts data to everything but only gets accepted by the destination

Transceiver

- At the end of the data link between host and device is a transceiver circuit
- Typical upstream end transceiver is located nearer to the host. The upstream end has two 15K pull-down resistors
- The equivalent downstream end transceiver are found in end devices
- individual receivers on each line are able to detect single ended signals (Single Ended Zero - SE0)

Speed Identification

- The device end of the link, a 1.5K ohm resistor pulls one of the lines up to a 3.3V supply from VBUS
- **D- for low speed devices**, and **D+ for a high speed device**
- High speed device will initially present itself as a full speed device with the pull-up resistor on D+

Three things to remember:
Version 1 - low speed - 1.5K resistor **connected to D-**
Version 1.2 - full speed - 1.5K resistor **connected to D+**
Version 3 - high speed - 45 ohm resistor on **each end of both D+ and D-**