

California State University, Fresno

Department of Electrical and Computer Engineering

ECE 1L – Introduction to Electrical and Computer Engineering Laboratory

Laboratory 1: Introduction to Microcontrollers

(The Boe-Bot, Board of Education, HomeWork Board, BASIC Stamp 2, and BASIC Stamp Editor are registered trademarks of Parallax Inc.)

Background Information

A microcontroller is a kind of miniature computer that you can find in all kinds of gizmos. Some examples of common, every-day products that have microcontrollers build-in are shown in Figure 1-1. If it has buttons and a digital display, chances are it also has a programmable microcontroller brain.



Figure 1-1

Everyday examples of devices that contain microcontrollers.

Try making a list and counting how many devices with microcontrollers you use in a typical day. Here are some examples: if your clock radio goes off, and you hit the snooze button a few times in the morning, the first thing you do in your day is interact with a microcontroller. Heating up some food in the microwave oven and making a call on a cell phone also involve operating microcontrollers. That's just the beginning. Here are a few more examples: turning on the television with a hand held remote, playing a hand held game, using a calculator, and checking your digital wristwatch. All those devices have microcontrollers inside them that interact with you.

The BASIC Stamp 2 – Your New Microcontroller

Parallax, Inc.'s BASIC Stamp 2 module shown in Figure 1-2 has a microcontroller built onto it. It's the black chip with the lettering on it that reads "PIC16C57". The rest of the components on the BASIC Stamp module are also found in consumer appliances you use every day. All together, they are correctly called an embedded computer system. This name is almost always shortened to just "embedded system". Frequency, such modules are commonly just called "microcontrollers".

The activities in the text "Robotics with the Boe-Bot" will guide you through building circuits similar to the ones

found in consumer appliances and high-tech gizmos. You will also write computer programs that the BASIC Stamp module will run. These programs will make the BASIC Stamp module monitor and control these circuits so that they perform useful functions.



Figure 1-2

The BASIC Stamp 2 microcontroller module.

BASIC Stamp 2 modules are the most popular microcontrollers made by Parallax, Inc.



In this manual, “BASIC Stamp” refers to Parallax Inc.’s BASIC Stamp 2 microcontroller module. There are other BASIC Stamp modules, some of which are shown in Figure 1-3. Each BASIC Stamp module is color coded. The BASIC Stamp 2 is green. The BASIC Stamp 2e is red. The BASIC Stamp 2SX is blue, and the BASIC Stamp 2p is gold. Each variation on the BASIC Stamp 2 is slightly different, featuring higher speed, more memory, additional functionality, or some combination of these extra features.

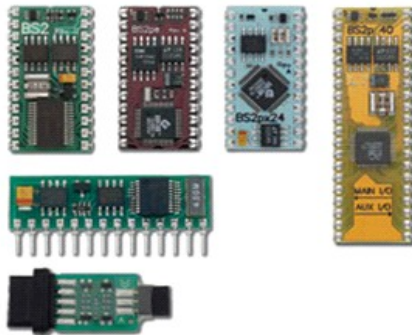


Figure 1-3

BASIC Stamp modules.



Figure 1-4

Educational robots.

Parallax Boe-Bot (left)

First Competition robot (right).

Amazing Inventions with BASIC Stamp Microcontrollers

Consumer appliances are not the only things that contain microcontrollers. Robots, machinery, aerospace designs and other high-tech devices are also built with microcontrollers. Let's take a look at some examples that were created with BASIC Stamp modules.

Robots have been designed to do everything from helping students learn more about microcontrollers, to mowing the lawn, to solving complex mechanical problems. Figure 1-4 shows two example robots. On each of these robots, students use the BASIC Stamp 2 to read sensors, control motors, and communicate with other computers. The robot on the left is Parallax Inc.'s Boe-Bot™. The projects in the Robotics with the Boe-Bot text can be tackled using the Boe-Bot after you've worked through the activities in this one. The robot on the right was built by a group of students and entered into a First Robotics competition. The goal of the contest is different each year. In the example shown, the goal was to see which group's robot could sort colored hoops the fastest.

Other robots solve complex problems, such as the autonomous remote flight robot shown at the left of Figure 1-5. This robot was built and tested by mechanical engineering students at the University of California, Irvine. They used a BASIC Stamp module to help it communicate with a satellite global positioning system (GPS) so that the robot could know its position and altitude. The BASIC Stamp also read level sensors and controlled the motor settings to keep the robot flying properly. The mechanical millipede robot on the right was developed by a professor at Nanyang Technical University, Singapore. It has more than 50 BASIC Stamp modules, and they all communicate with each other in an elaborate network that helped control and orchestrate the motion of each set of legs. Robots like this not only help us better understand designs in nature, but they may eventually be used to explore remote locations, or even other planets.



Figure 1-5

Examples of research robots that contain microcontrollers.

Autonomous flying robot at UC Irvine (left) and Millipede Project at Nanyang University (right).

With the help of microcontrollers, robots will also take on day-to-day tasks, such as mowing the lawn. The BASIC Stamp module inside the robotic lawn mower shown in Figure 1-6 helps it stay inside the boundaries of the lawn, and it also reads sensors that detect obstacles and controls the motors that make it move.



Figure 1-6
Robomow robotic lawn mower.

Microcontrollers are also used in scientific, high technology, and aerospace projects. The weather station shown on the left of Figure 1-7 is used to collect environmental data related to coral reef decay. The BASIC Stamp module inside it gathers this data from a variety of sensors and stores it for later retrieval by scientists. The submarine in the center is an undersea exploration vehicle, and its thrusters, cameras and lights are all controlled by BASIC Stamp microcontrollers. The rocket shown on the right is one that was part of a competition to launch a privately owned rocket into space. Nobody won the competition, but this rocket almost made it! The BASIC Stamp controlled just about every aspect of the launch sequence.



Figure 1-7
High-tech and aerospace microcontroller examples.
Ecological data collection by EME systems (left), undersea research by Harbor Branch Institute (center), and JP Aerospace

From common household appliances all the way through scientific and aerospace applications, the microcontroller basics you will need to get started on projects like these are introduced here. By working through the activities in this manual and the “Robotics with the Boe-Bot” book, you will get to experiment with and learn how to use a variety of building blocks found in all these high-tech inventions. You will build circuits for displays, sensors, and motion controllers. You will learn how to connect these circuits to the BASIC Stamp 2 module, and then write computer programs that make it control displays, collect data from the sensors, and control motion. Along the way, you will learn many important electronic and computer programming concepts and techniques. By the time you’re done, you might find yourself well on the way to inventing a gizmo of your own design.

The Parallax Boe-Bot

Parallax, Inc's Boe-Bot robot is the focus of the activities, projects, and contests in ECE 1. The Boe-Bot and a close-up of its BASIC Stamp 2 programmable microcontroller brain are shown in Figure 1-8. The BASIC Stamp 2 module is both powerful and easy to use, especially with a robot.

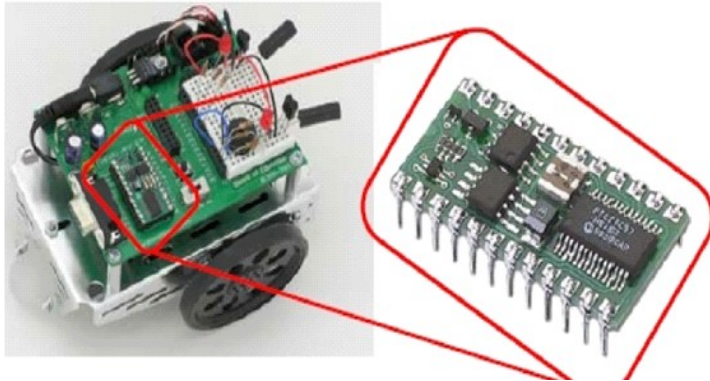


Figure 1-8
BASIC Stamp 2
module on a Boe-Bot
robot.

The activities in the “Robotics with the Boe-Bot” text will guide you through writing simple programs that make the BASIC Stamp and your Boe-Bot do four essential robotic tasks:

1. Monitor sensors to detect the world around it
2. Make decisions based on what it senses
3. Control its motion (by operating the motors that make its wheels turn)
4. Exchange information with its Robotician (that will be you!)



The programming language you will use to accomplish these tasks is called **PBASIC**, which stands for:

- Parallax – Company that invented and makes BASIC Stamp microcontrollers.
- Beginners – Made for beginners to use to learn how to program computers.
- All-purpose – Powerful and useful for solving many different kinds of problems.
- Symbolic – Using symbols (terms that resemble English word/phrases).
- Instruction – To instruct a computer how to solve problems.
- Code – In terms that you and the computer understand.

Hardware and Software

Getting started with the BASIC Stamp microcontroller modules is similar to getting started with a brand-new PC or laptop. The first things that most people have to do when they get a new PC or laptop is take it out of the box, plug it in, install and test some software, and maybe even write some software of their own using a programming language. Since this is your first time using a BASIC Stamp module, you will be doing similar activities.

Specifically, the following pages will show you how to get up and running with BASIC Stamp programming as it guides you through:

1. Finding and installing the programming software
2. Connecting your BASIC Stamp module to a battery power supply
3. Writing your first few PBASIC programs
4. Disconnecting power when you're done

ACTIVITY #2: Getting/Running the Software

You only need to perform this activity, if you wish to install the software at home. It is provided here for your information.

The BASIC Stamp Editor (version 2.0 or higher) is the software you will use in most of the activities and projects in this text. You will use this software to write programs that the BASIC Stamp module will run. You can also use this software to display messages sent by the BASIC Stamp that help you understand what it senses.

The BASIC Stamp Editor is available on all of the lab computers. To use it in the laboratory, click on the Parallax folder, and then the BASIC Stamp Editor icon to launch the program. If you wish to install the editor on a home computer, it's easy to download the BASIC Stamp Editor software from the Parallax web site. The web page shown in Figure 1-9 may look different from the web page you see when you visit the site. Nonetheless, the steps for downloading the software should still be similar to these:

- Using a web browser, go to <http://www.parallax.com> (shown in Figure 1-9). Click on the "Downloads" header to be taken to the downloads page.



Figure 1-9: The Parallax Web Site (www.parallax.com)

- Point at the BASIC Stamp Software link and click to select it.
- When you get to the BASIC Stamp Software page, find the most recent version of the BASIC Stamp Windows Editor download, with a version number of 2.0 or higher.
- Click the Download icon. In Figure 1-10, the download icon looks like a file folder to the right of the description: “BASIC Stamp Windows Editor version 2.x”.

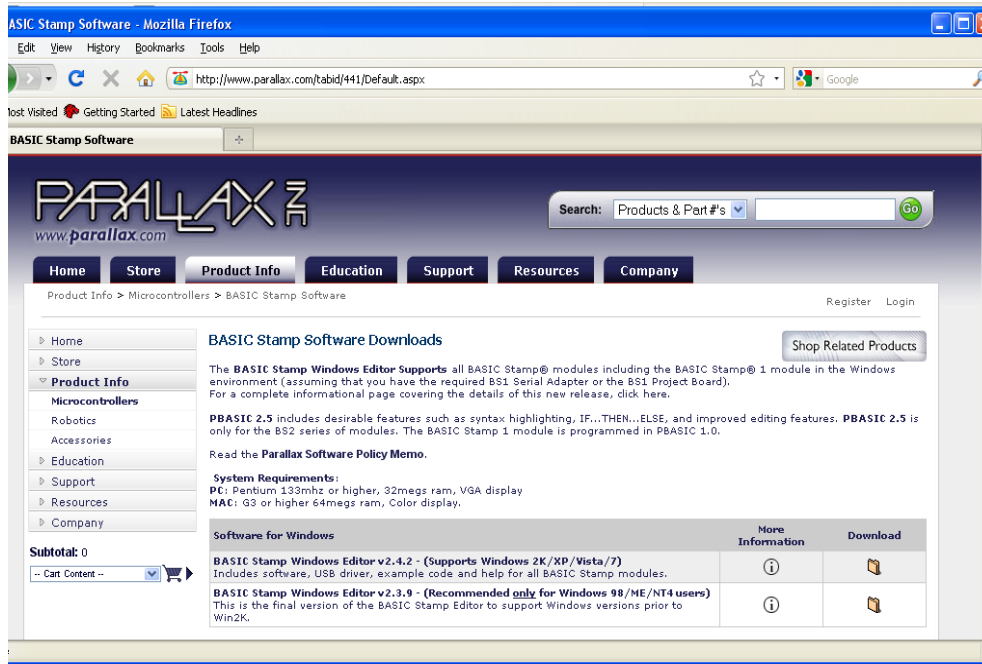


Figure 1-10: The Parallax Web Site Download Page

ACTIVITY #3: Setting up the Hardware and Testing the System

The BASIC Stamp module needs to be connected to power for it to run. It also needs to be connected to a PC so it can be programmed. After making these connections, you can use the BASIC Stamp Editor to test the system.

Introducing the BASIC Stamp and Board of Education

A BASIC Stamp 2 module and a Board of Education carrier board are shown in Figure 1-11. As mentioned earlier, a BASIC Stamp module is like a very small computer. This very small computer plugs into the Board of Education carrier board. As you will soon see, the Board of Education makes it easy to connect a power supply and serial cable to the BASIC Stamp module. In later activities, you will also see how the Board of Education makes it easy to build circuits and connect them to the BASIC Stamp. Be sure to follow the directions for the BASIC Stamp Board of Education, and not the Basic Stamp HomeWork Board in subsequent activities.

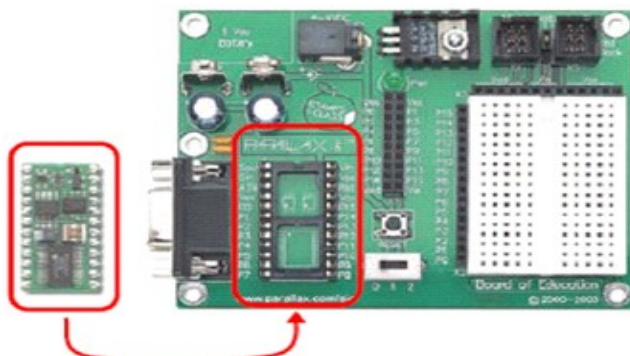


Figure 1-11

BASIC Stamp 2 Module
(left) & Board of Education
Carrier Board (right)



What's the difference?

Using a Board of Education carrier board and BASIC Stamp module gives you additional features such as headers for plugging in servo motors, control over the type of power supply the servos receive, and a handy, 3-position switch you can use to control what parts of the system receive power. The BASIC Stamp 2 module is removable, and can be replaced.

The BASIC Stamp HomeWork Board has no servo ports, external power supply jack or power switch, but it also costs less. You have to build your own servo connections, and to control power by disconnecting it from the board, or by building your own power control circuits. The BASIC Stamp 2 microcontroller is built right into the board, and each I/O pin is protected by a surface-mounted 220 Ω resistor.

The BASIC Stamp needs to be connected to power for it to run. It also needs to be connected to a PC so it can be programmed. After making these connections, you can use the BASIC Stamp Editor to test the system. This activity will show you how.

Universal Serial Bus (USB) Setup

The Board of Education or BASIC Stamp HomeWork Board should be connected to your PC or laptop by either a serial cable or a USB to Serial Adapter.

1. Since you are using a USB cable, connect the end with the larger plug to one of the two USB ports on the front of the lab computer. Connect the smaller end to the Board of Education. Please ask your instructor for help if you are confused.

The Board of Education has a 3-position switch (see Figure 1-12). Position-0 is for turning the power to the Board of Education completely off. Regardless of whether or not you have a battery or power supply connected to the Board of Education, when the 3-position switch is set to 0, the device is off.



Figure 1-12

3-position switch. Set the position to 0 to turn off the power.

2. Set the 3-position switch on the Board of Education to position-0.
3. Load the batteries into the battery pack as shown in Figure 1-13. The battery pack is located on the bottom of the Boe-Bot. Make sure to follow the polarity

(+ and -) markings on the inside of the battery pack's plastic case when inserting each battery.

4. Plug the battery pack into the 6-9 VDC battery jack



Figure 1-13

Battery Pack. Polarity indicators on molded plastic (left) and loaded with correct polarity (right).

5. Move the 3-position switch from position-0 to position-1 to turn the power on.



Figure 1-14

3-position switch. Set to position-1 to turn the power back on.


The green light labeled Pwr on the Board of Education should now be on.

Testing for Communication


First, run your BASIC Stamp Editor by double-clicking the shortcut on your desktop or within the ECE 1 folder. It should look similar to the one shown in Figure 1-15.



Figure 1-16: BASIC Stamp Editor Shortcut. Look for a shortcut similar to this on your computer's desktop.

	<p>The Windows Start Menu can also be used to run the BASIC Stamp Editor. Click your Windows Start Button, then select Programs → Parallax, Inc. → Stamp Editor 2..., then click the BASIC Stamp Editor Icon.</p>
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Your BASIC Stamp Editor window should look similar to the one shown in Figure 1-16.

	<p>The first time you run your BASIC Stamp Editor, it may display some messages and a list of your COM ports found by the software.</p> <ul style="list-style-type: none">● If you know the number of the COM port your BASIC Stamp is connected to, check to make sure it is included in the list.● If it is not included in the list, follow the BASIC Stamp Editor's instructions for adding a COM port.● If you're not sure about your COM port, click OK for now.
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- To make sure your BASIC Stamp is communicating with your computer, click the RUN menu, then select Identify.

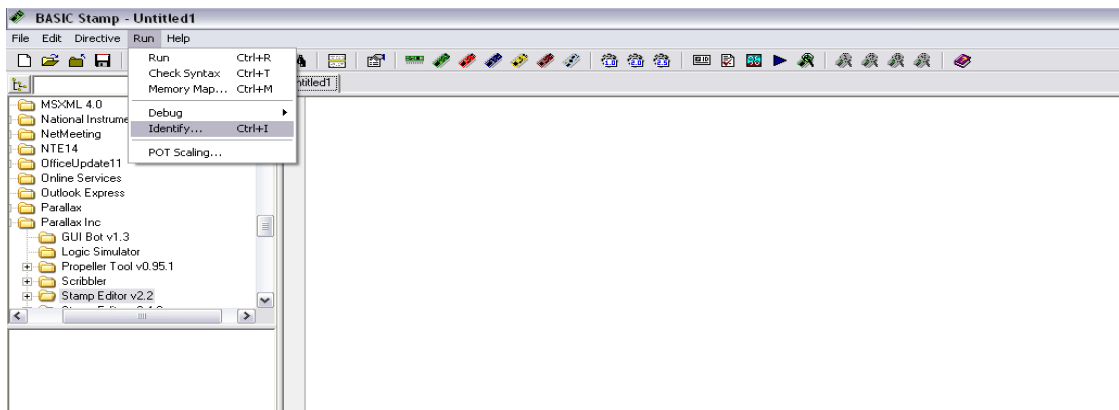


Figure 1-16: BASIC Stamp Editor

An identification window similar to the one shown in Figure 1-17 will appear. The example in the figure shows that a BASIC Stamp 2 has been detected on COM 8.

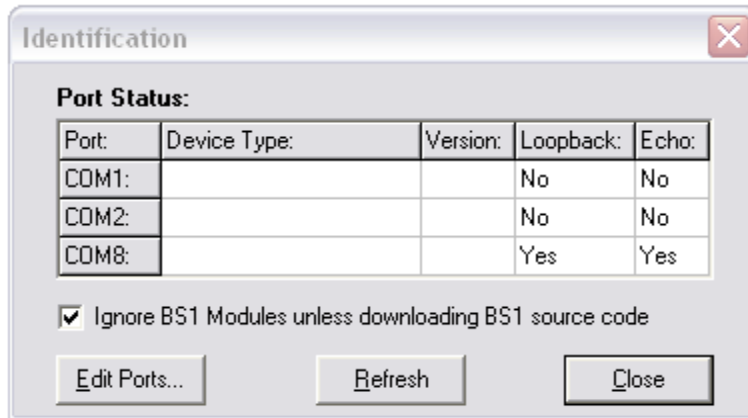


Figure 1-17: Identification Window

- Check the identification window to make sure a BASIC Stamp 2 has been detected on one of the COM ports. If the BASIC Stamp 2 has been detected, then you are ready for Activity #4: Your First Program.
- If the identification window does not detect a BASIC Stamp 2 on any of the COM ports, go to page 301 in "Robotics with the Boe-Bot" (Appendix A: PC to BASIC Stamp Communication Trouble-Shooting).

ACTIVITY #4: Open the "Robotics with the Boe-Bot" manual to Page 22 and perform Activity #4.

ACTIVITY #5: Continue on with Activity #5 in the Robotics with the Boe-Bot manual.

Once you are finished, replace all the parts back into the cabinet. Make sure you remember which Boe-Bot number/microcontroller board you used for this first lab – you will want to use the same one each week.