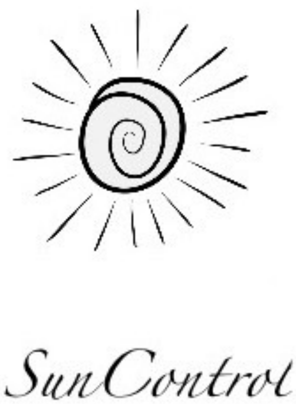
SwitchDoc Labs

SunControl Solar Power Controller Board

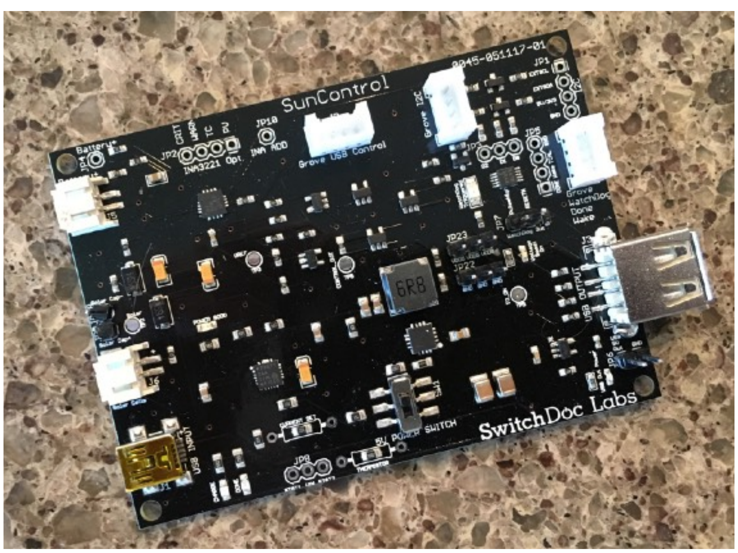
The **SunControl Solar Power Controller Board** for Raspberry Pi, Arduino and Cell Phone Charger is a 4th Generation Solar Charging and Sun Tracking Board designed by and manufactured by SwitchDoc Labs.



You can use this board to power, measure and control your Solar Power projects. It incorporates a number of outstanding features in a very compact, inexpensive single fully assembled and tested PC Board. SunControl is customizable with your software and hardware.

Features and Benefits:

- Perfect for Solar Power SYSTEM design
- Uses 6V Solar Cells
- Use 3.7V LiPo Cells for batteries
- Has LiPo to 5V voltage boost built in
- Directly powers Raspberry Pi / Arduino
- Grove Connectors
- Works Raspberry Pi (3.3V) GPIO and Arduino (5.0V) GPIO
- INA3221 - 3 channel current/voltage measurement Built-in
- USB PowerControl for Load Built-in
- Hardware WatchDog Timer Built-in
- Charges iPhones and other phones or devices
- Approximates an MPPT (Maximum Power Point Tracking) charging system
- 3D SunControl Tracker OpenSCAD files available and STL files
- Low Power
- Low Cost
- Open Source Software
- Full Test Code Supplied
- Quantity Discounts Available
- Immediate Availability

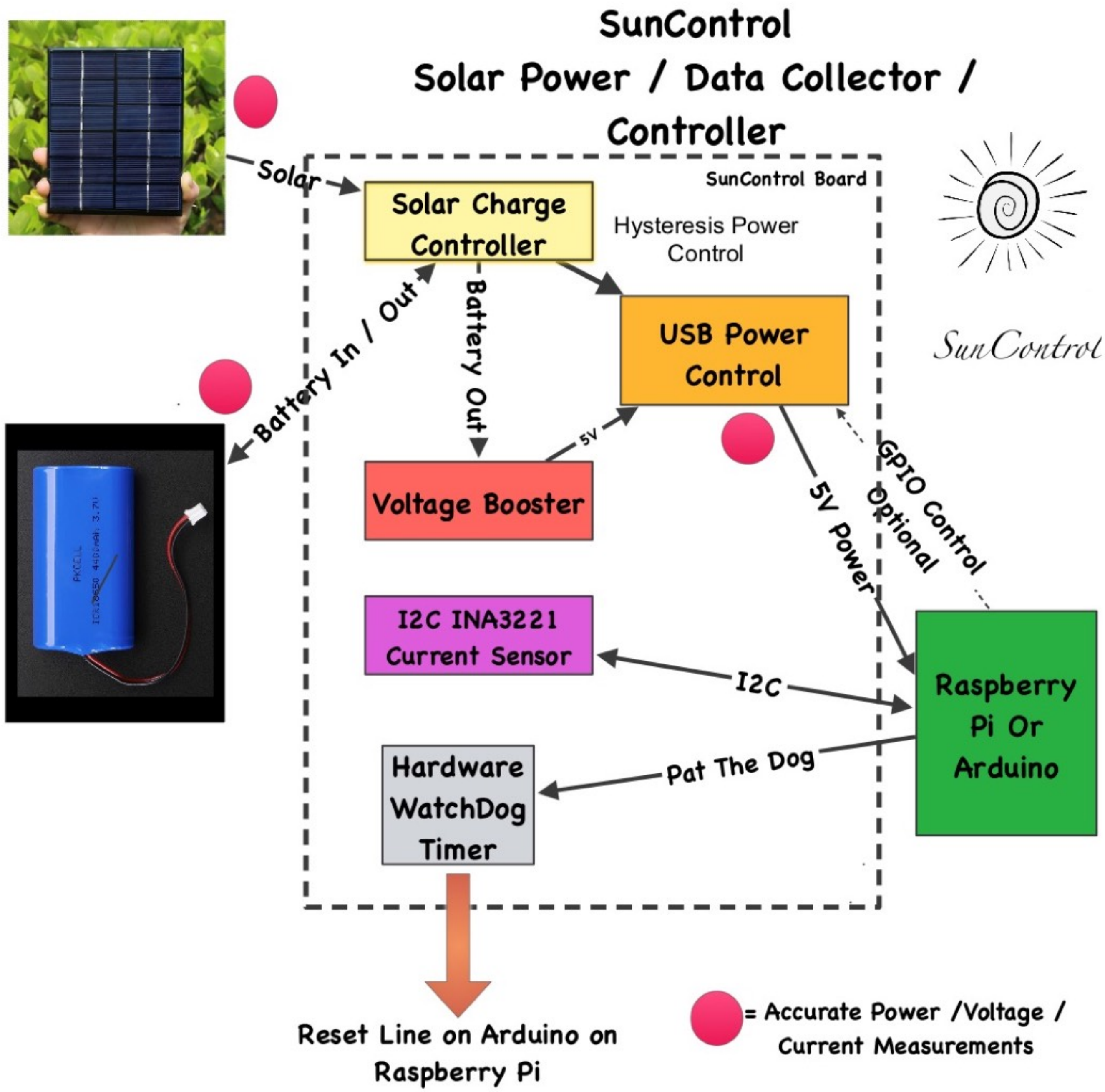


Introduction

SunControl is a solar power controller / sun tracker / power supply system developed by SwitchDoc Labs to power Arduino and Raspberry Pi based systems. The board has solar panel charge control system, a voltage booster, an A/D system data collection monitor and USB solid state relay and a hysteresis based power control system.

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

Block Diagram



Theory of Operation

Solar Charge Controller

The Solar Charge Controller on SunControl is based around a MCP73871 Load Sharing Lithium Ion Battery Charge Controller to run the charging sequence for the batteries. The chip does an approximation of the MPPT (Maximum Power Point Tracker).

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.

The MCP73871 device is a fully integrated linear solution for system load sharing and Li-Ion / Li-Polymer battery charge management with connected solar panels and USB port power sources selection. It's also capable of autonomous power source selection between input or battery.

The MCP73871 device automatically obtains power for the system load from a single-cell Li-Ion battery or an input power source (ac-dc wall adapter or USB port). The MCP73871 device specifically adheres to the current drawn limits governed by the USB specification. With an ac-dc wall adapter providing power to the system, an external resistor sets the magnitude of 1A maximum charge current while supports up to 1.8A total current for system load and battery charge current.

We carefully designed the solar power charging circuitry to make maximum use of the solar cell power coming to SunControl. We have circuitry that prevents solar panel "voltage collapses" that plague many simpler boards.

Voltage Booster

In order to boost the nominal 3.7V - 4.2V output from the LiPo batteries up to 5.1V, SunControl uses a voltage booster. We take the voltage up to 5.1V to allow for voltage drops that happen on many inexpensive USB cables. The TPS61030 used in SunControl devices provide a power supply solution for products powered by Li-Ion or Li-polymer. The booster generates a stable output voltage that is either adjusted by an external resistor divider or fixed internally on the chip. It provides high efficient power conversion and is capable of delivering output currents up to 1 A at 5 V at a supply voltage down to 1.8 V. The implemented boost converter is based on a fixed frequency, pulse-width- modulation (PWM) controller using a synchronous rectifier to obtain maximum efficiency. At low load currents the converter enters Power Save mode to maintain a high efficiency over a wide load current range. The Power Save mode can be disabled, forcing the converter to operate at a fixed switching frequency. It can also operate synchronized to an external clock signal that is applied to the SYNC pin. The converter can be disabled to minimize battery drain. During shutdown, the load is completely disconnected from the battery. A low-EMI mode is implemented to reduce ringing and, in effect, lower radiated electromagnetic energy when the converter enters the discontinuous conduction mode.

Current/Voltage Sensors - INA3221

This is one of the most interesting parts of the SunControl board. It allows you to get dynamic and accurate information on how your Solar Power system is running.

The INA3221 is a three-channel, high-side current and bus voltage monitor with an I2C interface. The INA3221 monitors both shunt voltage drops and bus supply voltages in addition to having programmable conversion times and averaging modes for these signals. There are three 0.1 Ohm shunts on the board.

Below are some results from the INA3221 test software.

```
Test SDL_Pi_INA3221 Version 1.0 - SwitchDoc Labs

Sample uses 0x40 and SunControl board INA3221
Will work with the INA3221 SwitchDoc Labs Breakout Board


------------------------------
LIPO_Battery Bus Voltage: 4.15 V
LIPO_Battery Shunt Voltage: -9.12 mV
LIPO_Battery Load Voltage:  4.14 V
LIPO_Battery Current 1:  91.20 mA

Solar Cell Bus Voltage 2:  5.19 V
Solar Cell Shunt Voltage 2: -73.52 mV
Solar Cell Load Voltage 2:  5.12 V
Solar Cell Current 2:  735.20 mA

Output Bus Voltage 3:  4.88 V
Output Shunt Voltage 3: 48.68 mV
Output Load Voltage 3:  4.93 V
Output Current 3:  486.80 mA
```

Software for the INA3221 is available from SwitchDoc Labs on http://github.com/switchdoclabs.

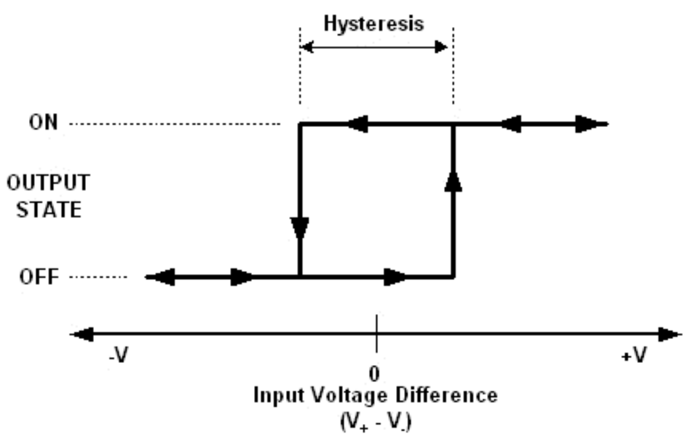
The default I2C address is 0x40. You can adjust this on the SunControl board by using the JP10 (INA ADD) pin.

USB PowerControl

The USB PowerControl section of SunControl is very similar to the SwitchDoc Labs product USB PowerControl. This section of SunControl is a digitally controlled power switch for your Arduino or Raspberry Pi. Anything you can plug into a USB port can be controlled with this USB Port. It is either controlled by the input of the LiPo battery voltage (LIPOBATIN) or by GPIO lines connected to the Grove USB Control port.

In order to control a USB Port based on a battery voltage, you need to turn on at one voltage and turn off at another. This process is called Hysteresis and prevents damage to your Raspberry Pi SD card or other processors caused by rapid on and off power cycles. What causes this is you get to a certain voltage and the USB port turns on and connects to the load, which lowers the battery voltage and the USB port turns off again. The cycle then repeats. The input to the board was designed to come directly from a LiPo battery so the computer won't be turned on until the LiPo battery was charged up above 3.7V. We provide a hysteresis circuit so the board won't turn off until the voltage goes below around 3.3V. This is an excellent board to shut on and off USB powered devices like a Raspberry Pi and Arduino. It works just like a conventional relay, except that it requires virtually no current to keep it on or off. Like a latching relay.

The SunControl Hysteresis circuit on LIPOBATIN is based on a TA75S39 Operational Amplifier used as a comparator. A comparator with hysteresis has two important thresholds: upper and lower. Unlike a simple comparator, however, the output of the comparator doesn't depend solely on whether the input is above or below one of these thresholds. It depends on both the current state of the output **and** the current value of the input. If the output is high, it will stay high until the input voltage drops below the lower threshold. If the output is low, it will stay low until the input voltage rises above the upper threshold.



The diagram to the right shows a hysteresis 'loop' that describes how a comparator functions. The horizontal 'X' axis is the input, and represents the difference of the two input voltages. The vertical "Y" axis represents the comparator's output state.

If the comparator is initially 'OFF', the MINUS input voltage has to become slightly above the PLUS input voltage before the comparator output turns 'ON'. This is represented by moving right along the bottom part of the loop.

Once the comparator is 'ON', the MINUS input voltage needs to drop slightly below the PLUS input voltage before it turns 'OFF' again (moving left along the top of the loop).

The 'ON' state is set in the USB PowerControl to be 3.7V and the 'OFF' state is set to be about 3.3V. The output of the comparator drives the input to the Load Switch.

The Grove Digital Input that allows you to control the USB PowerControl using two GPIO Lines (one enable and one control line) to switch on and off from a Grove Digital Port. The Grove Enable Line, when high, disables the LIPOBATIN line and makes control of the device under the Grove CONTROL Line. When the Grove Enable Line is low, the LIPOBATIN line controls the relay as in the original USB PowerControl. The Grove Enable Line is pulled down by a 43K resistor so if it is disconnected by default it uses LIPOBATIN.

Independent Hardware WatchDog Timer

SunControl contains an independent hardware WatchDog Timer for project use. We found virtually every solar project we have built ends up having need of a WatchDog timer to recover from brownouts, issues with solar power and of course, mistakes in your programming.

SunControl contains a TPL5000 hardware watchdog timer. The TPL5000 is designed for use in interrupt-driven applications and provides selectable timing from 1 second to 64 seconds. The TPL5000 realizes this watchdog function without consuming additional power.

You can connect the input of the WatchDog timer via a GPIO line (or the provided Grove connector) to “pat the dog” via your processor, thus keeping the dog from resetting your processor. If your computer quit “patting the dog”, then the WatchDog resets your processor so your software can start again.

You can make your project more reliable by using an external Hardware 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/).

Controlling the USB Port

Grove USB Control

The Digital Grove USB Control port is used to control and configure the USB port power circuitry.

This circuitry is provided to allow the USB Port to be controlled by either LIPOBATIN (the connected LiPo battery voltage) or the state of the CONTROL Line (J2 Pin 1). ENABLE (J2 Pin 2) controls whether the USB PowerControl is switched by LIPOBATIN or the CONTROL line.

SunControl defaults to LIOPBATIN control. If LIPOBATIN is above about 3.7V it is considered a digital “1”. For behavior of LIPOBATIN below 3.7V, please refer to the hysteresis section above (the turn on voltage is about 3.7V and the turn off voltage is about 3.3V), otherwise it remains in the previous state until one of these levels is breached.

The truth table for the USB PowerControl is given below:

USB Port Control Behavior			
LIPOBATIN	**ENABLE**	**CONTROL**	**USB OUT POWER**
0	0	0	OFF
0	0	1	OFF
0	1	0	OFF
0	1	1	ON
1	0	0	ON
1	0	1	ON
1	1	0	OFF
1	1	1	ON

Operating Values

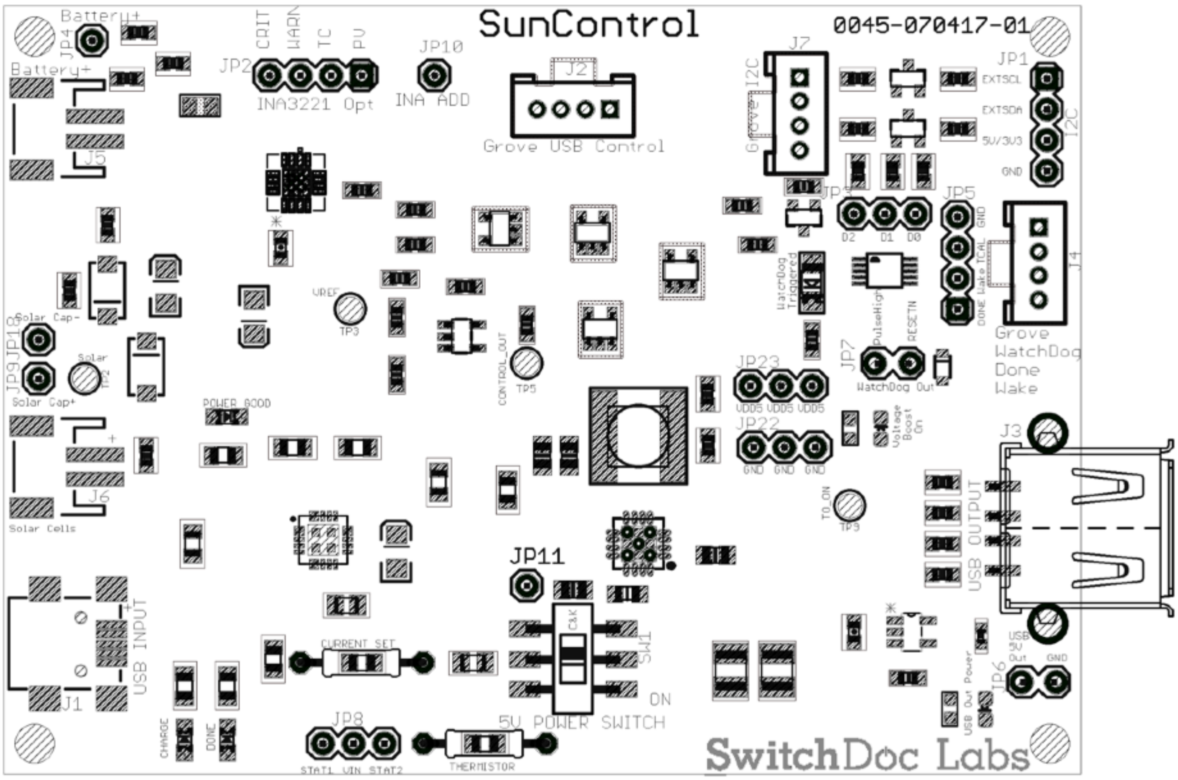
	Min	Normal	Max	Unit
Vin Solar	4.8	5.0	6.5	V
Icharge			1800	mA
Iload	0		1000	mA
Vbattery		4.2		V
Vsource USB		5.1		V
Vdestination USB (VDD5)	4.75	5.0	5.25	V

SunControl Board Jumper Pin and Plug Locations

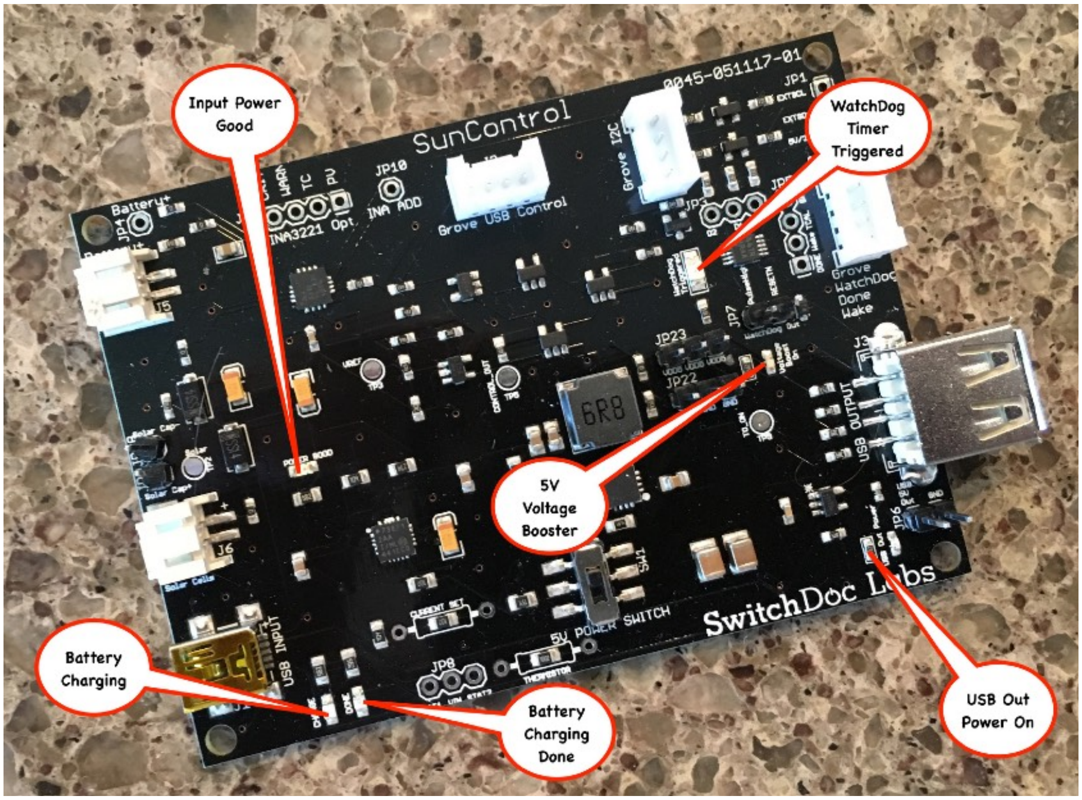
Physical dimensions of board: 63.5mm x 89mm x 12mm(max). Mounting holes inset 2.0mm x2.0mm from each corner to center of hole. Diameter of hole 2mm.

I/O Key:

I - Digital Input
O - Digital Output
A - Analog


SunControl
0045-070417-01
Battery+
JP4
Battery-
JP2
CRIT
WARN
TC
PV
INA3221 Opt
JP10
INA ADD
J2
Grove USB Control
J7
Grove I2C
JP1
EXTSCL
EXTSDA
5V/3V3
GND
I2C
J5
JP3
D2
D1
D0
JP5
J4
Grove
WatchDog
Done
Wake
VREF
TP3
Solar Cap-
JP18
JP9
Solar
TP2
Solar Cap+
POWER GOOD
CONTROL_OUT
TP5
JP23
VDD5 VDD5 VDD5
JP22
GND GND GND
JP7
WatchDog Out
PulseHigh
RESETN
WatchDog Triggered
J3
J6
Solar Cells
TO_ON
USB OUTPUT
JP11
USB INPUT
J1
CURRENT SET
SW1
ON
5V POWER SWITCH
JP8
STAT1 VIN STAT2
THERMISTOR
CHARGE
DONE
JP6
USB 5V Out
GND
USB Out Power
SwitchDoc Labs

LED Indicators



NAME	I/O	DESCRIPTION
CHARGE	A	Battery Charging - GREEN
DONE	A	Battery Charging Done - ORANGE
POWER GOOD	A	Input Power Good - RED
VOLTAGE BOOST ON	A	5V Voltage Boost On
USB OUT POWER	A	USB 5.1V Power On
WATCHDOG TRIGGERED	A	Flashes when WatchDog is Triggered - Defaults to every 30 seconds (i.e. if you don't pat the WatchDog)

The red **POWER GOOD** LED indicates that there is good power connected to the charger. If this LED is not lit something is not connected or wrong with the power supply.

The orange **CHARGE** LED indicates current charging status. When this LED is lit, the charger is working to charge up a battery. It also acts as a low battery indicator (fixed at 3.1V) when no power is connected. When you don't have USB/ Solar wired up, and when the battery voltage drops below 3.1V, the orange **CHARGE** LED will come on.

The green **DONE** LED indicates the the battery is charged up and the charging is complete.

Grove Connectors

J2 - Grove USB Control Plug

Used to control USB PowerControl Port. Grove Digital Port

NAME	PIN	I/O	DESCRIPTION
CONTROL	J2 / 1	I	USB PowerControl ON = 1, OFF = 0 - Enabled by ENABLE - pulled down to GND with 43K Ohm resistor
ENABLE	J2 / 2	I	Enable = 0, LIPOBATIN Controls. Enable = 1, CONTROL controls, - pulled down to GND with 43K Ohm resistor
N/C	J2 / 3	A	N/C - No Connection
GND	J2 / 4	A	Ground

J4 - Grove WatchDog Done / Wake Plug

Used to control USB PowerControl Port. Grove Digital Port

NAME	PIN	I/O	DESCRIPTION
DONE	J4 / 1	I	Logic Input for watchdog functionality. This is the pin with which you "pat the dog" to stop the WatchDog from triggering
WAKE	J4 / 2	O	Timer output signal generated every t_{DP} period from WatchDog Chip
N/C	J4 / 3	A	N/C - No Connection
GND	J4 / 4	A	Ground

J7 - Grove I2C Plug

Connect to Computer to read the INA3321 results: Voltage/Current for Solar Cells, Battery and Load

NAME	PIN	I/O	DESCRIPTION
SCL	J4 / 1	I	I2C Clock Line - Open Drain 10KOhm Pullup
SDA	J4 / 2	I/O	I2C Data Line - Open Drain 10KOhm Pullup
VDD	J4 / 3	A	I2C Supply Voltage (3.3V or 5V Compatible)
GND	J4 / 4	A	Ground

Jumper Pin Functions

JP1 - External I2C Pin Headers

These are connected to the same pins on the Grove I2C Connector

NAME	PIN	I/O	DESCRIPTION
SCL	JP1 / 1	I	I2C Clock Line - Open Drain 10KOhm Pullup
SDA	JP1 / 2	I/O	I2C Data Line - Open Drain 10KOhm Pullup
VDD5	JP1 / 3	A	I2C Supply Voltage (3.3V or 5V Compatible)
GND	JP1 / 4	A	Ground

JP2 - INA3221 Optional Headers

These signals are connected to the INA3221 3 Channel Current / Voltage I2C IC. See TI INA3221 Specification.

NAME	PIN	I/O	DESCRIPTION
PV	JP2 / 1	O	Power valid alert; open-drain output.
TC	JP2 / 2	O	Timing control alert; open-drain output.
WARN	JP2 / 3	O	Averaged measurement warning alert; open-drain output.
CRIT	JP2 / 4	O	Conversion-triggered critical alert; open-drain output.

JP10 - INA3221 I2C Address Select

You can change the I2C address of the INA3221 on SunControl by tying this to VDD5, GND, SDA, or SCL. The state of the INA ADD pin is sampled on every bus communication and should be set before any activity on the interface occurs.

NAME	PIN	I/O	DESCRIPTION
INA ADD	JP10 / 1	I	Power valid alert; open-drain output.

	CONNECTED TO	I2C ADDRESS
INA ADD	GND	Default: 0x40 - 10KOhm Pulldown Resistor
INA ADD	VDD5	0x41
INA ADD	SDA	0x42
INA ADD	SCL	0x43

JP3 - Tdp WatchDog Period Select

These signals set to “111” (64 seconds) by default. See TI TPL5000 Specification.

NAME	PIN	I/O	DESCRIPTION
D0	JP3 / 1	O	Logic Input to set period delay (t_{DP}). 39KOhm Pullup tied to VDD5 (Off Voltage Booster)
D1	JP3 / 2	O	Logic Input to set period delay (t_{DP}). 39KOhm Pullup tied to VDD5 (Off Voltage Booster)
D2	JP3/ 3	O	Logic Input to set period delay (t_{DP}). 39KOhm Pullup tied to VDD5 (Off Voltage Booster)

Table 1. Timer Delay Period

D2	D1	D0	Time (s)	Factor N
0	0	0	1	2^6
0	0	1	2	2^7
0	1	0	4	2^8
0	1	1	8	2^9
1	0	0	10	$10*2^6$
1	0	1	16	2^{10}
1	1	0	32	2^{11}
1	1	1	64	2^{12}

JP5 - WatchDog Timer Pin Headers

DONE and WAKE are also on Grove WatchDog Timer Plug. TCAL is for optional timer calibration. See TI TPL5000 Specification.

NAME	PIN	I/O	DESCRIPTION
DONE	JP1 / 1	I	Logic Input for watchdog functionality. This is the pin with which you "pat the dog" to stop the WatchDog from triggering
WAKE	JP1 / 2	O	Timer output signal generated every t_{DP} period from WatchDog Chip
TCAL	JP1 / 3	O	Short duration pulse output for estimation of TPL5000 timer delay. For Calibration.
GND	JP1 / 4	A	Ground

JP7 - WatchDog Out

See TPL5000 Specification. Used to reset computer or other circuitry when WatchDog is triggered.

NAME	PIN	I/O	DESCRIPTION
RESETN	JP7 / 1	O	Open Drain Output of WatchDog Timer. Use to pull RESETN down on Arudino / Raspberry Pi. Pulls down for 15.625mS. Diode protected. Anode faces TPL5000.
PULSEHIGH	JP7 / 2	O	Drive Pulse High to VDD5 when Output of WatchDog Timer is low (RESETN Active). Pulls down for 15.625mS. Driven both High and Low.

JP6 - USB 5.1V Out Auxiliary Pin Headers

NAME	PIN	I/O	DESCRIPTION
USB 5.1V OUT	JP6 / 1	A	Utility Connection to switched USB 5.1V Voltage Out
GND	JP6 / 2	A	Utility Connection to GND

JP22 - Utility Ground

NAME	PIN	I/O	DESCRIPTION
GND	JP22 / 1	A	Utility Connection to GND
GND	JP22 / 2	A	Utility Connection to GND
GND	JP22 / 3	A	Utility Connection to GND

JP23 - Utility VDD5 - Output of Voltage Booster

NAME	PIN	I/O	DESCRIPTION
VDD5	JP23 / 1	A	Utility Connection to VDD5 - Output of Voltage Booster before the USB Port Control Switch
VDD5	JP23 / 2	A	Utility Connection to VDD5 - Output of Voltage Booster before the USB Port Control Switch
VDD5	JP23 / 2	A	Utility Connection to VDD5 - Output of Voltage Booster before the USB Port Control Switch

JP4 - LiPo Battery Out

Direct output from the LiPo Battery.

NAME	PIN	I/O	DESCRIPTION
LiPo Battery Out	JP4 / 1	A	Direct connection from + terminal on LiPo Battery

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

JP8 - Solar / Battery Charger / Controller Option Pin Headers

NAME	PIN	I/O	DESCRIPTION
STAT2	JP8 / 1	O	Charge Status 2
VIN	JP8 / 2	A	Input Voltage to the Charger Circuitry
STAT1	JP8 / 2	O	Charge Status 1

The charge status outputs have two different states: Low (L), and High Impedance (Hi-Z). The charge status outputs can be used to illuminate LEDs. Optionally, the charge status outputs can be used as an interface to a host computer.   The CHARGE LED is on when the STAT 1 is pulled down (indicating charging is happening) and the DONE LED is on when the STAT 2 is pulled down (indicating charging is complete).   The following table gives you all the states, faults and and meaning.   The POWERGOOD LED shows the state of /PG. If /PG is low, the POWERGOOD LED is On. Otherwise the POWERGOOD LED off.

CHARGE CYCLE STATE	STAT1	STAT2	$\overline{PG}$
Shutdown ($V_{DD} = V_{BAT}$)	Hi-Z	Hi-Z	Hi-Z
Shutdown (V_{DD} = IN)	Hi-Z	Hi-Z	L
Preconditioning	L	Hi-Z	L
Constant Current	L	Hi-Z	L
Constant Voltage	L	Hi-Z	L
Charge Complete - Standby	Hi-Z	L	L
Temperature Fault	L	L	L
Timer Fault	L	L	L
Low Battery Output	L	Hi-Z	Hi-Z
No Battery Present	Hi-Z	Hi-Z	L
No Input Power Present	Hi-Z	Hi-Z	Hi-Z

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 for 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.

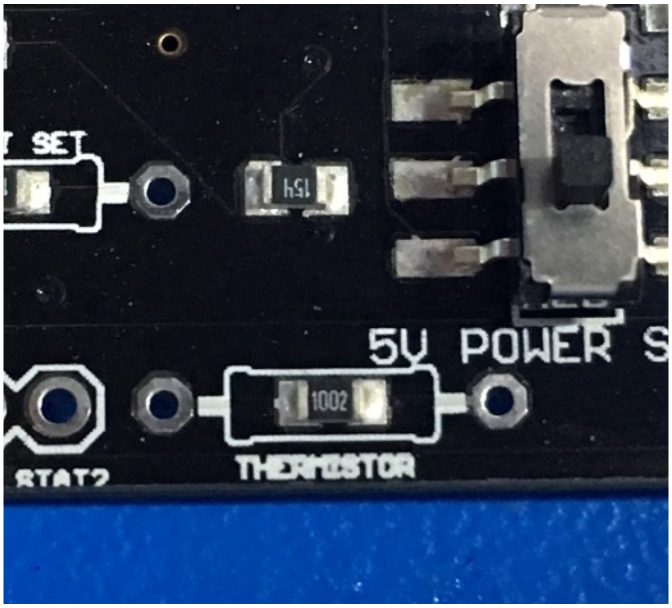
NAME	PIN	I/O	DESCRIPTION
+	J6 / 1	A	Connect to + Terminal of 6V Solar Cell Panel. Diode protected for back EMF.
GND	J6 / 2	A	Connect to - Terminal of 6V Solar Cell Panel

Switch Functions

SW1 - Turn 5V Voltage Booster On/Off

Turning this switch off disabling 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. ON is towards the bottom of the board, OFF is towards the top of the board.

Temperature Monitoring



If you plan to have your project outside or unattended for long periods of time, you may want to add the optional 10K NTC 3950 Thermistor.

The MCP73871 device on SunControl continuously monitor battery temperature during a charge cycle by measuring the voltage between the THERMISTOR and GND pins. An internal 50µA current source provides the bias for most common 10 kΩ negative-temperature coefficient thermistors (NTC). The MCP73871 device compares the voltage at the THERMISTOR pins to factory set thresholds of 1.24V and 0.25V, typically.

Once a voltage outside the thresholds is detected during a charge cycle, the MCP73871 device immediately suspends the charge cycle. The MCP73871 device suspends charge by turning off the charge pass transistor and holding the timer value. The charge cycle resumes when the voltage at the THERMISTOR pins returns to the normal range.

You can find an inexpensive compatible 10K NTC 3950 Thermistor on store.switchdoc.com.

How to Add a Thermistor to SunControl

Simply remove the 10K surface mount resistor from the THERMISTOR pads (or cut the trace going to it), and solder in a 10K NTC thermistor in the provided holes. You can test out the temperature system by trying to charge while you place the thermistor in a freezer or against some ice, as well as in a cup of > 50°C hot water.

SunControl should stop charging the battery and the CHARGING LED should turn off.

When you are done testing, attach the sensing element (the epoxy bulb) so it is resting against the battery.

What is a Grove Connector?

The way we have been wiring I2C connections before just didn't work for large projects. Basically, we used to put the I2C bus to screw terminals or snap down connectors and then ran wires to each device. This would not work for complex projects. Because of this, we moved to Grove connectors.

There are dozens of Grove I2C sensors out now.   Many different kinds of cables and I2C Hubs.

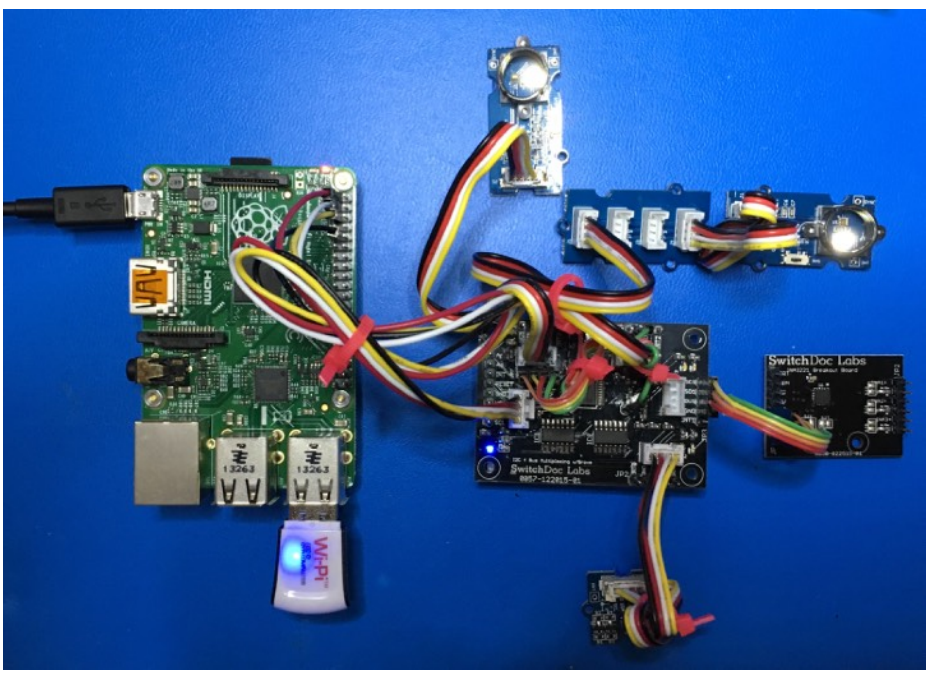
We quickly found the connectors and their respective cables very useful. With the large selection of Grove I2C devices available, we decided to include a Grove connector on all our future I2C boards.

Connecting to Grove Connectors

There are a number of Grove shields and Hats for Raspberry Pi and Arduino devices.
Grove I2C Connectors are keyed so they can not be plugged in incorrectly.

Here is a tutorial for connecting Non-Grove devices to Grove Devices using jumper plugs.

http://www.switchdoc.com/2017/03/using-grove-adaptors-on-pin-header-sensors/



Default Assumed SunControl Connections

INA3221 I2C Address = 0x40

USBControlCONTROL = 21
USBControlENABLE = 26

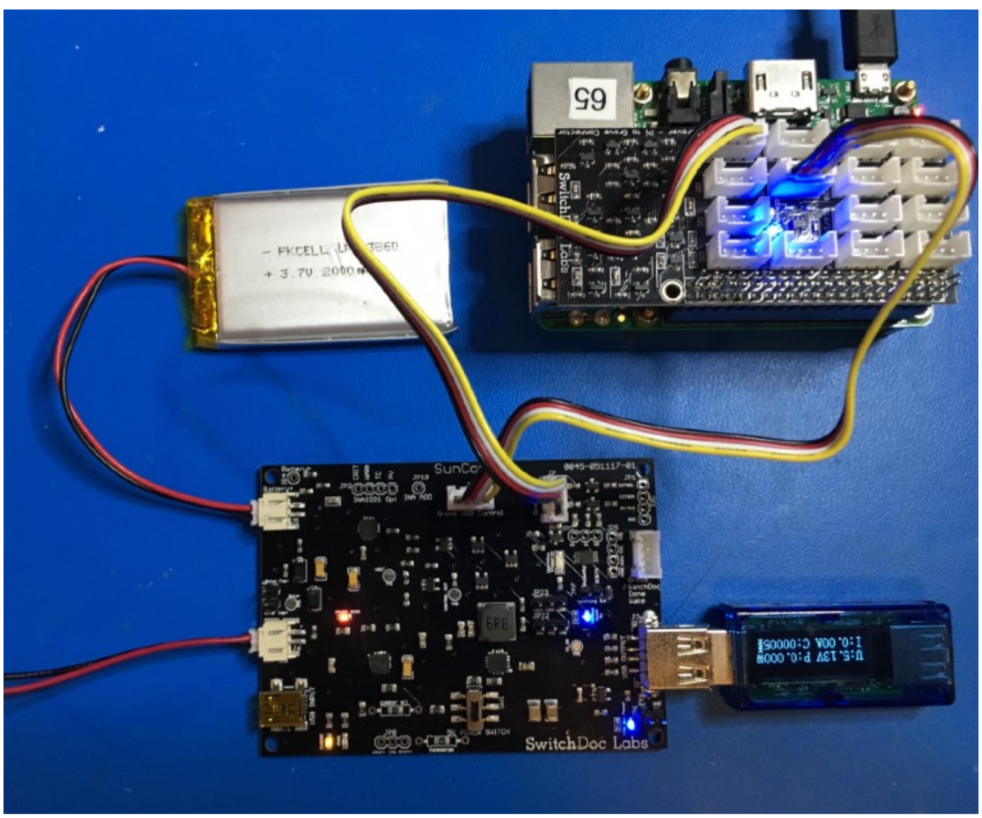
WatchDog_Done = 13 (This is the “pat the dog” input for the Hardware WatchDog timer)
WatchDog_Wake = 16 (Optional: This is a pulse from the watchdog that can wake your computer)

You can change these in the software.   See the test programs in SDL_Pi_SunControl or SDL_Arduino_SunControl.

GitHub.com/switchdoclabs/SDL_Pi_SunControl

GitHub.com/switchdoclabs/SDL_Arduino_SunControl

Here is a the results of testSunControl on a Raspberry Pi (with a USB Current Measuring display connected as a Load).   The results are shown after the picture.



```
pi@RPi3-65:~/SDL_Pi_SunControl $ sudo python testSunControl.py

Test SDL_Pi_SunControl Version 1.0 - SwitchDoc Labs

Program Started at:2017-07-07 08:46:31

------------------------------
SunControl Voltages and Currents
------------------------------
LIPO_Battery Load Voltage :       4.11 V
LIPO_Battery Current :            15.20 mA

Solar Cell Load Voltage :   0.00 V
Solar Cell Current :        0.00 mA

Output Load Voltage :             5.13 V
Output Current :            12.40 mA

------
USB Power turned OFF
------
------------------------------
SunControl Voltages and Currents
------------------------------
LIPO_Battery Load Voltage :       4.11 V
LIPO_Battery Current :            4.80 mA

Solar Cell Load Voltage :   0.00 V
Solar Cell Current :        0.00 mA

Output Load Voltage :             5.13 V
Output Current :            4.40 mA
------
USB Power turned ON
```

SunControl Voltages and Currents

LIPO_Battery Load Voltage : 4.11 V
LIPO_Battery Current : 14.40 mA

Solar Cell Load Voltage : 0.00 V
Solar Cell Current : 0.00 mA

Output Load Voltage : 5.13 V
Output Current : 12.00 mA

USB Power turned OFF

SunControl Voltages and Currents

LIPO_Battery Load Voltage : 4.11 V
LIPO_Battery Current : 4.40 mA

Solar Cell Load Voltage : 0.00 V
Solar Cell Current : 0.00 mA

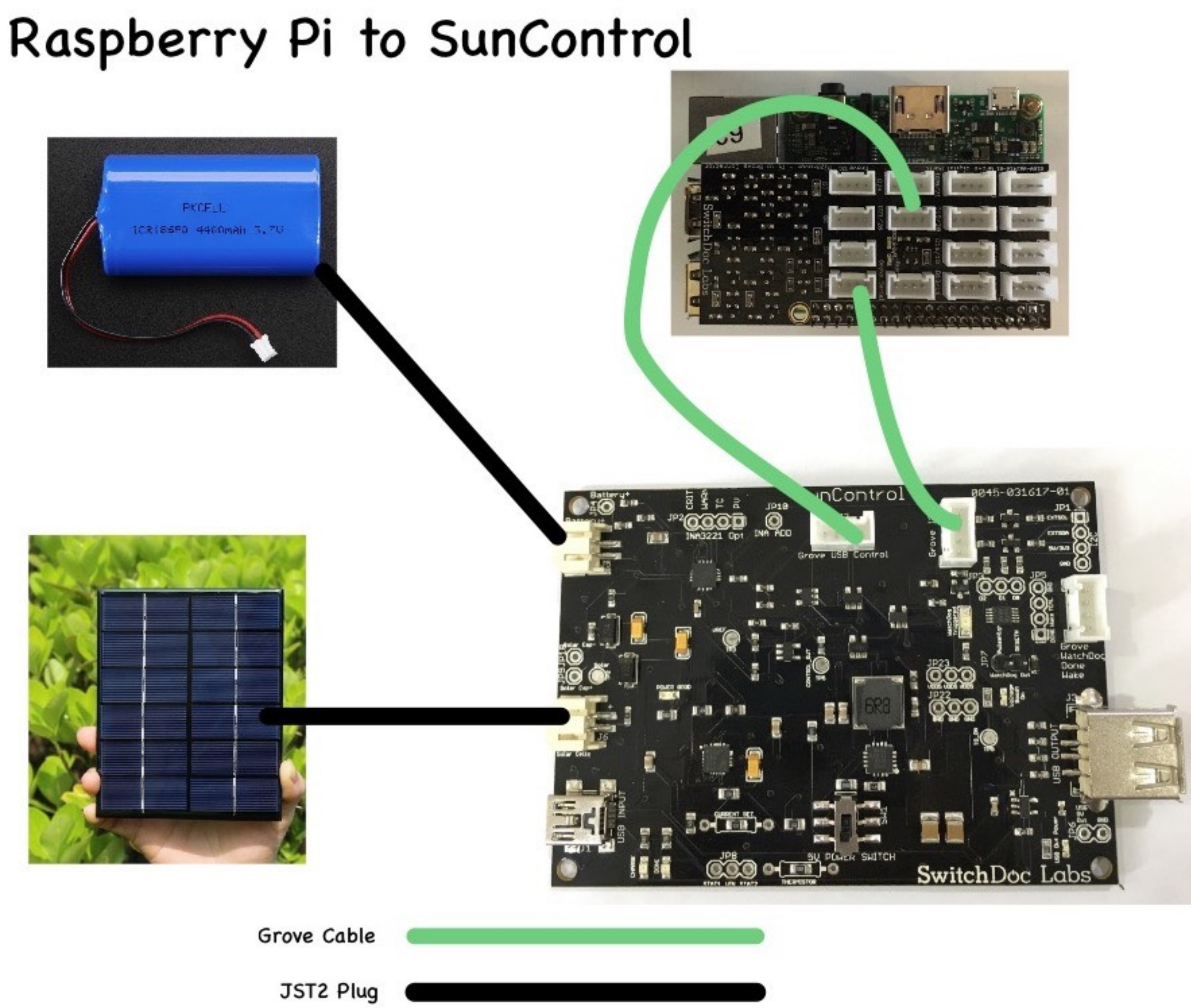
Output Load Voltage : 5.13 V
Output Current : 4.40 mA

Applications

To connect up SunControl to processor using Grove connectors is simple.

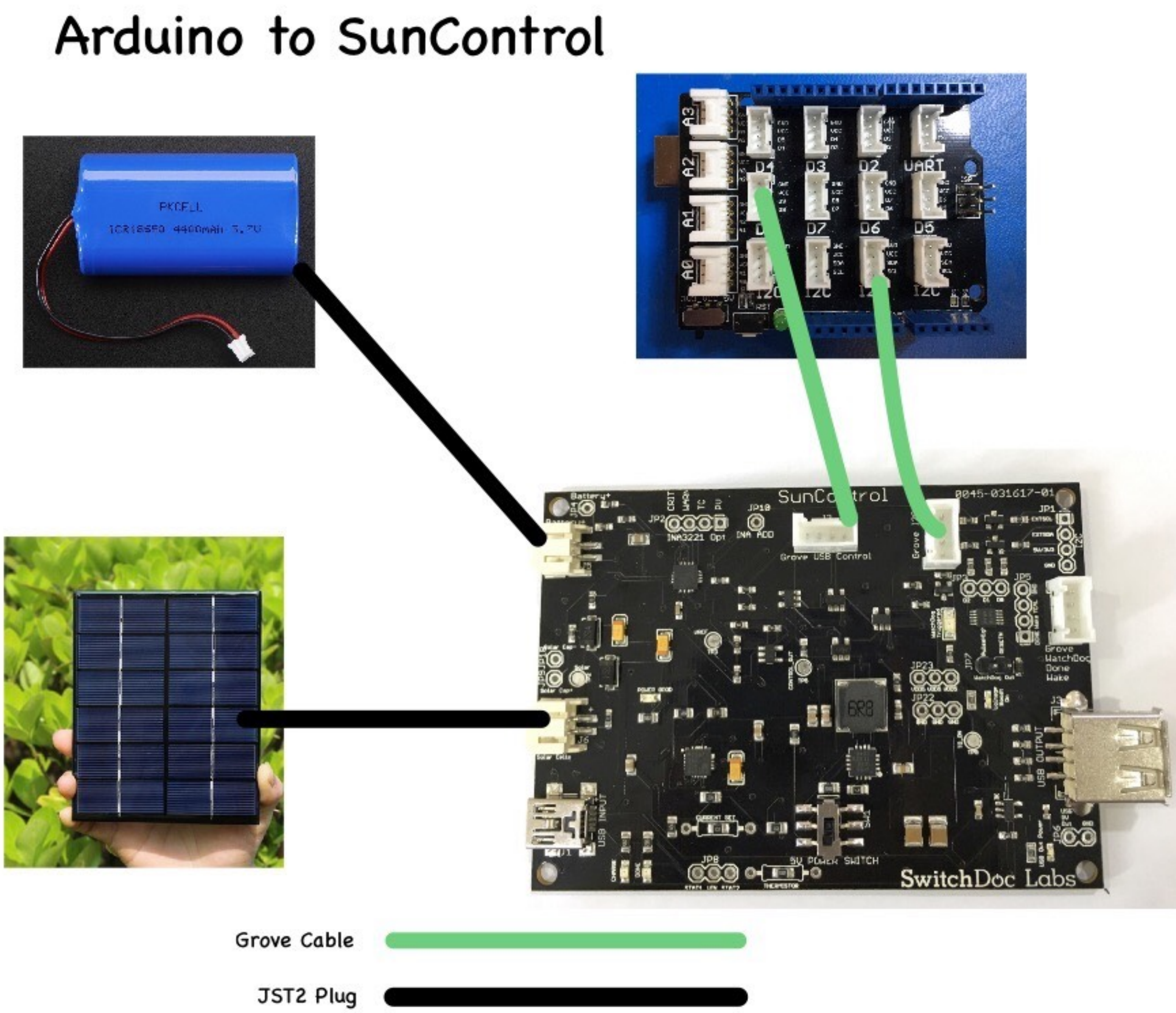
Raspberry Pi

To hook up a Raspberry Zero, Raspberry Pi2. pr Raspberry Pi3 you first put a Pi2Grover Grove hat on the Raspberry Pi GPIO pins. Then you connect up SunControl as is shown in the below diagram.



Arduino

To hook up an Arduino to SunControl, you use an Arduino Grove Shield and then connect up SunControl as shown in the below diagram.



Wiring Lists

For non Grove devices (you can buy Grove shields and Hats for Raspberry Pi and Arduino devices), To convert, we suggest using the pin header to Grove conversion cables as shown in this tutorial:

http://www.switchdoc.com/2017/03/using-grove-adaptors-on-pin-header-sensors/

These wiring lists cover the I2C bus and the USB Power Control. Please refer to the SunControl WatchDog Timer Application Note for use of the WatchDog Timer.

Raspberry Pi (A/B/A+/B+/Pi 2/Zero)

Signal Name	Raspberry Pi A/B/A+/B+/Pi 2	SunControl
SCL	I2C1_SCL (GPIO/5)	Grove I2C Plug (Pin 1 Yellow)
SDA	I2C1_SDA (GPIO/3)	Grove I2C Plug (Pin 2 White)
Power	3.3V (GPIO/1)	Grove I2C Plug (Pin 3 Red)
GND	GND (GPIO/6)	Grove I2C Plug (Pin 4 Black)
USB CONTROL (Optional)	GPIO 21 (GPIO/12)	Grove USB Control Plug (Pin 1Yellow)
USB ENABLE (Optional)	GPIO 26	Grove USB Control Plug (Pin 2 White)
GND	GND (GPIO/9)	Grove USB Control Plug (Pin 4 Black)

Arduino Uno

Signal Name	Arduino Uno	SunControl
SCL	ADC5/SCL (ANALOG IN/A5)	Grove I2C Plug (Pin 1 Yellow)
SDA	ADC4/SDA (ANALOG IN/A4)	Grove I2C Plug (Pin 2 White)
Power	5.0V (POWER/5V)	Grove I2C Plug (Pin 3 Red)
GND	GND (POWER/GND)	Grove I2C Plug (Pin 4 Black)

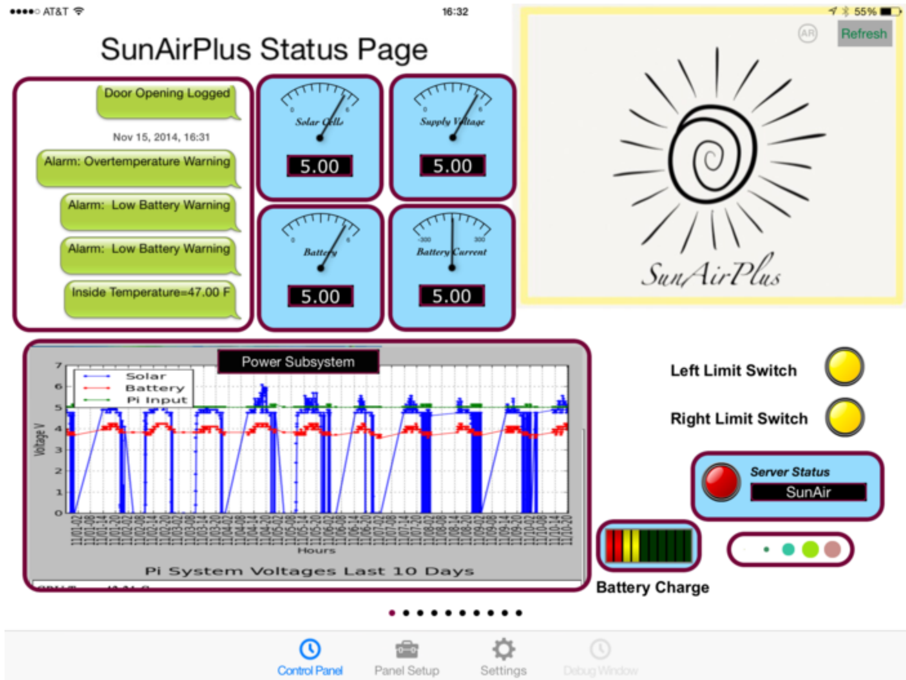
Signal Name	Arduino Uno	SunControl
USB CONTROL (Optional)	8 (DIGITAL)	Grove USB Control Plug (Pin 1Yellow)
USB ENABLE (Optional)	9 (DIGITAL)	Grove USB Control Plug (Pin 2 White)
GND	GND (POWER/GND)	Grove USB Control Plug (Pin 4 Black)

Arduino Mega 2560

Signal Name	Arduino Mega 2560	SunControl
SCL	SCL (COMMUNICATIONS 21)	Grove I2C Plug (Pin 1 Yellow)
SDA	SDA (COMMUNICATIONS 20)	Grove I2C Plug (Pin 2 White)
Power	5.0V (POWER/5V)	Grove I2C Plug (Pin 3 Red)
GND	GND (POWER/GND)	Grove I2C Plug (Pin 4 Black)
USB CONTROL (Optional)	8 (PWM/DIGITAL)	Grove USB Control Plug (Pin 1Yellow)
USB ENABLE (Optional)	9 (PWM/DIGITAL)	Grove USB Control Plug (Pin 2 White)
GND	GND (POWER/GND)	Grove USB Control Plug (Pin 4 Black)

Control Panels

RasPiConnect and ArduinoConnect are available on the Apple Appstore. The control panel for SunControl is shown below. If you already own RasPiConnect or ArduinoConnect, the configuration files are available on github.com/switchdoclabs.



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

Revisions

0045-051117-01: First Manufacturing Version
0045-070417-01: Added Optional JP11 Pin - No Functional Changes