US011-SOLCHRGEV1Z

Smart Solar Battery Charger

Description

The US011-SOLCHRGEV1Z Smart Solar Battery Charger evaluation board uses the ISL81801 buck-boost converter and RA2L1 32-bit MCU to convert energy from a solar panel (user-provided) to charge a lead-acid battery with Maximum Power Point Tracking (MPPT).

Features

- Supports up to 60V input and 60V output for compatibility with a wide range of solar panels and batteries.
- Delivers up to 4A output current for faster and more efficient charging.
- Programmable output to match battery requirements up to 60V
  - Currently optimized for 12V,12Ah lead-acid battery
- Uses a four-stage charging algorithm (trickle, bulk, absorption, float) with temperature compensation to extend battery life and ensure safety.
- Implements MPPT (Perturb & Observe) to maximize power extraction from solar panels under changing sunlight.
- Includes comprehensive protection features against overcurrent, over/undervoltage, reverse polarity, reverse current, and unsafe connections.

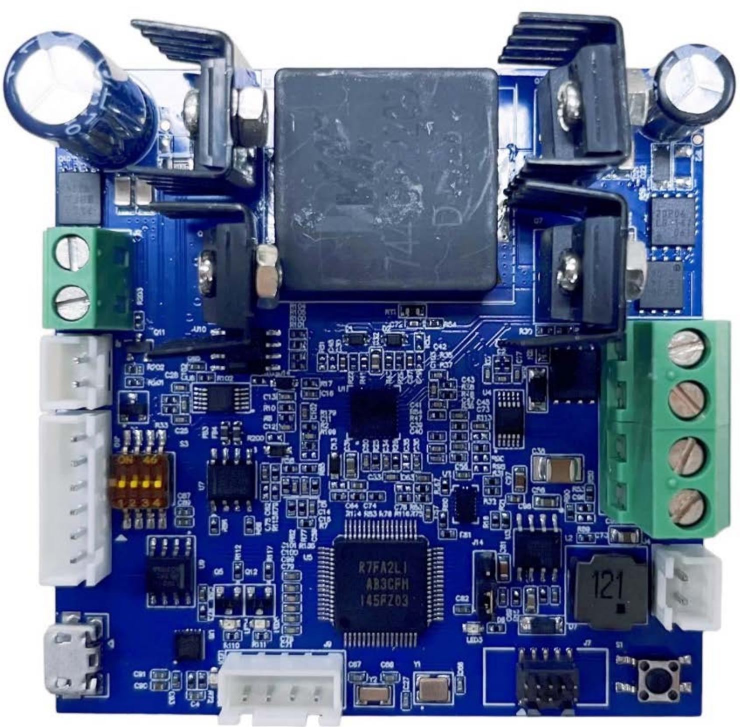


Figure 1. US011-SOLCHRGEV1Z Board

Contents

1. Overview

The US011-SOLCHRGEV1Z is designed to provide a quick and easy method for creating a solar battery charger. This board uses the ISL81801 buck-boost controller to convert the voltage from an external solar panel into the appropriate voltage to charge a lead-acid battery. RA2L1 MCU gathers telemetry data and uses it to manage the controller and follow the battery charging algorithm. The MCU is powered by the RAA212831 buck regulator, and the two ISL28022s monitor the input/output current/voltage for the system with higher precision.

The simple control of the bi-directional buck-boost converter ISL81801 for this board only requires changing the feedback voltage by using the RA2L1 to achieve control of the input voltage, the output voltage, and the maximum output current. The MPPT software maximizes the power drawn from the solar panel by controlling the input voltage of the ISL81801, and the RA2L1 controls the output voltage and the maximum output current to follow a safe charging profile for the lead-acid battery.

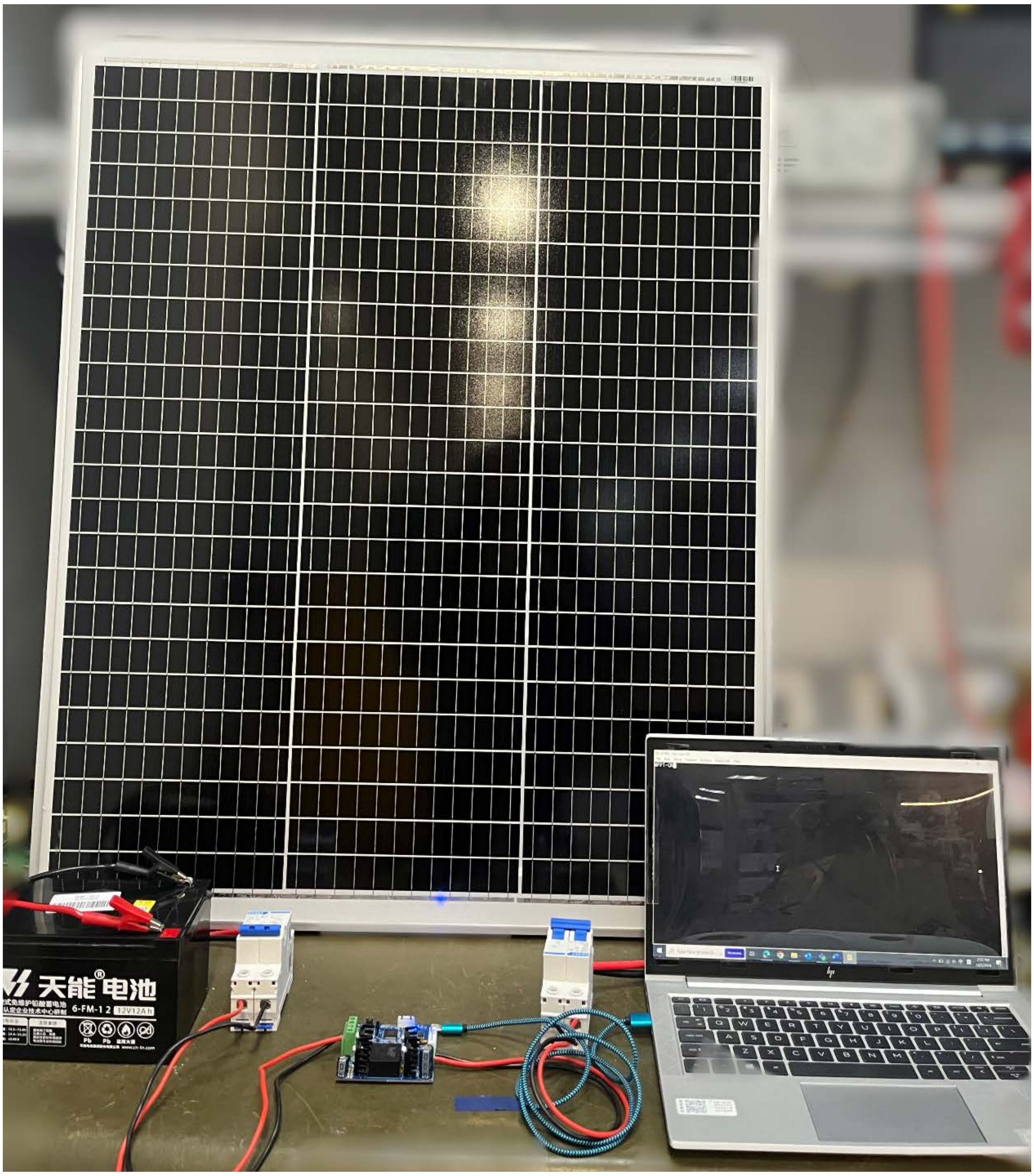


Figure 2. System

Note: An external fan is required to cool the board when operating in the bulk stage or the absorption stage.

1.1 Highlight Products

1.1.1 Target Devices

- RA2L1
- ISL81801
- ISL28022
- RAA212831
- UPC277G2
- SLG88104
- RJK1003DPP-A0
- NP20P06YLG

1.1.2 RA2L1 (Microcontroller)

The RA2L1 group is based on the Arm® Cortex®-M23 core, the most energy-efficient CPU among Arm Cortex-M today. The optimized processing and Renesas' low power process technology make it the industry's most energy-efficient ultra-low power microcontroller. The RA2L1 group supports a wide operating voltage range of 1.6V to 5.5V, and a maximum CPU clock frequency of 48MHz, lower active mode current, and standby mode current. The RA2L1 group also features an enhanced Capacitive Touch Sensing Unit (CTSU2), a set of serial communication interfaces, highly accurate converters, and timers. The products are available with pin counts ranging from 48-pin to 100-pin.

The Renesas RA6T2 Group is the second RA ASSP product targeting motor and inverter control solutions. The RA6T2 combines an Arm Cortex-M33 with a hardware accelerator for motor control and high-speed flash memory for high-speed real-time performance at 240MHz. It can also realize next-generation high-speed, high-response motor algorithms and improve parallel processing performance such as other communication processing. In total, there are 20 different part names using five different package types. The Flexible Software Package (FSP) and the Arm Partner Ecosystem ensures an easy-to-use solution for highly efficient and accurate motor and inverter control.

- Up to 256-KB code flash memory
- 32-KB SRAM
- 12-bit A/D Converter (ADC12)
- 12-bit D/A Converter (DAC12)
- Security features

1.1.3 ISL81801 (Buck-Boost Controller)

The ISL81801 is an 80V bidirectional, 4-switch synchronous buck-boost controller with peak and average current sensing and monitoring at both ends. With wide input and output voltage ranges, the controller is suitable for industrial, telecommunication, and other industrial applications.

The ISL81801 uses a proprietary buck-boost control algorithm with valley current modulation for Boost mode and peak current modulation for Buck mode control.

The ISL81801 has four independent control loops for input and output voltages and currents. Inherent peak current sensing at both ends and cycle-by-cycle current limit of this family of products ensures high operational reliability by providing instant current limit in fast transient conditions at each end and in both directions. It also has two current monitoring pins at both input and output to facilitate Constant Current (CC) limit and other system management functions. CC operation down to low voltages avoids any runaway condition at overload or short-circuit conditions. In addition to multilayer overcurrent protection, it also provides full protection features such as OVP, UVP, OTP, average and peak current limit on both input and output to ensure high reliability in both unidirectional and bidirectional operation. The unique DE/Burst mode at light-load dramatically lowers standby power consumption with consistent output ripple over different load levels.

The IC is packaged in a space-conscious 32 LD 5mm × 5mm TQFN package or easy to assemble 4.4mm × 9.7mm 38 LD HTSSOP package. Both packages use an EPAD to improve thermal performance and noise immunity. Low pin count, fewer external components, and default internal values make the ISL81801 an ideal solution for time to market simple power supply designs.

1.1.4 ISL28022 (Precision Digital Power Monitor)

ISL28022 is a bidirectional high-side and low-side digital current sense and voltage monitor with serial interface. The device monitors current and voltage and provides the results digitally along with calculated power.

It provides tight accuracy of less than 0.3% for both voltage and current monitoring over the entire input range. The digital power monitor has configurable fault thresholds and measurable ADC gain ranges.

It also handles common-mode input voltage ranging from 0V to 60V. The wide range permits the device to handle telecom, automotive, and industrial applications with minimal external circuitry. Both high-side and low-side ground sensing applications are easily handled with flexible architecture.

The ISL28022 consumes an average current of just 700µA and is available in a 10 Ld MSOP package. The ISL28022 is also offered in a space-saving 16 Ld QFN package. The part operates across the extended temperature range from -40°C to +125°C.

1.1.5 RAA212831 (DC/DC)

The RAA212831 is a triple output regulator combining a 4.5V to 72V input, 0.5A buck regulator with two LDO outputs. The buck regulator has a fixed switching frequency of 350kHz in Continuous Conduction mode (CCM) and operates in pulse-skipping mode at lighter loads when it enters Discontinuous Conduction mode (DCM). The two LDOs operate from a 12V (or lower) input voltage. The LDOs are rated at 100mA and 50 mA of output current. The buck regulator output can be set from 1.25V to VIN × Dmax. The LDOs can support an input voltage range of 6V to 12V, and the output voltages are fixed at 3.3V and 5V. The IC provides a compact, highly integrated power management solution, and its integrated buck regulator and LDO outputs minimize system component count.

1.1.6 UPC277G2 (Comparator)

The µPC277, µPC393 are dual comparators designed to operate for a single power supply. The features include low-voltage operation, a common-mode input voltage that ranges from V− (GND) level, an open collector output, and low current consumption. Furthermore, these products can operate on a split power supply and are used widely for various voltage comparison applications. Depending on the usage and operating ambient temperature range, the µPC277 is designed for communication industries and the µPC393 is designed for general purposes. In addition, a compatible DC parameter selection for the comparators is available. Along with this series of lineup, the quad type comparators, µPC177 and µPC339 with the same circuit configuration are also available.

1.1.7 SLG88104 (OP-AMP)

- A micropower Operational Amplifier for GreenPAK

The SLG88104 is a wide voltage range, 375nA quad-channel CMOS input operational amplifier capable of rail-to-rail input and output operation. Each amplifier can be individually powered down.

1.1.8 RJK1003DPP-A0 (N-ch MOSFET)

- Nch Power MOSFET 100V 50A 11mΩ TO-220F

These MOSFETs are suitable for switching (motor drive and others) and load switch applications, while low on-resistance with high-speed switching and high-robustness.

1.1.9 NP20P06YLG (P-ch MOSFET)

- Pch Power MOSFET -60V -20A 47mΩ Power SON-8 5x6 for Automotive

The NP20P06YLG is P-channel MOS Field Effect Transistor designed for high current switching applications.

1.2 Kit Components

1.2.1 Hardware Components

The Kit includes the following components:

- Solar Charger Board

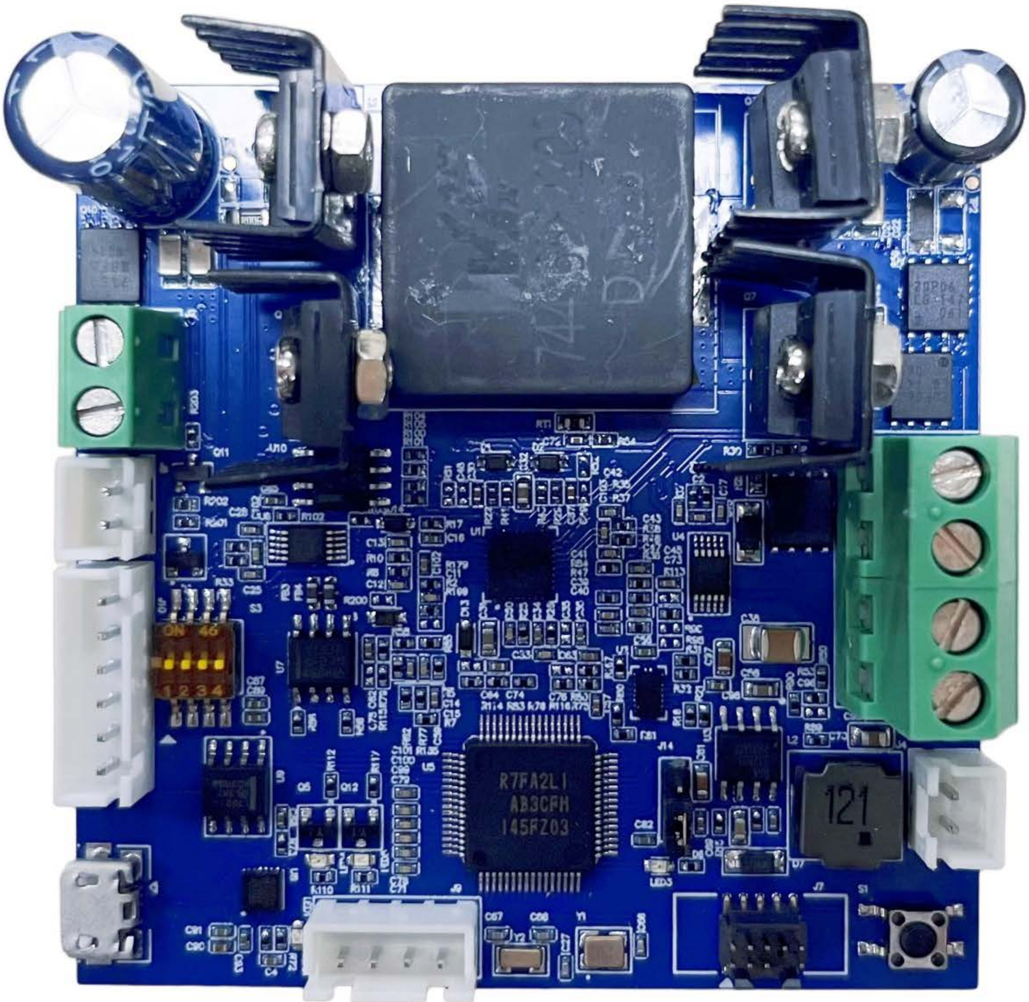


Figure 3. Solar Charger Board

1.2.2 Software Components

- MCU Firmware
  - US011_1_RA2L1_SolarPanelBatteryCharger.zip
- HEX File
  - US011_1_RA2L1_SolarPanelBatteryCharger.hex
- Drivers/USB-UART
  - CDM212364_Setpup.zip – USB driver

1.3 Features

1.3.1 Block Diagram

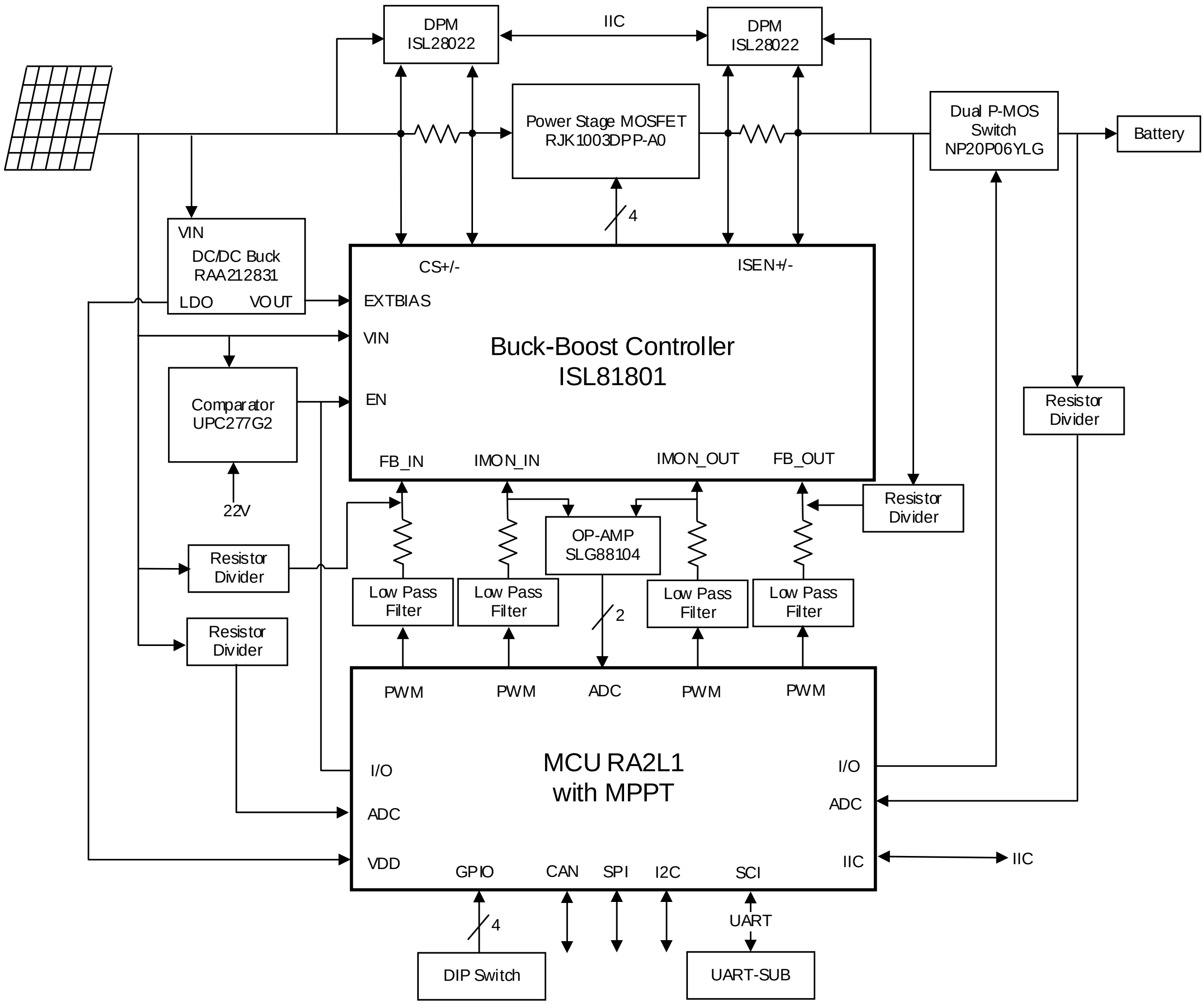


Figure 4. Block Diagram

1.3.2 Specifications

- Currently optimized for default a 12V, 12Ah lead-acid battery.
  - Default: V_{OUT}: Buck Charge = 14.9V at up to 3.6A, Float Mode = 13.7V at ≤ 0.6A.
- Automatically goes to float mode to maintain battery after a full charge.
- Maximum power point tracking in software optimizes the power from the solar panel.

Table 1. Key System Specifications

Parameter	Test Condition	Minimum	Typical	Maximum	Unit
Input Voltage	-	22	-	60	V
Output Voltage	-	1	15	37	V
Input Current	-	-	2	4	A
Output Current	-	-	-	4	A

Table 2. Protection Specifications

Parameter	Description	Minimum	Typical	Maximum	Unit
HW Under Input Voltage	-	-	<21	-	V
SW Overvoltage	Input Voltage	-	>62	-	V
	Output Voltage	-	> (Vpeak+4)	-	V
SW Overcurrent	Input Current	-	>10	-	A
	Output Current	-	>10	-	A
SW Undervoltage	Input Voltage	-	<8	-	V
	Battery Voltage	-	< (Vtrck-4)	-	V
Reverse Protection	Input Current	-	<-0.1	-	A
Power Good Indicator	PGOOD pin of ISL81801	-	Low	-	-
Under-temperature	-	-	<-40	-	℃
Over-temperature	-	-	>50	-	℃

Note: Vpeak (**14.9V**) is the output setting voltage in buck charge stage and absorption charge stage. Vtrck (**12.6V**) is the output setting voltage in trickle charge stage when using a 12V/12Ah Battery.

2. Quick Start

2.1 Demo Board

Figure 4 shows all interfaces on the board. A detailed explanation of how to use them is described in the following sections.

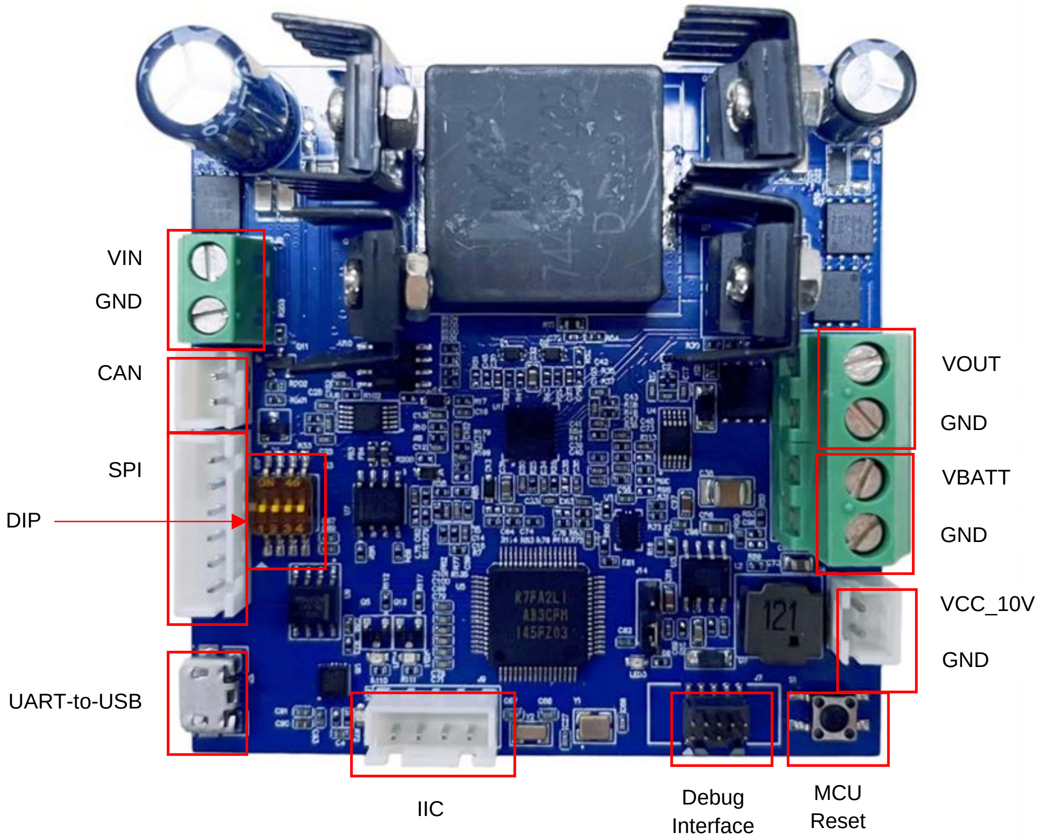


Figure 5. Demo Board

2.2 Specification of PV Panel and Battery Pack Used in Testing

2.2.1 PV Panel

Figure 6. PV Panel

Model: TY-100M36V	
Maximum Power (Pmax)	100 (W)
Voltage at Pmax (Vmp)	36 (V)
Current at Pmax (Imp)	2.48 (A)
Short-Circuit Current (Isc)	2.70 (A)
Open-Circuit Voltage (Voc)	47.81 (V)
Maximum Tolerance	±3%

2.2.2 Battery Packs

Figure 7. 12V/12Ah Battery

Model: 6-FM-12 (Lead-Acid Battery 12V/12Ah)	
Standby Use	13.5~13.8V
Cycle Use	14.4~15.0V
Charging Current	≤3.60A

2.3 User Interface

2.3.1 KEY

KEY	Function	Description
S1	RESET	Reset the RA2L1 MCU.

2.3.2 LED

- LED1 (Blue) is for the UART-USB indicator.
- LED2 (Blue) is for the 10V power indicator.
- LED3 (Yellow) is for the 3.3V/5V power indicator.

State	LED4 (Red)	LED5 (Blue)
Calibration	ON	ON
Fault	ON	Blink
Run	Blink	Blink (Blink slowly when battery charging is in float stage)
Standby	OFF	Blink

2.3.3 USB

Install the USB-UART driver CDM212364_Setup.zip manually before connecting the cable with Micro B to J11 of board, which is in the folder **Software/Drivers/USB-UART**.

Send the Command from PC:

- DATA-ON – MCU starts to send measurement voltage and current values.
- DATAOFF – MCU stops sending.
- MPPT-ON – MPPT is allowed to work.
- MPPTOFF – MPPT is not allowed to work.
- Default – 115200bps, 8bit data, 1bit parity

2.4 Default Configuration Settings

This solution is set to charge a 12V, 12Ah lead-acid battery.

Table 3 shows the default configurations in software.

Table 3. Default Configuration for 12V/12Ah Battery

Parameters	Value	Descriptions
g_batt_para.tempH/tempL	-40~50℃	Temperature threshold
g_batt_para.AhRating	12Ah	Capacity (Ah rating)
g_batt_para.Itrck	0.6A	Trickle stage current is 5 percent of the Ah rating. Itrck = 0.05 × g_batt_para.AhRating.
g_batt_para.Iconst	3.6A	Bulk stage current is 30 Percent of Ah rating. Iconst = 0.3 × g_batt_para.AhRating.
g_batt_para.IlowSat	0.6A	Float stage current is 5 Percent of Ah rating. IlowSat = 0.05 × g_batt_para.AhRating.
g_batt_para.Vpeak	14.9V	Bulk stage and Absorption stage voltage
g_batt_para.Vfloat	13.7V	Float stage voltage
g_batt_para.Vrecharge	12.9V	Recharge threshold
g_batt_para.Vtrck	12.6V	Trickle stage voltage

2.5 Quick Start Guide

The default setting and function of jumper (J4) are as follows.

Jumper pin	Default setting	Function
J4	1-2pin short	1-2pin short: select 5V as MCU VCC 2-3pin short: select 3.3V as MCU VCC

Check if J4 is configured before powering on (see Figure 8).

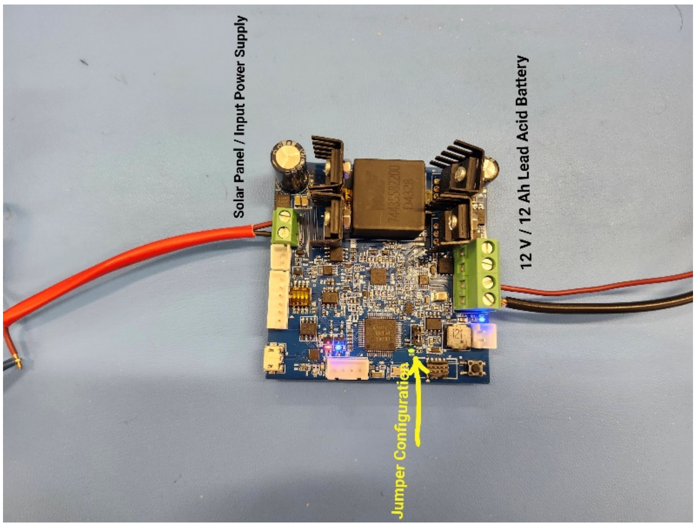


Figure 8. Top View of the Board

1. Start by connecting the wires from the solar panel to the screw rising cage clamp terminals on the input of the board. The pin-1 of J2 is VIN, and pin-2 of J2 is GND (see Figure 9). The LED2 and LED3 light up.

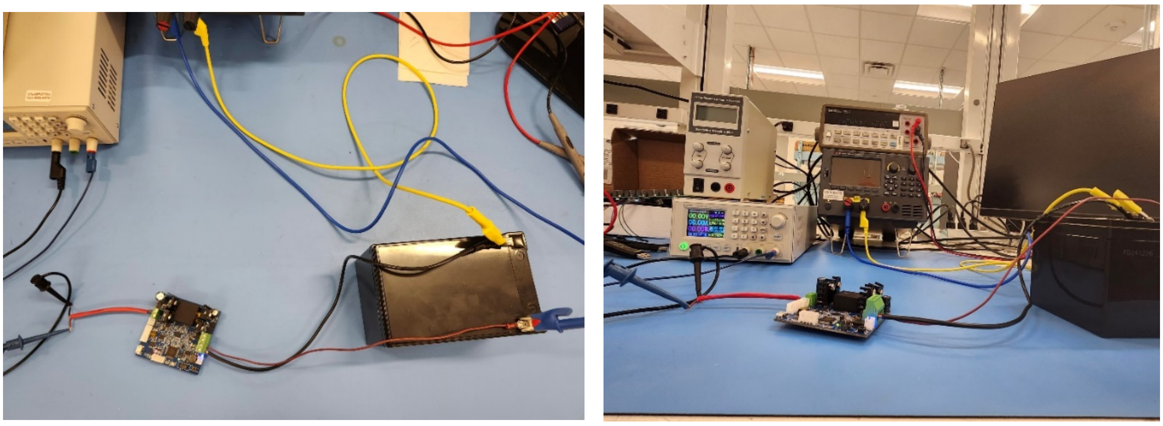


Figure 9. Connection Setup

2. The RA2L1 turns on the LED5 (BLUE) to show it is active and initializes the board. When all systems are nominal, the LED5 begins to blink.
3. Connect a USB-cable to micro-USB type-B connector on the board. Use a Serial Debugging Tool and send a MPPT-ON string to RA2L1 to enable MPPT function.
4. Connect the battery to the output of the board by pin-3 of J3 (VBATT) and pin-4 of J3 (GND) with the screw rising cage clamp terminals (see Figure 9). The output voltage is monitored by the MCU, and the controller is enabled when the voltage is above 8.6V (Vtrck - 4) and below 12.9V (Vrecharge). After it is operational, the output voltage and current are measured to determine the appropriate charging stage so that the battery charging proceeds accordingly.

Note: Ensure the battery is a standard 12V/12Ah lead-acid battery in good operating condition.

5. Battery charging goes through three or four different stages depending on the battery power level.
   a. If the voltage of battery is below 12.6V, the battery charging enters trickle stage. In this first stage, the charging current remains 0.6A.
   b. If the voltage of battery is above 12.6V, the battery charging directly enters the bulk stage. In the bulk stage, the output of the ISL81801 is set to 14.9V and the battery pulls lower as it charges with a fixed 3.6A max current.
   c. After the battery stops pulling VOUT down, the current starts to decrease, and the system enters the absorption stage.
   d. The fourth stage activates when the output current drops below 600mA and is the float stage. The output voltage is decreased to 13.7V. The battery is fully charged when it hits float stage and can remain on the charger in float stage indefinitely or be removed from the system as required. The LED5 blinks slowly to indicate the system is in float mode.

Notes:

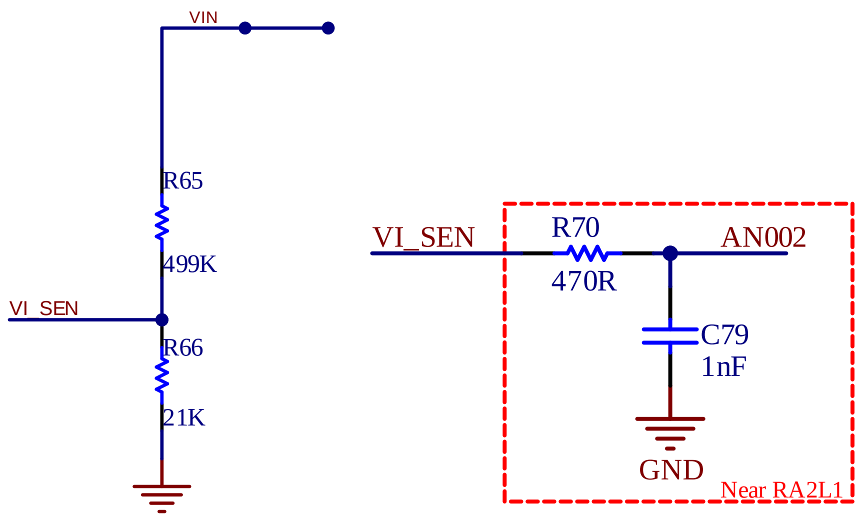
- If the solar panel is incapable of delivering 0.6A due to weather conditions, the system measures the voltage on VBATT to determine if it should enter the float stage or stay in bulk mode. If the battery voltage stays near 13.7V (VOUT for float stage) while pulling less than 0.6A, it is assumed the battery is fully charged.
- An external fan is required to cool the board when operating in the bulk stage or the absorption stage.

3. Hardware

3.1 Analog Singal Detection

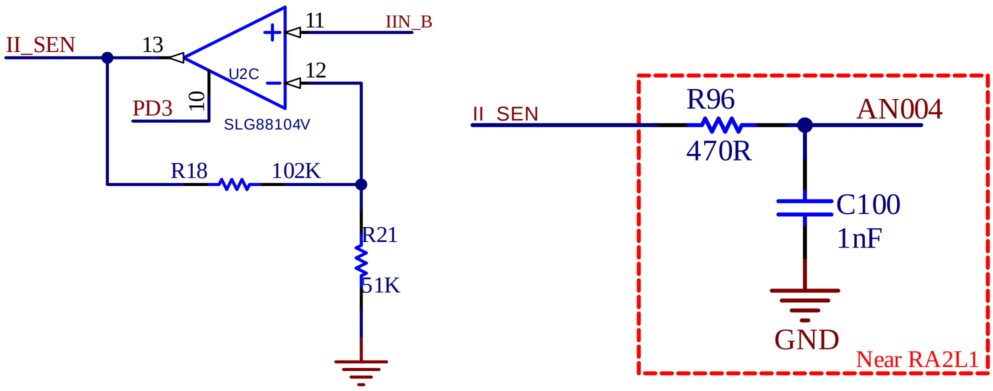
3.1.1 Input Voltage Detection

Input voltage sampling is carried out in the mode of resistance voltage division. After RC filtering, it is sent to the MCU.



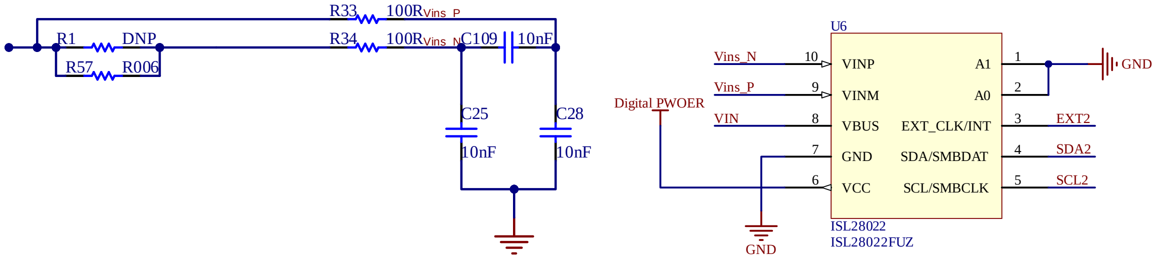
3.1.2 Input Current Monitor Detection

Determine whether the current input current meets the predetermined requirements by detecting the voltage at the IMON_IN pin of the ISL81801.



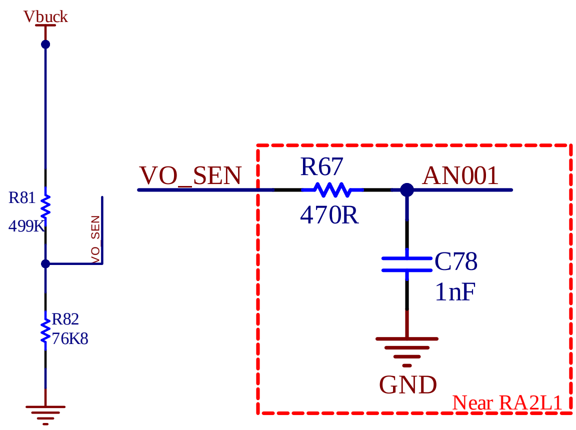
3.1.3 Input Current Detection

The input current is sampled using a combination of a current-sense amplifier and a sampling resistor. The current detecting amplifier converts the current value into a digital signal to be sent to the MCU through the IIC.



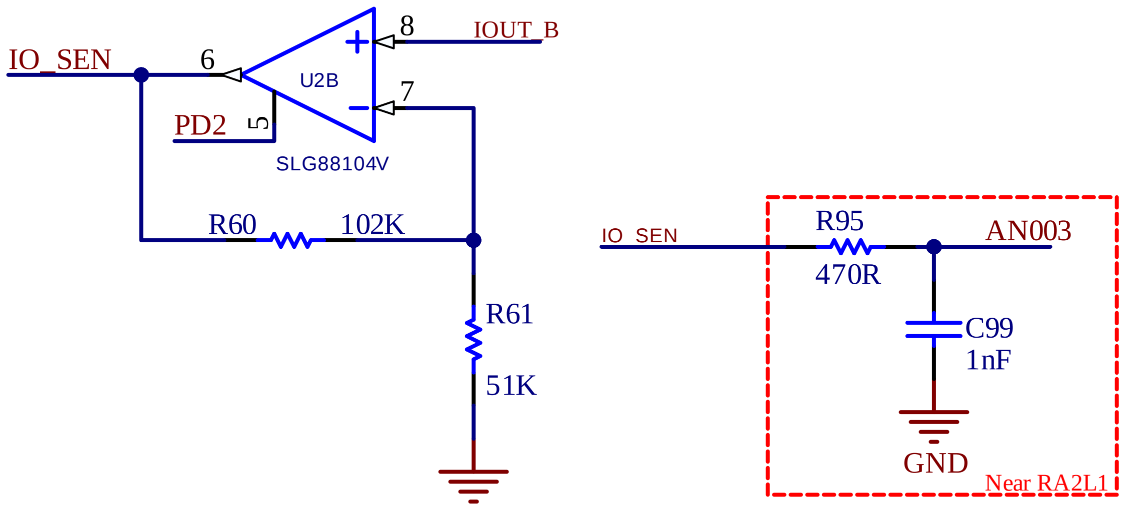
3.1.4 Output Voltage Detection

Output voltage sampling was carried out in the mode of resistance voltage division. After RC filtering, it is sent to the MCU.



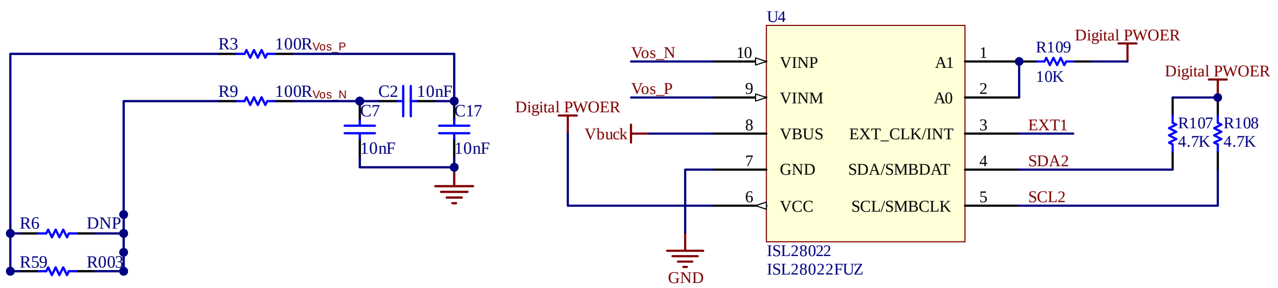
3.1.5 Output Current Monitor Detection

Determine whether the current output current meets the predetermined requirements by detecting the voltage at the IMON_OUT pin of the ISL81801.



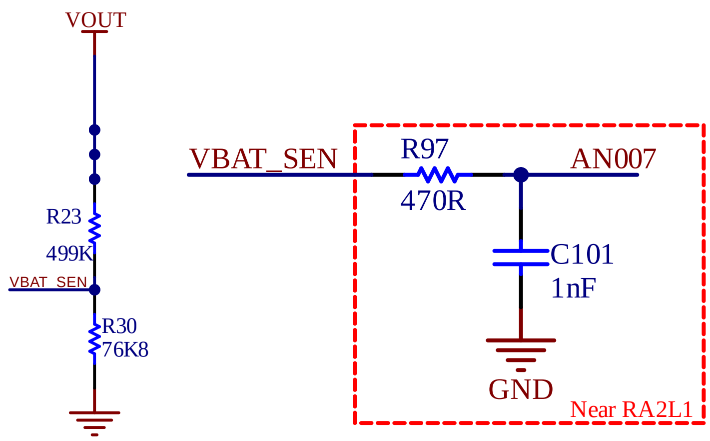
3.1.6 Output Current Detection

The output current is sampled using a combination of a current-sense amplifier and a sampling resistor. The current detecting amplifier converts the current value into a digital signal to be sent to the MCU through the IIC.



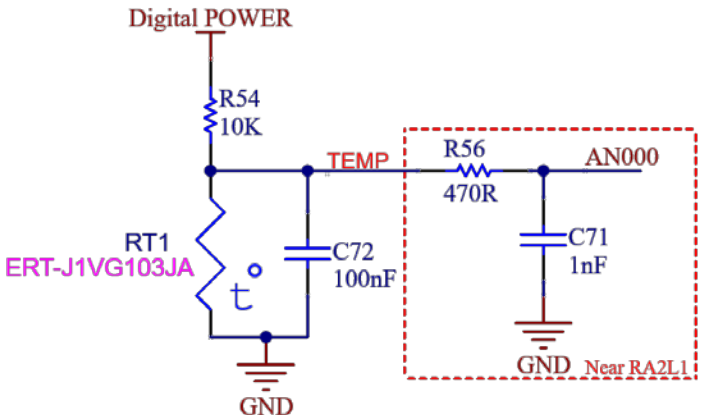
3.1.7 Battery Voltage Detection

Battery voltage sampling is carried out in the mode of resistance voltage division. After RC filtering, it is sent to MCU.



3.1.8 Battery Voltage Detection

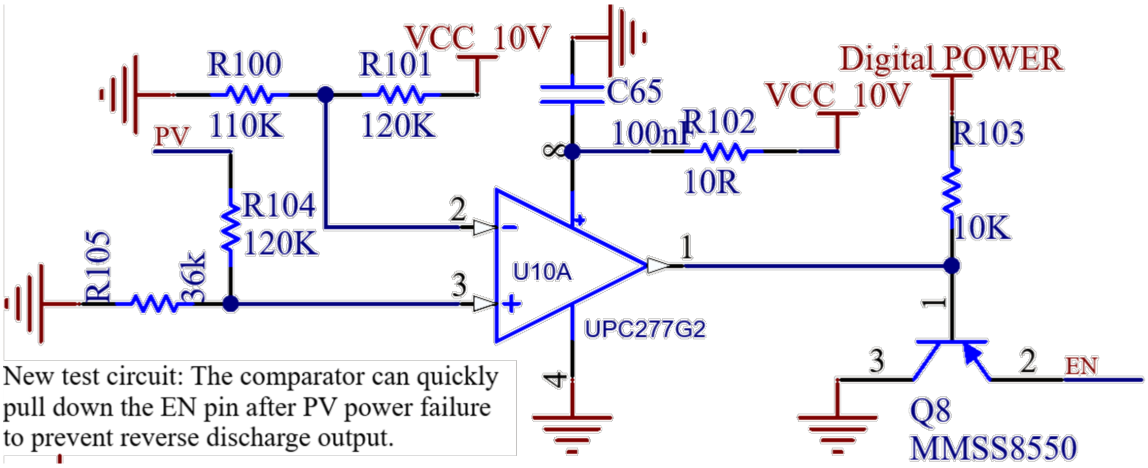
When the circuit board is running, the legitimate temperature is increased, and the temperature must be monitored. If the temperature is abnormal, corresponding protection actions are taken.



3.2 Protection Circuit

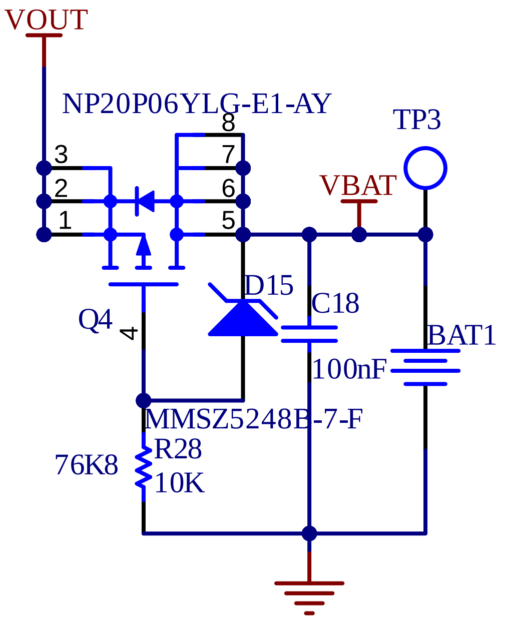
3.2.1 Input Undervoltage Protection

When the input voltage is less than the set value, the EN pin of ISL81801 is not enabled and the circuit stops working.



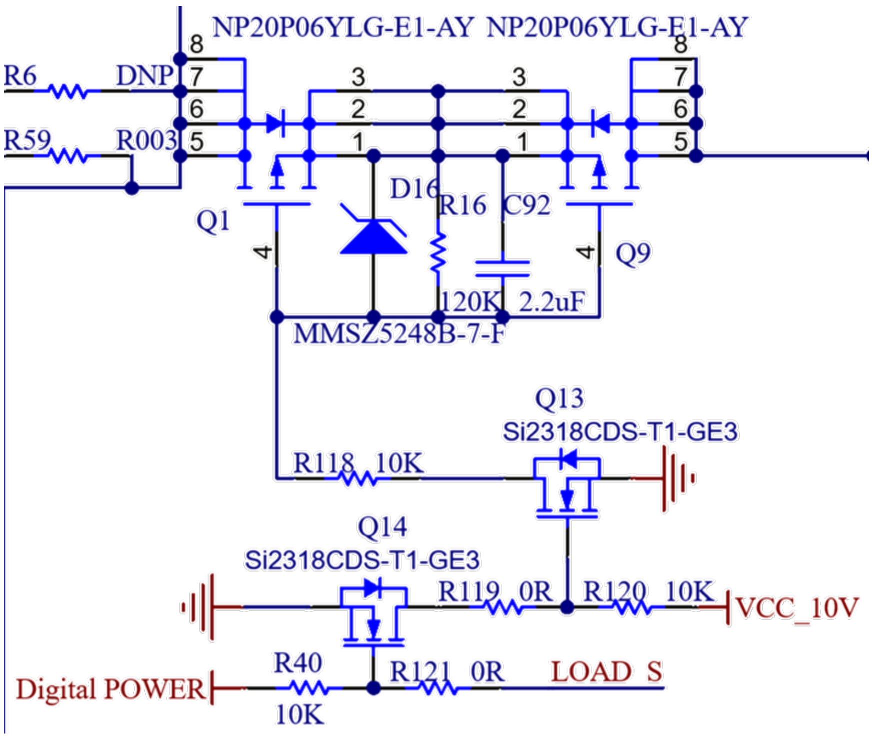
3.2.2 Battery Anti-Reverse Connection Circuit

It uses the PMOS feature to close the path when the battery is reversed to avoid frying the motherboard.



3.2.3 Bidirectional Interoperability Protection

When the voltage at the VOUT terminal is detected to be too high, the output is not activated or the output is cut off.



4. Software

4.1 Integrated Development Environment

The sample code has been developed under the conditions listed in Table 5.

Table 4. Operation Conditions

Item	Description
Microcontroller	RA2L1 (R7FA2L1AB3CFM)
Operating voltage	3.3V/5V
Integrated development environment	e^2 studio v2024-04 from Renesas Electronics Corp.
FSP version	5.4.0
Toolchain	GNU ARM Embedded 12.2.1.arm-12-mpacbti-34
Emulator	J-Link from SEGGER

4.2 Related Links

- RA2L1
- e2studio v2024-04
- FSP v5.4.0
- Arm GNU 12.2.MPACBTI-Rel1

4.3 Project

4.3.1 Pin Configuration

The pin configuration of RA2L1 is in Table 6.

Table 5. MCU Functions and Pins to be Used

Peripheral Function	Pin	Usage	
ADC	AN000/P000	Measure the voltages, currents and temperature every 1ms.	Temperature
	AN001/P001		V_{OUT}
	AN002/P002		V_{IN}
	AN003/P003		I_{OUT}
	AN004/P004		I_{IN}
	AN007/P012		$V_{BATTERY}$
GPT	GTIOC2A/P113	Control the maximum input voltage, input current, output voltage and output current.	V_{IN}
	GTIOC8A/P107		I_{IN}
	GTIOC3B/P112		V_{OUT}
	GTIOC1A/P105		I_{OUT}
PORT	P402	Power-down input pin of OP-AMP.	
	P403		
	P304		
	P303		
	P205	Input of DIP switch.	
	P015		
	P409		
	P408		
	P014	For LEDs control.	
	P013		
	P407	Power-good indicator of ISL81801.	
	P208	Enable pin of ISL81801.	
	P206	MOSFET on/off control.	
	P111		
IIC2	SDA2/P302	Communication with the two IPS28022s.	
	SCL2/P301		
UART0	TXD0/P411	Communication with PC.	
	RXD0/P410		
IIC0	SDA0/P401	Reserved	
	SCL0/P400		

Peripheral Function	Pin	Usage
SPI	TXD1/P501	
	RXD1/P502	
	SCK1/P100	
	CTS1/P101	
CAN	CRX0/P102	
	CTX0/P103	

4.3.2 Folder and File Configuration

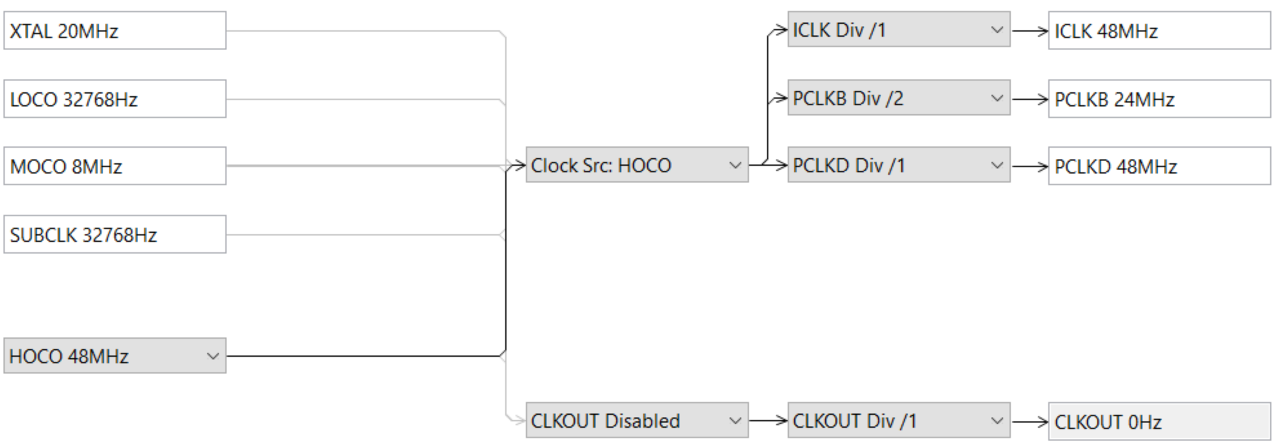
Introduction to folder and files in the project:

Table 6. Folder and File Configurations of the Project Programs

Project folder	Files	Description
src	hal_entry.c	Program entrance
	user_main.c (user_main.h)	Main routine file
	board.c (board.h)	Peripheral settings and functions
	mppt.c (mppt.h)	MPPT algorithm
	battery_charging.c (battery_charging.h)	Battery charging routine
	protection.c (protection.h)	Error handler
	comm_uart.c (comm_uart.h)	UART communication operation
ra	--omitted	Generated automatically by FSP
ra_gen		
ra_cfg		

4.3.3 Software Specification

4.3.3.1 Clock



4.4 Timer

Use GPT1, GPT2, GPT3, GPT8 at 100 kHz in Saw-wave PWM mode 1.

- The control step of VOUT is 0.18V.
- The control step of VIN is 0.27V.
- The control step of IOUT is 0.05A.
- The control step of IIN is 0.025A.

4.5 ADC

- 12bit SAR mode. ADCLK Source: PCLKD 48MHz.
- Sampling state: 44.5 ADCLK states (default).
- Conversion time (each channel) = (1/48MHz) × (31.5+13) = 0.93µs.
- ADC conversion frequency is 1kHz.

4.6 Interrupt

In this project, there are six interrupts shown in Table 8.

Table 7. The Interrupts

Function	Event	ISR	Callback Function	Priority
IIC2	SCI2 TXI	sci_i2c_txi_isr	sci_i2c_master_callback	1
	SCI2 TEI	sci_i2c_tei_isr		
ADC0	ADC0 Scan end	user_adc_scan_end_a_isr	-	2
AGT0	AGT0 INT	user_agt0_int_isr	-	2
GPT0	GPT0 COUNTER OVERFLOW	user_gpt0_conter_overflow_isr	-	3
RTC	RTC CARRY	rtc_carry_isr	-	3
UART0	SCI0 TXI	sci_uart_txi_isr	g_uart0_callback	3
	SCI0 TEI	sci_uart_tei_isr		
	SCI0 RXI	sci_uart_rxi_isr		
	SCI0 ERI	sci_uart_eri_isr		
CAN0	CAN0 ERROR	can_error_isr	can_callback	3
	CAN0 FIFO RX	can_rx_isr		
	CAN0 FIFO TX	can_tx_isr		
	CAN0 MAILBOX RX	can_rx_isr		
	CAN0 MAILBOX TX	can_tx_isr		

4.6.1 State Machine

The state machine for the system is shown in Figure 10.

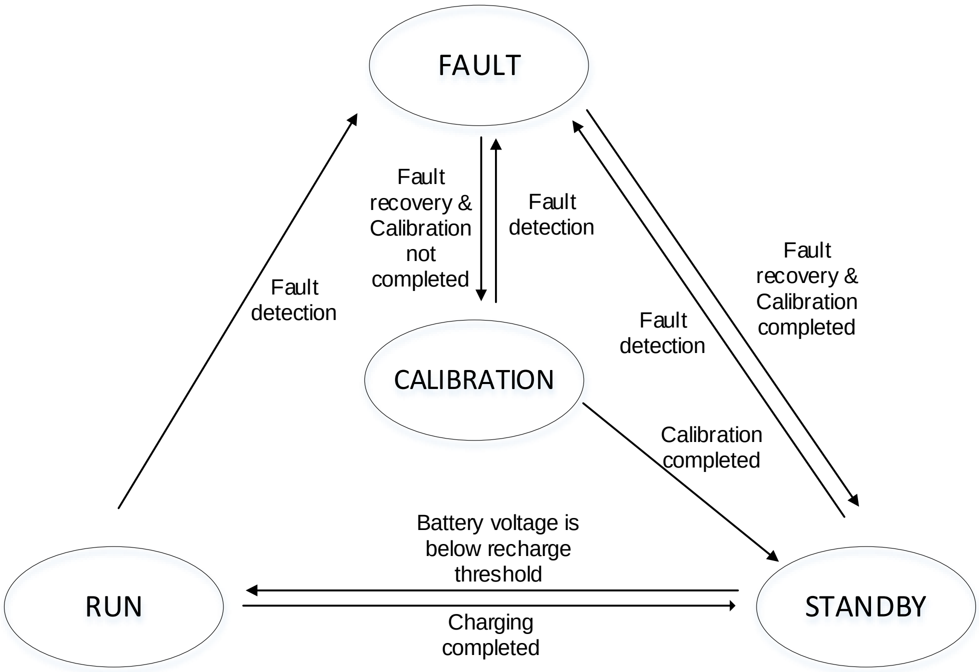


Figure 10. State Machine

Calibration – If there are no errors after power on, calibrate the output voltage. Next, enter the Standby state. During this mode, the buck-boost controller is enabled to output voltage without turning on the MOSFET at the front of the battery.

Standby – Disable the buck-boost controller and turn off all MOSFETs. If the battery voltage is below recharge threshold, enter the Run state.

Run – The buck-boost controller is enabled and all MOSFETs are turned on. The MCU follows a charging profile to charge the batteries. MPPT starts working after a 1 second delay. When the battery is fully charged, the system enters Standby state.

Fault – If an out of range occurs for the current, voltage, or temperature, the protection is triggered, and the system enters the Fault state. The buck-boost controller is disabled and all MOSFETs are turned off. After the fault is recovered, clear the fault flag and return to the Standby state or Calibration state.

4.6.2 Flowchart

4.6.2.1 Main Flowchart

The main flowchart after the MCU is powered on is shown in Figure 11:

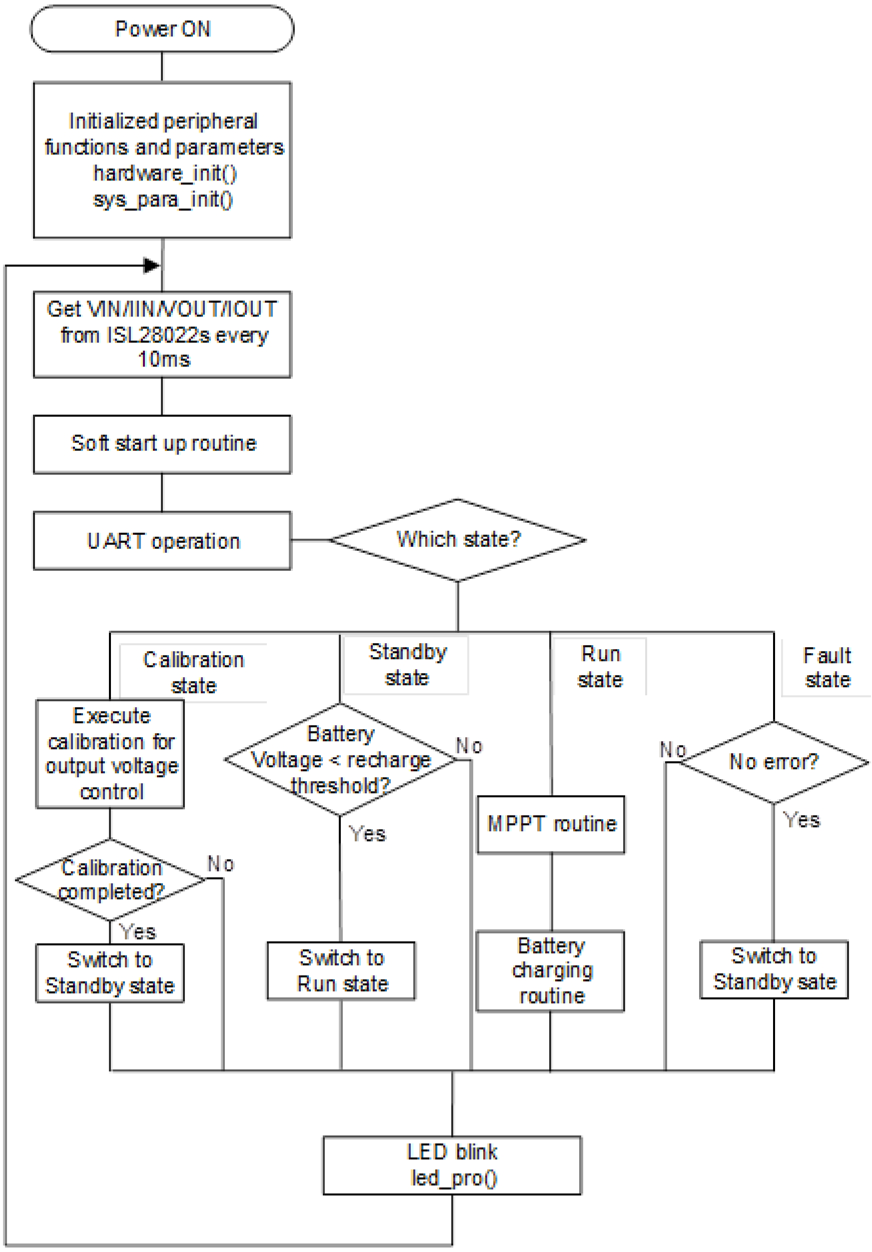


Figure 11. Main Flowchart

4.7 Algorithm

4.7.1 Maximum Power Point Tracking (MPPT)

MPPT uses the Perturbation and Observation (P&O) algorithm, which is easy to implement. The method is as follows:

1. Detect the PV panel voltage and current: V_{IN} and I_{IN}.
2. Calculate the input power.
3. Adjust the VIN voltage according to changes in power.
4. If Battery is fully charged, disable the panel MPPT function.

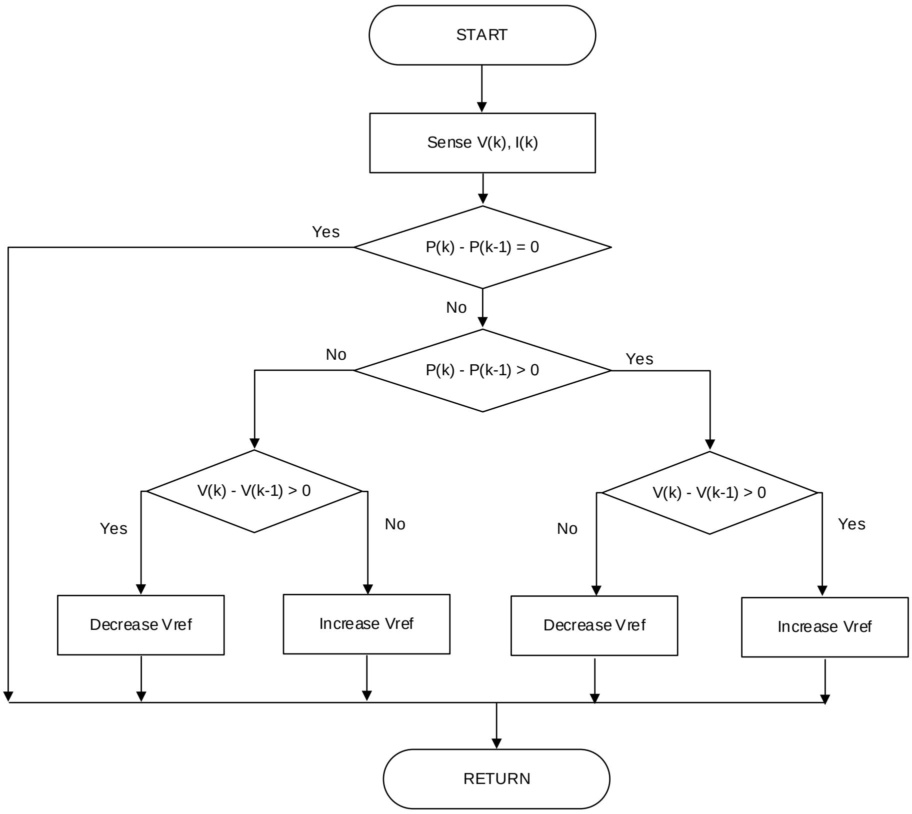


Figure 12. P&O Algorithm

4.7.2 Charging Stages of a Lead-Acid Battery

Stage 1: Trickle charging

If V(battery) < V(tickle voltage threshold), CC charging, I(charge) = I(trickle stage current).

Stage 2: Bulk charging

If V(battery) < V(output voltage at bulk stage), CC charging, I(charge) = I(bulk stage current).

Stage 3: Absorption charging

If V(battery) < V(output volage at bulk stage), CV charging, V(charge) = V(bulk stage voltage). When the current decreases to the low saturation current, enter float stage.

Stage 4: Float charging

If I(battery) < I(low saturation current), CV charging, V(charge) = V(float stage voltage).

Note: However, the actual current is determined by both MPPT and the battery condition.

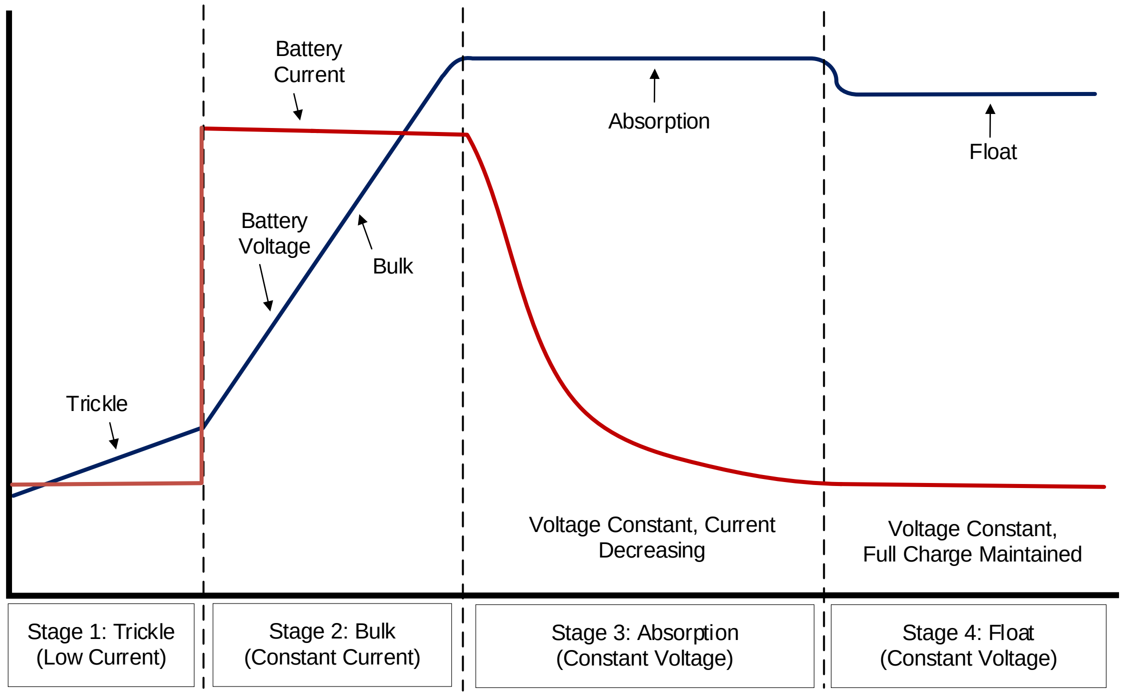


Figure 13. Charging Stages

5. Ordering Information

Part Number	Description
US011-SOLCHRGEV1Z	Smart Solar Battery Charger Evaluation Board

6. Revision History

Revision	Date	Description
1.01	Dec 16, 2025	Removed references to the 24V/7Ah lead-acid battery.
1.00	Sep 10, 2025	Initial release.

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.
2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.
3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.
4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.
5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.
6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).
7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.
8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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