



TSWIRX-5V-EVM
Wireless Charging Receiver

WIRELESS CHARGING

User Guide

TSWIRX-5V-EVM
Low Power Wearables Receiver

Introduction

The Semtech TSWIRX-5V-EVM is an evaluation platform for the test and experimentation of a wireless charging receiver based on the Semtech TS51221 High Efficiency Regulator IC for Wireless Power Receiver Applications. This evaluation module, in conjunction with its compatible receiver the TSWITX-EVM, provides a complete system solution for low-power, wearable infrastructure power transmission.

Objectives

The objective of this User Guide is to provide a fast, easy and thorough method to experiment with and evaluate the Semtech solutions for wireless charging systems. Sufficient information is provided to support the engineer in all aspects of adding wireless charging support to their products. Semtech offers a range of solutions to meet the needs of a wide range of system developers. Developers are provided with all the information on how this EVM was built as a starting point for their own designs based on the TS51221.

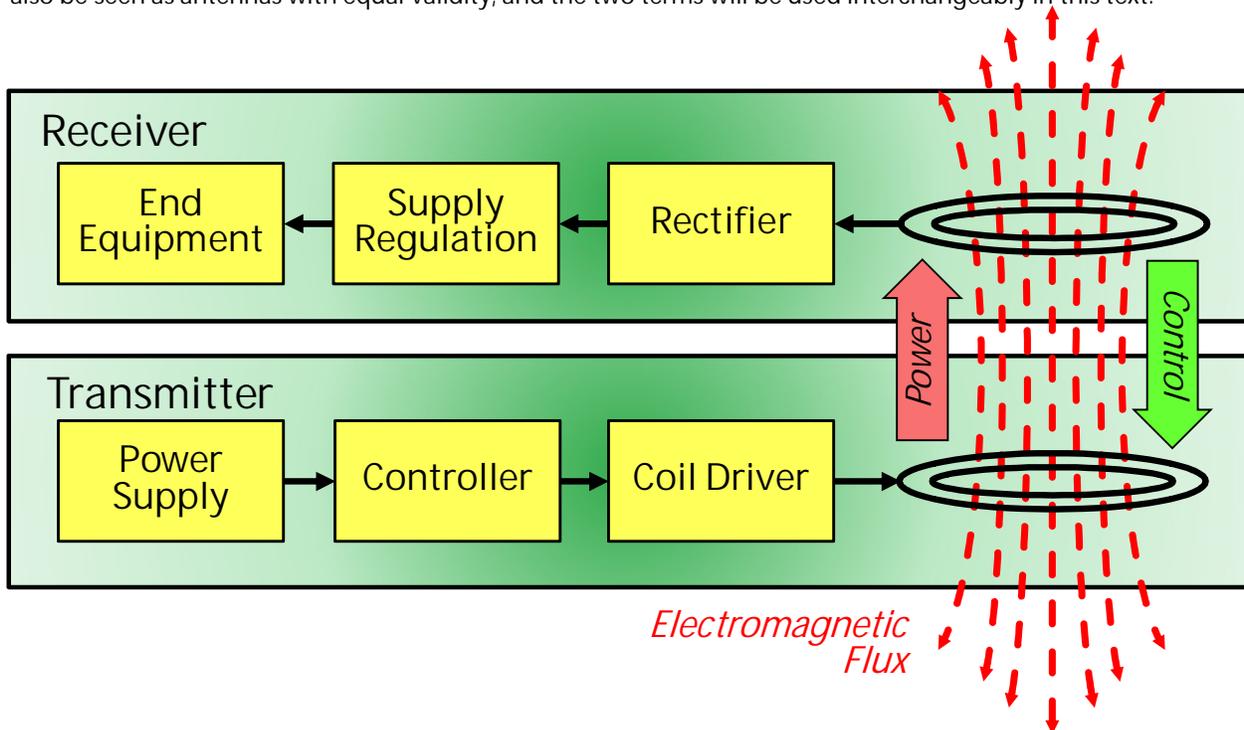
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Wireless Charging Concepts

Wireless power transfer is, essentially, a transformer. Power is provided to a primary coil which produces an electromagnetic (EM) field. In this field, a secondary coil is placed. The EM field induces a current into the secondary coil, providing power to whatever it is connected to.

However, unlike a conventional power transformer that operates at line frequencies and requires an iron core for efficiency, low power wireless power systems for wearable devices have been designed to operate in the 1 MHz range, and thus can perform efficiently with an air core. As such, the primary and secondary windings, if closely spaced, can be in separate devices, the primary being part of a transmitter and the secondary within a receiver. This implementation can also be described as a radio broadcast process, and as such, these transformer coils can also be seen as antennas with equal validity, and the two terms will be used interchangeably in this text.



Wireless power systems differ in another major aspect from conventional transformers, in that they are intelligently managed. A transmitter will only provide power when a receiver is present, and only produce the amount of power requested by the receiver. The intelligent management of the wireless power transmission process is achieved through the programming of the transmitter-resident TS80002, which first searches for a receiver. Once found, the receiver informs the transmitter of its power requirements, and transmission begins. The system then verifies the right amount of power is being sent. The receiver continually provides ongoing requests for power to maintain the transaction. If the requests cease, the transaction terminates. Via this protocol, even complex charging patterns can be supported, as the transmitter can provide varying amounts of power at different times, as requested by the receiver. Should the receiver require no further power, such as when a battery charge is completed, it can request no further power be sent, and the transmitter will reduce its output accordingly.

Wireless power systems have been broken into three basic power categories. “Wearable” devices, such as headsets, wrist-band devices, medical sensors, and so forth - all operate in the low power range, up to 5 watts. Medium power devices, in the 5- to 15-watt range, include most handheld devices, such as cell phones, tablets, and medical electronics. High power wireless systems are intended to support devices such as power tools, radio controlled (“RC”) devices such as drones, and other equipment requiring 15 to 100 watts of power.

Product Description

The TSWIRX-5V-EVM Evaluation Module is a ready-to-use demonstration platform allowing testing of approximately 1 watt of wireless power transmission. Its output power will range from about 0.5 to 2 watts depending on antenna coil selection.

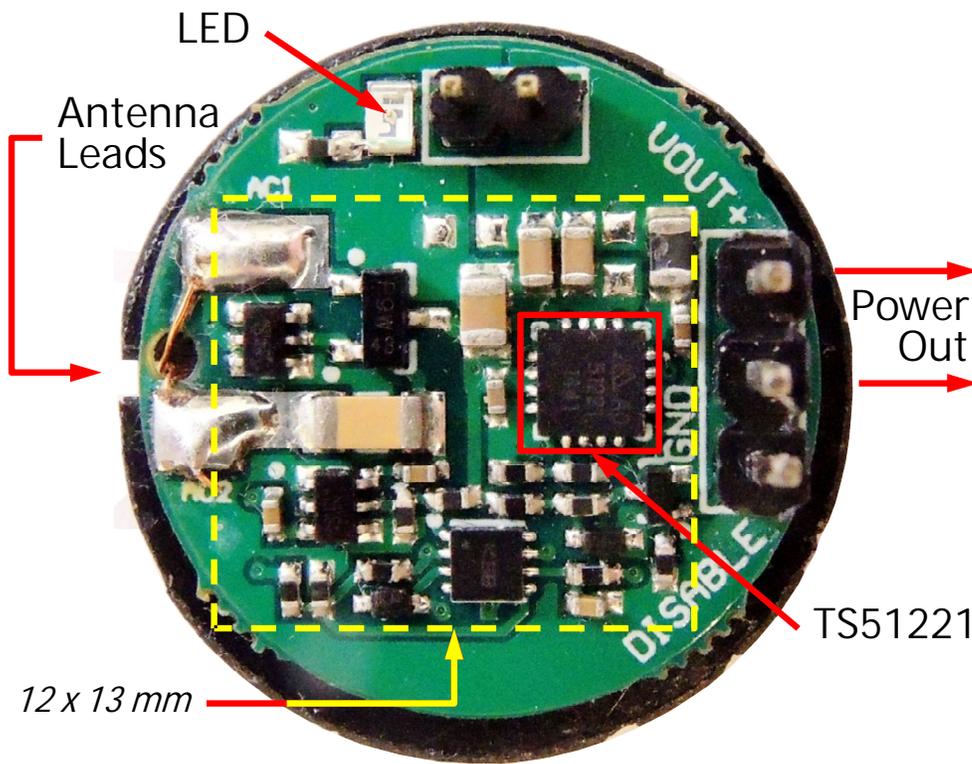
The receiver is coupled with its compatible transmitter module, the Semtech TSWITX-EVM, to form a complete wireless power transmission system. Together, they allow a variety of experiments to easily be performed in order to learn more about the behavior of the system.

Those who wish to develop their own board, or integrate this functionality into an existing system can use the EVM as a starting point for their design, as it demonstrates a working model from which to proceed. Toward this end, all documentation for the EVM is provided to make the process as efficient as possible.

The key technology in the EVM is the Semtech TS51221, which is a high efficiency regulator device for low-power wireless power receiver applications. Its 1 MHz switching frequency enables the use of small filter components resulting in minimal board space and reduced costs. It integrates a wide range of protection circuitry including input supply under-voltage lockout, output voltage soft start, current limiting, and thermal shutdown. The TS51221 can produce up to 1 amp of current, though this EVM was designed as an example of a system to provide about 1 watt of power. Developers can vary the supporting componentry to meet their goals as desired.

In this user guide, an introduction will be provided to the evaluator for how to use the EVM for wireless power transmission as well as how the TSWITX-EVM can be used in conjunction with it.

Once the system is set up and working, a selection of tests and activities will be described that the evaluator can choose to perform.



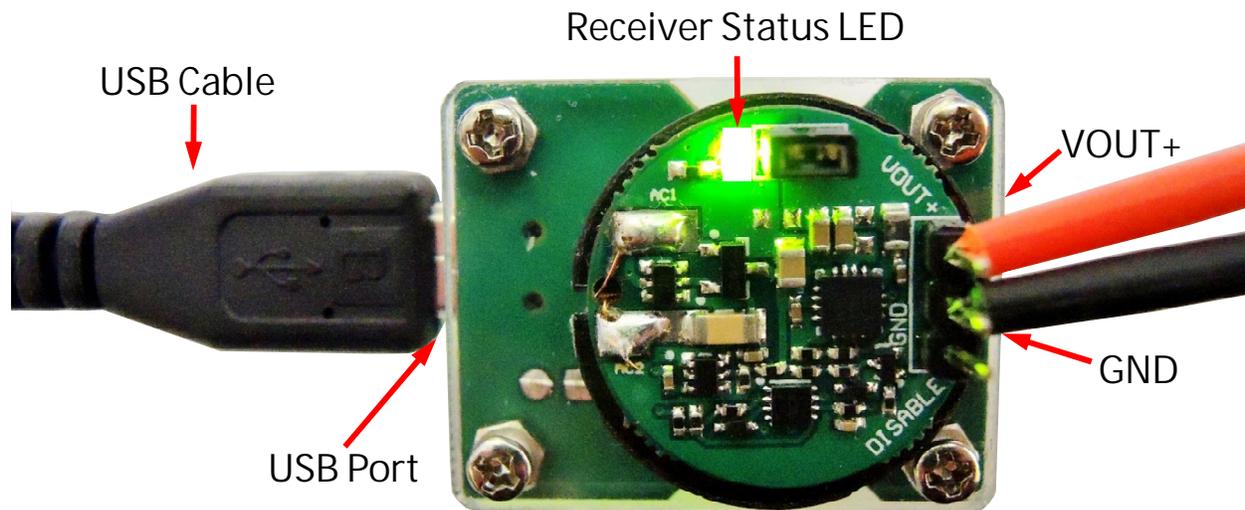
Standard Use

The TSWIRX-5V-EVM is easy to set up and use. Connect a USB cable from any USB port capable of driving up to 2 watts (most PCs will suffice) to the USB port on the TSWITX-EVM. On application of power, its green LED should light, indicating the board is now active.

At this point, the transmitter EVM is ready to transmit power. A few times each second, the transmitter emits a 'ping' of energy in search of a compliant receiver in range.

When in range, the receiver is powered by the ping sufficiently to be able to announce its presence to the transmitter, and a transaction begins. The transmitter provides a small amount of power to the newly discovered receiver, so it can tell the transmitter what its power requirements are.

At the completion of this handshake, the transmitter begins providing the requested power. During power transfer, the receiver continuously communicates with the transmitter, actively directing the process. In this way, it is assured that power is only sent when and how it is required by an available and desirous receiver – and in the way that is compatible with the requirements of the receiver. If required, a receiver can actively increase or decrease its power request, and the transmitter will act accordingly. As such, equipment with complex charging requirements can be precisely supported and only the desired amount of power is provided.



EVM Receiver Tests

A variety of tests can be performed with the use of the TSWITX-EVM transmitter module.

Connect a USB cable from any USB port capable of driving up to 2 watts (most PCs will suffice) to the USB port on the TSWITX-EVM. On application of power, its green LED should light, indicating the board is now active.

In order to use the TSWIRX-5V-EVM as a target receiver, simply place the receiver over the target circle (the 'primary coil' or 'transmitter antenna') on the transmitter EVM module. You should see the LED on the receiver EVM turn green, indicating power is being received. The EVM's purpose is to receive power; next you can decide what to deliver that power to.

The user has a number of possible options to choose from. The optimal load to select would be a Programmable DC Electronic Load. A 'load box' can easily be set to draw a selected current or power at the turn of a knob, making them very flexible and easy to use in observing power supply operation in general. If a load box is not available, a power resistor decade box is nearly as convenient, as it can easily be set to any desired resistance to simulate a range of load conditions. If need be, a selection of resistors could be used as test loads, though without the ease of modification of the prior options. Be sure the test load is rated for at least the amount of power being tested. Finally, any device that uses a 5 volt input up to 1 watt of power can be used as a test load should that be desired.

Whatever load is selected, wires must be run from the VOUT+ and GND pins of the receiver EVM to the selected test load, as per the illustration above. Once the load is added, the receiver EVM can be used to perform a variety of tests.

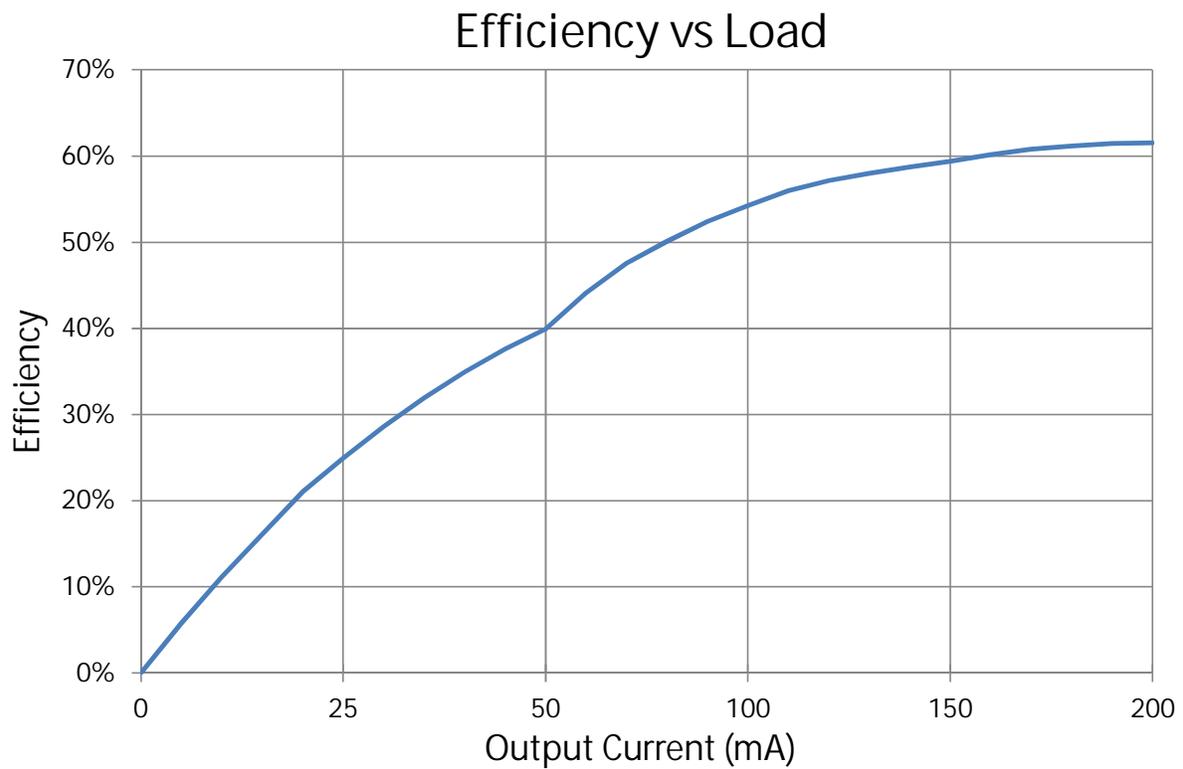
Connect a DC voltmeter across the VOUT+ and GND pins to monitor the voltage being output to the load, and a DC ammeter in series with the VOUT+ line. Set levels to allow for up to 10 volts and 1 amp to be observed.

With no load selected, place the receiver on the center of the transmitter target circle. Once transmission begins, you should observe approximately 5 volts and 0 amperes on the meters.

Apply a variety of loads to observe performance up to one the watt level. Voltage should remain nearly constant, and current should follow the $P=V*I$ relationship. Experiment with the maximum power that can be drawn before the system reaches its limits and output voltage falls off.

Measure Efficiency

By measuring the power from the receiver's VOUT+ and GND pins in comparison to the power entering the transmitter EVM, you can determine the efficiency of the power transfer through the system. The diagram below was obtained from the TSWITX-EVM and TSWIRX-5V-EVM. When measuring efficiency, be sure to remove the jumpers on the receiver and transmitter that enable the status LEDs, as these will affect the measurements.

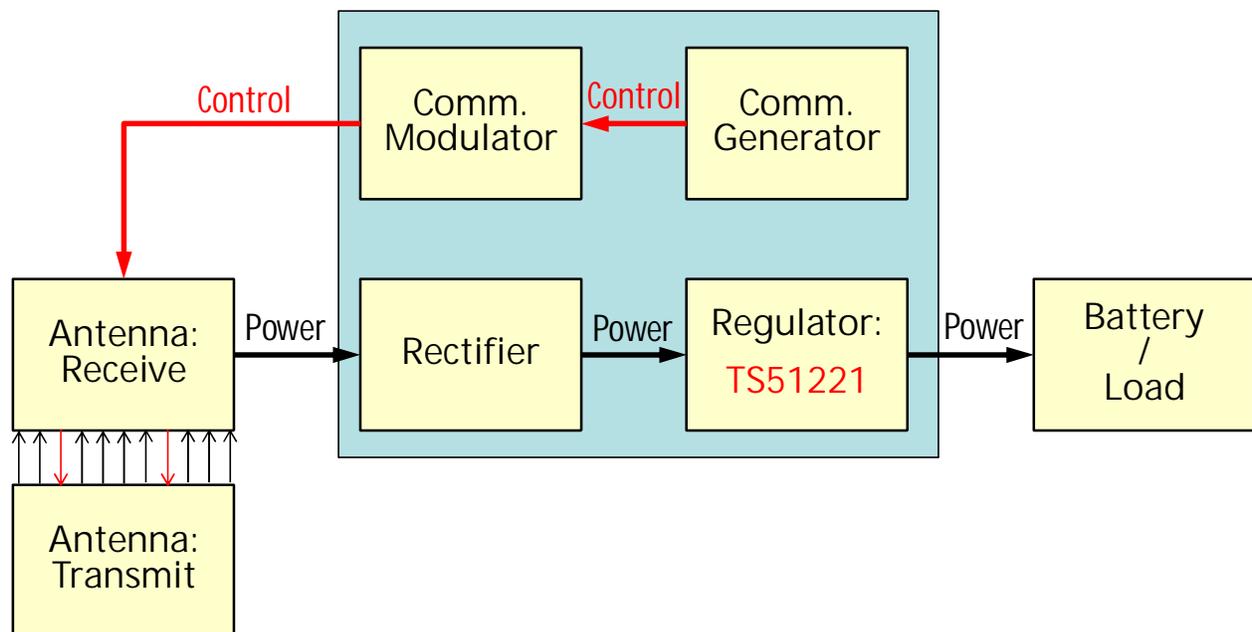


Documentation

The following sections document the hardware design of the TSWIRX-5V-EVM. This information can be used to better understand the functionality of the design, as well as assist in creating your own hardware solution based on this design

A. Block Diagram

The TSWIRX-5V-EVM may be divided into a number of sub-blocks as show in the diagram below:



Antenna: Transmit – primary coil providing power to the receiver; part of TSWITX-EVM

Antenna: Receive – secondary coil in the flux field of the transmit antenna; part of the 1 MHz resonant tank

Rectifier – converts AC voltage from the antenna to positive values; FET based for high efficiency conversion

Regulator - based on the TS51221; converts rectified input to regulated 5v output; includes protection circuitry

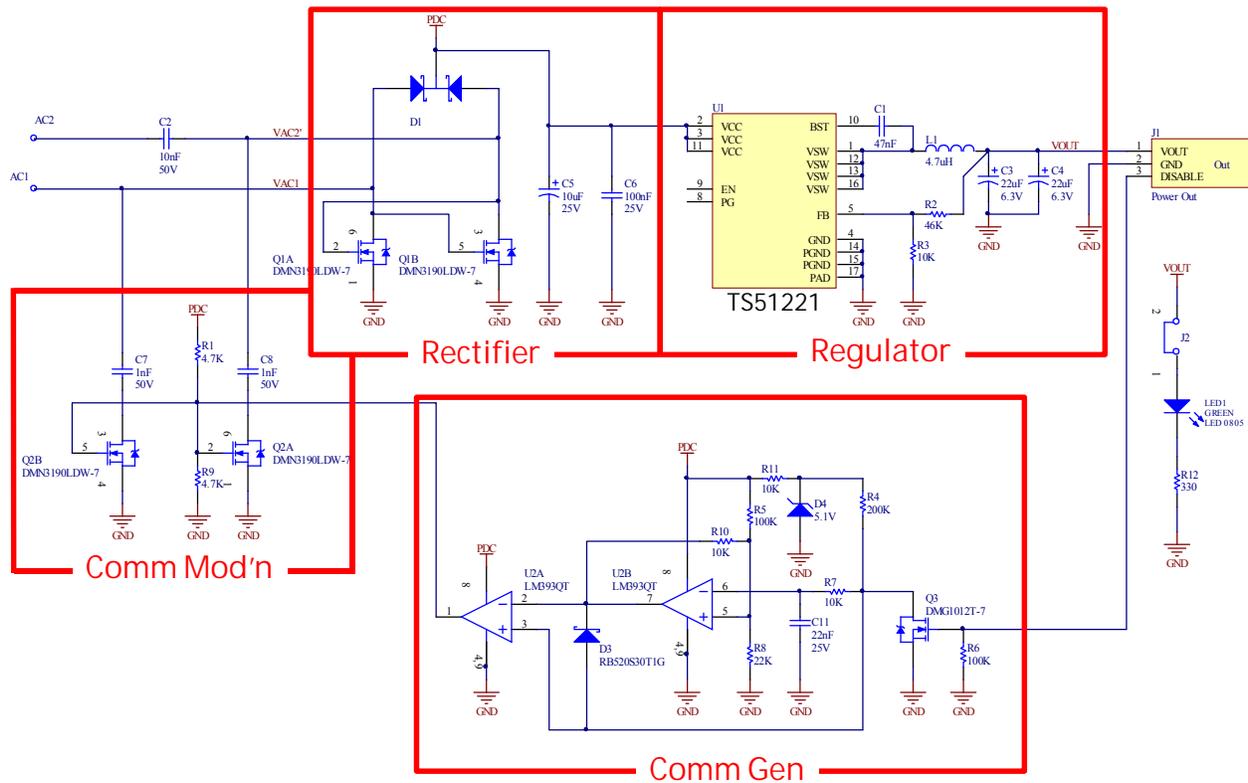
Comm. Generator - produces the 'handshake' signal telling the transmitter to provide power

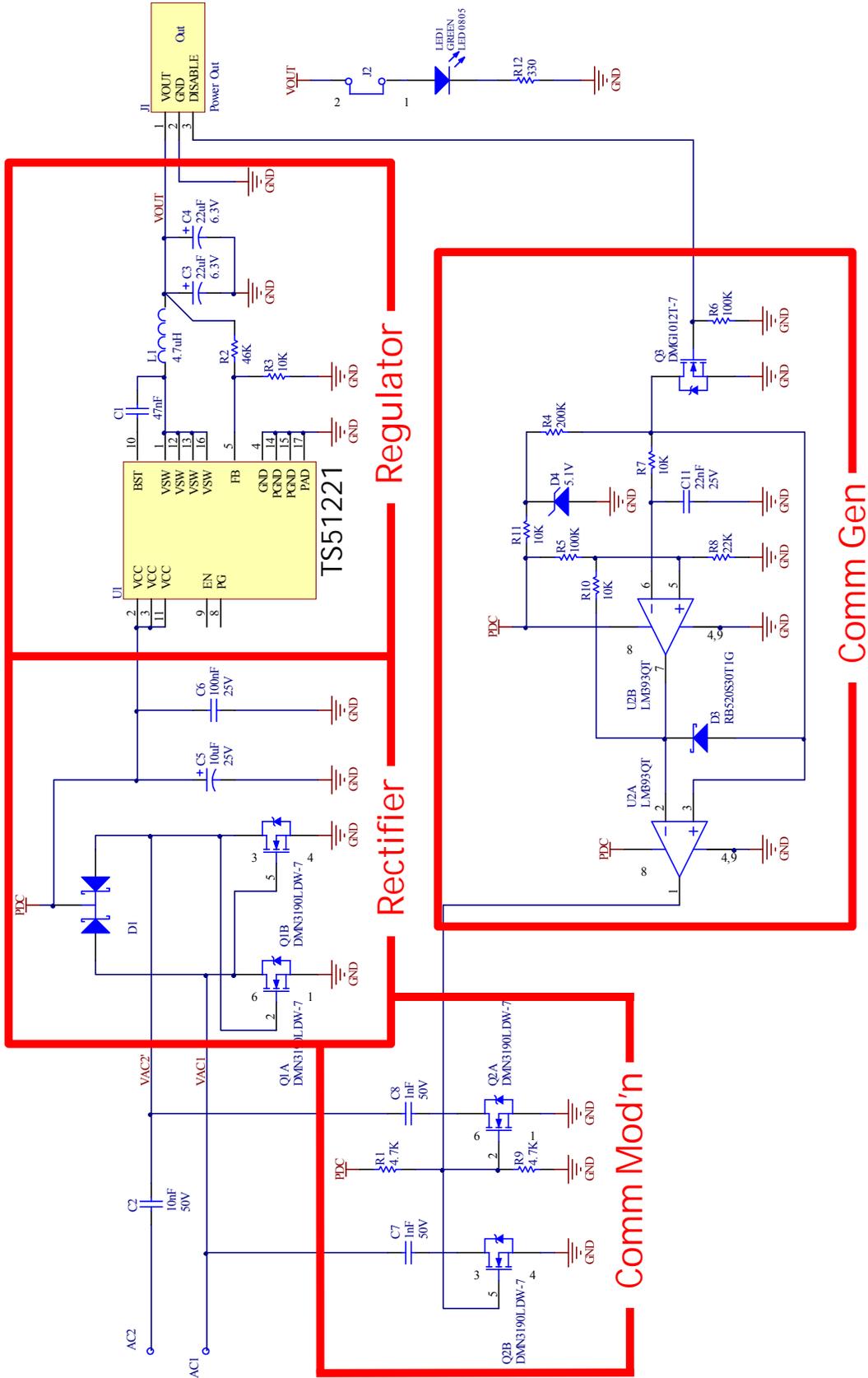
Comm. Modulator --- sends the handshake signal to the transmitter

Battery/Load – end equipment to be powered by the wireless receiver

B. Schematic

Below are two copies of the schematic for the TSWIRX-5V-EVM. The first will be best when viewed on-screen, as it is normally oriented and can be zoomed in on for readability. The second will allow better use in print-out form, as the landscape orientation allows a larger image to be provided. For each, annotation has been added to indicate which part of the block diagram each component is a member of.





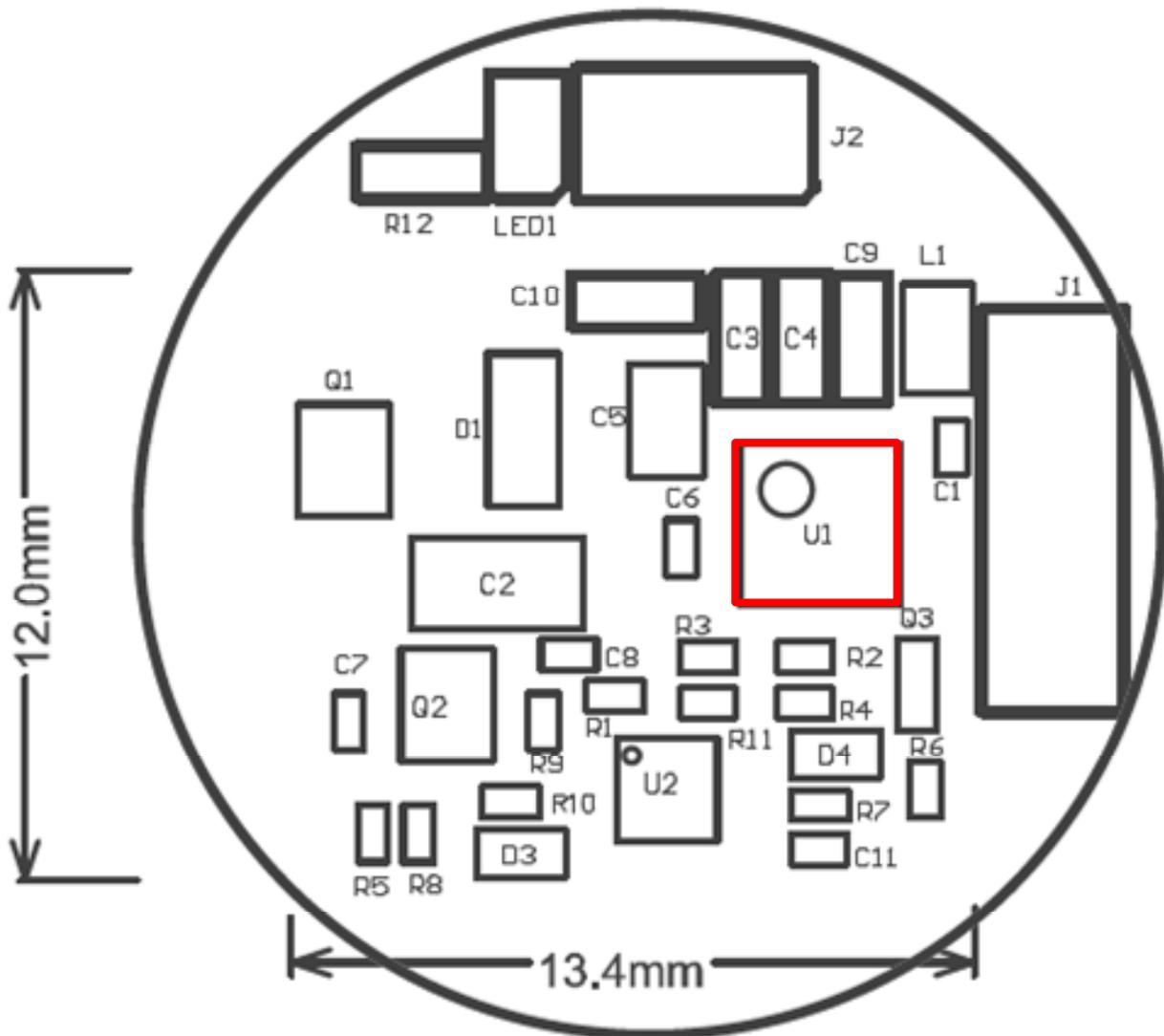
C. Bill Of Materials "BOM"

Below is a listing of the parts used in the TSWIRX-5V-EVM. Note that only a few dozen components were required to implement the complete receiver solution. An excel spreadsheet file with this information is available on the Semtech website as an added convenience.

Required Circuit Components					
SN	Designator	#	Item	Description	Manufacturer
1	C1	1	GRM155R71E473KA88#	0402 47nF 25V X7R	Murata
2	C2	1	GRM319R71H103KA01#	1206 10nF 50V X7R	Murata
3	C3,C4	2	GRM188R60J226MEA0D	0603 22uF 6.3V	Murata
4	C5	1	GRM21BR61E106KA73L	0805 10uF 25V	Murata
5	C6	1	GRM155R71E104KE14#	0402 100nF 25V	Murata
6	C7, C8	2	GRM1555C1H102JA01#	0402 1nF 50V	Murata
7	C11	1	GRM155R71E223KA61#	0402 22nF 25V	Murata
8	D1	1	PMEG3005CT,215	Schottky Diode	NXP
9	D3	1	RB520S30T1G	Schottky Diode	ON Semi
10	D4	1	MM5Z5V1T1G	Zener Diode 5.1V	ON Semi
11	Jumper	1	Black Jumper 2.0mm	2.0mm Jumper	
12	L1	1	MLP2012S4R7M	0805 4.7uH	TDK
13	Q1, Q2	2	DMN3190LDW-7	DUAL MOSFET	
14	Q3	1	DMG1012T-7	N-Channel Pwr MOSFET	Diodes, Inc.
15	R1, R9	2	Resistor	0402 4.7K 1%	
16	R2	1	Resistor	0402 46K 1%	
17	R3,R7,R10,R11	4	Resistor	0402 10K 1%	
18	R4	1	Resistor	0402 200K 1%	
19	R5, R6	2	Resistor	0402 100K 1%	
20	R8	1	Resistor	0402 22K 1%	
21	U1	1	TS51221	DC/DC Controller	Semtech
22	U2	1	LM393QT	2-Channel Comparator	ST
23	Coil(AC1,AC2)	1	Y31-60150F 1521	Coil	E&E
Other Components					
	Designator	#	Item	Description	Manufacturer
24	R12	1	Resistor	0402 330R 1%	
25	LED1	1	APT1608SGC	0805 LED Green	APT1608SGC
26	J1	1	22-03-2031	HDR 1×3Pin 2.54mm	Molex
27	J2	1	1×2Pin 2.0mm	HDR 1×2Pin 2.0mm	Molex

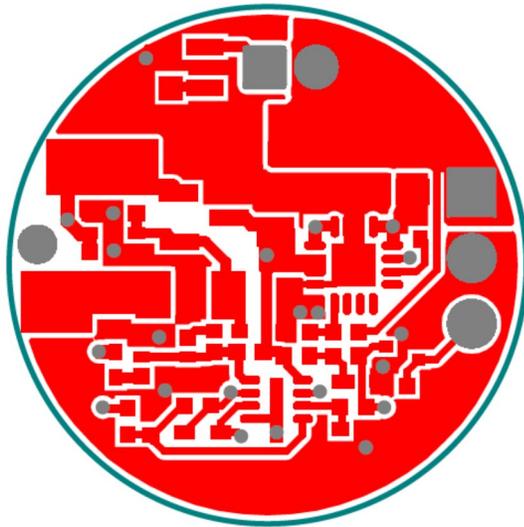
D. Board Layout

The diagram below shows the locations of the components used in the TSWIRX-5V-EVM PCB. Note that the transmitter solution itself fits easily inside a 12x13.4mm rectangle with single-sided construction. Smaller layouts can readily be created if required.

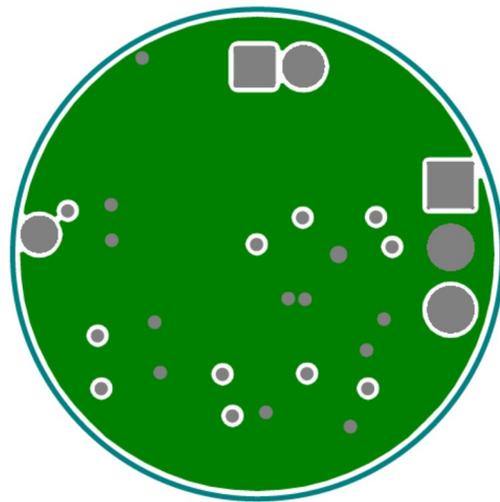


E. Board Layers

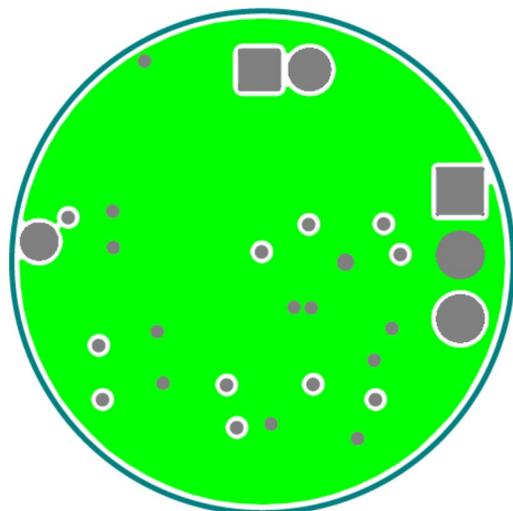
The TSWIRX-5V-EVM PCB is based on a four layer design as shown below. The ground plane in layer two is recommended to reduce noise and signal crosstalk. The EVM placed all components on the top of the board for easier evaluation of the system. End product versions of this design can be made significantly smaller by distributing components on both sides of the board. The Gerber files for this artwork can be downloaded from the Semtech web page.



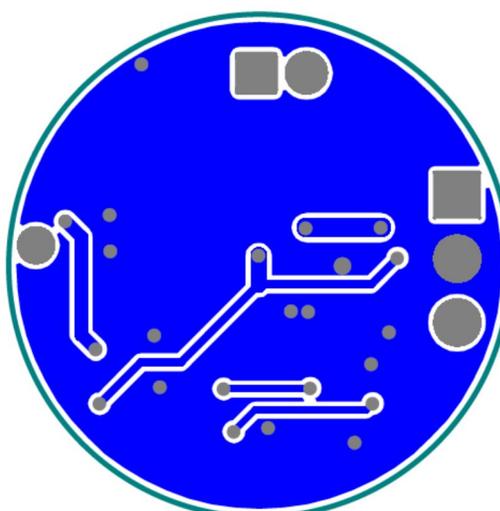
Top Layer



Ground Plane



Signal Layer



Bottom Layer

FAQs

Q: What output voltage is provided by the TSWIRX-5V-EVM system?

A: The output is 5 volts, with a maximum power of 0.5 to 2 watts, depending on the antenna employed.

Q: Is the TSWIRX-5V-EVM compliant with Qi or another wireless transmission standard?

A: These low power wearable solutions are not based on existing standards in order to employ smaller coils and other optimizations that better suit the low power system environment.

Q: Does the EVM part number represent something in particular?

A: Yes. The part number is broken into a prefix, main body, and suffix, separated by dashes. The prefix is comprised of three two letter groupings that each help define the product represented. As such, the part number can be read as follows:

Prefix characters:

1+2 = Company :	TS = Triune/Semtech	
3+4 = Environment :	DM = Dual Mode	WI = Wearable Infrastructure
5+6 = Type :	TX = Transmit	RX = Receive

Mid-section = Device Voltage or Wattage

Suffix = Equipment type:

EVM = Evaluation Module
MOD = Production Module

Thus, the TSWIRX-5V-EVM is a Wearable Infrastructure, 5 volt Receiver Evaluation Module provided by Semtech.

Q: Does the TSWIRX-5V-EVM implement Foreign Object Detection (FOD)?

A: FOD detection is an important protection in higher power systems, but in low power wearable infrastructure systems there is no risk of overheating, rendering FOD management unnecessary.

Q: What if my questions weren't answered here?

A: Go to the Semtech website as described on the next page. An updated FAQ for the TSWIRX-5V-EVM is maintained there and may contain the answers you're looking for. Your local Semtech FAE can also assist in answering your questions.

Next Steps

For more information on Wireless Power, go to the Semtech webpage at:

<https://www.semtech.com/power-management/wireless-charging-ics/>

You may also scan the bar code to the right to go to the above web page:



There you can find the downloadable copies of the schematic, BOM, and board artwork, as well as additional information on how to obtain Semtech wireless power products, from the chip level all the way to complete board modules, as your needs require.



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