

Measuring Efficiency of the bq25504 Energy Harvesting Battery Charger

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ABSTRACT

This application note explains how the data for the bq25504 data sheet efficiency curves was measured.

Background

Efficiency for output voltage regulating power supplies (that is, ac/dc or dc/dc converters) is typically reported as **efficiency vs. load current for a given fixed output voltage and input voltage**. The power source to these supplies has an impedance that is significantly lower than that of the converter. Energy harvesting ICs, like the bq25504, take power from sources with output impedances that are relatively higher and that vary with environmental conditions. Therefore, the bq25504 has a circuit that regulates its input voltage to a pre-determined level in order to prevent the source from collapsing while charging the attached storage element (that is, a battery) or during times of excessive resistive load by the system. Called the **maximum power point tracking (MPPT) circuit**, this circuit extracts the maximum power from the source and delivers as much power as possible to the capacitor on the VSTOR output and any system load. Any additional system load demands must come from the bq25504 attached storage element. Reporting efficiency vs. fixed output load current does not accurately reflect an input voltage regulating energy harvester's optimized state of operation. Hence, energy harvesting ICs, like the bq25504, report efficiency vs. input current for a fixed output voltage and input voltage or efficiency vs. input voltage for a fixed output voltage and input current without a battery attached.

Test Setup

Instead of reporting efficiency versus output load current as with traditional power supplies, the bq25504 energy harvester boost-based battery charger reports efficiency with **fixed input current**, self-regulated input voltage, fixed output voltage and the resulting output current. The harvester's storage element (that is, battery) should not be attached to the output. The list of equipment for the measurement is as follows:

1. One source meter capable of being configured as a **constant current source**
2. One source meter capable of being configured as a **constant voltage source**
3. One voltage source

Figure 1 shows the recommended test setup.

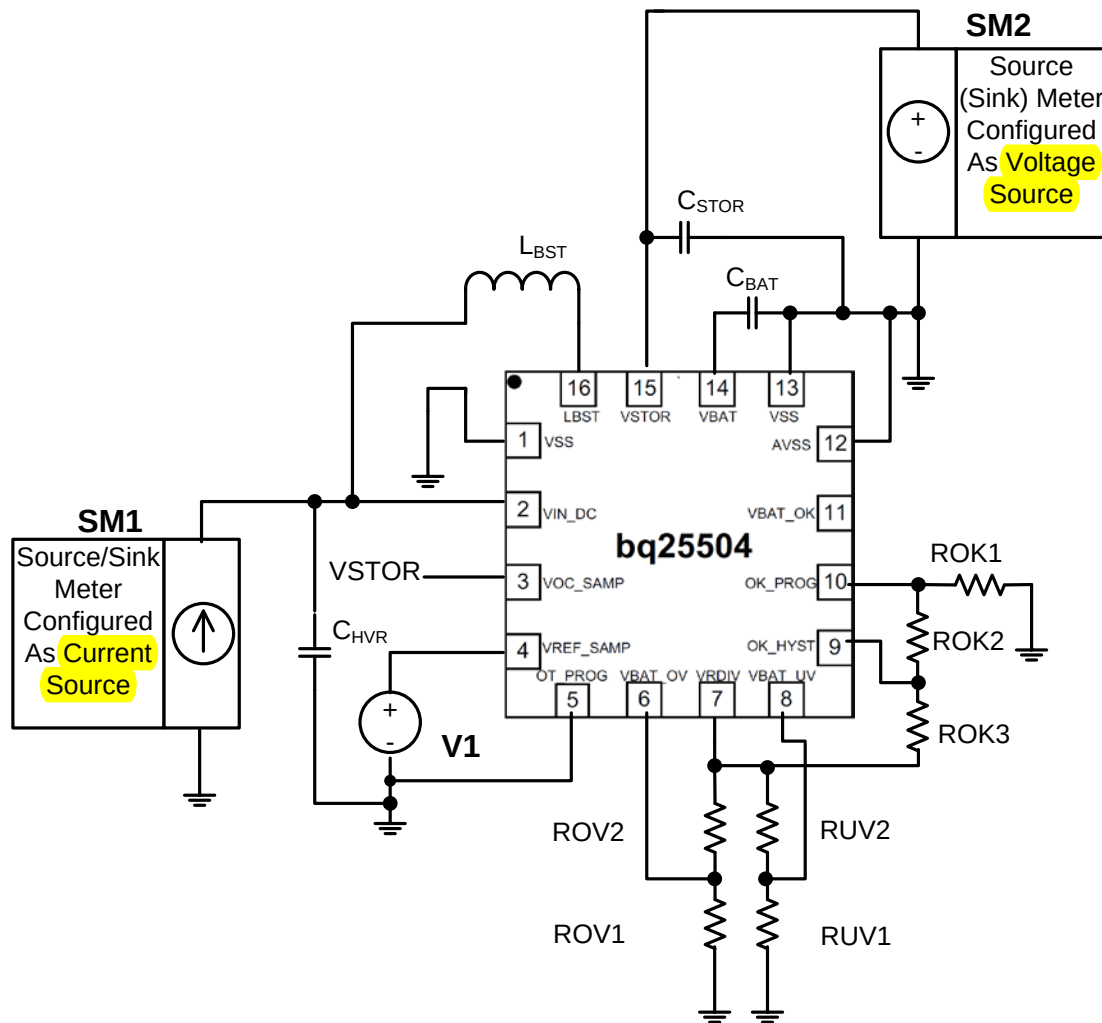


Figure 1. Bq25504 Efficiency measurement

ROV1 and ROV2 must be sized so that VBAT_OV is higher than the largest voltage setting expected on SM2. RUV1 and RUV2 must be sized so that VBAT_UV is lower than the lowest voltage setting expected on SM2. ROKx resistors can be at any setting or removed.

VOC_SAMP is tied to VSTOR in order to disable the sampling component of the MPPT circuit.

The input source, SM1, is connected to VIN_DC and provides a fixed input current (I_{IN}). SM1 should have a compliance voltage set to the intended open circuit voltage of the simulated high impedance source, VOC, but less than 5.5V. For $I_{IN} \leq 500\mu A$, C_{HVR} can remain at $4.7\mu F$ per the EVM. For $500\mu A < I_{IN} \leq 100mA$, C_{HVR} must be increased to a low leakage $47\mu F$ in order to reduce the input voltage ripple. Otherwise, the source meter will not accurately measure the DC input voltage. Voltage source V1, connected to VREF_SAMP, sets the voltage to which the MPPT circuit will regulate VIN_DC. The source meter (SM1) also measures this voltage (V_{IN}). Due to the peak inductor current being clamped at 200mA typical, $I_{IN} > 100mA$ may overpower the input voltage regulation circuit and cause the input voltage to rise to the BAT_OV voltage. The output source meter, SM2, is set to a desired output voltage (V_{OUT}), with compliance greater than the expected maximum expected output current, and sinks the resulting output current (I_{OUT}). Efficiency can then be computed as $\eta = (V_{OUT} \times I_{OUT}) / (V_{IN} \times I_{IN})$.

IMPORTANT:

When measuring nA- μA currents with a source meter, setting the source meter current range no higher than 10X the expected current range and use the normal measurement speed with the filter average count of 50 or more samples is recommended. No scope probes should be attached to any of the pins during the measurement.

Efficiency vs. Input Current

The data in Figure 3 was gathered by setting the SM1 current source of V1 to $10\mu A$, the SM2 voltage source to 1.8V and then varying the voltage compliance of V1 from 0 to 3V. The current sweep was repeated with the SM2 voltage source set to 3V and finally 5.5V.

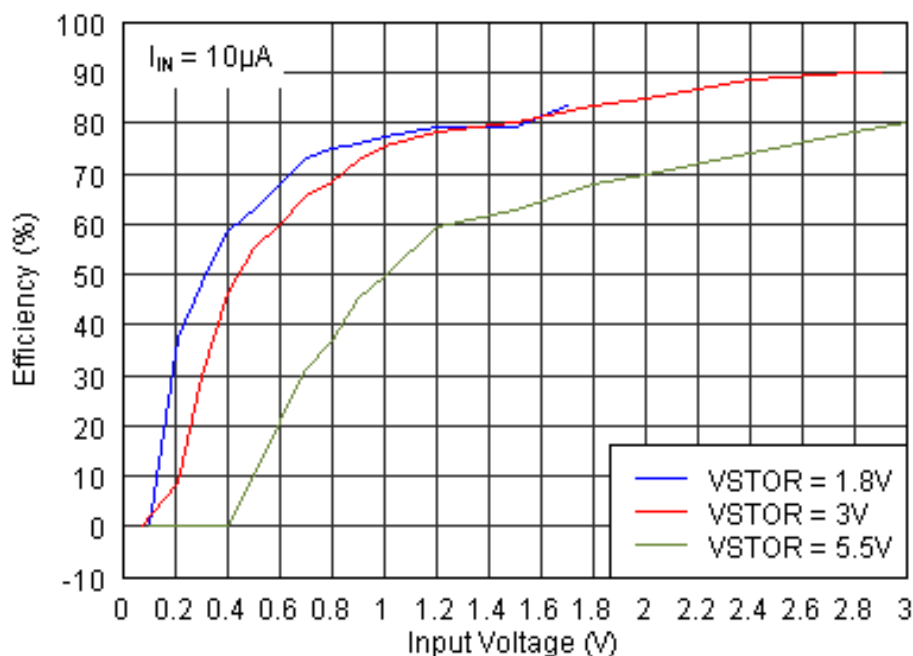


Figure 2. Example Bq25504 Efficiency vs. Input Voltage

Efficiency vs. Input Current Example

The data in Figure 3 was gathered by setting the V1 voltage compliance to 2V, the SM2 voltage source to 1.8V and then varying the SM1 current source from 0.01 to 100mA. The current sweep was repeated with the SM2 voltage source set to 3V and finally 5.5V.

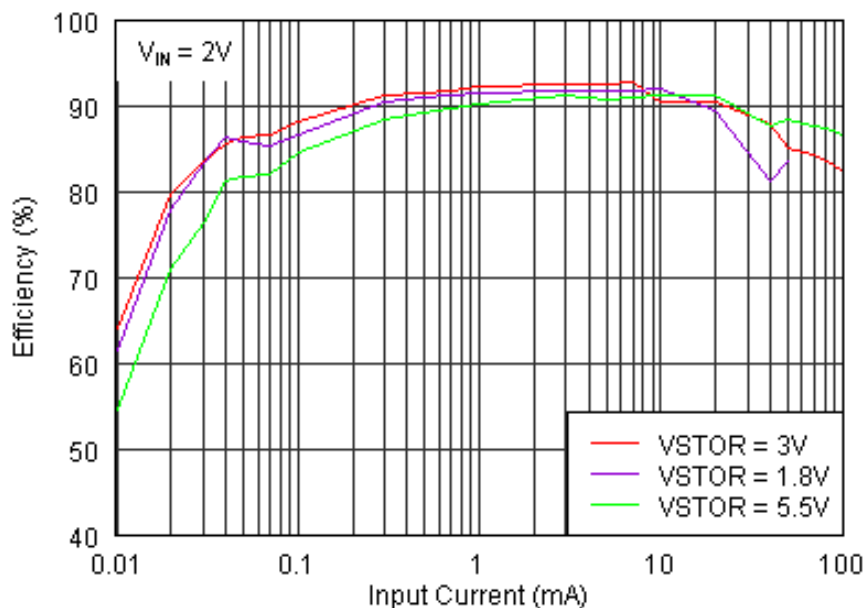


Figure 3. Example Bq25504 Efficiency vs. Input Current

References

1. Bq25504 Data sheet ([SLUSAH0](#))

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