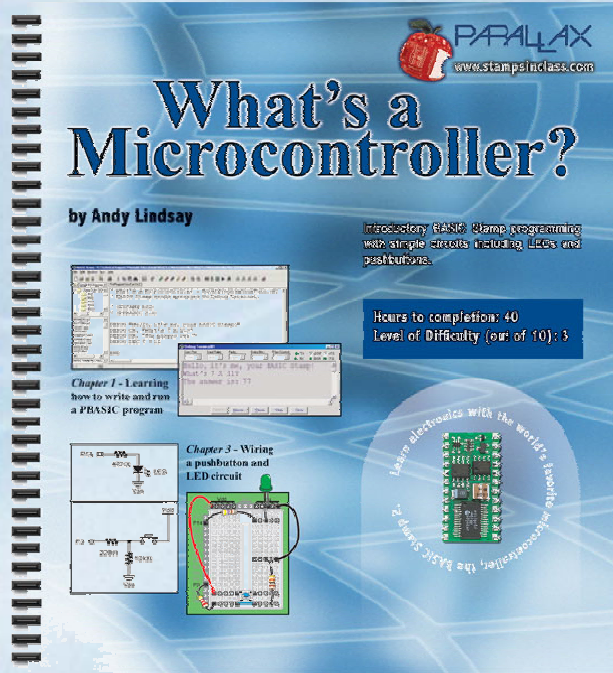




# Chapter 2: Light on- Lights off



What's a Microcontroller?



Presentation based on:  
"What's a Microcontroller ?"  
By Andy Lindsay  
Parallax, Inc

Presentation developed by:  
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9/02/03





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# Use and Copyright

## What's a Microcontroller?

This presentation supplements "**What's a Microcontroller**" by Andy Lindsay. ([Link to text](#))

- ✓ This presentation is not a replacement for the text.
- ✓ Important concepts of the text are highlighted.
- ✓ In some cases, additional material has been added to augment the text. Denoted by titles colored **gold**.
- ✓ Full program listings are generally not provided in the presentation.

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# Indicator Lights

What's a Microcontroller?

Indicator lights are so common to almost be not noticed.



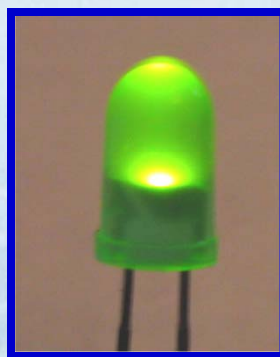
Using lights for indication is simply a matter of connecting and disconnecting them from a power source.



# The LED as a Light

What's a Microcontroller?

An LED (pronounced L-E-D), Light Emitting Diode, is a very popular choice as an indicator light because of its low power use and extremely long life.



It is quite simple to control with the low voltage of the BASIC Stamp but requires:

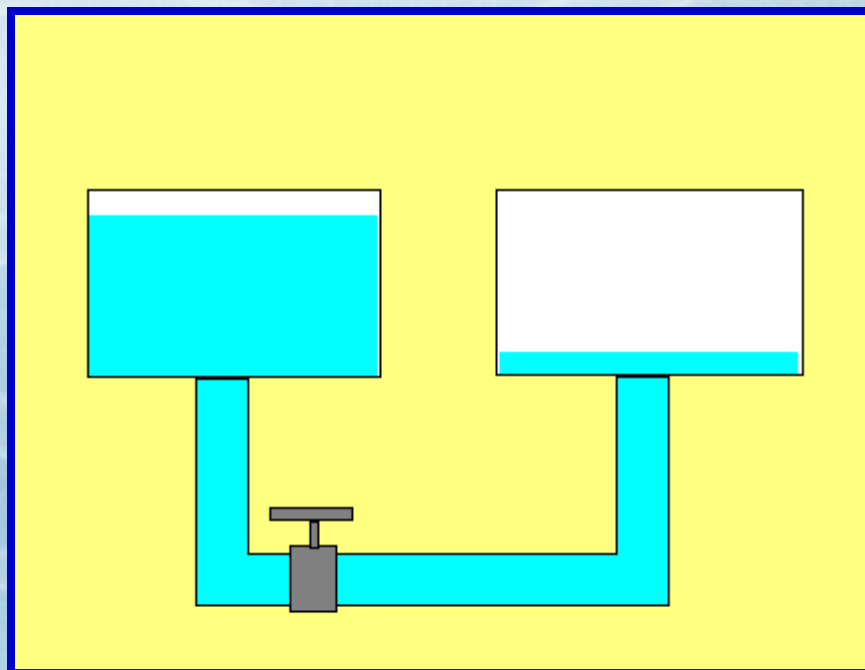
- ✓ A resistor to limit the current.
- ✓ Being connected in the correct orientation.



# Voltage and Current

What's a Microcontroller?

Voltage and current can be compared to water pressure and flow. When the valve is opened, what will happen? What determines how fast the water will flow?







## What's a Microcontroller?

Of course water will flow from the fuller tank because it has greater pressure than the empty tank.

The flow rate is dependent on:

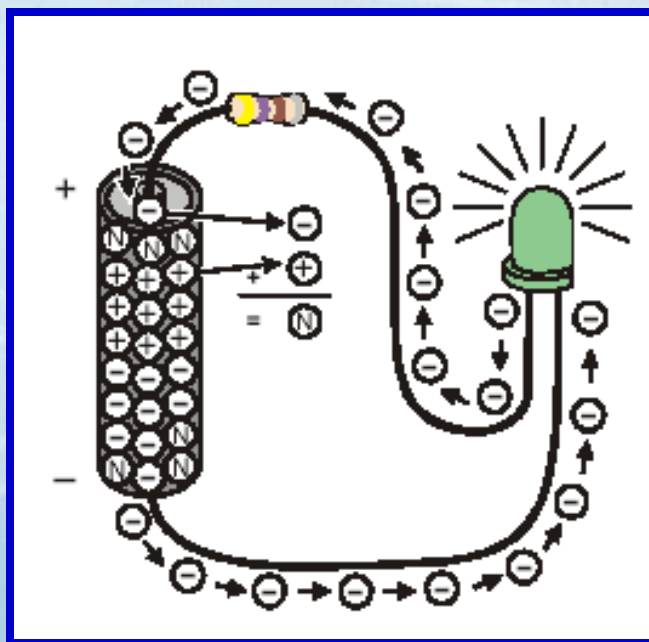
- ✓ The difference in pressure between the two tanks.
- ✓ The amount of restriction to flow in the pipe and valve.

The water that flows from your facet is dependent on the height of your town's water tank, the size of the pipes, and how far you open the faucet.



# What's a Microcontroller?

In a battery, there is surplus of electrons on one side, and a deficiency of electrons on the other side (holes).



When a circuit is completed, such as putting an LED in it, a flow exists from one side to the other. This is called **Current**.

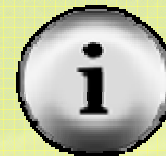
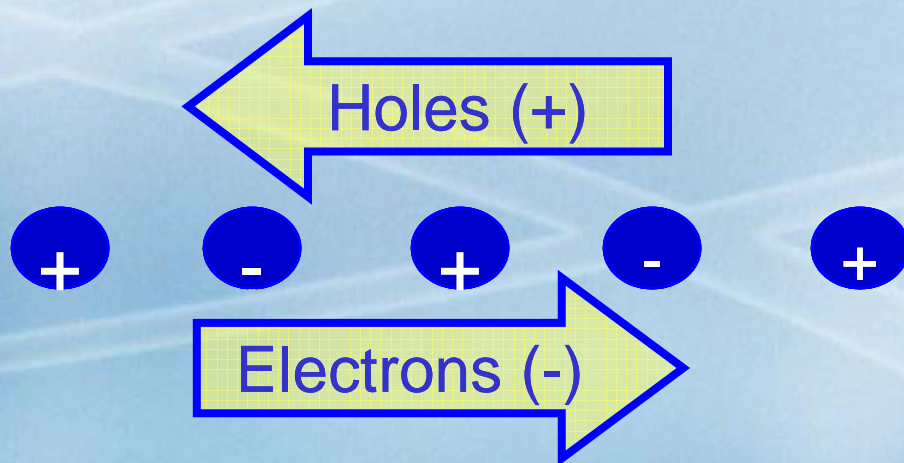


Current can be viewed in one of 2 ways:

✓ **Electron Flow:** Electrons flow from the negative side(-) to the positive side.

OR

✓ **Hole Flow or Conventional Flow:** Holes, or the absence of electrons, move from positive to negative as the electrons move.



An atom with an excess of electrons has a - charge. One with a deficiency of electrons has a + charge.



## What's a Microcontroller?

Which version of flow is used doesn't matter. How much flows does. Just as with the water tanks:

- ✓ The greater the pressure, or the difference in potential (Voltage), the greater the amount of current that can flow in a unit time (Amperes).
- ✓ The greater the restriction to flow (Ohms), the lower the amount current that can flow.



# Ohm's Law

What's a Microcontroller?

- ✓ **Ohms Law states:** The amount of current (I) that will flow is proportional to the voltage applied (V), and inversely proportional to the resistance (R) of the circuit.

$$I = V/R$$

- ✓ As Resistance increases, current decreases.



## What's a Microcontroller?

LEDs have minimal resistance to current flow. A 5 volt source can destroy an LED if current is not restricted. From Ohm's Law, if R is 1  $\Omega$ , how much current will try to flow? An LED drops approximately 1.4V, leaving 3.6V.

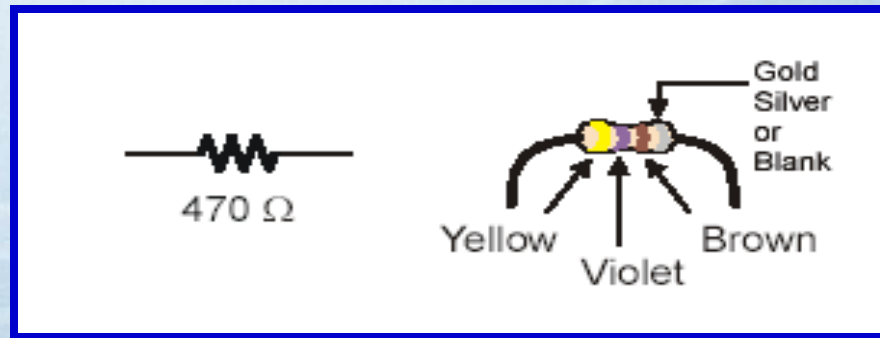
$$I = (5V - 1.4V) / 1\Omega = 3.6 \text{ A}$$

The maximum current a typical LED can handle is around 30mA, or .030 A.



# The Resistor

The resistor is a device used to limit the amount of current in a circuit. Because it is so small, color bands are used to identify the value.



Schematic Symbol

Part Drawing

- ✓ 1<sup>st</sup> Band: 1<sup>st</sup> Digit
- ✓ 2<sup>nd</sup> Band: 2<sup>nd</sup> Digit
- ✓ 3<sup>rd</sup> Band: Multiplier
- ✓ 4<sup>th</sup> Band (if present): Tolerance.



# What's a Microcontroller?

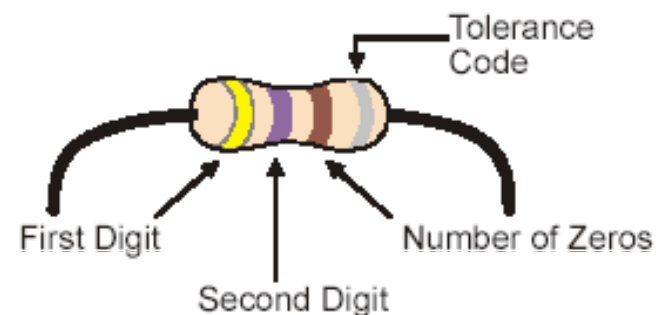
For the resistor shown:  
Yellow = 4, 1<sup>st</sup> Digit  
Violet = 7, 2<sup>nd</sup> Digit  
Brown = 1, add 1 zero.  
470 Ohm or 470Ω

Tolerance is how far off it  
could be from the labeled  
value:

Gold: 5%  
Silver: 10%  
none: 20%

**Table 2-1:**  
Resistor Color  
Code Values

Digit	Color
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Gray
9	White







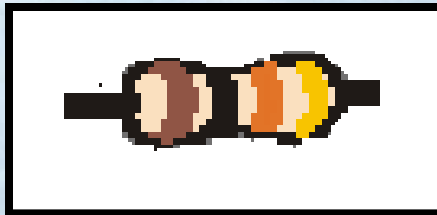
Using the  $470\Omega$  resistor in series with the LED, how much current will be able to flow with a 5V source?

$$(5V - 1.4V) / 470\Omega = 0.0077 \text{ Amps or } 7.7\text{mA}$$



# What is the resistance of a resistor colored Brown-Black-Orange?

(Click slide for answer)



**Table 2-1:**  
Resistor Color Code Values

Digit	Color
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Gray
9	White

Answer: Brown = 1, Black = 0, Orange = 3  
1, 0 , + 3 zeros = 10,000 ohms or 10K Ohm



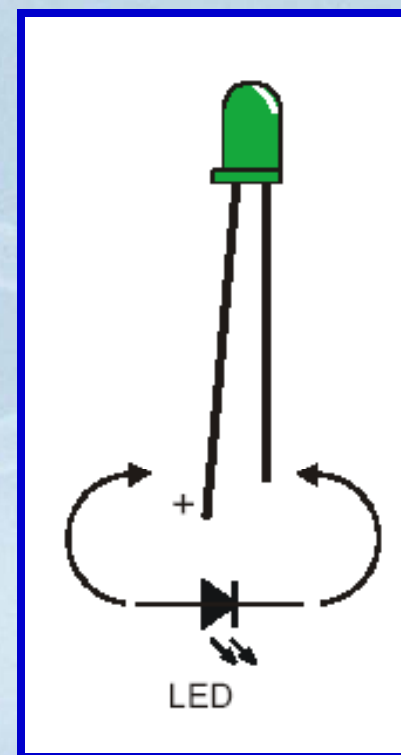
# LEDs

What's a Microcontroller?

A Diode is like a one-way check valve in that current can flow in only one direction. An LED is a diode that emits light as current is passed through it (Light Emitting Diode).

Note the connections on the LED:

- ✓ **Anode:** Connected to + side of voltage. Typically has a longer lead.
- ✓ **Cathode:** Connected to – side of voltage. Typically has a shorter lead AND a flat portion on the lens.



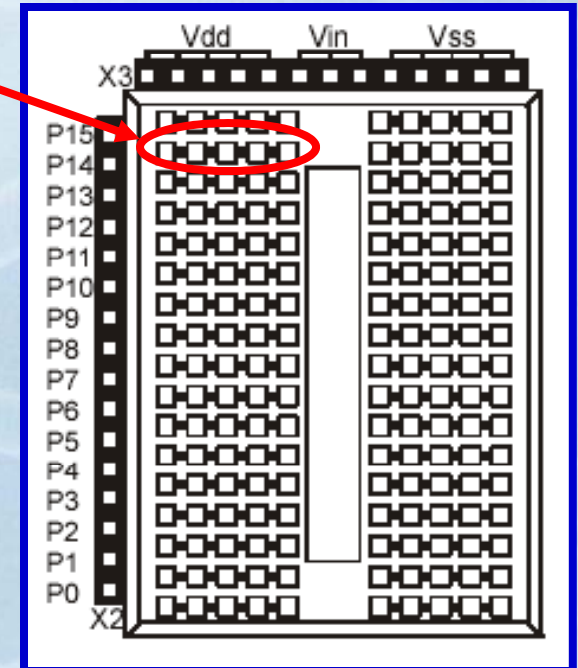


# Breadboard Area

What's a Microcontroller?

A Breadboard is an electrical testing area for prototyping by quickly connecting components.

- ✓ The rows are electrically connected to make connections between devices.
- ✓ Headers are provided on 2 sides for:
  - **I/O connections** to the BASIC Stamp (P0-P15)
  - **Vdd**: + Voltage
  - **Vss**: - Voltage
  - **Vin**: Supply Voltage from battery or wall transformer

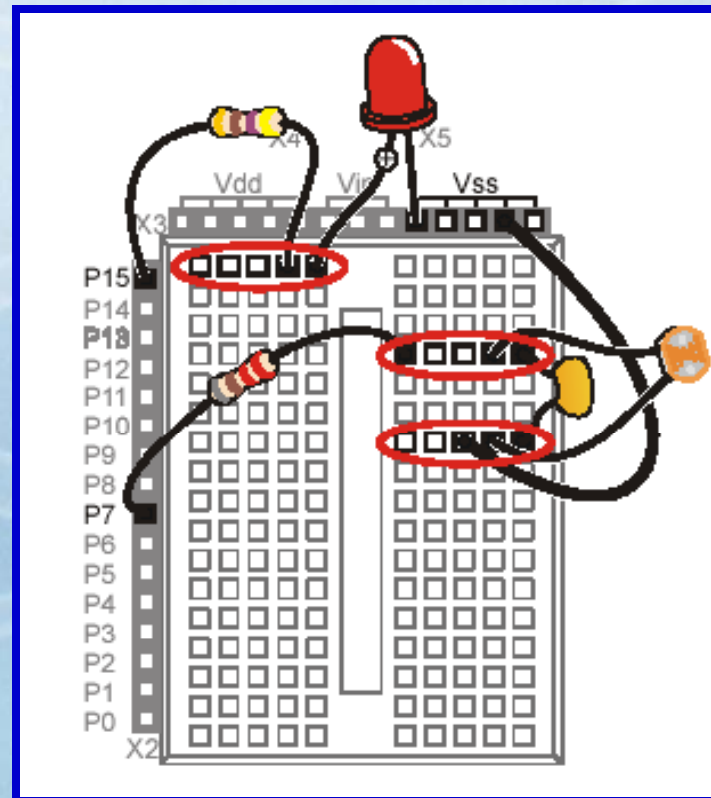


Use of Vin should be used only as directed as it can damage the BASIC Stamp or components.



# What's a Microcontroller?

Example connections of devices. **Do Not Build.** Note how the rows of sockets make complete paths of current between devices and from I/O headers and Vdd or Vss.

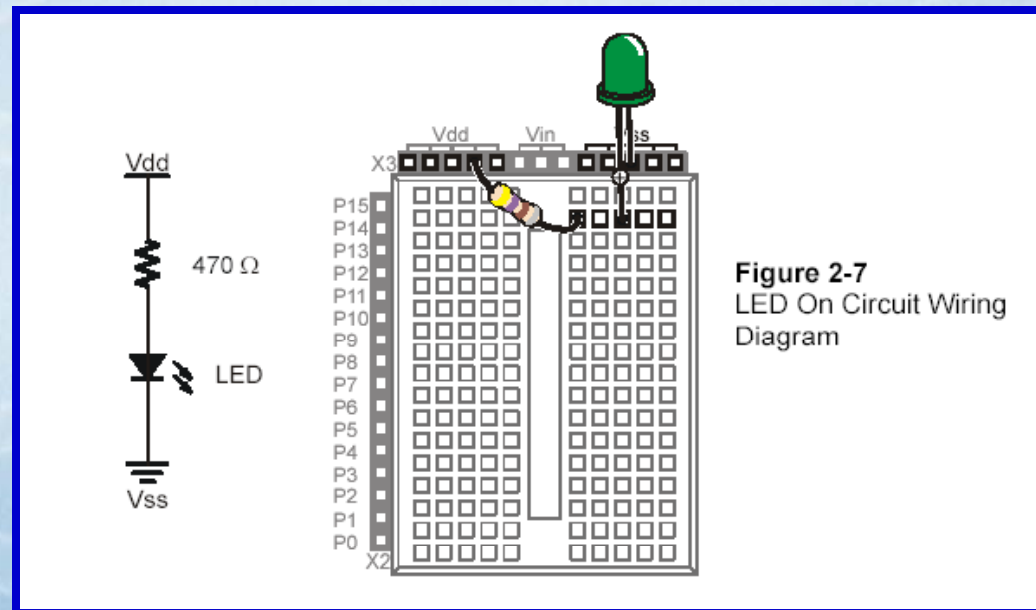




## Activity #1 Building and Testing the Light Circuit

What's a Microcontroller?

- ✓ Construct the circuit per your text.
- ✓ As the current path from Vdd(+) to Vss(-) is completed, the LED will light.

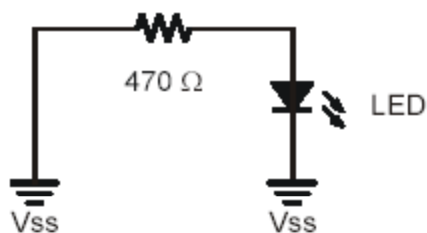


- ✓ What happens if the LED is reversed?
- ✓ What happens if a 1K ohm resistor is used?



# What's a Microcontroller?

- ✓ What happens when both sides are connected to the same supply? With no difference in potential (electrical pressure), no current will flow, and the LED will not light.

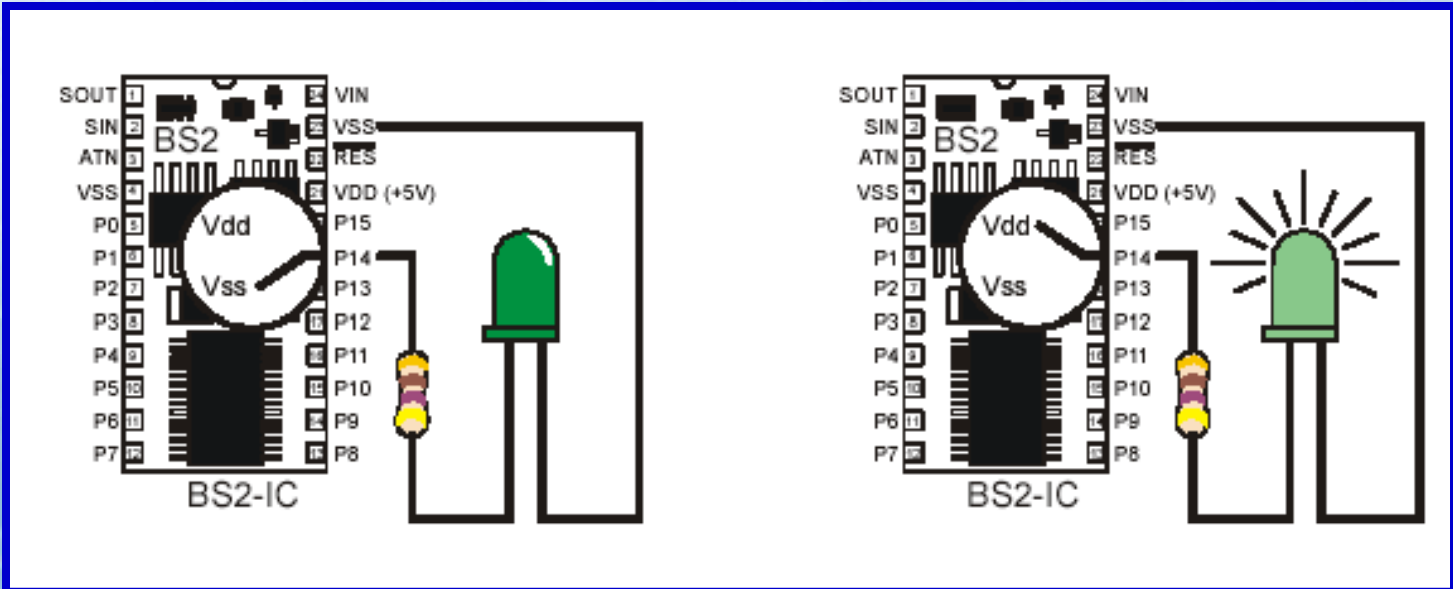




## Activity #2: On/Off Control With the BASIC Stamp

What's a Microcontroller?

With the BASIC Stamp the Input/Output pins (P0-P15) are controlled to supply either the Vdd (+) or Vss (-) potential. This will control whether a device has a path for current to flow or not.

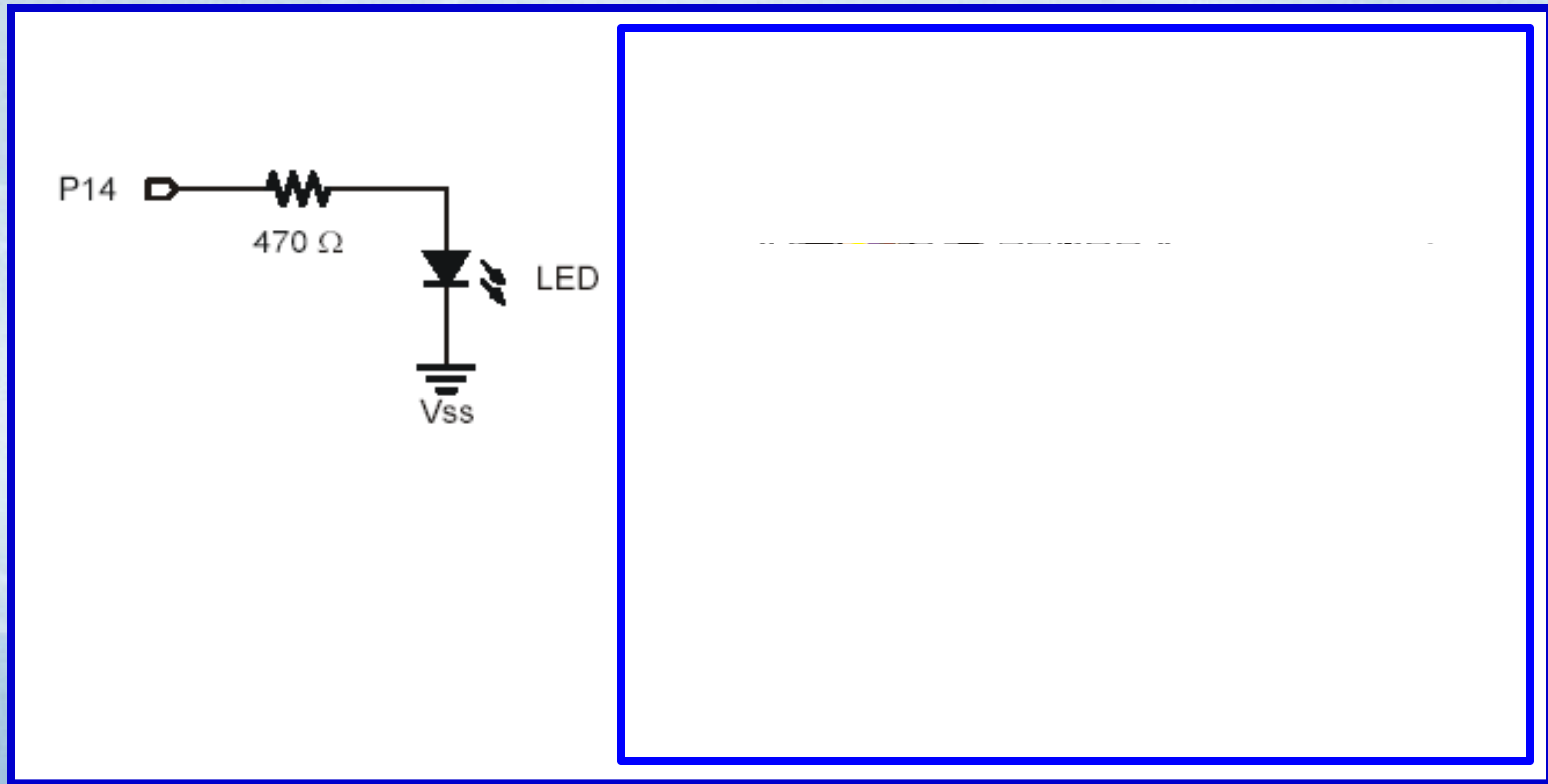






# What's a Microcontroller?

✓ Connect the circuit per your text.





# What's a Microcontroller?

- ✓ Enter the code to control and run per the text:

```
' What's a Microcontroller - LedOnOff.bs2
' Turn an LED on and off. Repeat 1 time per second indefinitely.
' {$STAMP BS2}
' {$PBASIC 2.5}
DO
  HIGH 14
  PAUSE 500
  LOW 14
  PAUSE 500
LOOP
```



## What's a Microcontroller?

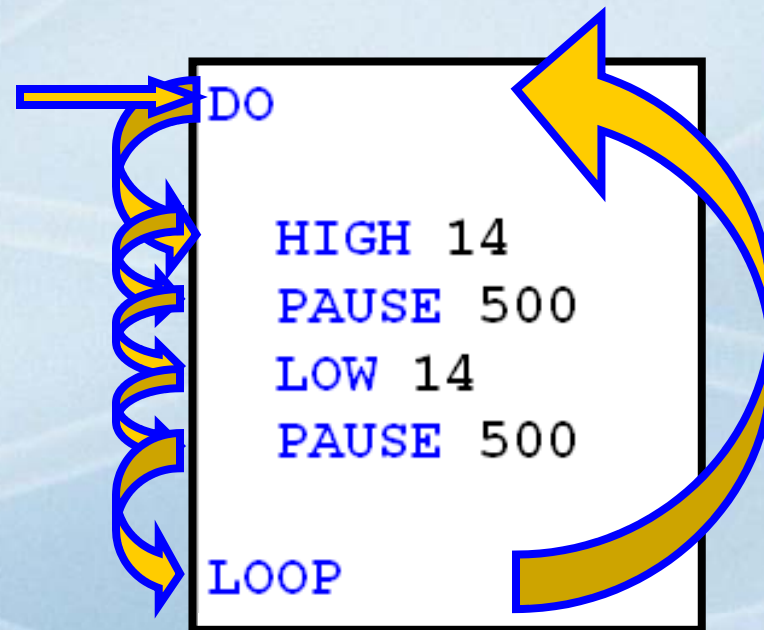
- ✓ The LED should be flashing on and off once per second.
- ✓ Key Commands:
  - **HIGH 14**: Places I/O pin P14 High. This correlates to 5V or Vdd (digital 1). Current flows between P14 and Vss energizing the LED.
  - **PAUSE 500**: BASIC Stamp pauses operation for the specified time in milliseconds.  
500 milliseconds = 0.5 seconds
  - **LOW 14**: Places I/O pin P14 Low. This correlates to 0V or Vss (digital 0). Current does not flow between P14 and Vss, LED is not energized.
  - **DO** and **LOOP**: Creates a looping structure for repetition.



# Sequential Flow & Looping

What's a Microcontroller?

**Sequential Flow:** Computer programs generally start at the 'top' of the program or routine and progress line by line executing each instruction.



**Looping:** An instruction causes execution to branch to an earlier point.



# Pseudo-Code & Flowcharts

What's a Microcontroller?

As programs become more complex, programming tools are beneficial in the planning of the code.

**Pseudo-Code:** Descriptive statements to describe what the program will do.

**Flowcharts:** Graphical representation of what the program will do.



## Pseudo-Code Example

What's a Microcontroller?

An example of Pseudo-Code for the LED on/off program may be:

1. Start
2. Turn on LED
3. Wait for  $\frac{1}{2}$  second
4. Turn off LED
5. Wait for  $\frac{1}{2}$  second
6. Go back to start

A program for this pseudo-code could be written in any number of computer languages.



# Flowcharts

What's a Microcontroller?

Flowcharts use symbols to represent the type of action that is taking place at each step of a program, and graphically illustrate the flow.



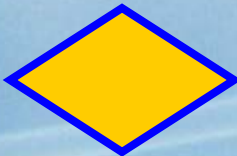
**Oval - Start/Stop:** Beginning or end of a program or routine.



**Rectangle - Process:** Indicates a process being performed that is internal to the controller/ computer.



**Parallelogram – Input/Output:** Indicates reading an input or controlling an output.

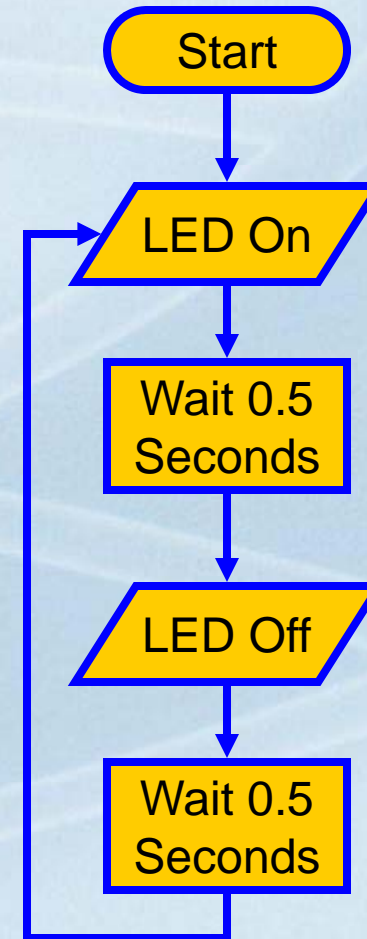


**Diamond – Decision:** The state of a condition is checked, and execution branches to 1 of 2 directions based on the result – True or False.



The LED On/Off program flowchart would be the following.

Note how the **Flow Lines** show the sequence and direction.







## Where's the program?

### What's a Microcontroller?

Now that the LED is blinking per the program, test this:

- ✓ Disconnect the serial cable from the BASIC Stamp. What happens? Why?
- ✓ Turn off power to your BASIC Stamp... count to 10... turn it back on. What happens? Why?



## What's a Microcontroller?

The program was transmitted to the BASIC Stamp, stored in a permanent memory (EEPROM-- programmable, non-volatile ROM) and the computer is no longer required.

The BASIC Stamp could now be placed into some device to become Embedded Control for the device.

A program CANNOT be retrieved from a BASIC Stamp, so make sure you save yours!



## What's a Microcontroller?

- ✓ What happens as the arguments for the PAUSE instructions are changed?
- ✓ What happens if the DO and LOOP instructions are commented out (placing apostrophes in front of them)?



## Activity #3: Counting and Repeating

What's a Microcontroller?

Counting and making decisions based on a value are key components to many programs.

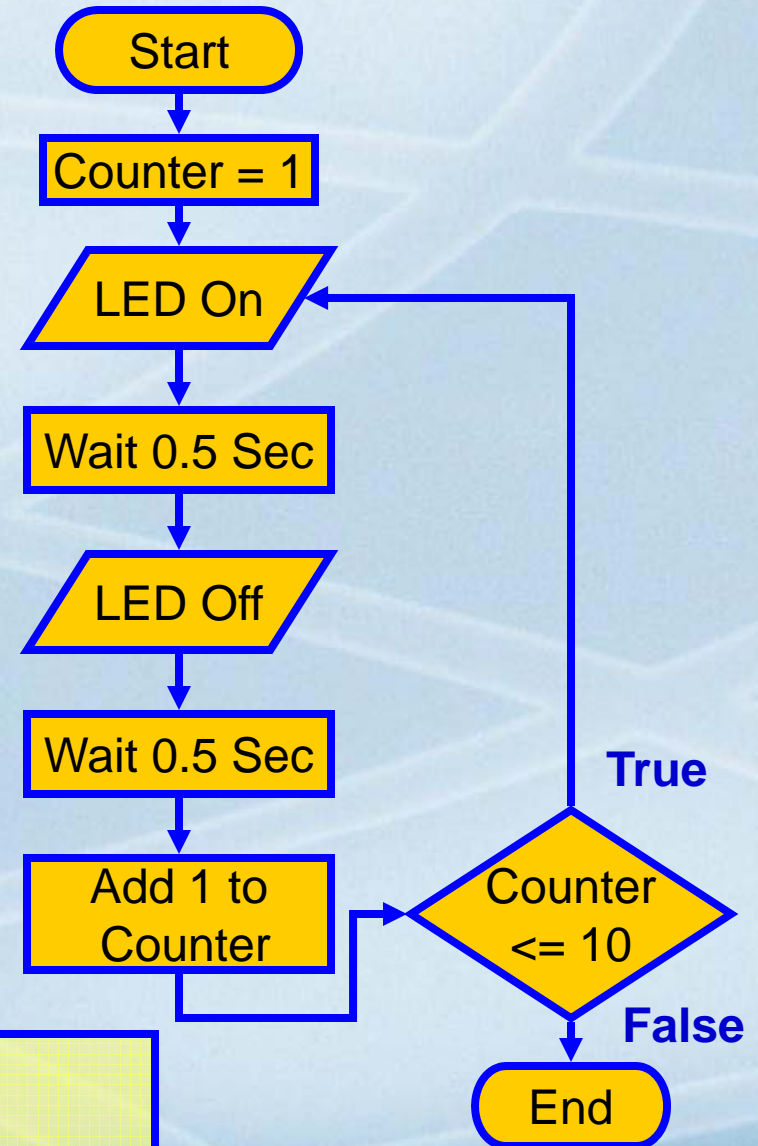
It is desired to make the LED blink 10 times through looping and then stop. Consider the pseudo-code and flowchart on the next slide.



# Flow for LED On-Off 10 times

What's a Microcontroller?

1. Start
2. Begin count at 1
3. Turn LED On
4. Pause 1/2 second
5. Turn LED off
6. Pause 1/2 second
7. Increment count
8. Count < 10?
  - ✓ True, loop back to step 4
9. End Program



The diamond decision symbol evaluates Counter and flow branches one of two directions based on the result.



## Using a DO-LOOP WHILE

What's a Microcontroller?

One way the code could be written is to use a DO-LOOP WHILE structure. The Loop will continue as long as the condition of Counter  $\leq$  10 is true. This is a **Conditional Loop**.

Note that the counter is:

✓ Initialized

✓ Updated

✓ Checked

```
Counter VAR Byte
Counter = 1
DO
  HIGH 14
  PAUSE 500
  LOW 14
  PAUSE 500
  Counter = Counter + 1
LOOP WHILE (Counter <= 10)
END
```

What is the value of Counter when the loop is complete? 11.



# Counting with a FOR-NEXT Loop

What's a Microcontroller?

A FOR-NEXT Loop is a simple structure to count between 2 values. The NEXT increments the value and the loop (NEXT) will repeat if not at the end value.

```
Counter VAR Byte  
  
FOR Counter = 1 TO 10  
  DEBUG ? Counter  
  HIGH 14  
  PAUSE 500  
  LOW 14  
  PAUSE 500  
NEXT  
  
DEBUG "All Done!"  
END
```



Notice that code inside a loop is indented. This is a visual aid to assist in seeing blocks of common code, such as in a loop.



## Code with full comments:

```
Counter VAR Byte           ' Variable to hold count

FOR Counter = 1 TO 10      ' Counter starts at 1 up to 10
  DEBUG ? Counter         ' Display Counter value
  HIGH 14                  ' LED on
  PAUSE 500                ' 0.5 Second Wait
  LOW 14                   ' LED Off
  PAUSE 500                ' 0.5 Second Wait
NEXT                        ' Increment for next value of
                            ' Counter
DEBUG "All Done!"         ' Display end message
END                         ' End program
```



The flowchart and pseudo-code do not change (neglecting the added DEBUGs which would be outputs), just the code to complete the task has.





# Variables

What's a Microcontroller?

Variables are named locations in RAM memory that hold data values. The general format for defining a variable is: **Name VAR Type**

The name you select should be representative of what the variable holds and has the following limitations:

1. Cannot be a word used by PBASIC, such as END or LOOP.
2. Cannot contain spaces.
3. May contain numbers or underscores, but cannot start with those.
4. Must be less than 33 characters long.

By convention, variables start with upper-case for each word in it. Examples:

**MyValue, ValueIn, Left\_Drive**



Variable type defines how large a value a variable can hold. The larger the variable, the greater the amount of RAM memory used.

<b>Variable Type</b>	<b>Value Range</b>
Bit	0 to 1
Nib (short for Nibble)	0 to 15
Byte	0 to 255
Word	0 to 65535



Create a variable to hold the number of pups born in a litter.  
(click for example code)

```
Pups_In_Litter    VAR    Nib
```

A Nib was chosen because a typical maximum is 8, and a Nibble is the smallest type which could hold this value.



## What's a Microcontroller?

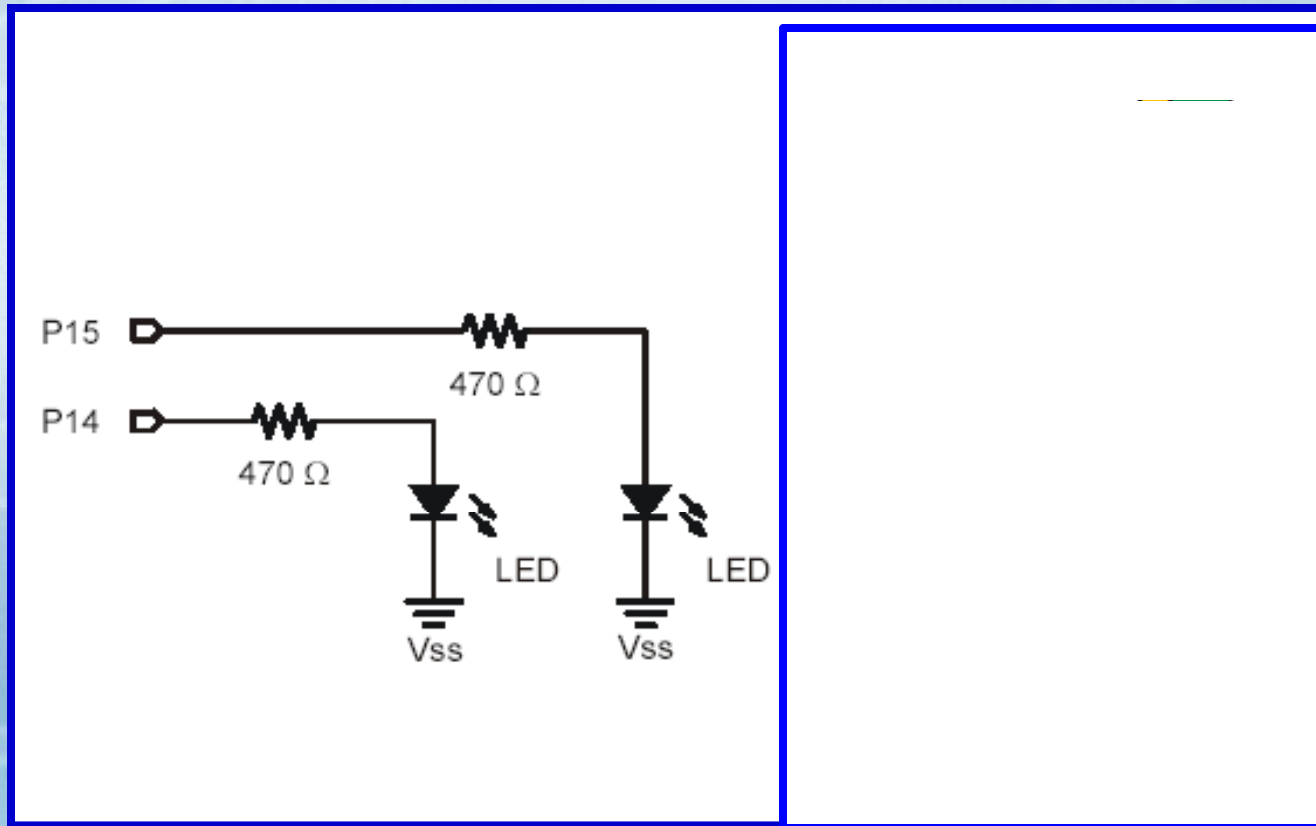
- ✓ What happens as you change the start and end values of the FOR loop?
- ✓ What does the STEP command do for a FOR-NEXT?  
FOR Counter = 1 TO 120 STEP 10



## Activity #4: Second LED Circuit.

What's a Microcontroller?

- ✓ Add a second LED on P15.
- ✓ Test code to control this LED and both LEDs.

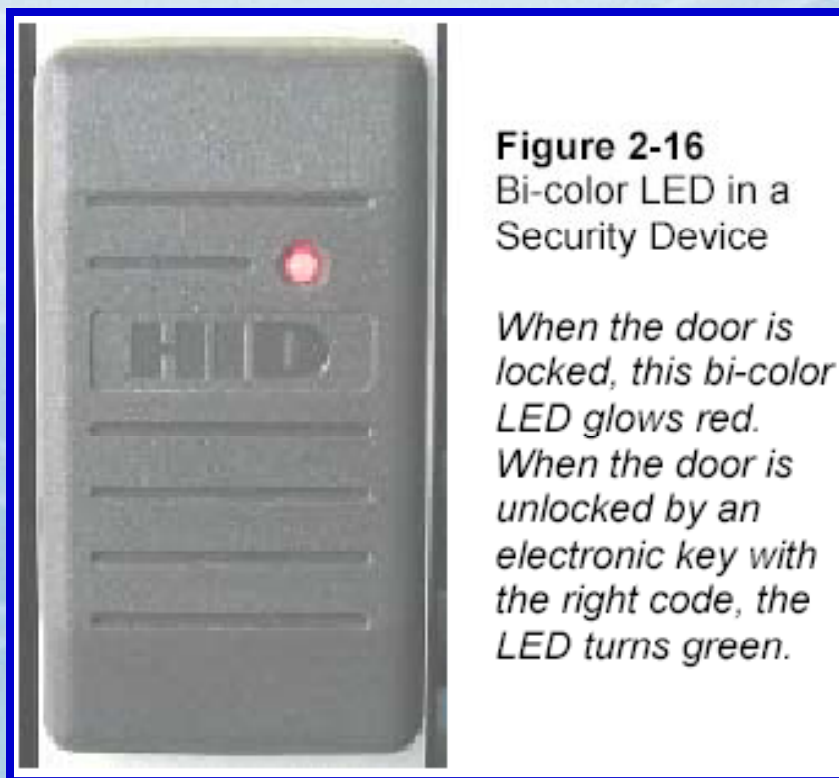




## Activity #5: Using a Bi-Color LED

What's a Microcontroller?

A Bi-Color LED is one which will light 2 different colors, such as red or green, depending on direction of current flow through it. An example is a security light.



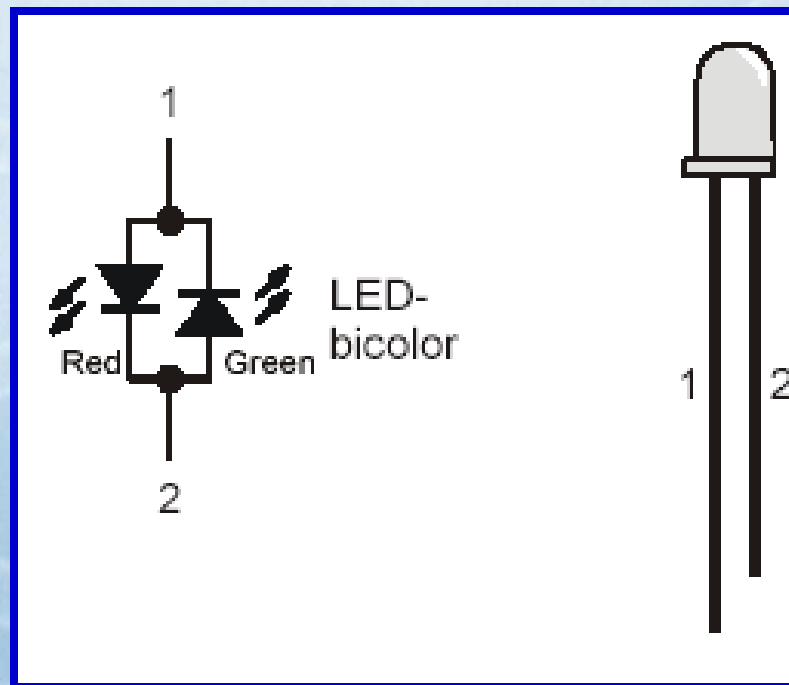
**Figure 2-16**  
Bi-color LED in a  
Security Device

*When the door is locked, this bi-color LED glows red. When the door is unlocked by an electronic key with the right code, the LED turns green.*



# What's a Microcontroller?

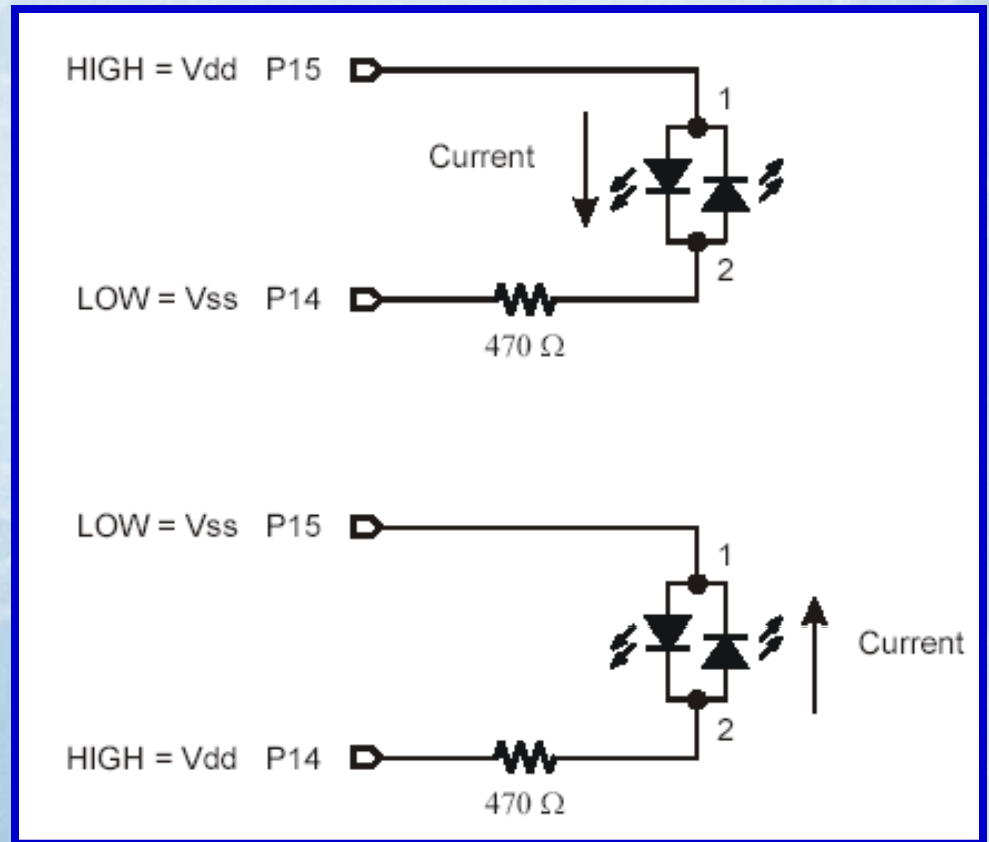
The bi-color LED is simply 2 LED elements in a single package connected in opposite ways.





# What's a Microcontroller?

By using 2 I/O Pins and defining which is Vss (LOW) and which is Vdd (HIGH) the direction of current flow can be controlled.







## What's a Microcontroller?

LEDs are just one example of a device that can be controlled with simple HIGHs and LOWs from the BASIC Stamp.

You will find many more in your education and experimentations!



## Chapter 2 Review

### What's a Microcontroller?

- ✓ Why are LEDs are popular choices as indicator lights.
- ✓ In what direction can current flow in an LED?
- ✓ What defines the amount of current that can flow in a circuit?
- ✓ What is the purpose of a resistor?
- ✓ BASIC Stamp I/O pins can act as \_\_\_\_ or \_\_\_\_ to control devices.
- ✓ How many times will a simple DO-LOOP repeat?
- ✓ What are 2 examples of conditional loops?
- ✓ \_\_\_\_\_ and \_\_\_\_\_ are programming tools for code development.
- ✓ What a variables, and what sizes can they be?



## Links

What's a Microcontroller?

- ✓ [BASIC Stamp Home](#)
- ✓ [Stamps In Class Home](#)
- ✓ [BASIC Stamp Software](#)
- ✓ [BASIC Stamp Robots](#)
- ✓ [BASIC Stamp Yahoo Group](#)
- ✓ [Stamps In Class Yahoo Group](#)
- ✓ [SIUC EST Degree](#)