TIDA-00762 Test Report

Bill Johns BMS/WLPC

Abstract

The TIDA-00762 is a wireless power transmitter using the bq50002 and bq500511 devices in a small form factor design targeted at low power wearable devices. Input voltage to the unit is 5V from a Micro USB connector. The low power design is recommended for operation with receiver (load) devices at up to 1W (5V @ 200mA).

All key transmitter circuits are laid out in a 280mm^2 area (less than 14mm x 22mm). The transmitter coil is a Wurth P/N 760308101103. PCB is 38mm X 76mm (1.5" X 3.0").

The design is based on WPC-Qi compatible components and may operate with many Qi compliant receivers. Due to its reduced output power capability and smaller diameter coil it cannot be certified to the Qi standard. For higher power applications, the TIDA-0334 reference design can be used for 2.5W output power. For 5W and 10W applications standard bq50/51xxx EVM modules can be used.

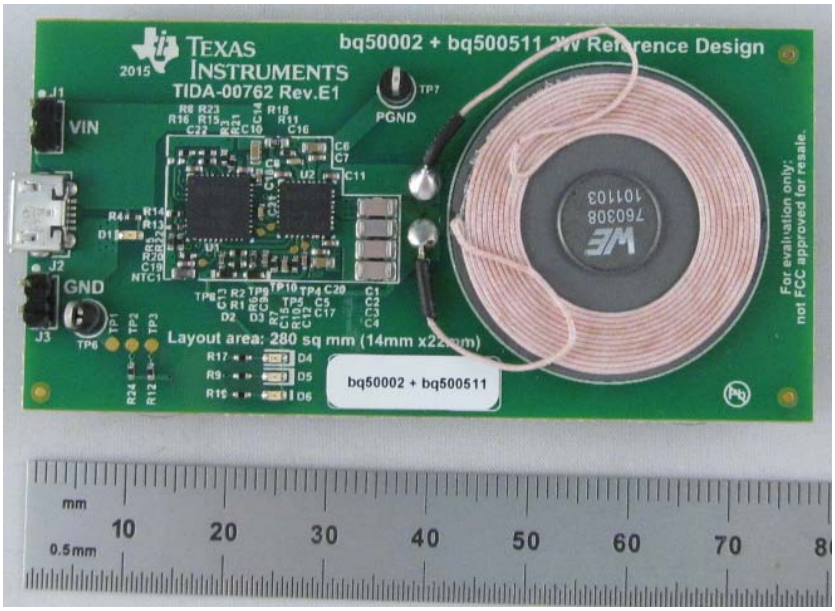

Figure 1. TIDA-00762 Photo

Document History

Version	Date	Author	Notes
1.0	Dec 2015	Bill Johns	First release

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Wireless Power System Overview:

The typical wireless power system has two parts, the transmitter (TX) and receiver(RX). The transmitter will converter DC input power to AC power. The AC power is transferred through a magnetic field created by the transmitter coil to the receiver coil. The receiver will convert the AC power back to DC power for the load. The receiver controls the transmitter and power transfer with a serial communications protocol sending such information as operating point, error and additional control / information.
For more information on TI wireless power see **www.ti.com/bqTESLA.**

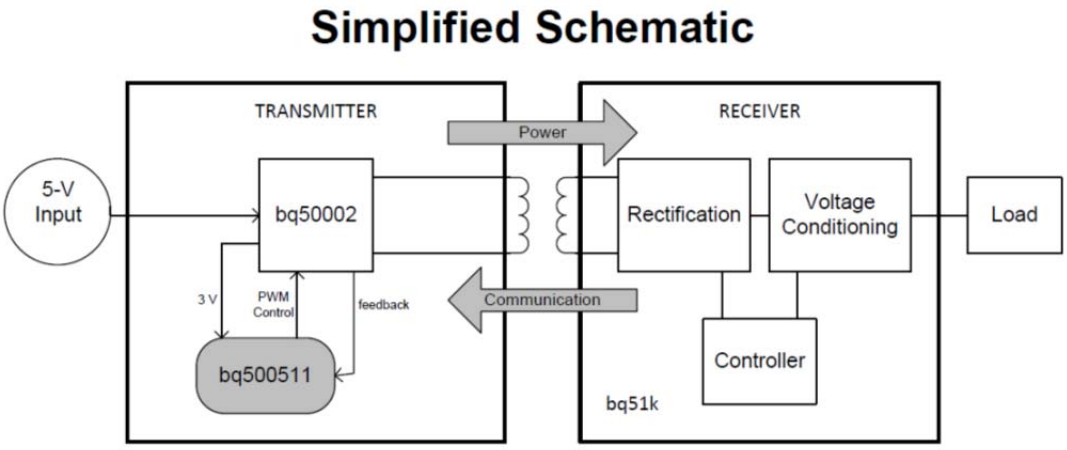

Figure 1 Typical Wireless Power System

Adaptations from standard wireless transmitter circuits:

The TIDA-00762 solution is created by combining two low cost devices, the Analog Front End (bq50002) and the Transmitter Controller (bq500511). This combination is a popular choice for up to 5W, WPC Qi-compatible wireless power designs. This wireless power transmitter controller has the advantage of being powered from a common +5VDC power source, such as a USB adapter. The standard wireless power transmitter application circuit that has been certified to meet the WPC – Qi standard is shown in the bq50002 EVM: http://www.ti.com/tool/bq50002evm-607.

For smaller, more customized designs found in wearable applications, the Qi-compatibility requirement may be relaxed if the system can match a specific transmitter (TX) circuit to a specific receiver (RX) circuit. In general, wireless power system designs with very small RX coils as used in small-form-factor products work best with correspondingly matched smaller TX coils. See article http://www.ti.com/lit/ml/slyt570/slyt570.pdf for further reference. Wearable products may require a range of power levels, typically under 2.5W total for battery charging.

Products that require 2.5W output power (e.g. charging a Li-Ion cell at approximately 500mA) can utilize the previous reference design TIDA – 00334, which uses a 30mm diameter coil and can fit all the electronics into the same space (circular area with 30mm diameter).

The TIDA-00762 is intended for the smaller, lower power category of wearable devices that require the smallest possible receiver coils in the range of 10 – 20mm diameters. The TIDA-00762 uses a very small 30mm diameter TX coil to allow use with very small RX coils. Because of the very small coil size, the recommended output power to the load is 1 Watt maximum (e.g. Li-Ion battery charging at 150 ~ 200mA max) based on typical thermal limitations. Higher power is possible but evaluation of thermal performance in the specific application would need to be evaluated.

The TIDA-00762 will use a 30mm TX coil P/N 760308101103 from Würth Elektronik this a 6.5µH coil with DCR of 0.15 Ω. Other coils with the same Inductance and DCR can be used.
For a smaller solution the 20mm TX coil P/N 760308101104 from Würth can be used.

A smaller TX coil will work better with smaller RX coils; similar size will improve coupling and efficiency. But charging area will be reduced and alignment is more critical possibly requiring mechanical alignment aid.

Note—RX to TX coil distance should be a min of 2.5mm and max of 5.0mm. To maintain a min distance from TX coil to RX coil it is recommended to add a plastic cover similar to what is used on the standard evaluation module, bq50002EVM-607.

Compatible Receivers / Coils for testing with TIDA-00762:

bq51xxx EVMs and Reference Designs

- The bq51003 wireless power receiver is optimized for low power applications. However, the standard coil used on this EVM is relatively large and not typically useful for small / low power wearable applications. The TDK WR222230 (26 µH) is an example of a smaller coil that is half the diameter of the standard EVM coil. The combination of the bq51003 and WR222230 are an example of a small low power receiver solution. The standard bq51003 EVM, or alternatively other TI receiver reference designs such as TIDA-00318 (http://www.ti.com/tool/tida-00318) can be used in combination with the TIDA-00762 transmitter design, but the standard coil should be replaced with the smaller coil. Care must be taken to tune the AC1 capacitance to match any changes in coil inductance. In general, receiver coils in the 20mm diameter range can be used with the TIDA-00762 reference design. Smaller receiver coils will require greater inductance values for good power transfer.

- If using a bq5105xB – based receiver circuit, the wireless receiver can be connected directly to the Li-Ion cell and provides direct charge control for the battery. However the charge current should be scaled according to the power level available from the transmitter (typically 200 – 250mA max into the cell). Because the bq5105xB is capable of providing max charge current up to 1A, the full range of charge current available from this receiver cannot be achieved with the low power TIDA-00762 transmitter. Also, the current taper control accuracy of the bq5105xB is limited, and the bq5105xB is not recommended for charge currents < 100mA ("fast charge") since the taper current detection will not be accurate at low levels (< 25mA).
- The TIDA-00318 reference design uses a bq51003 low power receiver (5V out) and a bq25100 low-current precision charger. This allows charging and precise control of the low currents (< 250mA with 1mA accurate taper control) used in small / wearable device batteries.

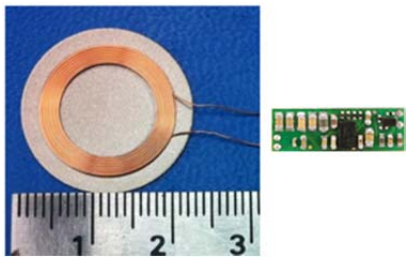

Figure 2 Test Receiver Coil TIDA – 00318 Reference Design

Block Diagram:

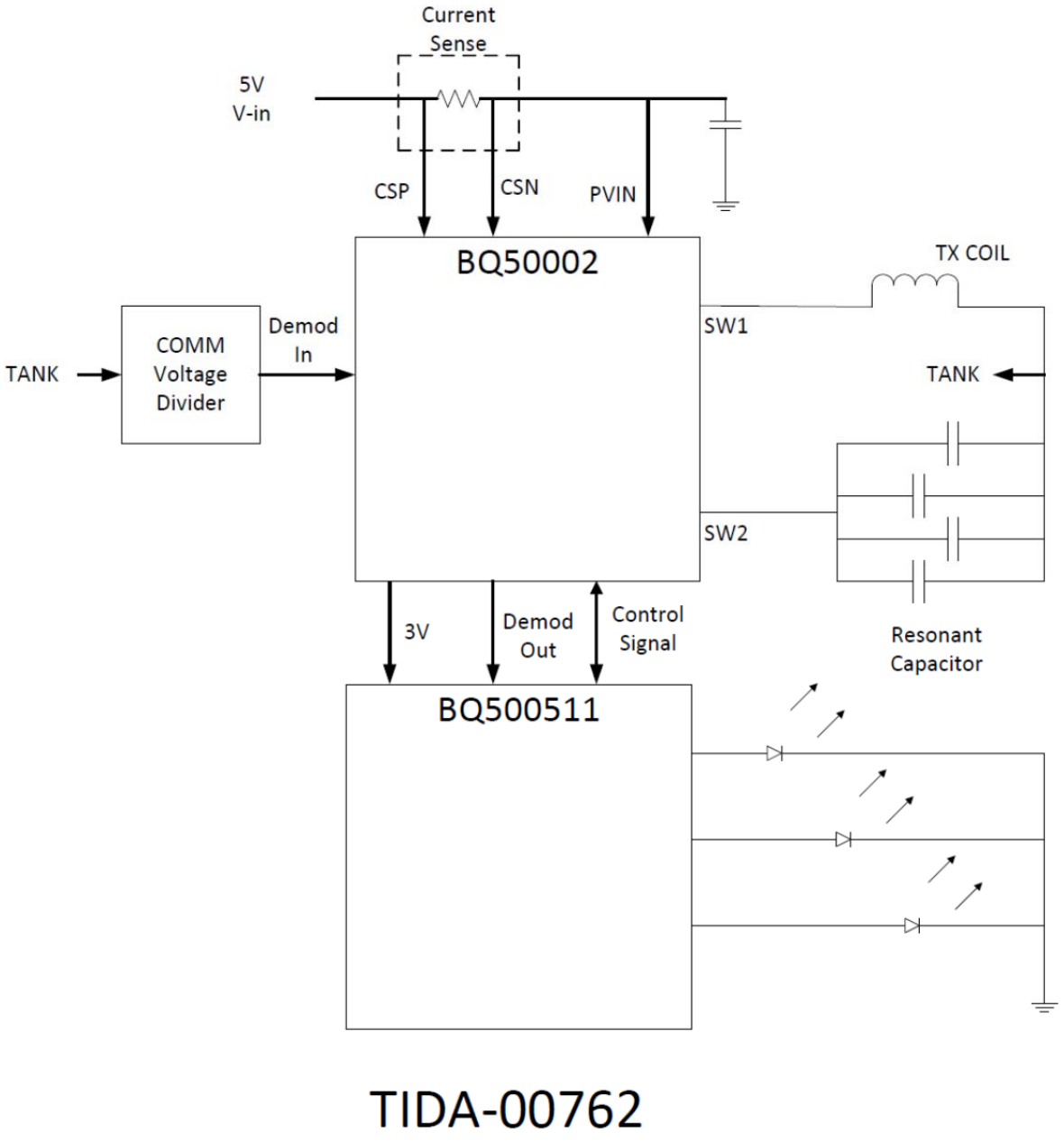

Figure 3 TIDA – 00762 Block Diagram

Schematic:

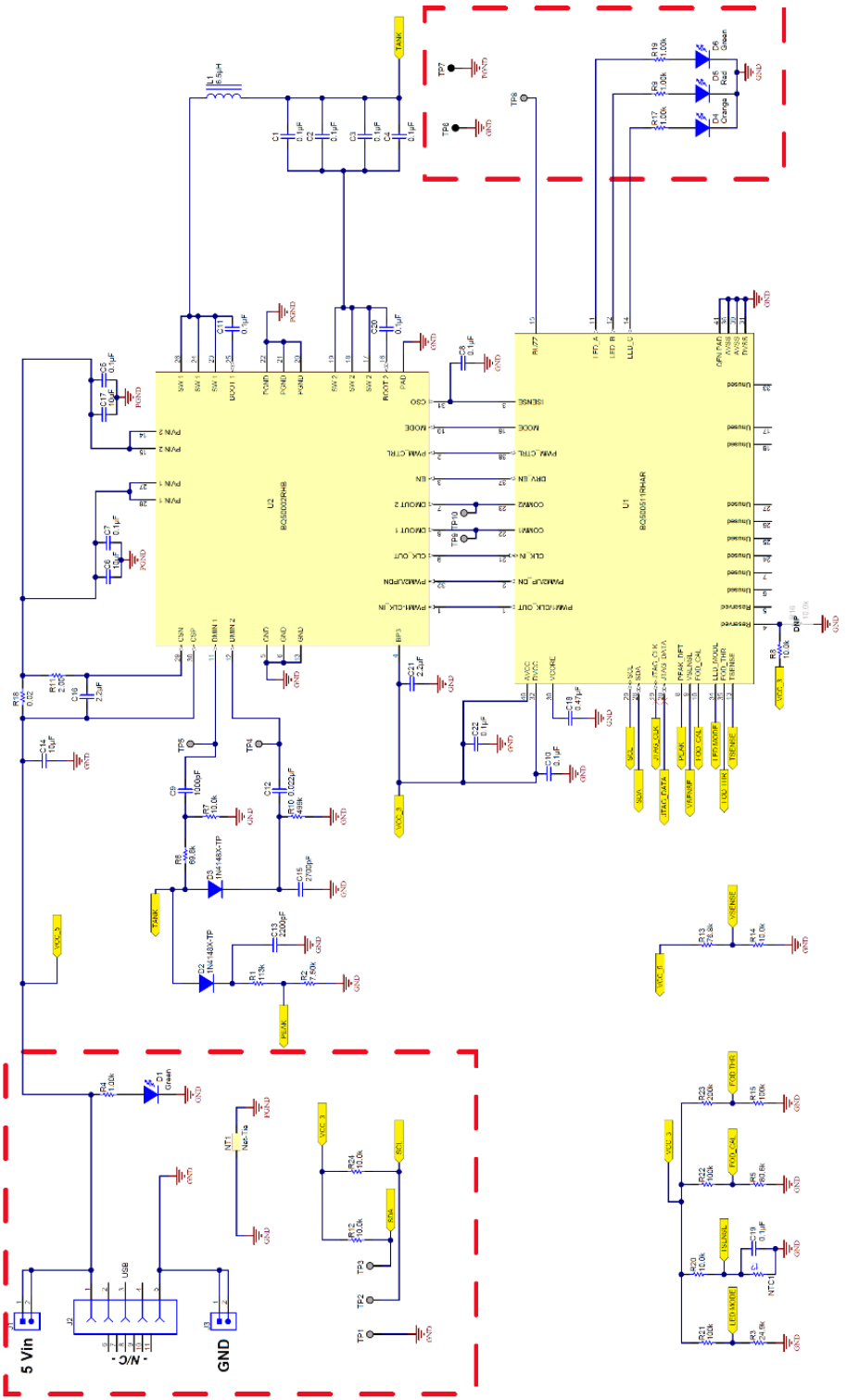

Figure 4 Circuit Schematic

Configuration Options:

LED Mode – Resistors R21 & R3 control the behavior of status LED D4, D5 and D6. The recommended value for this circuit is 100k / 24.9k Ω for control option 9.

In this mode:

Standby---all LEDs are off
Power Transfer---Green LED will blink (about 1 Hz)
Charge Complete---Green LED is on
Fault---Red LED is on
FOD Warning---Red LED blinks fast (about 5 Hz)
DPL---Red LED blinks slow (about 1 Hz)

Other modes are available see bq5000511 data sheet Table 1.

BUZZ (TP8) – Optional external buzzer connections. See bq500511 data sheet for additional information.

SDA / SCL / AGND – I^2C interface to the bq500511 can be used with software tools to monitor device operation.

Test Results:

- Figure 6 shows a typical start up behavior for the TX and RX as the RX is placed on a TX in standby. The TX can be seen transitioning from standby to power transfer.

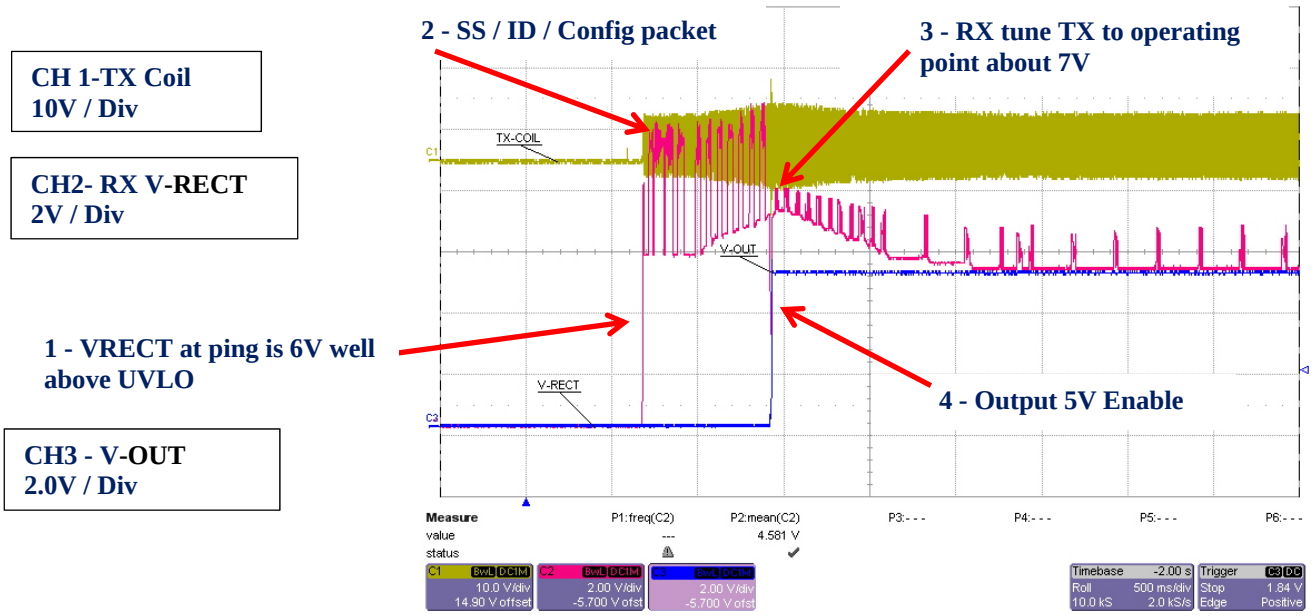

Figure 6 Start Up into 200mA load, Horizontal Axis 500ms/div

Figure 7 shows the TX and RX behavior during Charge Complete, EPT 01. The bq51003 is configured to send EPT 01 constantly (EN1 / 2 high). In response TX will end power transfer and send analog ping every 500ms and digital ping every 5.2us.

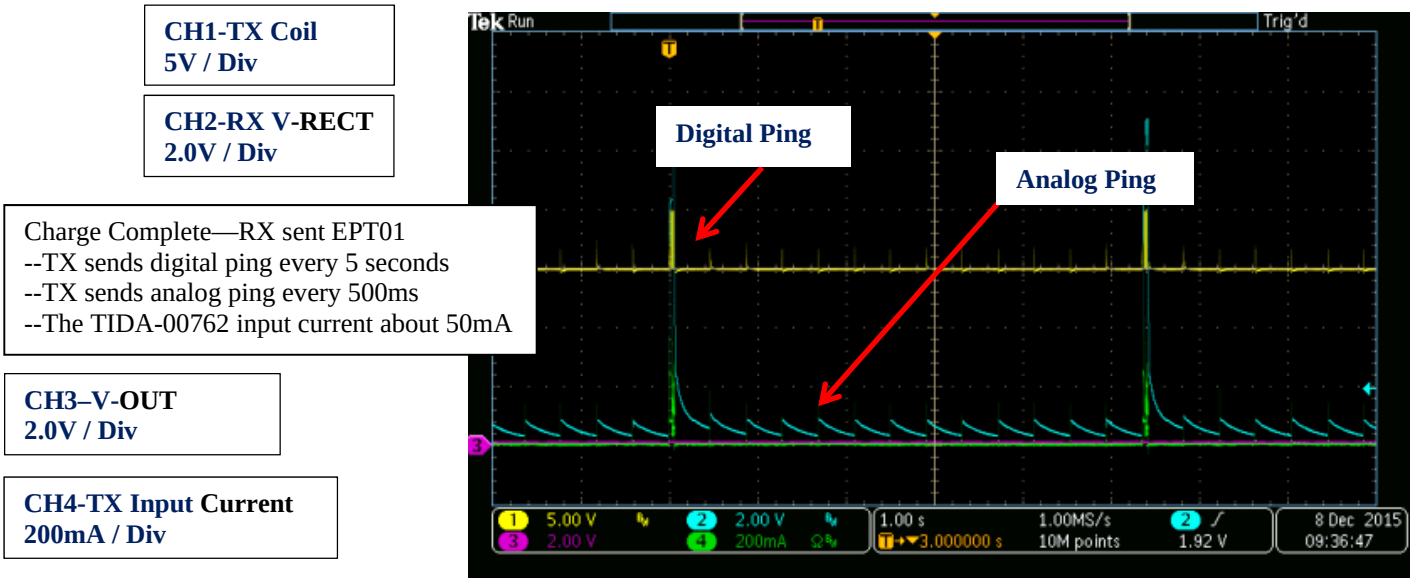

Figure 7 Charge Complete, End Power Transfer 01, Horizontal Axis 1000ms/div

Figure 8 shows the TX and RX behavior during Standby with no RX on the TX charging pad. TX will use a low power analog ping to check for the RX then send digital ping. The digital ping is higher power and can power a receiver. Analog ping is sent every 500ms and digital ping every 5 seconds.

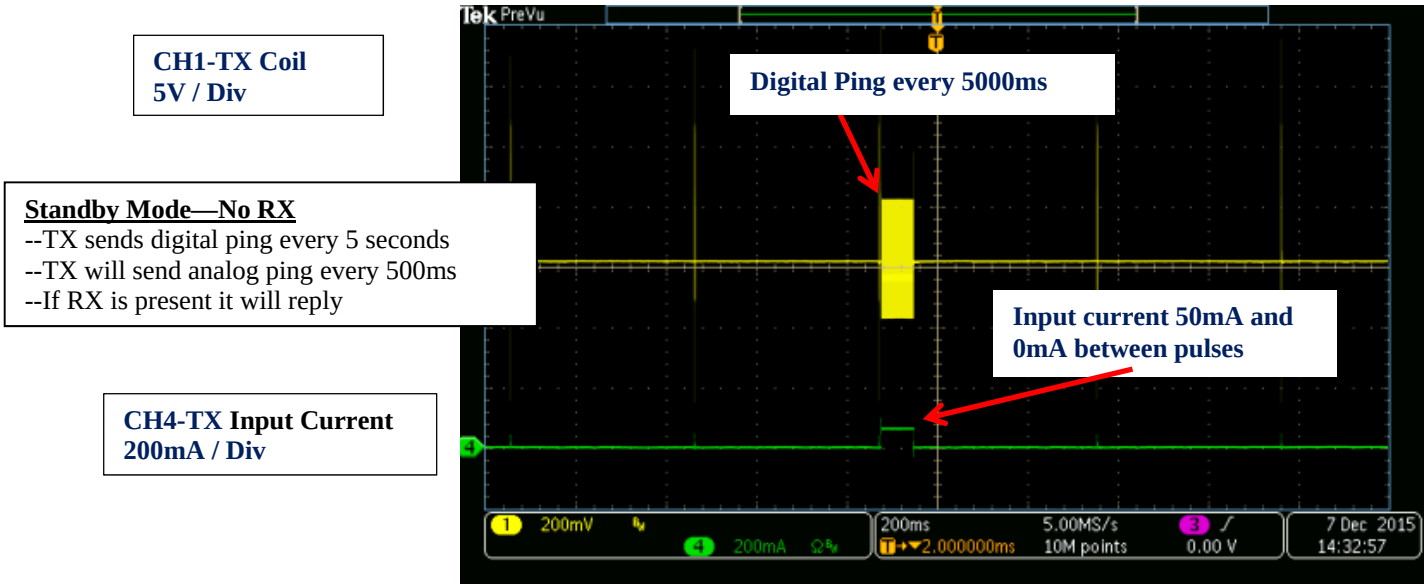

Figure 8 Standby – No RX on TX, Horizontal Axis 200ms/div

- Figure 9 shows the efficiency across the power range with the bq51003EVM-764 with TDK coil WR222230. This is the total system efficiency including the transmitter, coils and receiver. Note recommended output power is 1W.

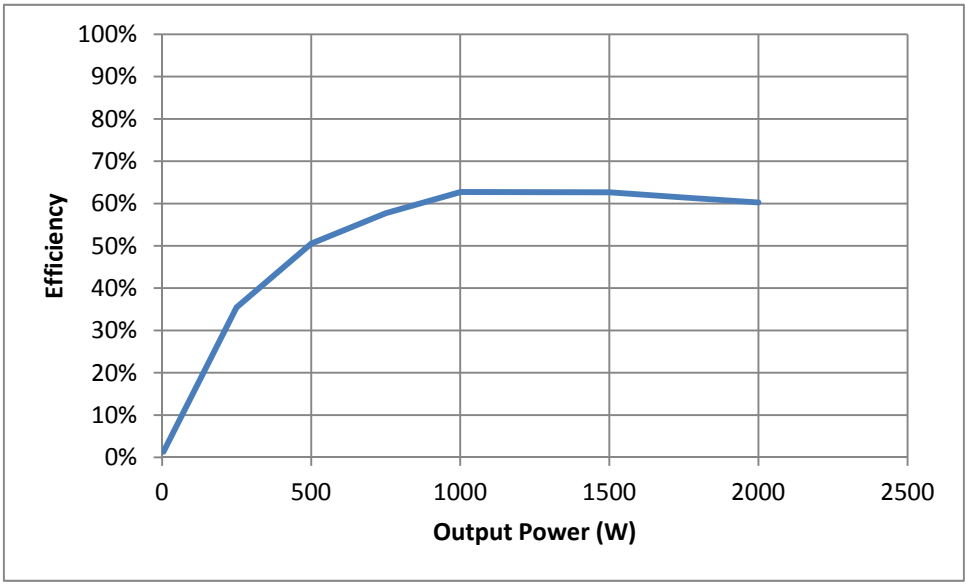

Figure 9 TIDA-00762 Efficiency with bq51003

FOD Protection:

- This circuit does have Foreign Object Protection (FOD) for detection of metal objects between the RX and TX during charging. FOD can be disabled by connecting FOD_THR to 3V.
- FOD_THR is set by R23 and R15. This will set the point where FOD declares a fault.
- FOD_CAL is set by R22 and R5. This will adjust the slope of the loss curve.
- See data sheet for additional information on FOD.

Thermal Measurements

- The following figure shows a thermal image of the TIDA-00762 operating with the bq51003EVM-764 RX at 250mA output load, 1.25W. Note recommended output power is 1W but 1.25W is shown to demonstrate design margin.

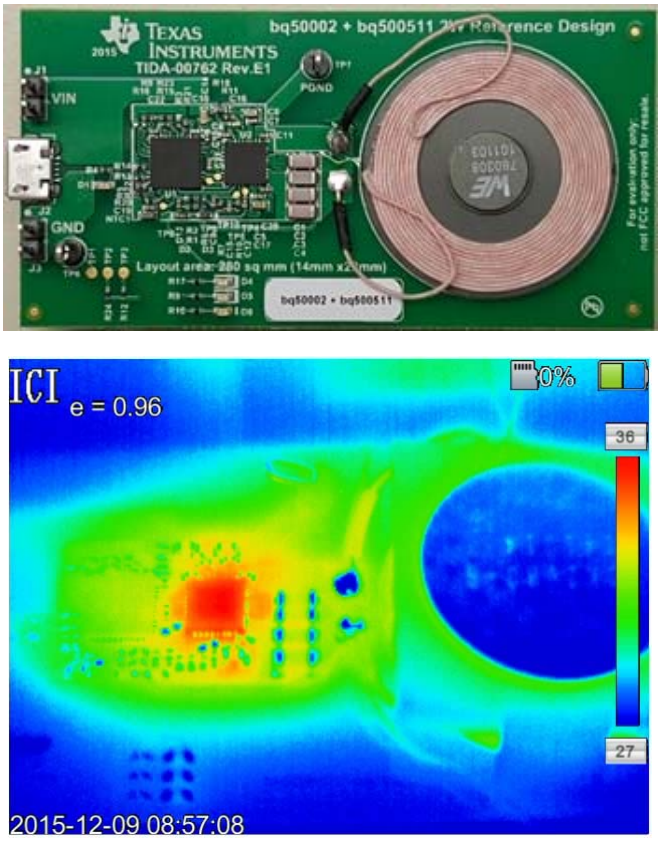

Figure 10 TIDA-00762, RX output current 250mA

References

1. Data Sheet bq50002 Wireless Power Transmitter Analog Front End for WPC (SLUSBW1A)
2. Data Sheet bq500511 Wireless Power Transmitter Controller for WPC (SLUSCD3A)
3. Data Sheet bq51003 Wireless Power Receiver for WPC (SLUSBC8)
4. User Guide bq51003 Wireless Power Receiver (SLUUAU8)
5. TI Designs TIDA-00318 Wireless Charger for Lower Power Wearable Applications

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