UM2681

User manual

Getting started with the wireless power evaluation board for Qi inductive receiver with STWLC68JRH

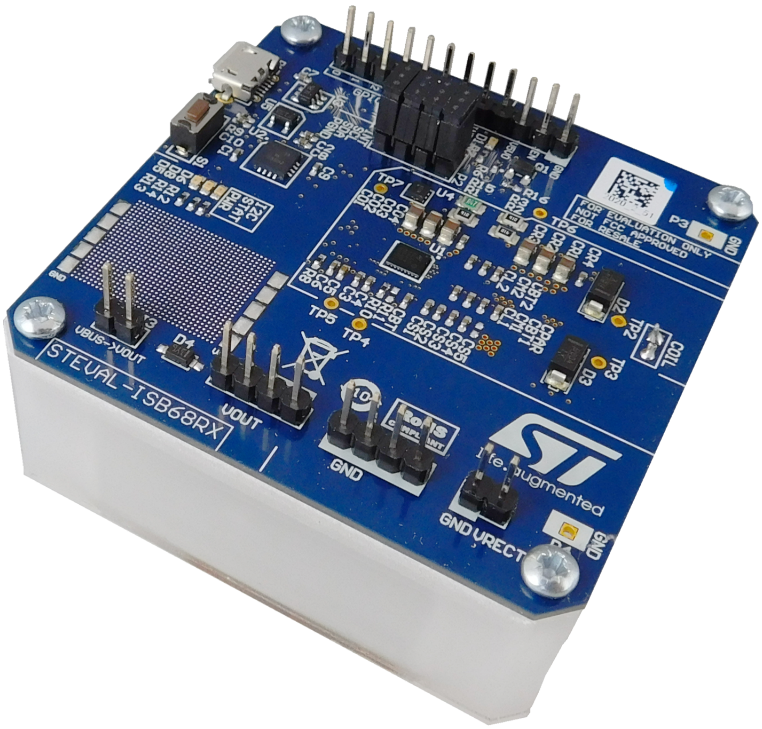
Introduction

The STEVAL-ISB68RX is an evaluation board based providing a Qi-compliant (Qi specifications 1.2.4) reference solution for a wireless power receiver with 5 W capability and based on the STWLC68JRH chip.

The STEVAL-ISB68RX consists of a PCB housing the STWLC68JRH and a 40 x 40 mm receiving coil: the two elements are mechanically mated through a plastic frame that also acts as 1.5 mm plastic spacer for the coil. The PCB board also embeds a USB-to-I^{2}C converter that directly interfaces with the STWLC68JRH, allowing the user to modify parameters and settings via a Graphical User Interface (GUI). The converter can be conveniently used to configure and control the final application via I^{2}C bus.

The STEVAL-ISB68RX has a default setting for a 5 V output voltage and full compliance with Baseline Power Profile (BPP).

Figure 1. STEVAL-ISB68RX



1 Board overview

The STEVAL-ISB68RX evaluation board default configuration is optimized for performance.

The board features:

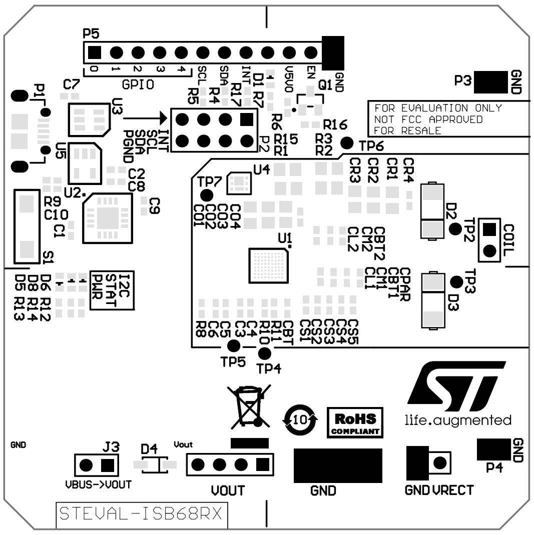
- STWLC68JRH wireless power receiver chip with up to 5 W output power capability (Qi specification 1.2.4, BPP)
- Constant 5 V output voltage (default setting)
- Total (TX input to RX output) system efficiency up to 80%
- Foreign Object Detection (FOD) supported
- 400 kHz I2C interface for communication with host system (optional)
- Built-in USB-to-I^2C converter for interfacing to STWLC68JRH chip
- Configurable GPIOs (e.g. status monitoring or auxiliary control signals)
- Solder pads matrix for customization of evaluation board
- Complete kit (Board with embedded receiving coil, Graphical User Interface control software)
- RoHS compliant

2 Board configuration and test points

The STEVAL-ISB68RX has several connectors and test points to ease access to key signals.

- P1 connector: micro-USB female receptacle for connection of the USB-to-I^{2}C converter to the host PC
- P2 connector/jumper: bridging point between the I^{2}C bus (on-board converter) and the STWLC68JRH. Jumpers placed as per Figure 3 allow controlling the STEVAL-ISB68RX via GUI. If the jumpers are removed, the connector turns into the I^{2}C bus access point for controlling external STWLC68JRH devices.
- P3 & P4 connectors: grounding points for probing.
- P5 connector: auxiliary STWLC68JRH control signals access point. Programmable GPIOs, chip enable and other STWLC68JRH pins are routed to this connector.
- J3 jumper (VBUS->VOUT): this jumper connects the 5 V supply rail of the USB to the output of STWLC68JRH. It is used to communicate with STWLC68JRH when the receiver is not placed on a transmitter (DC mode). Also used to supply the STWLC68JRH chip during OTP flashing. If closed, the STEVAL-ISB68RX should not be put on transmitter.
- TP2: test-point connected to AC2 (rectifier input of STWLC68JRH).
- TP3: test-point connected to AC1 (rectifier input of STWLC68JRH).
- TP4: test-point connected to internal V1V8 LDO output (STWLC68JRH digital section supply rail).
- TP5: test-point connected to internal V5V0 LDO output (STWLC68JRH analog section supply rail).
- TP6: test-point connected to IEXT pin. Used to monitor the operation of the over-voltage protection (active clamper).
- VRECT connector: rectifier output voltage (VRECT pins of STWLC68JRH)
- VOUT/GND connectors: main linear LDO regulator output voltage (VOUT pins of STWLC68JRH). Power output rail of the wireless power receiver.
- COIL connector: terminals for the receiving coil.

Figure 2. Top silkscreen of evaluation board



3 Operating mode

The STEVAL-ISB68RX works out-of-the-box as a standalone wireless power receiver when placed on a suitable transmitter. Default settings are automatically retrieved from OTP memory at power-up.

The Graphic User Interface allows the user evaluating all the available functions of the STEVAL-ISB68RX, as well as temporary changing the default parameter via I^{2}C communication.

The jumpers at connector P2 must be closed as shown in Figure 3 to connect the STWLC68JRH to the USB-to-I^{2}C converter, then a USB cable can be plugged into P1 to connect the STEVAL-ISB68RX to the host PC. Before launching the GUI on the host PC, the STEVAL-ISB68RX should be placed on an active transmitter, so that the STWLC68JRH is properly powered and the I^{2}C communication established.

Note: *The enable pin of the STWLC68JRH is held low by the USB-to-I^{2}C converter resulting in reset state of STWLC68JRH. By the opening the GUI, the USB-to-I^{2}C converter is initialized and the STWLC68JRH is enabled.*

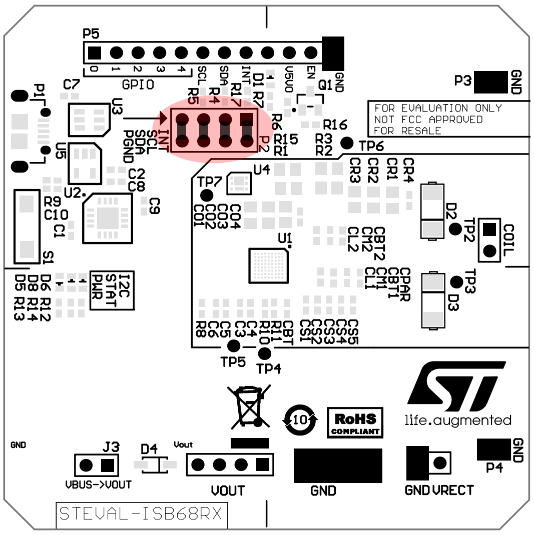


Figure 3. **Configuration of jumpers**

The D1 LED is connected to the GPIO0 pin of the STWLC68JRH and it lights up when the output of the main LDO linear regulator is enabled, i.e. when power transfer is established between the transmitter and the STEVAL-ISB68RX.

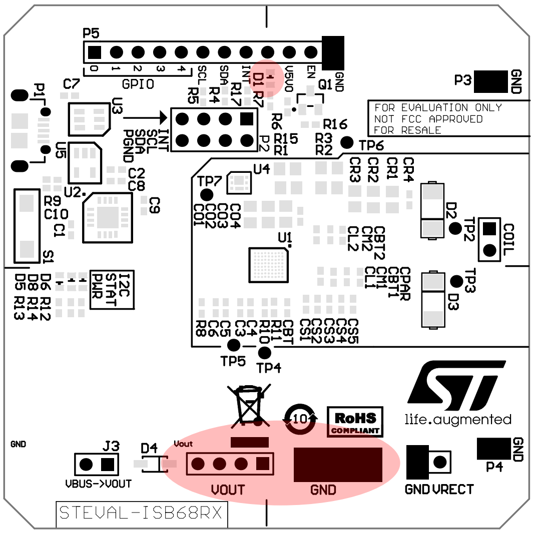


Figure 4. **Output and indication LED**

The STEVAL-ISB68RX has three additional LEDs dedicated to the USB-to-I^{2}C converter: D8 LED indicates the correct initialization, D6 LED indicates I^{2}C bus activity and D5 LED is the power-on indicator (USB supply rail).

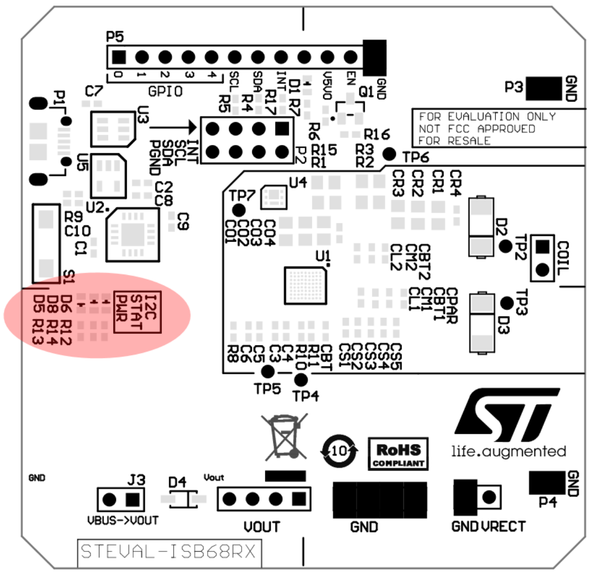


Figure 5. **Status LEDs**

4 Default configuration of STWLC68JRH

The configuration settings of the STWLC68JRH chip are retrieved from the OTP memory at power-up, but they can be temporary changed via GUI once the STEVAL-ISB68RX is powered by the transmitter and the modified values are kept until a reset of chip occurs.

The default STWLC68JRH settings are the following ones:

- The output voltage is set to 5.0 V.
- The output is disabled if the VRECT voltage is lower than 4 V. This threshold is programmable, and it is used to prevent the supply voltage of the STWLC68JRH from being too low because of severe output load transient or TX/RX coils misalignment.
- The output current limit is set to 1.5 A.
- The INTB pin is set as open-drain and it is assigned to over-temperature, over-current and over-voltage protections interrupts.
- The dummy load is set to 40 mA. All wireless power systems are designed to transfer a minimum amount of power, below which the ASK modulation and the output voltage regulation are not well controlled. To overcome these problems and to ensure proper RX-to-TX communication stability, a dummy load function can be enabled. The dummy load is a constant current internally drawn at the VOUT output and it progressively fades away as soon as the external load increases. The default 40 mA value is a good trade-off between internal power dissipation at no load and ASK communication stability over the full output power range.
- A deeper ASK modulation index is enabled when the output current is lower than 100 mA. The STWLC68JRH has two pairs of pins dedicated to ASK modulation. In normal conditions only the COMM1 and COMM2 pins are used. In light-load conditions the CLAMP1 and CLAMP2 pair can be activated to provide a deeper ASK modulation that significantly enhances the RX-to-TX communication signal-to-noise ratio.
- The output of STWLC68JRH is automatically enabled when the voltage at VRECT (output of the rectifier) crosses 5.08 V threshold.
- The nominal STWLC68JRH idle current is set to 17 mA. This current is application-dependent and reflects the consumption of the chip and the circuitry eventually connected to V5V0 and V1V8 pins. The value of the current is important for the correct tuning of the Foreign Object Detection function.
- The GPIO0 pin is set as open-drain output and assigned to D1 LED, so that it lights on when the output is enabled.

  The STWLC68JRH implements over-temperature, over-voltage and over-current protections to prevent damage to the chip itself, to the load and to the external components. The device has two internal temperature sensors, physically located close to the rectifier and to the main LDO linear regulator.
- The default setting for the over-temperature protection consists in disabling the output and sending EPT packet to the transmitter in case one of the above-mentioned sensors detects more than 80 °C. As a further protection, a second, higher threshold of 125 °C triggers an internal circuitry that shorts to ground both AC1 and AC2 pins.
- The protection based on external NTC sensor is disabled by default. This function is mostly used to monitor and protect the receiving coil against over-heating.
- The over-voltage protection the STWLC68JRH monitors the voltage at the output of the rectifier. A lower threshold (set by default to 12 V) triggers a momentary VRECT clamper: the IEXT pin goes low and a discharge current flows through the external resistor connected between VRECT and IEXT. This action is effective in reducing the VRECT voltage and generally it is intended to take place in case of brief, non-repetitive voltage spikes at VRECT (for example due to abrupt change in the coupling factor of the RX/TX coils). Usually this protection does not interrupt the power transfer process. In STEVAL-ISB68RX the default settings associate an EPT packet generation to this protection too, therefore the power transfer is terminated by the transmitter.

  A higher threshold, set to 25 V, triggers the already mentioned AC1-AC2 short-to-ground mechanism as a further safety.
- The output over-current protection is set to 1.5 A, resulting in output disconnection an EPT packet generation once triggered.

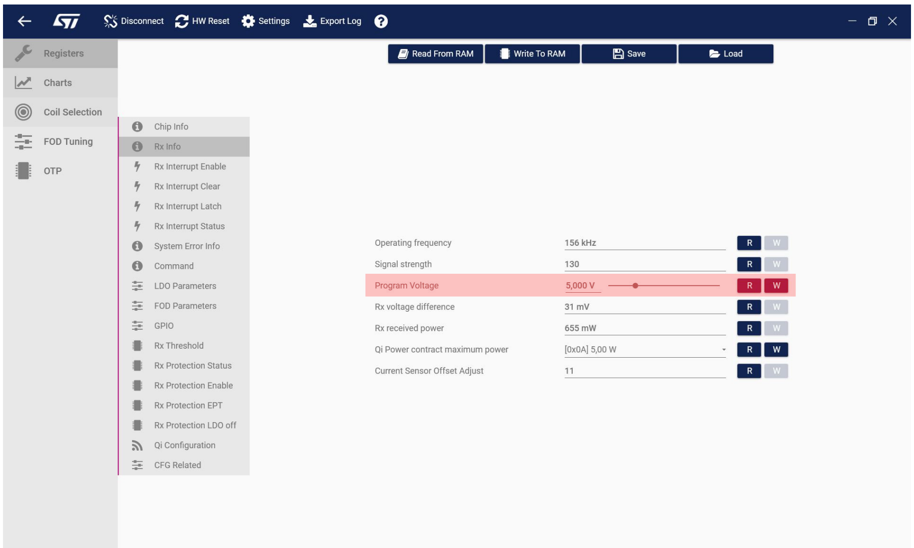
5 Graphical User Interface (GUI)

The GUI offers a user-friendly interface to access and modify the STWLC68JRH registers. The same GUI is the tool, in conjunction with the on-board USB-to-I2C converter, to rely on for eventually tuning the final application.

Figure 6 shows how to change the output voltage of the STEVAL-ISB68RX on-the-fly from the registers page. By acting on the slider (or directly writing the desired value) and writing the related register, a new value is set.

Note: Increasing the output voltage may impact on the external components (e.g. proximity to maximum voltage rating of VRECT and VOUT capacitors) 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.

Figure 6. Changing of output voltage via GUI



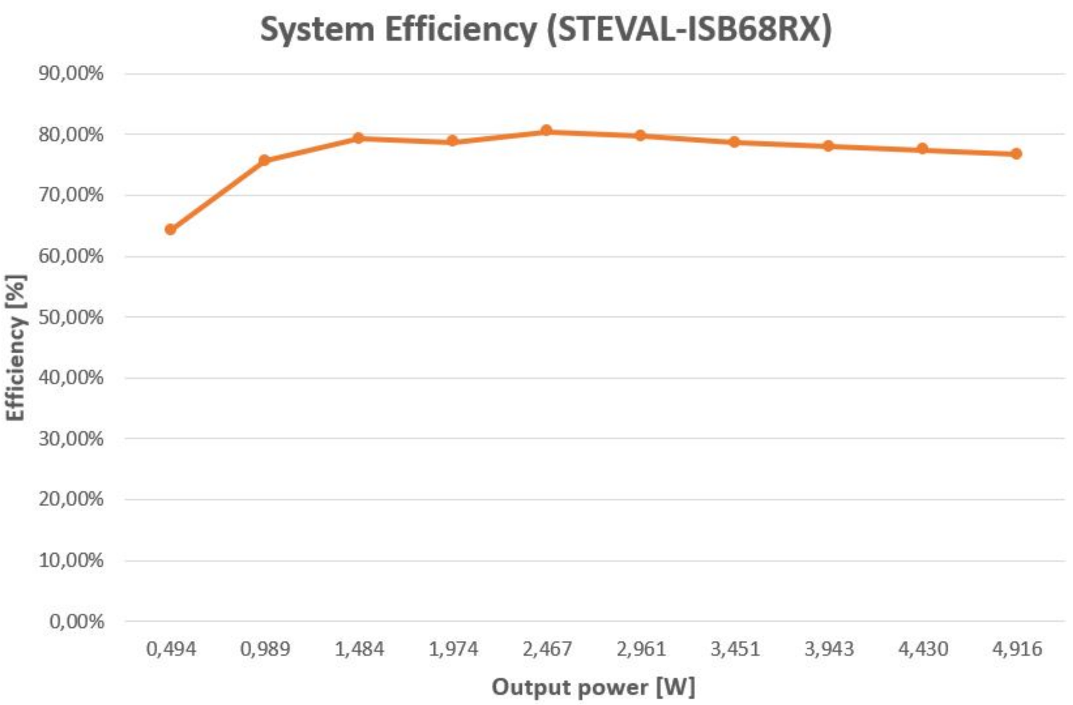
The GUI also allows to monitor in real-time key parameters by reading the internal ADC channels of the STWLC68JRH and plotting voltages, current and temperatures. Figure 7 shows the behavior of VRECT and VOUT voltages, as well as the rectifier output current (ISNS). For further details and a comprehensive description of the GUI, please refer to the GUI user manual on www.st.com

Figure 7. Plotting key parameters via GUI

6 Baseline power profile (BPP) RX mode performance

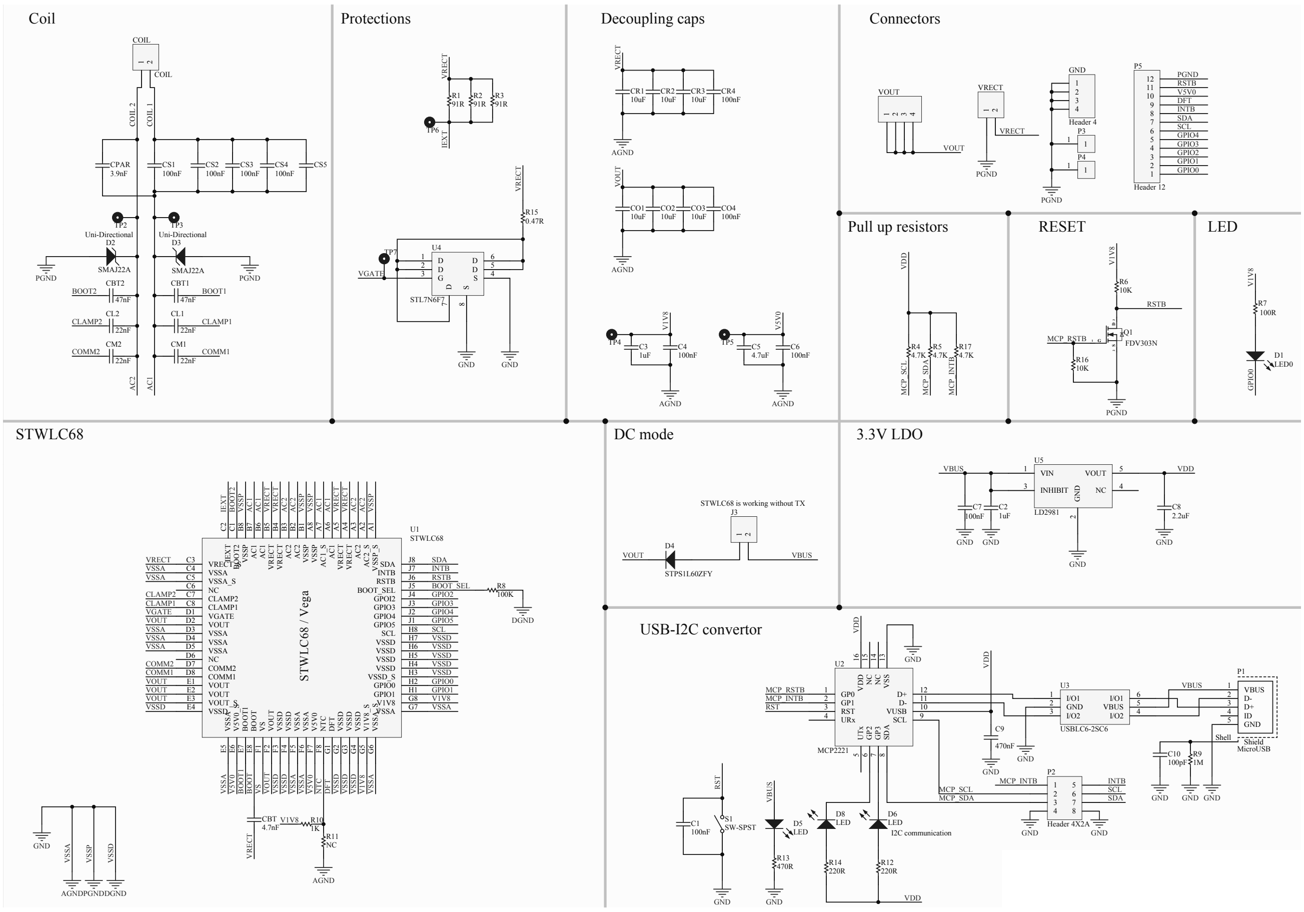
Figure 8 reports the typical TX-input to RX-output efficiency of the STEVAL-ISB68RX placed on open-loop transmitter.

Figure 8. STEVAL-ISB68RX evaluation board performance: efficiency vs output power in BPP



7 Schematic

Figure 9. Schematic of STEVAL-ISB68RX



8 BOM

Table 1. **Bill of material**

Item	Q.ty	Ref.	Value	Description	Manufacturer	Part number
1	10	C1, C4, C6, C7, CO4, CR4, CS1, CS2, CS3, CS4	100nF, 1005[0402], 50 VDC V, 10%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	Murata	GCM155R71H104KE02D
2	6	CO1, CO2, CO3, CR1, CR2, CR3	10uF, 2012[0805], 35 VDC V, 10%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	Murata	GRM21BR6YA106KE43L
3	6	TP2, TP3, TP4, TP5, TP6, TP7	TestPoint 1.5/0.8,	Do not place		DNP
4	4	CL1, CL2, CM1, CM2	22nF, 1005[0402], 50 VDC V, 10%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	Murata	GRT155R71H223KE01D
5	3	R1, R2, R3	91R, 2012[0805], 91 R V, 500 m W, 5%,	Thick Film Resistors - SMD	Panasonic	P91ADCT-ND
6	3	R4, R5, R17	4.7K, 1005[0402],	Resistor		Any
7	2	C2, C3	1uF, 1005[0402], 25 VDC V, 10%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	Murata	GRM155R61E105KA12D
8	2	CBT1, CBT2	47nF, 1005[0402], 50 VDC V, 10%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	TDK	C1005X7R1H473K050BB
9	2	D2, D3	DO-214AC (SMA), 22 VDC V,	ESD Suppressors		SMAJ22A
10	2	GND, VOUT	HDR1X4,	Header 1x4 pin, 2.54mm pitch		Header, 4-Pin
11	2	J3, VRECT	HDR1X2,	Header 1x2 pin, 2.54mm pitch		Header, 2-Pin
12	2	P3, P4	2mm_PIN,	Do not place		DNP
13	2	R12, R14	220R, 1005[0402],	Resistor		Any
14	2	R6, R16	10K, 1005[0402],	Resistor		Any

Item	Q.ty	Ref.	Value	Description	Manufacturer	Part number
15	1	D5	Q_SMD_LED_0603_DIN1608M, 2 VDC V, 20 m A,	RED LED	Wurth Electronik	150060RS55040
16	1	D6	Q_SMD_LED_0603_DIN1608M, 2 VDC V, 20 m A,	GREEN LED	Wurth Electronik	150060VS55040
17	1	D8	Q_SMD_LED_0603_DIN1608M, 2 VDC V, 20 m A,	YELLOW LED	Wurth Electronik	150060YS55040
18	1	C10	100pF, 1005[0402],	Capacitor		Any
19	1	C5	4.7uF, 1005[0402], 10 VDC V, 20%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	Murata	GRM155R61A475MEAAD
20	1	C8	2.2uF, 1005[0402], 6.3 VDC V, 20%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	Murata	GRM155R60J225ME95D
21	1	C9	470nF, 1005[0402], 16 VDC V, 10%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	Murata	GRM155R61C474KE01D
22	1	CBT	4.7nF, 1005[0402], 50 VDC V, 10%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	Murata	GCM155R71H472KA37D
23	1	COIL	8uH, HDR1X2,	Coil		760308102207
24	1	CPAR	3.9nF, 1005[0402], 50 VDC V, 10%,	Multilayer Ceramic Capacitors MLCC - SMD/SMT	Murata	GRM155R71H392KA01D
25	1	CS5	DNP, 1005[0402],	Do not place		DNP
26	1	D1	Q_SMD_LED_0603_DIN1608M,	RED LED	Wurth Electronik	150060RS55040
27	1	D4	SOD-123, 60 VDC V, 1 A,	Schottky Rectifiers	STMicroelectronics	STPS1L60ZFY
28	1	P1	MICROUSB-629105150921,	Fermale Micro USB Type AB Connectors	Wurth Elektronik	629105150921
29	1	P2	HDR2X4_CEN,	Header 2x4 pin, 2.54mm pitch		Header, 4-Pin, Dual row
30	1	P5	HDR1X12,	Header 1x12 pin, 2.54mm pitch		Header, 12-Pin
31	1	Q1	G_SMD_SOT23_TO-236AB, 25 VDC V, Id 680 mA,	MOSFET	ON Semiconductors	FDV303N
32	1	R10	1K, 1005[0402],	Resistor		Any
33	1	R11	DNP, 1005[0402],	Do not place		DNP
34	1	R13	470R, 1005[0402],	Resistor		Any
35	1	R15	0.47R, 2012[0805], 250 mW,	Current Sense Resistors	Susumu	RL1220S-R47-F

Item	Q.ty	Ref.	Value	Description	Manufacturer	Part number
36	1	R7	100R, 1005[0402],	Resistor		Any
37	1	R8	100K, 1005[0402],	Resistor		Any
38	1	R9	1M, 1005[0402],	Resistor		Any
39	1	S1	SWITCH_P-DT2112C, 12 VDC V, 50 mA,	Tactile Switche		P-DT2112C
40	1	U1	WLC68_72BUMPS,	Wireless charging IC	STMicroelectronics	STWLC68
41	1	U2	QFN16,	USB Interface IC	Microchip	MCP2221A-I/ML
42	1	U3	SOT23-6L,	ESD Suppressors	STMicroelectronics	USBLC6-2SC6
43	1	U4	PowerFLAT, VDS 60 VDC V, Id 7 A,	MOSFET	STMicroelectronics	STL7N6F7
44	1	U5	SOT23-5L, 3.3 VDC Output V, 100 mA Output A,	LDO Voltage Regulators	STMicroelectronics	LD2981CM33TR
45	1	Plastic case				
46	4	Jumpers			Sullins Connector Solutions	QPC02SXGN-RC

Revision history

Table 2. **Document revision history**

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

Contents

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