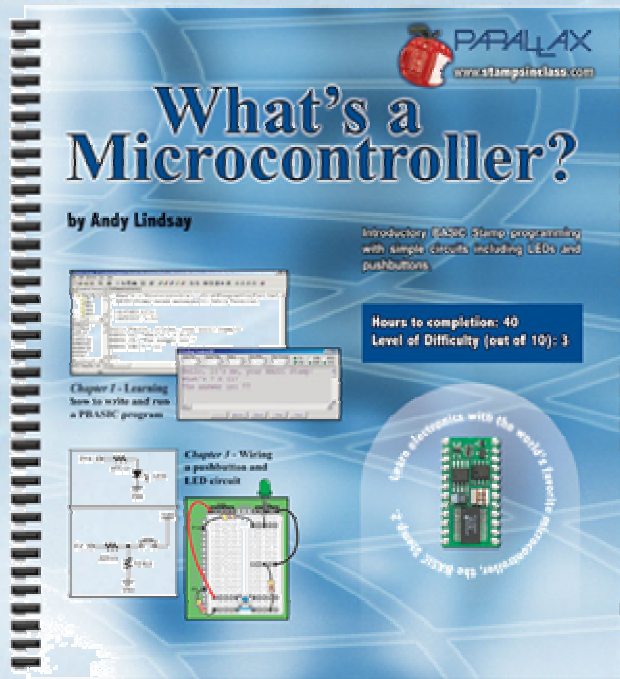




# Chapter 1: Getting Started



What's a Microcontroller?



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

Presentation developed by:  
Martin A. Hebel  
Southern Illinois University Carbondale  
College of Applied Sciences and Arts  
Electronic Systems Technologies

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.
- ✓ Full program listings are generally not provided in the presentation.

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# Uses of Microcontrollers

What's a Microcontroller?

- Microcontrollers are 'single chip' computers specifically designed to:
- ✓ Read input devices, such as buttons and sensors.
  - ✓ Process data or information.
  - ✓ Control output devices, such as lights, displays, motors and speakers.

## Embedded Control

Microcontrollers are placed in devices, or embedded, for operation and control.



Can you name other devices in your life that have embedded control?



# What's a Microcontroller?

In general, developing with micro-controllers require:

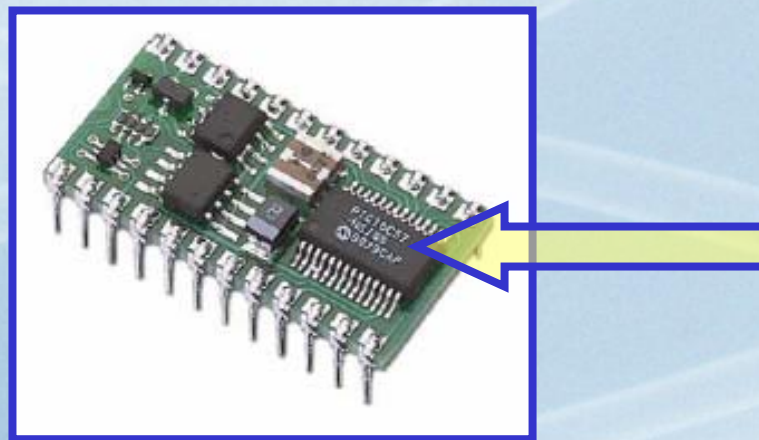
- ✓ Specialized hardware for programming.
- ✓ Knowledge of complex languages (sometimes very expensive) and configuration settings.
- ✓ External components for timing and communications.





# The BASIC Stamp 2

The BASIC Stamp 2 embeds a microcontroller, the PIC16C57, on a module to make programming and use very simple, yet very powerful.



Additional components on the module provide everything needed to start developing your own control systems.

What's a Microcontroller?



# Module Components

What's a Microcontroller?

## Serial Signal Conditioning

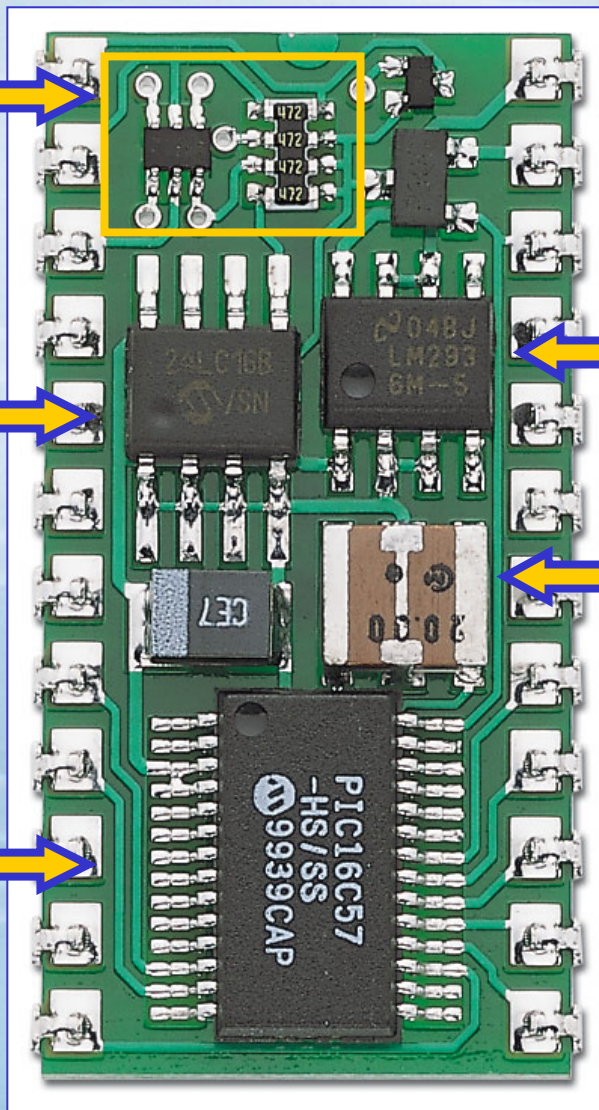
Conditions voltage signals between PC serial connection (+/- 12V) and BASIC Stamp (5V) for Programming.

## EEPROM

Stores the tokenized PBASIC program.

## Interpreter Chip

Reads the BASIC program from the EEPROM and executes the instructions.



## 5V Regulator

Regulates voltage to 5V with a supply of 5.5VDC to 15VDC

## Resonator

Sets the speed at which instructions are processed.



# Module Pins

What's a Microcontroller?

Pin 1: **S<sub>OUT</sub>**  
Transmits serial data during programming and using the DEBUG instruction

Pin 2: **S<sub>IN</sub>**  
Receives serial data during programming

Pin 3: **ATN**  
Uses the serial DTR line to gain the Stamps attention for programming.

Pin 4: **V<sub>SS</sub>**  
Communications Ground (0V).

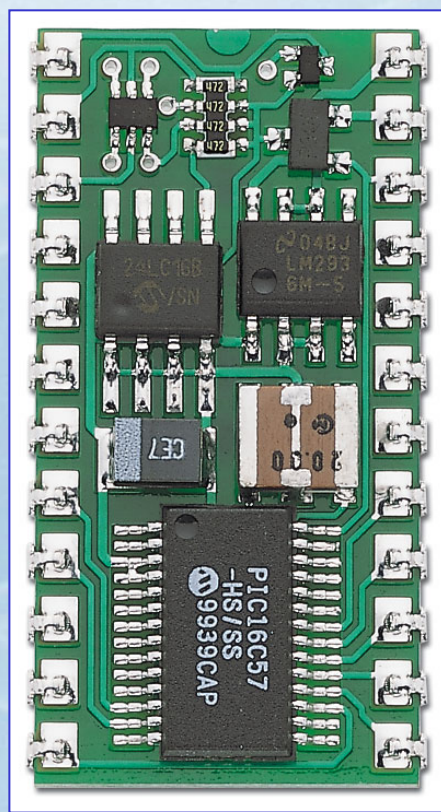
**Pins 5-20:**  
Input/Output (I/O) pins P0 through P15

Pin 24: **V<sub>IN</sub>**  
Un-regulated input voltage (5.5-15V)

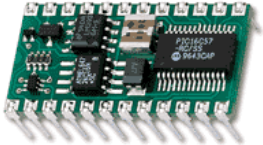

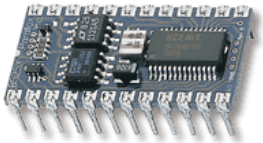

Pin 23: **V<sub>SS</sub>**  
Ground (0V)

Pin 22: **RES**  
Reset- LOW to reset

Pin 21: **V<sub>DD</sub>**  
Regulated 5V.



- ✓ There are several versions of the BASIC Stamp. The text has been written for the BASIC Stamp 2 (BS2) series of controllers.
- ✓ Each BASIC Stamp has different features, below are the most popular:

	Version	Memory	Speed	Additional Features
	BS2	2K Bytes 500 lines of code	20MHz 4000 instructions/ second	26 Bytes of RAM
	BS2 OEM	2K Bytes 500 lines of code	20MHz 4000 instructions/ second	26 Bytes of RAM Less expensive, easy to replace components.
	BS2sx	16K Bytes in 8 2K banks. 4000 lines of code	50MHz 10,000 instructions/ second	26 Bytes of RAM 63 bytes of scratchpad memory
	BS2p 24 and 40 pins versions	16K Bytes in 8 2K banks. 4000 lines of code.	20 MHz Turbo	I2C, Dallas 1- Wire, LCD, polling capabilities. 16 extra I/O on 40 pin version.



# The BASIC Stamp in Use

BASIC Stamps have been used in multitudes of projects and systems.

- ✓ Educational Robotics



The Parallax  
Boe-Bot



First Competitions

What's a Microcontroller?

# ✓ Research Robots



Autonomous Flying Robot at UC, Irvine



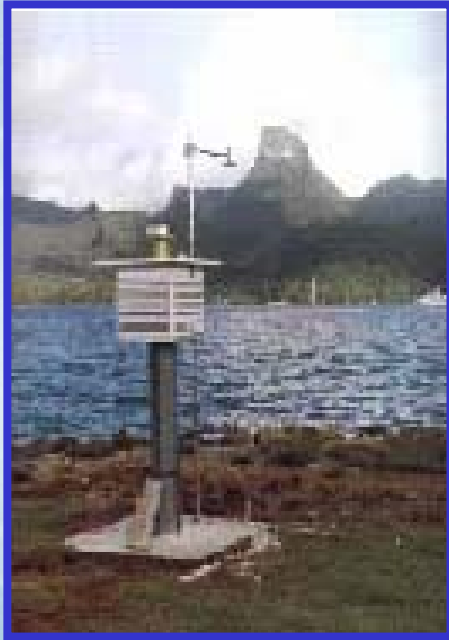
Millipede Project at Nanyang University

## ✓ Helpful Robots



Robotic Lawn Mower  
Prototype by the Robot Shop

✓ High-Tech and Aerospace use



Ecological  
Data Collection  
EME Systems



Undersea Research  
Harbor Branch  
Institute



JP Aerospace  
Test Launch

# ✓ Process Control & Technical Education



Oil Flow Control  
Southern Illinois University  
Electronic Systems Technologies





# BASIC Stamp Editor

What's a Microcontroller?

Embedded systems are a combination of:

- ✓ **Hardware** - The components which the controller monitors and controls.
- ✓ **Software** - The program to tell the controller what to monitor and how to control.

The software used to write programs for the BASIC Stamp is the BASIC Stamp Editor.



# Activity #1: Getting the Software

The BASIC Stamp is programmed in **PBASIC**, a version of the popular BASIC programming language. Code is written in the editor and downloaded to the BASIC Stamp.

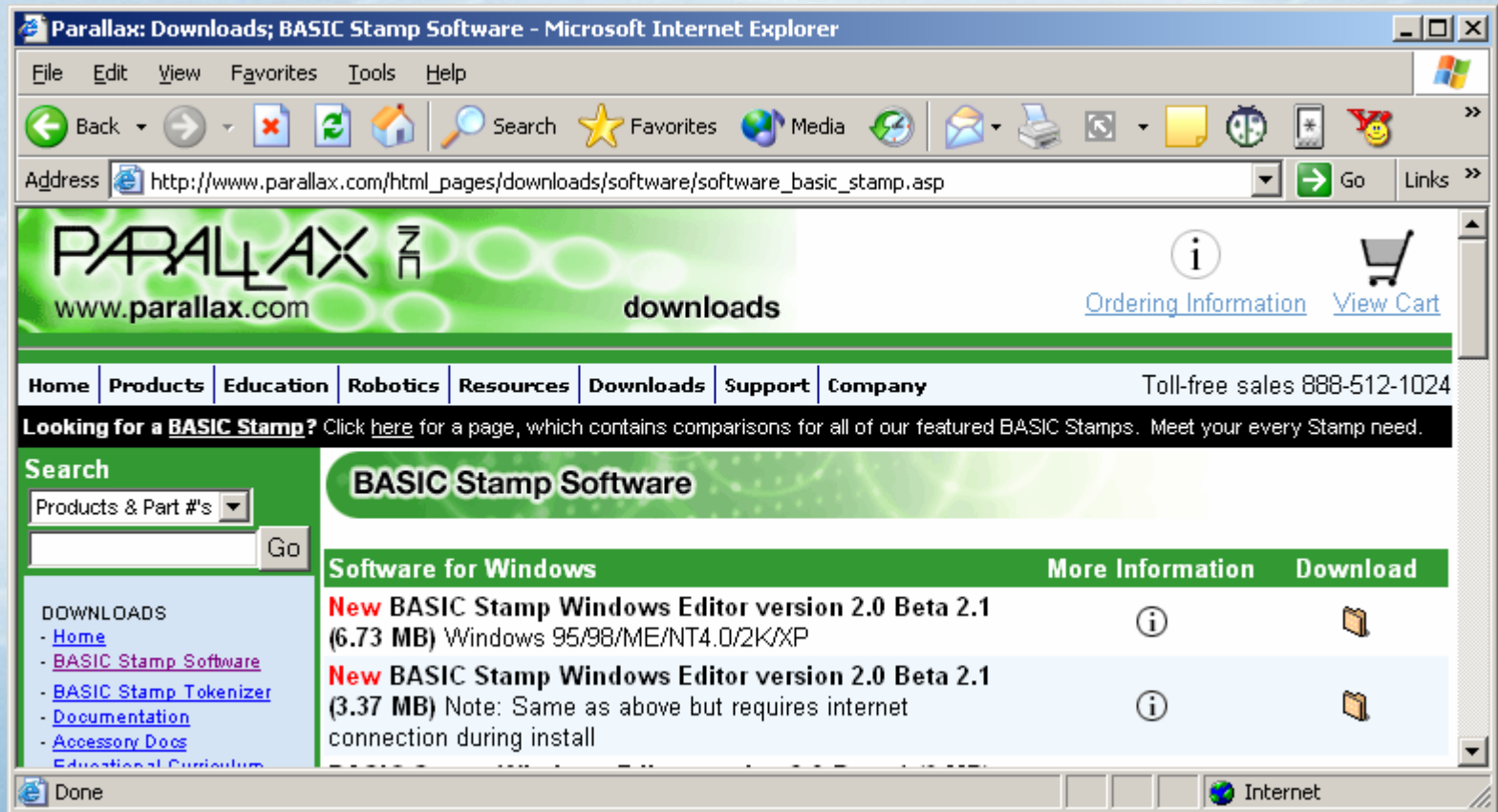
The BASIC Stamp Editor may be downloaded from Parallax's website and installed, or installed directly from the Parallax CD.



Be sure to install Version 2 or higher of the editor.

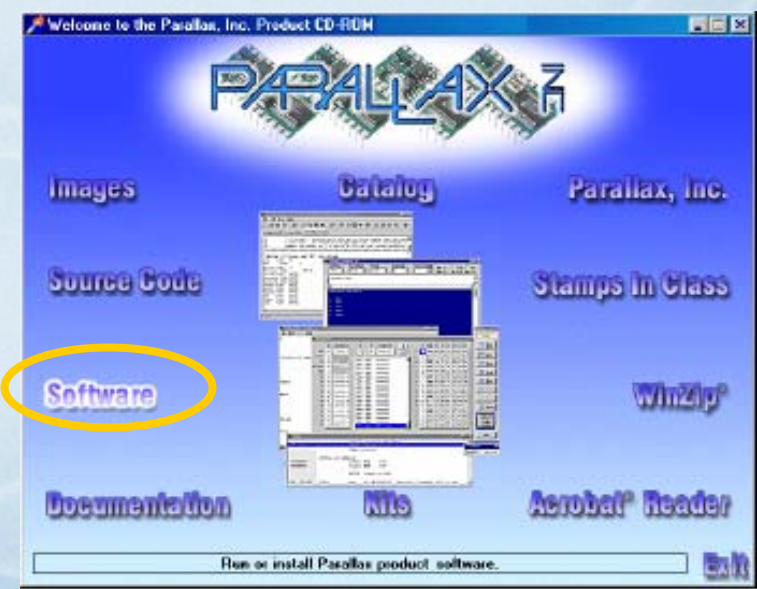



# ✓ Website Link





- ✓ Install from CD
  - Select Software
  - Expand BASIC Stamps
  - Expand Windows folder
  - Select Stamp 2/2e...
  - Click Install



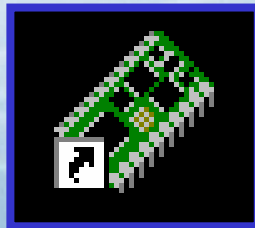
 Verify the date is newer than April, 2003 on the front of the CD.



# Activity #2: Installing the Software

What's a Microcontroller?

- ✓ Run the Installation Program
- ✓ Typical Setup
- ✓ Once installed, the Editor is available through:
  - A shortcut on the Desktop



- The Start Menu under **Programs --> Parallax, Inc --> Stamp Editor 2**



# Activity #3: System Setup and Testing

Once the software is installed, the next step is to setup and test the hardware.

The BASIC Stamp can be used on a variety of **carrier boards**, from Parallax, other vendors, or designed yourself. A carrier board is used for programming and testing.

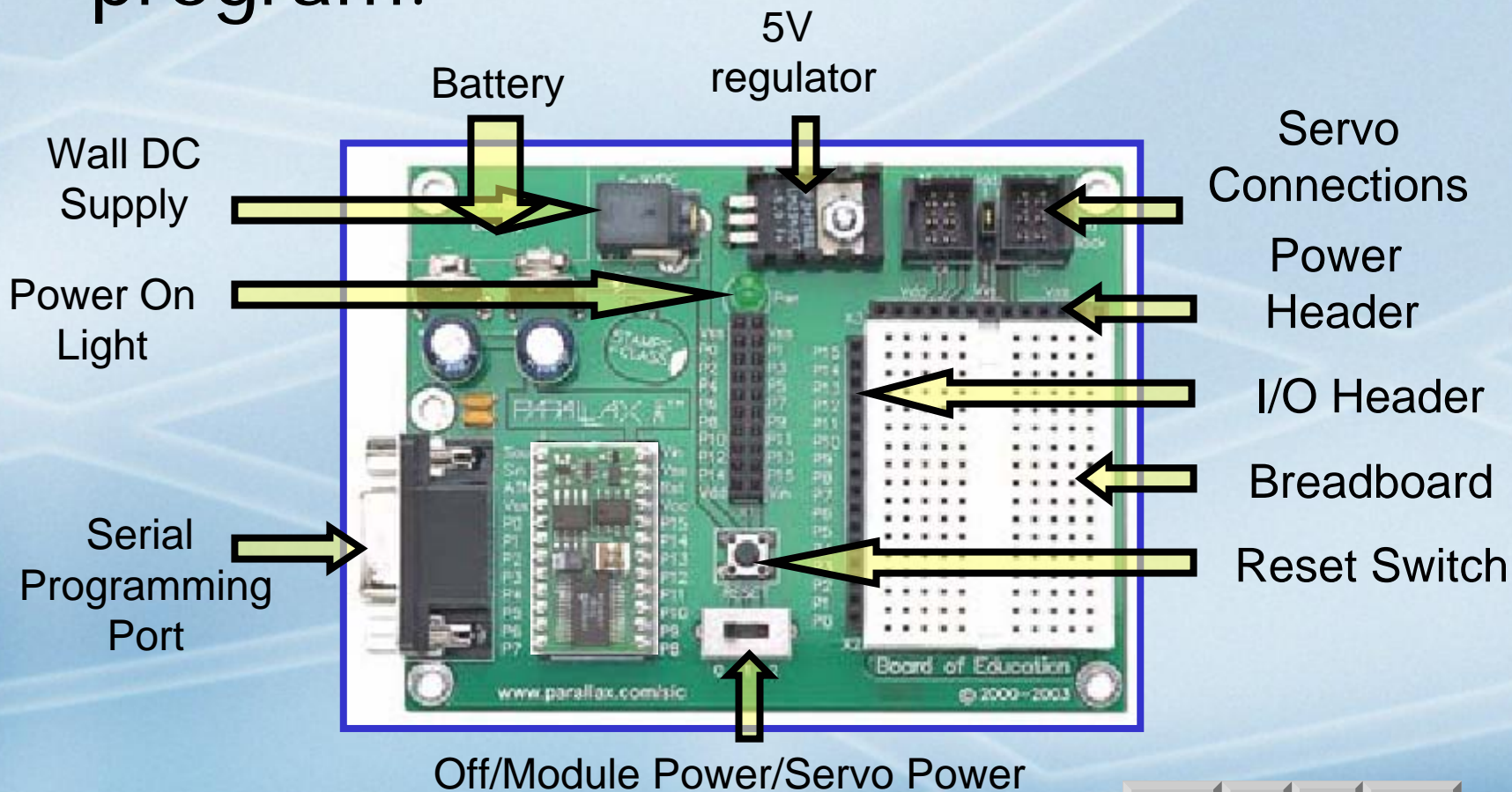
The most popular are:

- ✓ The Board of Education (BoE)
- ✓ The HomeWork Board (HWB)



# The Board of Education

The Board of Education makes it easy to connect devices, power up and program.

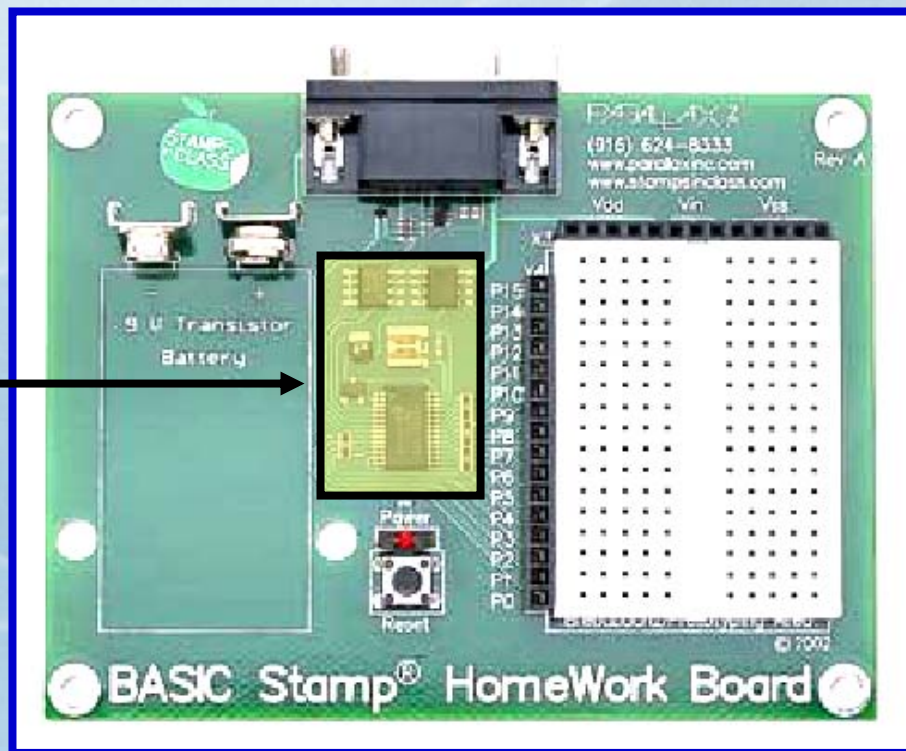


What's a Microcontroller?

# The HomeWork Board

The HomeWork Board has a BASIC Stamp integrated on the board and not as many frills to make it more affordable for students.

Integrated  
BASIC Stamp



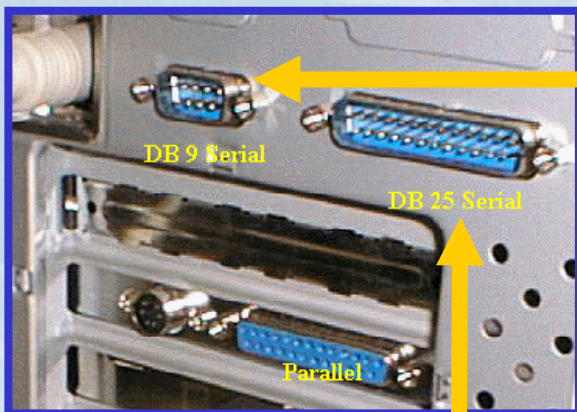




# Connecting the Hardware

What's a Microcontroller?

- ✓ Connect the serial cable to your PC or Laptop.



The cable is typically connected to an available DB 9 COM port.



A null-modem cable cannot be used.



A DB 25 to DB 9 adapter may be needed on older systems

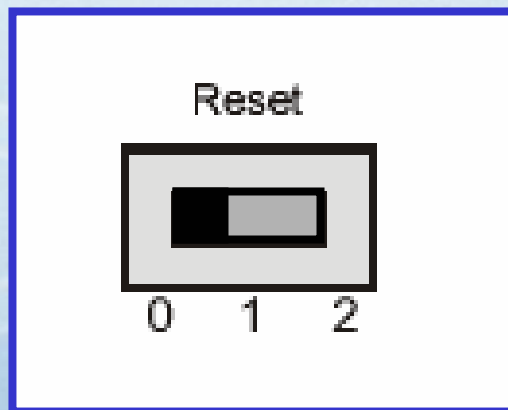


Newer systems may only have USB ports and require a USB-to-Serial Adapter. Please see your text.



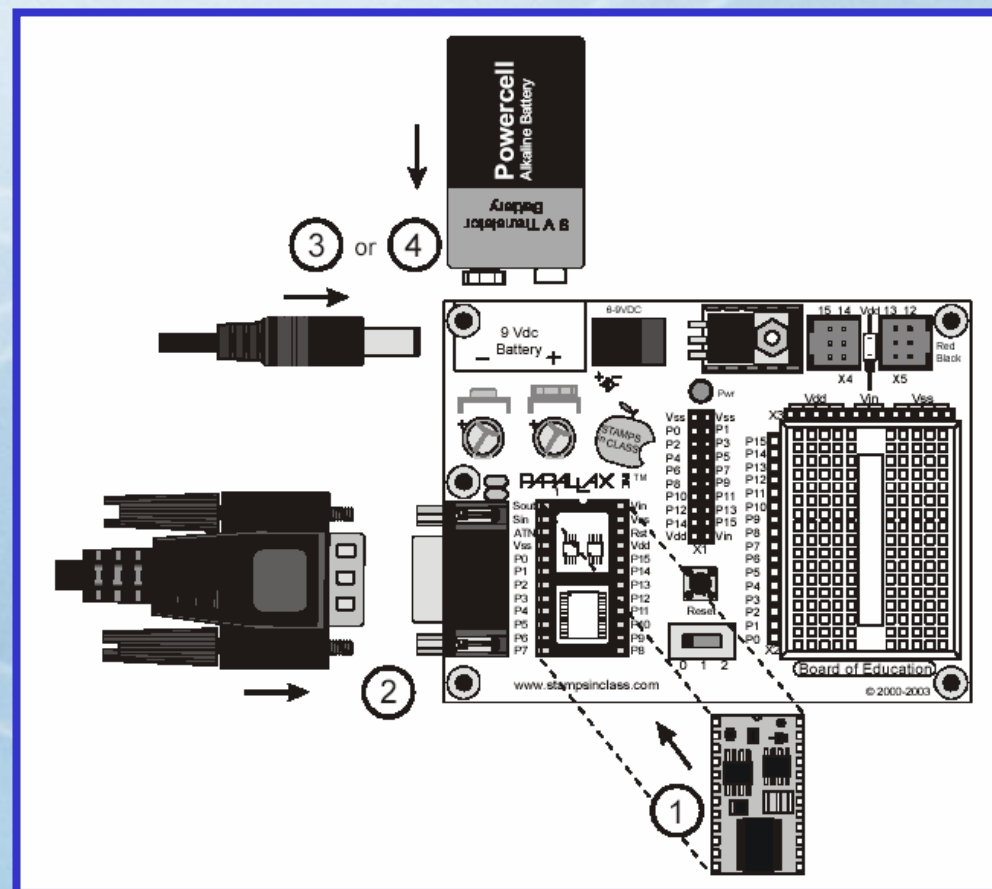
# Setting up the Board of Education

- ✓ On the Board of Education, turn the 3-position switch to position 0 – Off.

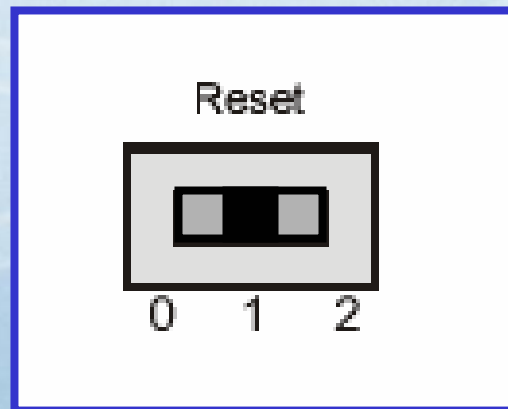


Only Rev C of the BOE has a switch. Other boards are powered down by removing power.

1. Insert the BASIC Stamp if required.
2. Connect the serial cable.
3. Connect a 6 to 9VDC power jack.  
or
4. Connect Battery.



- ✓ Place the switch in position 1 to power up the BASIC Stamp but not the servo headers.



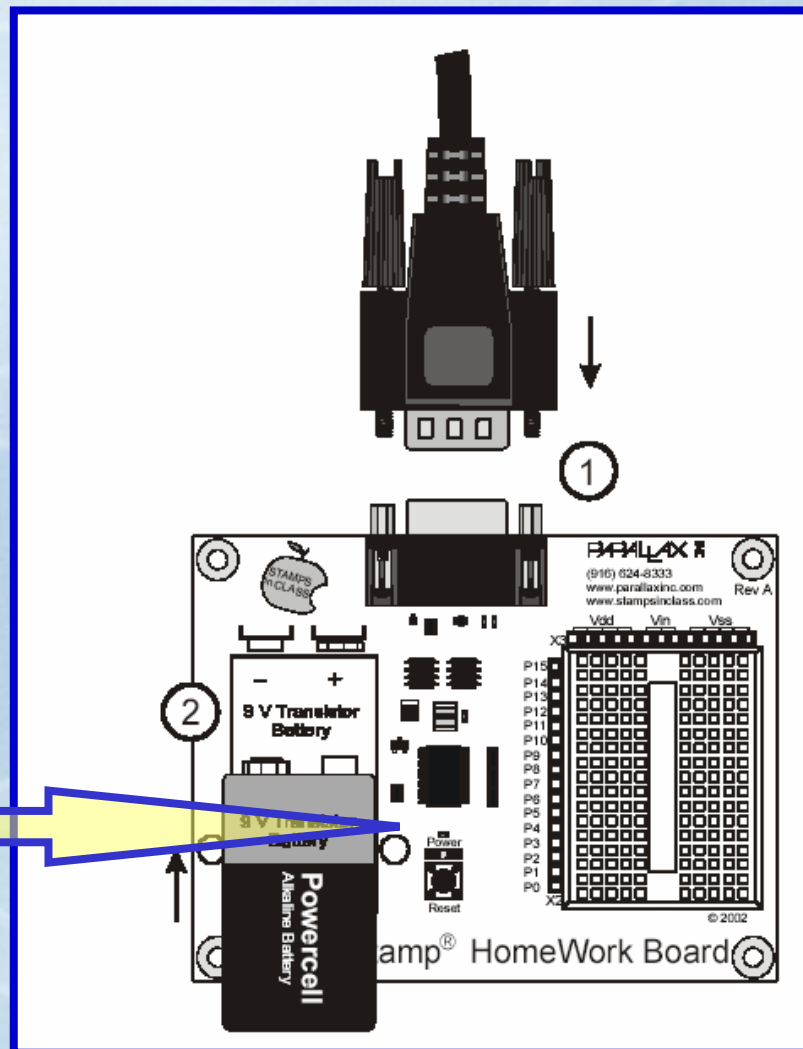


# Setting up the HomeWork Board

1. Connect the serial cable.
2. Connect a battery.



The HWB Power light will be on only when the BASIC Stamp is active processing instructions.

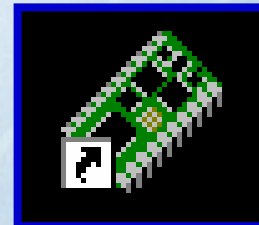


What's a Microcontroller?



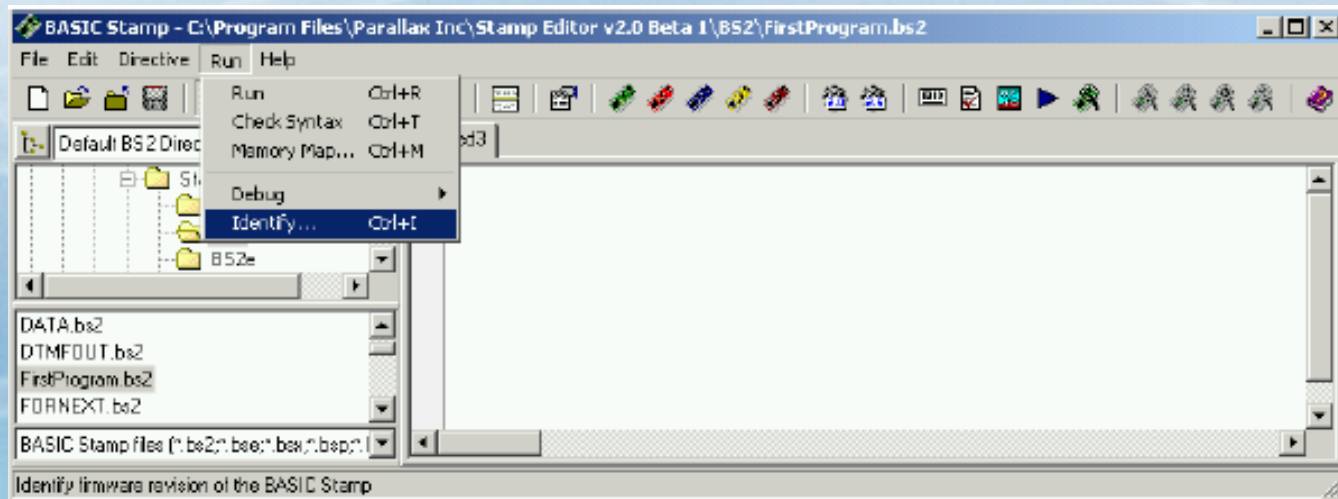
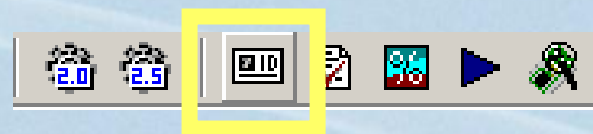
# Testing Communications

- ✓ Open the BASIC Stamp Editor.

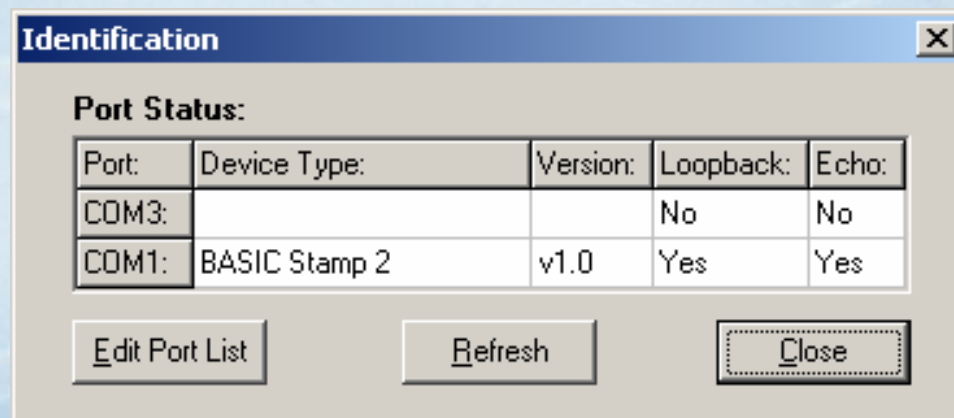


When first ran, the Editor may ask several questions. Simply click OK.

- ✓ Use menu option **Run**→**Identify** or click the **ID Button**.



- ✓ The Identification box should show similar to the following for the COM port you are connected to.



- ✓ All 4 entries should be as above. If not, refer to Appendix E in your text.



# Activity #4: Your First Program

- ✓ Enter your first program into the BASIC Stamp Editor.

```
' What's a Microcontroller - FirstProgram.bs2  
' BASIC Stamp sends message to Debug Terminal.  
' {$PBASIC 2.5}  
' {$STAMP BS2}
```

```
DEBUG "Hello, it's me, your BASIC Stamp!"
```

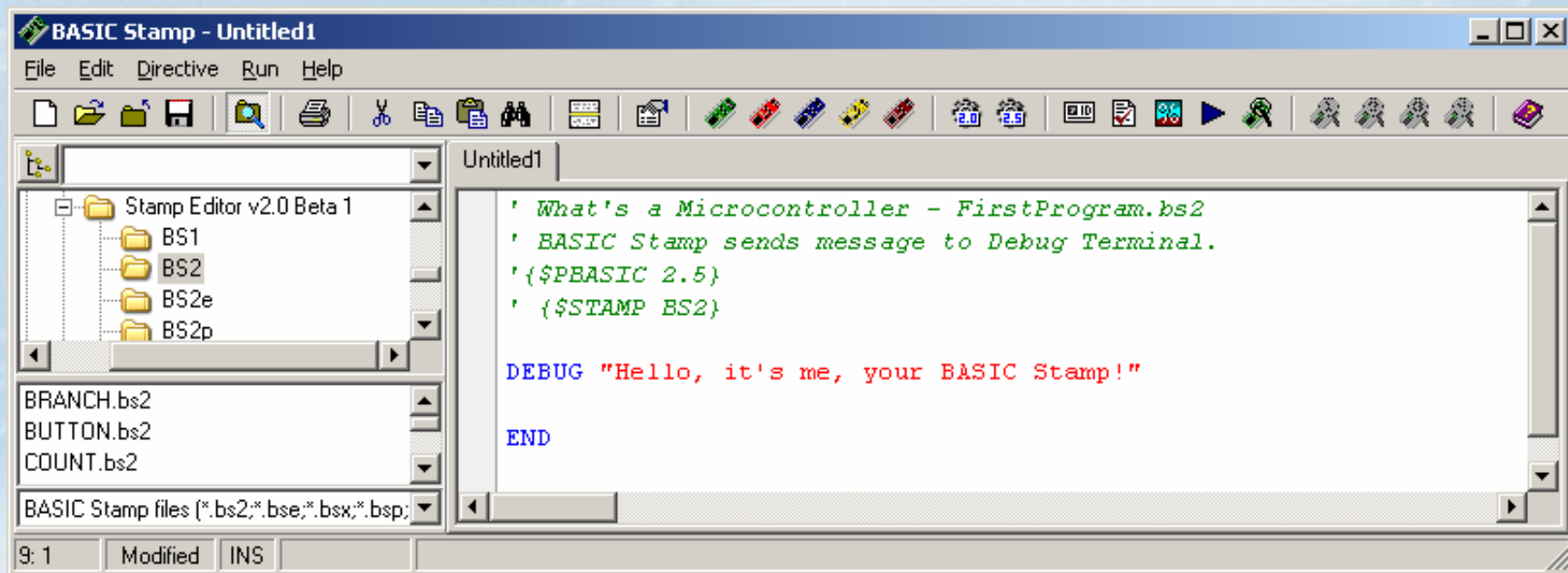
```
END
```

What's a Microcontroller?





# What's a Microcontroller?

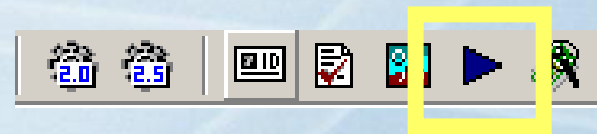


✓ Save the program as "FirstProgram"

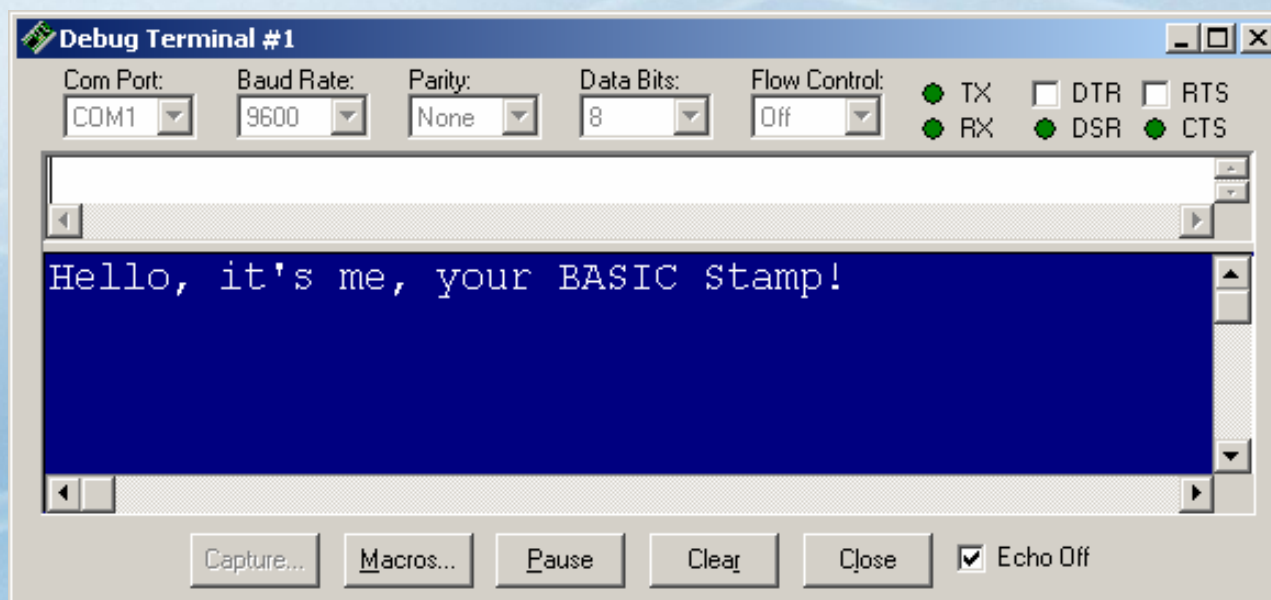


# 'Running' Your Program

- ✓ Download, or Run your program by clicking the **Run button**.



- ✓ The DEBUG Window should appear showing your message.

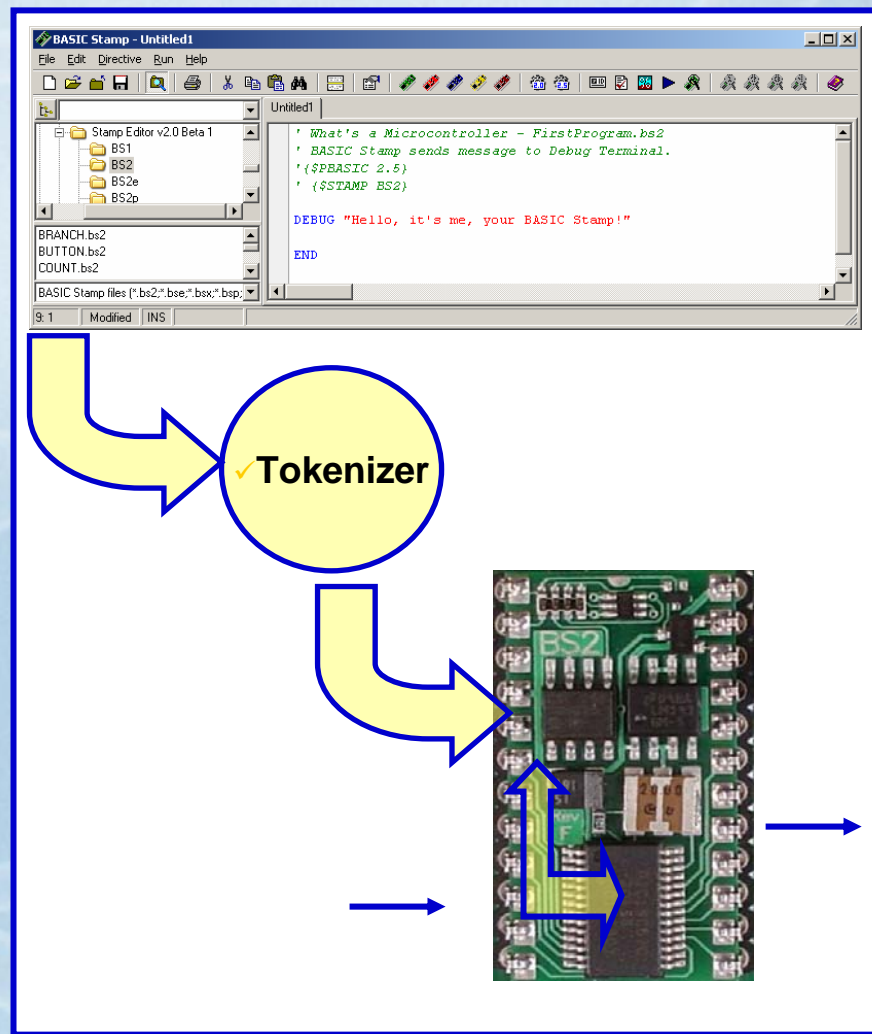




# How a Program is Placed on the Module

What's a Microcontroller?

- ✓ A program is written in the BASIC Stamp Editor.
- ✓ The program is tokenized, or converted into symbolic format.
- ✓ The tokenized program is transmitted through the serial cable and stored in EEPROM memory.
- ✓ The Interpreter Chip reads the program from EEPROM and executes the instructions.





# Understanding the Code

What's a Microcontroller?

It's important to understand the code so that:

- ✓ When you make mistakes entering a program, you can find the problem faster.
- ✓ You can start writing your own programs.



- ✓ Notice that different code appears in different colors. This is a great help in writing correct code!

A screenshot of a BASIC Stamp IDE window titled 'Untitled1'. The window contains the following code with syntax highlighting: green for comments, blue for keywords, and red for strings.

```
' What's a Microcontroller - FirstProgram.bs2
' BASIC Stamp sends message to Debug Terminal.
' {$PBASIC 2.5}
' {$STAMP BS2}

DEBUG "Hello, it's me, your BASIC Stamp!"

END
```



# Commenting Code

Commenting is very important for the user to annotate and explain the program.

- ✓ Comments are lines that start with an apostrophe ( ' ) and appear in green in the editor.
- ✓ They are not used when tokenizing, nor downloaded to the BASIC Stamp.
- ✓ After typing an apostrophe, you are free to write anything you like for understanding your program later.

```
' What's a Microcontroller - FirstProgram.bs2  
' BASIC Stamp sends message to Debug Terminal.
```



# Directives

What's a Microcontroller?

Directives are special instructions to the Editor ensuring the the code is tokenized for the correct PBASIC version and for the correct BASIC Stamp.

```
' {$PBASIC 2.5}  
' {$STAMP BS2}
```

- ✓ When starting a new program, be sure to click the buttons to add these directives to your program.





# Key Commands - DEBUG & END

What's a Microcontroller?

Controllers are a little like dogs.

- ✓ Dogs only understand special commands such as sit, lay, shake, and so on.
- ✓ In programming only commands understood by the controller can be used.
- ✓ The two commands used in this program were **DEBUG** and **END**.
- ✓ While not required, by convention instructions are in upper-case.





# Syntax Errors Due to Invalid Commands

- ✓ Notice a properly entered command turns blue.

```
DEBUG "Hello, it's me, your BASIC Stamp!"  
  
END
```

- ✓ If an instruction is improperly typed, three things will happen:
  - It will not turn blue.
  - An error message will appear when ran.
  - The editor will try to point out the problem area.

```
DEBUG "Hello, it's me, your BASIC Stamp!"
```

```
END
```



- ✓ This is a form of a **syntax error**.
- ✓ The editor does not understand the instruction you are using.



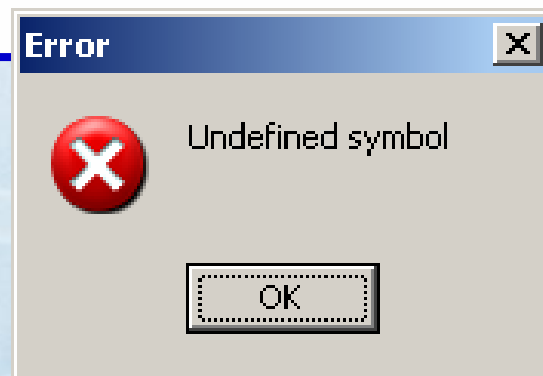
# Syntax Errors Due to Incorrect Parameters

What's a Microcontroller?

Most commands need to be told what to do.

- ✓ If you were told to "ADD 1 and 2" you would understand.
- ✓ If you were told to "ADD Tree and Fish" you would be a little confused!
- ✓ BASIC Stamp commands are similar, you need to be very specific in telling it what to do and giving it the correct **parameters** or **arguments**.

```
DEBUG Hello, it's me, your BASIC Stamp!  
  
END
```



Error messages will vary:

- ✓ Verify the command is correct.
- ✓ Verify using Help (discussed soon) that the correct parameters are being used.



# The DEBUG Command

**DEBUG** is used to send serial data from the BASIC Stamp back to the computer to be displayed.

- ✓ While DEBUG can be used in many ways, the simplest is to send back a string (enclosed in double-quotes).

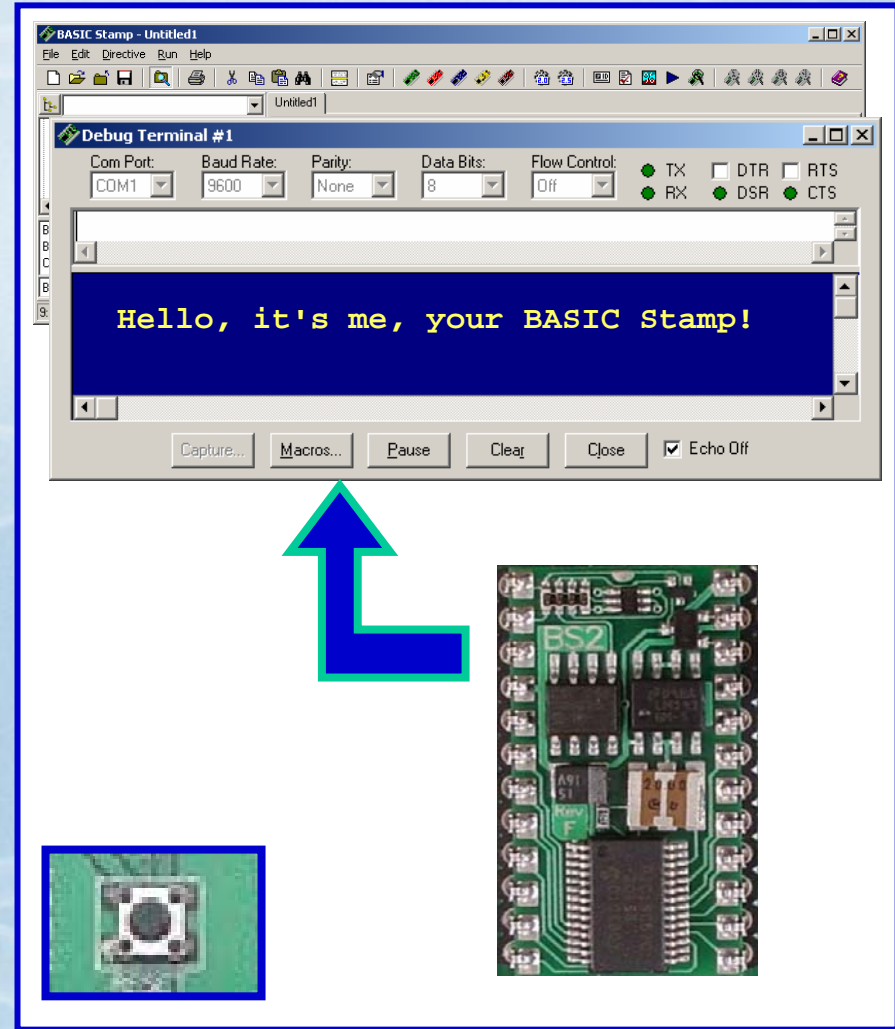
```
DEBUG "Hello World!"
```

- ✓ Notice strings appear in red in the editor.



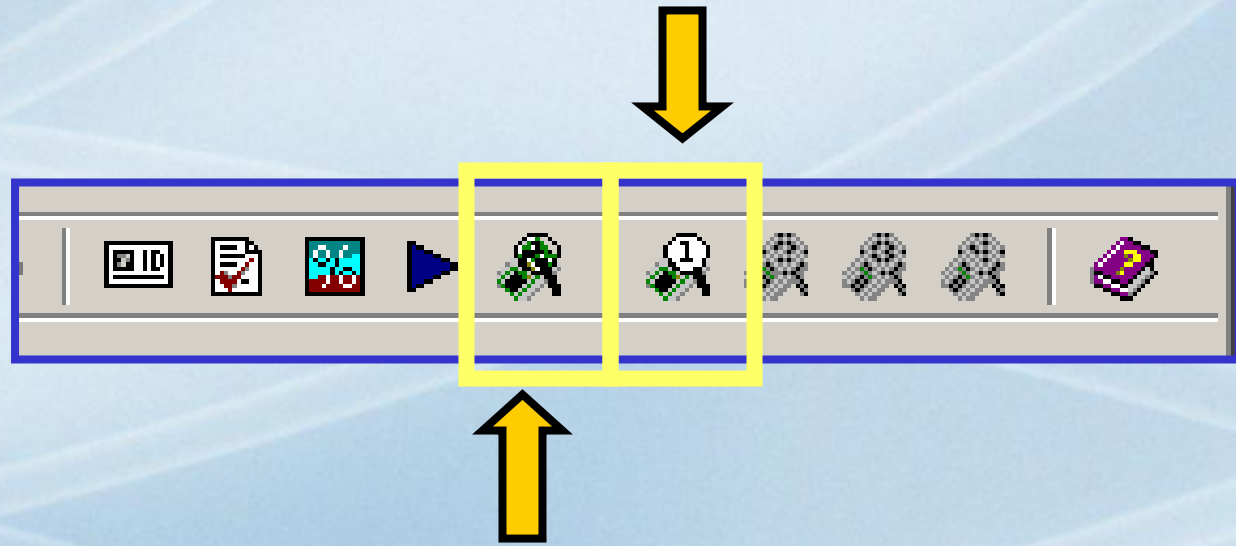
# DEBUG Window

- ✓ When a program contains a DEBUG command, the Editor opens the DEBUG Window.
- ✓ Data is sent back through the serial cable as characters to be viewed. This data is sent very quickly!
- ✓ The RESET button on board will start the program on your Stamp again.

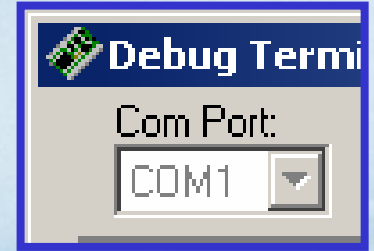


What's a Microcontroller?

✓ It can be easy to 'lose' your DEBUG Window. Buttons can be used to view an open window.



✓ A DEBUG Window can also be opened manually. Once open, select the COM port.





# DEBUG Formatters

What's a Microcontroller?

Formatters are used to display data in a defined manner.

- ✓ One DEBUG Formatter is **DEC** which displays the decimal value.

```
DEBUG DEC 7 * 11
```

Debug Window: **77**

- ✓ What occurs if DEC is left out?

```
DEBUG 7 * 11
```

Debug Window: **M**

- ✓ 77 is the numeric code representing the letter M (ASCII Code).





# DEBUG Control Characters

- ✓ Control codes may be used with DEBUG to help format your text on the screen.
- ✓ **CR** inserts a carriage return (starts on the next line)
- ✓ **HOME** starts text back at the top.
- ✓ **CLS** clears the Debug Window text.
- ✓ Note that each parameter in DEBUG must be separated by a comma.

```
DEBUG CLS, "Hello World!", CR  
DEBUG DEC 7*11, CR
```



# The END Command

**END** is used to inform the BASIC Stamp the program is complete.

- ✓ END will also place your BASIC Stamp in a low-power mode to save energy and make your battery last much longer!
- ✓ The BASIC Stamp will stay in low-power mode until reset or a new program is downloaded.



# Logical Errors

**Logical Errors** are those which cause your program to act improperly, but the BASIC Stamp is perfectly happy doing it!

- ✓ What's wrong with this program and what will it do?

```
' What's a Microcontroller - FirstProgram.bs2  
' BASIC Stamp sends message to Debug Terminal.  
' {$PBASIC 2.5}  
' {$STAMP BS2}
```

```
END
```

```
DEBUG "Hello, it's me, your BASIC Stamp!"
```



## Activity #5: Getting Help!!!

What's a Microcontroller?

There are numerous commands and numerous ways to use many commands which makes the BASIC Stamp Editor's HELP invaluable.

- ✓ Each command is provided with help for:
  - Syntax for the command.
  - Explanation of use.
  - Example code.



# What's a Microcontroller?

**PBASIC Syntax Guide**

Hide Back Print Options

Contents Index Search


Type in the keyword to find:

debug

- DEBUG
- DEBUGIN
- DEC
- DIG
- DIRS
- DO
- DTMFOUT
- EEPROM
- ELSE
- END
- ENDIF
- ENDSELECT
- EXIT
- FOR
- FREQOUT

Display

## DEBUG



[Example](#)

Syntax: **DEBUG** *OutputData* (*,OutputData*)

### Function

Display information on the PC screen within the BASIC Stamp editor program. This command can be used to display text or numbers in various formats on the PC screen in order to follow program flow (called debugging) or as part of the functionality of the BASIC Stamp application.

- **OutputData** is a variable/constant/expression\* (0 - 65535) that specifies the information to output. Valid data can be ASCII characters (text strings and control characters), decimal numbers (0 - 65535), hexadecimal numbers (\$0000 - \$FFFF) or binary numbers (up to %1111111111111111). Data can be modified with special formatters as explained below.



- ✓ Braces { } in the parameter list indicate those parts are optional.

Syntax: `DEBUG OutputData (,OutputData)`

- ✓ Different styles of BASIC Stamps may not use all instructions, or use them slightly differently. A legend is used to signify which BASIC Stamps are being discussed.



 BASIC Stamp 2 Series Formatting

On the all BASIC Stamps except the BS1, the **DEBUG** command, by default, displays everything as ASCII characters. What if you want to display a number? You might think the following example would do this:



- ✓ Example code is ready to copy, paste, and test though your hardware would need to match in some cases.

```
x      VAR      Byte

Init:
  x = 65

Main:
  DEBUG x              ' Show value of x
  END
```

- ✓ Use Help to look up the END command.



# BASIC Stamp Manual

- ✓ The BASIC Stamp Manual is a bound text with full command listing, examples, explanations, and discussion on use.
- ✓ [Click to purchase or download.](#)
- ✓ This text is also on the Parallax CD.
- ✓ [Click to see other texts](#)







# Need More Help?

- ✓ BASIC Stamps users share and help each other at: <http://groups.yahoo.com/group/basicstamps/>

**Yahoo! Groups : basicstamps - Microsoft Internet Explorer**

Address: <http://groups.yahoo.com/group/basicstamps/>

**Description** Category: [Microcontrollers](#)

**BASIC Stamps GROUP**

The BASIC Stamp ® is a single-board computer that runs the Parallax PBASIC language interpreter in its microcontroller.

This forum is for BASIC Stamp enthusiasts who wish to discuss current projects and ideas and share knowledge between beginners and experts.

This list is brought to you by [Parallax, Inc.](#) While occasional discussion of other products are acceptable, postings intended to advertise other products are unwelcome.

**Membership**

You are a member of this group

[ [Edit My Membership](#) ]  
[ [Leave Group](#) ]

**Group Info**

Members: 2885  
Founded: **Sep 7, 1999**  
Language: **English**

**Group Settings**

- Listed in directory
- Restricted membership
- Unmoderated
- All members may post
- Public archives
- Email attachments are not permitted

**Most Recent Messages** [View all Messages \(32957\)](#)

Jun 17 [Re: Mounting a Memsic accelerometer - mmarpet](#)  
I've been following this thread; I am also using Memsic accelerometers. Just t

Jun 17 [Re: 4-20mA interface... - Pat M](#)  
I use the same one - oodles of channels, 12 bit resolution - costs the same as

Jun 17 [Re: "Chattering" relays solution - steve\\_in\\_nevada](#)  
Tim- Four things: - Maybe just a typo, but I can't make sense of "inA=outB".

Jun 17 [Re: math help - Tracy Allen](#)  
That range you have, 2000 to 65535, allows this other approximation. X

Jun 17 [Re: Erroneous Readings - kwasson](#)  
Thanks for the advice. I do not have a 3K resistor on the ATN line to ground bu

What's a Microcontroller?



## Activity #6: When You are Done

- ✓ When you are done programming, or leave your equipment for any length of time, it's a good idea to disconnect power.
  - With the REV C BoE, turn your switch to position 0.
  - Other boards, remove power.
  
- ✓ This will conserve your batteries and ensures your BASIC Stamp doesn't gain intelligence and try to take over the world!



# Chapter 1 Review

What's a Microcontroller?

- ✓ Devices that use microcontrollers?
- ✓ What is the BASIC Stamp?
- ✓ What is the BASIC Stamp software used for?
- ✓ What are common carrier boards?
- ✓ How is the hardware connected and tested?
- ✓ What are comments? Directives?
- ✓ What are commands? Parameters?
- ✓ What does DEBUG do? How can it be used?
- ✓ What does END do?
- ✓ What are syntax and logical errors?
- ✓ How can you get help?



# Links

- ✓ [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](#)
- ✓ [Electrically Monitored Ecosystems](#)

What's a Microcontroller?