



**H**igh power step down dc/dc converters have long benefited from multiphase operation. But the advantages of multiphase operation, such as reduced input and output ripple currents, lower output noise and lower component stresses, can also be realised in step up applications.

Until recently, most high power step up converters have used non optimised solutions due to the lack of an available multiphase boost controller. A common solution has been to use the top side drivers of a two phase synchronous step down controller configured to drive two low side power mosfets 180° out of phase. Another solution has been to use two or more single phase step up controllers and an external clock circuit to achieve the required channel to channel phase relationship. However, these solutions suffer from significant drawbacks.

In the automotive environment, the next generation of low emissions diesel fuel injection systems requires a 2A supply at a voltage between 70 and 110V, delivered from a 12V battery that can vary from 9V to 28V. This input to output voltage conversion requires a boost converter with a duty cycle of more than 92% and constant frequency operation.

Meanwhile, high power car audio amplifiers often need a main supply ranging between 25 and 35V, with the ability to supply up to 1000W. This makes multiphase operation essential. By splitting the power stage into multiple paralleled phases, thermal stress is reduced on the power components, as are output voltage ripple and noise. This allows the use of smaller output capacitors and improves system efficiency.

As power densities continue to rise, multiphase boost designs become a necessary option to keep input currents manageable, whilst increasing efficiency and power density. With mandates on automotive energy savings more common, a multiphase converter topology may be the only way to achieve these design objectives. A two phase or higher converter built around Linear

# Bringing a boost

*Automotive applications benefit from multiphase boosters.*

*By Bruce Haug and Tick Houk.*

Technology's LTC3862, can demonstrate the benefits of this approach.

## A multiphase solution

The LTC3862 is a non synchronous multiphase controller which uses a constant frequency, peak current mode control scheme. Its two power stages operate 180° out of phase.

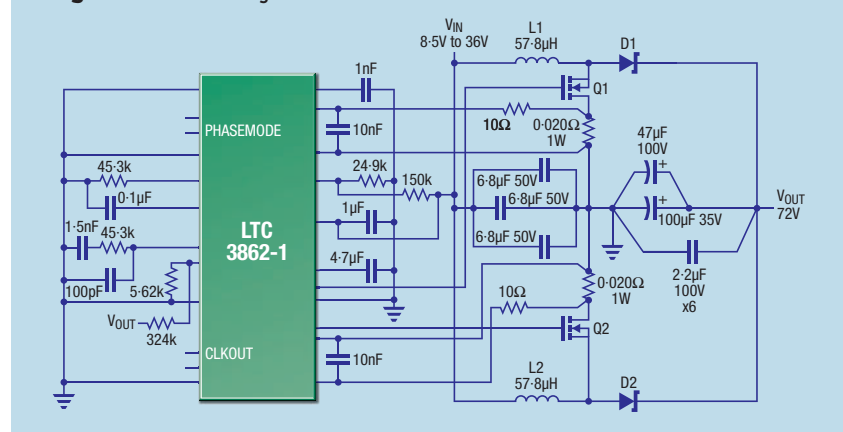
Each power stage is comprised of a single inductor, mosfet, Schottky diode and current sense resistor. The two phases are balanced closely with a tight current limit threshold and a highly accurate transfer function from the ITH pin (the output of the error amplifier) to

the current comparator sense inputs, both from channel to channel and chip to chip. Because of this, the peak inductor current matching is kept accurate, forcing a balanced current in multiphase applications.

A two phase converter requires one LTC3862, with the two output stages driven 180° out of phase. In a three phase converter, two LTC3862 chips are needed and the output stages are driven 120° out of phase and so on, until a 12 phase application, where six chips would be used, with each channel 30° out of phase.

Using multiple power paths, conduction losses can be reduced and

**Figure 1:** A fuel injection boost converter





*“As power densities rise, multiphase boost designs become a necessary option to keep input currents manageable.”*

thermal stresses can be balanced between a larger number of components and over a larger board area. Output noise can also be reduced significantly.

Conversely, for a given output voltage ripple, multiphase operation will bring a smaller total output capacitance; important in high voltage applications, where the output capacitor’s voltage coefficient typically reduces effective capacitance.

The LTC3862 provides a 5V gate drive for logic level mosfets and the LTC3862-1 provides a 10V gate drive for higher output voltage applications.

### Diesel fuel injection

Figure 1 illustrates a boost converter designed for low emissions diesel fuel injection systems. This operates over a wide input voltage range to accommodate conditions ranging from cold crank to a double battery connection for jump starts.

Because of the input voltage range (8.5 to 36V), the converter must be able to operate at high duty cycles and maintain constant frequency operation. The LTC3862 has a minimum on time of approximately 180ns and a maximum duty cycle of 96%, both parameters being user

programmable. Operating frequency can be programmed from 75 to 500kHz using a single resistor and a phase lock loop can be used to synchronise the operating frequency to an external clock.

Because a single ended boost converter regulates the current in the source of the low side switch, the maximum current that can be delivered is a function of input voltage. As a result, this converter can deliver 0.5A at 8.5V, 1.5A at 24V and 2A at 32 to 36V.

Two pins – CLKOUT and PHASEMODE – allow chips to be daisy chained for higher current multiphase applications. For a three or four phase design, the master CLKOUT signal is connected to the slave’s SYNC input in order to synchronise additional power stages for a single high current output. The PHASEMODE pin adjusts the phase relationship between channel 1 and CLKOUT.

The phases are calculated relative to 0°, defined as the rising edge of the GATE1 output. In a six phase application, the CLKOUT pin of the master controller connects to the SYNC input of the second controller and the CLKOUT pin of the second controller connects to the SYNC input of the third controller.

### Audio amplifier supply

Figure 2 illustrates a two phase car audio power supply that operates from a 5V to 24V input and produces a 24V/5A output. Multiple phase operation can be used for higher power applications.

This multiphase boost converter protects the load from mild overloads by imposing a current limit on each phase (boost converters are typically not short circuit proof due to the diode and inductor connection from input to output).

Audio applications have short duration peak power demands that are much higher than the average output power. Therefore, the current limit must be set high enough to satisfy these requirements.

To maintain constant frequency operation and low output ripple voltage, a single ended boost converter is required to turn the power mosfet off every cycle for some amount of time. This energy to be transferred from the inductor to the output capacitor and load.

A high maximum duty cycle is desirable, especially in low  $V_{in}$  to high  $V_{out}$  applications. The maximum duty cycle for the LTC3862 is 96% with the Dmax pin connected to ground. For other topologies, such as a non isolated flyback converter, it is desirable to limit the maximum duty cycle in order to balance the volt-sec of the transformer.

### Conclusion

Multiphase operation results in lower component stresses, smaller input and output capacitance, smaller solution size, better thermal management and lower output noise. With its programmability up to 12 phases using multiple daisy chained controllers, the LTC3862 serves the needs of step up power supplies from 100W to 1000W in automotive fuel injection systems and high power audio amplifiers.

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Figure 2: A two phase car audio power supply

