

Calculating and Measuring the No Load Input Current of the Boost Converter

JasperLi

ABSTRACT

This application report introduces how to calculate the no load input current of a low quiescent current boost converter. It also provides a simple method to measure the no load input current without using a current meter.

Contents

1	Introduction	1
2	Input Current Calculation	1
3	Input Current Measurement	3
4	Conclusion	5
5	References	5

List of Figures

1	Current Consumption of the System	2
2	Operation Waveform at Burst Mode.....	3
3	Efficiency of TPS610981 at Low Power Mode.....	3
4	Switching Frequency at No Load Condition.....	4
5	Method to Measure the No Load Input Current.....	4

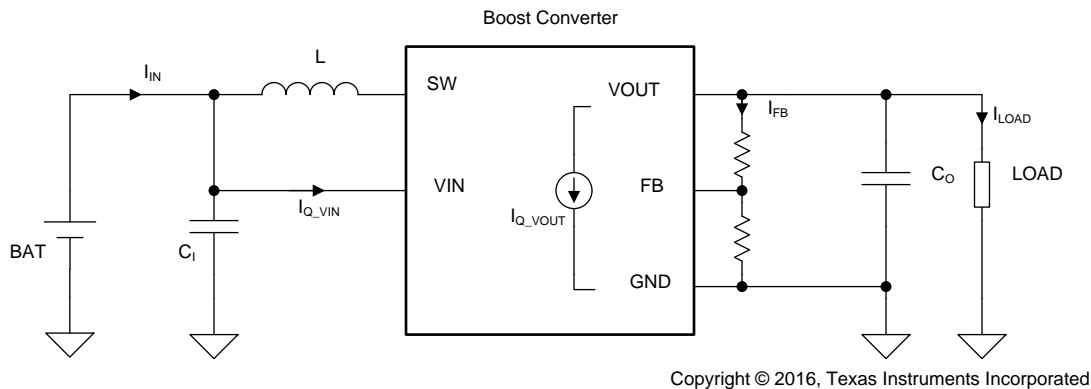
1 Introduction

The no load or very light load input current of a boost converter is critical for some applications that require primary battery and a boost converter to power the whole system. In these applications, the system loads operate at idle mode for most of the time, which consume little energy. The efficiency of a boost converter at this special condition may be not found in the datasheet. So we need to calculate or measure the total input current of the boost converter (also the output current of the battery) at the idle mode to estimate the battery lifetime.

Taking TPS610981 as an example, this application report introduces the methods to calculate and measure the input current of a boost converter at no load or very light load condition.

2 Input Current Calculation

As shown in [Figure 1](#), the input current is determined by the current consumed by the boost IC, the feedback divider and the system load. For fixed output voltage version IC, the resistor divider current is zero.



Copyright © 2016, Texas Instruments Incorporated

Figure 1. Current Consumption of the System

The current consumed by the internal circuit of the IC has two parts, the quiescent current I_Q into the VIN pin and into the VOUT pin, which is shown in [Table 1](#). Details about the definition of I_Q can be found in [I_Q: What it is, what it isn't, and how to use it, SLYT412](#).

Table 1. IQ Specification from TPS610981 Datasheet

Parameter		Test Condition	MIN	TYP	MAX	UNIT
I_{Q_VIN}	Quiescent current into VIN pin in Low Power Mode	MODE = Low, Boost or Pass-through		5	90	nA
I_{Q_VOUT}	Quiescent current into VOUT pin in Low Power Mode	MODE = Low, Boost or Pass-through, No Load, No Switching, T _J = 25°C		300	400	nA

The current into the VOUT pin, the current flowing through the resistor divider and the load current I_{LOAD} are transferred from the battery when the device is switching. So the total input current of the boost converter can be calculated by [Equation 1](#). The unknown parameter of the formula is the efficiency η_1 .

$$I_{IN} = I_{Q_IN} + \frac{V_{OUT}}{V_{IN} \times \eta_1} \times (I_{Q_OUT} + I_{FB} + I_{LOAD})$$

where

- I_{Q_VIN} is the I_Q into the VIN pin
- V_{OUT} is the output voltage of the boost converter
- V_{IN} is the input voltage of the boost converter, or the battery voltage
- η_1 is the efficiency when the boost converter is switching
- I_{Q_VOUT} is the I_Q into the VOUT pin
- I_{FB} is the current of the feedback resistor divider. It is zero in TPS610981
- I_{LOAD} is the load current.

(1)

[Figure 2](#) shows the operating waveform of the TPS610981 at burst mode with 1.2-V input voltage. In the Phase #1, the boost converter switches and transfers the energy from the battery to the output side. In the Phase #2, the boost converter stops switching and the energy in the output capacitors supports the I_{Q_VOUT} and I_{LOAD} . The efficiency η_1 of Phase #1 is approximately the same at different load conditions if the boost converter still operates in the burst mode. So we can set the η_1 to be the efficiency value at the load condition that is one hundred times of the larger one of the I_{Q_VOUT} and I_{Q_VIN} . The reason is that the I_{Q_VOUT} and I_{Q_VIN} have little impact on the efficiency at this load condition if the IC still works in burst mode.

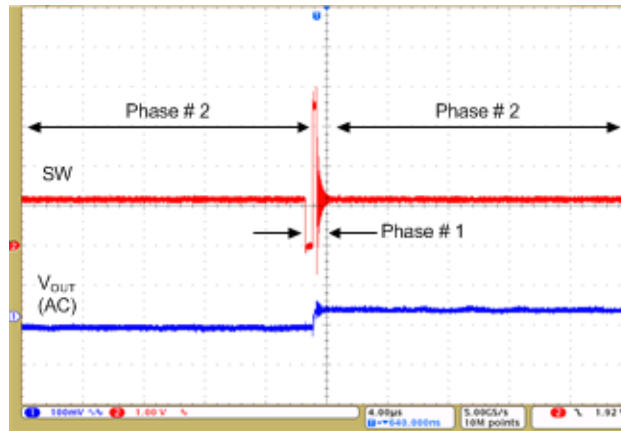


Figure 2. Operation Waveform at Burst Mode

In the TPS610981, we can choose the efficiency value at $I_{LOAD} = 100 \times I_{Q_VOUT} = 40 \mu A$ condition to be η_1 . Figure 3 shows the TPS610981 efficiency curve from the TPS610981 datasheet (SLVS873D). The efficiency at $I_{OUT} = 40 \mu A$, $V_{IN} = 1.2 V$ condition is approximate 85%. And the efficiency increases to 90% when $V_{IN} = 2 V$.

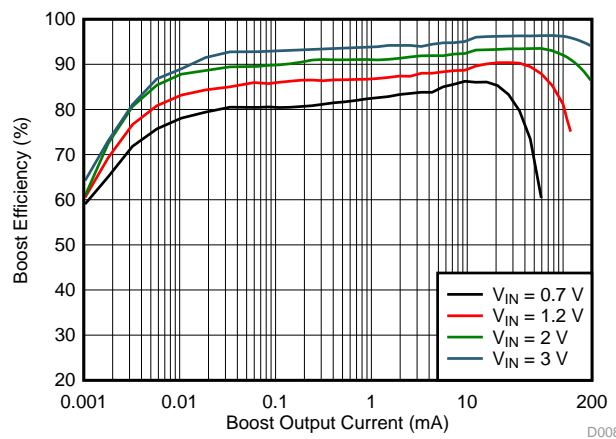


Figure 3. Efficiency of TPS610981 at Low Power Mode

Then the no load input current at $V_{IN} = 1.2 V$ can be calculated as shown in Equation 2. The output voltage is 3.48V when $I_{LOAD} = 0 mA$.

$$I_{IN} = I_{Q_IN} + \frac{V_{OUT}}{V_{IN} \times \eta_1} \times (I_{Q_OUT} + I_{FB} + I_{LOAD}) = 0.005 + \frac{3.48}{1.2 \times 0.85} (0.4 + 0 + 0) \approx 1.36 \mu A \quad (2)$$

When the V_{IN} is 2 V, the η_1 is 0.9 and the no load input current is approximately 0.778 μA .

3 Input Current Measurement

At no load or very light load condition, the switching frequency of the boost converter is very low, as shown in Figure 4. The input current is pulsating in the same frequency which makes the input current hard to be measured using a current meter.

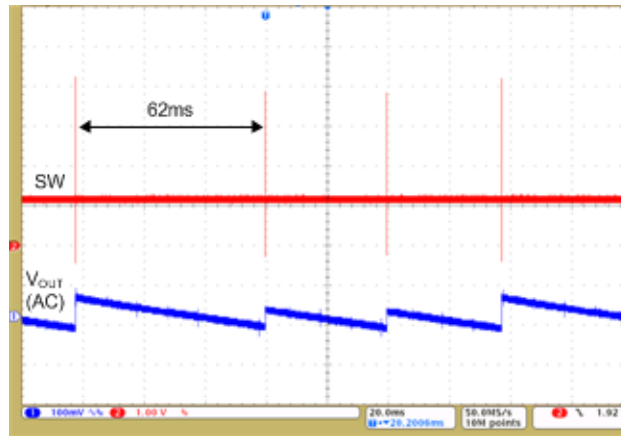


Figure 4. Switching Frequency at No Load Condition

A simple RC filter circuit shown in [Figure 5](#) helps to solve this problem. The cut-off frequency of the RC filters must be much lower than the switching frequency of the boost converter.

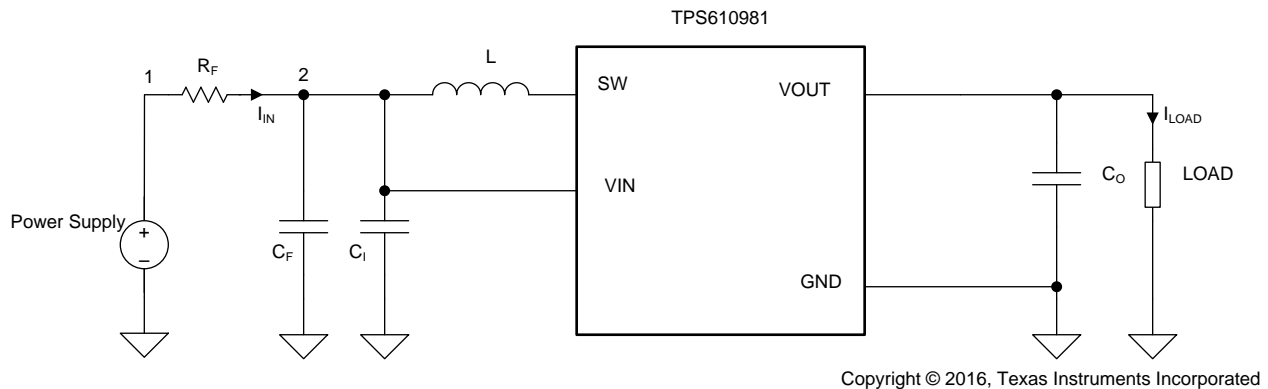


Figure 5. Method to Measure the No Load Input Current

From [Figure 4](#), the switching period is 62 ms, so the time constant of the RC filter can be set to 6 seconds. Based on the input current calculated by [Equation 2](#), we can select 10 kΩ for R_F and 600 μF for C_F . Large R_F results in large voltage difference between the power supply voltage and the real input voltage, which cause trouble in setting the right input voltage. Small R_F results in large ceramic C_F , which increase the cost.

Firstly, connect the power supply to node 2 shown in [Figure 5](#) to charge the C_F and start up the boost converter. Then move power supply quickly to node 1. The input current can be calculated by measuring the voltage drop across the R_F with a multi-meter. It is suggested to wait at least ten minutes until the input current becomes stable. [Table 2](#) shows the calculation and measurement results of the no load input current at different input voltages conditions. The calculated values are closed to the measurement results.

Table 2. Calculation and Measurement Results of No Load Input Current

Calculation and Measurement Results of No Load Input Current			
VIN (V)	1.2	2.4	3
Calculation (μA)	1.36	0.65	0.51
Measurement (μA)	1.24	0.62	0.50

4 Conclusion

The application note introduces methods to calculate and measure the input current at no load or very light load condition. If the load current is known, a formula can be used to estimate the input current; if load condition is unknown or accuracy data is required, the input current can be measured by adding a simple RC filter.

5 References

[*\$I_o\$: What it is, what it isn't, and how to use it*](#)

[*TPS61098x Ultra-Low Quiescent Current Synchronous Boost with Integrated LDO/Load*](#)

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com