Sun Small Programmable Object Technology (Sun SPOT) Owner's Manual

Sun Labs

July 2006

Sun Microsystems, Inc.
4150 Network Circle
Santa Clara, CA 95045 U.S.A.
650 960-1300

Part No. ***NEED TO GET***
Revision 1.0, July 2006

Sun Small Programmable Object Technology (Sun SPOT) Owner's Manual

This document provides a quick introduction to the Sun Small Programmable Object Technology (Sun SPOT) kit.

Contents of the Sun SPOT kit

A Sun SPOT kit contains the following:

- one basestation Sun SPOT unit
- two free-range Sun SPOT units
- a USB cable for connection between a standard USB port and a Sun SPOT unit
- one Sun SPOT CDROM disks
- a mounting bracket allowing a Sun SPOT unit to be wall-mounted
- this manual

How to open a SPOT

You must open the Sun SPOT unit lid to be able to reach the switches and LEDs on the sensor board. To open the lid, press down *firmly*, down and back, on the edge of the lid near the small raised dot. You can think of that small-raised dot as the fingernail-catching dot. The closer to the edge of the lid that you press, the easier the lid will open. The opposite end of the lid will pop up.

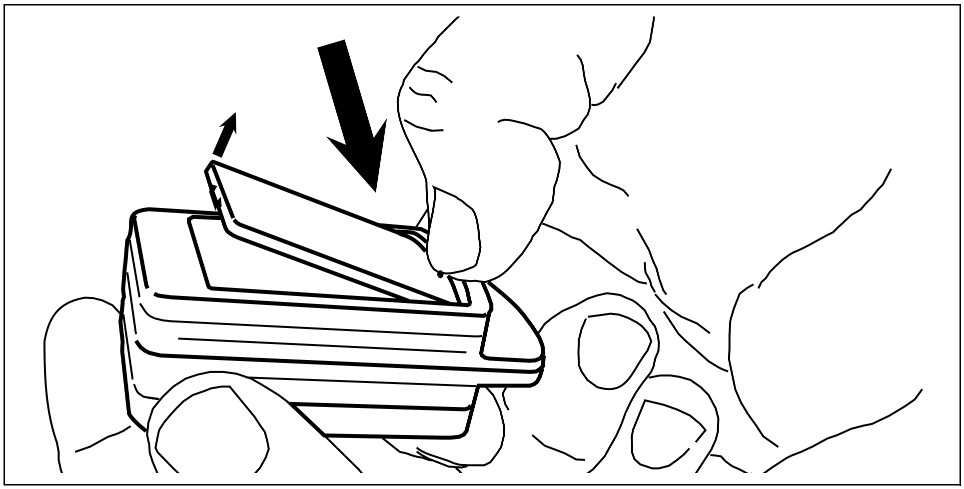


FIGURE 1 Press down *firmly* on the edge of the lid marked with a small raised dot.

After the lid will pops up, pull the lid out and away.

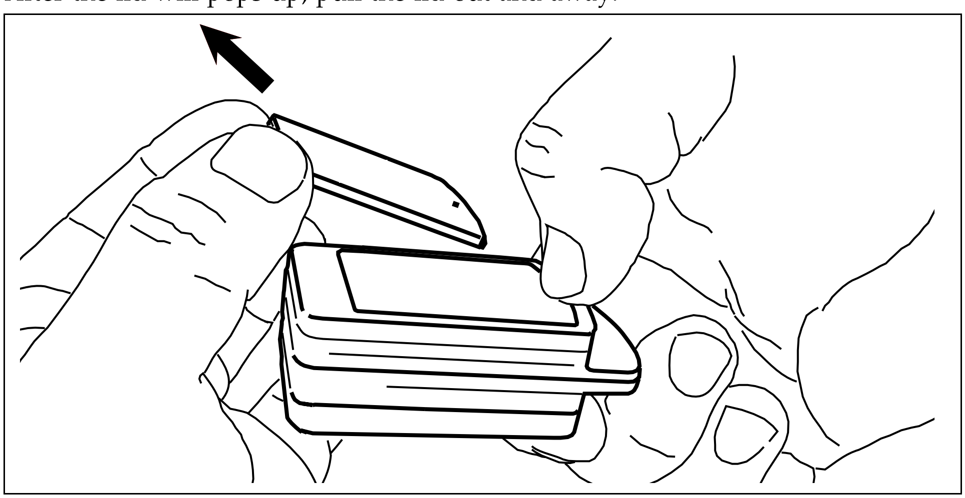


FIGURE 2 Pull the lid out and away.

Guided tour of SPOT switches and LEDs

The Sun SPOT unit has one switch and one connector which are accessible without removing the case lid. These are shown below:

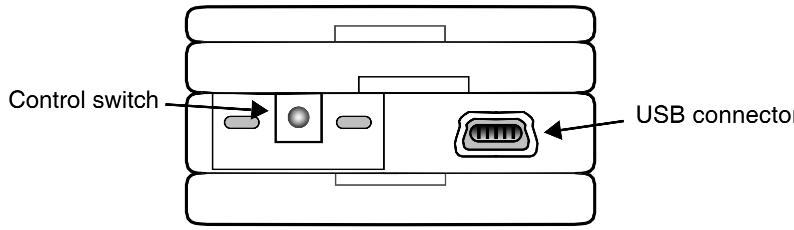


FIGURE 3 Sun SPOT exterior switch and connector

The connector is the micro-USB connector which allows the Sun SPOT unit to be connected to a host workstation.

The switch is the Sun SPOT unit control switch. If the Sun SPOT unit is off, pressing the switch will turn the Sun SPOT unit on and cause it to boot. If the Sun SPOT unit is on, pressing the control switch will cause the Sun SPOT unit to reboot. If the Sun SPOT unit is on, pressing the control switch and holding it down will turn the Sun SPOT unit off.

This end of the Sun SPOT unit also has two LEDs behind the plastic casing.:

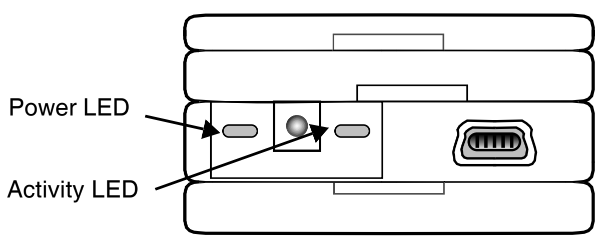


FIGURE 4 Sun SPOT unit LEDs

The power LED is to the left of the power switch. This LED will exhibit the following behaviors:

TABLE 1 Power LED Behavior

Power State	Power LED Behavior
Powering up	One bright green pulse, sharp on, soft off
Powering down	Three bright red flashes
Charging the battery while CPU is active	Slowly alternate between a dim green and a bright green on a eight second cycle
Charging the battery when CPU is asleep	Slowly alternate between off and a dim green on an eight second cycle
External power supplied, but not charging, CPU active	Steady dim green
Battery low	Slowly alternate between off and a dim red
Power fault	Two short red flashes
CPU going to sleep	Short red flash, short green flash
External interrupt or alarm, including button tap.	One short green flash

The activity LED is to the right of the power switch. This LED is under Java program control and can be used in your applications. There are system programs that use this LED. These are:

- When the Sun SPOT unit is attempting to synchronize with a host workstation, the activity LED will flash amber 16 times a second. This flashing will last for two seconds or until synchronization is complete, whichever comes first.
- When the Sun SPOT unit is being used as a basestation, that is, for wireless communication between a host workstation and free-range Sun SPOT units, the green component of the activity LED will change state, i.e. switch from off to on or the reverse, for every packet received on the Sun SPOT unit from the host workstation. The red LED component of the activity LED will change state for every packet sent to the host workstation from the Sun SPOT unit.

If the Sun SPOT unit lid has been removed, there are two switches and eight multi-color LEDs that become accessible.

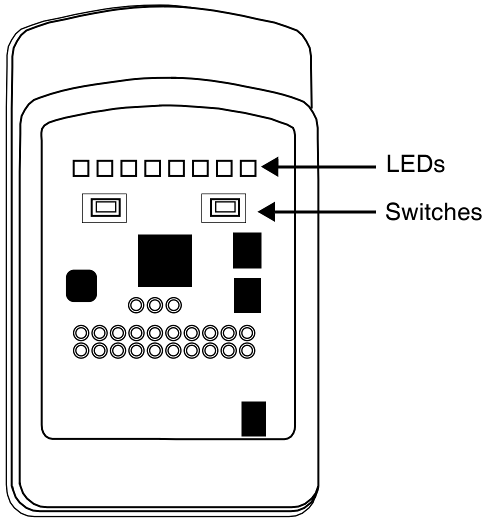


FIGURE 5 The Sun SPOT unit after the lid has been removed

The LEDs have red, blue and green components. The switches and LEDs have no fixed purpose and are under Java program control.

Powering a SPOT

The capacity of the built-in battery is 720 milliamp-hours.

The drain of the system varies with use.

TABLE 2 Power usage for typical a Sun SPOT unit

Processor board state	Radio	Sensor Board	Current draw
Deep sleep mode	Off	Any	<50 microamperes
Shallow sleep[1]	Off	Not present	~24 milliamperes
Shallow sleep	On	Not present	~31 milliamperes
Awake, actively calculating	Off	Not present	~80 milliamperes
Awake, actively calculating	On	Not present	~86 milliamperes
Shallow sleep	Off	Present	~34 milliamperes
Shallow sleep	On	Present	~40 milliamperes
Awake, actively calculating	Off	Present	~98 milliamperes
Awake, actively calculating	On	Present	~104 milliamperes

1. Shallow sleep means devices active, but no active threads.

LEDs also use power.

TABLE 3 Power draw for a single Sun SPOT LED

LED	Current draw
All elements, full brightness	25 milliamps
Blue element, full brightness	10 milliamps
Red element, full brightness	9 milliamps
Green element, full brightness	5 milliamps

The current draw for the LEDs is reasonably linear. An LED at half-brightness will draw approximately half the current of an LED at full brightness.

The approximate length of time that a full-charged Sun SPOT unit can operate is shown below for most of the conditions of interest:

TABLE 4

Sun SPOT state	Battery life estimate
Deep sleep	627 days
Shallow sleep, no radio	21 hours
Shallow sleep, radio on	12 hours
CPU busy, no radio	6 hours
CPU busy, radio on	5 hours
Shallow sleep, 8 LEDs on, no radio	3 hours

A power fault occurs when one of these conditions occurs:

- external power exceeds 5.5V
- Vbatt exceeds 4.9V
- Vcc ± 10% of 3.0V
- Vcore ± 10% of 1.8V
- Battery Discharge current exceeds 500ma

Programming a SPOT

The easiest way to begin programming a Sun SPOT is to copy a demo project. That will get you all of the Ant scripts for compiling and deploying the code to the Sun SPOT. Alternately, there is a sample application in *SDK-Install-Directory*/samples/template. You can copy that directory to get an extremely simple, "Hello, World" application to work from.

Sun SPOT applications are just Java applications, so they aren't hard to program. The main issues for most programmers will be (1) debugging the code and (2) determining how to get access to the peripherals on the demo sensor board.

Debugging on a Sun SPOT

On the initial software Sun SPOT software release, code named "Beagle," the best way to debug is with print statements. The next software release, "Giraffe," should have a better debugging facility.

Until then, load the application to be debugged onto a Sun SPOT which is connected to the host workstation. As you debug, add calls to `System.out.println()`. For example:

```
System.out.println("Got to the Foobar method call");
```

Start the application using either the Run command from within NetBeans or by issuing an "ant run" command at command-line prompt. The debugging output will appear on the host workstation. In NetBeans, it will appear in an XXXX window. In a command-line window, the debugging output will appear as part of the output from the "ant run" command.

Accessing the Sensor Board

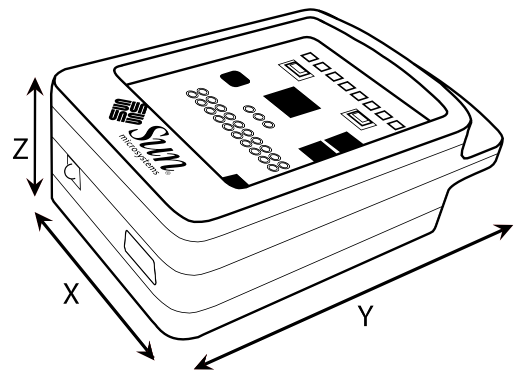
The sensor board includes a 3D accelerometer, a temperature sensor, a light sensor, 8 LEDs, and two switches.

Accelerometer

The accelerometer has two modes of operation that determine what range of values it will measure. The ranges are, approximately: -2G to 2G and -6G to 6G. The raw reading from the accelerometer will be a number between 0 and 1023, where 0 indicates the lower end of the range and 1023 represents the higher end of the range.

There are three axes on which the accelerometer measures acceleration. The Z-axis is perpendicular to the Sun SPOT boards. The X-axis is parallel to the row of LEDs on the sensor board. The Y-axis is parallel to the long edge of the sensor board.

FIGURE 6 Accelerometer X, Y and Z axes



To use the accelerometer:

1. Create an accelerometer interface instance:

```
IAccelerometer3D ourAccel =
EDemoBoard.getInstance().getAccelerometer();
```

2. Set the range over which you want the accelerometer to operate. Sending a zero to the method `IAccelerometer.setRange()` will set the range to approximately -2G to 2G. A one will set the range to approximately -6G to 6G. After setting the range, the accelerometer must settle for about 100 milliseconds before it will generate accurate readings:

```
// 0 is the 2G range, 1 is the 6G range
ourAccel.setRange(0);    //use 2G scale
// sleep for 120 milliseconds to allow the accelerometer to settle
try{
Thread.sleep(120);
} catch (InterruptedException ex) {
// ignore any exceptions
}
```

3. Read from the accelerometer to get the raw accelerometer reading:

```
Int x-accel = ourAccel.getXaxis().getValue();
Int y-accel = ourAccel.getYaxis().getValue();
Int z-accel = ourAccel.getZaxis().getValue();
```

The raw reading may be enough for some applications. The zero-gravity reading is likely to be around 486. The formula for conversion of a raw reading on the 2g scale into g-forces is:

$$gForce = \frac{rawReading - 466.5}{186.2}$$

The formula for conversion of a raw reading on the 6g scale into g-forces is:

$$gForce = \frac{rawReading - 466.5}{62}$$

The 466.5 is, in each case, the estimate of the raw reading with the sensor for that access in a zero-gravity position. Experimentation with particular units may give you a more accurate estimate for that unit.

The Ectoplasmic Bouncing Ball Demo

Before the Demo

Your Sun SPOT kit should have come with two free-range Sun SPOT units and one basestation unit. The basestation unit is thinner and does not have a battery board.

If you want to use the host workstation and the basestation unit in the demo, you must first install the Sun SPOT development software on the host workstation, then attach the basestation to the host workstation.

If you do not want to use the host workstation and the basestation in the demo, you can still run the demo on the free-range Sun SPOT units alone.

Starting the Demo

To start the demo, turn the free-range Sun SPOT units on. The power switch is located on one of the narrow ends of the Sun SPOT unit. If the free-range Sun SPOT units have a charged battery, they each will go through a boot process lasting two or three seconds. After they have booted, each Sun SPOT unit will start to run the demo.

If the free-range Sun SPOT unit does not boot, it probably needs to charge its battery. To charge a Sun SPOT unit battery, attach the unit, using the supplied USB cable, to the USB port on a working computer. The USB power will charge the Sun SPOT unit in approximately three hours.

To start the demonstration on the host workstation and the basestation Sun SPOT unit, open NetBeans and select the BounceDemo from the list of projects on the left. Select “Host Run” from the menu bar. A window will open containing an image of a

Sun SPOT unit. This Sun SPOT unit can participate in the demo in the same way as a physical Sun SPOT unit. Your mouse can be used to manipulate this soft Sun SPOT unit. The basestation Sun SPOT unit does not participate in the demo except to pass radio packets between the free-range Sun SPOT units and the soft Sun SPOT unit running (virtually) on the host workstation.

The Effect

The row of LEDs on the top board of each Sun SPOT unit represents a tube. The red LEDs at each end of the LED row represents a cork in the tube. Any other LED which is lit represents an ectoplasmic ball. At first the balls on any Sun SPOT unit will be blue. However, if the Sun SPOT units are able to communicate with each other, they will allocate colors for the ectoplasmic balls to avoid, as much as possible, duplication.

Pick up a Sun SPOT unit and tilt it. Note how the red corks keep the ectoplasmic ball from escaping the tube.

If you press the switch next to the LED that represents a cork, that cork will partially open. To reach the switch, you will need to open the lid of the plastic case. To open the lid, press *firmly* on the lid, down and back, on the edge of the lid near the small raised dot. You can think of that small-raised dot as the fingernail-catching dot. The closer to the edge that you press, the easier the lid will open. The opposite end of the lid will pop up. Grasp that opposite end to remove the Sun SPOT unit's lid.

See the illustration below:

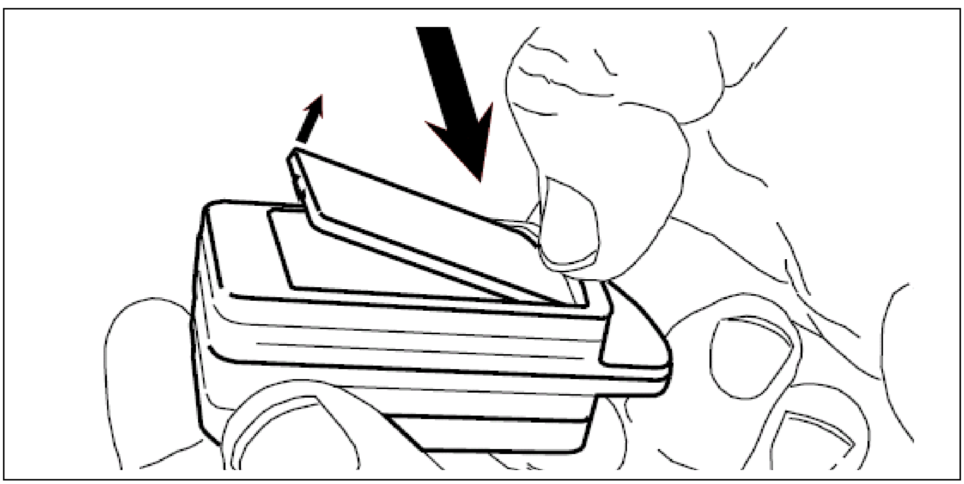
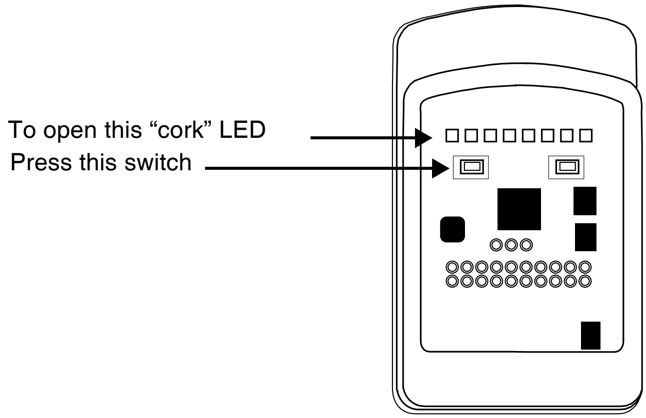


FIGURE 7 Opening a Sun SPOT Unit Lid

Once you have opened the Sun SPOT lid, press the switch nearest a cork LED to open it.



We don't want to lose any of the precious ectoplasm, though, so the cork won't fully open until there is another Sun SPOT unit, within range, with a cork that is also half-open. If two Sun SPOT unit with half-open corks find each other, both corks will fully open, and you can pour ectoplasmic balls from one Sun SPOT unit to another.

A cork that is closed displays as a steady red LED. A cork that is half-open displays as a blinking red LED. A cork that is fully open does not show at all. To close a cork that is open, press the switch closest to it.

The ectoplasm is sticky. See if you can get two ectoplasmic balls to come to rest in the same place. They will then merge into one ball. The color of the new ball will be the merged color of the original balls. For example, a red ball and a blue ball will merge to form a purple ball.

To restart the demo, press the control switch momentarily. The Sun SPOT unit will reboot and restart the demo.

The Implementation

The Sun SPOT units use radio communication at the beginning of the demonstration to choose colors for each ectoplasmic ball. They poll the 3-D accelerometer to determine the orientation of the Sun SPOT unit. They use the orientation information to determine the movement of the ectoplasmic balls. The switches are also polled to determine the appropriate cork state. Radio communication is used to determine if there is another Sun SPOT unit within range and if there is an open cork on that unit. If there is, radio communication is used to pass the ball back and forth.

Source code for the demonstration is in the Sun SPOT SDK directory at the location: `[SDKdirectory]/Demos/eSpotBounceDemo`.

Battery Warnings

Do not short-circuit battery. A short-circuit may cause fire, explosion, and/or severe damage to the battery.

Do not drop, hit or otherwise abuse the battery as this may result in the exposure of the cell contents, which are corrosive.

Do not expose the battery to moisture or rain. Keep battery away from fire or other sources of extreme heat. Do not incinerate.

Exposure of battery to extreme heat may result in an explosion.

No other battery substitutions or different chemistry batteries should be used.

Do not bypass the battery protection circuit.

Dispose of batteries properly. Do NOT throw these batteries in the trash. Recycle your batteries, if possible.

Federal Communications Commission Compliance

> NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try and correct the interference by one or more of the following measures: Reorient or locate the receiving antenna. Increase the separation between the equipment and receiver. Connect the equipment into an outlet on a circuit different from that to which the receiver is connected. Consult the dealer or an experienced radio/TV technician for help.

The Sun SPOTs are supplied with a shielded USB cable. Operation with a non-shielded cable could cause the Sun SPOTs to not be in compliance with the FCC approval for this equipment. The antenna used with this transmitter must not be colocated or operated in conjunction with any other antenna or transmitter; to do so could cause the Sun SPOTs to not be in compliance with the FCC approval for this equipment. Any modifications to the Sun SPOTs themselves, unless expressly approved, could void your authority to operate this equipment..

> FCC Declaration of Compliance:
>
> Responsible Party:
> Sun Microsystems, Inc.
> 4150 Network Circle
> Santa Clara, CA 95054
> Phone: US 1-800-555-9786; International 1-650-960-1300
>
> Products:
> SLS-E5-XXXX
> where “X” is any alphanumeric character or a blank.
>
> This device complies with Part 15 of the FCC Rules. Operation is subject to the following conditions: this device may not cause harmful interference and this device must accept any interference received, including interference that may cause undesired operation.