Application Report
SLVA810–August 2016

Low Quiescent Current with Asynchronous Buck Converters at High Temperatures

ABSTRACT

This application report provides a summary of the Low Quiescent Current with Asynchronous Buck Converters at High Temperatures for TPS65320/1-Q1 devices.

1 Introduction

Many modern Buck Converters are advertised with very low quiescent currents (Iq) in the order of between 10 and 40 µA. In reality, the *no-load input current* is significantly higher. At elevated temperatures, the input current may even change by orders of magnitude.

This application report discusses the contributors to no-load input current in addition to the Iq of the converter itself and associated temperature dependency. Furthermore, this analyzes when this effect is of concern and what to do about it.

1.1 Contributors to No-Load Input Current

The Iq of a converter is one contributor only and its definition and test conditions also indicate that, in reality, the converter will show a higher-current consumption at no load. Quiescent current of a converter refers to the supply current drawn at no load, non-switching by biasing the feedback pin at reference voltage, or slightly above, and potentially at room temperature only. Consequently, non-switching indicates that no switching losses are accounted for, even though a converter will switch occasionally at no load. There will be some leakage and also a recharge of the boot-capacitors or a charge-pump is likely required, which adds to the losses. A drift of the quiescent current over temperature may, or may not, be specified separately. Luckily, the temperature drift of most converters is expected in the order of an approximately 10% increase at higher temperatures. For test-purposes to specify the Iq of a converter, the feedback is biased to the reference voltage. Thus, this eliminates the feedback-divider to sense the output voltage. Consequently, the current flowing through it (mostly in the order of 10 µA..50 µA) as well as switching of the FETs is prevented and associated losses saved. In reality, those effects do contribute to the *no-load input current*. Figure 1 illustrates the contributors that, in addition to the quiescent current, draw current from the supply.

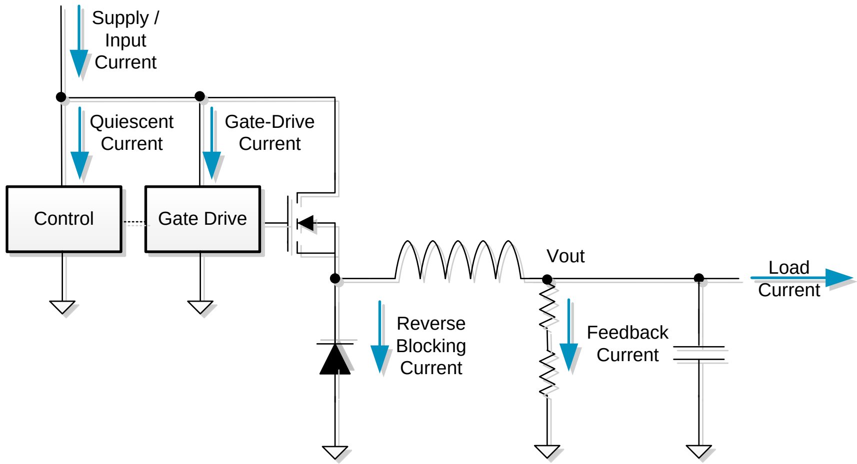

Figure 1. Asynchronous Buck Converter and Associated Currents

A step-down converter with a specified quiescent current of 30 µA will – at room-temperature – most likely draw in excess of 50 µA of no load-current, which accounts for feedback-divider-current and switching losses.

However, this does not explain the orders of magnitude of increase with higher temperature as observed with asynchronous converters: here, the catch-diode plays a significant role in this case: the majority of diodes show an increased reverse current, mostly about 100 times higher at higher temperatures (85°C or higher) compared to room temperature.

For low-voltage and low-current diodes (for example: 10 V, 500 mA), one can find diodes with as low as 1 µA-rated reverse current at room temperature, which consequently rises to about 100 µA at higher temperatures. Unfortunately, for low loads, blocking will be the diode status for the vast majority of the time. For higher-voltage and higher-current diodes (40 V, 4 A), the few microamperes or few dozen microamperes at room temperature will account for several milliamperes at elevated temperatures.

Another factor to consider is the increase in reverse current with increased reverse voltage. Here a rise of about one decade has to be expected from low voltages to maximum-rated voltages. However, clearly defined diode data sheets usually specify the maximum-reverse current at maximum-rated blocking voltage (and at discrete temperatures). Consequently, any asynchronous converter will exhibit a significantly higher no-load current at higher temperatures, heavily dominated by the catch-diode and its increase of reverse current with temperature.

1.2 When This is a Concern

Obviously, if the respective system is not exposed to relatively high temperatures, this is of no concern. Similarly, if the system is only operating in normal mode, hence normal switching operation as opposed to power-save or no-load mode at higher temperatures, this may be negligible. An example could be an automotive application, where a unit such as the front-view-camera, is either off when hot, like for a car parked in the sun, or in normal operation when the car is running and the alternator is working, and therefore a small loss in efficiency can be tolerated. Similarly in industrial applications, a system is hardly ever in standby mode, but either off or in normal mode. For consumer systems that are battery driven, it could be applicable depending on the expected temperatures. To what extent the effect is seen also depends on the blocking voltage, hence the battery voltage in most cases and load-current that drives the diode selection.

1.3 What to Do if This Effect is of Concern

Keep cool! Admittedly, this is easier said than done. A more appropriate solution is to choose a synchronous converter, which eliminates the diode and replaces it with an active FET. A slight increase in quiescent current still needs to be expected with temperature, but it is approximately 10% with a synchronous converter, rather than orders of magnitude with the asynchronous converter and catch diode.

1.4 Conclusion

The quiescent current is only one contributor to the no-load-current consumption. For an asynchronous converter, the catch-diode’s reverse current is a significant contributor, in particular at high temperatures. In some applications, this may be irrelevant or tolerable. In case a low-quiescent current at elevated temperatures is of concern, a synchronous converter is likely the better choice.

2 References

- *IQ: What it is, what it isn’t, and how to use it*
- *Efficiency of synchronous versus nonsynchronous buck converters*
- *Low Quiescent Current with Asynchronous Buck Converters at High Temperatures?*

Revision History

DATE	REVISION	NOTES
August 2016	*	Initial release

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