I²C Quad Buck Regulator Packs Performance, Functionality, Versatility and Adaptability in a 3mm × 3mm QFN

by Joe Panganiban

Introduction

The LTC3562 is an I²C quadruple step-down regulator composed of four extremely versatile monolithic buck converters. Two 600mA and two 400mA highly adjustable step-down regulators provide a total of 2A of available output current, all packed inside a 3mm × 3mm QFN package. All four regulators are 2.25MHz, constant-frequency, current mode switching buck converters whose output voltages and operating modes can be independently adjusted through I²C control. The 2.7V to 5.5V input voltage range makes it ideally suited for single Li-Ion battery-powered applications requiring multiple independent voltage supply rails.

I²C Programmable Operating Modes

All four LTC3562 step-down regulators have the unique ability to be programmed into four distinct operating modes to satisfy the various noise/power demands of a variety of applications. These four modes are pulse skipping mode, Burst Mode operation, forced Burst Mode operation, and LDO mode.

Pulse skipping mode allows the regulator to skip pulses at light load currents, providing very low output voltage ripple while maintaining high efficiency. Burst Mode operation and forced Burst Mode operation deliver bursts of current to the buck output and regulate the output voltage through hysteretic control, giving the highest efficiency at low load currents. In LDO mode, the bucks are converted to DC linear regulators and deliver continuous power from the switch pins through the inductor, providing the lowest possible output noise as well as the lowest no-load quiescent current.

I²C Programmable Output Voltages

Another unique feature of the LTC3562 is its ability to adjust the output voltage of each regulator through I²C control. The chip contains two different flavors of output adjustable regulators. The Type A regulators (R600A, R400A) have programmable feedback servo voltages, while the Type B regulators (R600B, R400B) have directly programmable output voltages that do not need external programming resistors.

The Type A regulators use external feedback resistors to set the output voltage based on a programmable feedback servo voltage. The feedback voltage values can be programmed from 800mV (full scale) down to 425mV in 25mV steps. This results in 16 possible feedback servo voltages, and thus 16 different output voltage settings for the same external programming resistors.

Table 1. Feature comparison of the LTC3562's four integrated regulators (two 600mA and two 400mA)

	R600A	R400A	R600B	R400B
Type	A	A	B	B
Output Current	600mA	400mA	600mA	400mA
I²C Programmable Operating Modes	Pulse Skip Burst Forced Burst LDO	Pulse Skip Burst Forced Burst LDO	Pulse Skip Burst Forced Burst LDO	Pulse Skip Burst Forced Burst LDO
Feedback Servo Voltage	I²C Programmable 425mV–800mV 25mV steps (16 settings)	I²C Programmable 425mV–800mV 25mV steps (16 settings)	600mV (Fixed)	600mV (Fixed)
Output Voltage	Adjustable using External Resistors	Adjustable using External Resistors	I²C Programmable 600mV–3.775V 25mV steps (128 settings)	I²C Programmable 600mV–3.775V 25mV steps (128 settings)
RUN Pins	Yes	Yes	No	No

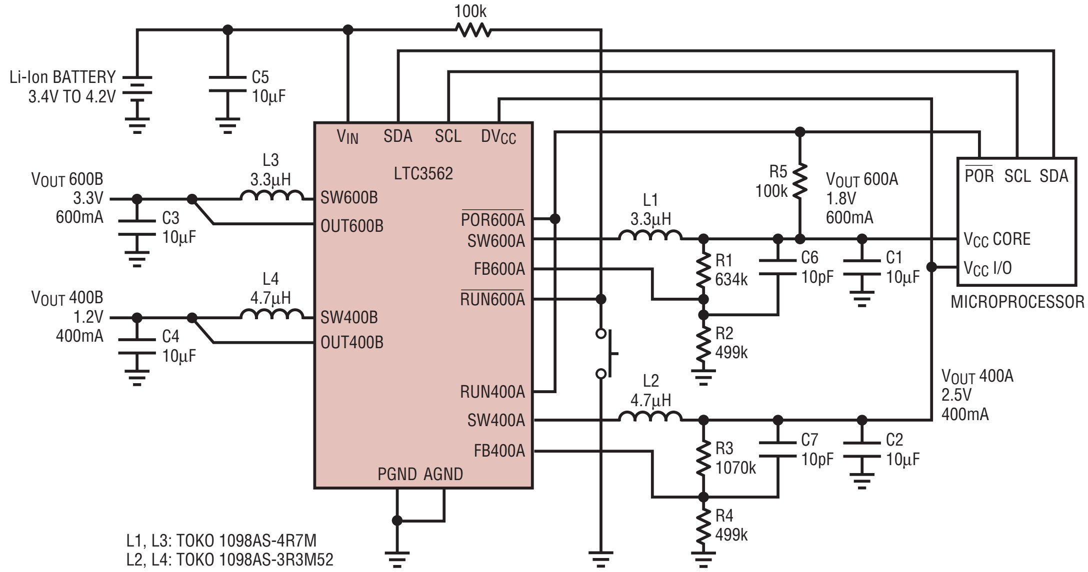

Figure 1. The LTC3562 configured in a quad step-down converter with pushbutton control and power sequencing.

The Type B regulators (R600B, R400B) do not require external programming resistors at all because they are integrated inside the chip. These internal feedback resistors not only save valuable board space, they are also I²C programmable. The values of the internal feedback resistors can be adjusted through I²C control to directly program the regulator output voltages from 0.6V to 3.775V in 25mV increments. That is 128 possible output voltage settings for each Type B regulator.

RUN pins and Default Settings

I²C applications generally have a microprocessor in charge of the I²C communications between the various system blocks. A multi-channel buck converter such as the LTC3562 provides an excellent solution for efficiently stepping down the microprocessor's core and I/O supply voltages from a higher input supply or battery. At the surface, using an I²C controllable voltage converter to generate the microprocessor's power supplies seems to pose a bootstrap problem at system start-up. If the microprocessor initially has no power and thus there is no I²C control, what programs the LTC3562's output to the proper voltage for the patiently waiting microprocessor?

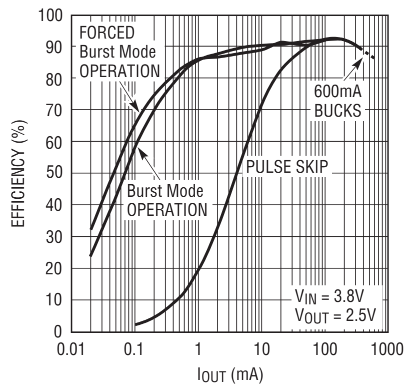

Figure 2. Efficiency of the 2.5V regulator

The LTC3562 gets around this start-up issue by providing individual RUN pins for the two Type A regulators. These RUN pins bypass the I²C controls and enable the regulators if I²C is unavailable. When a RUN pin is used, the corresponding Type A regulator is enabled in a default setting, which is 800mV for the feedback voltage and pulse skipping mode for the operating mode. Once I²C becomes available to the system, these default settings can always be modified on the fly through I²C.

Pushbutton Control and Power Sequencing

Figure 1 shows an application circuit that uses the LTC3562 to power the core and I/O supplies of a system microprocessor. The RUN pin of R600A connects to a pushbutton circuit with a pull-up resistor used to power on the system. When the button is pushed, the RUN pin goes low which enables R600A to ramp up the power supply for the microprocessor's core. The RUN pin of R400A is tied to R600A's power-on-reset output signal (POR600A). Once R600A reaches regulation, POR600A goes high after a 230ms time delay, which would then enable R400A to power the I/O supply of the microprocessor.

After both the core and I/O supplies are up, the microprocessor could then communicate back to the LTC3562 through I²C to program the part such that it keeps R600A enabled even after the pushbutton stimulus is removed. The microprocessor then can enable regulators R600B and R400B in any mode and program the output voltages to desired levels.

Low Power Adaptability

The ability to change the operating modes and output voltages at any time allows the LTC3562 to adapt to the constantly changing demands of many high performance systems. An example of this adaptability would be during lower power standby operation in handheld battery-powered systems. When going into standby mode, the regulators can be programmed into Burst Mode operation or forced Burst

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synchronization, user adjustable switching frequency and a SHARE pin for paralleling modules. The LTM8022 also employs Burst Mode operation, drawing only 50µA quiescent current at no load while maintaining only 30mV of output voltage ripple. Like the LTM8020, the quiescent current when shut down is less than 1µA. The schematic is very simple, with examples of 3.3V and 8V output designs shown in Figures 3 and 4, respectively.

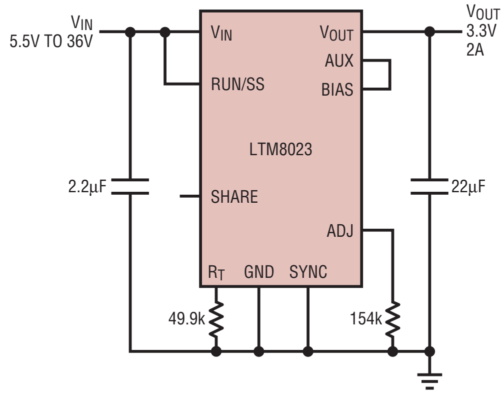

Figure 5. The LTM8023 produces 3.3V at 2A with the same footprint and components required for the LTM8022 producing 1A.

...Or, Even More Power...

The LTM8023 is the big brother of the LTM8022, capable of producing up to 2A of output current. The LTM8023 has the same input, output voltage range, and control features as the LTM8022. It also features Burst Mode operation and low quiescent current. The LTM8022 and LTM8023 share the same footprint and pin pattern, so even if you start a design with the LTM8022 but later find that you need more current, you can simply drop in the LTM8023. In most cases, the design will use identical passive components as the LTM8022, as seen in the 3.3V example in Figure 5.

Table 1. Summary of LTM8000 series µModule regulators

Part Number	V_{IN} Range	Max Load	V_{OUT} Range	Size
LTM8020EV	4V to 36V	200mA	1.25V to 5V	6.25 × 6.25 × 2.32mm
LTM8022EV	3.6V to 36V	1A	0.8V to 10V	11.25 × 9 × 2.82mm
LMT8023EV	3.6V to 36V	2A	0.8V to 10V	11.25 × 9 × 2.82mm

Conclusion

The LTM8020, LTM8022 and LTM8023 µModule regulators make power supply development fast and easy. Their broad input and output voltage ranges, load capabilities and small size (see Table 1) make them readily fit into a wide variety of applications.

LTC3562, continued from page 35

Mode operation to maximize power efficiency at light loads. Under no-load conditions, the regulators can also be programmed into LDO mode, which provides the lowest quiescent current (all four regulators in LDO mode only draw a combined 80µA for the entire chip).

To save even more power, the LTC3562 can be programmed to reduce the regulators' output voltages in Burst Mode operation or forced Burst Mode operation during light load conditions. Since power dissipation is directly proportional to the supply voltage multiplied by the load current, dropping the supply voltage effectively reduces the circuit's total power dissipation. If the output load is resistive in nature, reducing the supply voltages has an even greater effect, since power dissipation in the load is proportional to the supply voltage squared.

Conclusion

The LTC3562 is a highly flexible I^2C quad step-down converter composed of two 600mA and two 400mA buck regulators in a 3mm × 3mm QFN package. The output voltages of the regulators can be switched on the fly using servo control or I^2C control. Each regulator can also be switched on the fly into four possible high efficiency or low-noise operating modes. This is a perfect device for high performance applications that require constant control of the power supply. It can also be used to simplify design, build and test cycles, since output voltages can easily be changed without changing components.

LTC3813 and LTC3814-5, continued from page 21

the output is drawing full load. Its efficiency is shown in Figure 7.

Conclusion

The LTC3813 and LTC3814-5's synchronous architecture and high voltage capability make them ideally suited for high voltage high power boost converters. They decrease complexity by eliminating the requirement for a large diode package and heat sink to dissipate its high power loss. Programmable frequency and current limit, wide output voltage range, and ability to drive logic-level or higher threshold MOSFETs provide maximum flexibility in using them for a variety of boost applications. Other features such as such as strong gate drivers to minimize transition losses, an accurate voltage reference, accurate cycle-by-cycle current limit, and an on-chip bias supply controller make the LTC3813 and LTC3814-5 the obvious choice for high performance, high power boost converters.