Evaluation board for the SLB series with energy harvesting control

EVSLB-EHEP02A

User Guide

Description

Nichicon "SLB" series are "Small Lithium Titanate Rechargeable Batteries" ideal for powering IoT systems. The EVSLB-EHEP02A is an evaluation board that allows users to test the SLB series with combining various types of energy harvesting devices. With a built-in power management IC, the power collection efficiency can be optimized according to the energy harvesting element used. It is also equipped with 3 types of power output, it can be used properly according to the application. The EVSLB-EHEP02A provides an easy way to configure the energy harvesting powered source.

Note: This board has been prepared for the purpose of easy evaluation of the SLB series' characteristics at research and development, and we cannot guarantee its quality. This board is not intended to be used in products or any part thereof.

For product information on the SLB series, please refer to the following web page： https://www.nichicon.com/

Features

・All sizes of the SLB series are available for mounting on the board and usable without soldering
・e-peas AEM10300 (PV source) or AEM30300 (Vibration or AC source) PMIC
    Very low energy consumption, high energy conversion efficiency from an ambient energy harvester, used as Storage element charger
・On board AC source rectifier
・Supports an optimized configuration for efficient energy collection according to the characteristics of the harvester
・Reset switch for PMIC
・Pre-setting value and custom setting (custom mode) are available for charge /discharge control threshold of the storage element
・2 types of voltage output： Direct connection to SLB, or regulated voltage (3.3V)
    Regulated voltage is able to set from 3.0V to 5.0V with resistor
・MAX17225 DC/DC converter (Analog Devices) for regulated voltage output
    Ultra-low power consumption
・Over temperature protection for battery (charge/discharge shutdown)
・Dip Switch for configuration setting -easy to use-
・PMIC and voltage outputs are able to control by the logic-level signal from the control terminal
・Test pin on the major signal lines -For easier observation; with pin-header GND-

Applications

Various IoT systems requiring autonomous power sourcing
    Environmental monitoring/sensing system, Disaster prevention infrastructure, Asset management, Smart home, High functionality ESL, Wireless power receiving system   etc.

1. Specifications

・Input Terminal:　　2P screw type　　DC: 1 / AC: 1　　　diameter of wire: -AWG#16
　　　Input voltage range:　　0.1～4.5V (DC)
　　　　　　　　　　　　　±4.5Vpeak (AC)
・Output Terminal:　　2P screw type　　2 systems　　　diameter of wire: -AWG#16
　　　　1.　Direct output from SLB series (not stabilized) (*)
　　　　　　Voltage　　　　　　　　　1.8V - 2.8V (SLB normal product)
　　　　　　　　　　　　　　　　　1.5V - 2.8V (SLB high-temperature durable product)
　　　　　　Maximum current　　　7mA - 3A (continuous; depend on mounted SLB series)
　　　　2.　3.3V stabilized output (*)
　　　　　　Maximum current　　　Approximately 500mA (at 1. = 2.6V, less than 5% drop in output voltage)
　　　　　　Output voltage is able to set from 3.0V to 5.0V with resistor
　　　　　　(Maximum output current depends on the setting voltage)
・Configuration of maximum power point tracking (MPPT) control (*)
　　　Working voltage　　　7 kinds of pre-setting + ZMPP
　　　Sampling timing & duration　　4 kinds of pre-setting
　　　Note) MPPT preset values are different between AEM10300 and AEM30300. See the datasheet for details.
　　　　　It is also described at *4.3 Various setting*　in this guide.
・Threshold voltage setting for charge/discharge control (*)
　　　2 kinds of pre-setting + custom mode
　　　(Important) Allowed configurations are described in table 4.3.1a of this document.
　　　　　　Please do not use the setting of STO_CFG[2]=0 and STO_CFG[0]=1.
　　　　　　SLB series will be damaged to be overcharged beyond its rating.
・Output enable setting:　Always ON / controlled by PMIC / controlled from outside of this board
　　Outside control　　Logic high level　: 1.2V min (5V max)
　　　　　　　　　　　Logic low level　　: 0.1V max
・Dimensions:　90mm×70mm×12mm　(except for the height of SLB series)

(*) Please refer to individual datasheets for details.
　Small Lithium Titanate Rechargeable Battery "SLB" series (Nichicon)
　　　https://www.nichicon.co.jp/english/products/slb/
　PMIC AEM10300 (e-peas)
　　　https://e-peas.com/product/aem10300-solar-battery-charger-up-to-7-cells/
　PMIC AEM30300 (e-peas)
　　　https://e-peas.com/product/aem30300-rf-battery-charger/
　DC/DC converter MAX17225 (Analog Devices)
　　　https://www.analog.com/media/en/technical-documentation/data-sheets/MAX17220-MAX17225.pdf
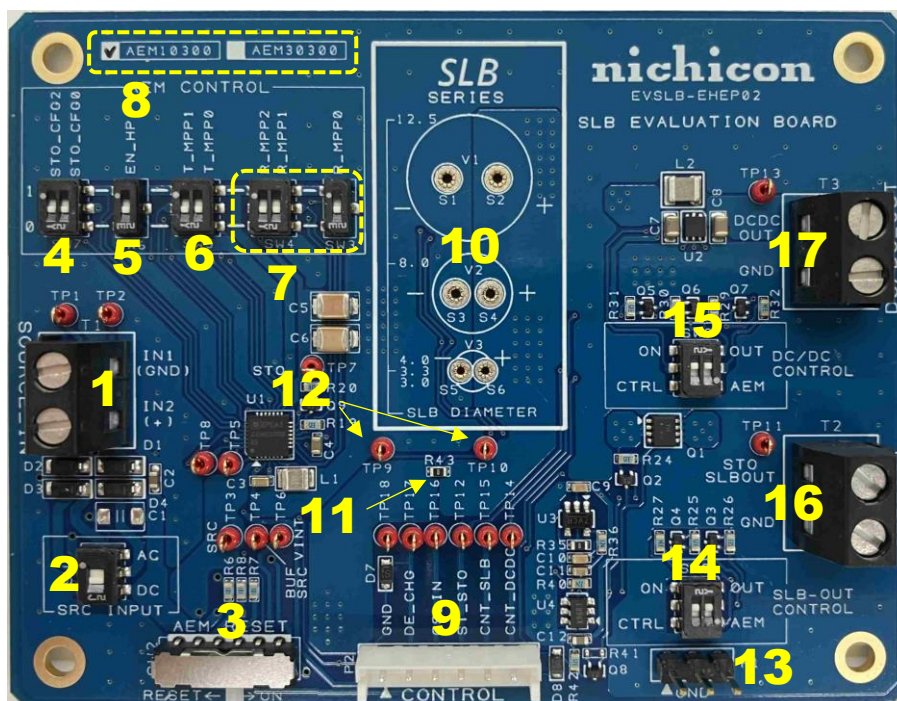
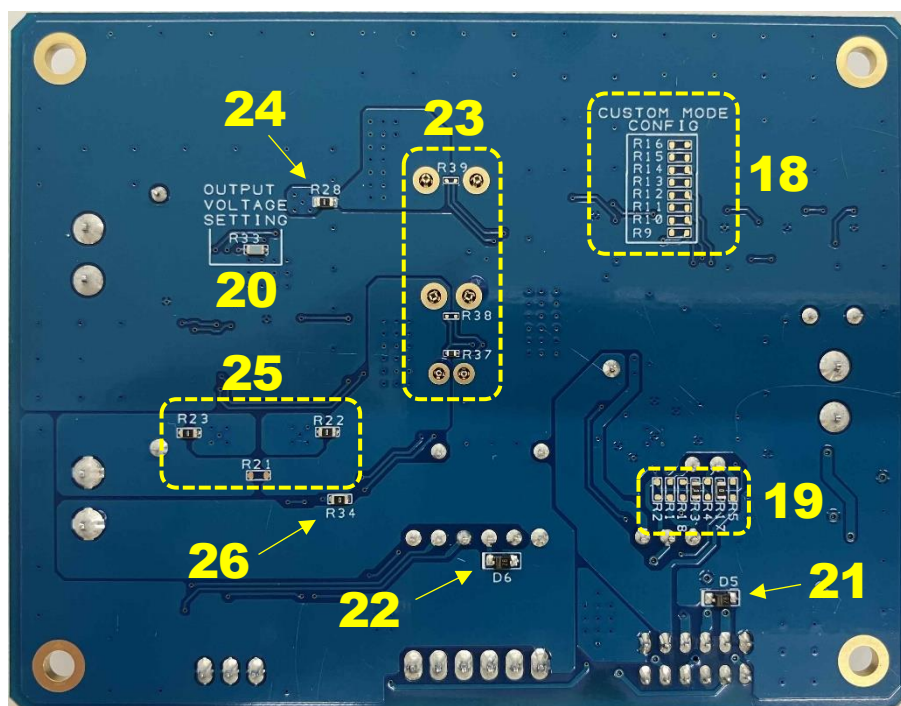## 2. Appearance and user interfaces

Fig 2-1   Front Side

Fig 2-2   Back Side

Table2-1   Function of terminals and switches

No.	Name	Ref-No.	Description
1	Harvest source input terminal	T1	Terminal that connects energy harvesting element. [DC output type] 　　'+' terminal of the element:　connect to IN 2 (+) 　　' - ' terminal of the element:　connect to IN 1 (GND) 　＊Allowable input voltage:　Voc < 4.5V [AC output type] 　　Connect outputs of the element to IN 1 (+) and IN 2 (GND) 　＊Allowable input voltage:　-4.5V < Voc < 4.5V (@duty=50%) 　　When the duty is not 50%, be careful with the voltage of SRC (see the table 2-2 for SRC) not beyond 4.5V. 　　When using a high-frequency (ex. RF) harvester, connect it to the DC input terminal after matching it externally and converting it to DC.
2	DC input / AC input switch	SW1	Switch that switches power path to the power management IC from DC or AC source input. Slide the switch according to the output type (DC or AC) of the connected energy harvesting element.
3	Reset switch	SW2	This switch is used to reset the PMIC settings. At the time of reset, wait for a few seconds or more to completely discharge the capacitor before turning on the switch. Also, when recovering from reset, be sure to follow the procedure described in *4.1 Precautions for use*.
4	Threshold voltage setting switch	SW7	Switch that sets operating threshold voltage about the storage element for the PMIC. For more information, see *4.3.1 PMIC settings*.
5	Power mode setting switch	SW6	Switch that sets power mode of the PMIC. For more information, see *4.3.1 PMIC settings*.
6	MPPT timing setting switch	SW5	Switch that sets Maximum power Point Tracking (MPPT) feature of the PMIC. For more information, see *4.3.1 PMIC settings*.
7	MPPT ratio setting switch	SW3 SW4	Switch that sets Maximum power Point Tracking (MPPT) feature of the PMIC. For more information, see *4.3.1 PMIC settings*.
8	PMIC number	-	PMIC number mounted on the evaluation board. Model number of the one with the check is mounted on the board.
9	Control terminal from outside	P2	Signal input / output terminal for controlling PMIC and output ON / OFF from the outside of this board. For more information, see *4.3.3 Output control settings*.
10	Mounting place for SLB series	V1 V2 V3	Mounting place for Nichicon "SLB" series. Select an appropriate place according to the diameter of the SLB series to be used, and insert the lead into the socket hole. Pay attention to the polarity of SLB series.

- Table 2-1   Continued   -

No.	Name	Ref-No.	Description
11	Resistor for charge current detection	R43	Resistor to monitor the charging current to SLB series by voltage drop. (Charging current detection is not possible by default. Jumper chip is mounted at R43.) If you need a charging current monitor, calculate a resistance value that fits your application and replace this resistor. For more information, see *4.3.6 Another settings*.
12	Test pin for charge current monitoring	TP9 TP10	Test pin for monitoring the charging current to the SLB series. The value of charging current is obtained by subtracting the TP10 voltage from the TP9 voltage and dividing by R43. For more information, see *4.3.6 Another settings*.
13	GND terminal	P1	Pin header connected to GND. This terminal can be used for observation with oscilloscope.
14	SLB output control switch	SW8	Switch to switch the signal that control the output from SLB output terminal (16). For more information, see *4.3.3 Output control settings*.
15	DC/DC output control switch	SW9	Switch to switch the signal that control the output from DC/DC output terminal (17). For more information, see *4.3.3 Output control settings*.
16	Direct output terminal from SLB	T2	Terminal that can provide energy direct from SLB series mounted on the PCB. The voltage fluctuates according to the stored energy in the SLB series. STO_SLBOUT : connect to positive side(+) of the load GND : connect to negative side (GND) of the load
17	DC/DC output terminal	T3	Terminal connected to the output of step-up DC/DC converter. By replacing R33 (20) located on the back of the board, it is possible to set any voltage between 3V and 5V (0.1V steps). Default voltage setting is 3.3V. For more information, see *4.3.2 DC/DC converter settings*. Since the operating frequency changes depending on the load current, the residual noise on the output varies depending on the load. DCDC_OUT : connect to positive side(+) of the load GND : connect to negative side (GND) of the load
18	Resistor for custom setting of threshold voltage	R9 ～ R16	These are used to customize the operating threshold voltage about the battery for the PMIC. For more information, see *4.3.1 PMIC settings*.
19	Resistor to set the input/output signals to/from PMIC	R1 R2 R3 R4 R5 R17 R18	Resistor land for connecting the circuit on the PCB to input/output of PMIC. Jumper chip is mounted on the resistor land for the selected signal. For more information, see *4.3.1 PMIC settings*.

- Table 2-1 Continued -

No.	Name	Ref-No.	Description
20	Resistor for output voltage setting of DC/DC converter	R33	Resistor used to set the output voltage of the DC/DC converter. For more information, see *4.3.2 DC/DC converter settings*.
21	Protection diode for PMIC input	D5	Over voltage protection for SRC pin on the PMIC. It can be removed in some cases, but see *4.3.5 Protection Circuits* for more information.
22	Protection diode for PMIC input	D6	Over voltage protection for CS_IN pin on the PMIC. It can be removed in some cases, but see *4.3.5 Protection Circuits* for more information.
23	NTC thermistor	R37 R38 R39	This is a sensor to protect the SLB series by controlling the circuit operation at high temperature (approximately beyond 60 ° C). It senses the temperature around the leads of the SLB series on the PCB. For more information, see *4.3.5 Protection Circuits*.
24	Resistor of power supply path to DC/DC converter	R28	This is the path that supplies power to the DC / DC converter, and jumper chip is mounted by default. It can be removed in some cases. See *4.3.3 Output Control Settings* for details.
25	Resistor for setting path from SLB	R21 R22 R23	Resistor for setting path from SLB to direct output terminal, whether or not to pass the SLB output ON / OFF control circuit is set by them. For more information, see *4.3.3 Output Control Settings*.
26	Resistor of power supply path to OTP circuit	R34	This is the path that supplies power to the over temperature protection (OTP) circuit, and jumper chip is mounted by default. It can be removed in some cases. See *4.3.5 Protection Circuit* for details.

Table2-2　　Test Pins

No.	Signal name	Signal description
TP1	IN1	One side of the signal line connected to the source input terminal. When SW1="DC", this signal line is connected to GND. When SW1="AC", the waveform before rectification can be monitored. When observing between TP1 and TP2 using an oscilloscope, pay attention to the reference potential.
TP2	IN2	One side of the signal line connected to the source input terminal. When SW1="DC" and SW2="ON", this signal line is connected to SRC (TP3). When SW1="AC", the waveform before rectification can be monitored. When observing between TP1 and TP2 using an oscilloscope, pay attention to the reference potential.
TP3	SRC	Signal line to the SRC pin of the PMIC. SW2= "ON" : Signal selected by SW1 is inputted to the SRC pin SW2= "RESET" : Connected to GND

- Table 2-2   Continued   -

No.	Signal name	Signal description
TP4	BUFSRC	Connected to the BUFSRC pin on the PMIC. SW2= "ON" : The energy input from the SRC pin is buffered by a capacitor. SW2= "RESET" : By connecting to GND via 100Ω, the charge in the capacitor is discharged.
TP5	ZMPP	Connected to the ZMPP pin on the PMIC.
TP6	VINT	Connected to the VINT pin on the PMIC. VINT is used as internal power supply of the PMIC. SW2= "ON" : It is able to observe the internal operating voltage of PMIC. SW2= "RESET" : By connecting to GND via 100Ω, the charge in the capacitor is discharged.
TP7	STO	Connected to the STO pin on the PMIC. This is the connection line to the storage element (SLB). SW2= "ON" : Connected to the plus terminal of SLB series via resistor for charging current monitor (R43). SW2= "RESET" : Disconnected from the plus terminal of SLB series and connected to GND via 100Ω. The charge in the capacitor connected to STO pin on the PMIC is discharged.
TP8	CS_IN_AEM	Connected to the cold start pin (CS_IN) on the PMIC.
TP9	STO_SLB_G	It is a charging path from PMIC to SLB series and is connected to reset switch (SW2). It can be used as an upstream-side voltage pin for charge current monitoring. For a detail of the charging current monitoring, see *4.3.6 Another settings*. SW2= "ON" : Connected to STO pin on the PMIC and to be the same voltage as TP7. SW2= "RESET" : Disconnected from t STO pin on the PMIC. Since no current flows through the reset switch, it has the same voltage as TP10.
TP10	STO_SLB	Connected to the positive side (+) land for mounting SLB series. It is connected to TP9 via a charging current detection resistor (R43), and can be used as a downstream-side voltage pin for charge current monitoring.
TP11	STO_SLBOUT	Connected to the positive signal line of direct output terminal from SLB. When the direct output from SLB is enabled, the voltage of this line is same as STO_SLB (TP10).
TP12	ST_STO	Connected to the storage status pin (ST_STO) on the PMIC. When ST_STO is asserted, the voltage level will be the same as STO (TP7).
TP13	DCDC_OUT	Output line of DC/DC converter.
TP14	CNT_DCDC	Control signal to control ON/OFF for DC/DC converter circuit through the control terminal (P2) from outside. High : DC/DC converter circuit is enabled Low : DC/DC converter circuit is disabled
TP15	CNT_SLB	Control signal to control ON/OFF for MOSFET switch on the SLB direct output circuit through the control terminal (P2) from outside. High : SLB direct output is enabled Low : SLB direct output is disabled

- Table 2-2   Continued   -

| No.	Signal name	Signal description
TP16	CS_IN	This line is to provide cold start energy for PMIC through the control terminal (P2) from outside. This is connected CS_IN pin on the PMIC through the resistor R18. (R18 is not implemented by default) For more information, see *4.3.1 PMIC settings*.
TP17	DE_CHG	This signal is to stop the charging operation of the PMIC through the control terminal (P2) from outside. 　High：stop the charging from PMIC to storage (SLB) 　Low：PMIC normal operation
TP18	GND	GND potential

3. Circuit configuration
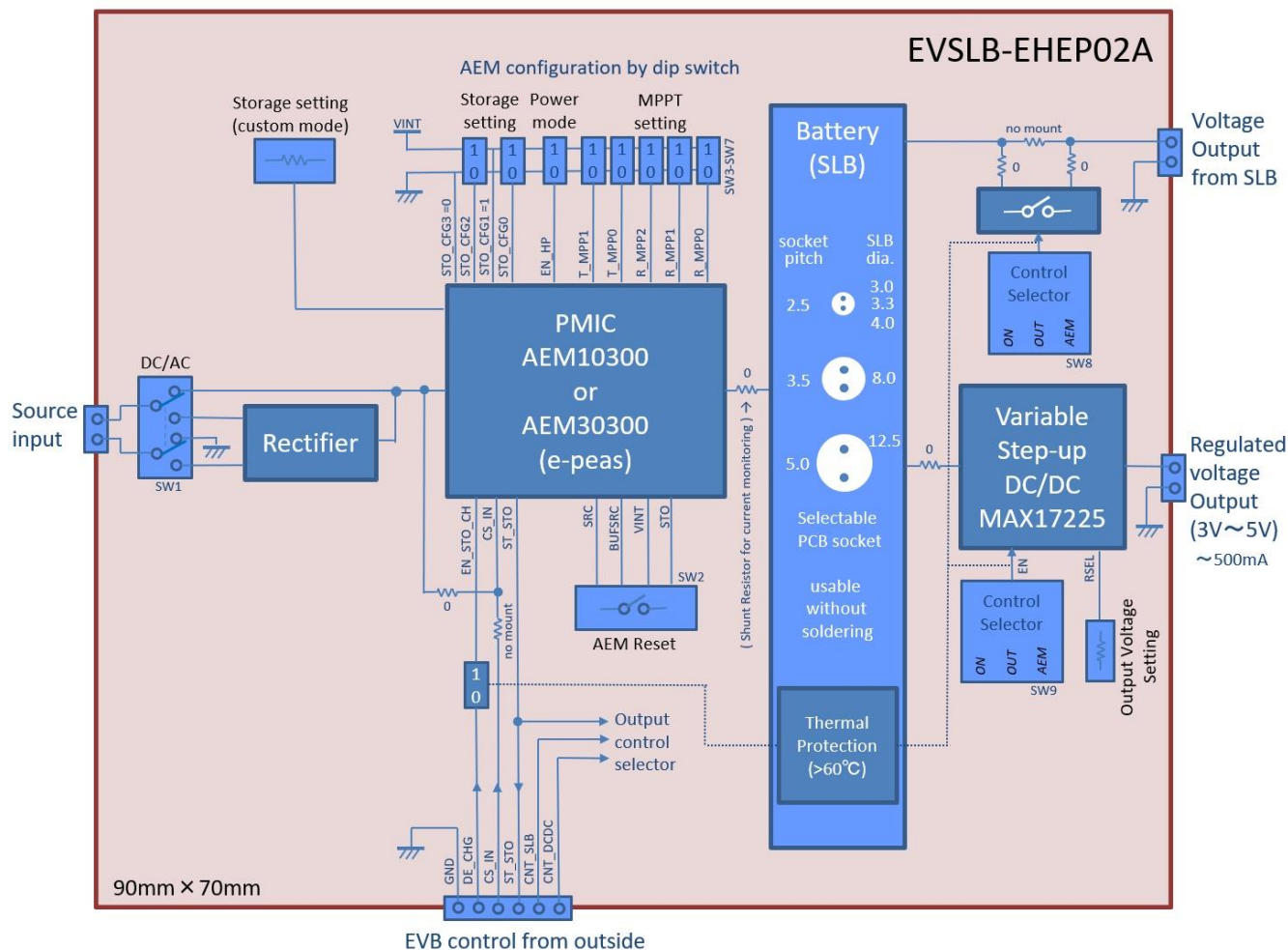
Fig 3   Block diagram

4. General Usage

4.1 Precautions for use

- Make sure that the output of energy harvesting element to be connected does not exceed the maximum input rating of the PMIC.

- The input terminal of this board is intended for connection to energy harvesting elements with a relatively high output impedance. When using a low output impedance power source such as a regulated power supply for experiments, it is recommended to use an appropriate resistor in series with the power supply output to avoid overloading the PMIC and malfunctioning of the MPPT function.

- Do not short the secondary battery (SLB) output. There is a risk of performance deterioration and damage.

- Pay attention to the GND potential of all the circuits and measuring instruments to be connected.
  Since the GNDs of all Input/ Output terminals on this board are connected within the board, external circuits with different reference potentials cannot be connected via this board.

【 Reset procedure for PMIC 】
In order to avoid damaging the PMIC, it is recommended to disconnect the Harvester source first, then the Storage element, then the applications.
   a. Disconnect all wiring and measuring instruments
   b. Slide the reset switch (SW2) to "RESET" position (left side)
   c. Wait for a few seconds or about 10 seconds to discharge the capacitor around the PMIC
   d. Configure the operating conditions by DIP switches and resistors
   e. Connect the load circuit to the appropriate output terminals (T2 and/or T3)
   f. Connect the SLB series (omitted if already mounted)
   g. Connect the energy harvesting element to the source input terminal (T1)
   h. Connect an external control circuit (omitted if not used)
   i. After reconfirming that all wiring and settings are correct, slide the reset switch to "ON" position (right side) to release the reset

Note) Depending on the position of the output control switch (SW8, SW9), the power may be supplied to the external circuit from the moment that wiring is connected in f.
If you want to avoid this, set the switch on the right side of SW8 and SW9 to the "CTRL" side and the switch on the left side to the "AEM" side, connect the wiring, and then change the setting if necessary.

Note) When the evaluation by supplying power from a measuring instrument instead of an energy harvesting element, please mention that a rush current cause for capacitor charging may flow when the reset is released.

4.2 Booting the board

When using this board for the first time, or when the connected elements or circuits are changed, it is recommended to reset the PMIC according to the reset procedure for PMIC described in **4.1 Precaution for use**. If there is no change in the connection, resetting is not necessary, but if there is something wrong with the PMIC operation, please reset the PMIC.

The moment that reset switch (SW3) is turned on, the PMIC is in the reset state, but when the available energy on the CS_IN pin exceeds the start threshold, the operation starts, and then it operates according to the setting of each switch.
For details on how to set each switch, refer to **4.3 Various Settings**.

4.3 Various setting

4.3.1   PMIC settings

Refer to the device datasheet for details.
AEM10300 :   https://e-peas.com/product/aem10300-solar-battery-charger-up-to-7-cells/
AEM30300 :   https://e-peas.com/product/aem30300-rf-battery-charger/

Table 4-3-1a   Battery control voltage threshold setting

Switch setting (SW7)				Control voltage threshold			Remarks
STO_ CFG3	STO_ CFG2	STO_ CFG1	STO_ CFG0	V_{OVDIS}	V_{CHRDY}	V_{OVCH}	
0 fixed	0	1 fixed	0	1.85V	2.40V	2.70V	For SLB normal product
	0		1	0.20V	1.00V	4.65V	Do not use (damage the SLB)
	1		0	1.85V	2.30V	2.60V	For SLB normal product
	1		1	Custom Mode			For SLB high-temperature durable product Threshold setting by R9 - R16

* Do not use the mode of STO_CFG[2]=0 and STO_CFG[0]=1.
SLB series will be damaged by overcharging.

* To prevent erroneous operation, SW7 may have tape attached to its top surface.
If you want to change the settings, please remove the tape before use.

In the preset mode, STO_CFG2 = 0 and STO_CFG0 = 0 are the most suitable for the normal SLB series, but if a threshold value other than the preset value is required, the custom mode is available. It is be able to set any voltage threshold value by implementing resistors R9 - R16 (resistance values are calculated from the below formula) and setting STO_CFG2 = 1 and STO_CFG0 = 1.

When using the high-temperature durable SLB product, it is necessary to set the appropriate voltage thresholds by using the custom mode.

< How to set the voltage threshold and resistance value in custom mode >

$$RT = (R9+R10) + (R11+R12) + (R13+R14) + (R15+R16)$$

$$1M\Omega \leqq RT \leqq 100M\Omega$$

$$R15 + R16 = RT \times (1 / V_{OVCH})$$
$$R13 + R14 = RT \times (1 / V_{CHRDY} - 1 / V_{OVCH})$$
$$R11 + R12 = RT \times (1 / V_{OVDIS} - 1 / V_{CHRDY})$$
$$R9 + R10 = RT \times (1 - 1 / V_{OVDIS})$$

$$V_{OVDIS} + 0.05V \leqq V_{CHRDY} \leqq V_{OVCH} - 0.05V$$

$V_{OVDIS} \geqq 1.8V$, $V_{OVCH} \leqq 2.8V$ (for SLB normal product)
$V_{OVDIS} \geqq 1.5V$, $V_{OVCH} \leqq 2.5V$ (for SLB high-temperature durable product)
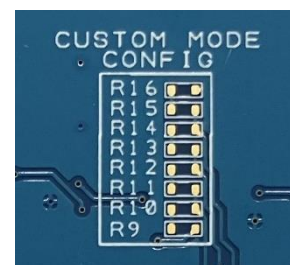

Fig. 4-3-1a
Resistor lands
for custom mode configuration

A convenient tool for setting resistance value is available on the e-peas AEM10300 product site.
https://e-peas.com/product/aem10300/

When using the custom mode, an always energy-consuming-path is performed trough R9 to R16 from the SLB. Therefore, energy loss can be suppressed by setting the combined resistance RT as high as possible within the possible range.

< Example of voltage threshold setting when using high-temperature durable SLB product >

Set STO_CFG2=1, STO_CFG0=1 for SW7 to select custom mode.

Table 4-3-1b   Resistor setting and voltage threshold (Example)

Resistor for setting custom-mode								Voltage threshold		
R9	R10	R11	R12	R13	R14	R15	R16	V_{OVDIS}	V_{CHRDY}	V_{OVCH}
10M	0	5.6M	470k	1.2M	240k	12M	510k	1.50V	2.15V	2.40V
10MΩ		6.07MΩ		1.44MΩ		12.51MΩ				
R4		R3		R2		R1				
Circuit number at the e-peas' configuration tool										

Table 4-3-1c   Power mode setting   - Please refer to PMIC datasheet for more details -

Switch setting (SW6)	Power mode
EN_HP	
0	Low power mode
1	High power mode

Table 4-3-1d   MPPT timing setting   - Please refer to PMIC datasheet for more details -

Switch setting (SW5)		MPPT timing (AEM10300)		MPPT timing (AEM30300)	
T_MPP1	T_MPP0	Sampling duration	Sampling period	Sampling duration	Sampling period
0	0	5.19ms	280ms	3.82ms	18.28ms
0	1	70.8ms	4.5s	5.1ms	280ms
1	0	280ms	17.87s	71.6ms	1.12s
1	1	1.12s	71.7s	1.12s	71.7s

Table 4-3-1e   MPPT ratio setting   - Please refer to PMIC datasheet for more details -

Switch setting (SW3, SW4)			MPPT ratio (AEM10300)	MPPT ratio (AEM30300)
R_MPP2	R_MPP1	R_MPP0	V_{MPP} / V_{OC}	V_{MPP} / V_{OC}
0	0	0	60%	35%
0	0	1	65%	50%
0	1	0	70%	60%
0	1	1	75%	65%
1	0	0	80%	70%
1	0	1	85%	75%
1	1	0	90%	80%
1	1	1	ZMPP	ZMPP

＜ R4 resistance range when using ZMPP mode ＞

$10\Omega \leqq R4 \leqq 100k\Omega$
For detailed operation of ZMPP mode, please refer to PMIC datasheet.

When connecting a low output impedance power source (such as a regulated power supply) + current limiting resistor to the input terminal, the harvested power will be maximized when the input impedance of the PMIC is the same as the current limiting resistor value. Under this condition, the ratio of the input voltage on the energy harvesting period to the open-circuit-voltage of the energy source is 50%, so using a preset value close to 50% for the MPPT ratio will enable efficient power collection.

The AEM10300 does not have a preset R_MPP of 50% and cannot be selected, but if you use the ZMPP mode and install a resistor of the same value as the current limiting resistor in R1, you will be able to harvest at a voltage of 50% of the open-circuit-voltage of energy source (Regulated power supply).

◇PMIC input signal path

The signal input / output paths of the PMIC are as Fig.4-3-1b by default, but it can be changed by changing the mount place of resistor to another land if necessary.
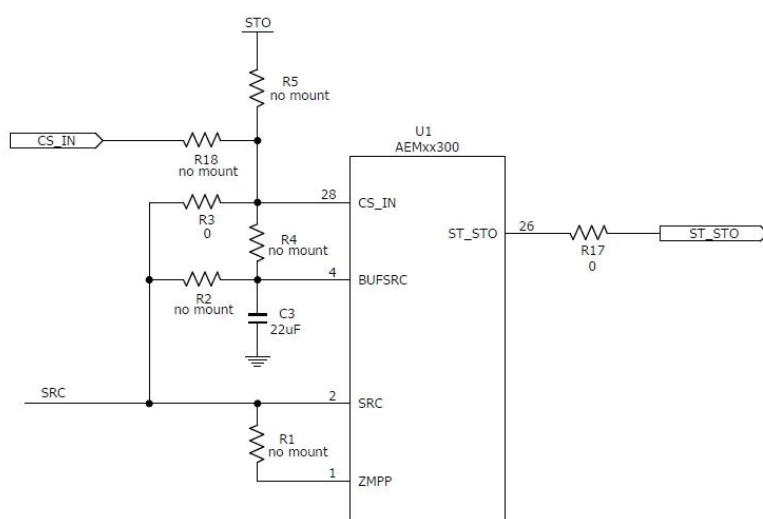

Fig. 4-3-1b   I/O signal path around the PMIC and resistor lands

4.3.2 DC/DC converter settings

See the device data sheet for details on DC / DC converters.

MAX17225 :

https://www.analog.com/media/en/technical-documentation/data-sheets/MAX17220-MAX17225.pdf

◇ The output voltage of the DC/DC converter can be changed by replacing the resistor mounted on R33. (Default is 3.3V setting)

Table 4-3-2   Resistance value of R33 corresponding to each output voltage

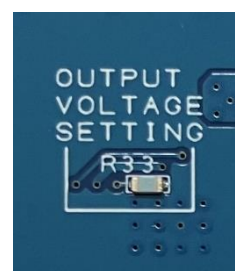| Output voltage (V)	R33 (kΩ) Tolerance: 1%	Output voltage (V)	R33 (kΩ) Tolerance: 1%
3.0	133	4.0	23.7
3.1	113	4.1	20
3.2	95.3	4.2	16.9
3.3	80.6	4.3	14
3.4	66.5	4.4	11.8
3.5	56.2	4.5	10
3.6	47.5	4.6	8.45
3.7	40.2	4.7	7.15
3.8	34	4.8	5.9
3.9	28	4.9	4.99
		5.0	0

Fig. 4-3-2
Resistor for output voltage
setting of DC/DC converter

4.3.3 Output control settings

Table 4-3-3   Output control setting (Common to each output control switch of SLB direct and DCDC out)

Switch setting (SW8/SW9)		Output control
Left side	ON	Always ON Right side switch setting is disabled
	CTRL	Controlled by PMIC or control signal from outside The signal path to control is selected by the right side switch
Right side	OUT	ON/OFF is controlled from outside signal Use with the left side switch set to "CTRL"
	AEM	ON/OFF is controlled by the PMIC Use with the left side switch set to "CTRL"

◇ When the output is controlled by PMIC (setting of "CTRL" on the left side and "AEM" on the right side), the output turns off when there is no power input from the energy harvesting element (This is PMIC specifications).

Ex) Situations where there is no light when using solar cells (nighttime, etc.)

If this specification causes any inconvenience, set the corresponding output control setting to always ON, or control the output ON / OFF with an external signal.

◇ If the DC/DC converter is not used, you can reduce power consumption to set the left side of SW9 to "CTRL" and the right side to "OUT".
(When using external control, set the control signal to Low.)

If you want to further reduce the power consumption, you can reduce the flow-in current to zero by removing jumper chip in the power supply path to the DC/DC converter.

- power supply path resistor to DC / DC converter   R28

If you use the board with removing R28, set the left side of SW9 to "CTRL" and the right side to "OUT", and do not control it from the outside. (Set pin 6 of the CONTROL terminal (P2) to floating or Low.)

◇ If ON / OFF control of SLB direct voltage output is not required, it is possible to directly connect the positive (+) pole of SLB series and SLB direct voltage output terminal (STO_SLBOUT) by replacing the resistor below. This rerouting bypasses and disables the MOSFET switch, and cuts the operating current of load switch (approximately 800nAmax).

- Remove R20 and R24 (both of jumper chip), and mount a jumper chip at R19

Note) Please mention that the cutoff function to SLB direct output under high temperature does not work when the above resistors are replaced.

4.3.4 External control terminal

Table 4-3-4   Signal list of external control terminal (P2)

Pin No.	Signal name	I/O	Description
1	GND	—	GND connection
2	DE_CHG	IN	Stopping the charging operation of the PMIC from outside. High：stop the charging from PMIC to storage (SLB) Low：PMIC normal operation
3	CS_IN	IN	This line is connected to CS_IN pin on the PMIC through the resistor R18. (R18 is not implemented by default). When supplying cold start energy for PMIC from the outside through this terminal, mount a jumper chip on R18. Note the absolute maximum rating of the PMIC.
4	ST_STO	OUT	This line is connected to the storage status pin (ST_STO) on the PMIC. When ST_STO is asserted, the voltage level will be the same as STO.
5	CNT_SLB	IN	Controlling the load switch of the SLB-direct-output. High：SLB-direct-output Load switch ON Low：SLB-direct-output Load switch OFF
6	CNT_DCDC	IN	Controlling the DC/DC converter circuit. High： DC/DC converter circuit is enabled Low： DC/DC converter circuit is disabled

The voltage range of each control pin (2,5,6) is preferable 1.2V to 5V.

The connector housing that fits into this terminal is HER-6, and the contact is SEH-00xT-P0.6(L) (Both are made by JST)

4.3.5 Protection circuits

◇ This board is equipped with a circuit that stops the circuit operation at high temperatures (approximately over 60 ℃) to protect the SLB series, and that has the configuration shown in Fig. 4-3-5a.
R37 to R39 are NTC thermistor lands, and this circuit is intended to be used by mounting parts in one of them. By default, the NTC thermistor is mounted on the land of R37, and it is optimized for the SLB mounting position with a diameter of less than 4.0 mm. If more accurate temperature detection near the component is required when using other diameter products, replace the NTC thermistor with the land of R38 or R39 that closest to the SLB series mounting position.

Note) Do not use any parts other than the specified NTC thermistor (NPC15WM474E03RC: Murata). And do not mount more than one component. The protection set temperature will deviate significantly.
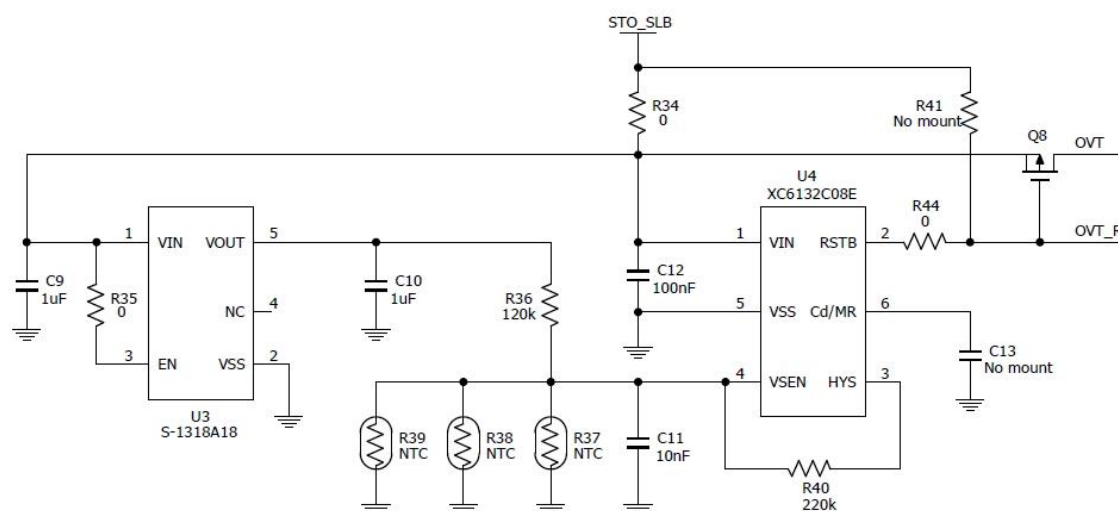

Fig. 4-3-5a   Thermal protection circuit

◇ Thermal protection starts up when the VSEN terminal of U4 in Fig. 4-3-5a falls below the threshold voltage (0.8V). "OVT" in the figure disables the PMIC charge operation and DC/DC converters. Also "OVT_R" turns off the MOSFET switch of the SLB direct output to shut off the output.
For the DC/DC converter circuit, note that if you set SW9 to always ON, thermal shut down function on the Fig.4-3-5a will be disabled in the circuit.

◇ If the thermal protection function is not required, the current flowing into the thermal protection circuit (about 4.8 µA @ 25 ° C, SLB voltage 2.4 V) can be reduced to zero by removing the jumper chip of R35.
When doing this, be sure to remove the jumper chip on R44 and mount it on R41 so that the MOSFET switch in the subsequent circuit will not be turned on via the body diode in the output stage of U4.

◇ Zener diodes are mounted (D5, D6) on the external signal input line of the PMIC for overvoltage protection, but they can be removed if current leaks are a concern.
If you remove the protection diode, be careful not to apply more voltage than the absolute maximum rating of the input pins of the PMIC.
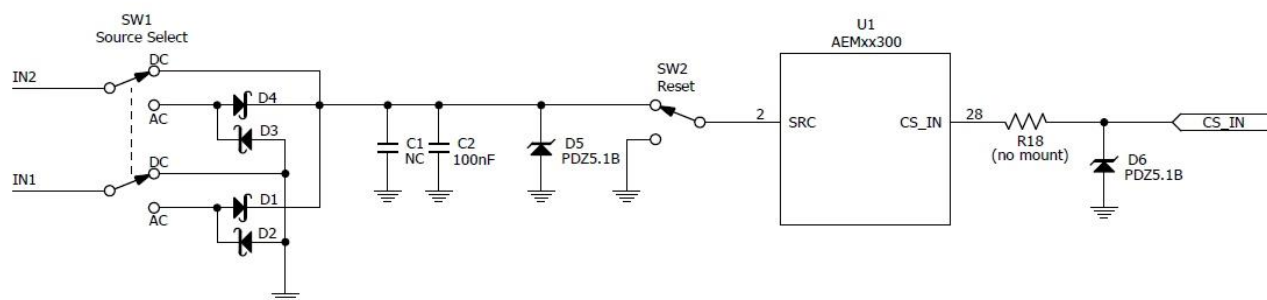
Fig. 4-3-5b   Over voltage protection for input pins on the PMIC

4.3.6   Another settings

◇ This board is equipped with a charge current detection resistor (R43) for monitoring the current from the PMIC to the SLB series, and test pin terminals (TP9, TP10) connected to both ends of the resistor. With TP9 on the upstream (PMIC) side and T10 on the downstream (SLB) side, measure the voltage between both test pin terminals and divide by the value of R43 to obtain the current value that charges the SLB series. (Current monitoring is not possible by default because jumper chip is mounted on R43.)
If current monitoring is desired, after removing the jumper chip on R43, choose a resistance value appropriate for your application and mount that resistor to R43.
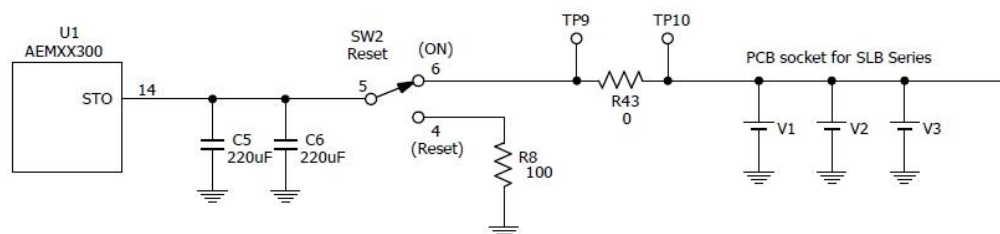
Fig. 4-3-6a   Circuit diagram around current monitoring resistor

Fig. 4-3-6b　　　Current monitoring resistor and test pins

Notes：

・ If a current detection resistor is inserted, the full charge voltage (V_{OVCH}) controlled by the PMIC will be the voltage of the SLB series plus the voltage drop due to the current detection resistor. Therefore, if the value of the current detection resistor is inappropriate, the SLB series may not be fully charged or the charging speed may be extremely slow.
It is recommended to select the smallest possible resistance value. If the voltage drop is too small, it is recommended to amplify the voltage externally.

・ It is unavailable to monitor the current flowing from the SLB series to the load side by using TP9 and TP10.

5. Schematics

Input Block

nichicon
www.nichicon.com
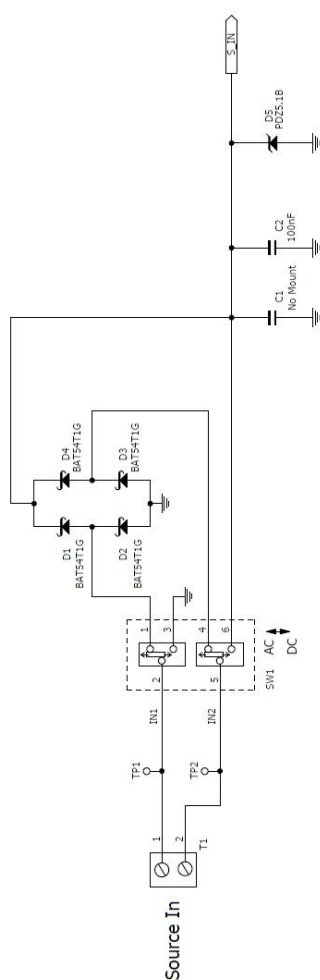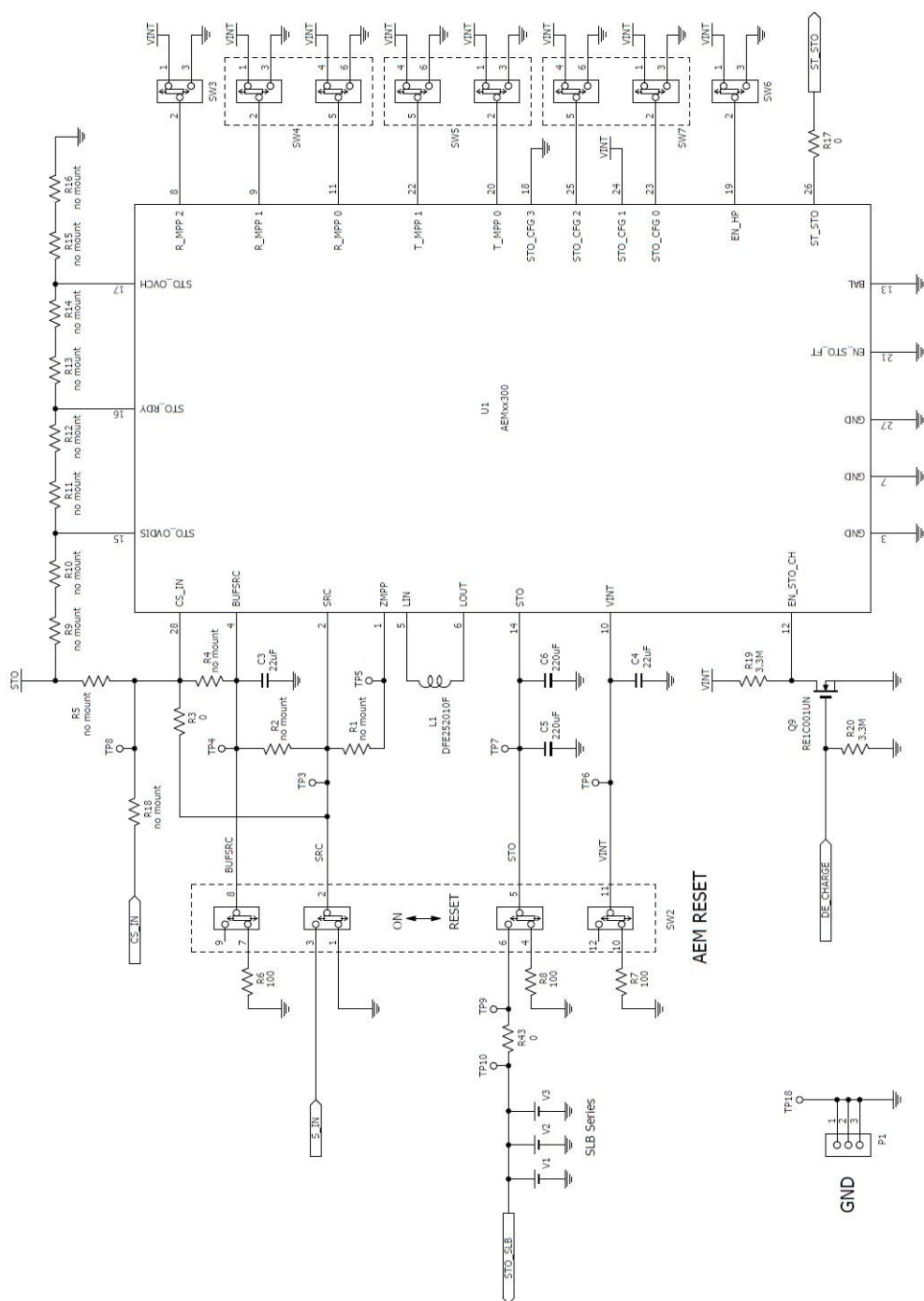
PMIC Block

Protection / Output Block

6. Parts list

Table 6   Parts list

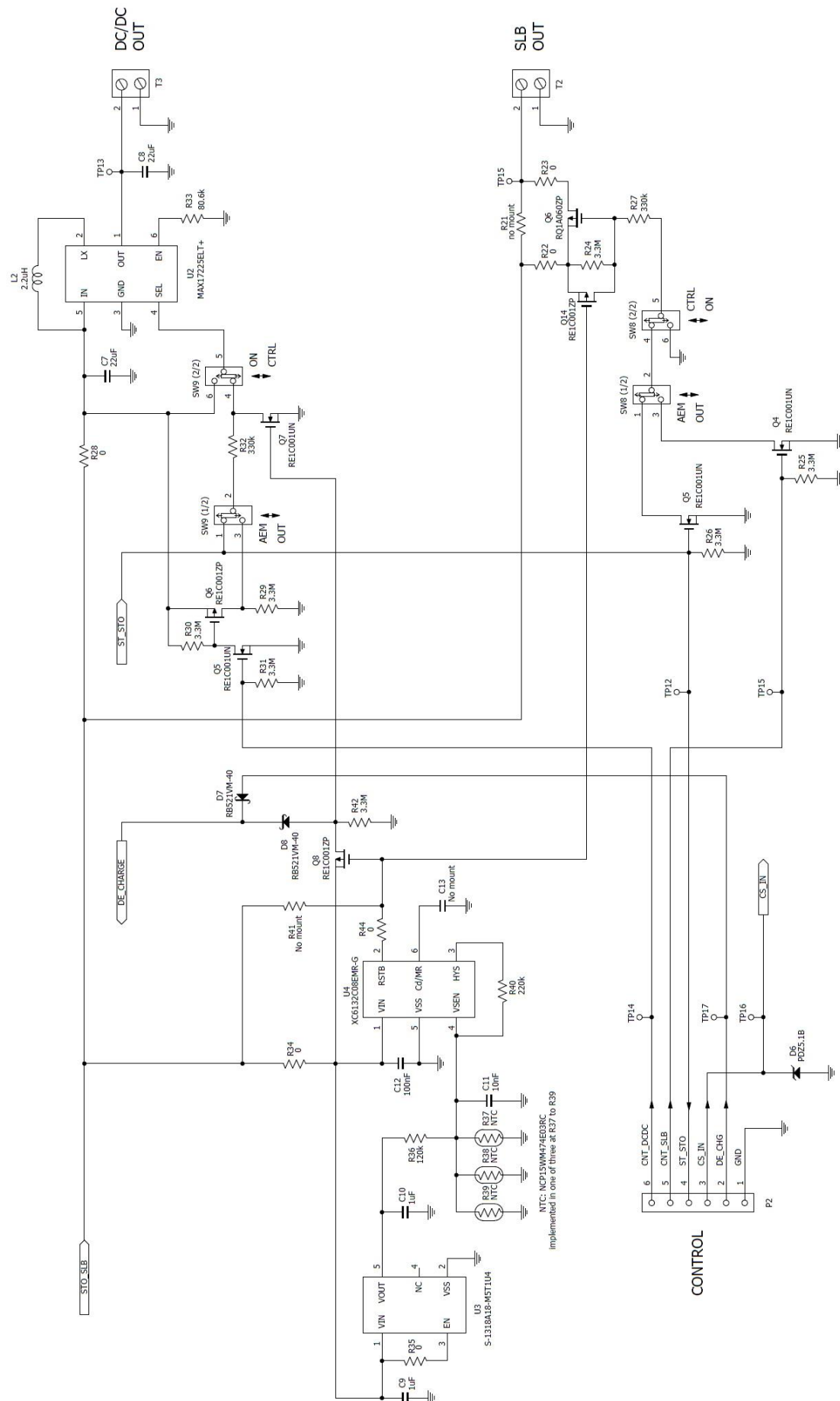| Ref No.	Component	Value	Manufacturer	Description
C1	Capacitor	No mount		
C2	Capacitor	0.1uF	Murata	GCJ188R71H104KA12D
C3	Capacitor	22uF	Murata	GRM188R61A226ME15J
C4	Capacitor	22uF	Murata	GRM188R61A226ME15J
C5	Capacitor	220uF	Murata	GRM32ER60J227ME05L
C6	Capacitor	220uF	Murata	GRM32ER60J227ME05L
C7	Capacitor	22uF	Murata	GRM21BC81C226ME44L
C8	Capacitor	22uF	Murata	GRM21BC81C226ME44L
C9	Capacitor	1uF	Murata	GCM188R71C105KA64D
C10	Capacitor	1uF	Murata	GCM188R71C105KA64D
C11	Capacitor	10nF	Murata	GCM188R72A103KA37D
C12	Capacitor	0.1uF	Murata	GCJ188R71H104KA12D
C13	Capacitor	No mount		
D1	Diode	-	ONSemi	BAT54T1G
D2	Diode	-	ONSemi	BAT54T1G
D3	Diode	-	ONSemi	BAT54T1G
D4	Diode	-	ONSemi	BAT54T1G
D5	Diode	-	Nexperia	PDZ5.1B
D6	Diode	-	Nexperia	PDZ5.1B
D7	Diode	-	Rohm	RB521VM-40
D8	Diode	-	Rohm	RB521VM-40
L1	Inductor	10uH	Murata	DFE252010F-100M
L2	Inductor	2.2uH	Murata	1276AS-H-2R2M
P1	Pin header	2.54mm/3P	Amphenol	68001-103HLF
P2	Connector post	2.50mm/6P	JST	B6B-EH-A
Q1	MOSFET	-	Rohm	RQ1A060ZP
Q2	MOSFET	-	Rohm	RU1C001ZP
Q3	MOSFET	-	Rohm	RU1C001UN
Q4	MOSFET	-	Rohm	RU1C001UN
Q5	MOSFET	-	Rohm	RE1C001UN
Q6	MOSFET	-	Rohm	RU1C001ZP
Q7	MOSFET	-	Rohm	RE1C001UN
Q8	MOSFET	-	Rohm	RU1C001ZP
Q9	MOSFET	-	Rohm	RE1C001UN
R1	Resistor	No mount		
R2	Resistor	No mount		
R3	Resistor	0Ω	KOA	RK73Z1JTTD
R4	Resistor	No mount		
R5	Resistor	No mount		
R6	Resistor	100Ω	KOA	RK73H1JTTD1000F
R7	Resistor	100Ω	KOA	RK73H1JTTD1000F
R8	Resistor	100Ω	KOA	RK73H1JTTD1000F

- Table 6　Continued -

Ref No.	Component	Value	Manufacturer	Description
R9	Resistor	No mount		
R10	Resistor	No mount		
R11	Resistor	No mount		
R12	Resistor	No mount		
R13	Resistor	No mount		
R14	Resistor	No mount		
R15	Resistor	No mount		
R16	Resistor	No mount		
R17	Resistor	0Ω	KOA	RK73Z1JTTD
R18	Resistor	No mount		
R19	Resistor	3.3MΩ	KOA	RK73H1JTTD3304F
R20	Resistor	3.3MΩ	KOA	RK73H1JTTD3304F
R21	Resistor	No mount		
R22	Resistor	0Ω	KOA	RK73Z1JTTD
R23	Resistor	0Ω	KOA	RK73Z1JTTD
R24	Resistor	3.3MΩ	KOA	RK73H1JTTD3304F
R25	Resistor	3.3MΩ	KOA	RK73H1JTTD3304F
R26	Resistor	3.3MΩ	KOA	RK73H1JTTD3304F
R27	Resistor	330kΩ	KOA	RK73H1JTTD3303F
R28	Resistor	0Ω	KOA	RK73Z1JTTD
R29	Resistor	3.3MΩ	KOA	RK73H1JTTD3304F
R30	Resistor	3.3MΩ	KOA	RK73H1JTTD3304F
R31	Resistor	3.3MΩ	KOA	RK73H1JTTD3304F
R32	Resistor	330kΩ	KOA	RK73H1JTTD3303F
R33	Resistor	80.6Ω	KOA	RK73H1JTTD8062F
R34	Resistor	0Ω	KOA	RK73Z1JTTD
R35	Resistor	0Ω	KOA	RK73Z1JTTD
R36	Resistor	120kΩ	KOA	RK73H1JTTD1203F
R37	NTC Thermistor	-	Murata	NCP15WM474E03RC
R38	NTC Thermistor	No mount		
R39	NTC Thermistor	No mount		
R40	Resistor	220kΩ	KOA	RK73H1JTTD2203F
R41	Resistor	No mount		
R42	Resistor	3.3MΩ	KOA	RK73H1JTTD3304F
R43	Resistor	0Ω	KOA	RK73Z1JTTD
R44	Resistor	0Ω	KOA	RK73Z1JTTD
S1	Socket	-	Mac8	AF-0.7(H)
S2	Socket	-	Mac8	AF-0.7(H)
S3	Socket	-	Mac8	AF-0.7(H)
S4	Socket	-	Mac8	AF-0.7(H)
S5	Socket	-	Mac8	AF-0.5(H)
S6	Socket	-	Mac8	AF-0.5(H)
SW1	Switch	-	Nidec Copal	CAS-220TA
SW2	Switch	-	Nidec Copal	MHS422

- Table 6   Continued -

Ref No.	Component	Value	Manufacturer	Description
SW3	Switch	-	Nidec Copal	CAS-120TA
SW4	Switch	-	Nidec Copal	CAS-D20TA
SW5	Switch	-	Nidec Copal	CAS-D20TA
SW6	Switch	-	Nidec Copal	CAS-120TA
SW7	Switch	-	Nidec Copal	CAS-D20TA
SW8	Switch	-	Nidec Copal	CAS-D20TA
SW9	Switch	-	Nidec Copal	CAS-D20TA
T1	Terminal	2P	Phoenix Contact	1869664
T2	Terminal	2P	Phoenix Contact	1869664
T3	Terminal	2P	Phoenix Contact	1869664
U1	IC	-	e-peas	AEM10300 or AEM30300
U2	IC	-	Analog Devices	MAX17225ELT+T
U3	IC	-	ABLIC	S-1318A18-M5T1U4
U4	IC	-	TOREX	XC6132C08EMR-G
V1	Battery	No mount	Nichicon	SLB12400L151
V2	Battery	No mount	Nichicon	SLB08115L140
V3	Battery	No mount	Nichicon	SLB04255L040 / 03090LR80 / 03070LR35
TP1	Test pin	-	Mac8	LC-3-G
TP2	Test pin	-	Mac8	LC-3-G
TP3	Test pin	-	Mac8	LC-3-G
TP4	Test pin	-	Mac8	LC-3-G
TP5	Test pin	-	Mac8	LC-3-G
TP6	Test pin	-	Mac8	LC-3-G
TP7	Test pin	-	Mac8	LC-3-G
TP8	Test pin	-	Mac8	LC-3-G
TP9	Test pin	-	Mac8	LC-3-G
TP10	Test pin	-	Mac8	LC-3-G
TP11	Test pin	-	Mac8	LC-3-G
TP12	Test pin	-	Mac8	LC-3-G
TP13	Test pin	-	Mac8	LC-3-G
TP14	Test pin	-	Mac8	LC-3-G
TP15	Test pin	-	Mac8	LC-3-G
TP16	Test pin	-	Mac8	LC-3-G
TP17	Test pin	-	Mac8	LC-3-G
TP18	Test pin	-	Mac8	LC-3-G

Revision history

Revision No.	Date	Description
0.90	Jun.7th, 2023	preliminary version
1.00	Jul.12th, 2023	Added product information link
2.00	Jul.15th, 2025	Added information about the high-temperature durable SLB product and how to use with the low impedance energy source