3-Phase Buck Controller for Intel VRM9/VRM10 with Active Voltage Positioning

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Introduction

Each new generation of CPUs demands more from power supplies than the last: more power, tighter voltage regulation and faster transient response. Meeting all of the new requirements is a difficult proposition, but the LTC3738 helps power supply designers do just that. It is a 3-phase buck controller with active voltage positioning specifically designed for Intel VRM9 and VRM10 (Figure 1).

High Power and Thermal Management

The LTC3738 can easily work with the 3-phase LTC3731 to form a 6-phase (up to 12-phase interleaved) power supply to deliver more than 100A current to its load. For such high currents, proper thermal management is crucial. The current mode architecture of the LTC3738 evenly distributes the load, and thus thermal stress, across the channels. This improves the thermal performance and reliability of the entire power solution. The LTC3738 also includes a thermal detector that generates a VR_HOTB warning signal when chip itself gets hot (around 120°C) plus a self-protect thermal detector that shuts down the device when chip becomes extremely hot and endangers the safety of the power supply. The LTC3738 also has a comparator for external thermal detection. Power designers can put thermal detection resistors at the hottest spot on the board and let the LTC3738 send a VR_HOTB signal to the CPU when its thermal comparator trips.

Accurate Load Line Control

The tight load line window of the VRM9/VRM10 specification asks for accurate static and dynamic voltage control. The ±1% DC regulation accuracy and precise programmable active voltage positioning of LTC3738 helps power designers meet the load line window easily. The unique active voltage positioning solution of LTC3738 makes the load line slope control easy and accurate. The slope is programmed by the ratio of two external resistors. LTC3738 senses true load current including ripple current of all three channels and generates an accurate AVP control voltage. The precise regulation of the LTC3738 gives more range for output voltage ripple. Hence power designers can use smaller output capacitor values

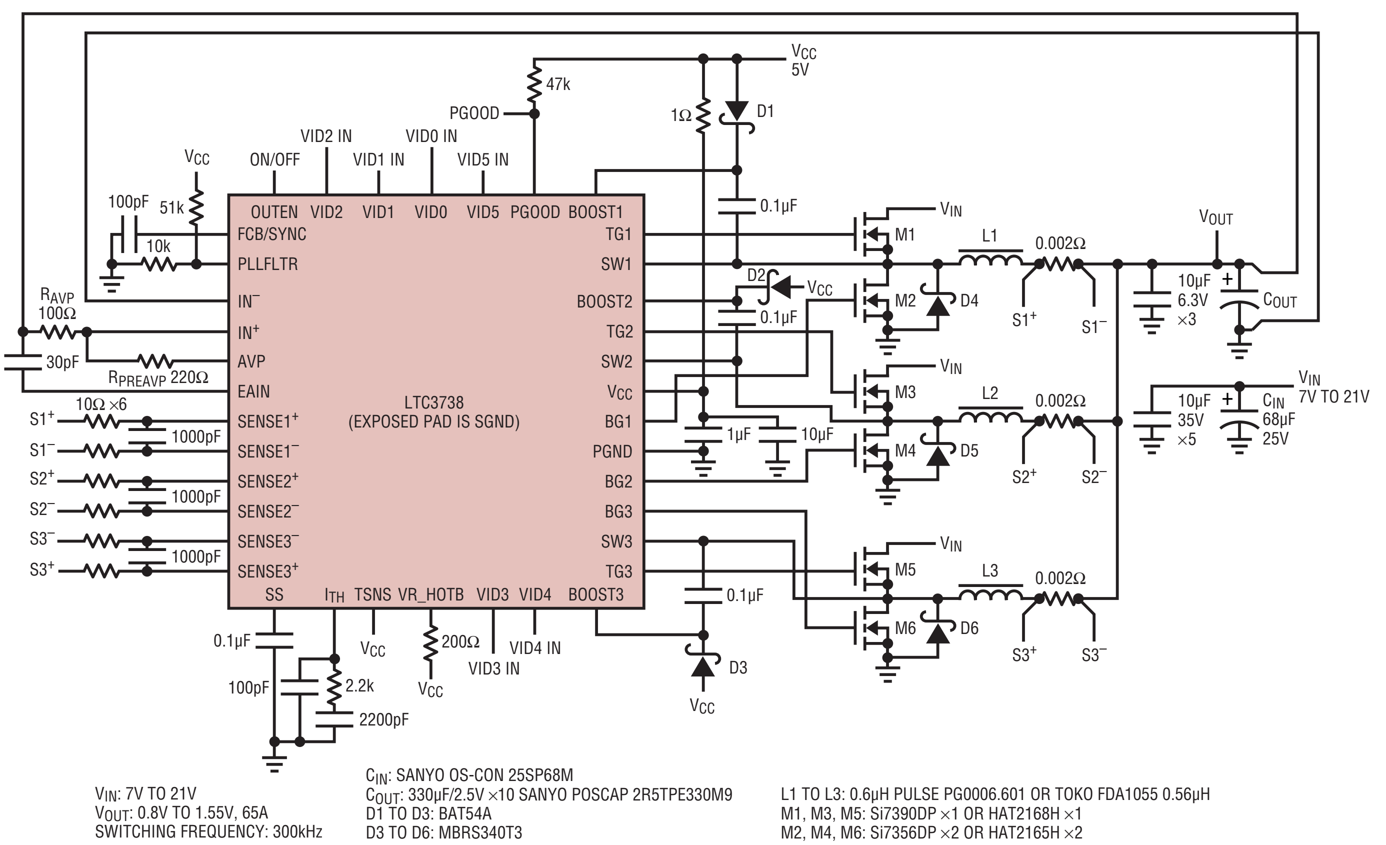

Figure 1. This 3-phase power supply manages the thermal problems inherent in high current Intel VRM10 applications.

and lower their total solution cost. Smaller output capacitor values also speed up the changing of the output voltage when the CPU generates a different VID code.

Other Features

The LTC3738 has a differential amplifier for remote sensing of both the high and low sides of the output voltage. There is no reverse current during start-up, which allows the LTC3738 to power up into a pre-biased output without sinking current from the output. The LTC3738 also has a defeatable short-circuit shutdown timer. Three operation modes—PWM, pulse skip and Stage Shedding™—allow power supply designers to optimize for efficiency and noise.

Conclusion

LTC3738 is specifically designed to simplify power supply designs for Intel VRM9/VRM10 applications. It is a complete power supply solution with essenntial thermal management features, accurate load line control, precise output voltage sensing, and comprehensive fault protection.

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from affecting the output by the inclusion of a pre-regulating Zener diode. With this extra input decoupling and the LT6650 circuitry operating from a 12V bus, 50V transients induce less than 0.5% V_{OUT} perturbation.

To obtain the micropower performance of the LT6650, quiescent currents of the internal circuitry are minute, which by nature, results in a higher output impedance than traditional references. Since output impedance is inversely related to the output stage operating current, a modest additional load current can easily reduce the output impedance by an order of magnitude from the unloaded case. Thus in applications where the output impedance and noise must be minimized, a light DC loading of the output provides enhanced performance. This loading can exist naturally in the application, or the feedback resistors can be designed to provide it. For example, setting the gain resistor value to 10kΩ establishes a moderate I_{OUT} = –40µA and decreases the output peak resistance value from hundreds of ohms to the tens of ohms shown in Figure 7.

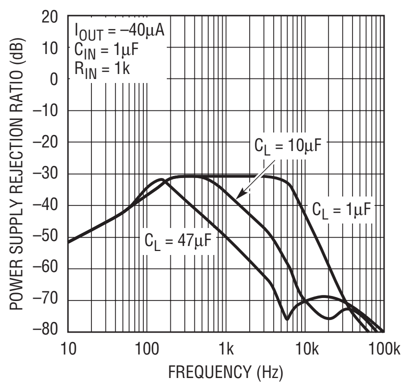

Figure 5. Improved supply noise rejection of Figure 4 reference circuit

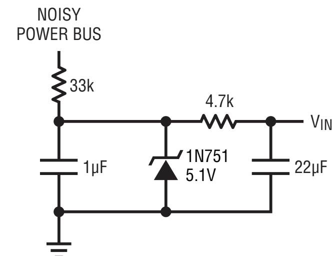

Figure 6. High noise-immunity input network allows 50V transients on automotive power bus.

Shunt-Mode Reference

When the output voltage is tied to the input voltage, the high side of the rail-to-rail buffer amplifier is effectively disabled and only the low side remains active. In this mode of operation the LT6650 operates as a shunt reference as shown in Figure 8. Any shunt reference voltage from ±1.4V up to ±18V can be established by the feedback resistor selection. The noise and load capacitors have the same functions as in the series mode of operation. A 10µF minimum load capacitance is recommended for best stability and transient response. In shunt mode, an external biasing resistor R_B is connected from the power supply to the output, and delivers all the current required for supplying the LT6650 and the load current. R_B is selected to ensure the operating current of the reference (I_Z in the Figure 8 zener-diode analogy) is in the range of 30µA to 220µA under all loading conditions.

Conclusion

The LT6650 voltage reference incorporates a unique blend of low voltage, micropower operation and functional versatility. With the additional features of series and shunt mode configurability, source and sink output current, wide output voltage range, adjustability, and a tiny ThinSOT-23 package, the LT6650 provides an excellent solution to the many design challenges in both portable and industrial voltage control.

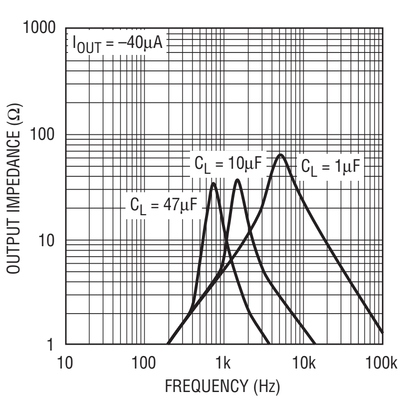

Figure 7. Output impedance is reduced while sourcing moderate current (40µA).

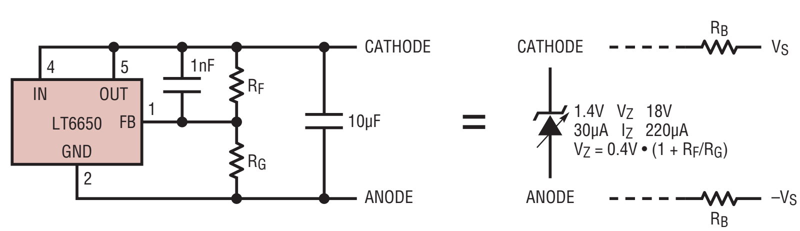

Figure 8. Create you own adjustable micropower "zener" 2-terminal reference.