RTK0EUG011D09020BJ

100W USB Type-C Battery System Reference Design for 2 to 7S Li-Ion

Description

The RTK0EUG011D09020BJ (RTK-251-SinkCharger-RAA489118) is an evaluation board for Universal Serial Bus Power Delivery (USB PD). The RTK-251-SinkCharger-RAA489118 is designed with USB PD controller R9A02G011 and On-Board Charger RAA489118 to support 2 to 7 battery cells in series configuration. This document is the instruction manual for the RTK-251-SinkCharger-RAA489118.

The RTK-251-SinkCharger-RAA489118 supports USB PD 2.0, USB PD 3.1, and USB Type-C® Specification. The RTK-251-SinkCharger-RAA489118 works as a USB Type-C power sink charger or a power bank. The board does not have a battery protection circuit on it, so Renesas strongly recommends using a battery module with Renesas' Battery Management System to avoid over-discharging under the power bank mode. The RTK-251-SinkCharger-RAA489118 can be combined with an Evaluation Module of the Battery Fuel Gauging IC (FGIC) RAJ2400100 with Filefish to realize a complete Battery Management System (BMS).

The configuration switches enable the selection of the number of battery cells, the maximum charge current and the operating mode.

VIDWriter 1.1.0.0 applies to the RTK-251-SinkCharger-RAA489118.

Target Devices

- 100W USB Type-C Charger or MAX 60W Power Bank: RTK-251-SinkCharger-RAA489118
  - USB Power Delivery Controller: R9A02G011
  - On-Board Charger: RAA489118
- Evaluation Module of Battery Fuel Gauging IC (FGIC) with Filefish: RAJ240100 Filefish EVM
  - Battery Fuel Gauging IC: RAJ240100

Target VIDWriter

- VIDWriter 1.1.0.0 (Version 1.1.0.0)

Related Document

Use this document in combination with the following documents.

The related documents mentioned in this publication may include preliminary versions. However, preliminary versions are not marked as such.

- R9A02G011 Datasheet: R19DS0088EJ
- R9A02G011 User's Manual: R19UH0102EJ
- E1 Emulator E20 Emulator User's Manual: R20UT0398EJ
- E2 Emulator Lite User's Manual: R20UT3240EJ
- E1/E20 Emulator, E2 Emulator Lite Additional Document for User's Manual (Notes on Connection of RL78): R20UT1994EJ
- Renesas Flash Programmer V3.13 Flash memory programming software User's Manual: R20UT5312EJ
- USB Power Delivery Controller VIDWriter 1.1.0.0 Instruction Manual: R19AN0272EJ
- RAA489118 Short-Form Datasheet: R16DO0024EU
- RAJ240100 Datasheet: R01DS0301EJ
- RAJ240100 Filefish User's Manual: R01AN6763EJ

Contents

1. Features

RTK-251-SinkCharger-RAA489118 supports the following features.

- USB Power Delivery and USB Type-C
  - Supports USB Power Delivery Specification Revision 2.0, USB Power Delivery Specification Revision 3.1, USB Type-C Cable and Connector Specification Revision 2.2.
  - Certified by USB Implementers Forum
    - RTK-251-SinkCharger: PowerBank/DRP state machine, TID = 10665
    - R9A02G011: PD Controller, TID = 64651080009
  - Power Role: Sink Only (SNK) or Dual Role Power (DRP)
  - Under Sink Only mode, RTK-251-SinkCharger-RAA489118 requires SPR mode 5, 9, 15, or 20V input from USB Type-C power sourcing device.
  - Under Power Bank mode, RTK-251-SinkCharger-RAA489118 requires 5, 9, 15, or 20V input from USB Type-C power sourcing device in sinking mode and supports source PDP ratings of 15W, 27W, 45W, or 60W in sourcing mode.
  - 1 USB Type-C port
- Interface
  - LED indicators
    - Power Supply Indicator (3 LEDs, green)
  - Switches
    - Battery Configuration control for RAA489118
    - Charging Current limits control for R9A02G011
  - On-chip debugging emulator interface
    - Renesas on-chip debugging emulator interface to write and debug firmware for R9A02G011.
  - Battery Management System interface
    - Renesas BMS evaluation board interface to communicate with Battery module including FGIC.

1.1 Block Diagram

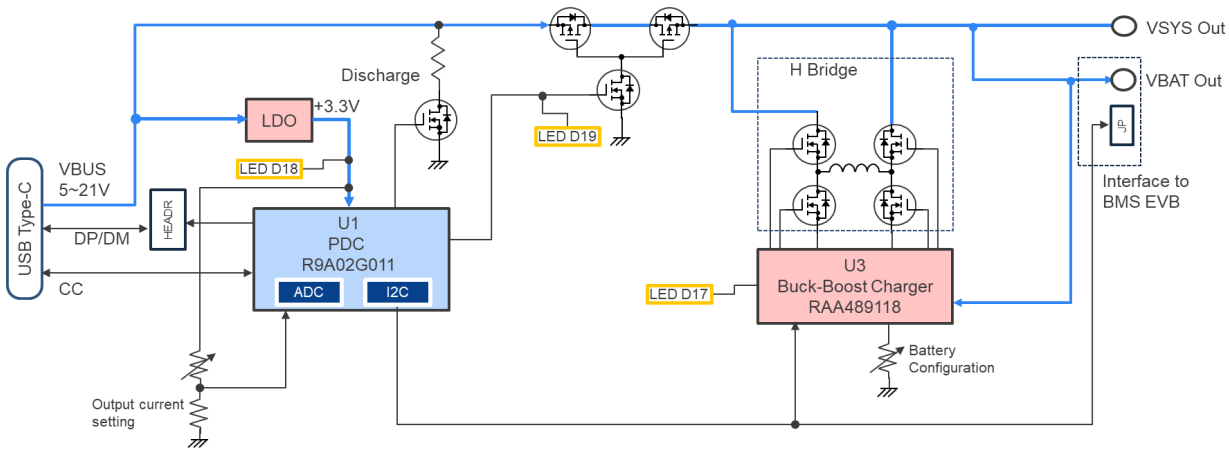
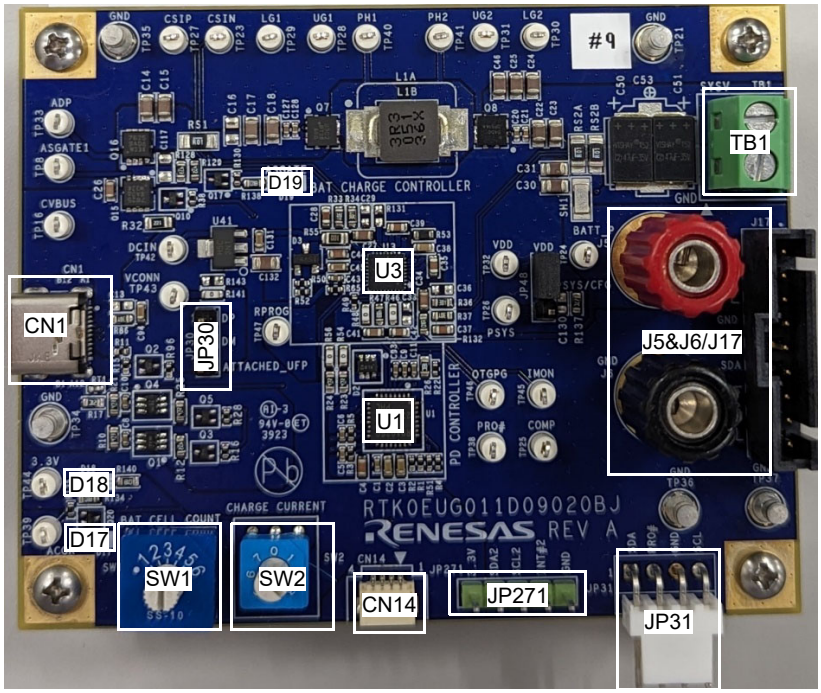


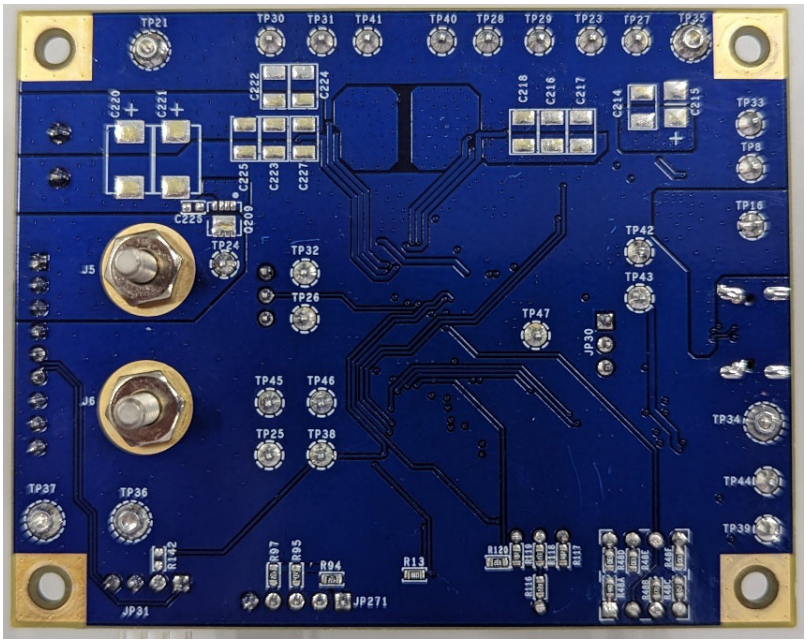
Figure 1. RTK-251-SinkCharger-RAA489118 Block Diagram

1.2 Component

1.2.1 Component Layout



Top Side



Bottom Side

Figure 2. Highlighted Main Parts on the Board

1.2.2 Component Information

Table 1. ICs

No.	Description	Remark
U1	R9A02G011 (USB Power Delivery Controller)	-
U3	RAA489118 (On-Board Charger)	-

Table 2. Connectors

No.	Description	Remark
CN1	USB Type-C receptacle	-
CN14	Renesas on-chip debugging emulator interface	-
JP30	USB2.0 Data interface	-
TB1	Connector for VSYS	-
J5&J6 /J17	Connector for Battery interface	-
JP271	SMBus Target SCL, SDA, alert on R9A02G011	P60, P61, P62
JP31	SMBus Controller SCL, SDA, alert on R9A02G011	P30, P31, P137

Table 3. Switches

No.	Description	Connects to
SW1	Rotary switch for configuration of number of Battery cells	RAA489118: PROG
SW2	Rotary switch for setting the Charger Current Limit	R9A02G011: P22

Table 4. LEDs

No.	Description	Connects to
D17	V_{BUS} presence Indicator	RAA489118: ACOK
D18	Power Supply Indicator for R9A02G011	+3.3V
D19	Indicator for VBUS gate control	R9A02G011: P73

Table 5. Test Points

No.	Description	Remark
TP16	V_{BUS} (Near USB Type-C receptacle)	-
TP34, TP37	GND	-
TP43	+5V	-
TP44	+3.3V	-
TP33	VADP (Monitor for BB-Charger input)	-

1.3 Function Assignment for R9A02G011

Figure 6 shows the functions assigned to R9A02G011 on RTK-251-SinkCharger-RAA489118.

Table 6. Functions Assigned to R9A02G011 Pins on RTK-251-SinkCharger-RAA489118

Pin Name	Function	Description
P16	Open	Reserved
P20	VBUSM	V_{BUS} voltage monitor input
P21	OTP	Input for Over Temperature Protection
P22	SW2	Input from Rotary Dip switch for Charging Current Limits control
P31	MSTSDA	SMBus controller data input/output (open-drain) connected to RAA489118
P30	MSTSCL	SMBus controller clock output (open-drain) connected to RAA489118
P40	TOOL0	Connected to on-chip debugging emulator interface for flash programming.
P61	SLVSDA	SMBus target data input/output (open-drain) connected to JP271
P60	SLVSCL	SMBus target clock input connected to JP271
P62	SLVALTB	Connected to JP271
P32	Open	-
P80	Attached_UFP	Connects to JP30 to indicate USB-C Attach/Detach. See Supports USB Peripheral Function when supporting USB peripheral function.
P50	INT1	USB-C Attach/Detach input
P51	Open	-
RD1	RD1	Rd resistor 1, Analog pin from CC-PHY.
CC1	CC1	Configuration Channel 1, Analog pin from CC-PHY
CC2	CC2	Configuration Channel 2, Analog pin from CC-PHY
RD2	RD2	Rd resistor 2, Analog pin from CC-PHY.
REG	REGCTX	Regulator capacitance for CC-PHY. Connecting regulator output stabilization capacitance for internal operation.
VDD	VDD	Power supply (+3.3V)
REGC	REGC	Regulator capacitance. Connecting regulator output stabilization capacitance for internal operation.
P121	Pull-down	-
P122	Pull-down	-
P137	MSTALTB	Connects to JP31
RESETB	RESETB	Chip Reset Input (active low)
P70	Open	-
P71	DISCHG	Discharge control for USB Type-C V_{BUS}
P72	Open	-
P73	Gate	Gate Enable for V_{BUS} line
P81	Open	-
P82	Open	-
P17	Open	Reserved

1.4 Function Assignment for RAA489118

Table 7 shows the functions assigned to RAA489118 on RTK-251-SinkCharger-RAA489118.

Table 7. Functions Assigned to RAA489118 Pins on RTK-251-SinkCharger-RAA489118

Pin Name	Function	Description
CSON	CSON	Battery current sense -input
CSOP	CSOP	Battery current sense +input
VSYS	VSYS	Provides feedback voltage for System Voltage regulation.
BOOT2	BT2	High-side MOSFET Q4 gate driver supply
UGATE2	UG2	High-side MOSFET Q4 gate drive
PHASE2	PH2	Current return path for the high-side MOSFET Q4 gate drive
LGATE2	LG2	Low-side MOSFET Q3 gate drive
VDDP	VDDP	Power supply for the gate drivers
LGATE1	LG1	Low-side MOSFET Q2 gate drive
PHASE1	PH1	Current return path for the high-side MOSFET Q1 gate drive
UGATE1	UG1	High-side MOSFET Q1 gate drive
BOOT1	BT1	High-side MOSFET Q1 gate driver supply
ASGATE	Open	Unused
CSIN	CSIN	Current sense -input from V_{BUS} path
CSIP	CSIP	Current sense +input from V_{BUS} path
ADP	ADP	Voltage Sense input from V_{BUS} path
DCIN	DCIN	Internal LDO input that provides power to the IC
VDD	VDD	Internal LDO output that provides the bias power for the internal circuit
ACIN	ACIN	V_{BUS} voltage sense input
OTGEN/CMIN	Pull-up	Unused
SDA	SDA	SMBus target data input/output (open-drain) connected to R9A02G011
SCL	SCL	SMBus target clock input connected to R9A02G011
PROCHOT#	PROCHOT#	Unused
ACOK	INDICATOR1	Power Supply Indicator, connected to D17
BATGONE	Pull-down	-
OTGPG/CMOUT	Open	-
PROG	PROG	Input from Rotary Dip switch for Configuration of the number of battery cells
COMP	COMP	Error amplifier output
AMON/BMON	AMON/BMON	Unused
CONFIG/PSYS	Pull-down	Configure IC for no BFET charging mode.
VBAT	VBAT	Battery voltage sense input
BGATE	BGATE	Unused

2. Function

2.1 Battery Configuration

Battery Configuration is set by SW1.

Table 8. Rotary Switch Setting Value for Battery Configuration

SW Position	RTK0EUG011D09020BJ: 2-7 Cells Version
1	2 Cells in series
2	3 Cells in series
3	4 Cells in series
4	5 Cells in series
5	6 Cells in series
6	7 Cells in series

The standard parameters of charger in firmware (FW) define MaxSysVol/cell as 4.048V and MinSysVol/cell as 2.816V, which correspond to typical voltages for Li-Ion battery chemistries such as $LiCoO_2$ and $LiMn_2O_4$ battery. Table 9 shows the default MaxSysVol and MinSysVol for each battery configuration.

Table 9. Battery Configuration vs MaxSysVol/MinSysVol for $LiCoO_2$ and $LiMn_2O_4$ Battery in Standard FW

Battery Configuration	MaxSysVol (mV)	MinSysVol (mV)
2 Cells in series	8096	5632
3 Cells in series	12144	8448
4 Cells in series	16192	11264
5 Cells in series	20240	14080
6 Cells in series	24288	16896
7 Cells in series	28336	19712

For example, the MaxSysVol/cell and MinSysVol/cell for a $LiFePO_4$ based battery are lower than those of other Li-Ion batteries such as $LiCoO_2$ and $LiMn_2O_4$ battery. Therefore, if using other MaxSysVol and MinSysVol values are required, VIDWriter 1.1.0.0 can generate a FW with such parameters. Refer to Charging Current Limits and Firmware Writing to the R9A02G011 on RTK-251-SinkCharger-RAA489118. The Charger's MaxSysVol range is 8V to 30.8V and the Charger's MinSysVol range is 5.12V to 25.088V, so the user can only set MaxSysVol and MinSysVol with these ranges.

Table 10 shows sample MaxSysVol and MinSysVol for each battery configuration of $LiFePO_4$ based batteries with MaxSysVol/cell at 3.4V and MinSysVol/cell at 2.2V.

Table 10. Battery Configuration vs Sample MaxSysVol/MinSysVol for $LiFePO_4$ Battery

Battery Configuration	MaxSysVol (mV)	MinSysVol (mV)
3 Cells in series	10200	6600
4 Cells in series	13600	8800
5 Cells in series	17000	11000
6 Cells in series	20400	13200
7 Cells in series	23800	15400
8 Cells in series	27200	17600

MaxSysVol represents the maximum battery charging voltage. It is defined as Full in this document. If VBAT reaches the Full value, the charger operates in Constant Voltage mode. MinSysVol represents the minimum allowed voltage during discharging mode. It is defined as Empty in this document. In charging mode, when VBAT is less than the Empty value, the Charger trickle charges the battery at a low current level. When VBAT is between Full and Empty value, the charger operates in Constant Current mode.

Standard FW includes both MaxSysVol and MinSysVol values that are matched to the battery cell configuration set by rotary switch SW1. If the battery configuration is fixed, the resistor values in Table 11 can be used in place of the rotary switch.

Table 11. Resistor Values for Substitute Circuit

Battery Configuration	Resistor Value (kΩ) for RAA489118[1]
2 Cells in series	61.9
3 Cells in series	93.1
4 Cells in series	133
5 Cells in series	178
6 Cells in series	237
7 Cells in series	316

1. Resistor value within a tolerance of ±1% must be used.

2.2 Charging Current Limits

SW2 sets Charging Current Limits and operating mode.

There are three operating modes; Board, BMS, and Manual. The default firmware uses Board mode, in which the switches on the board configure the EVB parameters. BMS sets EVB parameters by battery status information from BMS. Manual can set EVB parameters directly using the VIDwriter.

Note: To use Board DRP, or BMS, Manual modes, FW on the board must be rewritten by the VIDWriter 1.1.0.0-generated FW. If operating mode is changed to Board from BMS or Manual, FW on the board must also be rewritten by the VIDWriter 1.1.0.0-generated FW.

Table 12. Rotary switch setting value for Charging Current Limits

SW position	Charging Current Limits (SW2)	Operating mode
0	The specific values (MaxSysVol, MinSysVol, and Charging Current limit) can be set in FW	Manual
1	1A	Board (Default)
2	2A	
3	3A	
4	4A	
5	5A	
6	6A	
7	The values (MaxSysVol, Charging Current limit and so on) are retrieved via BMS interface	BMS

When using a battery evaluation module such as RAJ240100 Filefish EVM , SW2 must be set to SW position 7. In that case, R9A02G011 of RTK-251-SinkCharger-RAA489118 retrieves battery related information from FGIC controller on RAJ240100 Filefish EVM . The R9A02G011 then uses the information obtained from FGIC controller instead of SW2 value to configure the on-board charger. At the same time, R9A02G011 gets the number of series cells that the battery module has. Therefore, the SW1 setting is ignored in this case. FW is generated by VIDWriter 1.1.0.0 (See Firmware Writing to the R9A02G011 on RTK-251-SinkCharger-RAA489118).

If SW2 does not have a suitable charging current value and/or setting MaxSysVol and MinSysVol as standard values is not required, set SW2 to SW position 0 and set the expected charging current value, MaxSysVol and MinSysVol. Install them on FW that is generated by using the VIDWriter 1.1.0.0 as described in Firmware Writing to the R9A02G011 on RTK-251-SinkCharger-RAA489118. In this case, the SW1 setting is ignored.

If the charging current limit is fixed, the substitute circuit as shown in Figure 3 can be used in place of the rotary switch.

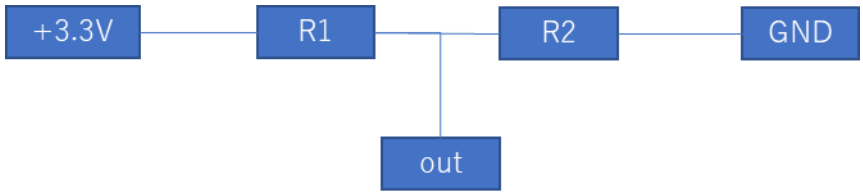


Figure 3. The Substitute Circuit for Output Voltage or Current

The resistor values in Table 13 can be used to define input level of P22.

Table 13. Resistors Values for Substitute Circuit

SW Position	Resistor value (Ω)[1]	
	R1	R2
0	Pull down to GND	
1	3.3k	2.7k
2	2.2k	2.7k
3	1.5k	2.7k
4	1.2k	2.7k
5	1k	2.7k
6	820	2.7k
7	Pull up to VDD	

1. R1 and R2 within a tolerance of ±5% must be used.

2.3 Operating Mode Selection

2.3.1 Sinking Mode

Under Sink Charger operation and sinking mode for Power Bank operation, R9A02G011 needs the sourcing PDP rating as shown in Table 14 to the connected PD sourcing device to realize fast charging when VBAT > MinSysVol. Even if the connected PD sourcing device cannot supply the sourcing PDP rating that is shown in Table 14, RTK-251-SinkCharger-RAA489118 charges the battery with the USB-C input power that the PD adapter can supply. For example, when a product can charge at 5V, 9V, and 15V, differentiation between 5V, 9V, and 15V charging voltage is charging speed.

Table 14. Expected Maximum Type-C Sourcing PD Power for Sinking Mode

Battery Configuration	1A	2A	3A	4A	5A	6A
2 Cells in series	2A@5V	3A@9V	2A@15V	3A@15V	3A@20V	3A@20V
3 Cells in series	2A@9V	2A@15V	3A@15V	3A@20V	4A[1]@20V	5A[1]@20V
4 Cells in series	3A@9V	3A@15V	3A@20V	4A[1]@20V	5A[1]@20V	5A[1]@20V
5 Cells in series	3A@9V	3A@20V	4A[1]@20V	5A[1]@20V	5A[1]@20V	5A[1]@20V

Table 14. Expected Maximum Type-C Sourcing PD Power for Sinking Mode (Cont.)

Battery Configuration	1A	2A	3A	4A	5A	6A
6 Cells in series	2A@15V	3A@20V	5A[1]@20V	5A[1]@20V	5A[1]@20V	5A[1]@20V
7 Cells in series	3A@15V	4A[1]@20V	5A[1]@20V	5A[1]@20V	5A[1]@20V	5A[1]@20V

1. EPR cable or 5A cable is required.

The BB-Charger co-works with a battery module. Charging modes for the Battery module are Trickle, Constant Current (CC), and Constant Voltage (CV). As long as VBAT is less than Empty, the charging current is set to 256mA. If VBAT is in between Full and Empty, the charger operates in Constant Current mode. If VBAT reaches Full, the charger works in Constant Voltage mode. If VBAT > MaxSysV, there is no charging/switching.

The current limit during CC and CV modes is defined by the lesser of the charger's current limit and the Type-C input current limit. When the battery is 7 cells (Full = 28.336V and Empty = 19.712V for Li-Ion batteries such as $LiCoO_2$ and $LiMn_2O_4$) and Type-C input is 100W, actual charging current is limited to around 3.4A at Full even if the Charging Current Limits is set to 6A. On the other hand, at a voltage just over Empty, actual charging current is around 5A. As the VBAT voltage approaches Full, the actual charging current reduces to 3.4A.

When the battery is 4 cells (Full = 16.192V and Empty = 11.264V for Li-Ion batteries such as $LiCoO_2$ and $LiMn_2O_4$) and Type-C input is 100W, actual charging current nearly reaches the 6A charging current limit at the Full voltage. At just over Empty, it is possible to supply over 9A charging current from Type-C input. However, because the charger’s current limitation is 6A, the charger can only supply a maximum of 6A to the battery.

Both the 5A and EPR cables have e-markers to notify the system of 5A capability.

2.3.2 Sourcing Mode

IMPORTANT: The RTK-251-SinkCharger-RAA489118 does not have a battery protection circuit on the board, so, Renesas strongly recommends using a battery module with Renesas’ Battery Management System to avoid over discharging under the power bank mode. RTK-251-SinkCharger-RAA489118 can support power bank mode as long as the battery module uses a protection circuit to avoid over-discharge and over-temperature. However, this should be done at the user’s own risk.

Under sourcing mode for Power Bank operating, RTK-251-SinkCharger-RAA489118 supports standard maximum sourcing PD Power as shown in Table 15 based on Equation 1.

(EQ. 1) $\text{Available Sourcing Power} = \text{MinSysVol} \times \text{Charging Current Limit} \times 2$

- The standard PD Power in FW = Max supply current (3A) × Standard supply voltage (5, 9, 15, or 20V) = 15, 27, 45, or 60W
- The Max sourcing PD Power in FW ≤ Available sourcing power

The max sourcing PDP is calculated by the MinSysVol value and Charging Current Limit value. For example, if the MinSysVol is 11.2V and the charging current limit is 1A, the available sourcing power is 22.4W. As a result, the maximum sourcing PDP of the FW is 15W. When the MinSysVol is 11.2V and the charging current limit is 3A, the available sourcing power is 67.2W. Therefore, the user can choose either 15, 27, 45, or 60W as the Max sourcing PDP. The Max sourcing PDP is calculated by the above formula even though MaxSysVol, MinSysVol, and Charging Current Limits are set manually.

In the BMS operating mode, the FW cannot recognize the MaxSysVol, MinSysVol, and Charging Current Limits until R9A02G011 retrieves the battery information from BMS. Therefore, set the appropriate Max sourcing PD Power that battery module can support.

The USB-PD PDO list, which is used on PD negotiation, is generated by this Max sourcing PDP. If the available sourcing power is less than 15W, RTK-251-SinkCharger-RAA489118 does not support sourcing mode for Power Bank operating.

Also, Max sourcing PDP is limited to 60W because there is no V_{CONN} power on RTK-251-SinkCharger-RAA489118. To support 100W sourcing PDP, V_{CONN} power is required on system board to check 5A capability of cable. At that case, FW modification is required. For assistance, contact Renesas' support.

Table 15. Supported Maximum Type-C Sourcing PD Power for Sourcing Mode

Battery Configuration	1A	2A	3A	4A	5A	6A
2 Cells in series	-	15W	27W	45W	45W	60W
3 Cells in series	15W	27W	45W	60W	60W	60W
4 Cells in series	15W	45W	60W	60W	60W	60W
5 Cells in series	27W	45W	60W	60W	60W	60W
6 Cells in series	27W	60W	60W	60W	60W	60W
7 Cells in series	27W	60W	60W	60W	60W	60W

Table 16. PDO List

	PDO1	PDO2	PDO3	PDO4
PDP 15W	5V/3A	-	-	-
PDP 27W	5V/3A	9V/3A	-	-
PDP 45W	5V/3A	9V/3A	15V/3A	20V/2.25A
PDP 60W	5V/3A	9V/3A	15V/3A	20V/3A

3. Board Setup and Usage

3.1 Required Materials

- RTK-251-SinkCharger-RAA489118: 1 unit
- USB Type-C Cable: 1pcs (When the required maximum Type-C sourcing PD Power is 20V at 5A, a 5A cable or EPR cable is required.)

Note: This board does not require an external power supply except for the batteries.

IMPORTANT: USE THIS BOARD WHEN YOU UNDERSTAND AND AGREE THAT RENESAS DOES NOT HAVE ANY RESPONSIBILITY, INDEMNIFICATION, OR LIABILITY FOR USE OF THIS BOARD.

3.2 Connecting Battery Module

RTK-251-SinkCharger-RAA489118 operation is managed by the type of battery module.

3.2.1 Charging Battery Module with the Standard Charger Parameters (Board Mode) without Renesas BMS Interface

When connected to a a source device, complete the following steps to charge the battery module.

1. Select the expected Charging Current Limit by setting the rotary switch (SW2) to one of positions 1 to 6 (see Charging Current Limits).
2. Select the expected battery configuration by rotary switch (SW1) (see Battery Configuration).
3. If DRP mode is selected, update FW including appropriate charger parameters that is generated by the VIDWriter 1.1.0.0 to RTK-251-SinkCharger-RAA489118.
4. Connect Battery module w/o Renesas BMS interface to J5 and J6.
5. Connect USB Type-C sourcing device to USB Type-C receptacle (CN1) using a USB Type-C cable and supply power to the battery module, confirming green LED (D19) light is on.

Figure 4. Power Indicator

6. The board supplies power to battery module.

Note: Never change SW1/SW2 when the Board power is ON.

3.2.2 Charging Battery Module with the Custom Charger Parameters (Manual Mode) without Renesas BMS Interface

When connected to a a source device, complete the following steps to charge the battery module.

1. Update FW including appropriate charger parameters that is generated by the VIDWriter 1.1.0.0, to RTK-251-SinkCharger-RAA489118.
2. Set the rotary switch (SW2) to position 0. (See Charging Current Limits)
3. Connect the Battery module w/o Renesas BMS interface to J5 and J6.
4. Connect a USB Type-C sourcing device to the USB Type-C receptacle (CN1) using a USB Type-C cable and supply power to the battery module, confirm green LED (D19) lights on as shown in Figure 4.
5. The board supplies power to battery module.

Note: Never change SW1/SW2 when the Board power is ON.

3.2.3 Charging Battery Module with Renesas BMS Interface

When connected to a a source device, complete the following steps to charge the battery module.

1. Must update FW including appropriate charger parameters that is generated by the VIDWriter 1.1.0.0, to RTK-251-SinkCharger-RAA489118.
2. Set the rotary switch (SW2) to position 7. (See Charging Current Limits)
3. Connect the Battery module w/ Renesas BMS interface to J17.
4. FW of RTK-251-SinkCharger-RAA489118 retrieves the maximum charging voltage and current limits using Renesas BMS interface and sets the appropriate battery charger value on RTK-251-SinkCharger-RAA489118.
5. Connect a USB Type-C sourcing device to the USB Type-C receptacle (CN1) using a USB Type-C cable and supply power to the battery module, confirm green LED (D19) lights on as shown in Figure 4.
6. The board supplies power to battery module.
7. FW of RTK-251-SinkCharger-RAA489118 frequently retrieves the maximum charging voltage and current limits using the Renesas BMS interface and updates the battery charger setting value on RTK-251-SinkCharger-RAA489118.

Note: Never change SW1/SW2 when the Board power is ON.

3.2.4 Power Bank Mode Setting

When using RTK-251-SinkCharger-RAA489118 in Power Bank mode (DRP) without USB2.0 data communication, install a jumper to short DP and DM of JP30.

Figure 5. Connector for Power Bank Mode Setting

If using RTK-251-SinkCharger-RAA489118 in Power Bank mode (DRP) with USB2.0 data communication, see Supports USB Peripheral Function.

3.3 Battery Module with Renesas BMS Interface

Battery module with Renesas BMS interface is described in this section. Renesas release Filefish that is a fixed firmware solution for Renesas Battery Fuel Gauging IC (FGIC), which requires no additional firmware development. Using this solution, the battery management system (BMS) can be easily and quickly designed, and the time to market can be significantly reduced.

RAJ240100 Filefish EVM is one of the battery evaluation modules including FGIC with Filefish.

RTK-251-SinkCharger-RAA489118 communicates with RAJ240100 Filefish EVM to realize battery management system.

3.3.1 RAJ240100 Filefish EVM Connection

RAJ240100 Filefish EVM connects to RTK-251-SinkCharger-RAA489118 using the J17 connector. RTK-251-SinkCharger-RAA489118 bundles a specific conversion cable to connect to RAJ240100 Filefish EVM as shown in Figure 6.

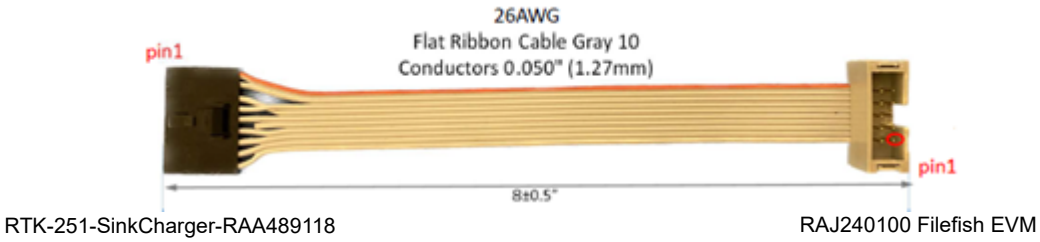


Figure 6. Conversion Cable

Table 17. Pin Assignment of Conversion Cable

RTK-251-SinkCharger-RAA489118		RAJ240100 Filefish EVM			
pin 1	VBAT	pin 10	VBAT	pin 9	VBAT
pin 2	VBAT	pin 8	GND	pin 7	VBAT
pin 3	VBAT	pin 6	SCL	pin 5	NC
pin 4	GND	pin 4	SDA	pin 3	GND
pin 5	SCL	pin 2	GND	pin 1	GND
pin 6	SDA	-		-	
pin 7	GND	-		-	
pin 8	GND	-		-	
pin 9	GND	-		-	

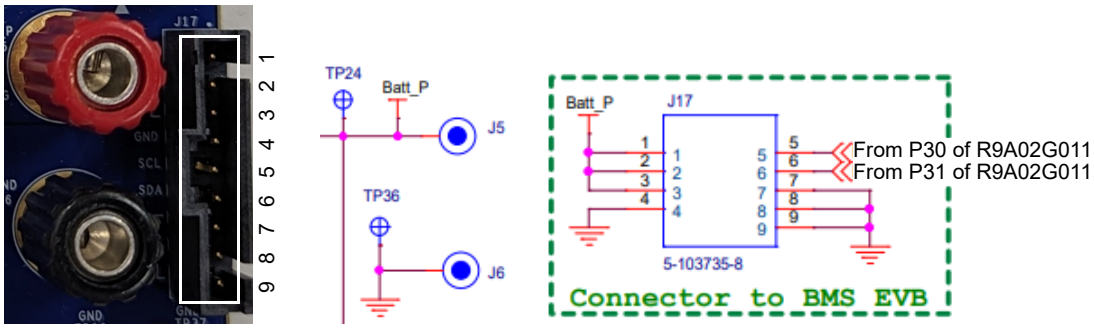


Figure 7. RTK-251-SinkCharger-RAA489118 Connector to BMS EVB and Pin Assignments

3.3.2 RAJ240100 Filefish EVM

It is necessary to program battery management configurations to FGIC depending on customer's application conditions. Refer to *RAJ240100 Filefish User's Manual (R01AN6763EJ)* for more details.

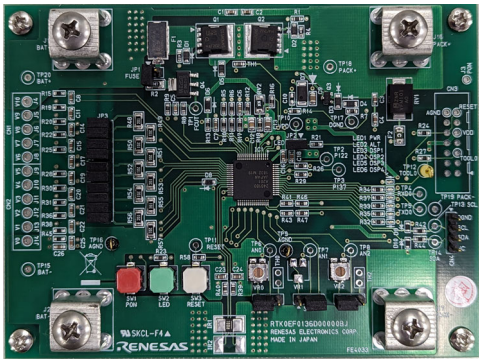


Figure 8. RAJ240100 Filefish EVM

Note: Minimum number of cells for Filefish (RAJ240100) is 3 cells in series.

For more information about Filefish, contact your Renesas representative.

3.4 Firmware Writing to the R9A02G011 on RTK-251-SinkCharger-RAA489118

This section describes how to generate and write the firmware (such as Intel HEX file) to the R9A02G011 in an appropriate method.

3.4.1 FW Generation

3.4.1.1 Operating Environment

- Host PC
  - Processor: 1GHz or faster
  - Main memory: At least 1Gbyte
  - Display: Resolution of 1024×768 or higher and 65536 or more colors
- Supported OS
  - Windows 10 (32-bit or 64-bit)
  - Windows 11 (32-bit or 64-bit)

Note: Microsoft.NET Framework 4.6.1 or later has to be installed.

3.4.1.2 Setup the VIDWriter

1. Install Microsoft .NET Framework 4.6.1 or later.
2. Uses .exe file including in the unzip directory. This tool can work without installation. DO NOT change directory structure in the unzipped data.
3. Check Tool version and FW package version in **Help** > **About**. VIDWriter 1.1.0.0 applies to the RTK-251-SinkCharger-RAA489118.

3.4.1.3 Run VIDWriter to generate ROM Image File

When VIDWriter 1.1.0.0 is ran, the window as shown Figure 9 displays.

Figure 9. Main Window for VIDWriter 1.1.0.0

1. Menu Bar – Check the Tool version and FW package version in **Help** > **About**. VIDWriter 1.1.0.0 applies to the RTK-251-SinkCharger-RAA489118.
2. Field B to select the required feature – Choose the features that match the required function in this field. When selected, the recommended turnkey solution is displayed in Field D and the possible configurations are shown in Field E.
3. Field C sets VID/PID number – If using different hexadecimal VID and PID numbers instead of the default VID/PID(0xFFFF/0x0000) numbers set in this field, overwrite the numbers to this field. Otherwise, leave VID: FFFF and PID: 0000.
4. Window for the Renesas recommended turnkey solution – RTK-251-SinkCharger-RAA489118 is displayed as the Renesas recommended turnkey solution in Field D.

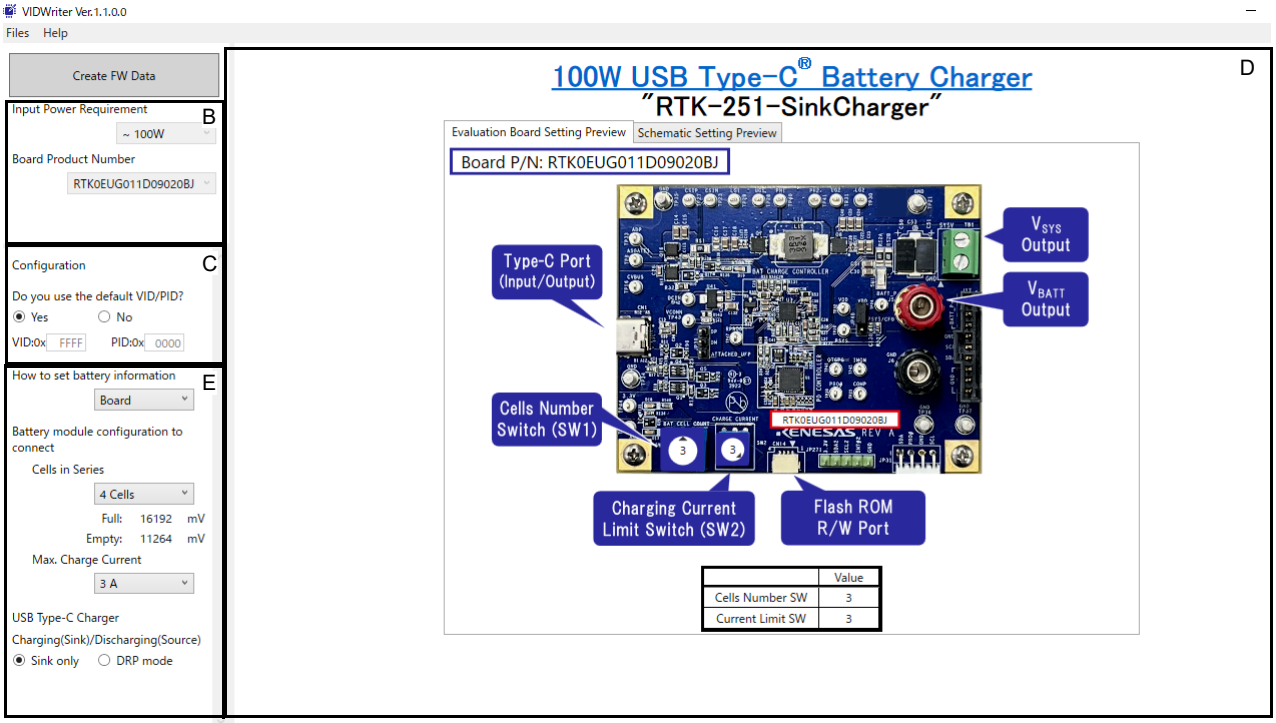


Figure 10. Main Window for VIDWriter 1.1.0.0 after Product Configuration

5. Field E configures the turnkey solution recommended by Renesas. – Field E sets the Full, Empty, Max Charging Current, and Max sourcing PDP (DRP mode). There are three operating modes; Board, BMS, and Manual. The default firmware uses Board mode, in which the switches on the board configure the EVB parameters. BMS sets EVB parameters by battery status information from BMS. Manual can set EVB parameters directly using the VIDwriter. After setting in Field E, Field D indicates the appropriate physical settings on the EVB. Next, set the switches on the board according to this picture.

Note: To use Board DRP, or BMS, Manual modes, FW on the board must be rewritten by this VIDWriter 1.1.0.0-generated FW. If operating mode is changed to Board from BMS or Manual, FW on the board also must be rewritten by this VIDWriter 1.1.0.0-generated FW.

IMPORTANT: The RTK-251-SinkCharger-RAA489118 does not have a battery protection circuit on the board; therefore, Renesas strongly recommends using a battery module with Renesas' Battery Management System to avoid over-discharging under the power bank mode. RTK-251-SinkCharger-RAA489118 can support power bank mode as long as the battery module uses protection circuit to avoid over-discharge and over-temperature. However, this should be done at user's own risk.

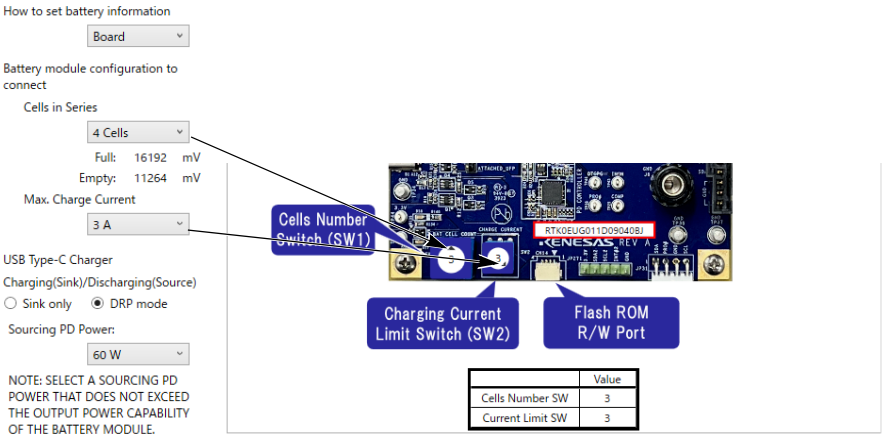


Figure 11. Field E and the EVB Setting vs Board Configuration

Full indicates the maximum battery charging voltage. Empty indicates the voltage at which the charger trickle charges the battery at a low current level if VBAT is below that value.

If achieving power bank function with RTK-251-SinkCharger-RAA489118 is required, select DRP mode. Otherwise, select Sink only. In the sourcing mode of Power Bank operating, select the sourcing PD Power from the drop-down list. Because default FW on board supports Sink Only mode, if supporting power bank function is required, rewrite the FW on the board with this VIDWriter 1.1.0.0-generated FW. See Sourcing Mode about the maximum sourcing PDP.

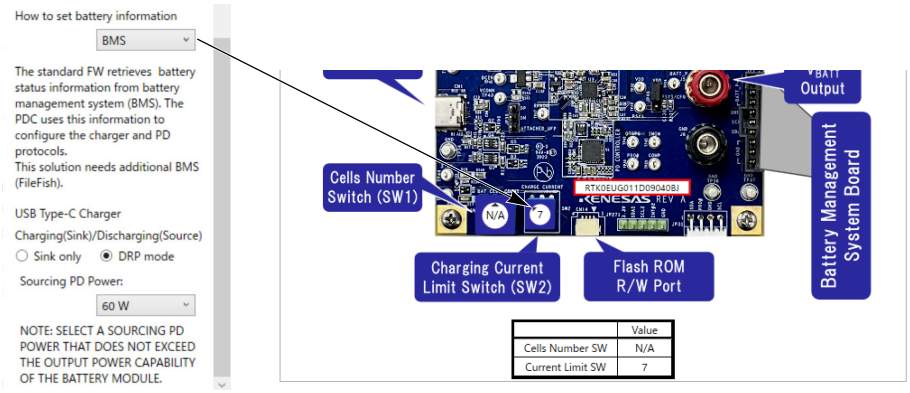


Figure 12. Field E and the EVB setting vs BMS configuration

In BMS setting, this EVB frequently retrieves battery related information from RAJ240100 Filefish EVM . In this operating mode, this EVB uses the information obtained from RAJ240100 Filefish EVM instead of the SW2 value to configure the on-board charger.

If achieving power bank function with RTK-251-SinkCharger-RAA489118 is required, select DRP mode. Otherwise, select Sink only. In this operating mode, the FW cannot recognize the MaxSysVol, MinSysVol, and Charging Current Limits until R9A02G011 retrieves the battery information from BMS. So, VIDWriter 1.1.0.0 cannot define the true maximum sourcing PD Power under sourcing mode. Therefore, set the appropriate maximum sourcing PD Power that the battery module can support. See Sourcing Mode for more information on how to set the maximum sourcing PDP.

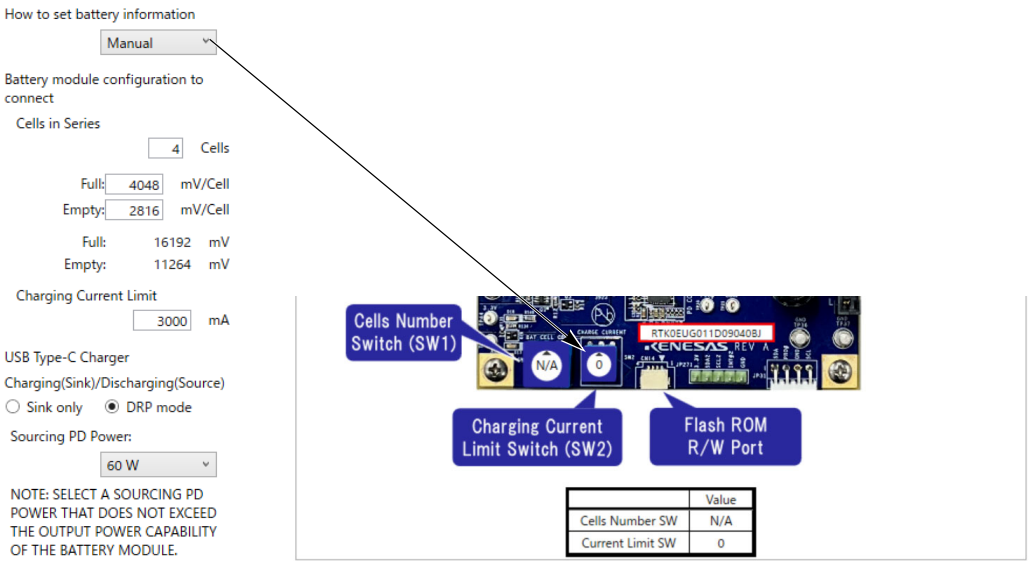


Figure 13. Field E and the EVB setting vs Manual Configuration

If there is no suitable charging current value on SW2 and/or setting Full and Empty as standard values is not required, set SW2 to SW position 0 and set the expected charging current value, Full and Empty. Full indicates the maximum battery charging voltage. Empty indicates the voltage at which the charger trickle charges the battery at a low current level if VBAT is below.

If achieving the power bank function with RTK-251-SinkCharger-RAA489118 is required, select DRP mode. Otherwise, select Sink only. In the sourcing mode of Power Bank operating, select the sourcing PD Power from the drop-down list. See Sourcing Mode for more information on how to set the maximum sourcing PDP.

6. Press the **Schematic Setting Preview** F tab in field D and the recommended turnkey schematics with appropriated parameters are displayed, such as Figure 14.

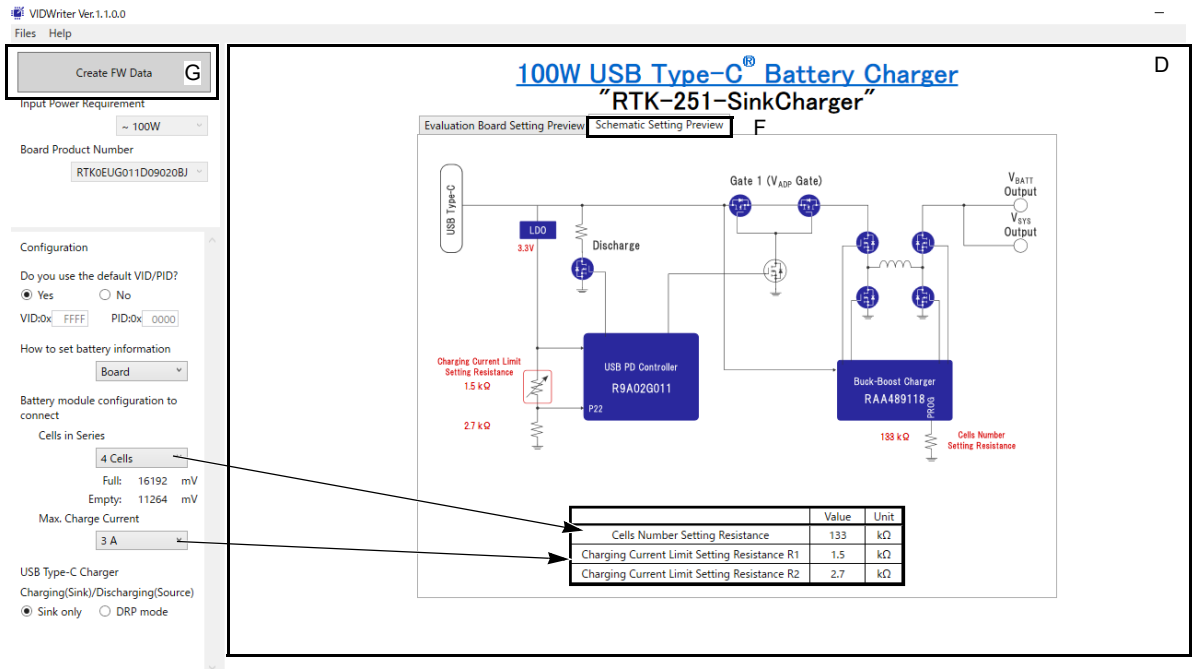


Figure 14. Main Window for VIDWriter 1.1.0.0 when Press Schematic Setting

7. Finally, after selecting the **Create FW Data** button, a file save dialog is displayed. The default storage location is the **My Documents** folder. The save location and file name of the ROM image can be changed if required. If rewriting this ROM image to R9A02G011 on the evaluation board, use the Renesas Flash Programmer V3 programming software.

3.4.2 Outline of Flash Memory Writing

The R9A02G011 supports serial programming interface like the RL78 MCU series. The code flash memory can be rewritten through serial programming using a flash memory programmer.

The following dedicated flash memory programmers can be used to write data to the R9A02G011 flash memory. For details, refer to the related tool documents.

- PG-FP6
- E1, E2, E2 Lite, E20 on-chip debugging emulator

Data can be written to the on-board flash memory by using a dedicated flash memory programmer. Table 18 shows the relationship between the situation when writing the firmware and the available writing tool for the writing method using this interface.

Table 18. Firmware Writing Method and Available Writing Tool

Interface	Situations	Available Writing Tool	Device Configuration	R9A02G011
Serial Programming (TOOL0)	Customer's manufacturing	Example, PG-FP6, SF2000A made by Superfly China	ON board	O
	Design debug, FW update	E1, E2, E2 Lite, E20 on-chip debugging emulator	ON board	O

3.4.2.1 On-Board Programming

The contents of the flash memory can be rewritten after the R9A02G011 has been mounted on the target system. The connectors that the dedicated flash memory programmer uses must be mounted on the target system.

Use the Renesas Flash Programmer V3 programming software. Refer to the following documents:

- *Renesas Flash Programmer V3.13 Flash memory programming software User's Manual* (R20UT5312)
- *List of MCUs supported by Renesas Flash Programmer V3* (R20UT3599)
- On the development of flash memory programmer by user, refer to *RL78 Microcontrollers (RL78 Protocol A) Programmer Edition Application Note* (R01AN0815).

Flash programing for R9A02G011 is compatible with the RL78 MCU series. Therefore, if using an available flash memory programmer that supports RL78 MCU, porting the library for that programmer is possible. Contact support for assistance.

Table 19. Wiring between R9A02G011GNP and Dedicated Flash Memory Programmer

Pin Configuration of Dedicated Flash Memory Programmer				Pin name	Pin No.
					R9A02G011GNP 32pin
Signal Name		IO	Pin Function		HVQFN
PG-FP6	E1, E2, E2 Lite, E20 on-chip debugging emulator				
SI/RxD	TOOL0	I/O	Transmit/receive signal	P40	7
/RESET	RESET	Output	Reset signal	RESETB	25
VDD	VDD	I/O	VDD voltage	VDD	20
GND	GND	-	Ground	GND Pad	GND PAD
FLMD1	EMVDD	-	Driving power for TOOL0 pin	VDD	20

Table 20. Wiring between R9A02G011GBG and Dedicated Flash Memory Programmer

Pin Configuration of Dedicated Flash Memory Programmer[1]				Pin name	Pin No.
					R9A02G011GBG 42pin
Signal Name		IO	Pin Function		BGA
PG-FP6	E1, E2, E2 Lite, E20 on-chip debugging emulator				
SI/RxD	TOOL0	I/O	Transmit/receive signal	P40	G1
/RESET	RESET	Output	Reset signal	RESETB	A5
VDD	VDD	I/O	VDD voltage	VDD	D4/D5/D6
GND	GND	-	Ground	GND Pad	A1/B1/G6
FLMD1	EMVDD	-	Driving power for TOOL0 pin	VDD	D4/D5/D6

1. Pins that are not indicated can be left open when using the flash memory programmer for flash programming.

3.4.3 FW Writing with Renesas On-Chip Debugging Emulator

Writing (load) firmware by Renesas on-chip debugging emulator is available. Since RTK-251-SinkCharger-RAA489118 does not have a full 14-pin connector for the emulator, connecting using a converter is required. The converter is made with a bundled cable when using Renesas on-chip debugging emulator.

1. Connect the conversion connector to CN14 on the board.
2. Connect the Renesas on-chip debugging emulator to the conversion connector.
3. Connect the emulator to the USB port of the PC.

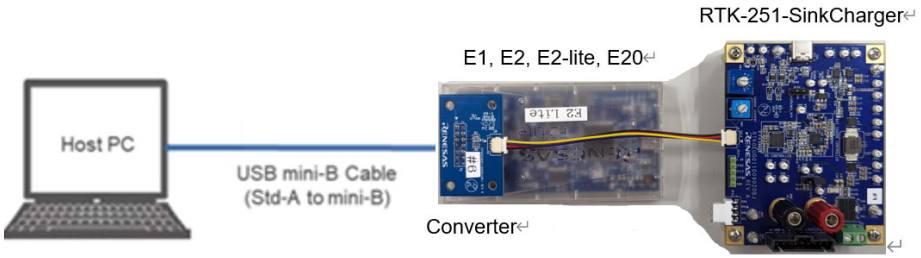


Figure 15. Board Connection for Programming by On-Chip Debugging Emulator

4. Execute the Renesas Flash Programmer V3.xx.
5. Create a New Project.

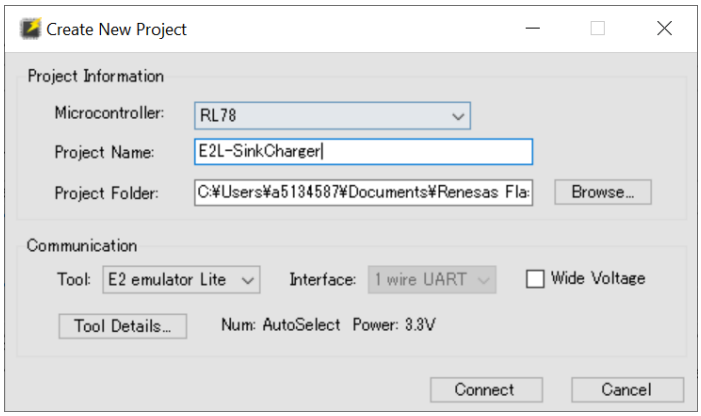


Figure 16. Create New Project Window

6. Select the **RL78** in the **Microcontroller** drop-down, input an arbitrary name in the **Project Name** field.
7. Select your on-chip debugging emulator product in the **Tool** drop-down.

8. Click the **Tool Details** and select the 3.3V in the **Power Supply** area, then click **Connect**.

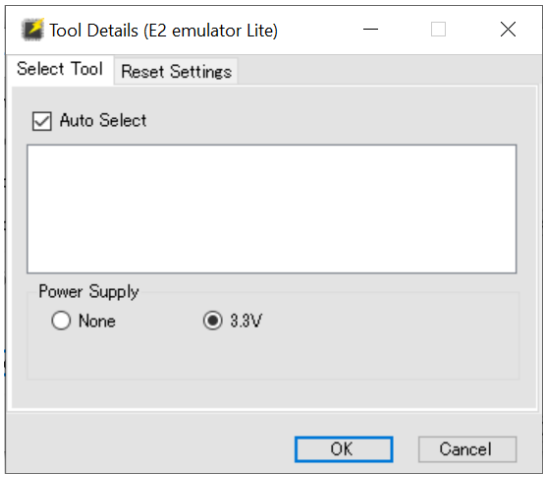


Figure 17. Tool Details Window

9. The following window appears if the new project is created correctly.

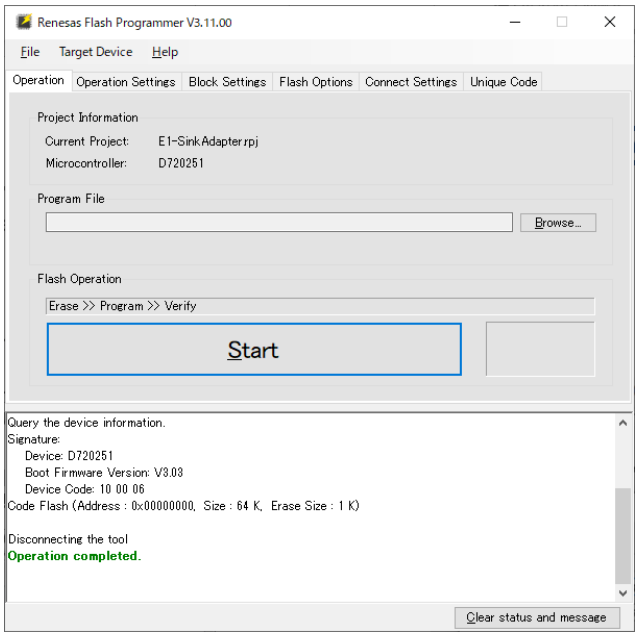


Figure 18. Project Information Window

Note: Confirm that the Microcontroller can detect D720251.

10. Select the **Erase**, **Program**, and **Verify** in the **Operation Settings** tab.

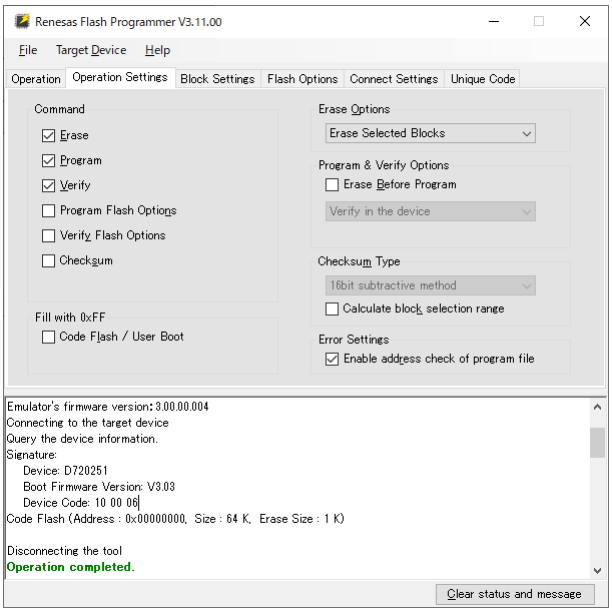


Figure 19. Operation Settings Tab

11. Click **Start** to start programming the flash memory data

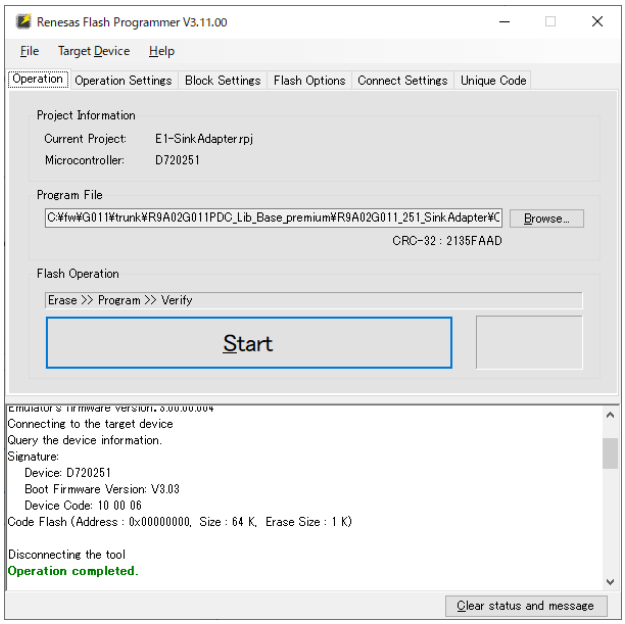


Figure 20. Operation Tab - Start Programming

12. **OK** is indicated if the program is completed successfully.

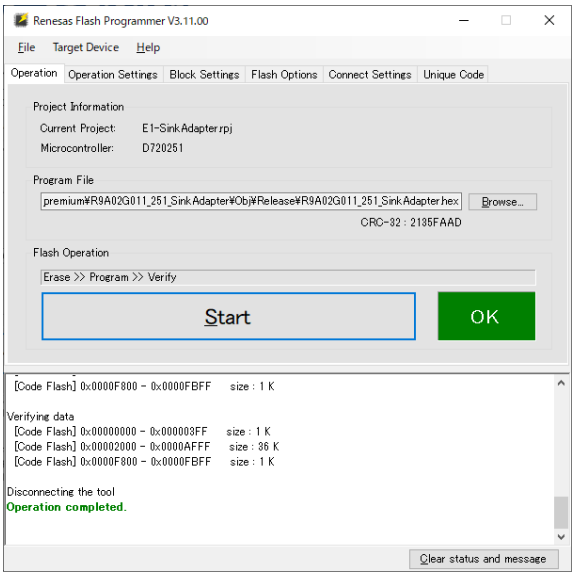


Figure 21. Successful Program Indicator

4. Optional Features

4.1 Supports USB Peripheral Function

RTK-251-SinkCharger-RAA489118 is designed for Sink only (SNK) Charger / Power Bank turnkey solution. There is no USB data communication feature on this board. It has an interface to expand the test/debug of USB2.0 based peripheral function with system.

DP
DM
Attached UFP

Figure 22. Connector for USB2.0-Based Peripheral Debugging

To debug USB2.0 peripheral on the RTK-251-SinkCharger-RAA489118, if there is a jumper between DP and DM of JP30, remove it and connect D+/D- signaling of system to DP/DM of JP30. Since V_{BUS} appears 0V~20V (maximum), the signal pin Attached UFP is allocated on JP30 to detect attach/detach on Type-C. The system can detect Type-C attach/detach by using this signal.

4.2 Supports SMBus Target Interface

RTK-251-SinkCharger-RAA489118 has an SMBus Target Interface to communicate with other controllers outside of this board. It is an interface to expand the feature with a total system.

Figure 23. Connector for SMBus Target Interface

To control the RTK-251-SinkCharger-RAA489118 board using an external controller through the SMBus Target Interface, connect the SMBus Controller signaling of the system to JP271. When the system wants to control RTK-251-SinkCharger-RAA489118, contact Renesas for support.

5. Ordering Information

Part Number	Description
RTK0EUG011D09020BJ	RTK-251-SinkCharger-RAA489118 (2-7 Cells)

6. Revision History

Revision	Date	Description
1.00	Nov 13, 2024	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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