
Getting started with the STEVAL-ISC004V1 evaluation board for the STUSB4710A USB PD controller with on-board DC-DC

Introduction

The STEVAL-ISC004V1 evaluation board is a ready-to-use USB PD source based on STUSB4710A and ST1S14 ICs. It demonstrates how to convert a fixed voltage DC power input into a USB PD variable voltage output.

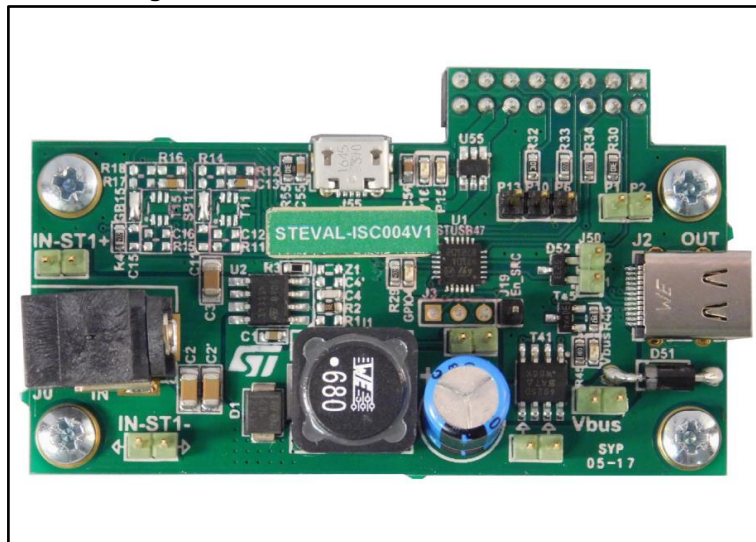
The STUSB4710A acts as a Type-C port interface that ensures power delivery advertising and negotiation, drives the DC-to-DC converter and power paths, and monitors V_{BUS} voltage.

The ST1S14 device manages the step down conversion from the DC input port to the negotiated V_{BUS} voltage.

The various LEDs indicate the operating status of the STUSB4710A and USB PD port.

The USB PD port is pre-configured with five different PDOs to address a broad range of applications (5 V, 9 V, 12 V, 15 V and 20 V).

Figure 1: STEVAL-ISC004V1 evaluation board



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1 Getting started

1.1 Board overview

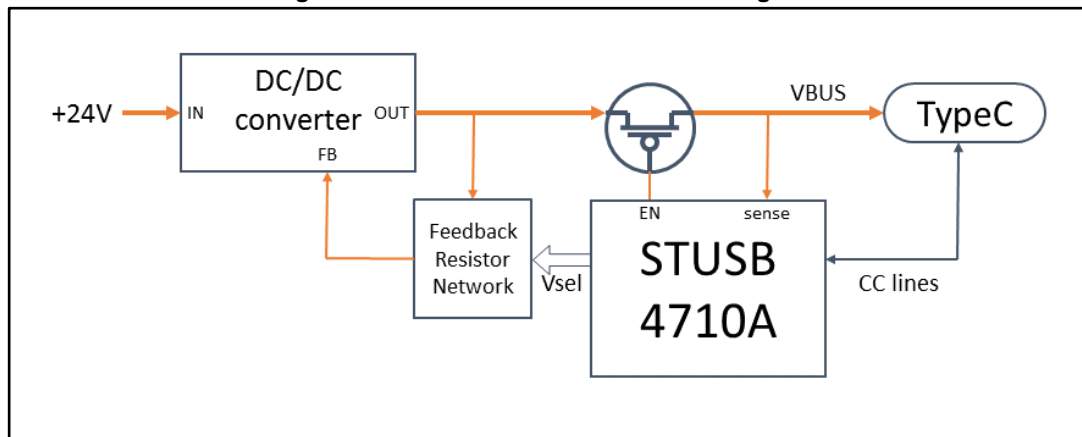
The STEVAL-ISC004V1 USB Type-C™ port is pre-configured with 5 PDOs at fixed voltage node (5 V, 9 V, 12 V, 15 V and 20 V).

The ST1S14 DC-DC is used as a step-down converter.

The STEVAL-ISC004V1 evaluation board features:

- 1 x USB PD port (source)
- STUSB4710A USB power delivery controller
- Compliant with:
 - USB Type-C r1.2
 - USB PD r2.0
- On-board DC-DC
- V_{BUS} power switches and discharge path
- Support for up to 5 power data objects (PDO)
- Short-to- V_{BUS} protections on CC pins (22 V) and V_{BUS} pins (28 V)
- Customizable start-up profiles
- Compatible with NUCLEO-F072RB board for configuration and debug interface
- RoHS compliant

Figure 2: STEVAL-ISC004V1 functional diagram

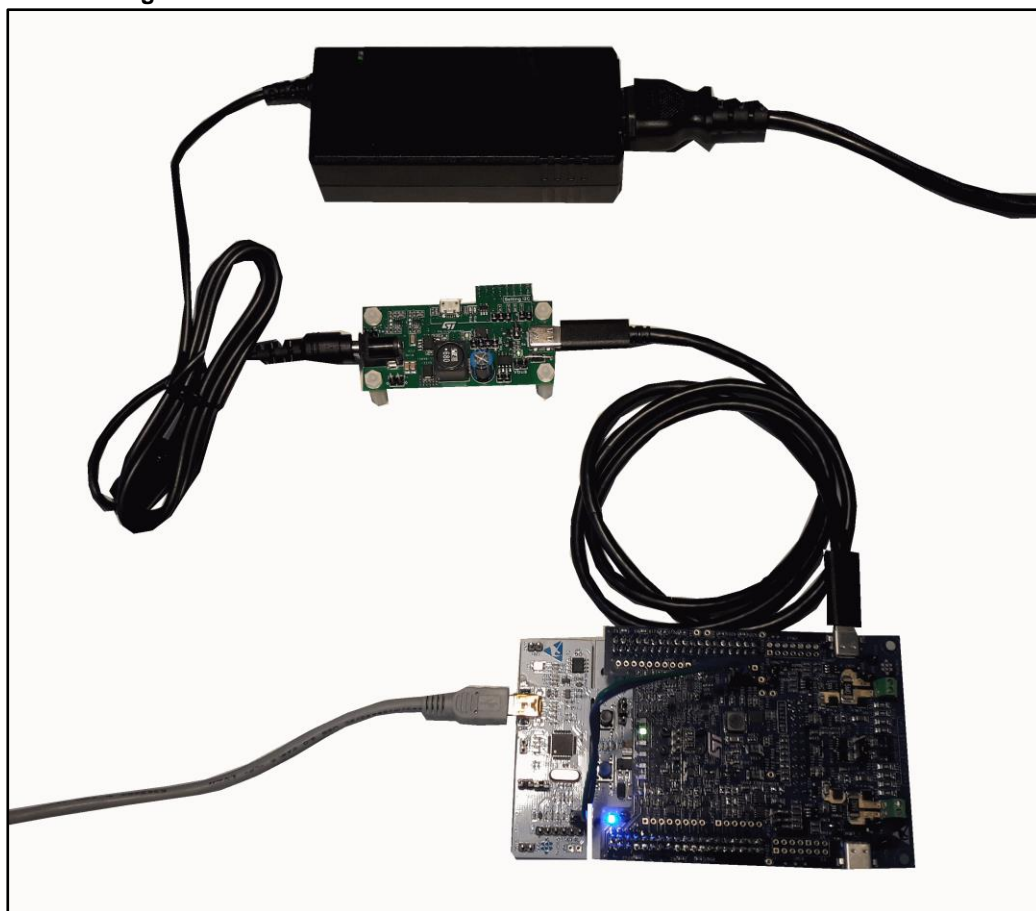


1.2 How to use the board

- 1 Connect a DC source with a minimum voltage of 22 V to either J0 DC socket or pins J0-A and J0-B.
- 2 Connect the Type-C receptacle J2 to any device with a USB Type-C port using a USB Type-C to Type-C cable. The green LED D12 lights up when a device is connected and the V_{BUS} supply is present. D12 lighting intensity changes according to the V_{BUS} voltage value.

The STUSB4710A I²C interface can be used to customize application parameters: PDO, V_{BUS} under and overvoltage limits, V_{BUS} discharge time, etc.

Figure 3: STEVAL-ISC004V1 connected to PNUCLEO-USB001 as a sink



3 Bill of materials

Table 1: STEVAL-ISC004V1 bill of materials

Item	Q. ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	9	C1, C12, C13, C16, C17, C22, C23, C26, C27	50 V, ± 10%, X7R 100 nF CMS - 0603	Ceramic capacitors	Murata	GRM188R71H104KA93D
2	3	C2, C2', C51	50 V, ± 10%, X5R 10 µF CMS - 1206	Ceramic capacitors	Murata	GRM31CR61H106KA12L
3	1	C3	100 V, ± 10%, X7R 220 nF CMS - 1206	Ceramic capacitor	Murata	GCM31MR72A224KA37L
4	1	C4	50V, ± 5%, C0G 100 pF CMS - 0603	Ceramic capacitor	Murata	GRM1885C1H101JA01D
5	1	C5a	20%, 35 V 220 µF Diam 6.3mm Step 3.5mm	Electrolytic capacitor	Vishay	MAL203850221E3
6	2	C5b, C5c	25 V, ± 20%, X5R 22 µF CMS - 0805	Ceramic capacitors	Murata	GRM21BR61E226ME44L
7	3	C6, C7, C9	16V, ± 10%, X5R 10 µF CMS - 0805	Ceramic capacitors	Murata	GRM21BR61C106KE15K
8	1	C8	50V, ± 10%, X7R 1 µF CMS - 0805	Ceramic capacitor	Murata	GRM21BR71H105KA12L
9	1	C55	50 V, ± 10%, X7R 4.7 nF CMS - 0603	Ceramic capacitor	Murata	GRM188R71H472KA01D
10	1	C56	25 V, ± 10%, X5R 1 µF CMS - 0603	Ceramic capacitor	Murata	GRM188R61E105KA12D
11	1	D1	60 V, 3 A STPS5L25 B DO- 214AA	Schottky diode	ST	STPS3L60U

Item	Q. ty	Ref.	Part/Value	Description	Manufacturer	Order code
12	1	D2	20 V, 500 mA, MBR0520L SOD-123	Schottky diode	Fairchild Semiconductors	MBR0520L
13	2	D12, D29	20 mA, 2.1 V - Vbus, GPIO4 CMS - 0603	Green LED	Kingbright	KP-1608CGCK
14	1	D51	400 V, 1 A 1N4004 DO-41	Rectifier diode	Vishay	1N4004-E3/54
15	1	D52	ESDA25L SOT 23-3	Dual Transil for ESD protection	ST	ESDA25L
16	1	D61	20 mA, 2 V - P15 CMS - 0603	Yellow LED	Kingbright	KP-1608SYCK
17	1	D62	20 mA, 1.9 V - P16 CMS - 0603	Red LED	Kingbright	KP-1608SURC
18	1	I1	3.2 A, 0.089 ohm 68 µH 12x12x10mm	Inductor	Würth Elektronik	7447709680
19	1	J0	5 A, 2.5 mm IN Right Angle PC Mount DC Power Jack, pin size 2.5	Jack Power DC	Switchcraft	RAPC712X
20	6	J0-A, J0-B, J1-A, J2-A, J2-B, J50	IN-ST1+, IN-ST1-, Vsrc, Vbus, GND, CC_Set SIP 2	Connectors	Harwin	M20-9990245
21	1	J1	SSQ Morpho SIP 8x2	Connector	Samtec	SSQ-108-01-G-D
22	1	J2	3 A OUT USB3-C FEMELLE- COUDE	USB3 type C	Würth Elektronik	632723300011
23	1	J55	USB-2 Micro B USB_Micro B	Micro USB-2 B	Molex	105017-0001
24	1	R1	NM NC CMS - 0603	Resistor	-	-
25	1	R2	75 V, 100 mW, ± 1% 200K CMS - 0603	Resistor	Vishay	CRCW0603200KFKEA

Item	Q. ty	Ref.	Part/Value	Description	Manufacturer	Order code
26	1	R3	75 V, 100 mW, $\pm 1\%$ 13K CMS - 0603	Resistor	Vishay	CRCW060313K0FKEA
27	1	R6	75 V, 100 mW, $\pm 1\%$ 8.66K CMS - 0603	Resistor	Vishay	CRCW06038K66FKEA
28	1	R5	75 V, 100 mW, $\pm 1\%$ 4.87K CMS - 0603	Resistor	Vishay	CRCW06034K87FKEA
29	1	R7	75 V, 100 mW, $\pm 1\%$ 33K CMS - 0603	Resistor	Vishay	CRCW060333K0FKEA
30	17	R11, R12, R13, R14, R15, R16, R17, R18, R21, R22, R23, R24, R25, R26, R27, R28, R41	75 V, 100 mW, $\pm 1\%$ 47K CMS - 0603	Resistors	Vishay	CRCW060347K0FKEA
31	4	R4, R29, R61, R62	75 V, 100 mW, $\pm 1\%$ 4.7K CMS - 0603	Resistors	Vishay	CRCW06034K70FKEA
32	2	R30, R55	75 V, 100 mW, $\pm 1\%$ 1M CMS - 0603	Resistors	Vishay	CRCW06031M00FKEA
33	1	R31	75 V, 100 mW, $\pm 1\%$ 100 CMS - 0603	Resistor	Vishay	CRCW0603100RFKEA
34	2	R32, R36	75 V, 100 mW, $\pm 1\%$ 10K CMS - 0603	Resistors	Vishay	CRCW060310K0FKEA
35	2	R33, R34	75 V, 100 mW, $\pm 1\%$ 2K2 CMS - 0603	Resistors	Vishay	CRCW06032K20FKEA

Item	Q. ty	Ref.	Part/Value	Description	Manufacturer	Order code
36	1	R35	150 V, 125 mW, \pm 1% 820 CMS - 0805	Resistor	Vishay	CRCW0805820RFKEA
37	1	R42	75V, 100mW, \pm 1% 22K CMS - 0603	Resistor	Vishay	CRCW060322K0FKEA
38	1	R45	75V, 100mW, \pm 1% 150K CMS - 0603	Resistor	Vishay	CRCW0603150KFKEA
39	1	R46	75 V, 100 mW, \pm 1% 3.9K CMS - 0603	Resistor	Vishay	CRCW06033K90FKEA
40	1	RD1	75 V, 100 mW, \pm 1% 200 CMS - 0603	Resistor	Vishay	CRCW0603200RFKEA
41	1	SB8	75 V, 100 mW 0R CMS - 0603	Strap Footprint	Vishay	CRCW06030000Z0EAHP
42	4	T11, T15, T21, T25	300 mA, 60 V 2N7002BKS SOT-363	Transistor - dual MOSFET-N	NXP	2N7002BKS
43	1	T45	190 mA, 60 V 2N7002K SOT23-3	Transistor - MOSFET-N	Vishay	2N7002K-T1-GE3
44	1	T35	130 mA, 50 V BSS84 SOT23-3	Transistor - MOSFET-P	Fairchild Semiconductors	BSS84
45	1	T41	8 A, 30 V Si4925DDY SO-8	Transistor - MOSFET-P	Vishay	SI4925DDY-T1-GE3
46	1	U1	STUSB47 QFN24 - 4x4	IC - USB Type C and power delivery interface	ST	STUSB4710AQTR
47	1	U2	5.5 V-48 Vin, 3 A out ST1S14 HSOP-8	IC - up to 3 A step-down switching regulator	ST	ST1S14PHR
48	1	U3	LDO, 2.5-24 Vin, 3.3 V Out, 150 mA Out TLV701 SOT- 23-5	IC - adjustable and fixed low drop positive voltage regulator	Texas Instruments	TLV70133DBVT

Item	Q. ty	Ref.	Part/Value	Description	Manufacturer	Order code
49	1	U55	SC6=SOT-23-6L; P6=SOT-666; SC6Y=SOT-23-6L USBLC6-2SC6 SOT-23-6L	USB very low capacitance	ST	USBLC6-2SC6

4 Board layout

Figure 5: STEVAL-ISC004V1: top layer

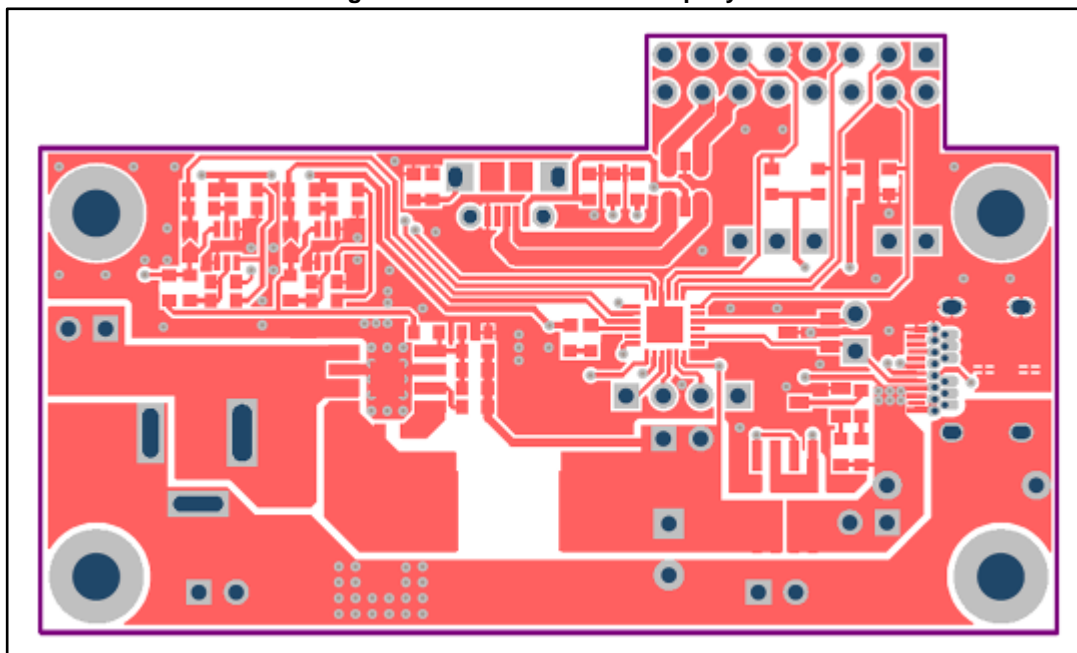


Figure 6: STEVAL-ISC004V1: bottom layer

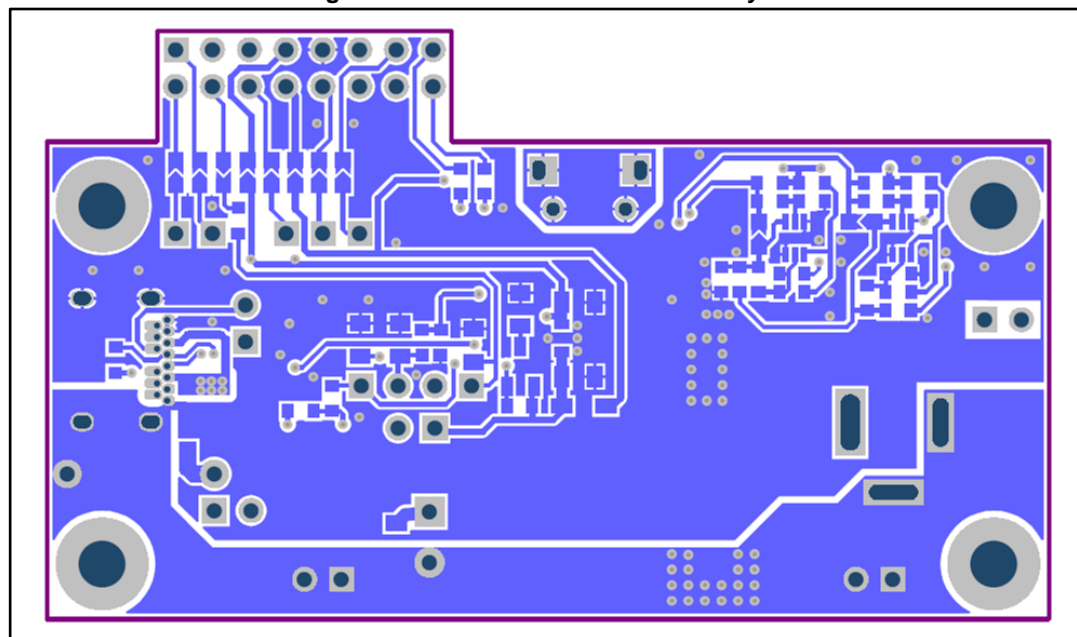


Figure 7: STEVAL-ISC004V1: top silkscreen

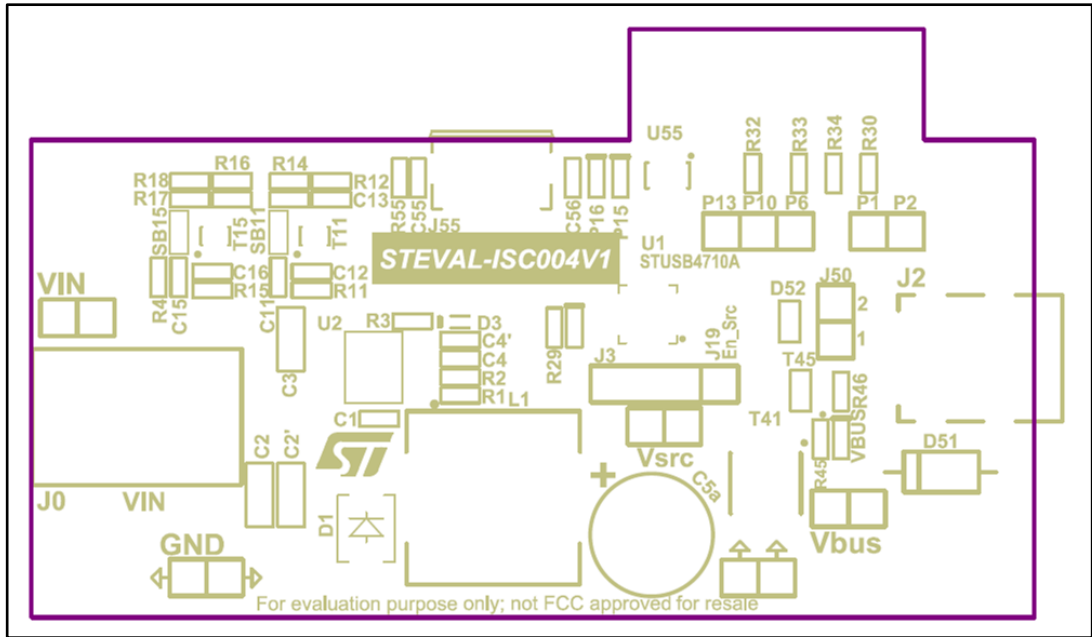


Figure 8: STEVAL-ISC004V1: bottom silkscreen

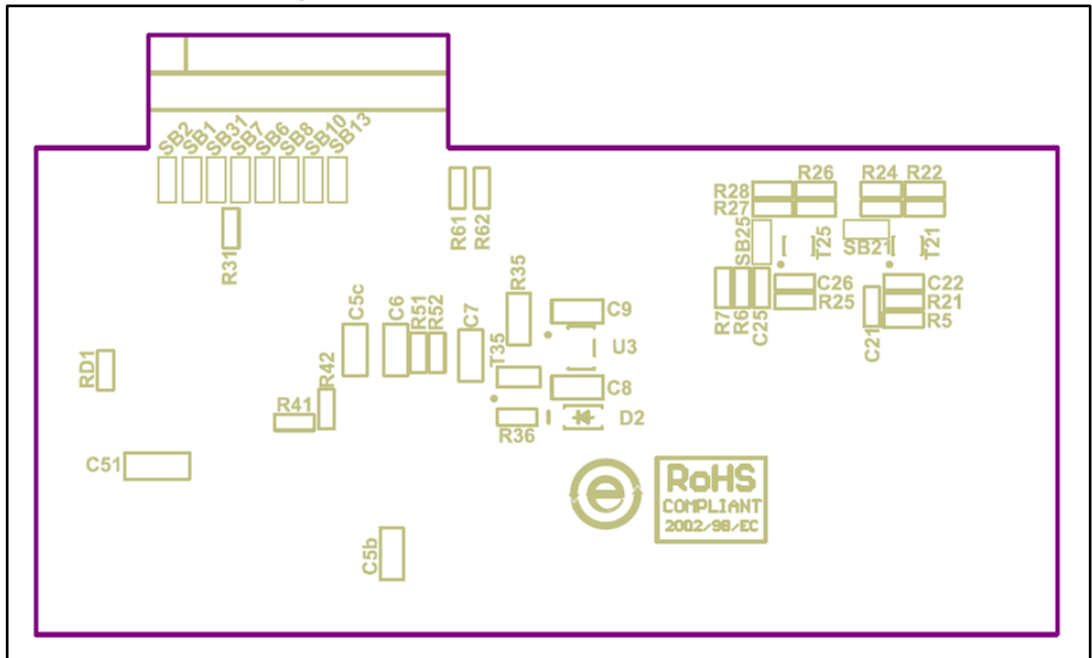


Figure 9: STEVAL-ISC004V1: top assembly

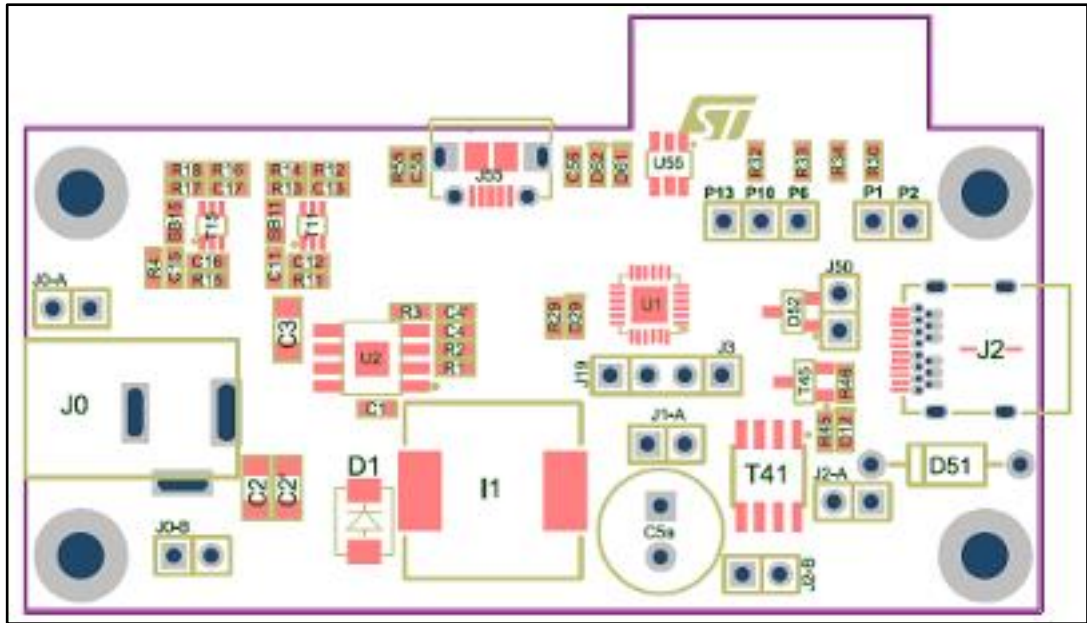
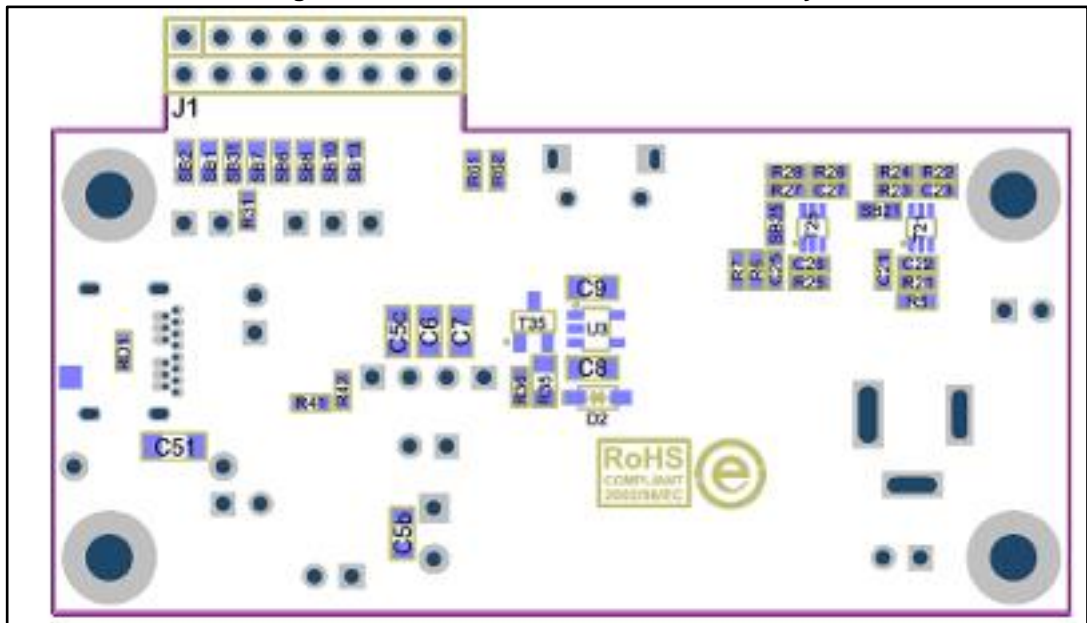


Figure 10: STEVAL-ISC004V1: bottom assembly



4.1 Layout constraints

As the V_{BUS} path can carry up to 3 A, power track between DC-DC, Power MOS and Type-C connector is large enough.

Special care must be taken for DC-DC layout and thermal dissipation.

The STUSB4710A monitors V_{BUS} and discharges the path. The monitoring signal should be separated from the power signal and QFN exposed pad must be connected to global GND plane through vias to allow thermal conduction.

5 Board customization

5.1 Power delivery through STUSB4710A and DC-DC regulator

The STUSB4710A advertises the voltage/current couple capability on the CC line (power delivery objects or PDO).

Each object is linked to a VSEL_PDO signal which controls the DC-DC converter.

When a contract is negotiated with the sink device connected to the Type-C connector, the VSEL signal corresponding to the selected power object is tied low.

The equivalent resistor bridge of the DC-DC controller must be set to match the output voltage with the selected PDO.

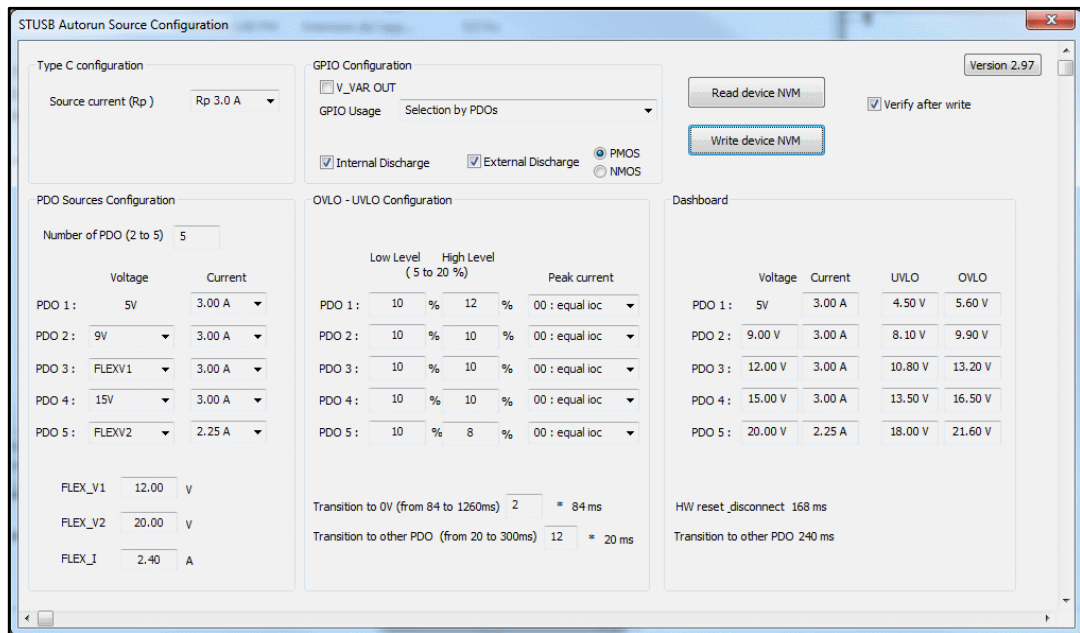
The STUSB4710A monitors the V_{BUS} voltage and disconnects the sink device when the voltage is not in the correct range.

5.2 Software configuration

The STUSB4710A settings are stored in non-volatile memory (NVM), accessible through I²C.

STMicroelectronics provides a graphical user interface for evaluation purposes to program this memory via PC.

The STEVAL-ISC004V1 PDO memory settings must be aligned with the hardware resistor configuration.



5.3 Hardware configuration

The buck application delivers 5 output voltages by default. The output voltages can be customized by changing R2, R3, R4, R5, R6 and R7 resistor values.

The STUSB4710A controls the output voltage through 4 GPIOs which change the voltage divider ratio on the basis of the feedback signal to the buck controller.

According to the voltage tuning, the voltage divider based on R2, R3, R4, R5, R6 and R7 resistors has to be tuned accordingly.

5.4 Voltage output trimming

The output voltage control is based on the voltage divider variation. Each time a PDO is modified, the set of R3, R4, R5, R6 and R7 resistors has to be modified accordingly.



R2 is fixed at 200 k for the ST1S14.

Firstly, you have to calculate the resistor associated with the divider ratio for each output voltage:

Equation 1

$$R_A = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} = \frac{200 \cdot 1.22}{5 - 1.22} = 64550\Omega$$

To limit the error propagation, the resistor computation should start from the highest voltage to the lowest one by integrating the previous computation at each step.

Equation 2

$$R_3 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22}$$

Equation 3

$$R_4 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} - R_3$$

Equation 4

$$R_5 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} - R_3 - R_4$$

Equation 5

$$R_6 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} - R_3 - R_4 - R_5$$

Equation 6

$$R_7 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} - R_3 - R_4 - R_5 - R_6$$

The following table shows the default STEVAL-ISC004V1 evaluation board set of resistors.

Table 2: STEVAL-ISC004V1 default resistors

V _{BUS} (V)	Theoretical value (Ω) $R = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22}$					Real resistor value in 1% series				
	R _A	R _B	R _C	R _D	R _E	R ₃	R ₄	R ₅	R ₆	R ₇
5	64550					13k0	4k7	4k87	8k66	33k0
9		31362				13k0	4k7	4k87	8k66	
12			22634			13k0	4k7	4k87		
15				17707		13k0	4k7			
20					12992	13k0				

6 Revision history

Table 3: Document revision history

Date	Version	Changes
03-Oct-2017	1	Initial release.

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