



TSDMTX-19V1-EVM
Wireless Charging Transmitter

WIRELESS CHARGING

User Guide

TSDMTX-19V1-EVM
Dual-Mode (Qi and PMA) Transmitter

Introduction

The Semtech TSDMTX-19V1-EVM is an evaluation platform for test and experimentation of a wireless charging transmitter based on the Semtech TS80000 Wireless Power Transmitter Controller, TS61001 FET Driver, TS30011 DC/DC Converter, and TS31023 LDO devices. This evaluation module provides a complete system solution for both Qi and PMA standards of power transmission, making this transmitter an ideal platform for powering the majority of wireless receivers in use today.

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 using the TS80000 and other Semtech components.

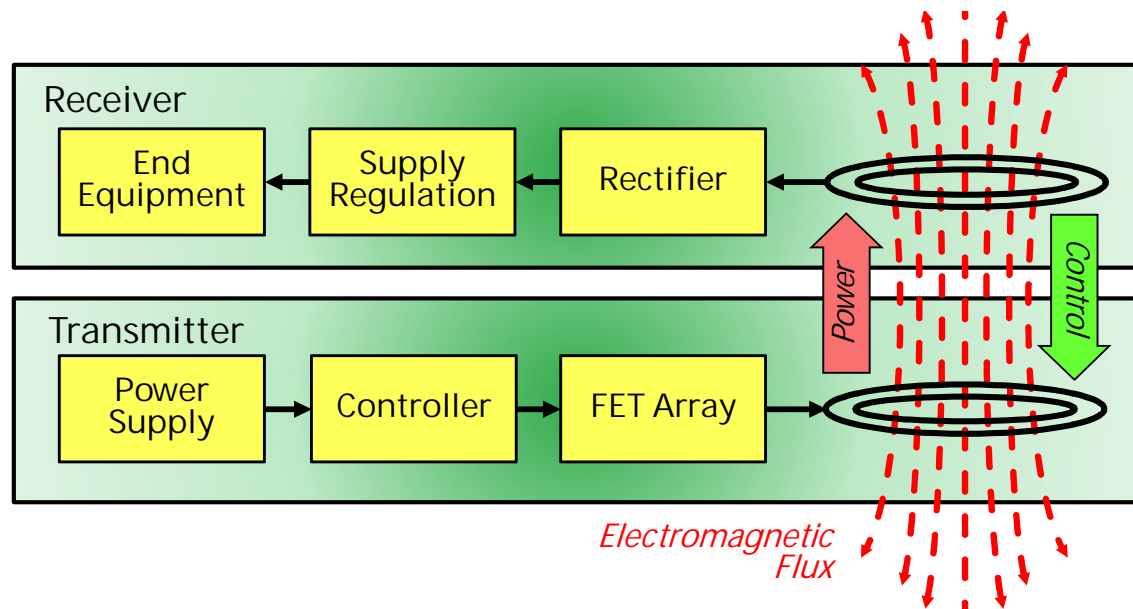
Table of Contents

<i>Wireless Charging Concepts</i>	2
<i>Product Description</i>	3
<i>Standard Use</i>	5
<i>Firmware Management</i>	8
<i>FOD Test</i>	9
<i>Documentation</i>	10
A. Block Diagram	10
B. Schematic	11
C. Bill Of Materials "BOM"	13
D. Board Layout.....	14
E. Board Layers.....	15
<i>FAQs</i>	17
<i>Next Steps</i>	18

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, wireless power systems are designed to operate in the 100 kHz 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. In addition, the system is capable of recognizing when the electromagnetic field has been interrupted by an unintended element, a 'foreign object', and will shut down the transfer to prevent any significant amount of power being absorbed by anything but a proper receiver. The intelligent management of the wireless power transmission process is achieved through the programming of the TS80000, 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, and that none is being lost to foreign objects. The receiver will continually provide 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 TSDMTX-19V1-EVM Evaluation Module is a ready-to-use demonstration platform allowing testing of up to 15 watts of wireless power transmission compliant with the dominant industry standards – Qi and PMA.

The transmitter may be coupled with any Qi or PMA receiver module to form a complete wireless power transmission system. For the system designer, a likely choice might be the complementary Semtech TSDMRX-9V/15W-EVM, which can allow a variety of experiments to easily be performed in order to learn more about the behavior of the system.

There are a number of other Semtech Receiver EVMs that support different power levels and output voltages, any of which can be used as all support the Qi and/or PMA standard and therefore are compatible with the TSDMTX-19V1-EVM transmitter.

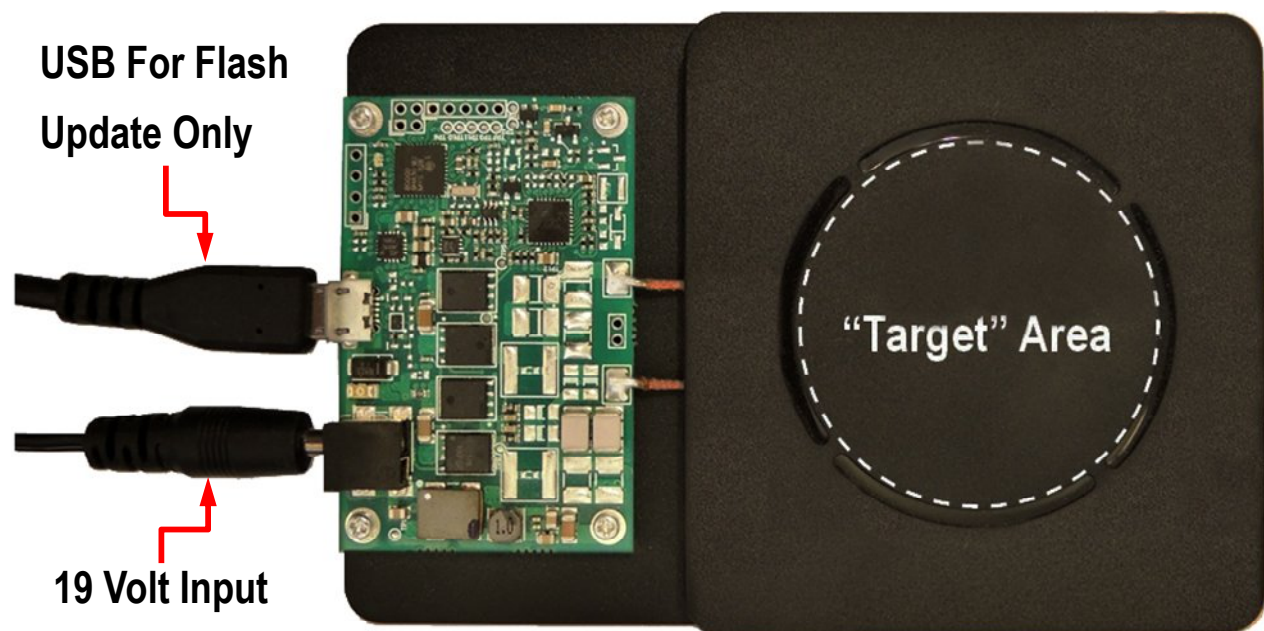
In addition, the evaluator can also use any existing Qi or PMA compliant product, though the limited access these devices offer may make the range of experiments that can be performed more limited.

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 TS80000 integrated circuit, which controls the system and implements the Qi and PMA protocols. Developers can vary the supporting componentry to meet their goals as desired.

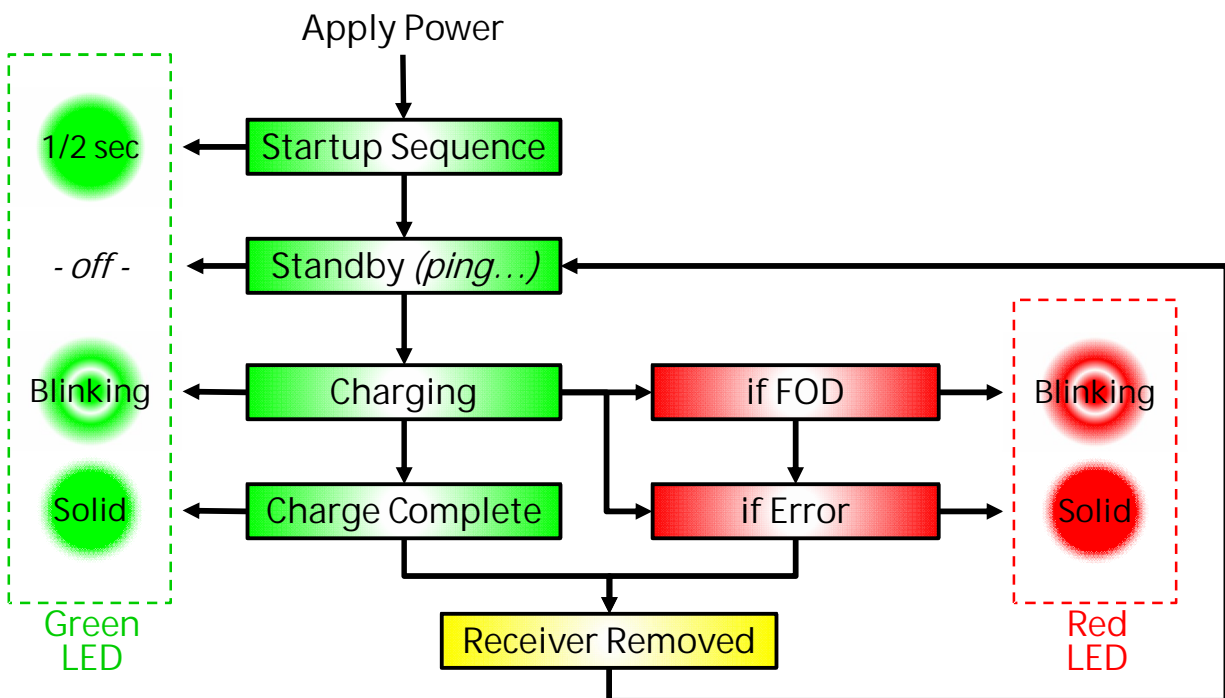
In this user guide, an introduction will be provided to the evaluator for how to use the EVM for wireless power transmission as well as how the TSDMRX-9V/15W-EVM can be used in conjunction with it.

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



LED Behavior

The red and green LEDs on the EVM let the user know what the transmitter is doing as it operates. As seen in the diagram below, when power is applied, the transmitter initializes as indicated by the green LED lighting for about a half second. Next, as the transmitter searches for a nearby receiver, no LED is lit, keeping power to a minimum in this standby state. When a receiver is located, the transmitter receives instructions on the upcoming transaction to perform. Power is then transmitted and the green LED flashes each second indicating an ongoing charging event. During charging, if a foreign object is detected, charging is aborted and the red LED will flash each second indicating the fault detected, and will continue to do so until the receiver is removed from the target zone. Similarly, other detected errors will also abort the charging process, indicated by a steady red LED that remains lit until the receiver is taken away. Error conditions include communication errors between receiver and transmitter, and detection of excess voltage, current, power, or temperature on the receiver or transmitter. Absent an error, charging continues until the receiver indicates no further power is required, usually when an attached battery is fully recharged. At this point, the transmitter enters the charge complete state, as indicated by the green LED being lit steadily, which it continues to do until the receiver is removed from the transmitter. Whenever the receiver is removed from the target area, the transmitter returns to the standby state, searching for another transaction to begin.



Standard Use

The TSDMTX-19V1-EVM is easy to set up and use. Use the power supply module and line cord that came with the EVM kit to apply power to the EVM via “J5”, the 19v power input jack. On application of power, the green LED should light for about a half-second and then turn off.

At this point, the 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 the handshake, the transmitter begins providing the requested power, indicated by a blinking green LED. 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 to 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.

Once charging is completed, the LED stops blinking and displays a steady green ‘completed’ state. If at any time an error is detected, the LED turns red and transmission is halted. To restart, the receiver must be removed from the range of the transmitter and returned to the target zone to start a new transaction.

Productized Receiver Test

If you have a product that is Qi or PMA compliant, simply place it on the circular target of the black plastic antenna cover. The transmitter should demonstrate the above actions, and the device receiving power should indicate it is taking a charge in whatever manner its users guide states. You can also perform foreign object detection (FOD) by following the steps in the “FOD Testing” section below.

EVM Receiver Tests

Additional testing can be performed with the use of an EVM receiver module. There are a number of Semtech Receiver EVMs that support different power levels and output voltages, any of which can be used, as all support the Qi and/or PMA standard and therefore are compatible with the TSDMTX-19V1-EVM transmitter. In this User Guide, the TSDMRX-9V/15W-EVM has been selected as the receiver to experiment with. Other Semtech receiver EVMs may be used instead in a similar manner; refer to the user guide for the selected receiver for details specific to the selected device.

In order to use the TSDMRX-9V/15W-EVM as a target receiver, simply place the receiver over the target circle on the transmitter EVM module. You should see the LEDs on each EVM turn green, indicating a transaction has been established. 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. In either case, be sure the test load is rated for at least the amount of power being tested. If need be, a selection of power resistors could be used as test loads, though without the ease of modification of the prior options. Finally, any device that uses a 9 volt input up to 15 watts 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 below. 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 3 amps 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 9 volts and 0 amperes on the meters.

Apply a variety of loads to observe performance at 5, 10, and 15 watt levels. 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 receiver detects an overload and cuts off power. You should be able to observe on a minor overload, the receiver will attempt to restore power by retesting the load intermittently. In the case of a major overload, the transmitter may register an error, as indicated by a red LED on the transmitter, which will halt further activity until the receiver is removed from the target area for several seconds before being returned to start a new transaction.

Observe Coil Signals

The following information is not required in order to use the EVM, as what can be observed below is entirely managed by the Semtech TS80000 Wireless Controller. However, it allows the observer an opportunity to see how the receiver and transmitter actively manage the wireless power process.

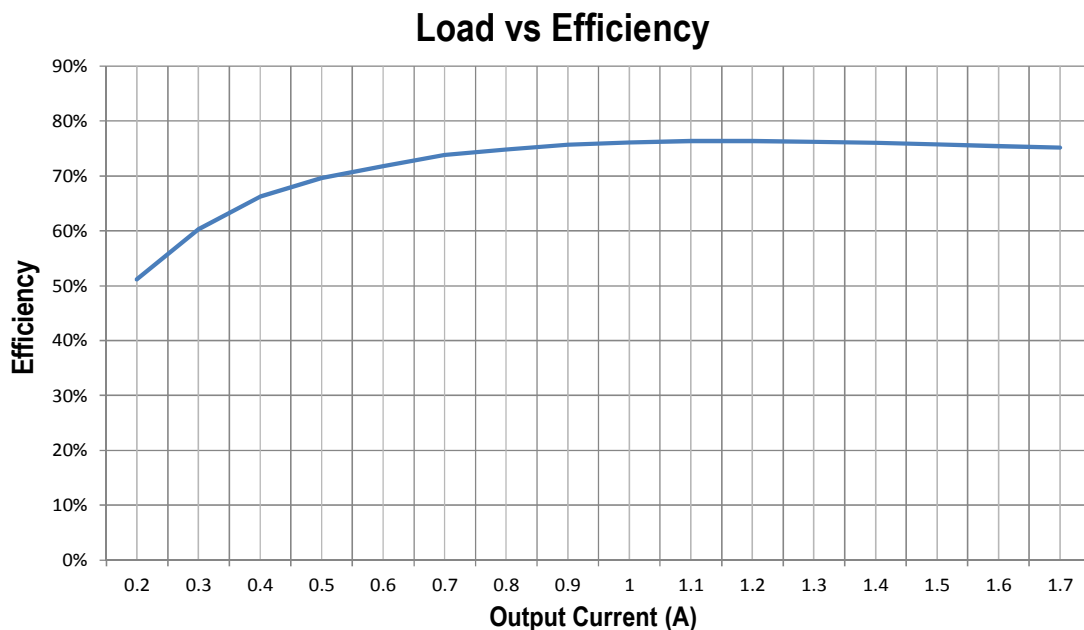
If you wish to observe the intrinsic wireless process, place an oscilloscope probe on one antenna lead, with the probe ground run to the board ground (one of the fastener screws will suffice). Be sure the scope can handle signals up to 200 volts. While the EVM power supply is only 19 volts, the antenna is part of a resonant circuit where considerably higher voltages are developed.

To observe the search ping, apply power to the transmitter and remove the receiver from the target zone. The scope should display a 'chirp' of 0.5 to 1mSec in duration with an initial peak of 15 to 20 volts. The frequency within the envelope of the chirp is in the 100-150 kHz range, which is the normal range of Qi and PMA systems.

Next, place the receiver on the transmitter target. With the scope set to 0.5 to 1 uSec and 10 to 20 volts per division, you should observe a signal that is a composite of the sinusoidal power signal with a digital 'notch' in the sinewave which is produced by the communication between the receiver and transmitter. Note as you vary the load and the location of the receiver on the target that the amplitude and frequency of the coil signal changes. The greater the load, the more signal is sent to transfer the power required by the load. Similarly, the less well coupled the receiver antenna is to the transmitter coil, the more power must be sent to compensate for the inefficient misalignment. You may note voltages near 140 volts peak-to-peak in the most demanding conditions.

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. For the EVMs used here, the diagram below demonstrates that efficiency is a function of output current, and runs about 75% at higher power levels, assuring good efficiency and minimal heat dissipation concerns.



Firmware Management

The EVM is shipped with the most current release of the firmware at the time it was manufactured. As the standard evolves, or enhancements are made to the board performance, updates to the firmware will be available via your Semtech FAE.

A small utility "FW_FLASH" allows you install the latest firmware to your board, and also to interrogate the board as to which version of the firmware is currently installed. FW_FLASH is also available via your Semtech FAE.

Once obtained, install FW_FLASH to any desired location on your computer. If you wish to obtain the latest firmware, obtain and install it as well.

Let Windows install an EVM Driver on your PC

- Connect a USB cable between the EVM and your PC.
- Apply power to the EVM
- Wait for windows to indicate that it has finished loading a driver for the EVM, then unplug the EVM.
- *Note: you do not need to locate a special driver for this process. Windows will select one of its own.*

Determine the EVM Flash Revision

- To set up the EVM hardware correctly for the flash utility, start with an unpowered EVM.
- Connect a USB cable between the EVM and your PC.
- Double click on the FW_FLASH icon on your computer.
- FW_FLASH will open a window on your PC.
- Apply power to the EVM
- The revision number of the flash firmware found on the EVM will be displayed in the FW_FLASH window.
- Close the window when you are done reviewing this information.

Updating the EVM Flash Revision

- Begin with an unpowered EVM.
- Connect a USB cable between the EVM and your PC.
- Drag the firmware file to send to the EVM onto the FW_FLASH icon.
- FW_FLASH will open a window on your PC.
- Apply power to the EVM.
- In the FW_FLASH window, the utility will indicate the progress of the flash update. In just a few seconds it should indicate the update has been completed.
- Close the window when you are done reviewing this information.

FOD Test

In a production device, FOD testing is an important feature, in that the transmission process is constantly inspected for the introduction of extraneous materials in the target area that could absorb the transmitted energy and become hot. When Foreign Objects are Detected ("FOD"), the TS80000 shuts down power transmission as a safety precaution, and indicates the detected problem by blinking the red status LED.

This process is bypassed in the receiver EVM, however, in order to allow engineers to test different antennas and make other hardware modifications without triggering the FOD protocols and complicating the testing process. When such hardware changes are made, the parameters of the feedback measurements change, which the FOD protocol would perceive as a foreign object in the field, and cause the system to shut down.

In order to test the FOD protocol, the experimenter can use as a receiver any Qi products certified to WPC 1.1.2 or higher. A list of such products can be found at:

http://www.wirelesspowerconsortium.com/products/?brand_name=&product_name=&type_number=&product_type=2&compliant_automotive=&sort=&direction=asc

Experiments can be run on foreign objects on receivers with and without FOD management enabled to observe the differences. With FOD disabled, the metal object in the field will absorb some of the transmitted energy and become warm. Using a FOD-enabled production device, power transmission will be aborted when any significant interference in power transfer has been detected.

Once a FOD abort takes place, the transaction is terminated, as indicated by a blinking red LED. To restart power transmission, the receiver must be removed from the target area and a new transaction must be initiated. If the FOD is still present, the transaction will fail again, and continue to do so until the FOD is removed from the target area.

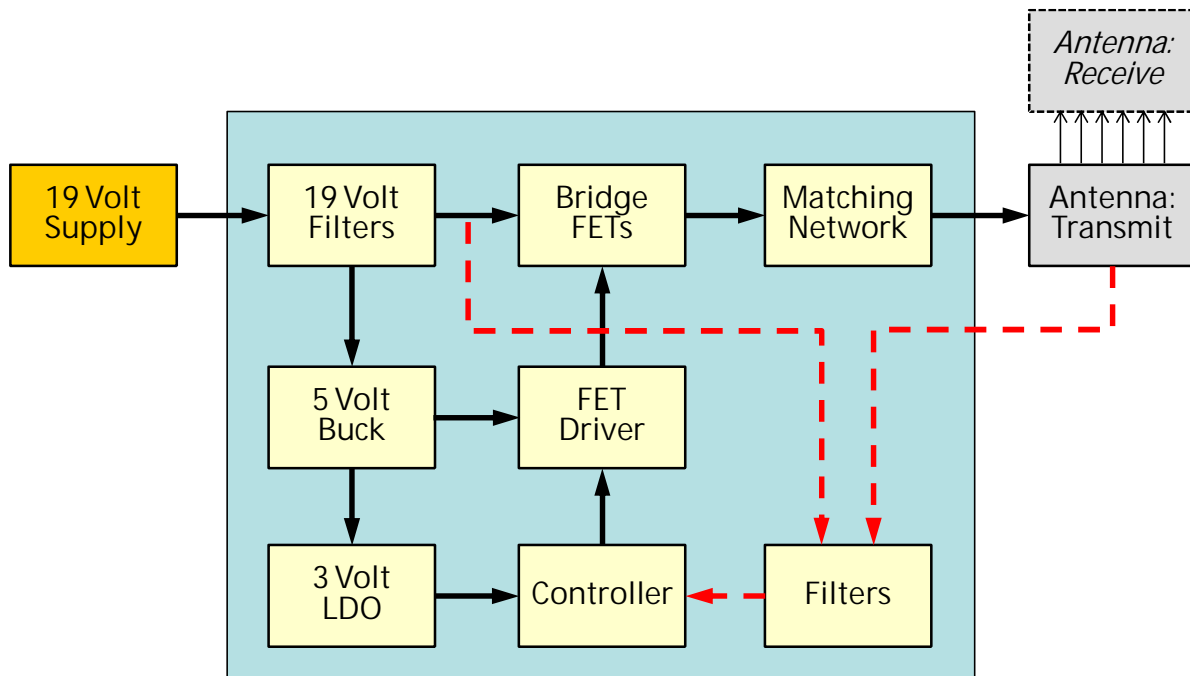
Based on prior information and experiments, what should be expected if FOD is introduced in the target area of an EVM that is not currently in a power transmission transaction? Why?

Documentation

The following sections document the hardware design of the TSDMTX-19V1-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 TSDMTX-19V1-EVM may be divided into a number of sub-blocks as show in the diagram below:



19 Volt Supply - the external 'brick' that converts AC power to 19 volts

19 Volt Filters – smooths the 19 volt input supply

5 Volt Buck – based on the TS30011, converts 19 vdc to 5 vdc

3 Volt LDO – based on the TS31023, converts 5 vdc to 3 vdc

Controller – based on the TS80000 Wireless Power Controller. Includes I/O: USB, I2C, Temp Sensor, LED display

FET Driver – based on the TS61001 Full-bridge FET Driver, powers FETs based on inputs from controller

Bridge FETs – gates drive power from the 19v supply to drive the resonant tank circuit (antenna)

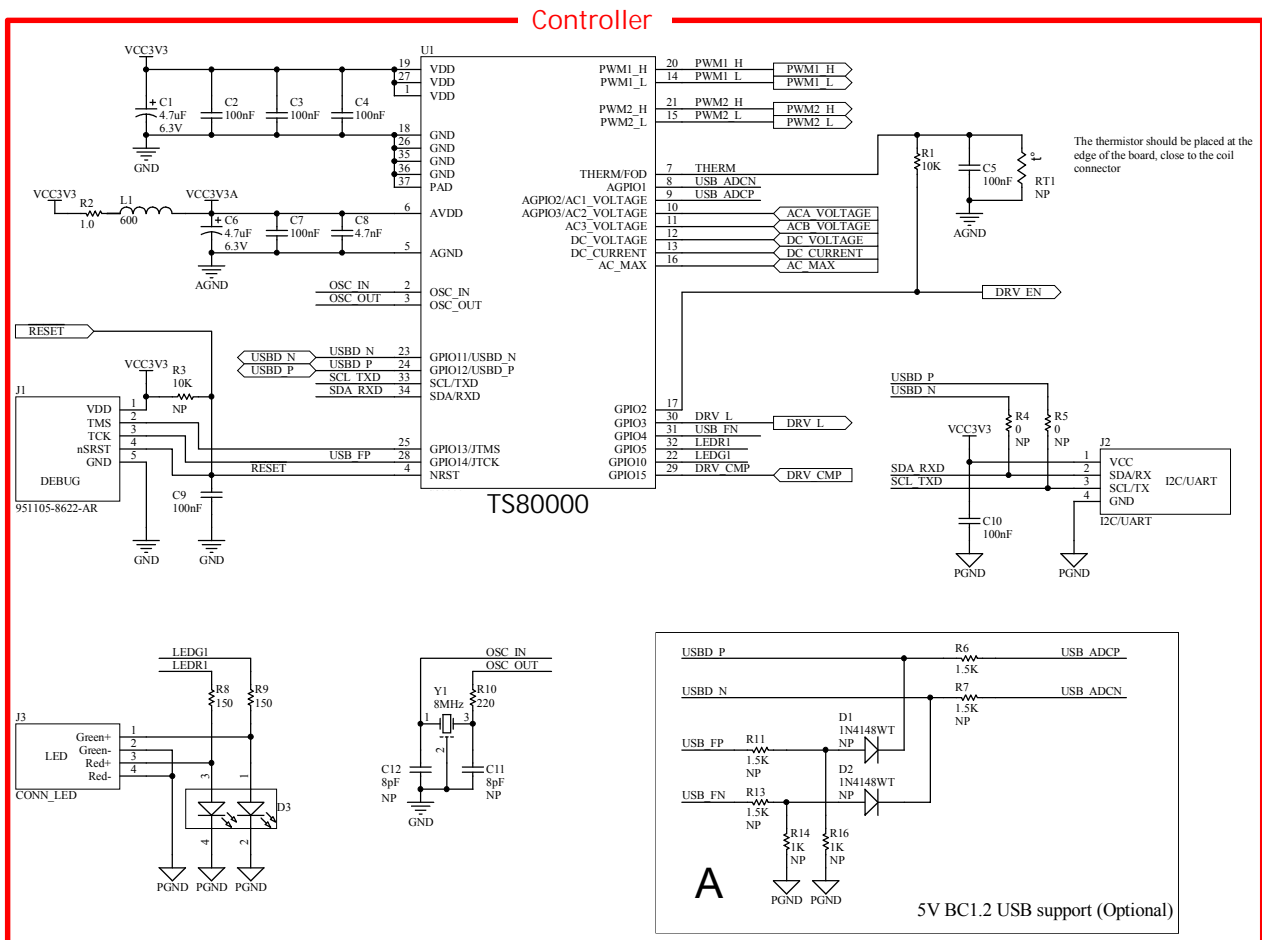
Matching Network – array of capacitors to create the resonant tank along with the antenna

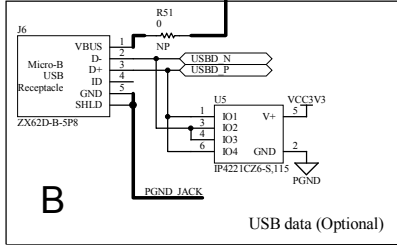
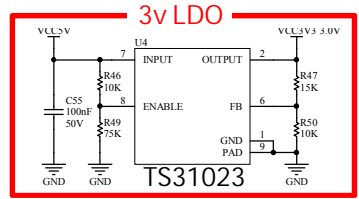
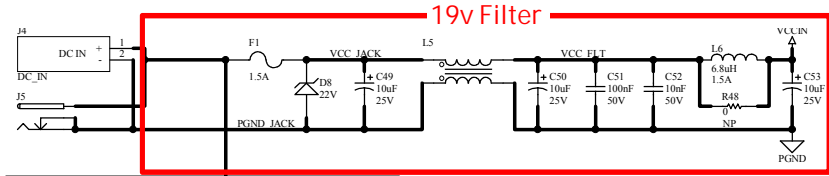
Antenna: Transmit – acts as the primary of an air-core transformer in conjunction with the receiver antenna

Filters – adapt the antenna and drive values for use as feedback input to the controller

B. Schematic

Below are the schematics for the TSDMTX-19V1-EVM. Annotation has been added to indicate which part of the block diagram each component is a member of:

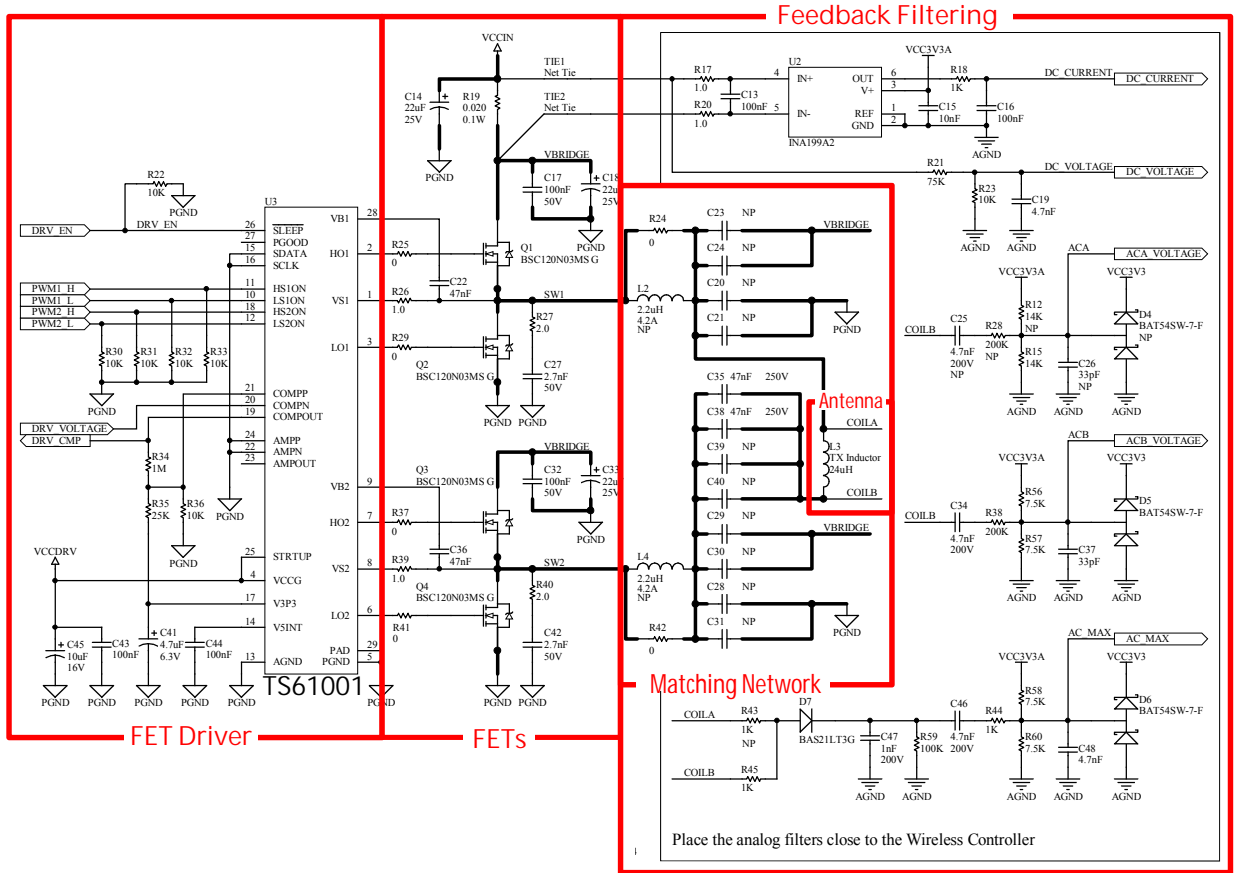
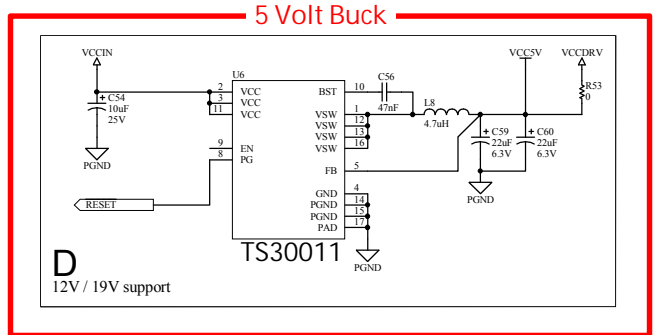
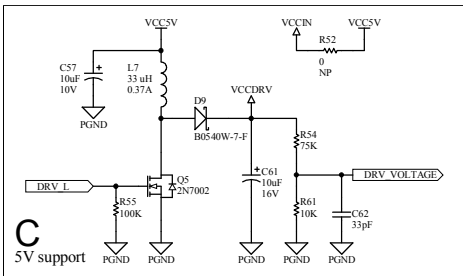
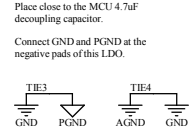




The Wireless Power TX PCB can be populated in one of the following two configurations:
 -- 5V DC input
 -- 12V and/or 19V DC input

5V DC configuration:
 -- populate block A (optional)
 -- populate block B (optional)
 -- populate block C (always needed for 5V)

12V/19V DC configuration:
 -- populate block B (optional)
 -- populate block D (always needed for 12/19V)



C. Bill Of Materials "BOM"

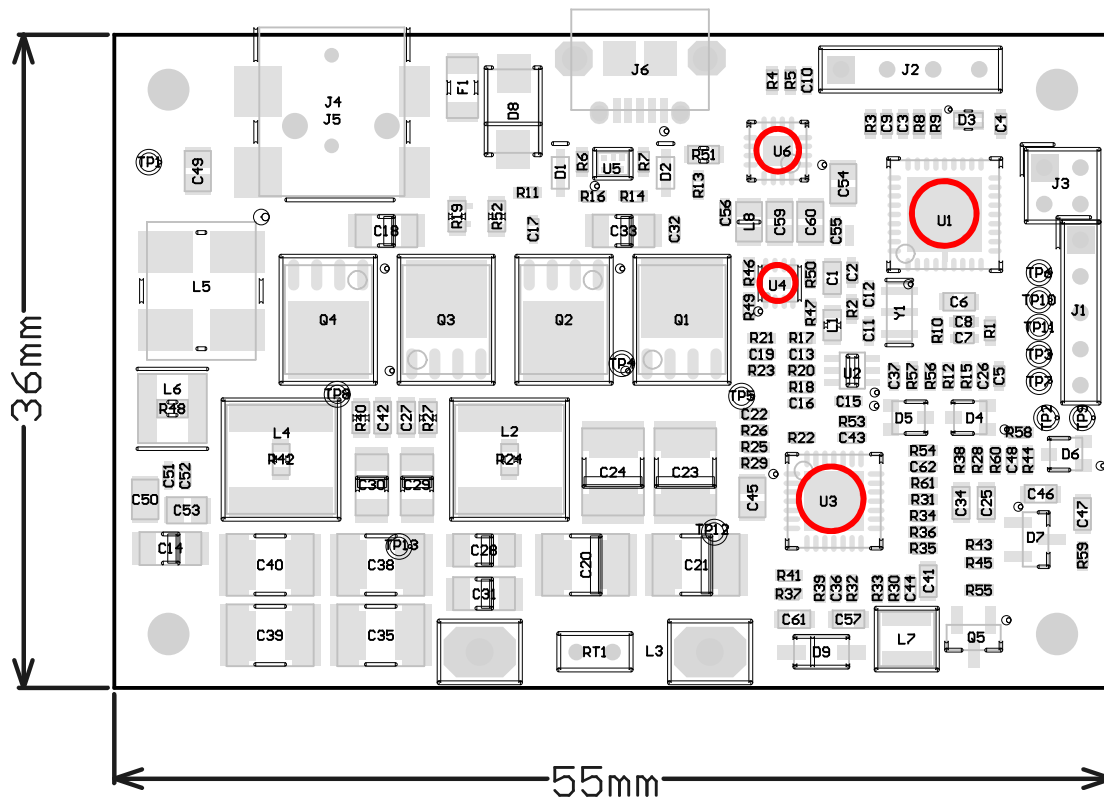
Below is a listing of the parts used in the TSDMTX-19V1-EVM. An excel spreadsheet file with this information is available on the Semtech website as an added convenience.

	Designator	Value	Val 2	Manufacturer	Manufacturer Code	#	Description
1	C1, C6, C41	4.7uF	6.3V	Taiyo Yuden	JMK107BJ475KA-T	3	Capacitor
2	C14, C18, C33	22uF	25V	Taiyo Yuden	TMK316BBJ226ML-T	3	Capacitor
3	C15	10nF	10V			1	Capacitor
4	C17, C32, C51, C55	100nF	50V			4	Capacitor
5	C2-C5, C7, C9, C10, C13, C16, C43, C44	100nF	10V			11	Capacitor
6	C22, C36, C56	47nF	25V			3	Capacitor
7	C27, C42	2.7nF	50V	Yageo	CC0603KRX7R9BB272	2	Capacitor
8	C34	4.7nF	200V	TDK	C1608X7S2A473K	1	Capacitor
9	C35, C38	47nF	250V	TDK	C3225C0G2E473J250AA	2	Capacitor - COG
10	C37, C62	33pF	10V			2	Capacitor
11	C45	10uF	16V			1	Capacitor
12	C46	4.7nF	200V			1	Capacitor
13	C47	1nF	200V			1	Capacitor
14	C49, C50, C53, C54	10uF	25V			4	Capacitor
15	C52	10nF	50V			1	Capacitor
16	C57	10uF	10V			1	Capacitor
17	C59	22uF	6.3V	Taiyo Yuden	JMK212BJ226MG-T	1	Capacitor
18	C60	22uF	6.3V			1	Capacitor
19	C61	10uF	16V			1	Capacitor
20	C8, C19, C48	4.7nF	10V			3	Capacitor
21	D3			Kingbright	APHB1608ZGSURKC	1	LED Dual Color
22	D5, D6			Zetex	BAT54SW-7-F	2	Schottky Diode
23	D7			ON Semiconductor	BAS21LT3G	1	Diode
24	D8	22V		Bourns	SMAJ22A	1	Zener Diode TVS
25	D9	40V	0.5A	Zetex	B0540W-7-F	1	Schottky Diode
26	F1	1.5A		CONQUER	CQ12PF	1	Fuse
27	J5			CUI	PJ-014DH-SMT	1	Low Voltage Power Supply Connector
28	J6			Hirose	ZX62D-B-5P8	1	Micro-B USB, Receptacle, 5 Position
29	L1	600		Murata	BLM18AG601SN1D	1	Ferrite Bead
30	L3	24uH		TDK	WT-505090-10K2-A11-G	1	Qi-Compliant TX Inductor
31	L5					1	Common Mode Choke
32	L6	6.8uH	1.5A	Vishay	IFSC1515AHER6R8M01	1	Inductor
33	L7	33 uH	0.37A	Taiyo Yuden	NR3015T330M	1	Inductor 33uH 370mA
34	L8	4.7uH		TDK	MLP2012S3R3M	1	Inductor
35	Q1, Q2, Q3, Q4			Infineon	BSC120N03MS G	4	N-Channel Power MOSFET
36	Q5			On Semiconductor	2N7002LT3G	1	N-channel Enhancement Mode FET
37	R1, R46	10K			RC0402FR-0710KL	2	Resistor
38	R10	220				1	Resistor
39	R15	14K				1	Resistor
40	R17, R20, R26, R39	1.0				4	Resistor
41	R18, R44, R45	1K				3	Resistor
42	R19	0.020	0.1W	Vishay	WSL0603R0200FEA	1	Current Sense Resistor
43	R2	1.0			RC0402FR-071RL	1	Resistor
44	R21, R49, R54	75K				3	Resistor
45	R22, R23, R30-R33, R36, R50, R61	10K				9	Resistor

	Designator	Value	Val 2	Manufacturer	Manufacturer Code	#	Description
46	R24, R42	0				2	Resistor
47	R25, R29, R37, R41, R53	0				5	Resistor
48	R27, R40	2.0				2	Resistor
49	R34	1M				1	Resistor
50	R35	25K				1	Resistor
51	R38	200K				1	Resistor
52	R47	15K				1	Resistor
53	R55, R59	100K				2	Resistor
54	R56, R57, R58, R60	7.5K				4	Resistor
55	R6	1.5K				1	Resistor
56	R8, R9	150			RC0402FR-07150RL	2	Resistor
57	U1			Semtech	TS80000	1	Wireless Power Transmitter Controller
58	U2			TI	INA199A2DCKR	1	Current Sense Amplifier
59	U3			Semtech	TS61001	1	Full-Bridge FET driver
60	U4			Semtech	TS31023	1	Linear Regulator
61	U5			NXP	IP4221CZ6-S,115	1	USB ESD Protection
62	U6			Semtech	TS30011-M050QFN	1	Synchronous Buck DC/DC Converter
63	Y1	8MHz		Murata	CSTCE8M00G55-R0	1	Ceramic Resonator

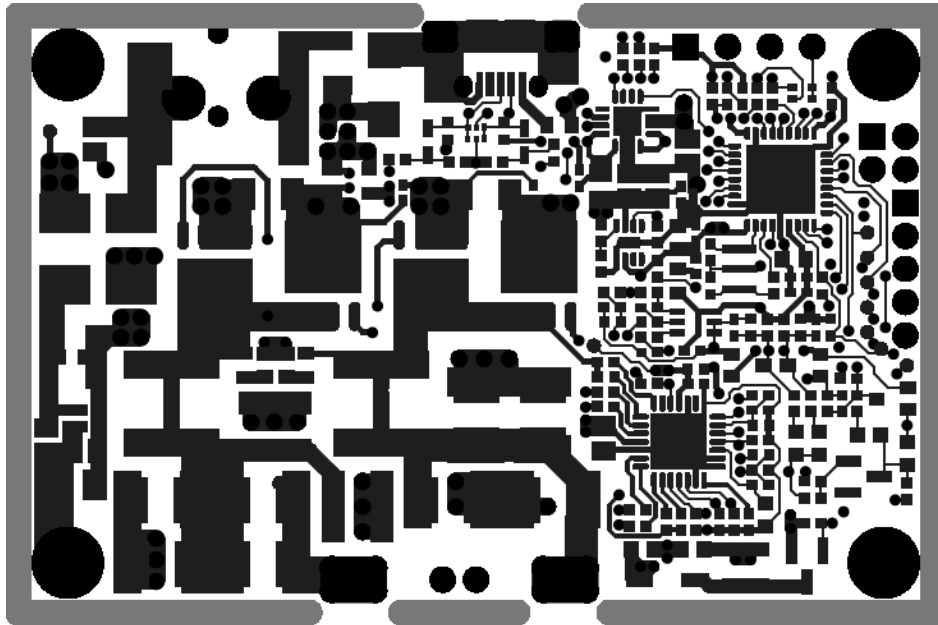
D. Board Layout

The diagram below shows the locations of the components used in the TSDMTX-19V1-EVM PCB.

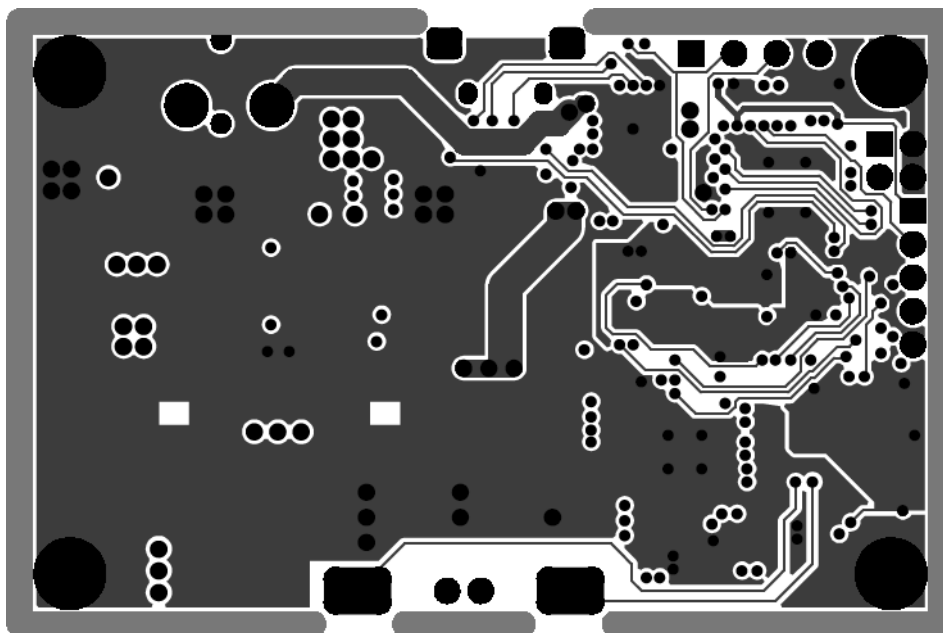


E. Board Layers

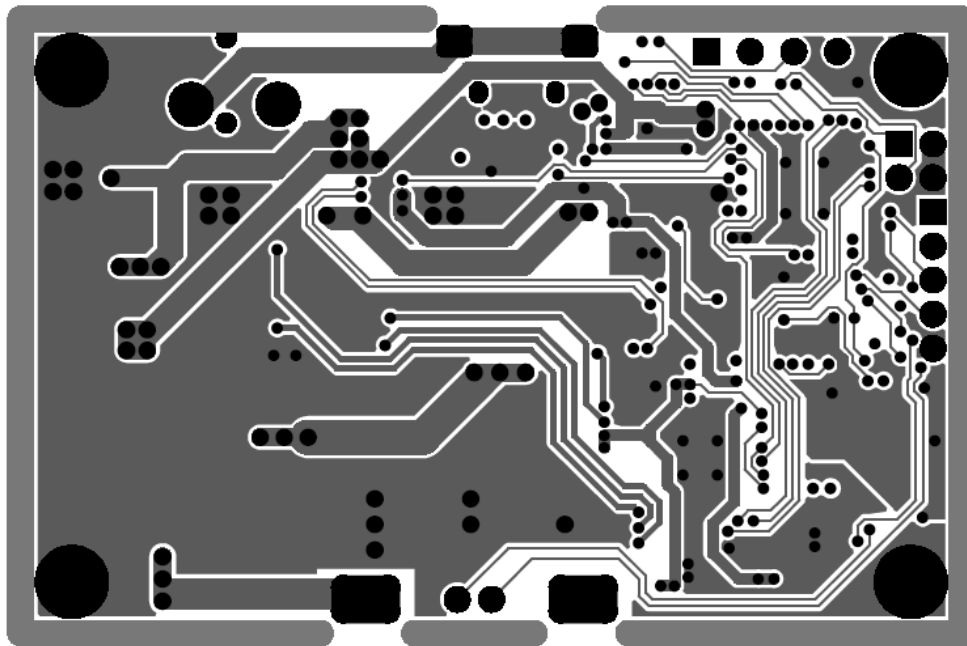
The TSDMTX-19V1-EVM PCB is based on a four layer design as shown below. The ground plane in layer two is recommended to reduce noise and signal crosstalk. The EVM placed all components on the top of the board for easier evaluation of the system. End product versions of this design can be made significantly smaller by distributing components on both sides of the board. The Gerber files for this artwork can be downloaded from the Semtech web page.



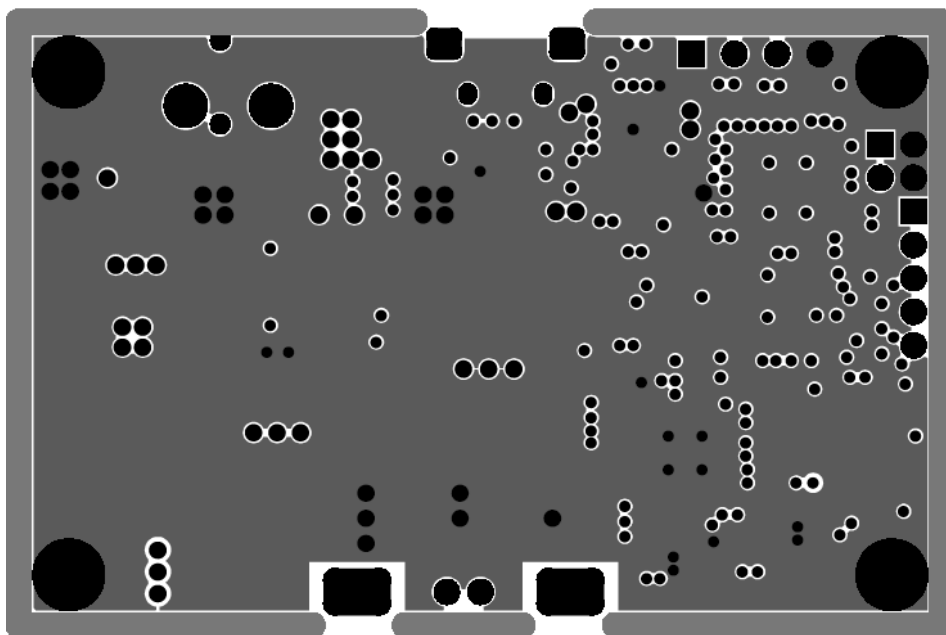
Top Layer



Ground Plane



Signal Layer



Bottom Layer

FAQs

Q: What output voltage is provided by the TSDMTX-19V1-EVM system?

A: It depends on which receiver is being used. For the TSDMRX-9V/15W-EVM, the output would be 9 volts, at up to 15 watts total power. If the TSDMRX-5W-EVM was used, the output would be 5 volts, at up to 5 watts.

Q: Where can I find more information on the Qi and PMA standards?

A: There are a number of websites that address this subject. A good starting point for Qi would be: <http://www.wirelesspowerconsortium.com/technology/how-it-works.html>. PMA, which is now joined with A4WP, is now called AirFuel. Information on them can be found at: <http://www.airfuel.org/technologies/inductive>.

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 and/or Wattage

Suffix = Equipment type:

EVM = Evaluation Module
MOD = Production Module

Therefore, the TSDMTX-19V1-EVM is a Dual Mode, 19 volt Transmitter Evaluation Module provided by Semtech.

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 TSDMTX-19V1-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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