EVAL_PMG1_B1_DRP kit guide

About this document

Scope and purpose

The EVAL_PMG1_B1_DRP is an evaluation kit for the EZ-PD™ PMG1-B1 USB Power Delivery (PD) microcontroller (MCU) with an integrated buck-boost battery charger. EZ-PD™ PMG1-B1 is targeted for battery-powered applications that are powered by USB-C PD such as cordless power tool chargers, wireless speakers, and portable electronics. EZ-PD™ PMG1 (Power Delivery Microcontroller Gen1) is a portfolio of high-voltage USB-C PD microcontrollers. These MCUs include Arm® Cortex® CPU core, USB-C PD controller, and configurable integrated analog and digital peripherals. EZ-PD™ PMG1-B1 is targeted at embedded systems that power from USB-C port and need an MCU to implement the product features.

Intended audience

This document is intended for designers who want to Sink or Source power through the USB-C PD port in applications such as the cordless power tool charger, wireless speakers, and portable electronics. The kit can be used to sink up to 100 W and source up to 27 W. The kit can also be used to charge 2 cell-5 cell batteries, and the battery charging algorithm is implemented as part of PMG1-B1 SDK in ModusToolbox™ software.

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Table 1 Safety precautions

	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *Maximum current that can be consumed by an external load connected to the EVAL_PMG1_B1_DRP kit board cannot exceed 7 A*
	**Caution:** *The EVAL_PMG1_B1_DRP kit board contains ESD-sensitive devices. Electrostatic charges readily accumulate on the human body and any equipment, which can cause a discharge without detection. Permanent damage may occur to devices subjected to high-energy discharges. Proper ESD precautions are recommended to avoid performance degradation or loss of functionality. Store unused EVAL_PMG1_B1_DRP kit boards in the protective shipping package*
	**Warning:** *End-of-life/product recycling* *The end-of-life cycle for this kit is five years from the date of manufacture mentioned on the back of the box. Contact the nearest recycler to discard the kit*
	**Caution:** *The EVAL_PMG1_B1_DRP kit is intended for use as an evaluation platform for hardware or software in a laboratory environment. The board is an open-system design, which does not include a shielded enclosure. Due to this reason, the board may cause interference to other electrical or electronic devices in close proximity. In such cases, take adequate preventive measures. Also, do not use this board near any medical equipment or RF devices.*
	**Caution:** *Attaching additional wiring to this product or modifying the product operation from the factory default may affect its performance and cause interference with other apparatus in the immediate vicinity. If such interference is detected, suitable mitigating measures must be taken.*

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1 Introduction

The EVAL_PMG1_B1_DRP is an evaluation kit for EZ-PD™ PMG1-B1 USB Power Delivery (PD) microcontroller (MCU) with integrated buck-boost battery charger. EZ-PD™ PMG1-B1 is targeted for battery powered applications that are powered by USB-C PD, such as cordless power tool chargers, wireless speakers, and portable electronics.

EVAL_PMG1_B1_DRP can be used to Sink or Source power through the USB-C PD port in applications such as the cordless power tool charger, wireless speakers, and portable electronics. The kit can be used to sink up to 100 W and source up to 27 W. The kit can also be used to charge 2cell-5cell batteries, and the battery charging algorithm is implemented as part of PMG1-B1 SDK in ModusToolbox™ software.

1.1 Kit contents

- EVAL_PMG1_B1_DRP kit board
- Quick start guide

1.2 Hardware not included with the kit

The EVAL_PMG1_B1_DRP kit requires the following items to perform the Kit operation or demo.

- A USB -C power adapter that can supply power over the Type-C port
- Electronically marked USB-C cable (if not already provided with the USB-C power adapter) for connecting the USB Type-C power adapter to the Type-C receptacle on the EVAL_PMG1_B1_DRP kit
- 2cell to 5cell lithium-ion battery that can be charged using EVAL_PMG1_B1_DRP kit
- Multimeter and other measurement equipment
- A 3-mm flat-head screwdriver

1.3 Getting started

For instructions on how to run a quick demonstration and observe the kit functionality, see Kit operation or demo.

2 Hardware

This chapter covers the hardware details of the EVAL_PMG1_B1_DRP kit board, a complete system overview, and description of the critical circuit blocks of the EVAL_PMG1_B1_DRP kit board schematic. For more details, see the schematics of the EVAL_PMG1_B1_DRP kit board on the kit web page.

2.1 Board details

Figure 1 shows the front view of the board with critical components highlighted.

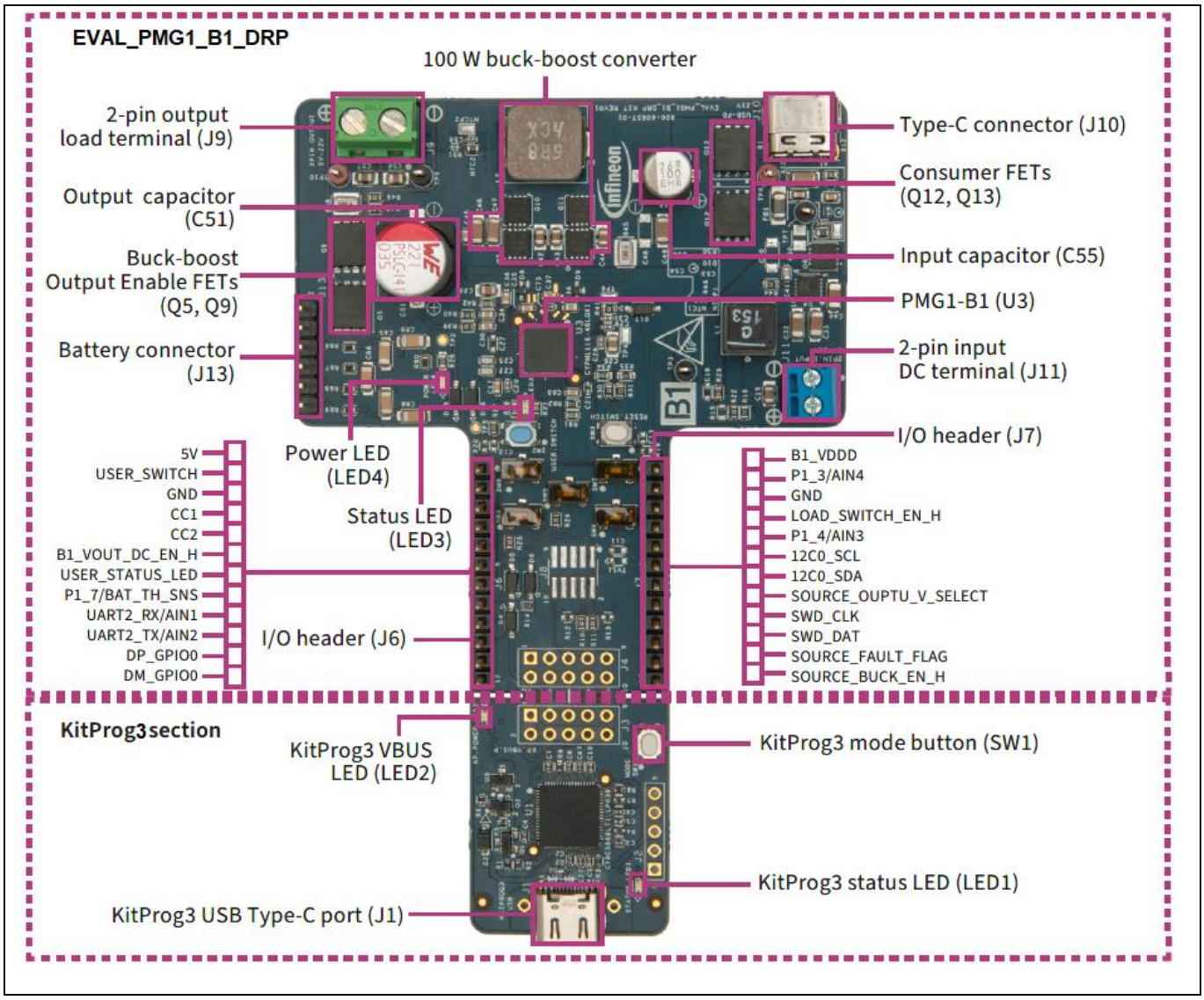


Figure 1 Board (top view) details

Figure 2 shows the back view of the board with critical components highlighted.

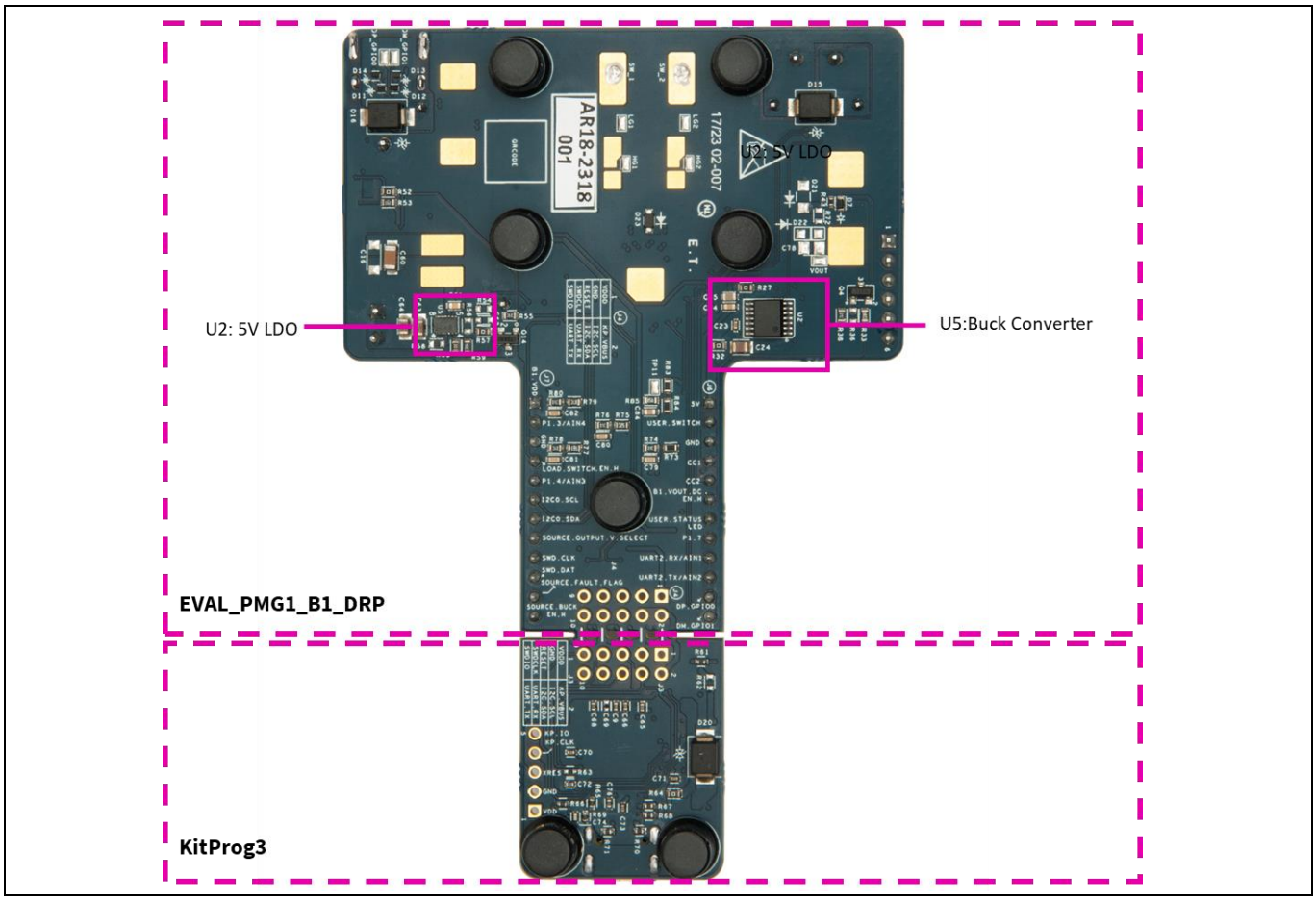


Figure 2 Board (back view) details

Table 2 lists the major components of the EVAL_PMG1_B1_DRP kit. A detailed bill-of-materials list is available in the design files on the EZ-PD™ PMG1-B1 High-voltage MCU with USB-C & PD webpage.

Table 2 List of components in the EVAL_PMG1_B1_DRP kit

REFDES	Component	Part number	Description
U3	EZ-PD™ PMG1-B1	CYPM1116-48LQXI	PMG1-B1 single-port USB Type-C PD and buck-boost controller 48-pin LQXI
Q7, Q8, Q10, Q11	Buck-Boost MOSFETs	BSZ063N04LS6ATMA1	MOSFET N-CH 40 V 15 A/40 A TSDSON
Q5, Q9	Buck-boost output enable FETs	BSC084P03NS3GATMA	MOSFET P-CH 30 V 14.9 A 8TDSON
Q12, Q13	Consumer FETs	ISC045N03L5SATMA1	MOSFET N-CH 30V 18 A/63 A TDSON
L2	Buck-boost power inductor	MPX1D1040L6R8	6.8 µH shielded drum core, wire-wound inductor 8.3 A 24.1 mΩ max nonstandard -
C55	Input electrolytic capacitor	HHXE250ARA101MF80G	CAP ALUM HYBRD 100UF 20% 25V SMD
C51	Output electrolytic capacitor	875075661008	CAP ALUM HYBRD 220UF 20% 35V SMD

Hardware

REFDES	Component	Part number	Description
J6	I/O header	TSW-112-14-G-S	CONN HEADER VERT 12POS 2.54MM
J7	I/O header	TSW-112-14-G-S	CONN HEADER VERT 12POS 2.54MM
J9	2 pin OUTPUT load terminal	691213510002	A 2-pin header to connect load up-to 5 A for testing application
J10	Type-C connector	2012670005	Type-C receptacle connector for interfacing with Type-C/PD source
J11	2-pin INPUT DC terminal	1776275-2	A 2-pin header to connect input to the buck converter
J13	Battery cell and Temperature monitoring connector	61300611121	CONN HEADER VERT 6POS 2.54MM
U5	Buck converter	AP63357	IC REG BUCK ADJ 3.5A 13DFN
U2	5-V LDO	TLE42744EV50XUMA1	Additional 5-V LDO

Table 3 EVAL_PMG1_B1_DRP kit board connector/jumper description

REFDES	Description	Default
J1	KITPROG Type-C connector used to program PMG1-B1	populated
J2	KITPROG programming connector to program U1	No load (this connector is not populated)
	Pin 1: P5LP_VDD (VDDD of U1)	
	Pin 2: GND	
	Pin 3: XRES	
	Pin 4: KP_CLK	
	Pin 5: KP_IO	
J3 & J4	KitProg3 target interface header	No load (this connector is not populated)
	Pin 1: B1_VDDD (PMG1-B1)	
	Pin 3: GND	
	Pin 5: RESET	
	Pin 7: SWDCLK	
	Pin 9: SWDIO	
	Pin 2: KP_VBUS_P	
	Pin 4: I2C_SCL	
	Pin 6: I2C_SDA	
	Pin 8: KP3_UART_RX	
	Pin 10: KP3_UART_TX	
J6	I/O HEADER	Populated
	Pin 1: 5 V (LDO)	
	Pin 2: USER_SWITCH	
	Pin 3: GND	
	Pin 4: CC1	
	Pin 5: CC2	
	Pin 6: B1_VOUT_DC_EN_H	
	Pin 7: USER_STATUS_LED	

Hardware

REFDES	Description	Default
	Pin 8: P1_7/BAT_TH_SNS	
	Pin 9: UART2_RX/AIN1	
	Pin 10: UART2_TX/AIN2	
	Pin 11: DP_GPIO0	
	Pin 12: DM_GPIO1	
J7	I/O HEADER	Populated
	Pin 1: B1_VDDD	
	Pin 2: P1_3/AIN4	
	Pin 3: GND	
	Pin 4: LOAD_SWITCH_EN_H	
	Pin 5: P1_4/AIN3	
	Pin 6: I2C0_SCL	
	Pin 7: I2C0_SDA	
	Pin 8: SOURCE_OUTPUT_V_SELECT	
	Pin 9: SWD_CLK	
	Pin 10: SWD_DAT	
	Pin 11: SOURCE_FAULT_FLAG	
	Pin 12: SOURCE_BUCK_EN_H	
J8	10-pin SWD/JTAG HEADER	No load (this connector is not populated)
	Pin 1: VTARG	
	Pin 3: GND	
	Pin 5: GND	
	Pin 7: GND	
	Pin 9: GND	
	Pin 2: SWD_DAT	
	Pin 4: SWD_CLK	
	Pin 6: NA	
	Pin 8: NA	
	Pin 10: RESET	
J9	2 pin OUTPUT load terminal	Populated
J10	Type-C connector (PMG1-B1)	Populated
J11	2-pin INPUT DC terminal	Populated
J13	Battery cell and Battery temperature monitoring connector	Populated
	Pin 1: Thermistor measurement	
	Pin 2: Cell 4 voltage measurement	
	Pin 3: Cell 3 voltage measurement	
	Pin 4: Cell 2 voltage measurement	
	Pin 5: Cell 1 voltage measurement	
	Pin 6: GND	

2.2 EVAL PMG1-B1 DRP kit block diagram and functional description

This EVAL_PMG1_B1_DRP kit has integrated the support for USB Power delivery as DRP, 2 cell - 5 cell lithium ion battery charging, battery cell monitoring, and battery temperature monitoring.

Figure 3 shows the EVAL_PMG1_B1_DRP kit block diagram.

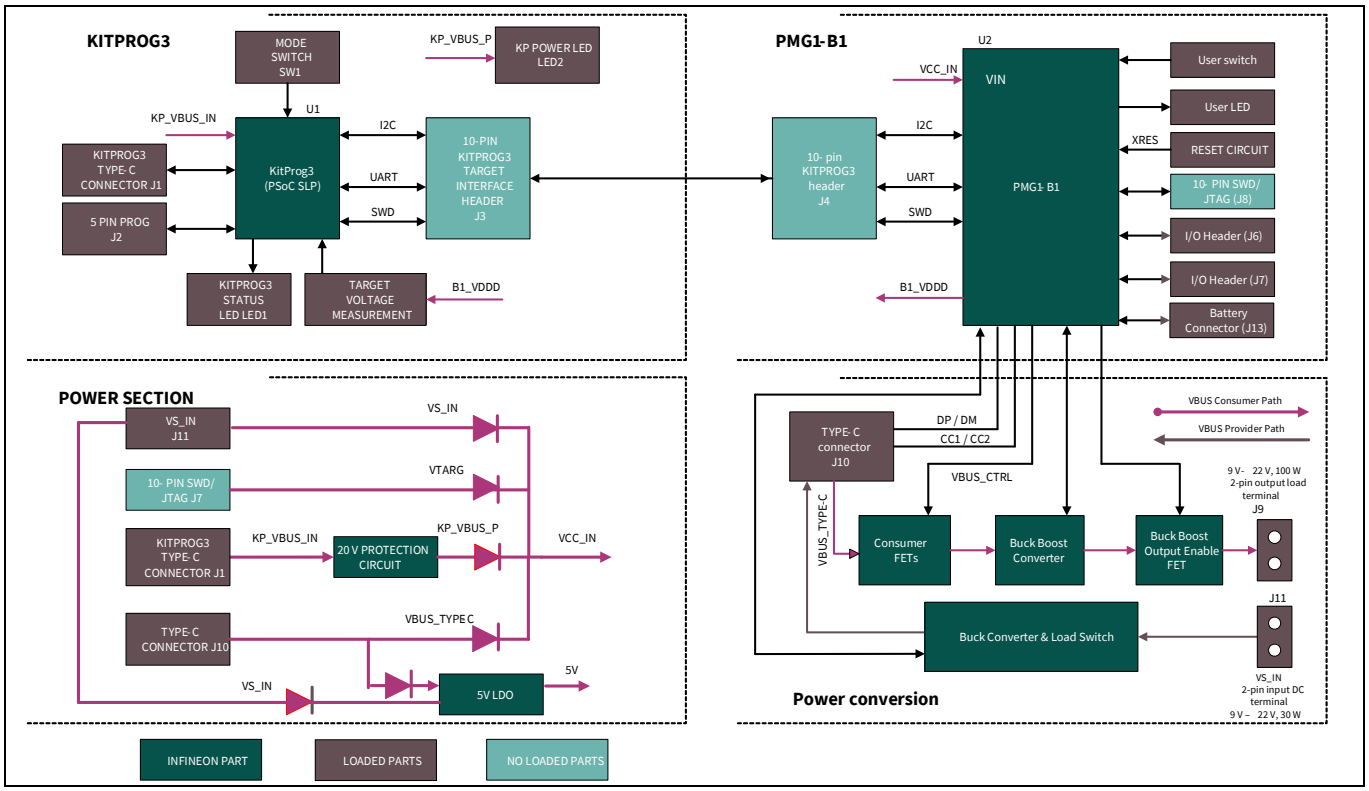


Figure 3 EVAL PMG1-B1 DRP kit block diagram

PMG1 is a family of high-voltage power delivery microcontrollers. These microcontrollers include CPU core, Power Delivery controller, and configurable integrated analog and digital peripherals. PMG1 is targeted for any embedded systems that powers from high-voltage USB-C port and needs a microcontroller to control the actions and features of a product.

PMG1-B1 is a new device in the PMG1 MCU portfolio with the following features:

- Programmable USB-PD 3.1 solution with an on-chip 32-bit Arm® Cortex®-M0 processor
- 128-KB Flash
- 16-KB RAM, 32-KB ROM
- Buck-boost controller
- Analog and digital peripherals such as NFET VBUS gate drivers, 12-bit ADC, PWMs timers, and 21x GPIOs

The EVAL_PMG1_B1_DRP kit includes the PSoC™ 5LP-based KitProg3 module to enable programming and debugging of PMG1-B1 without any additional hardware/ programmer module. There is an on-board Type-C connector to interface with the KitProg3 module. The PCB design enables users to break away the KitProg3 section of the board if required. The portion of the board which contains the PMG1-B1 MCU can operate independently even after the KitProg3 section is detached.

2.2.1 Buck-boost converter in sink mode

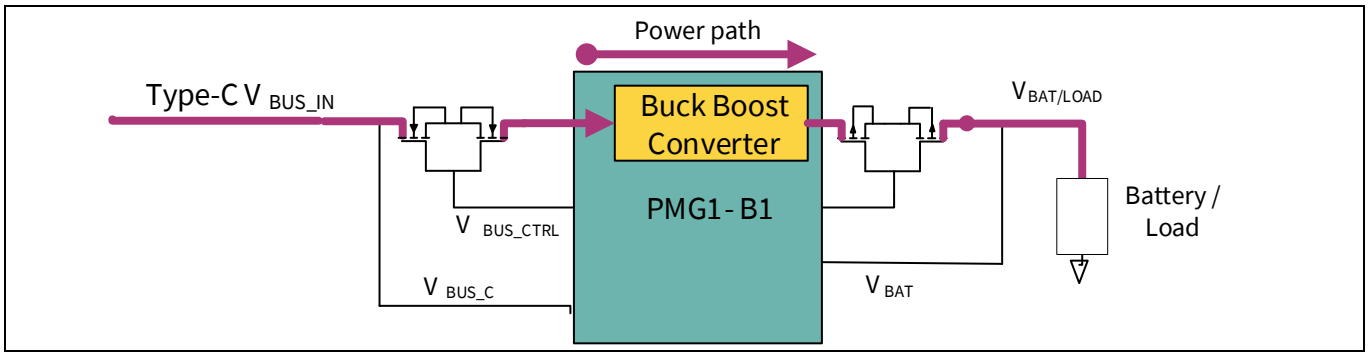


Figure 4 Buck-boost converter in sink mode of EVAL PMG1-B1 DRP kit

This kit can negotiate USB power delivery contract up to 100 W (20 V @5A) as a sink with any USB-C Charger and use the negotiated Type-C VBUS to output any fixed voltage(5 V to 21 V) or charge a lithium-ion battery in sink mode as shown in Figure 4.

2.2.2 Buck converter in Source mode

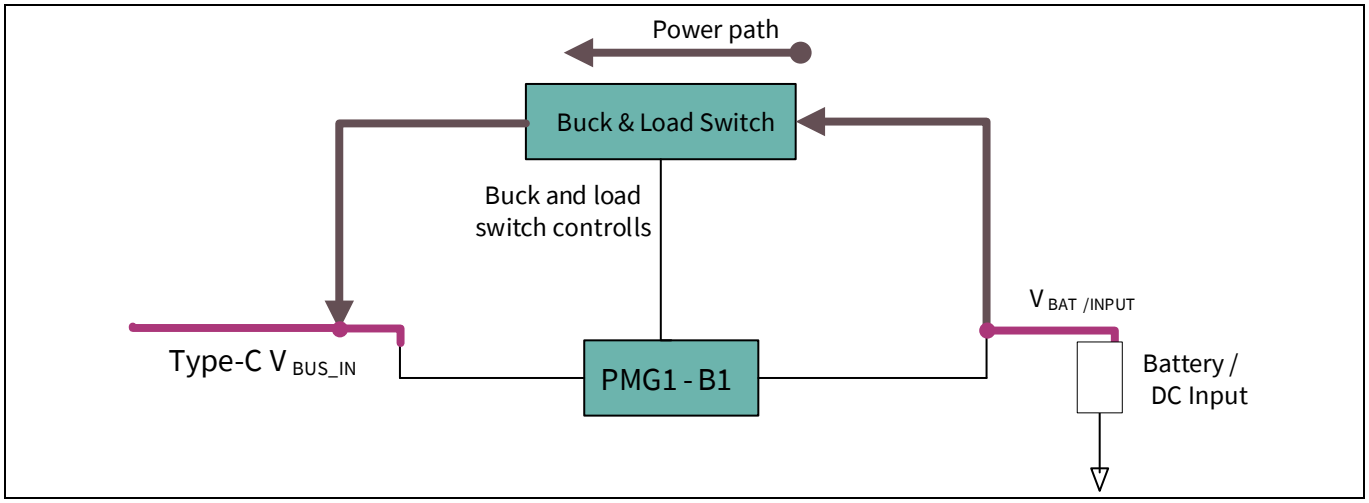


Figure 5 Buck converter in source mode of EVAL PMG1-B1 DRP kit

This kit can operate as a USB-C source and provide up to 27 W (9 V@ 3 A) and charge UCB-C devices as shown in Figure 5.

2.2.3 Battery cell and temperature monitoring

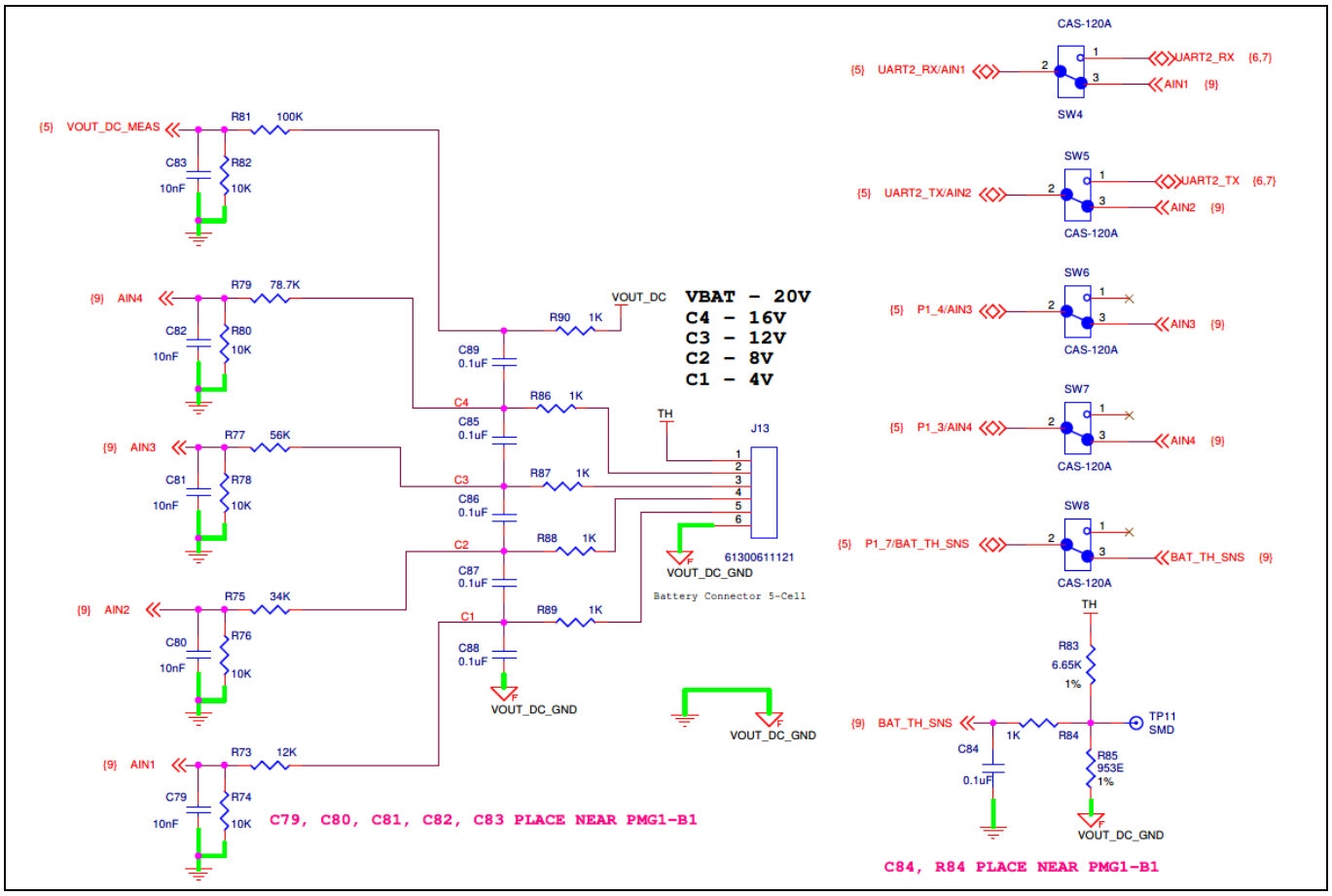


Figure 6 Battery cell voltage and temperature monitoring circuit of EVAL PMG1-B1 DRP kit

When the kit is used to charge a battery of 2 cell to 5 cell, individual cell voltages and battery temperature can be monitored using the circuitry shown in Figure 6.

Table 4 Switch configuration in DRP and battery charging

Switch	Position (SPDT)	Description
SW4	2-3(default)	Voltage of Cell 1 of the battery is measured
	2-1	UART2_RX is connected PMG1-B1
SW5	2-3 (default)	Voltage of Cell 2 of the battery is measured
	2-1	UART2_TX is connected PMG1-B1
SW6	2-3(default)	Voltage of Cell 3 of the battery is measured
	2-1	GPIO P1_4 is available on pin 5 of J7
SW7	2-3(default)	Voltage of Cell 4 of the battery is measured
	2-1	GPIO P1_3 is available on pin 2 of J7
SW8	2-3 (default)	Temperature measurement NTC of the battery is measured
	2-1	GPIO P1_7 is available on pin 8 of J6

2.2.4 I/O header for measuring different GPIOs

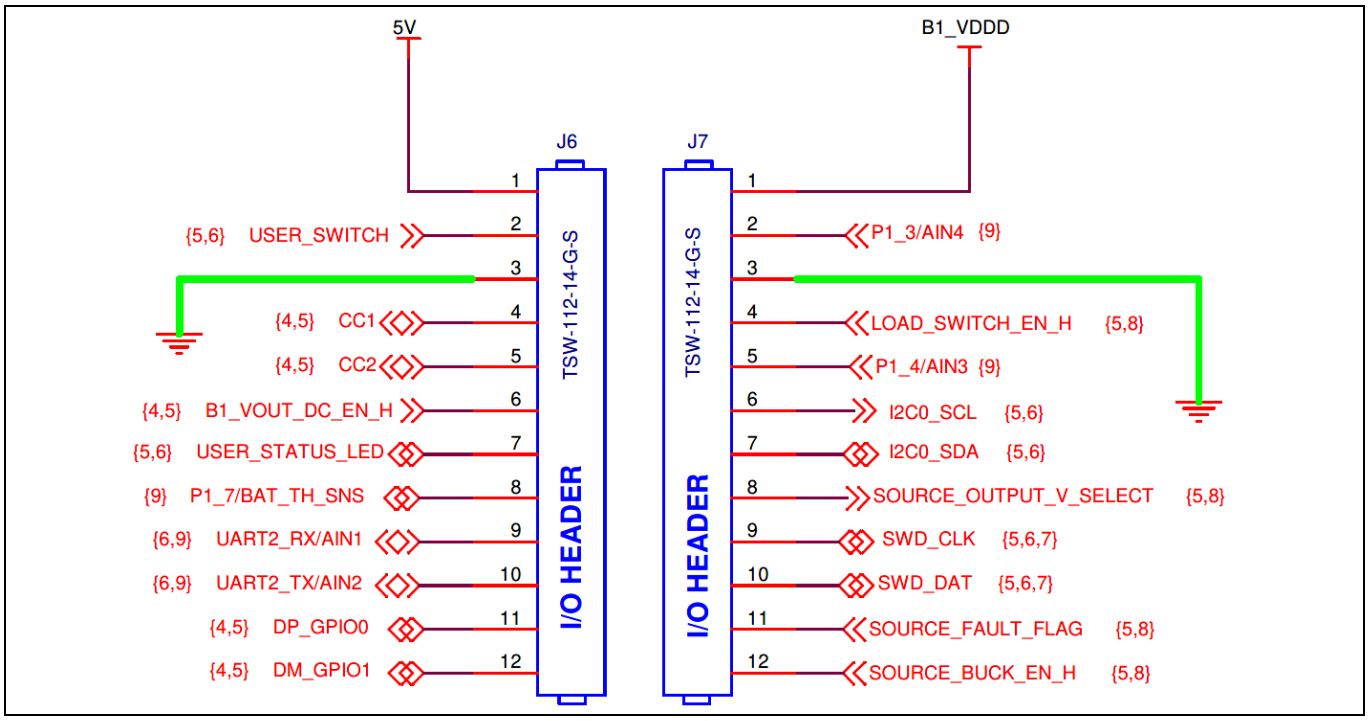


Figure 7 GPIO header of EVAL PMG1-B1 DRP kit

GPIOs of PMG1-B1 are brought through J6 and J7 to be accessible.

2.2.5 5-V LDO and power LED

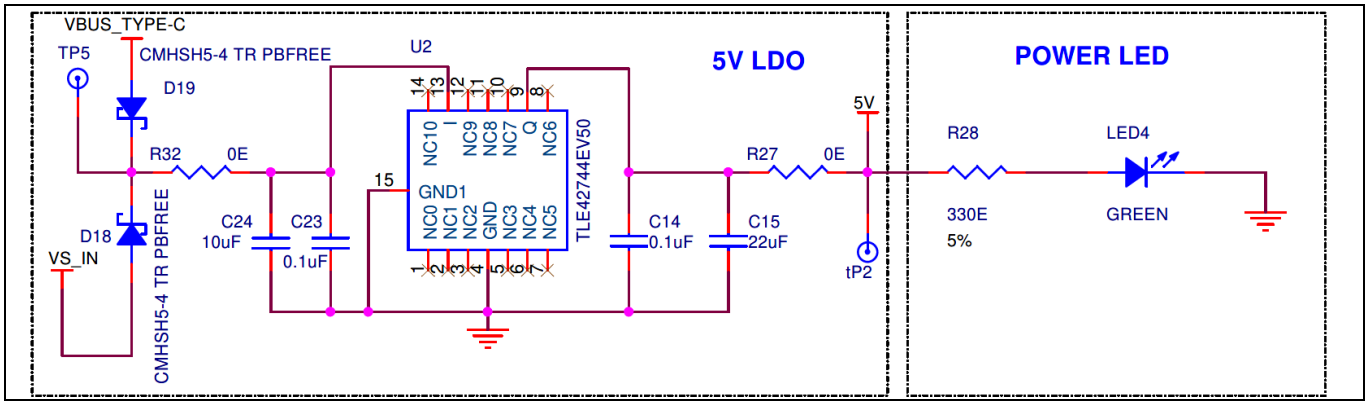


Figure 8 5-V LDO and power LED

This is an external 5-V LDO with an allowed maximum load current of 400 mA. When the kit is powered through J10 or J11, the status is seen at the power LED (LED4).

2.2.6 STATUS LED or USER LED

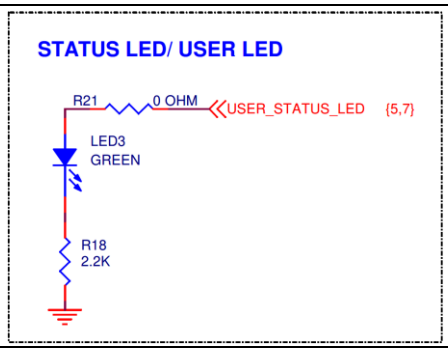


Figure 9 STATUS LED or USER LED

The STATUS LED helps to indicate the state of the kit. Different states of the kit are listed in Table 5.

Table 5 STATUS LED configuration

Sl. no.	State of kit	STATUS LED indication	Description
1	Sink – charging a battery	OFF	When Type-C is not attached at J10
		Blink (1s rate)	When Type-C attached at J10, and battery is charging
2	Sink – fixed output voltage	OFF	When Type-C is not attached at J10
		Blink (1s rate)	When Type-C attached at J10
3	Source	OFF	When Type-C is not attached at J10
		ON	When Type-C sink attached at J10
4	Output fault in sink mode	Blink (2s rate)	Battery or output over voltage, output current, or temperature faults
5	Battery charging time out fault	Blink (3s rate)	If battery charging time is greater than 6 hours

2.2.7 Reset circuit

The EVAL_PMG1_B1_DRP kit has a reset button to manually reset the device. When the reset button is pressed, the XRES pin on the device will pull down to the ground to reset PMG1-B1.

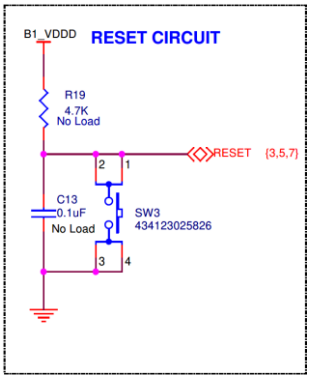


Figure 10 Reset circuit

2.3 KitProg3 (PSoC™ 5LP MCU)

An onboard PSoC™ 5LP MCU (CY8C5868LTI-LP039)-based KitProg3 module is used to program and debug the EZ-PD™ PMG1-B1 microcontroller.

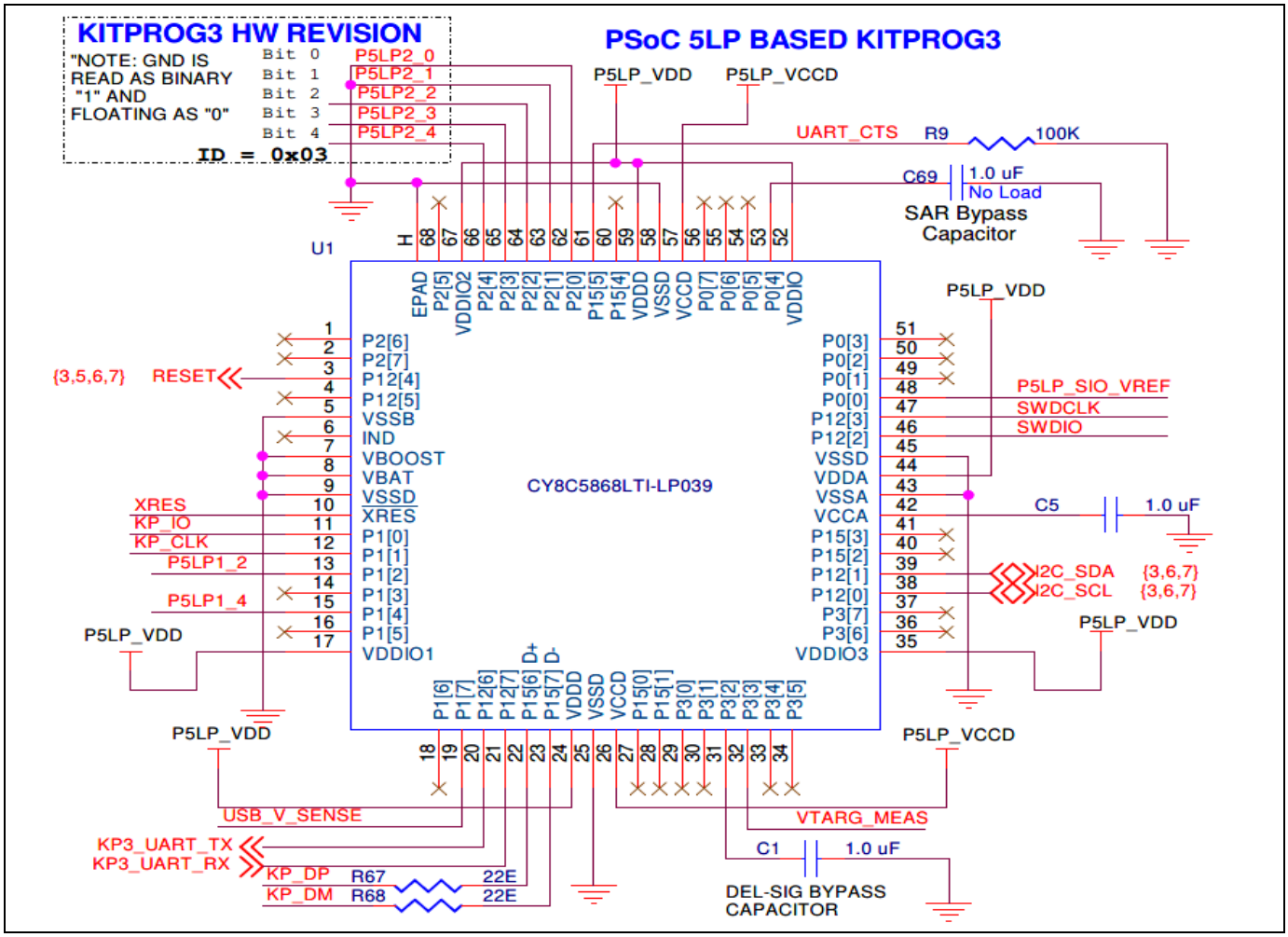


Figure 11 PSoC™ 5LP MCU device

The PSoC™ 5LP MCU device interfaces with a PC through a Type-C USB connector (J1), and functions as a bridge between the PC and EZ-PD™ PMG1-B1 MCU devices over SWD, I2C, and UART interfaces. The KitProg3 module gets power through the J1 port and receives and transmits data between the host PC through D+/D- signals. The programming/debugging module can access the EZ-PD™ PMG1 MCU device in programming or debugging mode via the SWD header. In addition to being an onboard programmer, the KitProg3 functions as an interface for the USB-I2C and USB-UART bridges.

The USB-Serial pins of PSoC™ 5LP MCU are hard-wired to the I2C pins of the EZ-PD™ PMG1-B1 MCU, and these pins are also available on the KitProg3 headers (J3 and J4).

The USB-UART bridge functionality is enabled by default by hard-wired connections of the UART lines between KitProg3 and EZ-PD™ PMG1-B1 MCU

The UART lines from the EZ-PD™ PMG1-B1 MCU are routed to the MCU I/O header (J6) and UART lines from KitProg3 are connected to the KitProg3 header (J3).

Do the following to establish the UART connection on older revisions of the PMG1 kit boards as listed above:

1. Connect J6.10 (EZ-PD™ PMG1-B1 MCU UART Tx) to J3.8 (KitProg3 UART Rx).
2. Connect J6.9 (EZ-PD™ PMG1-B1 MCU UART Rx) to J3.10 (KitProg3 UART Tx).

2.3.1 Mode button

The KitProg3 mode button on the EVAL_PMG1_B1_DRP kit enables the KitProg3 module to enter the bootloader mode. The bootloader mode is required to update the KitProg3 firmware on the PSoC™ 5LP MCU when the existing firmware is corrupted, or a newer version is available.

2.3.2 KitProg3 power and status LEDs

The KitProg3 power LED (amber) turns ON when the KitProg3 module is supplying power to the target MCU. The LED will always be ON in a fault-free condition when the kit is powered through the programming connector.

The status LED (amber) indicates the KitProg3 programming mode and the programming status. See the KitProg3 user guide [6] for more details.

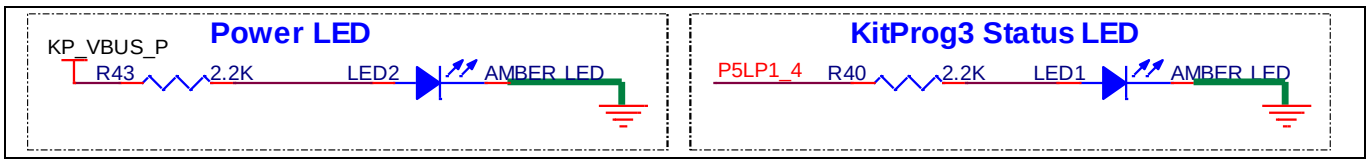


Figure 12 KitProg3 power and status LED

3 Kit operation or demo

This section describes how to configure the EVAL_PMG1_B1_DRP kit to demonstrate its functionality as a USB Type-C Power Sink/source mode.

3.1 External hardware required for demo

- A USB Type-C power adapter (for example, Apple power adapter, Google Type-C charger, HP laptop AC power adapter)
- A lithium-ion battery, preferably 5-cell battery. For internal testing, a 5-cell DeWalt lithium-ion battery (DCB210) is used.
- Electronically marked cable to connect the power adapter (if not already provided with the USB-C power adapter) to the Type-C receptacle(J10) on the EVAL_PMG1_B1_DRP kit
- A cable to connect the battery to the 2-pin output load terminal (J9)
- A 3-mm flat head screwdriver
- A multimeter to measure voltage.

3.2 Running demos

3.2.1 Demo#1 – Fixed output voltage in sink mode

In this demo, the EVAL_PMG1_B1_DRP kit's USB-C port operates in sink mode. The integrated buck-boost output voltage is configured to 20 V.

3.2.1.1 Test setup needed for Demo#1

The following items are needed to perform this DEMO:

- USB type-C power adapter
- USB-C to C cable
- Electronic load
- EVAL_PMG1_B1_DRP kit board
- Multimeter

3.2.1.2 Running Demo#1

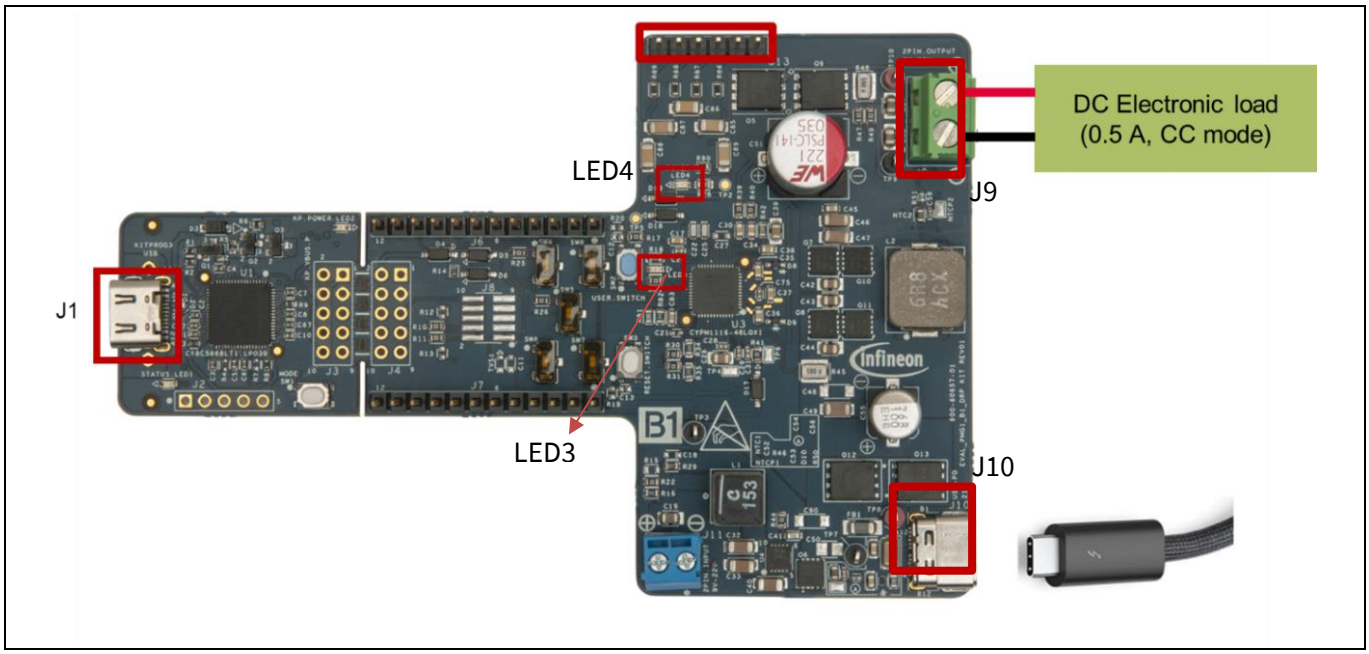


Figure 13 Connection for DEMO#1 (sink mode)

- Program the EVAL_PMG1_B1_DRP kit with USB PD DRP firmware or SINK only firmware by connecting a type-c cable on J1.
- Use default switch settings as shown in Table 4.
- Connect the positive and negative terminals of electronic load to J9; follow polarity as shown on the EVAL_PMG1_B1_DRP kit board.
- Connect the USB-C power adapter to J10 of the kit using USB-C to the C cable.
- Blinking LED3 (STATUS LED) indicates the sink mode of operation, LED4 (POWER LED) indicates board is powered.

  Higher load current can be drawn by modifying input current parameter as shown in the Modifying maximum input current in Sink mode of DRP or SINK firmware section.

Expected voltages and other behaviors are shown in Table 6.

Table 6 Expected voltages or behavior

Sl no	Reference designator	Expected voltage or behavior	Remarks
1	TP8 to TP7	20 V	Maximum PDO by power adapter connected on J10
2	TP10 to TP9	20 V	Output voltage
3	LED4	ON	Power LED indicates that board is powered
4	LED3	Blinking	Blinking indicates that board is operating in sink mode

3.2.1.3 Common problems and troubleshooting

If the demo is not functional, follow these guidelines to troubleshoot:

- Ensure that the correct firmware is programmed on the EVAL_PMG1_B1_DRP kit board
- Ensure that the power adapter is working as intended.
- Ensure that the polarity mentioned on the EVAL_PMG1_B1_DRP kit board is followed.

Note: *Better transient response can be seen if compensation network is modified to values shown in Table 7.*

Table 7 Compensation network update

Sl. no.	Reference designator	Existing value	Recommended value for better transient response
1	C38	0.1 µF	2.2 nF
2	C39	100 nF	1 µF
3	R42	100 Ω	2.7 kΩ

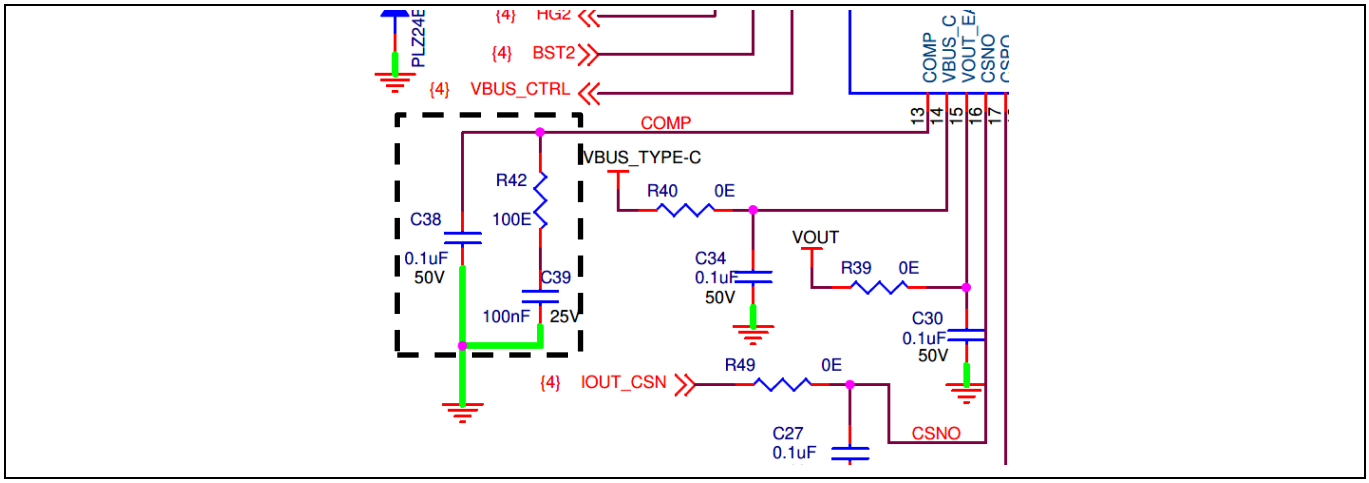


Figure 14 Schematic showing compensation network

3.2.2 Demo#2 – Source mode operation

In this demo, the EVAL_PMG1_B1_DRP kit's USB-C port operates in source mode and provides 5 V or 9 V at J11, with a maximum current of 3 A.

3.2.2.1 Test setup needed for Demo#2

The following items are needed to perform this demo:

- Any 5-V USB type-C sink device (USB type-C capable phone, for example Samsung Galaxy S20 FE 5G)
- 5-cell battery or bench-top power supply.
- USB-C to C cable
- EVAL_PMG1_B1_DRP kit board

3.2.2.2 Running Demo#2

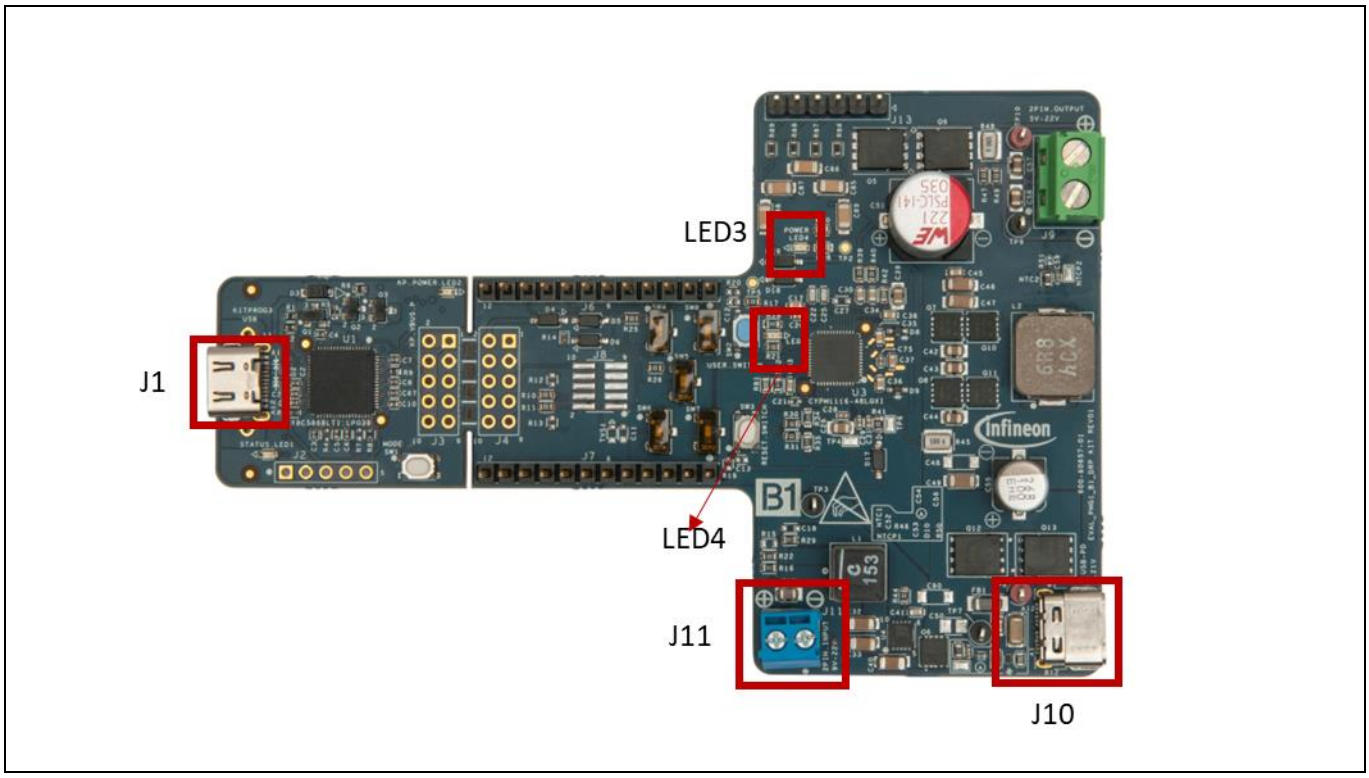


Figure 15 Connection for DEMO#2 (Source mode)

- Program PMG1-B1 with USB PD DRP firmware by connecting Type-C on J1. For more details, see Programming PMG1-B1.
- Ensure that you use the default switch settings as shown in Table 4.
- Connect the positive and negative terminals of the 5-cell battery or power supply at J11; follow polarity as shown on the EVAL_PMG1_B1_DRP kit board.
- Connect the Type-C sink device at J10 (examples of sink devices are a mobile phone with a Type-C charging port)
- LED3 (STATUS LED) source mode, LED4 (POWER LED) indicates board is powered. The Sink device connected on J10 is seen to charge.

Expected voltages and other behavior are shown in Table 8.

Table 8 Expected voltages or behavior

Sl. no.	Reference designator	Expected voltage or behavior	Remarks
1	TP8 to TP7	5 V or 9 V	voltage at which sink device is getting charged
2	LED4	ON	Power LED indicates that board is powered
3	LED3	ON	ON indicates that board is operating in source mode
4	Sink device (mobile)	Charging	Mobile can be seen charging

3.2.2.3 Common problems and troubleshooting

If the demo is not functional, follow these guidelines to troubleshoot:

- Ensure that the correct firmware is programmed on the EVAL_PMG1_B1_DRP kit board
- Ensure that the correct sink device is connected.
- Ensure that the polarity mentioned on EVAL_PMG1_B1_DRP kit board is followed

3.2.3 Demo#3 – Charging a 5-cell battery without battery cell monitoring

In this demo, the EVAL_PMG1_B1_DRP kit's USB-C port operates in sink mode to charge a 5-cell battery. Irrespective of the battery Ah, the battery is charged with a default fixed current of 2 A and could be modified based on the application requirement as shown in the Modifying battery charging application to enable trickle charging or charging currents lower than 300 mA section.

3.2.3.1 Test setup needed for Demo#3

The following items are needed to perform this demo:

- USB type-C power adapter
- USB-C to C Cable
- 5-cell battery (DCB210)
- EVAL_PMG1_B1_DRP kit board

3.2.3.2 Running Demo#3

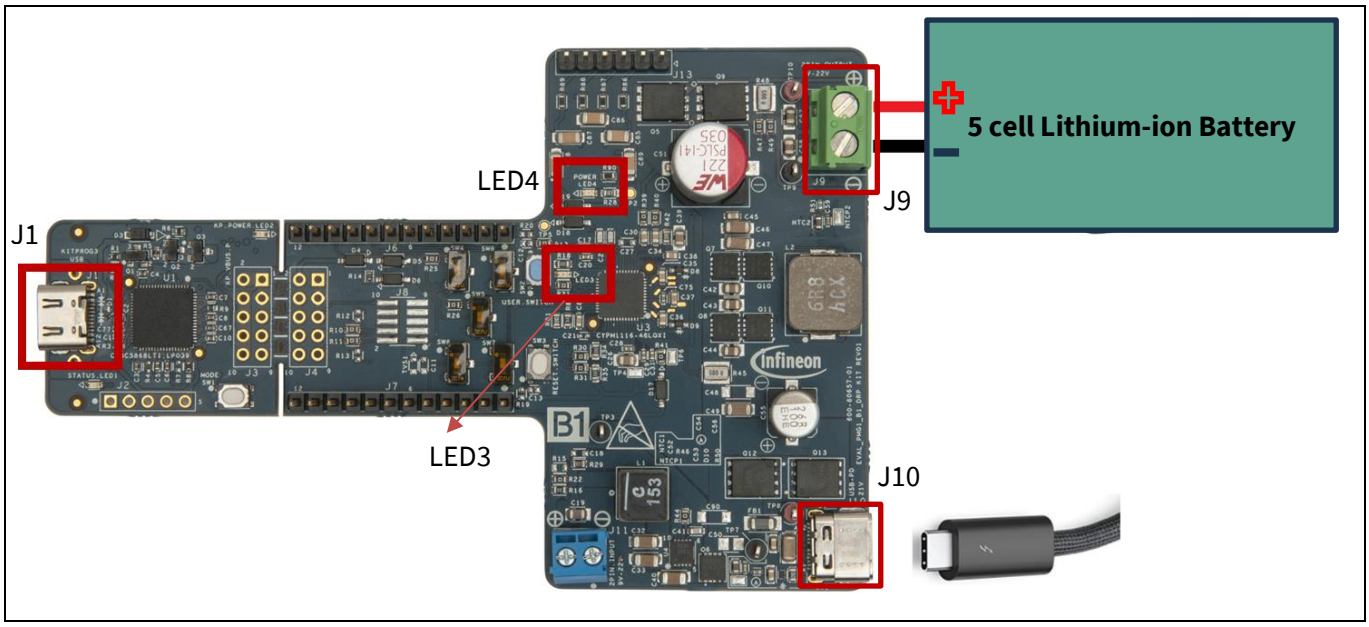


Figure 16 Connection for DEMO#3 (Charging a battery without cell monitoring)

- Program PMG1-B1 with battery-charging firmware by connecting a Type-C cable on J1. For more details, see Programming PMG1-B1.
- Ensure that you use the default switch settings as shown in Table 4.

- Connect the positive and negative terminals of 5-cell battery to J9; follow polarity as shown on the EVAL_PMG1_B1_DRP kit board.
- Connect the USB-C power adapter to J10 of the kit using USB-C to C cable
- LED3 (STATUS LED) blinking indicates charging the battery, LED4 (POWER LED) indicates the board is powered

Expected voltages and other behavior are shown in Table 8.

Table 9 Expected voltages or behavior

Sl. No.	Reference designator	Expected voltage or behavior	Remarks
1	TP8 to TP7	20 V	Maximum PDO by power adapter connected on J10
2	LED4	ON	Power LED indicates that board is powered
3	LED3	ON	ON indicates that board is operating in source mode
4	Sink device (mobile)	Charging	Mobile can be seen charging

3.2.3.3 Common problems and troubleshooting

If the demo is not functional, follow these guidelines to troubleshoot:

- Ensure that the correct firmware is programmed on the EVAL_PMG1_B1_DRP kit board
- Ensure that the power adapter is working as intended.
- Ensure that the battery is not fully charged.
- As cell monitoring and temperature monitoring of battery are disabled, do not connect any signals on J13
- Connect to the battery to EVAL_PMG1_B1_DRP kit after the battery connector is connected to DUT.

3.2.4 Demo#4 – Charging a 5-cell battery with battery cell monitoring

In this demo, the EVAL_PMG1_B1_DRP kit operates in sink mode, to charge a 5-cell or 3-cell battery. Irrespective of the battery Ah, the battery is charged with a fixed current of 2 A. To modify number of cells, charging current see Firmware updates.

3.2.4.1 Test setup needed for Demo#4

The following items are needed to perform this demo:

- USB type-C power adapter
- 5-cell (DCB210) DeWalt battery
- EVAL_PMG1_B1_DRP kit board

3.2.4.2 Running Demo#4

- For firmware modifications, see Enabling cell monitoring and temperature monitoring in battery..
- For hardware modifications, use the switch settings as shown in Table 10:

Table 10 Switch configuration in battery charging

Switch	Position	Description
SW1	NA	KITPROG Mode switch
SW2	NA	USER SWITCH
SW3	NA	RESET SWITCH
SW4	2-3	SPDT to connect UART2_RX or AIN1 on I/O header
SW5	2-3	SPDT to connect UART2_TX or AIN2 on I/O header
SW6	2-3	SPDT to connect P1_4 or AIN3 on I/O header
SW7	2-3	SPDT to connect P1_3 or AIN4 on I/O header
SW8	2-3	SPDT to connect P1_7 or BAT_TH_SNS on I/O header

- Connect Type-C of the power adapter to J10.
- Battery cell voltages and temperature can be monitored by connecting the respective pins on J13.
- Connect the positive and negative terminals of the 5-cell or 3-cell battery to J9, follow the polarity as shown on the EVAL_PMG1_B1_DRP kit board.
- Connect the other end of power adapter to wall socket.
- LED3(STATUS LED) indicates that the battery is charging. LED4(POWER LED) indicates that the board is powered.

3.2.4.3 Common problems and troubleshooting

If the demo is not functional, follow these guidelines to troubleshoot:

- Ensure that the correct firmware is programmed on the EVAL_PMG1_B1_DRP kit board.
- Ensure that the power adapter is working as intended.
- Ensure that the battery is not fully charged.
- Connect to the battery after the battery connector is connected to DUT. Do not connect vice versa.
- Ensure that the correct polarity of battery is connected to the DUT.
- Ensure the correct connection of signals on J13.

3.3 Firmware updates

3.3.1 Modifying maximum input current in Sink mode of DRP or SINK firmware

Modify the maximum input current in Sink mode of DRP or SINK firmware through the EZ-PD™ Configurator.

- Open EZ-PD™ configurator in ModusToolbox™.

Kit operation or demo

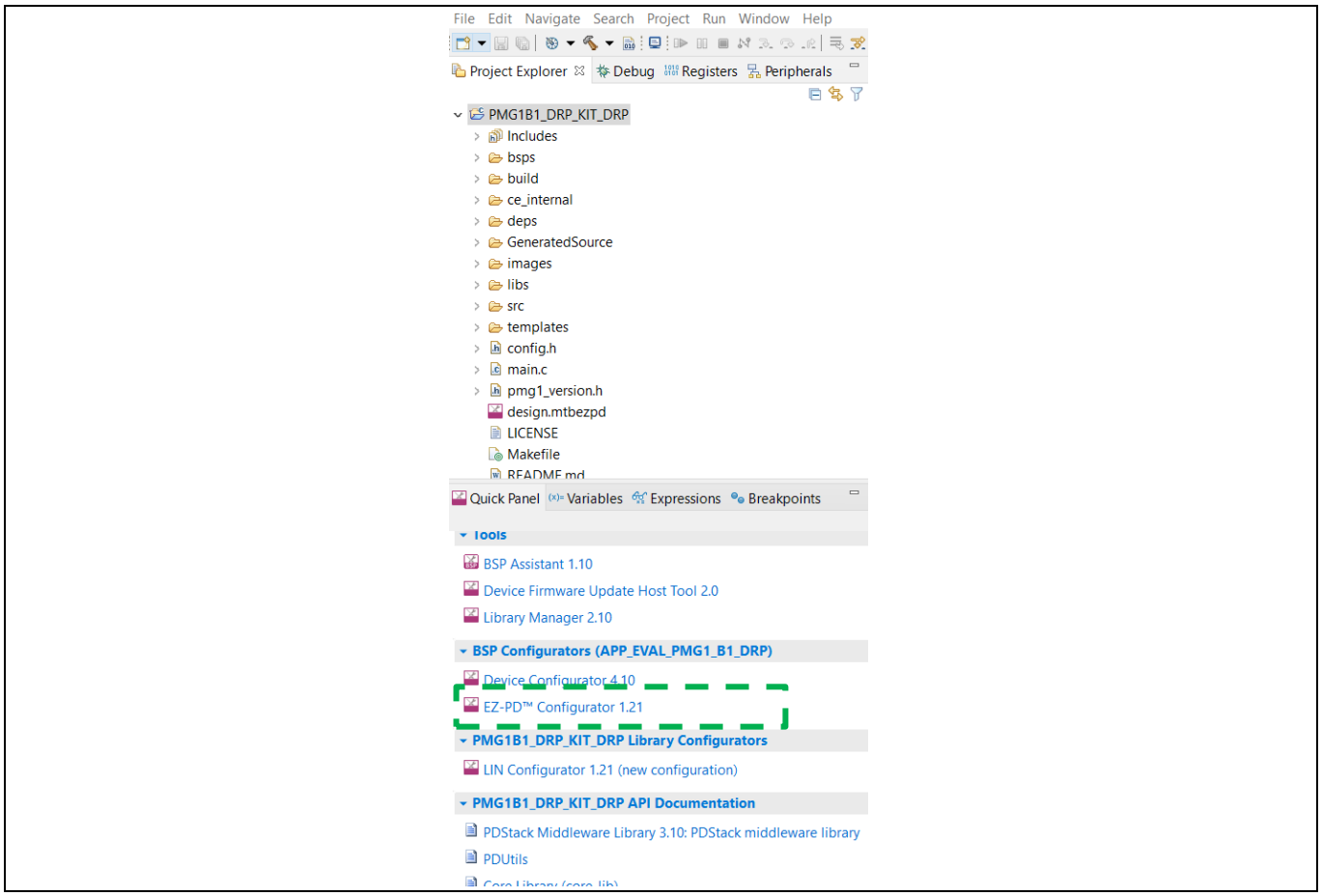


Figure 17 EZ-PD™ Configurator

- Modify “Min/Max Operating current(mA)” in “Sink PDO 1” to any value less than 5000 as shown in Figure 18.

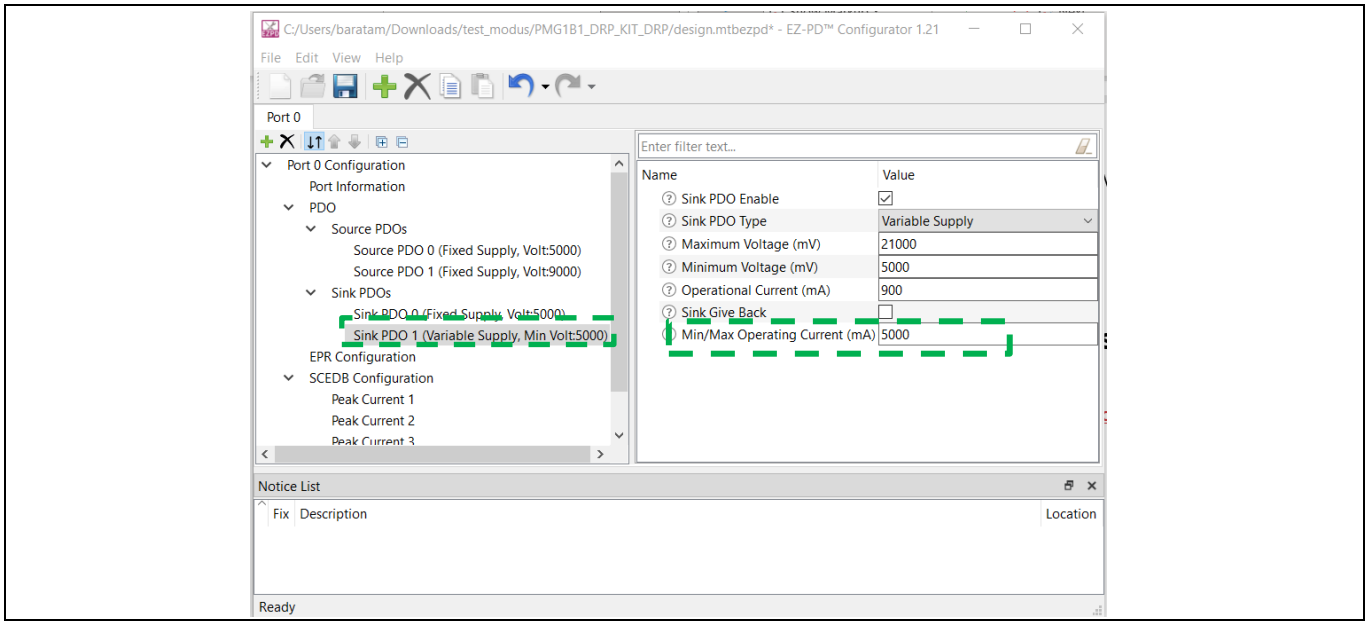


Figure 18 Modifying maximum input current in sink mode of DRP and SINK FW

After modifying as instructed above, save, build, and program PMG1-B1.

Note: Buck-boost turns-ON only when the available input power is greater than 7.5 W.

3.3.2 Modifying output voltage in sink mode of DRP or sinkfirmware

Modify the output voltage in Sink mode of DRP or sink firmware through the device configurator.

- Open Device Configurator in ModusToolbox™.

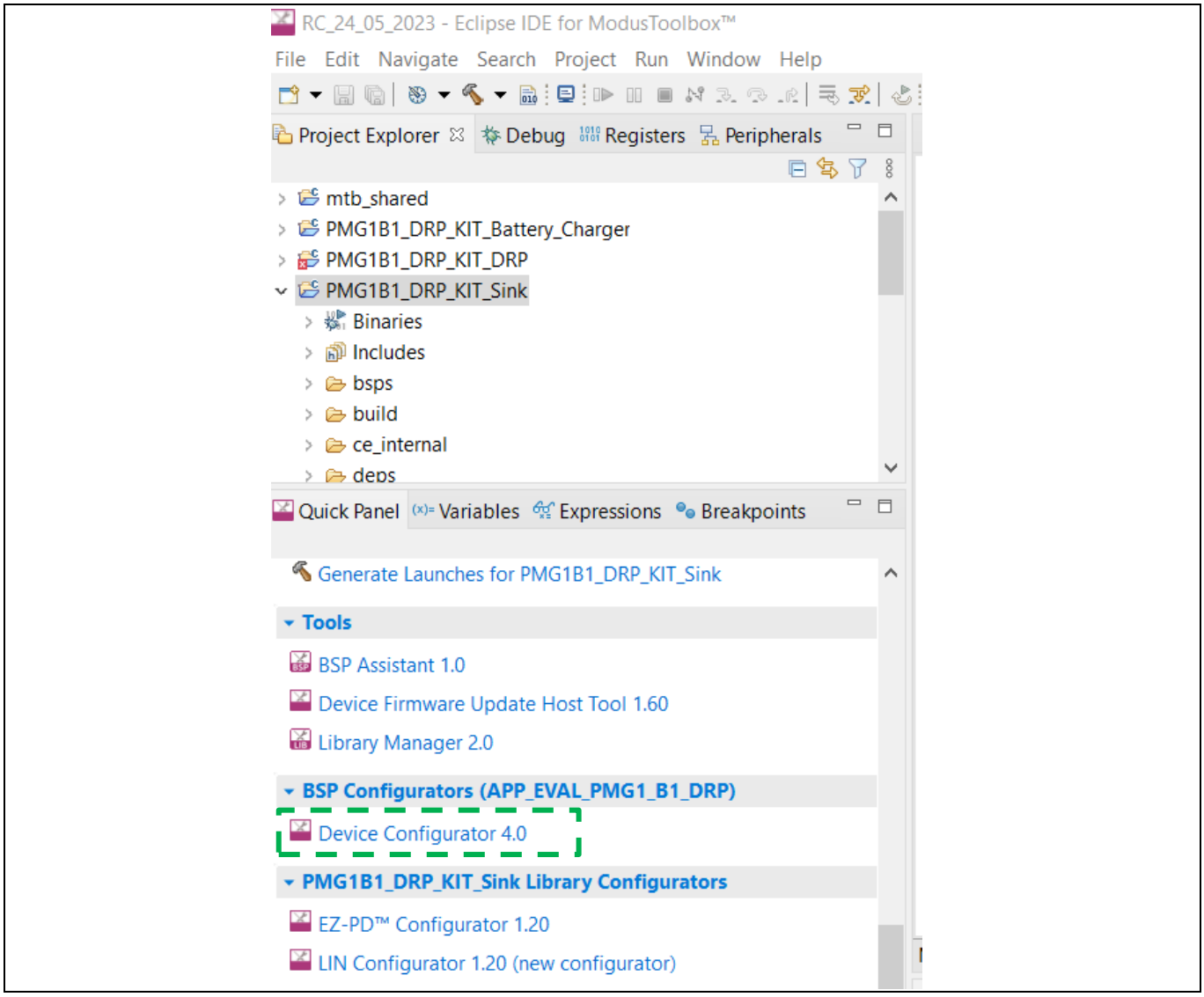


Figure 19 Device configurator

- The Device Configurator window pops up, as shown in Figure 19.
- Modify output voltage (in peripherals, communication, USB-C Power Delivery 0) as shown in Figure 20**.** After modifying the voltage to the desired value (5 V to 21 V), save and close the Device Configurator.

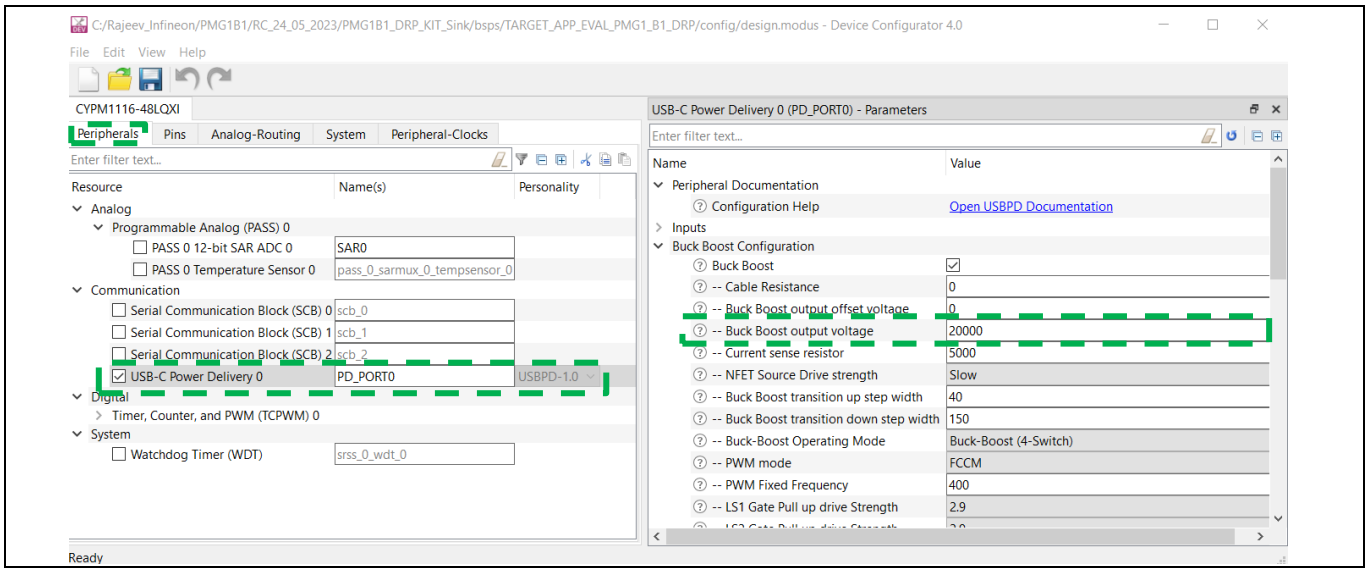


Figure 20 Output voltage is changing through Device Configurator

- Build the application in ModusToolbox™ and program PMG1-B1.

3.3.3 Migrating from 5-cell battery to 3-cell battery charging application without cell monitoring and temperature monitoring

Do the following firmware modification:

- Update the TOTAL_BATTERY_CELL_COUNT macro value from 5 to 3 in *config.h* file, as shown in Figure 21.

```
#define TOTAL_BATTERY_CELL_COUNT                    (3u)
```

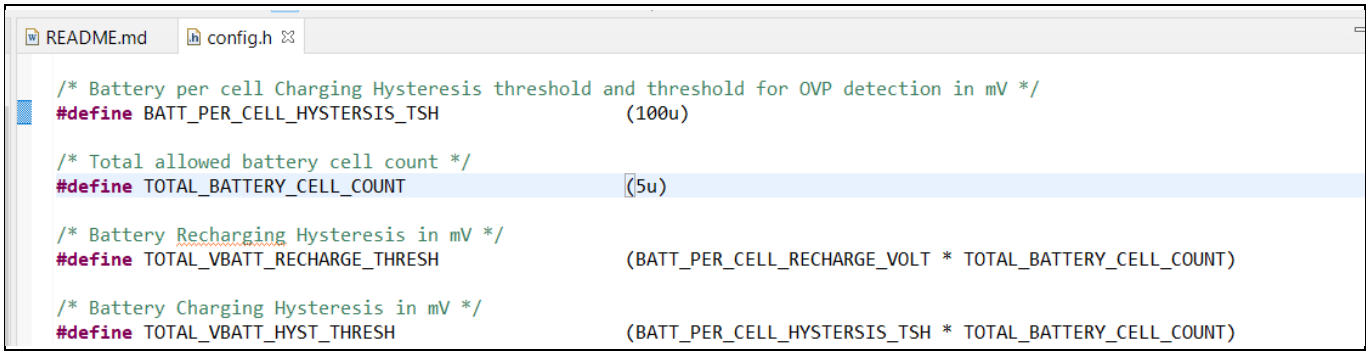


Figure 21 Firmware modification for modifying cell count

After the modification, save, build, and program PMG1-B1.

3.3.4 Enabling cell monitoring and temperature monitoring in battery

- See Table 11 for firmware modifications to enable cell monitoring and temperature monitoring of battery.

Table 11 Firmware modification to enable cell monitoring and temperature monitoring

Macro name	Default	Modify	File name
ENABLE_BATT_TEMP_MONITORING	0u	1u	config.h
CELL_MONITORING_DISABLE	1u	0u	config.h

- Do the following hardware modifications:
  - Ensure to connect cell voltage and temperature measurement signals on J13 as shown in Table 3
  - Use the switch settings as shown in Table 12:

Table 12 Switch configuration in DRP and battery charging

Switch	Position	Description
SW4	2-3	SPDT to connect AIN1 on I/O header
SW5	2-3	SPDT to connect AIN2 on I/O header
SW6	2-3	SPDT to connect AIN3 on I/O header
SW7	2-3	SPDT to connect AIN4 on I/O header
SW8	2-3	SPDT to connect BAT_TH_SNS on I/O header

After the modification, save, build, and program PMG1-B1.

3.3.5 Modifying 5-cell battery charging application to 3-cell battery charging application with cell monitoring and temperature monitoring

Follow the instructions mentioned in Migrating from 5-cell battery to 3-cell battery charging application without cell monitoring and temperature monitoring and Enabling cell monitoring and temperature monitoring in battery. After the modification, save, build, and program PMG1-B1.

3.3.6 Modifying battery charging application to enable trickle charging or charging currents lower than 300 mA

Do the following hardware modification:

- Replace R48 (current sense resistor) with 10 mΩ. (YAG6119CT-ND)
- Ensure only cell-1, cell-2 and full battery voltages are connected through J13 and J9

Do the following firmware modification:

- Modify the current sense resistor value through the Device Configurator to 10000, as shown in Figure 22.

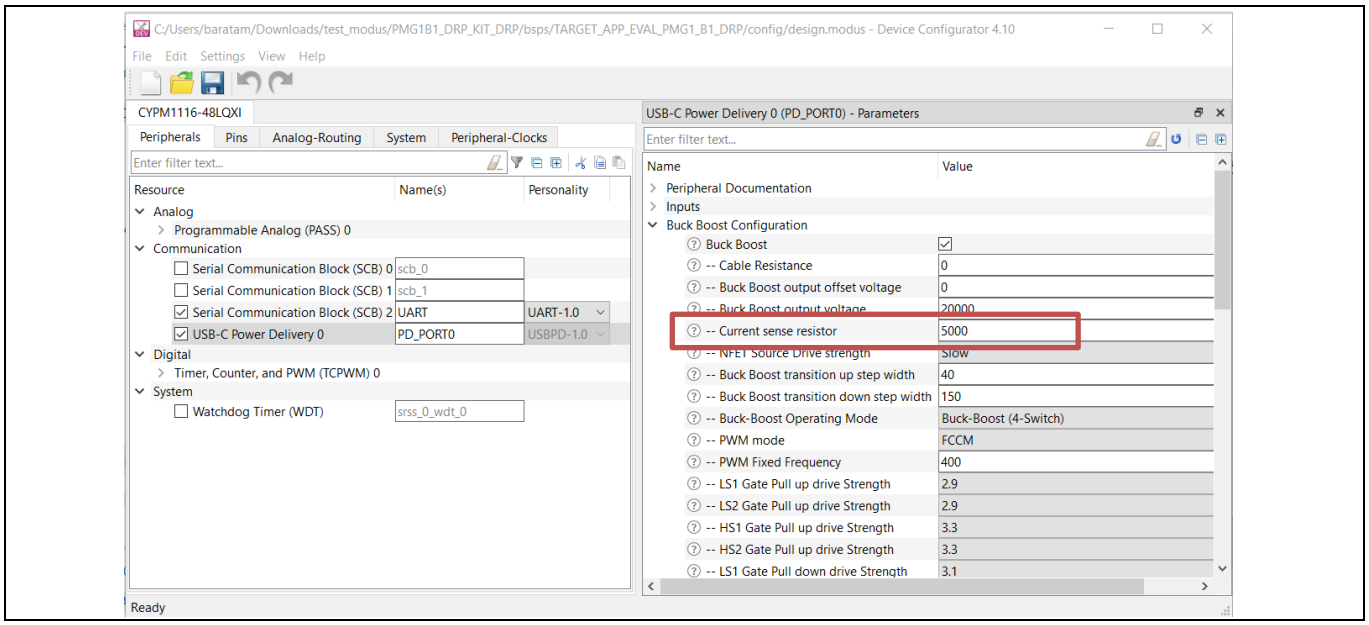


Figure 22 Modifying current sense resistor value using Device Configurator

- After the modification, save, build, and program PMG1-B1.

Note: Maximum allowed charging current is 3.5 A with 10 mΩ of current sense resistor(R48).

4 Programming PMG1-B1

PSOC™ 5 (U1-CY8C5868LTI-LP039) is preprogrammed in the EVAL_PMG1_B1_DRP kit board. The EVAL_PMG1_B1_DRP kit firmware is available in the ModusToolbox™ software. Follow the steps in this section to program the PMG1-B1 device. This firmware update is necessary for successful kit operation.

This section describes ModusToolbox™ Programmer, and the installation procedure. ModusToolbox™ programmer is a GUI-based tool to program EZ-PD™ PMG1-B1 MCU device.

4.1 ModusToolbox™ Programmer

ModusToolbox™ Programmer has the following features:

- ModusToolbox™ Programmer is a stand-alone, cross-platform, and flash programmer tool.
- Provides a GUI to program, erase, verify, and read the flash of the target MCU.
- Supports the HEX, SREC, ELF, and BIN programming file formats.

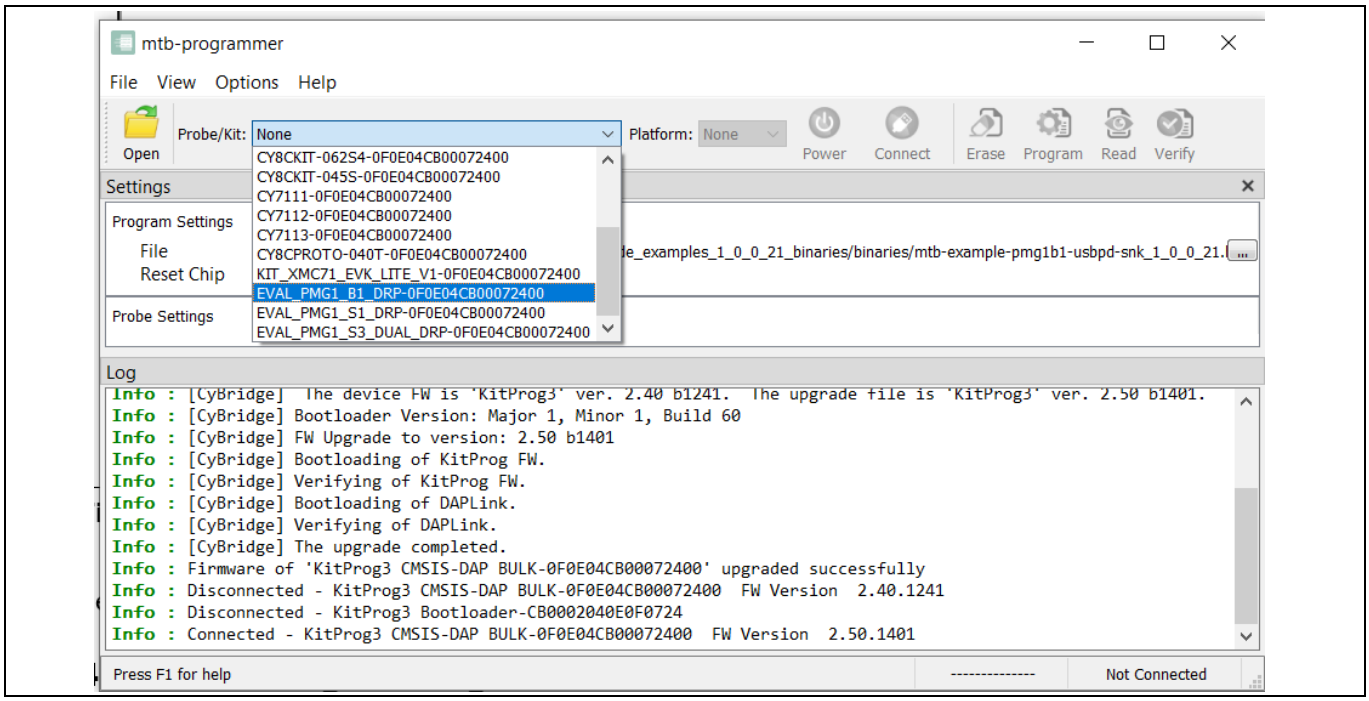


Figure 23 ModusToolbox™ Programmer

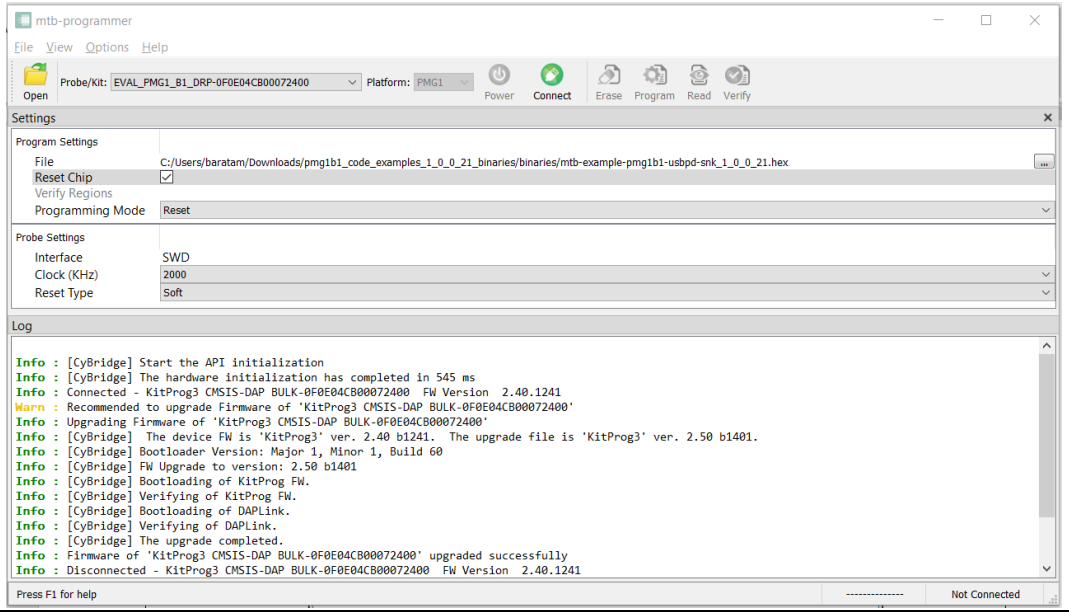
4.2 Programming PMG1-B1 device

Download and install ModusToolbox™ Programmer and follow these steps to program PMG1-B1:

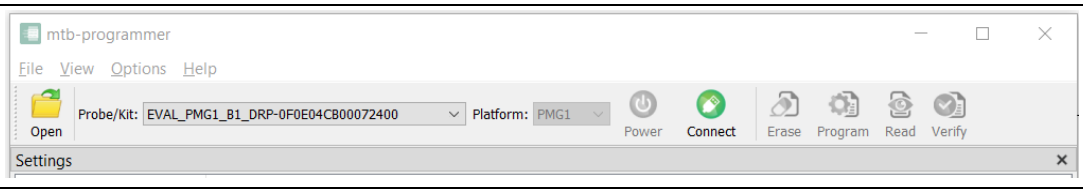
- Connect the device to the host computer, by connecting a Type-C cable on J1. Select the device name in the Probe/Kit drop-down (EVAL_PMG1_B1_DRP-0F0E04CB00072400)), and ModusToolbox™ Programmer displays the information under Probe Settings (if the Settings section is viewable).

4.2.1 Load the programming file

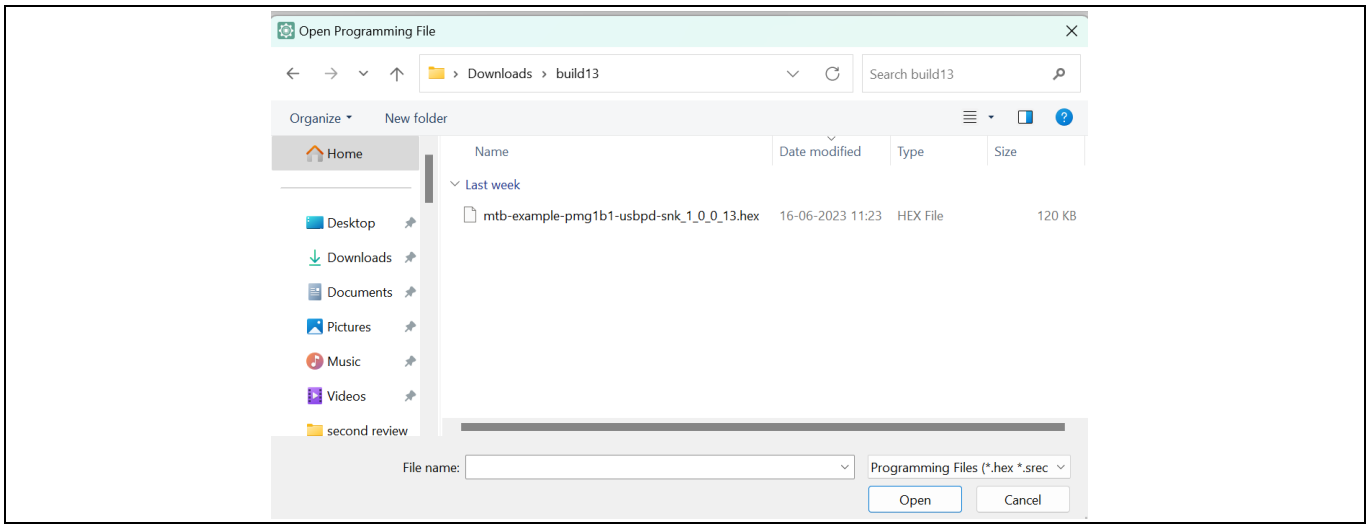
1. Connect the device to the host computer. Select the device name in the **Probe/Kit** drop-down, and CYP displays information under **Probe Settings** (if the **Settings** section is viewable).



2. Click **Open**.

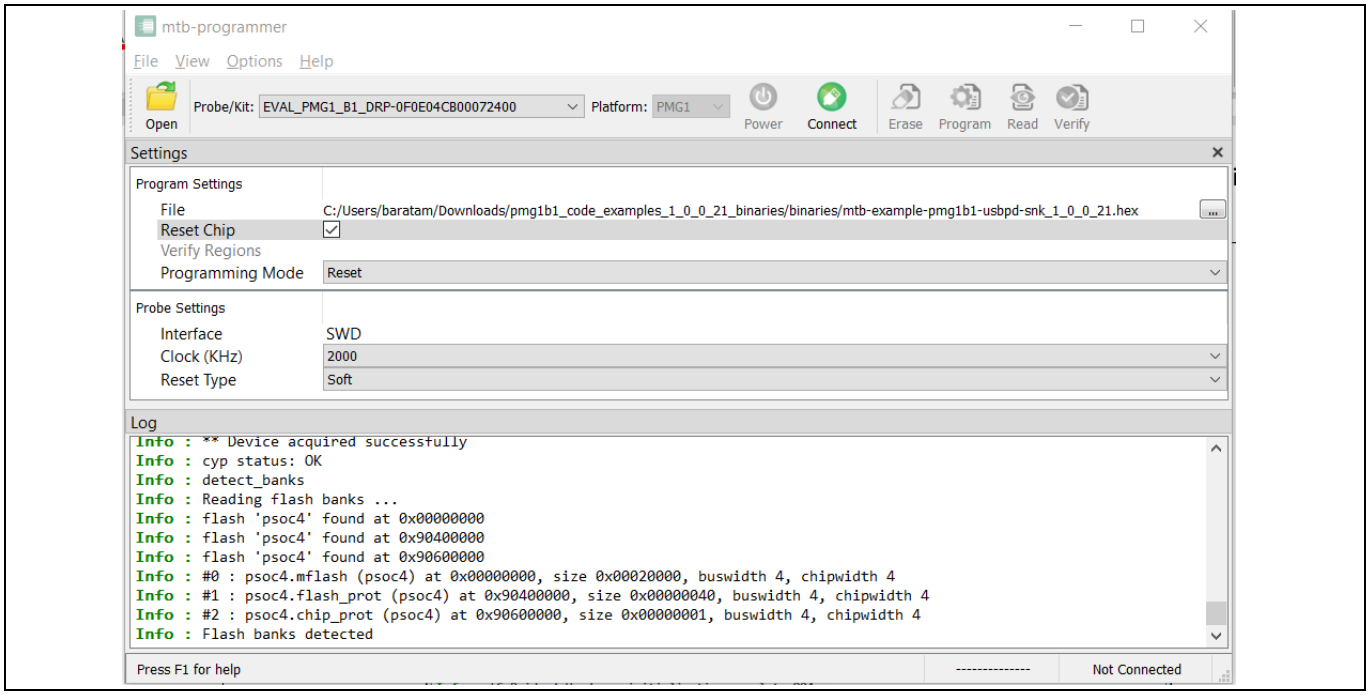


3. On the Open Programming File dialog box, navigate to the location of the HEX, SREC, ELF, or BIN file to load, select it, and click **Open**.

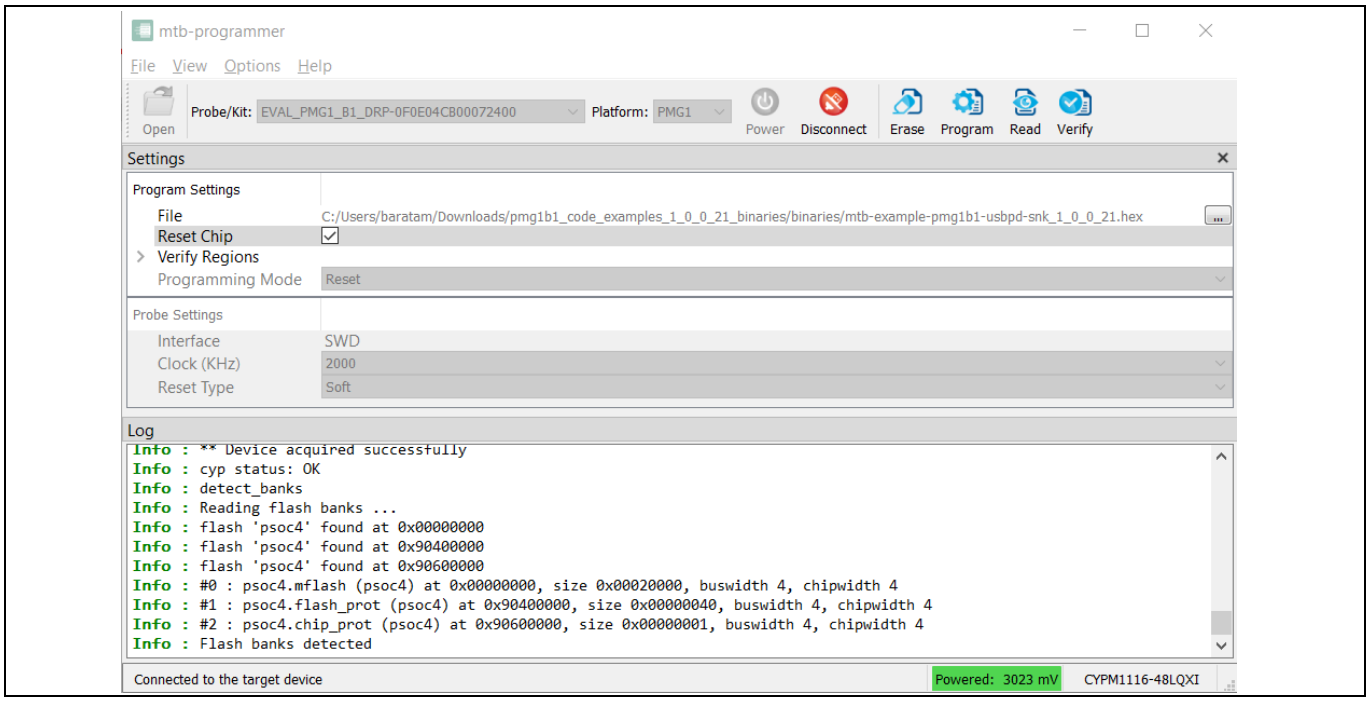


4.2.2 Connect the device

1. If the device is not powered, the status message “Not Powered” is displayed in the Status Bar. Click **Power** to power-up the device.



2. Click **Connect**. ModusToolbox™ Programmer communicates with the device and displays various messages in the **Log**. Then, a message in the Status Bar indicates that it is connected.



4.2.3 Program the device

Click **Program**. ModusToolbox™ Programmer downloads the program file on to the device and displays messages in the **Log**.

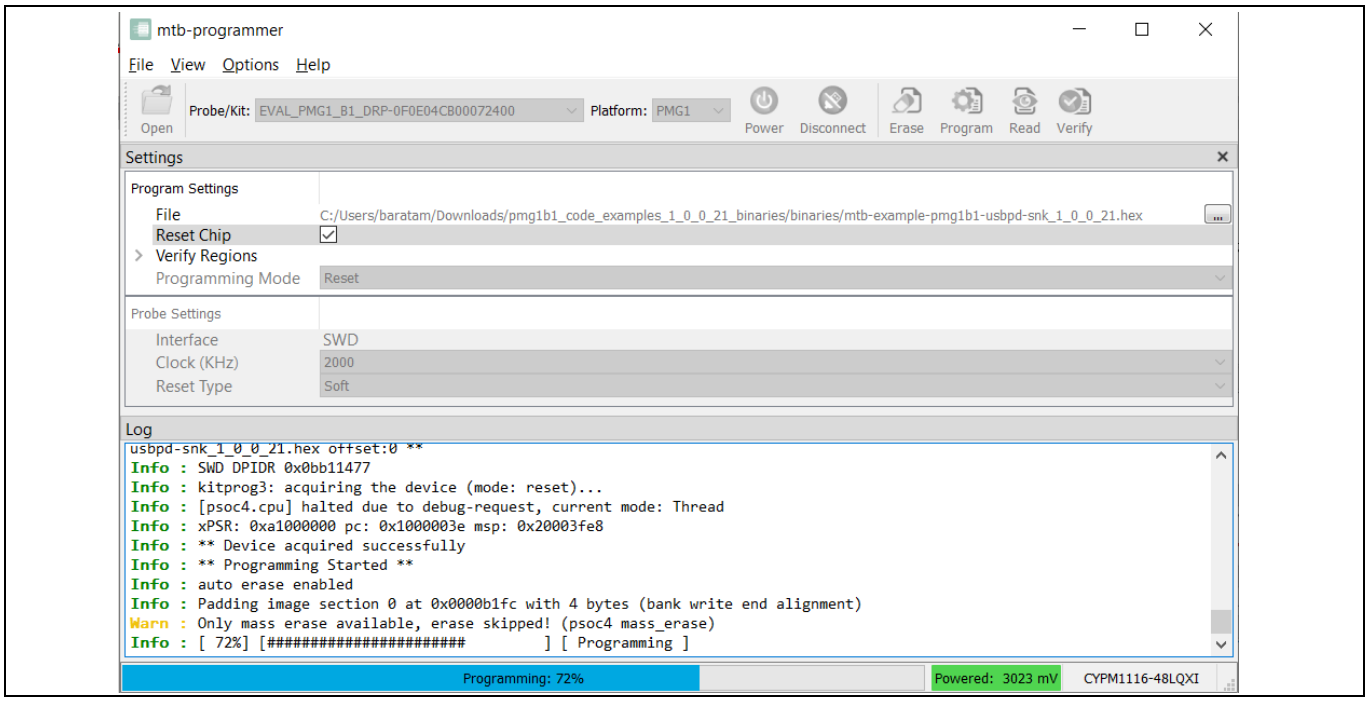


Figure 24 Programming through ModusToolbox™ Programmer

Related documents

[1] Overview: USB-C Power Delivery Controllers

[2] Product webpage:

- USB-C High Voltage Microcontrollers

[3] Kit webpage:

- EVAL_PMG1_B1_DRP kit

[4] Datasheets

- EZ-PD™ PMG1-B1 USB Type-C Buck-boost controller, Single-port

[5] AN232553 - Getting started with EZ-PD™ PMG1 MCU on ModusToolbox™ software

[6] KitProg3 user guide

[7] ModusToolbox™ tools package user guide

[8] ModusToolbox™ tools package installation guide

[9] ModusToolbox™ device configurator guide

Glossary

FET
Field-effect transistor

GPIO
General-purpose input/ output

IC
Integrated circuit

LED
Light-emitting diode

MCU
Microcontroller

MOSFET
Metal oxide semiconductor field effect transistor

NA
Not applicable

OVP
Overvoltage protection

PA
Power adapter

PD
Power delivery

PDO
Power data object

PFET
P-channel field effect transistor

PSoC™
Programmable system-on-chip

SoC
System-on-chip

Glossary

UFP
Upstream facing port

USB
Universal Serial Bus

USB-PD
Universal Serial Bus Power Delivery

UVP
Undervoltage protection

Revision history

Document revision	Date	Description of changes
**	2023-07-27	New kit guide.
*A	2023-09-26	Updated minor content wordings. Updated the Programming PMG1-B1 section.
*B	2023-11-23	Released to web.

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