SREH01-EVAL02

6 W wide input range solar charger using EH01

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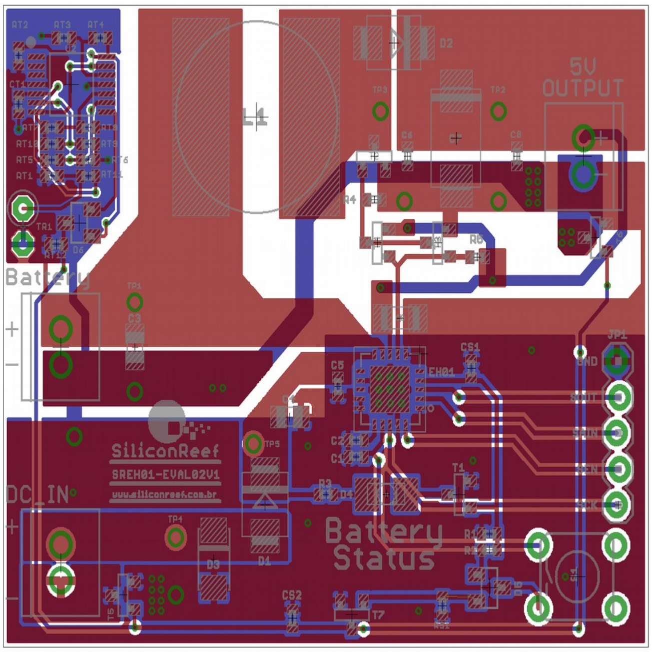

Features

- Input voltage from 4.0V to 7V
- Input current up to 1.5A
- Output voltage 5V@1.2A
- Complete all-in-one management of energy-harvesting process
- Works with both solar or conventional wall adapters
- Battery cell temperature monitor
- Regulated USB output, compliant with ITU – L.1000 standard for universal charger solution
- Serial communication Interface
- Operation mode consumption less than 5mW
- Total conversion efficiency greater than 80%
- Stand-by consumption less than 500µW
- PCB: 54mm x 46mm double side PCB

Description

The SREH01-EVAL02 is design to provide the best tradeoff between size, cost and performance for solar charger devices. The small board and low component count are achieved thanks to the use of EH01's features, that already include complete Li-Ion battery power management, output voltage regulation and status interface.

Among the basic elements within the SREH01-EVAL02, the Battery Status LED and push-button are the ones that actually interact with the user. The LED indicates the amount of charge stored at the battery. The number of times the LED blinks represents the percentage of the charge level stored in the battery. Thus, 1 blink indicates 20%, 2 blinks 40%, and so on. Once the push-button is pressed the LED becomes active. Furthermore, the board contains a serial communication interface that allows the user to check battery voltage level, battery charging/discharging state and other useful information (refer to datasheet).

The board allows for higher input voltage (up to 7V) than the specified for the EH01 chip (5.6V) due to the presence of a zener diode. Furthermore, the system is able to withstand higher input currents (1.5A) than the IC specified (1.2A) due to proper routing and pin distribution. Both of these features allow for higher versatility and flexibility regarding the input photovoltaic cell selection and target application. Additionally, the board is able to supply little over twice the current (1.2A) specified for the EH01 IC (0.5A) to the regulated output. An external power transistor and efficient control circuitry make this possible while maintaining a good cost/benefit tradeoff.

For proper operation, the interconnection wires for both the battery and the application load should be kept as short and as wide as possible.

Board Description

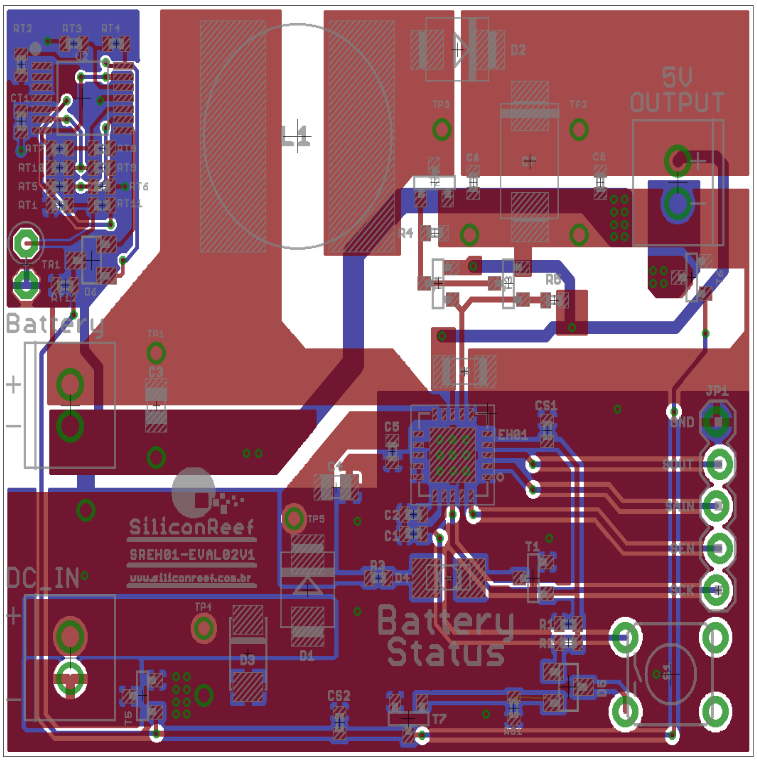

Figure 1: SREH01-EVAL02 evaluation board.

Table 1 Connector DC Input

Name	Type	Function
“+”	Power	Positive input connection
“-”	Power	Negative input connection

Table 2 Connector 5V Output

Name	Type	Function
“+”	Power	Positive output connection
“-”	Power	Negative output connection

Table 3 Connector Battery Cell

Name	Type	Function
“+”	Power	Positive battery connection
“-”	Power	Negative battery connection

Table 4 Connector JP1

Name	Type	Function
SCK	Digital Serial Interface	Clock signal
SEN	Digital Serial Interface	Enable signal
SAIN	Digital Serial Interface	Input Signal
SOUT	Digital Serial Interface	Output Signal
GND	Ground reference	Ground

Schematic Diagrams

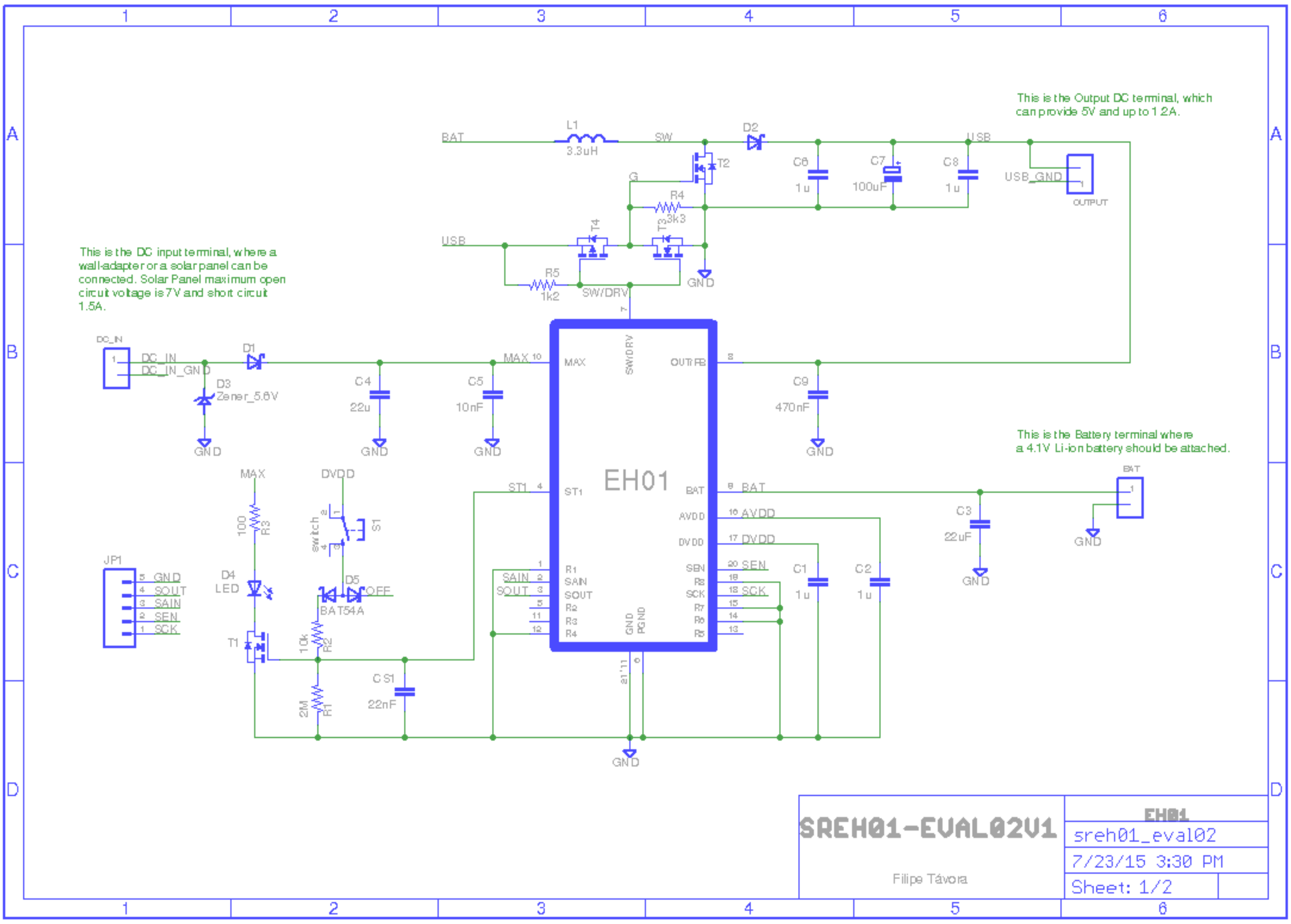

Figure 2: SREH01-EVAL02 evaluation board schematic.

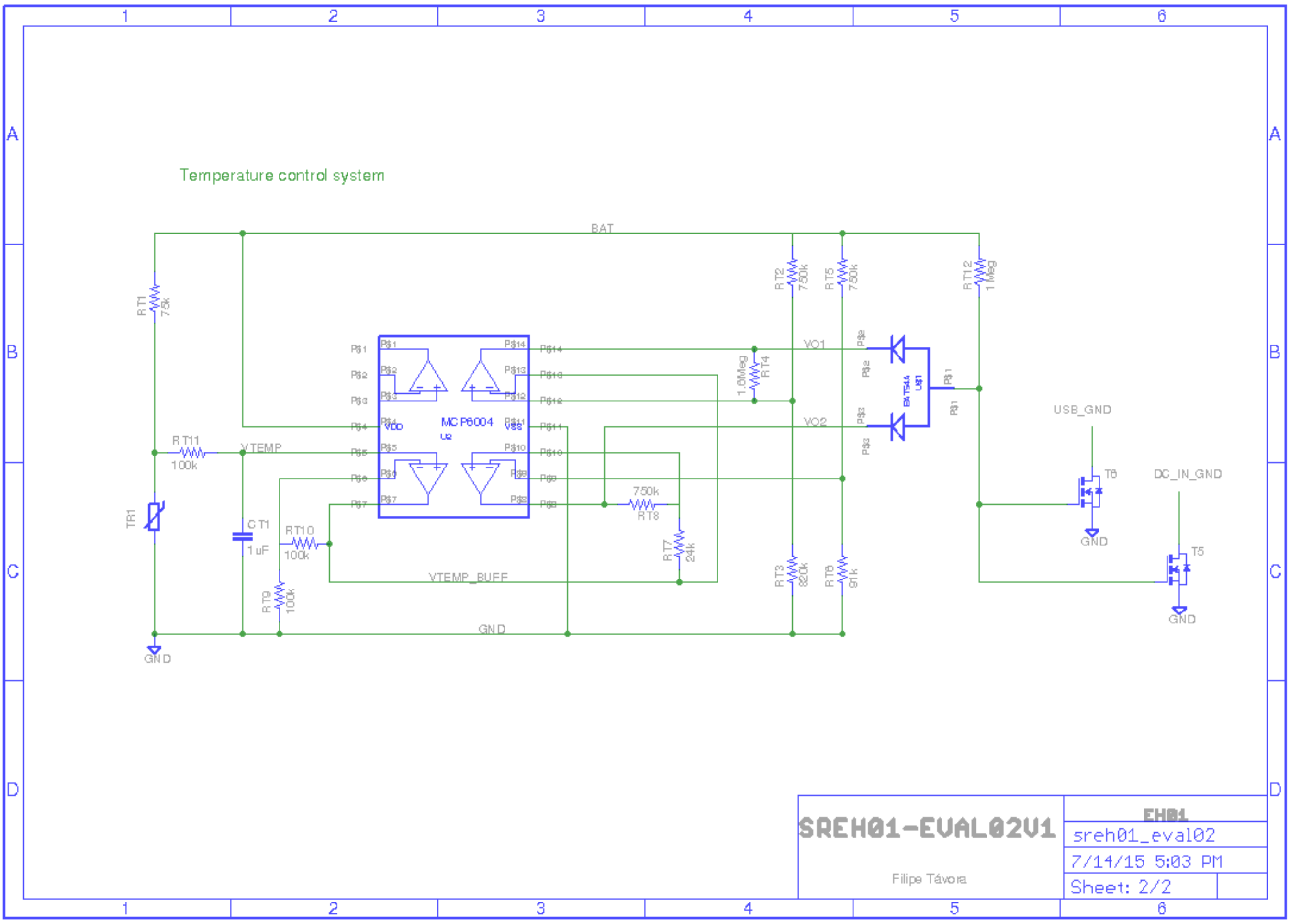

Figure 4: SREH01-EVAL02 evaluation board schematic.

Absolute Maximum Ratings

Parameter	Range
DC Input connector voltage[1]	7V
DC Input connector current[2]	0.6A
5V Output connector voltage	5.6V
5V Output connector current	2A
Battery Cell connector voltage	5.5V
Battery Cell connector current	3.9A

1. The maximum input voltage has a direct impact on the solar panel selection. Please refer to the Special Considerations section for further details.
2. The maximum input current has a direct impact on the solar panel selection. Please refer to the Special Considerations section for further details.

Electrical Characteristics

Parameter	Min	Typ	Max	Units
DC Input connector voltage[3]	3.6		7.0	V
Input current			0.6	A
Battery Cell connector regulated voltage	4.1	4.2	4.25	V
Fast Charge Current Limit	400	500	800	mA
Slow Charge Current Limit	100	150	200	mA
Slow/Fast charge Threshold	3.4	3.5	3.6	V
End of Charge Trigger	4.05	4.1	4.15	V
End of Charge Current	10	50	100	mA
End of charge Timeout	100	120	140	min
End of Discharge Trigger	2.9	3.0	3.15	V
Discharge current[4]			2.5	A
5V DC Output connector regulated voltage	4.75	5	5.25	V
Ripple Voltage		2		%
Output Current			1.2	A
Output Enable Trigger[5]	3.4	3.5	3.6	V
Switching frequency	0.8	1	1.1	MHz
Battery temperature upper threshold	53	55	57	°C
Battery temperature lower threshold	-2	0	2	°C
Temperature hysteresis		10		°C

Component Suggestions

The following table summarizes the external components that should be used to achieve the best performance for efficiency and output currents specified.

#	Part	Manufacturer Part Number	Description	Vendor
1	L1	SDR1307-3R3ML	3.3µH inductor 7.5A 8.7mΩ smd	Bourns
2	C1, C2, C6, C8, CT1	GRM155R61A105KE15D	1µF ceramic cap 10V X5R 0402	Murata
3	C3 and C4	GRM219R61A226MEA0D	22µF ceramic cap 10V X5R 0805	Murata
4	C5	GRM155R71C103KA01D	10nF ceramic cap 16V X7R 0402	Murata
5	C7	T520D107M010ATE055	100µF tantalum cap 10V 2917	Kemet
6	C9	MC1206B474K160CT	0.47µF ceramic cap 10V X7R 1206	Multicomp
7	CS1	GRM155R71C223KA01D	22nF ceramic cap 16V X7R 0402	Murata
8	CS2	GRM155R61A104KA01D	100nF ceramic cap 10V X5R 0402	Murata
9	D1 and D2	B340A-13-F	Diode Schottky 40V 3A DO214-AC	Diodes Inc.
10	D3	3SMAJ5919B-TP	5.6V zener diode 3W DO214AC	Micro Commercial

3. The main features of the system, such as battery charging and output regulation, are available and operational for a more specific input voltage range. For a more detailed explanation of the operation limits of this evaluation board please refer to the Special Considerations section.
4. The maximum battery discharge current is no longer determined by the EH01 chip. Hence, the stated value is inferred from the maximum output current and minimum input voltage scenario of the DC-DC converter. Moreover, since the discharge control feature has been relinquished, some precautions must be taken. For further information on this issue please refer to the Special Considerations section.
5. The Output Enable Trigger activates the output regulation feature of the system. However, it does not monitor the 5V DC Output Connector, but the Battery Cell Connector instead. For a more detailed explanation of the operation of this evaluation board please refer to the Special Considerations section.

#	Part	Manufacturer Part Number	Description	Vendor
11	D4	LTST-S115KGJRKT	Led 565nm wtr green 1206 smd	Lumex-Opto
12	D5, D6	BAT54A-7-F	Diode Array Schottky 30V SOT23-3	Diodes Incorporated
13	R1, RS1, RT12	MCR01MRTF2004	2MΩ resistor, 1%, 1/16W 0402	Rohm Semiconductor
14	R2	RC0402JR-0710KL	10kΩ resistor, 5%, 1/16W 0402	Yageo
15	R3	RC0402JR-07100RL	100Ω resistor, 1%, 1/16W 0402	Yageo
16	R4	MCR01MRTF3301	3.3kΩ resistor, 5%, 63mW 0402	Rohm Semiconductor
17	R5	MCR01MRTJ122	1.2kΩ resistor, 5%, 63mW 0402	Rohm Semiconductor
18	RT1	RMCF0402FT75K0	75KΩ resistor, 1% 1/16W 0402	Stackpole Electronics Inc
19	RT2, RT5, RT8	CRCW0402750KFKED	750KΩ resistor, 1% 1/16W 0402	Vishay Dale
20	RT3	CRCW0402820KFKED	820KΩ resistor, 1% 1/16W 0402	Vishay Dale
21	RT4	CRCW04021M60FKED	1.6MΩ resistor, 1% 1/16W 0402	Vishay Dale
22	RT6	RC0402FR-0791KL	91KΩ resistor, 1% 1/16W 0402	Yageo
23	RT7	RC0402FR-0724KL	24KΩ resistor, 1% 1/16W 0402	Yageo
24	RT9, RT10	RC0402FR-07100KL	100KΩ resistor, 1% 1/16W 0402	Yageo
25	RT11	RC0402FR-07100KL	100KΩ resistor, 1% 1/16W 0402	Yageo
26	TR1	NTCLE100E3103JT2	Thermistor NTC 10K 5% RADIAL	Vishay BC Components
27	S1	MJTP1230	Switch tactile spst-no 0.05A 12V	Apem
28	T1, T3, T7	NTR4003NT1G	MOSFET N-CH 30V 500mA sot-23	ON Semiconductor
29	T2	SI2312BDS-T1-E3	MOSFET N-CH 20V 3.9A sot-23	Vishay Semiconductor
30	T4	NTR0202PLT1G	MOSFET P-CH -20V 400mA sot-23	ON Semiconductor
31	T5, T6	AO3400A	MOSFET N-CH 30V 5.7A sot-23	Alpha & Omega Semiconductor Inc
32	U2	MCP6004T-I/ST	IC OPamp gp 1MHz rro 14tssop	Microchip Technology

Special Considerations

Though the nominal performance is detailed in the Electrical Characteristic section, there are some particular conditions to consider when using the SREH01-EVAL2 evaluation board.

The DC Input Connector voltage range, for instance, states that the system is able to withstand voltages as low as 3.6V and as high as 7.0V. If a voltage below 4.5V were to be applied at the DC Input Connector, the system would be able to regulate the 5V DC Output Connector at the proper level once the voltage at the Battery Cell Connector reaches the Output Enable Trigger value (3.5V). Nevertheless, the Battery Cell Connector would never rise to 4.2V, which in turn implies that the battery cell attached to it would never fully charge due to the voltage drop present in the schottky diode D1 (around 400mV). Furthermore, if a 400mV difference between the MAX and BAT pin of the EH01 IC is not guaranteed, the risk of battery charging currents surpassing the specified range exists and will be defined by the selected source current capability. Therefore, a voltage equal or higher than 4.9V must be supplied at the DC Input Connector if the user seeks both a regulated output and a fully-charged battery cell. Likewise, if a voltage higher than 5.4V is applied at the DC Input Connector, the DC-DC converter in the EH01 IC will cease to operate and the input voltage will simply be transferred to the 5V DC Output Connector. Hence, if the input voltage continues to increase the output voltage will follow the same behavior and no regulation will take place. However, once the DC Input Connector reaches 5.6V, the zener diode in the board (D3) will clamp the voltage at this value and, in doing so, protecting the EH01 IC. Consequently, only the battery charging feature of the system will be operational in this scenario.

Regarding the solar panel selection, the ideal scenario would be 3W photovoltaic cell with 6.5V of open circuit voltage (around 4.9V at maximum power point). Nevertheless, the maximum input voltage specified in Absolute Maximum Ratings section indicates that the SREH01-EVAL02 is compliant with solar panels with open circuit voltages up to 7.0V. Moreover, if a photovoltaic cell with power delivery greater than 3W is chosen, some precautions must be taken. The zener diode present in the board has the responsibility to protect the system against overvoltages at the input (>5.6V). Therefore, when this scenario arises the zener diode will drain all the current from the input source and, consequently, must be able to withstand the input source payload. Thus, the zener diode must be chosen accordingly. The one specified in the Component Suggestions section was chosen for the ideal solar panel scenario above mentioned. Another important aspect is the amount of input power that the system is able to actually use. In this configuration, the maximum load current can only be drained from the battery cell. Furthermore, the input source – weather is a wall adapter or a photovoltaic cell – is intended only to charge the battery cell, which in turn explains why there is no need for an input source with higher power delivery than 3W. This means that the available input current will not suffice to drive both the battery cell and the output load. The battery cell is the one in charge of delivering the maximum output power to the load. Therefore, in this configuration of high output power delivery, the first stage of energy transfer will always be the battery charging. If the user seeks to have both features simultaneously operational, it is best to make use of SREH01-EVAL01, aside from the fact that the maximum output power available to the load is half of what this evaluation board is able to supply.

Since the battery discharge control feature of the EH01 IC is bypassed, there is virtually no limit to the battery discharge current. The nature of the operation and other control features of the system end up setting some boundaries, nonetheless. The maximum discharge current is determined by the maximum output current and the efficiency of the system. Therefore, it is safe to assume that the maximum discharge current will take place when the maximum output current (1.2A) is being drained from the system and the battery voltage has dropped to the minimum value (3.0V) that allows the DC-DC converter to remain operational. From the basic conservative property of energy, the following expression is inferred:

$$I_{DISCH} = \frac{V_O \cdot I_O}{Eff \cdot V_{BAT}},$$

where V_O: output voltage (5V), I_O: output current (1.2A), Eff: system efficiency (85% for this specific scenario), V_{BAT}: battery voltage (3V), and I_{DISCH}: battery discharge current. Thus, the maximum discharge current reaches approximately 2.5A, which, in turn, implies that the battery selected for this particular scenario should have at least a 2500mAh capacity.

The EH01 IC possesses a DC-DC step-up converter that operates with a fixed 50% duty cycle and pulse skipping modulation. Although its average input current will not surpass 2.5A, there will be current peaks that will easily attain three times that value. This must be taken into consideration when selecting the components in order to avoid damage to the circuitry and ensure the proper operation of the system. The Component Suggestions section provides a good example of devices that meet this criteria.

Once the battery falls below 3.0V the DC-DC converter is disabled and the output simply follows the input (battery voltage). Hence, if the output load has no control mechanism – such as a resistive load, for instance – it will continue to drain current and the battery will keep on discharging even though the output voltage is no longer regulated at 5V, thereby risking full battery discharged. Therefore, the use of a semi-intelligent output load – usually implemented through active devices such as transistors – that possesses some sort of control mechanism is advised. Thus, if this scenario arises the control mechanism can break the interconnection to the evaluation board or disable the entire output load so that the system doesn't operate outside of its specified ranges.

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