

DESIGN NOTES

Simple Circuit Replaces and Improves on Power Modules at Less Than Half the Price – Design Note 347

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Introduction

Prefabricated power modules offer a simple but expensive solution to the complicated problem of efficiently converting high distribution voltages to the isolated low voltages required by digital ICs. Build-your-own solutions are much cheaper, but time constraints may drive even seasoned power supply designers to the power module shelf. The LT[®]1952 changes that. It simplifies the design of a high performance synchronous single switch forward converter enough to make it a feasible and straightforward cost-cutting alternative to a power module.

A synchronous forward converter is a good choice for output voltages in the 1.2V to 26V range. In the forward converter family, among the several topologies that can achieve high efficiency, the single-switch topology is the

most cost effective. It requires the least number of power MOSFETs and associated components. Until now, though, the single-switch forward converter required very complex PWM control circuitry, relegating it to the realm of power module makers.

In order for a single switch circuit to operate reliably, the PWM controller must provide soft-start, overcurrent protection and a volt-second clamp that ensures transformer core reset. Furthermore, the PWM controller must provide proper timing control for synchronous output rectification. The LT1952 PWM controller provides all of these functions and allows them to be adjusted for optimal performance. Additional adjustable features include undervoltage lockout (UVLO), leading edge blanking, current slope compensation and hysteretic start-up.

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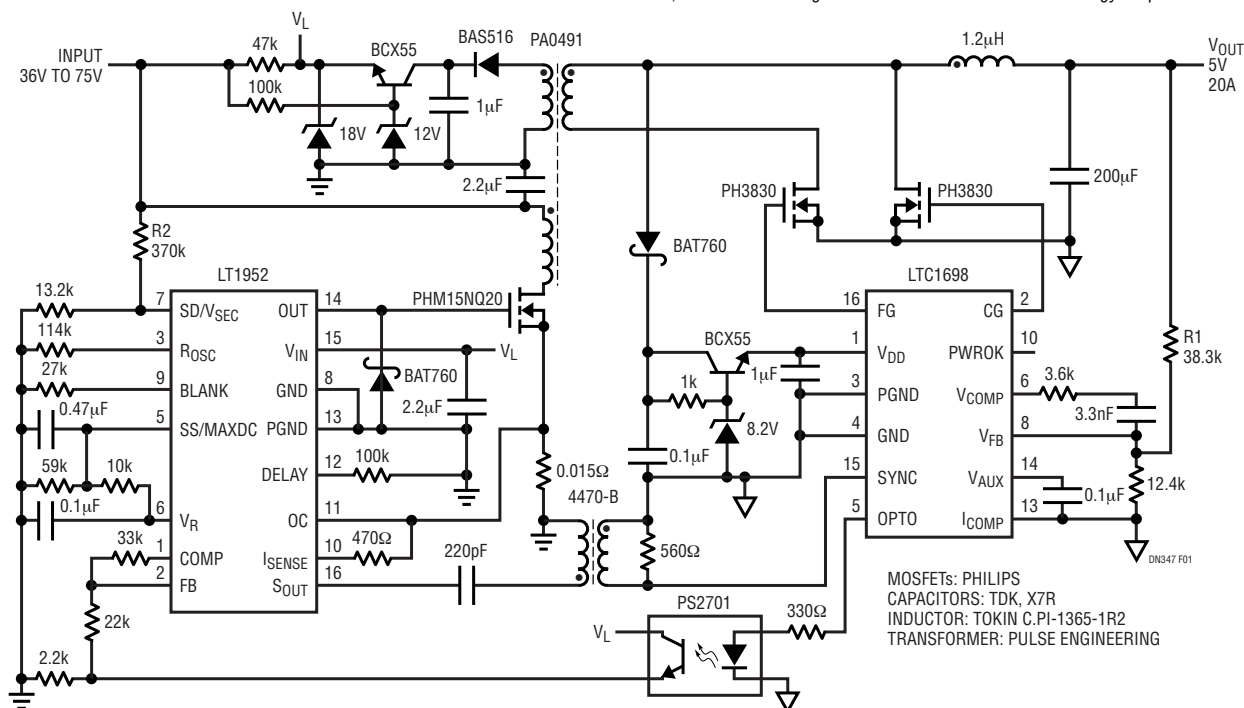


Figure 1. High Performance 100W Forward Converter Replaces Power Modules at a Fraction of the Cost. This Circuit is Easy to Modify for any Output Voltage from 1.2V to 26V

Perhaps the most important feature of the LT1952 controller is the programmable *adaptive* volt-second clamp. This function alone makes the LT1952 the easiest way to create a single switch forward converter. Single switch forward converters require a period of time when the primary MOSFET is turned off in order to reset the magnetic field inside the power transformer. Insufficient MOSFET off-time can saturate the transformer and lead to MOSFET failure. The LT1952 ensures that there is a sufficient amount of off-time for the transformer to reset under all input voltage conditions. This significantly reduces circuit size and cost as the transformer and MOSFET need not be over-sized, as would be required without the *adaptive* volt-second clamp.

Some PWM controllers provide a fixed maximum duty cycle clamp for transformer reset. This method does not account for the increased energy left in the transformer at high input voltages during transients. Therefore, a fixed duty cycle clamp requires a larger, and more expensive transformer to be used in order to withstand the higher volt-second product at high input voltage, during transients. Furthermore, higher voltage MOSFETs have to be used in order to provide the appropriate reset voltage at high input voltage.

100W Isolated Synchronous Forward Converter in an Eighth Brick Footprint

Figure 1 shows an example of a synchronous forward converter based on the LT1952. The converter in Figure 1 generates an isolated 5V, 20A output with a single set of power MOSFETs. Despite the simplicity of this circuit, performance is superior to most modules. Thanks to synchronous rectification and proper synchronous MOSFET timing, the efficiency is up to 93% (at 20A) and 95% (at 12A) as shown in Figure 2.

The converter in Figure 1 operates at 300kHz, utilizes only off-the shelf components, fits into an eighth brick footprint area and has a bill of materials cost which is less than half of an equivalent power module.

Due to current mode operation, a fast feedback loop, and programmable current slope compensation, the converter uses ceramic output capacitors to achieve excellent transient response characteristics while requiring the smallest amount of output capacitance. Ceramic capacitors also ensure high reliability.

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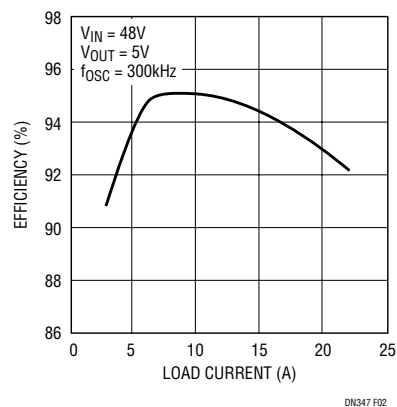


Figure 2. Efficiency is Very High for the Circuit in Figure 1

This Circuit is Flexible

The circuit in Figure 1 can be easily modified to fit a wide range of applications. For example, to change the output to 3.3V at 20A, simply change R1 to 21.5k. If higher current is required, add more MOSFETs in parallel and use a bigger transformer and output inductor. If lower power is required, smaller power components can be used. For lower input voltages use a lower voltage primary MOSFET, lower current sense resistor value, proportionally reduce the transformer turns ratio and lower the value of R2. Conversely, for higher input voltages, increase these values.

This circuit can also be modified to make a 12V, 20A bus converter. The accurate volt-second clamp of the LT1952 allows it to produce a more tightly regulated output over a wider input range than other bus converters. The LT1952 can regulate a 2:1 input voltage range to less than 10% regulation at the output. Because of the volt-second clamp, the opto-coupler can be removed, and the LTC1698 circuit in Figure 1 can be replaced with a smaller LTC3900 circuit. The performance of the 12V bus converter is excellent with full overcurrent protection, gentle soft-start and efficiencies over 95%.

Conclusion

The LT1952 provides improved performance and makes it possible to replace expensive power modules at a fraction of the cost. It offers a simple, scalable high performance solution that reduces the amount of power converter design experience required to produce a reliable power supply.

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