USB Type-C Controller series

Type-C Detector for Sink
BD91N01NUX EVK

BD91N01NUX-EVK-001 (Stand-Alone)

Introduction

The User's Guide describes the series of required procedures to operate and evaluate the EVK of the USB Type-C detector BD91N01NUX for Sink. The document also contains the circuit components, the operating procedures, and the Application Data.

Overview

BD91N01NUX-EVK-001 implements Stand-Alone Type-C detector IC of BD91N01NUX for Sink and performs the Type-C connection to a Source device. The EVK premises operation by VBUS power, so this EVK does not require an external power source. The EVK has a Type-A receptacle and is provided power from a Source device connected to the Type-C receptacle of the VBUS. The Type-C features of this EVK can be evaluated by connecting a USB Type-A Captive Cable or Type-A Plug device such as a mouse or a USB memory stick.

EVK Operation Condition

Parameter	Min	Typ	Max	Units	Conditions
VBUS Power Supply on Type-C receptacle	4.0	5.0	5.5	V	
VDDIO Power Supply	1.7	-	5.5	V	
VBUS Power Output on Type-A Receptacle	4.0	5.0	5.5	V	Guaranteed by USB Standard and connected Source.

No. 64UG058E Rev.001
2021.10

EVK Overview

Figure 1. BD91N01NUX-EVK-001(Top View)

Descriptions of EVK function

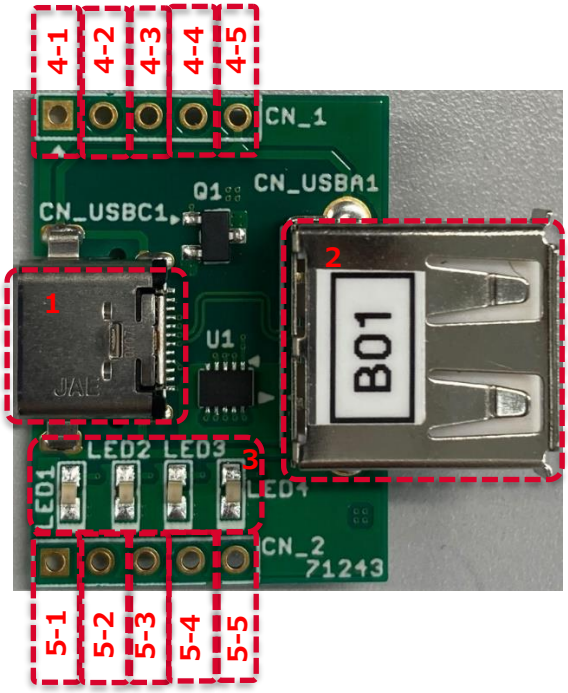

Figure 2. The descriptions of the part of BD91N01NUX-EVK-001

This EVK has the functions listed in Table 1.

Table 1. The descriptions of the available functions

No.	Function	Silk Indication	Description	Default Setting
1	Type-C Receptacle	CN_USBC1	Certified USB Type-C Receptacle TID: 5,200,000,020 Both Dp1 and Dp2, and both Dn1 and Dn2 have already been shorted so there is no need to consider the polarity of D+ and D- at the flip when plugging-in. The shorted Dp and Dn are connected to Dp and Dn in CN_USBA1, respectively.	-
2	Type-A Receptacle	CN_USBA1	The receptacle of USB Type-A	-
3	LEDs of Digital Outputs	LED1	TCC1 output, ON: TCC1=H, OFF: TCC=L	-
		LED2	TCC0 output, ON: TCC0=H, OFF: TCC=L	-
		LED3	ORIENT output, ON: Connected by CC2, OFF: Connected by CC1, or not connected	-
		LED4	SWMONI output, ON: VBUS in CN_USBA1 is on, OFF: VBUS in CN_USBA1 is open	-
4	Terminals of USB 2.0 signals	CN_1	4-1: GND 4-2: D+ Signal for USB 2.0 / 1.x 4-3: D- Signal for USB 2.0 / 1.x 4-4: VBUS in CN_USBA1 4-5: Type-C Receptacle SHELL*	-
5	Terminals of Digital Signals and VDDIO power	CN_2	5-1: TCC1 5-2: TCC0 5-3: ORIENT 5-4: SWMONI 5-5: IO power VDDIO for the above four digital outputs. It is connected to VBUS in CN_USB1 via RIO, so the power is supplied to VDDIO automatically after plugging the Source device.	-

*The USB standard mandates that the shell of the Type-C plug shall connect to the shield ground in the cable. Therefore, the shell of the Type-C receptacle is applied to GND level.

EVK schematic

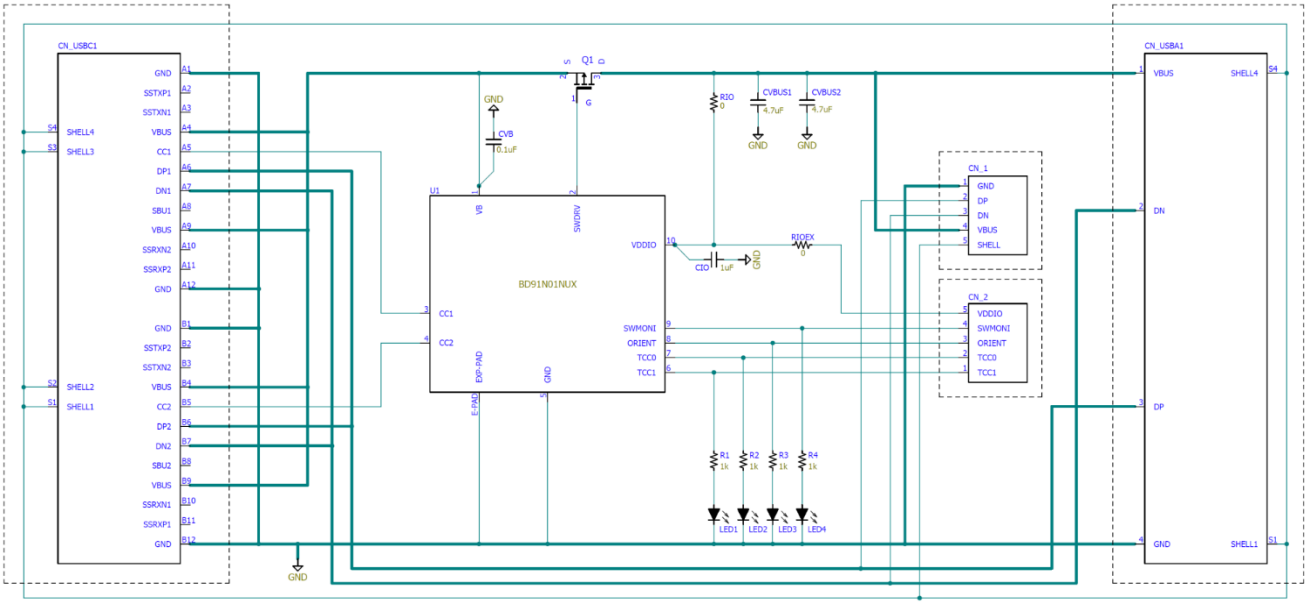

Figure 3. BD91N01NUX-EVK-001 Schematic

Operating Sequence

This EVK detects the Type-C connection with the Source device and provides power to the Sink device connected to the Type-A receptacle after detection. The lighting LED1 to LED4 indicate the status of the Type-C connection on the EVK board only.
If a more accurate evaluation close to an actual application is required, please prepare an appropriate Type-C meter, as well as an electrical load or similar USB Type-A Captive Cable or a Type-A Plug device.
(Check operation)

1. Prepare the Source device such as AC adapters then connect these to the Type-C receptacle on EVK via Type-C cable.
2. LED1 to LED4 will light up according to the status of the Type-C connection.

Table 2. Type-C current capability detection by TCC1 and TCC0

TCC1 (CN_2: 5-1)	LED1	TCC0(CN_2: 5-2)	LED2	Description
0V	OFF	0V	OFF	Disconnection from Source / Connection with any incompliance cables.
0V	OFF	5V	ON	USB Type-C default Current
5V	ON	0V	OFF	USB Type-C 1.5A
5V	ON	5V	ON	USB Type-C 3.0A

TCC1 and TCC0 only informs the status of the current capability that the connected Source device has, and the EVK / BD91N01NUX does not provide current sensing, current limiting, and current protection function.

Table 3. Flip orientation detection by ORIENT

ORIENT (CN_2: 5-3)	LED3	Description
0V	OFF	Disconnection or connection with CC1
5V	ON	Connection with CC2

Table 4. SWMONI power supply status

SWMONI (CN_2: 5-4)	LED4	Description
0V	OFF	SWDRV=5V, Q1=OFF, No power on VBUS in CN_USBA1
5V	ON	SWDRV=0V, Q1=ON, The power is supplied to VBUS in CN_USBA1

Table 5. The status of LED and connected devices

Connected devices	Cable	LED1 (TCC1)	LED2 (TCC0)	LED3 (ORIENT)	LED4 (SWMONI)
Source Type-C default	Type-C	OFF	ON	Depending on the Plug insertion CC2: ON, CC1 or not Connected: OFF	ON
Source Type-C 1.5A Capable		ON	OFF		
Source Type-C 3A Capable		ON	ON		
Source Type-C/PD Any		ON	Almost ON*		
Legacy-A	Type-A to C	OFF	ON		
Legacy-A supporting BC1.2		OFF	ON		
Proprietary Standard-A		OFF	ON		
Any	Un-compliant Cable**	OFF	OFF		OFF
Any Sink Type-C	Type-C	OFF			
Legacy-B	Type-B to C	OFF			

*It depends on the PD capabilities in the connected source.
**Please see the Application Note of BD91N01NUX for more detail

3. Confirm the nominal voltage of USB default voltage 5V being supplied to Type-C receptacle via CN1 4-4 using a digital multimeter. If there is no output voltage, there should be some issues as follows:
   - As described before, the EVK and BD91N01NUX has no current monitor and limit comparing for the sensed current capability of the Source side. Therefore, the Source device may stop supplying the VBUS power due to being latched-off by its own overcurrent protection.

- The Type-C device cannot be determined from the port shape whether it is a Source device or a Sink device. The connected device may be a Sink device.
- BD91N01NUX can detect specific non-standard Type-C cables and block the connection from the cable. Please confirm whether the cable has the USB-IF certification or not.
- The connected load to Type-A receptacle may cause a sudden inrush current, and the Source device may enter the latched-off state caused by overcurrent protection triggering. The EVK has no countermeasure for an inrush current, so please deal with it on the connected load side (Type-A board side).
- The overvoltage protection in the EVK is triggered due to an over voltage on VBUS in CN_USBC1. The EVK turns off the Pch-FET Q1 as the overvoltage protection to isolate the power source side of VBUS in CN_USBC1 from the power sink side of VBUS in CN_USBA1 safely when the overvoltage detected on the VBUS in CN_USBC1. The EVK maintains this protected condition until the applied voltage on VBUS in CN_USBC1, i.e., unplugging the Source device on CN_USBC1, is released. Please see the application note for more detail.

(An example of the connection and its supplements)

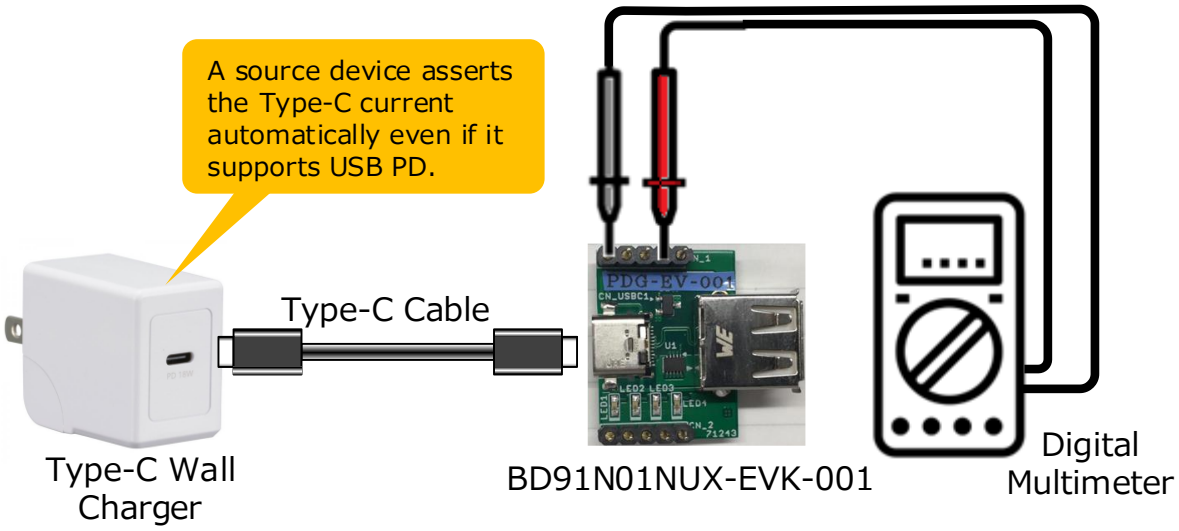

Figure 4. A single evaluation with a Type-C cable

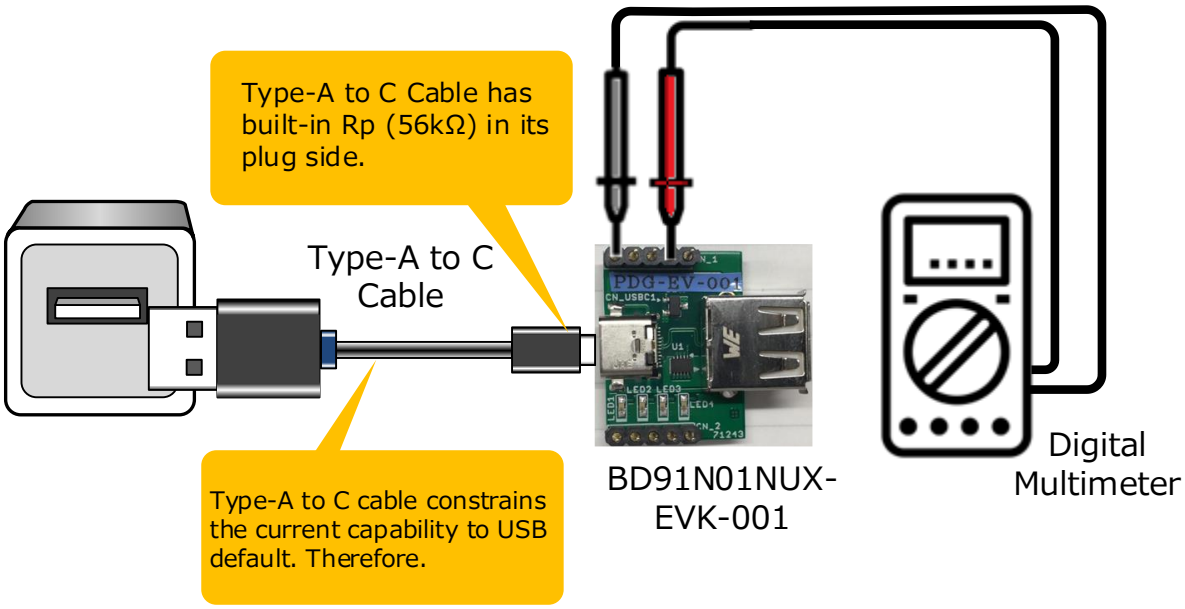

Figure 5. A single evaluation with a Type-A to C cable

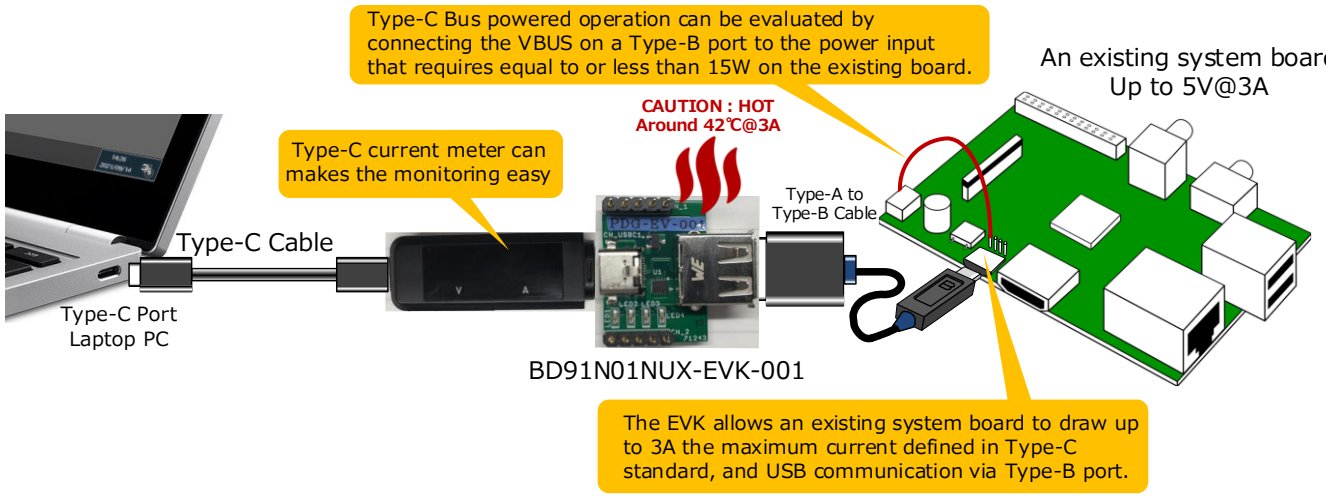

Figure 6. Powering an existing system board via the EVK

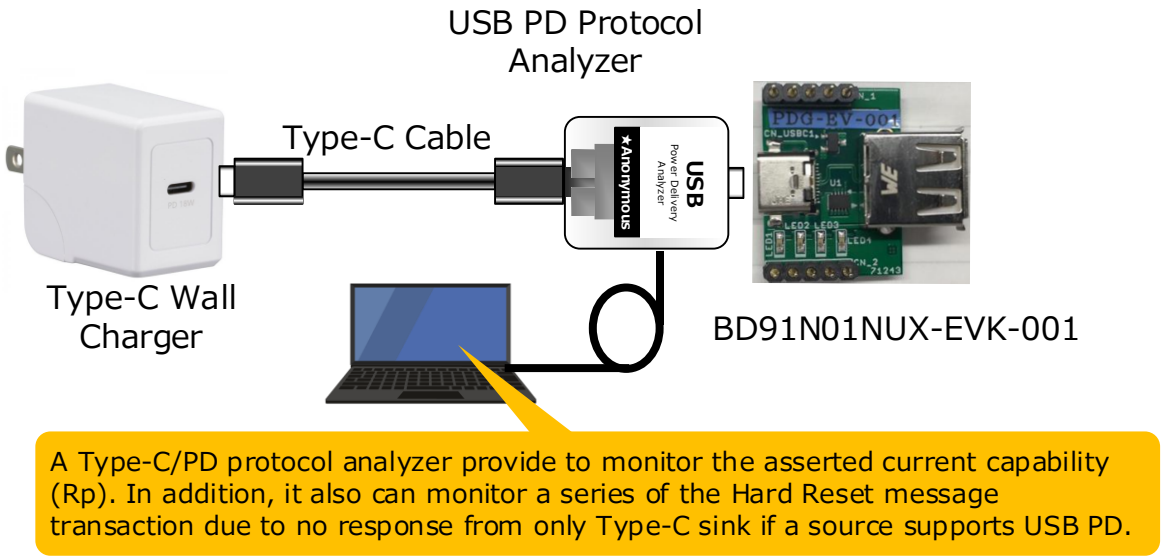

Figure 7. The evaluation environment with a protocol analyzer

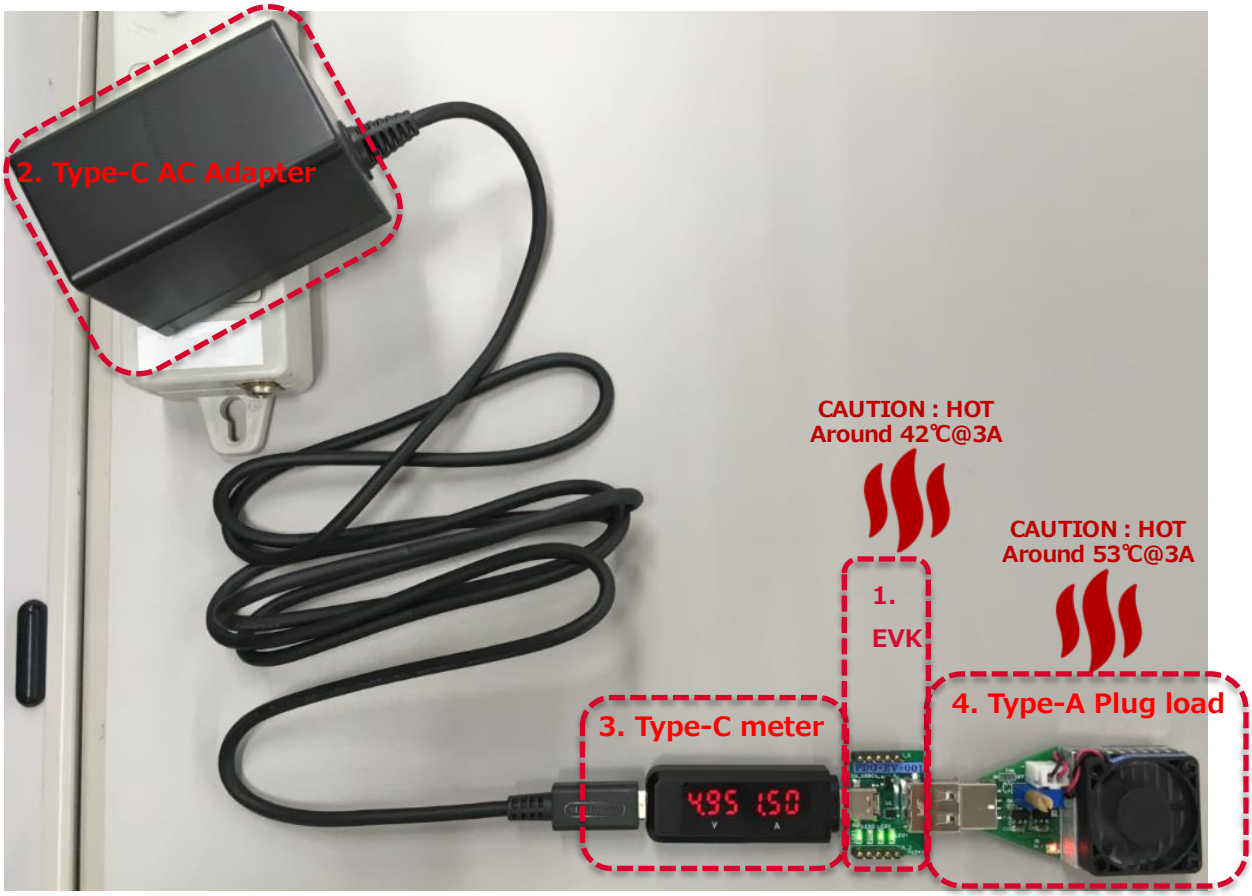

Figure 8. An example of the actual evaluation

Table 6. A list of the using instruments

No.	Parts	Manufacturer	Model / Spec
1	Evaluation Board	ROHM	BD91N01NUX-EVK-001
2	Type-C AC Adapter	Nintendo	HAC-002(JPN) 5V@1.5A / 15V@2.6A
3	Type-C Meter	Miyoshi	USB Current Checker for Type-C STE-02
4	Electrical Load with Type-A terminal	Kaumo	USB Load Resistor (Electronic) Load Adjustable Volume URF1 5V@0.15A to 3.00A

Parts List

Table 7. Parts list

Part	Value	Manufacturer	Model Number	Size [mm(inch)]
IC				
U1	BD91N01NUX	ROHM	BD91N01NUX	3.00 × 2.00
FET				
Q1	RQ5E035ATTCL	ROHM	RQ5E035ATTCL	TSMT3 (SOT-346T/SC-96)
Capacitor				
CVB	0.1μF	Not Mount	-	1608(0603)
CIO	1μF	Not Mount	-	1005(0402)
CVBUS1	4.7μF	Not Mount	-	1608(0603)
CVBUS2	4.7μF	Not Mount	-	1608(0603)
Resistor				
RIO	0Ω	ROHM	MCR03EZPJ000	1608(0603)
RIOEX	0Ω	Not Mount	-	1608(0603)
R1	1kΩ	ROHM	MCR03EZPJ102	1608(0603)
R2	1kΩ	ROHM	MCR03EZPJ102	1608(0603)
R3	1kΩ	ROHM	MCR03EZPJ102	1608(0603)
R4	1kΩ	ROHM	MCR03EZPJ102	1608(0603)
Connector				
CN_USBC1	DX07B024JJ1R1500	JAE	DX07B024JJ1R1500	USB TYPE-C Receptacle
CN_USBA1	TypeA	Würth Elektronik	614004190021	USB Type-A Receptacle
LED				
LED1	LED	ROHM	SML-D12M8W	LED
LED2	LED	ROHM	SML-D12M8W	LED
LED3	LED	ROHM	SML-D12M8W	LED
LED4	LED	ROHM	SML-D12M8W	LED
Contact Pin				
CN_1	HDR1X5	Not Mount	-	HDR1X5
CN_2	HDR1X5	Not Mount	-	HDR1X5

Board Layout

EVK PCB Information

Number of Layers	Material	Board Size	Cupper Thickness
4	FR-4	20.3mm x 27.9mm x 1.6mmt	1oz (35µm)

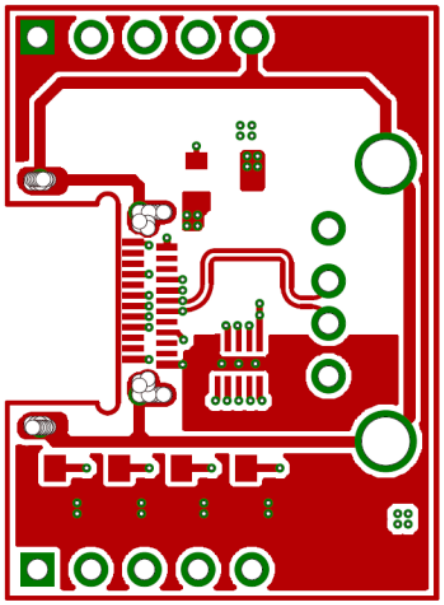

Figure 9. Top Layer (Top View)

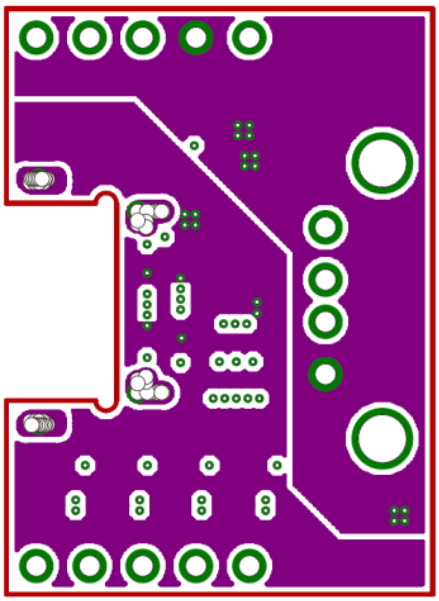

Figure 11. Middle Layer 2 (Top View)

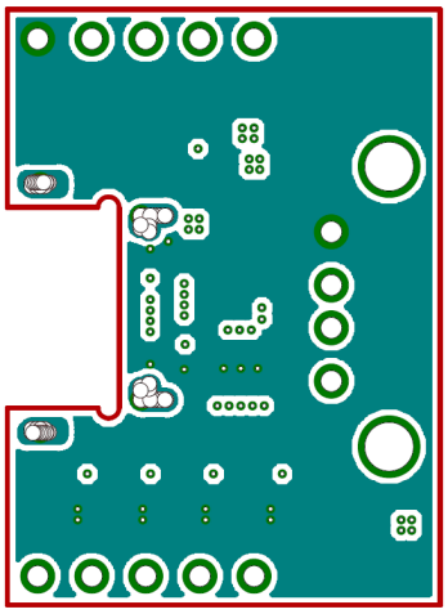

Figure 10. Middle Layer 1 (Top View)

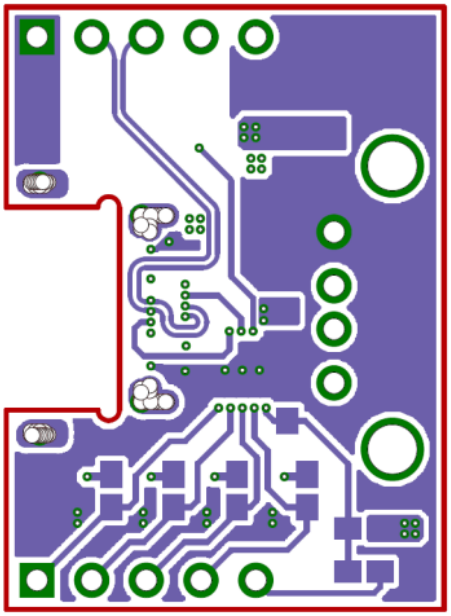

Figure 12. Bottom Layer (Top View)

Reference Application Data

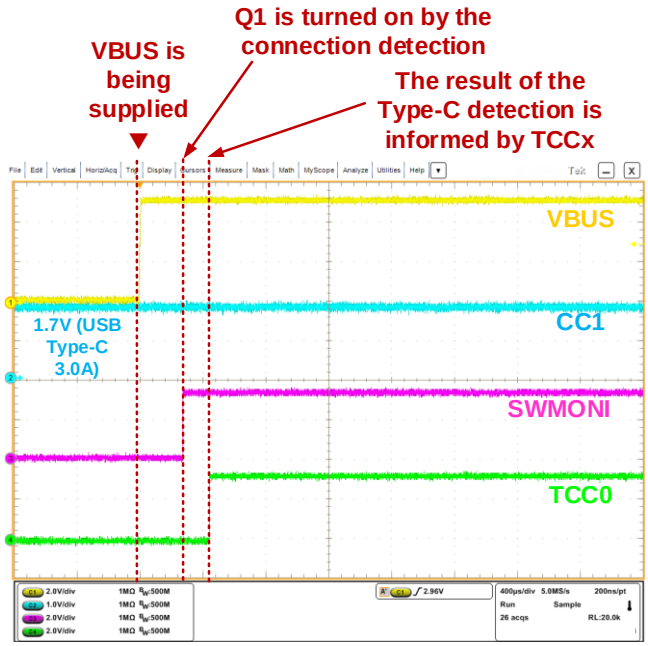

Figure 13. Type-C waveform at start-up

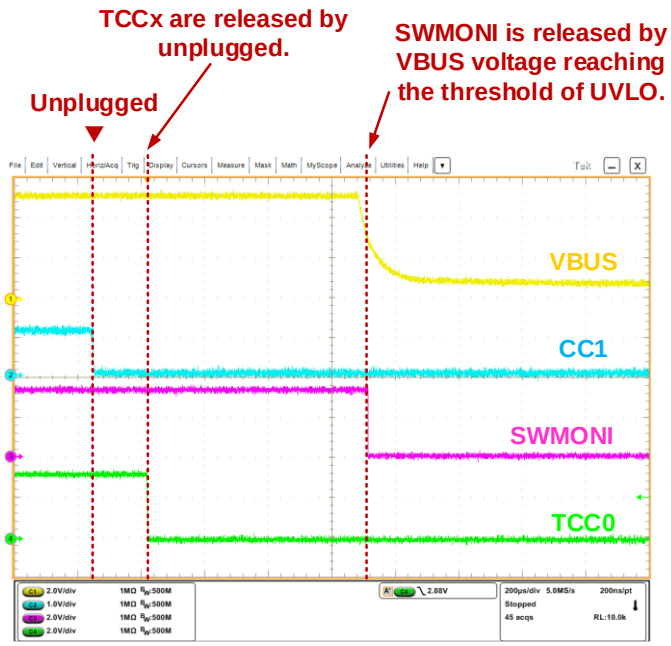

Figure 14. Type-C waveform at shutdown

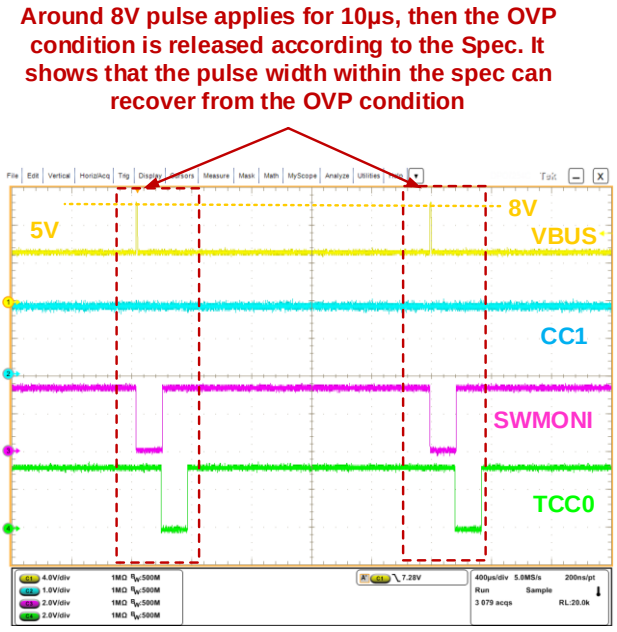

Figure 15. The recovering from OVP condition with applying OVP pulse for the maximum of the "Auto Recovery Pulse Width."

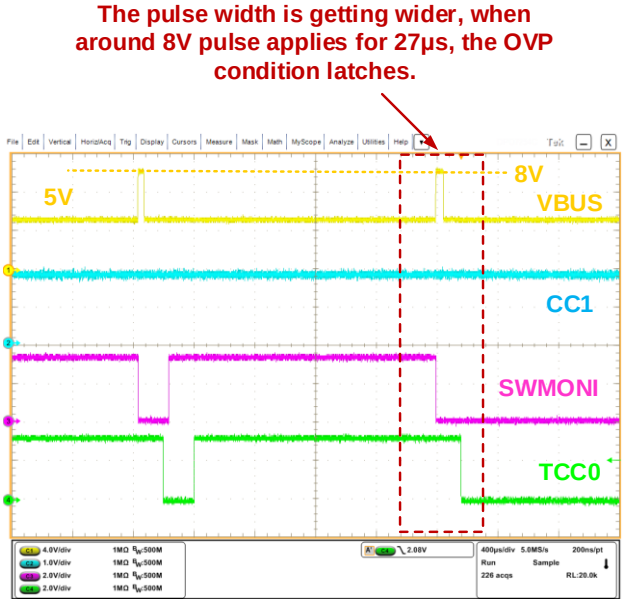

Figure 16. The latched-off condition by applying the pulse width for 27µs

APPENDIX: Overview of the USB Type-C Connectivity

USB Type-C does not have Host/Source or Peripheral/Sink assignments associated with port shapes or cables defined by traditional USB. Type-C cables have no polarity, and each connecting device is determined uniquely from the data role of Host or Peripheral, and the power role of Source or Sink by the resistor asserted on the CC (Configuration Channel) signal.

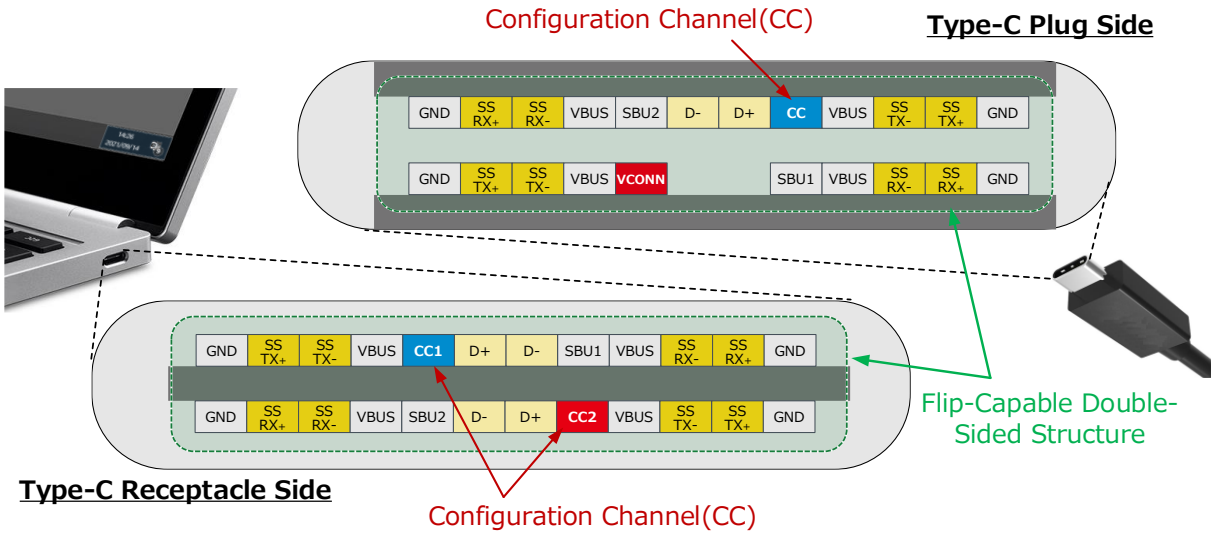

Figure 17. Type-C Receptacle and Plug pin assignment (Front View)

Devices that want to be Host/Source initially assert pull-up resistor Rp to CC. There are three types of Rp resistors defined, each assigned a Default current, Type-C 1.5A, and Type-C 3.0A defined in the USB standard.

Table 8.The definition of Rp resistance

Rp resistance on Host/Source side [Ω]*	The definition on USB Type-C standard	Note
56k	Default current in USB standard	Before the USB enumeration: Uniformly 100mA USB1.x/2.0: 500mA USB3.0/3.1: 900mA
22k	Type-C 1.5A	
10k	Type-C 3.0A	

*In case of pull up to 5V typically.

Devices that want to be Selected/Sink initially assert the pull-down resistor Rd to CC. One type of resistor is defined. There are other pull-down resistors for Powered Cable, but it shall be omitted here.

Table 9. The definition of Rd resistance

Rd resistance on Peripheral/Sink side [Ω]
5.1k

The voltage on the CC signal is applied to the divided voltage by both Rp and Rd. Then the Host/Source finds the connection and supplies 5V power to VBUS if the divided voltage enters the specific voltage range for a certain amount of time (max 200ms). Type-C Port has "Cold Socket" architecture that supplies the power after finding the connection safely, comparing with legacy Type-A that always supplies 5V to VBUS.

Peripheral/Sink device compares the divided voltage on CC signal with the three voltage ranges defined in the Type-C standard and determines the current capability of the Source device according to the asserted Rp value.

Table 10. The connection voltage range for the Sink

Connected to	Definition	The divided voltage on CC pin
Peripheral/Sink device	Open	< 0.15V
	Connecting range	0.25V to 2.18V
	USB Default	0.25V to 0.61V
	USB Type-C 1.5A	0.70V to 1.16V
	USB Type-C 3.0A	1.31V to 2.04V

The BD91N01NUX on this EVK removes the debounce of the CC signal during plug insertion, determines these voltage ranges, determines what current capability the connected Host/Source device has, and outputs the results to the TCC1 and TCC0 terminals.

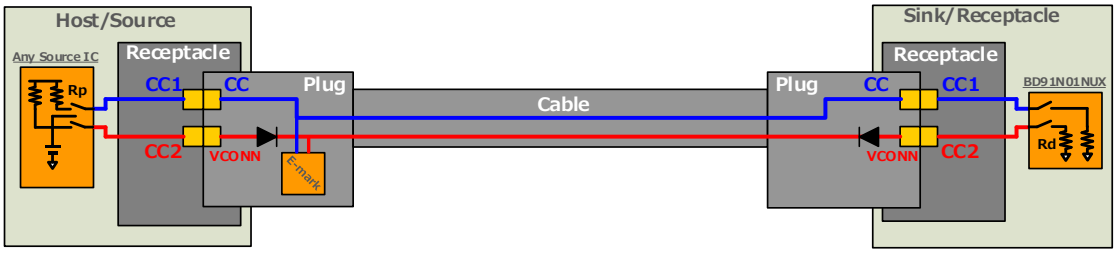

Figure 18.Type-C Receptacle and Plug Connection Overview (Sink detected on CC1 side / Normal connection)

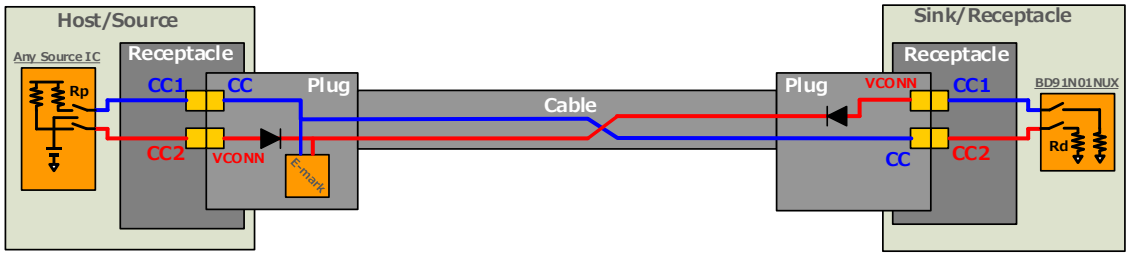

Figure 19. Overview of the connection of Type-C Receptacle and Plug Connection Overview (Sink detected on CC2 side / Flip connection)

In addition, Type-C can provide the flip plugging unlike the legacy USB. This means that the receptacle on each device has both CC1 and CC2 terminal, and only CC terminal connects each other in each plug on each far end of the cable.

A Host/Source device waits with Rp asserted to both CC1 and CC2 of its receptacle, and when connected via a cable, the Peripheral/Sink Rd detects the divided voltage on either CC1 or CC2, detecting the orientation of the inserted plug. Similarly, the Peripheral/Sink side detects the same divided voltage at either CC1 or CC2 terminals of its receptacle and recognizes the plug's orientation of the inserted cable.

Revision History

Date	Revision Number	Description
Oct. 20. 2021	001	Initial Release

Notes

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