FRC Electronics Level 2 Badge Items

Topic: Explain how PWM and CAN Communication methods differ

Similarities
Both communication ports can be used to control of the output voltage on a Motor Controller.
Talon SRX/SPX Motor Controllers uses the CAN bus while Victor SP Motor Controller requires a PWM port.

Differences

CAN (Common Area Network) Bus	PWM (Pulse Width Modulation) Ports
CAN is a two-wire serial bus.	PWM devices use a three-wire set from the roboRIO to each PWM Motor Controller
CAN provides feedback data from the device to the roboRIO.	PWM is only a one-way communication link
PDP, PCM, Talon SRX and Victor SPX motor controllers are CAN connected devices	SPIKE Relay and Victor SP Motor Controller are PWM connected devices
Several dozen CAN devices can be connected to a roboRIO	A maximum of 10 PWM ports are available on the roboRIO (two Motor Controllers can be 'chained to one PWM port)

Topic: Explain the components of Lead Acid, Alkaline and Nickel-Metal Hydride Batteries
Lead-acid batteries are composed of a Lead-dioxide cathode, a sponge metallic Lead anode and a Sulphuric acid solution electrolyte. This heavy metal element makes them toxic and improper disposal can be hazardous to the environment. The cell voltage of this battery type is 2 Volts (A 12-Volt battery contains six 2-Volt cells).

Lead Acid batteries are the technology of choice for FTC and FRC Robotics because they are robust, tolerant to abuse, tried and tested, value priced compared to other batteries and they can be recharged.

Alkaline Batteries are the most popular general-purpose battery available. In an alkaline cell the electrical energy is derived from the reaction of a metal with oxygen. **These batteries are not rechargeable**. Flashlights and remote controllers use these 1.5 V batteries.

Sealed Nickel-Cadmium (NICD) battery is a type of rechargeable battery using nickel oxide hydroxide and metallic cadmium as electrodes. The abbreviation NICD is derived from the chemical symbols of nickel (Ni) and cadmium (Cd). This battery was once widely used in portable power tools, photography equipment, flashlights, emergency lighting and portable electronic devices. Cell voltage is 1.2 Volts and these batteries were often used as a substitute for Alkaline batteries. Many NICD batteries are rechargeable. This technology has largely been supplanted by the Nickel-Metal-Hydride (NIMH) battery.

Sealed Nickel-Metal-Hydride (NIMH) batteries are closely related to sealed Nickel-Cadmium (NiCAD) batteries. Differing only in that instead of cadmium (Cd) , hydrogen (H) obtained from rare Earth alloys such as Lanthanum (La) is the active element. Cell voltage is 1.2 Volts and these batteries are often used as a substitute for Alkaline batteries. Most NIMH batteries are rechargeable

Topic: Use Ohms Law to determine Voltage, Current, Resistance in series and parallel circuits
You have seen and worked with the basic components of series and parallel circuits. Current (I), measured in Amperes (A), flows through the surface of a conductor from negative to positive. Voltage, measured in Volts (V) is the difference in the electrical potential between two points, and the potential energy that provides the force that pushes the current through the conductor between those two points. Resistance (R), measured in Ohms (Ω) is provided by resistors which restrict the flow the current (I) through the circuit.

Common terms and units of measurement:

Term	Measurement Unit
Current (I)	Ampere (A)
Electricity/Energy (V)	Volt (V)
Resistance (R)	Ohm (Ω)

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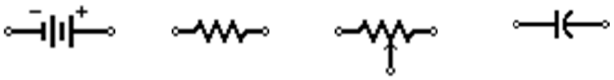
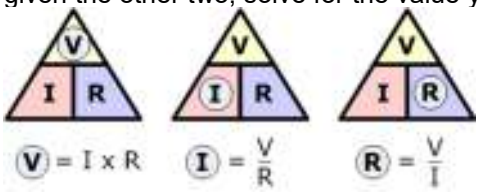
Basic Symbols

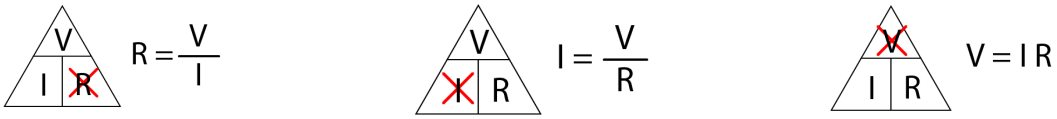


Battery Resister Potentiometer Capacter

Ohm's Law Triangle

If you are given two of the three properties of a circuit, you can always solve for the third property by using Ohms Law equations. Below are helpful images to aid in solving for the third property. Picture a triangle with voltage (V) on top with Current (I) and Resistance (R) on each side of the base of the triangle. If you are trying to find one of the properties when given the other two, solve for the value you are looking for.





For example, to find resistance (R) when given the voltage (V) and the current (I), cover the "R" and you'll get the formula for resistance R = V/I.

The relationship between these components can be described using Ohm's Law expressed as:
R (resistance) = V (voltage)/I (Amperes) =

> Another way to consider this is the Resistance (R) is equal to the product of the voltage and the inverse of the current of a circuit.

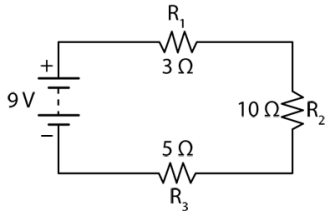
Ohm's Law applied to Series Circuits

If we look at a series circuit, you can see the Ohms Law relationship. In the following series circuit, the source of voltage (battery) provides 9V to the circuit, with one resistor providing 3Ω of resistance.

I =V/R (From the Ohms Law Triangle)
I =9V/3Ω = 3A

In the above circuit, the current (I) measures 3 Amperes.

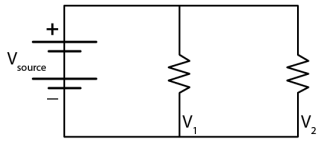
In the example below, there are more resistors added to the circuit. The big idea to keep in mind is in a series circuit, the current runs through **each** resister in series. To determine the total resistance of a series circuit, add each resistor's value in the circuit: 3Ω + 10Ω + 5Ω = 18Ω (R_{totat})



I_{total} =V/R_{total} becomes 9V/18Ω = 0.5A
For extra credit solve for the individual voltage drop across each resister in the circuit in this circuit.

Ohm's Law applied to Parallel Circuits

Recognize that in a parallel circuit, every branch circuit has the same Voltage level. Therefore, each resistor's voltage is equal to the source voltage. Remember in a parallel circuit, there are only two sets of common points. The voltage from the battery is equally applied to all resistors.

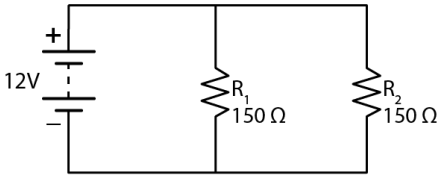


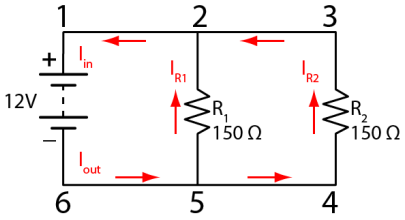
$V_{source} = V_1 = V_2$

In other words, if the source voltage is 12 Volts each branch circuit will conduct the full 12 volts.

How can we find the current for a parallel circuit?

Let's look at the following example. We will also use a table to keep track of each figure:





DC Current flow model

We know the voltage drop across each resister in each branch of this parallel circuit is 12V.

V_{source}	12V	12V	12V
I	I_{R1}	I_{R2}	Itotal
R	R_1	R_2	Rt_{total}

We know the resistance value of each branch circuit is 150Ω. We can use Ohm's law in the form I = V/R to find the current through each branch resister.

$I_{R1} = V_{R1}/R_1 + I_{R2} = V_{R2}/R_2$

If we put in the values of voltage and resistance for all branches of the circuit, then solve for each branch circuit:

V	R_1	R_2	Total
V_{source}	12V	12V	12V
I_{Rx}	0.08A	0.08A	0.16A
R_{total}	150Ω	150Ω	?

The current for each branch is the total current (I_{total}) to the sum of both currents (I_{R1} + I_{R2}).

As the current from the source travels through the circuit a portion of I_{total} flows through branch (I_{R1}) and a portion of I_{total} flows through I_{R2}. I_{total} is the **sum** of the current draw of each branch of the circuit.

How does the sum of each branch resister affect the **total** resistance of the circuit?

Applying Ohm's Law, you can determine the total resistance in this parallel circuit:

$R_{total} = V_{total}/I_{total}$

R_{total} = 12V/0.16A = 75Ω

Another calculation method to find the total resistance is to use the reciprocal formula.

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

We can verify the answer of 75Ω by:

$R_{total} = 1/(1/150)+(1/150) = .0.0133$

$R_{total} = 1/0.0133 = 75Ω$

An important difference between the resistance in series circuits vs resistance in parallel circuits is this: **In a series circuit, the total resistance is always the added sums of the individual resistors in the circuit**.

In a parallel circuit the total resistance will always be less than any one of the branch resistors in the circuit. In the parallel circuit example, the total resistance of the circuit equals 75Ω and is much lower than resistors R_1 or R_2 which was 150Ω each.

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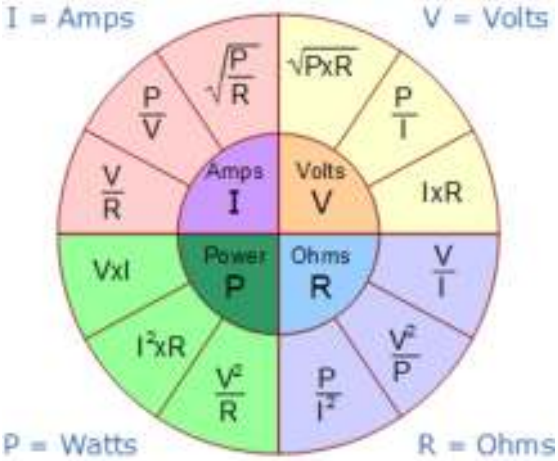
Ohm's Law calculations with Power
Power (P) is a measurement of the amount of work that is done in a given amount of time. With regards to circuits, Power value is the multiplier function of voltage (V) and current (I). The Power unit of measurement is the Watt (W) and the Ohms Law formula is expressed as: $P = V \bullet I$

Ohms Law formulas can be used in many combinations to calculate Power (W), Voltage (V), Current (I) or Resistance (R). Other formulas to calculate power include $P = I^2 \bullet R$ or $P = V^2 / R$

Expanded Ohms Law Pie Chart



To summarize
In a Series Circuit:
$V_{total} = V_{R1} + V_{R2}$ $R_{total} = R_1 + R_2$ I_{totaal} is constant through all resisters $P_{total} = P_{R1}+P_{R2}$

In a Parallel Circuit:
V_{total} is constant across all branches of the circuit $I_{total} = I_{R1} + I_{R2}$ $R_{total} = 1/((1/R_1)+(1/R_2)$ $P_{total} = P_1 + P_2$

Apply this knowledge to the real world
A home appliance plugged into its power outlet uses power when in operation. Choose a common household appliance, for example: Blender, Toaster, TV, Hair Dryer, and use Ohm's Law to determine the Power (W) used when the appliance is running. Determine the Resistance (Ω) of the appliance and Power (W) consumed in operation.

For consistency, assume the home has a 120V circuit for the source voltage. You can determine the current draw by reading the Underwriters Laboratory (UL) label or the manufacturer's provided information typically found at the back or bottom of the appliance.