The Best of Two Worlds

Linear regulators' continued popularity stems from their ease-of-use and rapid design time to market. The devices also feature low output noise, can provide the highest power supply rejection ratio (PSRR) of any traditional regulator, and give designers the fast transient response that their applications require. When combined together, it's easy to see why linear regulators are so popular and their use so pervasive.

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Figure 1: SuperLNR provides the 'good' characteristics of linear and switching regulators

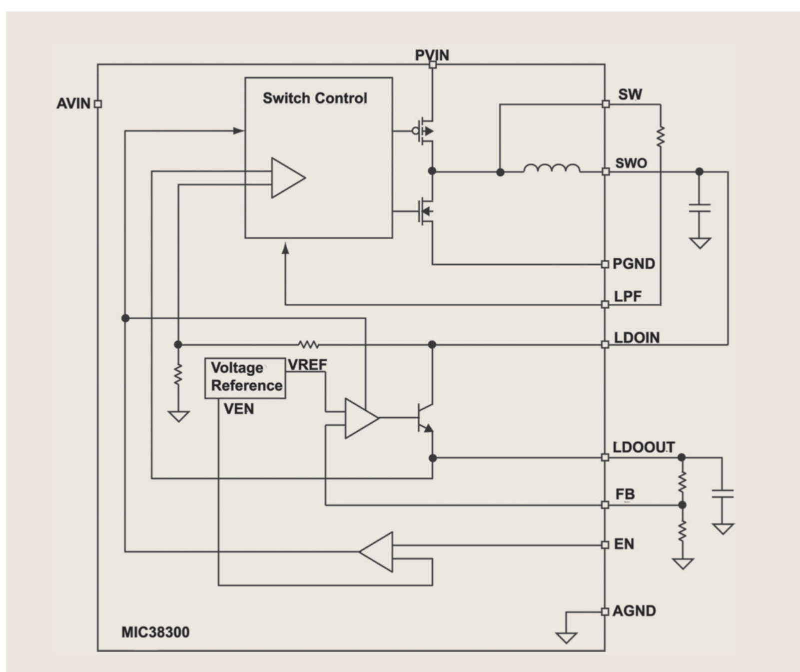
All these excellent qualities aside, the linear regulator does have unwanted power dissipation. As a linear element, the power lost in the conversion process can be calculated via a simple mathematical formula: the input voltage minus the output voltage multiplied by the output current. As the market trend for lower output voltages outpaces the reduction of common input voltage rails, the linear regulator's power dissipation is fast becoming too high a burden. In order to minimise power dissipation, designers have started using DC/DC converters which produce less heat over a wide input voltage range. In noise sensitive applications, DC/DC converters are inferior to linear regulators, as they require a higher degree of design expertise to use and generate higher noise signals on both the output and adjacent devices. Clearly, there exists a need for a topology that combines the 'good' characteristics of a linear regulator without the high power dissipation.

SuperLNR architecture

Micrel's new SuperLNR architecture combines a simple DC/DC converter with an internal inductor with a series Low Dropout Regulator (LDO). The DC/DC converter efficiently drops the excess voltage that causes heat generation in the LDO, but leaves just enough voltage 'headroom' on the LDO, providing the 'good' characteristics of high PSRR, transient response or low noise, according to Figure 1.

Figure 2 shows a block diagram of the MIC38300, the first SuperLNR device. The switcher drives the pass transistor connected between LDOin and LDOout, while the error amplifier ensures the validity of the output voltage. To maximise efficiency, the Switch Control block compares the LDOin to LDOout voltage drop, maintaining a minimum dropout voltage between them. The MIC38300 also includes a hysteretic frequency control utilising an external resistor between the SW and to adjust the frequency of the

Figure 2: Block diagram of the SuperLNR MIC38300



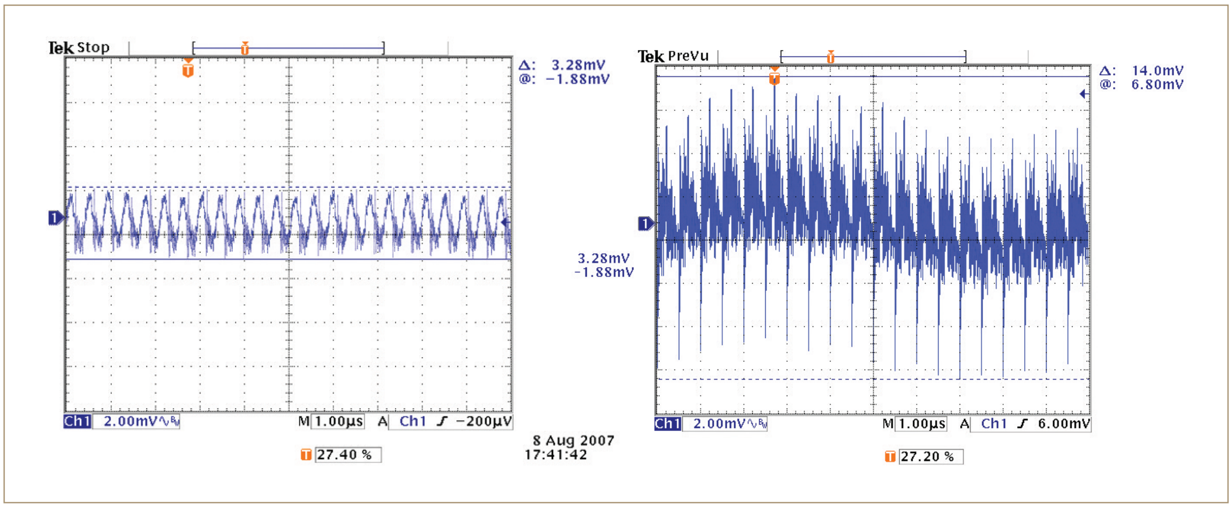


Figure 3: Comparison of output noise ripple from MIC38300 SuperLNR (left) with noise ripple from a 2MHz Buck regulator

switching regulator, reducing inductor ripple and output noise. By electing to use a NPN bipolar transistor, the MIC38300 is capable of providing more than 70dB (at 1kHz) of PSRR, thereby rejecting the noise from the switching output and further minimising output ripple.

Performance advantages

A synchronous, fully loaded, single-phase DC/DC converter has between 10 and 100mV of output voltage ripple. Figure 2 compares output noise ripple from a MIC38300 SuperLNR with the noise ripple from a 2MHz Buck regulator, when driving a 2A load. Due to the high PSRR and hysteretic frequency control, the output noise from the MIC38300 is substantially lower than buck regulators.

Other technology roadblocks exist when supplying today's advanced processors. Operating frequencies of ASICs and FPGAs have risen to GHz speeds, creating fast and high load changes that result in fluctuations on the supply voltage varying upon the response time of the voltage regulator used. Switching regulators have 10 to 100 times slower response times to load changes when compared to linear regulators.

With less noise and faster transient performance, it would seem that a linear regulator is the ideal solution for powering processor applications. The essential drawback to using linear regulators is power dissipation. Figure 4 compares the power dissipation within the device of a 3A linear regulator to the SuperLNR. With a 2A load, a lossless 3A LDO would have almost three times the power dissipation of a SuperLNR device.

The SuperLNR architecture is designed to save power, but by implementing the architecture into a one chip solution, the MIC38300 is able to save valuable board space. For a 3A LDO solution, a package capable of dissipating that much power would require 150mm². A switching regulator solution also requires a bigger footprint to allow for a low DCR inductor with a saturation current rating of 3A, increasing the footprint to more than 300mm². The MIC38300, with a LDO compensating for a saturated internal inductor, requires only a 50mm² footprint.

Conclusion

Micrel's SuperLNR achieves fast dynamic performance and maintain less than 30mV of output deviation during fast load transients. The first device in this family (MIC38300) fits into a 4mm x 6mm x 0.9mm MLF package that produces less than 5mV of output noise. Because this package already includes an internal inductor, layout is simplified, providing a solution as easy to use as linear regulators. The SuperLNR architecture offers benefits of both switching and linear regulators, providing another solution to the trade-off low noise versus efficiency.

Figure 4: Comparison of power dissipation within the device of a 3A linear regulator to the SuperLNR device