UM2208
User manual

Getting started with the STEVAL-ISC003V1 STUSB4710 evaluation board USB PD controller with on-board DC-DC

Introduction

The STEVAL-ISC003V1 evaluation board is a ready-to-use USB PD source using the STUSB4710 and ST1S14 ICs. It is used to demonstrate the features of the STUSB4710 controller by converting a single-voltage power supply into a Type-C power delivery source.

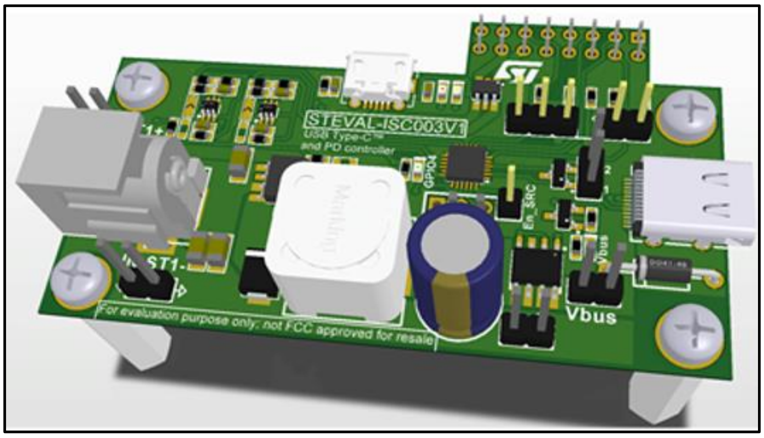
The STUSB4710 controls the Type-C port ensuring power delivery advertising and negotiation, controls the DC-to-DC converter and power paths, and monitors V_{BUS} voltage.

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

The various LEDs indicate the operating status of the STUSB4710 and USB PD port.

The USB PD port is pre-configured with five different PDO voltages, covering all main applications (5 V, 9 V, 12 V, 15 V and 20 V).

Figure 1: STEVAL-ISC003V1 evaluation board



Contents

1 Getting started 5
1.1 Board overview 5
1.2 How to use the board 6
2 Schematic diagram 7
3 Bill of materials 8
4 Board layout 12
4.1 Layout constraints 14
5 Board customization 15
5.1 Power delivery through STUSB4710 and DC-DC regulator 15
5.2 Software configuration 15
5.3 Hardware configuration 15
5.4 Voltage output trimming 16
6 Revision history 17

List of tables

Table 1: STEVAL-ISC003V1 bill of materials 8
Table 2: STEVAL-ISC003V1 default resistors 16
Table 3: Document revision history 17

List of figures

Figure 1: STEVAL-ISC003V1 evaluation board 1
Figure 2: STEVAL-ISC003V1 functional diagram 5
Figure 3: STEVAL-ISC003V1 connected to PNUCLEO-USB001 as a sink 6
Figure 4: STEVAL-ISC003V1 circuit schematic 7
Figure 5: STEVAL-ISC003V1: top layer 12
Figure 6: STEVAL-ISC003V1: bottom layer 12
Figure 7: STEVAL-ISC003V1: top silkscreen 13
Figure 8: STEVAL-ISC003V1: bottom silkscreen 13
Figure 9: STEVAL-ISC003V1: top assembly 14
Figure 10: STEVAL-ISC003V1: bottom assembly 14
Figure 11: STUSB4710 NVM settings 15

1 Getting started

1.1 Board overview

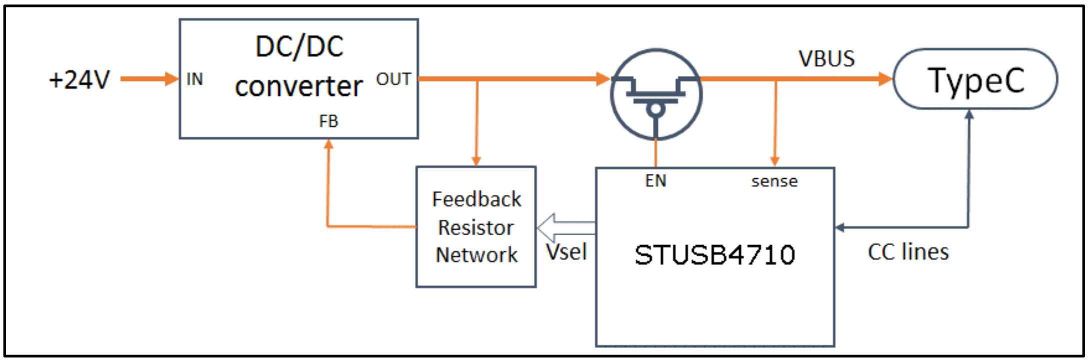
The STEVAL-ISC003V1 USB Type-C™ port is pre-configured with 5 PDOs at fixed voltage node (5 V, 9 V, 12 V, 15 V and 20 V).

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

The STEVAL-ISC003V1 evaluation board features:

- 1 x USB PD port (source)
- STUSB4710 USB power delivery controller
- Compliant with:
  - USB Type-C™ r1.2
  - USB PD r2.0
- On-board 20 V/3 A DC-DC
- V_{BUS} power switches and discharge path
- V_{CONN} support (programmable up to 600 mA)
- Support up to 5 power data objects (PDO)
- Pre-configured PDOs
- High voltage protection on connector pins
- Customizable startup profiles
- Compatible with NUCLEO-F072RB board for configuration and debug interface
- RoHS compliant

Figure 2: STEVAL-ISC003V1 functional diagram

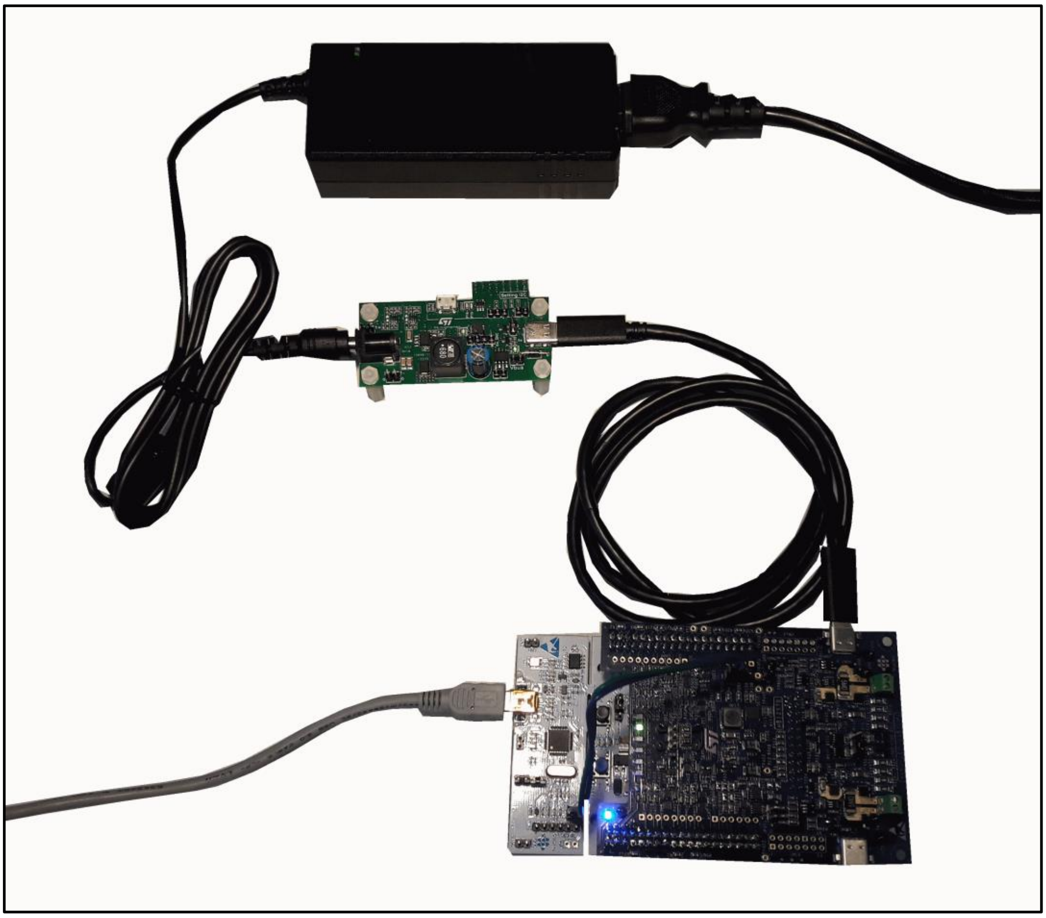


1.2 How to use the board

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 VBUS supply is present. D12 lighting intensity changes according to the VBUS voltage value.

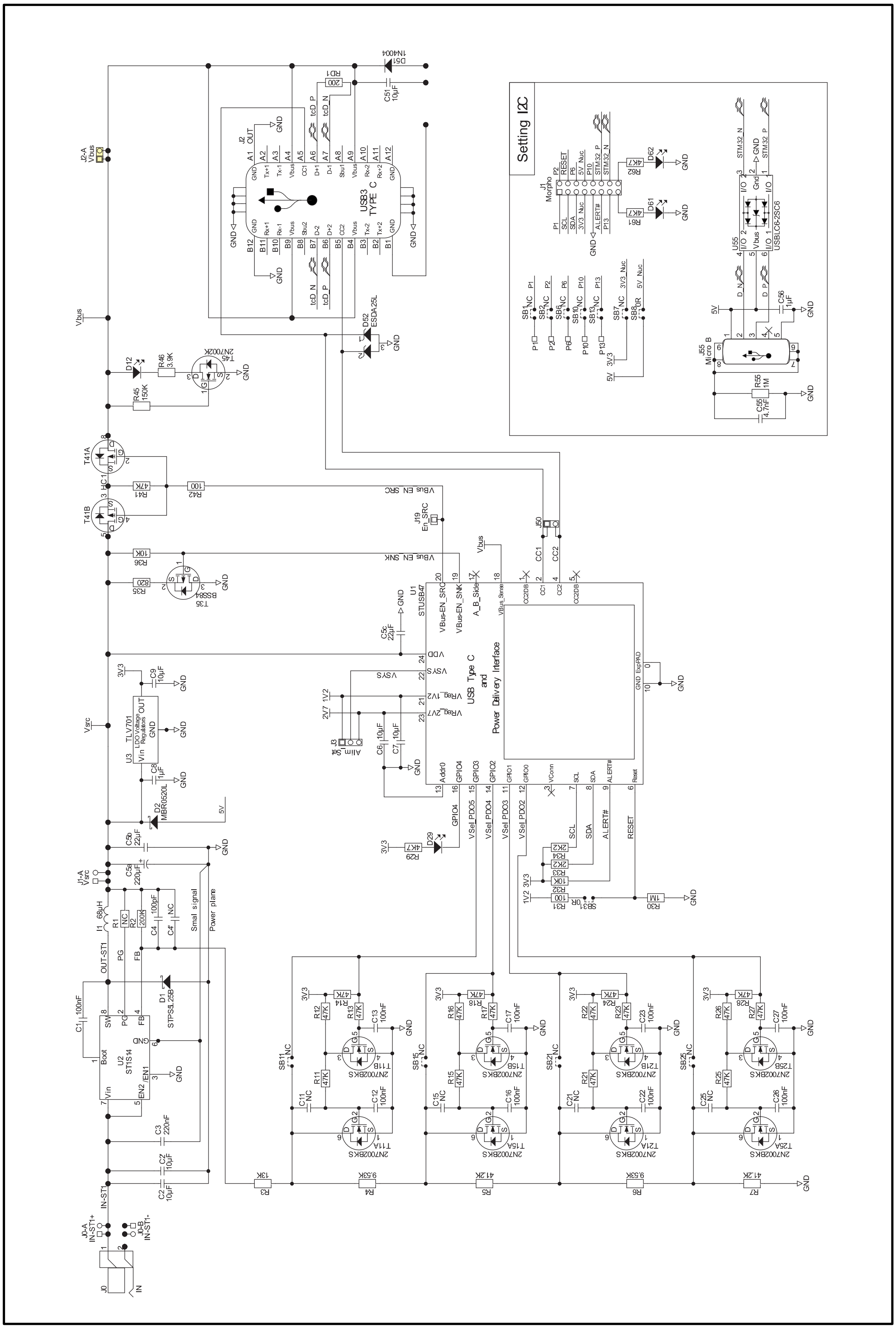
   The STUSB4710 I2C interface can be used to customize application parameters: PDO, VBUS under and over voltage limits, VBUS discharge time, etc.

Figure 3: STEVAL-ISC003V1 connected to PNUCLEO-USB001 as a sink



2 Schematic diagram

Figure 4: STEVAL-ISC003V1 circuit schematic



3 Bill of materials

Table 1: STEVAL-ISC003V1 bill of materials

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	9	C1, C12, C13, C16, C17, C22, C23, C26, C27	100 nF, 0603, 50 V, ± 10%, X7R	Cercamic capacitor	MURATA	GRM188R71H104KA93D
2	3	C2, C2', C51	10 µF, 1206, 50 V, ± 10%, X5R	Cercamic capacitor	MURATA	GRM31CR61H106KA12L
3	1	C3	220 nF, 1206, 100 V, ± 10%, X7R	Cercamic capacitor	MURATA	GCM31MR72A224KA37L
4	1	C4	100 pF, 0603, 50 V, ± 5%, C0G	Cercamic capacitor	MURATA	GRM1885C1H101JA01D
5	1	C5a	220 µF, 6.3mm, pitch 3.5 mm ±20%, 35 V	Electrolytic capacitor	VISHAY	MAL203850221E3
6	2	C5b, C5c	22 µF, 0805, 25 V, ± 20%, X5R	Cercamic capacitor	MURATA	GRM21BR61E226ME44L
7	3	C6, C7, C9	10 µF, 0805, 16 V, ± 10%, X5R	Cercamic capacitor	MURATA	GRM21BR61C106KE15K
8	1	C8	1 µF, 0805, 50 V, ± 10%, X7R	Cercamic capacitor	MURATA	GRM21BR71H105KA12L
9	1	C55	4.7 nF, 0603, 50 V, ± 10%, X7R	Cercamic capacitor	MURATA	GRM188R71H472KA01D
10	1	C56	1 µF, 0603 25 V, ± 10%, X5R	Cercamic capacitor	MURATA	GRM188R61E105KA12D
11	1	D1	STPS5L25B, 60 V, 3 A	Schottky diode	ST	STPS3L60U
12	1	D2	MBR0520L SOD-123, 20 V, 500 mA	Schottky diode	FAIRCHILD SEMICONDUCTOR	MBR0520L
13	2	D12, D29	0603 20 mA, 2.1 V	Green LED	KINGBRIGHT	KP-1608CGCK
14	1	D51	1N4004 DO-41, 400 V, 1 A	Rectifier diode	VISHAY	1N4004-E3/54
15	1	D52	ESDA25L SOT 23-3	Dual transil for ESD protection	ST	ESDA25L
16	1	D61	0603, 20 mA, 2 V	Yellow LED	KINGBRIGHT	KP-1608SYCK

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
17	1	D62	0603, 20 mA, 1.9 V	Red LED	KINGBRIGHT	KP-1608SURC
18	1	I1	68 µH, 0.089 Ω	Inductor	WURTH ELEKTRONIK	7447709680
19	1	J0	IN right angle PC mount DC power jack, pin size 2.5 5 A, 2.5 mm	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	Connector M/ - 1 rows 2 cts - Step 2.54 mm	HARWIN	M20-9990245
21	1	J1	Morpho SIP	Connector M/ - 2 rows	SAMTEC	SSQ-108-01-G-D
22	1	J2	OUT USB3	USB3 type C	WURTH	632723300011
23	1	J55	Micro B USB_Micro B USB-2	Micro USB-2 B	MOLEX	105017-0001
24	0	R1	0603- DNM	Resistor	-	-
25	1	R2	200 K, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW0603200KFKEA
26	1	R3	13 K, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW060313K0FKEA
27	1	R6	8.66 K, 0603 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW06038K66FKEA
28	1	R5	4.87 K, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW06034K87FKEA
29	1	R7	33 K, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW060333K0FKEA
30	17	R11, R12, R13, R14, R15, R16, R17, R18, R21, R22, R23, R24, R25, R26, R27, R28, R41	47 K, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW060347K0FKEA
31	4	R4, R29, R61, R62	4.7 K, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW06034K70FKEA
32	2	R30, R55	1 M, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW06031M00FKEA

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
33	1	R31,	100 K, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW0603100RFKEA
34	2	R32, R36	10 K, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW060310K0FKEA
35	2	R33, R34	2K2, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW06032K20FKEA
36	1	R35	820, 0805 150 V, 125 mW, ± 1%	Resistor	VISHAY	CRCW0805820RFKEA
37	1	R42	22 K, 0603, 75 V, 100 mW, ± 1%	Resistor	VISHAY	CRCW060322K0FKEA
38	1	R45	150 K, 0603, 75 V, 100 mW, ± 1%	Resistor - 0603	VISHAY	CRCW0603150KFKEA
39	1	R46	3.9 K, 0603, 75 V, 100 mW, ± 1%	Resistor - 0603	VISHAY	CRCW06033K90FKEA
40	1	RD1	200, 0603, 75 V, 100 mW, ± 1%	Resistor - 0603	VISHAY	CRCW0603200RFKEA
41	1	SB8	0 R, 0603 75 V, 100 mW	Strap Footprint	VISHAY	CRCW06030000Z0EAHP
42	4	T11, T15, T21, T25	300 mA, 60 V	Transistor - Dual MOFSET-N - SOT 363	NXP	2N7002BKS
43	1	T45	190 mA, 60 V	Transistor - MOFSET-N - SOT 23-3L	VISHAY	2N7002K-T1-GE3
44	1	T35	BSS84 SOT23-3 Canal P, -130 mA, -50 V	Transistor - MOFSET-P - SOT 23-3L	FAIRCHILD SEMICONDUCTOR	BSS84
45	1	T41	Si4925DDY SO-8 Canal P, -8 A, -30 V	Transistor - MOFSET-P - SO 8	VISHAY	SI4925DDY-T1-GE3
46	1	U1	STUSB47 QFN24	IC - USB Type C and Power Delivery Interface	ST	STUSB4710QTR
47	1	U2	ST1S14 HSOP, 8 5.5 V, 48 V in, 3 A out	IC - Up to 3 A step-down switching regulator - HSOP-8	ST	ST1S14PHR

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
48	1	U3	2.5 V-24 V IN, 3.3 V OUTt, 150 mA OUT	IC - Adjustable and fixed low drop positive voltage regulator - SOT23-5	TEXAS INSTRUMENTS	TLV70133DBVT
49	1	U55	USBLC6-2SC6 SOT 23-6L SC6=SOT-23-6L; P6=SOT-666; SC6Y=SOT-23-6L	USB - very low capacitance	ST	USBLC6-2SC6

4 Board layout

Figure 5: STEVAL-ISC003V1: top layer

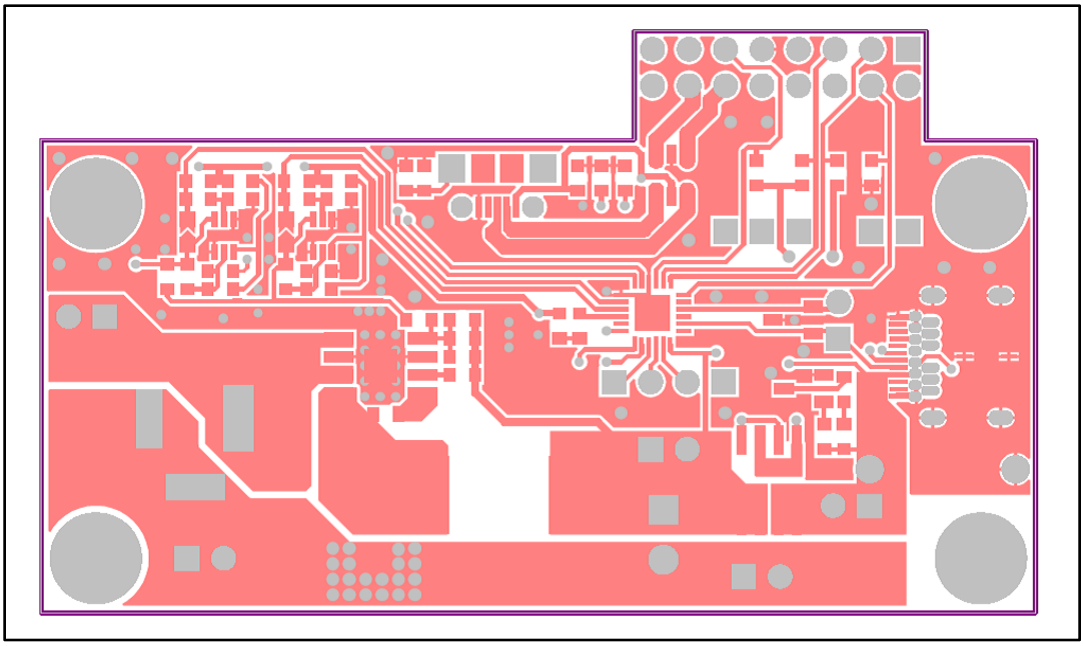


Figure 6: STEVAL-ISC003V1: bottom layer

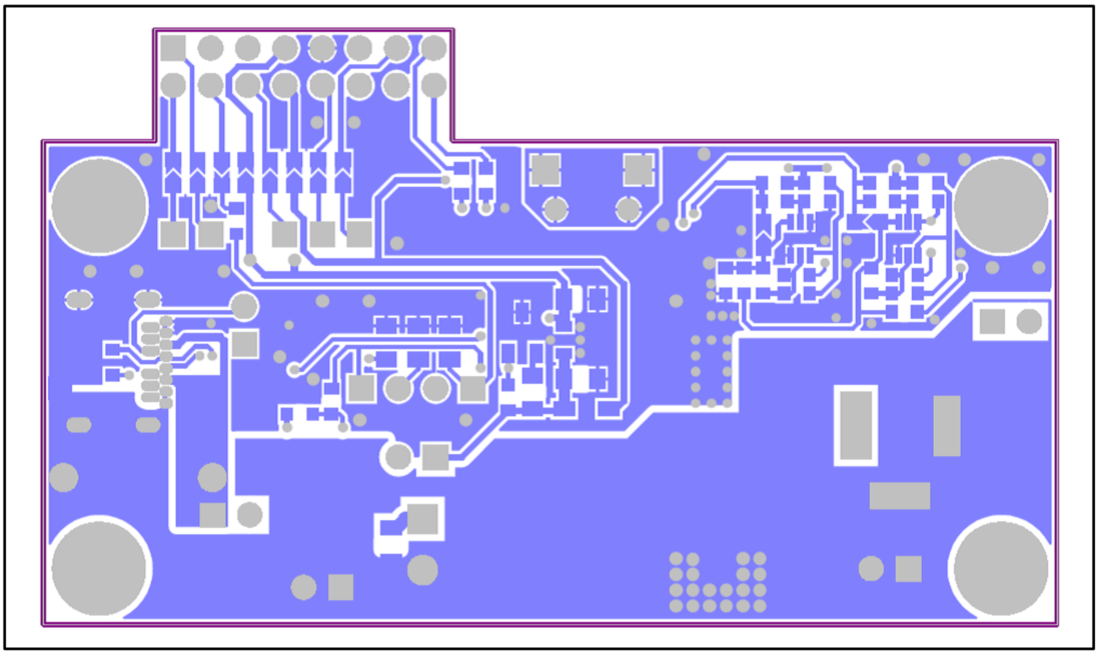


Figure 7: STEVAL-ISC003V1: top silkscreen

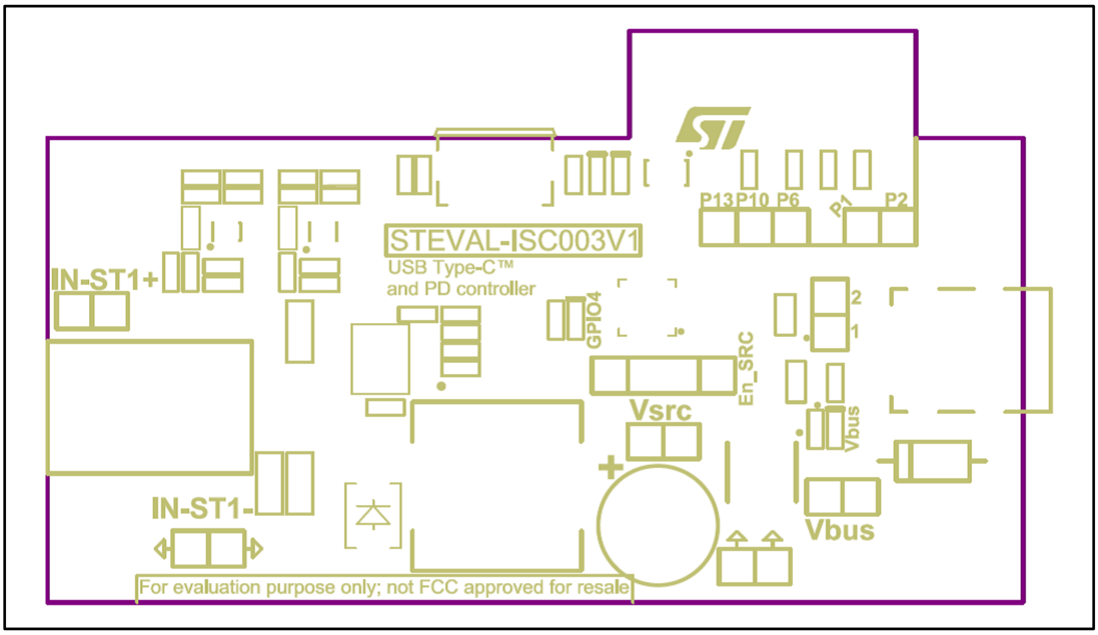


Figure 8: STEVAL-ISC003V1: bottom silkscreen

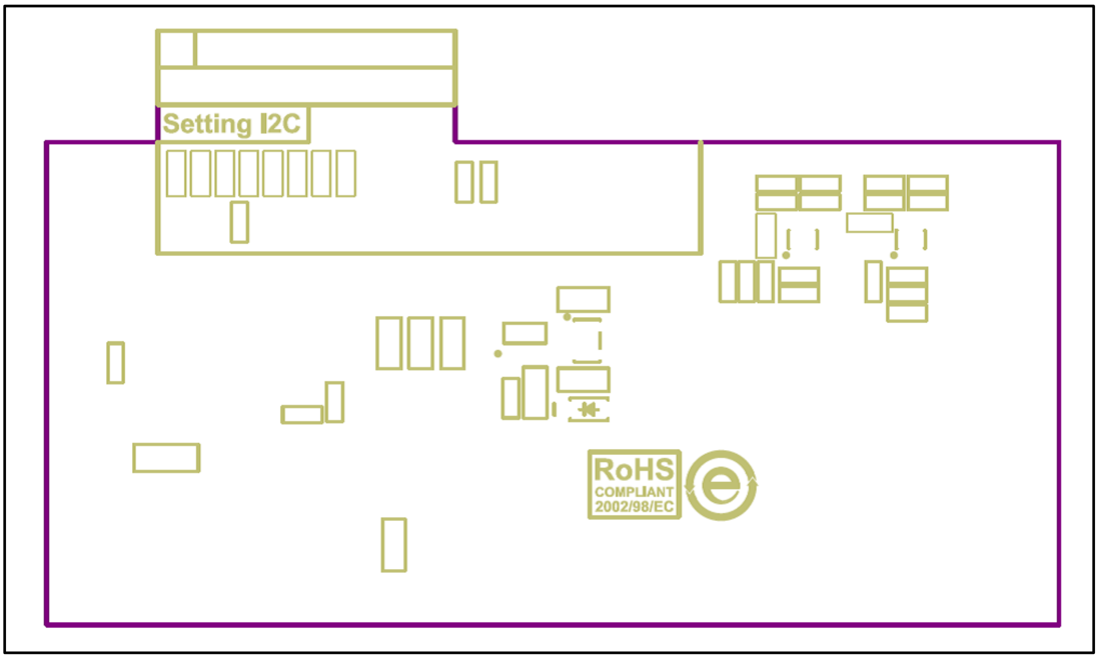


Figure 9: STEVAL-ISC003V1: top assembly

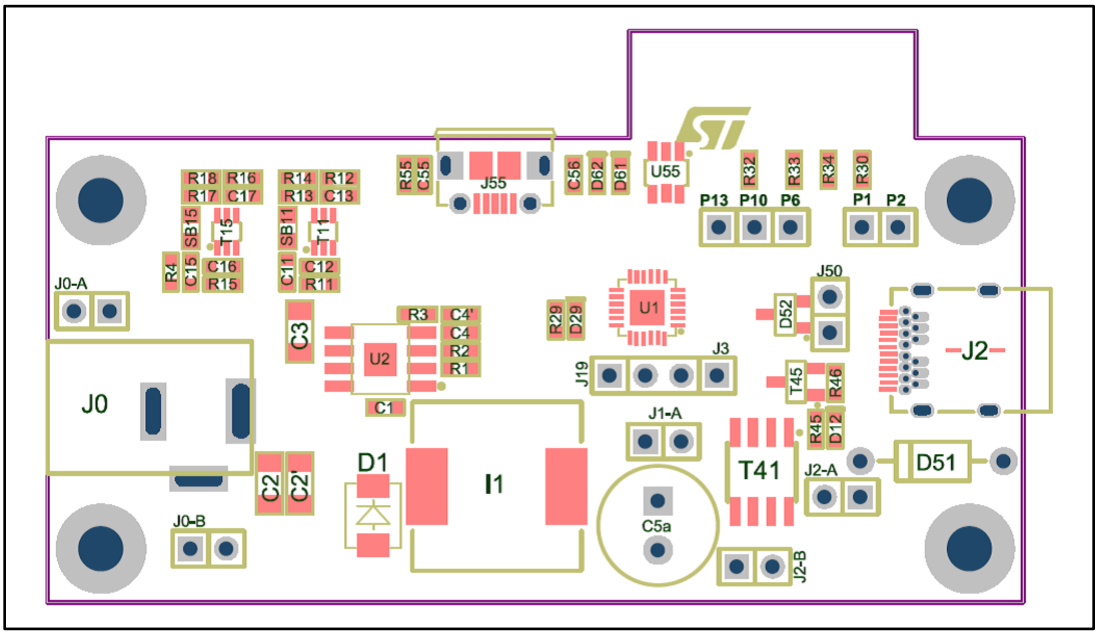
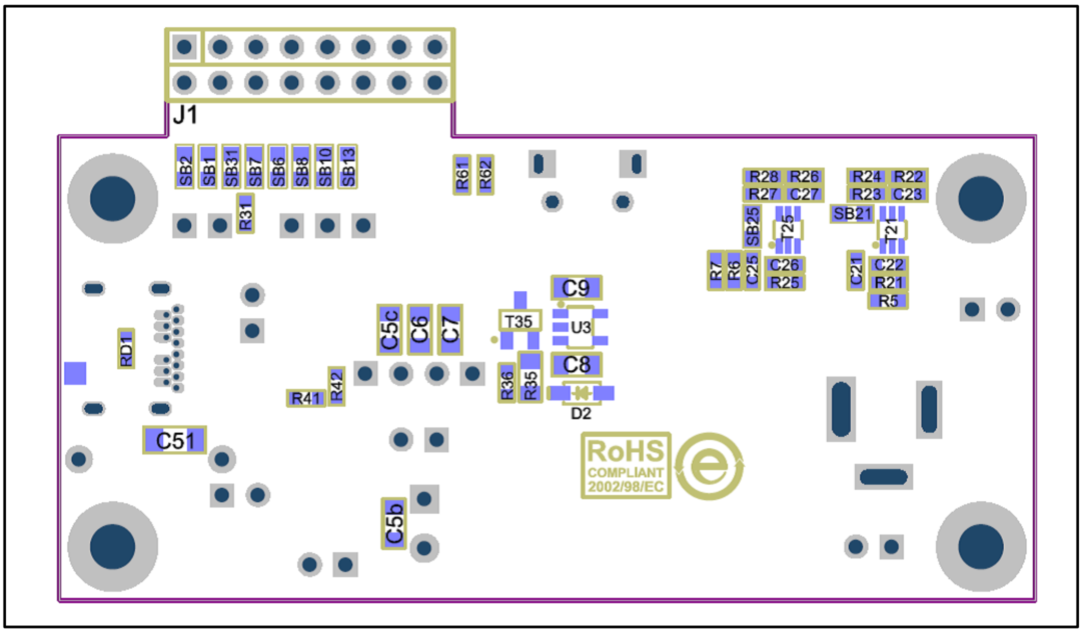


Figure 10: STEVAL-ISC003V1: bottom assembly



4.1 Layout constraints

As the VBUS 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.

STUSB4710 monitors VBUS 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 STUSB4710 and DC-DC regulator

STUSB4710 advertises capability on the CC line (power delivery objects or PDO), made of a voltage/current couple.

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, 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.

STUSB4710 monitors the VBUS voltage and disconnects the sink device when the voltage is not in the correct range.

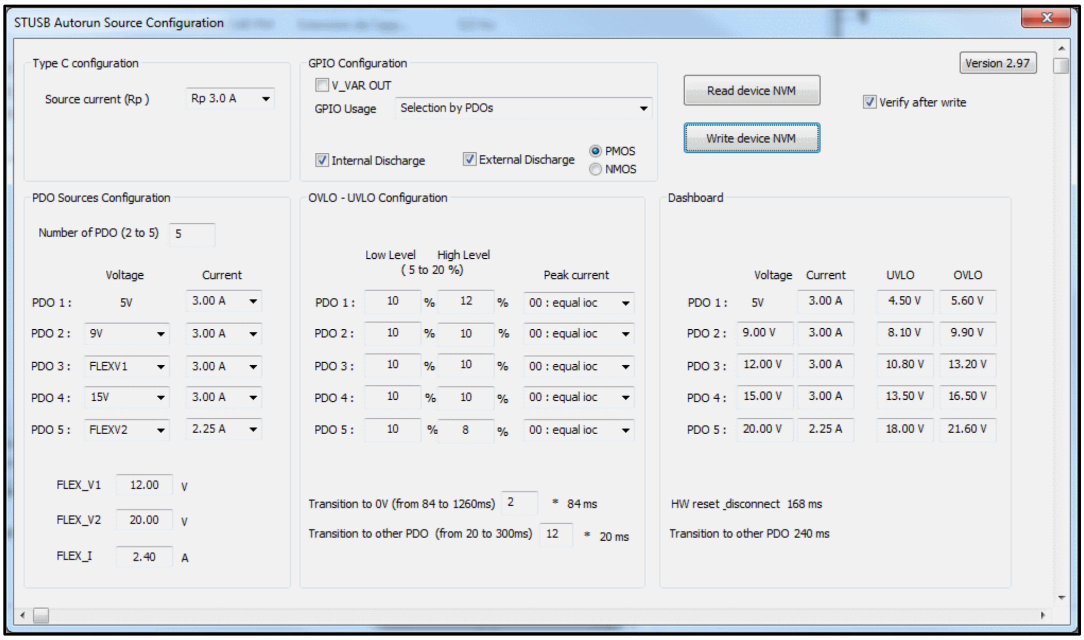
5.2 Software configuration

STUSB4710 settings are stored into a non-volatile memory (NVM), accessible through I^2C.

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

The STEVAL-ISC003 PDO memory settings must be aligned with the hardware resistor configuration.

Figure 11: STUSB4710 NVM settings



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 STUSB4710 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 to 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-ISC003 evaluation board set of resistors.

Table 2: STEVAL-ISC003V1 default resistors

Vbus (V)	Theoretical value (ohm) $R = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22}$					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
10-May-2017	1	Initial release.