

DESIGN NOTES

ThinSOT Micropower Buck Regulator Has Low Output Ripple

Design Note 373

Keith Szolusha

Introduction

High voltage monolithic step-down converters simplify circuit design and save space by integrating the high-side power switch into the device. In most cases, the switch is an n-type transistor (NMOS or NPN) with a boot-strapped drive stage, requiring an external boost diode and capacitor as well as the main catch diode, complicating the applications circuit.

The LT[®]3470 is a 40V step-down converter with the power switch, catch diode and boost diode integrated in a tiny ThinSOT[™] package. The boosted NPN power stage provides high voltage capability, high power density and high switching speed without the cost and space of external diodes.

The LT3470 accepts an input voltage from 4V to 40V and delivers up to 200mA to load. Micropower bias current and Burst Mode[®] operation enable it to consume merely 26 μ A with no load and a 12V input. Hysteretic current mode control and single-cycle bursts result in very low output ripple and stable operation with small ceramic capacitors. The combination of small circuit size, low quiescent current and 40V input makes the LT3470 ideal for automotive and industrial applications.

Current Mode Control

The LT3470 uses a hysteretic current control scheme in conjunction with Burst Mode operation to provide low output ripple and low quiescent current while using a tiny inductor and ceramic capacitors. The switch turns on until the current ramps up to the level of the top current comparator, then turns off and the inductor current ramps down through the catch diode until the bottom current comparator trips and the minimum off-time has been met.

In continuous mode, the difference between the top and bottom current comparator levels is about 150mA. Since the switch only turns on when the catch diode current falls below threshold, switching frequency decreases, keeping switch current under control during start-up or short-circuit conditions.

If the load is light, the IC alternates between micropower and switching states to keep the output in regulation (Figure 3a). Hysteretic mode allows the IC to provide single switch-cycle bursts for the lowest possible light-load output voltage ripple (<20mV peak-to-peak from 12V to 3.3V at zero load.) During continuous switching mode (Figure 3b) at higher current levels, the output voltage ripple is even smaller (<10mV peak-to-peak).

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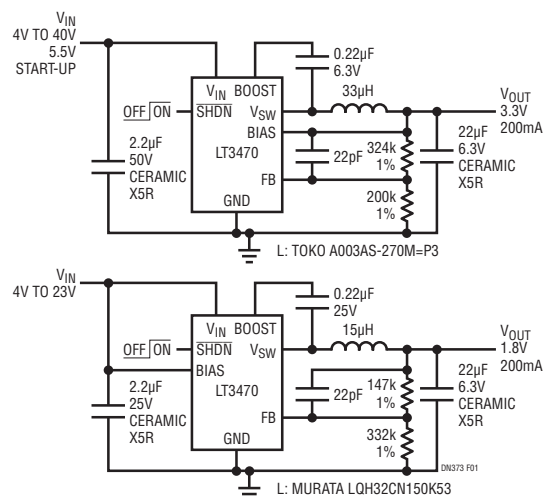


Figure 1. Typical 3.3V and 1.8V Output Applications

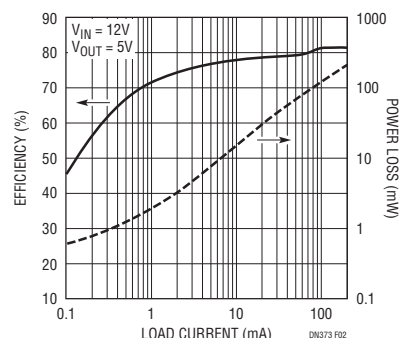


Figure 2. Efficiency and Power Loss vs Load Current

Design Flexibility with Integrated Boost Diode

A high side NPN power switch in a buck regulator design needs a driver voltage that is at least a few volts higher than the switch or input voltage. When there are no other high voltage lines available, a bootstrapping method of providing several volts of boost to the IC is required. When there is at least 2.5V on the output, the boost voltage can be most efficiently derived from the output. If the output voltage is too low, 1.8V for example, the boost voltage must be derived from the input.

Integration of the high side bootstrapping boost diode into the IC does not limit boost diode flexibility. Boost diode flexibility such as the ability to connect to various sources and/or the inclusion of a Zener blocking diode is needed for both high and low output voltages with and without wide input voltage ranges. The anode of the boost diode can be connected to different sources

via the BIAS pin. In most cases, this is a simple connection to either the input, when the output voltage is below 2.5V, or the output, for output voltages above 2.5V. Additional Zener diode voltage drop in the boost diode path or a transistor bias supply as shown in Figure 4 protects the IC from BOOST pin overvoltage when there is a wide input voltage range.

Conclusion

The LT3470 is a wide input voltage range, hysteretic mode, fully integrated monolithic 300mA step-down DC/DC converter. The onboard high side NPN power switch, Schottky boost diode, and Schottky catch diode combined with the small ThinSOT package and high 40V input voltage make this a simple and versatile IC to use for many step-down applications with less than 200mA load current.

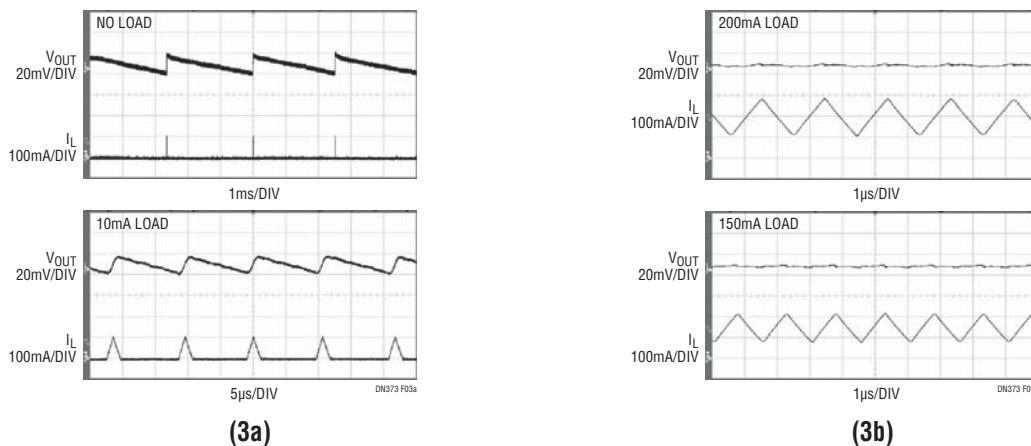


Figure 3. (3a) Burst Mode Operation—Single Pulse Burst Mode Operation Has Only 20mV_{p-p} Ripple. (3b) Continuous Operation—Extremely Low Output Voltage Ripple

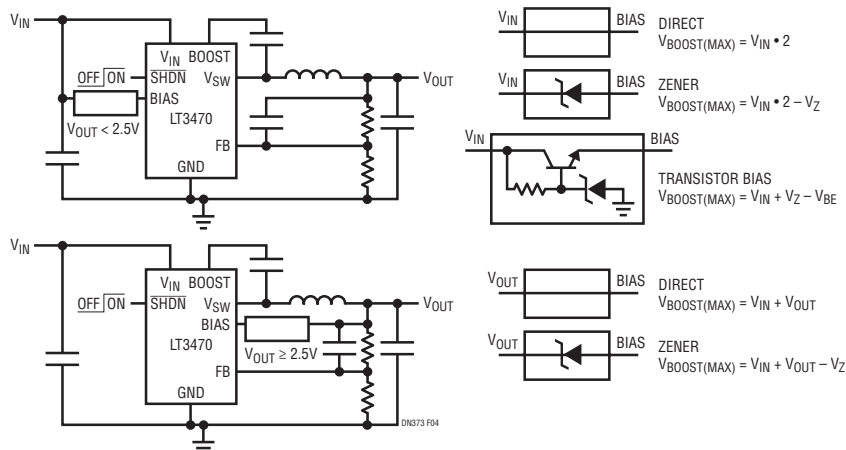


Figure 4. BIAS and BOOST Pin Connection Variations Provide Input and Output Voltage Range Flexibility

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