STDES-WLC38WA Wireless Power Receiver User Guide

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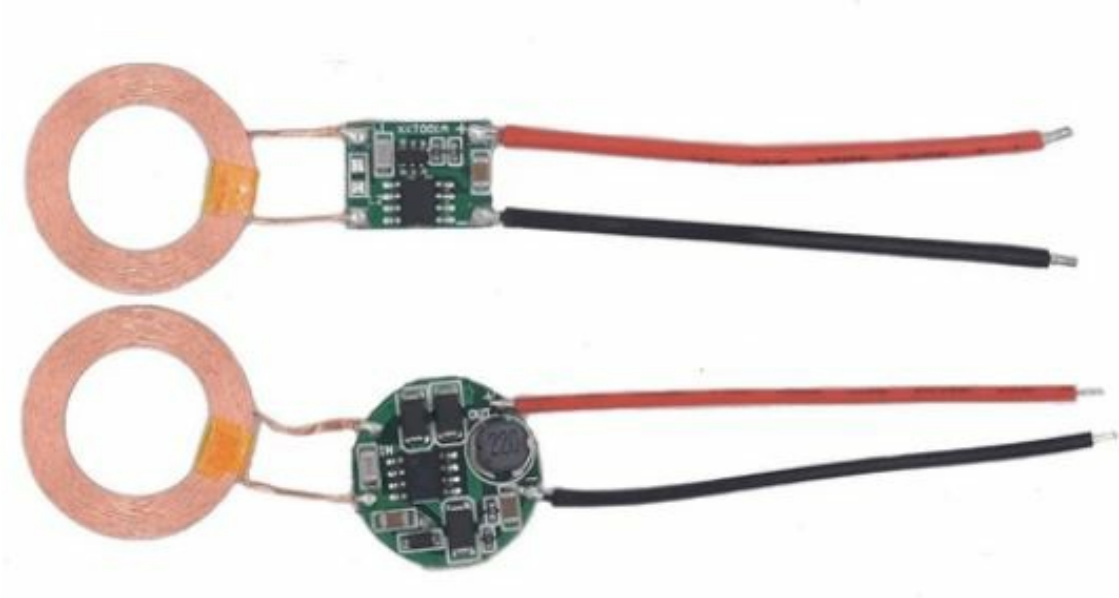
STDES-WLC38WA Wireless Power Receiver



Product Information

The STDES-WLC38WA is a wireless power receiver reference design developed by STMicroelectronics. It is optimized for performance and features several components and functionalities:

- 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

The STDES-WLC38WA is equipped with all the necessary components for standalone operation. It requires the connection of a coil to the COIL1 and COIL2 pads. The AC1 pad is used for debug purposes.

Product Usage Instructions

To use the STDES-WLC38WA wireless power receiver reference design, follow these steps:

1. Connect the coil to the COIL1 and COIL2 pads on the board.
2. Ensure that the AC1 pad is not connected unless for debug purposes.
3. Make sure that the default configuration is suitable for your needs. The default configuration includes enabled interrupts, GPIOs, and protections. Refer to the user manual for details on the default configuration.
4. Power on the board using a suitable power source.
5. Monitor the performance of the wireless power receiver by measuring the charging performance at various

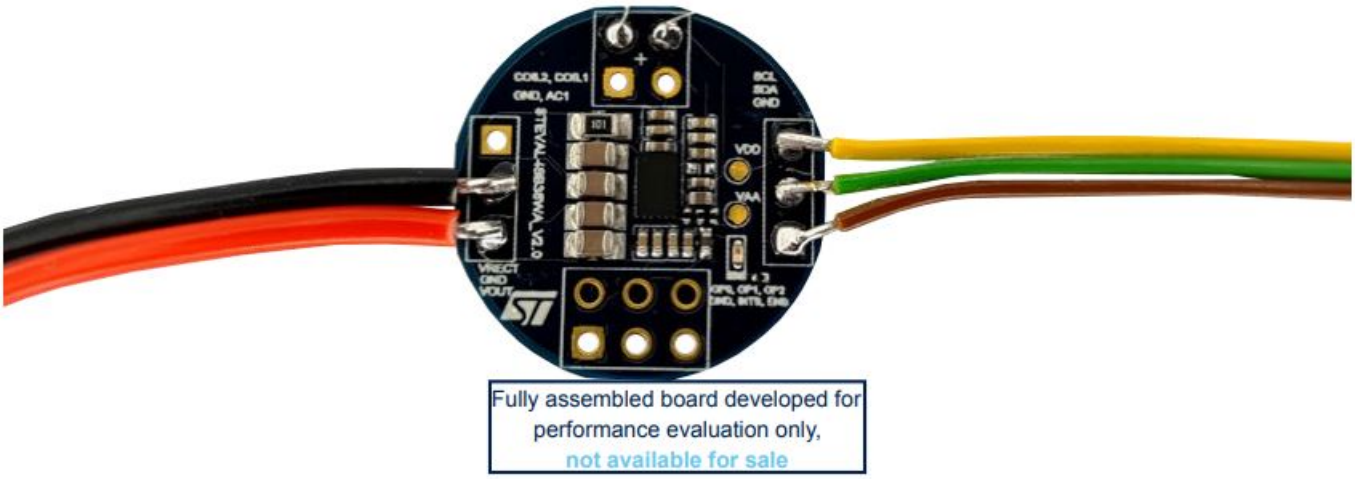
load currents. Refer to the user manual for typical performance characteristics.

For further information or assistance, please contact your local STMicroelectronics sales office or visit the official website at **www.st.com**.

Introduction

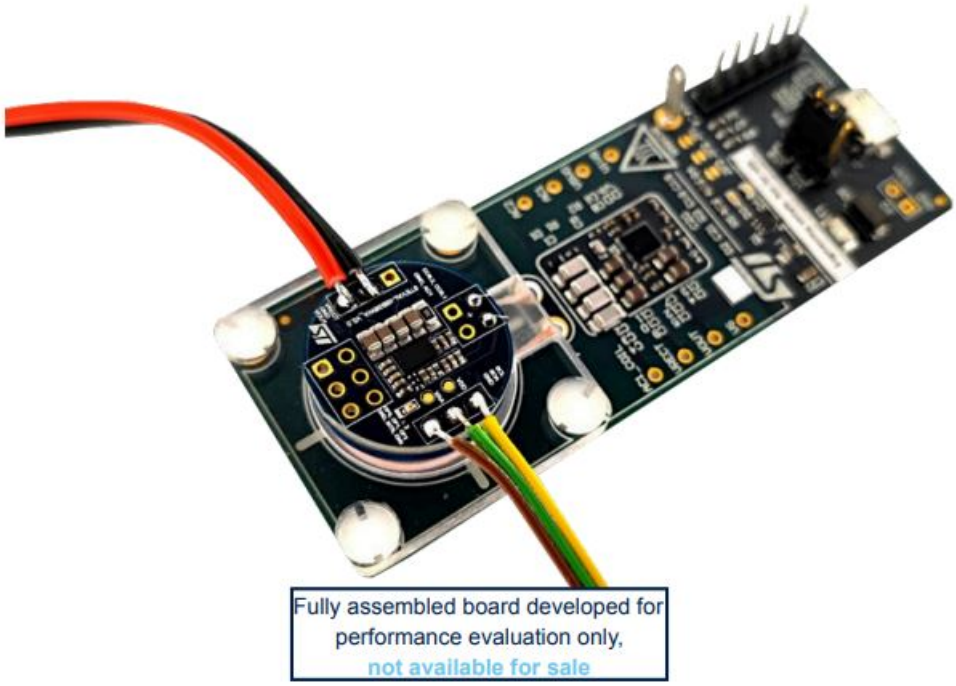
The STDES-WLC38WA reference design, based on STWLC38, is designed for wireless power receiver applications. It allows the user to start a 2.5 W wireless charging project quickly. It features a small size, good thermal performance, and stable power transfer. The integrated circuit requires only few external components. The device output voltage is adjustable (the default value is 5 V). Through an external USB-to-I²C converter, you can monitor and control the STWLC38 using the STSW-WPSTUDIO GUI. The STDES-WLC38WA 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 the receiving coil.

Figure 1. STDES-WLC38WA reference design



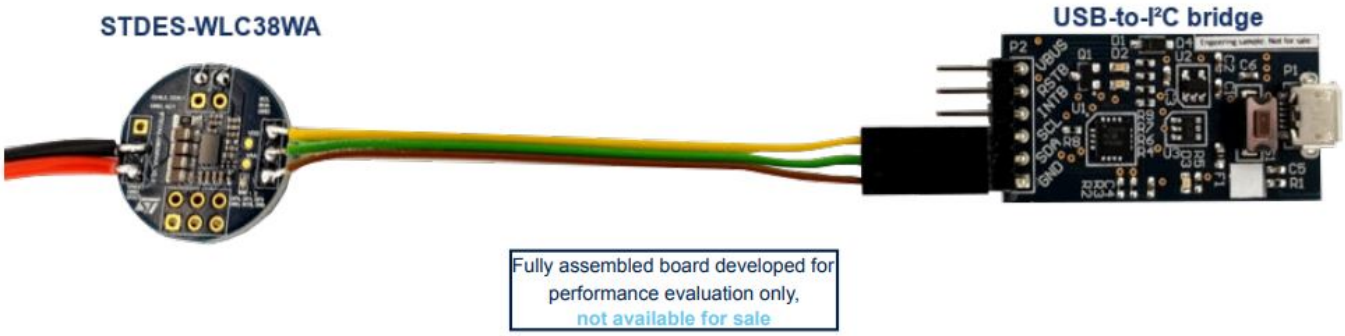
The STDES-WLC38WA reference design is ready to use with the STDES-WBC86WTX.

Figure 2. STDES-WLC38WA reference design plus STDES-WBC86WTX



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.

Figure 3. STDES-WLC38WA reference design plus USB-to-I²C bridge



The GUI supports MCP2221 and FT260Q-T USB-I²C converters. Standard connections are described in the datasheets of the converters.

Overview

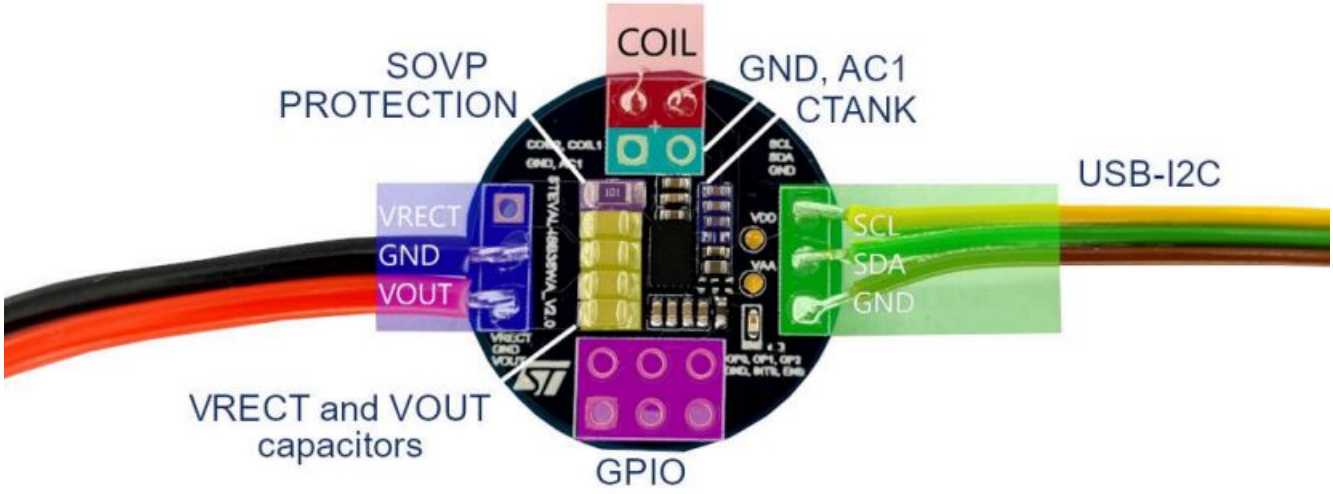
The STDES-WLC38WA is optimized for performance. The board and IC feature:

- 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 4. STDES-WLC38WA connection overview

Figure 4. **STDES-WLC38WA connection overview**



The STDES-WLC38WA is equipped with all components necessary for a standalone operation. The coil has to be connected to pads (COIL1 and COIL2). The pad labeled as AC1 is used for debug purposes. The rectifier output is labeled VRECT. The output voltage is VOUT. The I²C interface is used to monitor/control the device. GPIOs are accessible on the six-pin header.

Test points
STDES-WLC38WA 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

Target specification of the STDES-WLC38WA reference design are listed in the table below.

Table 2. STDES-WLC38WA specifications

Parameter	Description
RX application PCB area	20 mm
RX coil specifications	Inductance 11.8 µH, dimensions Φ15 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	58.24% (2.5 W operation)with STDES-WBC86WTX 60.23% (peak efficiency)with STDES- WBC86WTX at 2 W Total distance between coils 3mm.
Applicable charging gap between Tx and Rx coils (z-distance)	4 mm (X and Z axis; 2.5 W output) with the STDES- WBC86WTX transmitter, maximum 7 mm – stable communication without output enabled
Operational modes	Receiver only

Default configuration

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 between Vrect and ground
    - TSHUT (HW OVTP)
        - Disable VOUT
        - Short RX COIL
    - HOVP (HW OVP)
        - Short RX COIL
    - OCP (HW)
        - Disable VOUT

PCB layout

Figure 5. STDES-WLC38WA top layer

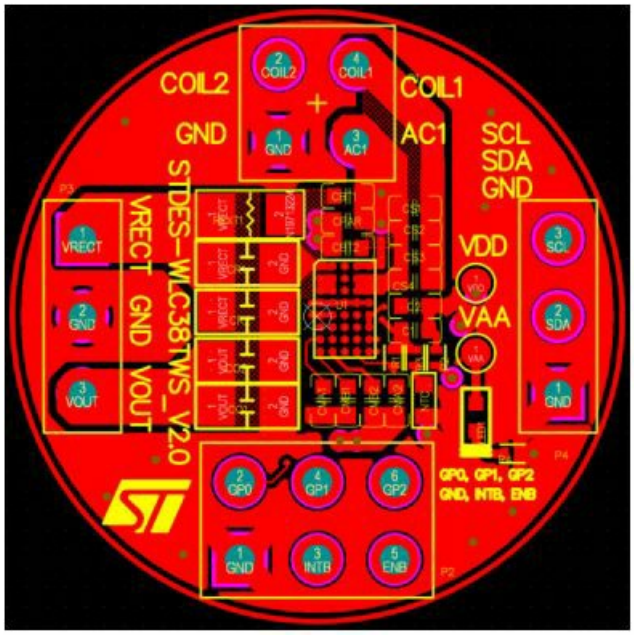


Figure 6. STDES-WLC38WA inner1 layer

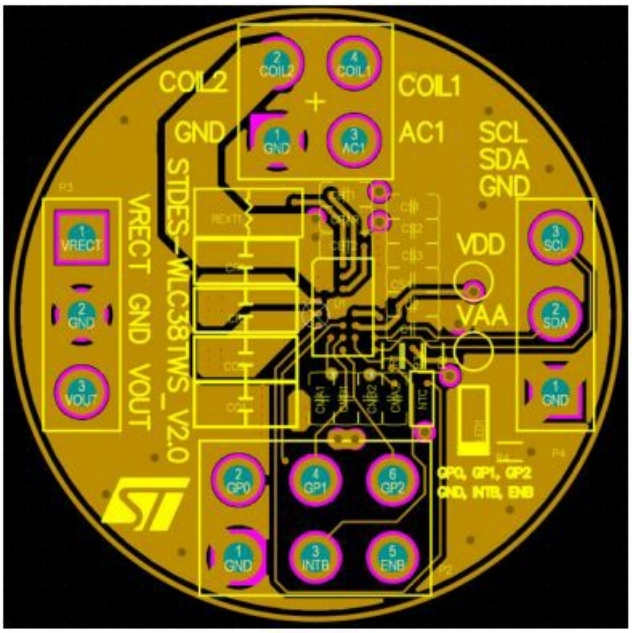


Figure 7. STDES-WLC38WA inner2 layer

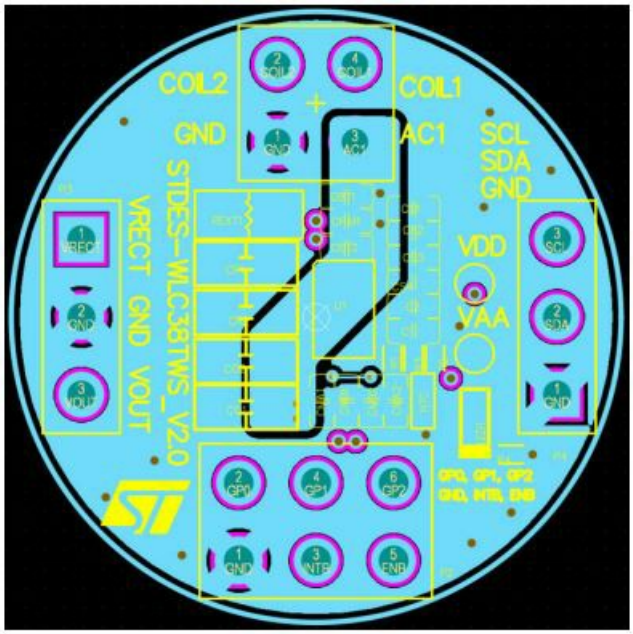
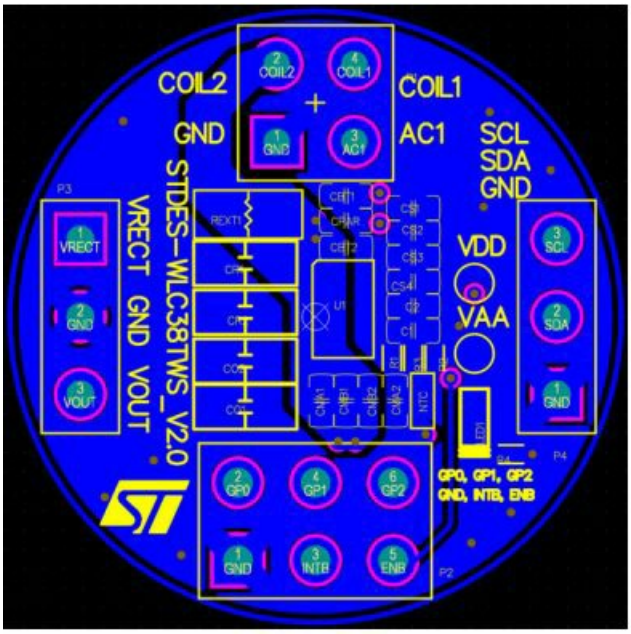


Figure 8. STDES-WLC38WA bottom layer



Typical performance characteristics

The following table shows charging performance of the STDES-WBC86WTX/STDES-WLC38WA (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]
5.09	263	1338.67	5.035	100	503.5	37.61	42	37
5.042	382	1926.04	5.032	200	1006.4	52.25	45.5	39
5.026	502	2523.052	5.032	300	1509.6	59.83	49.8	44
4.986	670	3340.62	5.03	400	2012	60.23	58.2	49
4.985	860	4287.1	5.028	500	2514	58.64	65.2	57

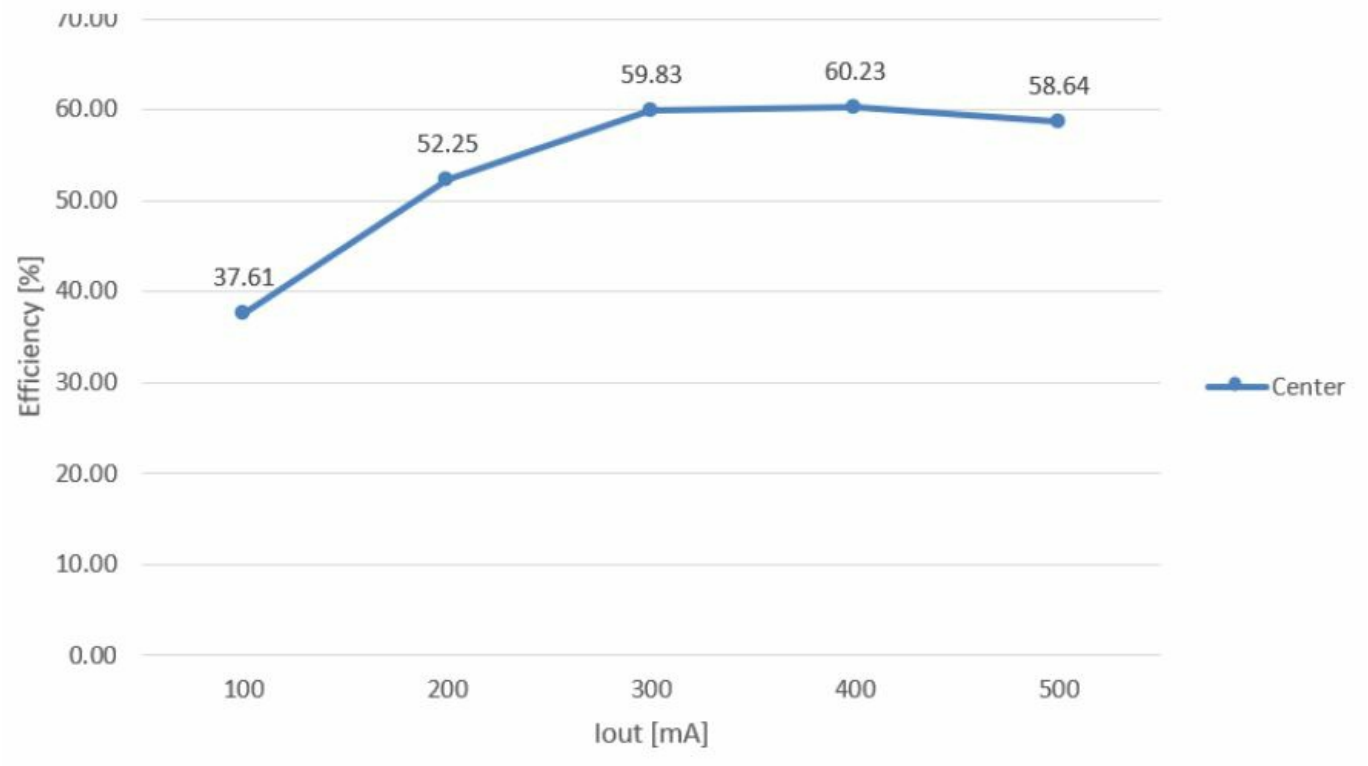
Efficiency and spatial freedom in the XY plane
Efficiency is one of the most important metrics of wireless charging performance evaluation. Another important metric is the spatial freedom, that is the size of the area in which a power receiver can be placed on the power transmitter, which still allows sufficient power to be transmitted. The STDES-WLC38WA efficiency and spatial freedom have been measured with the STDES-WBC86WTX as the receiver. The efficiency has been measured from the transmitter DC input to the receiver DC output. The measurement 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 (STDES-WBC86WTX)
- a receiver (STDES-WLC38WA)
- an electronic load in CC mode (model BK Precision 8500)

The maximum efficiency achieved with this setup was 60.23% at a 2 W (5 V/400 mA) load. The total gap between the Rx and Tx coils was 3 mm.

Note:
This efficiency measurement has been performed with a Φ15 mm small Rx coil and a Φ20mm Tx coil.

Figure 9. STDES-WLC38WA and STDES-WBC86WTX efficiency test



Thermal performance
The following picture shows the STDES-WLC38WA 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 10. STDES-WLC38WA thermal performance (1 of 2)

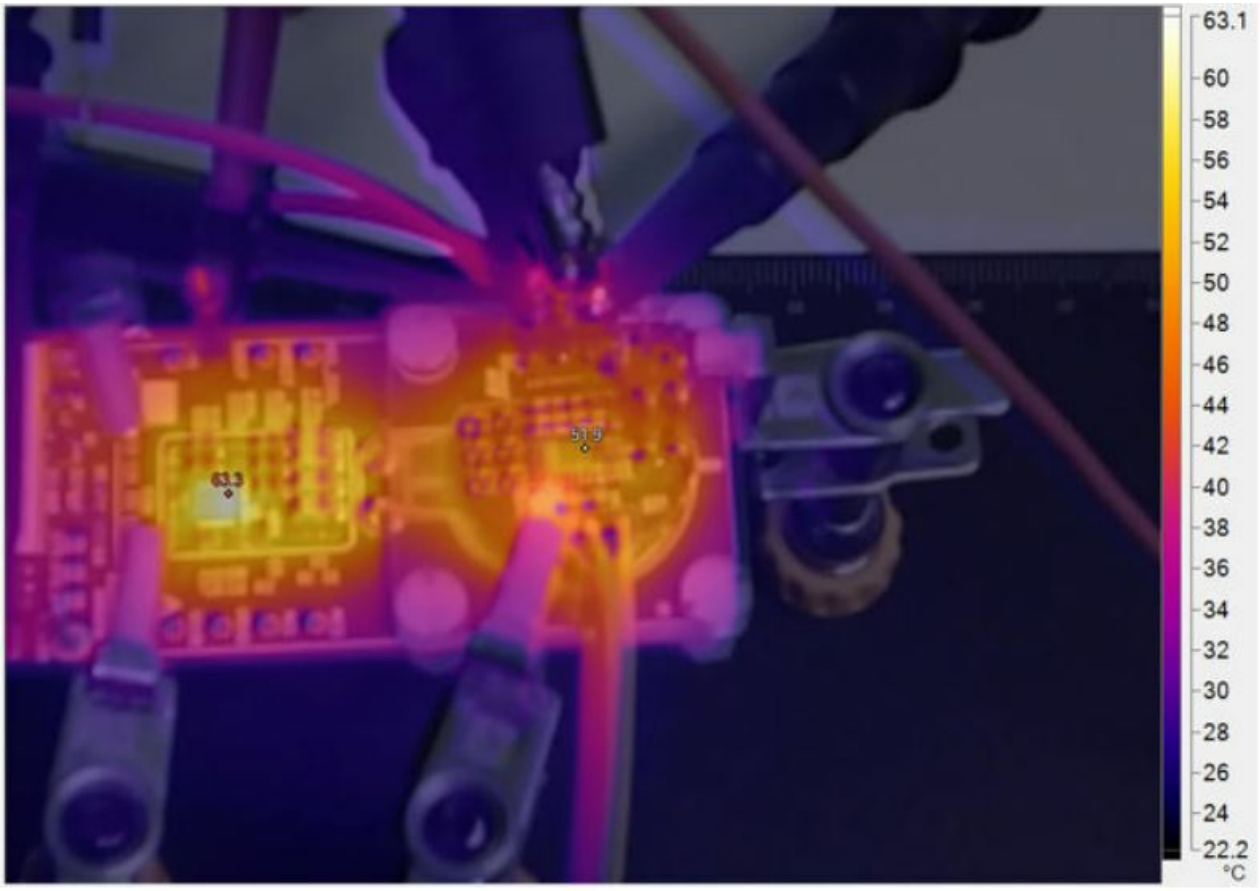
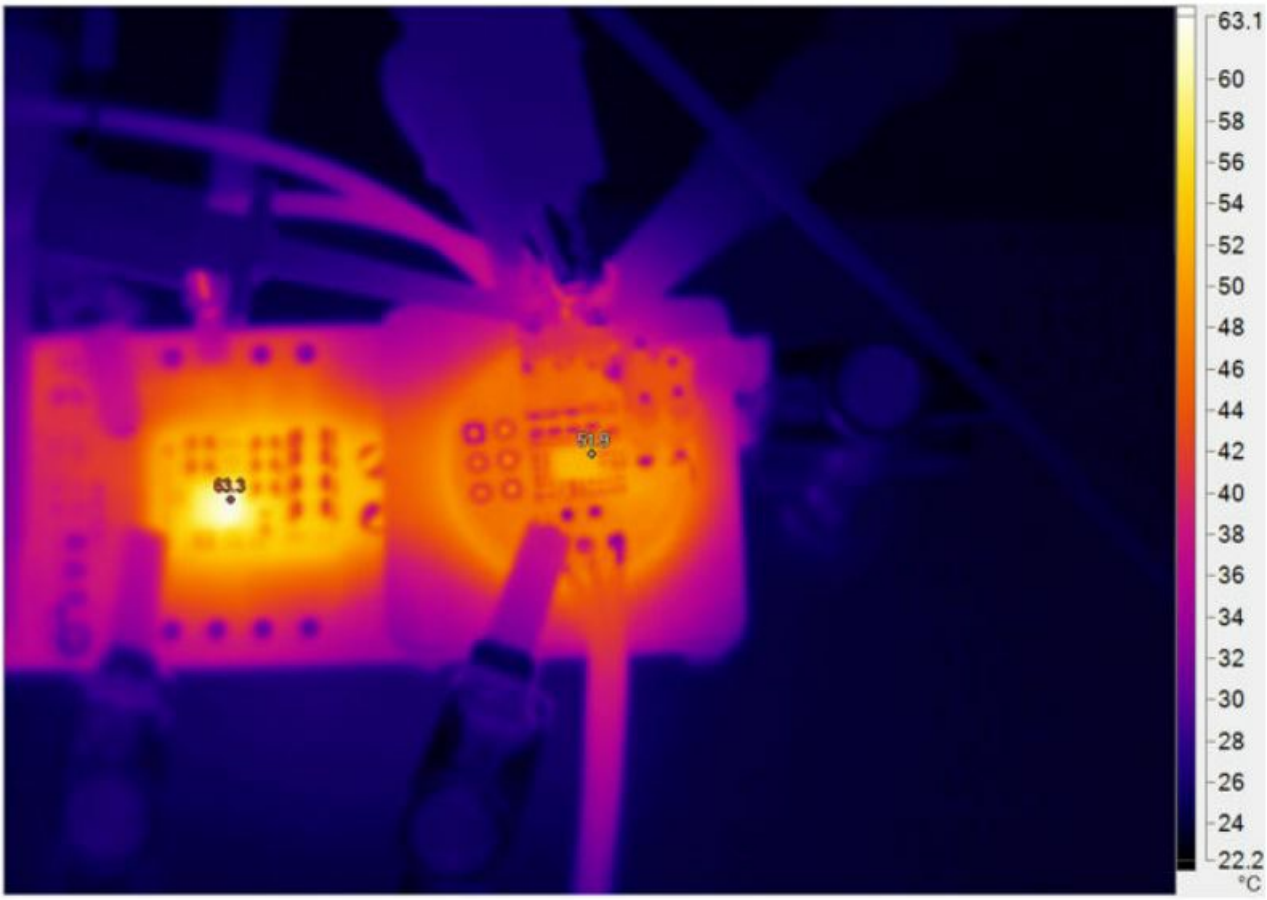


Figure 11. STDES-WLC38WA thermal performance (2 of 2)

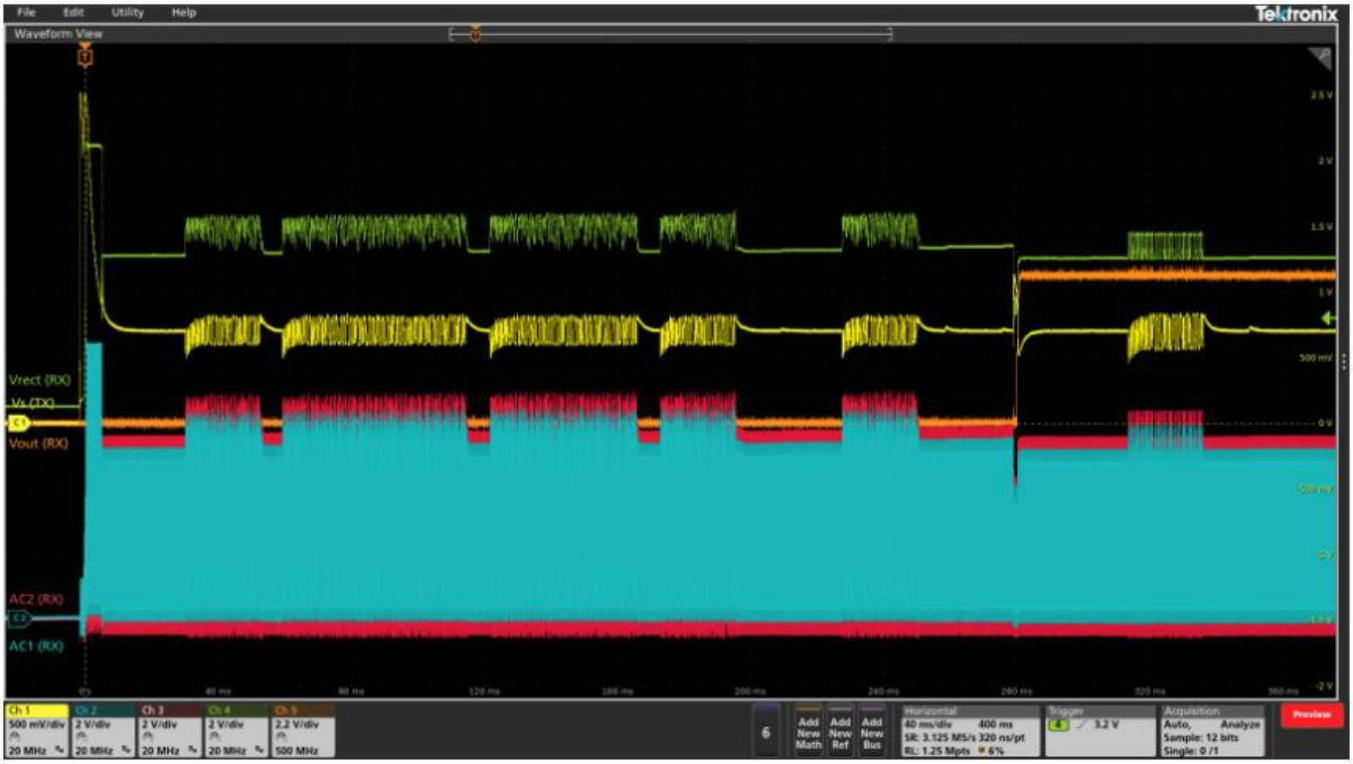


Startup waveform

A start-up waveform of STDES-WLC38WA and STDES-WBC86WTX is shown below. The start-up conditions are

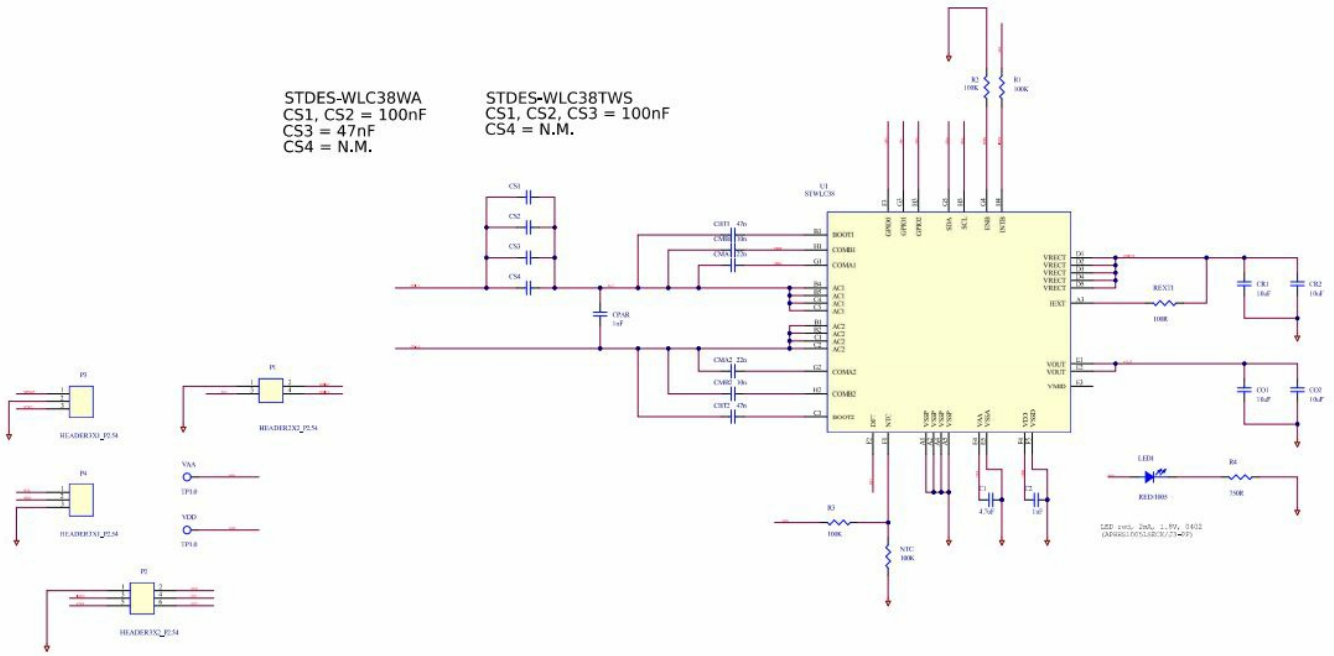
center position of RX and TX coil, 3mm gap between coil and 100mA load on Rx Vout. The STDES-WBC86WTX is powered from a 5 V power supply.

Figure 12. STDES-WLC38WA startup waveform



Schematic diagrams

Figure 13. STDES-WLC38WA circuit schematic



Bill of materials

Table 5. STDES-WLC38WA bill of materials

Item	Q.ty	Ref.	Value	Description	Manufacturer	Part Number
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	3	CBT1, CBT2,CS3	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	10nF, 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	2	CS1, CS2	100n, C0402, 25 V	100nF, 25V, ±10%, X7R, 0402	Wurth Elektronik	885012205085R
9	1	CS4	N.M., C0402	N.M.		N.M.
10	1	LED1	RED/1005, LED1005, 1.8 V	RED, 2mA, 1.8 V, 0402	Kingbright	APHHS1005LSECK/J3 - PF
11	1	NTC	100K, R0402	100Kohm, ±1%	Murata	NCP15WF104F03RC

12	1	P1	HEADER2X2_P2.54	11.8uH, T=0.6 mm, Φ=15mm, solder on pin 2 and 4 (edge of PCB)	Wurth	760308101219
13	1	P2	N.M., HEADER3X2_P2.54	Header	Samtec	TSW-103-23-F-D
14	2	P3, P4	N.M., HEADER3X1_P2.54	Header	Harwin	M20-9990345
15	3	R1, R2, R3	100K, R0201	Resistors	YAGEO	RC0201FR-07100KL
16	1	R4	750R, R0201	–	YAGEO	RC0201FR-07750RL
17	1	REXT1	100R, R0805, 500m W, 0.05 %	100Ω, 0805	Panasonic	ERJ-P06J101V
18	1	U1	STWLC38JRM, WLCSP40 2.126X3.327X0.546 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.	Any	Any
20	1	–	–	Plastic spacer	–	–
21	1	–	–	Adhesive tape 2 mm	–	–

Conclusions

The test results show that the STDES-WLC38WA reference design can automatically detect TX and is able to receive requested power from the STDES-STWBC86WTX transmitter board. The peak efficiency of STDES-STWBC86WTX and STDES-WLC38WA is 60.23% at 2 W. At 2.5 W the efficiency is 58.24%. The STDES-WLC38WA reference design achieved expected performance with the STDES-STWBC86WTX transmitter board.

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 and application 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 sense resistors which can be identified in the reference design schematic diagrams.

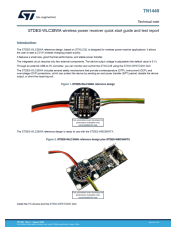
STMicroelectronics reference designs are solely intended to assist designers (“buyers”) who are developing systems that incorporate STMicroelectronics semiconductor products (herein, also referred to as “components”). The buyer understands and agrees that he/she is the only responsible for independent 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 of components 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
10-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.

Documents / Resources

	ST STDES-WLC38WA Wireless Power Receiver [pdf] User Guide STDES-WLC38WA Wireless Power Receiver, STDES-WLC38WA, Wireless Power Receiver, Power Receiver

References

- STMicroelectronics: Our technology starts with you
- STMicroelectronics Trademark List - STMicroelectronics
- STDES-WBC86WTX - 2.5W Qi compatible wireless power transmitter reference design for wearable applications - STMicroelectronics
- STDES-WLC38WA - Qi-1.3 compatible wireless power receiver reference design for 2.5W wearable applications - STMicroelectronics
- STSW-WPSTUDIO - Graphical user interface for wireless power receiver and transmitter evaluation boards - STMicroelectronics
- STWLC38 - Qi-compliant inductive wireless charger power receiver for up to 15W applications - STMicroelectronics