CY4534 EZ-PD™ barrel connector replacement-plus (BCR-PLUS) evaluation kit guide

About this document

Scope and purpose

The CY4534 EZ-PD™ barrel connector replacement plus (BCR-PLUS) evaluation kit (EVK) is based on the CYPD3176 device which is part of the BCR product family of Infineon's USB Type-C and power delivery controllers. This document serves as the user guide for this CY4534 EZ-PD™ BCR-PLUS EVK.

Intended audience

This EVK is primarily intended for Infineon's USB Type-C customers who want an evaluation platform to replace an existing barrel/power input connector with a USB-C connector.

Abbreviations and definitions

Table 1 Abbreviations

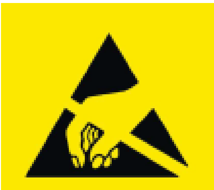
Abbreviation	Definition
AFC	adaptive fast charging
BC	battery charging
BCR	barrel connector replacement
CC	configuration channel
CCG	cable controller generation
DFP	downstream facing port
DNP	do not populate
EC	embedded controller
EMCA	electronically marked cable assembly
ESD	electrostatic discharge
EVK	evaluation kit
FET	field-effect transistor
GPIO	general-purpose input/ output
HPI	host processor interface
IC	integrated circuit
I^2C	inter-integrated circuit
LED	light-emitting diode
NA	not applicable
OVP	over voltage protection
PA	power adapter
PD	power delivery
PDO	power data object
PFET	P-channel field effect transistor

Abbreviation	Definition
PSoC™	programmable system-on-chip
QC®	Qualcomm quick charge
SDK	software development kit
SoC	system-on-chip
UFP	upstream facing port
USB	universal serial bus
USB-PD	universal serial bus power delivery
UVP	under voltage protection

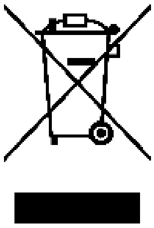
Safety information

This 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.

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.



This 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 boards in the protective shipping package.



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.

General safety instructions

ESD protection

ESD can damage boards and associated components. Infineon recommends that the user perform procedures only at an ESD workstation. If an ESD workstation is not available, use appropriate ESD protection by wearing an antistatic wrist strap attached to the chassis ground (any unpainted metal surface) on the board when handling parts.

Handling the boards

The board provided with this kit is sensitive to ESD. Hold the board only by the edges. After removing the board from the box/casing, place it on a grounded, static-free surface. Use a conductive foam pad, if available. Do not slide the board over any surface.

Do's and Don'ts

Maximum current that can be consumed by an external load connected to the EVK board cannot exceed 5 A.

Table of contents

1 Introduction

The CY4534 EZ-PD™ barrel connector replacement plus (BCR-PLUS) evaluation kit (EVK) is based on the CYPD3176 device which is part of the BCR product family of Infineon's USB Type-C and power delivery controllers. This EVK is intended to be an evaluation vehicle for customers who want to replace an existing barrel/power input connector with a USB-C connector. Implementing this solution in an end-product allows the system to be powered by any USB-C compliant power adapter.

A device, such as a speaker, shaver, power tool, modem, etc. that use a barrel connector for power will benefit from using a universal power interface such as USB Type-C. To make the transition easier, the CY4534 EZ-PD™ BCR-PLUS EVK provides a USB Type-C receptacle to consume power from a charger and then supply it over a terminal block. A barrel connector can be attached to this block by using wires to convert a barrel input to USB Type-C.

The CY4534 EZ-PD™ BCR-PLUS EVK ships with pre-programmed firmware with functionality as documented in the CYPD3176 device datasheet. As an additional option, customers who prefer further customization of the BCR-PLUS firmware solution can make changes to the configuration parameters using the EZ-PD™ configuration utility to fit the needs of their end-application.

1.1 Kit contents

- CY4534 EZ-PD™ BCR-PLUS EVK board
- Quick start guide

1.2 Hardware not included with the kit

The EVK does not come with all the hardware required to perform the demonstrations mentioned in **Kit operation**. The following items are not included:

- A USB Type-C power adapter that can supply power over the Type-C port
- A two-wire cable with a barrel plug to supply power to an existing device
- A device that accepts power from a barrel connector input
- 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 EVK
- Multimeter and other measurement equipment
- A 3-mm flat-head screw driver (for turning the SW1 rotary switch knob)
- CY4500 EZ-PD™ protocol analyzer

1.3 Getting started

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

2 Hardware

This chapter covers the hardware details of the CY4534 EZ-PD™ BCR-PLUS EVK board, a complete system overview, and description of the critical circuit blocks of the EVK board schematic. For more details, refer to the schematics of the CY4534 BCR-PLUS EVK board on the kit webpage.

2.1 Board details

Figure 1 below shows the pictures of the front and back of the board with critical components highlighted.

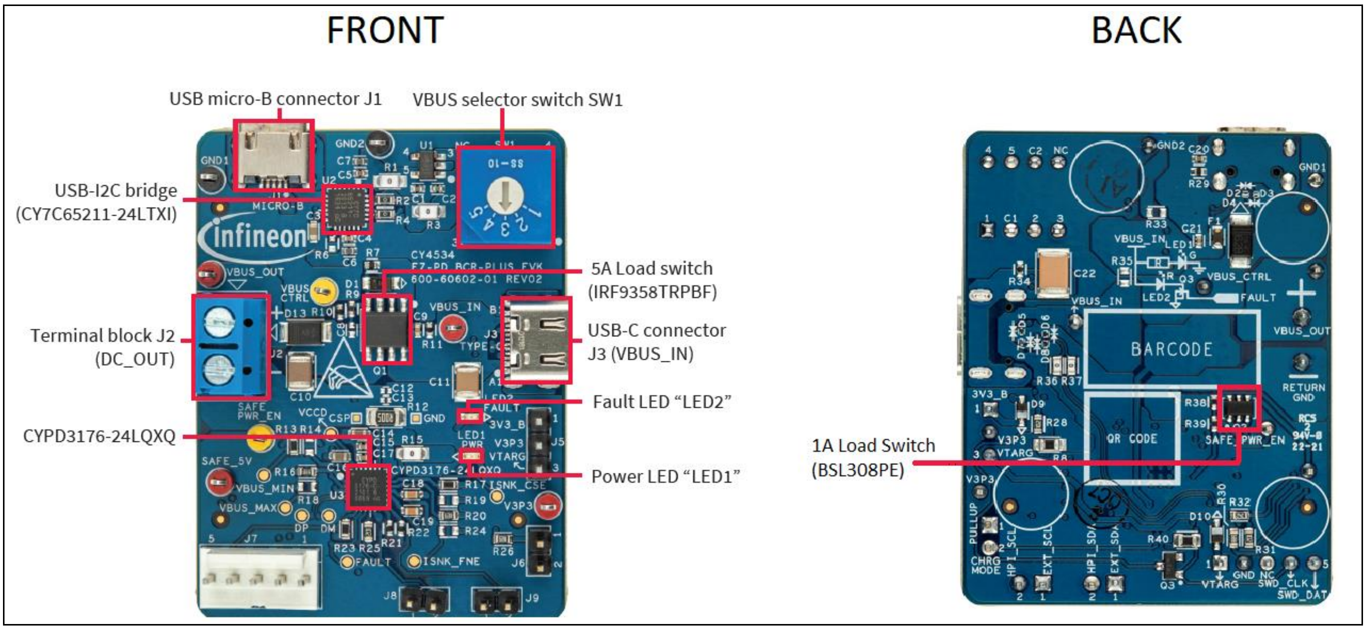


Figure 1 Board (front and back) details

Table 2 lists the major components of the EVK. A detailed bill-of-materials list is available in the design files on the kit webpage.

Table 2 A brief list of components in the CY4534 EZ-PD™ BCR-PLUS EVK

REFDES	Component	Description
U3	EZ-PD™ BCR-PLUS controller	Barrel connector replacement controller plus i.e. CYPD3176-24LQXQ device (referred to as "BCR-PLUS" through this document). This part manages the USB Type-C port and controls the load switch (PFET).
U2	USB-I2C bridge controller	Infineon's USB-serial part (CY7C65211-24LTXI) is connected to the USB micro-B connector (J1) of the EVK. This part works as a USB-I2C bridge for downloading firmware and configuring the BCR-PLUS device using the EZ-PD™ configuration utility
SW1	Rotary switch	A single-pole 5-throw switch. Set this switch to different positions to change the maximum voltage negotiated on VBUS. See **VBUS voltage and current selectors** for details.
J1	USB Micro-B connector	A USB micro-B connector connects to the PC host for downloading the firmware or configuring the device.

REFDES	Component	Description
J2	"DC_OUT" terminal block	Terminal block to measure the output voltage of the EVK or to connect any external electronic load.
J3	Type-C connector	A power-only USB Type-C connector with D+/D-.
J5	Alternate power selection jumper	Power selection jumper to select the alternate power to supply the BCR-PLUS device. See **Alternate power source selection** jumper for details.
J6	Legacy charging mode selection header	A header to enable or disable the legacy charging protocol support feature. See **Legacy charging mode selection jumper** for details.
J7	Debug header	5-pin debug header for internal use
J8, J9	External HPI connection header	Headers to route the external HPI (HPI_SDA, HPI_SCL) connection to the BCR-PLUS device. See **External host processor interface (HPI) connection header** for details.
LED1	VBUS-powered LED	Power LED indicating system state
LED2	Fault LED	LED indicating system faults. See **Fault LED and VBUS-powered LED** for details.
Q1	PFET as a main 5 A load switch	A back-to-back PMOSFET used as a 5-A load switch that isolates the system power from VBUS. See **DC power transfer system** for details.
Q2	PFET as a safe 5 V 1 A load switch	A back-to-back PMOSFET used as a safe 5-V 1A load switch, enabled when the PD contract defaults to 5 V due to mismatching capabilities. See section **EVK behavior under mismatched capabilities** for details.
R16, R18	VBUS_MAX resistor selector	Resistor dividers that set the maximum and minimum voltages that the BCR-PLUS device will negotiate with the USB Type-C charger. See **VBUS voltage and current selectors** for details.
R13, R14	VBUS_MIN resistor selector	
R17, R19	ISNK_COARSE resistor selector	Resistor dividers that set the coarse and fine settings for minimum current that the BCR-PLUS device will negotiate with the USB Type-C charger. See **VBUS voltage and current selectors** for details.
R20, R24	ISNK_FINE resistor selector	

2.2 BCR system overview

All DC-powered electronic devices need a power source to operate normally or to charge their battery. Such devices often have a barrel receptacle connector and a corresponding DC barrel power adapter to supply power.

Figure 2 is an example of one such combination.

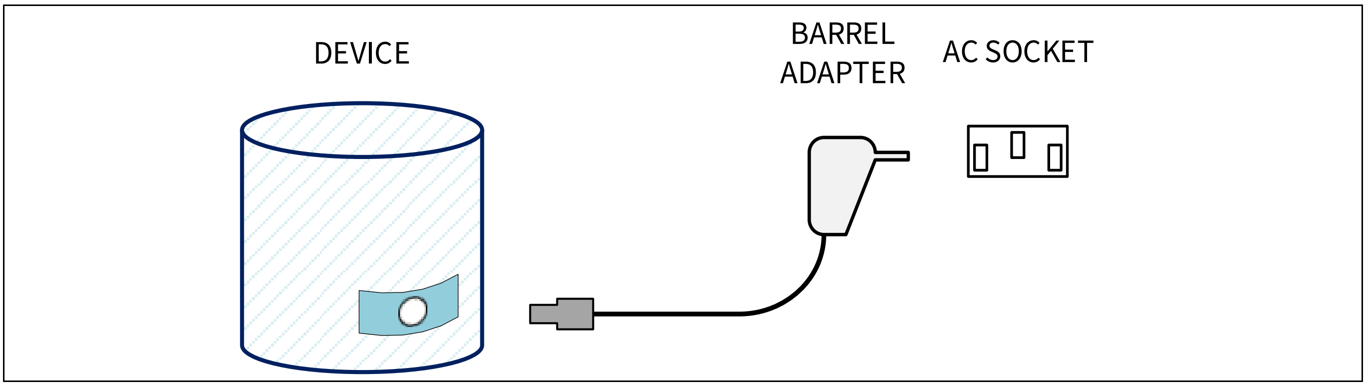


Figure 2 **Typical electronic device and its DC barrel power adapter**

Such electronic devices usually require a specific voltage and current output from the power adapter. To satisfy this, the DC barrel adapter's plug is often custom-made for a device.

USB was the first connector to introduce a standard method of supplying 7.5-W power at 5 V to electronic devices. A device with a USB micro-B connector can use a standard USB charger that can also be used with other devices with micro-B ports.

USB Type-C extends this approach for devices that consume up to 100 W of power.

The EZ-PD™ BCR-PLUS controller device makes the transition from DC barrel connector to USB Type-C connector easier by offering a plug-and-play approach to power input design.

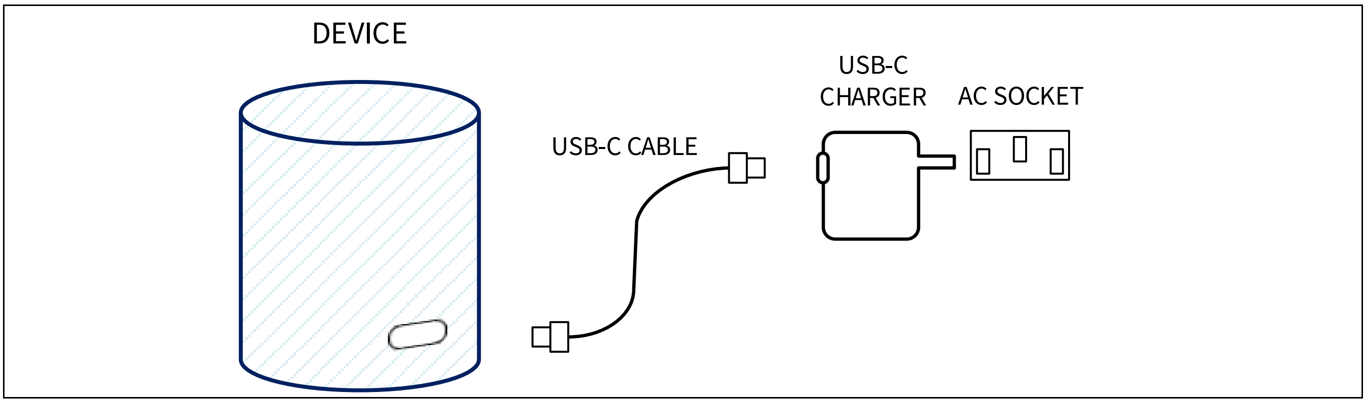


Figure 3 **Newer electronic devices powered by USB Type-C power adapters**

The CY4534 EZ-PD™ BCR-PLUS EVK has a USB Type-C connector (J3) on one end to negotiate power with Type-C power adapters. It has a terminal block (J2) to which any cable with a DC barrel plug can be connected. The EVK is therefore a converter between a USB Type-C connector and a DC Barrel plug.

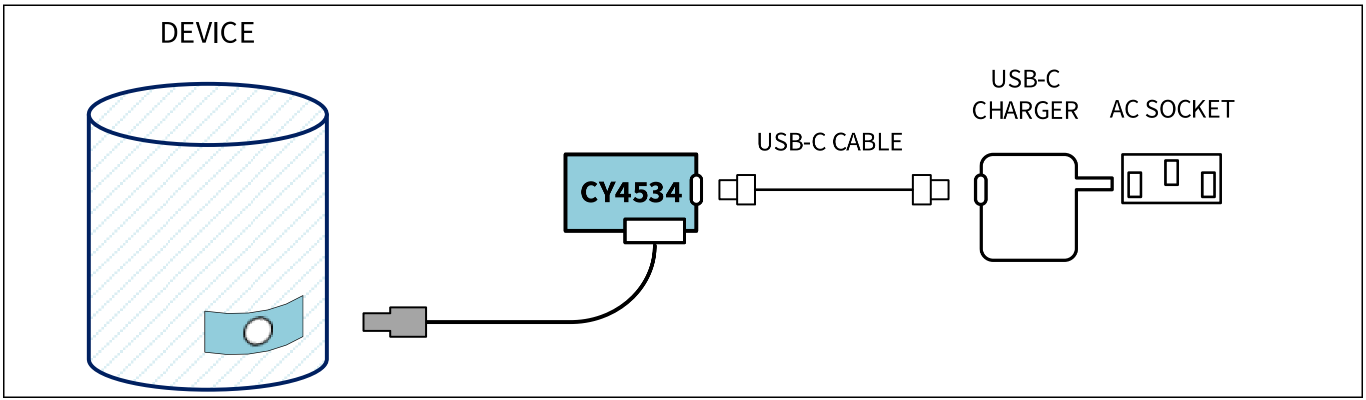


Figure 4 Using the CY4534 EZ-PD™ BCR-PLUS EVK to convert USB Type-C power adapter to legacy barrel adapter

2.3 Block diagram and functional description

Figure 5 shows the block diagram of the CY4534 EZ-PD™ BCR-PLUS EVK board.

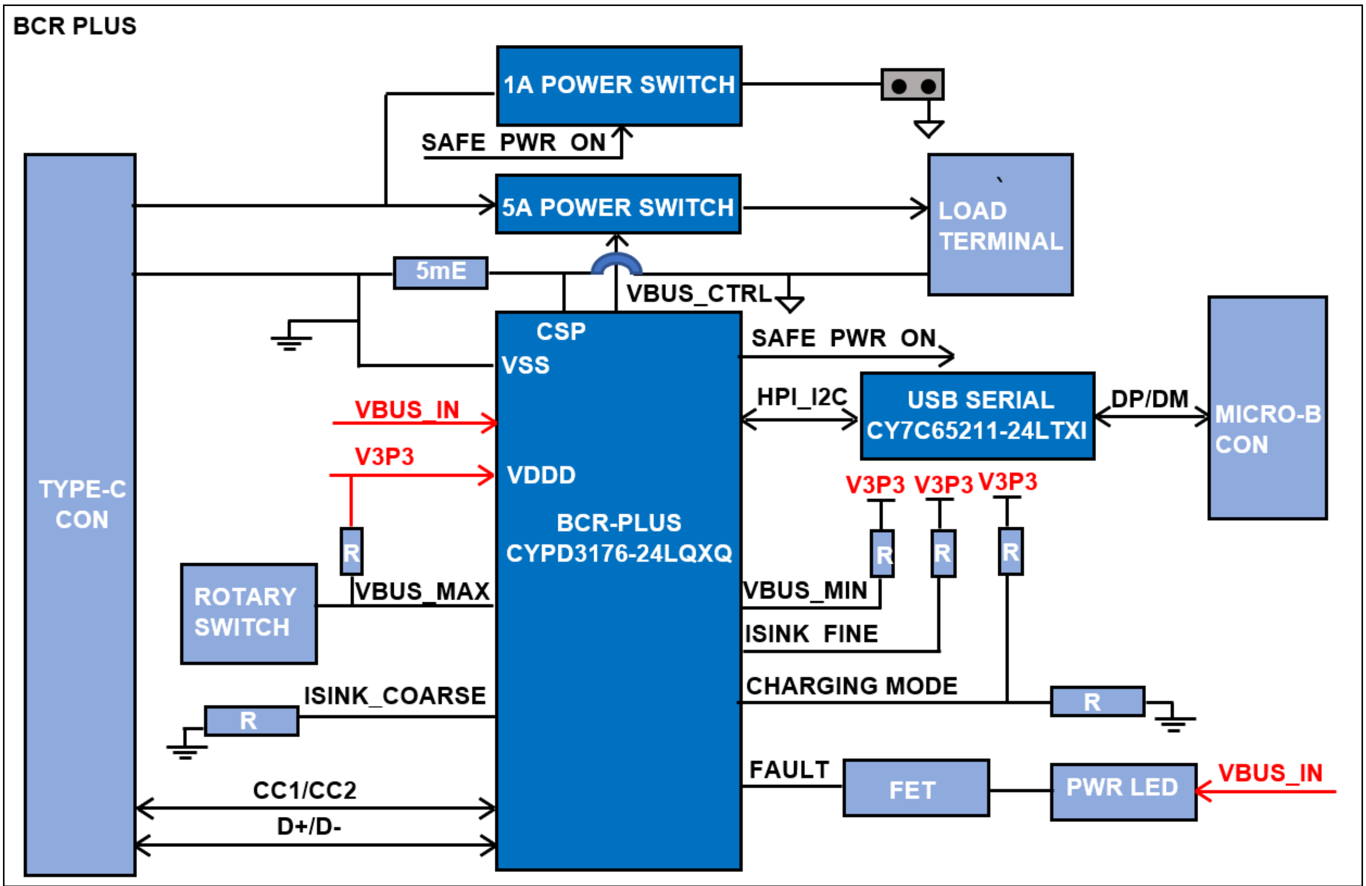


Figure 5 CY4534 EZ-PD™ BCR-PLUS EVK board block diagram

The EZ-PD™ BCR-PLUS controller is a new device in the USB Type-C family for barrel connector replacement (BCR) applications. This device combines a certified USB Type-C rev 1.2 and power delivery rev 3.0 subsystem, high-voltage analog for protection, sink-side overcurrent protection and monitoring, legacy charging support (for BC 1.2, QC2.0, AFC, and Apple Charging), and a load switch controller in an easy-to-use package.

The EZ-PD™ BCR-PLUS controller supports an I^2C bootloader for downloading firmware or updating the configuration parameters of the configuration table using the EZ-PD™ configuration utility.

The CY4534 EZ-PD™ BCR-PLUS EVK features an on-board BCR-PLUS controller which communicates with a USB Type-C power adapter to negotiate for the proper voltage and current, as specified by on-board resistors. The DP and DM lines from the BCR-PLUS controller are connected to the Type-C connector for legacy charging protocol support.

The EVK has a green LED (LED1) to indicate the availability of VBUS and a red LED (LED2) to indicate a fault with the expected output.

2.3.1 EZ-PD™ BCR-PLUS controller features

- Fixed-function USB Type-C and power delivery controller supporting USB-PD Rev 3 and Type-C Rev 1.2
- Integrated precision Rd and dead-battery Rd termination resistors
- Integrated regulator to power from VBUS
- Supports a high-voltage P-MOSFET gate driver with slew-rate control
- Supports on-chip OVP and UVP to protect system from faults
- Supports legacy charging protocol (BC1.2, QC2.0, AFC and Apple Charging).
- System-level ESD protection on CC, VBUS, DP and DM pins. ± 8-kV contact discharge and ± 15-kV air gap discharge based on IED61000-4-2 level 4C
- Available in a 24-pin QFN package

For more information, see the BCR-PLUS datasheet.

2.3.2 DC power transfer system

Figure 6 shows the PFET load switch circuitry and the VBUS path of the EVK board.

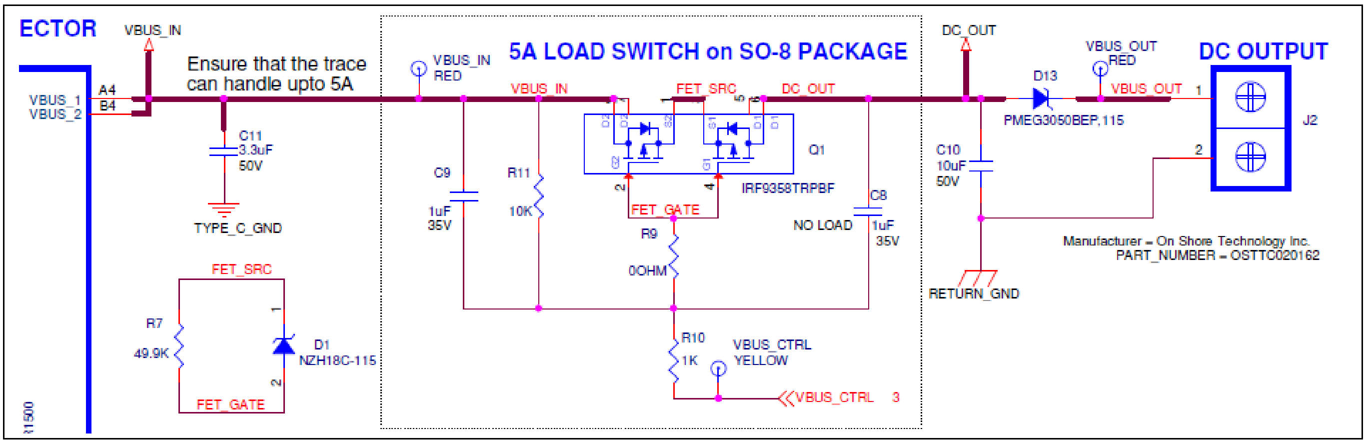


Figure 6 **VBUS Path and P-FET load switch**

Power supplied by the USB Type-C power adapter is sent to an external device or load through a set of back-to-back power PMOSFETs. The PMOSFETs are used for the following functions:

- Reduce the in-rush current due to large capacitive loads. The BCR-PLUS device turns the FETs on slowly to ensure that the in-rush current is limited and controls the rise time of the DC output voltage. The RC circuit of R11 and C9 also helps in slowing the FET turn-on time; its values can be modified to change the turn-on behavior for application-specific needs. Additional fine tuning, if required, can be performed by selecting slower turn-on options using the EZ-PD™ configuration utility.
- When the VBUS input on the USB Type-C connector is out of range, the BCR-PLUS device turns the FETs off to protect the rest of the system.
- If the attached USB Type-C power adapter cannot supply the voltages required by the system (as indicated by the resistor divider selectors), the BCR-PLUS device turns the PMOSFET load switch off.

The output of the FETs is connected to terminal block J2. The system to be evaluated can be connected and powered via this block.

2.3.3 VBUS voltage and current selectors

Figure 7 shows the voltage and current resistor divider networks of the EVK board. The voltage and current ranges that the BCR-PLUS device will negotiate with the USB Type-C power adapter are determined by this set of resistor dividers.

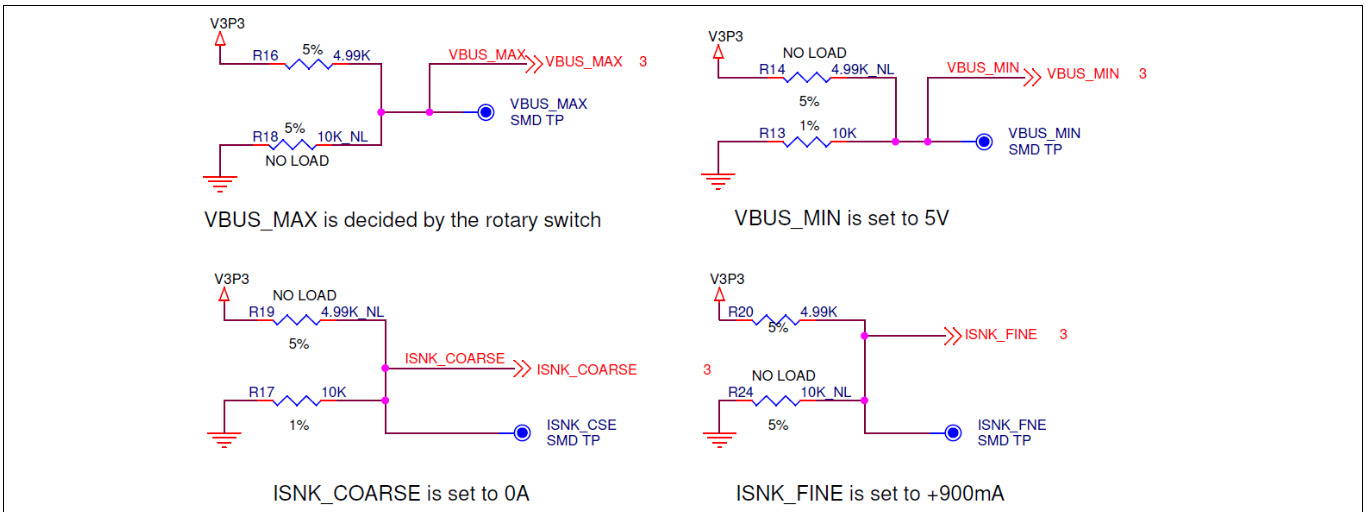


Figure 7 Four resistor dividers that select the VBUS voltage and current

The dividers on the VBUS_MIN and VBUS_MAX pins of the BCR-PLUS (R16 and R18 for VBUS_MAX, R14 and R13 for VBUS_MIN) determine the minimum and maximum voltages that BCR-PLUS device will negotiate. By default, VBUS_MIN is set to 5 V and the 5-position switch is used to determine VBUS_MAX. However, for customers using the BCR-PLUS device for their end application, the VBUS_MIN and VBUS_MAX voltages can be finalized using the resistor divider network values as shown in **Table 3**. To use the resistor divider network on the kit for VBUS_MAX, SW1 must be at position 5.

For example, if the divider on VBUS_MIN is set to 9 V (i.e., R14 = 5-kΩ pull-up, R13 = 1-kΩ pull-down) and VBUS_MAX is set to 12 V (R16 = 5-kΩ pull-up, R18 = 2.4-kΩ pull-down), the BCR-PLUS device will request any voltage between 9 V and 12 V from the power adapter, always preferring the highest voltage. If the power adapter cannot supply power at 9 V, 12 V, or a value in between, the BCR-PLUS device will turn the load switch OFF and will assert the FAULT pin.

See **Table 3** for a complete list of the available pull-up and pull-down resistor values.

Table 3 Resistor divider values for achieving the desired VBUS_MIN and VBUS_MAX voltages

Voltage on VBUS_MAX or VBUS_MIN pin of BCR_PLUS device (V)	Correlated VBUS voltage(V)	Pull-up resistor value for R14 or R16 (kΩ)	Pull-down resistor value for R13 or R18 (kΩ)
V = 3.3 * (0/6)	5	None (DNP)	0
V = 3.3 * (1/6)	9	5	1
V = 3.3 * (2/6)	12	5	2.4
V = 3.3 * (3/6)	15	5	5
V = 3.3 * (4/6)	19	5	10
V = 3.3 * (6/6)	20	0	None (DNP)

Similarly, the resistor dividers on ISNK_COARSE and ISNK_FINE determine the operating current communicated to the Type-C power adapter (in the request data object; see Section 6.4.2 of the USB-PD specification rev 3.0 version 1.2). The operating current value (ISNK) is the sum of currents indicated by ISNK_COARSE and ISNK_FINE. By default, the maximum current is set to 900 mA. See **Table 4** and **Table 5** for a complete list of the pull-up and pull-down resistor values for the resistor dividers on ISNK_COARSE and ISNK_FINE respectively. For scenarios where the operating current value ISNK is greater than 5 A (i.e., ISNK_COARSE + ISNK_FINE > 5 A), the BCR-PLUS device will limit the operating current (ISNK) value to 5 A.

Table 4 Resistor divider values for achieving the desired ISNK_COARSE current values

Voltage on ISNK_COARSE (V)	Pull-up resistor on ISNK_COARSE (R19) (kΩ)	Pull-down resistor on ISNK_COARSE (R17) (kΩ)	ISNK_COARSE (A)
V = 3.3 * (0/6)	None (DNP)	0	0
V = 3.3 * (1/6)	5	1	1
V = 3.3 * (2/6)	5	2.4	2
V = 3.3 * (3/6)	5	5	3
V = 3.3 * (4/6)	5	10	4
V = 3.3 * (6/6)	0	None (DNP)	5

Table 5 Resistor divider values for achieving the desired ISNK_FINE current values

Voltage on ISNK_FINE (V)	Pull-up resistor on ISNK_FINE (R20) (kΩ)	Pull-down resistor on ISNK_FINE (R24) (kΩ)	ISNK_FINE (mA)
V = 3.3 * (0/6)	None (DNP)	0	0
V = 3.3 * (1/6)	5	1	250
V = 3.3 * (2/6)	5	2.4	500
V = 3.3 * (3/6)	5	5	750
V > 3.3 * (3/6)	0	None (DNP)	900

See **Changing the VBUS voltage and current requested from the power** adapter for details on how the BCR-PLUS uses these pins to select VBUS voltages.

2.3.4 Fault LED and VBUS-powered LED

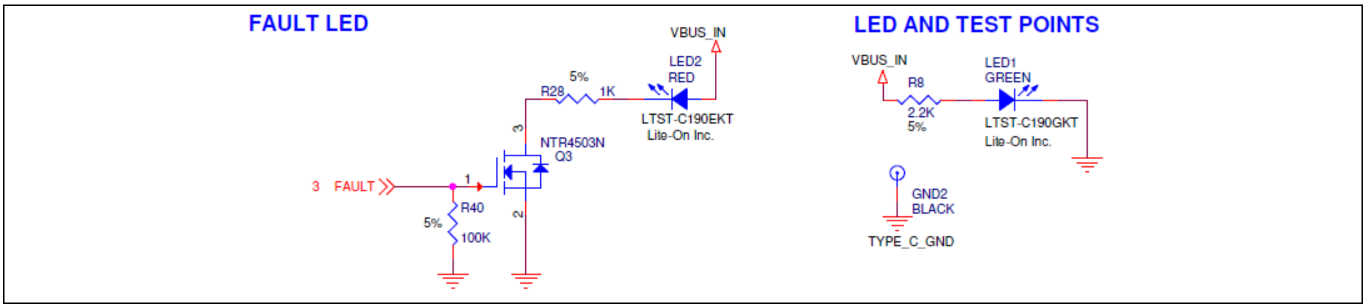


Figure 8 Red FAULT LED and green VBUS-powered LED

The fault LED will be turned on by driving the FAULT pin HIGH under the following conditions:

- A USB-PD contract could not be negotiated and the VBUS_MIN voltage indicated is not 5 V.
- A USB-PD contract was negotiated but none of the voltages offered are within the VBUS_MIN and VBUS_MAX ranges.
- Voltages offered by the power adapter is within range but the current offered is below the ILIM limit.
- VBUS voltage supplied by power adapter is outside expected limits.
- The load draws more current than the expected current threshold when Sink OCP is enabled using the EZ-PD™ configuration utility.
- The sink device temperature measured by an external thermistor exceeds the programmed threshold (only when OTP is enabled using the EZ-PD™ configuration utility).

2.3.5 Alternate power source selection jumper

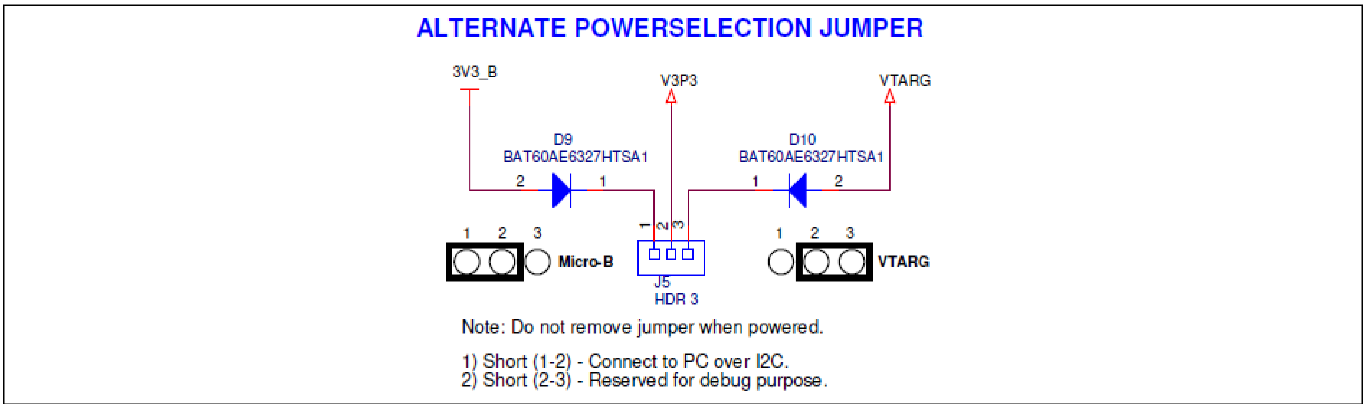


Figure 9 Alternate power selection jumper circuit

The EVK has a 3-pin jumper (J5) which is designed with a 3-position 100-mil pitch male header. The jumper header is used for selecting the alternate power supply to power the BCR-PLUS device during the debug process.

Before using the EVK board for debugging purposes, the alternate power selection jumper (J5) should be placed at position 2-3. In addition to this, the USB Type-C connector (J3) and USB micro-B connector (J1) should be left unconnected.

Before using the EZ-PD™ configuration utility for updating the configuration parameters of the BCR-PLUS device on EVK board, the alternate power selection jumper (J5) should be placed at position 1-2. In addition to that, the USB Type-C connector (J3) should be left unconnected and the USB Micro-B connector (J1) should be connected to the PC (which has the EZ-PD™ configuration utility installed) using a USB Micro-B cable.

2.3.6 External host processor interface (HPI) connection header

HPI is a proprietary protocol on top of I^2C that exposes the control and status registers of the BCR-PLUS device. See the EZ-PD™ BCR-PLUS/BCR-LITE Host Processor Interface specification for details.

The HPI pins (HPI_SCL and HPI_SDA) of the EVK are exposed on external HPI connection headers (pin 2 of J8, pin 2 of J9) with an internal 2-kΩ resistor pulled up to V3P3. An external embedded controller (EC) can connect to these pins directly and communicate to the BCR-PLUS device using the EZ-PD™ BCR-PLUS HPI protocol. The BCR-PLUS appears as an I^2C slave with a 7-bit slave address of 0x08.

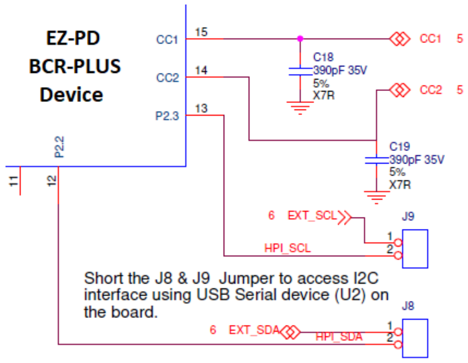


Figure 10 External HPI connection header circuit

2.3.7 Legacy charging mode selection jumper

The CHARGING_MODE pin of the BCR-PLUS device on the EVK board is connected to the legacy charging mode selection jumper header (J6). Upon power-up, the BCR-PLUS device will check the status of the CHARGING_MODE detection pin to determine which legacy charging protocols to support.

- Keep J6 open/unconnected to support all legacy charging protocols. The negotiation sequence will be as follows:
  - **Negotiation sequence:** (USB-PD → BC1.2 → AFC → QC2.0 (Class B) →Apple →Type-C Only)
- Short J6 to support the BC1.2 legacy charging protocol only.

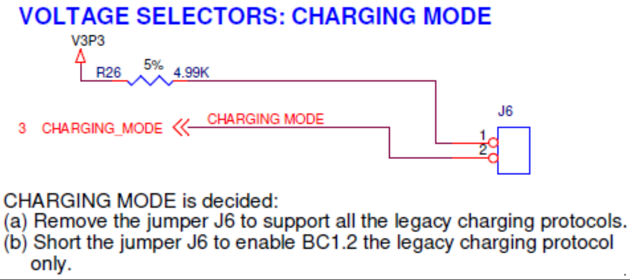


Figure 11 Legacy charging mode selection jumper circuit

2.4 Changing the VBUS voltage and current requested from the power adapter

The BCR-PLUS device executes a capability matching algorithm to select the best voltage and current from the attached USB Type-C power adapter.

Internally, the BCR-PLUS device maintains a 'Sink Capabilities' list based on the VBUS voltage and current selector pins.

Table 6 Sink capabilities stored inside the BCR-PLUS device

Field in the PDO	Sink capability/PDO #1	Sink capability/PDO #2
PDO (power delivery object) type	Fixed supply	Variable supply
Min voltage	5 V	VBUS_MIN value
Max voltage	5 V	VBUS_MAX value
Current	900 mA	ISNK_COARSE + ISNK_FINE

If the VBUS_MIN value is higher than 5 V, the "Higher Capability" bit is set in the first sink power delivery object (PDO). This tells the Type-C power adapter that voltages higher than 5 V are needed by the system.

The capability matching algorithm works as follows:

1. Loop through the power adapter's source PDOs from highest voltage first to find the first PDO that satisfies the following conditions:
   a) Source_PDO_Voltage ≥ VBUS_MIN
   b) Source_PDO_Voltage ≤ VBUS_MAX
   c) Source_PDO_Maximum _Current ≥ ISNK_COARSE + ISNK_FINE
2. If all three conditions are satisfied, the BCR-PLUS device sends a request for this PDO with operating current set to ISNK_COARSE + ISNK_FINE.
3. If any condition is not satisfied, the BCR-PLUS device requests 5 V (PDO #1) with 900 mA operating current. The BCR-PLUS device also sets the 'CapabilityMismatch' flag in the request message.
   a) Once this mismatch of capabilities is detected, FAULT goes HIGH (3.3 V strong drive) and the "Safe 5V" load switch (Q3) turns ON.

To modify the VBUS_MAX value, use the rotary switch. To modify the VBUS_MIN, ISNK_COARSE, and ISNK_FINE values, mount the correct resistor values (see **Table 3**, **Table 4**, **Table 5**) for the resistor divider networks for each on the bottom of the board.

For details, see the schematics of the CY4534 EZ-PD™ BCR-PLUS EVK board on the kit **webpage**.

3 Kit operation

This chapter describes how to configure the CY4534 EZ-PD™ BCR-PLUS EVK to demonstrate the functionality as a USB Type-C power sink attached to an external device or load.

3.1 External hardware required for demos

- A USB Type-C power adapter or power bank device
  - **Example power adapters: Apple 30W power adapter**, **HP 45W laptop AC power adapter**
  - **Example power banks: Anker PowerCore 13000 C**, **Anker PowerCore III 45W PD Portable Charger**
- A USB Type-A power adapter that is capable of handling legacy charging protocol like QC 2.0 (for eg: **Anker 60W PIQ 3.0 dual port charger**)
- A cable to connect the power adapter or power bank (if not already provided with the USB-C power adapter) to the Type-C receptacle on the CY4534 EZ-PD™ BCR-PLUS EVK board
- An electronic device that is powered by a DC barrel connector (for **Demo #1: Test with a multimeter and the EZ-PD™ protocol analyzer**)
- A DC barrel power adapter for the electronic device (for **Demo #1: Test with a multimeter and the EZ-PD™ protocol analyzer**)
- A 3-mm flat-head screwdriver
- A wire stripper
- A USB micro-B cable
- A multimeter to measure voltages (for **Demo #1: Test with a multimeter and the EZ-PD™ protocol analyzer**)

3.2 Running the demos

3.2.1 Demo #1: Test with a multimeter and the EZ-PD™ protocol analyzer

In this demo, a multimeter is connected to the EVK to test the various voltages offered by the USB Type-C power adapter (or power bank). You can also connect an electronic load in parallel with the multimeter to test current capabilities of the power adapter (or power bank) and the EVK.

In addition, you will use the **CY4500 EZ-PD™ protocol analyzer** to observe and analyze the USB power delivery packets exchanged between BCR-PLUS device and the USB Type-C power adapter.

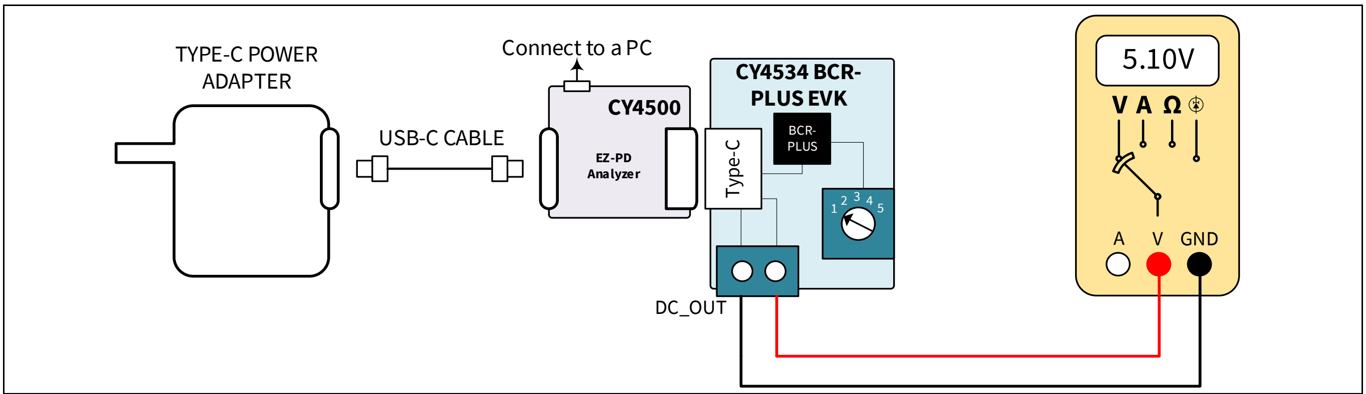


Figure 12 **CY4534 EZ-PD™ BCR-PLUS EVK, multimeter, Type-C power adapter and CY4500 protocol analyzer**

To set up the demo, perform the following steps:

1. Connect a multimeter to the DC_OUT terminal block (J2) of the CY4534 EZ-PD™ BCR-PLUS EVK. If desired, you may also have a load connected in parallel with the multimeter. See **Board details** to determine the polarity of the terminal block or look at the markings on the back of the board.
2. Connect the EVK to the EZ-PD™ protocol analyzer's plug. Connect the EZ-PD™ protocol analyzer to your PC using the USB micro-B cable supplied with it.
3. Ensure that the protocol analyzer software (known as EZ-PD™ analyzer utility) and the necessary drivers are installed. See the **CY4500 EZ-PD™ protocol analyzer** kit webpage for details.
4. Open the EZ-PD™ analyzer utility and start a capture.
5. Connect a USB Type-C power adapter to the Type-C receptacle of the protocol analyzer. You will observe USB power delivery packets captured on the EZ-PD™ analyzer utility.

Each USB Type-C power adapter will advertise a list of voltage and current combinations (called PDOs). The BCR-PLUS device will select the best PDO based on a set of rules described in the **Changing the VBUS voltage and current requested from the power** adapter section.

In short, the VBUS_MAX rotary switch governs the highest voltage that the BCR-PLUS device will request. If that voltage is unavailable, it looks for the next highest voltage, and so on.

To test this, perform the following steps on the demo setup:

6. Set the VBUS_MAX rotary switch (SW1) to position 1. Verify that the multimeter connected to the DC_OUT terminal (J2) displays a voltage between 4.5 V and 5.5 V. Detach the power adapter after this observation is verified. Note that unlike the CYPD3177 EZ-PD™ BCR device, the CYPD3176 BCR-PLUS device requires a power cycle to register the change in VBUS_MIN and VBUS_MAX voltages.
7. Set the VBUS_MAX rotary switch (SW1) to position 2. Re-attach the Type-C power adapter. Verify that the multimeter displays a voltage between 8.55 V and 9.45 V. If the power adapter does not support this voltage, you will observe ~5 V.
8. Repeat steps 6 and 7 through all switch positions and observe the output voltage on the multimeter connected to DC_OUT terminal (J2). If the power adapter supports that voltage, the multimeter reading will be in the range of VBUS_MAX ± 5%.

3.2.2 Demo #2: Change the sink capabilities from the EZ-PD™ configuration utility

The configuration parameters in the default firmware running in the BCR-PLUS device contain PDO#1 as a fixed supply PDO and PDO#2 as a variable supply PDO. This demonstration shows how to change the BCR-PLUS device's sink capabilities by using the EZ-PD™ configuration utility to remove the PDO#2 variable supply PDO to disable the feature to request various voltages from the USB Type-C power adapter. The result is that the kit will always request 5 V from the fixed supply PDO#1.

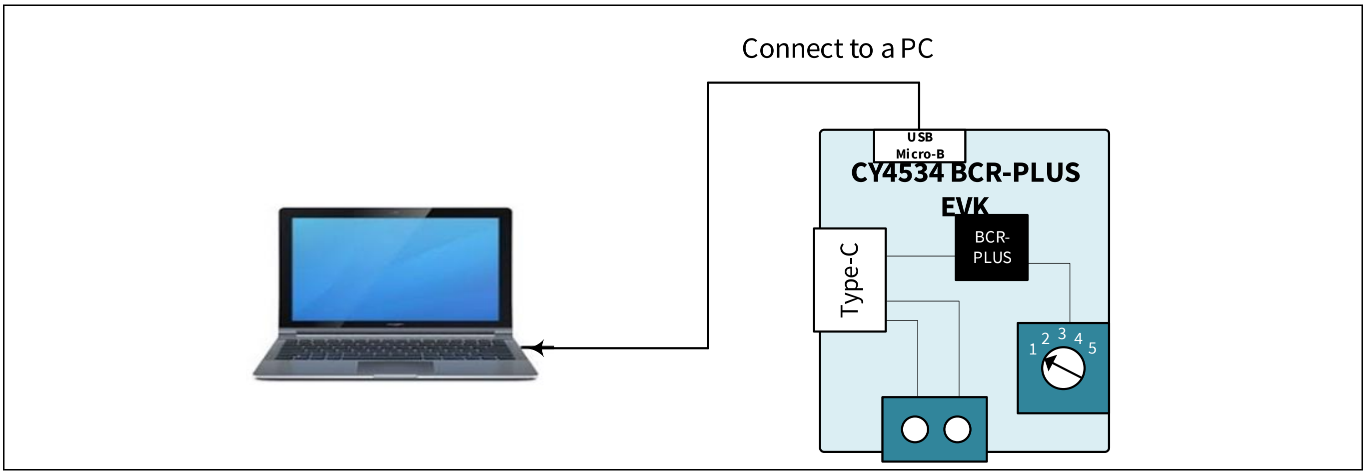


Figure 13 Configuring the BCR-PLUS device on the CY4534 EZ-PD™ BCR-PLUS EVK

To set up the demo as shown in **Figure 13**, perform the following steps:

1. Set jumper J5 to position 1-2 to select the power source from the USB micro-B connector for the EVK board.
2. Install jumpers J8 and J9 to short the external HPI connection header in order to route the HPI signals HPI_SDA and HPI_SCL to the USB-I2C bridge controller CY7C65211(U2).
3. Connect the EVK's USB micro-B connector J1 to your PC using a USB micro-B cable.
4. Ensure that the EZ-PD™ configuration utility and the necessary drivers are installed on your PC. See EZ-PD™ configuration utility's **web page** for details.
5. Launch the EZ-PD™ configuration utility as shown in **Figure 14**. After installation, the configuration utility is available on the start menu at:
   Windows > Start > All Programs > Cypress > EZ-PD™ configuration utility > EZ-PD™ configuration utility

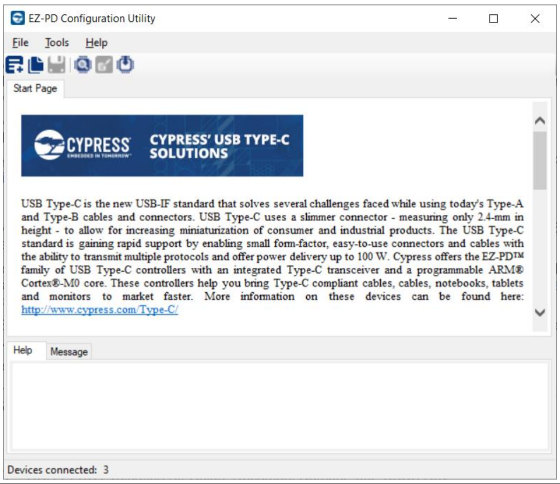


Figure 14 Launch the EZ-PD™ configuration utility on PC

6. Select **File** > **Read from Device** to read the existing configuration parameters from the BCR-PLUS device as shown in **Figure 15**.

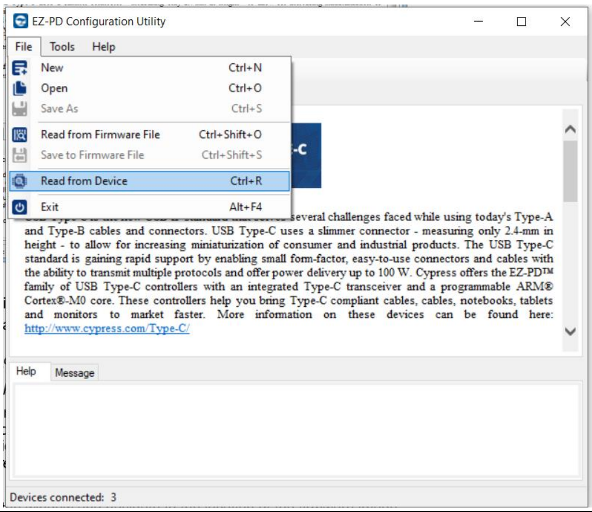


Figure 15 Read existing configuration parameters

7. The existing configuration parameters will be displayed. Before proceeding further, save this default configuration on your PC so that you can reload it once you are done with this demo.
8. In the panel on the left of the EZ-PD™ configuration utility window, select **CCGx Configuration** > **BCR configuration** as shown in **Figure 16**. In the **Power Selection** option on the right-side panel, use the dropdown menu and change the option from "**Use BCR pins**" to "**Use configuration table**" as shown in **Figure 16**. This option allows the users to override the VBUS_MAX, VBUS_MIN, ISNK_COARSE and ISNK_FINE values set using the rotary switch SW1 or the resistor dividers and use the sink PDOs set in the configuration table using the EZ-PD™ configuration utility.

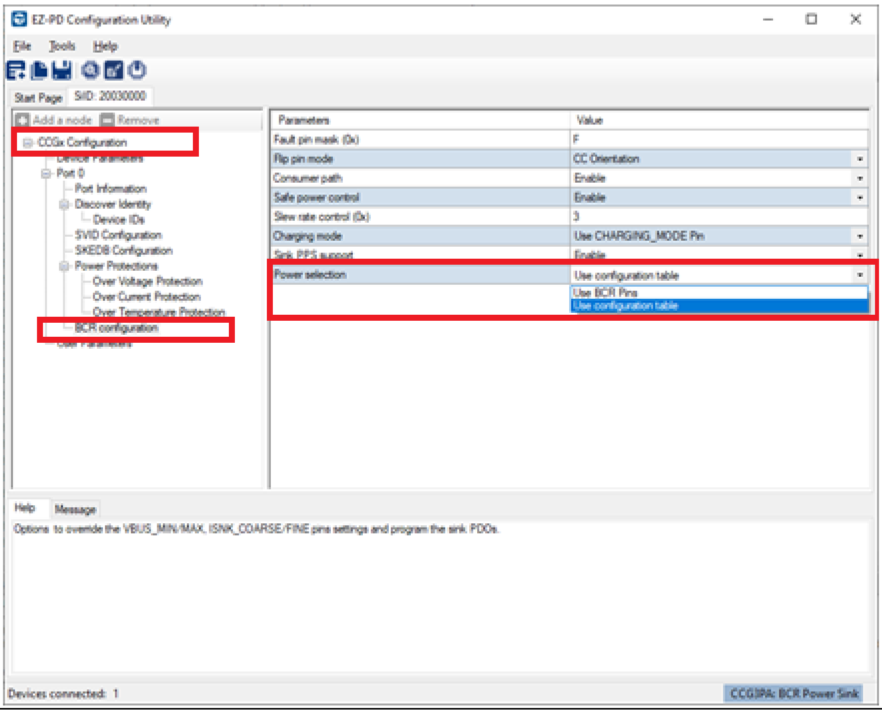


Figure 16 Changing the power selection to "Use configuration table"

9. Select **CCGx Configuration** > **PDO** > **Sink PDO** and remove the **Sink PDO 1** from the configuration table by clicking on the **Remove** button as shown in **Figure 17**.

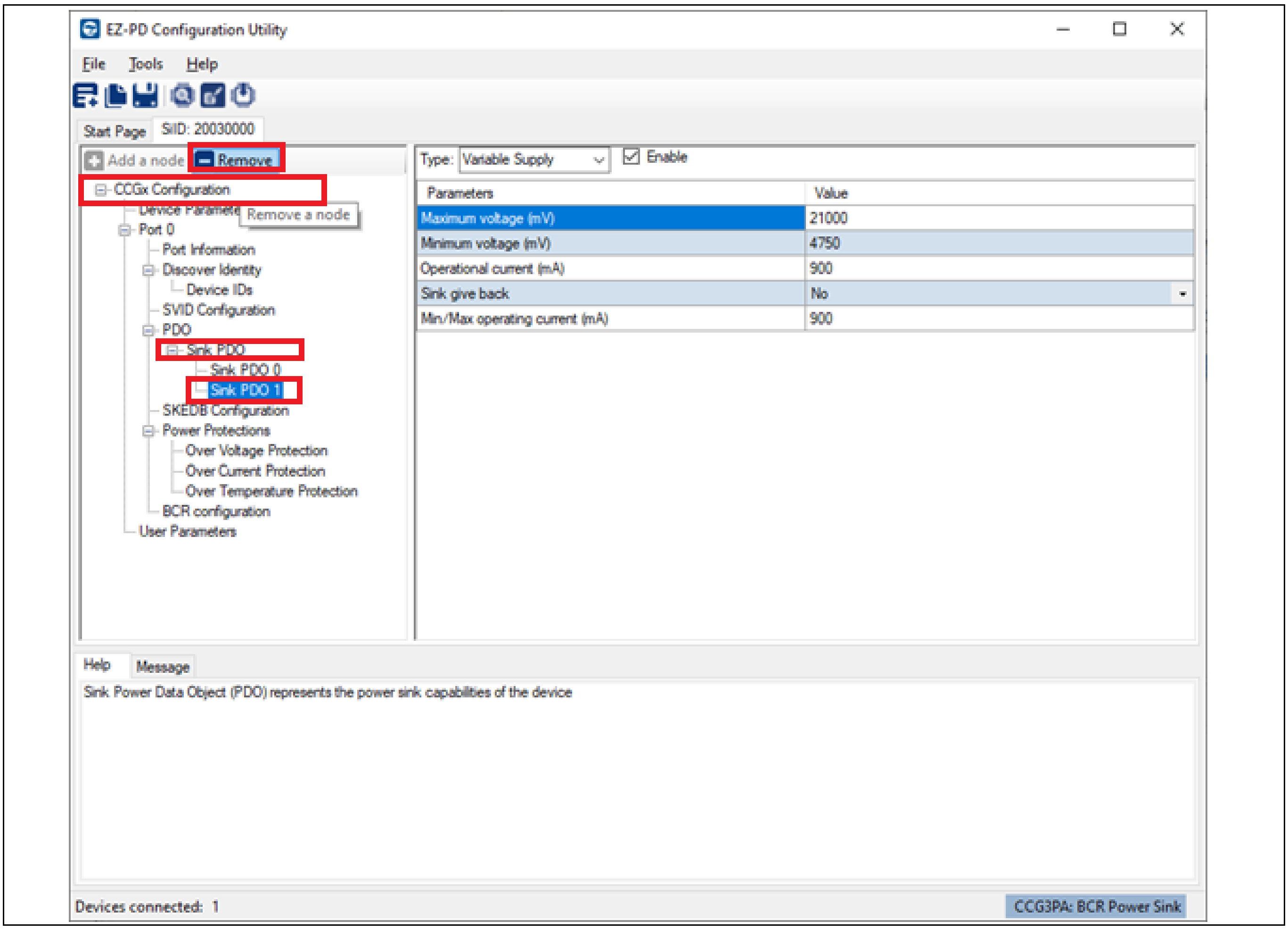


Figure 17 **Removing the sink variable PDO#2 from the configuration table**

10. Save your project on your PC to a different file than the default configuration that you saved earlier.
11. In the main menu, select **Tools** > **Configure Devices**. A new window to configure the device will open as shown in **Figure 18**.
12. In this window, under **Select Target**, select **BCR_POWER_SINK.** Point to the configuration file (.cyacd file) saved in the previous step.
13. Click **Program.** The EZ-PD™ configuration utility will load the configuration file on to the BCR-PLUS device on the EVK board and a message – "Flash updated successfully" will pop up.

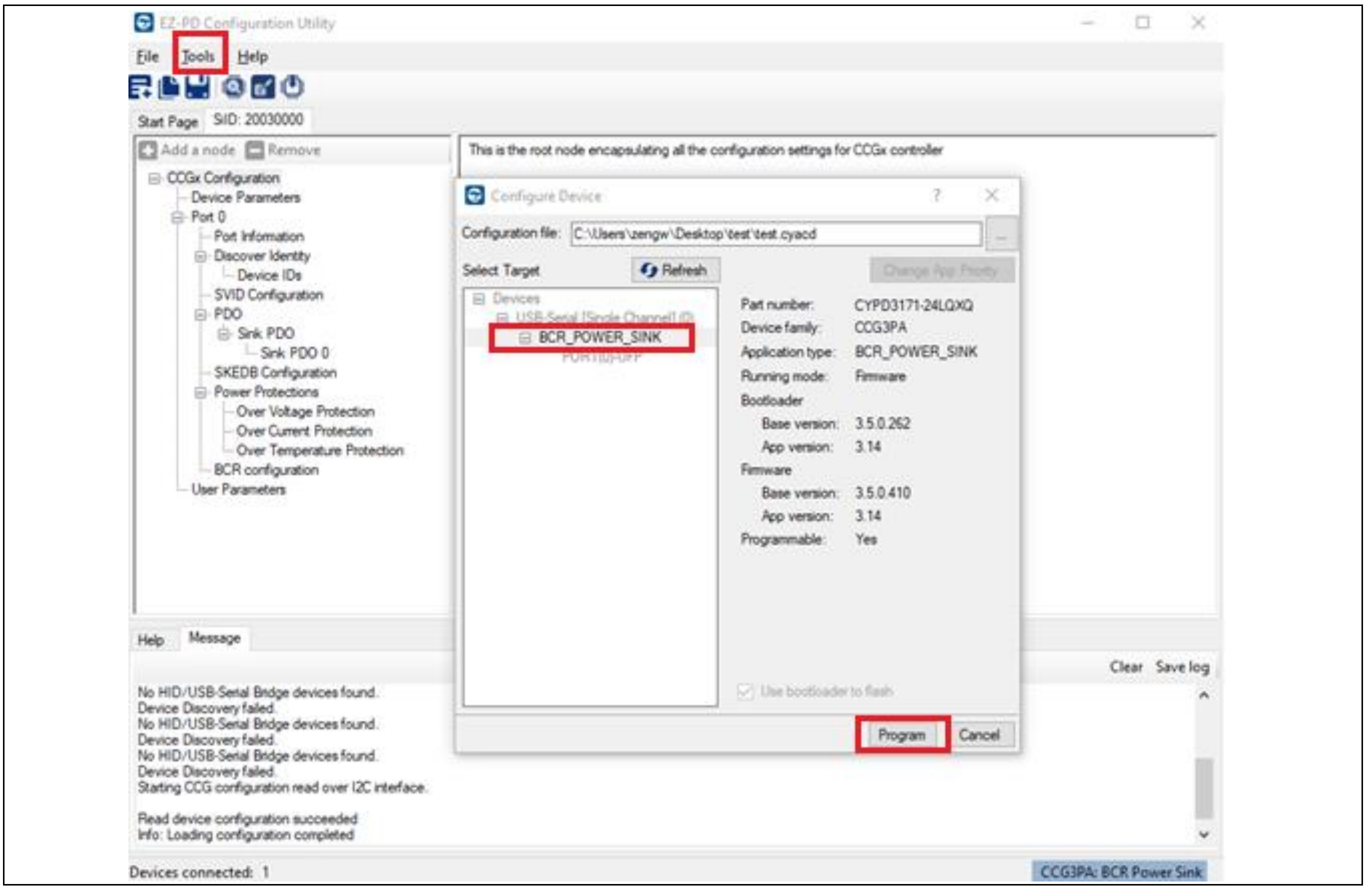


Figure 18 **Configure the BCR-PLUS device using the EZ-PD™ configuration utility**

14. After programming is complete, recycle power to the EVK board by disconnecting and re-connecting the USB micro-B cable from the EVK board.
15. Repeat Step 6 described earlier to read the configuration table from the connected device. Observe that there is only one sink PDO option available as 'Sink PDO 0' under the PDO field in CCGx configuration.

As mentioned earlier, each USB Type-C power adapter will advertise a list of voltage and current combinations known as PDOs. The BCR-PLUS device will select the best PDO based on the sink capabilities from the configuration table.

Do the following steps on the demo setup to test this:

1. Set the VBUS_MAX rotary switch (SW1) to either of the positions 1, 2, 3, 4, or 5.
2. Verify using a multimeter that the output voltage on the terminal jack J2 is 5 V, irrespective of VBUS_MAX rotary switch selection position.
   The reason for this is because the BCR-PLUS device now only supports a single PDO which is 5 V@900 mA.
3. Recycle power to the EVK board and repeat this test for other switch positions to verify the operation.

Once the operation is verified, re-load the default configuration that you saved in step 7 earlier by repeating steps 11 through 14.

3.2.3 Demo #3: Test with legacy charging mode feature

The CY4534 EZ-PD™ BCR-PLUS EVK ships with pre-programmed firmware supported to enable or disable the Legacy charging protocol by changing the jumper J6's setting for the CHARGING_MODE pin. For details, refer to the **Legacy charging mode selection jumper** section.

In this demo, a multimeter is connected to the CY4534 EZ-PD™ BCR-PLUS EVK to test the various voltages offered by the USB Type-A power adapter (or power bank) which supports legacy charging protocol (for eg: QC 2.0). The **Anker 60W PIQ 3.0 dual port charger** is used as an example. Users can also connect an electronic load in parallel with the multimeter to test current capabilities of the power adapter (or power bank) and the CY4534 EZ-PD™ BCR-PLUS EVK.

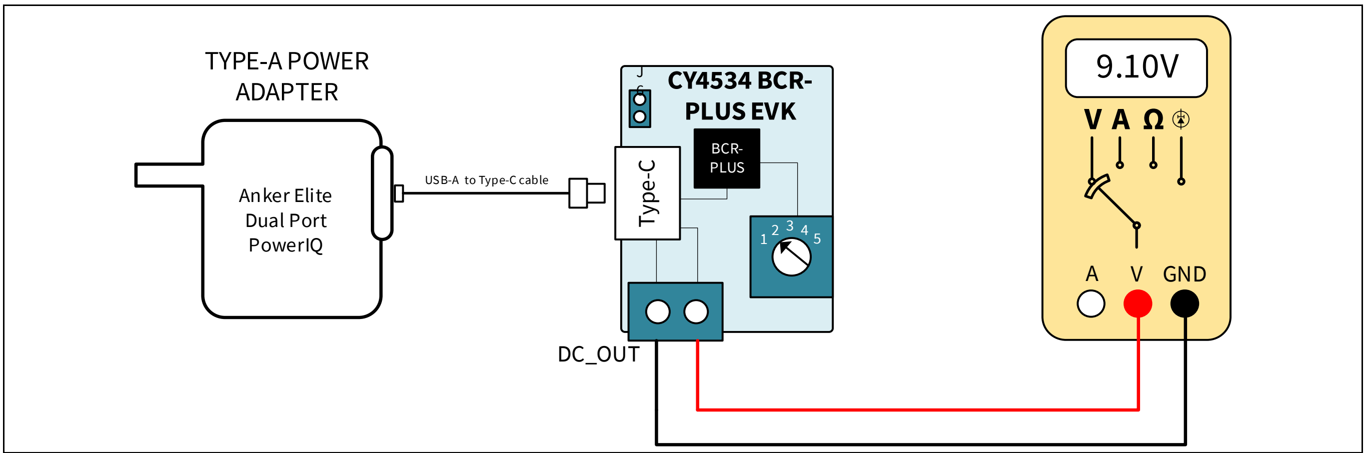


Figure 19 CY4534 EZ-PD™ BCR-PLUS EVK, multimeter and Type-A power adapter (Anker 60 W dual port)

Since the Anker dual port powerIQ supports 9 V AFC legacy charging protocol, the BCR-PLUS controller will select the best voltage requested based on a set of rules described in **Changing the VBUS voltage and current requested from the power adapter**.

In other words, the VBUS_MAX rotary switch governs the highest voltage that the BCR-PLUS device will try to request with legacy charging support enabled. If that voltage is unavailable, it looks for the next available highest voltage, and so on.

To test legacy charging support for all supported protocols (BC1.2, AFC, QC 2.0, Apple charging), perform the following steps on the demo setup:

1. Connect a multimeter to the DC_OUT terminal block J2. If desired, you may also have a load connected in parallel with the multimeter. See **Board details** to determine the polarity of the terminal block or look at the markings on the back of the board.
2. Leave J6 open/unconnected on the CY4534 EZ-PD™ BCR PLUS EVK board to enable the legacy charging support for BCR-PLUS device.
3. Connect the Type-A port of the charger to the CY4534 EZ-PD™ BCR PLUS EVK using a Type-A to Type-C cable.
4. Set the VBUS_MAX rotary switch (SW1) to position 1. Verify that the multimeter displays a voltage between 4.5 V and 5.5 V. Disconnect the power adapter after this is verified.
5. Set the VBUS_MAX rotary switch (SW1) to position 2. Reconnect the power adapter and verify that the multimeter displays a voltage between 8.55 V and 9.45 V.
6. Remove the USB-A to Type-C cable from the CY4534 EZ-PD™ BCR-PLUS EVK's Type-C receptacle connector.

To test legacy charging support for BC1.2 protocol only, perform the following steps on the demo setup:

7. Short J6 pin 1 and pin 2 to disable the legacy charging support for all protocols other than BC1.2 for the BCR-PLUS device.
8. Set the VBUS_MAX rotary switch (SW1) to position 1. Reconnect the power adapter using the USB-A to Type-C cable. Verify that the multimeter displays a voltage between 4.5 V and 5.5 V. Disconnect the power adapter after this is verified.
9. Set the VBUS_MAX rotary switch (SW1) to position 2. Reconnect the power adapter and verify that the multimeter displays a voltage between 4.5 V and 5.5 V. This is because the BC1.2 protocol can only support a typical voltage of 5 V on VBUS.

3.3 EVK behavior under mismatched capabilities

If the attached USB Type-C power adapter can supply a VBUS voltage within VBUS_MIN and VBUS_MAX limits, the CY4534 EZ-PD™ BCR-PLUS EVK will turn the load switch ON to pass the voltage onto the DC_OUT terminal block (J2).

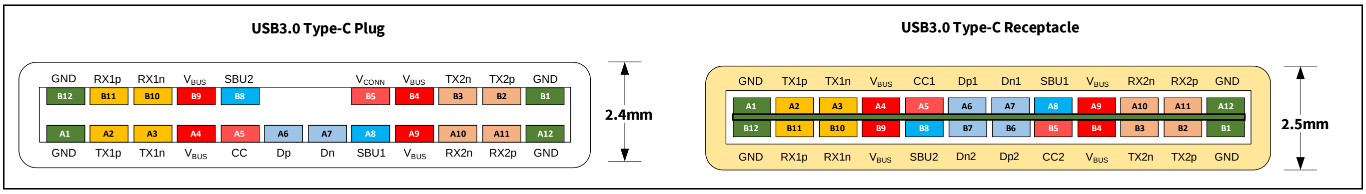
On the other hand, if the attached power adapter does not have a matching voltage/current combination, the BCR-PLUS device will indicate a capability mismatch to the power adapter and will turn the load switch OFF. See **VBUS voltage and current selectors** for details.

Under mismatch conditions, the red LED2 for FAULT turns ON, the main 5 A load switch is turned off, a 5 V contract is negotiated with the Type-C power adapter and the 5 V available on the VBUS power rail is routed to the SAFE_5V test point by turning on the 1 A load switch. See **Fault LED and VBUS-powered LED** for details.

4 Terminology

This guide assumes that you are familiar with the fundamentals of the Type-C connectivity and the USB power delivery protocol. A brief description of Type-C terms is provided here for reference.

- **Alternate modes**: A feature of a USB Type-C system whereby one or both SuperSpeed lanes may be repurposed for use with a different serial protocol, such as a DisplayPort, eSATA, or Thunderbolt.
- **Client**: A USB peripheral such as a hub, docking station, or monitor.
- **Configuration channel (CC)**: A USB Type-C bus wire used to transmit protocol signals. This is a half-duplex 300-kHz signal.
- **Consumer**: A Type-C port that sinks power from VBUS.
- **DisplayPort**: A digital display interface standard developed by the Video Electronics Standards Association. It is used primarily to connect a video source to a display such as a computer monitor.
- **Downstream facing port (DFP)**: A USB Type-C port on a host or a hub to which devices are connected.
- **Dp, Dn**: USB Type-C bus wires used to transmit and receive USB 2.0 data.
- **Dual-role port (DRP)**: A USB Type-C port that can operate as either a DFP or a UFP.
- **Electronically Marked Cable Assembly (EMCA)**: A USB cable that includes an IC that reports cable characteristics (such as current rating) to the Type-C ports.



- **Host**: A USB host system such as a PC.
- **PDO**: Power Data Object used to expose a Source Port's power capabilities or a Sink's power requirements.
- **Provider**: A Type-C port that sources power over VBUS.
- **Sideband use (SBU)**: A USB Type-C bus wire used for non-USB control signals, such as DisplayPort control signals.
- **Type-C Transceiver**: A transmitter/receiver that communicates over the CC.
- **TX1p, TX1n, RX1p, RX1n, TX2p, TX2n, RX2p, and RX2n**: USB Type-C bus wires used to transmit and receive SuperSpeed USB and PCIe or DisplayPort data.
- **Upstream facing port (UFP)**: A USB Type-C port on a device or a hub that connects to a host or the DFP of a hub.
- **USB power delivery (USB PD, PD)**: A new USB standard that increases maximum power delivery over USB from 7.5 W to 100 W.
- **USB Type-C (Type-C)**: A new standard with a slimmer USB connector and a reversible cable, capable of sourcing up to 100 W of power and supporting Alternate Modes.
- **VBUS**: A USB Type-C bus wire used for power; initially 5 V, but can be increased up to 20 V on USB PD systems.
- **VCONN**: A USB Type-C bus wire used to power the IC in the EMCA.

Revision history

Date	Version	Description
2021-10-21	**	Initial release

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