STDES-WLC38TWS Wireless Power Receiver User Manual

Contents

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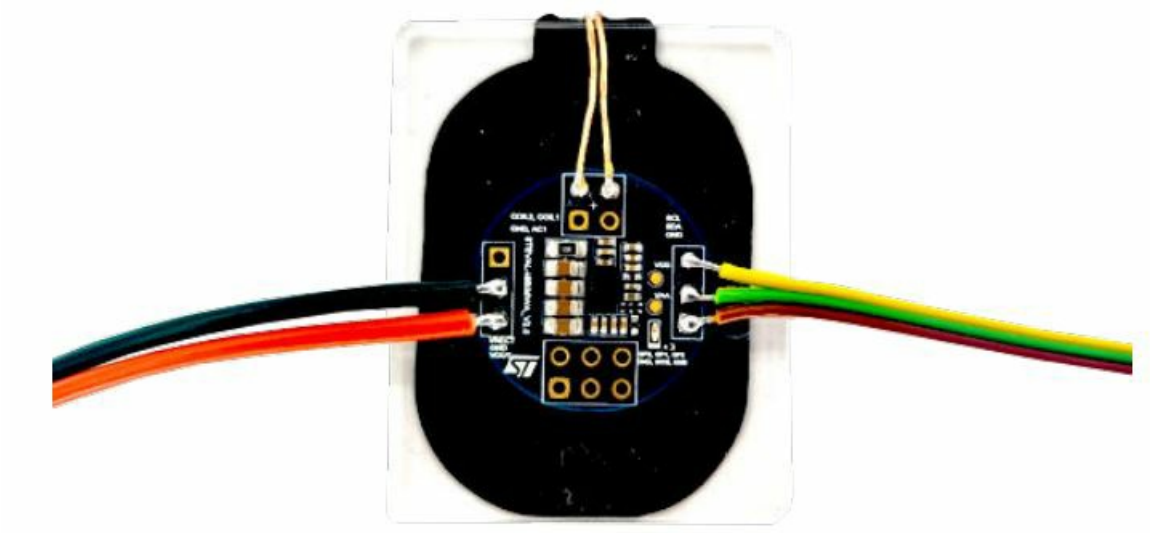
STDES-WLC38TWS Wireless Power Receiver



Product Information

STDES-WLC38TWS Wireless Power Receiver

The STDES-WLC38TWS is a reference design for wireless power receivers. It is optimized for performance and features a small size, good thermal performance up to 2.5 W, and stable power transfer with standard Qi wireless chargers.

The key features of the STDES-WLC38TWS reference design include:

- High efficiency (98% typical) synchronous rectifier operating up to 800 kHz
- Low drop-out linear regulator with output current limit and input voltage control loop
- Adaptive rectifier configuration (ARC) mode for enhanced spatial freedom
- 4 V to 12 V programmable output voltage
- 10-bit A/D converter
- Configurable GPIOs
- Multilevel ASK modulator, enhanced FSK demodulator
- Output overvoltage clamping protection
- Accurate voltage/current measurement for foreign object detection (FOD)
- On-chip thermal management and protections
- Flip chip 40 bumps (2.12 mm x 3.32 mm) package
- Small, ready to use 20 mm board

Connection Overview

The STDES-WLC38TWS is equipped with all components necessary for standalone operation. The TWS coil needs to be connected to pads (COIL1 and COIL2), and the AC1 is the debug output. GPIOs are alsoavailable on the header.

Reference Design Specifications

Parameter	Description
RX application PCB area	20 mm
RX coil specifications	Total distance between coils: 3 mm
Output voltage (Vout)	5 V
Output current (Iout)	0.5 A
Host MCU	Receiver only
Efficiency	67% (2.5 W operation) with the STEVAL-WBC86TX
Applicable charging gap between Tx and Rx coils (z-distance)	3 mm
Operational modes	Receiver only

Product Usage Instructions

Connection

To use the STDES-WLC38TWS, follow these steps for connection:

1. Connect the TWS coil to the COIL1 and COIL2 pads.
2. Connect the AC1 debug output.
3. Use the available GPIOs on the header if needed.

Test Points

The STDES-WLC38TWS features several connectors and test points for easy access to key signals. The connectors and test points are as follows:

Name	Description
P1	Coil connection and AC1 debug output
P2	GPIO and INT connector
P3	VRECT and VOUT connector
P4	Test point
VAA	Test point
VDD	Test point

Default Configuration

The default configuration of the STDES-WLC38TWS includes the following:

- Enabled interrupts
- GPIOs

- Protections enabled
- Send EPT
- Disable VOUT
- Connect IEXT resistor from Vrect through IEXT resistor, internal transistor to Ground
- Short RX COIL
- Disable VOUT

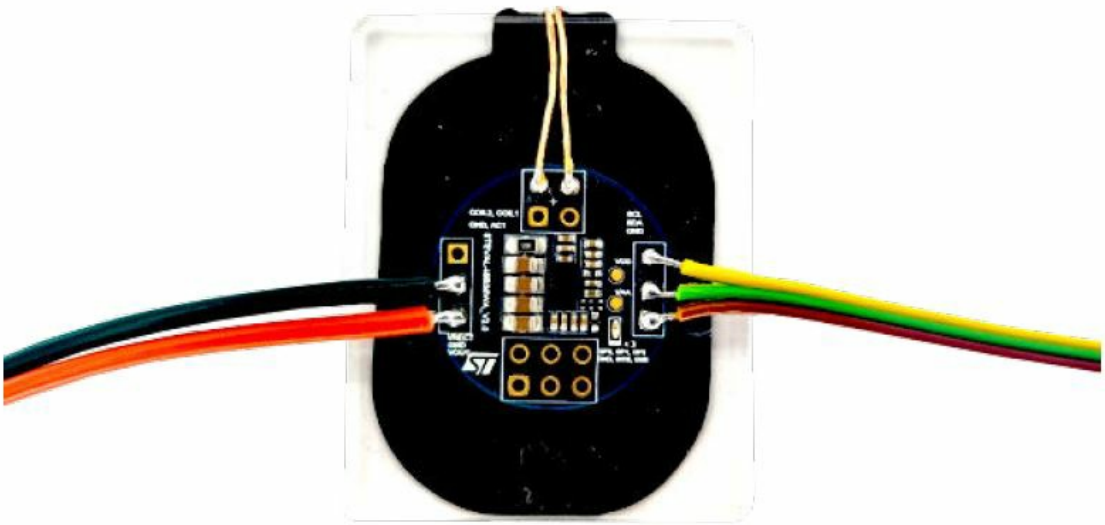
PCB Layout

The STDES-WLC38TWS has a 3-layer PCB layout. The top, inner1, inner2, and bottom layers of the PCB are shown below:

Introduction

- The STDES-WLC38TWS reference design, based on STWLC38, is designed for wireless power receiver applications. It allows the user to start a 2.5 W wireless charging project quickly.
- The integrated circuit requires only few external components. It can work with adjustable output voltage (the default output voltage is 5 V).
- Through an external USB-to-I²C converter, you can monitor and control the STWLC38 using the STSW-WPSTUDIO GUI. The STDES-WLC38TWS includes several safety mechanisms that provide overtemperature (OTP), overcurrent (OCP), and overvoltage (OVP) protections, which can protect the device by sending an end power transfer (EPT) packet, disable the device output, or short coil inputs.

Figure 1. STDES-WLC38TWS reference design



Fully assembled board developed for performance evaluation only, not available for sale

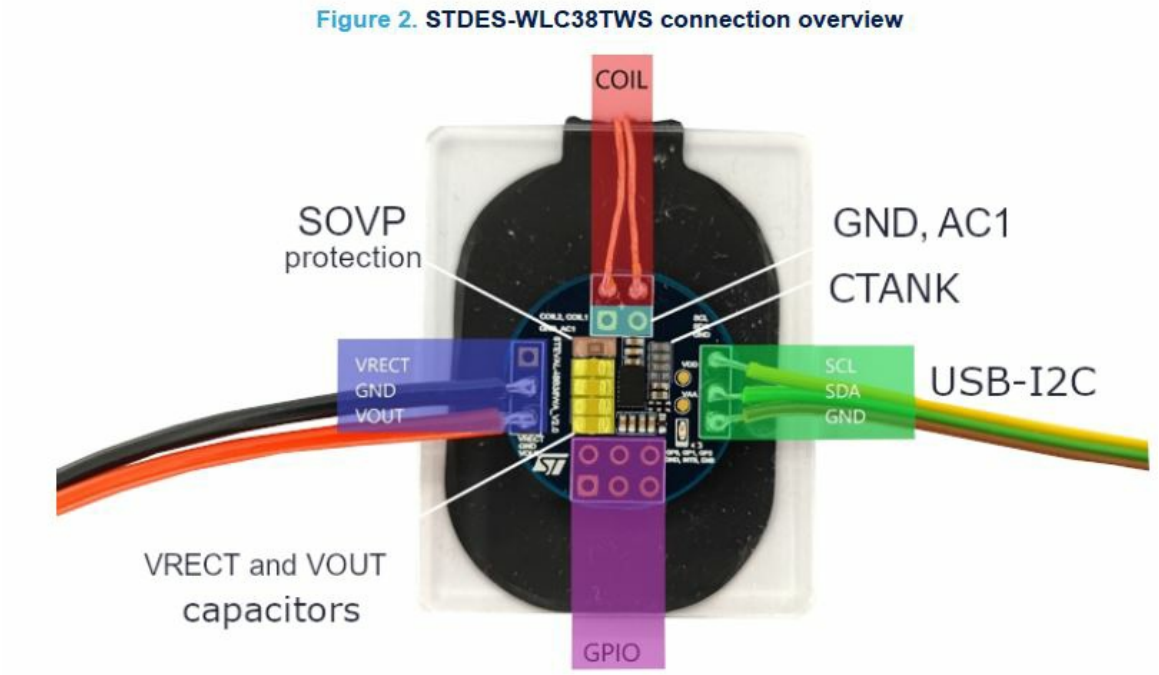
The STDES-WLC38TWS reference design is ready to use. It features a small size, good thermal performance up to 2.5 W, and stable power transfer with standard Qi wireless chargers. Install the I²C drivers and the STSW-WPSTUDIO GUI. Using an external USB-to-I²C bridge, connect the board to your PC (connector P2 on the USB-I²C bridge). This allows you to communicate with the board, program it, and monitor its functions. The GUI supports MCP2221 and FT260Q-T USB-I²C converters with the standard connections described in the datasheet of the USB-I²C bridge.

Overview

The STDES-WLC38TWS is optimized for performance. The board and IC feature:

- High efficiency (98% typical) synchronous rectifier operating up to 800 kHz
- Low drop-out linear regulator with output current limit and input voltage control loop
- Adaptive rectifier configuration (ARC) mode for enhanced spatial freedom
- 4 V to 12 V programmable output voltage
- 32-bit, 64 MHz Arm® Cortex® M0+ core with 32kB RRAM, 16 KB SRAM, 64kB ROM
- 10-bit A/D converter
- Configurable GPIOs
- I²C slave interface
- Multilevel ASK modulator, enhanced FSK demodulator
- Output overvoltage clamping protection
- Accurate voltage/current measurement for foreign object detection (FOD)
- On-chip thermal management and protections
- Flip chip 40 bumps (2.12 mm x 3.32 mm) package
- Small, ready to use 20 mm board
- I²C connector, GPIO, and INT connector, SOVP resistor

Figure 2. **STDES-WLC38TWS connection overview**



The STDES-WLC38TWS is equipped with all components necessary for a standalone operation. The TWS coil has to be connected to pads (COIL1 and COIL2). The AC1 is the debug output. The rectifier output is labeled VRECT. The output from the main regulator is VOUT. The I²C interface is led by connector SDA, SCL and GND for connection to the I²C bus USB-I²C bridge. GPIOs are available on the header as well. The board includes capacitors for VRECT and VOUT, CTANK capacitors calulated with the TWS coil, SOVP resistor, and other necessary components.

Test points
STDES-WLC38TWS features several connectors and test points to provide easy access to key signals.

Table 1. Connectors and test points

Connector/test point	Name	Description
Connector	P1	Coil connection and AC1 debug output
Connector	P2	GPIO and INT connector
Connector	P3	VRECT and VOUT connector
Connector	P4	I²C connector
Test point	VAA	Test point of internal LDO
Test point	VDD	Test point of internal LDO

Reference design specifications

The STDES-WLC38TWS target specifications are listed in the table below.
Table 2. Reference design specifications

Parameter	Description
RX application PCB area	20 mm
RX coil specifications	Inductance 13 µH, dimensions 40×30 mm
Output voltage (Vout)	5 V
Output current (Iout)	0.5 A
Host MCU	STM32 used as a reference, the reference I²C driver can be ported to any other MCU family
Efficiency	67 % (2.5 W operation) with the **STEVAL-WBC86TX** Total distance between coils 3 mm
Applicable charging gap between Tx and Rx coils (z-distance)	8 mm (X; 2.5 W output) with **STEVAL-WBC86TX** transmitter, maximum 14 mm – stable communication without output enabled 10 mm (Z; 2.5 W output) with STDES- WBC86WTX transmitter, maximum 15 mm – stable communication without output enabled
Operational modes	Receiver only

Default configuration

Basic parameters:

Table 3. Basic parameters

RX rectifier mode	**Full sync**
Minimum operating frequency	110 kHz
Maximum operating frequency	205 kHz
Overcurrent protection (OCP – FW / HW)	1.85 A/1.93
Overvoltage protection (OVP – FW / HW)	VOUT+4 V/16 V
Overtemperature protection (OVTP – FW / HW)	85°C/105°C
Default output voltage	5 V

- Enabled interrupts
  - OCP triggered
  - OVP triggered
  - OVTP triggered
  - UVLO triggered
  - OUTPUT enabled
  - Message received
- GPIOs
  - GPIO3 – Interrupt pin
- Protections enabled
  - ADC OCP
  - Send EPT
  - Disable VOUT
  - ADC OVTP
  - Send EPT
  - Disable VOUT
  - SOVP
  - Connect IEXT resistor from Vrect through IEXT resistor, internal transistor to Ground
  - TSHUT (HW OVTP)
  - Disable VOUT
  - Short RX COIL
  - HOVP (HW OVP)
  - Short RX COIL
  - OCP (HW)
  - Disable VOUT
  - TN1441
  - Default configuration
  - TN1441

PCB layout

Figure 3. **STDES-WLC38TWS top layer**

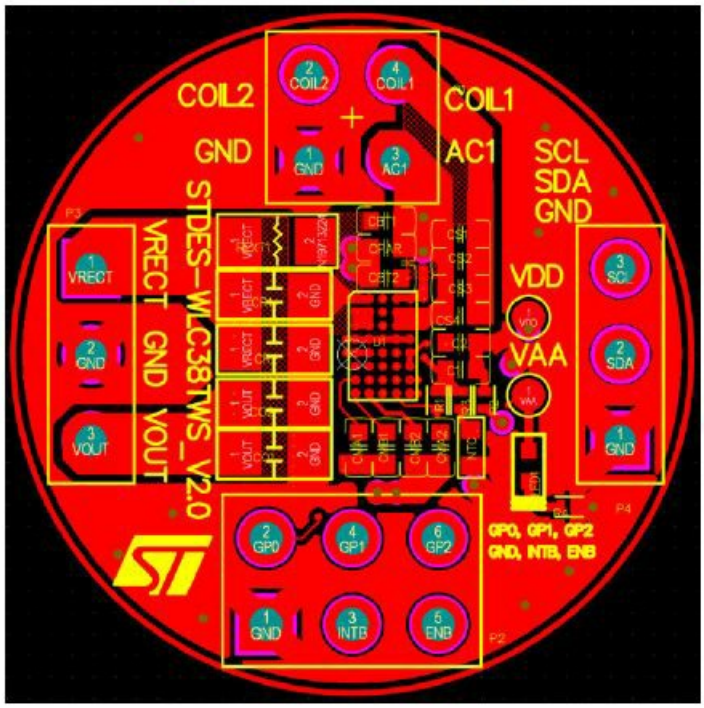


Figure 4. **STDES-WLC38TWS inner1 layer**

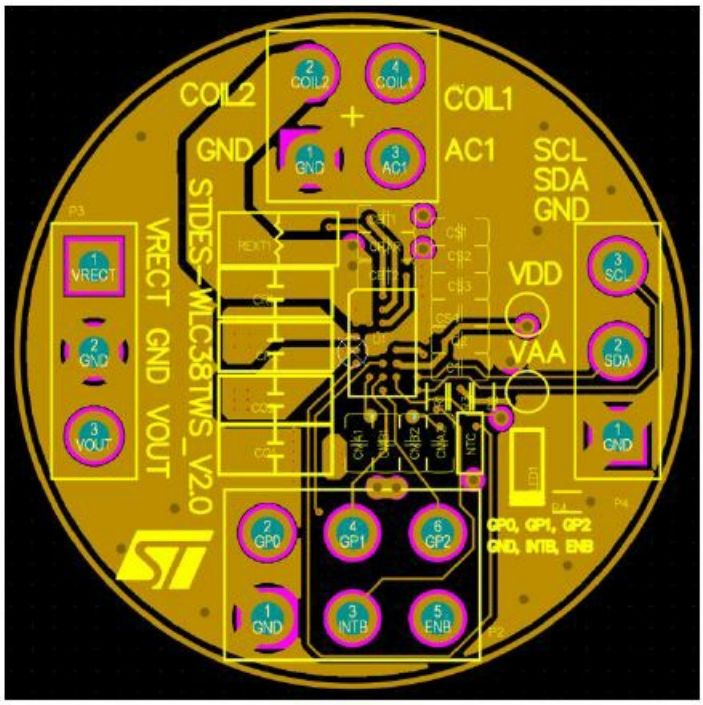


Figure 5. **STDES-WLC38TWS inner2 layer**

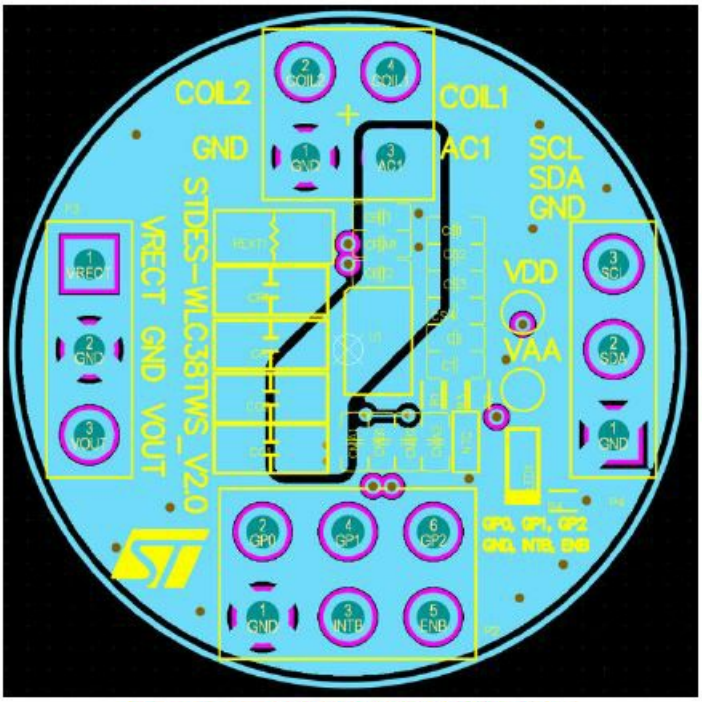
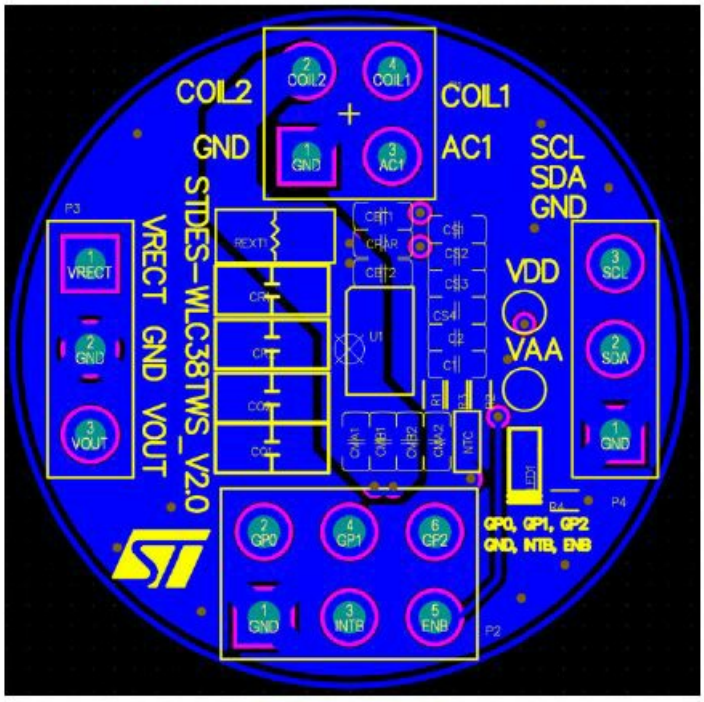


Figure 6. **STDES-WLC38TWS bottom layer**



Typical performance characteristics

The following table shows charging performance of the STEVAL-WBC86TX/STDES-WLC38TWS (Tx/Rx) setup at various load currents, with the temperature being measured after 5 minutes of continuous operation

Table 4. Typical performance characteristics

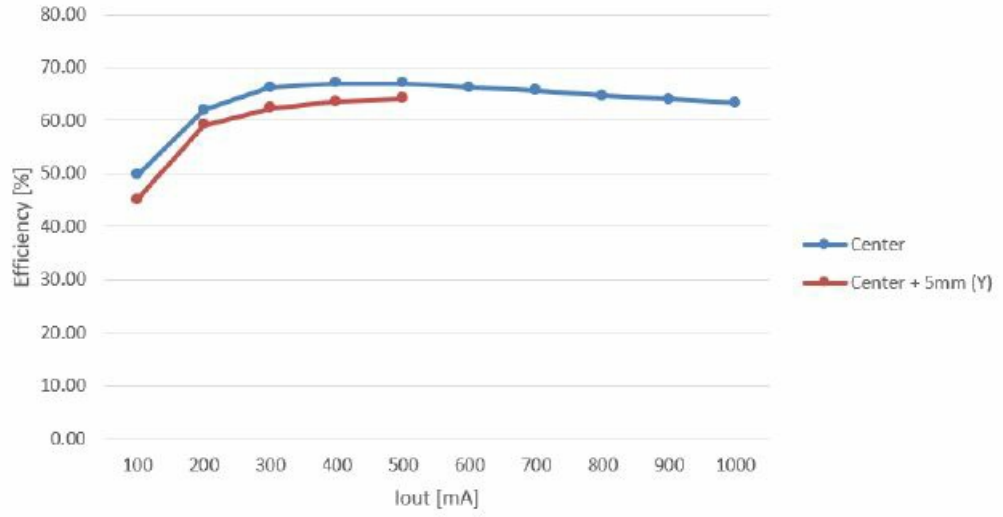
Vin [V]	Iin [mA]	Pin [mW]	Vout [V]	Iout [mA]	Pout [mW]	Eff [%]	TX Trect [°C]	RX Trect [°C]
5.03	200	1006	5	100	500	49.70	30.2	37
5.01	322	1613.22	5	200	1000	61.99	30.3	41
5	453	2265	5	300	1500	66.23	32	45
4.989	598	2983.422	5	400	2000	67.04	33.9	50
4.97	750	3727.5	5	500	2500	67.07	36.2	56
4.96	913	4528.48	5	600	3000	66.25	36.9	63
4.95	1075	5321.25	4.99	700	3493	65.64	40.2	67
4.94	1249	6170.06	4.989	800	3991.2	64.69	43.7	72
4.93	1423	7015.39	4.987	900	4488.3	63.98	47.3	77
4.91	1602	7865.82	4.984	1000	4984	63.36	51.6	81

Efficiency and spatial freedom in the XY plane

Efficiency is one of the most important metrics of wireless charging performance evaluation. Another important metric is the spatial freedom, that is the size of the area in which a power receiver can be placed on the power transmitter, which still allows sufficient power to be transmitted. The STDES-WLC38TWS efficiency and spatial freedom have been measured with the STEVAL-WBC86TX as the receiver. The efficiency has been measured from the transmitter DC input to the receiver DC output. Themeasurement does not include any power losses in the input cable from the power supply.
The test setup consists of:

- a power supply (HMP4040)
- a transmitter (STEVAL-WBC86TX)
- a receiver (STDES-WLC38TWS)
- an electronic load in CC mode (model BK Precision 8500)

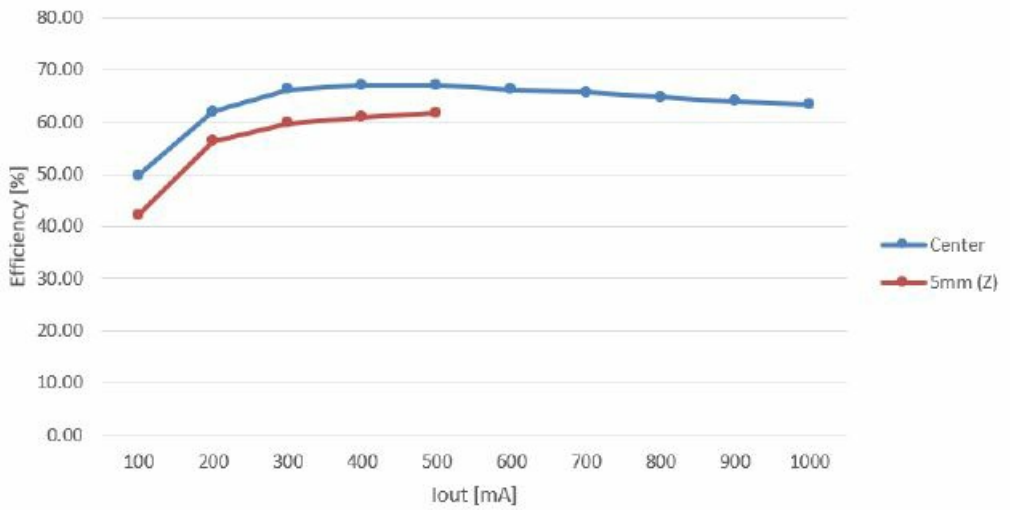
The maximum efficiency achieved with this setup was 67% at a 2.5 W (5 V/500 mA) load. The total gap between the Rx and Tx coils was 3 mm.
Efficiency curves for various misalignments in the X and Y axis are shown in the figure below.



Efficiency and spatial freedom in the Z-axis
The Z-axis distance between the coils, also known as the charging gap, is an additional parameter, which

significantly affects the charging performance. Therefore, the STDES-WLC38TWS has also been tested atvarious charging gap distances.
Efficiency curves for misalignment in the Z-axis are shown in the figure below.

Figure 8. STDES-WLC38TWS and STEVAL-WBC86TX efficiency test in the Z-axis



A Z-distance of 3 mm is a typical value for most applications (2 mm on the Tx side + 1 mm on the Rx side). The transmitter can deliver sufficient power even with a 5 mm charging gap. However, the efficiency rapidly decreases proportionally to the increasing charging gap. Therefore, minimizing the Z-distance whenever possibleis recommended.

Thermal performance

The following picture shows the STDES-WLC38TWS thermal performance with a 2.5 W load (5 V/0.5 A on the Rx side) after 10 minutes of continuous operation

The temperature measured by the thermal-imaging camera can be different from the value measured by TRECT, as the TRECT temperature is measured inside the device.

Figure 9. STDES-WLC38TWS thermal performance (1 of 2)

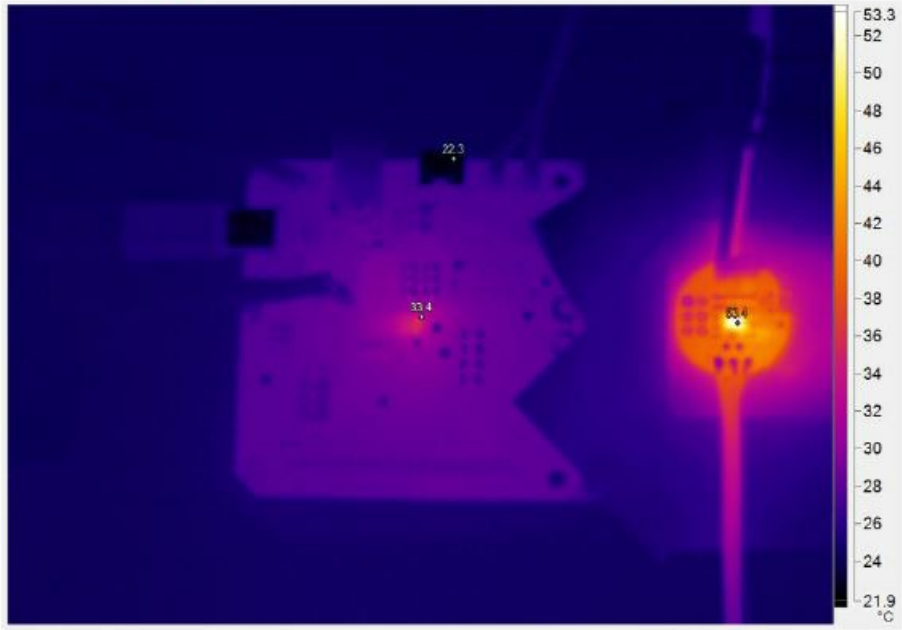
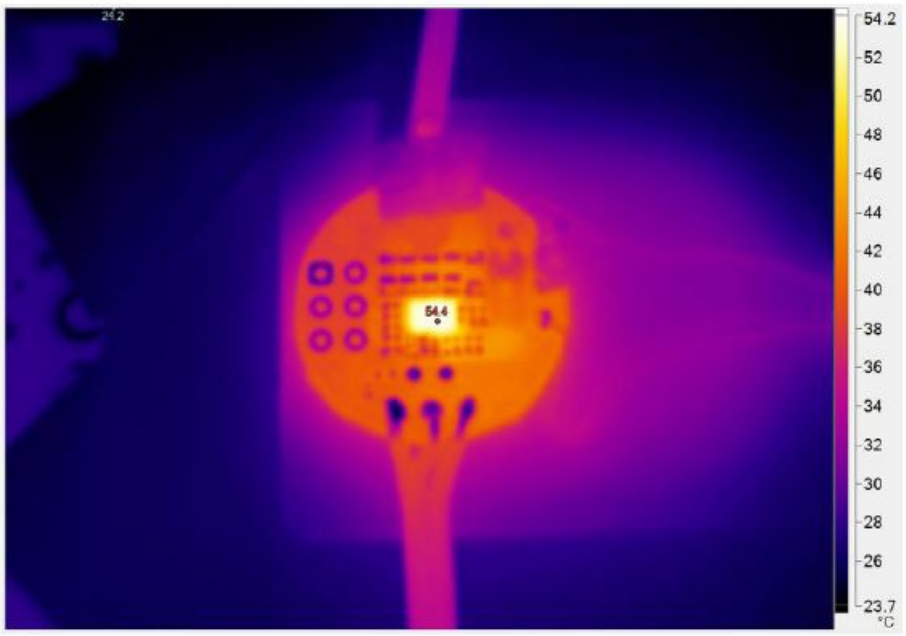


Figure 10. **STDES-WLC38TWS thermal performance (2 of 2)**



Startup waveform

A startup waveform of STDES-WLC38TWS and STEVAL-WBC86TX is shown below. The startup conditions are center position of Rx and Tx coil, 3 mm gap between coil and 100 mA load on Rx Vout.The STEVAL-WBC86TX is powered from a 5 V power supply.

Figure 11. **STDES-WLC38TWS startup waveform**

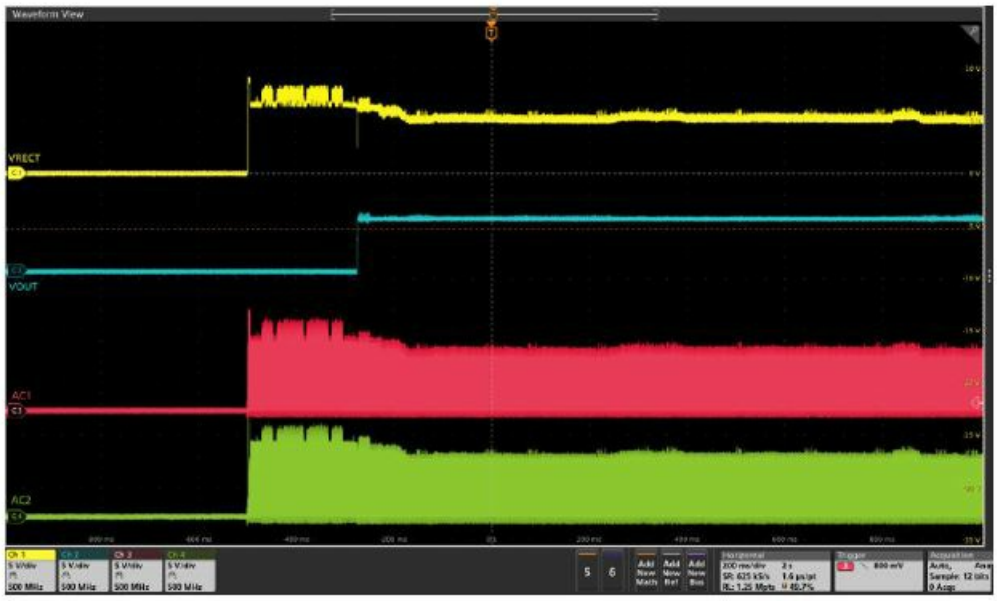
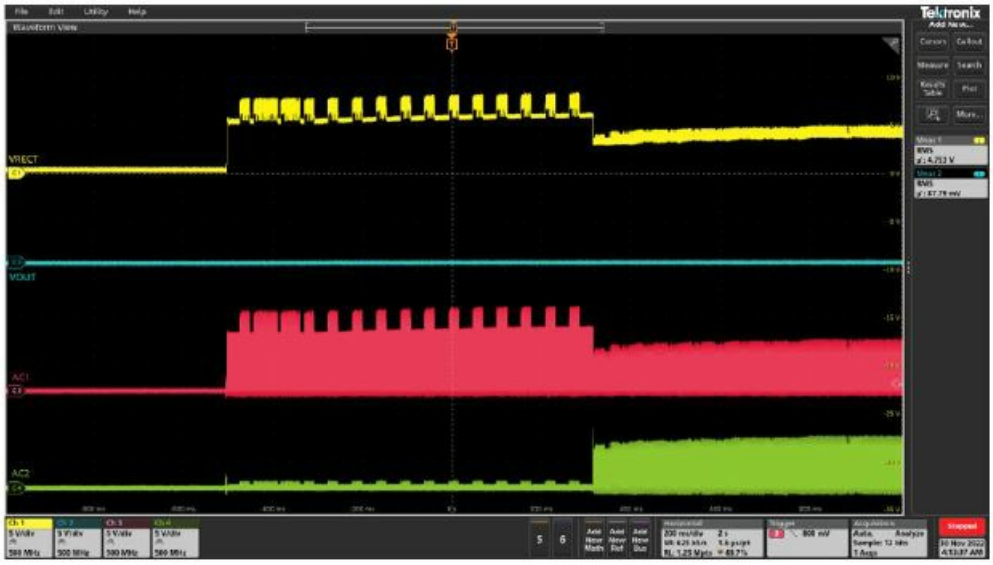
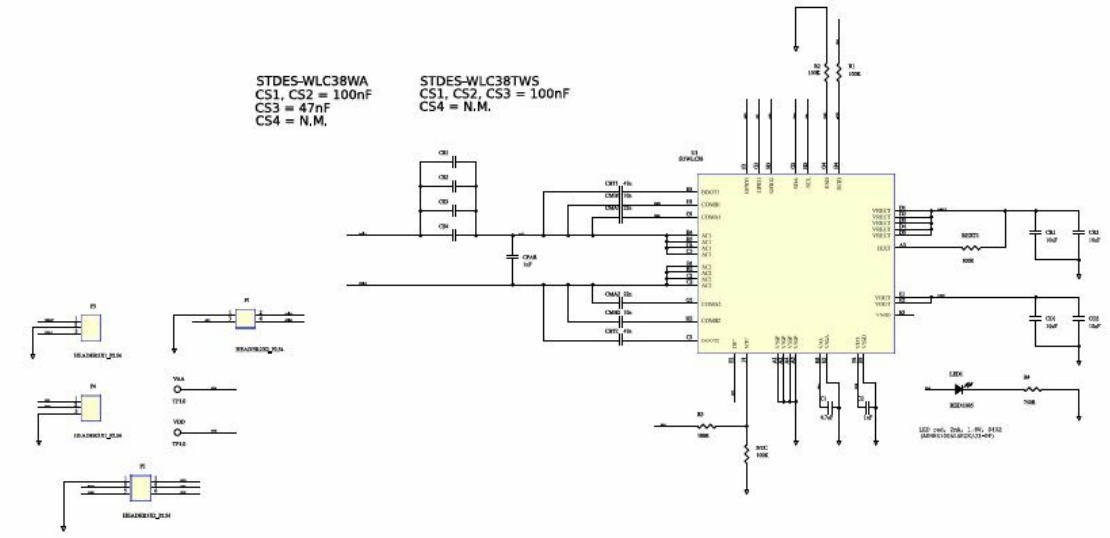


Figure 12. **STDES-WLC38TWS startup waveform with ARC mode and Z gap 14mm**



Schematic diagrams



Bill of materials

Table 5. STDES-WLC38TWS bill of materials

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
1	1	C1	4.7uF, C0402, 6.3 V	4.7uF, 6.3V, ±10%, X5R, 0402	Wurth Elektronik	885012105008
2	1	C2	1uF, C0402, 6.3 V	1µF, 6.3V, ±10%, X7R, 0402	Wurth Elektronik	885012105006

3	2	CBT1, CBT2	47n, C0402, 25 V	47nF, 25V, ±10%, X7R, 0402	Wurth Elektronik	885012205054
4	2	CMA1, CMA2	22n, C0402, 25 V	22nF, 25V, ±10%, X7R, 0402	Wurth Elektronik	885012205052
5	2	CMB1, CMB2	10n, C0402, 25 V	10 , 25V, ±10%, X7R, 0402	Wurth Elektronik	885012205050
6	4	CO1, CO2, CR1, CR2	10uF, C0805, 25 V	10uF, 25V, ±10%, X5R, 0805	Murata	GRM21BR61E106KA73L
7	1	CPAR	1nF, C0402, 25 V,	1nF, 25V, ±10 %, X7R, 0402	Wurth Elektronik	885012205044
8	3	CS1, CS2, CS3	100n, C0402, 25 V	100 , 25V, ±10%, X7R, 0402	Wurth Elektronik	885012205085R
9	1	CS4	N.M., C0402	N.M.	–	–
10	1	LED1	RED/1005, LED1005, 1.8 V	RED, 2mA, 1.8V, 0402	Kingbright	APHHS1005LSECK/J3-PF
11	1	NTC	100K, R0402	100Kohm, ±1 %	Murata	NCP15WF104F03RC
12	1	P1	HEADER2X2_P 2.54, HEADER2X2_P 2.54	13uH, T=0.6 mm, solder on pin 2 and 4 (edge of PCB)	Luxshare	LE15FP005-1H
13	1	P2	N.M., HEADER3X2_P 2.54		Samtec	TSW-103-23-F-D

14	2	P3, P4	N.M., HEADER3X1_P 2.54		Harwin	M20-9990345
15	3	R1, R2, R3	100K, R0201		YAGEO	RC0201FR-07100KL
16	1	R4	750R, R0201		YAGEO	RC0201FR-07750RL
17	1	REXT1	100R, R0805, 500 mW, 0,05 %	100Ω, 0805	Panasonic	ERJ-P06J101V
18	1	U1	STWLC38JRM, WLCSP402.126X3.327X0.546 0.4P 0	Qi-compliant inductive wireless power receiver for up to 15W applications	ST	STWLC38JRM
19	2	VAA, VDD	TP1.0, TP1.0	Test points N.M.	–	–

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
20	1	–	–	Plastic spacer	Any	Any
21	1	–	2 mm	Adhesive tape	Any	Any

Conclusions

The test results show that the STDES-WLC38TWS reference design can automatically detect TX and able to receive requested power from the STEVAL-WBC86TX transmitter board. The peak efficiency of STEVAL-WBC86TX and STDES-WLC38TWS is > 67 % at 2.5 W. The STDES-WLC38TWS reference design achieved expected performance with the STEVAL-WBC86TX transmitter board.

Appendix

Appendix A Reference design warnings, restrictions and disclaimer

Important: The reference design is not a complete product. It is intended exclusively for evaluation in laboratory/ development environments by technically qualified electronics experts who are familiar with the dangers andapplication risks associated with handling electrical/mechanical components, systems and subsystems.

Danger: Exceeding the specified reference design ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings, contact an STMicroelectronics field representative prior to connecting interface electronics, including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the reference

design and/or interface electronics. During normal operation, some circuit components may reach very high temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current senseresistors which can be identified in the reference design schematic diagrams.

STMicroelectronics reference designs are solely intended to assist designers (“buyers”) who are developing systems that incorporate STMicroelectronics semiconductor products (herein, also referred to as “components”). The buyer understands and agrees that he/she is the only responsible for independent analysis, evaluation and judgment in designing his/her own systems and products. STMicroelectronics has conducted only the measurements and tests specifically described in the published documentation for the specified reference design. STMicroelectronics may correct, enhance, improve its reference designs for future development. STMicroelectronics reference designs are provided “as is”. STMicroelectronics does not promise that reference designs are accurate or error free. STMicroelectronics makes no warranties or representations with regard to the reference designs or use of the reference designs, express, implied or statutory, and specifically disclaims all warranties, express or implied, as to the accuracy or completeness of the information contained therein. STMicroelectronics disclaims any warranty of title and any implied warranties of merchantability, fitness for a particular purpose and non-infringement of any third-party intellectual property rights concerning STMicroelectronics reference designs or their use. STMicroelectronics shall not be liable for and shall not defend or indemnify buyers against third-party infringement claim that relates to or is based on a combination ofcomponents provided in an STMicroelectronics reference design.In no event shall STMicroelectronics be liable for any actual, special, incidental, consequential or indirect damages, however caused, on any theory of liability and whether or not STMicroelectronics has been advised of the possibility of such damages, arising in any way out of STMicroelectronics reference designs or buyer’s use of STMicroelectronics reference designs. You further acknowledge and agree that the reference designs may not be used in or in connection with any legal or administrative proceeding in any court, arbitration, agency, commission or other tribunal or in connection with any action, cause of action, litigation, claim, allegation, demand or dispute of any kind.

Revision history

Table 6. Document revision history

Date	Revision	Changes
07-Mar-2023	1	Initial release.
01-Aug-2023	2	Modified title in cover page. Updated **Section 6 Schematic diagrams** and **Section 7 Bill of materials**.

List of tables

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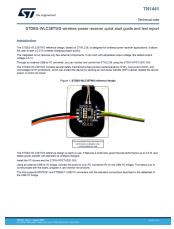
Documents / Resources



TN1445

Technical note

STDES-WLC38TWS wireless power receiver quick start guide and test report

Introduction

Figure 1. STDES-WLC38TWS reference design

	ST STDES-WLC38TWS Wireless Power Receiver [pdf] User Manual STDES-WLC38TWS Wireless Power Receiver, STDES-WLC38TWS, Wireless Power Receiver, Power Receiver, Receiver