

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.

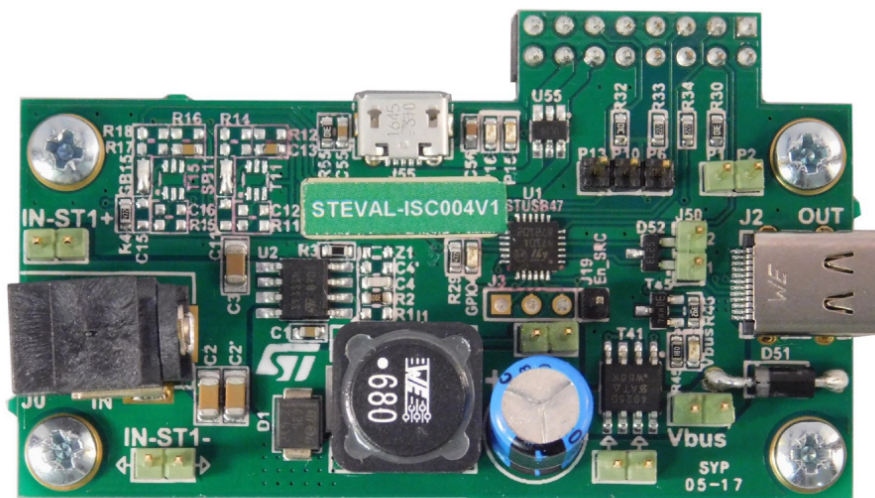
The STUSB4710A acts as a Type-C port interface that ensures power delivery advertising and negotiation, drives the DC-to-DC converter and power paths, and monitors V_{BUS} voltage.

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



1 USB PD board overview

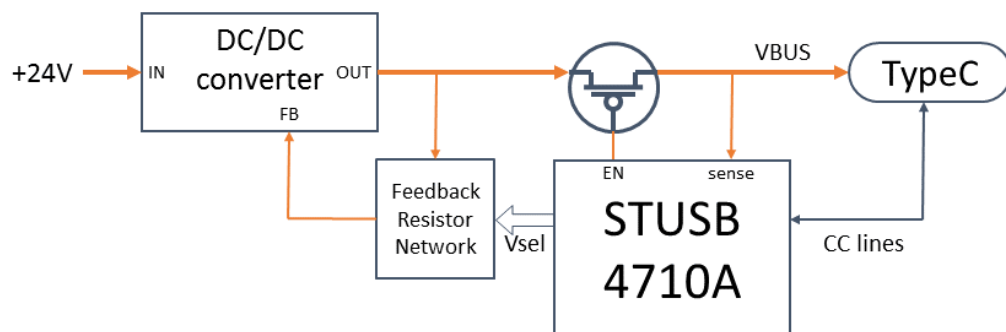
The STEVAL-ISC004V1 USB Type-C™ port is pre-configured with 5 PDOs at fixed voltage node (5 V, 9 V, 12 V, 15 V and 20 V).

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

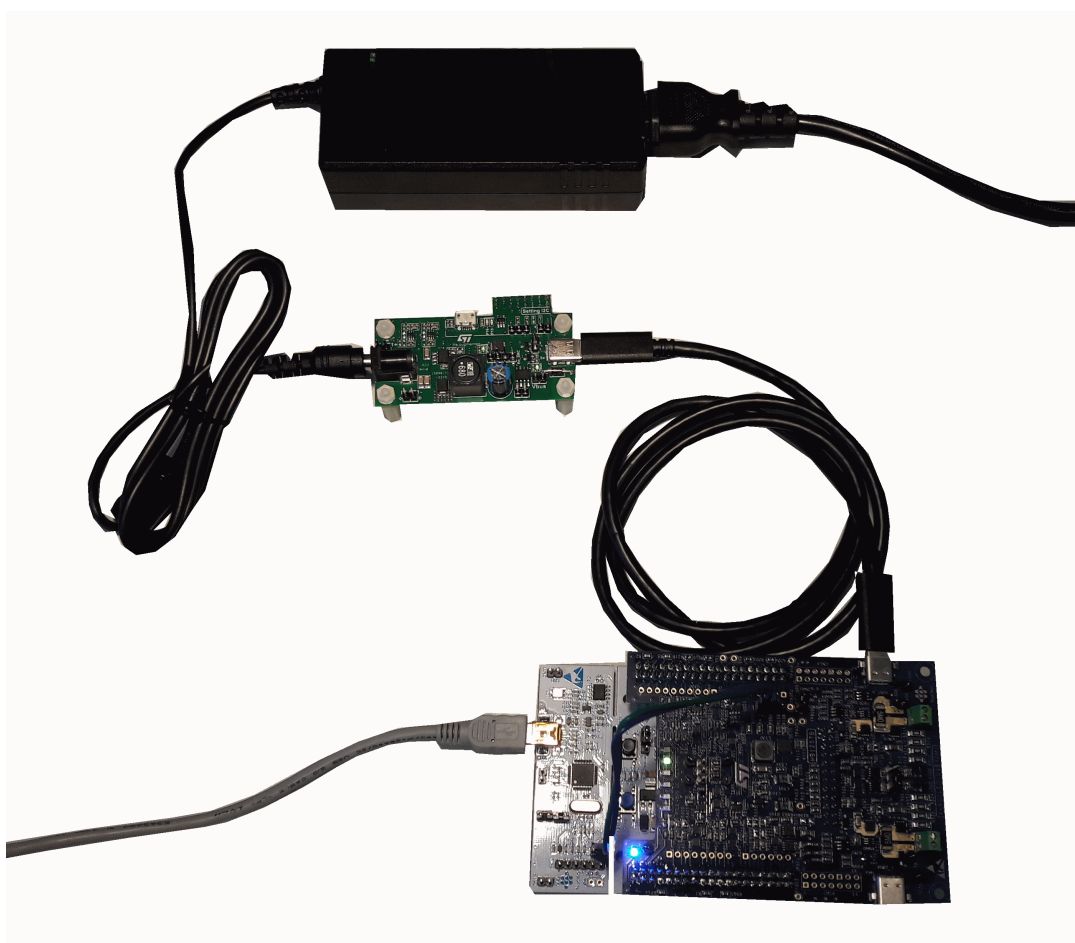
Figure 2. STEVAL-ISC004V1 functional diagram



1.1 How to use the board

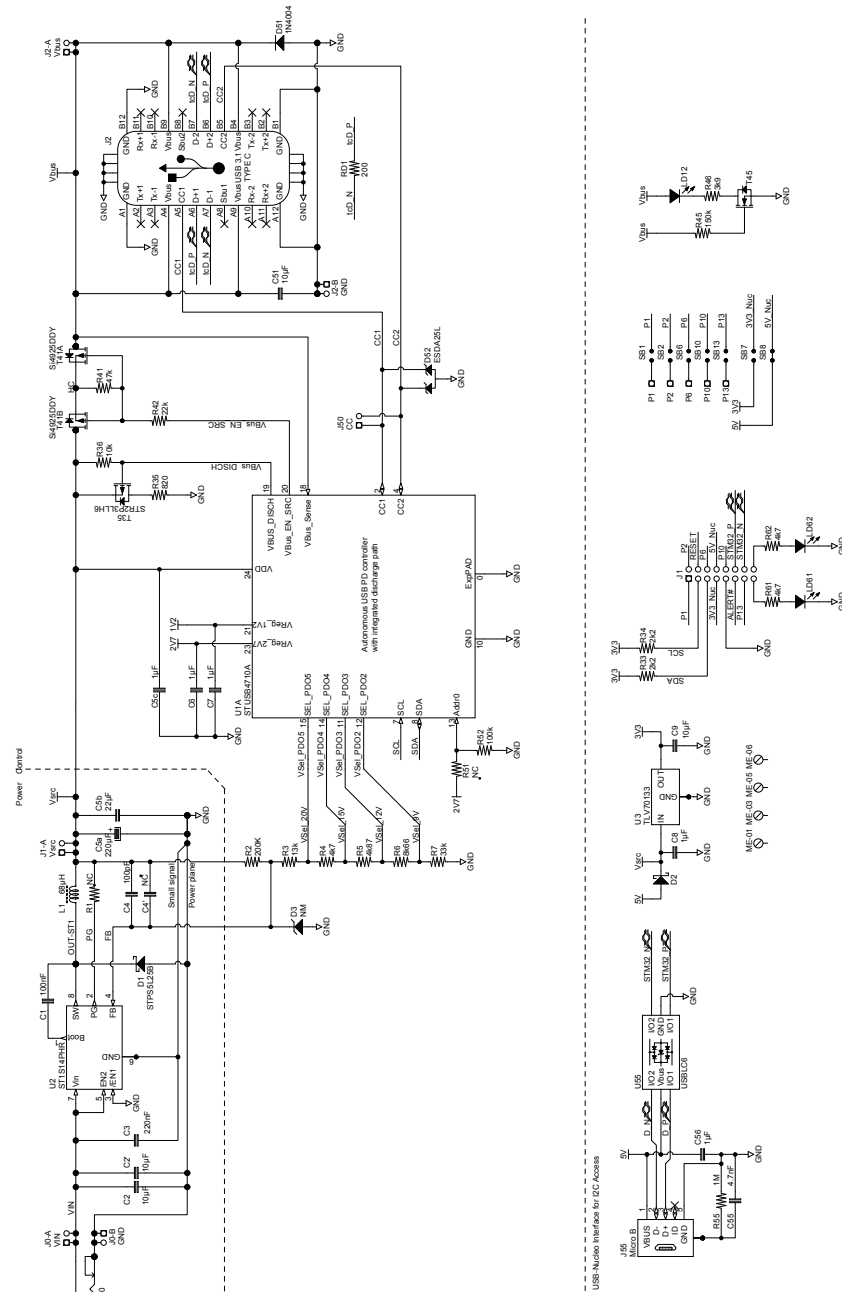
- Step 1.** Connect a DC source with a minimum voltage of 22 V to either J0 DC socket or pins J0-A and J0-B.
- Step 2.** Connect the Type-C receptacle J2 to any device with a USB Type-C port using a USB Type-C to Type-C cable. The green LED D12 lights up when a device is connected and the VBUS supply is present. D12 lighting intensity changes according to the VBUS voltage value.
- The STUSB4710A I²C interface can be used to customize application parameters: PDO, VBUS under and overvoltage limits, VBUS discharge time, etc.

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



2 Schematic diagram

Figure 4. STEVAL-ISC004V1 circuit schematic



3 Bill of materials

Table 1. STEVAL-ISC004V1 bill of materials

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	C1	100nF, 50V ±10%	Capacitor X7R 0603	Würth Elektronik	885012206095
2	3	C2, C2', C51	10µF, 25V ±20% 1206	Capacitor X5R 1206	Würth Elektronik	885012108021
3	1	C3	220nF, 100V ±10% 1206	Capacitor X7R 1206	Würth Elektronik	885012208089
4	1	C4	100pF, 50V ±5%	Capacitor COG 0603	Würth Elektronik	885012006057
5	1	C5a	220µF 35V ±20%	Capacitor Electro P 3.5mm D 8mm H 11.5mm	Würth Elektronik	860020574012
6	1	C5b	22µF, 25V ±20%	Capacitor X5R 1210	Würth Elektronik	885012109014
7	4	C5c, C6, C7, C8	1µF, 50V ±20%	Capacitor X7R 0805	Würth Elektronik	885012207103
8	1	C9	10µF, 16V ±20%	Capacitor X5R 0805	Würth Elektronik	885012107014
9	1	C55	4.7nF, 50V ±10%	Capacitor X7R 0603	Würth Elektronik	885012206087
10	1	C56	1µF, 25V ±20%	Capacitor X5R 0603	Würth Elektronik	885012106022
11	2	D0, D51	22V, Vbr = 24.6	High power transient voltage suppressor, QFN1610	ST	ESDA25P35-1U1M
12	1	D1	60 V, 3 A	Schottky Diode, SMT, DO-214AA	ST	STPS3L60U
13	1	D2	40V, 300mA	Small signal Schottky diode, SOD123	ST	BAT54ZFILM
14	1	D12	1.6 x 0.8 mm	Green LED, 0603	Würth Elektronik	150060VS75000
15	1	D52	25V	Dual Transil Array For ESD Protection, SOT 23-3L	ST	ESDA25L
16	1	D61	1.6 x 0.8 mm	Yellow LED, 0603	Würth Elektronik	150060YS75000
17	1	D62	1.6 x 0.8 mm	Red LED, 0603	Würth Elektronik	150060RS75000
18	1	J0	2.5x5.5mm	Right Angle PC Mount DC Power Jack, pin size 2.5	Würth Elektronik	694108301002
19	6	J0-A, J0-B, J1-A, J2-A, J2-B, J50	1x2, 2.45mm pitch	2-position connector; header; through hole	Würth Elektronik	61300211121

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
20	1	J1	2x8, 0.100" (2.54mm)	16-position receptacle connector, through hole gold	Würth Elektronik	61301621821
21	1	J2	USB 3.1 Type C	Receptacle Horizontal THR WR-COM 1.6mm PCB thickness, SMT	Würth Elektronik	632723300011
22	1	J55	USB 2.0 Type Micro B	SMT Horizontal 5 Contacts	Würth Elektronik	629105136821
23	1	L1	68µH, 3.2A, 0.089Ω, 12x12x10mm	Inductor	Würth Elektronik	7447709680
24	4	ME-01, ME-03, ME-05, ME-06	M3 and 20mm Spacer	Screw	-	-
25	1	R2	200K ±1%	0603 SMD resistor	-	-
26	1	R3	13k ±1%	0603 SMD resistor	-	-
27	1	R4	4k7 ±1%	0603 SMD resistor	-	-
28	1	R5	4k87 ±1%	0603 SMD resistor	-	-
29	1	R6	8k66 ±1%	0603 SMD resistor	-	-
30	1	R7	33k ±1%	0603 SMD resistor	-	-
31	3	R33, R34, R61	2k2 ±5%	0603 SMD resistor	-	-
32	1	R35	820 ±5%	0805 SMD resistor	-	-
33	1	R36	10k ±5%	0603 SMD resistor	-	-
34	1	R41	47k ±5%	0603 SMD resistor	-	-
35	1	R42	22k ±5%	0603 SMD resistor	-	-
36	1	R45	150k ±5%	0603 SMD resistor	-	-
37	1	R46	3k9 ±5%	0603 SMD resistor	-	-
38	1	R52	100k ±5%	0603 SMD resistor	-	-
39	1	R55	1M ±5%	0603 SMD resistor	-	-
40	1	R62	4k7 ±5%	0603 SMD resistor	-	-
41	1	RD1	200 ±5%	0603 SMD resistor	-	-
42	5	SB8, SB11, SB15, SB21, SB25	0 ±5%	0603 SMD resistor 0R	-	-
43	1	T35	-30V, 0.048Ω typ., -2A	P-channel STripFET™ H6 Power MOSFET, SOT 23-3L	ST	STR2P3LLH6
44	1	T41	30V	Dual P-Channel (D-S) MOSFET, SO 8	Vishay Siliconix	Si4925DDY

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
45	1	T45	60V, 300mA	N-channel Trench MOSFET, SOT 23-3L	-	2N7002
46	1	U1	-	Autonomous USB PD controller with integrated discharge path in QFN24 4x4mm	ST	STUSB4710AQTR
47	1	U2	3A out, 5.5V-48V in	step-down switching regulator, HSOP-8	ST	ST1S14PHR
48	1	U3	24V in, 150mA, 3V3	Ultralow IQ Low-Dropout Regulator, SOT 23-5L	Texas Instruments	TLV70133DBVT
49	1	U55	-	Very low capacitance ESD protection, SOT 23-6L	ST	USBLC6-2SC6

4 Board layout

Figure 5. STEVAL-ISC004V1: top layer

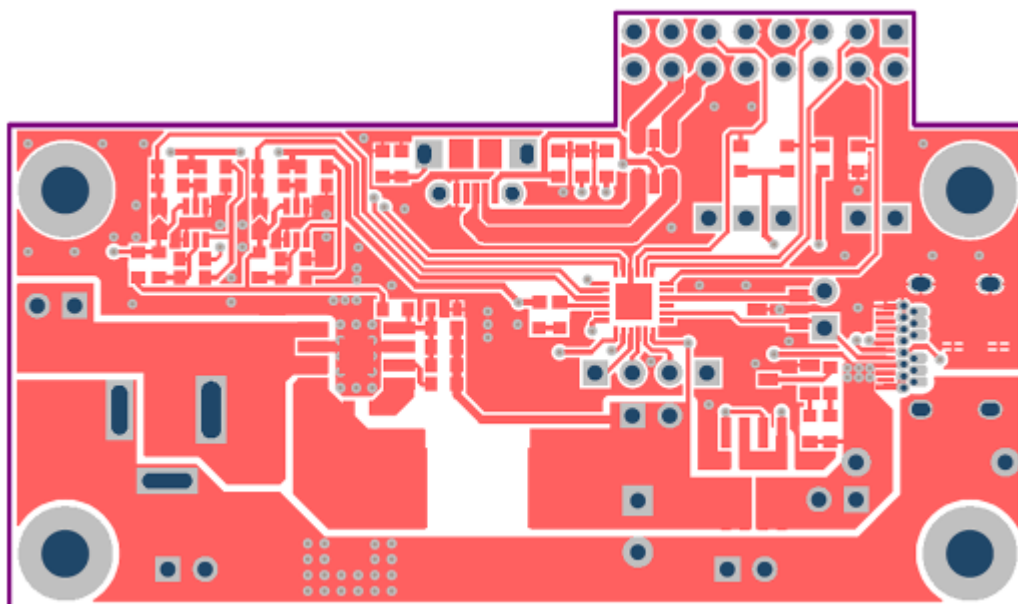


Figure 6. STEVAL-ISC004V1: bottom layer

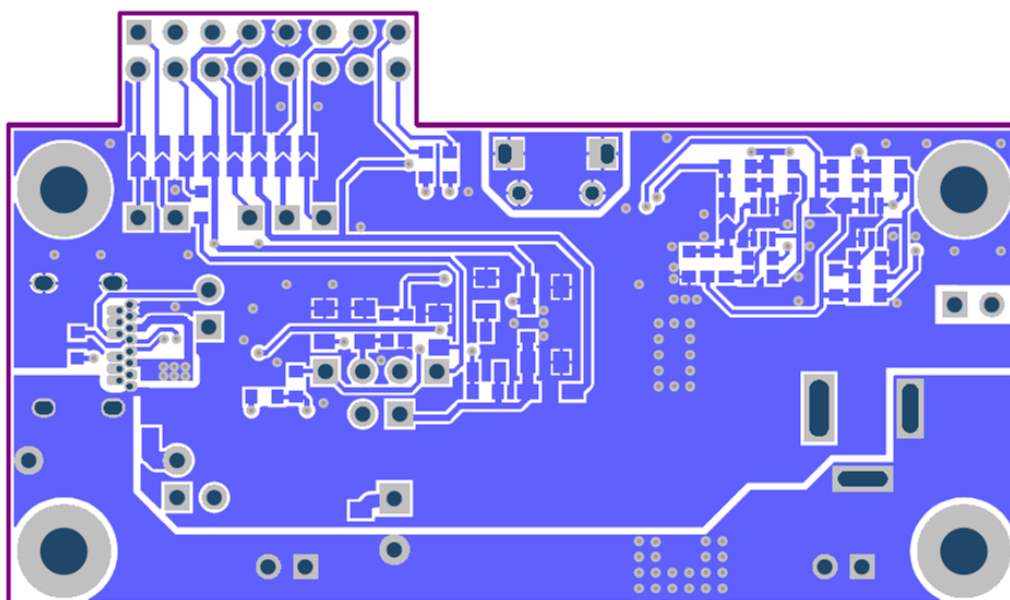


Figure 7. STEVAL-ISC004V1: top silkscreen

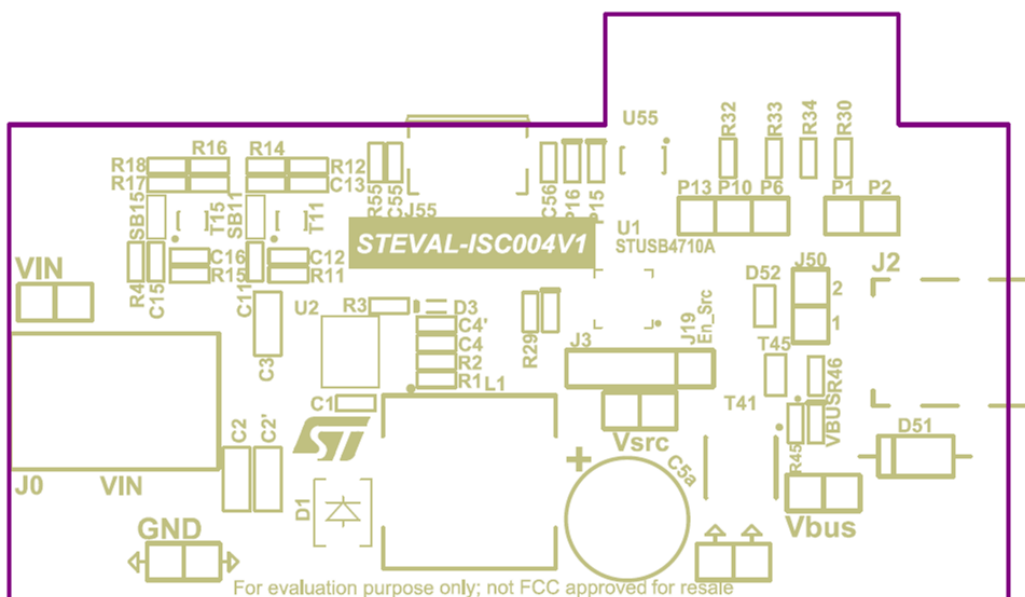
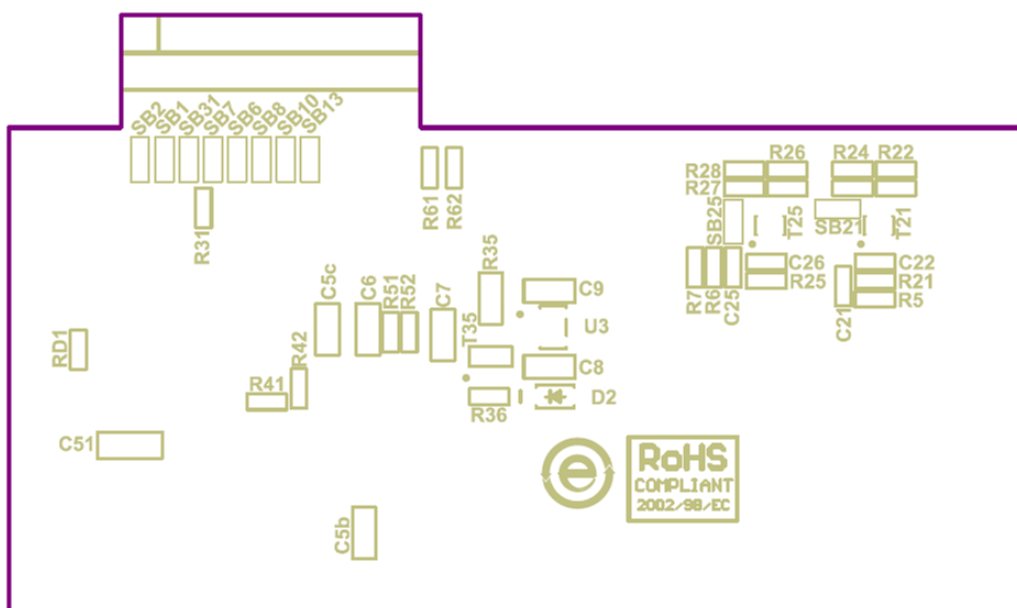


Figure 8. STEVAL-ISC004V1: bottom silkscreen



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

The STUSB4710A 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 STUSB4710A and DC-DC regulator

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.

STUSB4710A monitors the VBUS 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.

Figure 11. STUSB4710A NVM settings

The screenshot displays the 'STUSB4710A NVM settings' software interface. It features several configuration panels:

- Type C configuration:** Includes 'Source current (Rp)' set to 'Rp 3.0 A'.
- PDO Sources Configuration:** Lists 5 PDOs with their configured voltages and currents:

PDO	Voltage	Current
PDO 1	5V	3.00 A
PDO 2	9V	3.00 A
PDO 3	FLEXV1	3.00 A
PDO 4	15V	3.00 A
PDO 5	FLEXV2	2.25 A
- GPIO Configuration:** Shows 'V_VAR OUT' and 'GPIO Usage' (Selection by PDOs). It includes checkboxes for 'Internal Discharge' and 'External Discharge', and radio buttons for 'PMOS' and 'NMOS'.
- OVLO - UVLO Configuration:** Provides 'Low Level' and 'High Level' settings (5 to 20 %) for each PDO, along with 'Peak current' and transition times.
- Dashboard:** A summary table of the configured PDOs:

PDO	Voltage	Current	UVLO	OVLO
PDO 1	5V	3.00 A	4.50 V	5.60 V
PDO 2	9.00 V	3.00 A	8.10 V	9.90 V
PDO 3	12.00 V	3.00 A	10.80 V	13.20 V
PDO 4	15.00 V	3.00 A	13.50 V	16.50 V
PDO 5	20.00 V	2.25 A	18.00 V	21.60 V

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.

Note: 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:

$$R_A = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} = \frac{200 \cdot 1.22}{5 - 1.22} = 64550\Omega \quad (1)$$

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.

$$R_3 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} \quad (2)$$

$$R_4 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} - R_3 \quad (3)$$

$$R_5 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} - R_3 - R_4 \quad (4)$$

$$R_6 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} - R_3 - R_4 - R_5 \quad (5)$$

$$R_7 = \frac{R_2 \cdot 1.22}{V_{OUT} - 1.22} - R_3 - R_4 - R_5 - R_6 \quad (6)$$

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				

Revision history

Table 3. Document revision history

Date	Version	Changes
03-Oct-2017	1	Initial release.
13-May-2019	2	Updated Section 3 Bill of materials Formatting updates throughout document

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