Mechatronics (ROB-GY 5103 Section A)

- **Today's lecture:**
  Introduction to BS2 microcontroller and BS2 Programming, Hardware, & Interfacing
- (See Topics #1 from Main Text for details)

Office Hours

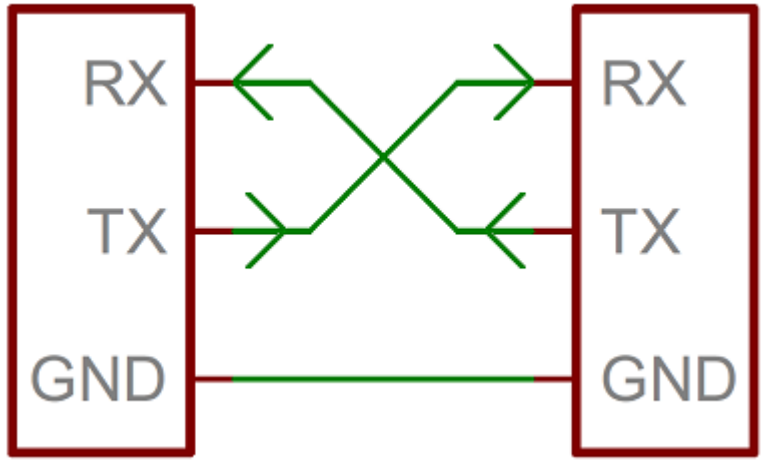
- Updated

MakerSpace

- Do the training
- Do useful things
- Have some fun
- https://makerspace.engineering.nyu.edu/

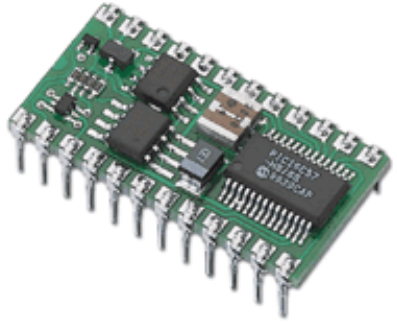
Serial Communications Standards

- Physical interface:
  - Two wires: receiving and sending/transmission between **RX/TX** pins
  - High/Low are voltage levels
- Protocol:
  - How to start?
  - How to stop?
  - One bit at a time
  - MSB (most significant bit)
  - LSB (least significant bit)



Basic STAMP μC

- Name originates from μC's footprint approx. the size of a typical postage stamp
- Simple and easy to use μC platform
- Uses a PIC-based PBasic interpreter
    - PBasic is a form of programming language adapted from Basic for embedded computing applications (**P**arallax **Basic** → **PBasic**)
- Two main lines:
    - Basic Stamp 1 (BS1) introduced in 1992
    - Basic Stamp 2 (BS2) introduced in 1995 (our focus)



Basic STAMP: Overview

Package

- 24 pin DIP (dual in-line package) module useful for hobby purposes, educational environments, etc. Other packages are available for OEMs.

Power

- 5-15 VDC (direct current voltage)
- However, we will use a 9 volt battery power or 6-9 volt wall adapter!

Basic STAMP: Overview

Input/Output

- 16 + 2 Digital I/O pins:
  - 16 TTL-compatible devices can be interfaced
    - All 16 TTL-compatible pins are reprogrammable
      Can change direction (from input pin to output pin and vice-versa) on the fly
  - 2 Serial pins (for USB)
    - One to transmit (TX) and one to receive (RX)
    - Baud rate of 9600 bits per second

*For TTL (transistor-transistor logic) logic family:

- Low or "0" = 0.0 – 0.8 volts
- High of "1" = 2.0 – 5.0 volts

Basic STAMP: Overview

Processing Power

- BS2 is based on PIC16C57 μC
  - PIC16C57 runs at processor speed of **20 MHz** (5 MIPS/Mega instructions per second)
  - BS2 executes **3000–4000** PBasic instructions per second

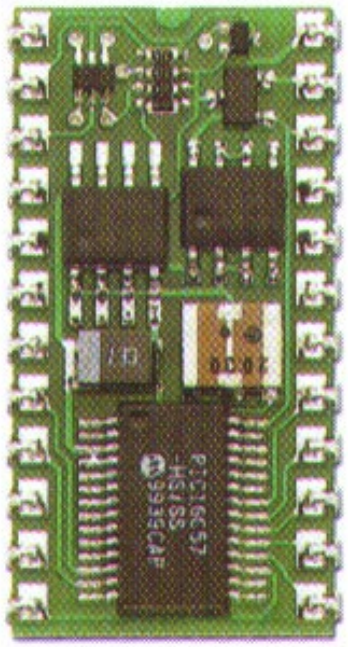
Basic STAMP: PBasic interpreter

- PIC16C57 serves as the hardware platform (manufactured by **Microchip Technology**)
- **Parallax** loads their firmware, i.e., program, onto PIC16C57 ROM and Interpreter Chip
  - PBasic language instruction set is permanently stored on **EEPROM**
  - Recall **P**Basic stands for **Parallax** Basic!

Basic STAMP: Memory

- Non-volatile EEPROM also used to store **user programs**
  - EEPROM size: 2048 bytes ≅ 2KB
  - 2KB of storage allows for up to 500 lines of PBasic code
  - Unused storage can store field data, even on long-term basis!
  - After the program is downloaded, the program stays in EEPROM even after power is removed
- EEPROM can be reprogrammed 10 million times
- Only one program can be stored in EEPROM at a given time

Other BS2 Specs



BASIC Stamp 2

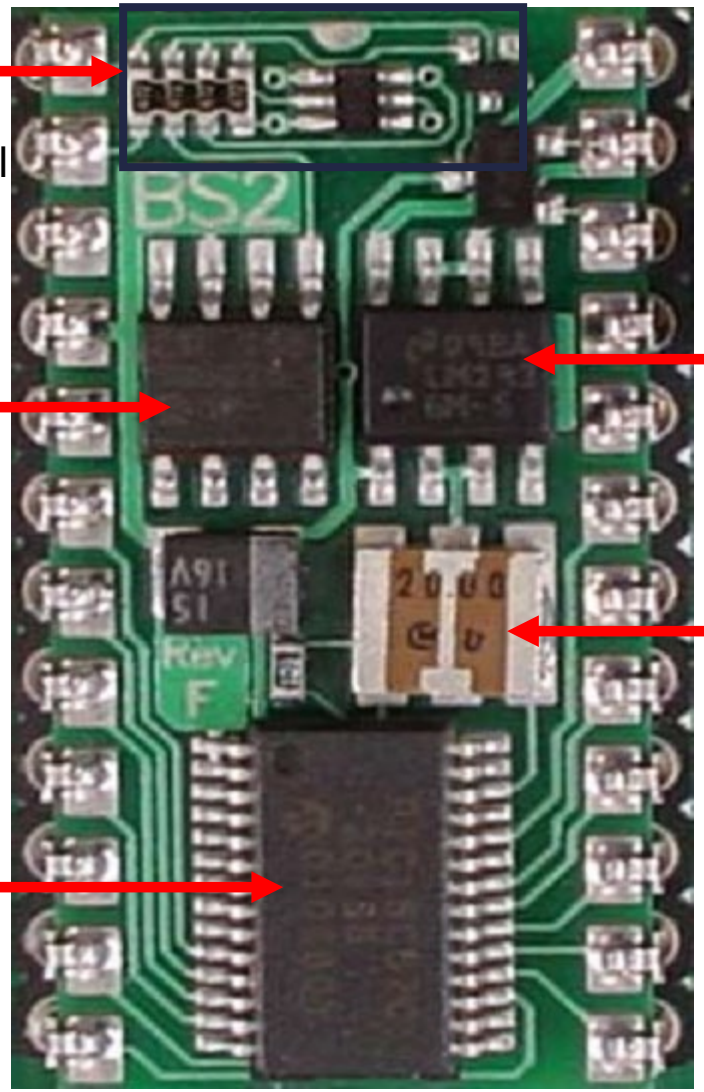
Package:	24-pin DIP
Environment:	0°-70° C (32 -158° F)
Microcontroller:	Microchip PIC16C57
Processor Speed:	20 MHz
Program Execution Speed:	~4,000 instructions/sec
RAM Size:	32 Bytes (6 I/O,26 Variable)
EEPROM (Program) Size:	2K Bytes,~500 instructions
Number of I/O Pins:	16 + 2 Dedicated Serial
Voltage Requirements:	5 - 15 vdc
Current Draw @ 5V:	8 mA Run / 100 µA Sleep
Source/Sink Current per I/O:	20 mA / 25 mA
Source/Sink Current per unit:	40 mA / 50 mA per 8 I/O pins
PBASIC Commands:	36
PC Programming Interface:	Serial Port (9600 baud)
DOS Text Editor:	STAMP2.EXE
Windows Text Editor:	Stampw.exe

BS2 Anatomy — I

Serial Signal Conditioning
Conditions voltage signals between PC serial connection (+/- 12V) and BASIC Stamp (5V)

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.

BS2 Anatomy — II

Pin 1: S_{OUT}

Transmits serial data during programming and using the DEBUG instruction

Pin 2: S_{IN}

Receives serial data during programming

Pin 3: ATN

Uses the serial DTR line to gain the Stamps attention for programming.

Pin 4. V_{SS}

Communications Ground (0V).

Pins 5-20:

Input/Output (I/O) pins P0 through P15

Pin 24. V_{IN}

Un-regulated input voltage (5.5-15V)

Pin 23. V_{SS}

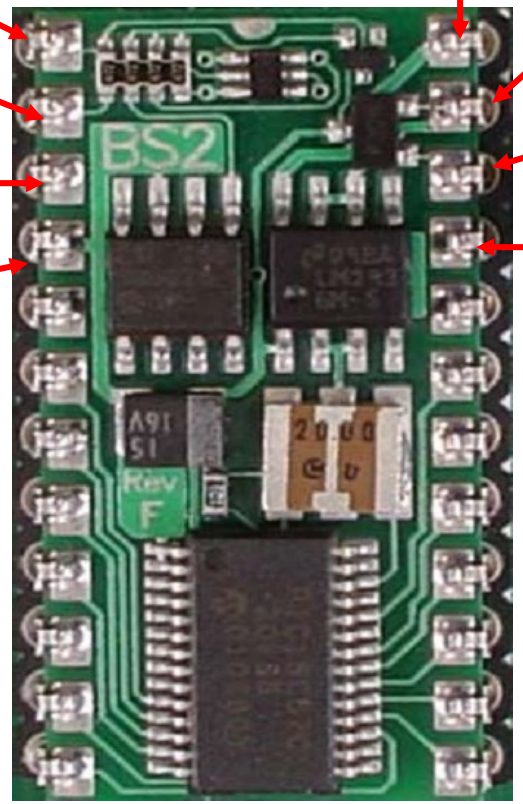
Ground (0V)

Pin 22. RES

Reset- LOW to reset

Pin 21. V_{DD}

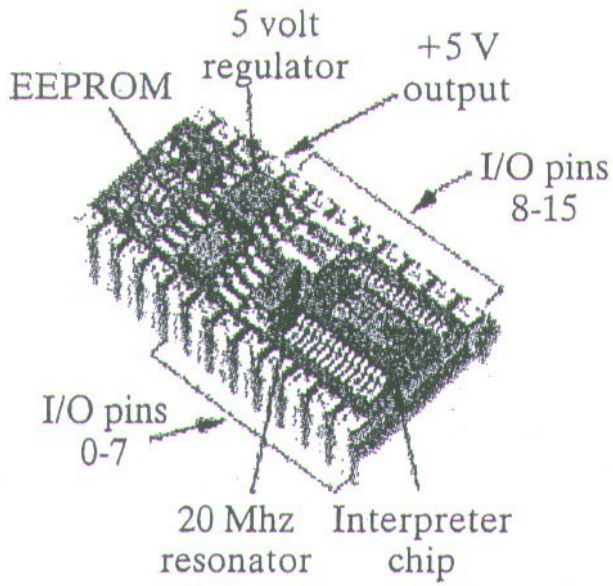
Regulated 5V.

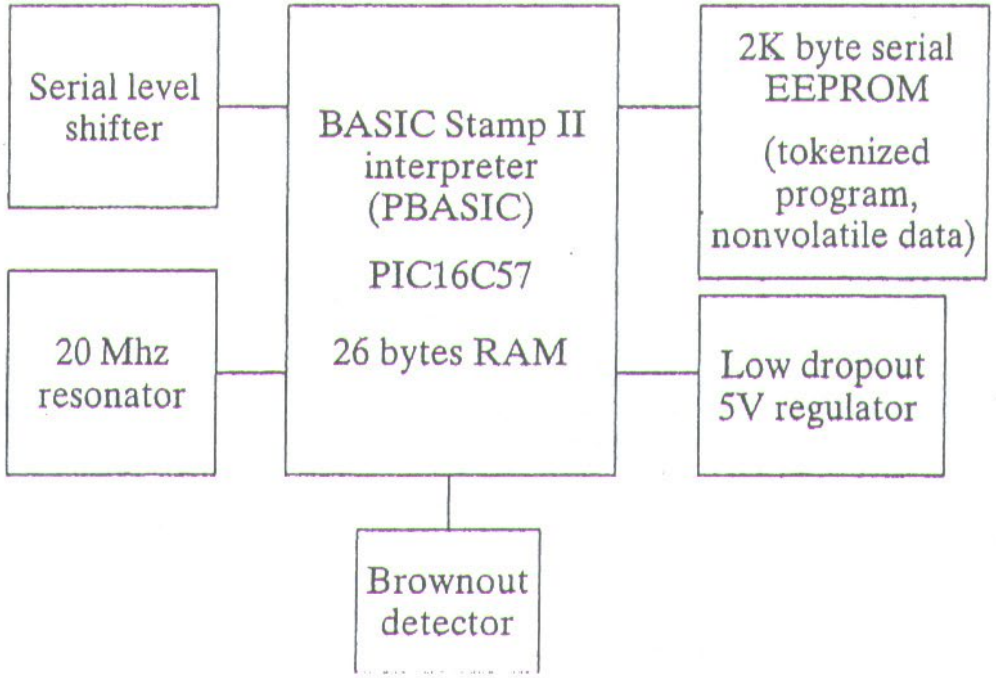


P0 P1 P2 P3 P4 P5 P6 P7

P15 P14 P13 P12 P11 P10 P9 P8

BS2 Anatomy — III

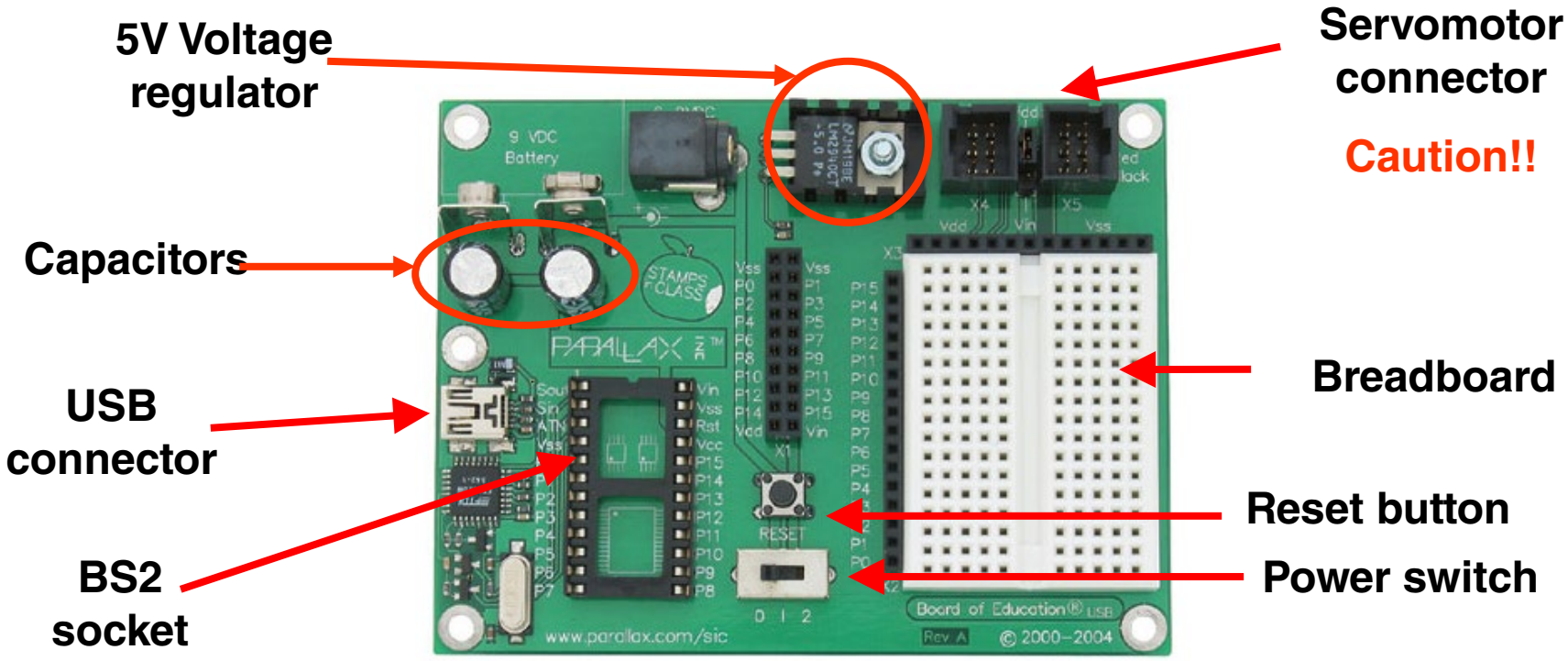




Dropout, Brownout, Blackout

BS2 Development Hardware from Parallax: Carrier/Experiment Board

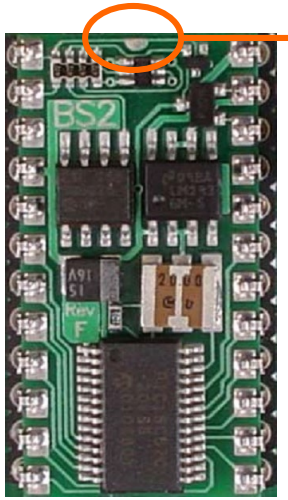
- User can designs power and communication circuits for BS2
- A variety of carrier/experimenter boards are available from Parallax that speed development and testing.
  - The Board of Education (BOE) will be used throughout this course.



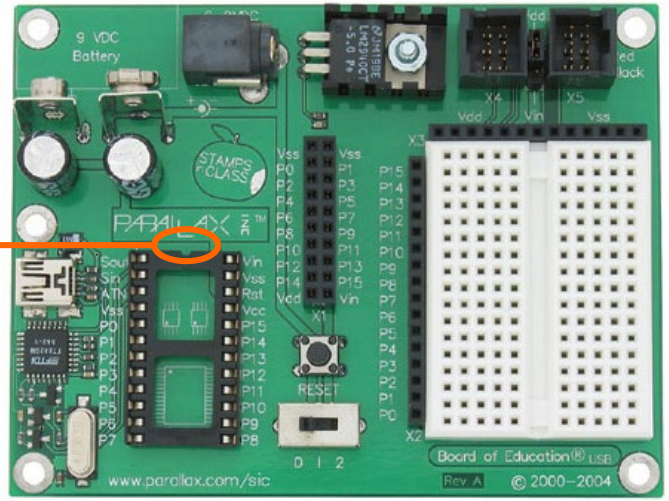
Board of Education

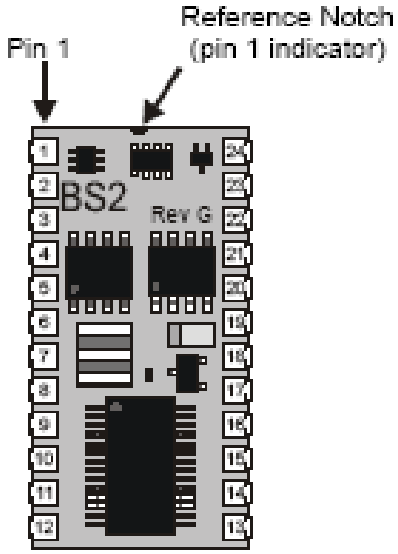
Quick Start: Installing BS2 on BOE

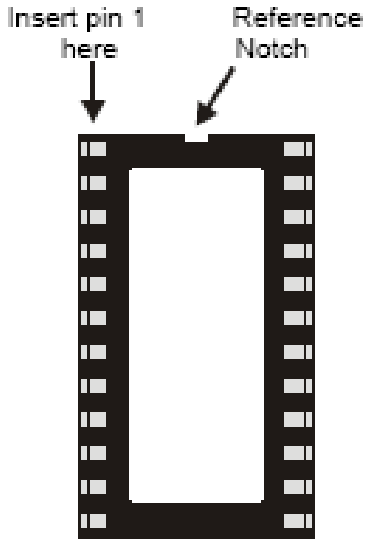
- Notch on BS2 must match with socket on BOE for correct installation direction

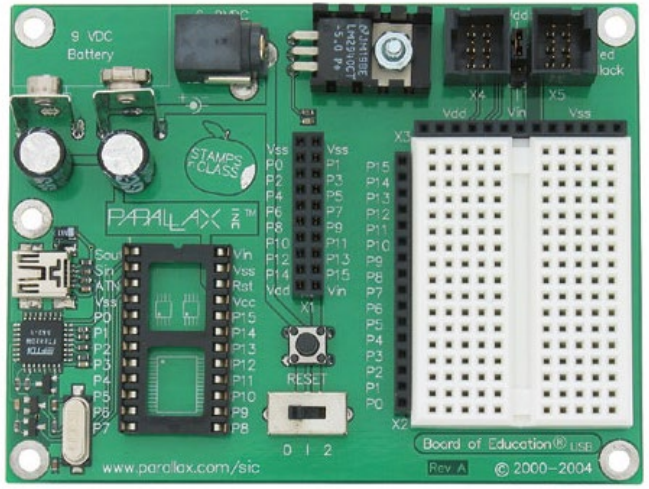


Note the notch at the top of the BASIC Stamp and socket indicating module direction.



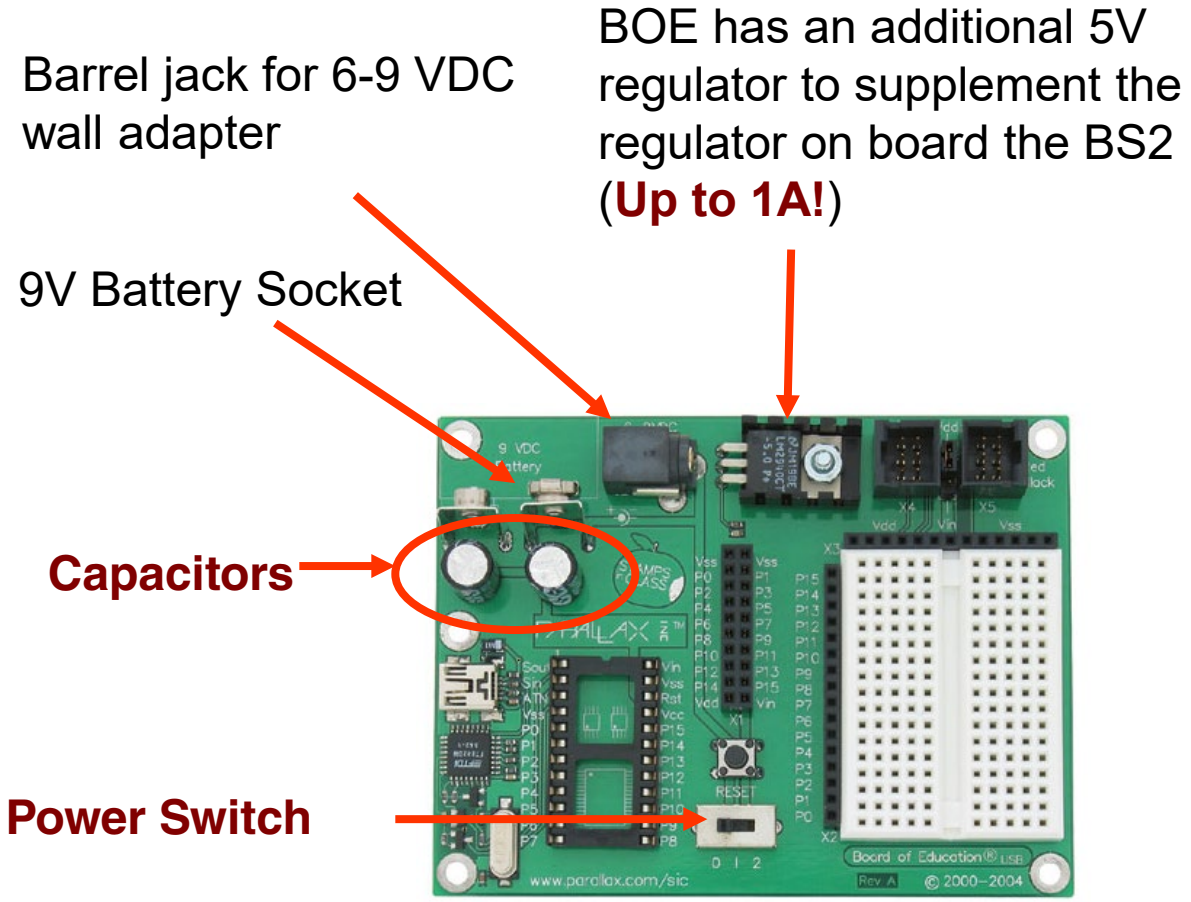






Quick Start: Power Connections

- The Board of Education may be powered using a 9V battery or a wall adapter.
- **Power on:**
  - Connect USB and power source
  - Switch on power switch from 0 to 1 or 2
- **Power off**
  - Switch off power switch from 1 or 2 to 0
  - Disconnect USB and power source

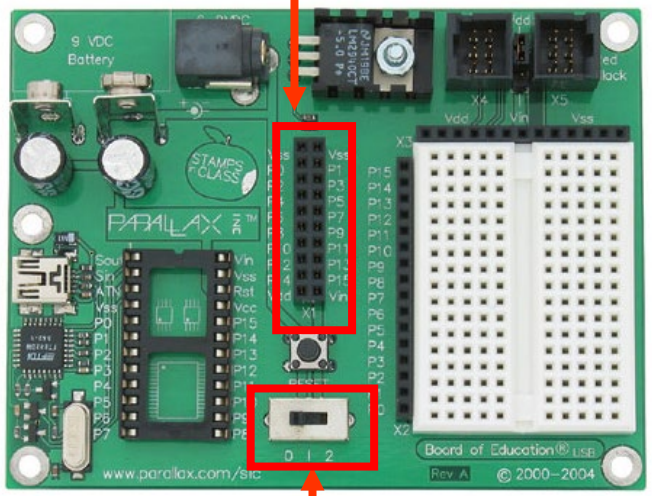


Quick Start: Power Connections

3-Position Power Switch:

- The leftmost position (0) is OFF – all power is disconnected. Always place the switch in this position when adding or changing components on the breadboard.
- The middle position (1) provides Vin (unregulated battery or power supply voltage) to the regulator, the BASIC Stamp socket, and to the connectors marked "Vin." This switch position also makes Vdd (5 volts) available to Vdd sockets on the breadboard and AppMod connectors.
- The rightmost position (2) also provides power to the servo connectors X4 and X5. Especially if your program causes a robot with servos connected to X4/X5 to start moving immediately, you can keep the 3-position switch in position (1) while loading the program, then switch to position (2) when you are ready for the robot to start moving.

AppMod Connector (for other Parallax devices)



Power Switch

Quick Start: Communications/Data Connections

- A serial cable connects the BS2 and the PC's serial communication port (COM port).
  - Specifically, you are using a USB A to Mini B cable
  - Serial means that data is sent or received one bit at a time.
  - The serial cable is used to download the stamp with the program written in the text editor and is sometimes used to display information from the BASIC Stamp using the DEBUG instruction.
    - DEBUG is the only way you can see what is happening "in the code" vs. in the physical circuit

5V Voltage regulator

Servomotor connector

Caution!!

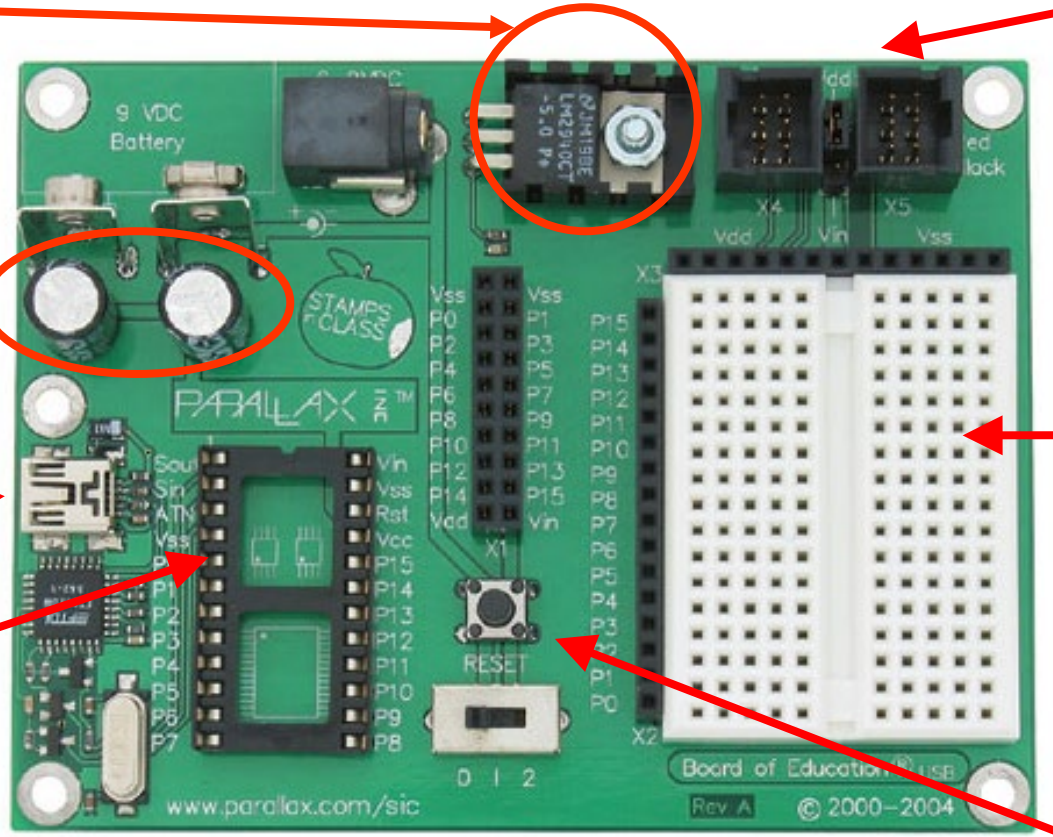
Capacitors

USB connector

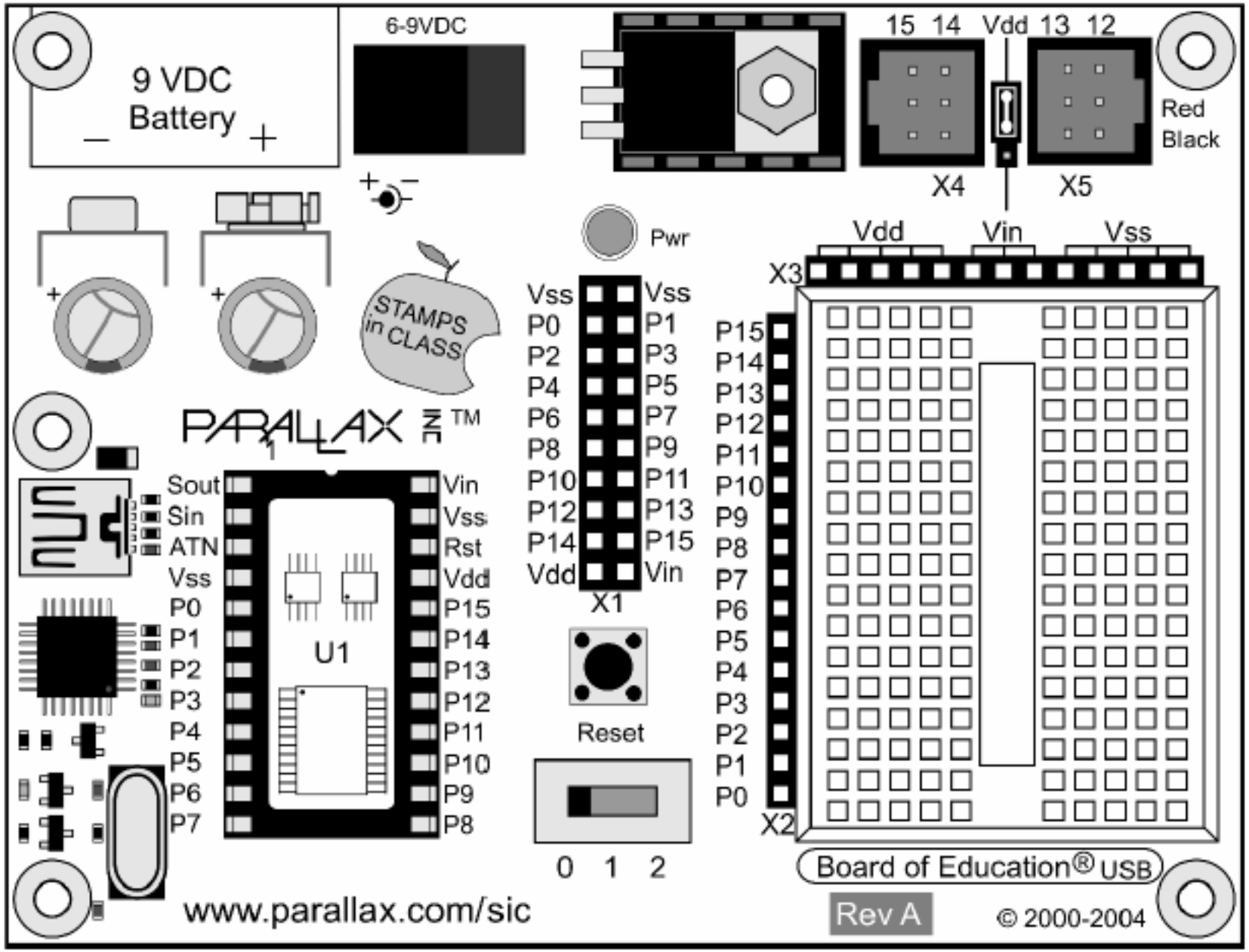
BS2 socket

Breadboard

Reset button



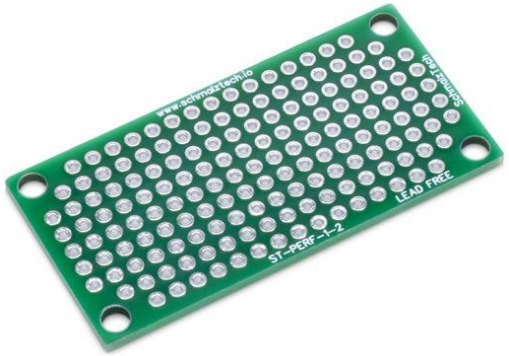
Board of Education

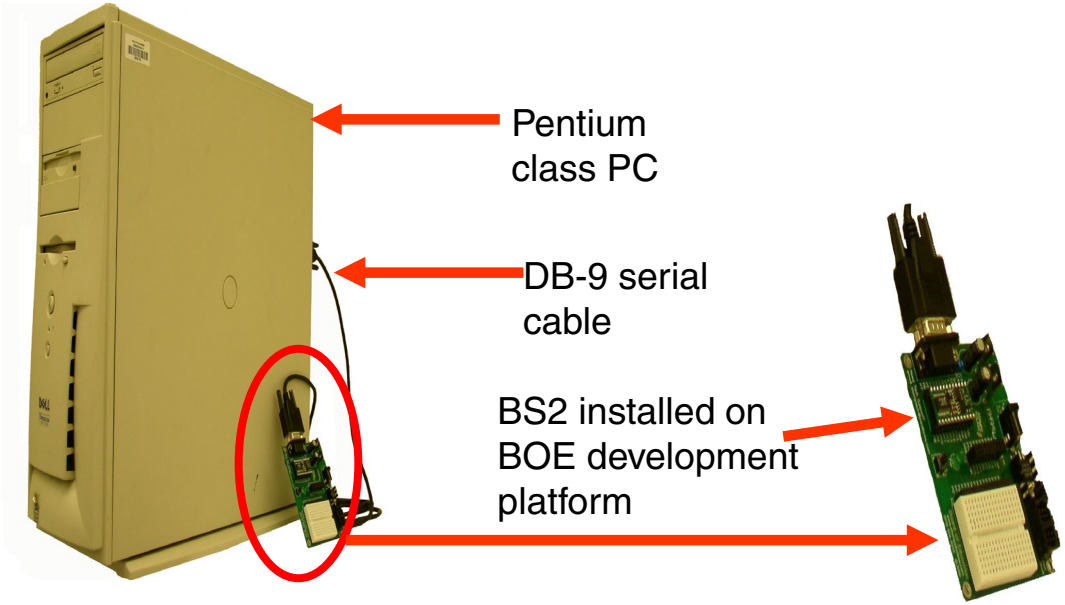


- **Note you are using Rev K**

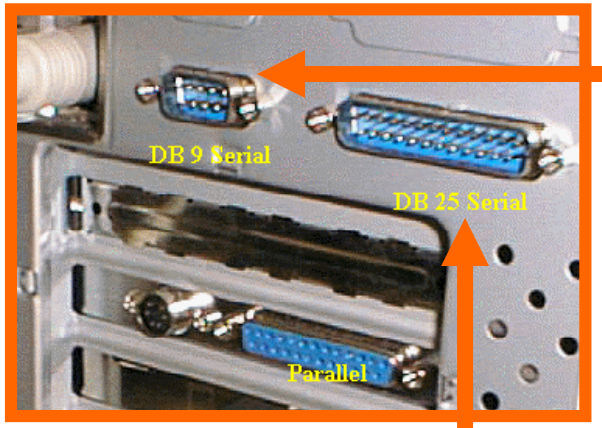
BS2 Development Hardware

- Develop your project circuit on a breadboard, printed circuit board, or perf board.
- Older versions use DB9 programming cable. We use a USB A to mini B cable

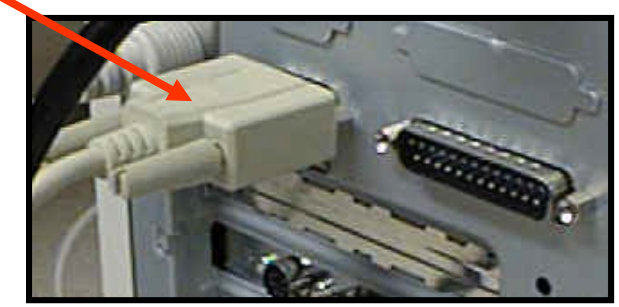


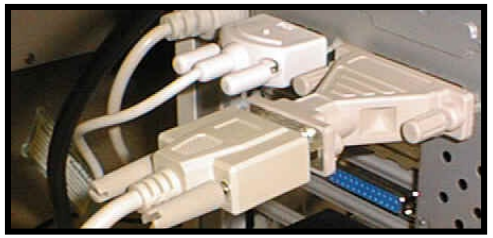


Quick Start: Older Serial Data Connectors

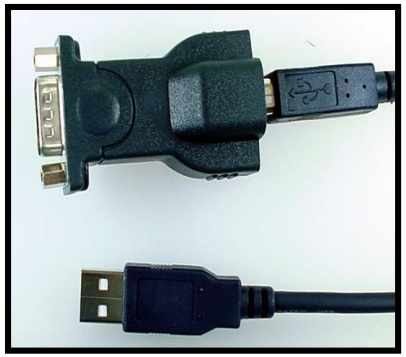


The cable is typically connected to an available DB 9 COM port.





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.

Miscellaneous

- Rubber feet/work on insulating surface
- Servomotor connections X4/X5
  - Vdd is default “jumped” to Red for Servomotors Connections
  - Also connected to P12, P13, P14, and P15 I/O pins

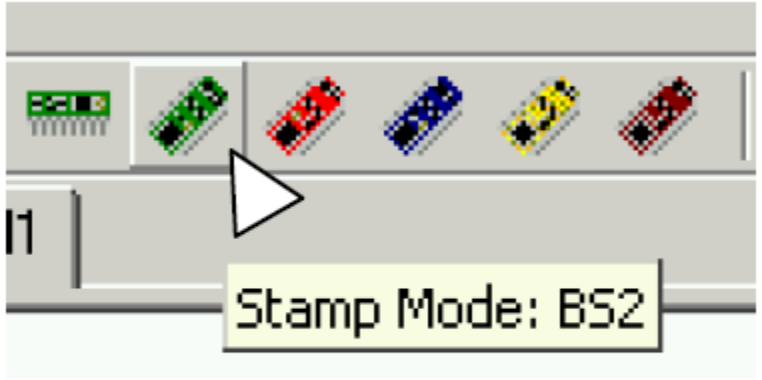
Quick Start: Software Installation

- On Parallax CD: go to Software → Basic Stamp → Windows section to locate latest version of the Basic Stamp Editor software.
- Online: www.parallax.com → Support → Downloads → Basic Stamp Software.
  - **Parallax IDE Chrome for Mac users**
  - **Setup-Stamp-Editor-v2.5.4.exe for Windows users**
- PBasic code for BS2 is written using Windows Stamp Editor: Stampw.exe.

Quick Start: Hello World—I

- Enter the $STAMP and $PBASIC directives from the Basic Stamp Editor's toolbar
  - When using BS2 and PBasic 2.5, the following directives should be placed at the start of the code

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



Click on the icon that corresponds to your BASIC Stamp model to automatically place the $STAMP directive in your program.

Click on the icon for the PBASIC language version that is compatible with your BASIC Stamp model.

Quick Start: Hello World—II

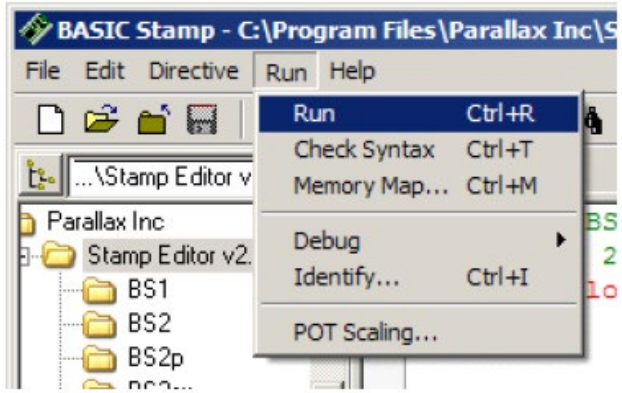
- Type the line DEBUG “Hello World!” below the compiler directives.

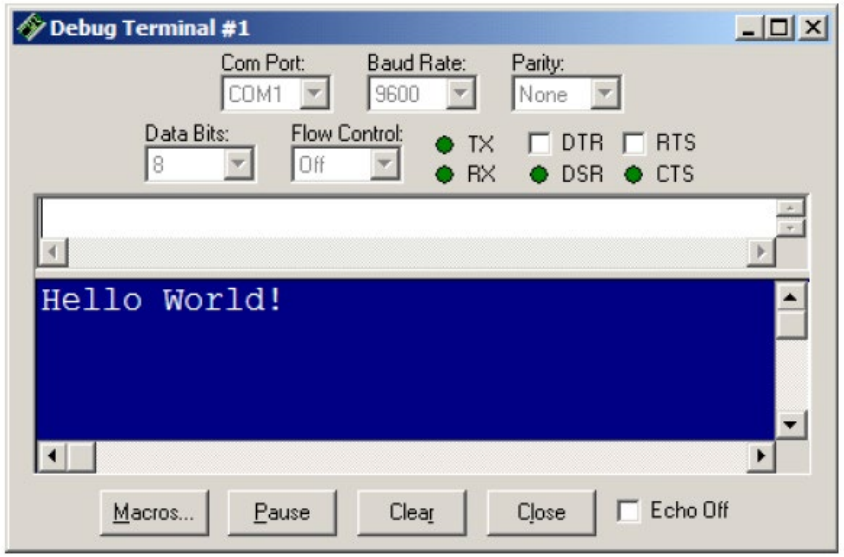
  ```
  ' {$STAMP BS2}

  ' {$PBASIC 2.5}

  DEBUG "Hello World!"
  ```

- Debug instruction sends serial data back to the PC on the serial cable. A *debug terminal window* opens on the PC to display the returning data.
- Tokenize and download this program into the BASIC Stamp.
  - Select Run → Run from the menu bar
  - Press CTRL-R from the keyboard or
  - Click on the Run ► icon on the toolbar
- A progress bar window should appear. Then a debug window should appear and display “Hello World!”
- The "Hello World!" text appearing on the debug terminal window is sent from the BASIC Stamp, through the programming cable, to the PC.
- The DEBUG button may be used to manually open a DEBUG window.





Hands-on Exercises

BASIC Stamp Syntax and Reference Manual 2.2 – DEBUG *BASIC Stamp Command Reference*	**p159 – p169**
DEBUG format	p159
DEBUG basic examples	p162
DEBUG conversion formatter	p163
DEBUG cursor position	p168
DEBUGIN	p171 – p174
StampWorks *Programming Essentials & The Elements of PBASIC Style*	**p.11 – 24**
BASIC Stamp Frequently Asked Questions	**All**