# US274-100USBPDPOCZ

100W USB Power Delivery (PD) Source

## Description

The US274-100USBPDPOCZ board is a Universal Serial Bus Power Delivery (USB PD) evaluation board that supports DC input and USB PD output. It is designed with the RAA489000 – a digitally configurable buck-boost battery charger with USB-C® Port Controller (TCPC).

The US274-100USBPDPOCZ supports USB PD 2.0, USB PD 3.1, and USB Type-C® specifications, and works as a USB Type-C SPR power source capable of delivering 100W (20V, 5A) from DC power to a USB-C interface. The RAA489000 TCPC controller integrates TCPC PHY, CC-Logic, and VCONN switches and supports reverse buck, boost, or buck-boost operation. The USB-C Port Manager (TCPM) function is implemented in the RL78F14 series MCU R5F10PBE via I²C. The LIN interface allows the charger to communicate with the other modules in automobile applications.

## 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.
- Supported features:
  - Power Role: source only
  - Under Source Only mode: US274-100USBPDPOCZ can provide SPR mode 5, 9, 15, or 20 V output as USB Type-C power sourcing device
- One USB Type-C port
- Interface:
  - Renesas on-chip debugging emulator interface to write and debug firmware for R5F10PBE

## Target Devices

- RAA489000 – a USB-C Port Controller (SPR TCPC) and buck-boost battery charger
- R5F10PBE – a USB-C Port Manager (TCPM: 32-pin plastic VQFN, 64kB Flash, 6kB RAM)

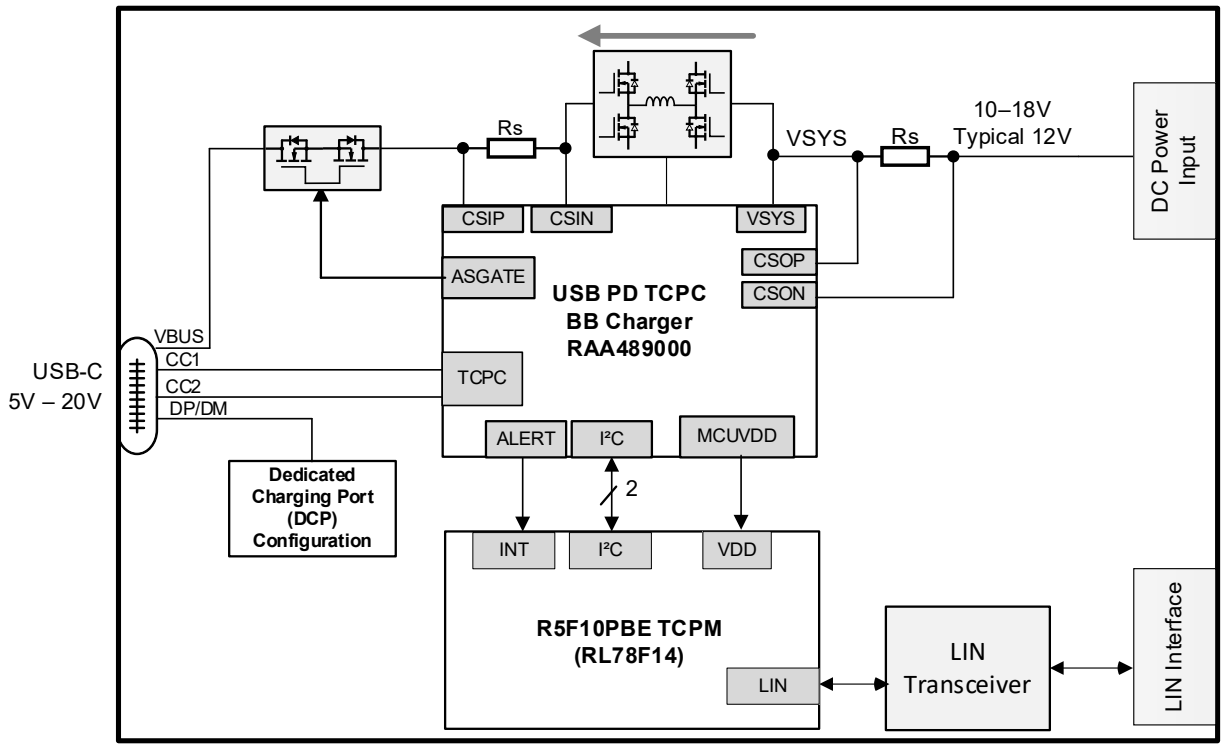


**Figure 1. US274-100USBPDPOCZ Block Diagram (20V, 5A, SPR Mode)**

# Contents



# Figures



# Tables

# 1. Related Documents

Use the US274-100USBPDPOCZ Evaluation Board manual in combination with the following documents:

- RAA489000 Datasheet
- R5F10PBELNA#G5 User Manual
- E1 Emulator E20 Emulator User's Manual
- E2 Emulator Lite User's Manual
- E1/E20 Emulator, E2 Emulator Lite Additional Document for User's Manual (Notes on Connection of RL78)
- Renesas Flash Programmer V3.13 Flash Memory Programming Software User's Manual

*Note*: The related documents above may include preliminary versions. However, preliminary versions are not always marked accordingly.

# 2. Board Design

## 2.1 Overview

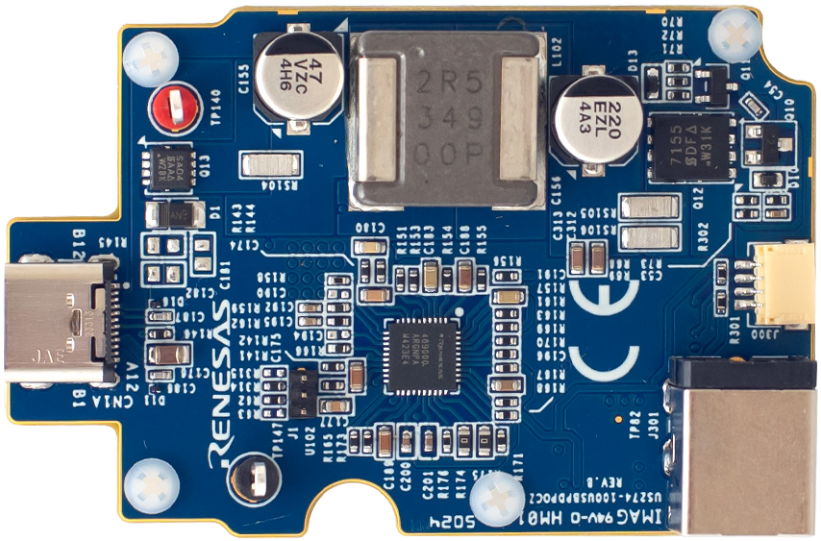

**Figure 2. US274-100USBPDPOCZ USB PD Source Evaluation Board (Top)**

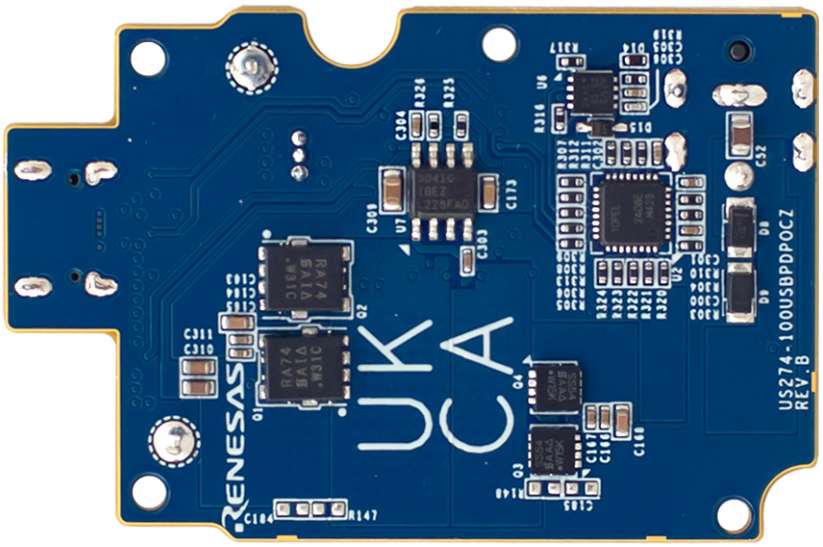


**Figure 3. US274-100USBPDPOCZ USB PD Source Evaluation Board (Bottom)**

## 2.2 Required Materials

- US274-100USBPDPOCZ: 1 unit
- USB Type-C Cable: 1pc (when the required maximum Type-C sourcing PD Power is 20V at 5A, 5A cable or EPR cable that has 5A capability is required.)

***Important***: Renesas does not have any responsibility, indemnification, or liability for the use of this board.

## 2.3 Board Components

The following is an overview of only the board's main components.

*Note*: there are no switches or LEDs incorporated on this board.

### 2.3.1 ICs

- **U102** – RAA489000 (48V USB-C Port Controller: SPR/EPR TCPC, Buck Booster charger). For more details, see section 2.3.3.1.
- **U2** – R5F10PBELNA#G5 (USB-C Port Manager: TCPM). For more details, see section 2.3.3.2.
- **U6** – TJA1021TK/20 (ISO 17987/LIN 2.x/SAE J2602 transceiver)
- **U7** – ISL80410 (5V output LDO)

### 2.3.2 Connectors

- **CN1a** – USB Type-C receptacle
- **J300** – Renesas on-chip debugging emulator interface
- **J301** – DC power input
- **J1** – $I^2C$/SMBus Target SCL, SDA, on R5F10PBE (U2: P10/P11 or P62/P63)

### 2.3.3 Test Points

- **TP140** – USB C VBUS
- **TP147** – GND

#### 2.3.3.1 RAA489000 Pin Assignments and Functions

| Pin Name | Function | Description |
|---|---|---|
| Bottom Pad | GND | Ground. |
| VDDP | VDD | Power supply for the gate drivers. Connected to the VDD pin through a resistor. |
| 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. |
| BGATE | Open | - |
| VBAT | VAUTO | DC jack input voltage sense input. |
| CSON | CSON | DC jack input current sense "-" input. |
| CSOP | CSOP | DC jack input current sense "+" input. |
| NC | Open | - |
| PROG | PROG | With 232ohm PROG-GND resistor, $I^2C$ Address is 1 and the default current limit is 0.476A. |
| COMPF | COMPF | Error amplifier output for Forward/Charging mode. |
| COMPR | COMPR | Error amplifier output for Reverse/OTG mode. |

| Pin Name | Function | Description |
|---|---|---|
| AMON/BMON (IMON) | Open | - |
| ACLIM | ACLIM | hardware-based adapter current limit. |
| ASRC | Gate | N-channel MOSFET source input reference for ASGATE/PD FETs. |
| CSIN | CSIN | Current sense “-“ input from VBUS path. |
| CSIP | CSIP | Current sense “+” input from VBUS path. |
| ASGATE | Gate | Gate drive output of the N-channel system back to back MOSFETs. |
| VBUS | VBUS | USB-C VBUS; input to the HV selector for LDO power. |
| VSYS | VSYS | DC jack input voltage; input to the HV selector for LDO power. |
| BATGONE/NTC | BATGONE | Pull down to GND by 10kohm resistor. No battery present. |
| VDD | VDD | Output of the internal LDO |
| PROCHOT# | Open | - |
| MCU_VDD | VDD | Output for the 3.3V LDO to supply an external RL78 MCU. |
| VDD2P5 | Open | - |
| ALERT_C | ALERT | Interrupt line for the TCPC, SDA_C and SCL_C; open-drain ;connected to RL78 MCU. |
| CC1 | CC1 | Configuration Channel 1. |
| CC2 | CC2 | Configuration Channel 2. |
| ALERT_B | ALERT | Open-drain output. Interrupt function output. |
| SCL_B | SCL_B | SMBus target clock input connected to RL78 MCU. |
| SDA_B | SDA_B | SMBus target data input/output (open-drain) connected to RL78 MCU. |
| VCONN_POWER | VCONN | Power supply (+5V) for VCONN. |
| SCL_C | SCL_C | SMBus target clock IO connected to RL78 MCU; for TCPC. |
| SDA_C | SDA_C | SMBus target data IO (open-drain) connected to RL78 MCU; for TCPC. |
| OTGEN/CMIN | DRP | Connected to MCU_VDD through 10k resistor. |
| 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. |

### 2.3.3.2 R5F10PBE Pin Assignments and Functions

| Pin Name | Function | Description |
|---|---|---|
| P120 | Open | - |
| P41 | Open | - |
| P40/TOOL | TOOL0 | Connected to on-chip debugging emulator interface for flash programming. |
| RESET | RESET | Chip Reset Input (active low). |
| P137/INTPO | ALERT_B | SMBus controller ALERT_B input connected to RAA489000. |
| P122 | Open | - |
| P121 | Open | - |
| REGC | REGC | Regulator capacitance. Connecting regulator output stabilization capacitance for internal operation. |
| VSS | GND | Ground. |
| VDD | VDD | Power supply (+3.3V) connected to MCU_VDD pin of RAA489000. |
| P60 | Open | - |
| P61 | Open | - |
| P62/ SCLLA0 | SCL_C | SMBus target clock input connected to SCL_C of RAA489000. |
| P63/SDAAA0 | SDA_C | SMBus target data input/output (open-drain) connected to SDA_C of RAA489000. |
| P30/INTP2 | ALERT_C | SMBus controller ALERT_C input connected to RAA489000. |
| P17/SCL00 | Open | - |
| P16/SDA00 | Open | - |
| P15 | Open | - |
| P14/LRXD0 | LIN_TDX | Currently not supported by firmware. |
| P13/LTXD0 | LIN_RXD | Currently not supported by firmware. |
| P12 | LIN_SLEEP | Currently not supported by firmware. |
| P11/SDA10 | SDA_B | SMBus target clock input connected to SCL_B of RAA489000 |
| P10/SCL10 | SCL_B | SMBus target data input/output (open-drain) connected to SDA_B of RAA489000. |
| P33 | Open | - |
| P34 | Open | - |
| P80 | Open | - |
| P81 | Open | - |
| P82 | Open | - |
| P83 | Open | - |
| P84 | Open | - |
| P85 | Open | - |
| P125/INTP1 | Open | - |

# 3. Functional Operation

## 3.1 Sourcing Mode

The US274-100USBPDPOCZ runs under sourcing mode, meaning that the board draws the current from DC power and output to USB-C.

It supports the standard maximum sourcing PD power as shown in Table 1 is based on the following formula.

The standard PD power in the FW is:

- Maximum supply current (3 or 5A) × standard supply voltage (SPR: 5, 9, 15, or 20V)
- 5, 27, 45, or 60 W (SPR and 3A cable), or 100W (SPR and 5A cable)

The maximum sourcing PD power in the FW ≤ available sourcing power.

The USB-PD fixed PDO list, which is used on PD negotiation, is as follows:

**Table 1. PDO List**

| | SPR PDO1 | SPR PDO2 | SPR PDO3 | SPR 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 |
| PDP 100W | 5V/3A | 9V/3A | 15V/3A | 20V/5A [1] |

1. When the connected cable does not have 5A capability, the US274-100USBPDPOCZ presents 20V/3A PDO instead of 20V/5A PDO.

*Note*: The range of DC input voltage is 11V–18V. If the DC input is lower than 11V, some of the PDO requests in Table 1 might not be achieved.

## 3.2 Firmware Writing to the RL78

This section describes the method of writing the firmware (for example, Intel HEX file) to the RL78F14 MCU.

### 3.2.1 Firmware Generation – ROM Image File

The US274-100USBPDPOCZ board is shipped with the default firmware already flashed.

*Note*: The instruction tool “VIDWriter” that generates the firmware is currently under development.

### 3.2.2 Outline of Flash Memory Writing

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 flash.

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

For more details, refer to the Related Documents section.

Data can be written to the flash memory on-board by using a dedicated flash memory programmer. Table 2 shows the relationship between the situation of the firmware writing method and the available writing tool using this interface.

**Table 2. Firmware Writing Method and Available Writing Tool**

| Interface | Situation | Available Writing Tool | Device |
|---|---|---|---|
| Serial Programming (TOOL0) | Customer's manufacturing | Example: PG-FP6<br>SF2000A made by Superfly China | On-board |
| | Design debug, FW update | E1, E2, E2 Lite, E20 on-chip debugging emulator | On-board |

#### 3.2.2.1 On-Board Programming

The contents of the flash memory can be rewritten after the MCU have 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 as programming software. Refer to the following documents:

- Renesas Flash Programmer V3.13 Flash Memory Programming Software User's Manual
- List of MCUs supported by Renesas Flash Programmer V3
- RL78 microcontrollers (RL78 Protocol A) Programmer Edition Application Note (on the development of flash memory programmer by user)

**Table 3. Wiring between RL78/F14 MCU R5F10PBE and Dedicated Flash Memory Programmer**

| Pin Configuration of Dedicated Flash Memory Programmer | | | | R5F10PBE 32-pin QFN | |
|---|---|---|---|---|---|
| Signal Name | | IO | Pin Function | | |
| PG-FP6 | E1, E2, E2 Lite, E20 on-chip debugging emulator | | | Pin Name | Pin No. |
| SI/RxD | TOOL0 | I/O | Transmit/Receive signal | P40 | 3 |
| /RESET | RESET | Output | Reset signal | RESET | 4 |
| VDD | VDD | I/O | VDD voltage | VDD | 10 |
| GND | GND | - | Ground | GND Pad | GND PAD |
| FLMD1 | EMVDD | - | Driving power for TOOL0 pin | VDD | 10 |

*Note*: Pins that are not indicated in the above table can be left open when using the flash memory programmer for flash programming.

### 3.2.3 Firmware Writing with Renesas On-chip Debugging Emulator

Firmware can written (loaded) with the Renesas on-chip debugging emulator. Since the US274-100USBPDPOCZ does not have a full 14-pin connector for the emulator, the connection is made via a converter made with the bundled cable when using the Renesas on-chip debugging emulator. Follow the steps below.

1. Connect conversion connector to J300 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.

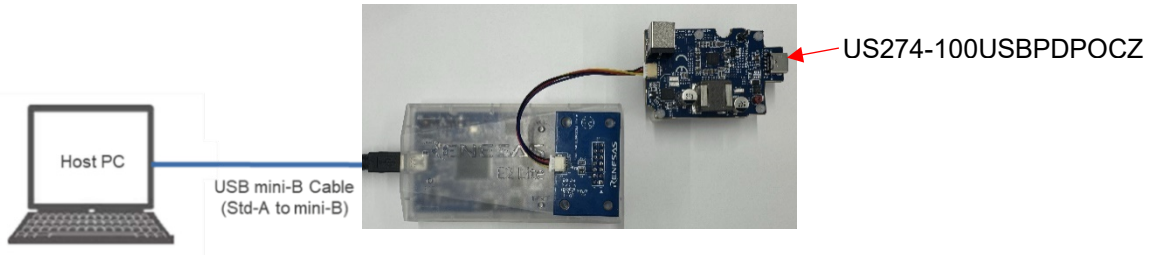


**Figure 4. Board Connection for Programming by On-chip Debugging Emulator**

4. Execute the Renesas Flash Programmer V3.xx.
5. Create a “New Project”. See Figure 5.

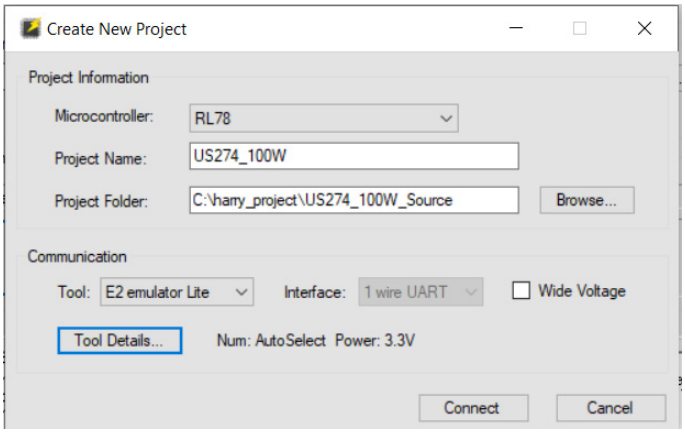


**Figure 5. New Project Window**

6. Select *RL78* from the “Microcontroller” pull-down list, then input an arbitrary name in the “Project Name” field.
7. Select the preferred on-chip debugging emulator product in the “Connection > Tool” pull-down list.
8. Click *Tool Details* and select “3.3V" Power Supply, then click *OK*. See Figure 6.

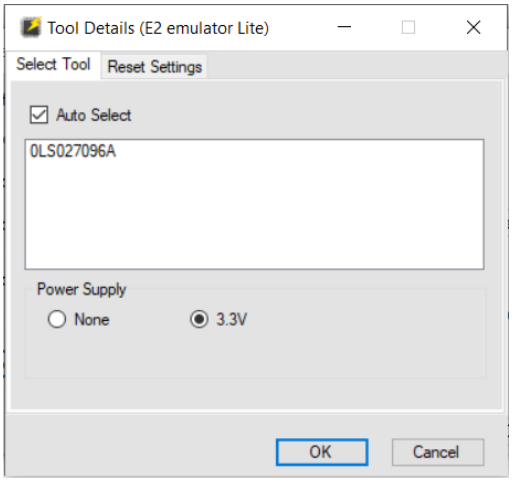


**Figure 6. Power Supply Connection Window**

After selecting the Power Supply, click *Connect* in the “Create new Project” window.

9. Once the project has been successfully created, the following window displays (see Figure 7).
   *Note*: confirm that the Microcontroller detects **R5F10PBE**.

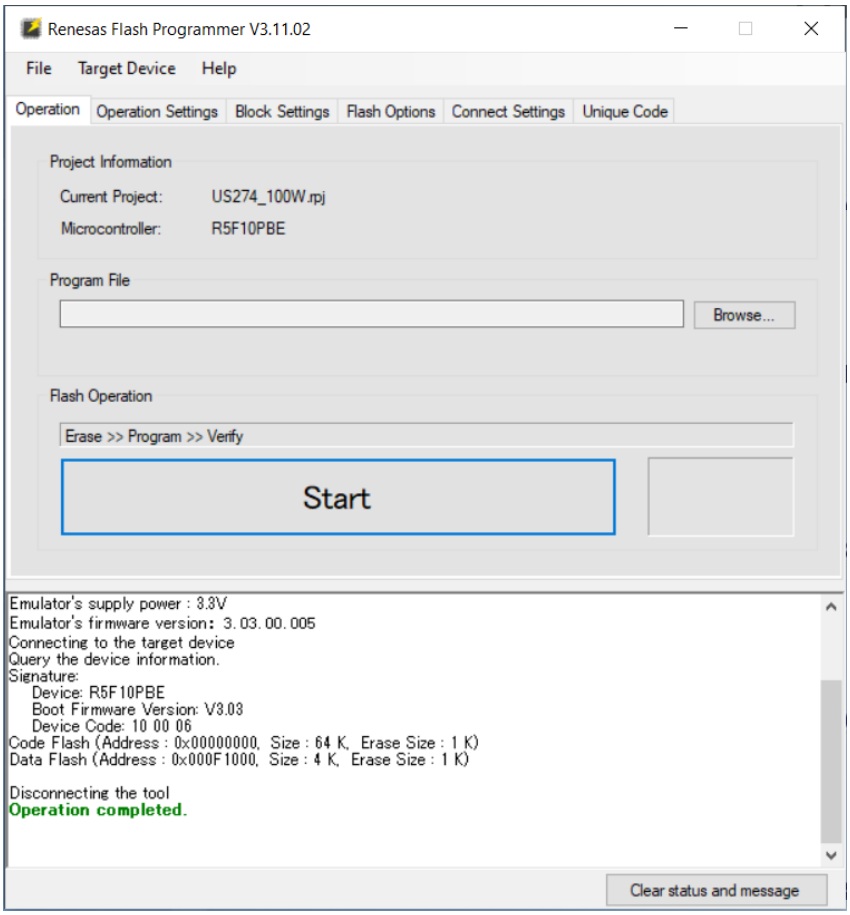


**Figure 7. Renesas Flash Programmer Window – Operation Tab**

10. Click on the “Operation Settings” tab (see Figure 8). Check the *Erase*, *Program* and *Verify* boxes.

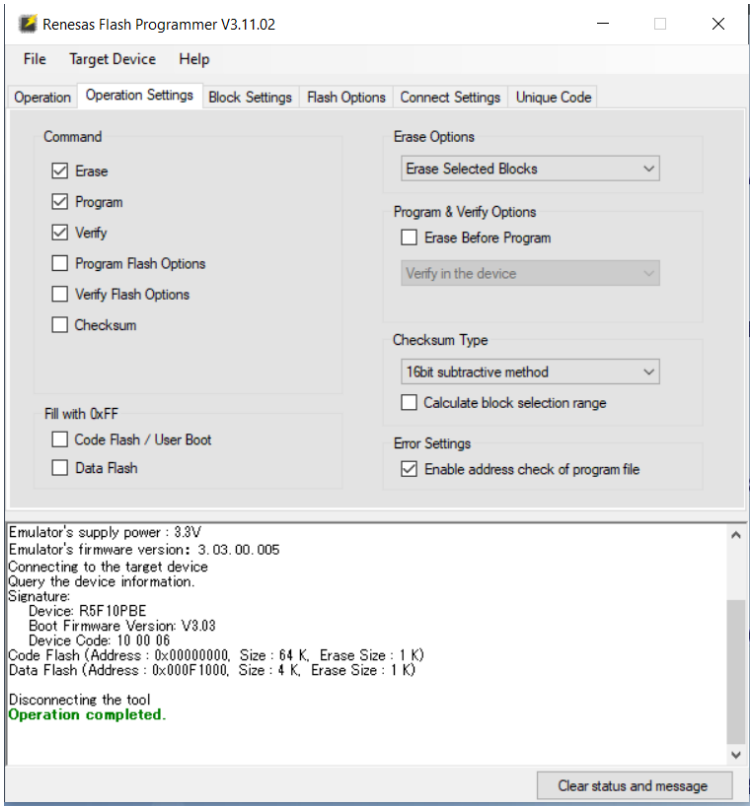


**Figure 8. Operation Setting Tab**

11. Select the “Operation” tab and click on *Browse* to select the HEX file (see Figure 9). Click the *Start* button to start programming the flash memory data.

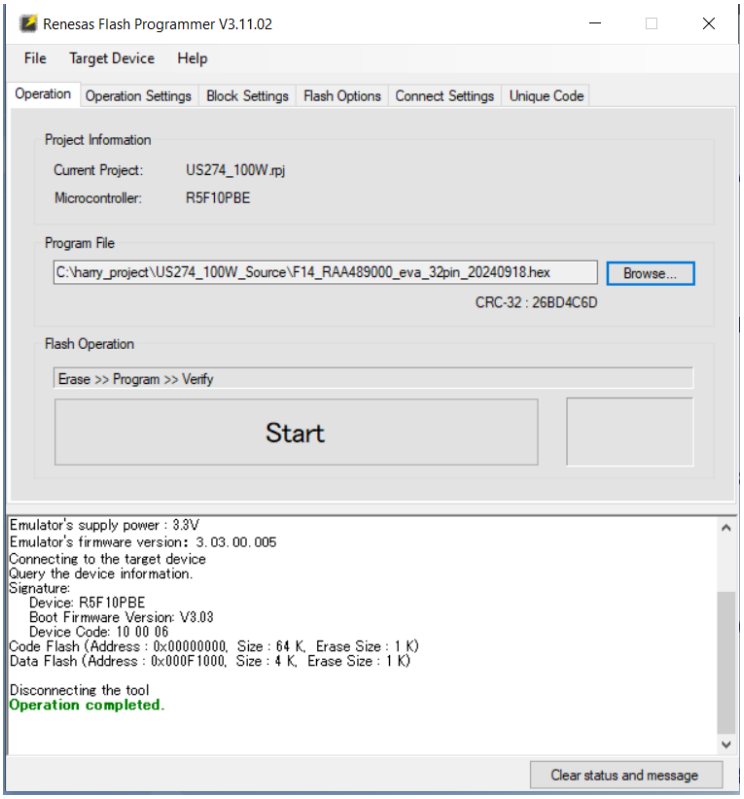


**Figure 9. Select HEX File**

12. If the program is successfully completed, the green *OK* indicator displays (see Figure 10).

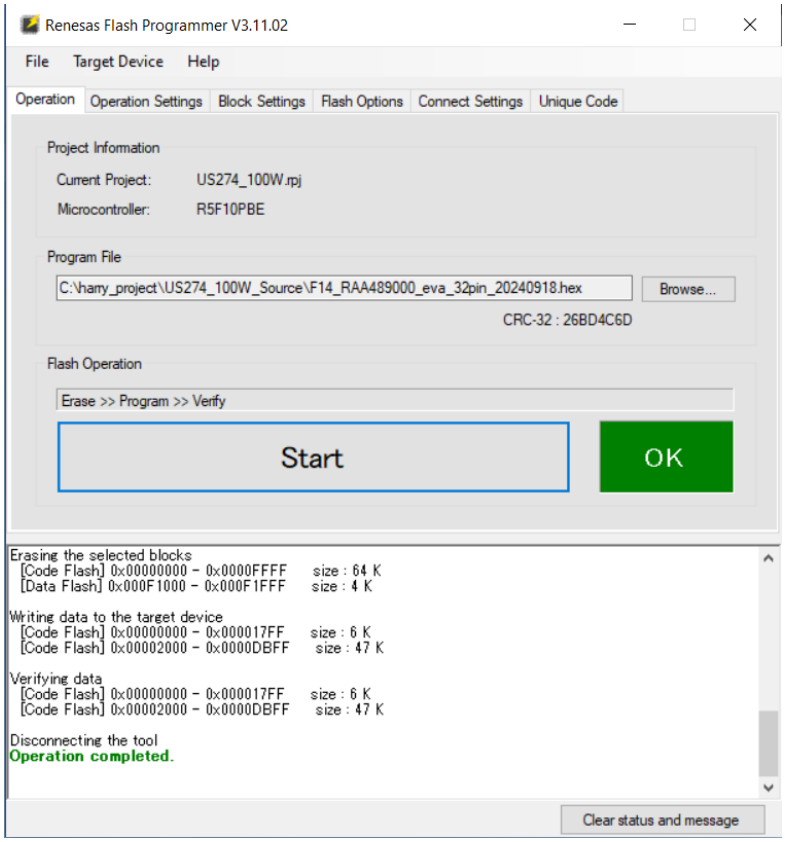


**Figure 10. Program Success Window**

## 3.3 Board Test

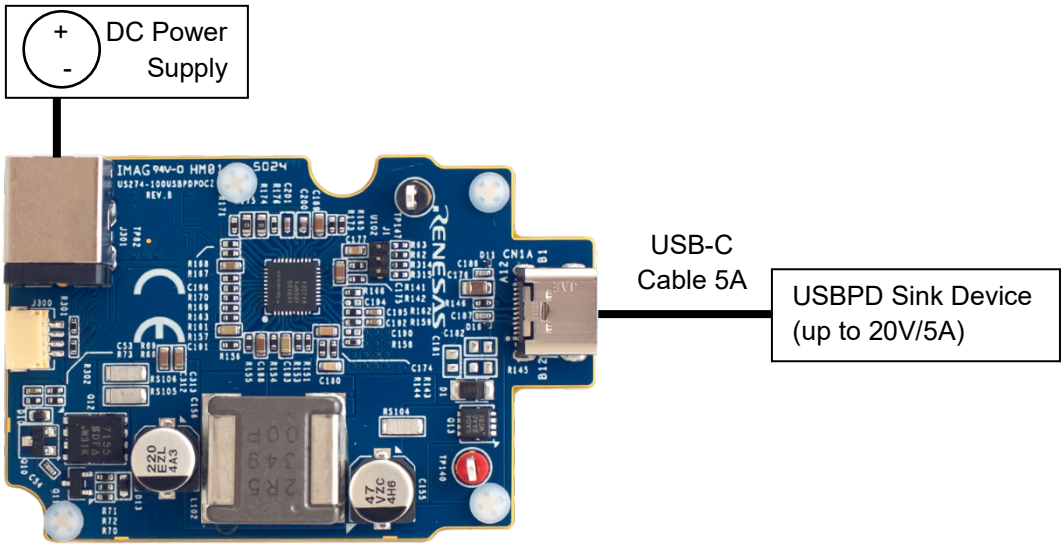


**Figure 11. Board DC Power Supply Input and USBPD Output**

### 3.3.1 DC Input

The range of DC input voltage is 11V–18V. If the DC input is lower than 11V, some of the PDO requests in Table 1 might not be achieved. Typically, DC input can be set to 12V. The DC power supply should be able to provide at least 150W/up to 15A power.

A male plug is required to match the DC jack (ID:2.50mm/0.098, OD: 5.50mm/0.217, Mating Depth: 0.324" /8.23mm) on the board for the DC cable. The current rating of the DC cable is at least 10A.

### 3.3.2 USB PD Output

- The US274-100USBPDPOCZ works as a source device. A USB PD device requiring less than 100W can be powered by this board.
- User 5A USB C cable for test.
- The USB-C output voltage is decided by the requested PDO by the USB PD sink device (see Table 1).
- The range of output voltage on the USB Type-C receptacle is 0.95 × PDO voltage to 1.05 × PDO voltage. For example, if it is 5V output, the actual output voltage will be in the range of 4.75V to 5.25V depending on the current load. The maximum current is 3A for 5V, 9V, 15V and the maximum current can be up to 5A for 20V PDO.
- TP140(VBUS) and TP147(GND) can be used for the voltage measurement of USB-C output.
- A USB-C meter/tester is recommended to measure the voltage and current of USB-C output.

# 4. Optional Features

## 4.1 SMBus Target Interface

The board has an SMBus target interface to communicate with other controllers outside of this board to expand the feature with the total system.

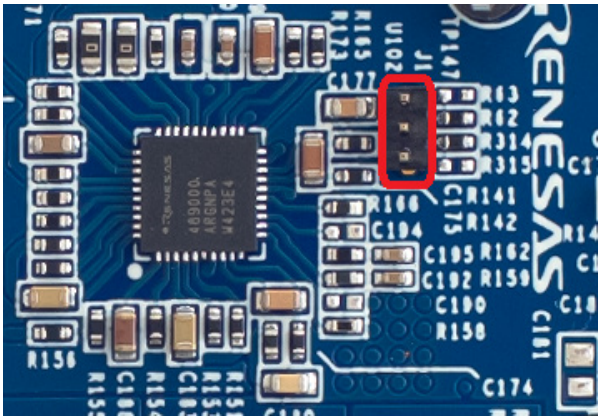


**Figure 12. Connector for SMBus Target Interface**

To control US274-100USBPDPOCZ by external controller via the SMBus Target Interface, the SMBus Controller signaling of the system is to be connected to J1.

*Note*: The shipped software does not support SMBus target interface. For more information, contact Renesas support.

## 4.2 LIN Interface

The board has a LIN interface to communicate with other controllers outside of this board. The LIN interface is accessed via TP82.

*Note*: The shipped software does not support LIN interface. For more information, contact Renesas support.

# 5. Ordering Information

| Part Number | Description |
|---|---|
| US274-100USBPDPOCZ | 100W USB Power Delivery Source Evaluation Board |

# 6. Revision History

| Revision | Date | Description |
|---|---|---|
| 1.00 | Mar 18, 2025 | Initial release. |

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