Two High Power Monolithic Switching Regulators Include Integrated 6A, 42V or 3.3A, 42V Power Switches, Built-in Fault Protection and Operation up to 2.5MHz

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Power supply designers looking to shrink applications and simplify layout often turn to monolithic switching regulators. Monolithics simplify power supply layout by including the power switch on the die—no external FETs or precision sense resistors are needed. Monolithics can also operate at substantially higher switching frequencies than their controller-only counterparts, thus reducing the size and number of external passive components. The benefits of monolithic regulators are clear, but they traditionally have one major limitation: as the required power level goes up, the likelihood of finding a suitable monolithic regulator diminishes. Two new high power monolithics, the LT3579 and LT3581, solve this problem by integrating 6A (42V) and 3.3A (42V) power switches, respectively.

The LT3579 and LT3581 are highly flexible parts and can be configured in boost, SEPIC, inverting, or flyback configurations. They also offer many unique performance and fault protection features. When configured as high power boost converters, these parts can survive output overloads with only a few additional external components. They can also be configured to provide hot-plug and reverse input voltage protection. In addition, a novel master and slave power switch design allows high voltage charge pump circuits to be made with low power dissipation and few components.

Both parts can be programmed to free-run from 200kHz to 2.5Mhz or can be synchronized with an outside clock source. The parts also provide a clock output pin, enabling the ICs to synchronize other switching regulators. The LT3579 comes in a 4mm × 5mm QFN and 20-lead TSSOP package, and the LT3581 comes in a 4mm × 3mm DFN and 16-lead MSE package.

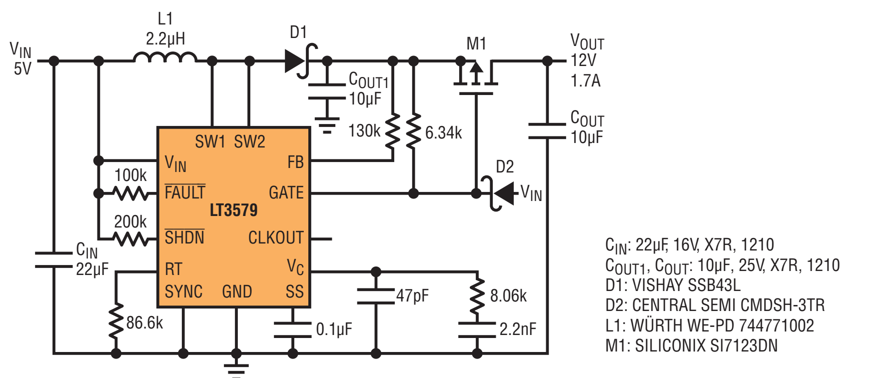


Figure 1. This 5V to 12V boost converter can survive the infamous metal file test where a wire attached to the output is dragged across the jagged surface of a grounded metal file

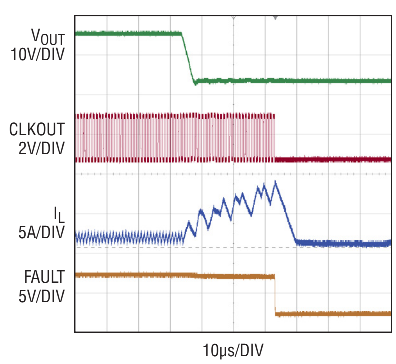


Figure 2. Operating waveforms for Figure 1 circuit during brutal metal file test

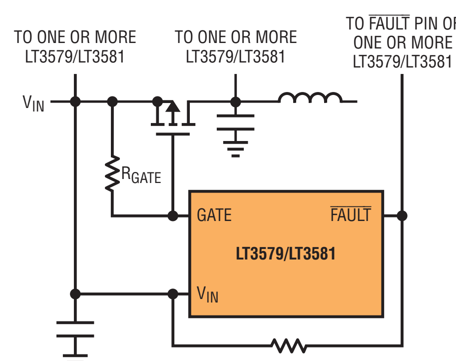


Figure 3. Input disconnect schematic

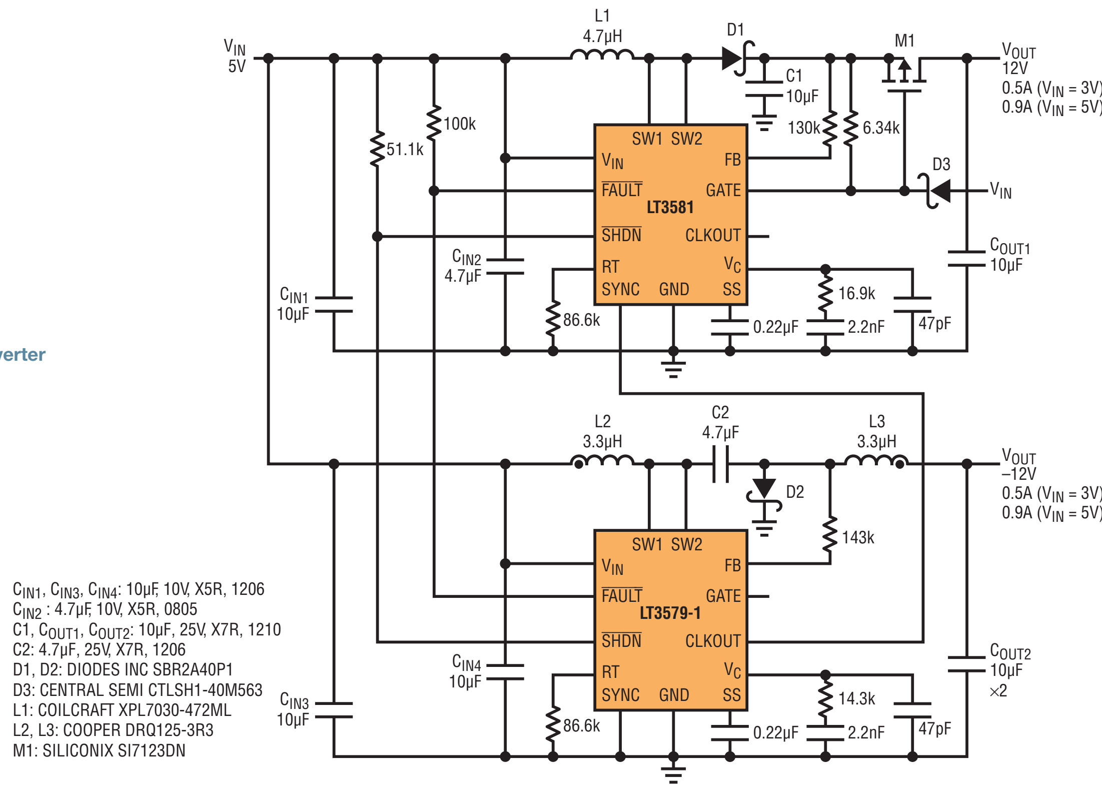


Figure 4. A 3V–5V input to ±12V output converter

FAULT PROTECTION FEATURE: CURRENT OVERLOADS

Most high power boost converters cannot survive an output overload condition because of the inherent DC pathway that exists from the input to output through the inductor and rectifying diode. An output overload or short causes the current in this pathway to increase and run away, thus damaging anything in this pathway or connected to it. The LT3579 and LT3581 include features that protect against such fault events.

Figure 1 shows an LT3579 configured as a 5V input to 12V output boost converter with output short protection. An external PFET, diode, and resistor are all it takes to implement robust output short protection. In fact, this circuit can survive the infamous “file test,” where a wire tied to the output is swiped across the surface of a metal woodworking file tied to ground. Figure 2 shows the operating waveforms during this normally destructive test—the LT3579 survives this brutal test without any problems.

These parts also protect against several other types of fault conditions, including overcurrent conditions, overvoltage on V_{IN}, and over-temperature inside the part.

In systems where multiple LT3579s/LT3581s are incorporated to produce multiple rails, a single PFET and resistor can be used on the input side to protect all the rails from a current overload. Figure 3 shows how to set this up. Simply tie the FAULT pins of all ICs together and connect to a single pull-up resistor. The fault control scheme is designed so that if one part goes into fault, it pulls its FAULT pin low, causing the other parts to go into fault as well. Switching activity in all parts stops and all enter into a time-out period. This time-out period allows the components in the system to cool down. Only after the last part exits the time-out period do all parts attempt to restart. To

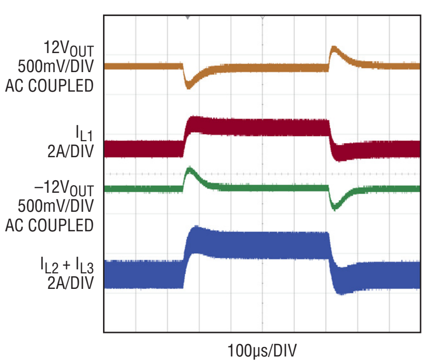


Figure 5. Load step from 0.25A to 0.75A between +12V and −12V rail, with 5V input

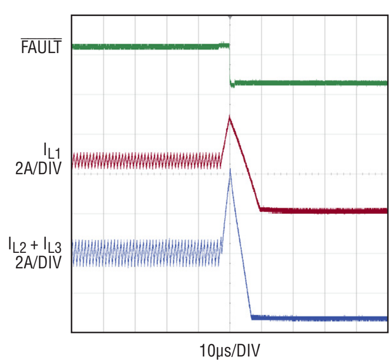


Figure 6. Transient short between rails with 5V input, 0.9A load before short

The LT3579 and LT3581 include features that protect against a number of fault events including output overloads or shorts, overcurrent conditions, overvoltage on V_{IN}, and over-temperature inside the part.

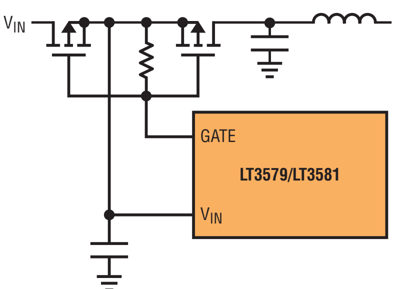


Figure 7. Recommended connections for hot plug, reverse input voltage, and input overvoltage events

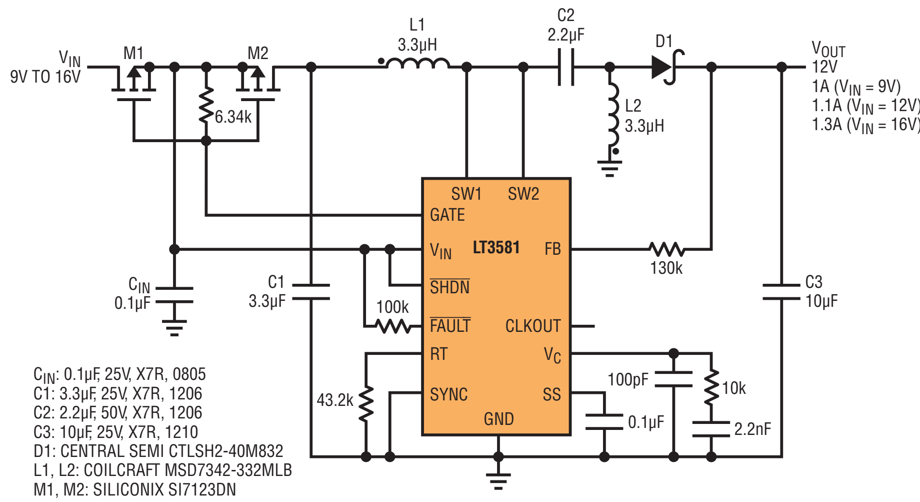


Figure 8. A 9V–16V input to 12V output SEPIC with hot plug, reverse input voltage, and input overvoltage protection

isolate a fault to only one part, simply do not connect the $\overline{\text{FAULT}}$ pins together.

The LT3579 and LT3581 can be easily mixed within a system while maintaining all overload and protection features. Figure 4 shows the LT3579-1 configured as an inverting converter working together with an LT3581 configured as a boost converter. Together, these converters generate a regulated ±12V output at up to 0.9A running off a 3V–5V input, with overload and over-temperature protection. The LT3579-1 is used because it features low input ripple (see page 19 for more about this feature of the LT3579-1). Figure 5 shows the load step response. This system not only accommodates output shorts and overloads between each rail to ground, but it can also tolerate these conditions between the rails as shown in Figure 6.

FAULT PROTECTION FEATURES: HOT PLUG, REVERSE INPUT VOLTAGE, AND INPUT OVERVOLTAGE

The GATE pin, SS pin and related circuitry can also be used to protect against hot plug, reverse input voltage, and input overvoltage events. Figure 7 shows one way to set this up. Hot plug protection is

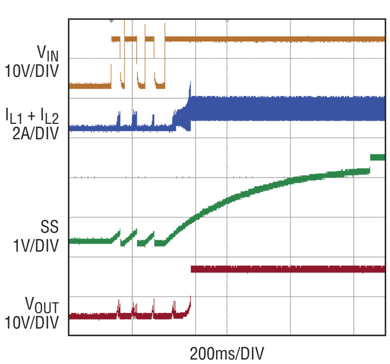


Figure 9. Operating waveforms for a hot plug event

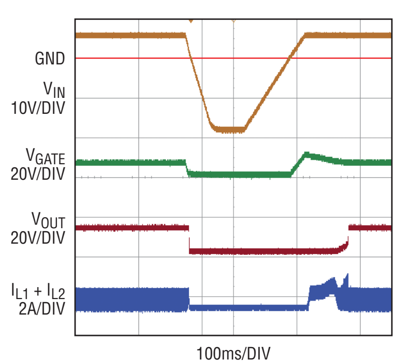


Figure 10. Operating waveforms for a negative V_{IN} transient

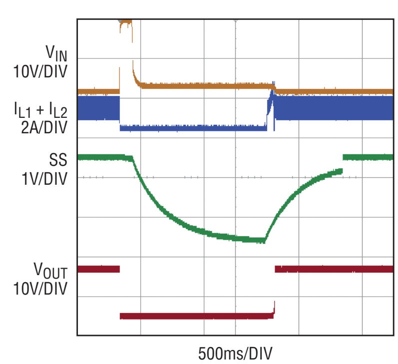


Figure 11. Operating waveforms for a V_{IN} overvoltage transient

Packed with the latest features and some of the highest power levels of any monolithic converters in the industry, the LT3579 and LT3581 venture into applications once reserved for controllers with external FETs.

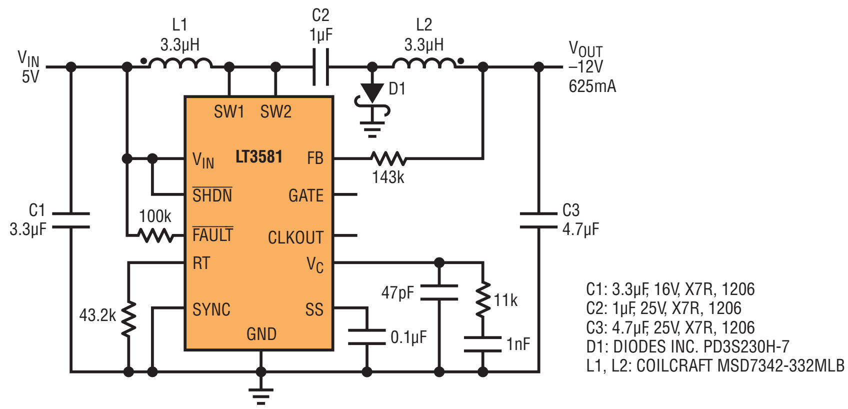


Figure 12. A 5V input to –12V output inverting DC/DC converter

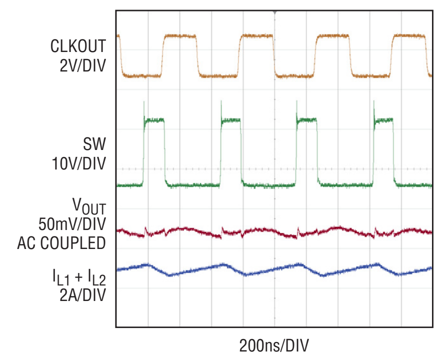


Figure 13. High operating frequency results in low output ripple, even at maximum load

useful for limiting the surge current when the input to the power supply is suddenly stepped from low voltage to normal. In a boost converter, there is a DC path from the input to the output capacitors of the circuit. Since these capacitors are initially discharged, large surge currents are possible if this feature is not used.

Figure 8 shows a circuit designed to handle all these potentially dangerous conditions. Figure 9 shows the operating waveforms during a hot plug event, Figure 10 shows the waveforms during a negative V_{IN} transient, and Figure 11 shows the result of a V_{IN} overvoltage transient. The LT3579/LT3581 survives all these fault conditions and when the fault is removed, resumes a normal start-up cycle.

HIGH POWER AND HIGH SPEED

The combination of high current capability and high switching frequency make the LT3579/LT3581 useful in a wide range of applications. Not only can the parts be set for an internal oscillator frequency between 200kHz and 2.5MHz, but the parts can synchronize to an external clock. The CLKOUT pin on the parts is designed to drive the SYNC pins of other switching regulators. The LT3579 and LT3581 also encode die temperature information into the duty cycle of the CLKOUT signal, making thermal measurements simple.

Figure 12 shows a 2MHz, 5V input to –12V output inverting converter with 625mA of output current capability using the LT3581. Due to the high switching frequency, external components are small. The amount of output ripple is also very low, as shown in Figure 13. Figure 14 shows a 2.8V to 4.2V input to 5V output boost running at 2MHz using the LT3579. This circuit is configured to survive output overloads and can deliver up to 2A of output current.

USE THE LT3579-1 FOR EVEN MORE POWER AND SPEED

The LT3579-1 is nearly identical to the LT3579 with one exception: the CLKOUT pin has a 50% duty cycle that does not vary

Figure 14. Li-ion battery to 5V output boost running at 2MHz can deliver 2A of output current.

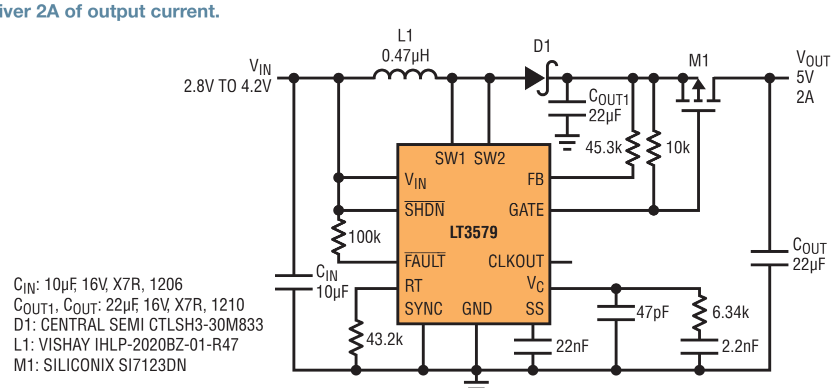
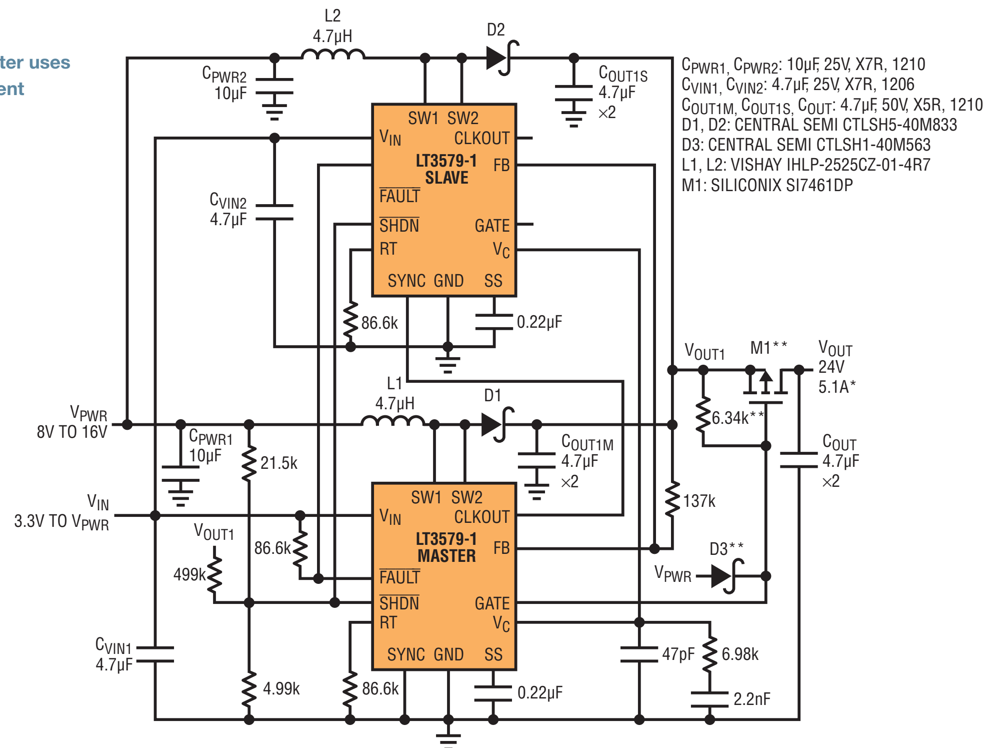


Figure 15. Dual phase 8V–16V input to 24V boost converter uses two LT3579-1s and can deliver up to 5.1A of output current



***MAX OUTPUT CURRENT**

	V_{PWR} = 8V	V_{PWR} = 12V	V_{PWR} = 16V
V_{IN} = 3.3V TO 5V	2.4A	3.7A	5.1A
V_{IN} = V_{PWR}	2.2A	3.1A	3.9A

**OPTIONAL FOR OUTPUT SHORT CIRCUIT PROTECTION

with die temperature and is 180° out of phase with its own internal clock whether the part free runs or is synchronized. This difference allows for the construction of a dual phase converter in the boost, SEPIC, or inverting configurations.

A major benefit of out-of-phase operation is an inherent reduction in input and output ripple. Figure 15 shows an 8V–16V input to 24V output dual-phase boost converter capable of delivering up to 5.1A of output current. Each part operates at 1MHz, but because the outputs operate out of phase the effective switching frequency of the converter is 2MHz. Figure 16 shows the output ripple at maximum load, Figure 17 shows the transient load response, and Figure 18 shows the efficiency. This circuit features output short circuit protection, which is easily removed if not needed.

MASTER AND SLAVE SWITCHES

Both the LT3579 and LT3581 have a novel master/slave switch configuration. To implement current mode control, the master switch (SW1 pin) has a current comparator to monitor the current. The slave switch (SW2 pin) has no current comparator and simply operates in phase with the master. For most applications, simply tie SW1 and SW2 pins together to get a 6A or 3.3A total current limit for the LT3579 and LT3581, respectively. Since it may be desirable in some situations to have a lower current limit with an easy way to upgrade to a higher current in the future, these parts can operate using only the master switch. To do this, simply float the slave switch pins. As a result, the LT3579 becomes a 3.4A part and the LT3581 becomes a 1.9A part.

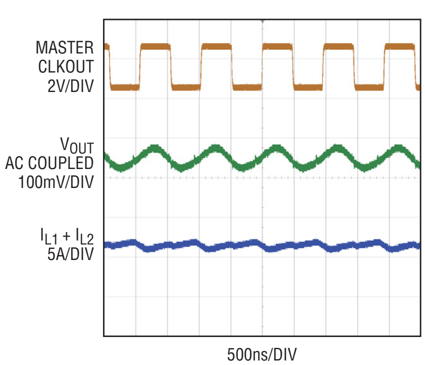


Figure 16. Output ripple at maximum load for the dual phase circuit shown in Figure 15

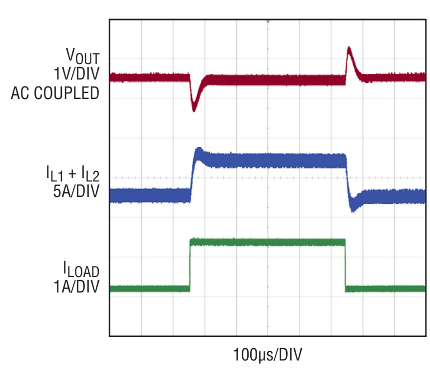


Figure 17. Transient load response for the dual phase circuit shown in Figure 15

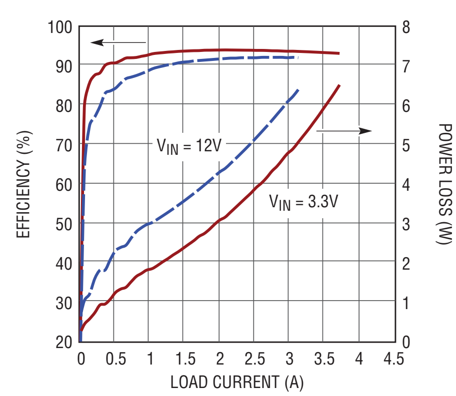


Figure 18. Converter efficiency reaches 93% for the dual phase circuit shown in Figure 15

The master/slave architecture provides a clear advantage when creating high voltage charge pump circuits. It is common practice to create high voltage rails by building a boost converter and adding charge pump stages to double or even triple the boost converter's output voltage.

At higher power levels, it becomes necessary to dampen the current spikes inherent in these charge pump circuits. Figure 19 shows a traditional approach, which uses high power resistors within the charge pumps. Without these resistors, the current spikes would cause the switching regulator to false trip, causing erratic and unstable operation. The problem is that these resistors add to the component count and generate additional heat.

Figure 20 shows a better solution in which the master/slave switch configuration eliminates the need for the high power resistors. All current spikes caused by the charge pump stages are only seen by the slave switch, eliminating the possibility of false tripping.

BEST IN CLASS SPECIFICATIONS

With so many new features, it is easy to overlook that the LT3579 and LT3581 include all the standard features available in many modern Linear Technology switching regulators. Both parts feature a wide input operating voltage range. The LT3579 can operate from 2.5V to 16V and survive transients to 40V. The LT3581 can operate from 2.5V to 22V with transients to 40V. Both parts have built-in programmable soft-start and automatic frequency foldback. Single pin feedback enables both positive and negative output voltages. Each part has an accurate comparator/reference for the $\overline{\text{SHDN}}$ pin, allowing the pin to be used as a programmable undervoltage lockout.

CONCLUSION

Packed with the latest features and some of the highest power levels of any monolithic converter in the industry, the LT3579 and LT3581 venture into applications once reserved for controllers. Monolithic converters can operate at clock speeds far beyond the ability of controllers, resulting in solution sizes unachievable by controller solutions. Advanced fault protection features make it possible to produce compact and rugged solutions without additional ICs.

A new master and slave switch architecture not only allows adjustment of the current limit but also significantly eases the design of high voltage boost plus charge pump circuits. These new features are simple to implement, yet stay out the way if not required. The LT3579, with a 6A, 42V switch comes in a 4mm × 5mm QFN or 20-lead TSSOP package. The LT3581, with a 3.3A, 42V switch comes in a 3mm × 4mm DFN or 16-lead MSE package. ■

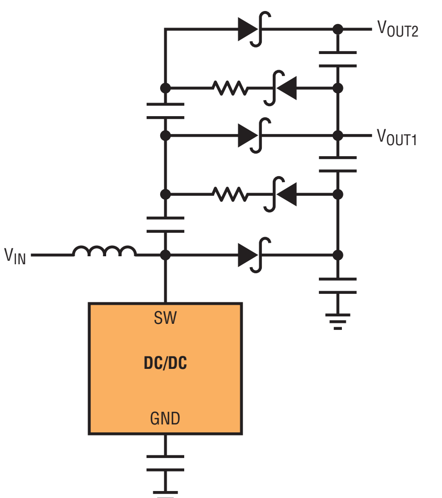


Figure 19. Traditional method for building high power boost plus charge pump circuits

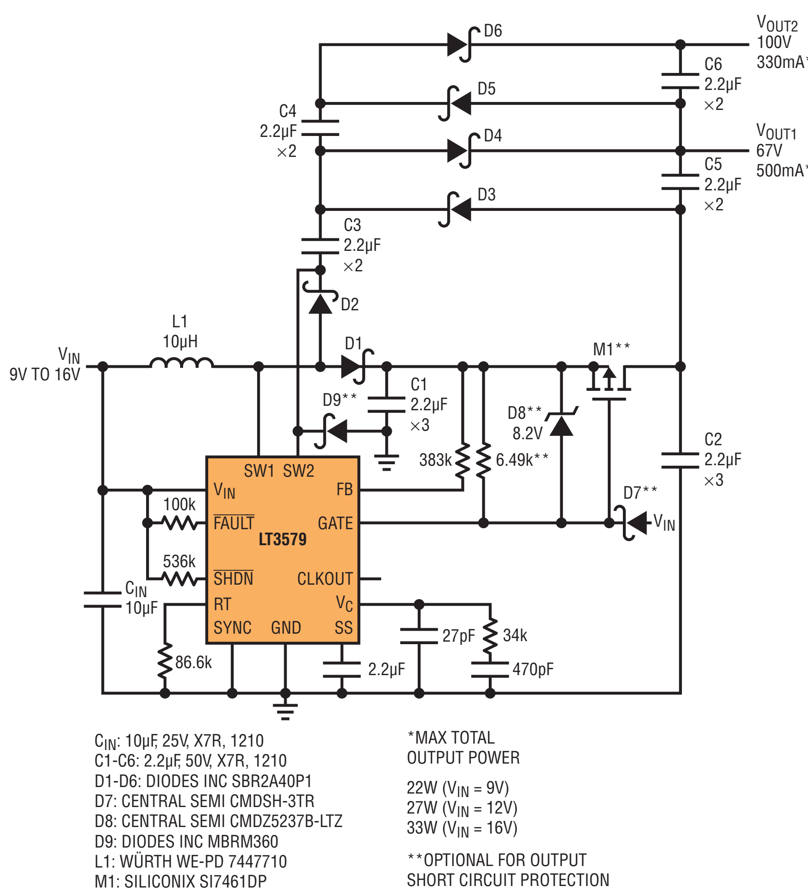


Figure 20. Master and slave switches of the LT3579/LT3581 allow a cooler running, simpler method for building boost plus charge pump circuits.