Battery Management System Reference Design

Maxell's All-solid-state Battery + Nano Energy™ Collaboration Board for Energy Harvesting

REFLVBMS003-EVK-001

Introduction

This user's guide provides the information and necessary procedures to operate and evaluate Maxell's all-solid-state battery (PSB401010H or PSB401515H) + Nano Energy™ collaboration board for energy harvesting. It includes the board schematic, peripheral parts list, and operating instructions.

Please note that this board has been prepared for the purpose of simple evaluation of Maxell's all-solid-state battery and Nano Energy™ characteristics, and we cannot guarantee its quality. In addition, this evaluation board is intended to be used by professionals for research and development purposes. This board is not intended to be used in mass production products or any part thereof.

Note: Nano Energy™ is a trademark or registered trademark of ROHM Co., Ltd.

Description

This collaboration board has the function to charge Maxell's all-solid-state battery (PSB401010H or PSB401515H) with the generated current from an energy harvester, such as a solar cell, and to boost and stabilize the power stored in this all-solid-state battery to the voltage required for the application. The voltage boosting DC converter IC (BD8B133NVX) is equipped with Nano Energy™ ultra-low current consumption technology to maximize the battery life.

For the specifications of the Charger IC dedicated for Maxell's all-solid-state battery and step-up DC-DC converter IC, please refer to the datasheet in ROHM Co. Ltd.'s website. For the specifications of the all-solid-state battery (PSB401010H and PSB401515H), please refer to the datasheet in Maxell's website.

Maxell, Ltd., web site (https://www2.maxell.co.jp/) Maxell's all-solid-state battery special web site (https://biz.maxell.com/en/rechargeable_batteries/allsolidstate.html)	
Battery	PSB401010H, PSB401515H
ROHM Co., Ltd. web site (https://www.rohm.com/)	
Charger IC	ML9077
Step-up DC-DC converter	BD8B133NVX (Under development *As of July 2023)

Storage Precautions

The board is equipped with a battery. When storing the board, keep it in individual bags to prevent short-circuit between the positive and negative terminals of the battery. Also, set the EN switch of the board to "L" to turn off the DC-DC converter.

Operating conditions

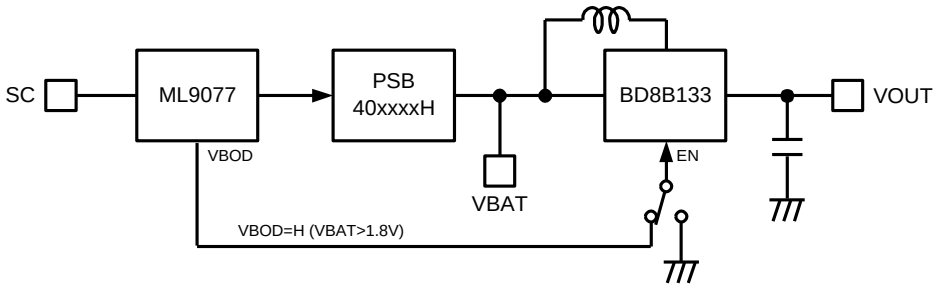


Figure 1：Block Diagram of Battery and each ICs

Figure 1 shows the block diagram of the collaboration board. Connecting an energy harvester (current output power generation device like a solar cell) to the SC terminal initiates charging of the all-solid-state battery (PSB401010H or PSB401515H) from the charge control IC (ML9077). If charging is not required, leave the SC terminal open.

The charger IC (ML9077) constantly monitors the terminal voltage of the all-solid-state battery and starts the DC-DC converter operation when the battery voltage exceeds the set detection voltage.

The DC-DC converter (BD8B133NVX) converts the power stored in the all-solid-state battery (PSB404010H or PSB401515H) with high efficiency. The discharge time is determined by the power stored in the battery.

Below are the recommended operating conditions for the Maxell's all-solid-state battery + Nano Energy™ collaboration board:

Item	Symbol	Min	Typ	Max	Unit	Conditions
SC input voltage	V_{SC}	0	–	3.6	V	Charger Input
VOUT output current	I_{OUT}	–	–	(*1)	mA	*1 (All solid-state battery capacity) /boost-up ratio
Operating Ambient Temperature (Charging)	$T_{a,chg}$	-20	–	70	°C	Depends on Charger IC regulations
Operating Ambient Temperature (Discharge)	$T_{a,dischg}$	-20	–	70	°C	Depends on Charger IC regulations

Table 1：Recommended Operating Conditions

Typical characteristics are shown below. For the detailed characteristics, please refer to the datasheet of each IC.

Item	Symbol	Min	Typ	Max	Unit	Conditions
DC-DC converter on voltage	V_{dcdcon}	1.7	1.8	1.9	V	BOD detection of Charger IC
Output voltage setting range	V_{OUTSEL}	3.0	-	3.3	V	2-step setting (VSEL=L or H)
Output Voltage Accuracy	V_{TOL}	-4.0	0.0	4.0	%	Iout＝0mA
Startup load	R_{stup}	3.0	–	–	kΩ	Activatable load resistance
Charge voltage	V_{CHG}	0	–	2.7	V	SCLV=L
Charge current	I_{CHG}	–	(*2)	–	μA	*2 Energy Harvester Generation Current

Table 2：Typical Specification Values of ICs (Excerpt)

Board Overview

This board achieves an area-saving layout by using an ultra-compact all-solid-state battery and an IC enclosed in an ultra-small package. Since it has charge and discharge functions to manage the battery on the same board, the total characteristics of the "battery + power supply" can be evaluated.

The ML9077 charges the all-solid-state battery using the generated current from the energy harvester, and the BD8B133NVX efficiently boosts and stabilizes the power charged in the all-solid-state battery and supplies it to the system. The all-solid-state battery is implemented with either the PSB401010H or the PSB401515H. (The photo on figure 2 shows the board which has a mounted PSB401515H all-solid-state battery.)

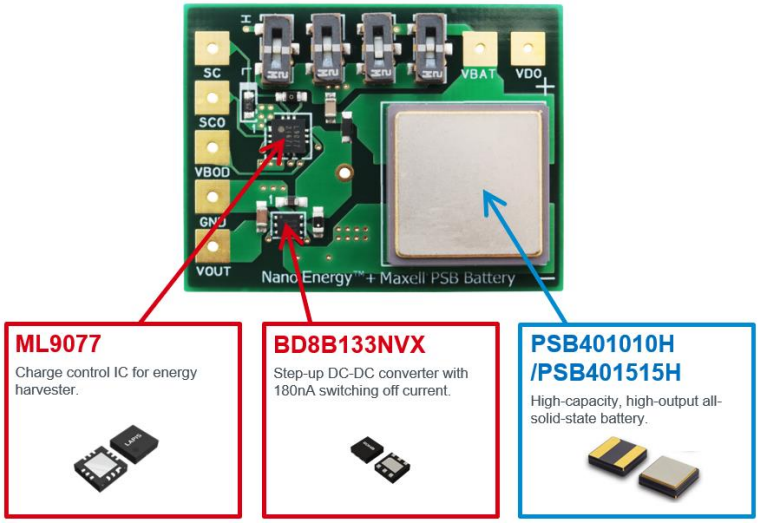
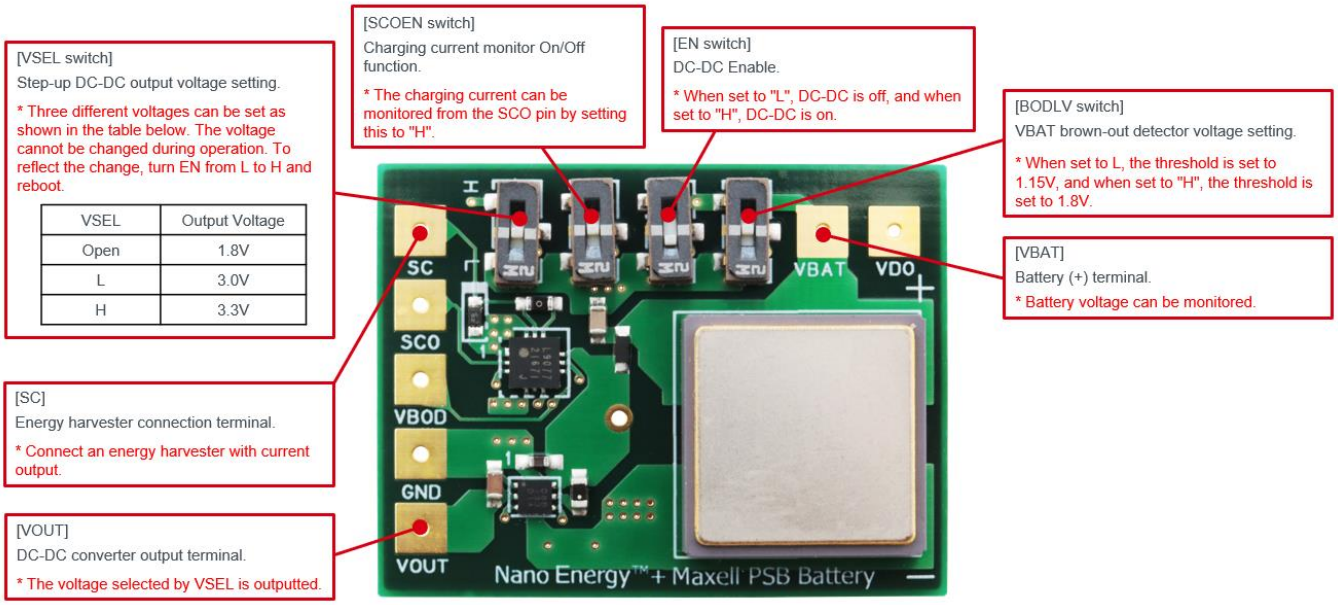


Figure 2 : Collaboration Board Mounted Products

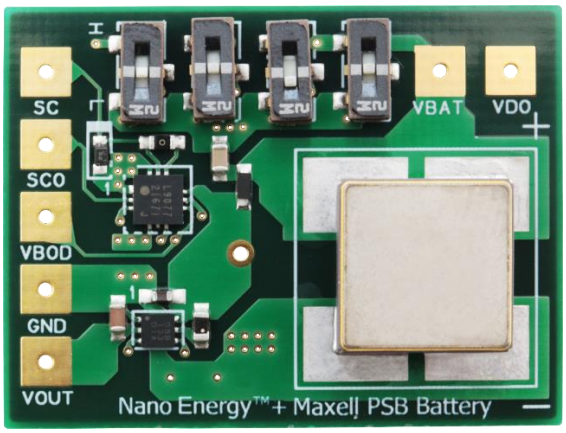
Board Description



The factory default pin setting is EN=L.

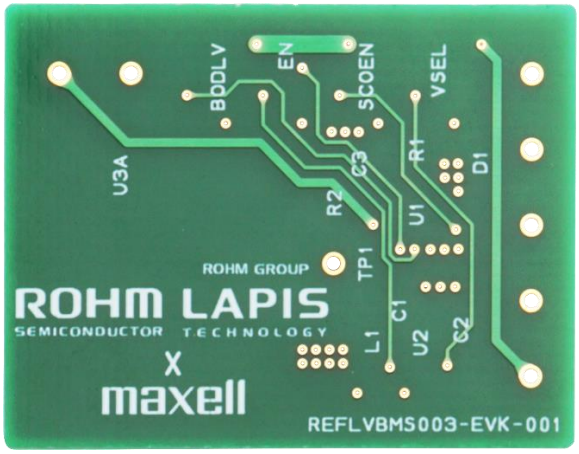
Figure 3 : Collaboration Board Pin and Switch Description

Board photo



Top View（PSB401010H mounting board）

Top View（PSB401515H mounting board）



Bottom View

Figure 4：Collaboration Board Photo

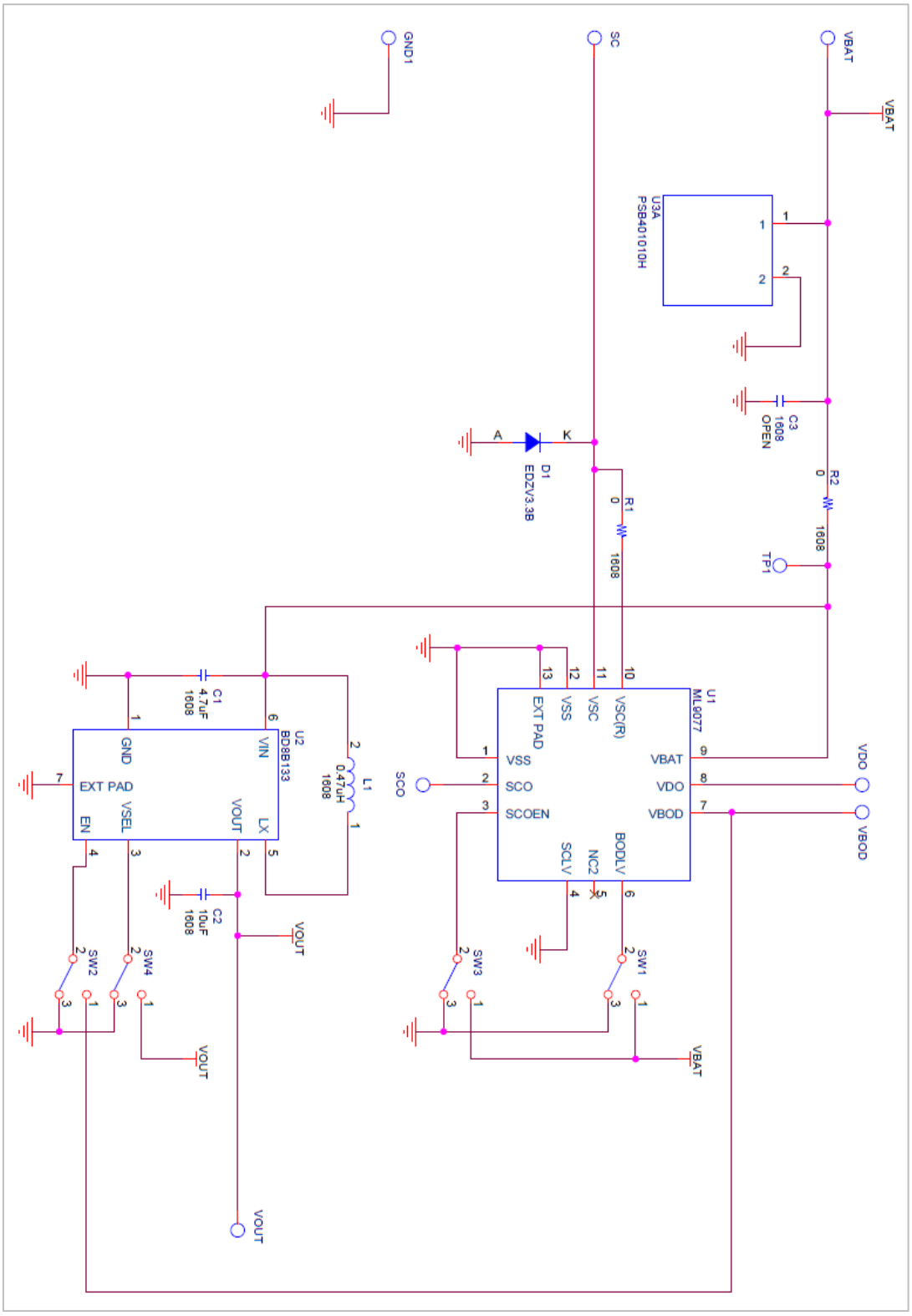
About Switch Settings

Each switch on this board uses CJS-1201A1 which is manufactured by Nidec Components Corporation.

When setting the H and L levels, slide the switch to the H or L side as specified by the silk on the board. It is also possible to set the switch to OPEN state by sliding the switch to the center.

Figure 5：CJS-1201A1 switch（Source: From the website of Nidec Components Corporation）

Board Schematic



Note: Refer to the parts list on the next page for the fixed value of the parts on the above schematic.

Figure 6 : Board Schematic

Parts List

Unit	Part	Value	Description		
Charger	U1	-	IC	LAPIS	ML9077
	R1	0Ω	Resistor	ROHM	MCR03EZPJ000
	D1	-	Diode		
	C3	47μF	Capacitor	Murata	GRM188R60J476ME01#
	SW1	-	Switch	Nidec Components	CJS-1201A1
	SW3	-	Switch	Nidec Components	CJS-1201A1
DC-DC	U2	-	IC	ROHM	BD8B133NVX
	C1	4.7μF	Capacitor	Murata	GRM155D71A475ME15D
	C2	10μF	Capacitor	Murata	GRM188Z71A106KA73D
	L1	0.47μH	Inductor	Murata	DFE18SANR47MG0#
	SW2	-	Switch	Nidec Components	CJS-1201A1
	SW4	-	Switch	Nidec Components	CJS-1201A1
Battery	U3A	-	Battery	Maxell	PSB401010H/PSB401515H
Other	R2	0Ω	Resistor	ROHM	PMR03EZPJ000

Table 3：Parts List of Collaboration Board

Board Operating Procedure

■ **Connection between substrate and energy harvester (e.g., solar cells)**

Connect an energy harvester with a current output, such as a solar cell, between SC and GND. The application can be connected to the battery management system with an energy harvester by simply connecting it between VOUT of the boost DC-DC output and GND.

Select a solar cell with an open circuit voltage of more than 2.6V.

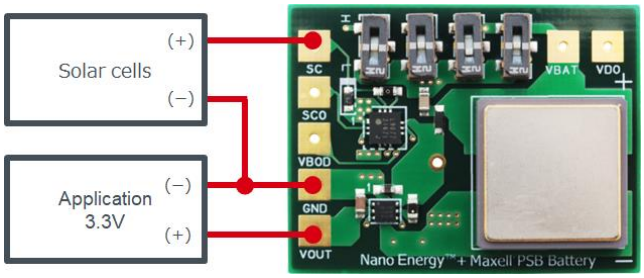


Figure 7：Board connection diagram

■ **Procedure for charging the all-solid-state batteries (PSB401010H/PSB401515H)**

Simply connect an energy harvester with a current output, such as a solar cell, between SC and GND and the all-solid-state battery will charge through the ML9077. Please refer to the datasheet of ML9077 for the sequence and functions related to charging.

When the EN switch is in the "H" state, the DC-DC converter will continue to operate during charging.

■ **Procedure for operating the DC-DC converter**

To operate the DC-DC converter, set EN = H.

When startup is completed, the voltage of the step-up DC-DC converter is outputted to the VOUT terminal.

■ **Procedure for setting the output voltage of the DC-DC converter**

① Turn off the DC-DC converter with EN = L.

② Set the VSEL jumper state to the desired output voltage (see table below).

③ Set EN = H to turn ON the DC-DC converter. VOUT will be equal to the configured voltage output.

VOUT	VSEL
1.8V	Open (don't use)
3.0V	L
3.3V	H

Table 4：DC-DC Converter Output Voltage Setting with VSEL Switch

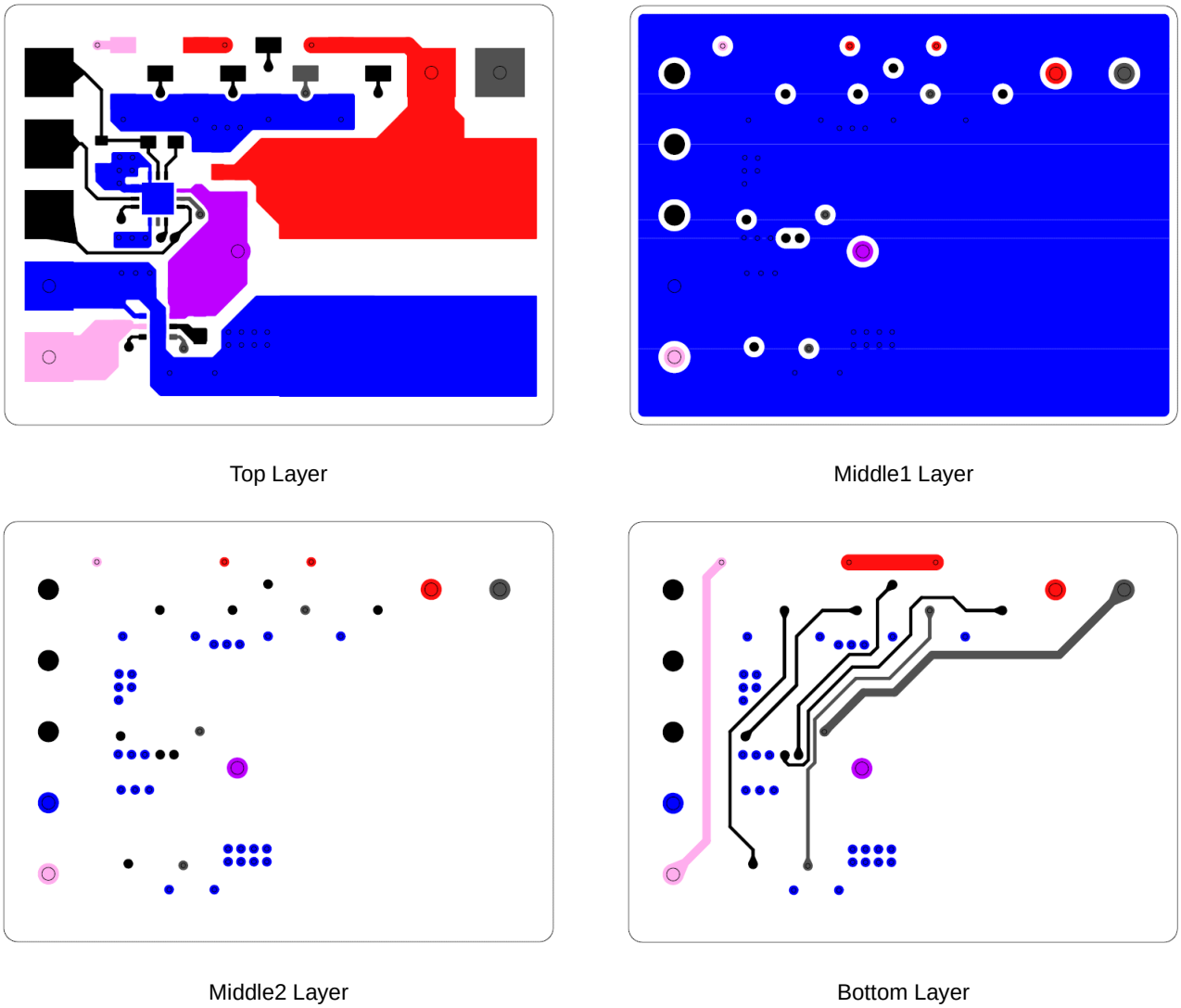
Board PCB Layout

■ **PCB information**

Layers	Material	Board dimension	Copper thickness
4	FR-4	34mm x 26mm x 1.0mm	1oz (35μm)

Table 5：PCB Information

■ **Board Layout**



Top Layer

Middle1 Layer

Middle2 Layer

Bottom Layer

Figure 8：Collaboration Board Layout

Specification Notes

- The step-up DC-DC converter on this board contains a product under development. Although the operation of the product has been fully verified, we will replace the product if it is defective.

- Since the battery terminals are exposed, when storing the product, set EN=L to turn off the DC-DC converter and store the product in individual bags to avoid short-circuiting the battery terminals.

- The output current of the step-up DC-DC converter is limited by the battery capacity, so do not connect a load that exceeds the battery capacity.

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