UM2693

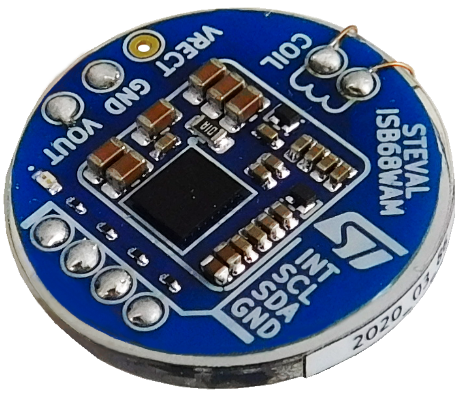
User manual

Getting started with STEVAL-ISB68WA wireless power receiver evaluation kit for wearable applications

Introduction

The STEVAL-ISB68WA is an evaluation kit based on STWLC68JRH wireless power receiver and it is designed as reference solution for wearable applications. The kit consists of a wireless receiver module and USB-to-I2C bridging dongle. The receiver is a 3-elements stack: a PCB housing the STWLC68JRH wireless power receiver and all the required external components, a 2 mm thick plastic spacer and a 15 mm diameter receiving coil facing the bottom side.

Figure 1. Receiver module



The module is configured to provide a constant 5 V output voltage with a maximum power capability of 2.5 W and it works out of the box when placed on a suitable wireless power transmitter.An on-board LED indicates when the communication with the transmitter succeeds and the power transfer is in progress.Thanks to the I2C interface, the module can be easily controlled and configured through the dedicated Graphical User Interface (GUI) by using the enclosed USB-to-I2C dongle.

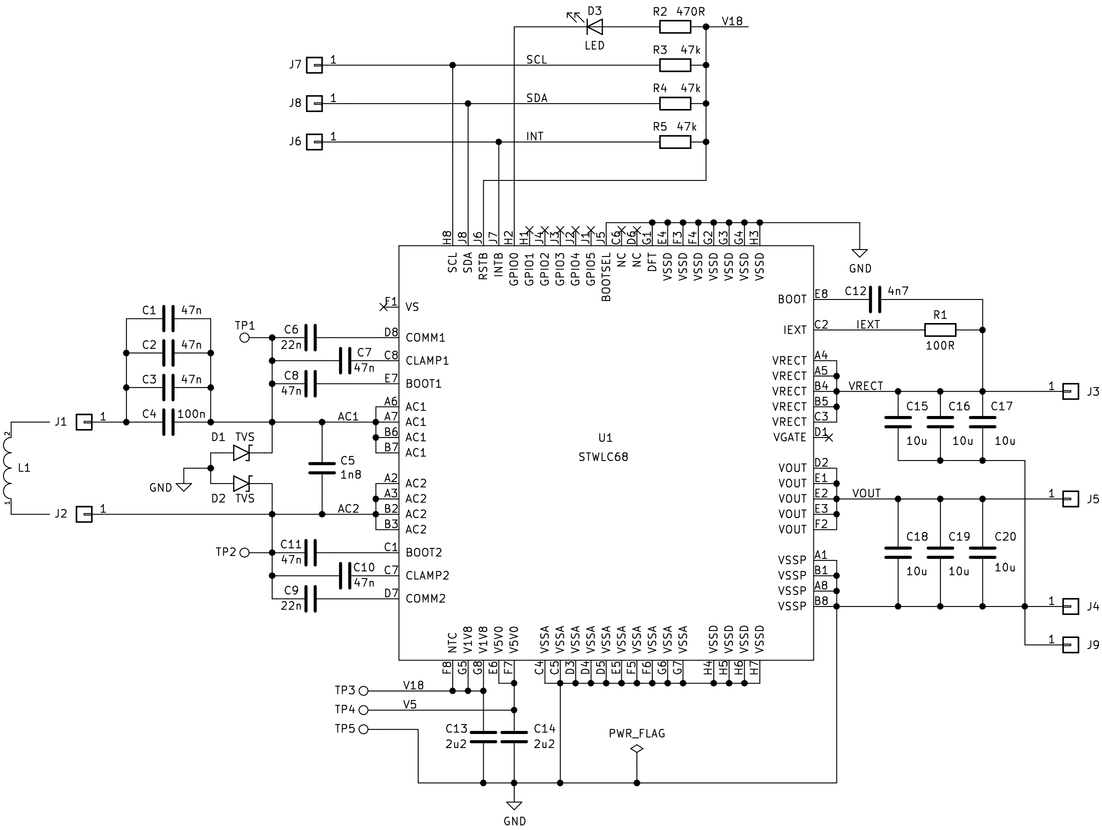
The complete reference application is confined in a 10x10 mm area of the PCB and all the components are intentionally spaced to ease probing and customization to the end user.

1 Wireless power receiver module

Overview

As visible in Figure 2, the schematic diagram of the wireless power receiver is relatively simple. The RX coil (J1-J2 terminal) is part of the series resonant circuit (C1 through C4 capacitors) that provides the AC voltage to the AC1-AC2 pins of the STWLC68JRH. The rectified voltage is filtered by C15 through C17 capacitors and accessible at J3 connector, mainly used to monitor the ping-up behavior and the ASK modulation. The output rail (VOUT pins) is filtered by C18 through C20 capacitors and made available at J5 terminal. Few additional components are needed to complete the wireless receiver: bootstrap capacitors for the rectifier (C8 & C11) and for the main linear regulator (C12), modulation capacitors (C6, C7, C9 and C10) and filtering capacitors for the 1.8 V and 5 V supply rails (C13 & C14). The R1 resistor is connected between VRECT and IEXT to implement an active clamper to prevent excessive voltages (Over-Voltage Protection). Transient voltage Suppressors (D1 & D2) are recommended to protect the application against ESD.

Figure 2. Receiver module schematic



The terminals for the receiving coil, the output load and the control signals are summarized in Table 1. The output rail and the control interface are already made easily accessible by means of wires terminated with pin header female connectors (Figure 4).

Table 1. Receiver module terminals

Terminal	Signal	Wiring color
J1	AC input (RX coil)	-
J2	AC input (RX coil)	-
J3	VRECT (rectifier output)	-
J4	Power return (ground)	Black (P1)
J5	VOUT power output	Red (P1)
J6	INT (digital output)	Orange (P2)
J7	SCL (digital input)	Yellow (P2)
J8	SDA (digital I/O)	Green (P2)
J9	Signal ground	Blue (P2)

Figure 3. Receiver module top and bottom silkscreen

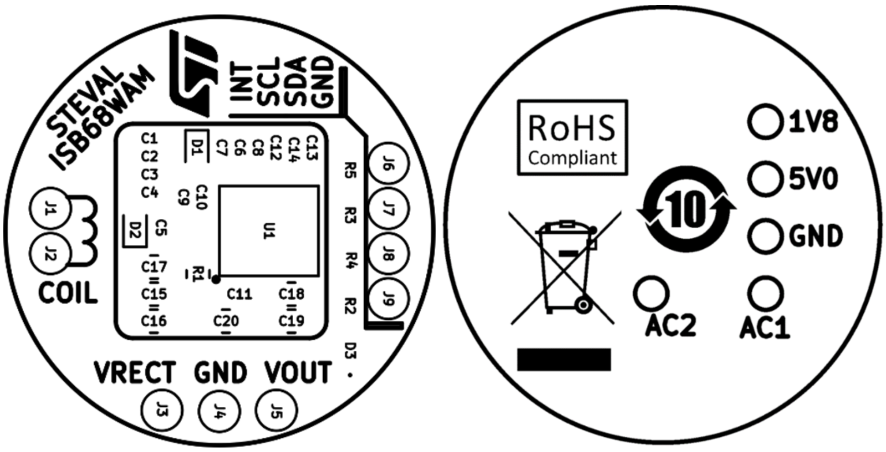
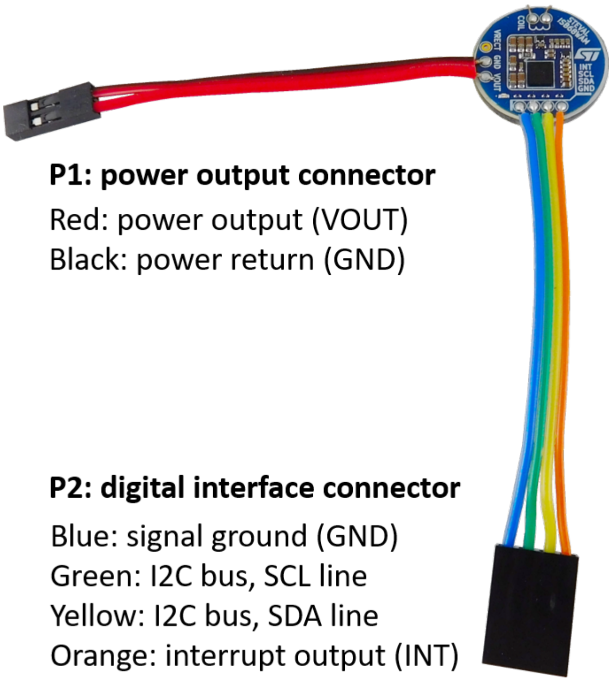


Figure 4. Receiver module wiring



Additional control signals and programmable general-purpose I/O pins are available at the STWLC68JRH, but they are not used in the module to keep the reference solution as simple as possible. The STWLC68JRH chip can handle up to 400 kHz speed over the I2C bus. Table 2 summarizes the default STWLC68JRH settings that are retrieved from OTP memory at power-up. Values eventually changed via I2C registers are lost if the receiver module is removed from the transmitter, unless VOUT or VRECT rails are externally kept above 4V (e.g. as per Figure 7b).

Table 2. Receiver module default settings

Parameter	Default setting
Output voltage	5.0 V
Minimum VRECT	4 V (output is disconnected if VRECT voltage is lower than this value)
Dummy load	40 mA (minimum load current to ensure ASK communication stability)
Nominal chip idle current consumption	17 mA (application dependent)
Output current threshold for deeper ASK modulation	100 mA (if the output current is higher than this value, auxiliary modulation pins CLAMP1 and CLAMP2 are activated)
GPIO0 pin function	Open drain, low when output is enabled (D3 LED)
INT pin function	Open-drain, low in case of over-temperature, over-current or over-voltage condition.
Over-Temperature protection	Lower 80°C threshold leading to output disconnection and EPT generation to terminate power transfer. Upper 125°C threshold leading to AC1 and AC2 pins short-to-ground.
Over-Voltage protection (VRECT rail)	Lower 12 V threshold leading to temporary IEXT activation (VRECT clamping). Upper 25 V threshold leading to AC1 and AC2 pins short-to-ground.
Over-Current protection	1.5 A threshold leading to output disconnection and EPT generation to terminate the power transfer.

As already mentioned, a LED (D3) is connected to GPIO0 and it is used as output state monitor: it turns-on when a correct power transfer is established between the receiving module and the transmitter, and the output voltage is enabled. All the settings shown in table 2 (and other additional ones) can be modified in the registers page of the GUI (see the related GUI user manual for details).

Table 3. Receiver module bill of material

Component	Value	Description	Part Number	Manufacturer
L1	11.8μH	RX coil, 15 mm	760308101219	Wurth
C1, C2, C3	47nF ±10%	MLCC, X7R, 50V, 0402	GRM155R71H473KE14D	Murata
C4	100nF ±10%		GCM155R71H104KE02D	
C5	1.8nF ±5%		GRM155R71H182JA01D	
C7, C8, C10, C11	47nF ±10%		GRM155R71H473KE14D	
C12	4n7 ±10%		GCM155R71H472KA37D	
C6, C9	22nF ±10%		GRM155R71H223KA12D	
C13, C14	2.2μF ±10%	MLCC, X5R, 25V, 0402	GRM155R61E225KE11D	Murata
C15, C16, C17, C18, C19, C20	10μF ±20%	MLCC, X5R, 25V, 0603	GRM188R61E106MA73D	Murata
D1, D2	12V	Uni-directional TVS, SOD882	PESD12VS1UL	NXP
D3		Red LED, 0402	SML-P12VTT86R	Rohm
R1	100R ±5%	Anti-surge resistor, 0.25 W, 0603	CRGP0603F100R	TE Connectivity
R2	470R ±5%	Resistor, 0.1 W, 0201		
R3, R4, R5	47k ±5%			
U1		Wireless power receiver, CSP-72	STWLC68JRH	STMicroelectronics

2 USB to I2C bridging dongle

Overview

The USB to I2C bridging dongle is the tool that allows interfacing the receiver to the Graphical User Interface running on a PC. The P2 connector signals are summarized in Table 4. Three LEDs monitor the operation of the bridge: D1 (green) indicates I2C bus activity, D2 (red) indicates correct initialization of the U1 chip and D3 (yellow) is a power-on indicator. When the dongle is plugged into the USB port, both D2 and D3 should be on.

Figure 5. USB-to-I2C bridging dongle top view

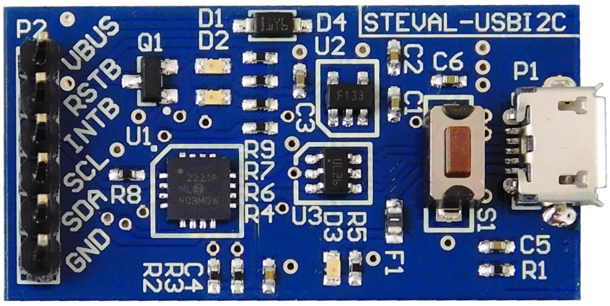


Figure 6. USB-to-I2C bridging dongle schematic

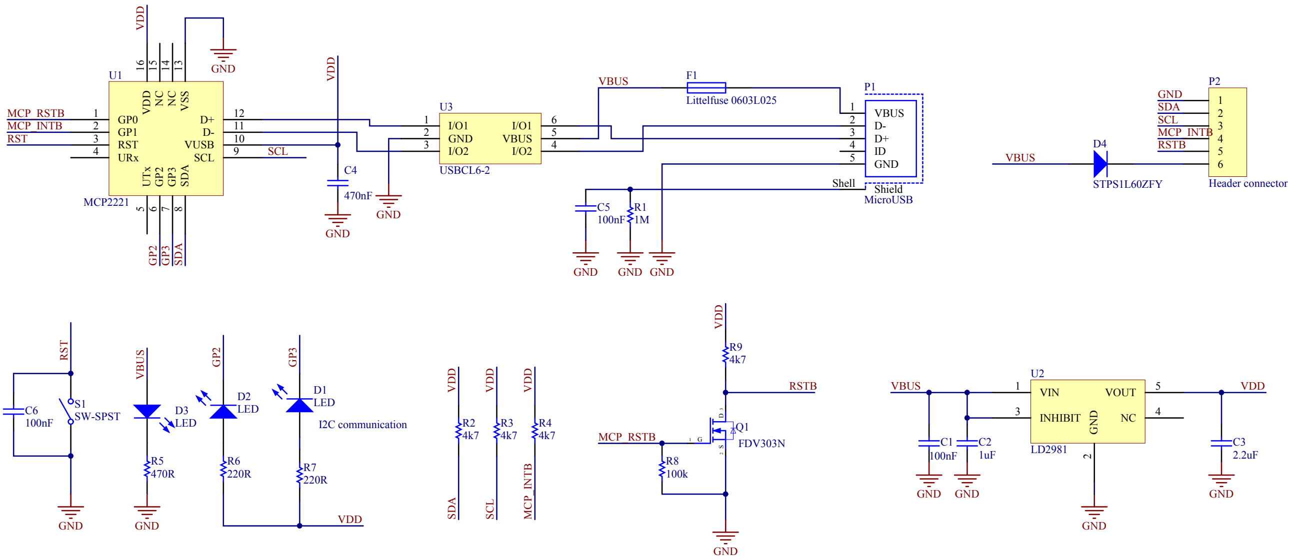


Table 4. USB-to-I2C bridging dongle P2 connector

Pin	Signal	Description
1	GND	Common return (ground)
2	SDA	I2C bus, SDA line
3	SCL	I2C bus, SCL line
4	INTB	I/O line dedicated to INT pin management (status reading)
5	RSTB	Reset signal for the STWLC68JRH chip, active low. Not used in the receiver module.

Pin	Signal	Description
6	VBUS	Auxiliary supply rail. Used to supply the STWLC68JRH chip via VOUT when the receiver module is not placed on a transmitter. The D4 diode (see Figure 6) avoids backflow toward the USB supply rail when VOUT is higher than 5V.

The receiver module must be connected to the dongle as shown in Figure 7a: the P2 connector of the receiver engages with the corresponding 4 signals of the P2 connector of the dongle. The communication over the I2C bus is possible only if the STWLC68JRH chip of the receiver is powered: when not placed on a transmitter, the receiver module can be powered through VOUT by wiring it to the VBUS pin of P2 (Figure 7b). This way of powering the receiver module is also required during OTP memory flashing.

Figure 7. Connection between receiver module and dongle

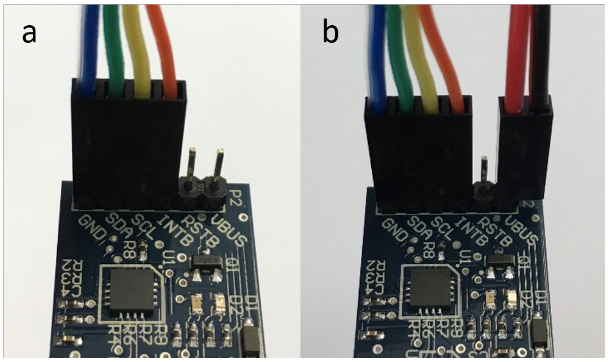


Table 5. USB-to-I2C bridging dongle bill of material

Component	Value	Description	Part Number	Manufacturer
C1, C5, C6	100nF ±10%	MLCC, X7R, 50V, 0402	GCM155R71H104KE02D	Murata
C2	1uF ±10%	MLCC, X7R, 25V, 0402	GRM155R61E105KA12D	Murata
C3	2.2uF ±20%	MLCC, X7R, 6.3V, 0402	GRM155R60J225ME95D	Murata
C4	470nF ±10%	MLCC, X7R, 16V, 0402	GRM155R61C474KE01D	Murata
D1		Red LED, 0603	150060VS55040	Wurth Elektronik
D2		Green LED, 0603	150060RS55040	Wurth Elektronik
D3		Yellow LED, 0603	150060YS55040	Wurth Elektronik
D4		Schottky diode, 60V, 1A, SOD123	STPS1L60ZFY	STMicroelectronics
R1	1M ±5%			
R2, R3, R4, R9	4k7 ±5%			
R5	470R ±5%	Resistor, 0.1W, 0402		
R6, R7	220R ±5%			
R8	100k ±5%			
Q1		N-channel MOSFET, 25V, 0.6A, SOT23	FDV303N	ON-Semi

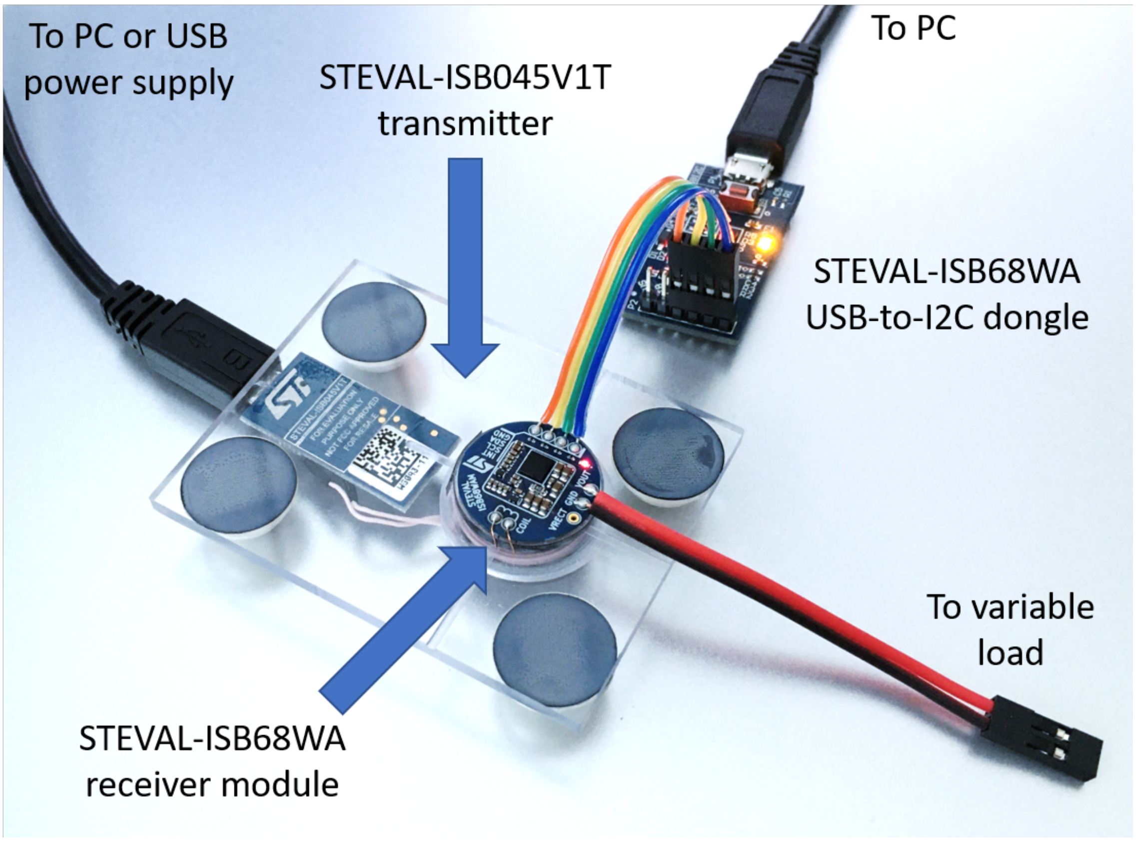
Component	Value	Description	Part Number	Manufacturer
P2		Pin header, 2.54 mm pitch		
U2		3.3V, 100 mA, Linear regulator, SOT23-5L	LD2981CM33TR	STMicroelectronics
F1		Fuse, 0.25A, 0603	0603L025	Littelfuse
U1		USB to I2C converter, QFN16	MCP2221A-I/ML	Microchip
U2		Linear regulator, 3.3V, 100 mA, SOT23-5L	LD2981CM33TR	STMicroelectronics
U3		ESD suppressor, SOT23	USBCL6-2SC6	STMicroelectronics
P1		Micro-USB connector	629105150921	Wurth Elektronik
S1		SMT tactile switch, 6mm x3.5 mm	P-DT2112C	Diptronic

3 STEVAL-ISB68WA test setup

The evaluation of the STEVAL-ISB68WA kit relies on a suitable wireless power transmitter that could mate with the coil of the RX module. A good coupling factor is essential for both power transfer efficiency and data communication reliability between the transmitter and the receiver.

The STEVAL-ISB045V1 wireless power transmitter evaluation kit contains the reference transmitter for the test setup. The complete test setup is shown in Figure 8.

Figure 8. STEVAL-ISB68WA evaluation setup



The receiver is connected to the dongle as per Figure 7a and placed on the transmitter.

Note: The transmitter must be configured (through its own GUI) to have a ping frequency of 120 kHz and a 130 kHz -170 kHz operating frequency range. These parameters are easily unlocked and configured in the "parameters" window (Figure 9).

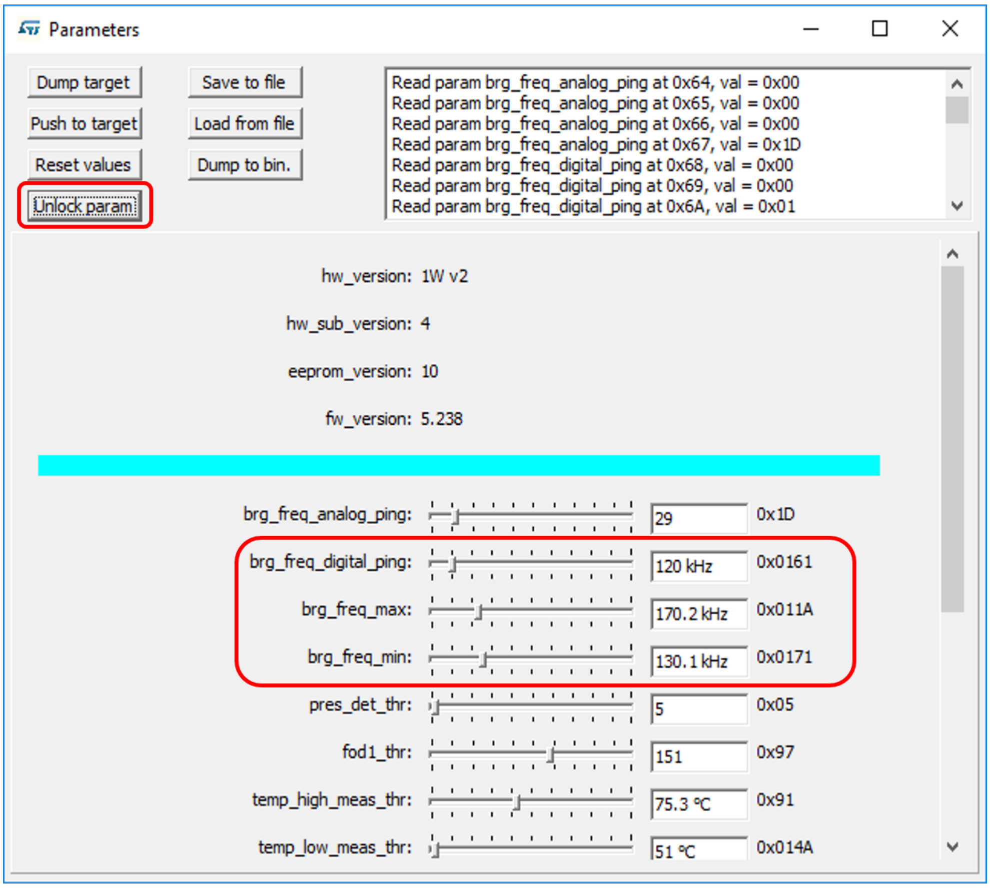
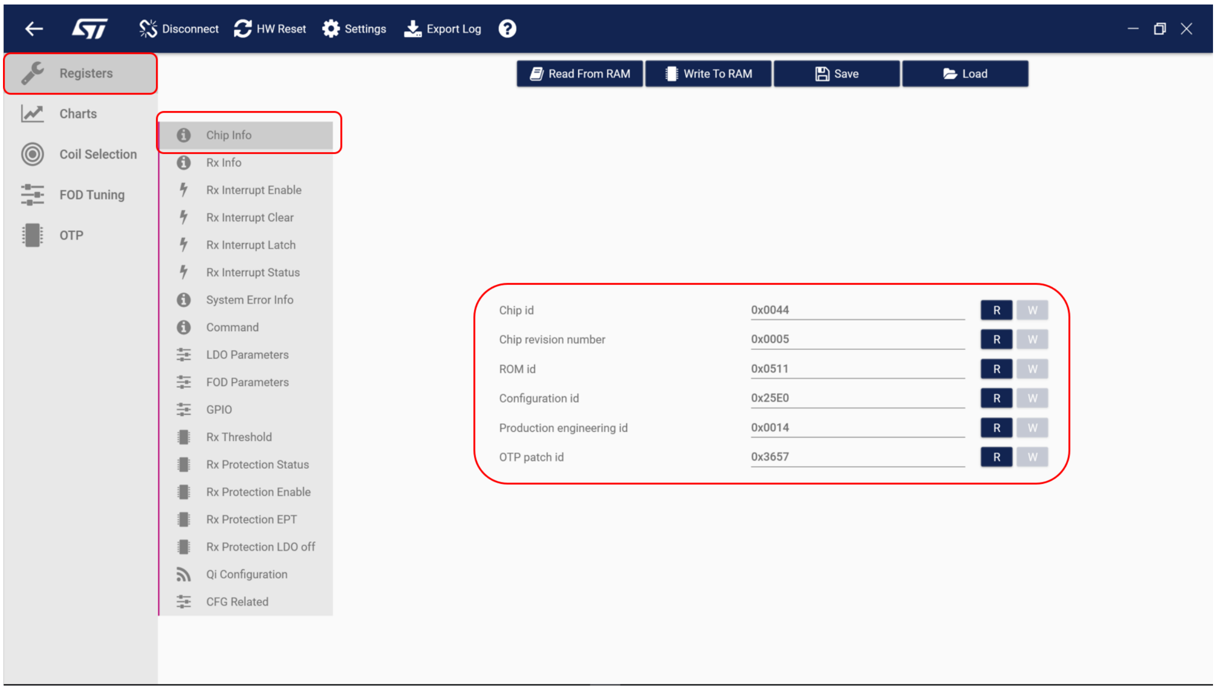


Figure 9. **Configuration of the transmitter**

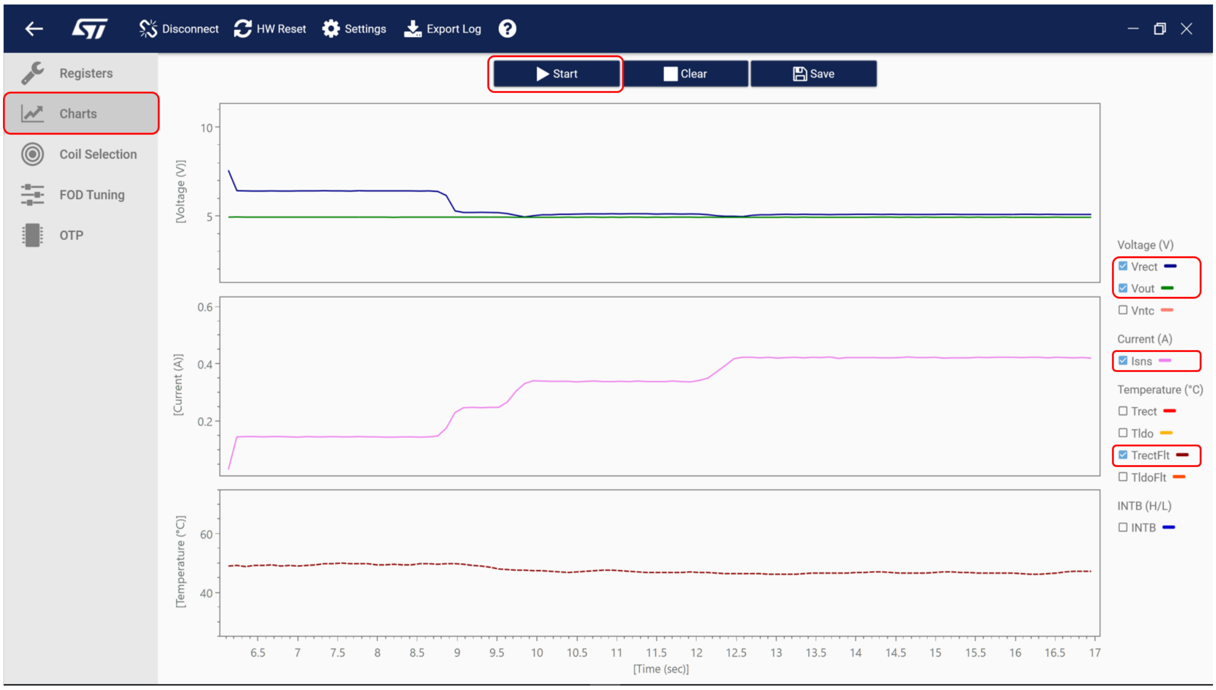
As soon as the LED on the receiver lights up, its control GUI can be launched. Connectivity with the STWLC68JRH is automatically verified and the chip info (IDs content) is shown in the registers page (Figure 10).

Figure 10. **Graphical User Interface registers page showing chip IDs**



To monitor the operation of the receiver, a real-time plotting of key parameters can be selected: in Figure 11 the VRECT and VOUT voltages, the temperature of the rectifier (TRECT) and its output current (ISNS) are shown.

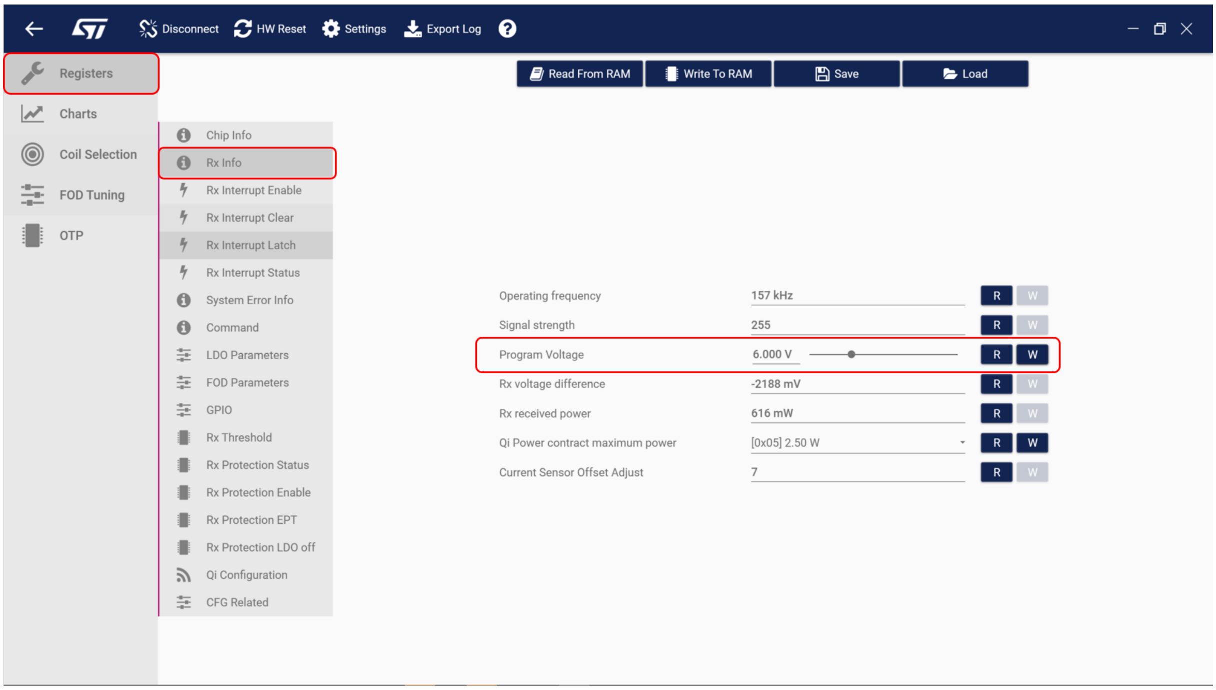
Figure 11. **Graphical User Interface charts page plotting a variable output load**



The load at VOUT can be increased up to 2.5 W. A 10 Ω purely resistive load (i.e. 2.5 W load at 5 V) is usually managed without problems also at ping-up. In some case (e.g. a following DC-DC converter stage) the load could show a remarkable capacitive behavior and a relatively high initial current may trigger the over-current protection or may exceed the dynamic capability of the transmitter. To avoid this, the load should be smoothly increased, or its capacitive component should be reduced.

Several parameters of the receiver module can be temporary changed through the GUI. Just to give an example, the output voltage can be changed on-the-fly by acting on the slider and writing the new value into the related register (Figure 12).

Figure 12. Changing the output voltage to 6 V via GUI

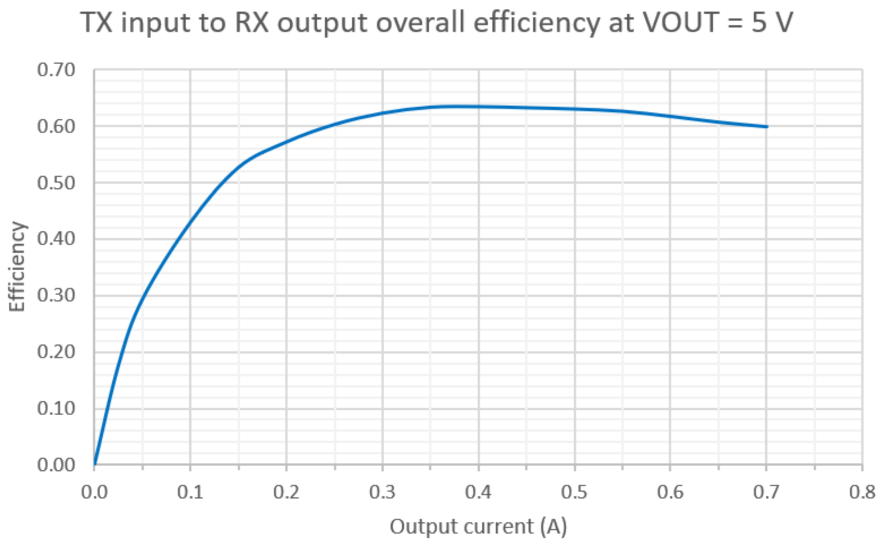


Note that increasing the output voltage may impact on the external components (e.g. proximity to maximum voltage rating of VRECT and VOUT capacitors or to clamping voltage of protection TVS diodes) and on some setting (the OVP threshold, for example, could be triggered if not conveniently adapted to the new operating conditions). Some transmitters may have inherent limitations and could terminate the power transfer if significant changes in the output voltage are applied.

An extensive description of the GUI and its functionalities can be found in the related user manual, while the complete register map of STWLC68JRH can be found in its datasheet.

Figure 13 reports the typical TX-to-RX efficiency of the paired STEVAL-ISB68WAM and STEVAL-ISB045V1T kits. Although the graph in Figure 13 has been extended to an output power of 3.5 W (0.7 A @ 5 V), the 2.5 W limit prevents over-heating of the RX coil.

Figure 13. **Transmitter input to receiver output overall efficiency**



Revision history

Table 6. **Document revision history**

Date	Version	Changes
19-Feb-2020	1	Initial release.

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