TI Design: TIDA-00669

500mA Wireless Charger Booster Pack with Gauge Reference Design

TEXAS INSTRUMENTS

TI Designs

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Design Resources

TIDA-00669	Design Folder
bq51050B	Product Folder
bq27421	Product Folder
bq29707	Product Folder
TPS61252	Product Folder
TPS63051	Product Folder

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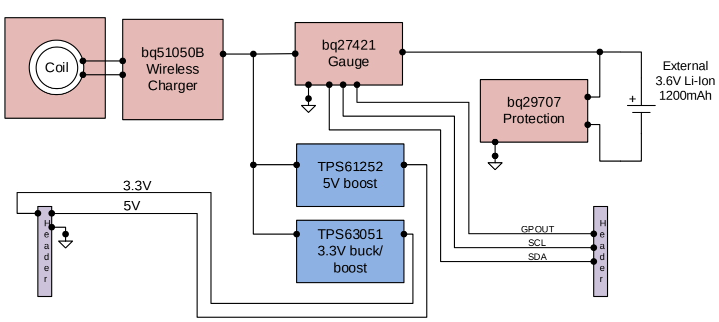
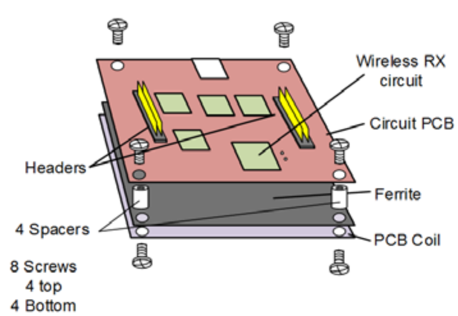
Block Diagram





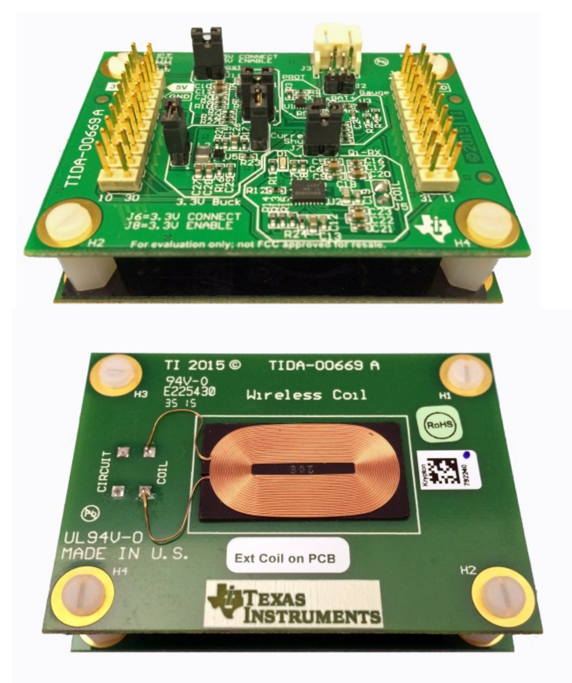
Design Features

- Wireless Charger Booster Pack designed for any TI Launchpad
- Li-Ion / Li-Polymer storage to 2A (Charges at 500mA)
- Qi Compatible - Recharge the battery from any Qi transmitter
- 3.3Vdc 500mA buck to power the Launchpad
- 5V 400mA boost to power support circuitry
- Stackable design allows for creating a complete solution

Featured Applications

- Factory Automation and Process Control
- Sensors and Field Transmitters
- Building Automation
- Portable Instruments
- IoT (Internet of Things)
- Wearables

Board Image



1 Key System Specifications

Wireless Receiver

Value	Suffix	Test	Setup
4.010	Vdc	Output voltage of the RX	Measure Pin 1 of J7 to ground
480	mA	Max load current from the wireless RX	Remove J7 and place a an electronic load on J7 pin 1 and measure max current
27.6	C	Wireless RX circuit thermal rise at max charge from ambient temperature 22.8C	Measure the ambient temperature under no load then load to max charge current for 15 minutes

Charger

4.042	Vdc	Measured BT1 voltage	Connect the Li-Polymer battery and place a current meter across J7. Remove J4 and J8 to disable both regulators.
480	mA	Charge current while charging from RX	Measure current through J7
31	mA	Charger term current high	Measure the current when the charger goes into terminate
4.195	Vdc	Charger term voltage high	Measure the voltage when the charger goes into terminate
84	mA	Pre-charge current	Discharge to 2V then turn on the charger and measure the current going into BT1
2.4	Vdc	Pre-charge threshold	Connect sourcemeter and power supply at 5V to charger in. Adjust sourcemeter from 3V down to 1.5V determine pre-charge threshold

3.3V Regulator

3.340	Vdc	Measured 3.3V out	Replace J8 and measure the output voltage of U5
3.339	Vdc	3.3V with BT1 at max voltage	Disconnect the battery, connect a power supply to BT1, adjust from low to high
910	mA	Abs max current on 3.3V regulator	Connect source meter to 3.3V and increase the load until 3.v drops out
3.200	Vdc	3.3V with 500mA current with BT1 at max	Connect a source meter and increase the load
3.36	Vdc	3.3V with BT1 at min voltage	Disconnect the battery and connect a power supply to BT1, adjust from high to low
3.22	Vdc	3.3V with a 500mA current with BT1 at min	Connect a source meter (Set to drop out voltage) and increase the load
2.8	Vdc	PG on threshold	Disconnect the battery and connect a source meter to BT1. Sweep low to high
0	Vdc	3.3V disable	Remove J8 measure output of 3.3V regulator
35	C	3.3V circuit thermal rise at 500mA (22.8C ambient)	Measure the ambient temperature under no load then load to max current for 15 minutes with BT1 at min

5V Regulator

5.048	Vdc	Measured 5V out	Replace J4 and measure the output voltage of U4
5.036	Vdc	5V with BT1 at max voltage	Disconnect the battery and connect a power supply to BT1, adjust from low to high

5.021	Vdc	5V with BT1 at min voltage	Disconnect the battery and connect a power supply to BT1, adjust from high to low
4.850	Vdc	5V with 430mA current with BT1 at min voltage	With BT1 at 3.0V, connect a source meter to the 5V regulator and increase the load
4.958	Vdc	5V with 500mA current with BT1 at max voltage	Connect a source meter and increase the load
490	mA	Abs max current on 5V regulator	Connect source meter to 5V and increase the load until the regulator drops below the acceptable threshold
0	Vdc	5V disable (Input voltage minus forward diode drop when off)	Remove J4 measure output of 5V regulator
39	C	5V circuit thermal rise at 50mA (22.8C ambient)	measure the ambient temperature under no load then load to max current for 15 minutes with BT1 at min

Protector

4.29	Vdc	Protection voltage max	Remove coin cell, connect a source meter to BT1. Sweep low to high
2.79	Vdc	Protection voltage min	Remove coin cell, connect a source meter to BT1. Sweep high to low
910	mA	Protection current	Remove coin cell, connect a power supply to BT1, connect source meter to 5V and increase the load thru the protection circuit to test max current

System

80	uA	Idle current from charger into fully charged BT1 with regulators disabled	Place on TX and charge till full, measure the current through J7 when the charger drops out
190	uA	Idle current from charger into fully charged BT1 with regulators enabled	Place on TX and charge till full, measure the current through J7 when the charger drops out

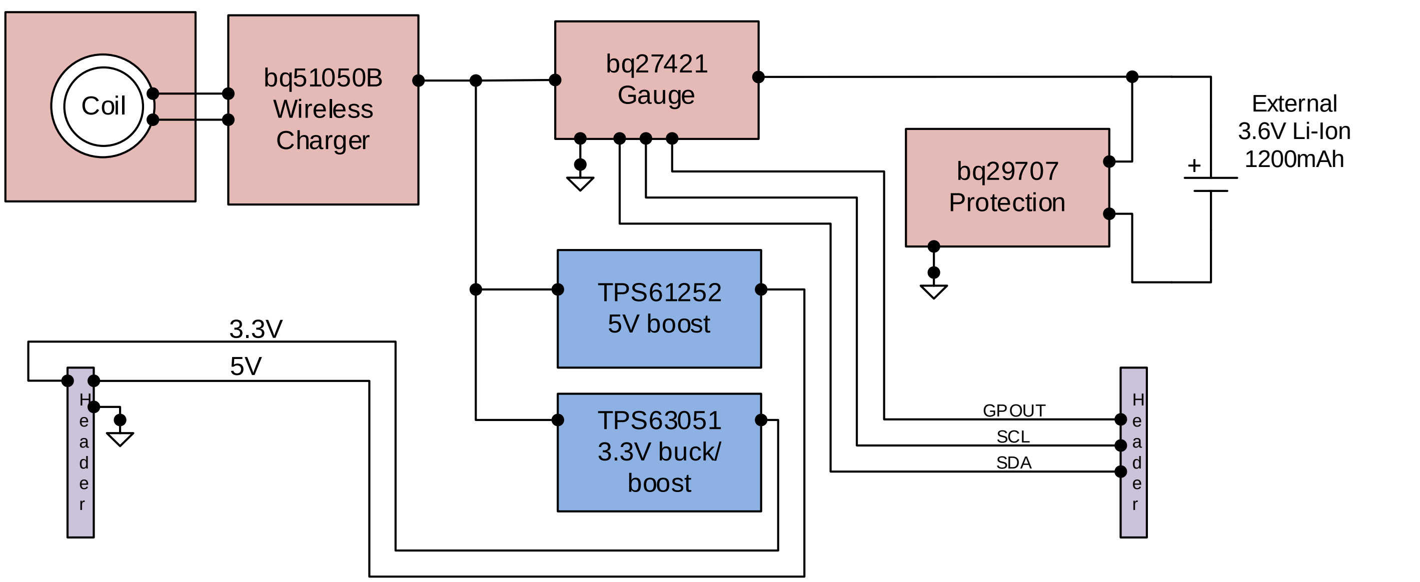
2 System Description

This is a 500mA Wireless Charger Booster Pack with gauge and is designed to be a complete wireless charger, battery management and power supply solution for use with Launchpad's and other development boards. This booster pack design was created with a Qi compatible wireless receiver circuit and an off the shelf receiver coil.

By placing the booster pack on any Qi Wireless compatible transmitter you will have the ability to recharge the battery at any time even while connected to the Launchpad and in operation. Use this booster pack with your favorite TI Launchpad development board to power your design from a small rechargeable Lithium Ion coin cell battery.

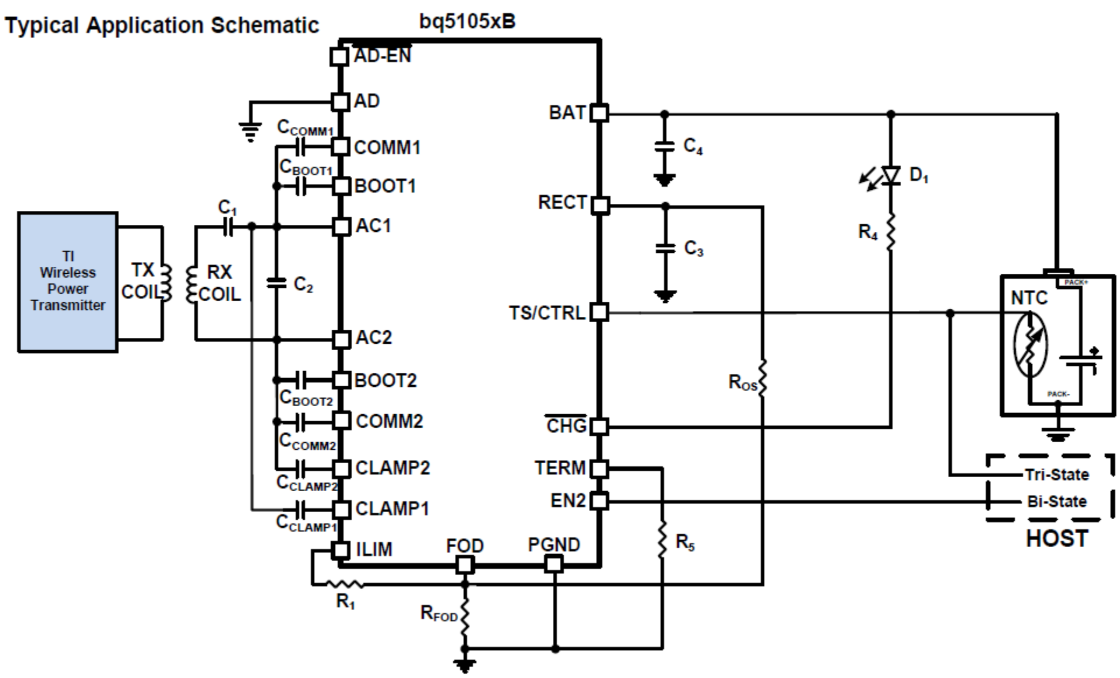
The buck converter will provide 3.3Vdc for the Launchpad power and an additional switching boost converter will supply 5V to run accessories. The total max current is 900mA as set by the protector. Make sure the combined 3.3V and 5V currents do not exceed the maximum current capabilities of this circuit.

The battery is protected by the bq29707 protection IC. The battery is disconnected if the battery voltage goes over 4.28V or under 2.8V or if the peak current goes over 900mA.



2.1 bq51050B

The bq5105x device is a high-efficiency, Qi-compliant wireless power receiver with an integrated Li-Ion/Li-Pol battery charge controller for portable applications.
The bq5105xB devices provide efficient AC-DC power conversion, integrates the digital controller required to comply with Qi v1.1 communication protocol, and provides all necessary control algorithms needed for efficient and safe Li-Ion and Li-Pol battery charging. Together with the bq500212A transmitter-side controller, the bq5105x enables a complete wireless power transfer system for direct battery charger solutions. By using near-field inductive power transfer, the receiver coil embedded With Input Overvoltage Protection in the portable device can pick up the power transmitted by transmitter coil. The AC signal from the receiver coil is then rectified and conditioned to apply power directly to the battery. Global feedback is established from the receiver to the transmitter to stabilize the power transfer process. This feedback is established by using the Qi v1.1 communication protocol.
The bq5105xB devices integrate a low-impedance synchronous rectifier, low-dropout regulator (LDO), digital control, charger controller, and accurate voltage and current loops in a single package. The entire power stage (rectifier and LDO) use low resistance N-MOSFETs (100-mΩ typical Rdson) to ensure high efficiency and low power dissipation.



2.2 bq27421

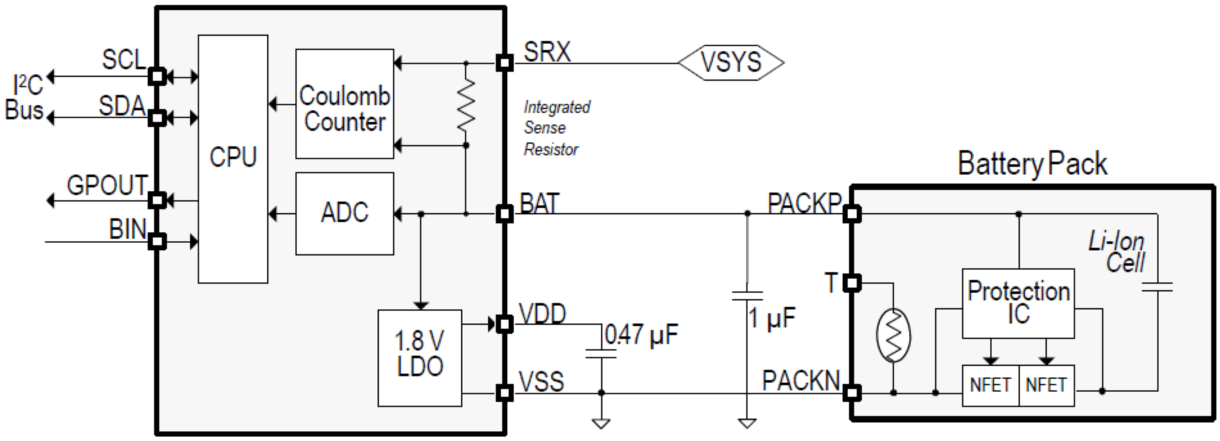
The Texas Instruments bq27421-G1 fuel gauge is an easy-to-configure microcontroller peripheral that provides system-side fuel gauging for single-cell Li- Ion batteries. The device requires minimal user configuration and system microcontroller firmware development.
The bq27421-G1 fuel gauge uses the patented Impedance Track algorithm for fuel gauging, and provides information such as remaining battery capacity (mAh), state-of-charge (%), and battery voltage (mV).
Information is accessed through a series of commands, called *Standard Commands*. Further capabilities are provided by the additional *Extended Commands* set. Both sets of commands, indicated by the general format *Command()*, are used to read and write information contained within the control and status registers, as well as its data locations. Commands are sent from system to gauge using the I2C serial communications engine, and can be executed during application development, system manufacture, or end-equipment operation.

The key to the high-accuracy gas gauging prediction is Texas Instruments proprietary Impedance Track™ algorithm. This algorithm uses cell measurements, characteristics, and properties to create state-of-charge predictions that can achieve high-accuracy across a wide variety of operating conditions and over the lifetime of the battery.

The fuel gauge measures the charging and discharging of the battery by monitoring the voltage across a small value sense resistor. When a cell is attached to the fuel gauge, cell impedance is computed, based on cell current, cell open-circuit voltage (OCV), and cell voltage under loading conditions.

The fuel gauge uses an integrated temperature sensor for estimating cell temperature. Alternatively, the host processor can provide temperature data for the fuel gauge.

Functional Block Diagram

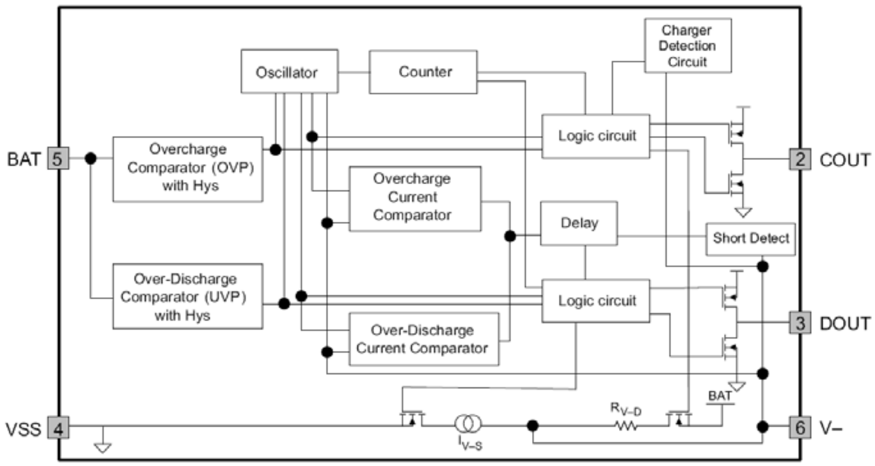


2.3 bq29707

The bq297xy battery cell protection device provides an accurate monitor and trigger threshold for overcurrent protection during high discharge/charge current operation or battery overcharge conditions.

The bq297xy device provides the protection functions for Li-Ion/Li-Polymer cells, and monitors across the external power FETs for protection due to high charge or discharge currents. In addition, there is overcharge and depleted battery monitoring and protection. These features are implemented with low current consumption in NORMAL mode operation.

Protector Simplified Block Diagram



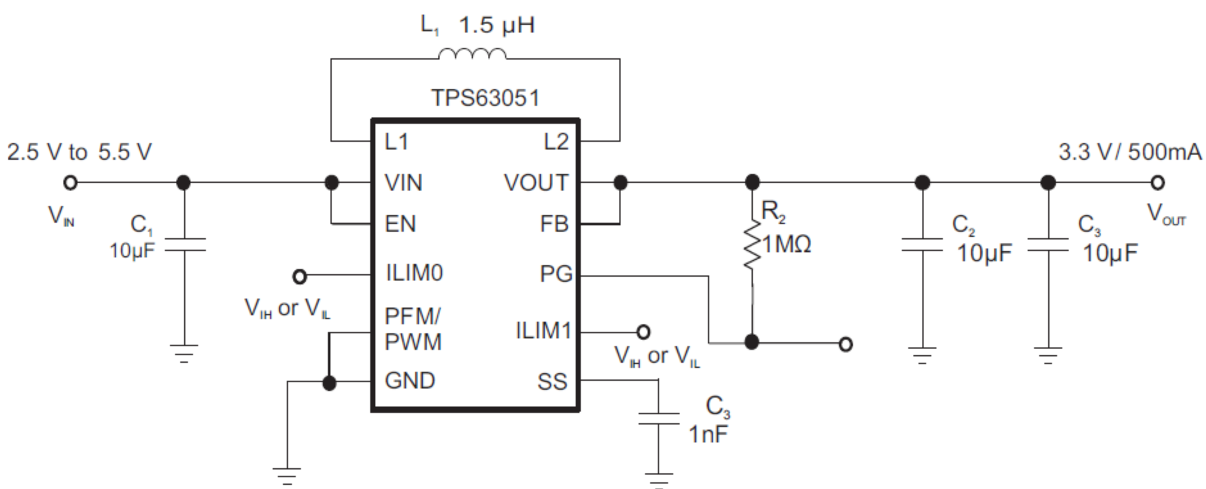
2.4 TPS63051

The TPS6305x is a single inductor buck-boost with 1-A switches and adjustable soft start. The TPS6305x family of devices is a high efficiency, low quiescent-current buck-boost converter, suitable for applications where the input voltage is higher or lower than the output. Continuous output current can go as high as 500 mA in boost mode and as high as 1 A in buck mode. The maximum average current in the switches is limited to a typical value of 1 A.

The TPS6305x family of devices regulate the output voltage over the complete input voltage range by automatically switching between buck or boost mode depending on the input voltage, ensuring seamless transition between modes. The buck-boost converter is based on a fixed- frequency, pulse-width-modulation (PWM) controller using synchronous rectification to obtain the highest efficiency. At low load currents, the converter enters Power Save Mode to maintain high efficiency over the complete load current range.

The PFM/PWM pin allows the user to select between automatic-PFM/PWM mode operation and forced- PWM operation. During PWM mode a fixed-frequency of typically 2.5 MHz is used. The output voltage is programmable using an external resistor divider, or is fixed internally on the chip. The converter can be disabled to minimize battery drain. During shutdown, the load is disconnected from the battery.

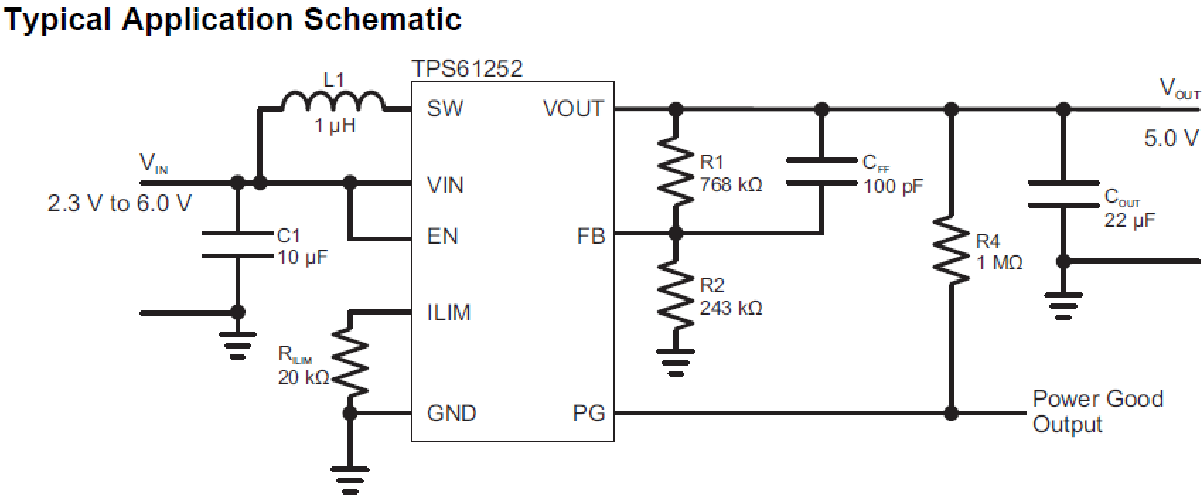
3.3V Buck-Boost Simplified Schematic.



2.5 TPS61252

The TPS61252 device is used for the 5V boost and provides a power supply solution for products powered by either a three-cell alkaline, NiCd or NiMH battery, or a one-cell Li-Ion or Li-polymer battery. The wide input voltage range is ideal to power portable applications like mobile phones or computer peripherals. The device has a resistor programmable (RILIM) input current limit and is suitable for a wide variety of applications.

During light loads, the device automatically enters skip mode (PFM), which allows the converter to maintain the required output voltage, while only drawing 30 µA quiescent current from the battery. This allows maximum efficiency at lowest quiescent currents. The TPS61252 allows the use of small inductors and capacitors to achieve a small solution size. The possibility to reduce the current limit by an external resistor offers the potential use of physically even smaller inductors with lower rated currents to further reduce total solution sizes of the power supply. During shutdown, the load is completely disconnected from the battery.



Getting Started

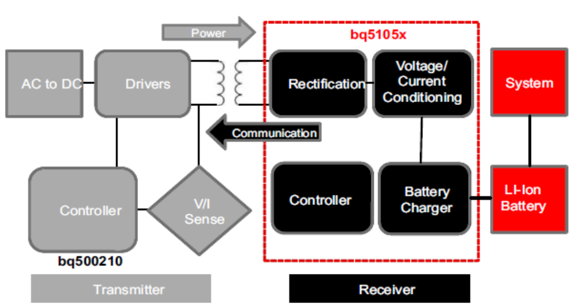
The 500mA Wireless Charger Booster Pack with gauge can be a great addition to your design development. Having a good understanding of some of the key features is very important. Before you start, take the time to understand these important concepts.

2.6 Wireless Receiver

A wireless system consists of a charging pad (primary, transmitter) and the secondary-side equipment. There are coils in the charging pad and in the secondary equipment which magnetically couple to each other when the equipment is placed on the charging pad. Power is transferred from the primary to the secondary by transformer action between the coils. Control over the amount of power transferred is achieved by changing the frequency of the primary drive.

The secondary can communicate with the primary by changing the load seen by the primary. This load variation results in a change in the primary coil current, which is measured and interpreted by a processor in the charging pad. The communication is digital - packets are transferred from the secondary to the primary. Differential bi-phase encoding is used for the packets. The rate is 2-kbps. Various types of communication packets have been defined. These include identification and authentication packets, error packets, control packets, power usage packets, end of power packet and efficiency packets.

The primary coil is powered off most of the time. It wakes up occasionally to see if a secondary is present. If a secondary authenticates itself to the primary, the primary remains powered up. The secondary maintains full control over the power transfer using communication packets.



WPC Wireless Power Charging System Indicating the Functional Integration of the bq5105x

2.7 WE Coil

The receiver coil is a Wurth Electronics coil part number 760308103206. The inductance of the coil is approximately 7.5uh with a 1.55A max current and a DCR of 0.34 Ohms. The coil tested well to 1.5A and is used to 500mA in this booster pack design.

2.8 Gauge

The Texas Instruments bq27421-G1 fuel gauge is an easy-to-configure microcontroller peripheral that provides system-side fuel gauging for single-cell Li-Ion batteries. The device requires minimal user configuration and system microcontroller firmware development.
The bq27421-G1 fuel gauge uses the patented Impedance Track™ algorithm for fuel gauging, and provides information such as remaining battery capacity (mAh), state-of-charge (%), and battery voltage (mV).
Battery fuel gauging with the bq27421-G1 fuel gauge requires connections only to PACK+ (P+) and PACK– (P–) for a removable battery pack or embedded battery circuit. The tiny 9-ball, 1.62 mm × 1.58 mm, 0.5-mm pitch NanoFree chip scale package (DSBGA) is ideal for space-constrained applications.

2.9 Battery

The battery part number and information about the battery is not in the BOM. The battery that was used for testing this reference design is from AEenergy, type 503759, part number AE503759P6HA. It is a Li-Polymer rechargeable battery rated at 3.7V 1200mAh. The size is 37mmx60mmx5mm. This battery does have basic thermal protection built in. TI recommends this battery for use in this design as it is UL rated and had been tested. The user may use an alternate battery for use with this battery back but it is the sole responsibility of the user to determine the safety and compatibility of the alternate battery. The gauge is capable of self-correcting, accurately gauging and monitoring an alternate battery when connected to a compatible LI-ion or Li-Polymer battery with a range of 3.0V min to 4.2V max and a current capacity of 1000mAh to 2000mAh. The user must verify that the battery can be charged and discharged with the existing settings 500mAh charge rate or change the settings of this booster pack appropriately. If you are not 100% positive about the compatibility of your battery, DO NOT connect your battery to this reference design.

2.10 3.3V and 5.0V regulators

This design has a 3.3V buck/boost regulator and will provide 3.3V through the entire operating range of the battery from 4.2V down to the protector's minimum voltage of 2.8V. The output voltage is fixed at 3.3Vdc. The regulator can supply up to 1000mA of current but the maximum suggested current is 500mA, so it is up to the user to make sure that there circuit does not draw more than the maximum current that the battery can supply. The recommended battery can supply over 1.2A so this should not be an issue unless an alternate battery is used.

The 5.0V regulator will operate down to the 2.8V cutoff of the protector. The output voltage of the boost regulator is resister programmable and is set to 5.00V. The max output current is 500mA. Because this is a boost converter the input current will always be higher than the output. At about 3.0V the input current will be high enough to exceed the current limit of the protector circuit of 900mA and the protector will disconnect the battery for over current.

2.11 Charger

The bq51050B is a highly integrated wireless receiver and single cell Li-Ion and Li-Polymer charger. The charger can be used to charge a battery, power a system or both. The charger has three phases of charging: pre-charge to recover a fully discharged battery, fast-charge constant current to supply the charge safely and voltage regulation to safely reach full capacity. The charger is very flexible, allowing programming of the fast-charge current and Pre-charge/Termination Current. The charger runs from input of the wireless receiver. The output current of the charger is set to about 500mA and a pre-charge of about 200mA. The termination current is about 30mA. All of this is resister programmable and can be changed if needed.

2.12 Protection

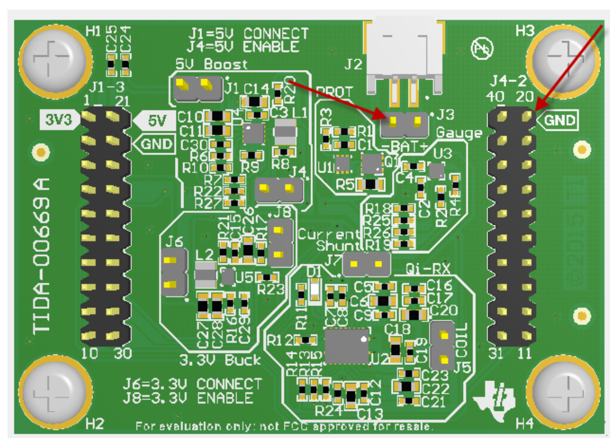
This bq29707 device is a primary protector for a single-cell Li-Ion/Li-Polymer battery pack. The device uses a minimum number of external components to protect for overcurrent conditions due to high discharge/charge currents in the application. In addition, it monitors and helps to protect against battery pack overcharging or depletion of energy in the pack. See the chart below for the functional levels of protection.

PART NUMBER	OVP (V)	OVP DELAY (s)	OVP REC DELAY (ms)	UVP (V)	UVP DELAY (ms)	UVP REC DELAY (ms)	OCC (V)	OCC DELAY (ms)	OCC REC DELAY (ms)	OCD (V)	OCD DELAY (ms)	OCD REC DELAY (ms)	SCD (V)	SCD DELAY (µs)
bq29707	4.280	1	12	2.800	96	8	0.090	6	8	0.090	16	8	0.3	250

In the condition when a fault is triggered, there are timer delays before the appropriate action is taken to turn OFF either the CHG or DSG FETs. There is also a timer delay for the recovery period once the threshold for recovery condition is satisfied. There is also a feature called zero voltage charging that enables depleted cells to be charged to an acceptable level before the battery pack can be used for normal operation. Zero voltage charging is allowed if the charger voltage is above 1.7 V.

When the battery is connected for the first time, the discharging circuit may not be enabled. In this case, short the V– pin to the VSS pin. Reference the two green arrows on the board.

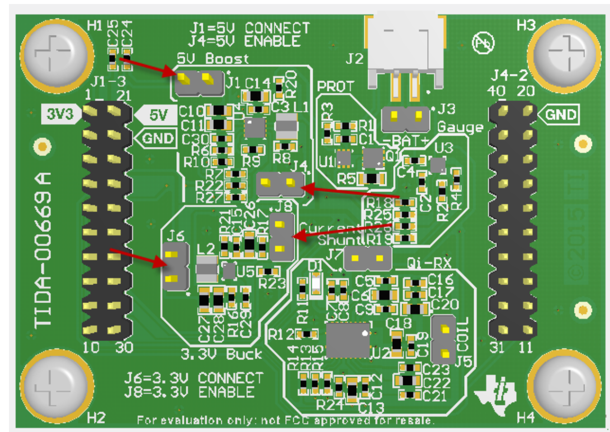
Alternatively, set the unit on a wireless transmitter.



2.13 Jumpers

This section will help the user to set up and configure the wireless charger booster pack for basic and custom applications

2.13.1 Regulators



J3 are the battery test pins. Never place a jumper across this connector as it will be a direct short across the battery.

J5 is the coil connector. We are soldering the coil directly to the PCB on this board.

J4 is the enable pin for the 5V Regulator. Remove this jumper and the 5V Regulator will not start up.

J1 will disconnect the output of the 5V regulator from the header pins. These pins can also be used to measure current out of the 5V regulator by adding a current shunt or meter in series

J8 is the enable pin for the 3.3V Regulator. Remove this jumper and the 3.3V Regulator will not start up.

J6 will disconnect the output of the 3.3V regulator from the header pins. These pins can also be used to measure current out of the 3.3V regulator by adding a current shunt or meter in series.

2.13.2 Shunt

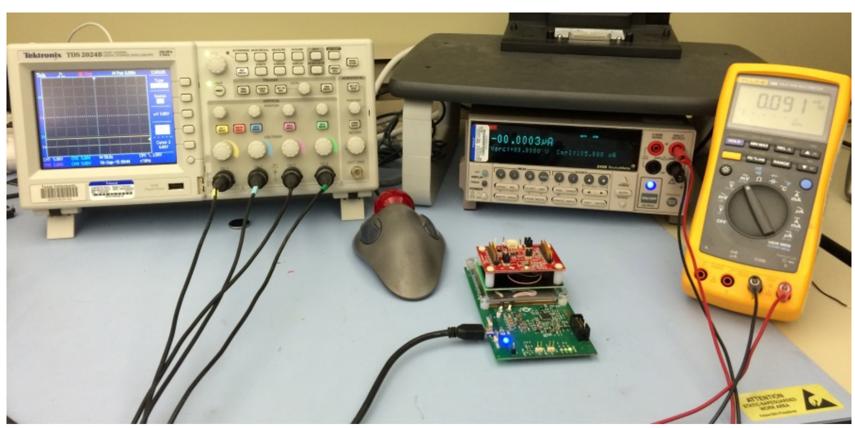
J7 is the current shunt between the Wireless receiver and the input of the charger. Place an amp meter across these pins to measure the current into the system from the wireless receiver.

R20 is a zero ohm resister and if removed it will isolate the 3.3V regulator. R21 is a zero ohm resister and if removed it isolate the 5V regulator. This will also remove the quiescent current of the regulator. Add a current shunt or meter in series with the pads of the resister to measure current in to the regulator. To fully isolate the 5V regulator, also remove J4 and J1. To fully isolate the 3.3V regulator, also remove J8 and J6.

3 Test Setup

Description of the test setup

Test equipment:



- TDS2024B Tektronix Scope
- 189 Fluke Multi-meter
- 2400 Keithley Source Meter
- E3649A Agilent Programmable Power Supply
- DI-158U Dataq Data Acquisition Module
- 2 - 1 Ohm 1% 5W Precision shunts
- Texas Instruments bq500212AEVM-550 Wireless Transmitter

The use of a precision multi-meter along with a 1 Ohm shunt will make a great current measuring solution. Set the meter to the DC milli-volt scale and read the current as milli and micro Amps. Example: 1mV = 1mA

The source meter and power supply was used to supply voltages to test the regulators, the charger, and as a load to test current limits and regulation in the circuits.

The data acquisition module has an adjustable gain that will allow measuring in the micro volts range. 1 channel was used with the shunt to measure the input current the second channel was used to measure charge and discharge current and the other 2 channels were used to measure Voltage for, VBAT and the regulators. After the cycle was finished the data was saved as a CSV file and imported into Excel for processing and plotting.

The wireless transmitter EVM was used to provide power to the wireless receiver circuit.

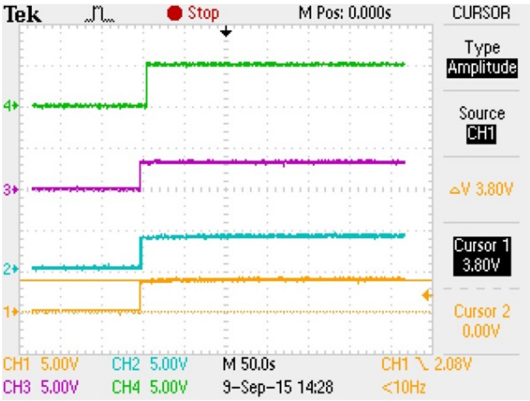
All measured test results are in the Key System Specifications section of this document.

4 Test Data

The following description explains the test plots and scope captures that

4.1 Reset Protection Circuit

Green 5V
Pink 3.3V
Blue PG (Power Good)
Yellow Battery

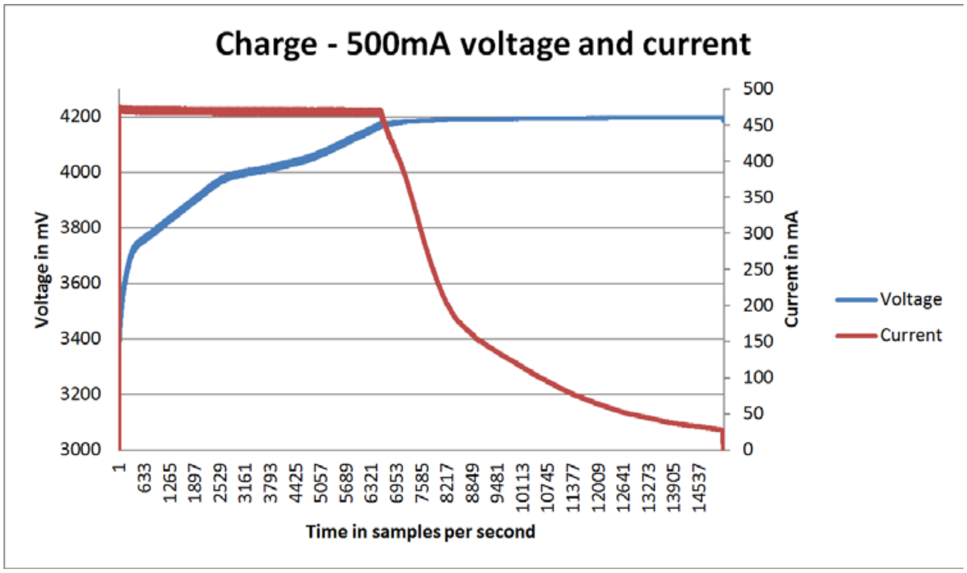


After the low voltage disconnect by the protector the battery voltage recovered to 3.47V but the protector has not reset.

Place the module onto the wireless transmitter to start the charger. This will reset the protector and the 3.3V and the 5V regulators will recover. The PG (Power Good) will toggle high to show that the battery is now good.

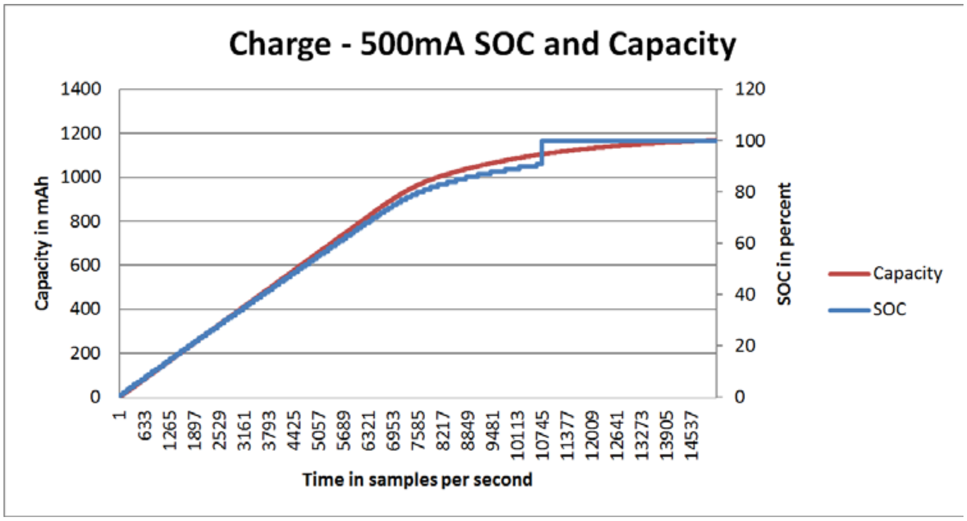
4.2 Charge Plot

This plot shows a normal charge cycle with battery voltage and battery current.



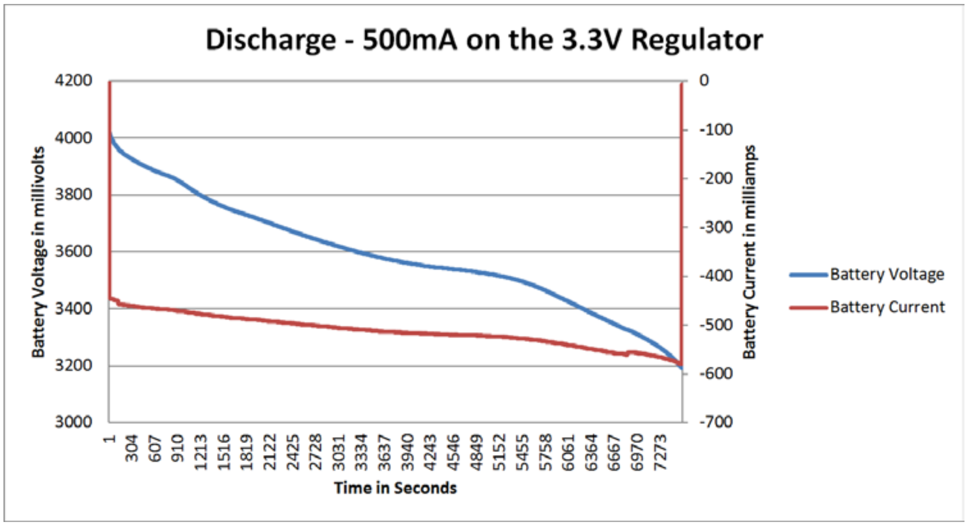
4.3 Charge SOC and Capacity Plot

This is a charge plot to show capacity and SOC (State of Charge). This was the first time charging the battery. Notice the gauge self-correct the SOC. With each discharge and charge cycle the SOC become more accurate until there was no correction.



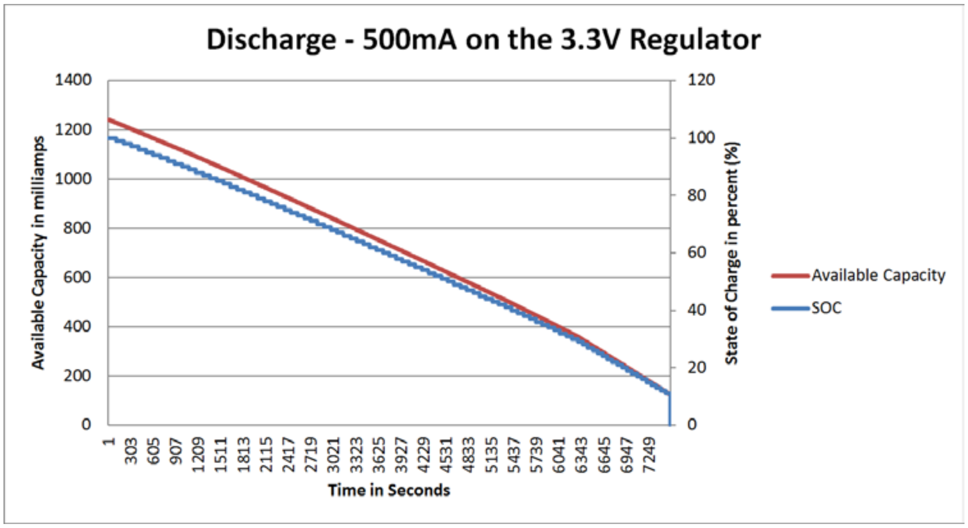
4.4 Discharge Plot

This is a discharge plot. The load was connected to the 3.3V regulator. The load was a constant current 500mA. This plot shows the load current, and battery voltage.



4.5 Discharge SOC and Capacity Plot

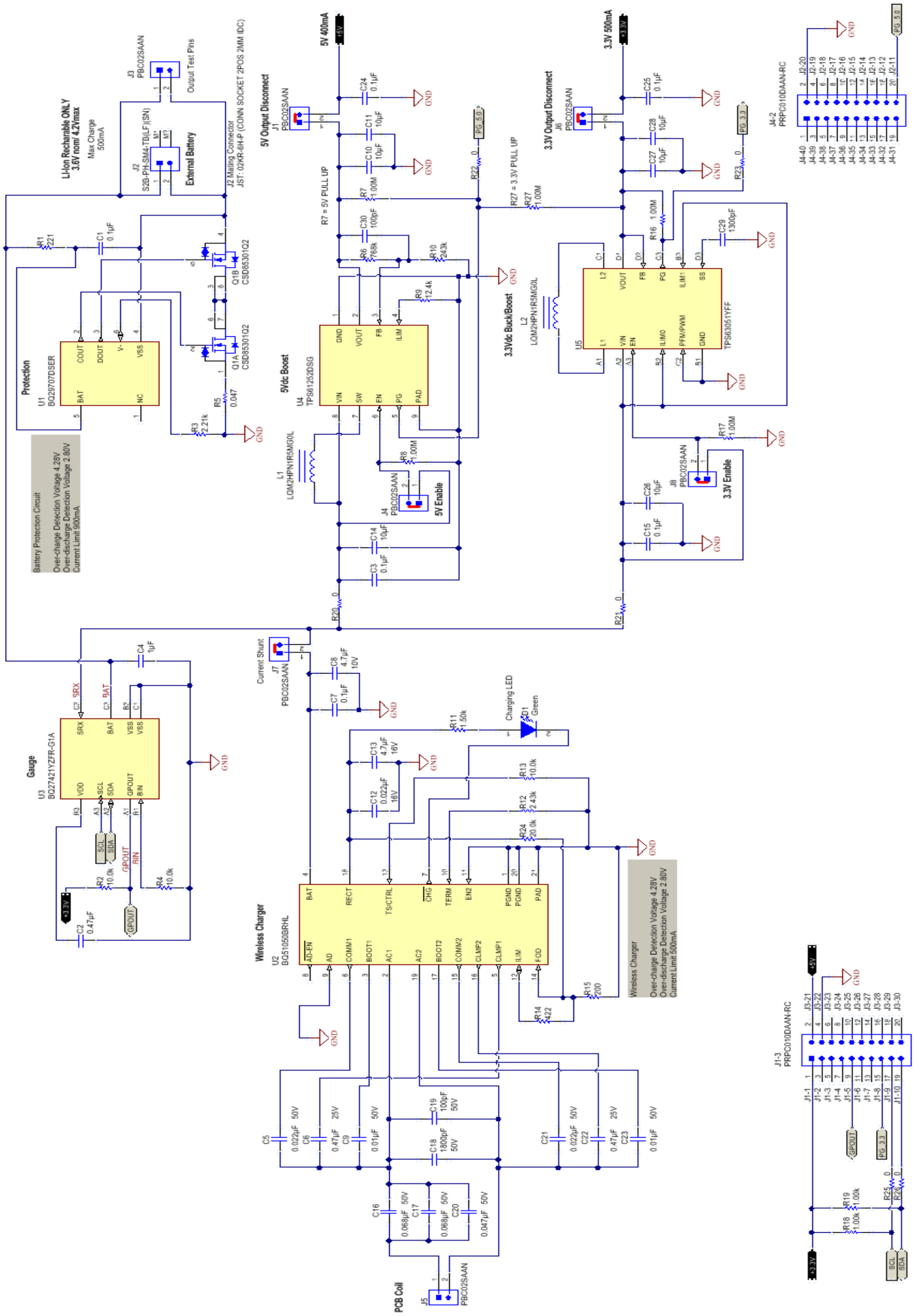
This is a discharge plot to show capacity and SOC (State of Charge). This was the first time discharging the battery. Notice the gauge self-correct the SOC at the end of the discharge cycle. With each discharge and charge cycle the SOC become more accurate until there was no correction



5 Design Files

5.1 Schematics

To download the Schematics for each board, see the design files at http://www.ti.com/tool/TIDA-00669



5.2 Bill of Materials

TID #: TIDA-00669

TIDA-00669 REV A Bill of Materials

Item #	Designator	Quantity	Value	PartNumber	Manufacturer	Description	PackageReference
1	!PCB1, !PCB2	2		TIDA-00669	Any	Printed Circuit Board	
2	C1, C3, C7, C15, C24, C25	6	0.1uF	GRM155R71A104KA01D	MuRata	CAP, CERM, 0.1 µF, 10 V, +/- 10%, X7R, 0402	0402
3	C2	1	0.47uF	GRM155R60J474KE19D	MuRata	CAP, CERM, 0.47 µF, 6.3 V, +/- 10%, X5R, 0402	0402
4	C4	1	1uF	GRM155R61A105KE15D	MuRata	CAP, CERM, 1 µF, 10 V, +/- 10%, X5R, 0402	0402
5	C5, C21	2	0.022uF	GRM155R71H223KA12D	MuRata	CAP, CERM, 0.022 µF, 50 V, +/- 10%, X7R, 0402	0402
6	C6, C22	2	0.47uF	GRM188R71E474KA12D	MuRata	CAP, CERM, 0.47 µF, 25 V, +/- 10%, X7R, 0603	0603
7	C8	1	4.7uF	C1005X5R1A475K050BC	TDK	CAP, CERM, 4.7 µF, 10 V, +/- 10%, X5R, 0402	0402
8	C9, C23	2	0.01uF	C0402C103J5RACTU	Kemet	CAP, CERM, 0.01 µF, 50 V, +/- 5%, X7R, 0402	0402
9	C10, C11, C14, C26, C27, C28	6	10uF	C0603C106M9PACTU	Kemet	CAP, CERM, 10 µF, 6.3 V, +/- 20%, X5R, 0603	0603
10	C12	1	0.022uF	C1005X7R1C223K	TDK	CAP, CERM, 0.022 µF, 16 V, +/- 10%, X7R, 0402	0402
11	C13	1	4.7uF	GRM188R61C475KAAJ	MuRata	CAP, CERM, 4.7 µF, 16 V, +/- 10%, X5R, 0603	0603
12	C16, C17	2	0.068uF	C1005X7R1H683K	TDK	CAP, CERM, 0.068 µF, 50 V, +/- 10%, X7R, 0402	0402
13	C18	1	1800pF	GRM1885C1H182JA01D	MuRata	CAP, CERM, 1800 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603
14	C19, C30	2	100pF	CC0402JRNPO9BN101	Yageo America	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0402	0402
15	C20	1	0.047uF	GRM188R71H473KA61D	MuRata	CAP, CERM, 0.047 µF, 50 V, +/- 10%, X7R, 0603	0603
16	C29	1	1300pF	0402YC132KAT2A	AVX	CAP, CERM, 1300 pF, 16 V, +/- 10%, X7R, 0402	0402
17	Coil 1	1	7.6uH Qi/PMA	760308103206	Wurth	Wireless coil	1.10x0.59x0.03
18	D1	1	Green	LTST-C190GKT	Lite-On	LED, Green, SMD	1.6x0.8x0.8mm
19	Ferrite 1	1	WE-FSFS	354005	Wurth	Ferrite shield	2.36x2.36x0.01
20	H1, H2, H3, H4, H5, H6, H7, H8	8		NY PMS 440 0025 PH	B&F Fastener Supply	Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw
21	HS1, HS2, HS3, HS4	4		1902B	Keystone	Standoff, Hex, 0.375"L #4-40 Nylon	Standoff
22	J1, J3, J4, J6, J7, J8	6		PBC02SAAN	Sullins Connector Solutions	Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator
23	J1-3, J4-2	2		PRPC010DAAN-RC	Sullins Connector Solutions	Header, 2.54mm, 10x2, Gold, TH	Header, 2.54mm, 10x2, TH
24	J2	1		S2B-PH-SM4-TB(LF)(SN)	JST Manufacturing	Header (shrouded), 2mm, 2x1, R/A, SMT	Header, 2x1, 2mm, R/A
25	L1, L2	2	1.5uH	LQM2HPN1R5MG0L	MuRata	Inductor, Multilayer, Ferrite, 1.5 µH, 1.5 A, 0.07 ohm, SMD	SMD, Body 2.5x2mm, Height 1.2mm
26	Q1	1	20V	CSD85301Q2	Texas Instruments	MOSFET, N-CH, 20 V, 6.7 A,	
27	R1	1	221	CRCW0402221RFKED	Vishay-Dale	RES, 221, 1%, 0.063 W, 0402	0402
28	R2, R4, R13	3	10.0k	CRCW040210K0FKED	Vishay-Dale	RES, 10.0 k, 1%, 0.063 W, 0402	0402
29	R3	1	2.21k	CRCW04022K21FKED	Vishay-Dale	RES, 2.21 k, 1%, 0.063 W, 0402	0402
30	R5	1	0.047	ERJ-L03KF47MV	Panasonic	RES, 0.047, 1%, 0.1 W, 0603	0603
31	R6	1	768k	CRCW0402768KFKED	Vishay-Dale	RES, 768 k, 1%, 0.063 W, 0402	0402
32	R8, R16, R17, R27	4	1.00Meg	CRCW04021M00FKED	Vishay-Dale	RES, 1.00 M, 1%, 0.063 W, 0402	0402
33	R9	1	12.4k	CRCW040212K4FKED	Vishay-Dale	RES, 12.4 k, 1%, 0.063 W, 0402	0402
34	R10	1	243k	CRCW0402243KFKED	Vishay-Dale	RES, 243 k, 1%, 0.063 W, 0402	0402
35	R11	1	1.50k	CRCW04021K50FKED	Vishay-Dale	RES, 1.50 k, 1%, 0.063 W, 0402	0402
36	R12	1	2.43k	CRCW04022K43FKED	Vishay-Dale	RES, 2.43 k, 1%, 0.063 W, 0402	0402
37	R14	1	422	CRCW0402422RFKED	Vishay-Dale	RES, 422, 1%, 0.063 W, 0402	0402
38	R15	1	200	CRCW0402200RFKED	Vishay-Dale	RES, 200, 1%, 0.063 W, 0402	0402
39	R18, R19	2	1.00k	CRCW04021K00FKED	Vishay-Dale	RES, 1.00 k, 1%, 0.063 W, 0402	0402
40	R20, R21, R22, R23, R25, R26	6	0	CRCW04020000Z0ED	Vishay-Dale	RES, 0, 5%, 0.063 W, 0402	0402
41	R24	1	20.0k	CRCW040220K0FKED	Vishay-Dale	RES, 20.0 k, 1%, 0.063 W, 0402	0402
42	SH-J1, SH-J4, SH-J6, SH-J7, SH-J8	5	1x2	969102-0000-DA	3M	Shunt, 100mil, Gold plated, Black	Shunt
43	U1	1		BQ29707DSER	Texas Instruments	Cost-Effective Voltage and Current Protection Integrated Circuit for Single-Cell Li-Ion/Li-Polymer Batteries, DSE0006A	DSE0006A
44	U2	1		BQ51050BRHL	Texas Instruments	High-Efficiency Qi v1.1-Compliant Wireless Power Receiver and Battery Charger, RHL0020A	RHL0020A
45	U3	1		BQ27421YZFR-G1A	Texas Instruments	System-Side Impedance Track Fuel Gauge With Integrated Sense Resistor, YZF0009AKAL	YZF0009AKAL
46	U4	1		TPS61252DSG	Texas Instruments	TINY 1.5-A BOOST CONVERTER WITH ADJUSTABLE INPUT CURRENT LIMIT, DSG0008A	DSG0008A
47	U5	1		TPS63051YFF	Texas Instruments	SINGLE INDUCTOR BUCK-BOOST WITH 1A SWITCHES AND ADJUSTABLE SOFT START, YFF0012AFAF	YFF0012AFAF
48	FID1, FID2, FID3	0		N/A	N/A	Fiducial mark. There is nothing to buy or mount.	N/A
49	J5	0		PBC02SAAN	Sullins Connector Solutions	Header, 100mil, 2x1, Gold, TH	Sullins 100mil, 1x2, 230 mil above insulator
50	R7	0	1.00Meg	CRCW04021M00FKED	Vishay-Dale	RES, 1.00 M, 1%, 0.063 W, 0402	0402

5.3 PCB Layout Recommendations

Layout Guidelines

As for all switching power supplies, the PCB layout is an important step in the design, especially at high peak currents and high switching frequencies. If the layout is not carefully done, the buck or boost converter could show stability problems as well as EMI problems. Therefore, use wide and short traces for the main current path and for the power ground paths. The input and output capacitors as well as the inductors should be placed as close as possible to the IC. For the boost charger the first priority is the output capacitors, including the 0.1uF bypass capacitor (CBYP). Next the input capacitor should be placed as close as possible between VIN and VSS. Last in priority is the boost charger's inductor, which should be placed close to LBOOST and VIN. For the buck converter, the output capacitor COUT should be placed as close as possible between VOUT and VSS. The buck converter inductor (L2) should be placed as close as possible between the switching node LBUCK and VOUT. It is best to use vias and bottom traces for connecting the inductors to their respective pins instead of the capacitors.

To minimize noise pickup by the high impedance voltage setting nodes the external resistors should be placed so that the traces connecting the midpoints of each divider to their respective pins are as short as possible. When laying out the non-power ground return paths (for example, from resistors and CREF), it is recommended to use short traces as well, separated from the power ground traces and connected to VSS. This avoids ground shift problems, which can occur due to superimposition of power ground current and control ground current. The PowerPAD should not be used as a power ground return path.

The remaining pins are either NC pins that should be connected to the PowerPAD as shown below or digital signals with minimal layout restrictions.

During board assembly, contaminants such as solder flux and even some board cleaning agents can leave residue that may form parasitic resistors across the physical resistors/capacitors and/or from one end of a resistor/capacitor to ground, especially in humid, fast airflow environments. This can result in the voltage regulation and threshold levels changing significantly from those expected per the installed components. Therefore, it is highly recommended that no ground planes be poured near the voltage setting resistors or the sample and hold capacitor. In addition, the boards must be carefully cleaned, possibly rotated at least once during cleaning, and then rinsed with de-ionized water until the ionic contamination of that water is well above 50 MOhm. If this is not feasible, then it is recommended that the sum of the voltage setting resistors be reduced to at least 5X below the measured ionic contamination.

Thermal Considerations

Implementation of integrated circuits in low-profile and fine-pitch surface-mount packages typically requires special attention to power dissipation. Many system-dependent issues such as thermal coupling, airflow, added heat sinks and convection surfaces, and the presence of other heat-generating components affect the power dissipation limits of a given component.

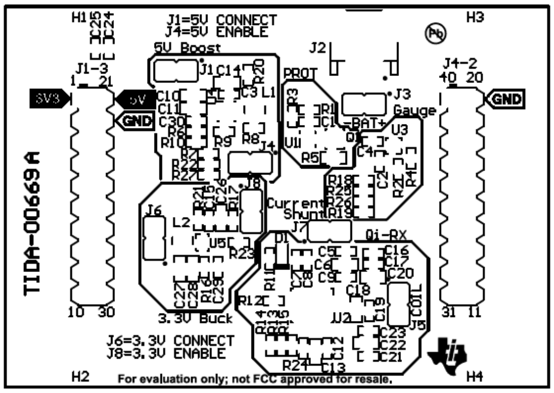
Three basic approaches for enhancing thermal performance are listed below.

- Improving the power-dissipation capability of the PCB design
- Improving the thermal coupling of the component to the PCB
- Introducing airflow in the system

For more details on how to use the thermal parameters in the dissipation ratings table please check the Thermal Characteristics Application Note (SZZA017) and the IC Package Thermal Metrics Application Note (SPRA953).

5.4 Layout Prints

To download the Layout Prints for each board, see the design files at http://www.ti.com/tool/TIDA-00669



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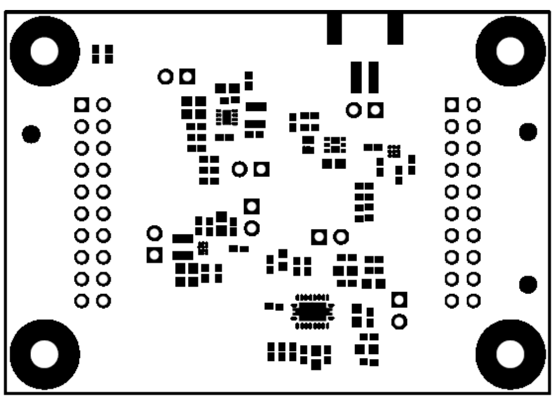
PLOT NAME = Top Overlay	GENERATED : 11/13/2015 8:18:45 AM		TEXAS INSTRUMENTS



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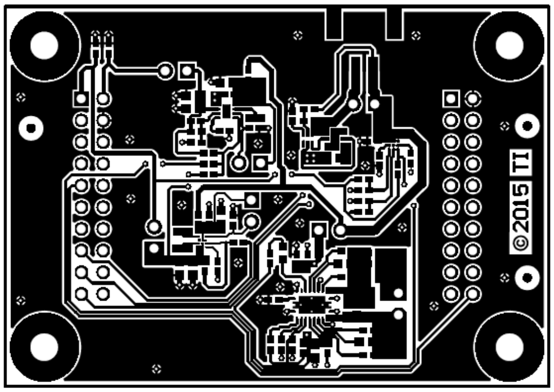

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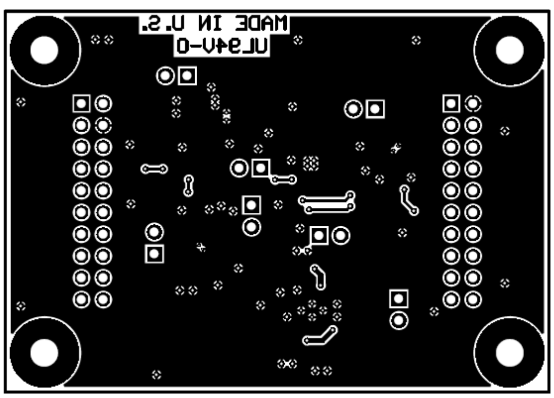

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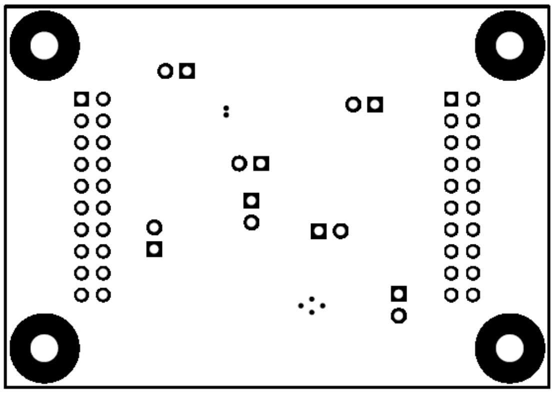

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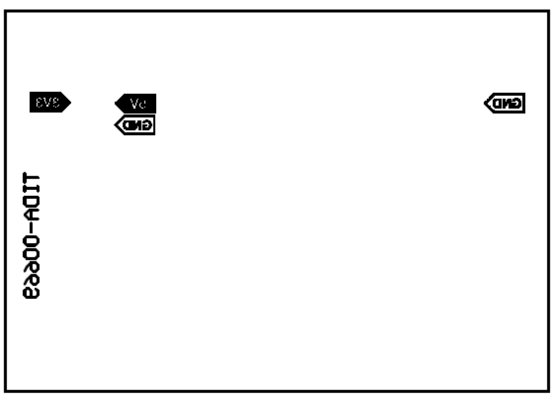

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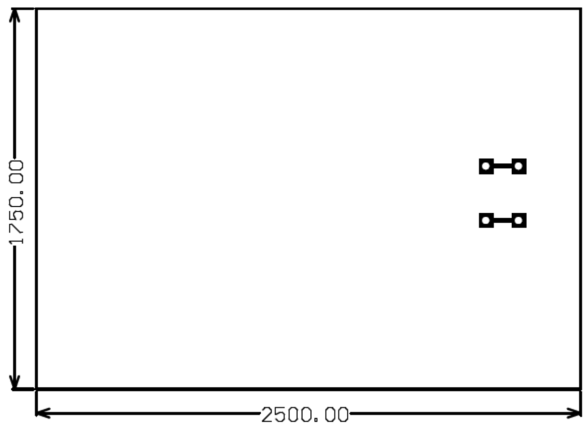
5.5 Coil PCB Layers

To download the Layout Prints for each board, see the design files at http://www.ti.com/tool/TIDA-00668



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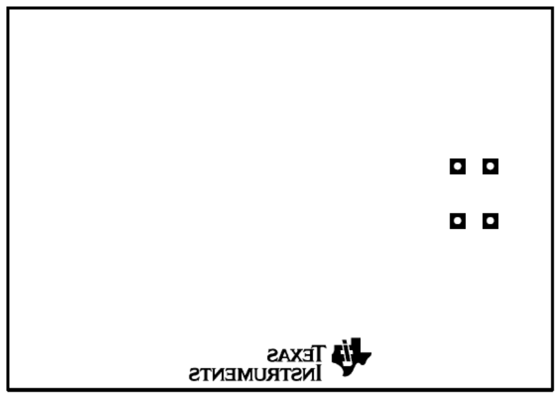

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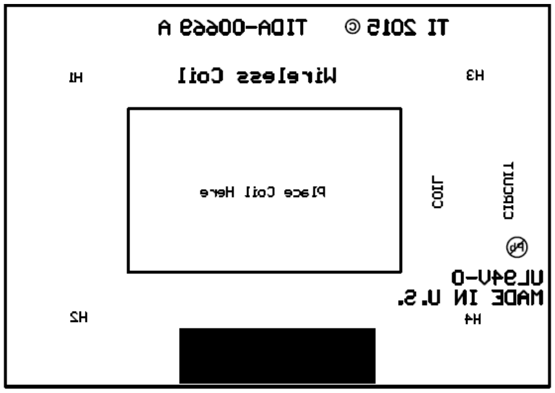

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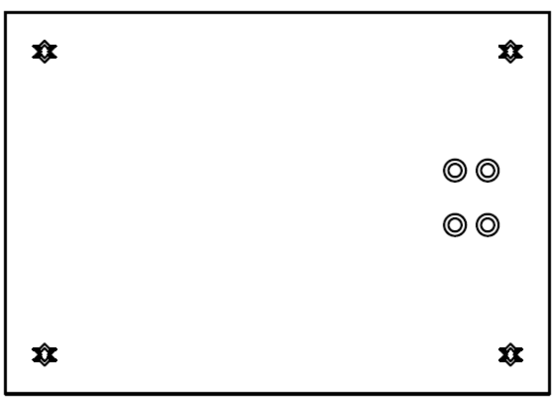

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LAYER NAME = Drill Drawing			
PLOT NAME = Drill Drawing	GENERATED : 11/17/2015 12:59:46 PM		TEXAS INSTRUMENTS

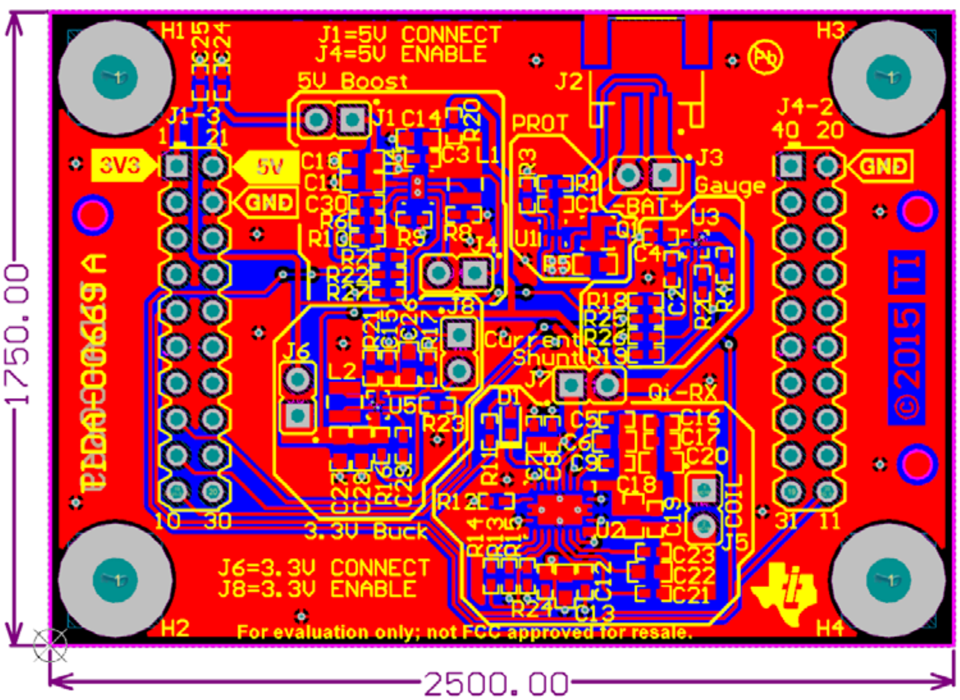
5.6 Booster Pack Pins

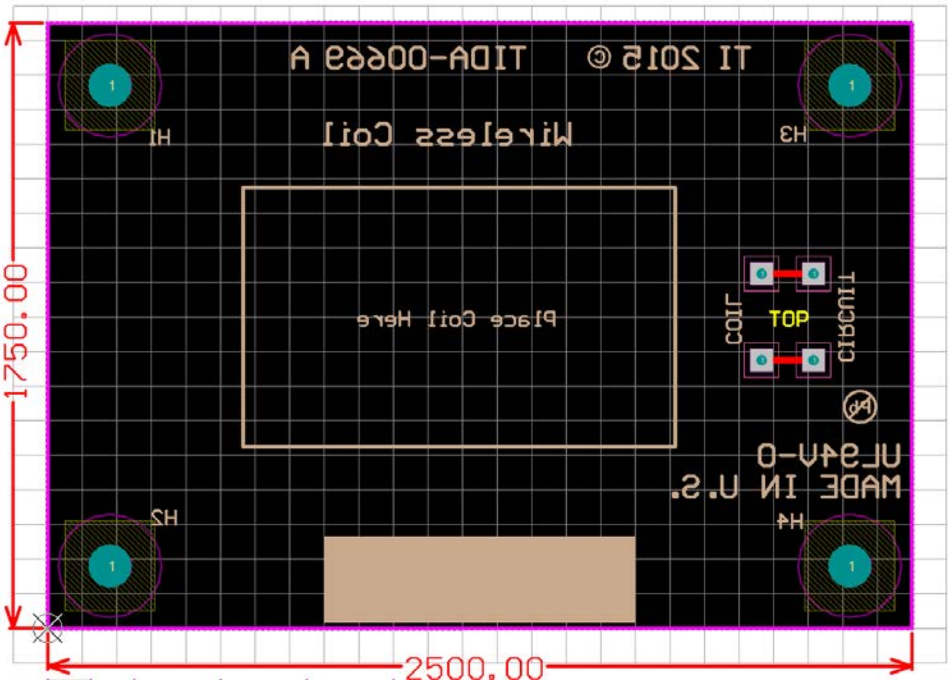
The Booster Pack pin configuration is in the table below

Low Power Wireless Booster Pack 40Pin																				
Pin	**J29**	**Pin Name**	**Function**	**IC Pin #**	**Pin**	**J29**	**Pin Name**	**Function**	**IC Pin #**		**Pin**	**J30**	**Pin Name**	**Function**	**IC Pin #**	**Pin**	**J30**	**Pin Name**	**Function**	**IC Pin #**
1	A1	3.3V_Main			***2***	C1	5V				***1***	D20				***2***	B20	GND		
3	A2	Analog In			***4***	C2	GND				***3***	D19				***4***	B19	PWM/GPIO		
5	A3	UART/RX			***6***	C3					***5***	D18				***6***	B18	SPI CS/GPIO		
7	A4	UART/TX			***8***	C4					***7***	D17				***8***	B17	GPIO		
9	A5	GPIO	GPOUT		***10***	C5					***9***	D16				***10***	B16	RESET	RST	
11	A6	Analog In			***12***	C6					***11***	D15				***12***	B15	SPI/MOSI		
13	A7	SPI CLK			***14***	C7					***13***	D14				***14***	B14	SPI/MISO		
15	A8	GPIO P3.4	PG_3.3	Power Good	***16***	C8					***15***	D13				***16***	B13	SPI/CS/DISPLAY		
17	A9	I2C/SCL	Gauge SCL		***18***	C9					***17***	D12				***18***	B12	SPI/CS/Other		
19	A10	I2C/SDA	Gauge SDA		***20***	C10					***19***	D11				***20***	B11	GPIO P1.3	PG_5.0	Power Good

5.7 Altium Project

To download the Altium project files for each board, see the design files at http://www.ti.com/tool/TIDA-00669

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