Linear Technology

DESIGN NOTES

LTC1702/LTC1703 Switching Regulator Controllers Set a New Standard for Transient Response – Design Note 206

Dave Dwelley

The LTC®1702 is the first in a new family of low voltage, high speed switching regulator controllers. It is designed to operate from a standard 5V logic supply and generate two lower voltage, high current regulated outputs. Running at a fixed 550kHz switching frequency, each side of the LTC1702 features a voltage feedback architecture with a 25MHz gain-bandwidth op amp as the feedback amplifier, allowing loop crossover frequencies in excess of 50kHz. Powerful onboard MOSFET drivers allow the LTC1702 to drive large, high current external MOSFETs efficiently at 550kHz. The high feedback loop bandwidth maintains excellent transient response, and the high switching frequency allows the use of small external inductors and capacitors even as load currents rise beyond 10A. The dual output LTC1702 is packaged in a space-saving 24-pin narrow SSOP.

Mobile PCs using the most recent Intel Pentium® III processors require LTC1702-level performance coupled with a DAC-controlled voltage at the core supply output. The LTC1703 is designed specifically for this application, and consists of a modified LTC1702 with an internal 5-bit DAC controlling the output voltage on side 1. The DAC conforms to the Intel Mobile VID specifications.

The LTC1702/LTC1703 each consist of two independent switching regulator controllers in one package. Each controller is designed to be wired as a voltage feedback, synchronous step-down regulator, using two external N-channel MOSFETs per side as power switches (Figure 2). A small external charge pump (D_{CP} and C_{CP} in Figure 2) provides a boosted supply voltage to keep Q1 fully turned on. The switching frequency is set internally at 550kHz. A user-programmable current limit circuit uses the synchronous MOSFET switch, Q2, as a current sensing element, eliminating the need for an external low value current sensing resistor.

Unlike conventional switching regulator designs, the LTC1702/LTC1703 use a true 25MHz gain-bandwidth op amp as the feedback amplifier. This allows the use of an OPTI-LOOP™ compensation scheme that can precisely

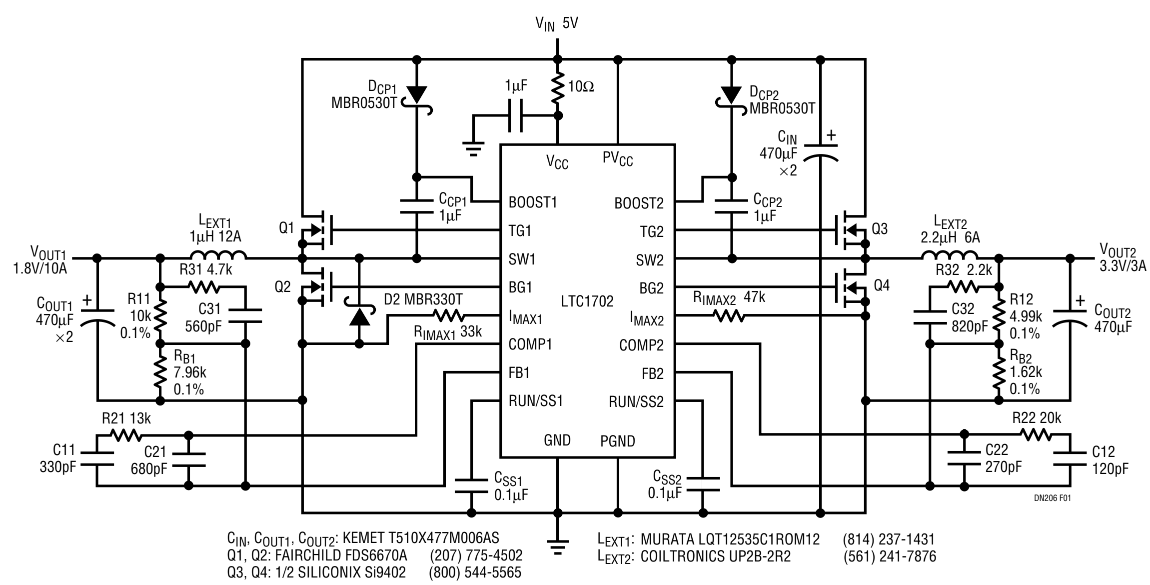

Figure 1. 28W Dual Output Power Supply

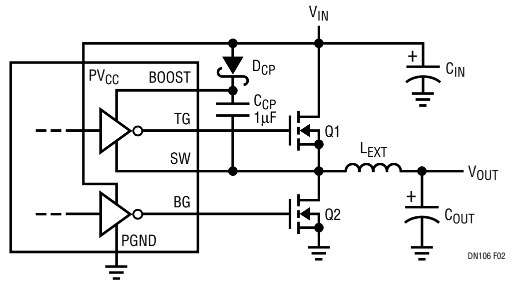

Figure 2. LTC1702/LTC1703 Switching Architecture

tailor the loop response. The high gain-bandwidth product allows the loop to be crossed over beyond 50kHz while maintaining good stability and significantly enhancing load transient response. Bias resistors, RB1 and RB2 (Figure 1) are used to set the DC output voltages along with two pole/zero pairs per side to compensate for phase shift caused by the inductor/output capacitor combinations.

Another feature of the LTC1702/LTC1703 reduces the required input capacitance with no performance penalty. The LTC1702/LTC1703 include a single master clock that drives the two sides such that side 1 is 180° out of phase with side 2. This technique, known as 2-phase switching, has the effect of doubling the frequency of the switching pulses seen by the input capacitor and significantly reduces their RMS value. With 2-phase switching, the input capacitor is sized as required to support the larger of the two sides at maximum load current. As the load increases on the lower current side, it tends to cancel, rather than add to, the RMS current seen by the input capacitor; thus no additional capacitance needs to be added.

The 550kHz clock frequency and the low 5V input voltage allow the use of external inductors in the 1μH range while keeping ripple current under control. The low inductance value helps in two ways: it reduces the energy stored in the inductor during each switching cycle, reducing the physical core size required, and it raises the attainable dI/dt at the output of the circuit, decreasing the time that it takes for the circuit to correct for sudden changes in load current. This, in turn, reduces the amount of output capacitance required to support the output voltage during a load transient. Together with the reduced capacitance at the input due to the LTC1702/LTC1703 2-phase internal switching significantly reduces the amount of total capacitance needed compared to a conventional design running at 300kHz or less.

Data Sheet Download

http://www.linear-tech.com/go/dnLTC1702

A typical LTC1702 application is shown in Figure 1. Input is taken from the 5V logic supply. Side 1 is set up to provide 1.8V at 10A, whereas side 2 is set to supply 3.3V at a lower 3A load level. System efficiency peaks at greater than 90% at each side. This circuit shows examples of both high power and lower power output designs possible with the LTC1702 controller. Side 1 uses a pair of ultralow $R_{DS(ON)}$ Fairchild SO-8 MOSFETs and a 1μH/12A Murata surface mount inductor. C_{IN} consists of two 470μF tantalum capacitors to support side 1 at full load, and C_{OUT1} uses two more 470μF devices to provide better than 3% regulation with 0A to 10A transients.

Side 2 uses a single SO-8 dual MOSFET and a smaller 2.2μH/6A inductor. C_{OUT2} is a single 470μF capacitor used to support 0A to 3A transients while maintaining better than 3% regulation. As the load current at side 2 increases, the LTC1702 2-phase switching actually reduces the RMS current in C_{IN}, removing the need for additional capacitance at the input beyond what side 1 requires. Both sides exhibit exceptional transient response (Figures 3, 4). The entire 28W converter can be laid out in less than 1.5 square inches.

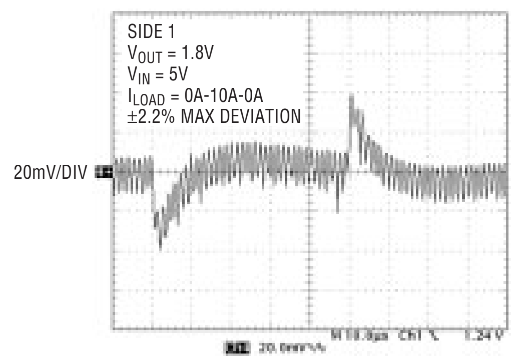

Figure 3. 0A to 10A Transient Response (Figure 1, Side 1)

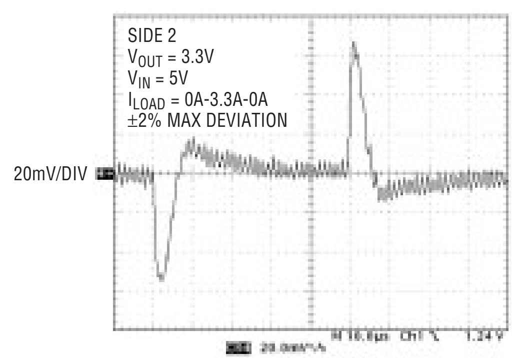

Figure 4. 0A to 3A Transient Response (Figure 1, Side 2)

For literature on our Switching Regulators, call **1-800-4-LINEAR**. For applications help, call (408) 432-1900, Ext. 2593

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408)432-1900 • FAX: (408) 434-0507 • www.linear-tech.com

dn206f LT/TP 0599 340K • PRINTED IN THE USA