

The Harsh Reality of Wide-Ranging 4V–36V Automotive Batteries Is No Problem for Triple Output Regulator in 4mm × 5mm QFN

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DC/DC converters for automotive applications must operate in an environment of extremes. Input transients can exceed the nominal battery voltage by a factor of five and last hundreds of milliseconds, while temperatures under the hood soar far above the capability of typical commercial grade ICs. In this harsh environment, space is tight, so even the most robust devices must perform multiple functions.

The LT3694/LT3694-1 meets these requirements by combining a 2.6A switching regulator and two low dropout linear regulators in a compact 4mm × 5mm QFN package or a thermally enhanced TSSOP. The switching regulator requires a single inductor and has an internal power switch, cycle-by-cycle current limiting and track/soft-start control. Each LDO requires only an external NPN pass transistor and includes foldback current limiting and track/soft-start control. An internal overvoltage detector shuts off the switching regulator when V_{IN} exceeds 38V, protecting the switch and the Schottky rectifier. This allows it to survive transients on V_{IN} up to 70V without damage to itself or the rectifier.

4V–36V INPUT SWITCHING REGULATOR

The LT3694/LT3694-1 includes a 36V monolithic switching regulator capable of providing up to 2.6A of output current from input voltages down to 4V. Output voltages can be set as low as the feedback reference of 0.75V.

The regulator uses a current mode, constant frequency architecture, which

keeps loop compensation simple. External compensation allows custom tailoring of loop bandwidth, transient response and phase margin.

TWO LOW DROPOUT LINEAR REGULATORS

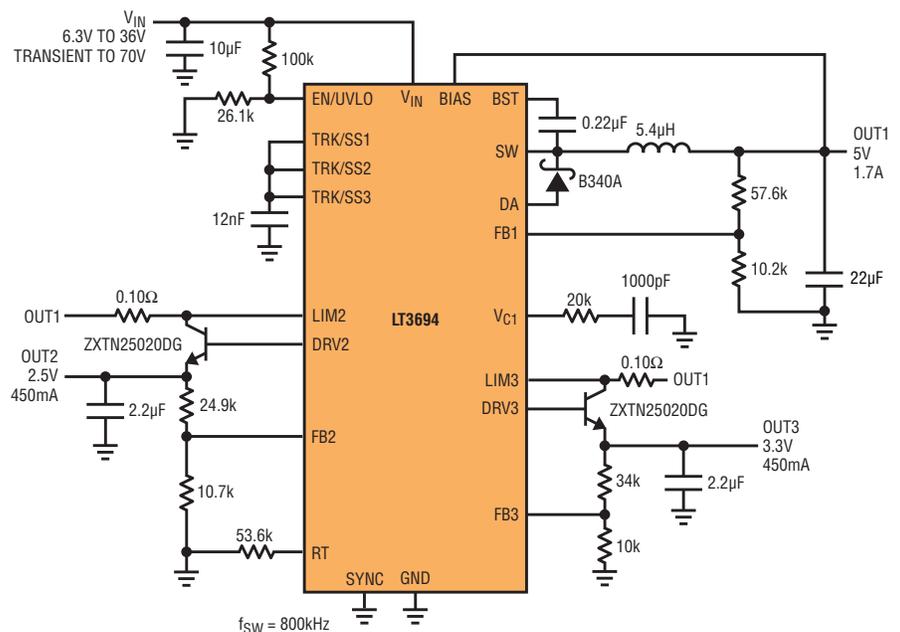
The LT3694/LT3694-1 includes two LDO linear regulators that use an external NPN pass transistor to provide up to 0.5A of output current. The base drive can supply up to

10mA of base current to the pass transistor and is current limited. The LDO is internally compensated and is stable with output capacitance of 2.2 μ F or greater. It uses the same 0.75V feedback reference as the switching regulators.

The LDO drive current is drawn from the BIAS pin if it is at least 0.9V higher than the DRIVE pin voltage, otherwise it's drawn from V_{IN} . This reduces the power consumption of the LDO, especially when V_{IN} is relatively high.

The LDO has foldback current limiting by monitoring a sense resistor in the collector of the NPN pass transistor. The initial threshold is set at 60mV, but folds back as V_{FB} decreases until at $V_{FB} = 0$ the threshold is at 26mV. A sense resistor of 0.1 Ω sets the operating current limit at 600mA, but

Figure 1. The LT3694/LT3694-1 in a wide input range, triple output application.



The LT3694/LT3694-1 combines a 2.6A switching regulator and two 500mA low dropout linear regulators in a compact 4mm × 5mm QFN package or a thermally enhanced TSSOP.

the short circuit current limit drops to 260mA. This reduces power dissipation in the pass transistor with a shorted output.

The LDOs can be shut down by pulling the FB pin above 1.25V with at least 30 μ A. If independent control of the LDOs is needed, each LDO output can be forced to 0V by pulling its TRK/SS pin low. If the track or soft-start functions are needed, use an open drain output in parallel with the track or soft-start circuitry described below. If track and soft-start are not necessary, then a standard CMOS output (from 1.8V to 5V) with a 1k series resistor works fine.

TRACK/SOFT-START CONTROL

The buck regulator and each LDO has its own track/soft-start (TRK/SS) pin. When this pin is below the 0.75V reference, the regulator forces its feedback pin to the TRK/SS pin voltage rather than the reference voltage. The TRK/SS pin has a 3 μ A pull-up current source.

The soft-start function requires a capacitor from the TRK/SS pin to ground. At start-up, this capacitor is at 0V, which forces the regulator output to 0V. The current source slowly charges the capacitor voltage up and the regulator output ramps up proportionally. Once the capacitor voltage reaches 0.75V, the regulator locks onto the internal reference instead of the TRK/SS voltage. The TRK/SS pin is pulled low on any shutdown event (overvoltage, overtemperature, undervoltage) in order to discharge the soft-start capacitor.

The track function is achieved by connecting the slave regulator's TRK/SS pin to a

resistor divider from the master regulator output. The master regulator uses a normal soft-start capacitor as described above to generate the start-up ramp that controls the other regulators. The resistor divider ratio sets the type of tracking, either coincident (ratio equal to slave feedback divider ratio) or ratiometric (ratio equal to master feedback divider ratio plus a small offset). The TRK/SS pins can also be tied together to a single capacitor to provide ratiometric tracking, but only if the LDOs are not shut down by pulling FB high (see the section "Two Low Dropout Linear Regulators" above).

ENABLE AND UNDERVOLTAGE PROTECTION

The LT3694/LT3694-1 includes an enable and user programmable undervoltage lockout function using the EN/UVLO pin. The undervoltage lockout can protect against pulse stretching. It can also protect the input source from excessive current since the buck regulator is a constant power load and draws more current when the input source is

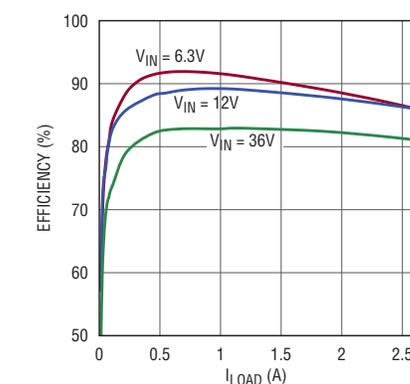


Figure 3. Switching regulator efficiency

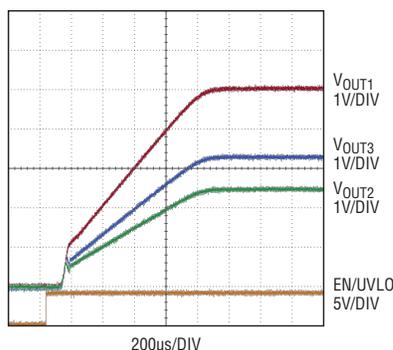


Figure 2. Ratiometric tracking waveforms

voltage. Safety features include bad-battery detection and NTC resistor input with fault indicator suitable for use with a LED. An internal input reverse voltage blocking diode is available to prevent leakage current from the battery when the power source is not present. The LTM8061 and LTM8062 are available in an ROHS compliant 9mm × 15mm × 4.32mm LGA package.

60V BATTERY CHARGING CONTROLLER AND POWER MANAGER

The LTC4000 is a high voltage controller and power manager that converts virtually any externally compensated DC/DC power supply into a full-featured battery charger. The LTC4000 is capable of driving typical DC/DC converter topologies, including buck, boost, buck-boost, SEPIC and flyback. The device offers precision input and charge current regulation and operates across a wide 3V to 60V input and output

voltage range—compatible with a variety of different input voltage sources, battery stacks and chemistries. Typical applications include high power battery charger systems, high performance portable instruments, battery back-up systems, industrial battery-equipped devices and notebook/sub-notebook computers.

The LTC4000 features an intelligent PowerPath™ topology that preferentially provides power to the system load when input power is limited. The LTC4000 controls external PFETs to provide low loss reverse current protection, efficient charging and discharging of the battery and instant-on operation to ensure that system power is available at plug-in even with a dead or deeply discharged battery. External sense resistors and precision sensing enable accurate currents at high efficiency, allowing the LTC4000 to

work with converters that span the power range from milliwatts to kilowatts.

The LTC4000's full-featured controller charges a variety of battery chemistries including lithium-ion/polymer/phosphate, sealed lead acid (SLA), and nickel-based. The device also provides charge status indicators through its FLT and CHRГ pins. Other features of the battery charger include: ±0.2% programmable float voltage, selectable timer or C/X current termination, temperature-qualified charging using an NTC thermistor, automatic recharge, C/10 trickle charge for deeply discharged cells and bad battery detection.

The LTC4000 is housed in a low profile (0.75mm) 28-pin 4mm × 5mm QFN package and a 28-lead SSOP package. ■

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digital feedback can be found in the video “Reduce Digital Feedback in High Speed Data Conversion Systems - LTC2261” at www.linear.com. There are also pin-compatible 14- and 12-bit versions of the dual LTC2185 that also provide excellent performance, and extremely low power consumption for high speed ADCs. The complete family can be seen in Table 1.

CONCLUSION

The LTC2195 is the perfect ADC for power-conscious, high resolution sensor applications, while the LTC6406 is a good match as a driver amplifier—it does not compromise the performance of the LTC2195 and its power requirements are also low. Data sheet performance of the ADC can be easily achieved by using a relatively low order

filter to reduce the wideband noise of the amplifier. The pairing of the LTC2195 and the LTC6406 is the ideal combination for any portable image sensor application, combining excellent performance with low power consumption. For more information about the LTC2195 family and the LTC6406 visit www.linear.com. ■

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allow smaller inductors and capacitors, but use more power and have a smaller allowable step-down range due to the minimum on and off time constraints.

This brings us to the difference between the LT3694 and the LT3694-1. The LT3694 switching frequency can be synchronized to an external clock by connecting it to the SYNC pin. The resistor on the RT pin should be set provide a free running frequency 20% below the sync frequency. The LT3694-1 replaces the SYNC pin with a CLKOUT pin, allowing

the LT3694-1 to be used as the master clock for synchronizing other switching regulators. The CLKOUT produces a clock signal running at ~50% duty cycle.

TRIPLE-OUTPUT CONVERTER WITH VOLTAGE TRACKING

Figure 1 shows a wide input range, 6.3V to 36V, converter that generates three outputs: 5V, 3.3V and 2.5V. The outputs track ratiometrically, set via a common TRK/SS connection. Figure 2 shows the start-up waveforms of the three outputs along with the enable signal.

Figure 3 shows the switching regulator efficiency at different input voltages.

CONCLUSION

The LT3694/LT3694-1 offers robust, compact power supply solutions by squeezing three regulators into a tiny 4mm × 5mm QFN or a 20-lead TSSOP package. One regulator is an efficient switching regulator and the other two are low noise, low dropout linear regulators. Just a few small external components are needed to create an extremely compact triple output solution. ■