

## BASIC Stamp HomeWork Board

#29158 10-pack of Breadboard version

#29157 10-pack of Through-Hole version

### Introduction

It's not often that we start technical documentation with a bit of marketing punch. If you like the low cost of a BASIC Stamp Rev. D (retails ~\$34) and the idea of a half-price BASIC Stamp 2 / Board of Education (retails ~\$109) then the BASIC Stamp HomeWork board is the ticket for your class. This is the least expensive way to get a large educational group started with the BASIC Stamp.

The HomeWork Boards were created exclusively for educators to *send home with students* with these uses in mind:

- BASIC Stamp-related homework assignments
- Dedicated science-fair, contest or hobby projects
- Students who express personal interest in further developing their BASIC Stamp projects but can't have their own Board of Education / BS2 due to it's higher cost

Since it's less expensive than the Board of Education / BS2 module, can the board be used for Stamps in Class experiments? Possibly, with the following considerations:

- Servo connection ports for robotics are not included on the HomeWork Board. It's possible to use male/male headers for servo connections with a second power supply jumpered to the HomeWork Board to control servos.
- 220 ohm resistors are built into each of the 16 I/O pins for current protection so the PBASIC interpreter cannot be easily damaged. This protects the BASIC Stamp from over-current conditions but also slightly changes the behavior of the Stamps in Class experiments if used on this board based on the command being used.
- Stamps in Class circuit pictorials do not match the HomeWork Board. Again, minor workaround once you understand the difference between the power supply options.
- Power supply is from a 9V battery, not the wall pack.
- Current supply from the on-board regulator is limited to 50 mA versus the Board of Education's amp or more.

However, these cost-reducing limitations do not limit the use of the HomeWork Board for other projects. In fact, the minimalist design is simple to use and entirely flexible for most projects.

## Package Contents

The BASIC Stamp HomeWork Board is sold only in quantities of 10. The reason for this is that the board is intended for the educational market only, to be purchased by educators for use in their classrooms. The kit includes only the boards – nothing else.

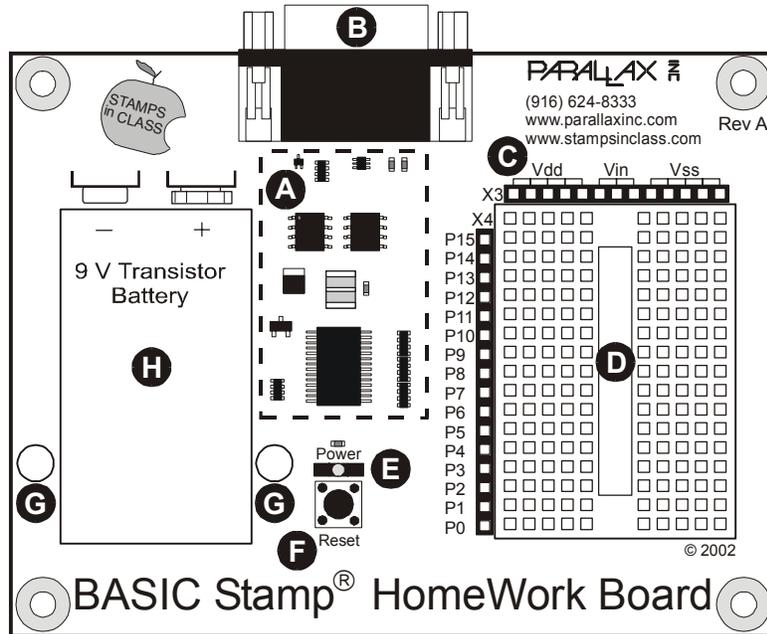
## BASIC Stamp HomeWork Board Hardware Design

BASIC Stamp HomeWork Board uses the BASIC Stamp 2 surface-mounted directly to the printed circuit board. The BASIC Stamp 2 has a wide variety of available support hardware, code examples and applications. Further, it performs most of the same functions of the newer BASIC Stamps though with less speed and memory. The BASIC Stamp 2's technical specifications are shown below (Table 1). Also review the hardware (Figure 1) and schematic (Figure 2).

Table 1		
BASIC Stamp HomeWork Board Specifications.	Microcontroller:	PIC16C57 surface mount
	Speed:	20 MHz / ~4,000 instructions per second
	EEPROM:	2K bytes (program and data)
	Program Length:	500 lines of PBASIC
	RAM (variables):	32 bytes (6 for I/Os and 26 for variables)
	Input / Outputs:	16 (up to 17 RS-232 communication ports)
	Source / Sink Current:	50 mA / 50 mA
	Serial Communication:	300-50K baud I/O
	Current Requirements:	7 mA running, 50 uA in sleep
	PC Interface:	Serial port
	Power Supply:	5 V through an LM2936 regulator from a 9V transistor battery
	Environment:	32 to 158° F (0 to 70° C), 70% non-condensing humidity
	HomeWork Board Size:	3" x 4"
	Project Area:	Built-in breadboard on StampLab
	Microcontroller:	PIC16C57 surface mount
	Speed:	20 MHz / about 4,000 instructions per second
EEPROM:	2K bytes (program and data)	
Program Length:	~500 to 600 lines of PBASIC	

Figure 1

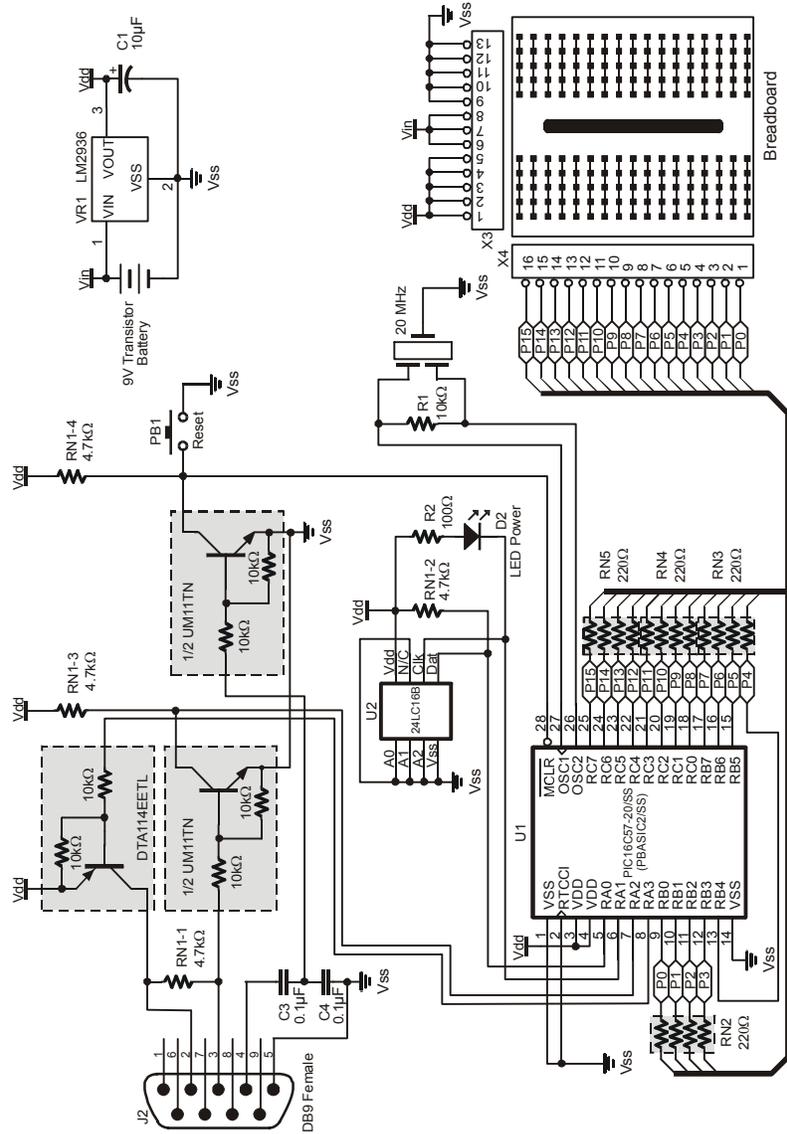
StampLab printed circuit board keyed with part identifications.



- A. **BASIC Stamp 2 Module.** The BASIC Stamp is comprised of several components: PIC16C57-20/SS - a Microchip 2K 8-bit microcontroller programmed with the the BASIC Stamp “Interpreter” that runs the Parallax BASIC Stamp code like a mini operating system; the 24LC16B EEPROM - a Microchip 2K EEPROM (electrically erasable programmable read-only memory) with a user-modifiable read-only memory (ROM) that can be reprogrammed with your BASIC Stamp code; a 20 mHz resonator to provide an accurate clock source for the BASIC Stamp; 220 Ohm resistors across the I/O pins to provide current protection for mistake wiring; an LM2936 voltage regulator which provides 50 mA for the BASIC Stamp and your circuits powered from the breadboard’s Vdd connection.
- B. **DB-9 Female.** The DB-9 port connects via serial cable to your PC’s serial port. This port is used to download programs to your BASIC Stamp and for the BASIC Stamp to send data back to the PC.
- C. **Power and Ground Connections.** Vdd is regulated 5V, Vin is 9V from the transistor battery, Vss is ground.
- D. **Breadboard.** Two areas of 5 column x 17 row breadboard project area. Connections are horizontal separated by the trough.
- E. **Power Button.** Illuminated when the BASIC Stamp is running a program only.
- F. **Reset Circuit.** Reset the BASIC Stamp by pressing this button.
- G. **Battery Tie-Downs.** If using the HomeWork Board Through-Hole Version for projects involving high-vibration (on R/C airplanes, robots, etc.) a “zip-tie” can hold the battery firmly to the board if looped through these holes.
- H. **Power Supply.** Accepts a 9V battery.

**Figure 2**

**BASIC Stamp HomeWork Board Schematic**



**Power Consumption and Battery Life**

Parallax normally designs BASIC Stamp boards with power jacks for wall transformers. Wall transformers provide plenty of power but they are not as portable for science fairs, robots and environmental datalogging. Considering that the BASIC Stamp draws only small amounts of current it could be deployed in a remote location and run from a battery for a long time.

The BASIC Stamp has commands for reduced power consumption, but what about the power indicator LED? It could drain the battery in a day or two by itself if being used to indicate a power supply! LEDs consume current, typically 10-12 mA. Removing the LED wasn't an option since it discloses the common technical support problem of a missing power supply.

The solution was to connect BASIC Stamp HomeWork Board's power LED to the "clock" line of the BASIC Stamp's EEPROM. The EEPROM's clock line is active only when the BASIC Stamp is actually running a program. Moreover, the BASIC Stamp HomeWork Board's power LED is a low current LED consuming only about 2 mA.



MilliAmp hours is a statistic measuring the amount of energy stored in a battery. For example, if you have a 1 mA-hr battery and a project drawing 0.5 milliamps, the battery will last for two hours. A typical 9V Duracell alkaline transistor battery provides about 565 milliAmp hours of energy.

If the BASIC Stamp is being used in a project where at least *some* small amount of time is spent doing nothing you can put it in a low-power mode to extend battery life using the SLEEP command (Table 2). The duration which you put the BASIC Stamp to SLEEP is accurate to  $\pm 1\%$  at 75° F and can range from 2.3 seconds to 18 hours (you can “wake up” and go back to sleep after 18 hours). By comparison, the PAUSE command is simply a delay in a PBASIC program yet the BASIC Stamp continues to draw full operating current. See the BASIC Stamp Windows Editor on-line help for all the details on the SLEEP and PAUSE commands.

Table 2			
BASIC Stamp 2 and Power LED current draw during different modes of operation.	BASIC Stamp Current Draw	Power LED Current Draw	Possible Battery Life
PAUSE Mode	8 mA	2 mA	(565 mAh/10 mA) = 56.5 hours
SLEEP Mode	40 $\mu$ A	0 mA	(565 mAh/(40 $\mu$ A/1000 mA) = 14,125 hours

Note: 1 mA is 1/1,000<sup>th</sup> of an Amp. 1 microAmp ( $\mu$ A) is 1/10,000<sup>th</sup> of an Amp.

Maybe putting a BASIC Stamp to SLEEP permanently only demonstrates that a 9V battery can last almost two years if you wake the BASIC Stamp once in a while. In reality, projects need to wake up and provide current to “loads” like LEDs and other chips used in your project. If you know the current draw of the individual components and how long they are activated you can make an educated guess at total current consumption and battery life. If you’re only visiting your North Pole weather station annually even a small battery can provide a long lifespan for the BASIC Stamp, not to mention larger batteries with more milliamp hours.

To clarify the BASIC Stamp’s different power consumption operating scenarios and their effects on battery life review the following two programs in conjunction with Table 2. Downloading and understanding these programs will require a look ahead to future chapters, so be prepared to re-visit this section.

Both programs have the same result. The BASIC Stamp will send numbers to the BASIC Stamp Windows Editor debug window and then go into a period of inactivity for a second. With the PAUSE example the power LED remains on because the EEPROM is still communicating with the BASIC Stamp interpreter chip, but with the SLEEP example the EEPROM is shut down and the power LED is off.

With this example the Power LED remains on when the PAUSE command is executed. Current consumption remains at 10 mA.

```
' POWER DEMO - PAUSE.BS2
' Demonstrating the power LED with SLEEP command
' {$STAMP BS2}

' I/Os, Constants and Variable definitions
loopCounter    VAR    Byte

' Main Program
Start:
FOR loopCounter = 0 to 99
  DEBUG Home, "loopCounter =", dec loopCounter
NEXT
PAUSE 1000
GOTO Start
```

With the SLEEP example the Power LED turns off when the SLEEP command is being executed because the EEPROM is inactive. Current consumption is 10 mA while the loop is being executed but drops to 40  $\mu$ A during the SLEEP command.

```
' POWER DEMO - SLEEP.BS2
' Demonstrating the power LED with SLEEP command STEve
' {$STAMP BS2}

' I/Os, Constants and Variable definitions
loopCounter    VAR    Byte

' Main Program
Start:
  FOR loopCounter = 0 to 99
    DEBUG Home, "loopCounter =", dec loopCounter
  NEXT
  SLEEP 1
  GOTO Start
```

## Precautions

Be alert to static sensitive devices and static-prone situations. The BASIC Stamp, like other integrated circuits, can be damaged by static discharge that commonly occurs touching grounded surfaces or other conductors. Environmental conditions (humidity changes, wind, static prone surfaces, etc) play a major role in the presence of random static charges. It is always recommended to use grounding straps and anti-static or static dissipative mats when handling devices like the BASIC Stamp. Since you don't have a dissipative mat, touch a grounded surface after you have approached your work area. This isn't as critical as you might think but being prudent only protects your hardware.

Before building circuits, disconnect the battery.

## Quick Start Programming Guide

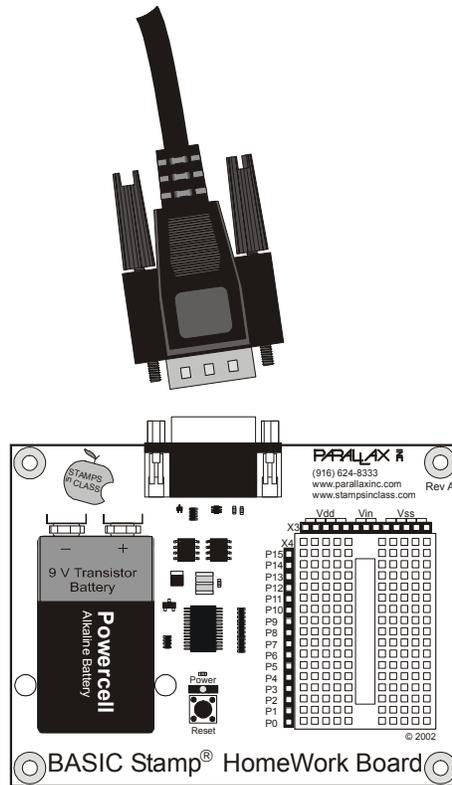
This chapter is a quick start guide to connecting the BASIC Stamp to the PC and programming it. Without even knowing how the BASIC Stamp functions, you should be able to complete the exercise without difficulty.

### Connecting Serial Cable and Power Supply

Connect the 9-pin female side of a serial cable to an available serial port on your computer. Connect the 9-pin male side of the cable to the DB9 connector to BASIC Stamp HomeWork Board. Plug in a 9V transistor battery to BASIC Stamp HomeWork Board (Figure 3).

Figure 3

Connect 9V battery and the serial cable to your StampLab.



The serial cable is straight-through and it is not a null modem cable. If you have null modem cables laying around put them away so you don't create an unnecessary problem.

### Install the BASIC Stamp Windows Editor Software

The BASIC Stamp Windows Editor is available for download from [www.parallaxinc.com](http://www.parallaxinc.com). Download and install as shown in Figures 4 through 8.



BASIC Stamp Windows Editor is frequently upgraded and improved with additional features. It is often a good idea to visit [www.parallaxinc.com/editor](http://www.parallaxinc.com/editor) to download the most recent version.

Figure 4

Software install  
Step 1 – just click  
“Next”.

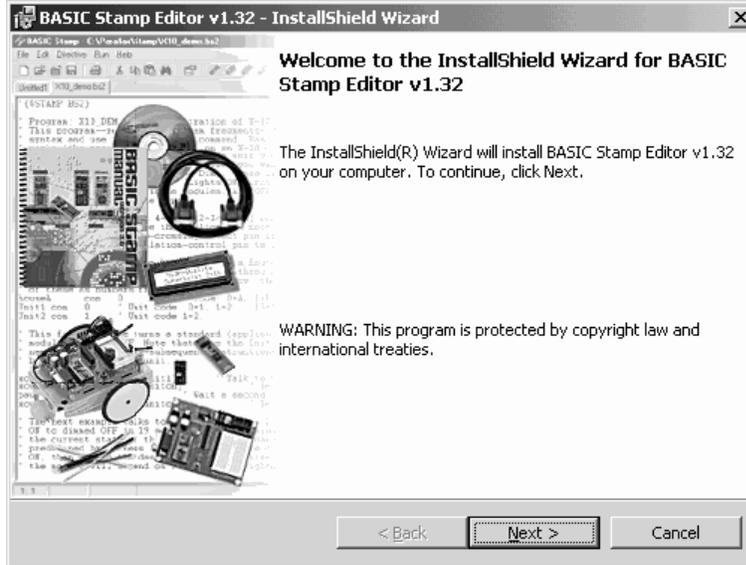


Figure 5

Software install  
Step 2. Choose  
“Typical” for a  
standard  
installation.

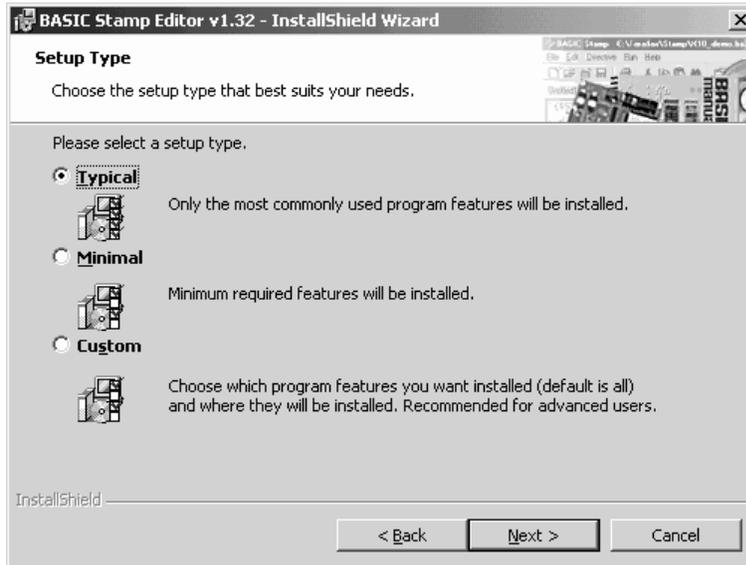


Figure 6

Software install  
Step 3. Click  
“Install” and finish  
the process.

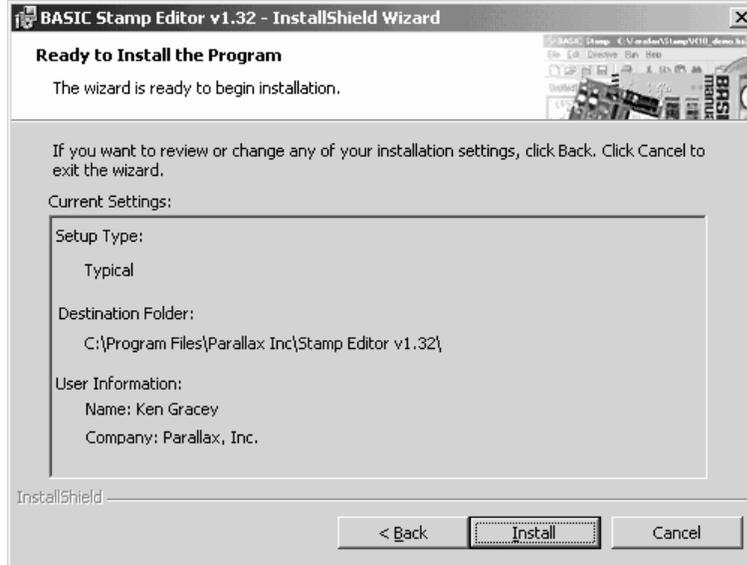


Figure 7

Finish the  
installation  
process..



## Downloading a Program

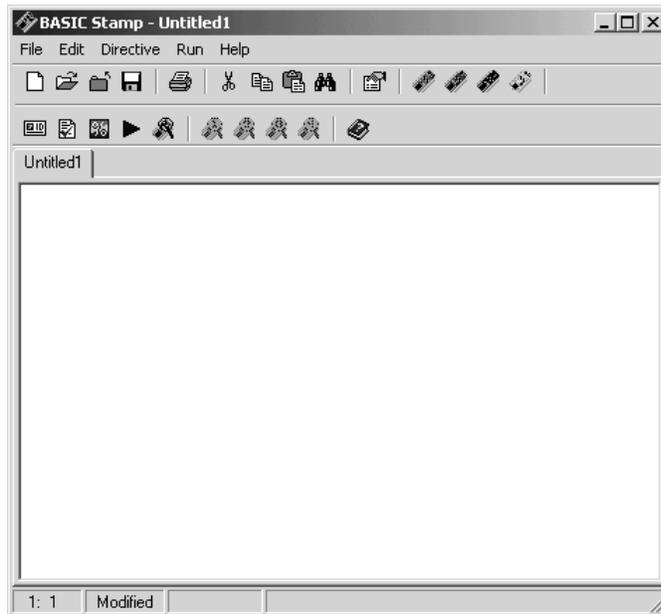
The BASIC Stamp Windows Editor was designed to be easy to use and mostly intuitive. Those who are familiar with standard Windows software should feel comfortable using the BASIC Stamp Windows Editor (Figure 9).

The editor consists of one main editor window that can be used to view and modify up to 16 different source code files at once. Each source code file that is loaded into the editor will have its own tab at the top of the page labeled with the name of the file. Source code that has never been saved to disk will default to “Untitled#”; where # is an automatically generated number. A user can switch between source code files by simply pointing and clicking on a file’s tab. File | Save allows the naming and saving of a file.

After entering the desired source code in the editor window, selecting Run -> Run (or pressing Ctrl-R) will tokenize and download the code to the BASIC Stamp (assuming the code is correct and the BASIC Stamp is properly connected).

Figure 9

BASIC Stamp  
Windows  
Editor.



Because the Windows editor supports more than one model of the BASIC Stamp, it is necessary to tell the editor which model you are trying to program. The STAMP directive is a special command that should be included (near the top) in a program to indicate the model of BASIC Stamp targeted. The line below is an example of the STAMP directive (in this case, it indicates that the program is intended for a BASIC Stamp 2):

```
' { $STAMP BS2 }
```

This line should be entered into your code, usually near the top, on a line by itself. The STAMP directive is read and acted upon by the BASIC Stamp Windows Editor any time a source code file is loaded, tokenized, downloaded (run). In order to test communication between the BASIC Stamp and your PC, download a simple program as shown below.

```
' { $STAMP BS2 }  
DEBUG "Hello World!"
```

After you've typed in the program, download it using the ► button or the Run | Run menu. If it worked, you'll see a blue "debug" window which displays characters sent by the BASIC Stamp to the PC for display (Figure 10).

Communication Problem? If the PC didn't successfully communicate with the BASIC Stamp, you would have received an error message similar to this one.

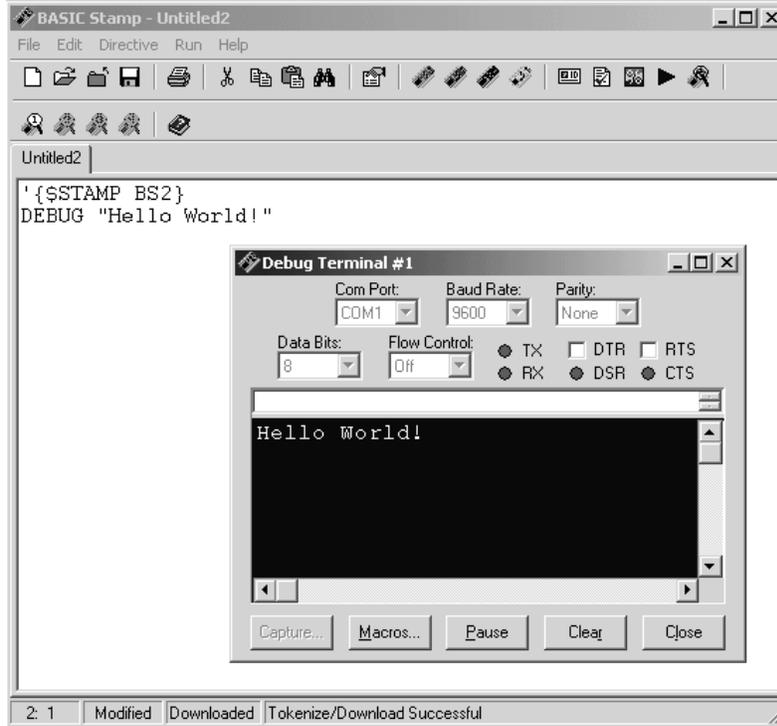
Troubleshooting suggestions:

- Check power supply and serial cable connection to PC
- Disable any communication port devices (Palm Pilots)
- Use CTRL-I to "identify" the BASIC Stamp. Put the successful COM port number in the Edit | Preferences | Editor Operation | Default COM port



**Figure 10**

Successful BASIC Stamp program download.



Want to program with a Palm Pilot, Macintosh or using Linux? In August 2002 Parallax released compiled "tokenizer" code that enables developers of other platforms to design programming interfaces for different operating systems. Check [www.parallaxinc.com/editor](http://www.parallaxinc.com/editor) for possible releases.

### File, Editing and Coding Shortcut Keys

The BASIC Stamp Windows Editor supports several shortcut keys that will speed your use of file management, editing and coding (Tables 3 to 5).

**Table 3**

File Functions shortcut keys.

Shortcut Key	Function
Ctrl+O	Open a source code file into the Editor window
Ctrl+S	Save current source code file to disk
Ctrl+P	Print current source code

**Table 4**

Editing functions shortcut keys.

Shortcut Key	Function
Ctrl+Z	Undo last action
Ctrl+X	Cut selected text to the clipboard
Ctrl+C	Copy selected text to the clipboard
Ctrl+V	Paste text from clipboard to selected area
Ctrl+A	Select all text in current source code
Ctrl+F	Find or Replace text
F3	Find text again
F5	Open Preferences window

**Table 5**

Coding functions  
shortcut keys.

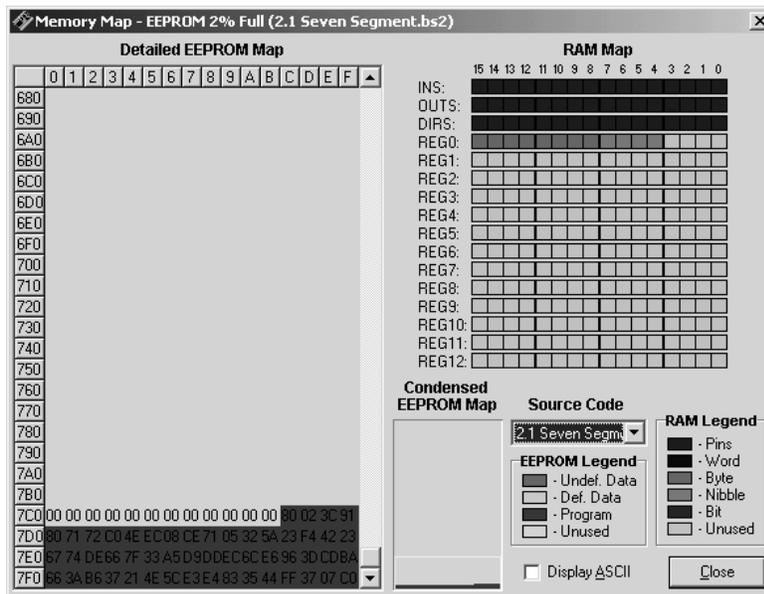
Shortcut Key	Function
F6 or Ctrl+I	Identify BASIC Stamp firmware
F7 or Ctrl+T	Perform a syntax check on code and display error messages
F8 or Ctrl+M	Open Memory Map window
F9 or Ctrl+R	Tokenize code, download to BASIC Stamp and open DEBUG window if necessary
Ctrl+	Switch to Editor window
ESC	Close current window

### Memory Map

The BASIC Stamp Windows Editor also features a Memory Map. The left side displays the amount of EEPROM being used by the current PBASIC program and any data you have stored. Put your cursor over the small yellow box and slide it up and down to see how much of the EEPROM your program is using. The right side of the Memory Map shows RAM (variables) register usage. Type CTRL+M, or press F7, to activate the Memory Map.

**Figure 11**

Memory Map example showing EEPROM usage (left side) and RAM usage (right side).



### BASIC and Parallax BASIC

BASIC (standing for Beginner's All Purpose Symbolic Instruction Code) was written (invented) in 1963, at Dartmouth College, by mathematicians John George Kemeny and Tom Kurtzas as a teaching tool for undergraduates. BASIC's popularity was spread by both Paul Allen and William Gates, in 1975. Gates and Allen (both Microsoft founding fathers) wrote a version of BASIC for the Altair personal computer. It was the first product Microsoft sold. Later Gates and Microsoft wrote versions of BASIC for the Apple computer, and IBM's DOS which Gates provided came with its' version of BASIC.

Parallax BASIC Stamps are programmed in PBASIC. This language is intended to be a simple, easy to learn language that is also well suited for the BASIC Stamp's architecture. It includes many of the instructions featured in other forms of BASIC (GOTO, FOR...NEXT, IF...THEN) as well as some specialized instructions (SERIN, PWM, BUTTON, COUNT and DTMFOUT). The BASIC Stamp Manual on the CD-ROM includes an extensive section devoted to each of the available instructions.

## Example Program

### Introduction

As we mention in the section on electronics fundamentals, Light Emitting Diodes (LED) are the most widely used indicators in the electronics world. They come in a tremendous variety of colors, shapes and sizes. Their low current requirements make them perfect for digital control. Through a simple series of experiments, you'll learn how to have control over an LED and also the ins-and-outs of working with BASIC Stamp microcontroller outputs. With this knowledge you'll be able to extend your digital control of the outside world to relays, motors – to any device that requires on or off control.

For our first experiment we'll need just an LED and a 220-ohm (Red-Red-Brown) resistor. Connect the 220-ohm resistor between pin P15 and the breadboard. Connect the LED between the same section of the breadboard and Vss. If you look closely at the LED you'll notice that one side of the body has a flat spot. The leg near the flat spot is the cathode side of the LED and connects to Vss (Figure 5.1).

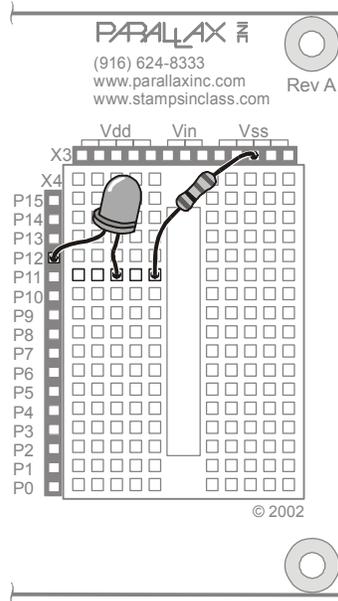
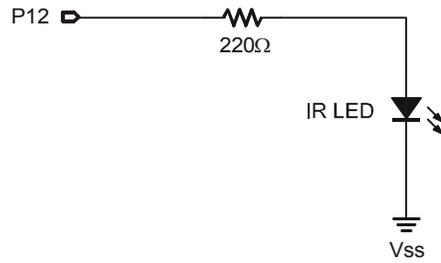
### How it Works

You know by now that we must provide a *forward-biased* current through the LED in order for it to illuminate. For this to happen, the anode (arrow) must be more positive in respect to the cathode (bar).

The BASIC Stamp output pins can have one of two states: off (0 volts) or on (5 volts). So if we cause the P15 output pin to be on, we will provide five volts to the anode of the LED through the resistors. In our circuit the LED will be forward biased and illuminate.

Figure 12

Blinking LED circuit.



### Code Listing

The simplest way to control a BASIC Stamp output pin is with the HIGH (on) and LOW (off) commands. Both commands require a pin number parameter. Let's take a look at Listing 1a to see HIGH and LOW in action.

```
' {$STAMP BS2}
' Program: LED Blink.BS2
' Purpose: Blinks an LED connected to BASIC Stamp pin P15
'
'-----
Start:
HIGH 15          ' turn LED on
PAUSE 500        ' wait one-half second
LOW 15           ' turn LED off
PAUSE 500        ' wait one-half second
GOTO Start       ' do it again
```

As you can see, the program starts by making pin 15 go high (5 volts). This will cause the LED to light. In order for us to see it, though, we must insert some time before we turn it back off. We can create a short program delay with the PAUSE command. Like HIGH and LOW, PAUSE requires a value parameter. For PAUSE, the value that follows is the delay time in milliseconds ( $1/1000$  second). In our program a PAUSE value of 500 will allow the LED to stay lit for one-half second.

Next, we make the LED control pin go to zero volts with LOW. With zero volts on both sides of the LED, no current can flow and it turns off. Again, we use PAUSE to create a delay so that we can actually see that it is off. Finally, we start the process over by jumping to the line labeled Start with the GOTO command.

Download and run the program – you should see the LED blink happily on and off. If you don't, double-check your connections; especially the orientation of the LED. If it doesn't blink you may have it in backward.

Now, as exciting as that was, we can do more and write "better" code. Better code is code that not only works, but is easy for us and others to understand. Let's improve our little program just a bit. Take a look at Listing 1b.

```
'{$STAMP BS2}

' Program: LED Blink.BS2 (Version B)
' Purpose: Blinks an LED connected to the BASIC Stamp

' -----

LedPin    CON    15      ' LED control pin
' -----

Start:
HIGH LedPin      ' turn LED on
PAUSE 500        ' wait one-half second
LOW LedPin       ' turn LED off
PAUSE 500        ' wait one-half second
GOTO Start      ' do it again
```

In this version we introduce constant (CON) values. Constants give us a way to assign a useful name to a value that doesn't change. There are a couple of good reasons for using constants in our program:

1. If we need to change the pin that controls the LED, we only have to change one place in the program. Using constants prevents program errors by not catching all the changes required when circuit connections are modified.
2. By using a constant, we now have more of an idea of what is being controlled. HIGH 15 could be controlling anything; a light, a bell, a heater. We're forced to explain the process of our program in comments. By using the constant name LedPin, others reading our code know what is being controlled and we can spend less energy explaining with comments.

Okay, so I'll bet you're wondering just how constants work.. They're actually used by the editor when the program is being compiled to run on the BASIC Stamp. At the beginning of the compilation process the editor will replace all the appearances of a constant name with its defined value. In our program, HIGH LedPin will be replaced with HIGH 15 and the program will work just as in our first version. And don't worry, this replacement is an internal process used by the compiler – our source code listing will not be changed.

Give it a try. You'll see that the program runs exactly the same as it did the first time. This time, though, our listing makes a bit more sense. Ready for more?

One of the things that makes HIGH and LOW easy is that each command actually does two operations – that's right, two. You see, to control a Stamp output pin we have to deal with two internal registers. The first is called Dirs. The Dirs register is 16 bits wide; one bit for each I/O pin. When a bit in the Dirs register is zero (default at start-up), the associated I/O pin will be an input. When we make a Dirs bit a one, the associated I/O pin will be an output.

The other register that we need to concern ourselves with is called Outs. Like Dirs, Outs is 16 bits wide. In this case, the bits in Outs are connected to the I/O pins when the associated Dirs bits are set to one. When a bit in

Outs is a zero, the associated output pin will be low (0 volts). When a bit in Outs is one, the associated output pin will be high (5 volts).

So, HIGH 15 is the same as:

```
Dir15 = 1
Out15 = 1
```

and LOW 15 is the same as:

```
Dir15 = 1
Out15 = 0
```

You'll remember from the variables overview in Chapter XX that Dirs and Outs can be accessed as a Word (16 bits), as two Bytes (8 bits), as four Nibbles (4 bits) or as 16 individual Bits. So, Dir15 corresponds to bit 15 of the **Dirs** register.

The advantage of going to this depth is that we can gain more flexibility and control over our programs – especially in terms of readability (this aspect will become much more important as our programs grow). Take a look at Listing 1c. Notice how we really don't need any comments to explain what's going on? Pretty cool, huh?

```
'{$STAMP BS2}
' Program: LED Blink.BS2 (Version C)
' Purpose: Blinks an LED connected to the BASIC Stamp

'-----

LedPin   VAR   Out15   ' LED on/off control
LedCtrl  VAR   Dir15   ' LED i/o pin control

On       CON   1
Off      CON   0

'-----

Initialize:
  LedCtrl = %1           ' make LED pin an output

Start:
  LedPin = On
  PAUSE 500
  LedPin = Off
  PAUSE 500
  GOTO Start
```

## Advanced LED Control

Another advantage to this program style is that we can cause the LED to follow the operation of a different value within our program. We can do this because Out15 is actually a bit-sized variable [a value that can change]. We can copy another bit-sized variable to it and cause the LED to follow the value of that variable.

Listing 1d is a bit advanced, but you can handle it. Take a look and then we'll go into all the details.

```
'{$STAMP BS2}

' Program: LED Blink.BS2 (Version D)
' Purpose: Blinks an LED connected to the BASIC Stamp (advanced)

'-----

LedPin    VAR   Out15    ' LED on/off control
LedCtrl   VAR   Dir15    ' LED i/o pin control

blinkVal  VAR   Byte     ' blink control value
blinkBit  VAR   Nib      ' blink control bit

'-----

Initialize:
  LedCtrl = %1          ' make LED pin an output

Start:
  DEBUG CLS
  FOR blinkBit = 0 TO 7      ' test all bits
    FOR blinkVal = 0 TO 255  ' test all values
      ' report
      DEBUG Home
      DEBUG "Blink Value = ", DEC blinkVal, " ", CR
      DEBUG "Blink Bit  = ", DEC blinkBit, CR
      DEBUG CR
      DEBUG "Blink Value = ", BIN8 blinkVal, CR
      DEBUG "Blink Bit  = ", REP "(7 - blinkBit), "^"
      ' control the LED
      LedPin = blinkVal.LowBit(blinkBit)
      PAUSE 5
    NEXT
  NEXT
  GOTO Start
```

In this program we'll need a couple variables. The first is called `blinkVal` and it is defined as a Byte (8 bits). You'll remember that a Byte can hold values from zero to 255. The other variable is called `blinkBit` and is defined as a Nib (4 bits). Being a Nib, `blinkBit` can hold values from 0 to 15, but we only need it to go up to seven. We will use `blinkBit` to point at a bit in `blinkVal` and the LED will follow that bit value. It will be on when the bit is a one; off when the bit is a zero.

The main part of the program starts by opening the DEBUG window and clearing it with CLS (clear screen). The DEBUG statement allows the BASIC Stamp send messages to the PC. This will let us know what's going on inside our program as it's running.

The bulk of the code is two FOR-NEXT loops; one nested inside the other. The outside loop is controlled by `blinkBit` and will run eight times (0 to 7). For each iteration of `blinkBit`, the inner loop, controlled by `blinkVal` will run 256 times (0 to 255). This is where the action takes place.

The first thing we'll do is create a report on what's happening. We start with DEBUG Home which causes the DEBUG cursor [not visible] to move to the first row, first column of the screen. Next we'll print out the values of blinkVal and blinkBit using the DEC modifier to specify their display as decimal numbers. If we leave DEC out, the DEBUG window will attempt to display the characters defined by their current value – that's not what we want.

Then we'll print blinkVal again, this time using the BIN modifier so that we see it as a binary value. Now we can see what's going on inside of blinkVal. As its value changes we'll be able to see the corresponding bits change. Finally, we'll use the value of blinkBit to position a pointer under the current blinkVal bit that is controlling the LED. This line of code uses the REP modifier to repeat a character. In our case we going to repeat a space. We position it under the proper bit by subtracting the current blinkBit value from seven. When blinkBit is zero, this line will print seven spaces, then the pointer. When blinkBit is one, it will print six spaces then the pointer. You get the idea.

Now that we know what's going on, let's make it happen. The line of code that actually controls the LED uses another advanced feature of the PBASIC language: variable modifiers. In this program we're using LowBit. Without an index (the value in parenthesis), LowBit will always point to bit zero of a variable. Since we want to point at all bits, starting with zero and ending with seven, we will use the index. The index value is and offset into the variable from bit zero. So, LowBit(0) points to bit zero, LowBit(1) points to bit one and so on.

And, finally, there is a very short PAUSE so we can see the LED blink when we're on the low bits. In actuality, sending the report to the DEBUG screen takes some time as well and contributes to the overall loop timing.

Wow, that was quite an interesting program for simply blinking an LED, wasn't it. If you're still not quite sure how it works, don't worry, it will set in with time and we will review these techniques in other projects.

#### Test Your Knowledge

If the forward voltage of the LED is 1.7 volts, what is the current through the LED with the total series resistance of 440 ohms (220 + 220)?