BASIC ELECTRONICS.CD INFO

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Last Updated: January 10, 2003

Previously Internet Guide to Electronics Site.

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BASIC ELECTRONICS.COM
The NEWMEDIA Way to Learn Electronics

Welcome!

This website allows you to browse the subject of ELECTRONICS. If you are just starting the learning journey, I hope you'll make use of the simple nature and graphical content of this site. Feel free to look around. Don't worry -- there are no tests at the end of the day. If you would like to contact me regarding this site, email me at basicelectronics@hotmail.com

John Adams - Author

(Place mouse over symbol to see selection in LCD screen then view explanation in the browser's status window. Non-Javascript browsers, scroll down for link explanations.)

THEORY | APPLY IT! | COMPONENTS | MESSAGE BOARD | REF/DATA/TOOLS
BOOKS/MAGs | LECTRIC LINKS | BASIC ELECTRONICS.CD INFO

ABOUT | EMAIL | WHATS NEW!

THEORY

Gain the basic understanding of electronic principles that you will be making use of later. This includes Ohm's Law, Circuit Theory, etc.

APPLY IT!

Putting the theory to work. This includes sections on how to solder, multimeters, and of course, **PROJECTS!**

COMPONENTS

Learn about various electronics components.

MESSAGE BOARD

Post your basic electronics related questions here for others to answer and read.

REFERENCE, DATA AND COOL TOOLS!

Resistor color code info, plenty of calculators, chart, electronics data and other cool tools! VERY POPULAR PAGE

BOOKS/MAGs

A list of books and magazines relating to the subject of electronics. Includes direct links to amazon.com for ordering online.

LECTRIC LINKS

A list of top-rated Electronics-related sites on the Web.

BASIC ELECTRONICS.CD INFO

This site will be extended onto a multimedia CD that will soon be available. Find out more information here.

ABOUT

I have been an author in the electronics/computer industires for 5 years. This section is about myself as well as my theories of the Internet and Electronics.

EMAIL

Your comments are always welcome. Due to recent time constrainsts, please direct all questions regarding electronics to the Message Board and I will answer the ones I am able to there.

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Click here to find out more about placing banner ads on this site or exchanging links.

NOTES:

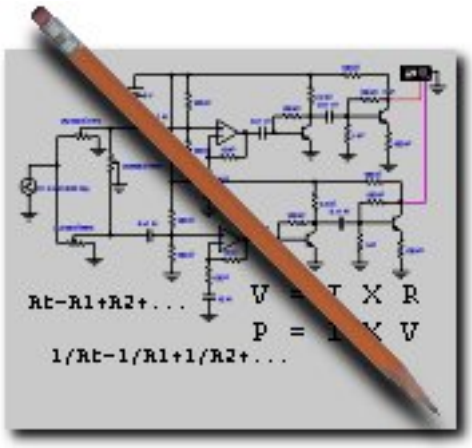
Beginners - I've visited nearly 2500 electronics related websites while researching my book, Howard W. Sams Internet Guide to the Electronics Industry. There was a mysterious lack of electronics sites with beginners information. Most of them assumed you knew something about electronics already. Not so with this site. I want to take you through the complete basics in an attempt to give you a stronger base in electronics knowledge. Hopefully these pages will help. Thanks.

Browse - It is my belief that the subject of electronics should be first browsed and not taught. Most people get started into electronics (myself included) by

trying to accomplish one specific task. They don't want a degree in electrical engineering but they do want a simple understanding to make their projects work. This is how I have approached the subject in this web site and with the Basicelectronics.CD.

Meter Notes: I am still working out the Javascript for this so forgive me if it is not working with your browser yet. Netscape 3, 4 should work fine as well as MSIE 4 and 5.

Theory of Electronics



The following sections cover the basic principles, ideas, concepts, laws, and formulas behind electronics. Don't be tempted to construct an electronics-based career or hobby on a weak foundation. Fully understanding these basic theories will allow you to build that skyscraper upon a firm foundation of concrete knowledge.

More sections will be added when ready.

CIRCUITS EXPLAINED:
Find out what a circuit is composed of and the various types of circuits.

VOLTAGE, CURRENT & RESISTANCE EXPLAINED:
Learn the three basic measurements in electronics and what they really mean.

OHMS LAW EXPLAINED:
Please learn this one well. It is the basis of electronics. Your future learning depends on you knowing this one inside and out.

OHM'S CALCULATOR:
Simple Javascript Ohm's Calculator to help you determine circuit values.

RESISTOR COLOR CODES:
Simple primer to help answer your basic resistor questions.

RESISTOR COLOR CALCULATOR:
This is a COOL javascript resistor color codes calculator - even has a graphic of a resistor with adjustable color bands. Thanks to Danny Goodman for this treat.
NOTE: You will need a Javascript enabled browser such as Netscape 3.0 or higher or MSIE 4.0. I don't think older versions of MSIE will work.

UNDERSTANDING AND CALCULATING SERIES, PARALLEL & COMBINATION CIRCUITS
These are the basic rules and calculations for series, parallel and combination circuits -- Just as important to learn well as Ohm's Law.

SCHEMATIC SYMBOLS:
A list of common schematical symbols used in electronics.

THEORY | LAST SECTION | CIRCUITS EXPLAINED | MAIN

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Last updated: April 1, 1999

INTERNET GUIDE TO ELECTRONICS

BASIC ELECTRONIC CIRCUITS EXPLAINED

In this section we will discuss what a circuit is. I won't belabor the principles of the atom -- let a physics text handle that (boring) task. Instead let's talk about the facts you will need to know to get started in electronics.

Circuit

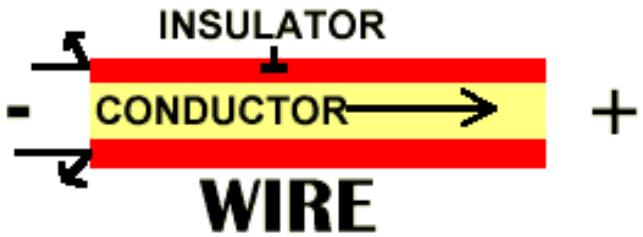
A circuit is a path for electrons to flow through. The path is from a power sources negative terminal, through the various components and on to the positive terminal.

Think of it as a circle. The paths may split off here and there but they always form a line from the negative to positive.

NOTE: Negatively charged electrons in a conductor are attracted to the positive side of the power source.

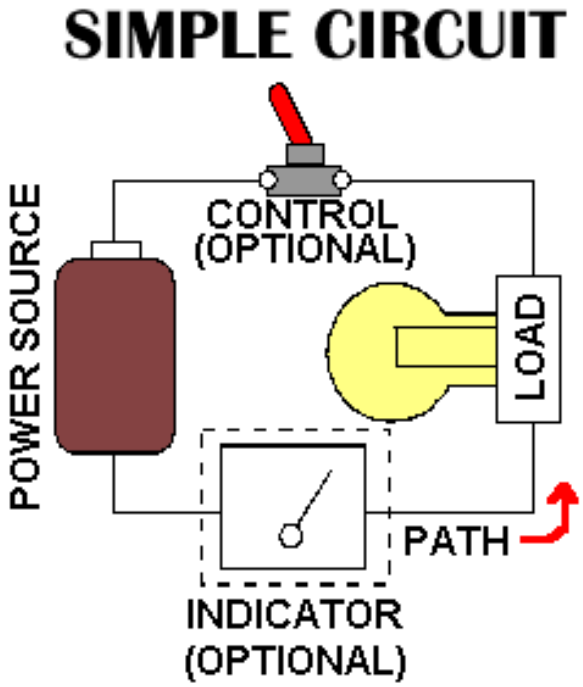
Conductor

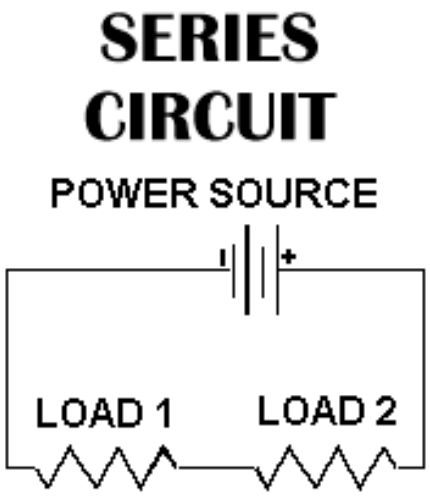
A conductor is a material (usually a metal such as copper) that allows electrical current to pass easily through. The current is made up of electrons. This is opposed to an insulator which prevents the flow of electricity through it.



Simple Circuit

If we break a circuit down to it's elementary blocks we get:
1) A Power Source -- eg: battery
2) A Path -- eg: a wire
3) A Load -- eg: a lamp
4) A Control -- eg: switch (Optional)
5) An indicator -- eg: Meter (Optional)



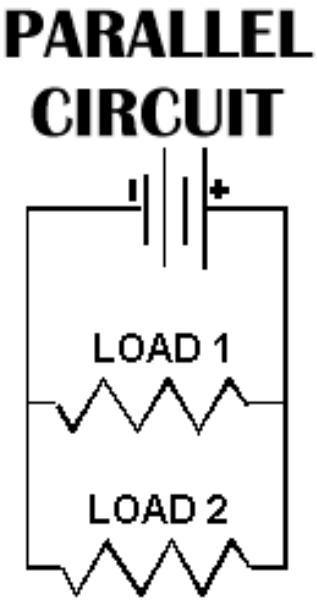


Series Circuit

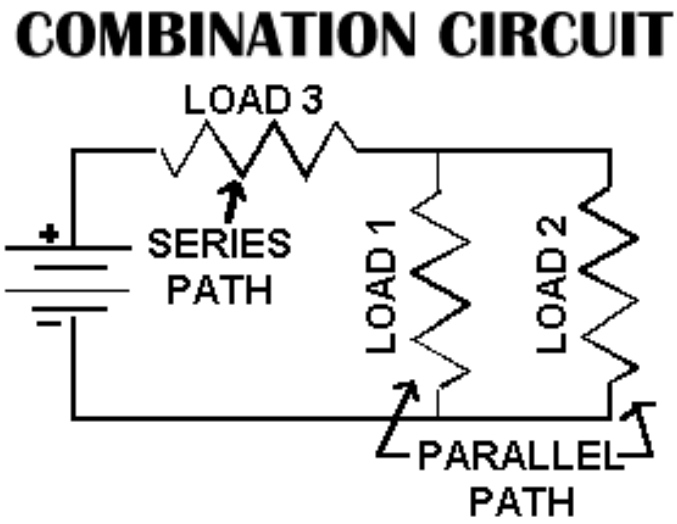
A series circuit is one with all the loads in a row. Like links in a chain. There is only ONE path for the electricity to flow. If this circuit was a string of light bulbs, and one blew out, the remaining bulbs would turn off. There are specific properties to this circuit that will be described in another section.

NOTE: The squiggly lines in the diagram are the symbol for Resistors. The parallel lines are the symbol for a battery.

Parallel Circuit



A parallel circuit is one that has two or more paths for the electricity to flow. In other words, the loads are parallel to each other. If the loads in this circuit were light bulbs and one blew out there is still current flowing to the others as they are still in a direct path from the negative to positive terminals of the battery. There are specific properties to a parallel circuit that will be described in another section.



Combination Circuit

A combination circuit is one that has a "combination" of series and parallel paths for the electricity to flow. Its properties are a synthesis of the two. In this example, the parallel section of the circuit is like a sub-circuit and actually is part of an over-all series circuit.

TOP
Next Section -- Voltage, Current & Resistance Explained
Main Page

INTERNET GUIDE TO ELECTRONICS

UNDERSTANDING & CALCULATING SERIES & PARALLEL CIRCUITS

As you learned from the first section, Circuits Explained, there are three types of circuits: Series, Parallel and Combination.

Now let's look at the properties of each and how to calculate voltage, amperage and resistance in each case. Make sure you thoroughly understand Ohm's Law before proceeding.

SERIES

, PARALLEL- COMPLETE

& COMBINATION- Complete!

TOP
Main Page

INTERNET GUIDE TO ELECTRONICS

UNDERSTANDING & CALCULATING SERIES CIRCUITS

BASIC RULES

A series circuit has certain characteristics and basic rules summized here:

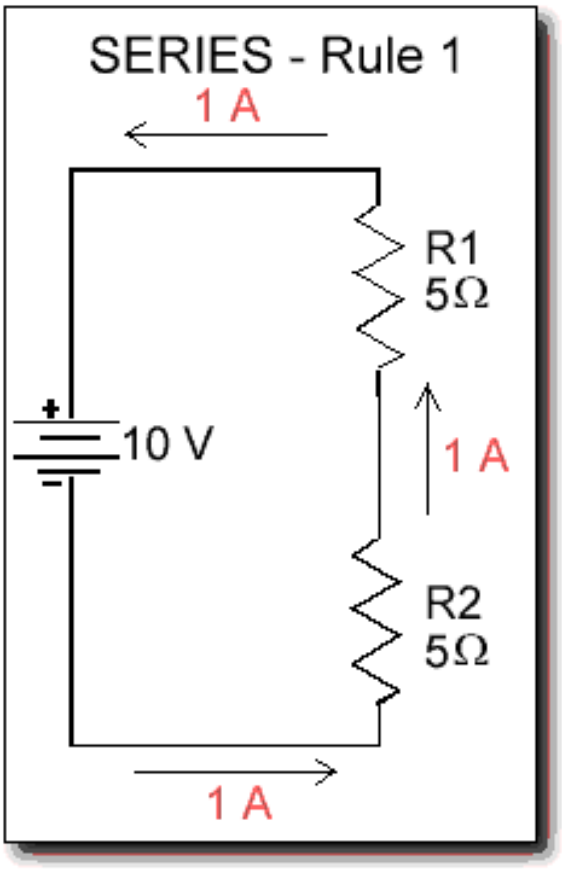
1. The same current flows through each part of a series circuit.
2. The total resistance of a series circuit is equal to the sum of individual resistances.
3. Voltage applied to a series circuit is equal to the sum of the individual voltage drops.
4. The voltage drop across a resistor in a series circuit is directly proportional to the size of the resistor.
5. If the circuit is broken at any point, no current will flow.

Let's look at each of these closer to gain an understanding of series circuits.

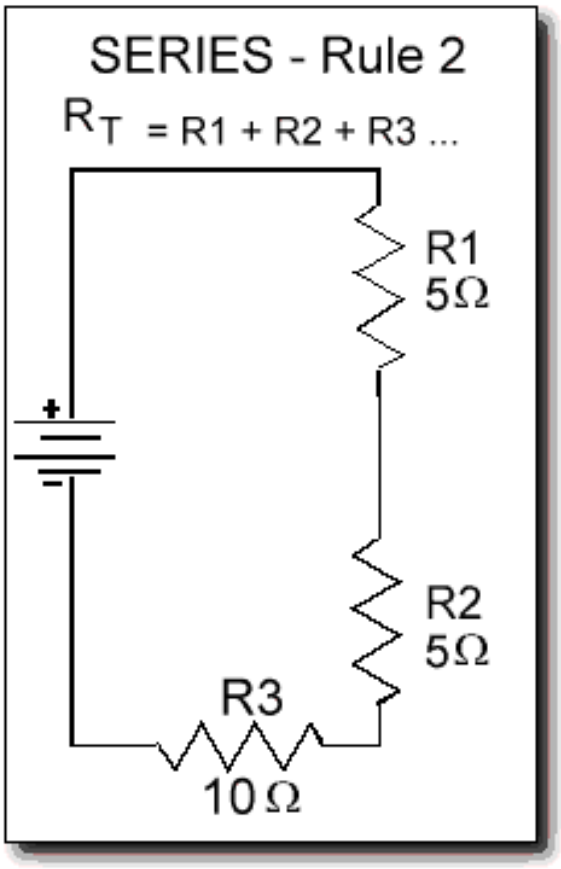
"1. The same current flows through each part of a series circuit."

In a series circuit, the amperage at any point in the circuit is the same. This will help in calculating circuit values using Ohm's Law.

You will notice from the diagram that 1 amp continually flows through the circuit. We will get to the calculations in a moment.



"2. The total resistance of a series circuit is equal to the sum of individual resistances."



In a series circuit you will need to calculate the total resistance of the circuit in order to figure out the amperage. This is done by adding up the individual values of each component in series.

In this example we have three resistors. To calculate the total resistance we use the formula:

```
RT = R1 + R2 + R3

5 + 5 + 10 = 20 Ohms

R total is 20 Ohms
```

Now with these two rules we can learn how to calculate the amperage of a circuit.

Remember from Ohms Law that *I = V / R*. Now we will modify this slightly and say ***I = V / R total***.

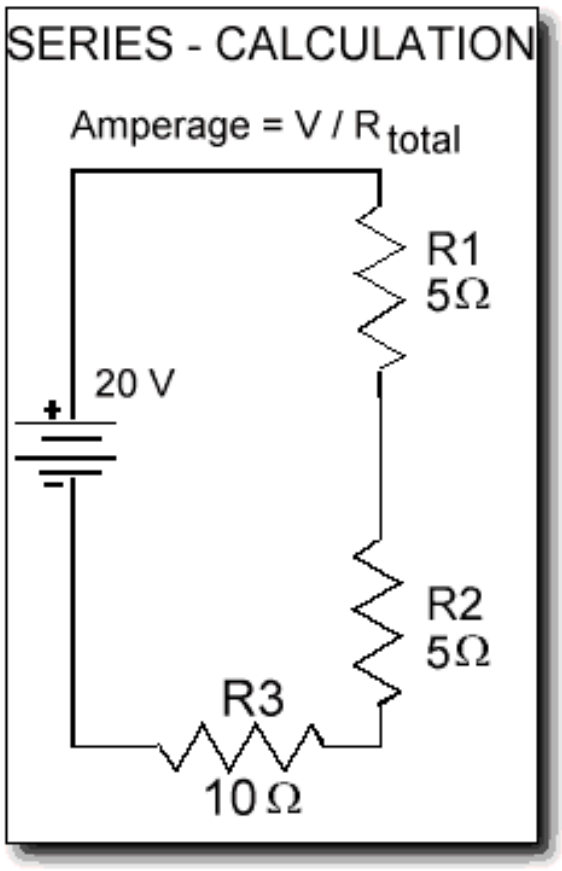
Lets follow our example figure:

```
RT = R1 + R2 + R3
RT = 20 Ohms

I = V / RT
I = 20V / 20 Ohms
I = 1 Amp
```

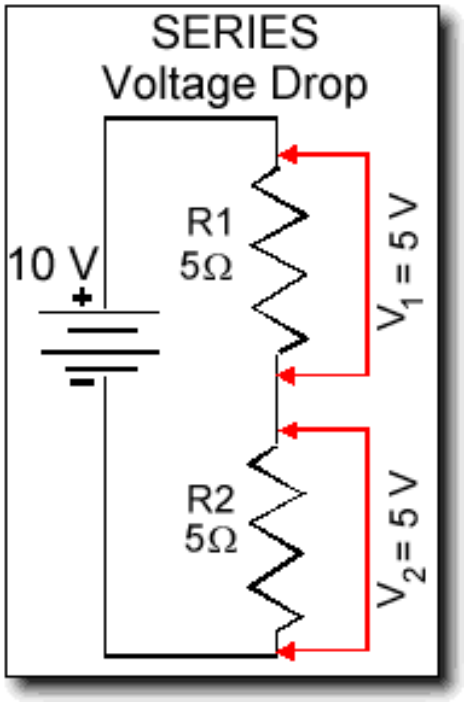
If we had the amperage already and wanted to know the voltage, we can use Ohm's Law as well.

```
V = I x R total
V = 1 A x 20 Ohms
```



```
V = 20 V
```

"Voltage Drops"



Before we go any further let's define what a "voltage drop" is. A voltage drop is the amount the voltage lowers when crossing a component from the negative side to the positive side in a series circuit. If you placed a multimeter across a resistor, the voltage drop would be the amount of voltage you are reading. This is pictured with the red arrow in the diagram.

Say a battery is supplying 10 volts to a circuit of two resistors; each having a value of 5 Ohms. According to the previous rules we figure out the total resistance.:

```
RT = R1 + R2 = 5 = 5 = 10 Ohms
```

Next we calculate the amperage in the circuit:

```
I = V / RT = 10V / 10 Ohms = 1 Amp
```

Now that we know the amperage for the circuit (remember the amperage does not change in a series circuit) we can calculate what the voltage drops across each resistor are using Ohm's Law (V = I x R).

```
V1 = 1A x 5 Ohms = 5 V
V2 = 1A x 5 Ohms = 5 V
```

Now we get to the next rule.

"3. Voltage applied to a series circuit is equal to the sum of the individual voltage drops."

This simply means that the voltage drops have to add up to the voltage coming from the battey or batteries.

V total = V1 + V2 + V3 ...

In our example above, this means that 5V + 5V = 10V.

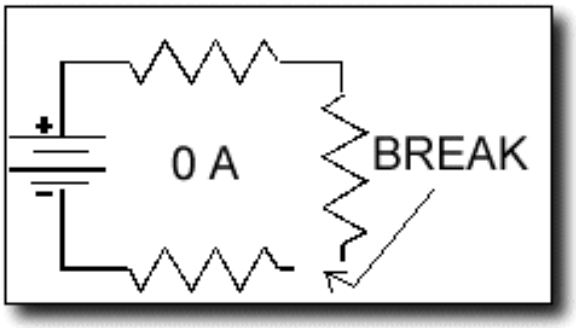
"4. The voltage drop across a resistor in a series circuit is directly proportional to the size of the resistor."

This is what we described in the Voltage Drop section above.

`Voltage drop = Current times Resistor size.`

"5. If the circuit is broken at any point, no current will flow."

The best way to illustrate this is with a string of light bulbs. If one is burnt out, the whole thing stops working.



Now that you know these rules and calculations, try a few problems yourself using Ohm's Law to guide you. Just draw up a series circuit and leave a value out here and there. Once you understand this well go onto the next section about the properties of

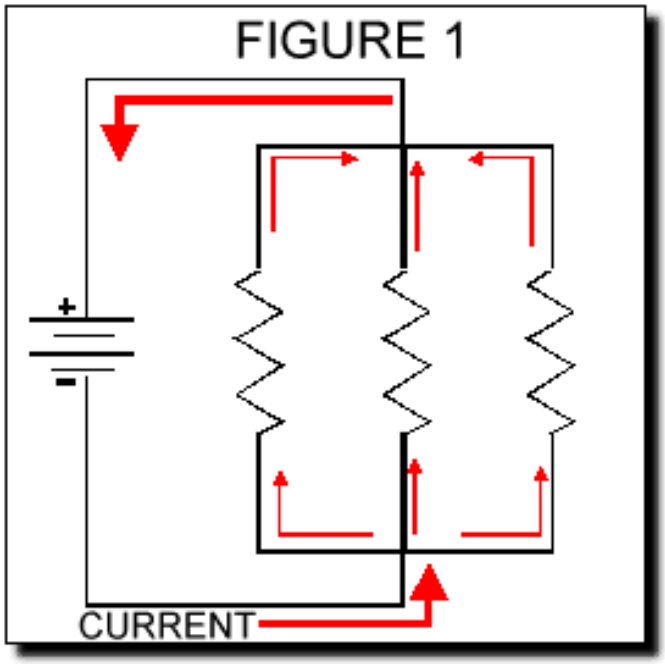
Parallel Circuits.

TOP Main Page

INTERNET GUIDE TO ELECTRONICS

UNDERSTANDING & CALCULATING PARALLEL CIRCUITS

EXPLANATION



A Parallel circuit is one with several different paths for the electricity to travel. It's a river that has been divided up into smaller streams. However, all the streams come back to the same point to form the river once again. See figure 1.

The parallel circuit has extremely different characteristics than a series circuit. For one, the total resistance of a Parallel Circuit is ***NOT*** equal to the sum of the resistors (like in a series circuit). The total resistance in a parallel circuit is *always less than any of the branch resistances.* Adding more parallel resistances to the paths causes the total resistance in the circuit to decrease. As you add more and more branches to the circuit the total current will increase. Why? Well remember from Ohm's Law that the lower the resistance, the higher the current.

BASIC RULES

A Parallel circuit has certain characteristics and basic rules summized here:

1. A parallel circuit has two or more paths for current to flow through.
2. Voltage is the same across each component of the parallel circuit.
3. The sum of the currents through each path is equal to the total current that flows from the source.
4. You can find total resistance in a Parallel circuit with the following formula:

$$1/Rt = 1/R1 + 1/R2 + 1/R3 +...$$

$$Rt = R\ (t)otal$$

Note: The formula is not as difficult as it looks. Bear with me.

5. If one of the parallel paths is broken, current will continue to flow in all the other

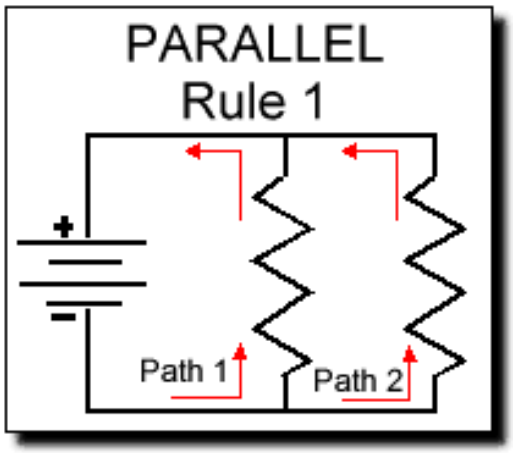
paths.

Let's look at each of these closer to gain an understanding of Parallel circuits.

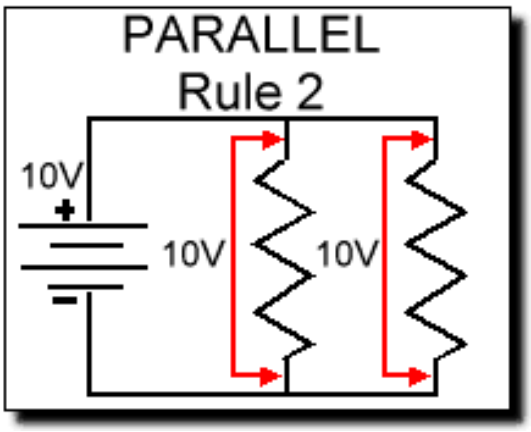
Keep in mind that the diagrams below represent resistors and a battery. But they can just as easily be any resistance source such as a light bulb or power source such as a wall adaptor.

"1. A parallel circuit has two or more paths for current to flow through."

This is self explanatory. Simply remember that PARALLEL means two paths up to thousands of paths. The flow of electricity is divided between each according to the resistance along each route.

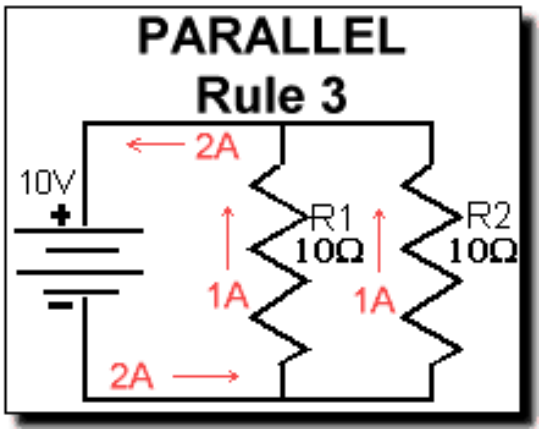


"2. Voltage is the same across each component of the parallel circuit."



You may remember from the last section that the voltage drops across a resistor in series. Not so with a parallel circuit. The voltage will be the same anywhere in the circuit.

"3. The sum of the currents through each path is equal to the total current that flows from the source."

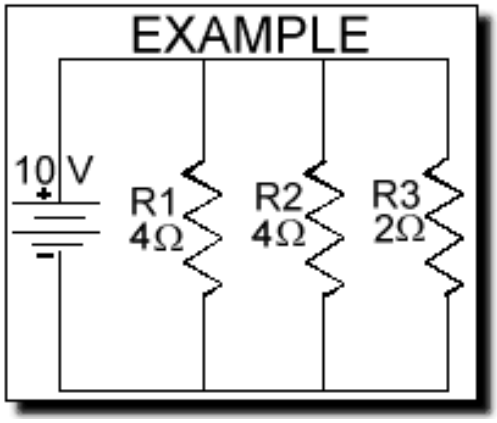


If one path is drawing 1 amp and the other is drawing 1 amp then the total is 2 amps at the source. If there are 4 branches in this same 2 amp circuit, then one path may draw 1/4A (.25A), the next 1/4A (.25), the next 1/2A (.5A) and the last 1A. Don't worry, the next rule will show you how to figure this out. Simply remember for now that the branch currents must tally to equal the source current.

"4. You can find TOTAL RESISTANCE in a Parallel circuit with the following formula: 1/Rt = 1/R1 + 1/R2 + 1/R3 + ...

Before we get into the calculations, keep in mind what we said at the start of this section: "The total resistance of a parallel circuit is ***NOT equal*** to the sum of the resistors (like in a series circuit). That said, let's dig into the formula.

We will use a parallel circuit with 3 paths as an example (it can just as easily be 2, 4 or a 1000 resistors in parallel). The power source is providing 10 volts and the value of the resistors are 4 Ohm, 4 Ohm and 2 Ohm.



Let's summize this EXAMPLE for clarity:

```
Voltage = 10V
R1 = 4 Ohm
R2 = 4 Ohm
R3 = 2 Ohm
```

Remember that "Rt" means Total resistance of the circuit.
R1, R2, etc. are Resistor one, Resistor two, etc.

Now we will apply the formula above to this example:

```
1    1    1    1
-- = -- + -- + --
Rt   R1   R2   R3

Therefore:
1    1    1    1
-- = -- + -- + --
Rt   4    4    2
```

It is easiest to change the fractions into decimal numbers (example 1 divide by 4 equals .25):

```
1/Rt = .25 + .25 + .5
1/Rt = 1
```

Now you have to get rid of the 1 on the left side so...
Rt = 1/1

Rt = 1 Ohm

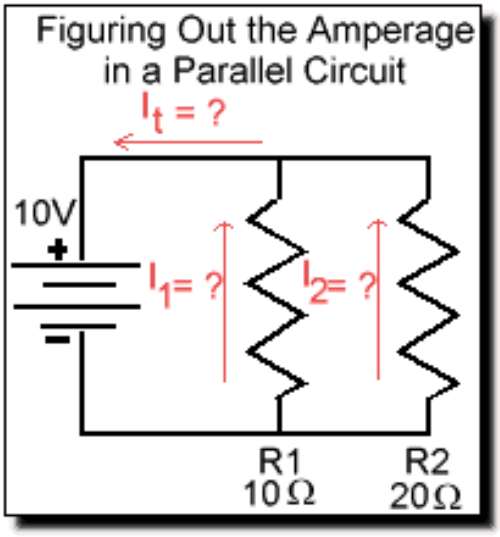
NOW, Let's try a more complex one:

```
Voltage = 120 Volts
R1 = 100 Ohms
R2 = 200 Ohms
R3 = 1000 Ohms
R4 = 1 Ohms

1/Rt = 1/100 + 1/200 + 1/1000 + 1/1
1/Rt = .01 + .005 + .001 + 1
1/Rt = 1.016
Rt = 1/1.016 = .98 Ohms
```

(NOTE: There was a miscalculation in previous editions. Thanks to Ron for the corrections)

This is quite a different result than if the circuit were if the resistors were in series (1301 Ohms).



Before we move on to the last rule I want to show you how easy it is to calculate the amperage through each path using OHM'S LAW.

In the example we see a 10 and 20 ohm resistor in parallel with a 10 Volt source. First we figure out the total resistance of the circuit:

```
1/Rt = 1/10 + 1/20
Rt = 6.67 Ohms
```

Now that you know this you can figure out the total amperage (It) using Ohm's Law:

```
I total (It) = 10V / 6.67 Ohms = 1.5 Amps
```

Therefore the total amperage between the two resistive paths must equal 1.5 Amps (Rule 3). Now we can figure out exactly what each path is pulling using Ohm's Law once more. Remember that the voltage is the same everywhere in a parallel circuit. So we know the voltage and the resistance:

```
I1 = 10V / 10 Ohm = 1 A
I2 = 10V / 20 Ohm = .5 A
```

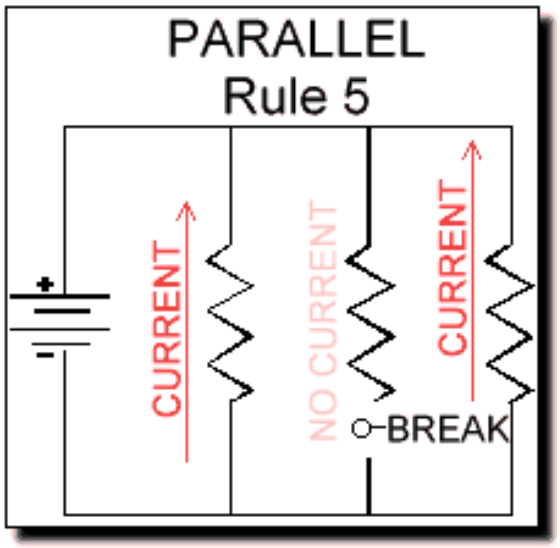
We figured the total amperage (It) previously, so now we can double check if the figures are correct:

```
I1 + I2 = It
1A + .5A = 1.5A - check
```

We will look at more calculations in future chapters.

"5. If one of the parallel paths is broken, current will continue to flow in all the other paths."

The best way to illustrate this is also with a string of light bulbs in paralallel. If one is burnt out, the others stay lit.



Now that you know these rules and calculations, try a few problems yourself using Ohm's Law to guide you. Just draw up a few parallel circuits and leave a value out here and there. Once you understand this we'll go onto the next section about the properties of

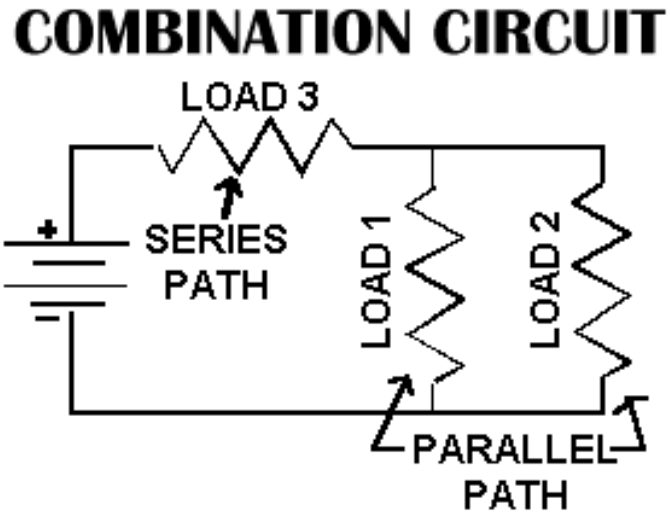
Combination Circuits.

TOP Main Page

INTERNET GUIDE TO ELECTRONICS

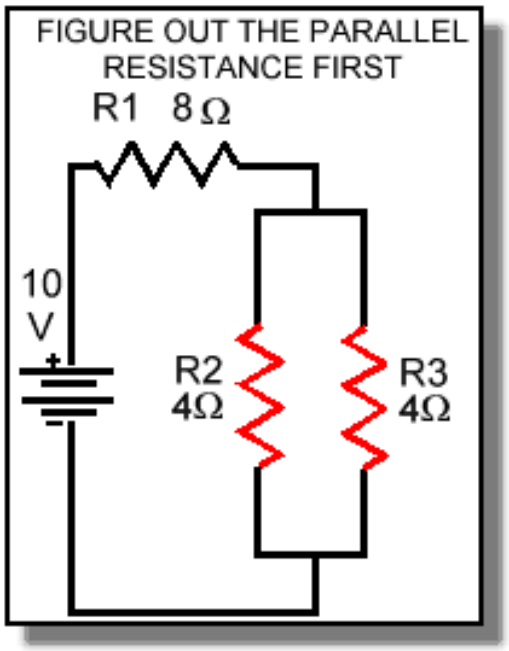
UNDERSTANDING & CALCULATING COMBINATION CIRCUITS

INTRODUCTION



A "COMBINATION CIRCUIT" is (as you may have already guessed) a circuit that is a blend of series paths and parallel paths. See Figure for a visual explanation. Most circuits are of this variety. Don't be afraid to tackle these circuits as far as the math goes. You merely have to break each part of the circuit down into either a series circuit or parallel circuit. Here's how this is done:

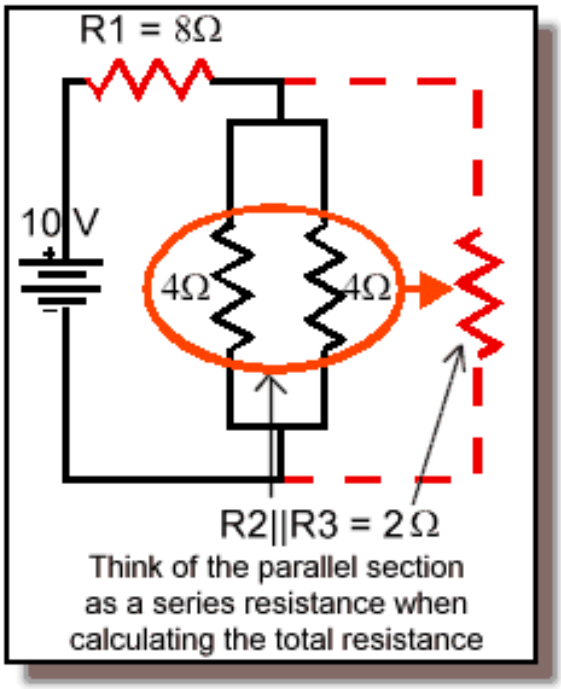
BASICS



You must first figure out the resistance of each individual parallel path in the circuit. Let's take the circuit to the right as an example. There is an 8 Ohm resistor in series (R1) and two 4 Ohm resistors in parallel, R2||R3 (*Note: The || means that the two resistors are in parallel*). To figure out the total resistance of that section of the circuit we use the following:

1. Find the resistance of the parallel circuit using the parallel formula.

$1/R = 1/R2 + 1/R3$
$1/R = 1/4 + 1/4$
$1/R = .25 + .25$
$1/R = .5$
$R2||R3 = 1/.5 = 2$ Ohms



Now that you know the resistance of the parallel 'subcircuit', you add all the series resistances. Remember the total resistance of R2||R3 can now be plugged into the series calculation to figure out the remaining values using Ohm's Law. See figure to the left.

2: Find the total resistance in the circuit by adding R1 and R2||R3.
Rt = R1 + (R2||R3)
Rt = 8 Ohms + 2 Ohms
R total = 10 Ohms

Now that you know the total resistance of the circuit you can figure out the total amperage using Ohm's Law.

I total = V divide by R total
It = 10V / 10 Ohms
I total = 1 Amp.

From here you can figure out each components voltage drop or current.

We will look at more calculations in future chapters.

The best advice in finding the values for a combination circuit is *to first break each part of the circuit down into series and parallel sections and follow those formulas.* Once that is complete, *combine them for your master calculations.*

Now that you know these rules and calculations, try a few problems yourself using Ohm's Law to guide you. Just draw up a few combination circuits and leave a value out here and there.

Be sure to check out my book -- Howard W. Sams **Internet Guide to the Electronics Industry***

Information

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* Spam or not, I have to make a living :-)

Contact the Webmaster Last Updated: July 3, 1998

INTERNET GUIDE TO ELECTRONICS

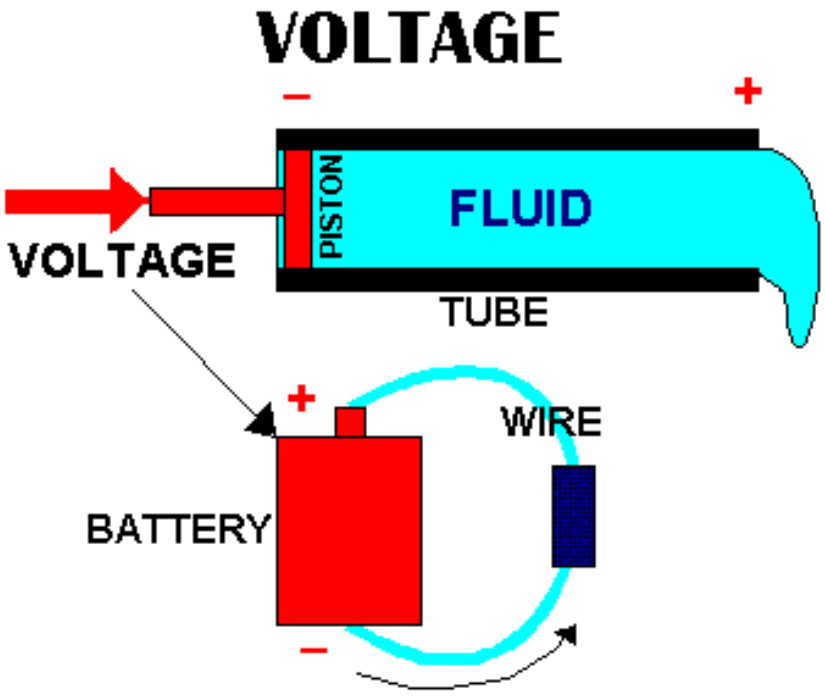
VOLTAGE, CURRENT & RESISTANCE EXPLAINED

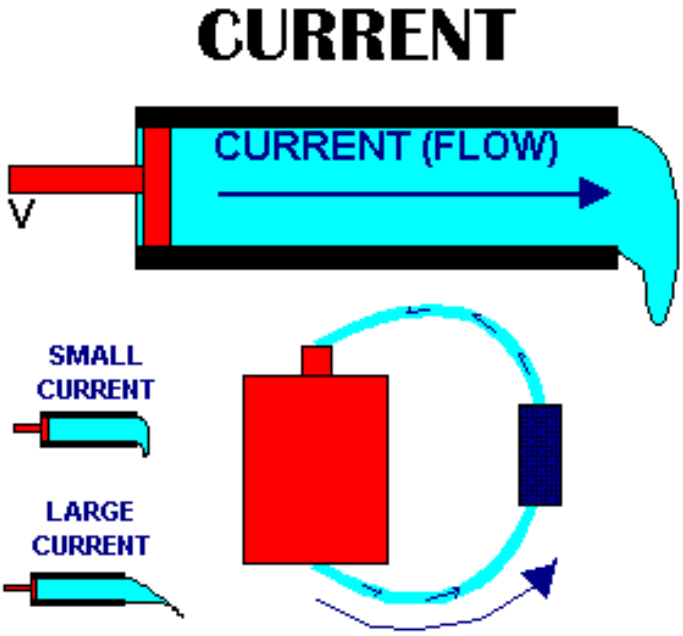
In electronics we are dealing with voltage, current and resistance in circuits. In the next section we'll learn that by using Ohm's Law we can determine one value by knowing the other two (For example: Figure out Current by using Voltage and Resistance values). So it is important to firmly grasp the basics of Voltage/Current/Resistance first.

We will describe these electrical terms using an analogy that closely resembles electronics — HYDRAULICS.

Voltage

Voltage is the electrical force, or "pressure", that causes current to flow in a circuit. It is measured in VOLTS (V or E). Take a look at the diagram. Voltage would be the force that is pushing the water (electrons) forward.





Current

Current is the movement of electrical charge - the flow of electrons through the electronic circuit. Current is measured in AMPERES (AMPS, A or I). Current would be the flow of water moving through the tube (wire).

Resistance

Resistance is anything that causes an opposition to the flow of electricity in a circuit. It is used to control the amount of voltage and/or amperage in a circuit. Everything in the circuit causes a resistance (even wire). It is measured in OHMS (Ω).

A few people mentioned the diagram for this section was misleading so I am changing it. Be available soon.

Resistance Diagram

TOP
Next Section -- Ohm's Law Explained
Main Page

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INTERNET GUIDE TO ELECTRONICS

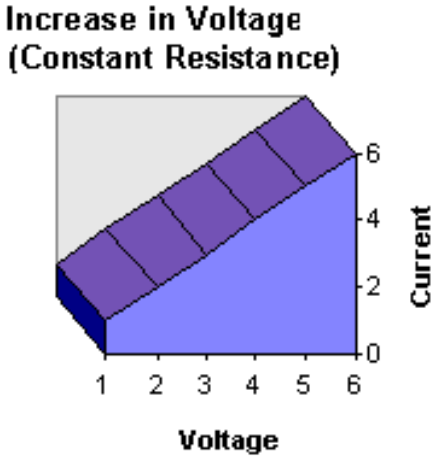
OHM'S LAW
EXPLAINED

"The amount of current flowing in a circuit made up of pure resistances is directly proportional to the electromotive forces impressed on the circuit and inversely proportional to the total resistance of the circuit."

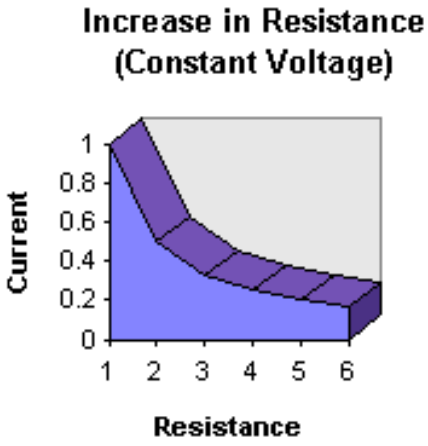
Don't let that quote scare you. It is not as scholarly as it sounds.

Before going further make sure you understand:
- What composes a circuit.
- What voltage, current and resistance are.

In simpler terms, Ohm's Law means:
1) A steady increase in voltage, in a circuit with constant resistance, produces a constant linear rise in current.



2) A steady increase in resistance, in a circuit with constant voltage, produces a progressively (not a straight-line if graphed) weaker current.



Ohm's Law is a set of formulas used in electronics to calculate an unknown amount of current, voltage or reistance. It was named after the German physicist Georg Simon Ohm. Born 1787. Died 1854.

Knowledge of this Law is often under-estimated by beginners. I have talked to people that can design complex circuitry and microprocessor systems that have said, "Ohm's Law? What's that?".

Unless you know this basic fundemental building block of electronics, you will never have a strong foundation to hold up the electronics towers you will be constructing in the future. Learn Ohm's Law. Learn it inside and out!

TECHNICAL DEFINITION ALERT!

Ohm's Law is a formulation of the relationship of voltage, current, and resistance, expressed as:

$$V = I \times R$$

$$I = \frac{V}{R} \quad \text{or} \quad R = \frac{V}{I}$$

Where:

V is the Voltage measured in volts

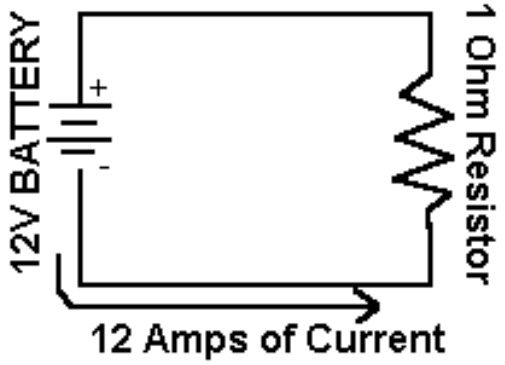
I is the Current measured in amperes

R is the resistance measured in Ohms

Therefore:

Volts = Amps times Resistance

Ohms Law is used to calculate a missing value in a circuit.



In this simple circuit there is a current of 12 amps (12A) and a resistive load of 1 Ohm (1Ω). Using the first formula from above we determine the Voltage:

V = 12 x 1 : V = 12 Volts (12V)

If we knew the battery was suppling 12 volt of pressure (voltage), and there was a resistive load of 1 Ohm placed in series, the current would be:

I = 12 / 1 : I = 12 Amps (12A)

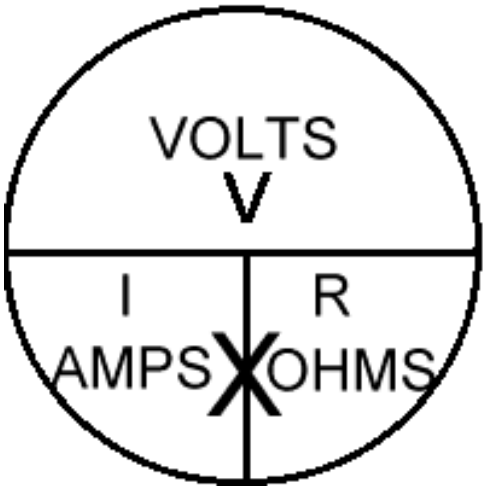
If we knew the battery was suppling 12V and the current being generated was 12A, then the Resistance would be:

R = 12/12 : R = 1Ω

Be sure to check out the Ohm's Calculator to help you determine circuit values.

Note: Remember a battery is not measured in amperage as is commonly believed with beginners to electronics. The battery supplies the pressure that creates the flow (current) in a given circuit. The amperage rating on a battery is "How long the battery will last for one hour while driving a circuit of that amperage". It is measured in Amperage-Hours. So a 1000mAh would last for 1 hour in a one amp circuit. (1000mAh is 1A for one hour)

An easy way to remember the formulas is by using this diagram.



To determine a missing value, cover it with your finger. The horizontal line in the middle means to divide the two remaining values. The "X" in the bottom section of the circle means to multiply the remaining values.

• If you are calculating voltage, cover it and you have I X R left (V= I times R).

• If you are calculating amperage, cover it, and you have V divided by R left (I=V/R).

• If you are calculating resistance, cover it, and you have V divide by I left (R=V/I).

Note: The letter **E** is sometimes used instead of **V** for voltage.

TOP
Next Section -- Voltage, Current & Resistance Explained
Main Page

Howard W. Sams Internet Guide to the Electronics Industry*

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BASIC ELECTRONICS.COM
The NEWMEDIA Way to Learn Electronics

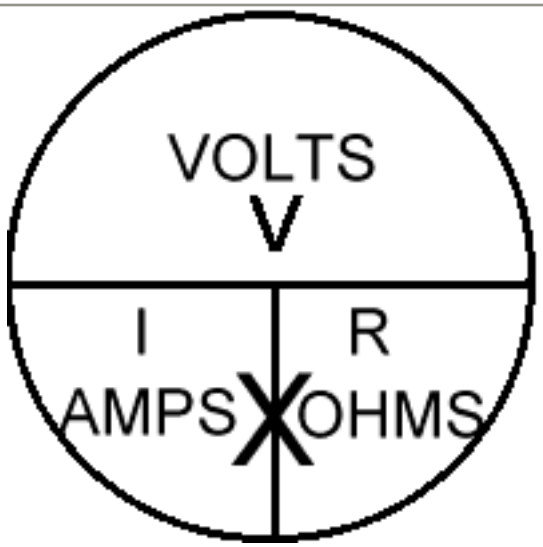
MAIN

OHM'S CALCULATOR

You will need a Javascript browser, such as Netscape 3,4+ or MSIE 4,5+.

Check Out OHM'S LAW EXPLAINED

Type in the Current **Amps**	Type in the Resistance **Ohms**	Calculate	This is the Voltage **Volts**
Type in the Voltage **Volts**	Type in the Resistance **Ohms**	Calculate	This is the Current **Amps**
Type in the Voltage **Volts**	Type in the Current **Amps**	Calculate	This is the Resistance **Ohms**



Check Out OHM'S LAW EXPLAINED for explanation of this diagram

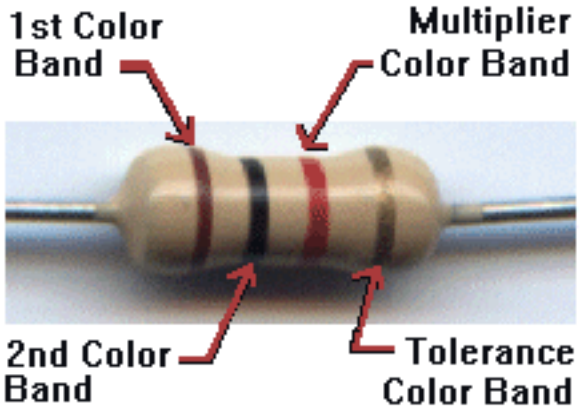
Email me at electronics@pobox.com

Last updated: April 10, 1999

Resistor Color Codes & Primer

NEW!!! Resistor Color Code Calculator

Common Resistor



Resistors are color coded for easy reading. Imagine how many blind technicians there would be otherwise.

To determine the value of a given resistor look for the gold or silver tolorance band and rotate the resistor as in the photo above.(Tolerance band to the right). Look at the 1st color band and determine its color. This maybe difficult on small or oddly colored resistors. Now look at the chart and match the "1st & 2nd color band" color to the "Digit it represents". Write this number down.

Now look at the 2nd color band and match that color to the same chart. Write this number next to the 1st Digit.

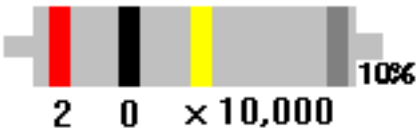
Resistor Color Code Chart

1st. & 2nd Color Band	Digit it Represents	-----Multiplier-----
BLACK	0	X1
BROWN	1	X10
RED	2	X100
ORANGE	3	X1,000 or 1K
YELLOW	4	X10,000 or 10K
GREEN	5	X100,000 or 100K
BLUE	6	X1,000,000 or 1M
VIOLET	7	Silver is divide by 100
GRAY	8	Gold is divide by 10
WHITE	• 9	• Tolerances • Gold= 5% • Silver=10% • None=20%

The Last color band is the number you will multiply the result by. Match the 3rd color band with the chart under multiplier. This is the number you will mulitple the other 2 numbers by. Write it next to the other 2 numbers with a multiplication sign before it. Example : 2 2 x 1,000.

To pull it all together now, simply multiply the first 2 numbers (1st number in the tens column and 2nd in the ones column) by the Multiplier.

Example:



= 200,000 Ohms = 200KΩ

- First color is **red** which is 2
- Second color is **black** which is 0
- third color is yellow which is 10,000
- Torerance is silver which is 10%

Therefore the equation is:

---

2 0 x 10,000 = 200,000 Ohms

Direct questions to:
electronics@pobox.com

BACK

Tolerance Explanation

Resistors are never the exact value that the color codes indicate.Therefore manufacturers place a tolerance color band on the resistor to tell you just how accurate this resistor is made. It is simply a measurment of the imperfections. Gold means the resistor is within 5% of being dead-on accurate. Silver being within 10% and no color band being within 20%. To determine the exact range that the resistor may be, take the value of the resistor and mutiply it by 5,10, 0r 20%. That is the number that the resistor may go either way.

Example: A 1,000 Ohm resistor with a gold band maybe any value between 950 to 1050 Ohms.

Example: A 22,000 Ohm resistor with a silver band maybe any value between 19,800 and 24,200 Ohms.

FAQ

Just a few common questions to help you out.

1) Which side of the resistor do I read from?

The Gold or Silver band is always set to the right, then you read from left to right. Sometimes there will be no tolerance band -- Simply find the side that has a band closest to a lead and make that the first band.

2) Sometimes the colors are hard to make out. How do I make certain what the value of the

resistor really is?

Occasionally the colors are jumbled or burnt off. The only way to read it then is with a multimeter across the leads

3) How do I remember this sequence of colors?

Remember the color codes with this sentence:
Big **B**rown **R**abbits **O**ften **Y**ield **G**reat **B**ig **V**ocal **G**roans **W**hen **G**ingerly **S**lapped.

INTERNET GUIDE TO ELECTRONICS

Main | Resistor Color Codes FAQ

RESISTOR COLOR CODE CALCULATOR

Black	Black	Black	Gold

GRAPHICAL RESISTANCE CALCULATOR in JAVASCRIPT
Version 2.0

by Danny Goodman (dannyg@dannyg.com)
Analyzed and described at length in
"JavaScript Bible"
(IDG Books ISBN 0-7645-3022-4)

Resistor Color Codes - FAQ and Primer
Main Page

Be sure to check out my book -- Howard W. Sams
Internet Guide to the Electronics Industry*
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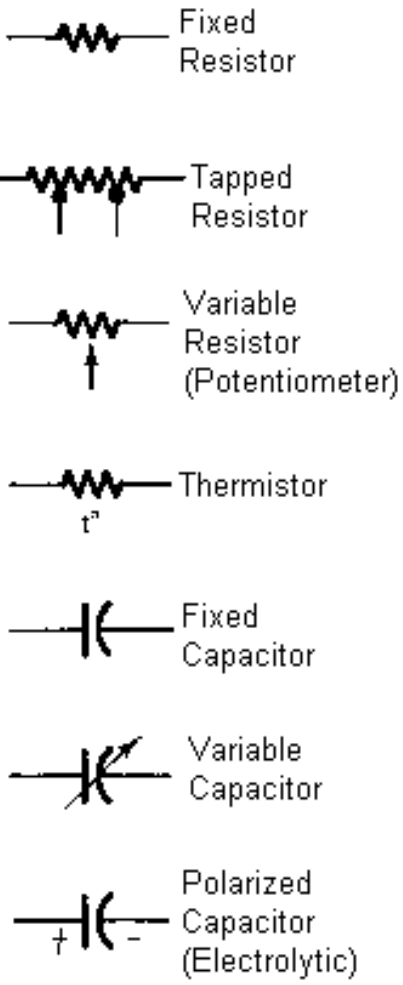
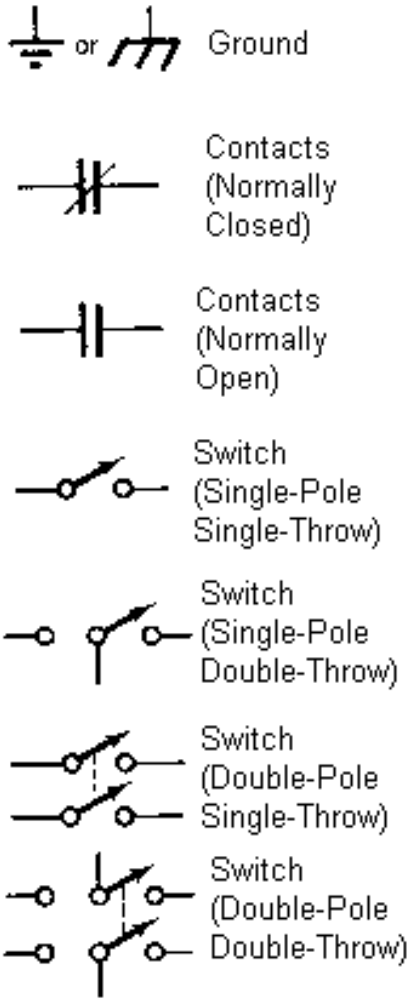
Contact the Webmaster Last Updated: October 10, 1997

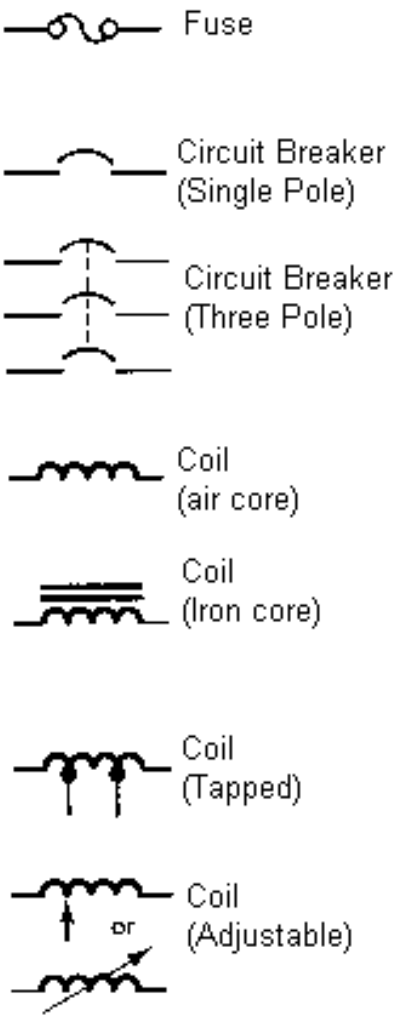
INTERNET GUIDE TO ELECTRONICS

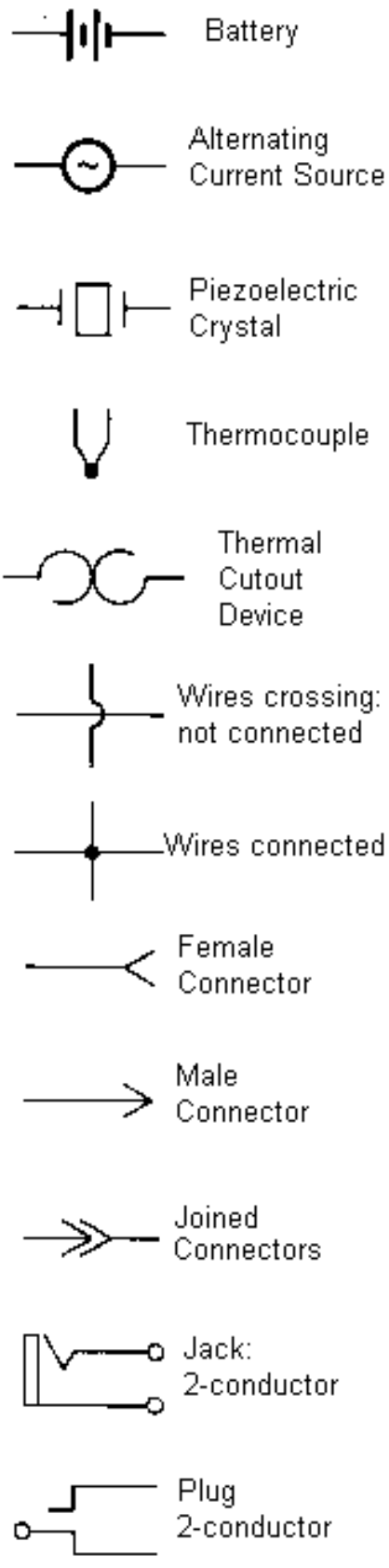
SCHEMATIC SYMBOLS

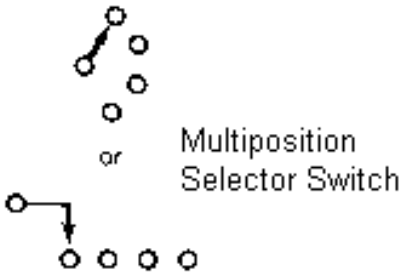
These are common schematic symbols used in electronics.

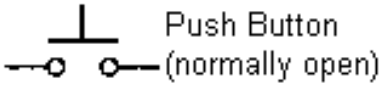


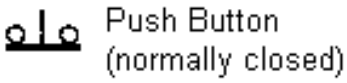

or
Ground
Contacts
(Normally
Closed)
Contacts
(Normally
Open)
Switch
(Single-Pole
Single-Throw)
Switch
(Single-Pole
Double-Throw)
Switch
(Double-Pole
Single-Throw)
Switch
(Double-Pole
Double-Throw)

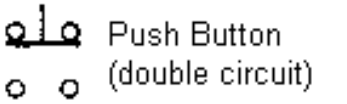

Fuse
Circuit Breaker
(Single Pole)
Circuit Breaker
(Three Pole)
Coil
(air core)
Coil
(Iron core)
Coil
(Tapped)
Coil
(Adjustable)
or

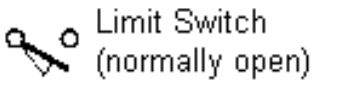

Battery
Alternating
Current Source
Piezoelectric
Crystal
Thermocouple
Thermal
Cutout
Device
Wires crossing:
not connected
Wires connected
Female
Connector
Male
Connector
Joined
Connectors
Jack:
2-conductor
Plug
2-conductor

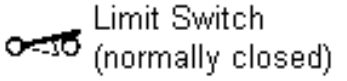

or
Multiposition
Selector Switch


Push Button
(normally open)

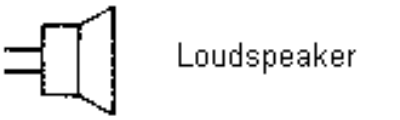

Push Button
(normally closed)

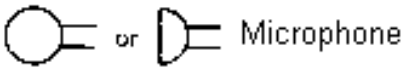

Push Button
(double circuit)

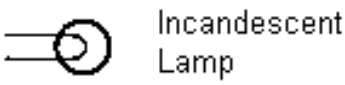

Limit Switch
(normally open)


Limit Switch
(normally closed)

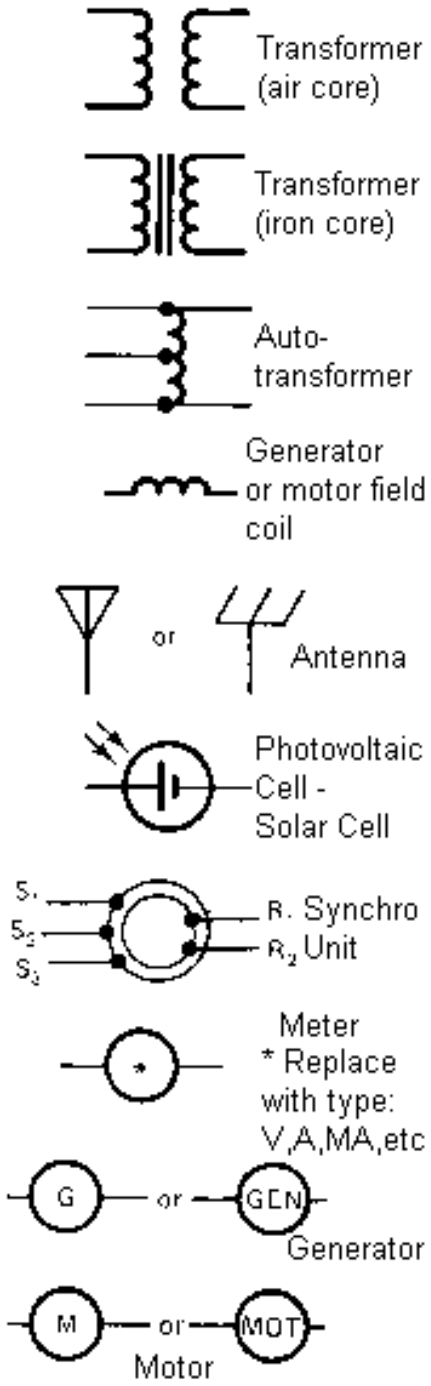

Electrical
Bell


Loudspeaker


or
Microphone


Incandescent
Lamp


Fluorescent
Lamp



SEMICONDUCTOR SYMBOLS

MORE TO FOLLOW IN THE NEXT FEW DAYS

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Industry*

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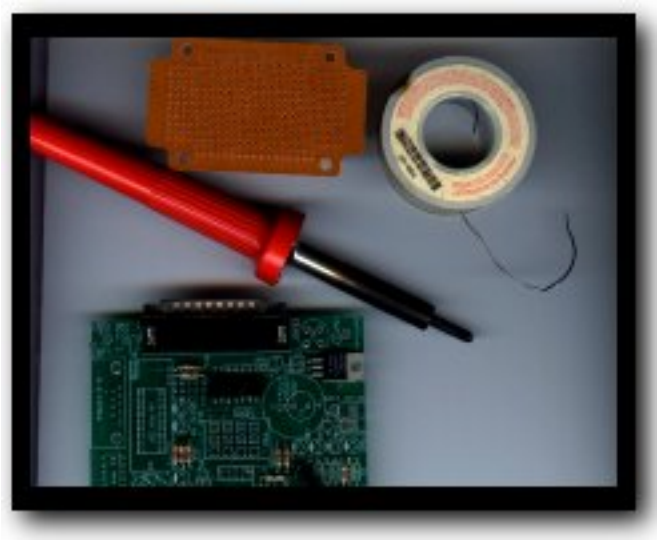
Apply IT!

Most people began electronics with a hands-on approach. Maybe you built a small project and/or kit and were hooked from then on. The whole point of learning electronics is to be able to apply it. That's where these sections come in. Time to get those finger tips burnt and those eyes strained creating electronic masterpieces.



NEW!!! YOUR PROJECTS SECTION:

I'm building this section to be an area where we can share our projects, get comments and of course a bit of advise. My own current project, a Bike Light for my mountain bike, will start it off. Please send in your links and a brief description and I will post them. If you cannot find any space check out http://geocities.yahoo.com/ or if you know of any other free web space sites, let me know at basicelectronics@hotmail.com.

ELECTRONICS ON A BUDGET:

This is a reprint of my first article published in Popular Electronics - *A little work and ingenuity can let a hobbyist have fun on even the most meager of bankrolls*

MULTIMETER ULTRA-BASICS:

What a multimeter is used for and what to look for when purchasing one.

BASIC TOOLS AND SUPPLIES NEEDED:

Check out this simple list of items you will need to get going n electronics. Its not as long as you may think.

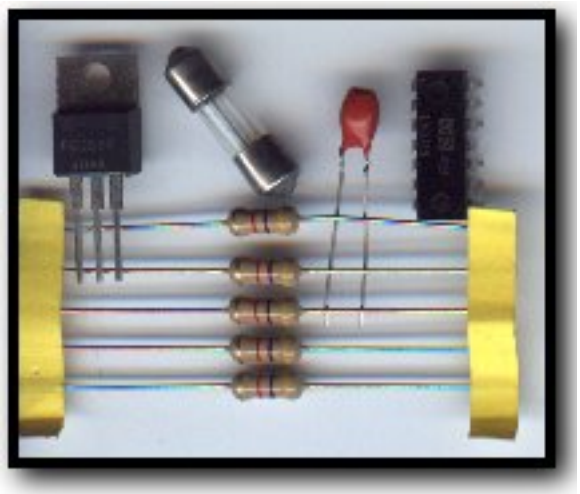
MORE TO COME

THEORY|APPLY IT!|COMPONENTS|MESSAGE BOARD|BOOKS/MAGs|LECTRIC LINKS|BASIC ELECTRONICS.CD INFO|ABOUT|EMAIL| NEW!
MAIN

Email me at basicelectronics@hotmail.com

Last updated: Jan 10, 2003

Electronics Components



Identifying and understanding electronic components is essential to learning this subject. These sections will show you what common components look like and expound upon their uses in circuits.

IDENTIFYING ELECTRONICS COMPONENTS - PASSIVE DEVICES:
How to identify simple electronics components used on circuit boards.

IDENTIFYING ELECTRONICS COMPONENTS - ACTIVE DEVICES:
How to identify semiconductor electronics components used on circuit boards.

HOW A TRANSISTOR WORKS:
Check out this page on the history and workings of the transistor by Lucent technology. I will be adding a page of my own later.

555 TIMERS:
Learn about the most common IC used in electronics.

MORE TO COME

Components | < LAST | IDENT. PASSIVE > | MAIN

THEORY|APPLY IT!|COMPONENTS|MESSAGE BOARD|BOOKS/MAGs|LECTRIC LINKS|BASIC ELECTRONICS.CD INFO|ABOUT|EMAIL| NEW!
MAIN

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Last updated: April 10, 1999

Electronics Reference, Data and Tools

Popular electronics reference items, basic electronics datasheets and some ***cool tools*** to speed your projects and learning. You may want to bookmark this page to refer to this data whenever possible. I will be adding new tools and info as fast as I can.

If you have any tools besides the types that are here, please let me know and I will post them. It must be in either Java/Script or a 'one file, free standing program'.

RESISTOR COLOR CALCULATOR:
This is a HANDY javascript resistor color codes calculator - even has a graphic of a resistor with adjustable color bands. Thanks to **Danny Goodman** for this treat.

NOTE: You will need a Javascript enabled browser such as Netscape 3.0 or higher or MSIE 4.0. I don't think older versions of MSIE will work.

Alot of people have asked me about 5 band resistors. I will try to modify the resistor calc later to handle these but for now check out Bob White's great little VB program at http://www.rjpw.freeserve.co.uk/

DOWNLOAD The Javascript Resistor Color Calc and Ohms Calc to run off-line. Download the zip file and unzip into a directory of your choice. Run your browser and open either the resist_calc.htm or ohms_calc.htm files.

RESISTOR COLOR CODES:
Simple primer to help answer your basic resistor questions.

OHM'S CALCULATOR:
Javascript Ohm's Calculator to help you determine circuit values.

SCHEMATIC SYMBOLS:
A list of common schematical symbols used in electronics.


VIRP CHART:
Voltage, Amperage, Resistance, Power Equation Chart. This is a colorful chart with all the various calculations posted on it. If you have a color printer you may want to make a copy to hang up in your shop.

If someone has a Javascript that will do each of these, I would be grateful if they sent it my way.

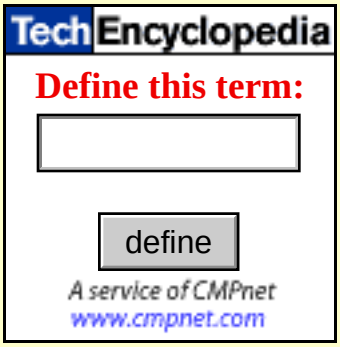
ECG CROSS REFERENCE SITE:

Note: NTE has purchased ECG's assets, meaning you will have to go to the address above and either download their Reference software after filling out their forms or simply choose the Cross reference site from the pull down menu.
Check out exactly what that part is. I have the actual book that this is based off of and it is totally dogeared from over use. You may want to pick up this book in an electronics store just to have the pinouts and data for each ECG replacement part..

555 ASTABLE AND MONOSTABLE CALCULATORS:

Figure out those Resistor and capacitor values fast with this Javascript calc.

NEW!!! I've been using this technology encyclopedia as a quick-n-dirty way to find basic electronics definitions. Check it out.



FCC ID SEARCH:

Have you ever wondered who actually makes your motherboard, video card or any other circuit? Find the FCC ID# on the printed circuit board (printed either as a copper trace or labelled), type it into this search engine and the manufacturer will be revealed. Want more info, visit that companies website.

Email me at electronics@pobox.com

Last updated: April 10, 1999

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GREAT BOOKS, MAGAZINES & MOVIES I RECOMMEND

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These are books/mags/videos that I have personal experience with and know to be useful, helpful or just plain cool!

Most of these books are available through Amazon.com for a discounted price - just click the link on the titles below (if you are purchasing this specific book, please use the link for that book provided on this page and not the main Amazon logo above). You can also order directly from most publishers. If an author offers a book themselves, do them a favor and order direct from them. We, authors need to make a living :-) If you want to order my Internet Guide to the Electronics Industry book please order directly from Howard W. Sams Site.

I wrote two other books and have a 4th and 5th in the works. I'll be adding these links soon.

I'll be adding more books later but this will keep you going for now.

ELECTRONICS RELATED BOOKS

THE ELECTRONIC FUNDEMENTALS: Circuits, Devices, and Applications (10+)
By: Thomas L. Floyd
Publisher: Prentice Hall
ISBN: 013835216X
This is *THE BOOK TO OWN* if you want to continue studying electronics! The cost is high ($83.00 US from Amazon) but well worth it. It has over a thousand pages loaded with simple to intermediate electronics information. It takes you from the basics to more advanced theories on a mild gradient. The layout, drawings and pictures are very useful.

People ask me which book I should get to further learn electronics -- this is it! I can't say enough about it.

UNDERSTANDING ELECTRONICS
R. H. Warring, G. Randy Slone.
Publisher: McGraw-Hill

ISBN: 0071573763
As far as a basic, cheap electronics book goes, you can't go wrong with this one. It is a little quick on explanations but most theories are explained well. I am not sure if Amazon can order this for you just yet but give them a shot...it is only $10.46 for the paperback right now.

THE ART OF ELECTRONICS
By: Paul Horowitz, Winfield Hill (Contributor)
Publisher: Cambridge Univ Press
ISBN: 0521370957
This book was mentioned to me by a few site visitors. It is more of an advanced book but definately a classic. I would put it on your "NEED TO GET AT SOME POINT" list. Also a 1000+ page book.

DON LANCASTER'S BOOK SERIES
By; Don Lancaster
Published by Synergetics
Check out Don's site for some really great books such as the CMOS and TTL Cookbooks. Awesome resource for begineers to digital electronics.

THE FORREST MIMS ENIGINEER'S NOTEBOOK (10)
By: Forrest Mims
Publisher: HighText Publications
ISBN: 1-878707-03-5
Possibly the best book I own to learn basic Integrated Circuits.

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101 SOLDERLESS BREADBOARDING PROJECTS
By: Delton T. Horn
Publisher: TAB
ISBN: 0830603859 - Note: Hard to find item. Allow some order time if you use

Amazon.com or try to find it in a used book store.
Possibly my all-time favorite. Once you have your basic electronics down pat (Ohm's Law, etc.) you will want to get this book first. It contains simple projects to help you learn the basic Integrated Circuits and their uses. Ten plus rating!

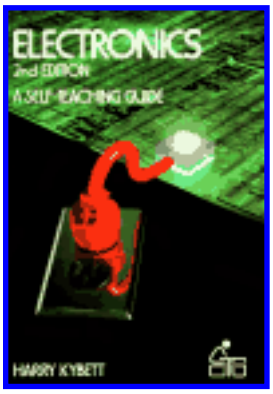
HOW TO TUNE & MODIFY FORD FUEL INJECTION
By: Ben Watson
Publisher: Motorbooks International
ISBN: 0-87938-621-5
This is such a cool book I had to put it here. If you deal with automotive electronics, or want to learn the basics of your car's computer, this book series is simple to understand and very informative. I used the book to modify my own Ford Thunderbird with great success.

DICTIONARY OF AUDIO & HI-FI (7)
By: Howard W. Sams Editorial Staff
Publisher: Howard W. Sams
ISBN: 0-672-21084-3
Dictionaries of Electronics Lexicon are hard to find. This is a great one for audio terms.

THE BEST OF CIARCIA'S CIRCUIT CELLAR
By: Steve Ciarcia
Hardcover
Publisher: McGraw Hill Text
ISBN: 0070110190
This is a heavy tech book with projects for microcontrollers. Definately for advanced electronics students but worth a peek.

ELECTRONIC DATABOOK
By: Rudolf F. Graf
Publisher: Tab

ISBN: 0442227965
Hard to get but if you are seriously into electronics it is worth the time to find it. It is packed with electronics formulas, definitions, etc.



ELECTRONICS: A SELF TEACHING GUIDE
By: Harry Kybett
Publisher: Wiley Press
ISBN: 0471009164
A great beginners guide to diodes, transistors. etc. Not a raw basic book but a good second book for beginners.

ENCYCLOPEDIA OF ELECTRONIC CIRCUITS VOLUME 1
ISBN: 0830619380
ENCYCLOPEDIA OF ELECTRONIC CIRCUITS VOLUME 2
ISBN: 0830631380
ENCYCLOPEDIA OF ELECTRONIC CIRCUITS VOLUME 3
ISBN: 0830633480
ENCYCLOPEDIA OF ELECTRONIC CIRCUITS VOLUME 4
ISBN: 0830638954
ENCYCLOPEDIA OF ELECTRONIC CIRCUITS VOLUME 5
ISBN: 0070110778
ENCYCLOPEDIA OF ELECTRONIC CIRCUITS VOLUME 6
ISBN: 0070112762
By:Rudolf F. Graf, William Sheets
Publisher: Tab Books
Each volume is like 800 pages and packed with just about every circuit known to man (and maybe even aliens). You may be able to save a few bucks buying a bunch at a time. Amazon has a 20% discount on them already though. Great deal!

COMPUTER RELATED BOOKS

FUTURE

SCIENCE FICTION BOOKS

I read quite a bit of sci-fi but here are some favorites for now.

ENDER'S GAME - PAPERBACK
by Orson Scott Card
The best Sci-Fi book ever written. I'll leave it at that.

MARS - Paperback - Hardcover
by Ben Bova
Ever wonder what it will be like when we begin to send humans to the Red Planet? Mr. Bova gives a detailed look into what the first mission to mars may be like.

RETURN TO MARS - Paperback - Hardcover
by Ben Bova
Sequel to MARS. Back to Mars to discover its secrets. Now Mars becomes a profit venture.

NON-FICTION BOOKS

SHOW STOPPER: The Breakneck Race to Create Windows Nt and the Next Generation at Microsoft
Ever wonder how they created the largest piece of software in the history of earth? All about the race to complete NT. It's a good look into the minds of programmers and their bosses. I enjoyed the look into Micro$oft.

CAR: A Drama of the American Workplace(Hard Cover) - Paperback
by Mary Walton

One of the best non-fiction books I have read in quite awhile. It is about how FORDs team off engineers created the 1996 Taurus. It takes it from the point where the first engineer sketched out the stylish front end of the Taurus on a napkin, to the first sale of a 1996 Taurus.

DVD & VIDEO

MATRIX ON DVD!!!

Mind blowing special effects. I watched this thing like 3 times in a row.

MATRIX ON VHS

Not quite the quality of the DVD, but then not everyone has a DVD player.

TOP

Main Page

Email me at electronics@pobox.com

Last updated: Nov 2, 1999

BACK
Main Page

FORWARD
Recommended Electronics Books

EMAIL ME

Last Updated:
Feb 1, 1999

INTERNET GUIDE TO ELECTRONICS

'LECTRIC LINKS'

These are a few links I have found helpful in electronics studies and projects. I have visited close to 2500 electronics related sites and can tell you these are some of the Top electronics related sites. My book contains about 1300 other links with various ratings*. You can pick it up from the Howard W.Sams site for only $16.95.

I will classify and add more as time allows. Send me your favorties as well. Thanks. John Adams

Oh yes. They are not in alphabetic order yet, or any order for that matter, so browse through and see which interests you.

*WARNING: This may contain lightly seasoned spam but I have to make a living just like anyone else :-) Hopefully the information is worth your time.

'WEB LINKS'

THE AMAZING LIFE OF NIKOLA TELSA! - Telsa was the most advanced person of his time and even this time. This page goes deep into his inventions and life. If you don't know who Telsa is, I suggest you have a peek at the site.

ELECTRONIX EXPRESS - If you are looking for discount parts, equipment, kits, surplus and closeouts, etc. or are an educator in need of project ideas, give this one a shot. They offer a free catalog as well as Web Specials. Be sure to look through all the content on the site, especially the 'Tips From Our Tech Department' section.

CIRCUIT CENTRAL - This is a major cool site with tons of electronics information and an eye-popping interface. Good work Feliks P.

Sci.Electronics FAQ - Answer all your questions about the sci.electronics newsgroups.

Filip Gieszczykiewicz's Sites - Contains just about anything to do with electronics and electronics repair including the sci.electronics.repair FAQ
Note: New location of the repair faq will be http://www.repairfaq.org/

Jaap van Ganswijk's Chip Directory - Numerically and functionally ordered chip lists, chip pinouts and lists of chip manufacturers, controller embedding tools manufacturers, electronics books, CDROM's, magazines, WWW sites etc.

Marshall Industries - An electronics distributor with a CONTENT filled site. Impressive!

Arrick Robotics - Ton of PIC and robotic resources with forum for your projects. Well worth an hour of your warped web time.

Howard W. Sams - Electronics book publisher

Beginners' PIC Page - Tons of helpful info for PIC projects. Also check out Matt's homepage for additional links

DonTronics Home Page - Maker of the SimmStick(tm), A PIC proto PCB the size of a 30 pin Simm Memory Module. You can also order the EASY PIC'n Beginners Guide to using PIC 16/17 MicroChip products from him

Don Lancaster's GURU's Lair Don is an author of a zillion electronics articles and books. Great site with reprints in PDF format.

Myke Predko's PIC and Microcontroller Reference Page
Myke has this new PIC microcontroller book out called "Programming and Customizing the PIC Microcontroller". It is a tutorial in using the PIC and comes complete with a disc. Great book!

Square 1 Electronics -- Home of the famous Easy PIC'n books. They just sent me a card telling me a new PIC book is out called "PIC'n Techniques". I would imagine it is of the same high-quality as the other two PIC'n series of books. These are highly recommended for beginners to Microchip's PICs which will be explained on this site in the future.

ECSC Electronics - EIO If you are looking at cheap surplus (used but not abused) electronics parts check this site out. It has forums, specials and just about everything else.

Alex's Electronic Resource Library - ....An Online Guide to Useful Electrical and Electronic Information. Great Links site for those hard to find URLs!

BASIC STAMP FAQ - Brought to you by AWC Electronics. Has all the information you need to know about the PIC-based, Basic language type programable module thingy. Its great for small projects that require fast programming.

DIBs Electronic Design - I found this site recently. If has a great link to "DIBs CIRCATS Circuit Catalog". This is a bunch of circuit diagrams in GIF or PDF format. Check out their other links as well.

I will be adding more over the next few weeks. Thanks for the patients.

Electronics Newsgroups

See sci.electronics FAQ for more information on each group.

sci.electronics.basics - Elementary questions about electronics.
sci.electronics.cad - Schematic drafting, printed circuit layout, simulation.
sci.electronics.components - Integrated circuits, resistors, capacitors.
sci.electronics.design - Electronic circuit design.
sci.electronics.equipment - Test, lab, & industrial electronic products.
sci.electronics.misc - General discussions of the field of electronics.
sci.electronics.repair - Fixing electronic equipment.
misc.industry.electronics.marketplace - Electronics products & services.(Ads)
alt.binaries.schematics.electronic
alt.engineering.electrical
sci.engr.electrical.compliance
sci.engr.electrical.sys-protection

TOP
Main Page

Be sure to check out my book --

Howard W. Sams Internet Guide to the Electronics Industry*

Information

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Howard W. Sams Site

* Spam or not, I have to make a living :-)

Contact the Webmaster Last Updated: Sept 25, 1997