Application Note

Wireless Power Solutions for Battery Chargers

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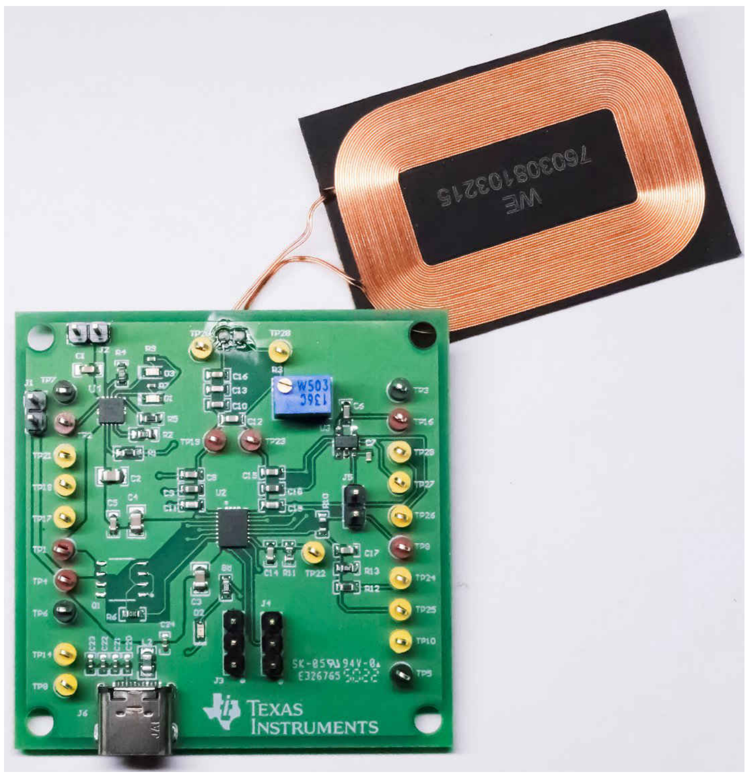
ABSTRACT

Wireless power is gaining popularity in modern electronics. Automotive devices are no exception. Automotive devices such as remote keyless entry keyfobs, fleet management systems, and asset tracking are applications where a charger paired with a wireless receiver can improve the overall system by moving to a wire-free implementation of power delivery. This application note shows the implementation of the BQ25171-Q1 and the BQ51013B-Q1 in a test friendly layout for evaluation prior to incorporating both of these devices into a design.



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1 Wireless Power Design

This application note goes over a wireless power design with the following requirements shown in Table 1-1.

Table 1-1. Design Requirements

Description	Value
Input Current	Up to 1 A
Battery Chemistry	Li-Ion
Output Voltage for Battery	Up to 4.2 V
Fast Charge Current for Battery	Up to 800 mA

1.1 Wireless Charging Input

The BQ51013B-Q1, when paired with a transmitter, allows for contactless power delivery using the Qi v1.2 protocol. The receiver has an overall peak AC to DC efficiency of 93% and a full synchronous rectifier. With dynamic rectifier control, dynamic efficiency limiting, foreign object detection (FOD), and an adaptive communication limit, the BQ51013B-Q1 makes the device designed for handheld devices that require an AEC-Q100 qualified wireless receiver.

To meet wireless power design requirements shown in Table 1-1, the BQ51013B-Q1 is configured with the following design requirements shown in Table 1-2.

Table 1-2. BQ51013B-Q1 Design Requirements

Description	Value
Input Current Limit	1 A
Power Input	Wired or Wireless
TS/CTRL	Not Used

To set the input current limit to 1 A, the device is calculated to have an R_{ILIM} of 118 Ohms with the recommended $R_{FOD}$of 196 Ohms. The design allows for enabling or disabling wireless or wired power based on the configuration for EN1 and EN2. These pins can be set to a low logic or a high logic.

Figure 1-1 shows the wireless receiver portion of the design using a Wurth Elektronik wireless charger coil (part number: 760308103215) and fixed current limit of 1 A. The output of this receiver is used as the input to the Li-Ion charger: BQ25171-Q1.

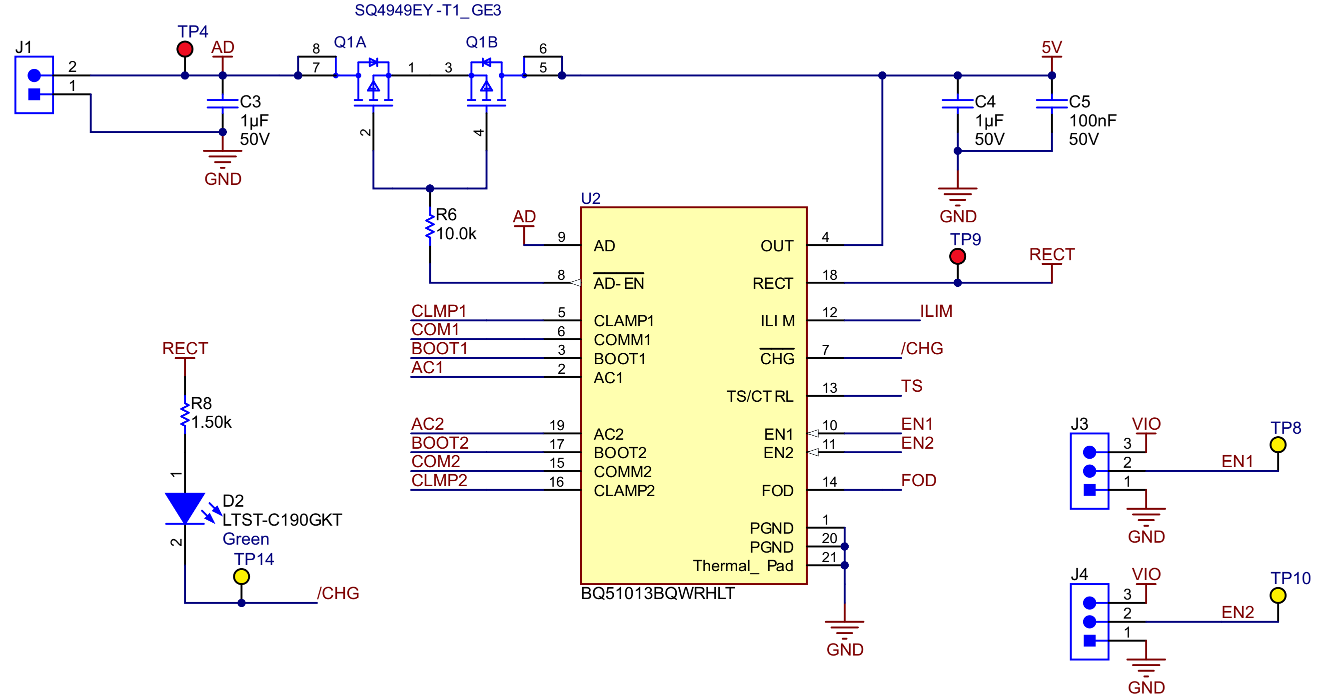

Figure 1-1. Wireless Receiver Schematic: BQ51013B-Q1 - Power and ENx pins

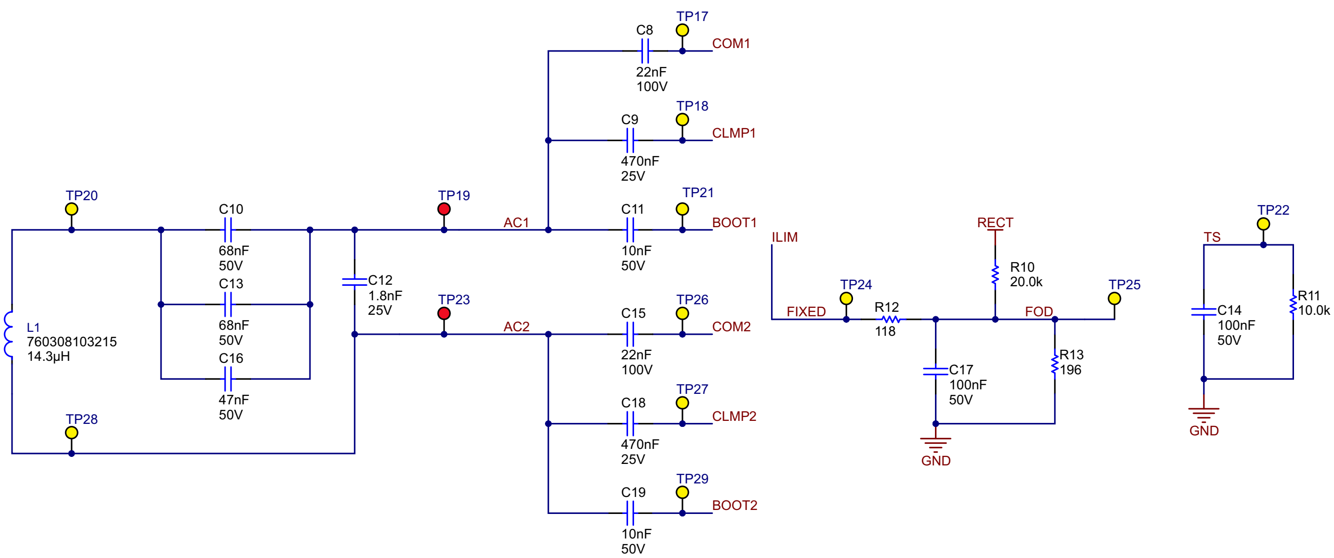

Figure 1-2. Wireless Receiver Schematic: BQ51013B-Q1 - Passive components

1.2 Battery Charger

The BQ25171-Q1 is an AEC-Q100 qualified linear charger that is capable of 800 mA and suitable for 1-2 cell Li-Ion, Li-Polymer, LiFePO4, as well as 1-6 cell NiMH. The charger operates as a standalone device where charge parameters such as charge current, battery chemistry, and regulation voltage are selected based by the resistor for each function. The input operating range of 3 V to 18 V and absolute maximum 40 V makes BQ25171-Q1 designed for automotive applications where a wide range of supply voltages can be used.

Figure 1-3 shows the charger portion of the design where the input is powered by the output of the BQ51013B-Q1. With 82-kΩ, 18-kΩ, and a potentiometer at the CHM_TMR, VSET, and ISET pins, the device is configured for charging 4.2 V Li-Ion batteries with a variable charge current. This configuration is done to meet the requirements in Table 1-3.

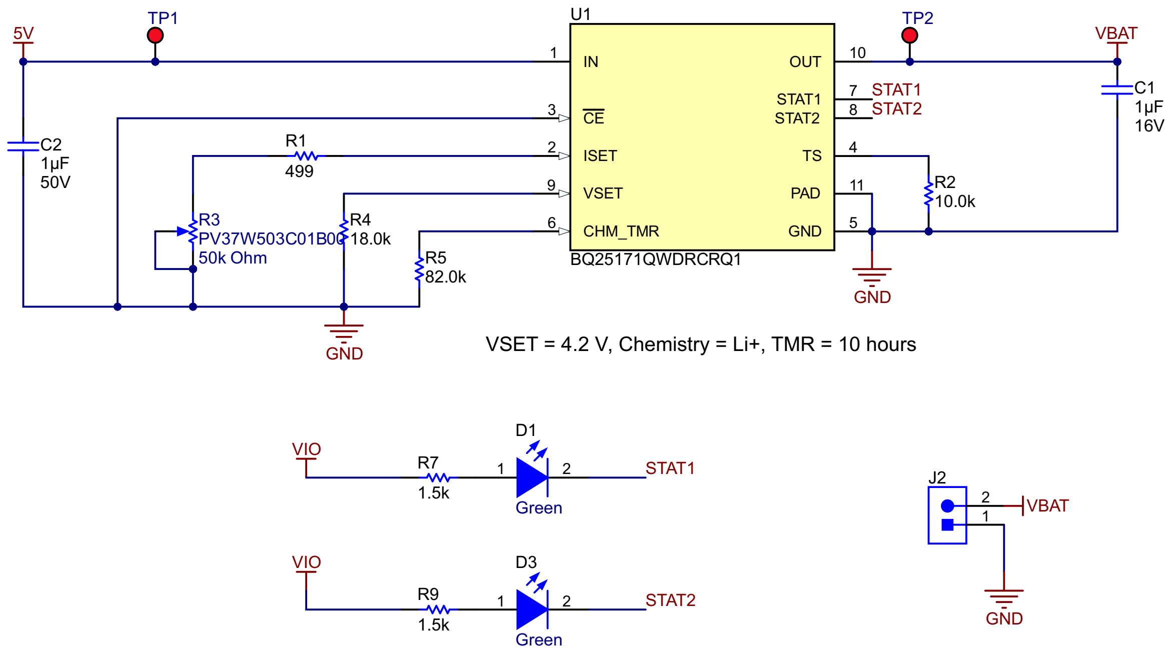

Figure 1-3. Battery Charger Schematic: BQ25171-Q1

Table 1-3. BQ25171-Q1 Design Requirements

Description	Value
Battery Chemistry	Li-Ion
Battery Regulation Voltage	4.2 V
Safety Charge Timer	10 hours

2 Layout Guidelines

2.1 Wireless Receiver (BQ51013B-Q1)

- Keep the trace resistance as low as possible on AC1, AC2, and BAT.
- Detection and resonant capacitors must be as close to the device as possible.
- COMM, CLAMP, and BOOT capacitors must be placed as close to the device as possible.
- Via interconnect on PGND net is critical for appropriate signal integrity and proper thermal performance.
- High frequency bypass capacitors must be placed close to RECT and OUT pins.
- ILIM and FOD resistors are important signal paths and the loops in those paths to PGND must be minimized.

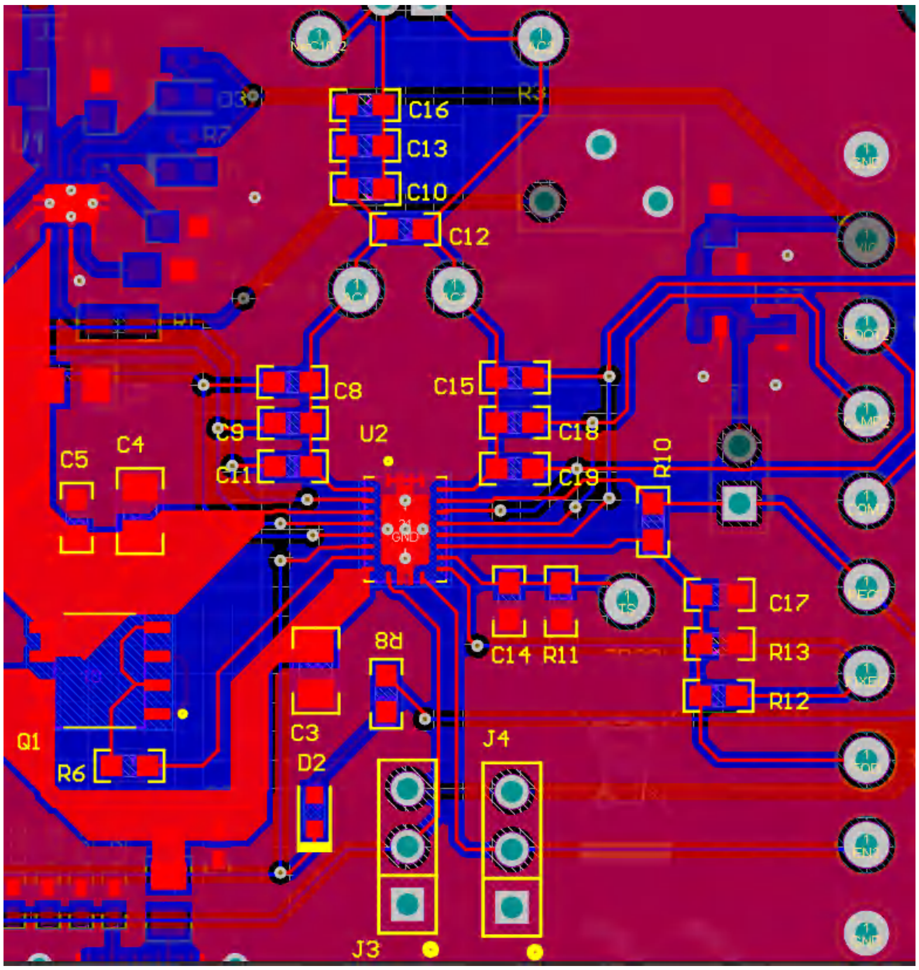

Figure 2-1. Layout of BQ51013B-Q1

2.2 Linear Charger (BQ25171-Q1)

To obtain optimal performance, the decoupling capacitor from IN to GND and the output filter capacitor from OUT to GND should be placed as close as possible to the device, with short trace runs to both IN, OUT and GND.

- All low-current GND connections should be kept separate from the high-current charge or discharge paths from the battery. Use a single-point ground technique incorporating both the small signal ground path and the power ground path.
- The high current charge paths into IN pin and from the OUT pin must be sized appropriately for the maximum charge current to avoid voltage drops in these traces.

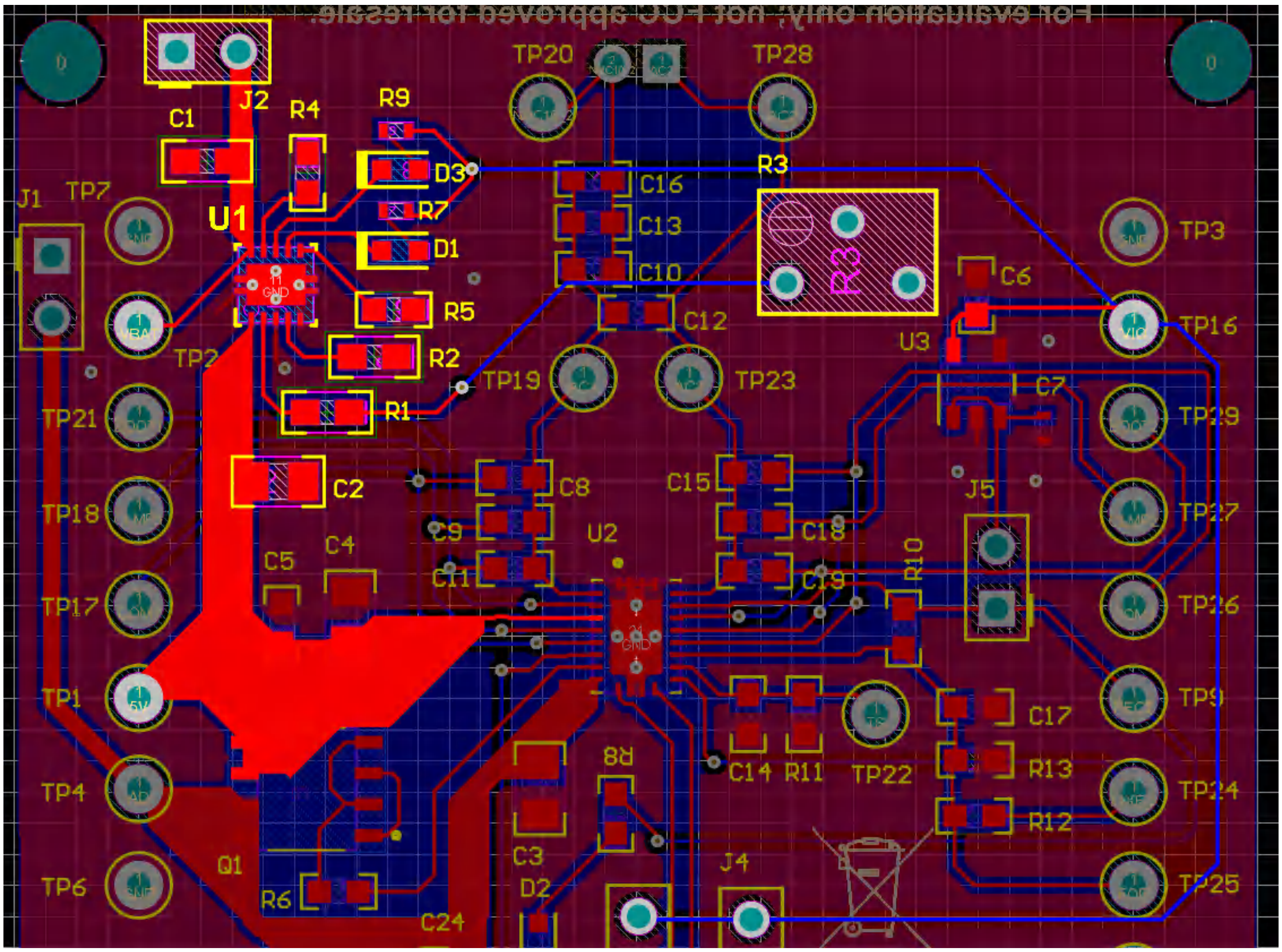

Figure 2-2. Layout of BQ25171-Q1

3 Experimental Results

3.1 Wireless Power Efficiency

Figure 3-1 shows the efficiency across of the wireless receiver stage. This was tested with a BQ500212AEVM, using the battery charger as a load configured for 600 mA charge current.

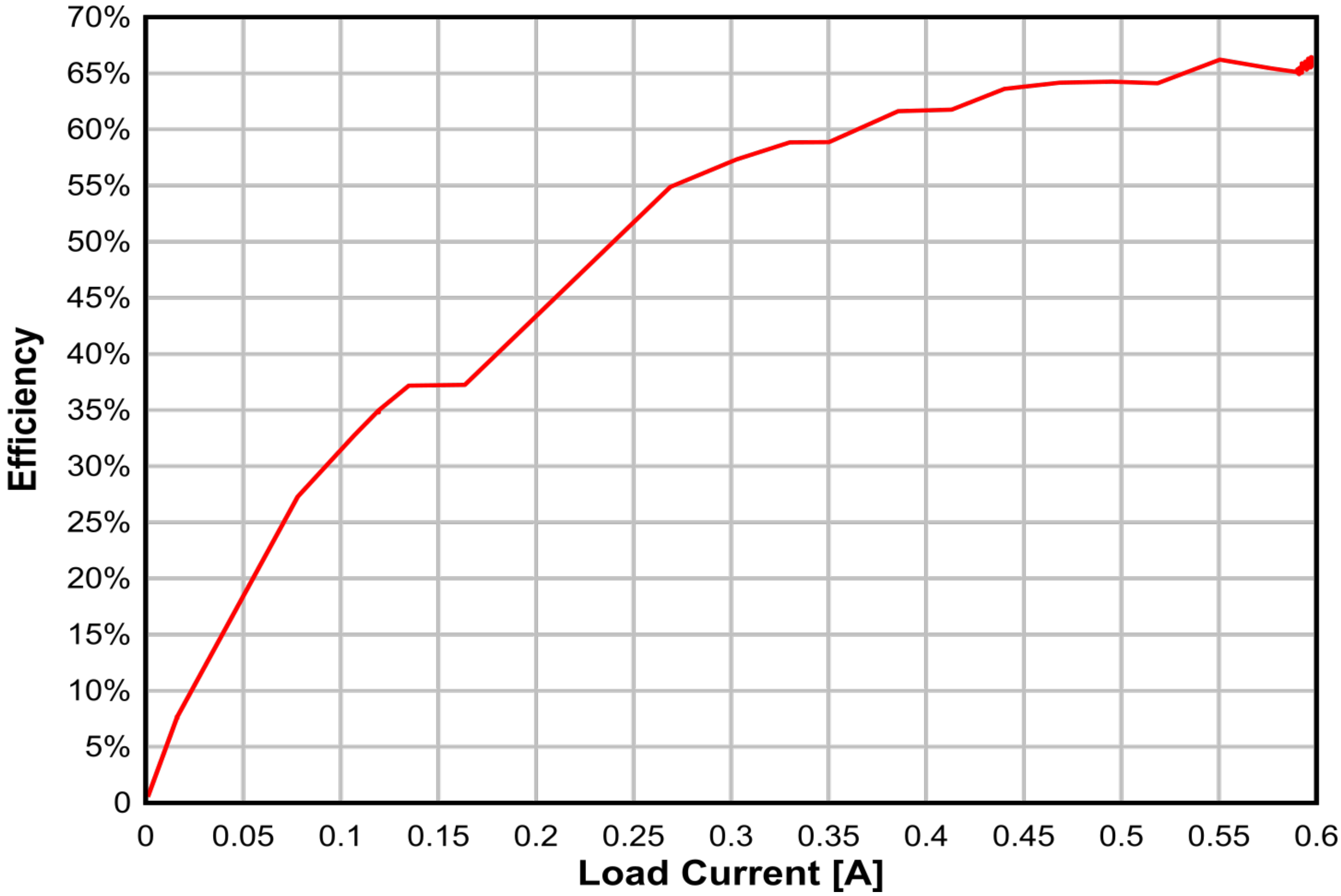

Figure 3-1. Efficiency Measured on Board Design

3.2 FOD Calibration

Foreign object detection calibration was also performed on this device to make sure that the device met Qi standards. The resistors that are modified are R13, R12, and R10. The adjustments to these resistors are based on the following information:

- R13 is adjusted to change the impact of the current on the reported power loss. This changes the slope of a power loss versus current plot
- R10 is calibrated to adjust the loss when the power output is low. This affects the offset of the data points on a power loss versus current plot
- R12 is adjusted to maintain a 1 A current limit.

Each adjustment is made after measuring the reported power loss as a function of current output from the BQ51013B-Q1. This was done until the power loss met the Qi standards for FOD. Qi standards require that the power loss reported across the expected load to be between -25 mW and -350 mW.

It was found that the values R13 = 210 Ω, R12 = 106 Ω, and R10 = 17 kΩ was a set of resistors that kept the power loss measurement between -25 mW and -350 mW across an expected current load. The data is shown in Figure 3-2.

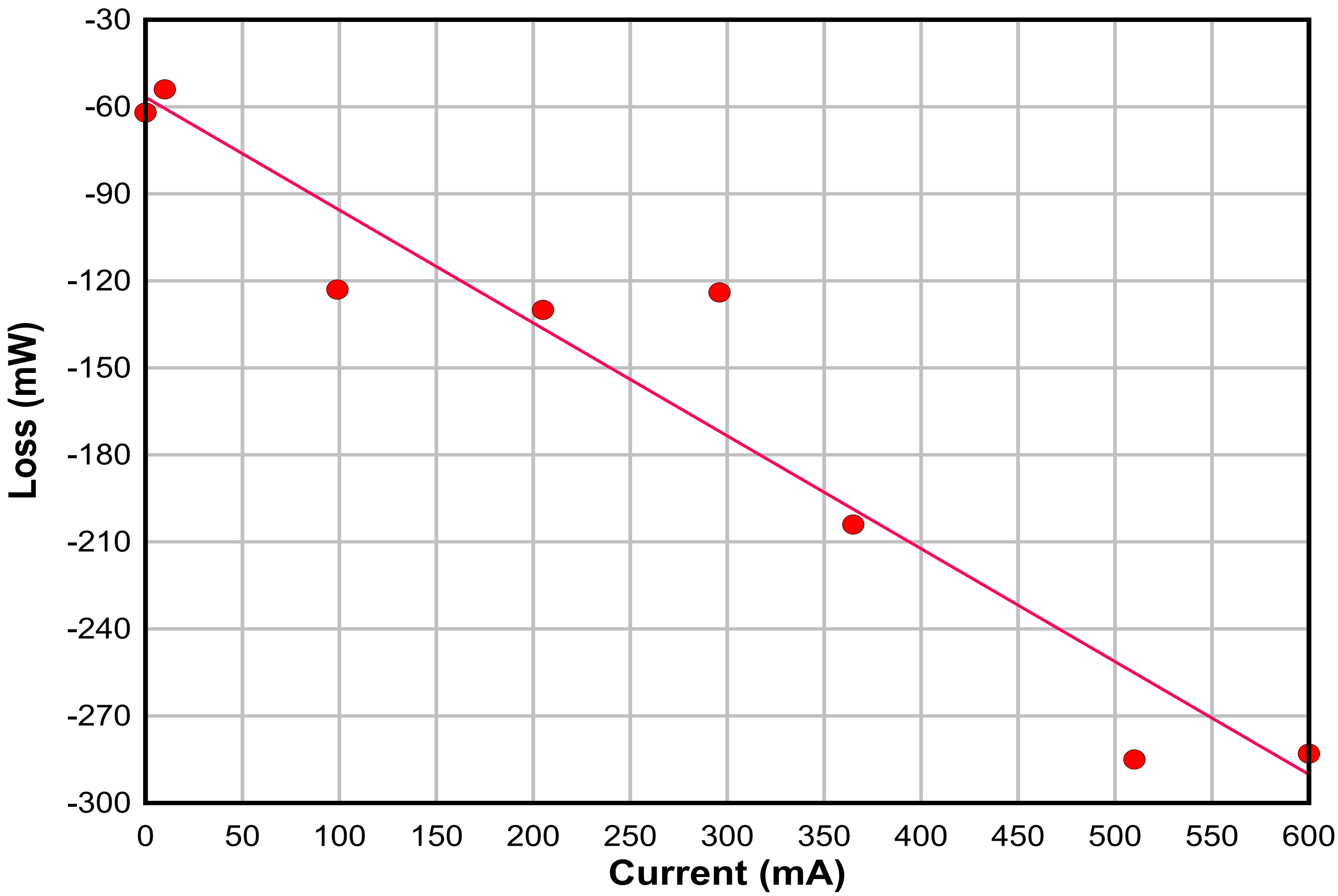

Figure 3-2. Power Loss Reported by BQ51013B-Q1 Based on Current Load

3.3 Battery Charge Profile

Figure 3-3 shows the charge profile when charging a 200 mAh Li-Ion battery at 200 mA. This battery was tested with a BQ500212A Qi Compliant 5 V Wireless Power Transmitter and BQ27421 impedance track fuel gauge EVM.

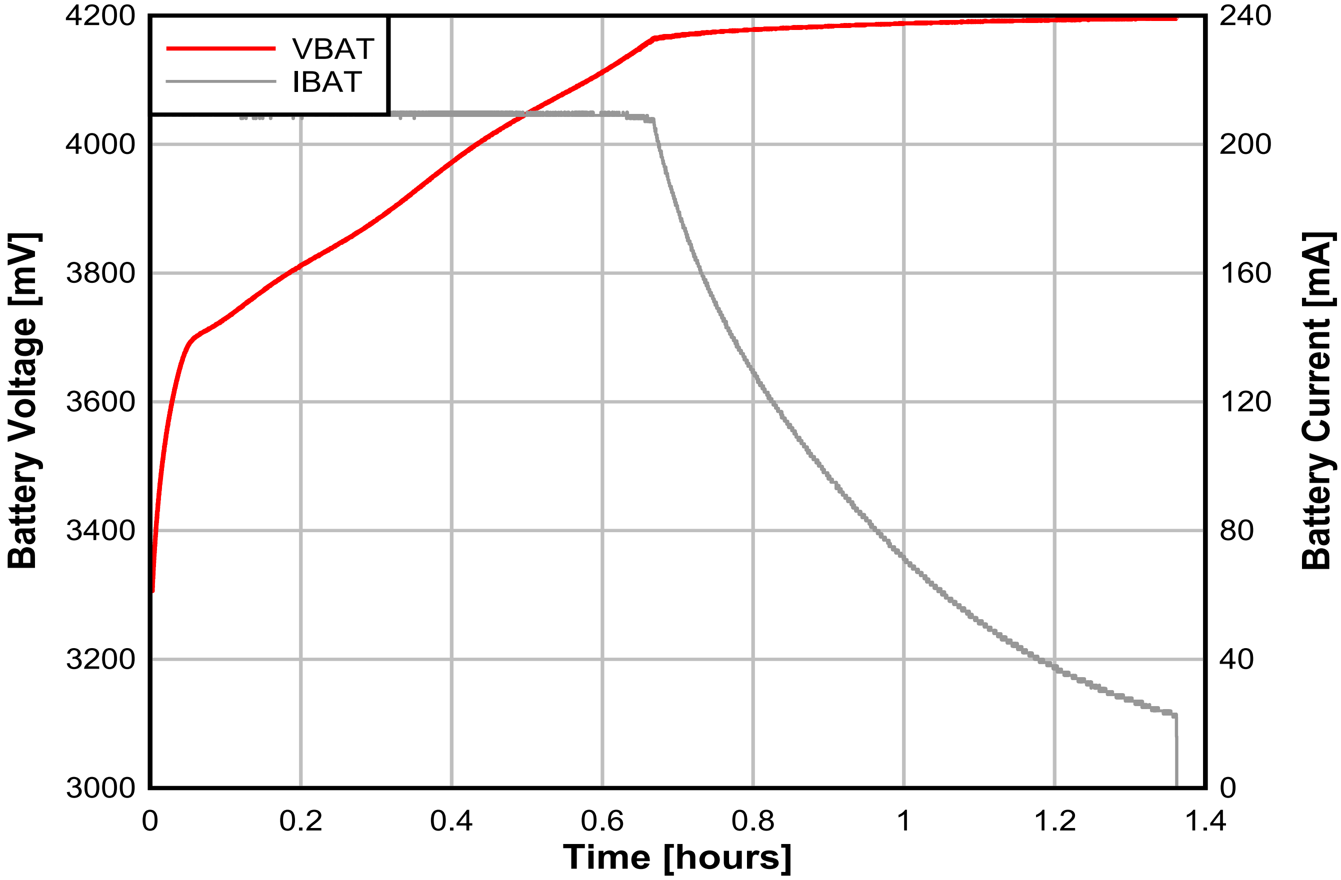

Figure 3-3. Charging 200 mAh Li-Ion Battery at 1C

4 References

- Texas Instruments, *BQ25171-Q1: Automotive, Standalone 800-mA Linear Battery Charger for 1- to 2-Cell Li-Ion, LiFePO4 , and 1- to 6-Cell NiMH*, data sheet.
- Texas Instruments, *BQ51013B-Q1: Automotive Highly Integrated Wireless Receiver Qi (WPC v1.2) Compliant Power Supply*, data sheet.
- Texas Instruments, TI E2E™ design support forums