SunAir Solar Power Controller Board

0041-120414-01

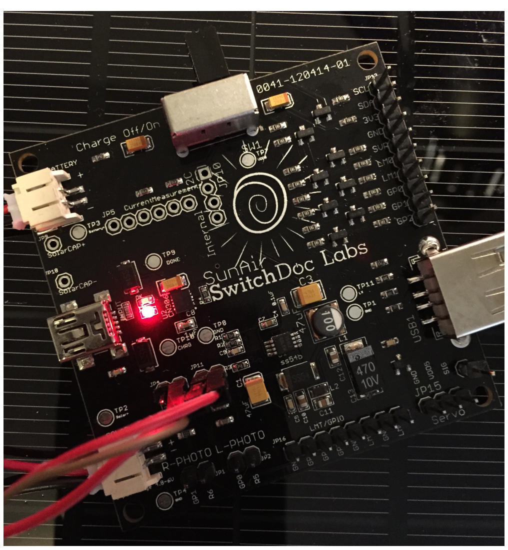
The **SunAir Solar Power Controller Board** for Raspberry Pi, Arduino and Cell Phone Charger is a 3rd Generation Solar Charging and Sun Tracking Board designed by and manufactured by SwitchDoc Labs.

You can use this board to power your projects and add a servo or stepper motor to allow it to track the sun using photoresistors to generate even more power. It incorporates a number of outstanding features in a very compact, inexpensive single fully assembled and tested PC Board. SunAir is customizable with your software and hardware.

Features and Benefits:

- Uses 6V Solar Cells
- Use 3.7V LiPo Cells for batteries
- Has LiPo to 5V voltage boost built in
- Directly powers Raspberry Pi / Arduino
- Works Raspberry Pi (3.3V) GPIO and Arduino (5.0V) GPIO
- Built-in Interface for Solar Tracking Photoresistor devices
- Built-in Interface for Servo motor or Stepper motor
- Built-in Interface for Limit Switches
- Charges iPhones and other phones or devices
- Approximates an MPPT (Maximum Power Point Tracking) charging system
- Comes with an iPhone / iPad based Control Panel App ($2 on App Store - SunAirPiConnect / SunAirArduinoConnect)
- 3D SunAir Tracker OpenSCAD files available and STL filesLow Power
- Low Cost
- Full Test Code Supplied
- Quantity Discounts Available
- Immediate Availability

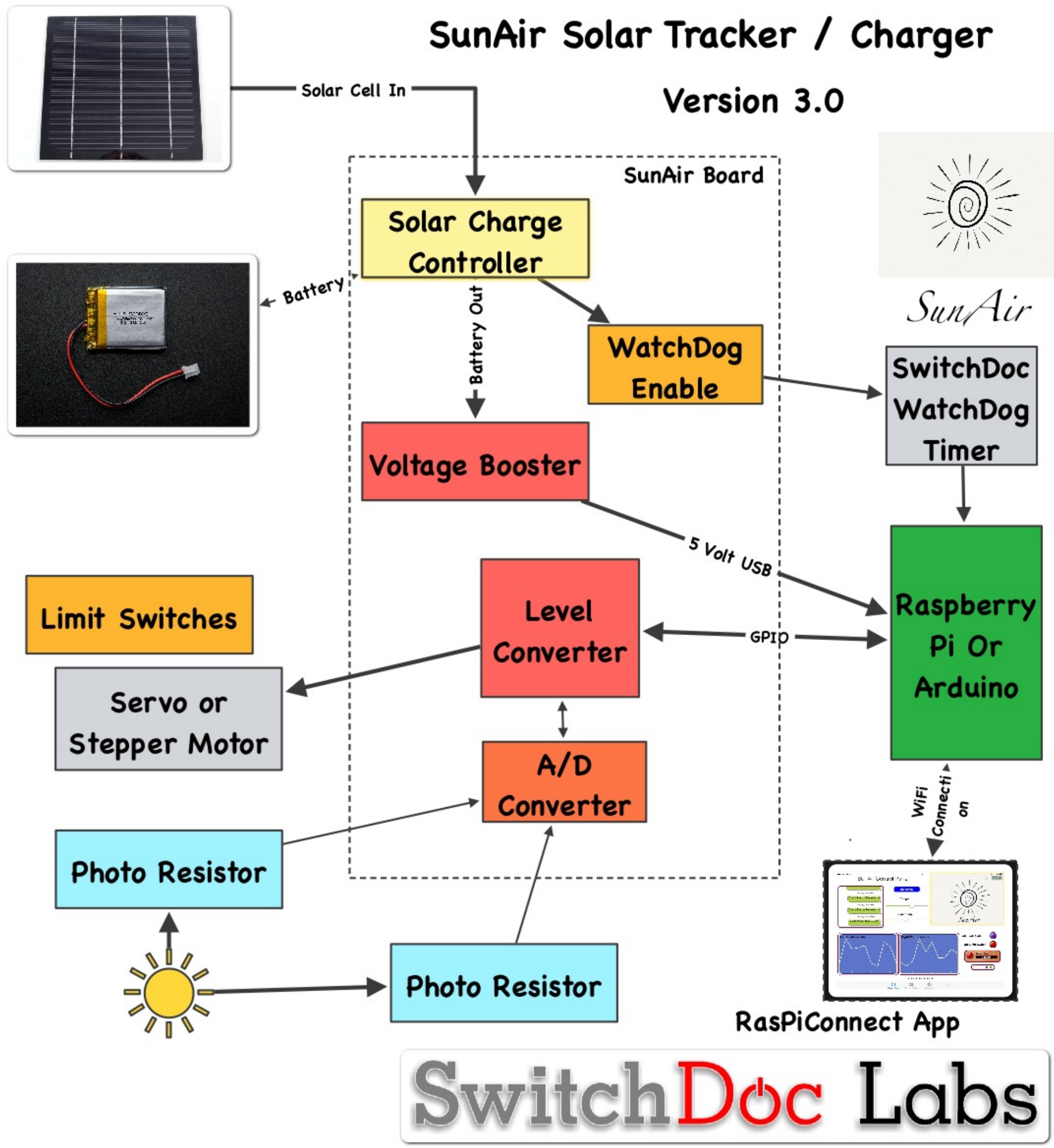
Introduction



SunAir is a solar power controller / sun tracker / power supply system developed by SwitchDoc Labs to power Arduino and Raspberry Pi based systems. Internally, it is not a simple system, but it is designed to be simple to use. The board has solar panel charge control system, a voltage booster, two A/D systems and GPIO interface circuitry systems for voltage level shifting and for servo motors as well as aiding in stepper motor control. SunAirPlus contains more robust A/D converters, voltage and current sensing circuitry and an optional stepper motor controller built into the SunAirPlus board.

Additional code and examples on www.switchdoc.com on the SunAir Product Page

Block Diagram



Theory of Operation

Solar Charge Controller

The Solar Charge Controller on SunAir is based around a CN3065 Lithium Ion Charge Controller to run the charging sequence for the batteries. The chip does an approximation of the MPPT (Maximum Power Transfer Tracking).

It is the purpose of the MPPT system to sample the output of the cells and apply the proper resistance (load) to obtain maximum power for any given battery and temperature conditions. Although the fully charged battery pack voltage may be close to the solar cell maximum power point voltage, this is unlikely to be true at sunrise when the battery has been partially discharged. Charging may begin at a voltage considerably below the solar panel maximum power point voltage.

When the batteries are fully charged and the solar power production exceeds the load of the computer, the CN3065 can no longer operate the panel at its maximum power point as the excess power has no load to absorb it. The CN3065 must then shift the solar power operating point away from the peak power point until production exactly matches demand.

The CN3065 is set in SunAir to deliver a maximum of 1000ma instantaneously to the connected LiPo batteries. Now note, that doesn't mean you can't use more than 6W of solar panels. The 6W solar panels won't be delivering 1000ma most of the time.

Voltage Booster

In order to boost the nominal 3.7V - 4.2V output from the LiPo batteries up to 5V, SunAir uses a voltage booster. It uses an ISL97156 PWM Step-Up Regulator to do the step up in voltage. This design uses an PWM (Pulse Width Modulated) oscillator run through an inductor with a feedback loop to increase the voltage up to a regulated 5V. Note that this voltage will start to come down below 5V when you overload the board (exceed 1000ma) or the LiPo batteries get below about 3.6V. A good system will monitor this voltage and cut the power to the computers when things get low. If you are charging your phone, it doesn't matter.

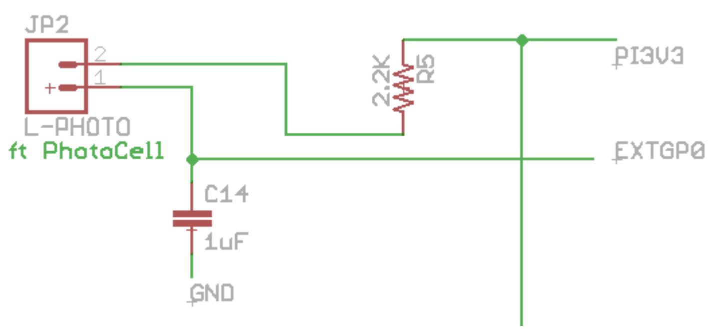
Level Converters

Outputs and inputs from the Raspberry Pi are 3.3V. You can't drive them with 5V lines without potentially destroying the Pi.   Why is this? The Raspberry PI has protection diodes between the pin and 3.3V and ground. Positive voltages greater than 3V3 + one "diode drop" (normally 0.5V) will be shorted to 5V, this means that if you put a 5V power supply on the GPIO pin you will "feed" the 3V3 supply with 4.5 Volt (5V - the diode drop of 0.5V) and that may damage 3V3 logic.

A designer should only use 3.3V outputs connected to your Raspberry Pi GPIO pins without putting a voltage level converter between the devices. Note: You can DRIVE most 5V device inputs with the Raspberry Pi 3.3V GPIO outputs. Most devices will read 3.3V inputs as a logic one. In SunAir there are bidirectional level converters. Figure 4 shows a simple bi-directional logic level FET based converter. You can set PI3V3 to either 3.3V or 5.0V and SunAir will adjust the levels..

A/D Converters

The internal A/D converters on the Arduino are sufficient for reading the photoresistors used by SunAir to track the sun, but since the Raspberry Pi has no built-in A/D converters, SunAir includes a simple circuit to do this shown in Figure 5. SunAirPlus contains an excellent built-in 12 bit 4 channel A/D converter.



First of all, the way a photoresistor works is if you shine light on it, the resistance drops. In the dark, the resistance is higher. If it is dark, it allows less current through than if there is light. To use this AD converter you do the following sequence.

1)Set the EXTGP0 signal (from a GPIO pin on the Raspberry Pi) to 0. Hold it for about 200ms.
2)Set the EXTGP0 to an input (making the GPIO pin a high impedance (open circuit) pin)
3)Start timing
4) When the GPIO signal becomes a 1, take the time difference between 3) and now.

That time difference is proportional to how long it take C14 to charge from 0V to the "1" threshold of the Raspberry Pi GPIO input. The time is proportional to how much resistance (hence the amount of light) the photoresistor currently has shining on it. It is not a very accurate or fast A/D but it does allow you to detect a set of graduated light changes.

Below is the Arduino code for using this circuit. The Raspberry Pi code will be very similar.

```
// Photoresistor code for SunAir

int getLightReading(int pinUnderTest)
{
    // Start by setting GP to GND
    pinMode(pinUnderTest, OUTPUT);
    digitalWrite(pinUnderTest, 0);


    // Hold 200ms
    delay(200);

    // Turn GP to HIGH Z (INPUT)
    pinMode(pinUnderTest, INPUT);
    int GPValue;
```

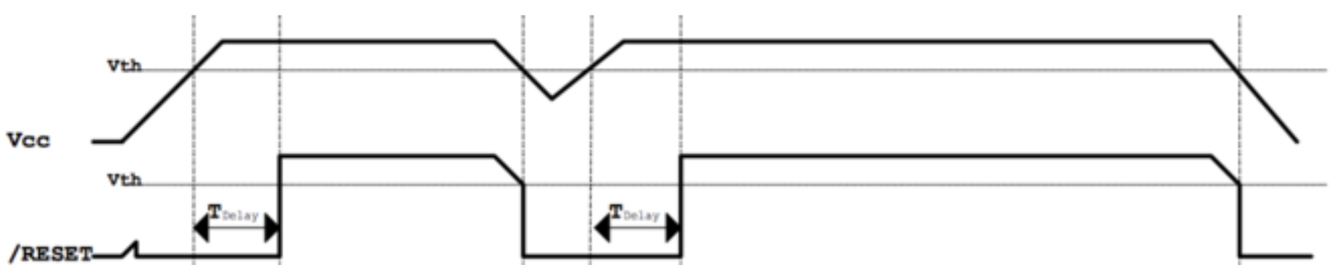
```
    long microsStart;
    long microsEnd;
    microsStart = micros();
    long i;
    while(1)
    {
     // READ GP0 until it becomes 1
     i = i+1;
     GPValue = digitalRead(pinUnderTest);

     microsEnd = micros();
     if (GPValue == 1)
       break;

    }
    return microsEnd - microsStart;
}
```

You can use these two photoresistors A/Ds with the SunTracker tubes (shown below in the 3D print) to pinpoint where the sun is and turn our panels to face the sun using a servo motor or stepper motor.

Other Modules

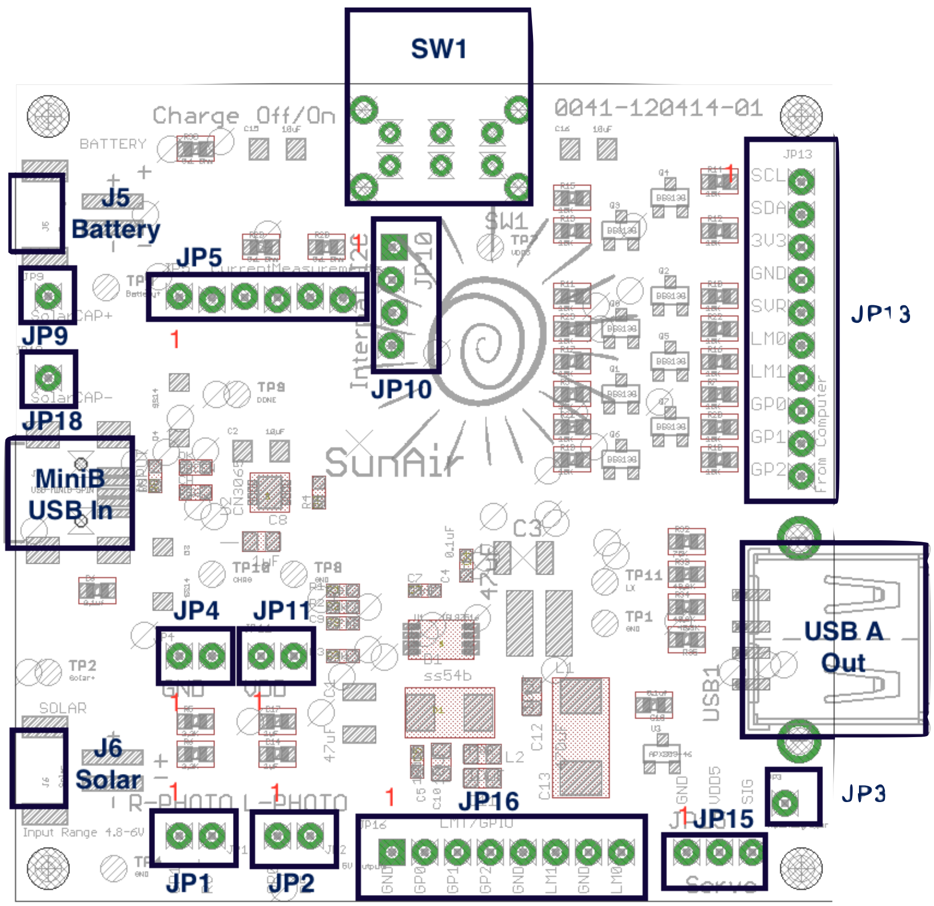
WatchDog Timer Enable

You can make your project more reliable by using an external WatchDog Timer (see the tutorial series on SwitchDoc.com - Reliable Projects: WatchDog Timers for Raspberry Pi and Arduinos - http://www.switchdoc.com/2014/11/reliable-projects-watchdog-timers-raspberry-pi-arduinos/) The tutorial series shows how you use one to make your small computer system more reliable. This piece of circuitry on SunAir will disable the WatchDog Timer if the supply voltage is too low (less than 4.65V in this case). This keeps the WatchDog Timer from trying to start the computer up when there isn't enough power to run the computer properly.



Operating Values

	Min	Normal	Max	Unit
Vin Solar	4.8	5.0	6.5 (10 seconds)	V
Icharge	800	1000	1200	mA
Iload	0		500	mA
Vbattery		4.3		V
Vsource USB		5.0		V
Vdestination USB (VDD5)	4.75	5.0	5.25	V



SunAir Board Jumper Pin and Plug Locations

Physical dimensions of board: 63.5mm x 64.5mm x 12mm(max). Mounting holes inset 2.0mm x2.0mm from each corner to center of hole. Diameter of hole 2mm.

I/O Key:

I - Digital Input
O - Digital Output
A - Analog

Jumper Pin Functions

JP1 - Right Photoresistor

Connected to A/D for measurement of the Photoresistor. No particularly accurate, but you can sense light magnitude. See A/D section above for code to measure Photoresistor.

NAME	PIN	I/O	DESCRIPTION
GP1	JP1 / 1	I/O	Connect to Photoresistor. Connected directly to EXTGP1 (Pi or Arduino GPIO pin). Not buffered.
R6	JP1 / 2	I	Connected to 2.2K Pullup Resistor to PIV3V

JP2 - Left Photoresistor

Connected to A/D for measurement of the Photoresistor. No particularly accurate, but you can sense light magnitude. See A/D section above for code to measure Photoresistor.

NAME	PIN	I/O	DESCRIPTION
GP0	JP2 / 1	I/O	Connect to Photoresistor. Connected directly to EXTGP0 (Pi or Arduino GPIO pin). Not buffered.
R5	JP2 / 2	I	Connected to 2.2K Pullup Resistor to PIV3V

JP3 - WatchDog Power

Use with external pullup resistor to power external low current WatchDog Timer board, such as the SwitchDoc Labs Dual WatchDog Timer. This is used to prevent an external watchdog timer from booting up the Arduino or Raspberry Pi if the output USB voltage is not above 4.6V.

NAME	PIN	I/O	DESCRIPTION
WatchDogPower	JP3 / 1	A	Pulled Low when VDD5 < 4.6V. Should connect an external pullup of 1K Ohms to VDD5 for powering the SwitchDoc Dual WatchDog Timer

JP4 - Ground

NAME	PIN	I/O	DESCRIPTION
GND	JP4 / 1	A	Utility Connection to GND
GND	JP4 / 2	A	Utility Connection to GND

JP11 - VDD5

NAME	PIN	I/O	DESCRIPTION
VDD5	JP11 / 1	A	Utility Connection to VDD5
VDD5	JP11 / 2	A	Utility Connection to VDD5

JP5 - Current Measurements

Using a good multimeter or a good A/D you can measure the voltages across the pins to measure current flowing in the system. SunAirPlus provides a 3 Channel Current and Voltage I2C chip for this purpose. You can also use the LIPO_BAT pin to measure the voltage of the battery for the use with the SwitchDoc Labs SunAirPowerControl Board.

NAME	PIN	I/O	DESCRIPTION
LIPO_BAT_INT	JP5 / 1	A	Connected to LiPo Battery + through 0.1 Ohm Resistor
LIPO_BAT	JP5 / 2	A	Output of LiPo Battery +
SOLAR_INT	JP5 / 3	A	Connected to Solar Cell + through 0.1 Ohm Resistor
SOLAR	JP5 / 4	A	Output of Solar Cell +
VDD5INT	JP5 / 5	A	Output of 5V Voltage Booster
VDD5	JP5 / 6	A	Connected to VDD5 Voltage Booster through 0.1 Ohm Resistor

JP9 - Solar Capacitor Plus

Adding an optional large filter 4700uF capacitor across JP9 and JP10 will help to stabilize the Solar Cell Voltage. Useful for some solar panels.

NAME	PIN	I/O	DESCRIPTION
SolarCAP+	JP9 / 1	A	Connect to + on Optional Filter Capacitor for Solar Cell

JP18 - Solar Capacitor Minus

NAME	PIN	I/O	DESCRIPTION
SolarCAP-	JP9 / 2	A	Connect to - on Optional Filter Capacitor for Solar Cell

JP10 - Spare Internal I2C

You can connect up additional 5V I2C devices to this port.

NAME	PIN	I/O	DESCRIPTION
SCL	JP10 / 1	I	Serial bus clock line; open-drain input. 10K Ohm Pullup to VDD5. Buffered.
SDA	JP10 / 2	I/O	Serial bus data line; open-drain input/output. 10K Ohm Pullup to VDD5. Buffered.
VDD5	JP10 / 3	A	Connected to VDD5 (5V I2C Bus)
GND	JP10 / 4	A	GND

JP13 - External Computer Connections

This is the main connection port to connect to external computers. Most of these pins are self-explanatory but several merit additional explanations.

- PI3V3 - Used to indicate what signal voltages are being supplied to SunAir. Connect to 5V for Arduinos and to 3.3V for Raspberry Pi. This tells how the internal level shifters should behave.
- EXTGP0 - Connected to Left Photocell A/D. Can be used as a Normal GP0 I/O line if you don't connect a Left Photocell. It still has a 1uF capacitor connected to GND even without a photocell connected. This will slows down the effective rate that you can switch this pin on and off.
- EXTGP1 - Connected to Right Photocell A/D. Can be used as a Normal GP0 I/O line if you don't connect a Right Photocell. It still has a 1uF capacitor connected to GND even without a photocell connected. This will slows down the effective rate that you can switch this pin on and off.

NAME	PIN	I/O	DESCRIPTION
EXTSCL	JP13 / 1	I	Serial bus clock line; open-drain input. 10K Ohm Pullup to PIV3V. Buffered.
EXTSDA	JP13 / 2	I/O	Serial bus data line; open-drain input/output. 10K Ohm Pullup to PIV3V. Buffered.
PI3V3	JP13 / 3	A	Connect to 3.3V for Pi and 5V for Arduino
GND	JP13 / 4	A	GND
EXTSERVO	JP13 / 5	I/O	Connected to Servo Signal Output on JP15 - can be used General I/O. 10K Ohm Pullup to PIV3V. Buffered.
EXTLIMIT0	JP13 / 6	I/O	Connected to LIMIT0 on JP16. 10K Ohm Pullup to PIV3V. Buffered.
EXTLIMIT1	JP13 / 7	I/O	Connected to LIMIT1 on JP16. 10K Ohm Pullup to PIV3V. Buffered.
EXTGP0	JP13 / 8	I/O	Connected to GP0 on JP16. 10K Ohm Pullup to PIV3V. Buffered. Also directly connected to L-Photo JP2. Additonal 2.2K Ohm Pullup to PI3V3.
EXTGP1	JP13 / 9	I/O	Connected to GP1 on JP16. 10K Ohm Pullup to PIV3V. Buffered. Also directly connected to L-Photo JP2. Additonal 2.2K Ohm Pullup to PI3V3.
EXTGP2	JP13 / 10	I/O	Connected to GP1 on JP16. 10K Ohm Pullup to PIV3V. Buffered.

JP15 - Servo Connection

You can drive a 5V Servo from this connection. Drive the EXTSERVO line on JP13 with a PWM line from an Arduino or from a GPIO line on the Raspberry Pi (Using a GPIO library that supports PWM).

NAME	PIN	I/O	DESCRIPTION
GND	JP15 / 1	A	GND
VDD5	JP15 / 2	A	Connected to VDD5
SERVO	JP15 / 3	I/O	Connected EXTSERVO on JP13. Buffered.

JP16 - Limit Switches / GPIO

These pins are used for general I/O purposes as well as providing an interface for Limit Switches. The Limit Switch pins can also be used for general I/O purposes.

NAME	PIN	I/O	DESCRIPTION
GND	JP16 / 1	A	GND
GP0	JP16 / 2	I/O	Connected to EXTGP0 through level shifting buffer. 10K Ohm Pullup to VDD5
GP1	JP16 / 3	I/O	Connected to EXTGP1 through level shifting buffer. 10K Ohm Pullup to VDD5
GP2	JP16 / 4	I/O	Connected to EXTGP2 through level shifting buffer. 10K Ohm Pullup to VDD5
GND	JP16 / 5	A	GND
LIMIT0	JP16 / 6	I/O	Connected to EXTLIMIT0 through level shifting buffer. 10K Ohm Pullup to VDD5
GND	JP16 / 7	A	GND
LIMIT1	JP16 / 8	I/O	Connected to EXTLIMIT1 through level shifting buffer. 10K Ohm Pullup to VDD5

Plug Functions

J1 - MiniB USB In - Charge and Programming

Female MiniB USB Plug. Used for charging the LiPo battery. D1, D+ are passed to the USB A Out plug allowing programming of Arduinos from the USB A Out plug. Diode Protected from back EMF.

J3 - USB A Out - Power and Programming

FemaleUSB A Plug. Used for powering the external computer. D1, D+ are passed to the USB A Out plug from the MiniB USB Plug allowing programming of Arduinos from this plug. USB A Out will also charge tables and cell phones.

J5 - LiPo Battery In

Battery connector is JST 2.0.

NAME	PIN	I/O	DESCRIPTION
+	J5 / 1	A	Connect to + Terminal of 3.7V Lithium Ion polymer battery
GND	J5 / 2	A	Connect to - Terminal of 3.7V Lithium Ion polymer battery

J6 - Solar Cells In

Solar Panel connector is JST 2.0.

NAME	PIN	I/O	DESCRIPTION
+	J6 / 1	A	Connect to + Terminal of 6V Solar Cell Panel - Diode Protected from back EMF
GND	J6 / 2	A	Connect to - Terminal of 6V Solar Cell Panel

Switch Functions

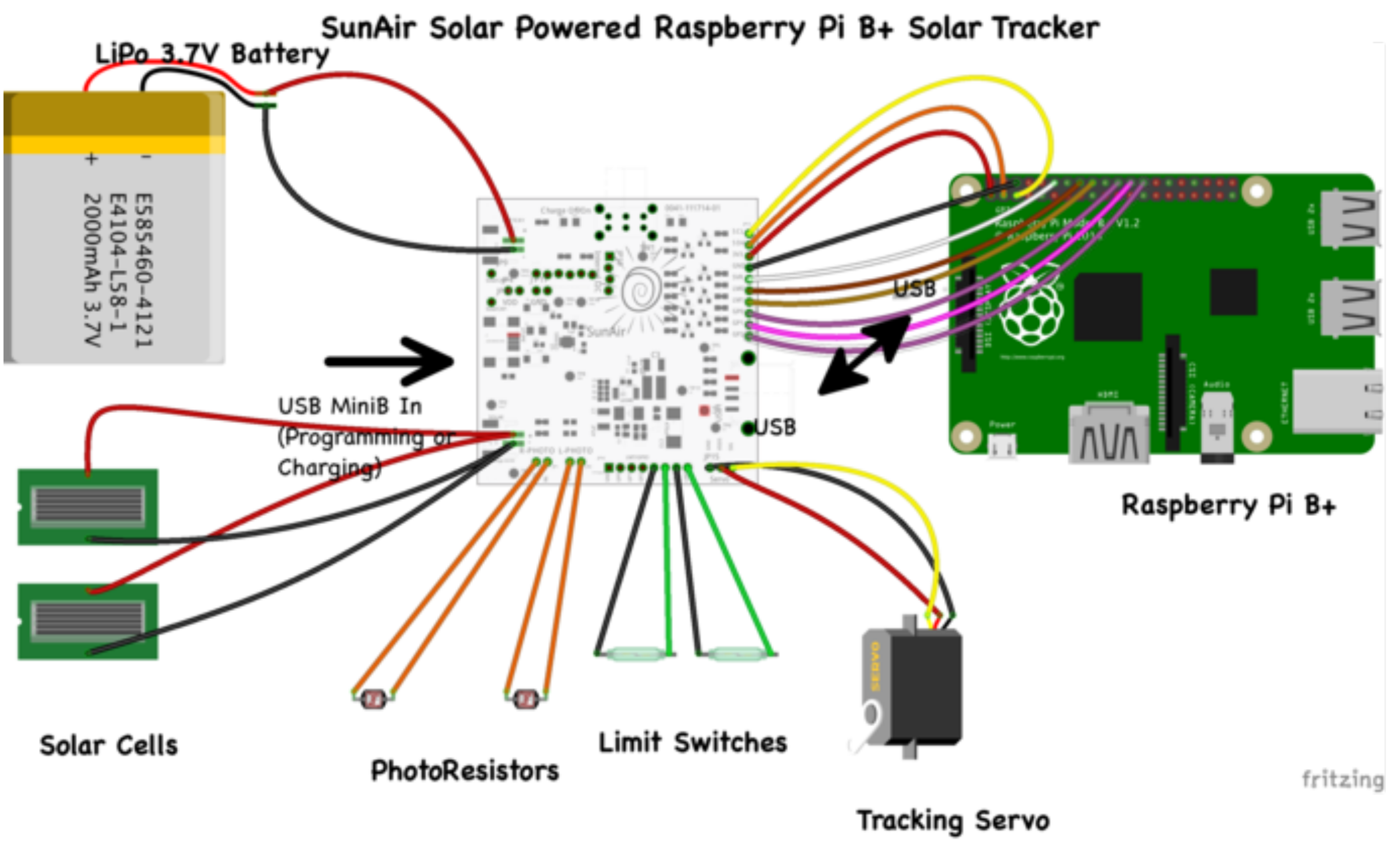
SW1 - Turn LiPo Battery to Voltage Booster On/Off

Turning this switch off disconnects the Charging circuitry from the Voltage Boosting circuitry which turns the power off to the USB A Plug out (for the external computer). Charging of the LiPo battery continues.

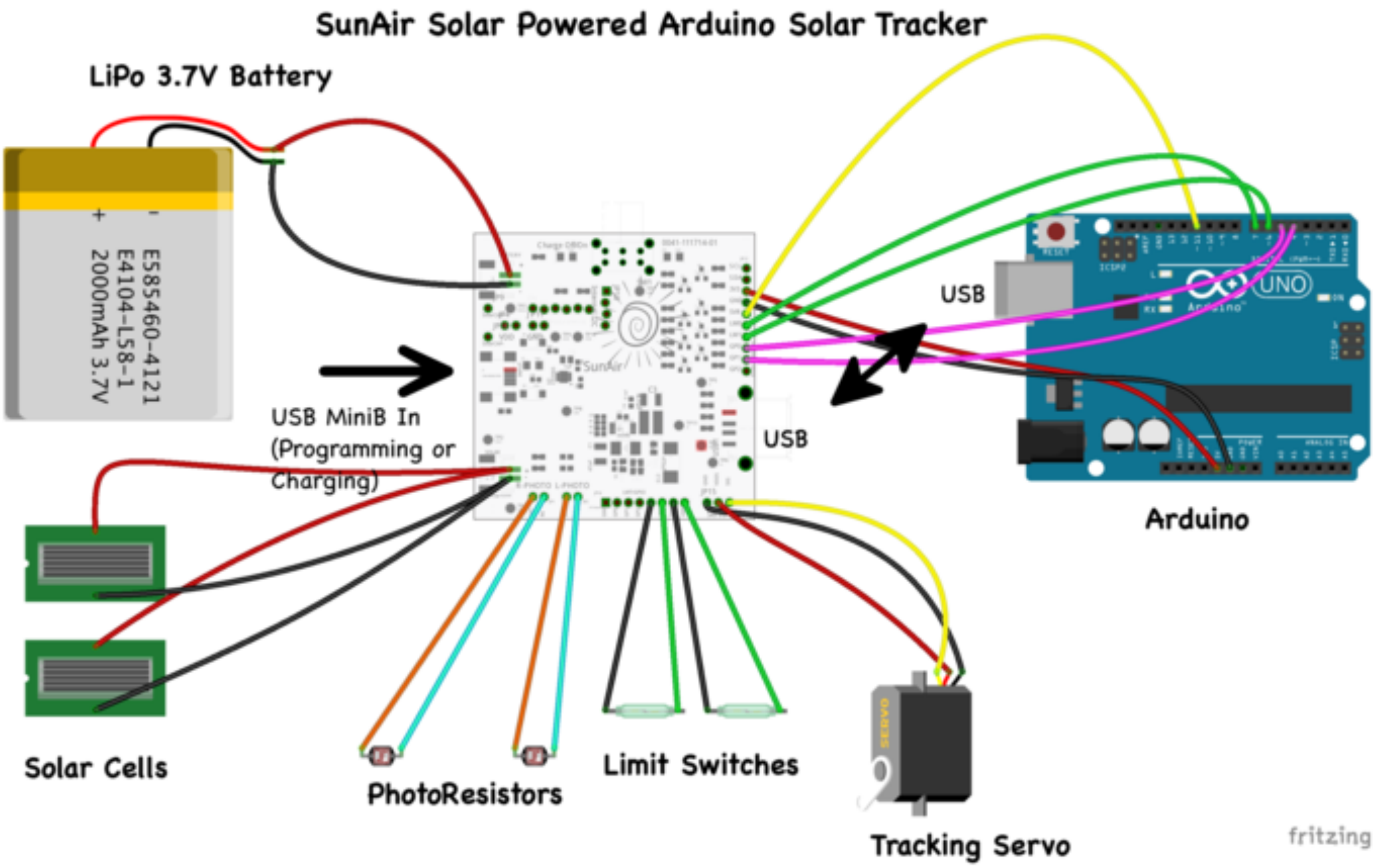
Example Applications

The following diagrams show how to hook up a SunAir board to a Solar Panel, LiPo Battery and the Raspberry Pi or Arduino. Example connections are also shown for photoresistors and for limit switches.

Connecting an Arduino to the SunAir Board

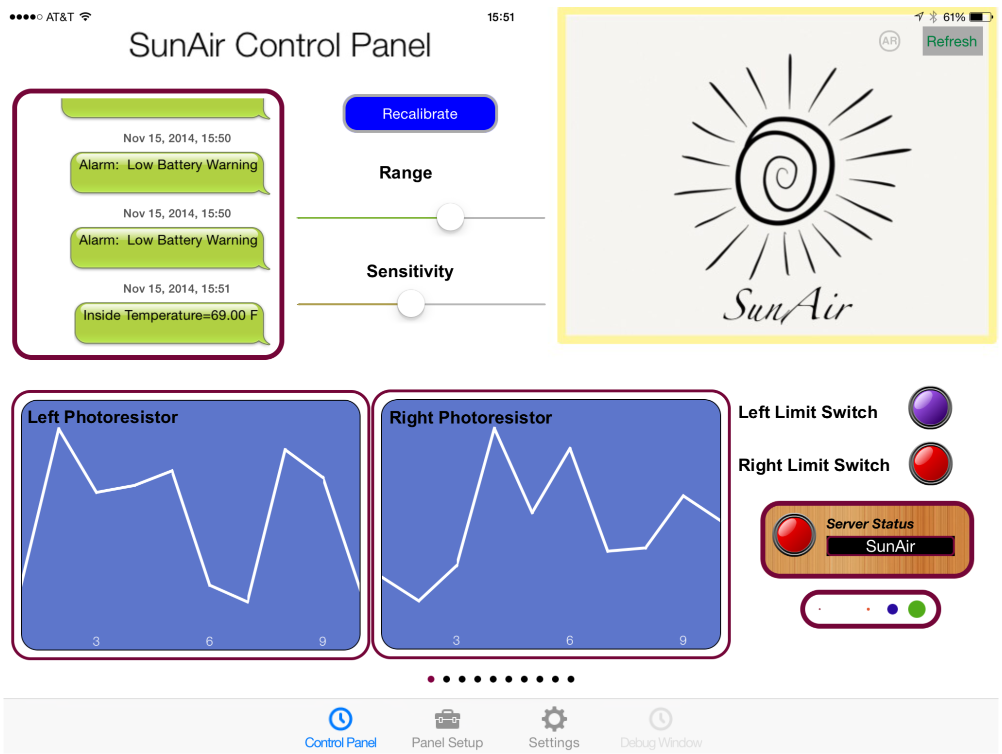


Connecting a Raspberry Pi B+ to the SunAir Board



Control Panels

Special versions of RasPiConnect and ArduinoConnect will be available for $2.00 on the Apple Appstore in February of 2015. The control panel for SunAir is shown below. SwitchDoc Labs has completed a licensing agreement with MiloCreek(www.milocreek.com) to put a version of RasPiConnect and ArduinoConnect up on the Appstore for SunAir customers. These will be sold by MiloCreek and will be called SunAirPiConnect and SunAirArduinoConnect.



Cautions

- Live exposed electronic components
- The board may get hot when supplying large loads
- Potential short circuit or electric shock, especially if device gets wet when placed outdoors for solar power collection