bq51013EVM-725 Evaluation Module

The bqTESLA™ wireless power evaluation kit from Texas Instruments is a high-performance, easy-to-use development kit for the design of wireless power solutions. Consisting of a single-channel transmitter and 5-V power supply receiver and associated magnetics, the kit enables designers to speed the development of their end-applications.

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1 Applications

The bq51013EVM-725 evaluation module (EVM) demonstrates the receiver portion of the bqTESLA™ wireless power system. This receiver EVM is a complete receiver-side solution that produces 5 V out at up to 1 A when coupled with the bqTESLA™ transmitter. The bq51013EVM-725 device shown on this EVM along with external components that support the device for a complete solution.

- The bqTESLA™ receiver can be used in any number of low-power battery portable devices as a power source for charging. With contact-free charging capability, no connections to the device are needed.
- Output voltage of 5 V up to 1 A
- External adapter switchover and control circuit
- Low-profile, external pick-up coil
- Frame is configured to provide correct receiver to transmitter spacing.
- Room above coil for testing with battery, key for tuning

2 bq51013EVM-725 Electrical Performance Specifications

Table 1 provides a summary of the bq51013EVM-725 performance specifications. All specifications are given for an ambient temperature of 25°C.

Table 1. bq51013EVM-725 Electrical Performance Specifications

Parameter		Notes and Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
V_{IN}	Input Voltage	Typical V-rectified voltage at TP12	4	5.5	8	V
$V_{ADAPTER}$	Adapter Input Voltage		4		20	V
OVP	Input Overvoltage Protection	Voltage at V-rectified		15		V
OUTPUT CHARACTERISTICS						
V_{OUT}	V J3 to J4			5		V
I_{OUT}	I J3			1		A
SYSTEMS CHARACTERISTICS						
F_S	Switching Frequency		110		205	kHz
Eff	Efficiency	Output Current 500 mA		74		%

3 Modifications

See the data sheet (SLVSAT9) when changing components. To aid in such customization of the EVM, the board was designed with devices having 0603 or larger footprints. A real implementation likely occupies less total board space.

Note that changing components can improve or degrade EVM performance.

4 Connector and Test Point Descriptions

4.1 Input/Output Connections

The connections points are described in the following paragraphs.

4.1.1 J1 – AD External Adapter Input, J2-GND

Power can be provided to simulate an external adapter applied to the receiver. When this is done, an End Power Transfer signal is sent to the transmitter which enters a low power state. External adapter voltage must be a minimum of 4 V but not exceed 20V.

4.1.2 J3 – Output Voltage, J4-GND

Output voltage is 5 V with a possible current of up to 1 A.

4.1.3 J6 – Programming Connector

This connector is unpopulated and is only useful at factory level.

4.2 Jumpers/Switches

The control jumpers are described in the following paragraphs.

4.2.1 JP1 – EN1 Enable 1

One of two Enable signals that controls the Adapter and Wireless power transfer. Low on EN1 enables the wireless power transfer; High disables the wireless power transfer. The Default Shorting jumper setting is Low.

4.2.2 JP2 – EN2 Enable 2

One of two Enable signals that controls the Adapter and Wireless power transfer. Low on EN2 enables the adapter power transfer; High disables the adapter power transfer. Default Shorting jumper setting is Low.

4.2.3 JP3 – TS Enable or Disable

This jumper enables the TS adjustment feature using R3. The Disable position sets voltage at the TS pin to a safe value. The Default Shorting jumper setting is disabled

4.3 Test Point Descriptions

The test points are described in the following paragraphs.

4.3.1 TP1 – AD_EN

This push-pull driver for the external PFET connects the Adapter and the Output from the bq51013.

4.3.2 TP2 – AC Input 2

This is the test point for measuring ac voltage applied to the EVM from the receiver coil.

4.3.3 TP3 – Com2 Communication 2 Drive

Communication driver signal, open-drain output connected to communication capacitor.

4.3.4 TP4 – AC Input 1

This is the test point for measuring ac voltage applied to the EVM from the receiver coil.

4.3.5 TP5 – CLMP 1

Overvoltage clamp driver signal, open-drain output is connected to OVP capacitor.

4.3.6 TP6 – CLMP 2

Overvoltage clamp drive signal, open-drain output is connected to OVP capacitor.

4.3.7 TP7 – OUT Output Voltage

This test point is the output voltage from the bq51013 or the Adapter input.

4.3.8 TP8 – Boot-1 Boot Capacitor

This Bootstrap capacitor 1 drive connects to the integrated circuit (IC).

4.3.9 TP9 – Boot-2 Boot Capacitor

This bootstrap capacitor 2 drive connects to the IC.

4.3.10 TP10 – CHG Charge

This output signal indicates that the output current is being delivered to OUT, the open-drain output.

4.3.11 TP11 – AC1 IC input

This is the ac input to the IC from series capacitors.

4.3.12 TP12 – Rectified Voltage

The input ac voltage is rectified into unregulated dc voltage; additional capacitance is used to filter the voltage before the regulator.

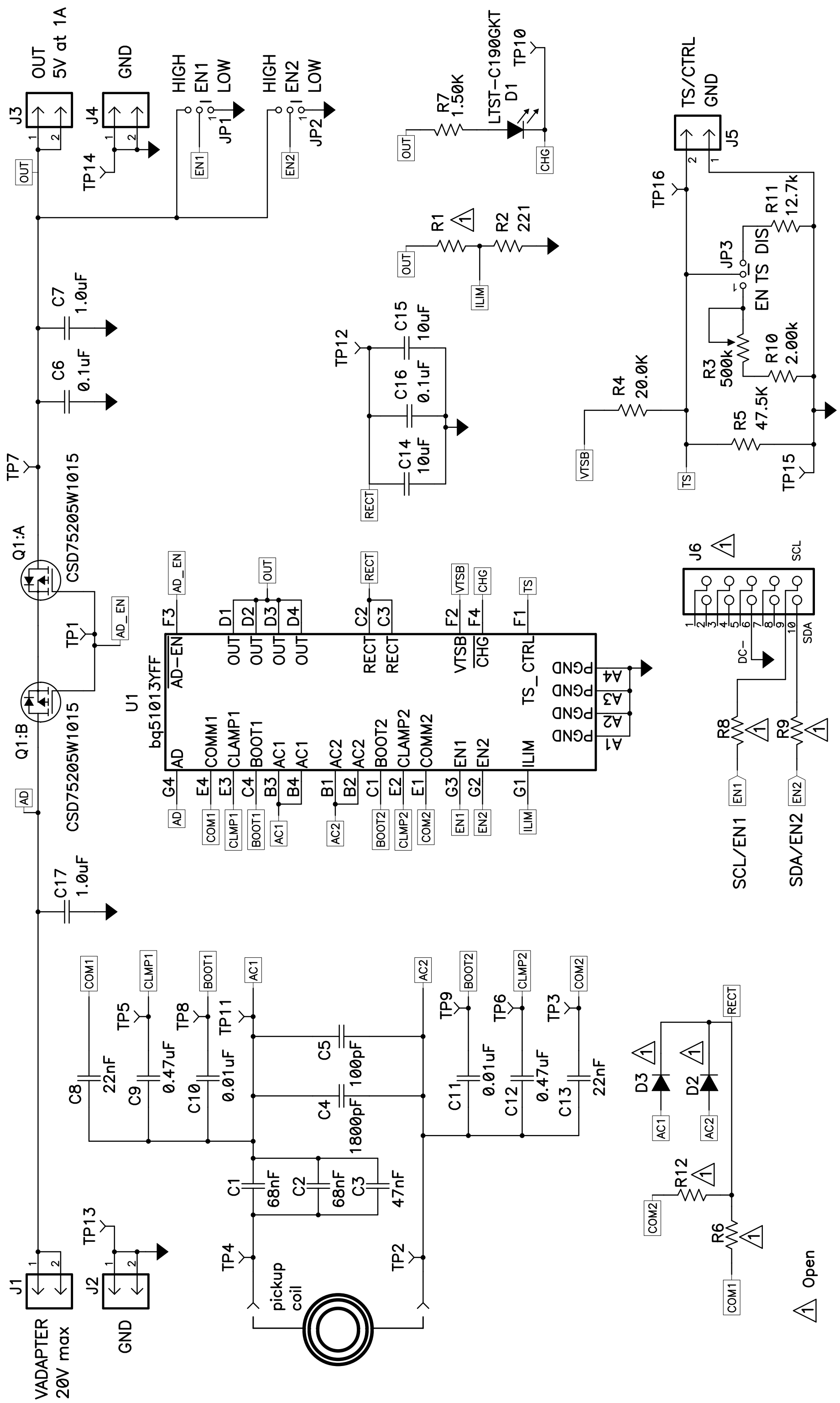
4.3.13 TP13, TP14, TP15 – GND

These are the ground test points.

4.3.14 TP16 – TS Temp Sensor

This is the connection point for external thermistor; see the data sheet for additional information.

5 Schematic and Bill of Materials



NOTE: For Reference Only, See Table 2 for Specific Values

Figure 1. HPA725EVM Schematic

Table 2. Bill of Materials

Qty	RefDes	Value	Description	Size	Part Number	MFR		
2	C1, C2	68 nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std		
1	C3	47 nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std		
1	C4	1800 pF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std		
1	C5	100 pF	Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std		
2	C6, C16	0.1 µF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std		
2	C7, C17	0.1 µF	Capacitor, Ceramic, 50V, X5R, 10%	0805	Std	Std		
2	C8, C13	22 nF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std		
2	C9, C12	0.47 µF	Capacitor, Ceramic, 25V, X5R, 10%	0603	Std	Std		
2	C10, C11	0.01 µF	Capacitor, Ceramic, 50V, X7R, 10%	0603	Std	Std		
2	C14, C15	10 µF	Capacitor, Ceramic, 25V, X5R, 10%	1206	Std	Std		
1	D1	LTST-C190GKT	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	0603	LTST-C190GKT	Lite On		
0	D2, D3	Open	Diode, Schottky, 2A, 20V	POWERLITE123	SMD22PL-TP	Micro Commercial Components		
1	Q1	CSD75205W1015	MOSFET, Dual PChan, -20V, 1.2A, 190 mΩ	CSP 1x1.5mm	CSD75205W1015	TI		
0	R1, R8, R9	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std		
1	R2	221	Resistor, Chip, 1/16W, 1%	0603	Std	Std		
1	R3	500k	Potentiometer, 1/4 in. Cermet, 12-Turn, Top-Adjust	0.25x0.17	3266W-1-504LF	Bourns		
1	R4	20.0K	Resistor, Chip, 1/16W, 1%	0603	Std	Std		
1	R5	47.5K	Resistor, Chip, 1/16W, 1%	0603	Std	Std		
0	R6, R12	Open	Resistor, Metal Film, 1/4 watt, ± 1%	1206	CRCW120624R0FKEA	Vishay		
1	R7	1.50K	Resistor, Chip, 1/16W, 1%	0603	Std	Std		
1	R10	2.00k	Resistor, Chip, 1/16W, 1%	0603	Std	Std		
1	R11	12.7k	Resistor, Chip, 1/16W, 1%	0603	Std	Std		
1	U1	bq51013YFF	IC, Wireless Secondary-Side Power Controller and Battery Charge	DSBGA	bq51013YFF	TI		
1			Case Modified Polycase LP-11B with 4 screws		J-6838A	Polycase		
1			Receiver Coil		IWAS-4832FF-50	Vishay		

6 Test Setup

6.1 Equipment

6.1.1 bqTESLA™ Transmitter

Power for the bq51013EVM-725 receiver EVM is supplied through a bqTESLA™ transmitter or WPC-certified transmitter. The input ac voltage is applied to the receiver through the coil located in the receiver bottom.

6.1.2 Voltage Source

Input power supply to the bqTESLA™ transmitter is typically 19 Vdc ±200 mV at 500 mA maximum, but consult transmitter specification. To simulate an external adapter, an additional 5 V at the 1-A power supply is used.

6.1.3 Meters

Output voltage can be monitored at TP7 with a voltmeter. Input current into the load must be monitored with an appropriate ammeter. Transmitter input current and voltage can be monitored also but the meter must use averaging function for reducing error due to communications packets.

6.1.4 Loads

A single load is required for 5 V with a maximum current of 1 A. The load can be resistive or electronic.

6.1.5 Oscilloscope

A multichannel oscilloscope with appropriate probes is used to observe the RECT voltage at TP12 and other signals.

6.1.6 Recommended Wire Gauge

For proper operation, 22 AWG wire is recommended when connecting the bq51013EVM-725EVM to loads.

6.2 Equipment Setup

- With the power supply off, connect supply to the bqTESLA™ transmitter.
- Place the bqTESLA™ receiver on the transmitter.
- Connect load to J3 with return to J4, monitor current through load with ammeter, and monitor current to load at TP7.
- Typical output voltage is 5 V, and the output current range is 0 mA to 1 A.

6.2.1 Equipment Setup Diagram

The diagram of Figure 2 shows the equipment test setup.

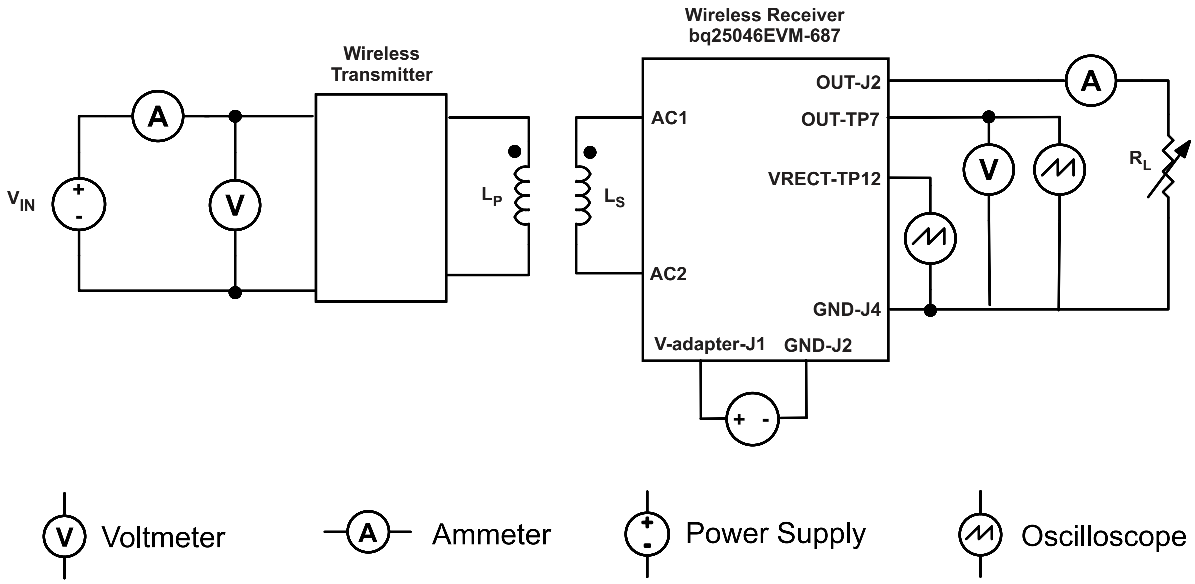


Figure 2. Equipment Setup

6.2.2 EVM Setup Procedures

This section guides the user through a few general test procedures to exercise the functionality of the presented hardware. A few key notes:

- To probe the output voltage of the receiver, connect the probe to TP7.
- To probe the rectifier voltage, connect the probe to TP12.
- The V-adapter supply which simulates an external adapter is connected to J1.
- All voltmeters must be Kelvin connected (at the pin) to the point of interest.
- The output load is recommended to be a variable power resistor or electronic load.

6.3 Load Step

The procedure for load step is as follows:

- Set up the test bench as described in Section 6.2.
- Power TX with 19 V.
- Provide a load step from no load (high impedance) to 10 Ω or 500 mA (if using a current source load).
- Monitor load current, rectifier voltage, and output voltage as shown in the following illustrations.

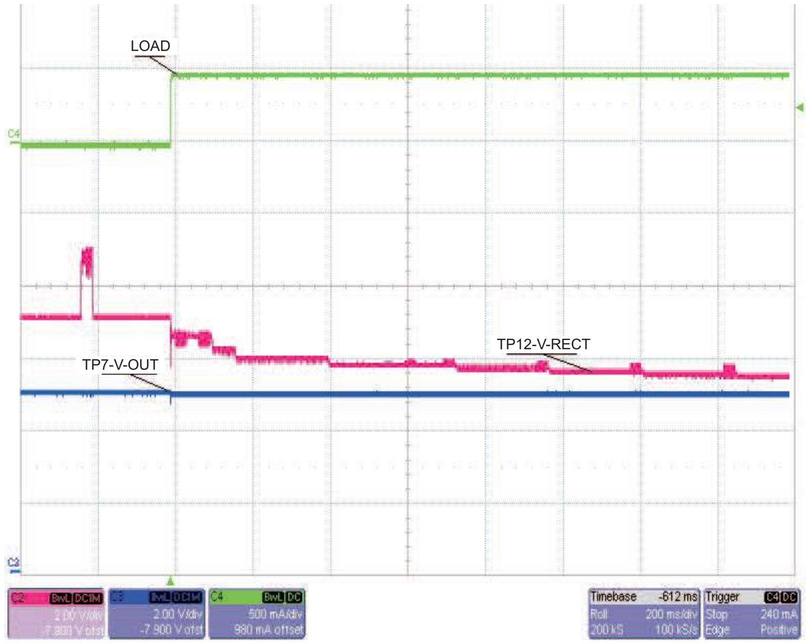


Figure 3. Load Step

6.4 *Load Dump*

The procedure for load dump is as follows:

- Set up the test bench as described in Section 6.2.
- Power TX with 19 V.
- Provide a load dump from 10 Ω or 500 mA (if using a current source load) to no load (high impedance).
- Monitor load current, rectifier voltage, and output voltage as shown in the following illustration.

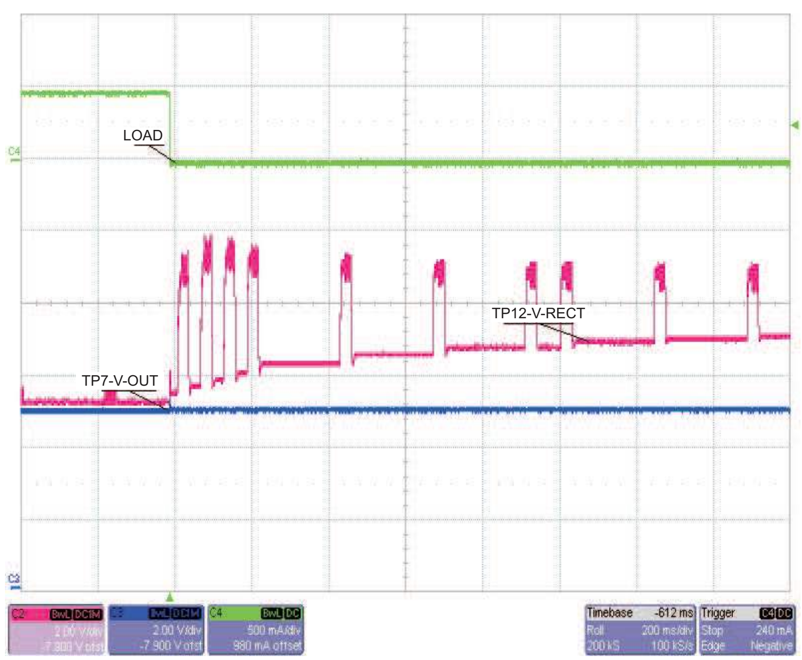


Figure 4. Load Dump

6.5 V-Adapter Input

The procedure for external adapter (wired adapter) testing is as follows:

- Set up the test bench as described in Section 6.2.
- Power TX with 19 V.
- Load output (the following was loaded with a X-Ω resistor).
- Apply a 6-V V-adapter input voltage.
- Monitor load current, rectifier voltage, output voltage, and V-adapter voltage as shown in the following illustration.

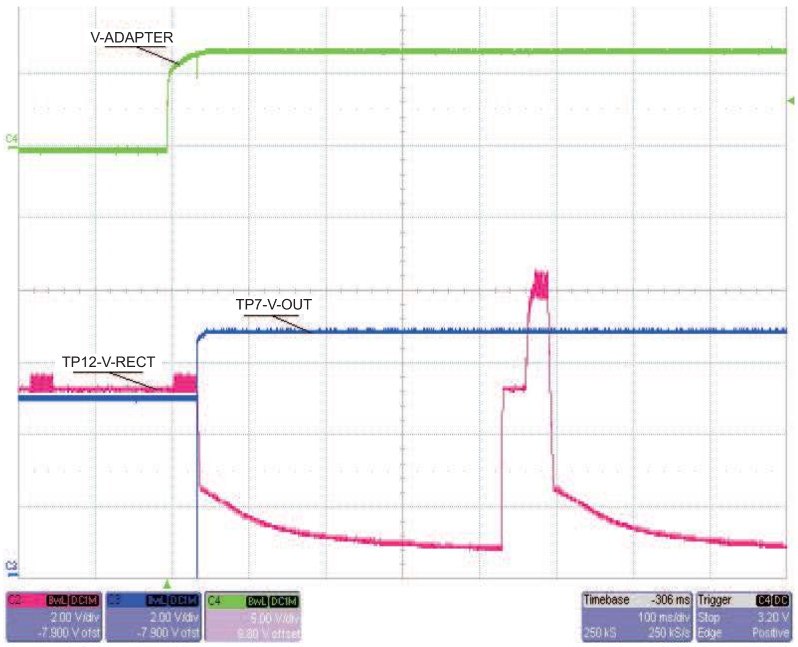


Figure 5. V-Adapter Input

6.6 Start-Up

The procedure demonstrates start-up:

- Set up the test bench as described in Section 6.2.
- Power TX with 19 V.
- Trigger scope sweep on TP2 AC IN.

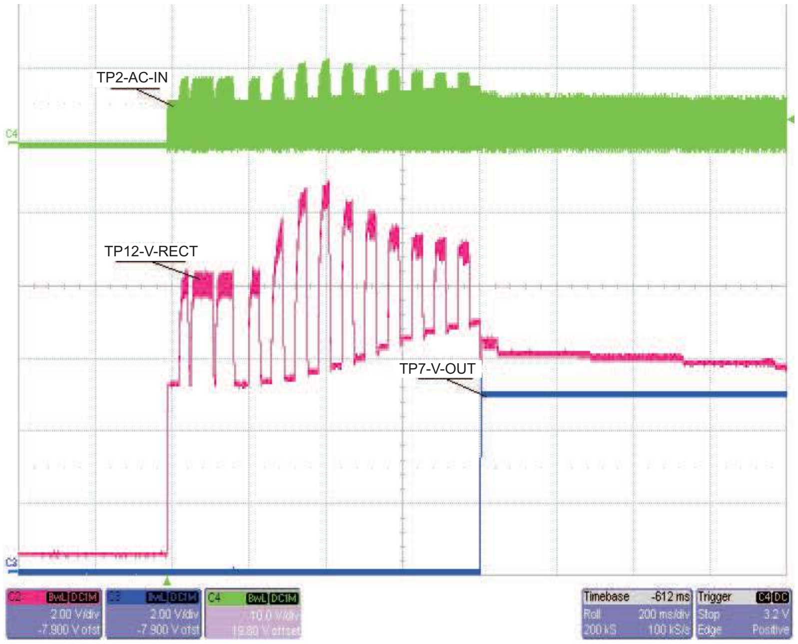


Figure 6. Start-Up

6.7 Disable Shutdown

The jumper JP2 (EN2)sends an End Power Transfer to Transmitter, Shutdown:

- With unit operating normally, move jumper JP2 from Low to High position.
- LED D1 turn OFF; output voltage drops to 0 V.
- Return jumper to Low position, RX restarts.

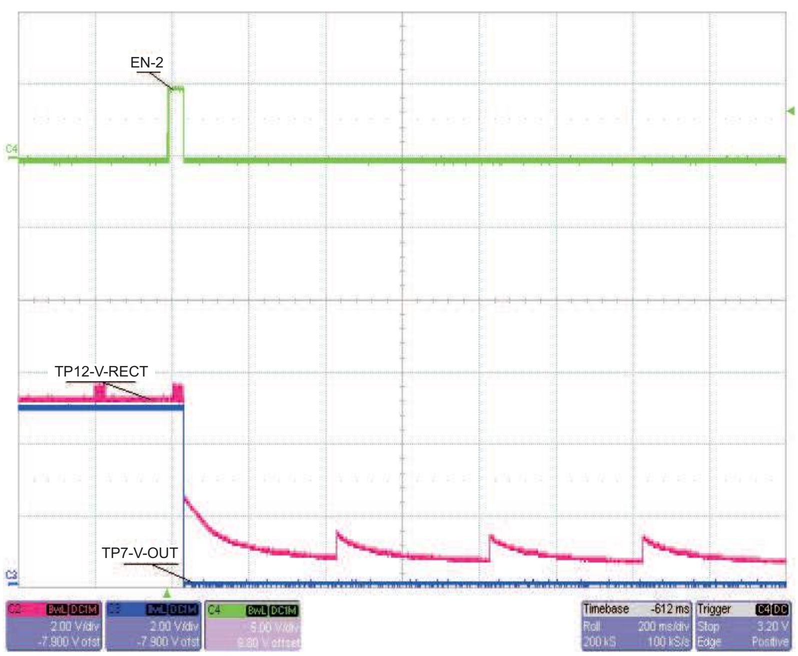


Figure 7. Equipment Shutdown Wireless Disable

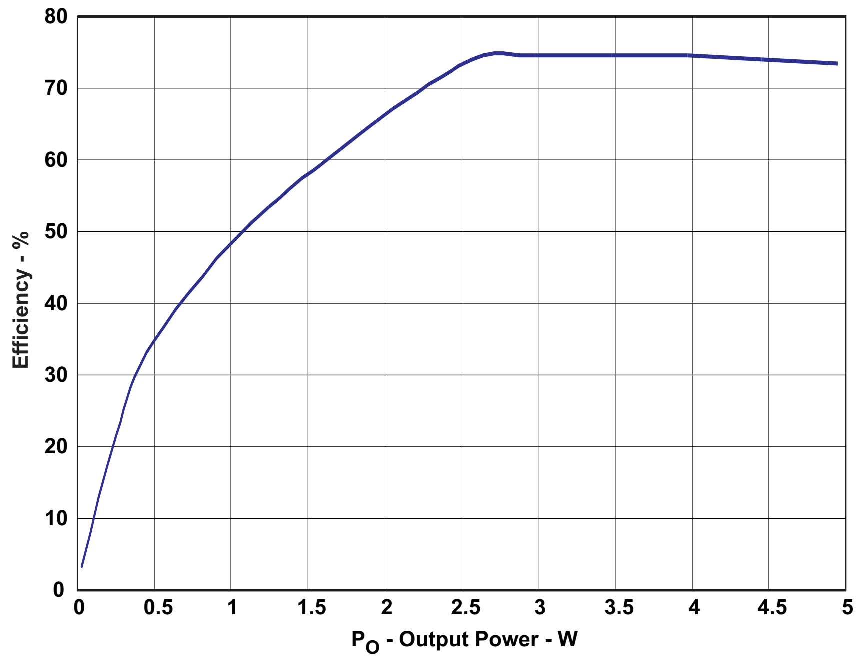


Figure 8. bq51013EVM-725 Efficiency vs Output Power

7 bq51013EVM-725 Assembly Drawings and Layout

The following figures (Figure 9 through Figure 12) show the design of the bq51013EVM-725 printed-circuit board (PCB). The EVM has been designed using a 2-layer, 2-oz, copper-clad PCB, 2.1-in. × 2.1-in. area to provide the user easy viewing, probing, and evaluating of the bq51013 IC in a practical double-sided application. Moving components to both sides of the PCB or using additional internal layers can offer additional size reduction for space-constrained systems.

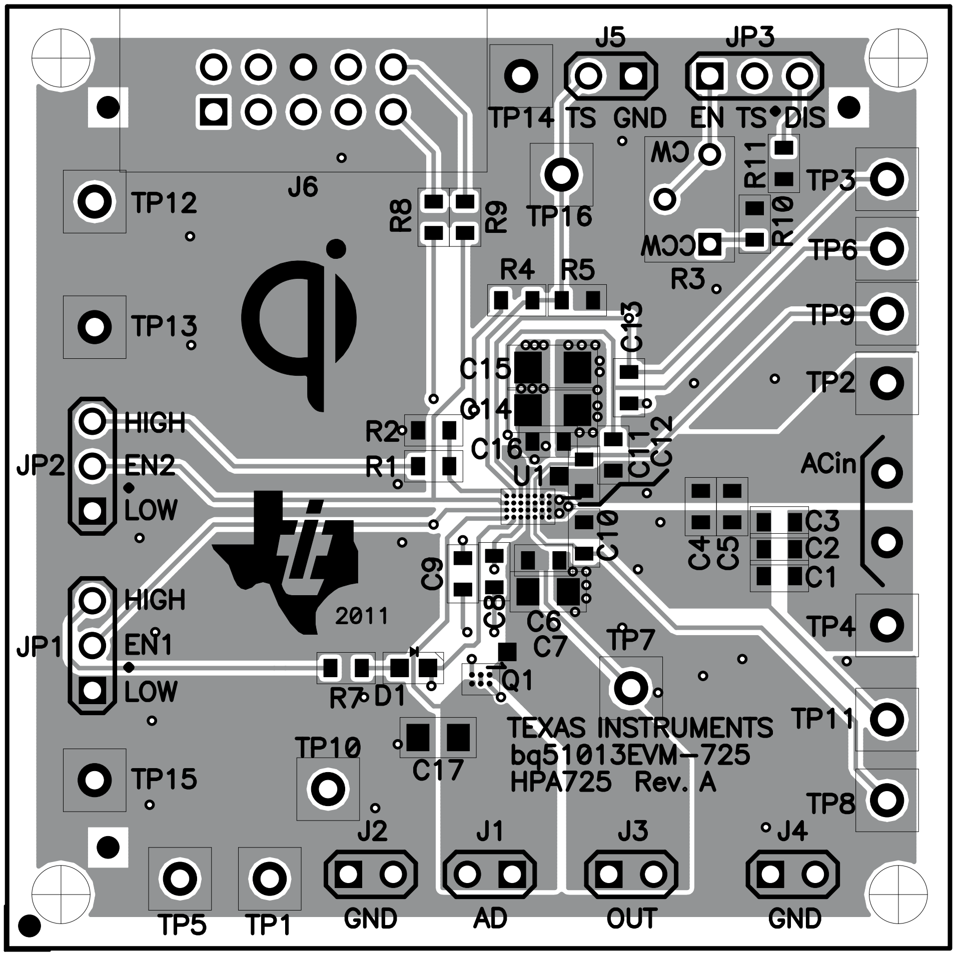


Figure 9. Top Assembly

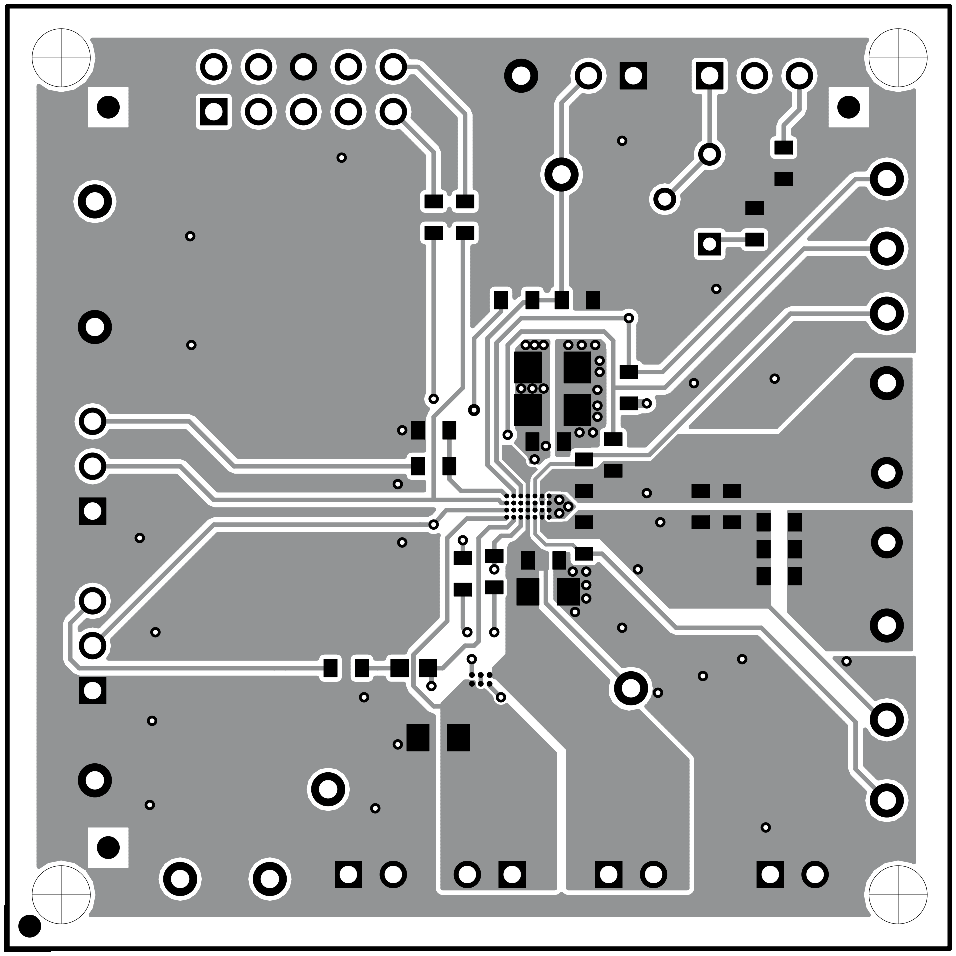


Figure 10. Top Copper Layer

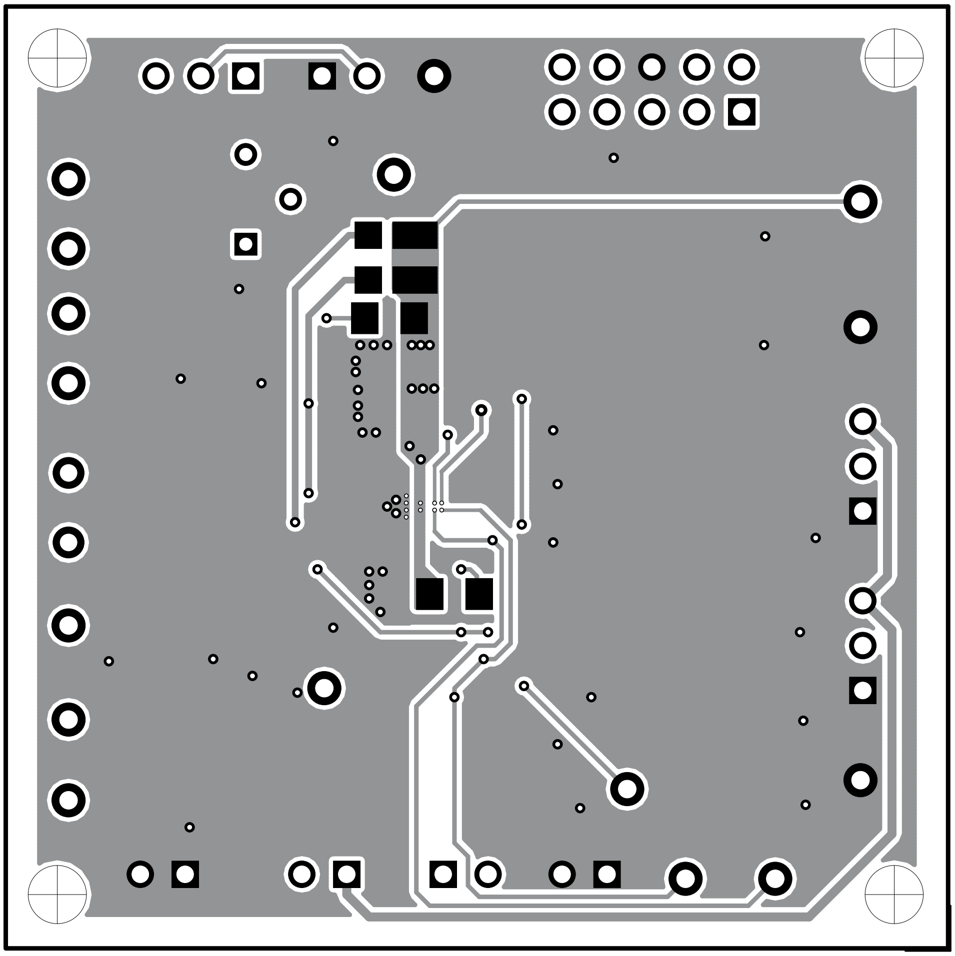


Figure 11. Bottom Copper Layer

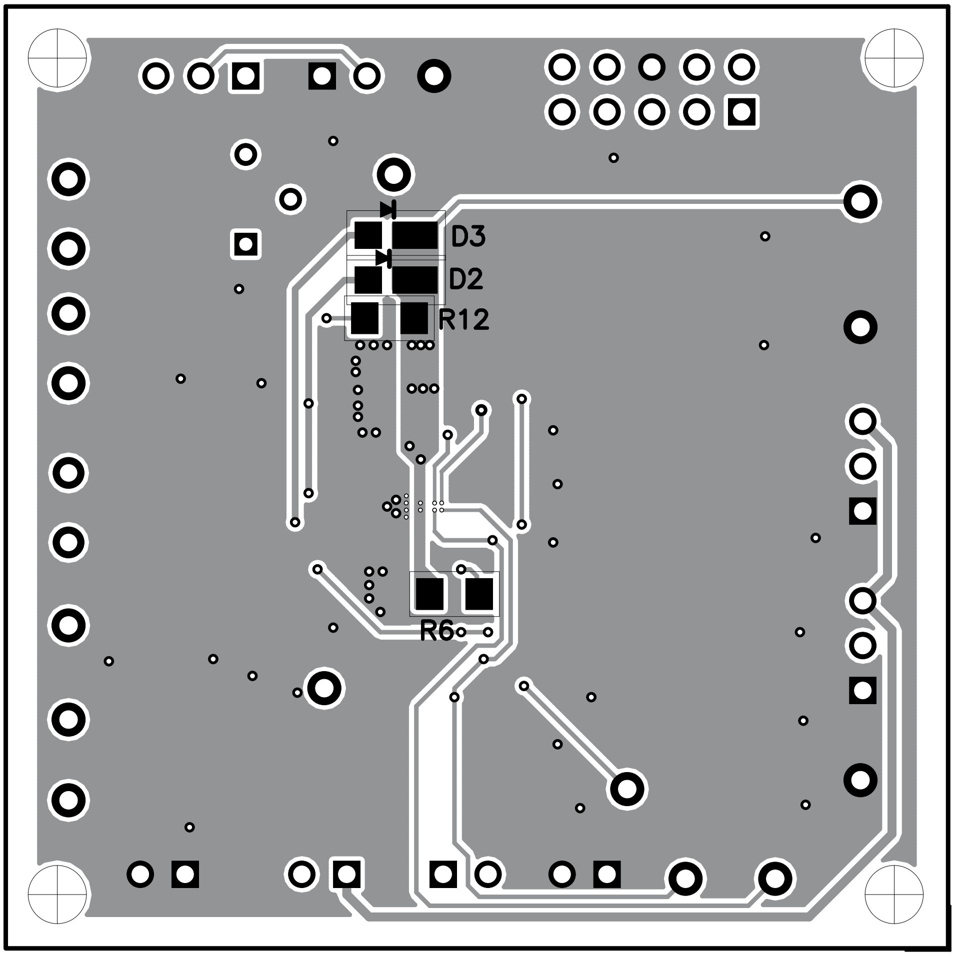


Figure 12. Bottom Assembly

8 Reference

For additional information about the bqTESLA100LP low-power, wireless, power evaluation kit from Texas Instruments, visit the product folder on the TI Web site at http://focus.ti.com/docs/toolsw/folders/print/bqtesla100lp.html.

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 0 V to 8 V and the output voltage range of 0 V to 5 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 65°C. The EVM is designed to operate properly with certain components above 65°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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