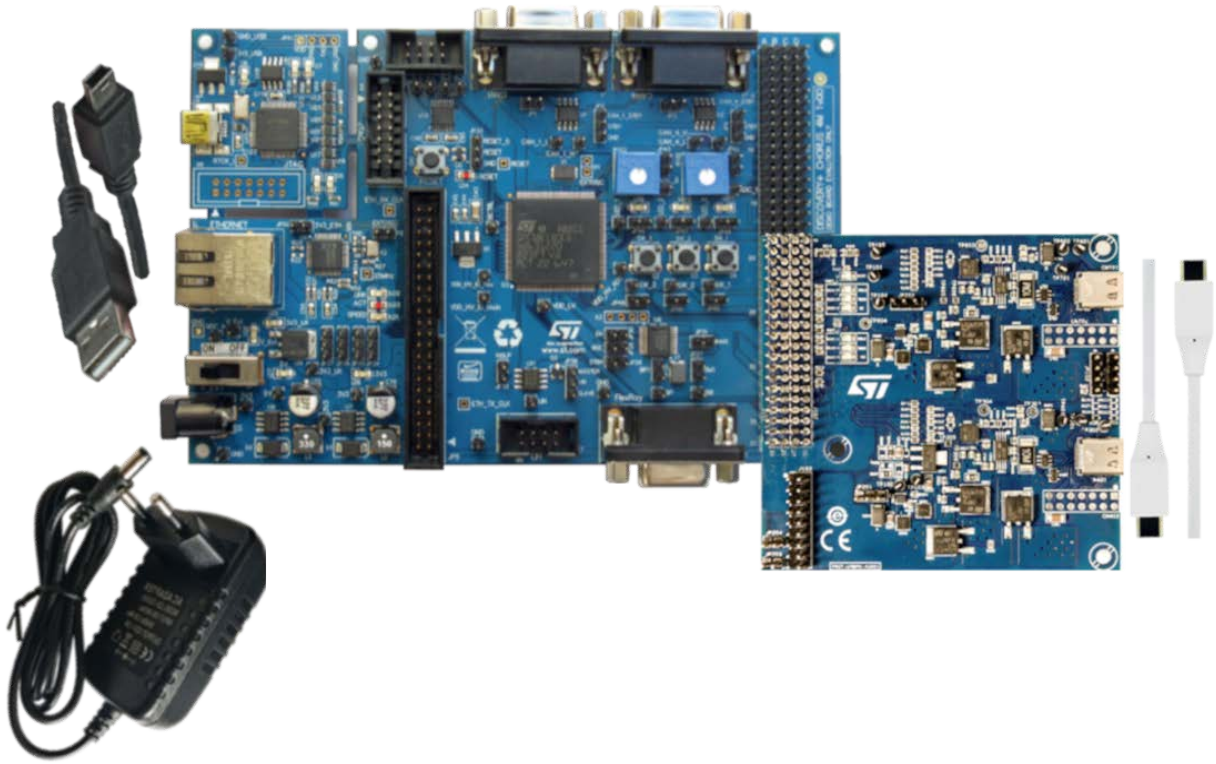
How to use the AEKD-USBTYPEC1 USB Power Delivery evaluation kit

Introduction

The USB Power Delivery evaluation kit is designed to help you evaluate the functions of the USB Power Delivery protocol stack implemented on the SPC58EC80E5 Chorus line of 32-bit automotive microcontrollers based on Power Architecture® technology, with 4 MB of flash memory.

You can also use the AEKD-USBTYPEC1 to prototype USB Power Delivery solutions to power compatible consumer devices via the USB Type-C™ ports.

Figure 1. AEKD-USBTYPEC1 USB Power Delivery evaluation kit

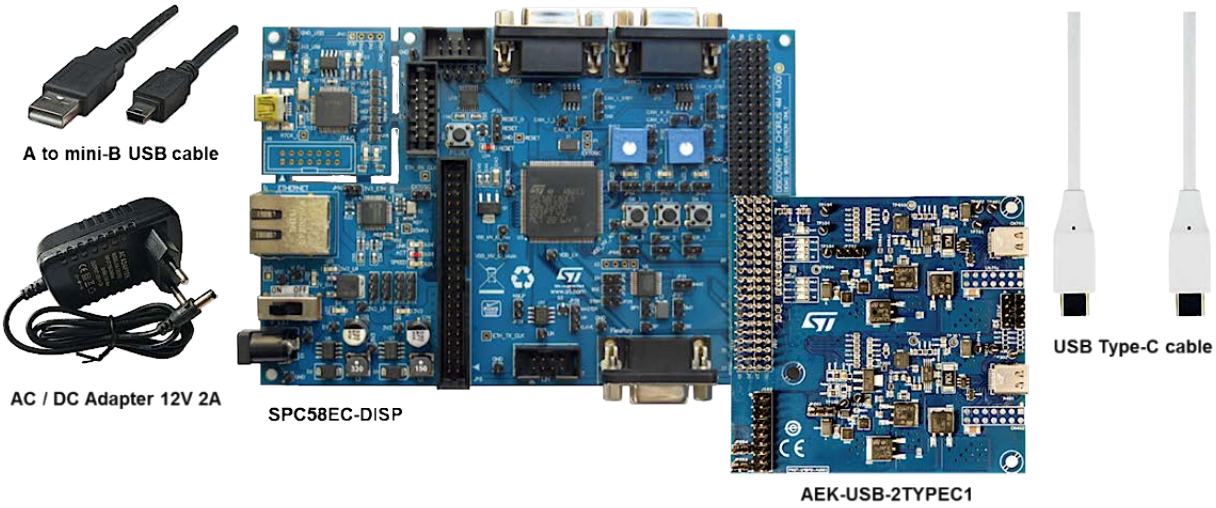


1 Evaluation kit overview

The AEKD-USBTYPEC1 kit consists of:

- An AEK-USB-2TYPEC1 dual-port USB Type-C interface board.
- An SPC58EC-DISP discovery board hosting a SPC58EC80E5 Chorus line 4 MB flash memory, 32-bit automotive microcontroller.
- A 1-Amp 12-Volt power supply for the SPC58EC-DISP board.
- A mini-B USB to USB Type-A cable to connect the MCU programmer.
- A USB Type-C to USB Type-C cable (not electronically marked).
- The STSW-USB2TYPEC1 flash image firmware and the related software package.

Figure 2. AEKD-USBTYPEC1 kit



The AEK-USB-2TYPEC1 interface board hosts a pair of STUSB1702Y automotive grade USB Type-C controllers; one for each USB Type-C port. The board contains a dual Transil™ array ESDA25LY and very low capacitance USBLC6-2SC6Y devices for ESD protection. The status of the ports is signaled on the board through a set of LEDs for each port. The board includes about 20 test points.

The main devices on the board are the STUSB1702Y USB Type-C controller with Tx/Rx line driver and bi-phase marked coding (BMC), and the physical layer (PHY) protocol for USB Power Delivery stack.

The AEKD-USBTYPEC1 kit supports a 5 V, 500 mA PDO based on the electrical characteristics of the SPC58EC-DISP. To extend the range of PDOs, you can add an external power board, not included in the kit.

The software package contains the following elements:

- The firmware for the SPC58EC-DISP discovery board (already pre-loaded on the board).
- A complex driver for the STUSB1702Y USB Type-C controller.
- An SPC5-STUDIO library plugin with the USB Power Delivery software stack.
- A demo application with predefined 5 V 500 mA PDO.

The standard USB Type-C cable provided in the kit is not electronically marked. It is not suitable for currents above 3 A and does not support USB 3.1 Gen1 or Gen2 signaling.

The USB Power Delivery Consumer role device may be a compatible mobile phone or a tablet accepting a 5 V, 500 mA PDO. You can add an external Power Board to increase the range of available PDOs. Alternatively, you can use the P-NUCLEO-USB002 demo kit as a consumer device.

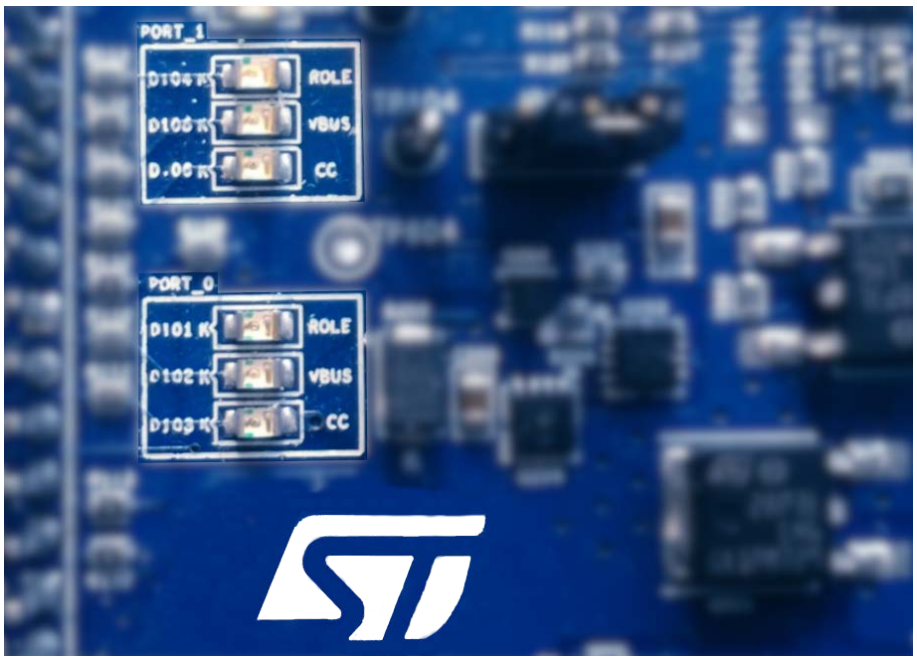
RELATED LINKS

3 Software package with firmware and USB PD project on page 10

http://www.usb.org/home

1.1 LED signals

Figure 3. Port status LEDs on the AEK-USB-2TYPEC1



The AEK-USB-2TYPEC1 interface board has the following status LEDs for each port:

1. Role: emits a continuous variable blue flashing light at about 1Hz indicating the device is a provider.
2. VBUS: emits a constant green light when the power negotiation has completed (i.e., the Explicit condition is reached). The provider can now begin to supply the negotiated power to the consumer.
3. CC: emits different orange flashing sequences to indicate the following conditions:
   a. flashes at about 1Hz: CC1 line is connected.
   b. flashes twice followed by a pause: CC2 line is connected.

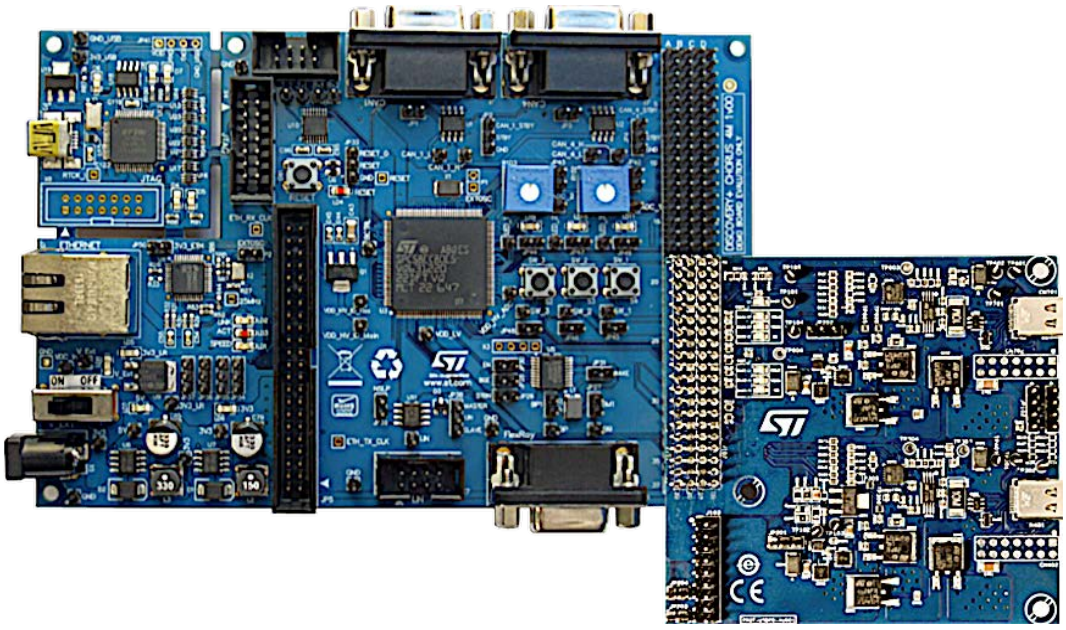
Note: The connected Configuration Channel (CC) indicates the direction of the USB cable connection, given the cable reversibility allowed by the USB Type-C standard.

2 How to use the AEKD-USBTYPEC1 kit

Step 1. Plug the AEK-USB-2TYPEC1 board on the SPC58EC-DISP

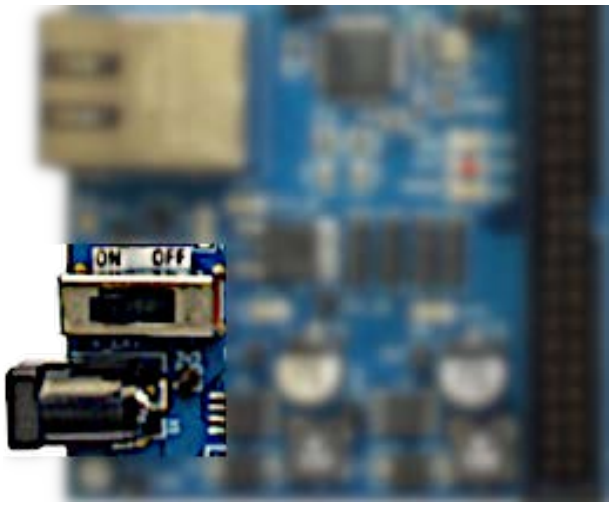
The AEK-USB-2TYPEC1 is plugged into the 4x37 male pin connector of the SPC58EC-DISP board via the 4x20 female pin connector from pins A18 to D37 (refer to pin numbering indications on the board).

Figure 4. AEKD-USBTYPEC1 plugged on SPC58EC-DISP



Step 2. Connect the 1-Amp 12-Volt power supply plug into the socket located on the SPC58EC-DISP and then turn on the board.

Figure 5. Voltage supply socket and power switch on SPC58EC-DISP



After about 5 seconds, the ROLE LED on the AEK-USB-2TYPEC1 board should start blinking at rate of 1 Hz to indicate the board is a provider.

Step 3. Connect a consumer to a USB Type-C port

You can connect one or two consumers to one or both USB Type-C ports. The USB Type-C ports supply 5 V each and 500 mA in total for both ports.

Power negotiation begins when the consumer is connected. If the negotiation concludes successfully (i.e., the “Explicit” condition is reached), the VBUS LED VBUS emits a green light.

If the consumer has a compatible PDO but it is not able to reach the “Explicit” condition, try to:

- Use another USB Type-C port on the consumer device, if available.
- Disconnect and reconnect the USB Type-C cable.
- Switch the SPC58EC-DISP board off and on and try to connect the Consumer device again.
- Try a different USB Type-C cable.

2.1 Pin mappings for an external power board

The power negotiation protocol between consumer and provider agrees on a PDO that is actuated on a power board (not included in the kit).

The microcontroller on the SPC58EC80E5 board can direct the power supplied by an external power board through GPIOs on the male connector on the AEK-USB-2TYPEC1 interface board.

Note: The external power board you use must be compatible with the consumer power requirements.

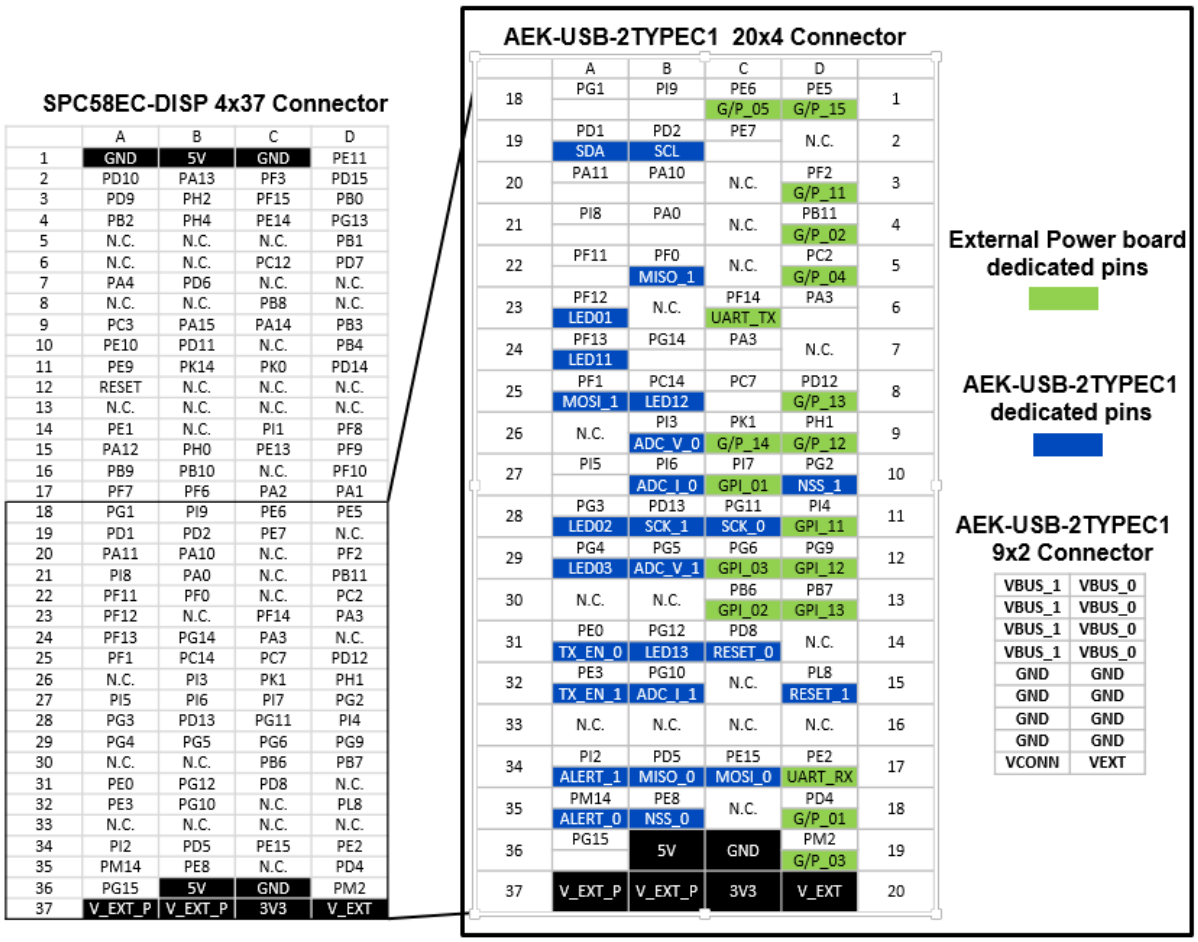
If the desired voltage is not provided within the time-out interval specified in the USB Power Delivery protocol, the STUSB1702Y informs the microcontroller that the voltage output in the port is not actuated and the microcontroller resets the system and starts power negotiation again.

Note: The connection of the external power board may require modifications in the software stack.

Communication between the STUSB1702Y and microcontroller is based on SPI protocol, where the STUSB1702Y has the master role in the communication.

The following figure shows the 4x37 connector on the SPC58EC-DISP board. The portion occupied by the AEK-USB-2TYPEC1 is zoomed to show the pins for the external power board (in green) and for the interface board (in blue).

Figure 6. Pin mapping of the AEK-USB-2TYPEC1 connectors



	A	B	C	D
1	GND	5V	GND	PE11
2	PD10	PA13	PF3	PD15
3	PD9	PH2	PF15	PB0
4	PB2	PH4	PE14	PG13
5	N.C.	N.C.	N.C.	PB1
6	N.C.	N.C.	PC12	PD7
7	PA4	PD6	N.C.	N.C.
8	N.C.	N.C.	PB8	N.C.
9	PC3	PA15	PA14	PB3
10	PE10	PD11	N.C.	PB4
11	PE9	PK14	PK0	PD14
12	RESET	N.C.	N.C.	N.C.
13	N.C.	N.C.	N.C.	N.C.
14	PE1	N.C.	PI1	PF8
15	PA12	PH0	PE13	PF9
16	PB9	PB10	N.C.	PF10
17	PF7	PF6	PA2	PA1
18	PG1	PI9	PE6	PE5
19	PD1	PD2	PE7	N.C.
20	PA11	PA10	N.C.	PF2
21	PI8	PA0	N.C.	PB11
22	PF11	PF0	N.C.	PC2
23	PF12	N.C.	PF14	PA3
24	PF13	PG14	PA3	N.C.
25	PF1	PC14	PC7	PD12
26	N.C.	PI3	PK1	PH1
27	PI5	PI6	PI7	PG2
28	PG3	PD13	PG11	PI4
29	PG4	PG5	PG6	PG9
30	N.C.	N.C.	PB6	PB7
31	PE0	PG12	PD8	N.C.
32	PE3	PG10	N.C.	PL8
33	N.C.	N.C.	N.C.	N.C.
34	PI2	PD5	PE15	PE2
35	PM14	PE8	N.C.	PD4
36	PG15	5V	GND	PM2
37	V_EXT_P	V_EXT_P	3V3	V_EXT

	A	B	C	D	
18	PG1	PI9	PE6 G/P_05	PE5 G/P_15	1
19	PD1 SDA	PD2 SCL	PE7	N.C.	2
20	PA11	PA10	N.C.	PF2 G/P_11	3
21	PI8	PA0	N.C.	PB11 G/P_02	4
22	PF11	PF0 MISO_1	N.C.	PC2 G/P_04	5
23	PF12 LED01	N.C.	PF14 UART_TX	PA3	6
24	PF13 LED11	PG14	PA3	N.C.	7
25	PF1 MOSI_1	PC14 LED12	PC7	PD12 G/P_13	8
26	N.C.	PI3 ADC_V_0	PK1 G/P_14	PH1 G/P_12	9
27	PI5	PI6 ADC_I_0	PI7 GPI_01	PG2 NSS_1	10
28	PG3 LED02	PD13 SCK_1	PG11 SCK_0	PI4 GPI_11	11
29	PG4 LED03	PG5 ADC_V_1	PG6 GPI_03	PG9 GPI_12	12
30	N.C.	N.C.	PB6 GPI_02	PB7 GPI_13	13
31	PE0 TX_EN_0	PG12 LED13	PD8 RESET_0	N.C.	14
32	PE3 TX_EN_1	PG10 ADC_I_1	N.C.	PL8 RESET_1	15
33	N.C.	N.C.	N.C.	N.C.	16
34	PI2 ALERT_1	PD5 MISO_0	PE15 MOSI_0	PE2 UART_RX	17
35	PM14 ALERT_0	PE8 NSS_0	N.C.	PD4 G/P_01	18
36	PG15	5V	GND	PM2 G/P_03	19
37	V_EXT_P	V_EXT_P	3V3	V_EXT	20

VBUS_1	VBUS_0
VBUS_1	VBUS_0
VBUS_1	VBUS_0
VBUS_1	VBUS_0
GND	GND
GND	GND
GND	GND
GND	GND
VCONN	VEXT

Connectors CN1 (4x20 male pin connector) and CN2 (2x9 male pin connector) are located on the opposite side of the USB Type-C ports. CN1 is for the control signals and CN2 is for the power supply. In the figure, the green cells in CN1 represent the pins to drive the external power board. The cell labels starting with “Pxx” represent the microcontroller ports mapped to the 4x37 connector. The microcontroller ports can assume different functions depending on the register settings of a specific microcontroller.

The following table contains the descriptions of the interface board pins.

Table 1. AEK-USB-2TYPEC1 4x20 connector interface board pin descriptions

Pin Name	Description
ADC_I_0	ADC channel to convert the current value provided by VBUS on to port 0.
ADC_I_1	ADC channel to convert the current value provided by VBUS on to port 1.
ADC_V_0	ADC channel to convert the voltage value (VBUS) applied to port 0.
ADC_V_1	ADC channel to convert the voltage value (VBUS) applied to port 1.
ALERT_0	Alert pin of STUSB1702Y device managing port 0
ALERT_1	Alert pin of STUSB1702Y device managing port 1
LED01(1)	To command the LED “ROLE” for port0
LED11(2)	To command the LED “ROLE” for port1
LED02	To command the LED “VBUS” for port0

Pin Name	Description
LED12	To command the LED “VBUS” for port1
LED03	To command the LED “CC” for port0
LED13	To command the LED “CC” for port1
MISO_0	Master Input Slave Output (MISO) of SPI protocol for port 0
MISO_1	Master Input Slave Output (MISO) of SPI protocol for port 1
MOSI_0	Master Output Slave Input (MOSI) of SPI protocol for port 0
MOSI_1	Master Output Slave Input (MOSI) of SPI protocol for port 1
NSS_0	Slave Select (NSS) of SPI protocol for port 0
NSS_1	Slave Select (NSS) of SPI protocol for port 1
SCK_0	Serial Clock (SCK) of SPI protocol for port 0
SCK_1	Serial Clock (SCK) of SPI protocol for port 1
SCL	Serial Clock of I^2C
SDA	Serial Data of I^2C
RESET 0	Used to reset the STUSB1702Y for port 0
RESET 1	Used to reset the STUSB1702Y for port 1
TX_EN_0	Used by slave to ask master to start the SPI communication for port 0 by resetting the NSS pin
TX_EN_1	Used by slave to ask master to start the SPI communication for port 1 by resetting the NSS pin

1. *It is recommended to remove the jumper from the jumper pins JP46 on the SPC58EC_DISP board.*
2. *It is recommended to remove the jumper from the jumper pins JP48 on the SPC58EC_DISP board.*

The following table shows the mapping between the external power board pins and the microcontroller ports. The table also shows the functions that can be assigned to each pin. Only one function can be mapped to a single microcontroller port at a time.

Table 2. AEK-USB-2TYPEC1 4x20 connector power board pin description

Pin name	Port #	Function[module instance]					
		GPIO (1)	CAN	SPI	ADC (12 bit) (2)	LIN	Timer (3)
G/P_01	PD[4]	GPIO52	RX[1] RX[3]	SCK[0] SCK[7]	-	TXD[3]	UC6 UC4
G/P_02	PB[11]	GPIO27	-	CS0[0] CS2[2]	-	RXD[2]	UC24 UC5
G/P_03	PM[2]	GPIO194	RX[6]	SOUT[1]	-	-	UC9
G/P_04	PC[2]	GPIO34 EIRQ10	-	-	-	TXD[15]	UC8 UC10
G/P_05	PE[6]	GPIO70	RX[0]	CS1[0] CS1[1]	-	RXD[1]	UC4 UC2
G/P_11	PF[2]	GPIO82 EIRQ6	RX[6]	CS2[1] SOUT[1] SOUT[3]	INJ_TRG NOR_TRG	RXD[2] RXD[8]	UC20 UC12

Pin name	Port #	Function[module instance]					
		GPIO (1)	CAN	SPI	ADC (12 bit) (2)	LIN	Timer (3)
G/P_12	PH[1]	GPIO113	RX[3]	SCK[2] CS0[6] SOUT[6] SIN[6]	-	RXD[6]	UC15
G/P_13	PD[12]	GPIO60	-	CS7[0] SIN[3] SOUT[3] SIN[4] SOUT[4] SIN[6]	EXT_DEC0 ANS[15] ANF[15]	TXD[14]	UC14 UC16
G/P_14	PK[1]	GPIO161	-	SCK[4]	-	-	UC24
G/P_15	PE[5]	GPIO69	TX[0]	CS0[0] CS0[1] CS0[7]	-	RXD[15]	UC3 UC1
GPI_01	PI[7]	GPIO135	-	-	ANS[50] ANF[50]	-	-
GPI_02	PB[6]	GPIO22	-	-	ANS[48] ANF[48]	-	-
GPI_03	PG[6]	GPIO102	-	-	ANS[44] ANF[44]	-	-
GPI_11	PI[4]	GPIO132	-	-	ANS[40] ANF[40]	-	-
GPI_12	PG[9]	GPIO105	-	-	ANS[53] ANF[53]	-	-
GPI_13	PB[7]	GPIO23	-	-	ANS[47] ANF[47]	-	-
UART_TX	PF[14]	GPIO94 EIRQ17	-	-	-	TXD[5] TXD[14]	UC26
UART_RX	PE[2]	GPIO66 EIRQ11	-	CS3[3] SIN[3] SIN[4] SOUT[3] SOUT[4]	ANS[13] ANF[13]	RXD[5]	UC13 UC15

1. *GPIO = General Purpose I/O; EIRQ = External interrupt.*
2. *INJ_TRG = Injected Conversion Trigger; NOR_TRG = Normal Conversion Trigger; EXT_DEC = External Decoder Address; ANS[x] = Standard Analog Channel x; ANF[x] = Fast Analog Channel x*
3. *Enhanced Modular IO Subsystem (eMIOS) provides functionality to generate or measure time events on up to 32 unified channels (UCs).*

RELATED LINKS

3.3 Configuration of the USB-PD library through SPC5-Studio on page 11

2.1.1 Output voltage selection

The following table shows the 3-bit binary combinations to select specific output voltage levels for USB Type-C port0 and USB Type-C port1.

The pins in the table are relative to the AEK-USB-2TYPEC1 board. The pins are digital inputs, so “L” represents 0 V and “H” represents 3.3 V.

Table 3. Output voltage selection

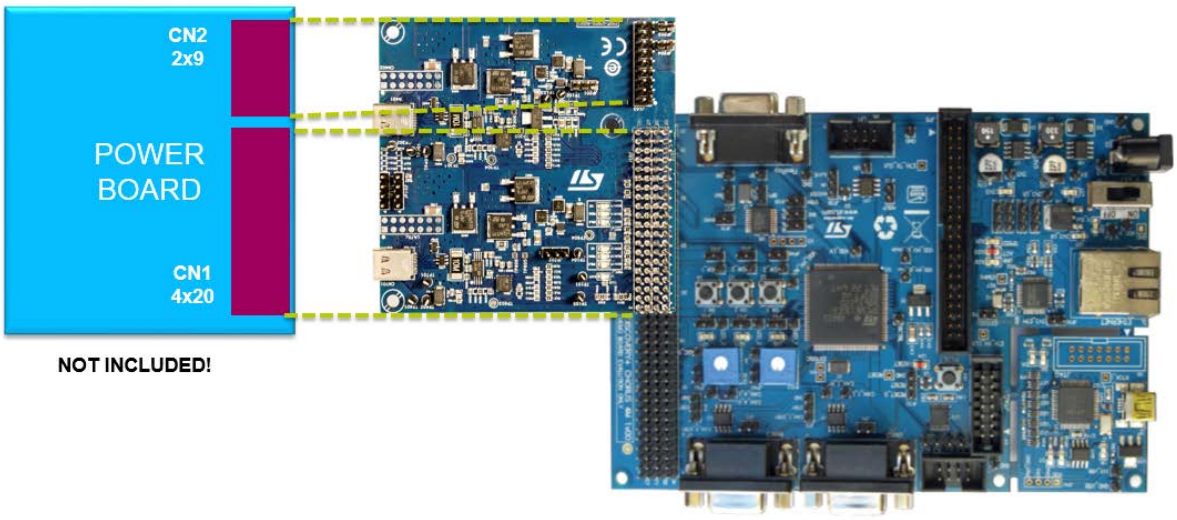
Output Voltage	USB Type-C port0			USB Type-C port1		
	Pin D18	Pin C9	Pin D9	Pin D5	Pin D4	Pin D3
5 V	L	L	L	L	L	L
9 V	H	L	L	H	L	L
15 V	H	H	L	H	H	L
20 V	H	H	H	H	H	H

The table represents the default settings provided in the STSW-USB2TYPEC1 software. You can change these settings in SPC5-STUDIO.

2.1.2 Connection of an external power board (not included in the kit)

The following figure shows the connection of an external power board to the CN1 and CN2 connectors on the AEK-USB-2TYPEC1 board.

Figure 7. Connection of an external power board



3 Software package with firmware and USB PD project

The software package for the kit is composed of the following parts:

1. STSW-USB2TYPEC1 firmware: a zip file containing the flash image of the USB Power Delivery demo firmware already loaded on the SPC58 microcontroller. You can download updates from the STSW-USB2TYPEC1 page on www.st.com.
2. USB Power Delivery SPC5-STUDIO project: contains the complex driver for STUSB1702Y device, the USB Power Delivery stack, and a demo application.

RELATED LINKS

1 Evaluation kit overview on page 2

3.1 How to program SPC58 microcontroller present on SPC58EC-DISP

The firmware STSW-USB2TYPEC1 is pre-loaded on the discovery board SPC58EC-DISP. In the zip file, the ".wsx" represents the hook file for the Universal Debug Engine® (UDE) to burn the USB-PD code onto the SPC58 microcontroller flash memory. Follow the procedure below to burn the code onto the flash memory of SPC58:

Step 1. Download and install SPC5-UDESTK-SW USB/JTAG debugger from www.st.com

Step 2. Connect the mini-B USB cable between your PC and the SPC58EC-DISP discovery board

Step 3. Turn-on the discovery board

Step 4. Run the UDE application on your PC

Step 5. In the UDE program, [**Open**] file st_usbpd.wsx

You will find the .wsx file in the zip in the UDE directory.

A window appears.

Step 6. In the new window, press [**Program All**]

A confirmation message appears in the same window when the operation is complete. At this point, the firmware is flashed to the microcontroller memory.

Step 7. Exit the window

Step 8. Reset the SPC58EC-DISP discovery board to run the updated firmware

3.2 How to open the SPC5 Studio project

The SPC5 Studio project gives you access to the USBPD library plugin source code. Follow the procedure below to open the project:

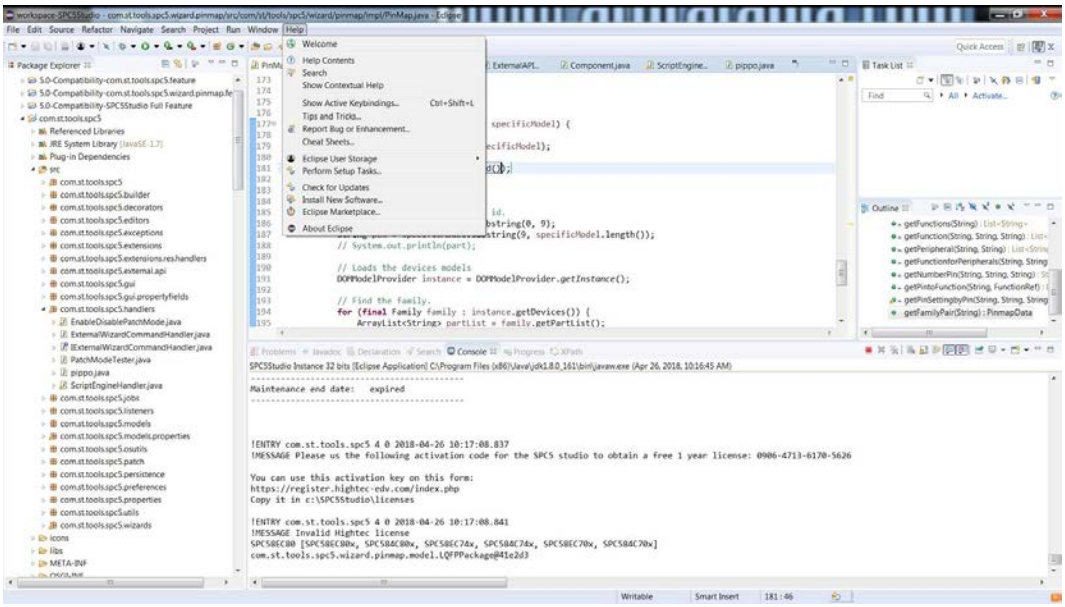
Step 1. Obtain a valid username and password: send an email to credentials@spc5studio.com and specify the following information:

- your company name
- your project
- project target run-rate
- the date

Step 2. Open SPC5 Studio

Step 3. Go to [**Help**]>[**Install new Software**] and then click the [**Add**] button

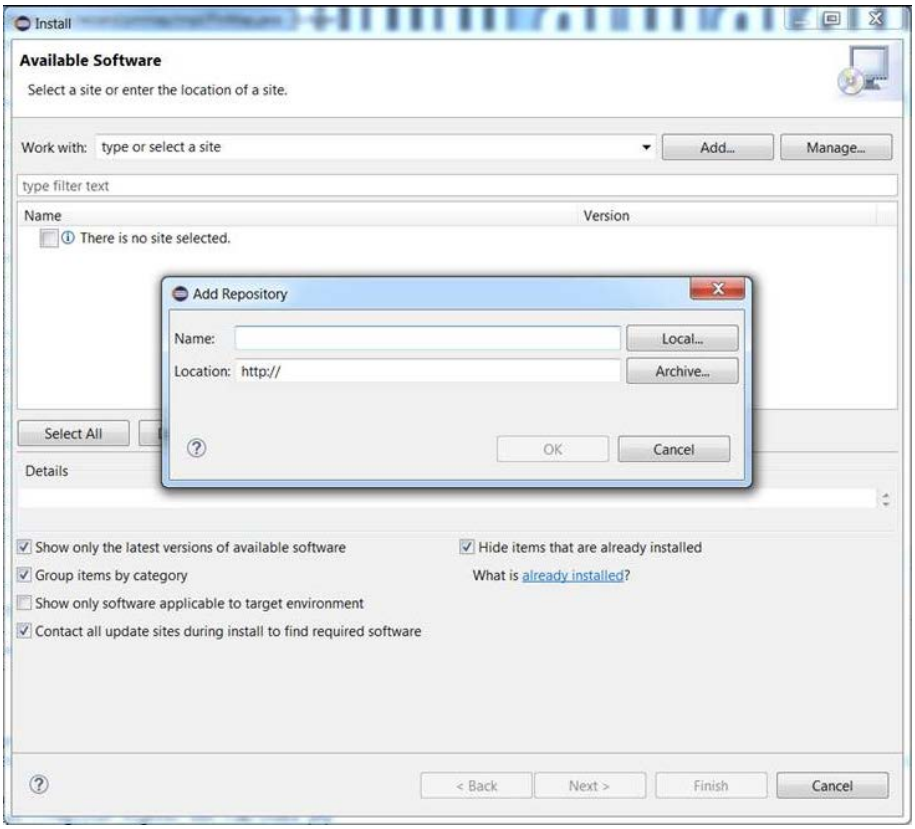
Figure 8. **Help menu in SPC5-Studio**



Step 4. Enter the text “USBPD” in the name field

Step 5. Enter “usbpd.spc5studio.com” in the location field

Figure 9. **Install window in SPC5-Studio**



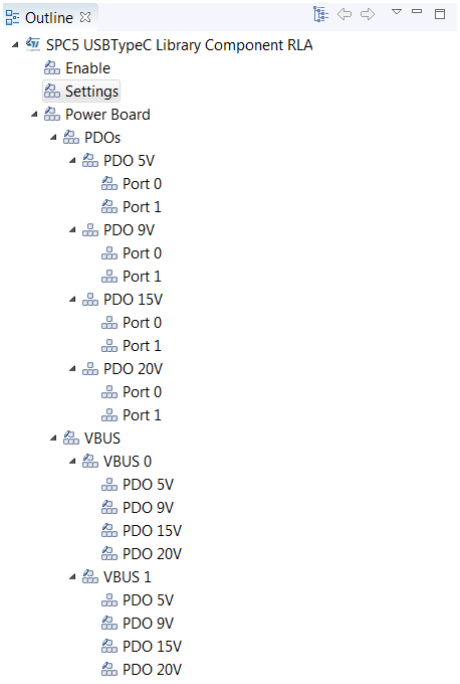
Step 6. Confirm the form

Step 7. Enter the username and password

3.3 Configuration of the USB-PD library through SPC5-Studio

After you download the package, you can open the project in SPC5-Studio and configure certain settings before you flash the firmware to the discovery board:

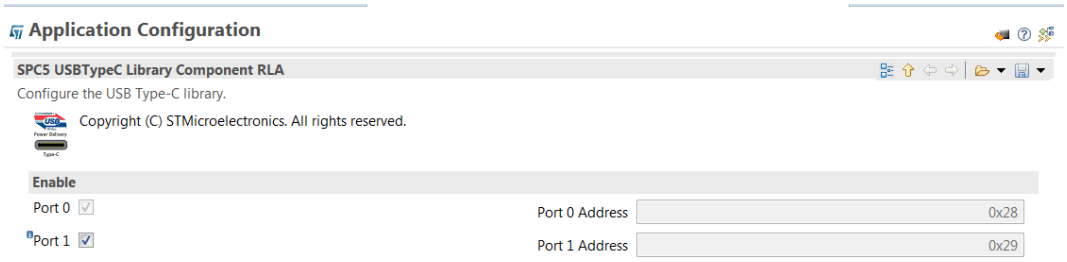
Figure 10. USB-PD Library structure



- Enable or disable Port 1 (enabled by default).

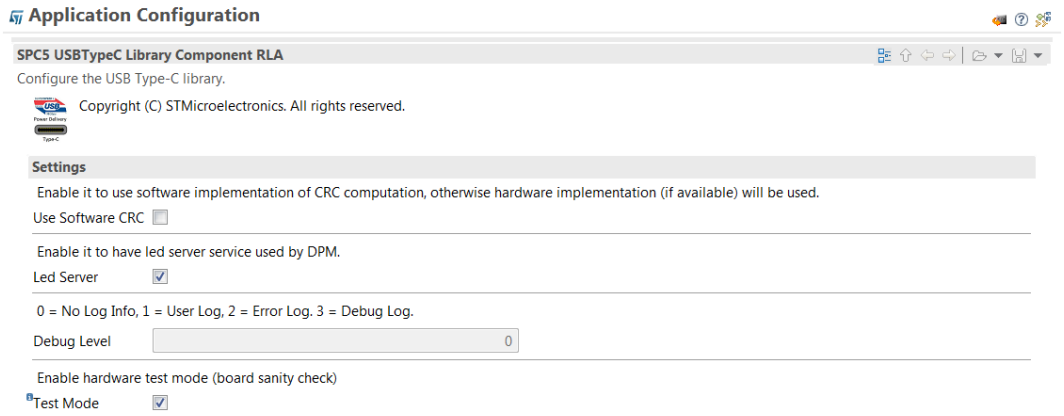
Note: Port 0 is always enabled.

Figure 11. USB Type-C Port 1 toggle



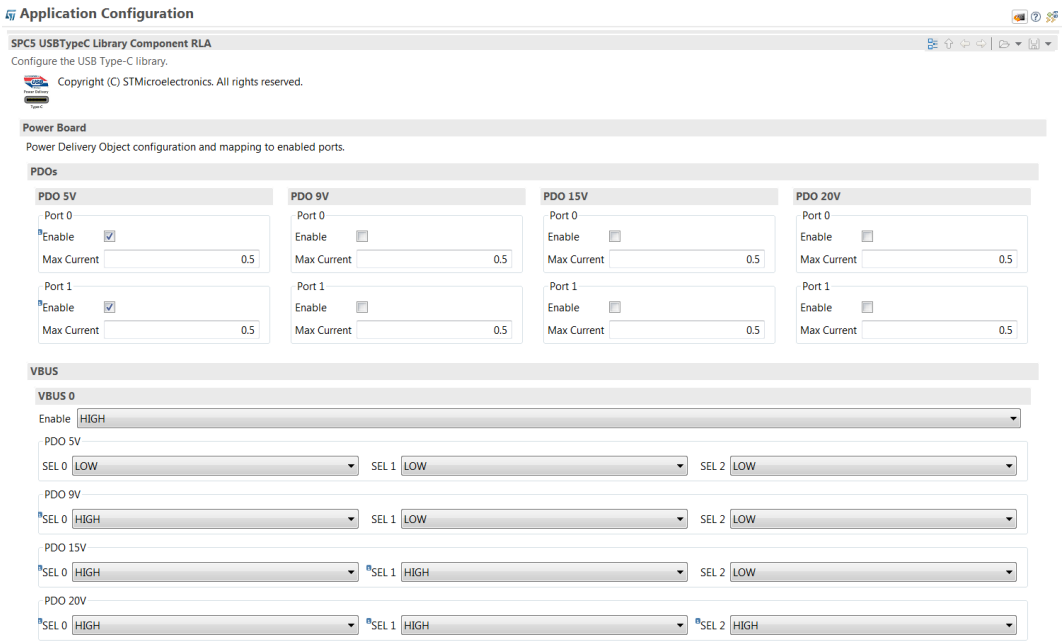
- Enable or disable hardware CRC (enabled by default). If it is disabled, a software version is used.

Figure 12. Hardware CRC, LED signals, and Test mode toggles



- Enable or disable LED signals (enabled by default).
- Enable or disable hardware Test mode (disabled by default), to check the hardware.
- Enable or disable additional PDOs. The PDOs must be compliant with the external power board connected. You can define the current capability and the port for each PDO.

Figure 13. PDO togles and output voltage selection table settings



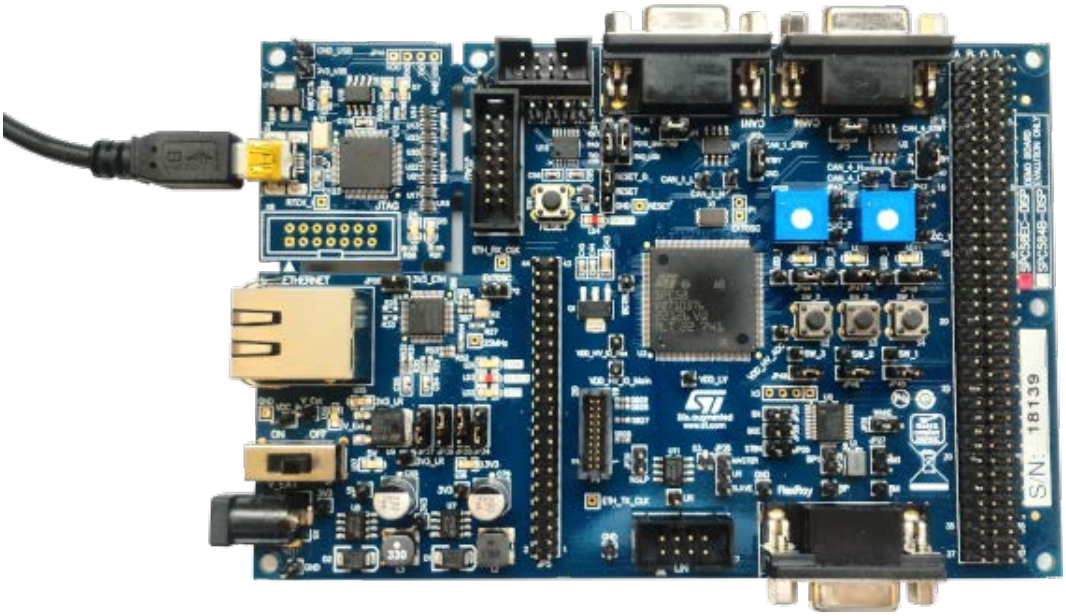
- Configure a logic table to determine the microcontroller pin combinations required to switch between different power profiles.

Table 4. Default logic table for Port 0 and Port1

Vout_x [V]	Port_sig1	Port_sig2	Port_sig3
5V	L	L	L
9V	H	L	L
15V	H	H	L
20V	H	H	H

If Test mode is enabled, you must connect a USB cable between the SPC58EC-DISP discovery board and your PC to print debug messages to a terminal window on your PC. Configure the corresponding COM port with 38400 baud and N81.

Figure 14. SPC58EC-DISP connected to computer via USB cable



RELATED LINKS

2.1 Pin mappings for an external power board on page 5

4 USB Power Delivery overview

The USB Type-C and USB Power Delivery specifications allow smarter connectivity with fewer cables, less connectors and universal chargers. The Type-C connector supports all the features of previous standards, and ports can be configured to only supply power in a Provider role, only sink power in a Consumer role, or be able to switch between both in a Dual role.

Both data and power roles can be independently and dynamically swapped using the USB Power Delivery protocol.

Most automotive applications require support for the Provider role only. When a USB device is connected, the Provider and the device (Consumer) negotiate a contract for the power objects through configuration channels.

The message exchange between Provider and Consumer are listed below:

1. The Provider sends a `Source Capabilities` message to the Consumer, advertising its power capabilities.
2. The device then sends a `Request` for one of the advertised power profiles.
3. The provider accepts or rejects this request according to its power balance
4. If confirmed, provider sends as an `Accept` message to the device
5. The provider then switches to the requested power profile and sends a `PS_Ready` confirmation message

Each received message is acknowledged with a `GoodCRC` to confirm correct reception. Incorrect receptions are ignored and persistent communication errors should trigger a soft reset to re-establish communication. If the error persists, a hard reset is performed.

5 ST's AutoDevKit development initiative

AutoDevKit governs the hardware and software connection between micro discovery boards and specific function boards for applications like stepper motor control, led control, etc.

Each function board has a dedicated driver with abstractions for the specific microcontroller peripherals to ensure portability between platforms. The drivers are SPC5 Studio plugins that are instantiated dynamically by the tool according to the microcontroller used for the development. The instantiation process generates the appropriate source code and indicates how a function board should be connected to the chosen discovery board.

5.1 AutoDevKit for AEKD-USBTYPEC1

The AEKD-USBTYPEC1 evaluation kit consists of a discovery board (SPC58EC-DISP) and a USB Type-C dual port interface function board (AEK-USB-2TYPEC1).

The 20x4 function board female connector on the function board is connected to the 4x37 male connector on the discovery board from the 18th pin to 37th pin. These pins cover the following purposes:

1. The connection between the USB function board and the discovery board.
2. The connection of a power board (not included in the demo kit) and the discovery board to be plugged on top of the function board 4x20 male connector.

Lines 1 to 17 on the discovery board 4x37 connector can be used to connect additional function boards according to the AutoDevKit development initiative.

Revision history

Table 5. **Document revision history**

Date	Version	Changes
26-Jul-2018	1	Initial release.

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Glossary

Table 6. **AEKD-USBTYPEC1 kit terminology**

Term	Definition
Power-data object (PDO)	As per USB Power Delivery Specification, the PDO represents the format of data exchanged between provider and consumer to define the power capability in terms of output voltage and maximum current.
SPC5-STUDIO	It is a software development tool built on Eclipse Plug-in Development Environment (PDE). With an intuitive look- and-feel, it provides all the features to design, build and deploy automotive embedded applications for SPC5 32-bit Power Architecture® microcontrollers.
Eclipse	It is an integrated development environment (IDE) used primary for developing Java applications, but also to develop applications in other programming languages using plug-ins.
Universal Serial Bus (USB) Type-C	It is the latest interface built on USB technology to serve newer computing platforms and devices as they trend toward smaller, thinner and lighter form-factors. It is a 24-pin double-sided USB connector system. A new USB connector ecosystem is necessary to address the evolving needs of platforms and devices maintaining a sort of compatibility with the existing connector form-factors. The standard USB Type-C provide up to 15W.
USB Power Delivery	The USB Power Delivery specification defines a power delivery system covering all elements of a USB system. This specification describes the architecture, protocols, power supply behaviour, connectors and cabling necessary for managing power delivery over USB up to 100W. This specification is intended to be fully compatible and extend the existing USB infrastructure.
Complex driver	It is a software written to implement functionalities related to a specific hardware. The peculiar point is that the software does not directly access hardware functions (e.g. registers, pins, etc.), but takes advantage of platform specific libraries. With this approach, the software is portable across various platforms.