LT1619 Boost Controller Provides Efficient Solutions for Low Voltage Inputs

by Bing Fong Ma and Kurk Mathews

Introduction

As logic voltages continue to fall, it is increasingly common to find a high current, low voltage (3.3V or less) supply satisfying a large portion of a circuit's power requirement. While this, in itself, is not a problem, generating subsequent voltages at even moderate currents from such a low voltage source can be challenging. Selecting a topology such as the boost, SEPIC or flyback converter is the easy part. Unfortunately, finding a switching regulator controller or MOSFET that works well at low voltages has been difficult until now.

The new LT1619 provides a complete solution for low voltage and other applications requiring low-side MOS power transistors. The LT1619 is a 300kHz (externally synchronizable to frequencies as high as 500kHz) current mode PWM controller capable of operating from inputs ranging from 1.9V to 18V. Its features include a rail-to-rail 1A MOSFET driver capable of driving an external MOSFET gate to within 350mV of the supply rail and to within 100mV of ground. A separate driver supply pin (DRV) allows the gate voltage to be bootstrapped above the input voltage. A 50mV low-side current limit threshold reduces the sense resistor's power dissipation, further improving efficiency. At light loads, the controller automatically switches to Burst Mode™ operation to conserve power. In shutdown, the LT1619 requires only 15µA of quiescent current. The LT1619 is available in 8-lead SO and MSOP packages.

3.3V to 5V Converters

Figure 1 shows a 3.3V to 5V/2.2A boost supply using the LT1619. Low parts count, small size and high efficiency make it a perfect solution when a moderate amount of 5V power is required in a predominately 3.3V system. The output voltage is returned to the DRV pin, further enhancing M1.

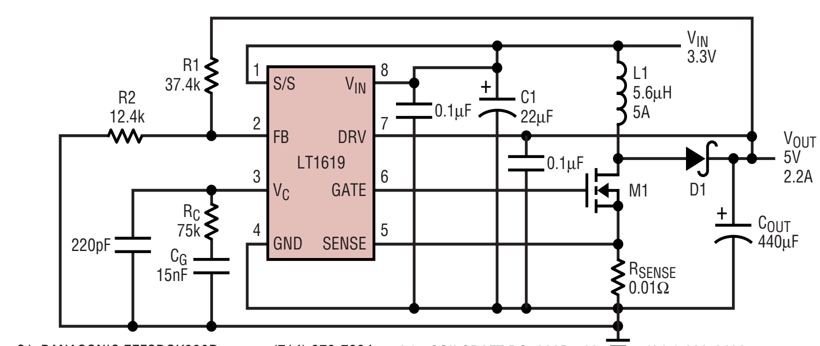
In Figure 2, the same basic circuit's output is increased to 40W (5V/8A) by substituting higher current components. The highlighted loop is kept tight on the PC board to reduce switching transients produced by high pulsating currents. Efficiency remains above 86% for output currents between 0.1A and 5A (83% at 8A). The LT1619 operates smoothly by not entering current limit with 16A peak current through the 0.002Ω sense resistor. The gate charging current tends to produce spikes across the sense resistor at switch turn-on. The internal current sense amplifier is blanked for 280ns to prevent these spurious switching spikes from causing PWM jitter. Although this blanking sets a minimum switch on-time, the controller is capable of skipping cycles at light load with Burst Mode operation disabled. In situations where the internal leading-edge blanking is not long enough, a lowpass filter can be used on SENSE pin to further suppress switching transients caused by diode reverse recovery or parasitic circuit elements.

Choosing the MOSFET

The LT1619 is designed to drive an N-channel MOSFET with up to 60nC of total gate charge (Q_g). Significant advances have been made in low voltage (<30V) power MOSFETs recently. 30mΩ, low voltage, low threshold FETs with less than 60nC of gate charge are readily available. Besides meeting voltage, current, gate drive and $R_{DS(ON)}$ requirements, choosing a transistor with Q_g < 60nC will allow direct gate drive from the controller, resulting in a simpler and lower cost design. For transistors with Q_g between 60nC and 80nC, first try driving the transistor from the controller before using an external driver. An external driver is recommended for MOSFETs with higher than 80nC of total gate charge.

5V to –48V Supply

The LT1619 is not limited to low output voltage supplies. As the demand for networking equipment grows, the need arises for a –48V supply capable of powering telecommunication lines.



C1: PANASONIC EEFCDOK220R (714) 373-7334
C_{OUT}: KEMET T495X227K010AS × 2 (408) 986-0424
D1: ON SEMICONDUCTOR MBRD835L (602) 244-6600
L1: COILCRAFT DO5022P-562 (847) 639-6400
M1: SILICONIX Si9804 (800) 554-5565

Figure 1. High efficiency 3.3V to 5V DC/DC converter

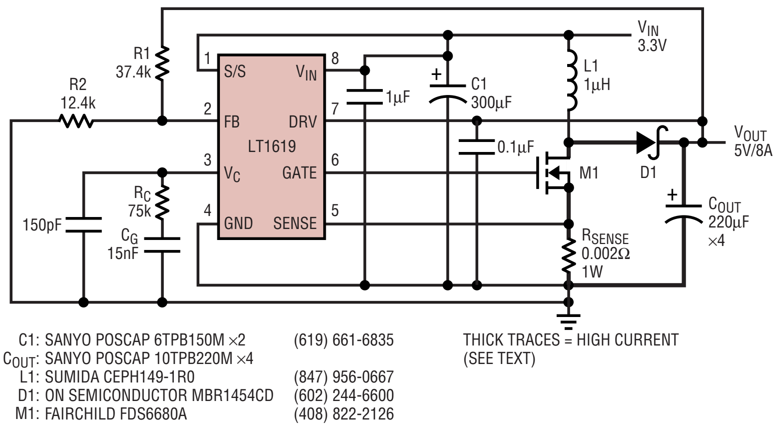


Figure 2. 3.3V to 5V/8A DC/DC converter

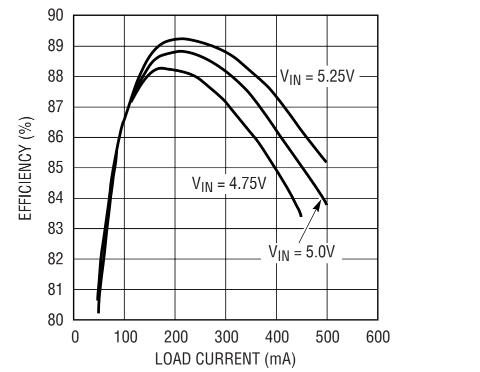


Figure 4. Efficiency of Figure 3's circuit

The circuit shown in Figure 3 is capable of delivering 24 watts at –48V from a 5V input. Although high current 5V sources are commonly available in many systems, lower input voltages generally mean higher input currents and lower efficiency. Fortunately, with a relatively simple topology and a 5V input, the circuit shown achieves well over 80% efficiency (see Figure 4).

T1 stores energy during the on-time of Q1, which is transferred to two stacked 24V outputs to make –48V. C6 charges to a DC value equal to 29V (V_{IN} + 24V), clamping T1's leakage inductance spike and providing a path for input current during Q1's off time. This results in continuous input current, reducing capacitor ripple current requirements. Reduced input ripple current (characteristic of this topology) demands sensing of switch current instead of input current. A number of other features improve the efficiency and performance of the circuit.

D3 and R9 provide undervoltage lockout. Q2 and Q3 translate the –48V output to 1.2V required by the feedback pin (V_{FB}) to regulate output voltage. The LT1619's fixed frequency, current mode operation with internal slope compensation permits high duty cycle operation required in this application.

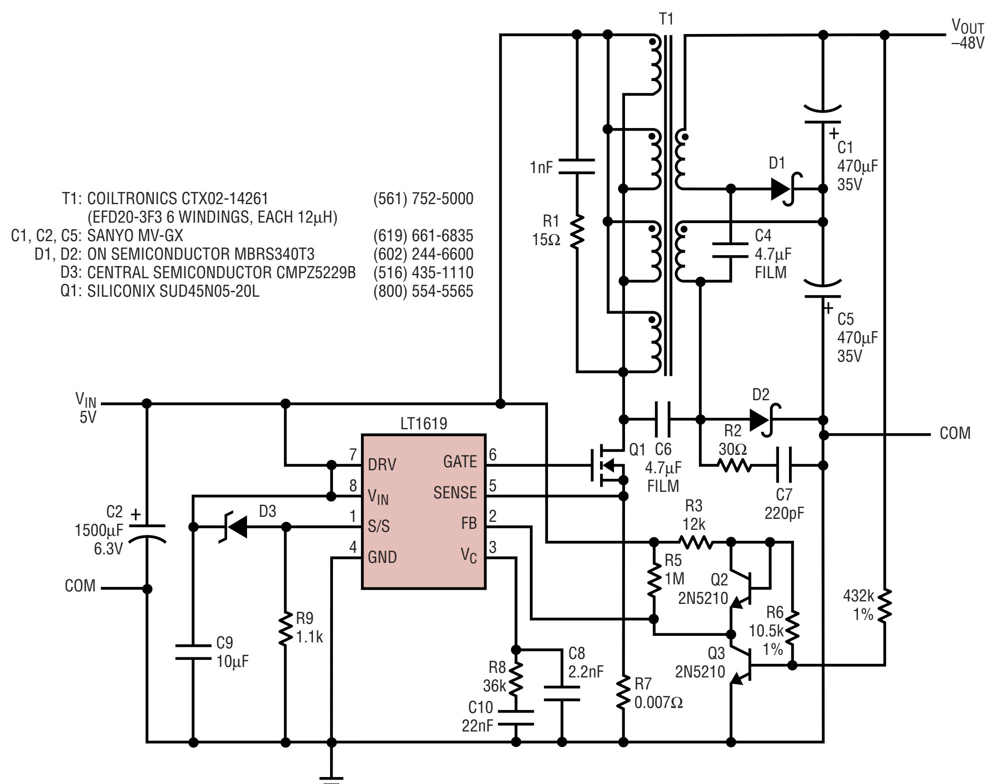


Figure 3. 24W, 4.75V to 5.25V in, –48V/5A out supply

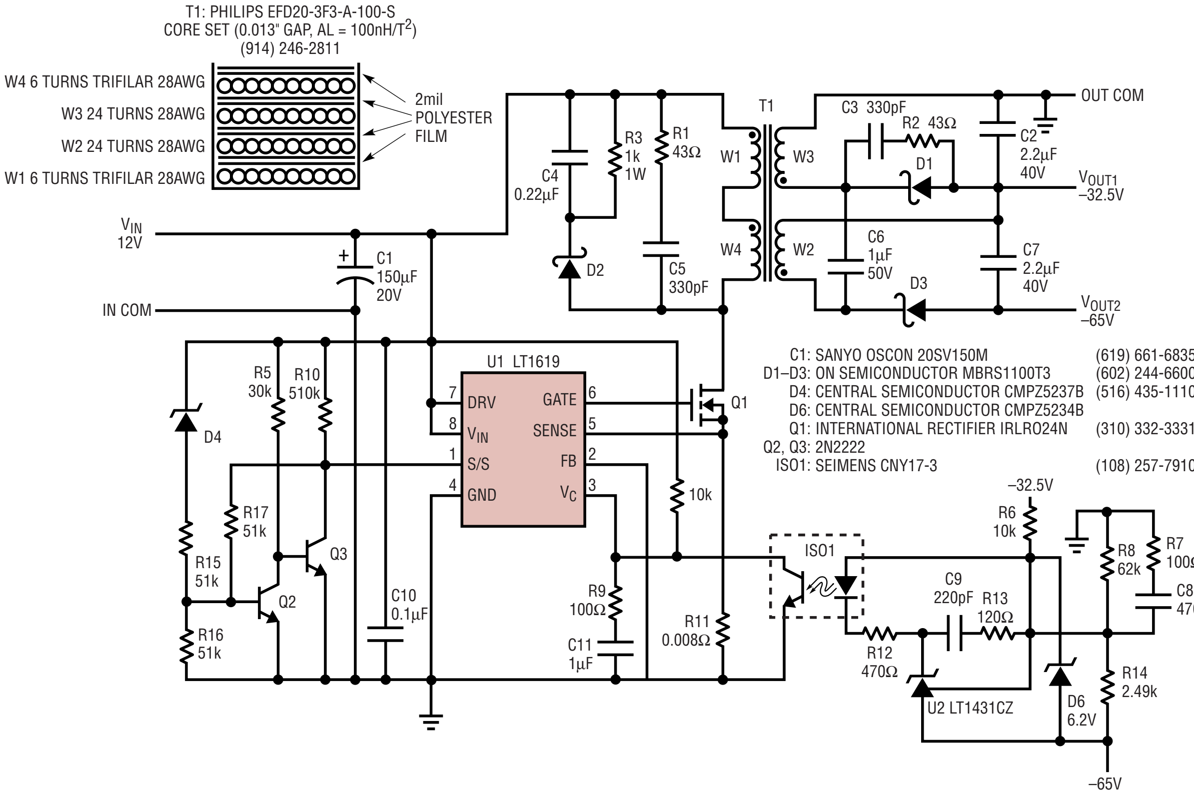


Figure 5. Isolated SLIC flyback supply; V_{IN} = 12V; V_{OUT} = –32V and –65V (20W maximum)

–32V and –65V Isolated Local SLIC Supply with UVLO

Subscriber line interface circuit (SLIC) devices are used to provide telephone interface functions; they require negative power supplies for interface and ringing. Figure 5 satisfies these requirements by providing isolated –32.5V and –65V supplies from a 12V source.

The supply is configured as a flyback converter. T1's secondary turns ratio is 1:1. U2, ISO1 and associated circuitry provide feedback to U1, maintaining 32.5V across each secondary winding. The two secondaries are stacked to provide –65V. C6 is added to improve cross-regulation, even when most of the power is drawn from one winding. An additional benefit of the stacked windings is a lower voltage stress on output diodes and capacitors. Other output voltages can be realized by adjusting T1 and the feedback components.

The value of primary current sense resistor, R11, is chosen to provide approximately 20 watts out with a 12V input. Power can be drawn from the –32.5V or –65V winding as required by the SLIC. Full load efficiency is 82%

D4, R5, R10, R15–R17, Q2 and Q3 provide undervoltage lockout to ensure adequate gate voltage to Q1. The LT1619 has an internal undervoltage lockout (UVLO) threshold of 1.85V. Although the threshold is ideal for low voltage boost converters, it is too low when operating from a higher voltage power source. The shutdown/synchronization pin (S/S) is used to modify the UVLO threshold. Shutdown is active low and, for normal operation, the S/S pin is tied to the input. The hysteretic UVLO circuit in Figure 5 has thresholds of 10V and 8.4V and operates on supply voltages as low as 0.9V. With V_{IN} rising but below the upper threshold, Q2 is off and Q3 saturates. The S/S pin is pulled to the ground and the controller is shut off. As V_{IN} crosses the upper threshold, Q2 turns on, Q3 turns off and the controller starts switching. The lower threshold is the V_{IN} voltage that causes Q2 to switch off. Resistors R15–R17 and the Zener diode set the trip voltages. The collector voltage of Q3 is made 1.4V (above the maximum shutdown threshold at the S/S pin) at the lower UVLO threshold.

With the addition of a capacitor on the V_{IN} pin and a resistor in the path between the V_{IN} pin and the input voltage, trickle-start from high voltage input sources (such as a 36V–72V telecom bus) is accommodated with the same basic circuit shown in Figure 5.

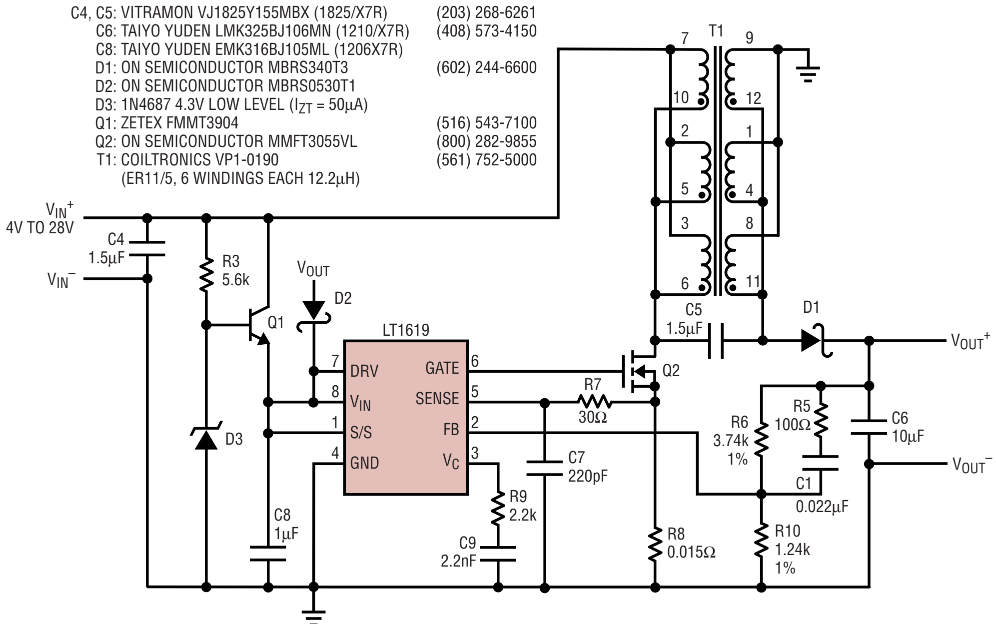


Figure 6. 2.5W, 4V to 28V in, 5V/0.5A out supply

12V to 5V Automotive Supply

Figure 6 show a 5V, 0.5A SEPIC (single-ended primary inductance converter) supply designed to operate from a 12V battery. Once started, D2 provides voltage to the LT1619 and Q2, allowing the input voltage to drop as low as 4V. Q1 and D3 limit the start-up voltage to the LT1619 and, along with Q2 (60V), allow operation to 28V. C5 provides a path for continuous input current and directs T1's leakage energy to the output. The result is increased efficiency and reduced input capacitor ripple current requirements. The LT1619's 300kHz operating frequency allows for smaller magnetics (T1 is approximately 0.5in^2) and smaller capacitors.

Modifying Burst Mode Operation

In some applications, the high output ripple voltage or audible noise of Burst Mode operation is undesirable. Due to the unique design of the current sense amplifier, the LT1619 can be easily modified so that it does not burst at light load. In Figure 7, the input bias current of the current-sense amplifier is used to develop an offset voltage across an external resistor, R_{OS}. This offset voltage makes the switch current appear higher to the sense amplifier, with the effect that the V_C operating range is shifted upwards. The peak switch current before entering Burst Mode operation is greatly reduced.

Conclusion

The LT1619 solves many of the problems associated with low input voltage source DC to DC converters. Its numerous features make it an ideal choice for a wide range of applications requiring low-side MOS power transistors.

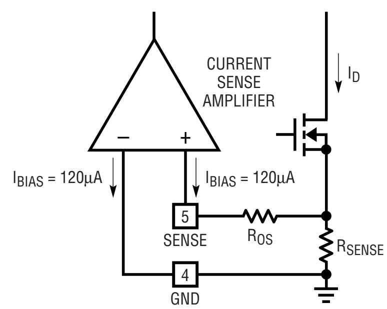


Figure 7. Lowering Burst Mode operation current limit

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