Getting started with the STEVAL-PCC020V2: USB to I²C UART interface board for STNRG01x products

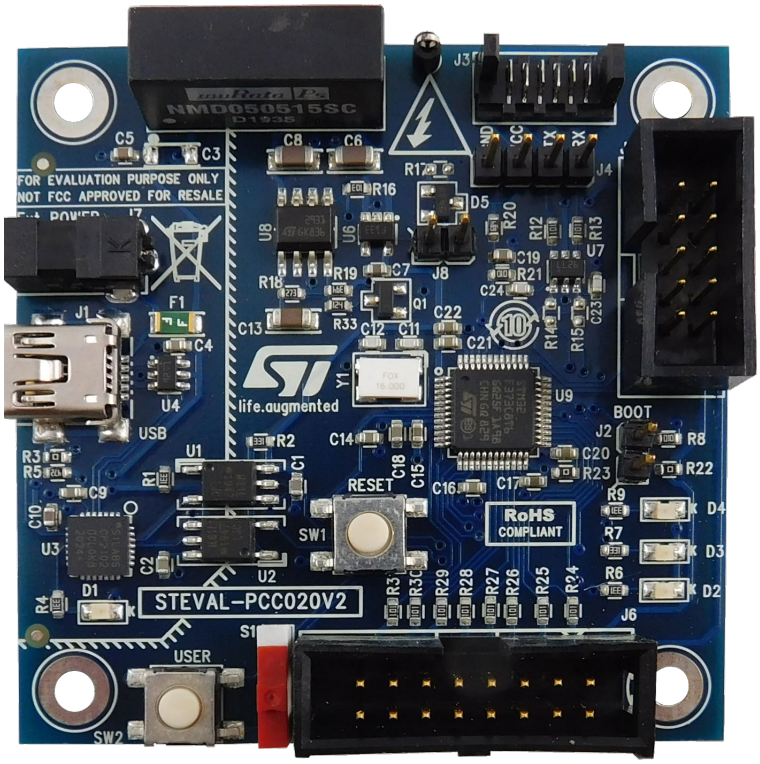
Introduction

The STEVAL-PCC020V2 USB to I²C/UART board interfaces a Windows®-based PC with STNRG01x digital power supply controllers.

It is basically a bidirectional bridge between USB and I²C/UART buses and embeds an on-board power supply to communicate and program the STNRG01x ICs without need of mains.

The associated GUI allows monitoring the status of the digital controller in real-time and tuning specific parameters according to customers' needs.

Figure 1. STEVAL-PCC020V2 interface board



1 Interface board aim

Figure 2 shows a customer typical application based on STNRG01x for the power supply section.

The host microcontroller receives information only from the STNRG01x using an opto-isolated connection: STNRG01x transmits metering information (instantaneous power) continuously, and the black box content at reset.

Hence, the host microcontroller does not have access to the STNRG01x optional E²PROM where the patch and black box history are stored.

Figure 2. Customer typical application

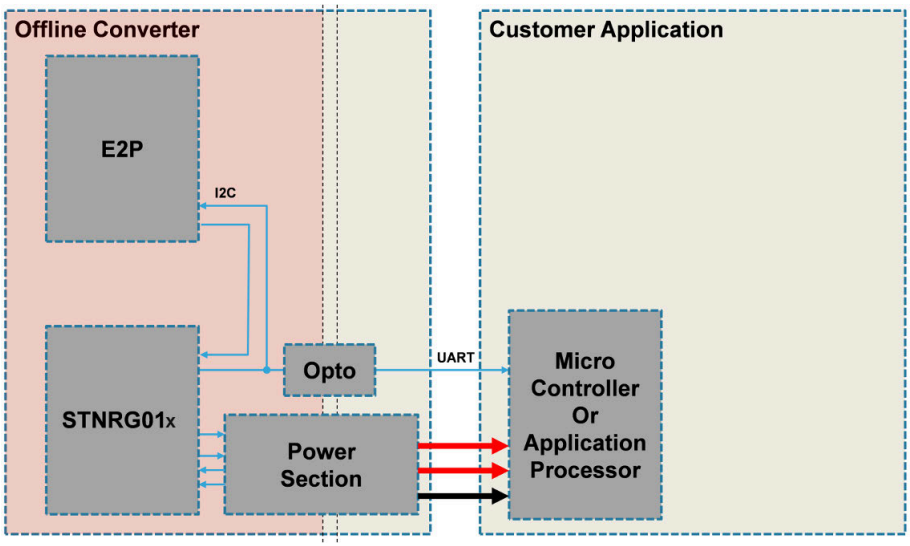


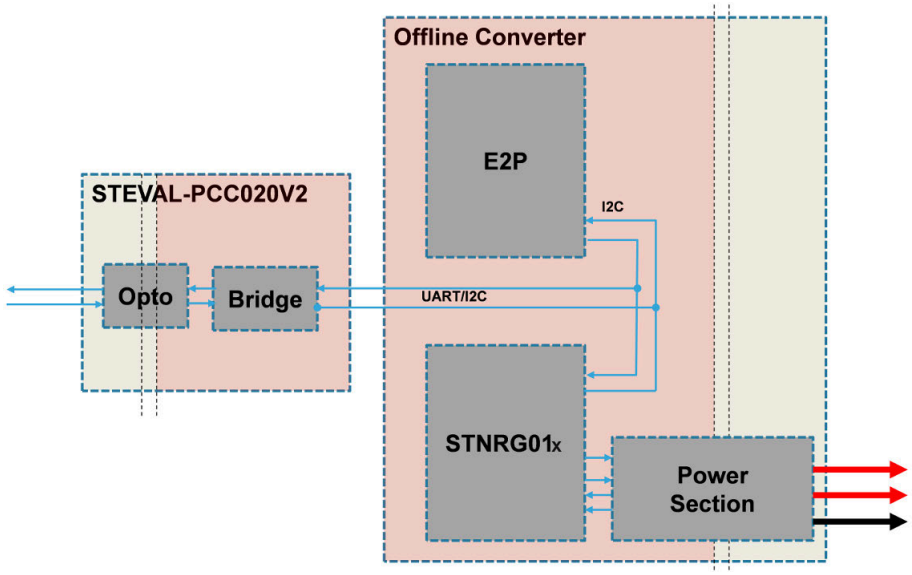
Figure 3 shows the STNRG01x on the STEVAL-PCC020V2 interface board or during debug configuration.

In the latter case, you can access the external optional E²PROM using the I²C protocol to program the associated patches and reset the black box content.

You also have to access STNRG01x using UART bidirectional communication to:

- program the STNRG01x NVM content to change specific parameters according to customers' needs
- display the system specific parameters in real-time to check its behavior during the debug and integration phases.

Figure 3. **STNRG01x in demo/debug configuration**



To minimize STNRG01x pin count, UART and I²C interfaces share the same pins. The interfaces are not isolated from the mains as they are located on the offline converter primary side.

Important: *This adapter board is exclusively designed to interface with STNRG01x products.*

In the final customer application, the tasks performed by the interface would be handled directly by the host microcontroller or the application processor.

2 Getting started

2.1 STEVAL-PCC020V2 interface board overview

The STEVAL-PCC020V2 interface board features are:

- Bidirectional communication between PC (USB) and ST-ONE/STNRG01x controller IC
- Self-powered from the USB line
- On-board VCC generation for chip NVM/flash programming IC
- An I²C bus running at 400 kHz
- A UART bus running up to 115200 bps
- UART and I²C bus mixed together on the same interface
- Dedicated connector for autonomous programming support
- On-board firmware upgrade through USB port
- RoHS compliant

2.2 GUI overview

The GUI key features are:

- Runs on Windows XP, Windows 7 (.NET 4.0 framework needed)
- Real-time monitoring of the digital controller status
- Access to STNRG01x NVM parameters
- Access to STNRG01x external E²PROM for patch upload, calibration and event history
- Embedded PFC calibration wizard

Dedicated user manuals describe the GUI details and are available at www.st.com in the web pages of STNRG01x family products.

2.3 Package contents

The STEVAL-PCC020V2 package includes:

- Hardware
  - the interface board
  - a 1.8 m USB A to USB mini-B cable
  - a 15 cm 6-wire flat cable for target connection to the STNRG01x devices
- Software
  - USB drivers
  - PC GUI installation package

Note: The complete software package is available at www.st.com.

2.4 System requirements

To use the STEVAL-PCC020V2 interface board, you need a PC with Windows® operating system.

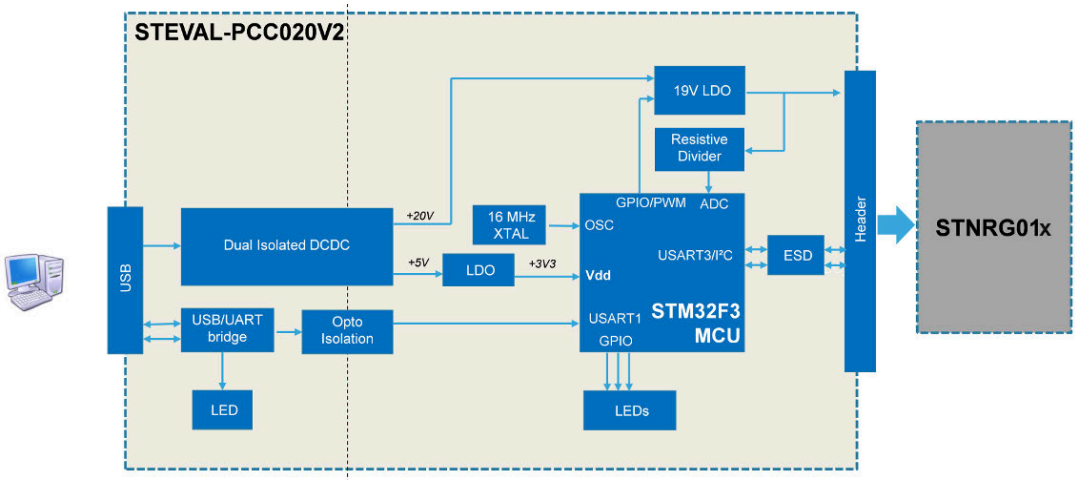
The graphical user interface (GUI) works with Microsoft Windows XP or later versions and .NET Framework 4.0.

Note: The .NET Framework 4.0 is not included in the Windows XP installation package.

3 Hardware description and setup

3.1 Block diagram

Figure 4. **STEVAL-PCC020V2 block diagram**



3.2 Galvanic isolation

The STNRG01x has to be placed on the offline converter primary side: the galvanic isolation between the USB and the remaining electronic of the board prevents any voltage from reaching the host PC and causing electrical damage or interference.

3.3 Power supply

The STEVAL-PCC020V2 interface board is self-supplied via the 5 V USB connector.

This voltage directly supplies U3 and the related circuitry.

A dual isolated DC-DC module (U5) is used to supply the remaining part of the board, maintaining the isolation among the PC and the target sides.

U5 generates two supplies, loosely regulated (+5 V and +20 V).

3.3.1 MCU subsystem supply (5 V)

The +5 V supply is later converted to a stable and clean +3V3 thanks to the linear regulator U6, which is always on.

3.3.2 V_{CC} generation (20 V)

The +20 V is always generated from +5 V and +15 V cascaded together (VOUT2- is referenced to VOUT1+ in place of ground).

This voltage is later on supplied by the linear regulator U8 which has the following roles:

- to generate a stable +18.5 V;
- to act as a switch; U8 is enabled thanks to the MCU GPIO PA14 configured in open drain mode. When the MCU wants to enable the V_{CC} generation, PA14 is driven low.

D5 provides an OR-ing diode which, by default, is short-circuited by R17 resistor (0 W).

3.3.2.1 V_{CC} soft start

At V_{CC} generation switch on, V_{CC} is typically decoupled by a 100 to 200 µF capacitor on the STNRG01x.

If the regulator is switched on abruptly, an inrush current is generated that cannot be sustained by the upfront DC-DC converter, which then enters current limitation.

Since the +20 V is generated by cascading +5 V and 15 V, the current limitation also impacts the +5 V supply (hence the MCU).

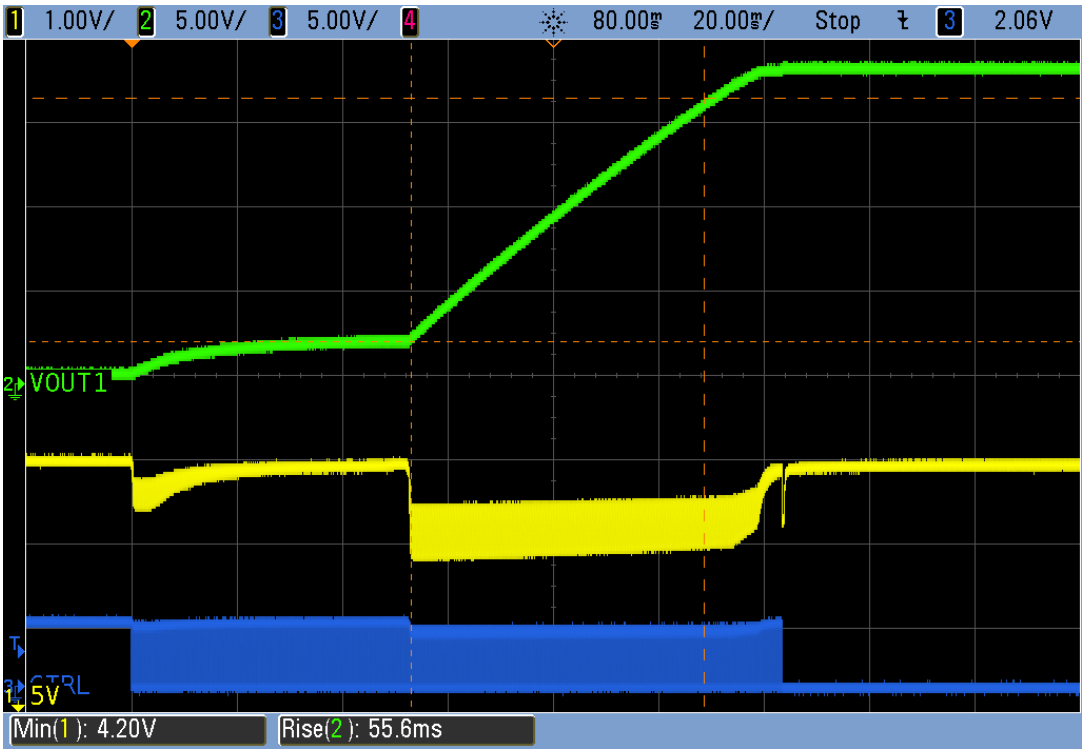
When the MCU supply drops below the **PowerOnReset** threshold, the MCU resets and the board reboots.

To avoid this behavior, the linear regulator U8 is switched on via a **soft start** using a PWM enable signal (which limits the current on the upfront DC-DC).

When V_{CC} has reached a stable value (that is, the V_{CC} capacitor is charged), the enable signal remains in the steady-state condition (always on, so always low).

Soft start phase usually lasts about 120 ms.

Figure 5. V_{CC} ramp-up typical waveform



3.3.2.2 *NVM programming*

The STEVAL-PCC020V2 interface board provides a VCC voltage to the target device that is high enough for an NVM programming operation.

STNRG01x programming requirements are +18 V and 35 mA max. current.

If the VCC on the target device is < 17 V, the programming V_{CC} can be simply connected to the target V_{CC} through a couple of OR-ing diodes.

The 19 V supply current delivered is limited to 100 mA by the on-board LDO (U8).

3.4 USB bridge

The communication between the STEVAL-PCC020V2 and the PC is managed by the latter as a standard serial peripheral; the IC U3 converts the USB connection into a virtual COM port (refer to the electrical schematic).

By default, the virtual COM port operates at 921600 bps.

A yellow LED near the mini-B USB connector turns on when the CP2102 has been recognized (enumerated) by the host operating system.

The VCP RX and TX signals are then isolated thanks to the opto-couplers U1 and U2 and connected to the STM32F3 (U9) microcontroller USART1.

Important: The USB port and the remaining part of the board are isolated from the mains.

The microcontroller performs:

- **Conversion between the host UART and I²C protocols**
  - The I²C speed can rise up to 1 MHz (maximum speed allowed by the STNRG01x).
  - The STM32F3 allows bidirectional communication between the PC and the target device through the UART to I²C conversion.
- **Conversion between the host UART and the STNRG01x UART**.

  This is mainly baud rate matching: STNRG01x operates at 19200 bps, whereas the host UART operates at 921600 bps.

Note: The microcontroller also manages the muxing of the UART and I²C protocols on the same interface.

3.5 V_{CC} monitoring

The MCU also monitors the STNRG01x V_{CC} line voltage.

STNRG01x V_{CC} is sampled periodically by the MCU via a simple resistive bridge divider plus a low-pass filter using R20, R21 and C19. The divider ratio is 10/78=1/7.8.

The divided voltage is then sent to STM32F3 PA0 pin on a regular 12-bit ADC.

For instance, this allows preventing the use of the on-board V_{CC} when the STNRG01x is already operating.

Note: This feature accuracy is ±100 mV.

4 Using the board

4.1 Board connectors, LEDs and buttons

Figure 6. STEVAL-PCC020V2 interface board connectors

1. Mini USB-B connector
2. STNRG01x connector
3. Firmware upgrade jumper
4. Status LEDs
5. Reset button
6. USB enumeration LED

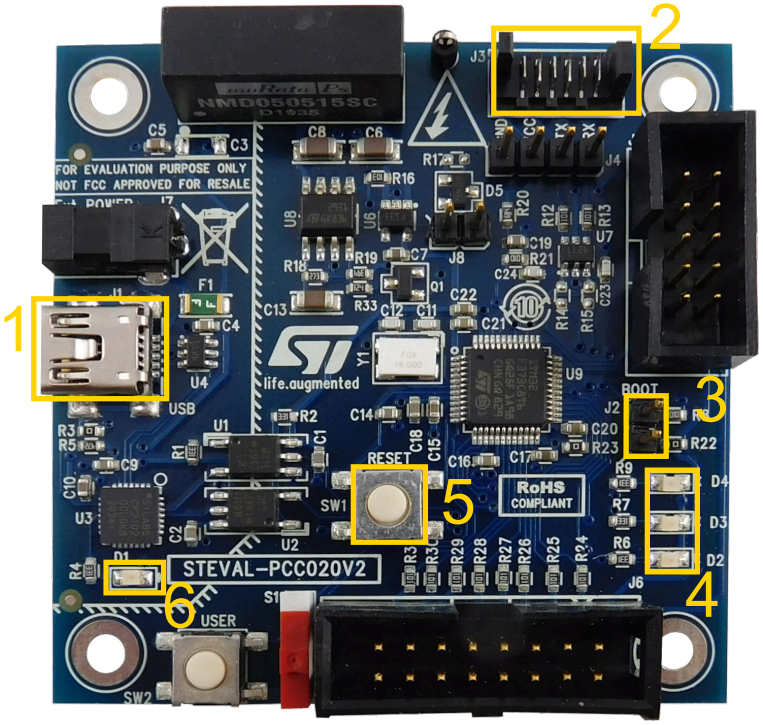


Figure 7. STEVAL-PCC020V2 interface board status LEDs

1. Yellow LED (USB)
2. Red LED (V_{CC} enabling)
3. Green LED (protocol)
4. Green LED (firmware status)

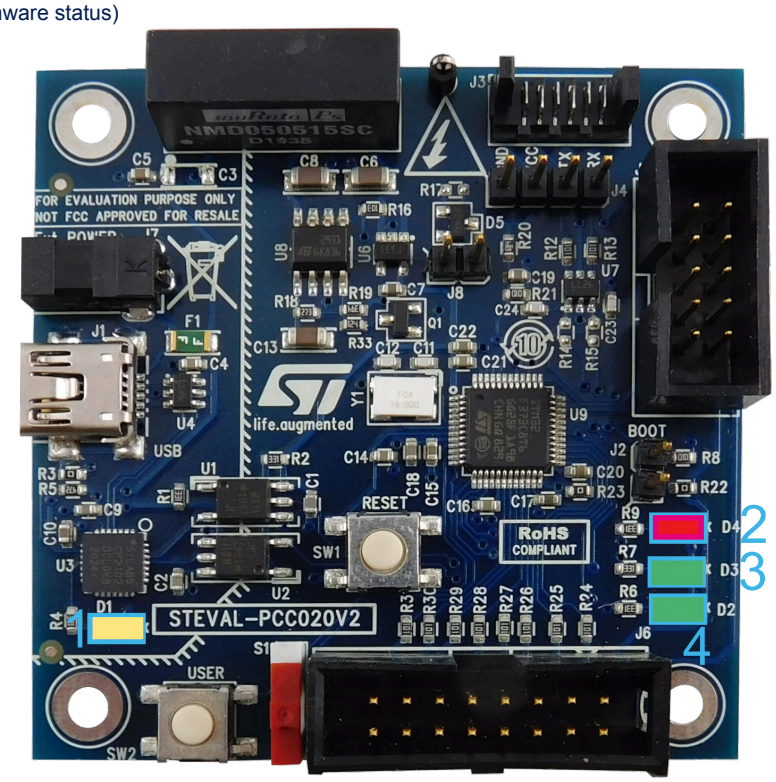
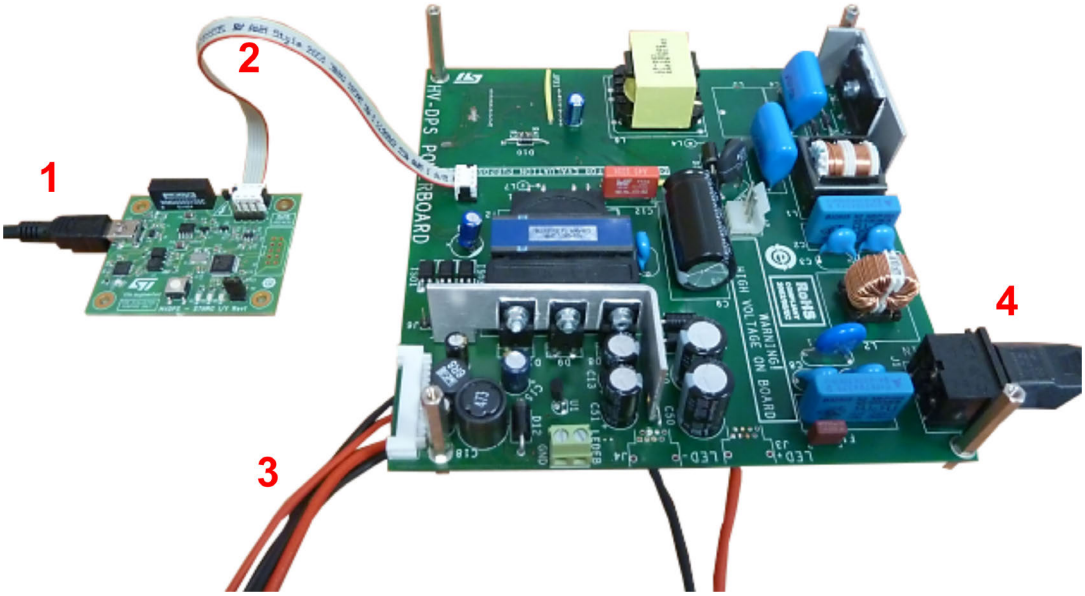


Table 1. STEVAL-PCC020V2 LEDs (ON, OFF, blinking state)

D1		D2		D3		D4	
ON	OFF	ON	Blinking	ON	Blinking	ON	OFF
VCP recognized by the PC	VCP not recognized/ inactive	Normal operation	Firmware error	Waiting for the STNRG01x frames	Receiving STNRG01x frames	Internal VCC enabled	Internal V_{CC} disabled

4.2 How to connect the STEVAL-PCC020V2 interface board to the offline converter

Figure 8. **STEVAL-PCC020V2 interface board typical connection**



Step 1. Connect the STNRG01x interface board to a PC via a USB cable.

Step 2. Connect the interface board and the offline converter board together through the 6-wire flat cable.

Step 3. Connect the offline converter to the load.

Step 4. Connect the mains.

Caution: You should never plug or unplug the interface board while the connection is running (for example, when the offline converter is running). If the 5 V UART signals and +15 V V_{CC} (typ.) are connected when the GND is not yet connected, the STNRG01x or the interface board might be damaged.

5 Software installation

You have to install the USB driver and the PC GUI before using the STEVAL-PCC020V2 interface board.

5.1 Virtual COM port driver installation (SiLabs CP2102)

To use the STEVAL-PCC020V2 interface board, first install one of the USB drivers located in the CD folder **Driver\CP210x_VCP_Windows**:

- CP210xCVCPInstaller_x86.exe (for 32-bit OS)
- CP210xCVCPInstaller_x64.exe (for 64-bit OS)

Alternatively, you can find the latest version of the drivers at SiLabs.

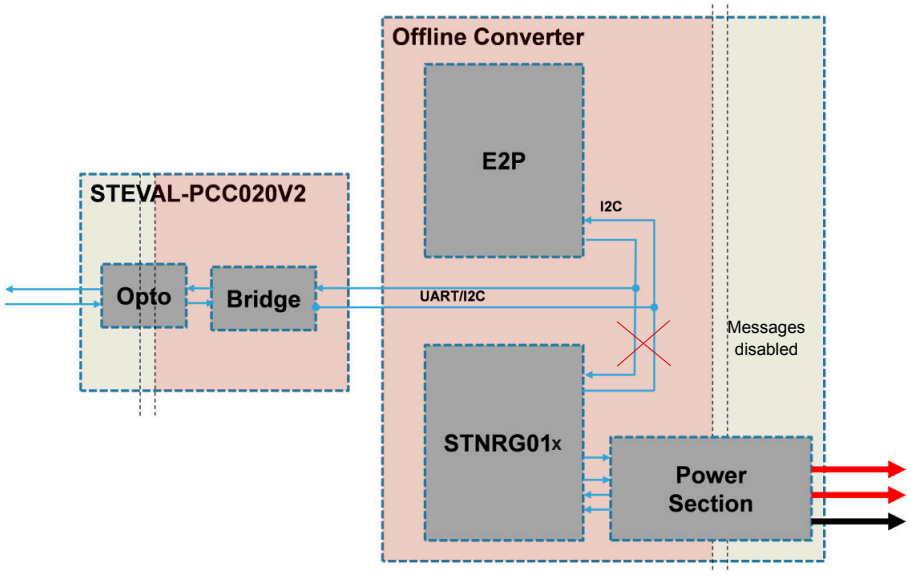
When the interface board is plugged to the PC, the driver is automatically installed.

6 E²P operations

Important: STNRG01x shares the E²P interface (SDA/SCL) with the UART interface to minimize pin count. During normal operation (switching), the optional E²P is only accessed at boot and when a fault occurs.

It is possible to access E²P in normal mode, but this might cause conflicts due to simultaneous access by the STNRG01x metering information (UART) and the GUI accessing the E²P.

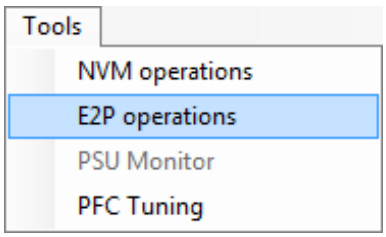
Figure 9. E²P simultaneous access conflicts on UART/I²C link



As a consequence, STNRG01x metering messages must be disabled, but this is only possible if UART uplink communication is enabled. Otherwise, E²P must be accessed while STNRG01x is disabled (e.g. no mains or external V_{CC} required thanks to the internal V_{CC} generation in ATE mode).

E²P operations are accessible via the **Tools** menu.

Figure 10. E²P operation menu



6.1 E²P dump

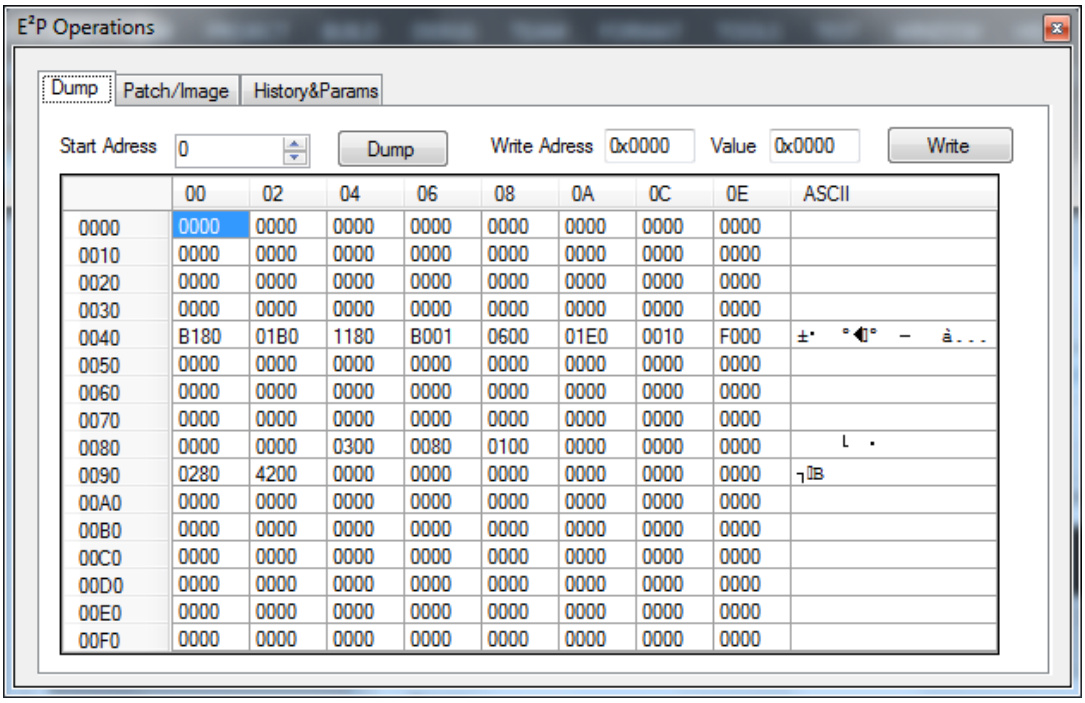
This feature allows displaying the content of the external E²P and is mainly used for debugging.

It is also possible to change a memory value by either clicking the address to be changed or by pressing the **Write** button in the **Address** and **Value** boxes.

Table 2. **E²P mapping**

Area	Meaning
0x0000-0x0022	Serial number and calibration data
0x0040-0x0047	Event history data
0x0048-0x004F	Running time, error counter, power on/off cycle counter
0x0080-0x0089	Cold/hot patch addresses definition
0x0090-0x0A80	Patch area

Figure 11. **E²P Dump tab**



6.2 E²P patch and image upload/download

This feature allows manipulating the entire E²P images and also programming the patch.

6.2.1 Full E²P image operation box

This tab button allows:

- reading the full E²P image and save it to disk
- computing E²P checksum
- comparing E²P to an existing image
- writing the entire E²P using an image previously saved on disk (performing the E²P parameters and E²P patch programming in a single step)
- erasing the entire E²P

*Note: If an E²P is connected, the STNRG01x firmware does NOT support an empty (FF) image. The E²P must be cleared using the **All 0s pattern**. Alternatively, a full image can be written (provided by ST).*

Both **Erase** and **Write** operations need confirmation to be saved.

6.2.2 Patch programming box

There are two different types of patches:

- **Cold**, downloaded from E²P to XRAM just before the IC starts switching
- **Hot**, downloaded after IC has started switching operations

Only the cold patching is used here.

Note: Normally, you do not have to specify the patch type (hot/cold). Patches are delivered as a full E²P image.

Important: Do not change the XRAM & E2P Address.

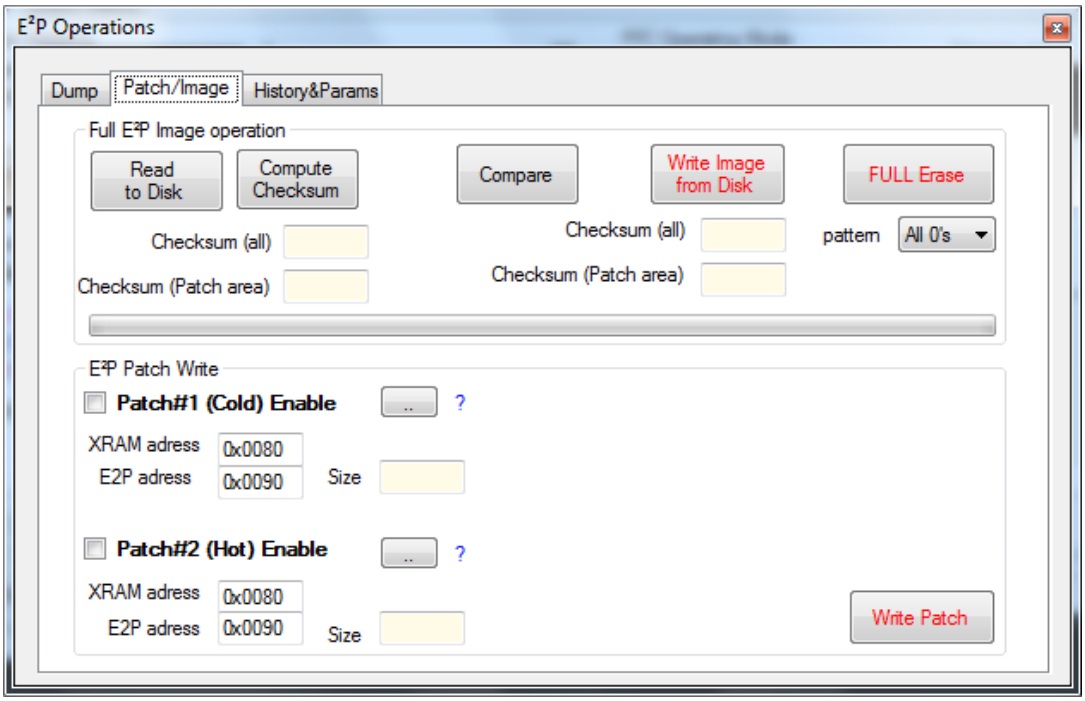
To program a patch:

Step 1. Click on the **..** button to select the patch to be used.
Only .bin format is supported.

Step 2. Tick the associated **Check** box.

Step 3. Press the **Write Patch** button.

Figure 12. E²P full import/export and patch operation tab



6.3 E²P parameter editor

This feature allows editing the factory data parameters and clearing the event history data.

Step 1. Press the **Read** button to read the content of the E²PROM

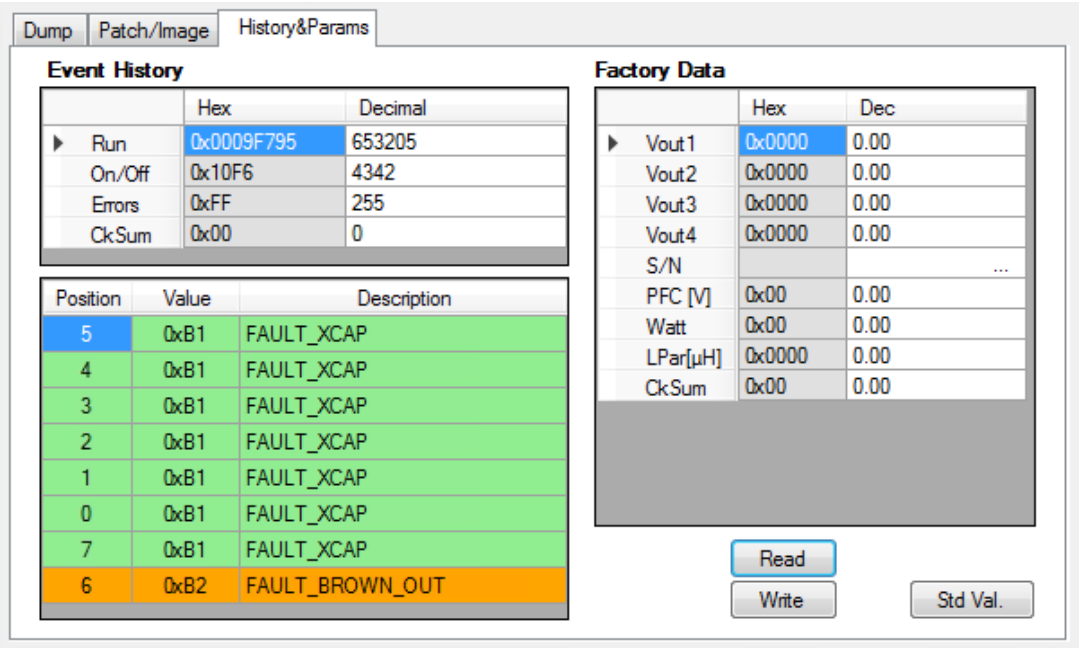
Step 2. Press the **Write** button to write the displayed values to the E²PROM

Step 3. Press the **Std Values** button to fill the table with default values
If you want to write the values to E²P, you have to press the **Write** button.

Note: Hex fields are only given for reference: they cannot be edited.

Important: It is recommended to edit these field with STNRG01x in ATE mode or via VCC externally powered.
If the parameters are written whilst STNRG01x is running, they will be overwritten when STNRG01x is shut down.
When STNRG01x is powered up, it makes a copy of the event history in its RAM, which changes during the active phase. At shutdown, the RAM content will be overwritten in the E²P, hence the E²P content will be overwritten.

Figure 13. E²P parameter editor tab



7 Troubleshooting

7.1 No LED activity detected on the STEVAL-PCC020V2 interface board

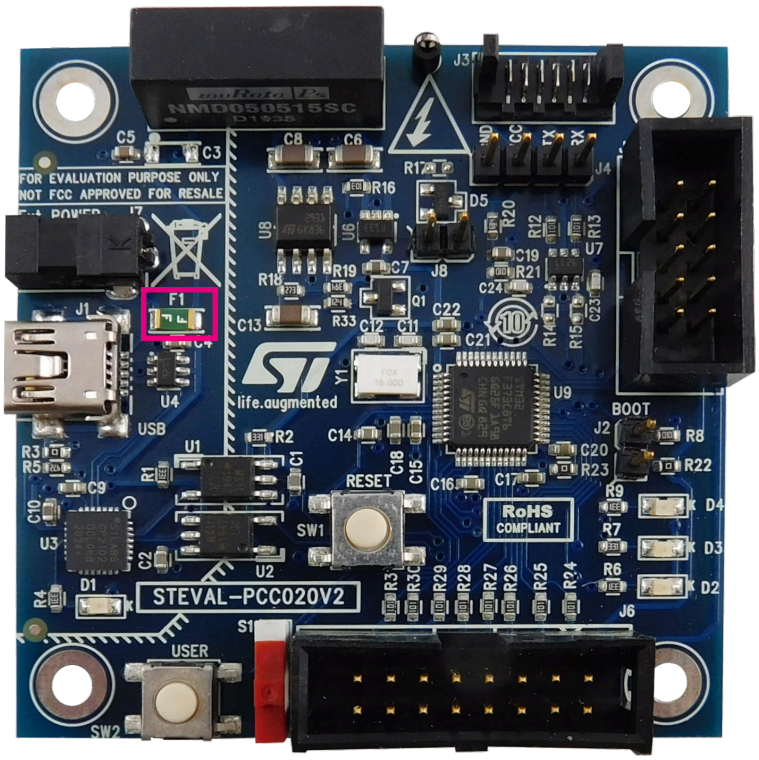
When the board is plugged to the system:

- LED D2 lights up, indicating the MCU is working, hence, the power supply is present;
- the yellow LED D1 starts blinking, indicating the USB port has been enumerated correctly.

If the LEDs are not working properly, it might be due to a power supply issue.

Step 1. Locate fuse F1 (close to the USB connector)

Figure 14. STEVAL-PCC020V2 interface board fuse



Step 2. Check the voltage between J1 ground (shield) and the right side of the fuse.
If it is not 5 V ±10%, it means an overcurrent occurred and the fuse has blown.

Step 3. Replace the fuse (0.5 A), after trying to fin out the root cause.

7.2 USB yellow LED shutdown in few seconds

The yellow LED D1 is wired to the USB suspend signal from CP2102; that is, it only lights up when the USB port is not in USB suspend mode.

Note: By default (for Windows 7 and 8), the system forces external devices to enter suspend mode to save power (for example, when the COM port is not used). It does not mean the power supply is shut down, but the CP2102 goes into low power mode.

To avoid this issue, select the SiLabs COM port, and go to the Power Management Tab and uncheck “Allow the Computer to turn off this device to save power”.

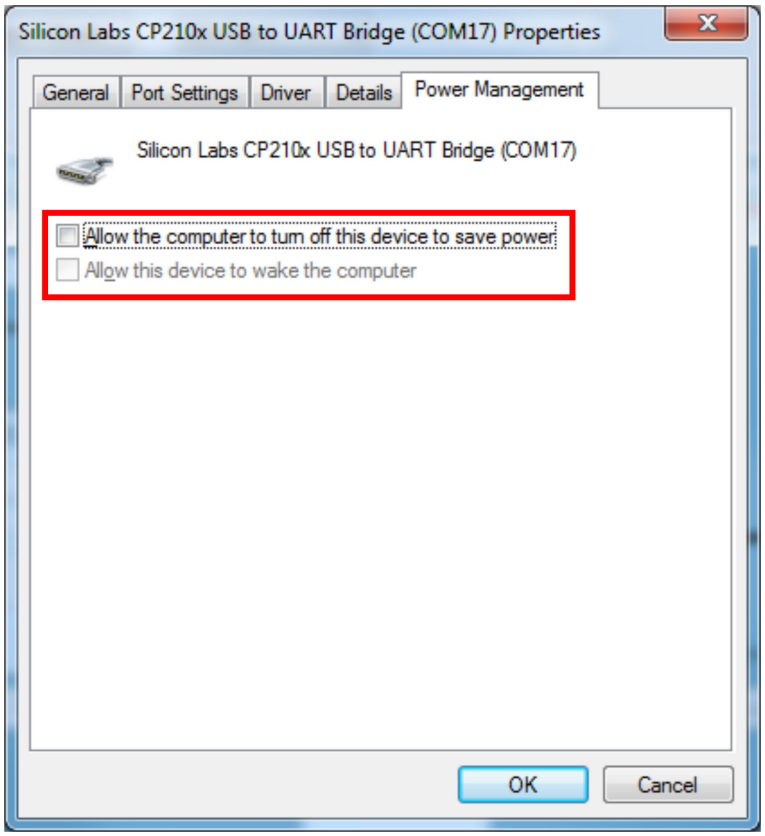
Step 1. Select **Device Manager**.

Step 2. Select the SiLabs COM port.

Step 3. Go to the **Power Management** tab.

Step 4. Untick the **Allow the computer to turn off this device to save power** box.

Figure 15. Disabling CP2102 USB suspend mode



8 STEVAL-PCC020V2 interface board hardware

8.1 Connector pinout

The connection between the supply and the interface board is made via a Molex 6-pin low profile connector (J3). The signals are also available on a 4-pin HE10 header (J4).

Figure 16. STEVAL-PCC020V2 interface board signal connectors

1. Pin 6
2. Pin 1
3. Pin 1
4. Pin 4

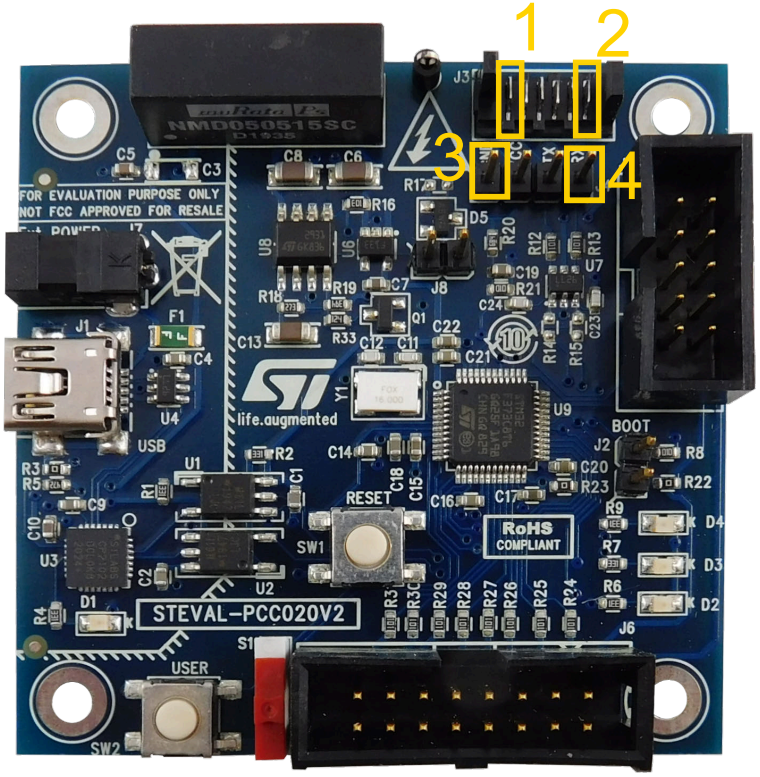


Table 3. STEVAL-PCC020V2 J3 and J4 pinout

Signal	4-pin header	6-pin Molex
GND	1	1
V_{CC}	2	3
UART_TX / SDA	3	5
UART_RX / SCL	4	4
NC	none	2.6

8.2 Firmware upgrade

Figure 17. **STEVAL-PCC020V2 interface board firmware update menu**

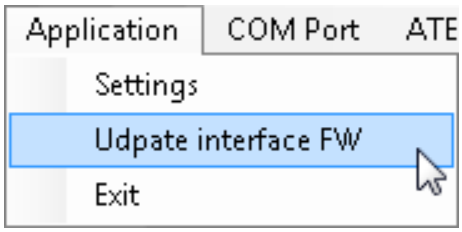


Figure 18. **STEVAL-PCC020V2 interface board firmware update window**

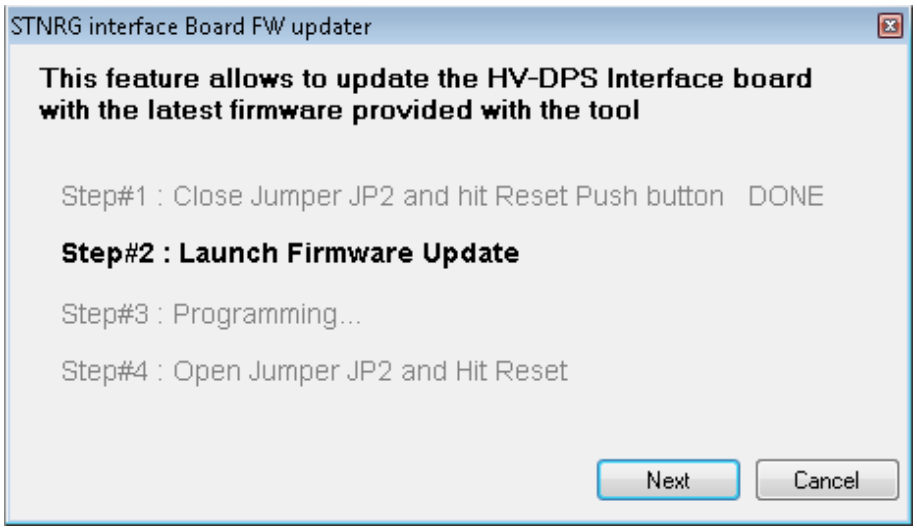
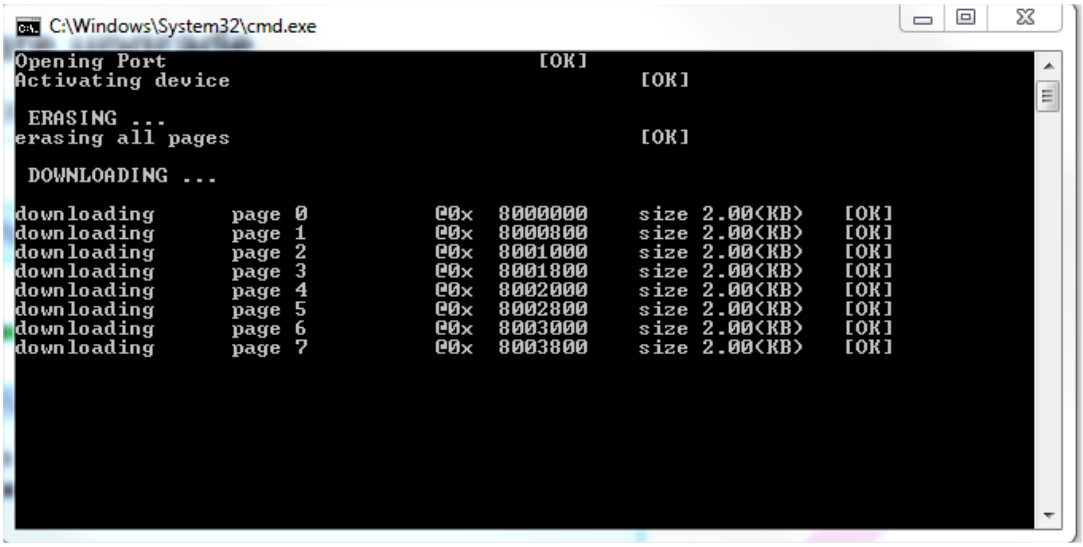
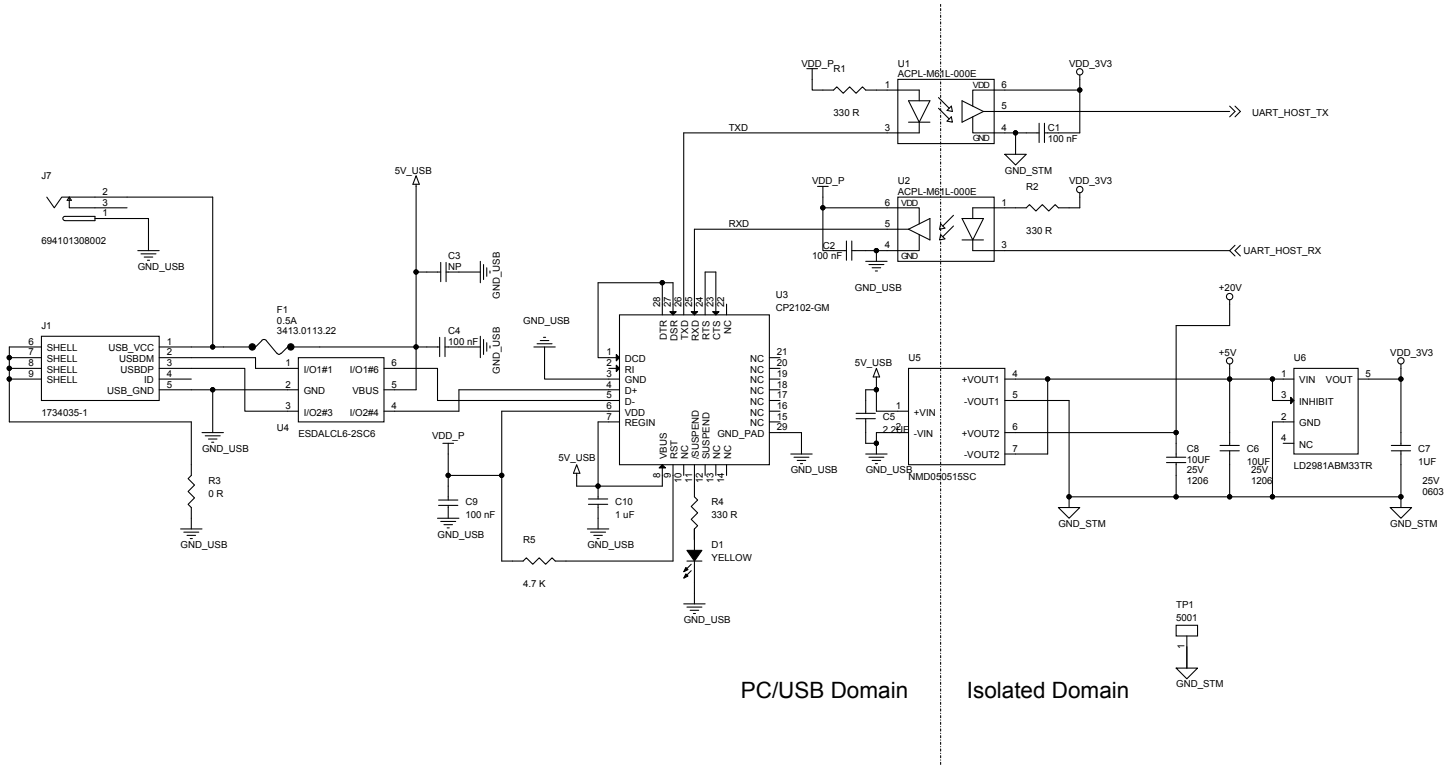


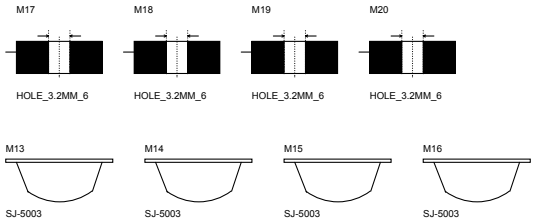
Figure 19. **STEVAL-PCC020V2 interface board firmware update in progress**



8.3 Schematic diagrams

Figure 20. STEVAL-PCC020V2 circuit schematic (1 of 2)





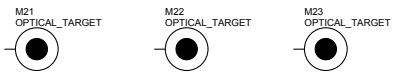
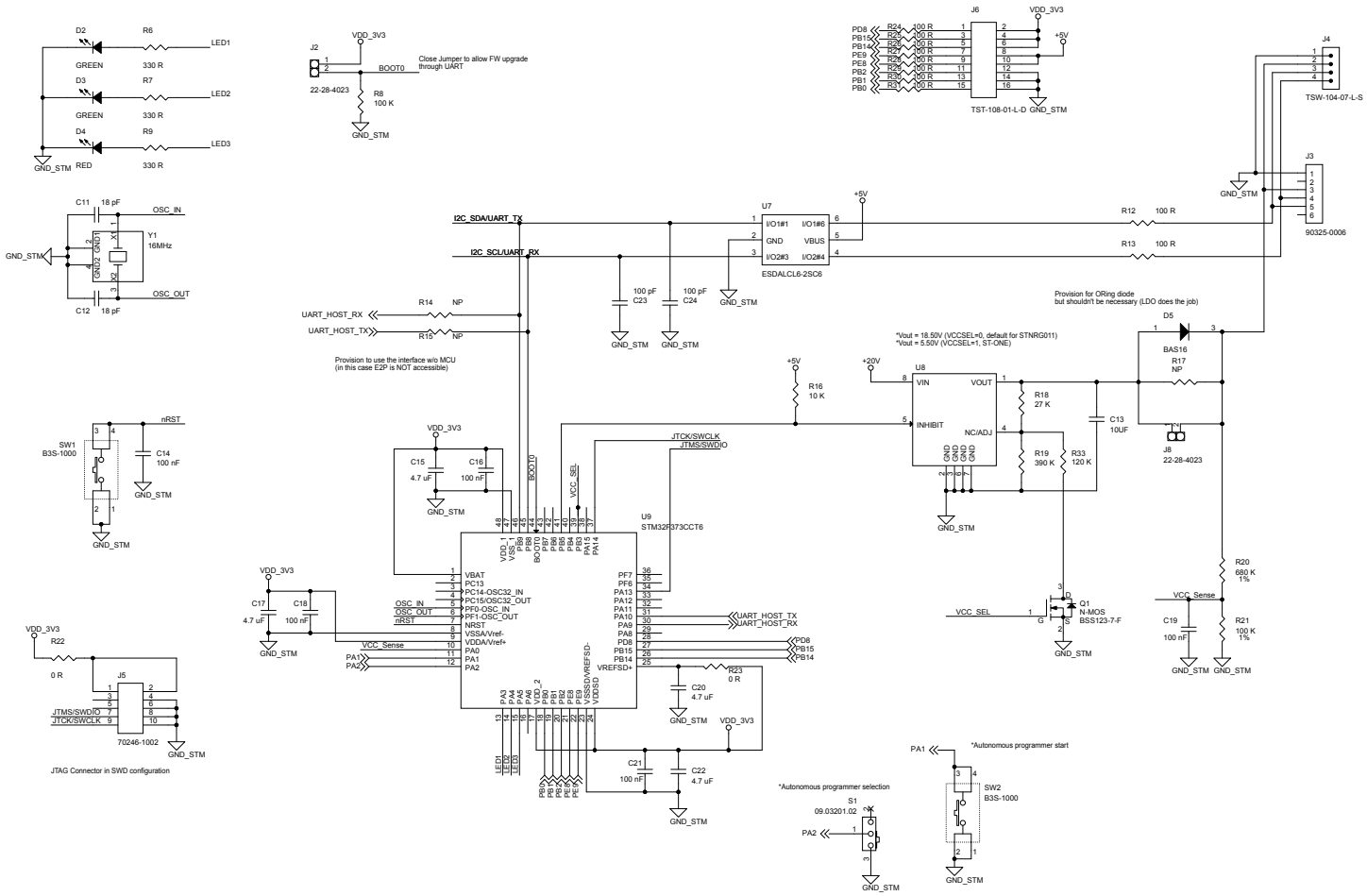


Figure 21. STEVAL-PCC020V2 circuit schematic (2 of 2)



8.4 Bill of materials

Table 4. **STEVAL-PCC020V2 bill of materials**

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	9	C1,C2,C4,C9,C14,C16,C18,C19,C21	100 nF 50V ±10% 603	CER	KEMET OR GENERIC	C0603C104K5RACTU
2	1	C3	NP 1206	CER	N.A.	C_NP_1206
3	1	C5	2.2µF 6.3V ±20% 603	CER	TDK	C1608X5R0J225MT000N
4	3	C6,C8,C13	10µF 25V ±10% 1206	CER	KEMET	C1206C106K3PAC7800
5	1	C7	1µF 25V ±10% 603	CER	KEMET OR GENERIC	C0603C105K3RACTU
6	1	C10	1 µF 25V ±10% 603	CER	KEMET OR GENERIC	C0603C105K3RACTU
7	2	C11,C12	18 pF 50V ±5% 603	CER	KEMET OR GENERIC	C0603C180J5GACTU
8	4	C15,C17,C20,C22	4.7 µF 6.3V ±10% 603	CER	KEMET OR GENERIC	C0603C475K9PACTU
9	2	C23,C24	100 pF 50V ±5% 603	CER	KEMET OR GENERIC	C0603C101J5GACTU
10	1	D1	YELLOW 805	LED	AVAGO	HSMY-C170
11	2	D2,D3	GREEN 805	LED	AVAGO	HSMG-C170
12	1	D4	RED 805	LED	AVAGO	HSMH-C170
13	1	D5	BAS16 SOT23	DIODE	NXP	BAS16
14	1	F1	0.5A 1206	FUSE	Schurter	3413.0113.22
15	1	J1	1734035-1	FUSE HOLDER	TE CONNECTIVITY	1734035-1
16	2	J2,J8	22-28-4023 2x1	HEADER	MOLEX	22-28-4023
17	1	J3	90325-0006	HEADER	MOLEX	90325-0006
18	1	J4	TSW-104-07-L-S	HEADER	SAMTEC	TSW-104-07-L-S
19	1	J5	70246-1002 HE10-2x5	HEADER	MOLEX	70246-1002
20	1	J6	TST-108-01-L-D	HEADER	SAMTEC	TST-108-01-L-D
21	1	J7	694101308002 POWER JACK DC	JACK	WURTH ELEKTRONIK	694101308002
22	4	M13,M14,M15,M16	SJ-5003	SPACER	SJ-5003 (BLACK)	SJ-5003
23	1	Q1	N-MOS SOT23	CMS	DIODES INCORPORATED	BSS123-7-F
24	6	R1,R2,R4,R6,R7,R9	330 R 1/10W ±5% 603	RES	YAGEO OR GENERIC	RC0603JR-07330RL
25	3	R3,R22,R23	0 R 1/10W ±5% 603	RES	YAGEO OR GENERIC	RC0603JR-070RL
26	1	R5	4.7 K 1/10W ±5% 603	RES	YAGEO OR GENERIC	RC0603JR-074K7L
27	1	R8	100 K 1/10W ±5% 603	RES	YAGEO OR GENERIC	RC0603JR-07100KL

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
28	10	R12,R13, R24,R25, R26,R27, R28,R29, R30,R31	100 R 1/10W ±5% 603	RES	YAGEO OR GENERIC	RC0603JR-07100RL
29	3	R14,R15, R17	NP 603	RES	N.A.	R_NP_0603
30	1	R16	10 K 1/10W ±5% 603	RES	YAGEO OR GENERIC	RC0603JR-0710KL
31	1	R18	27 K 1/10W ±5% 603	RES	YAGEO OR GENERIC	RC0603JR-0727KL
32	1	R19	390 K 1/10W ±5% 603	RES	YAGEO OR GENERIC	RC0603JR-07390KL
33	1	R20	680 K 1/10W ±1% 603	RES	YAGEO OR GENERIC	RC0603FR-07680KL
34	1	R21	100 K 1/10W ±1% 603	RES	YAGEO OR GENERIC	RC0603FR-07100KL
35	1	R33	120 K 1/10W ±5% 603	RES	YAGEO OR GENERIC	RC0603JR-07120KL
36	2	SW1,SW 2	B3S-1000 L6_W6.6_H4.3	BUTTON	OMRON	B3S-1000
37	1	S1	09.03201.02 L10_W6_H2.5	SWITCH	EOZ	09.03201.02
38	1	TP1	5001	TEST POINT	KEYSTONE	5001
39	2	U1,U2	ACPL-M61L-000E SO5	ISOLATOR	AVAGO	ACPL-M61L-000E
40	1	U3	CP2102-GM QFN28	CONVERTER	SILICON LABS	CP2102-GM
41	2	U4,U7	ESDALCL6-2SC6 SOT23-6L	Very low capacitance and low leakage current ESD protection	ST	ESDALCL6-2SC6
42	1	U5	NMD050515SC L19.5_W6_H10	CONVERTER	MURATA	NMD050515SC
43	1	U6	LD2981ABM33TR SOT23-5L	Ultra low drop voltage regulators with inhibit low ESR output	ST	LD2981ABM33TR
44	1	U8	LM2931CM SO8	CONVERTER	TEXAS INSTRUMENTS	LM2931CM
45	1	U9	STM32F373CCT6 LQFP48	Mainstream mixed signal Arm Cortex-M4 core MCU	ST	STM32F373CCT6
46	1	Y1	16MHz L5_W3.2_H1.2	QUARTZ	FOX ELECTRONICS	FQ5032B-16.000
47	1	Cable	92315-0620 CABLE	CABLE	MOLEX	92315-0620

Revision history

Table 5. **Document revision history**

Date	Revision	Changes
18-Oct-2021	1	Initial release.
15-Mar-2022	2	Updated Section 8.3 Schematic diagrams and Section 8.4 Bill of materials.

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