

# DESIGN NOTES

## Compact I<sup>2</sup>C-Controllable Quad Synchronous Step-Down DC/DC Regulator for Power-Conscious Portable Processors

Design Note 442

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### Introduction

The LTC<sup>®</sup>3562 quad output step-down regulator is designed for multicore handheld microprocessor applications that operate from a single Li-Ion battery. Its four monolithic, high efficiency buck regulators support Intel's mobile CPU-P-State and C-State energy saving operating modes. The output voltages are independently controllable via I<sup>2</sup>C, and each output can be independently started and shut down. Designers can choose from power saving pulse-skipping mode or Burst Mode<sup>®</sup> operation, or select low noise LDO mode. The space-saving LTC3562 is available in a 3mm × 3mm QFN package and requires few external components.

### Four I<sup>2</sup>C-Controllable Regulators

Two of the regulators provide up to 600mA of output current each while the other two provide up to 400mA each. All regulators are internally compensated, so no external compensation components are needed.

One of the 600mA regulators and one of the 400mA regulators (R600A and R400A) feature I<sup>2</sup>C-controllable feedback voltages, as shown in Figure 1. The output voltages of these "Type A" regulators are set by a combination of external programming resistors and I<sup>2</sup>C-adjustable feedback voltages—16 settings from 425mV to 800mV.

The "Type B" regulators (R600B and R400B) do not require external programming resistors because the resistors are integrated on-chip. The values of the internal feedback resistors are adjusted through the I<sup>2</sup>C port, resulting in 128 possible output voltages from 600mV to 3.775V in 25mV increments.

Inrush current limiting is provided by soft-start circuitry in all four regulators, as well as short-circuit protection and switch node slew rate limiting to reduce EMI.

### Power Saving Operating Modes

The LTC3562's step-down regulators offer four selectable modes of operation, which make it possible to balance low noise against efficiency. The four operating modes of the LTC3562 are shown in Figure 2.

At moderate to heavy loads, the constant frequency pulse-skipping mode provides the best output switching noise solution. At lighter loads, either Burst Mode operation or forced Burst Mode operation can be selected to maximize efficiency, though these modes produce higher ripple.

If the application calls for the lowest possible noise, LDO mode can be used for up to 50mA of load current.

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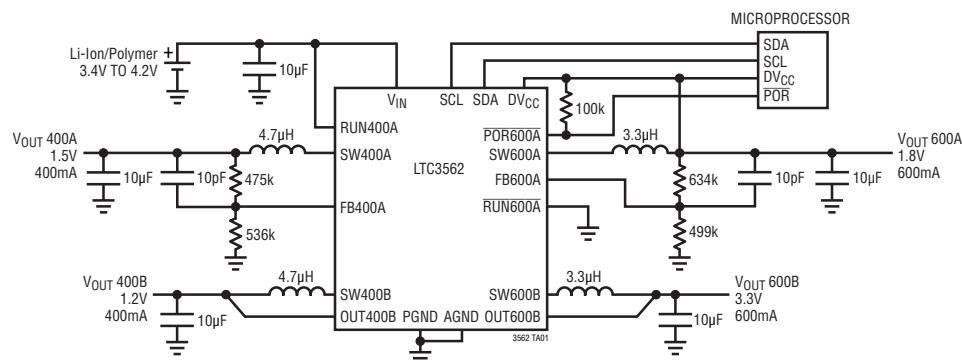


Figure 1. High Efficiency Quad Step-Down Converter with I<sup>2</sup>C Control

All four converters support 100% duty cycle operation when the input voltage drops very close to the output voltage setting.

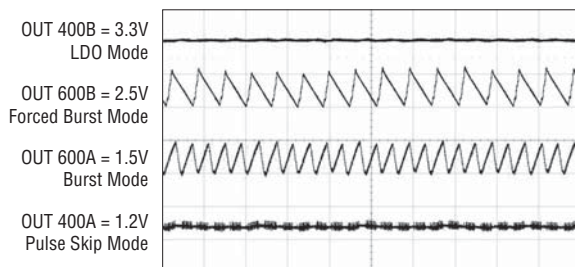


Figure 2. Modes of Operation

### I<sup>2</sup>C Programming of Output Voltages Allows Easy Sequencing, Tracking and Margining

Each output can be programmed on the fly and independently enabled or disabled. These features taken together enable almost any sequencing or tracking scheme. A sequencing example is shown in Figure 3.

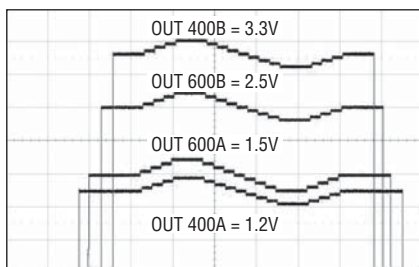


Figure 3. LTC3562 Voltage Sequencing and Margining

A coincident voltage tracking example is shown in Figure 4. All of the outputs are ramped up together at power up. At power down, the highest output is incrementally ramped down until it reaches the value of the next higher voltage,

which ramps down with the first. This is repeated until each output has tracked down to a minimum value and then disabled.

The ability to adjust the output voltage on the fly is also useful to margin the supplies for design evaluation or manufacturing quality audit testing. Voltage margining is applied to the nominal operating voltages in Figure 3 and Figure 4.

Reducing the voltage or shutting down any output can reduce battery life or reduce energy usage in 'green' applications.

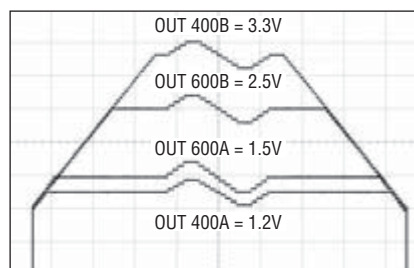


Figure 4. LTC3562 Voltage Tracking and Margining

### Conclusion

The LTC3562 is a versatile high efficiency quad output monolithic synchronous buck regulator controlled with an I<sup>2</sup>C interface in a 3mm × 3mm QFN package. Four modes of operation allow the switching regulators to be tailored to the system's efficiency and noise requirements. This device is well suited for handheld microprocessor applications operating from a single Li-Ion battery where battery life is critical. The ability to use I<sup>2</sup>C to adjust output voltages on the fly or disable output voltages supports Intel's mobile CPU P-State and C-State energy saving modes of operation and simplifies development and manufacturing tolerance testing.

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