Introducing the SunDuino

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Overview

General Description

The Sunduino is a complete micro-controller board with integrated battery system for instrumentation, data collection and portable equipment. Both solar panels and DC power source are used to charge external batteries and to supply power to regulated outputs. User written applications can be loaded into 48K bytes of free FLASH memory for execution in parallel with Sunduino battery charger and control software. A micro kernel provides cooperative multitasking between user and battery functions.

Software libraries supplied with the SunDuino provide a means for user applications to interface with SunDuino power functions. By using SLEEP mode support in these libraries a user application can easily execute using as little as 200ua of battery current.Small primary or rechargeable batteries to operate at this current for a year or more.

All connections to the Sunduino are made through a single 25 pin D male connector. Various connector styles such as including solder cup connectors and mass termination are available to simplify connection with user system components.

A SunDuino operates batteries of various chemistries and sizes. Charging and battery control is based on a down loadable EEPROM configuration table. Configuration tables are provided for various types and sizes of batteries. New battery support is easily downloaded.

SunDuino interfaces can be divided into four sections.

- Primary Power Input
- Battery Connection
- Regulated Power Output
- Control Logic

Primary Power Input

Unregulated DC power is applied to the SunDuino through the DC Input. This input provides power for both target operation, battery charging and internal operation. A low cost "Wall Wart" type supply is the most common source for primary power. Solar panels are supported along with provisions for setting the Maximum Power Point (MPP) of the connected solar panel. Charging logic will attempt to maintain the panel at this MPP point which maximizes power delivered by the panel.

A major requirement for the primary power source is the ability to maintain proper input voltages during both target operation and battery charging. To charge the battery and run loads DC input voltage must be maintained at a level greater than the peak battery voltage. For an 8 cell NiH battery pack the corresponding minimum DC input voltage must be greater than 14 volts. (A 13 volt charging voltage and 1.0 volt “Overhead.") Note that this 14 volt figure includes any ripple voltages. If the input voltage is ever less than 14 volts battery charging will halt. If the DC input voltage continues to drop the battery will start to discharge as the output converter will be switched to battery power.

A major source of failure in microprocessor based systems is the intermittent application of power. Rapid application and removal of power to a system will, at best, hang the system with a worst case being damage to power supplies or processing equipment. Hardware circuits and software logic within the SunDuino isolate the target from input variations and apply power to the target in a controlled manner.

Battery Operation

Battery operating characteristics are maintained within a table held in processor EEPROM. This table of approximately 43 parameters is configured to control operation of a specific battery type and size. These EEPROM constants can be over written by simple download of an alternate .hex configuration file. A checksum is included in this table and SunDuino software will verify this checksum when power is applied.

Optimization of battery life was a primary goal in SunDuino software design. Major logic functions include the limit of over discharge during battery usage and the limit of over charging during charge cycles. Charge limit is a particularly difficult task given the desire for 100% charge at a maximum rate. Internal software logic adjusts the charge cutoff point depending on total charge, cell voltage and temperature. Additional logic provides for peak charge maintenance without the overcharge associated and with constant current trickle charging.

While the SunDuino controls all phases of battery charging design of a robust system requires that a user have an understanding of battery basics. A greater understanding of battery operation will help with the selection of the proper battery pack for a specific load and will enhance system operation.

Batteries are complex chemical systems which convert energy between electrical and chemical forms. Power, or the rate of energy transfer, requires a corresponding chemical reaction rate. Batteries do not maintain a constant ability to react chemicals as their chemical composition changes. A fully charged battery contains a large amount of active material allowing delivery of energy at a high rate. Since the fixed output voltages on SunDuino outputs deliver constant power to the load the DC converter will require greater battery current as the battery voltage drops. A battery with a low charge does not contain the same supply of active chemicals. A partially discharged battery can not provide the high peak currents possible with a fully charged battery. Low temperatures will further reduce the ability of a battery to supply power. Significant battery derating is required for low temperature operation with partially discharged batteries.

When selecting a battery it is important to consider peak load currents in addition to the total mahr capacity. A good example is a portable instrument using a thermal print head. Print heads draw more than 2 amps during brief printing cycles while the remaining system might draw only 100ma. Selecting a 1 Amp Hour battery for 10 hours of operation will result in failure after 5 hours of operation. Failures take place when the print head energizes, battery voltage drops, the system loses power resetting the processor and jamming the printer. The key to a successful system is knowing the remaining battery capacity and disabling the printing process. The SunDuino maintains this information and makes it available to the user application for control of system operation.

Software logic within the SunDuino and EEPROM tables prevent operating the battery down to where cell reversal occurs. Detection of a minimum battery voltage will abort the discharge process and shut off regulated power. At this point the battery is considered EMPTY and battery usage will not resume. Restoring primary power will not clear the EMPTY condition. If primary power again fails while the battery is EMPTY the target is turned off and the battery is not used for power. Only after the battery is partially recharged will the EMPTY condition be cleared and the battery made available for target operation.

DC Outputs

Output Converter

A 100Khz flyback converter accepts energy from the DC input or battery and delivers this energy to 4 output windings. Since one of the flyback outputs (either the +5 or +3.3 outputs) controls flyback feedback, and given the nature of the coupled flyback secondaries, all 4 outputs remain at constant output voltage while the primary input voltage changes (Line Regulation). SunDuino line regulation is < 2%. As the target load changes the remaining 3 none monitored outputs do change voltage slightly, typically less than 5%. The single monitored output is very stable with load variations affecting output voltage less than 2%. The level of regulation is dependent on actual load current and minimal load current (about 10ma) can greatly improve flyback coupled regulation.

Digital systems typically require the greatest regulation on the main logic supply voltage with less regulation required on analog processing supplies. The SunDuino provides two such outputs, +5 and +3.3 volts, and either of these outputs can be directly regulated. Some systems require both +5 and +3.3 supplies. Strapping options on the SunDuino connector allow selection of the most variable load, or the most heavily loaded output, for direct regulation. Construction techniques used in manufacturing the main flyback inductor provide a high degree of regulation between the +5 and +3.3 sections.

Voltage for analog processes consist of two outputs, +15 and -15 volts. These outputs are not directly regulated but are filtered to reduce noise. Flyback operation maintains the load regulation of these outputs to within 10%. All output voltages are adjustable via a potentiometer mounted on the SunDuino PCB. All voltages are adjusted proportionally. The BB25E unit includes a 12V 100ma linear regulators with strapping options to allow selection of the 15V raw outputs or 12V regulated outputs. The BB10B is hard wired with 13V flyback regulated outputs.

BB25E units include additional common mode chokes for EMI control. Multiple winding common mode chokes provide a high degree of isolation for high frequency signals between the BB25E and the regulated outputs. This high level of filter isolation make the BB25E an ideal power source for sensitive analog processing and measurement instruments. High frequency noise on digital power lines is also blocked by these chokes simplifying system EMI filtering and regulatory compliance.

The BB10B is a smaller, lower power lower cost unit and it does not contain the additional common mode chokes. However both BB10B and BB25E units both incorporate multilayer PCBs which help to minimize system noise.

Control Logic

A single On/Off control signal and internal SunDuino software provide the user with a number of possible power control options. These options include:

- Push On - Push Off "Toggle" Operations
- Push On - Release Off Operation
- Continuous Operation (UPS Mode)
- Push On - Target Software Hold and Release

Control of the Battery Boss ON/OFF status is through a signal on the 25 pin connector. A 3 volt signal applied to this ON/OFF circuit (> 10K ohm input impedance) will cause the switching regulator to start if power conditions permit. Software logic will not permit the inverter to start if the primary voltage is less than permitted or if pervious operation has left the battery in an EMPTY condition. When the converter starts   hardware circuits limit inrush current and temporarily disable primary input voltage monitors.

Power Control

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Operating Modes

The Battery Boss operates in various configurations depending on application requirements. Variations include:

- Operation with both Battery and User Application
- Operation without User Application
- Operation without Battery

Operation with Battery and User App.

The most common application uses a battery for power backup while the SunDuino provides DC power conversion and battery charger control in the background. The On/Off signal on the 25 pin D can connects directly to either a momentary switch, toggle switch or an external control signal. Logic in lower level SunDuino allows a momentary switch to toggle power On then Off. A user application executing in the SunDuino can access these signals and also control the On/Off cycle of the user load. User application can also lock power into a ON state during critical operations such as data storage.

User applications are downloaded from a PC using the SunDuino Boot-Loader program. The Boot Loader operates using the Microchip AN-1310 protocol with a push button the the SunDuino PCB used to initiate communications. A 60 second timeout is provided within the SunDuino firmware to prevent inadvertent lockout of normal operation. The SunDuino status LED turns on solid during boot load phases. Additional features such as download of battery configuration files and controlling operation modes are also supported buy the boot Loader application.

Operation with Battery Only

Many application exist where the SunDuino provides only simple Uninterruptible Power Supply (UPS) operation. In this mode no user application is downloaded into SunDuino FLASH and only the internal control logic executes.

Operation of the target power is controlled by the On/Off signal (25 pin D connector) while UPS and battery charger function operate normally. If SunDuino EEPROM has be configured to operate with a solar panel the firmware will attempt to maintain operation at the Maximum Power Point (MPP) of the panel. The SunDuino Boot-Loader program is used to customize operating modes and setup solar panel operation.

Operation Without Battery

Operation of the SunDuino does not require that a battery be connected. Logic in SunDuino detects when a system battery is not connected and will automatically change operating modes. When power is applied to the DC input operation, and no battery is connected, the SunDuino will clear the Gas Gauge, start as normal and then start execution of the user application. When power is removed the SunDuino will shutdown as the input voltage fails. During SLEEP MODE operation the low level of operating current can result in the SunDuino running of internal filter caps for 10s of seconds.

Whenever the SunDuino detects a missing battery the Gas Gauge is reset to zero. This zero value is also written to a the EEPROM locations where remaining capacity is stored. If a battery is disconnected while the SunDuino is operating, and it remains disconnected for approximately 30 seconds or more, the SunDuino will declare the battery as missing and the Gas Gauge values will be reset. If a battery is disconnected for service it must be reconnected quickly. If a new battery is connected the user should wait 2 minutes to ensure the Gas Gauge has been cleared.

Sleep Mode Operation

Active vs Sleep Currents

When operating any system from a battery it is important to minimize execution time as this minimizes power requirements and increases battery run time and life. Turning off processor clocks and the powering down of various circuits is critical but also critical is the ability to wake quickly. A standard PC might take 10s of seconds to wake but an embedded processor might need to wake up in microseconds. The handling of how a system moves into and out of sleep is often a complex section of embedded design and is prone to unseen design issues. The SunDuino provides this function within its lower level RTOS kernel.

Internally the SunDuino maintains 4 major states, Idle, Running on Battery, Full and Charging. Idle is a key state as this state indicate the

DC power converter is off and NO input voltage is present from a DC supply or solar panel. It is in the Idle state when the SunDuino can possible enter sleep to reduce power consumption. During normal operation the basic SunDuino processor circuits draw approximately 10ma, in sleep the current is reduce to 10s of microamps. The key parameter to average power is the percentage of time the processor is operating and this is about 1% in the SunDuino including the execution of a minimal user application.. At a minimum the SunDuino exits from sleep at 8Hz (125ms) and executes for about 1ms. The result is approximately 150ua of average battery load. If the user application does significant processing (as in floating point operations) this average draw increases.

Entry into sleep must be coordinated with any user application running on the SunDuino processor. Since only the user application knows when it is safe to sleep the SunDuino library includes a function by which the processor can sleep. The function returns to the user application when one of sveral interrupt events are triggered.

Sleep Wake Up Events

There are several events that cause the processor to exit sleep and return to the user application.

- Real Time Clock tick at 8 Hz
- UART Receive character
- External ON/OFF signal change

If the processor is in sleep the above events will bring it out of sleep. There are also a number of processes that will prevent the processor from going into sleep.

- Battery system not in Idle state.
- Critical analog processing running.
- Various Errors. (Missing battery or power errors.)

Examples of using SLEEP MODE can be found in the various sample application provided with SunDuino toolkits. In general a "Main Loop" in a SunDuino will look something like:

```
    while (1) {
        do
        {
            SleepRes = bb_func_DoSleep ();
            RX_Process ();      //Check for incoming characters
            Sec = bb_time_getSeconds();
        } while ( Sec == j);
// Drop through means 1 second has passed, do something
         do_soething();
```

```
        j = Sec;                  //Setup to detect next second.
```

In the above loop code at "do_something()" will execute once a second. The SleepRes variable can be used to detect if or if not sleep mode was blocked and why. User application can use SleepRes to control other software threads if required. In this sample the processor will exit from sleep and use a change in the Real Time Clock Seconds counter to trigger execution of the do_something () routine.

SunDuino Software

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XC8 Compiler/Linker

XC8 is a free Microchip C compiler/linker for the PIC18F26K20 processor used in SunDuino products. Various XC8 versions are available including a free version with minimal code optimization. Even when using the free compiler with floating point and extensive printf functions only about 30% of the available 48K bytes of program FLASH is occupied. Simple applications without printf statements use only a small percentage of processor FLASH.

Processor Memory Model

SunDuino firmware for low level battery control and charging is stored in FLASH) ins locations 0x0000 to 0x3FFF. These locations are protected for external reading and writing. The remaining space in FLASH (0x4000 to 0xFFFF) is available for user applications which are typically written in C. SunDuino low level code also uses 256 bytes of RAM from locations 0x100 to 0x1FF.

Battery configurations and operating constants are stored in the low 128 bytes of EEPROM. These locations can be programmed with one of various battery files allowing users to easily switch between battery types and sizes. Example source code and .hex files for various battery types and sizes are provided. A Boot Loader is provided for downloading FLASH and EEPROM .hex files using a PC with COM port.

When a project is setup in the MPLAB tool both a code offset and RAM exclusions are required in the XC8 Linker:

Memory Model Tab:
RAM ranges default,-100-1fff

Additional Options Tab:
Codeoffset 4000

Both of these settings are required to ensure compiled C applications do not use RAM locations that conflict with SunDuino usage and to push executable code to the start of free FLASH (0x4000).

When the SunDuino powers on the battery charging and control firmware is initialized and if location 0x4000 is anything but erased (erased bytes are 0xff) a jump is made to location 0x4000. XC8 will place the run time startup code at 0x4000 (with code offset defined in linker) and C code executions takes place. The C application should execute withing a while (1) loop and never return.

C Library Functions

The following is a partial list of SunDuino library functions. See SunDuino_Vxxx.h for details.

Command Name	Cmd Letter
bb_battery_getGas()	Returns remaining capacity as mahr.
bb_battery_getPercentage()	Returns remaining capacity as 0 - 100.
bb_battery_getSize()	Returns full capacity of battery.
bb_getTemperature()	Returns battery temperature from -40C to 80C.
bb_volts_getVRun()(	Returns DC input voltage. 0V to 40V
bb_volts_getVBattery()	Returns battery voltage. 0v to 40V
bb_volts_getVCharger()	Returns voltage available to charge battery 0V to 40V
bb_amps_getAverageCurrent()	Returns current used by output regulator. 0 Amp to 6.5 Amp
bb_func_DoSleep()	Used to place processor in sleep if permitted.
bb_func_PwrOnOff(Sec)	Used to initiate an application WDT.
bb_func_PowerIsOn	Returns 1 or 0 if output regulator is On or Off.
bb_time_getxxxx()	Functions to read time from Real Time Clock.
bb_date_getxxxx()	Functions to read date from Real Time Clock.

Microchip provides a large library of C functions for many types of IO. The most useful of these are the I2C and printf functions. I2C allows user application to control a vast array of hardware functions while printf sends characters to external devices using true RS-232 levels. Various power control lines and analog readings are available from the SunDuino libraries and described in the SunDuino_Vxxx.h header file. Sample C files are provided.

Once a user application is compiled into a .hex file the SunSuino Boot Loader can be used to download this file into SunDuino FLASH or EPROM. The Boot Loader runs in a PC and uses a COM port to download code.

A button on the SunDuino PCB must be pushed to start the Boot Load process which also aborts all other SunDuino processes. Both the battery charger and output DC regulator is disabled during Boot Loader operation. Using the Boot Loader it is impossible to overwrite low level code (FLASH is write protected) but EPROM is writable. Various battery configuration .hex files are provided for EEPROM locations which then control operation for a specific battery type and size. Writing to any other bytes in the lower 128 bytes of EPROM is not recommended.

The Boot Loader allows .hex files and .ini files to be passed as command line (or .lnk file) options. A complete .ini file is written to a default fie name each time the Boat Loader closes. If this .ini file is copied to another directory and renamed it will completely define a programming session. Passing this renamed .ini file as a command line option will completely control a programming session and the default .ini file is ignored. When the Boot Loader uses a command line option the Boot Loader will automatically close allowing support with simple batch control files.

The default .ini file location is:

C:\ProgramData\IndexDesigns\SunD_Loader.ini

When a .hex file is passed on a command line the .hex file will be downloaded using programming options from the default .ini file. Again the Boot Loader will automatically close once the file is downloaded.

LED Blink Patterns

A small LED on the SunDuino PCB is used to provide feedback to the user about current operation.

- Fully Charged — Solid On
- Charging — 1 Second On and Off
- Run On Battery — 1/2 Second On 1.5 Off
- Sleep Mode — Short Blink Every 5 Second
- Boot Load Mode — Solid On

The Sleep Mode short blink is VERY short, only milliseconds in duration. Users must watch closely as this short blink only happens once every 5 seconds. This short blink was chosen to minimize current during SLEEP MODE operation.

SunDuino Hardware

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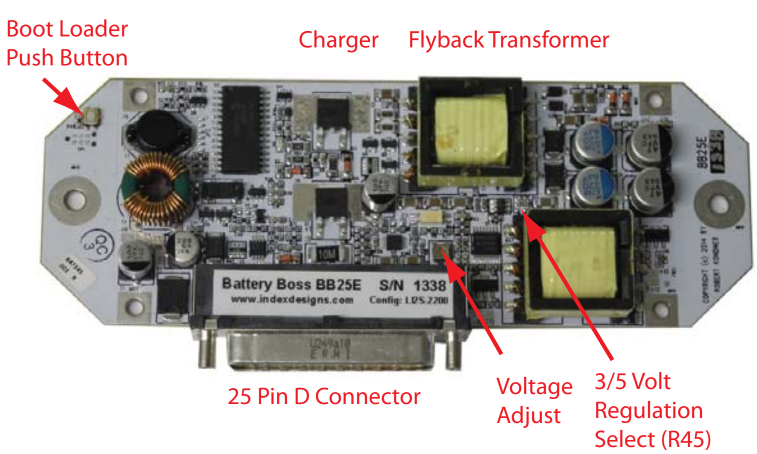
Overview

SunDuino hardware exists in two versionss, the BB25E and BB10B. Both are very similar in function and they both run the same firmware. The BB10 is smaller, lower power and less expensive. The BB25E is built using an aluminum backed PCB which supports operation at higher power through improved thermal management.

Each version provides a general purpose user analog input. A gain set resistor at locations R20 is open by default and an appropriate 0603 resistor value must be selected and installed. See schematic for details.

BB25E

The most distinguishing feature of the BB25E is the merging of a thin thermally conductive multi layer PCB and an aluminum base plate. The metal base rapidly removes and spreads heat from various power components which allows operation at higher power. This technique eliminates heat sinks and simplifies assembly of the final user system.



Two common mode chokes are included, one at the DC input (left side) and one on the four DC outputs. (On the lower right.) Two large mounting holes are provided (one on each side) and 4 smaller mounting holes exist for mounting simple user hardware. The back side is bare aluminum which is electrically isolated from other circuits. The top side of the mounting holes are connected to the CHASSIS GND signal. Inserting a metallic screw into these holes will bond CHASSIS GND to the aluminum base. Small ceramic bypass caps on both the input and output sides form AC connections to SIGNAL GND. Care must be takes that the CHASSIS GND to input and output GND voltage does not exceed the 50V rating of these bypass caps. See the schematics.

While the EFD20 sized flyback transformer will operate at 25 watts the true limits are controlled by input voltage, available battery current and thermal design. Attempting to supply 25 watts from a 6 volt battery would require 4 or 5 amps. Output diodes would be stressed electrically and thermally if that level of power was delivered to the 3.3V or 5V output. OEM implementation with output voltage higher than 5V can easily reach 25 watts or more with customer magnetic components.

The BB25E includes an opto-isolator and drive circuit which makes the 5, 3.3 and +/- 12 volt outputs optically isolated from the input power side. Care must be taken that any voltage difference do not exceed 50V as the circuits do contain small AC bypass capacitors between the various GND signals.

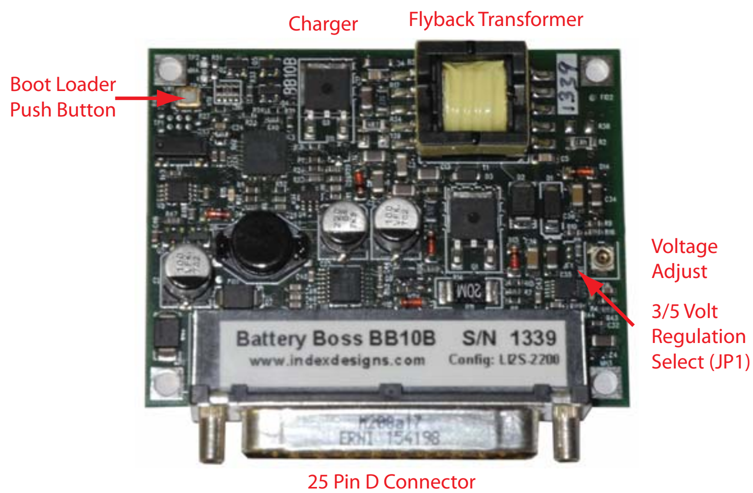
Two linear regulators are included for +/- 12V regulation from the flyback 15V outputs. Maximum output current from these regulators is 100ma. Flyback windings are designed to provide the +/- 15V which drives these linear regulators. Jumper pads are included on the lower and right PCB edges which can short out the regulators and allow deliver of +/- 15V to the SunDuino output. Solder blobs are easily added.

The BB25E also includes a location where .050 inch spaced posts can be mounted for the attachment of a Microchip In Circuit Development (ICD) connector. While small probe points are available for factory programming engineering development is simplified with a fixed ICD connection.

System test and development is best done using a BB25E. If development is accomplished through the ICD connector care must be taken to NOT ERASE FLASH . Doing so will delete the low level SunDuino operating code and RTOS. Erasing this flash will require factory re-flashing and the low level FLASH code is not released as a hex file for user programming,

BB10B

The BB10B is a simple four layer PCB built using 0.062 thick FR4 material. While internal power planes help conduct heat away from power components overall thermal characteristics limits total available power. A smaller flyback transformer and lower charger currents are a used as a consequence of this simplified thermal design.



Mounting can be accomplishes using thin layers of mounting adhesive tape or by using the 4 corner mounting holes with #4 hardware. The bottom side is void of component which allows simple mounting to a flat surface. The bottom side of the BB10B does contain circuit traces so mounting to conductive surfaces requires insulation.

CHASSIS GND on the PCB is connected to the 4 mounting holes. Small 50V ceramic bypass caps are included between electrical GND and CHASSIS GND so any voltage difference must be limited to 50V.

5V / 3.3V Regulation Selection

Each SunDuino version includes a 0603 sized set of mounting pads which can be used to control the source for output voltage regulation. The BB25E part is labeled as R45 while the BB10B part is labeled as JP1. When these locations are open (default) the 5V output is directly regulated. Installing a jumper (or solder blob) at this location connects the 3.3V output into the regulation circuit which causes the 3.3V output to be directly regulated. In place of a short a small resistor can be used to force regulations to a mid point of both 5 and 3.3 volt outputs.

Boot Loader

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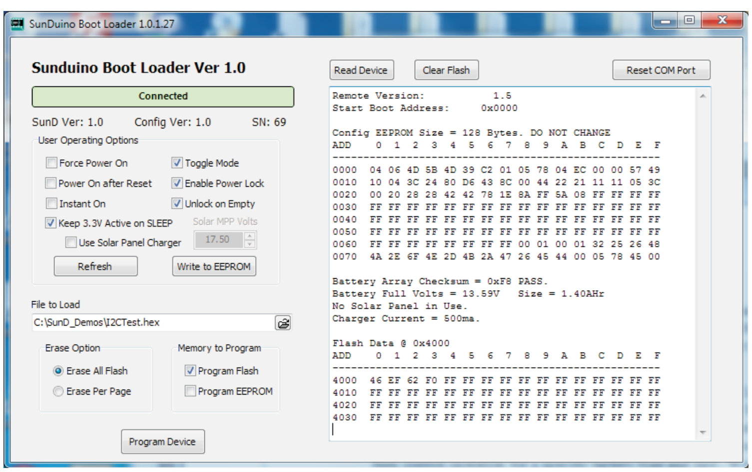
Overview

The SunDuino Boot Loader is a Windows PC application with the main form shown below. The left hand shows, from top to bottom the app version, green or red connection status, user options, download file, erase options and memory areas to program. The right hand side shows Read Device, Clear Flash and COM Port Select buttons. Also on the right hand side is an area where device content and programming status is displayed.

When the app connects or the Device Read button is clicked various key memory areas are read and the content summarized. The upper section shows EPROM content for the first 128 bytes with the lower section showing the start of FLASH. Users should never write to the lower 128 bytes of EEPROM. Only approved battery control files should be loaded into EEPROM. Notice that location 0x4000 contains compiled code which indicates a user application is present. This screen provides a quick reference to battery type, status and user application content.



SunDuino Boot Loader Main Screen

The green "Connected" area is red if the PC cannot detect a connected SunDuino that is in Boot Load Mode. A user must press the small button on a powered SunDuino to initiate Boot Load Mode. Assuming the COM Port is connected and working the pressing of the SunDuino PCB push button will allow the Boot Loader to connect as shown above. If a connection is not valid the Boot Loader application will display Not Connected in a red background.

This connection scheme also allows the user to verify the quality of the COM Port connection. Every 500ms the Boot Loader PC application verifies the SunDuino is still connected by sending a small message to the SunDuino PCB. If this connection fails an internal FAILED CONNECTION counter increments. If this counter is ever > 0 it is displayed in the green connection field. By leaving a SunDuino thus connected for several hours (over night) any connection loss will be captured and counted. A correctly operating COM connection should never fail.

The SunDuino firmware includes a 60 second connection time out timer. Should the push button on the PCB ever be pressed WITHOUT a connection to the Boot Loader application the SunDuino firmware will self reset after 60 second.

Operating Options

SunDuino firmware provides several options for controlling power operation. A number of check boxes are provided along with a WRITE button which allow a user to configure these options without any file downloads. When the user writes EPROM a new EEPROM checksum is calculated and also written to EEPROM. SunDuino firmware requires a valid checksum. Invalid checksum cause the on SunDuino PCB led to rapidly blink while all other operations are disabled.

Option Control	Description
Force Pwr On	Forces Output DC Regulator ON
Pwr On after Reset	Force Output DC ON after Reset. (With 2 Second Delay)
Instant On	Force Output DC ON after Reset. (No Delay)
Toggle Mode	Input ON/OFF signal Toggles Output DC On/Off
Enable Pwr Lock	Prevents On/Off switch from turning DC Output Off
Unlock On EMPTY	If Battery hits EMPTY then clear Power Lock.
Keep 3.3V Active	Keep Trickle regulator ON during SLEEP Mode
Use Solar Panel	Enable use of Solar Panel Charging Logic
Solar MPP Voltage	When using Solar Panel this filed defines panel MPP
Write EEPROM	Click this button to WRITE all Options to EEPROM
Refresh	Click the button to refresh controls from EEPROM

Advanced Usage

The Boot Loader allows .hex files and .ini files to be passed as command line (or .lnk file) options. A complete .ini file is written to a default fie name each time the Boat Loader closes. If this .ini file is copied to another directory and renamed it will completely define a programming session. Passing this renamed .ini file as a command line options will completely control a programming session. When the Boot Loader uses a command line option toe Boot Loader will automatically close allowing support of simle batch control files.

The default .ini file location is:

C:\ProgramData\IndexDesigns/SunD_Loader.ini

When a .hex file is passed on a command line the .hex file will be downloaded using control options from the defualt .ini file. Again the Boot Loader will automatically close once the file is downloaded.

Sample Wiring

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25 Pin D Signals

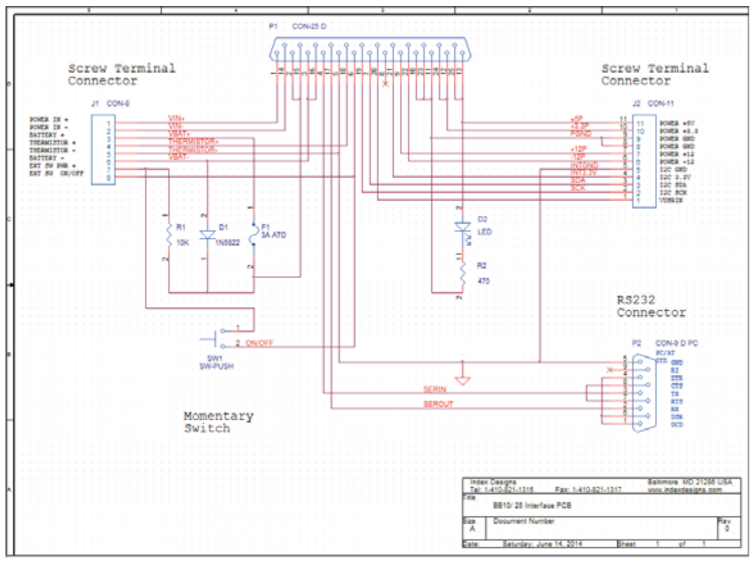
Connector Signals

The following table show the pinout for the SunDuino 20 pin D Connector.

Pin Number	Function
1	VIN+ DC Input Power
2	VBAT + Battery Positive Terminal. Connect in Parallel with Pin 15
3	VBAT- Battery Negative Terminal. Connect in Parallel with Pin 16.
4	RS-232 Serial Input
5	INTGND Internal Ground.
6	ON/OFF Control Signal. Turns on at 3V and is 20V tolerant.
7	SDA signal for I2C. Port C bit 4 on processor.
8	Clock Out from processor. Port A bit 6.
9	+12V linear regulator output on BB25E. +13V on BB10B.
10	Output GND. Optoisolated on BB25E. INTGND on BB10B.
11	Output GND. Optoisolated on BB25E. INTGND on BB10B.
12	+3.3V Output. Connect in Parallel with Pin 24.
13	+5V Output. Connect in Parallel with Pin 25.
14	VIN- Primary Power Input -
15	VBAT + Battery Positive Terminal. Connect in Parallel with Pin 2
16	VBAT- Battery Negative Terminal. Connect in Parallel with Pin 3.
17	RS-232 Serial Out
18	Battery Thermistor. 10K Ohm 0.5% NTC Battery Thermistor.
19	SCK signal for I2C. Port C bit 3 on processor.
20	Input Select. Connect to Pin 21 to Directly Regulate the 3.3V Output.
21	3.3V linear trickle regulator directly from battery. Max. current 10ma.
22	-12V linear regulator output on BB25E. -13V on BB10B.
23	Output GND. Optoisolated on BB25E. INTGND on BB10B.
24	+3.3V Output. Connect in Parallel with Pin 12
25	+5V Output. Connect in Parallel with Pin 25

Interface Board

To simplify connection external hardware to the SunDuino and aid in system integration a SunDuino "Break Out Board" is available. Power connection are divided by functions and brought out to terminalss with screw down connections. The RS-232 serial connection are brought out to a 9 pin D connector with a pinout for direct connection to a PC. (PC is DTE. Breakout Board is DCE).



Additional features such as a fuse, revers battery diode and On/Off switch are included. Note that the large diode will short a battery connected in reverse. The resulting current will clear the board fuse. A push button switch with external connections are connected to the SunDuino On/Off signal.

Also notice that the DC Output common signals are separate from the INTGND signal. The BB25E DC outputs are optically isolates while the low cost BB10B uses a common GND design. If I2C is to be used with circuits powered by the DC Outputs the two GNDs must be connected.

I2C Voltage Levels

3.3V and 5V I2C Operation

The SunDuino process uses a PIC18F26K20 processor at 3.3V and I2C lines must never be allowed to exceed 3.3 volts. During so would back drive the processor and alter the power supply voltage. The internal 3.3 volt regulator is a precision device which allows the power rails to be used as a reference voltage for analog to digital conversion. Back driving the power supply would cause errors in analog reading or possibly damage the processor.

I2C operation requires pull up resistors on both the SCK and SDA lines and these resistors are typically located on user hardware. If that hardware uses pull up resistors to +5 volts (or anything above 3.3) some means of limiting SDA and SCK voltages is required. The simple solution is to add a pull down resistor on the SDA and SCK lines such that the pull up voltage never exceeds 3.3 volts. For example a 5K ohm pull up resistor with a 10K pull down will only reach about 3.3 volts.

The 3.3V supply from the SunDuino internal 3.3V trickle regulator can be used as a pull up source but that would increase SLEEP MODE current. If user I2C hardware is operated using the SunDuino regulated output then using the regulated 3.3 volt output as a pull up source is suggested. If user software turns off the regulator the application software should also change the I2C into outputs driven with logic zeros. Driving a logic one into unpowered hardware will draw significant currents.

Examples of using pull down resistors with I2C operation can be found in the 4 Digit 7 Segment display board included with SunDuino files. WHen using red LEDs this board will operate directly from 3.3V. When using other colors 5V operation is sometimes required. The I2CTest.c source file (sample code directory) provides and example where the I2C lines are controlled as outputs when power is turned off.

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