SAM DAVIS, Editor in Chief

Controller IC Eliminates Remote Sense Lines for Long Cable Runs

By sensing the current in the cable line connecting a power supply to a distant load, a Virtual Remote Sense IC feeds back a control voltage that adjusts the power supply output to maintain an accurate load voltage.

Linear Technology's LT4180 is a Virtual Remote Sense™ power supply controller that eliminates the remote sense connections used with power converters to compensate for the voltage drop in lines going to the output load. To understand use of the LT4180, we first have to look at a power supply's role in regulating voltage applied to a load, which means it must obtain an accurate load voltage in order to maintain tight regulation. The LT4180 addresses various applications where a high current load is located a long distance from the power supply, such as lighting systems, remote instrumentation, and surveillance equipment.

In a typical system, lines that connect the power supply's output to its load have some resistance, so load current causes an unwanted voltage drop between the power supply and its load. Therefore, this voltage drop produces an inaccurate output voltage to be fed back to the supply for regulating the load voltage. For the tightest regulation, the power supply should feed back an accurate load voltage. As shown in *Fig. 1*, many power supplies have a remote sense function to eliminate inaccurate feedback voltage. Connecting two remote sense lines (plus and minus) that draw virtually no current from the power supply to the load, the supply can get an accurate load voltage as feedback for load voltage regulation. For proper operation, steps should be taken to ensure the remote sense wires do not pick up noise by either twisting the two sense wires together and/or shielding them from noise. Also, you must observe the correct polarities with the +sense line connected to the +V load and the –sense line connected to the –V load.

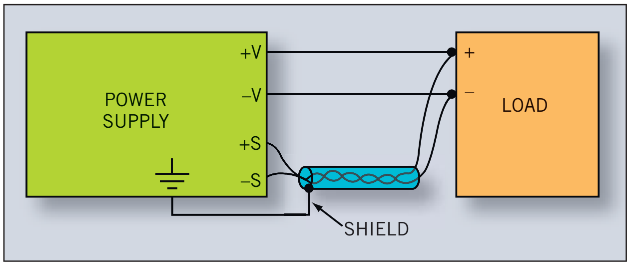

Fig. 1. Conventional remote sense for a power supply employs two sense lines (plus and minus) to obtain an accurate load voltage as feedback for load voltage regulation.

LT4180 FEATURES

- Tight Load Regulation without Remote Sense Wires
- Compatible with Isolated & Non-isolated Power Supplies
- Works with any topology
- V_{IN} Range from 3V to 50V
- Ability to drive opto-coupler
- Low turn-on transients
- Undervoltage and overvoltage protection
- Spread spectrum modulation dither
- ±1% internal reference voltage over temperature
- SSOP-24 package

Virtual Remote Sense (VRS) eliminates the need for the pair of remote sense wires. The basic VRS measures the incremental change in

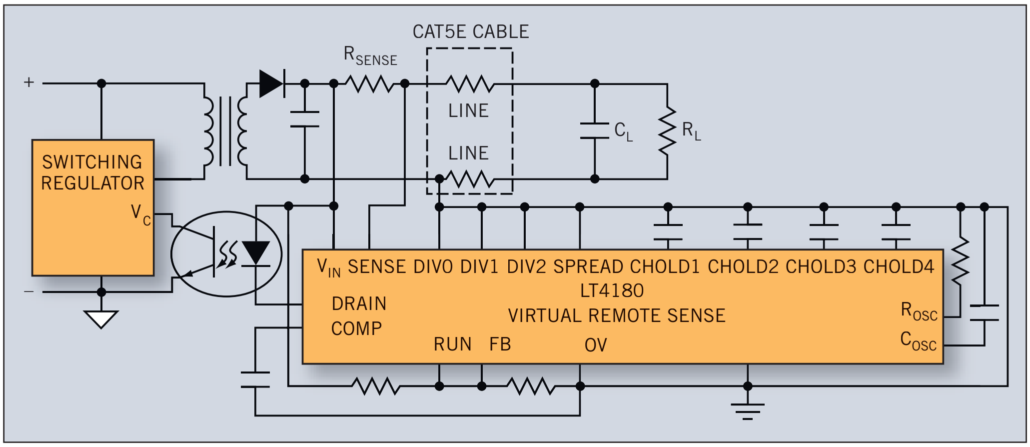

Fig. 2. Simplified virtual remote sensing circuit measures the incremental change in power supply output current that occurs with an incremental change in the output load.

voltage that occurs with an incremental change in current in the output voltage wiring (*Fig. 2*). The VRS circuit uses this measurement to compute and compensate the voltage drop in the line from the power supply to the load.

In the application shown in *Fig. 3*, The LT4180 continuously interrogates the line impedance and corrects the regulator's output voltage. The IC maintains a corrected, regulated voltage at the load regardless of current or line impedance. Virtual Remote Sense takes over control of the power supply via its feedback pin (FB) that drives the opto-coupler. The VRS circuit maintains tight regulation of load voltage at RL.

Virtual remote sensing relies on sampling techniques to hold the different voltages during a correction cycle. Because switching power supplies are commonly used or loads may be pulsed, the LT4180 uses a variety of techniques to minimize potential interference in the form of beat notes that may occur. Besides several types of internal filtering, and the option for VRS/power supply synchronization, the LT4180 also provides spread spectrum operation on the dither. Spread spectrum techniques dither the interrogation frequency from cycle to cycle. With spread spectrum, low modulation index pseudo-random phasing is applied to Virtual Remote Sense timing. This lowers the average value of the peaks and prevents beat notes if the load is pulsed at a frequency close to the interrogation cycle.

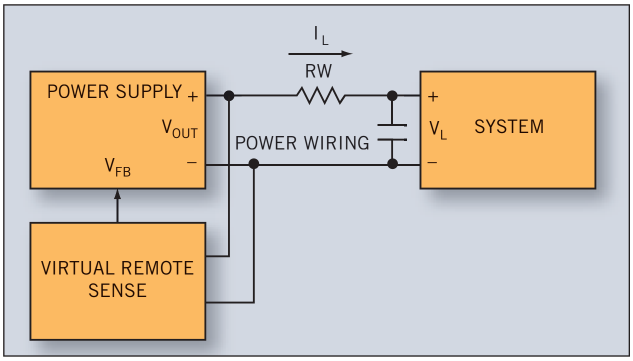

Fig. 3. Typical application of the LT4180 provides virtual remote sense for a flyback converter connected to a distant load (R_L).

SENSING LINE CURRENT

The voltage drop across R_{SENSE} is proportional to line current, IL. Select the value of R_{SENSE} so that it produces a 100mV voltage drop at maximum load current. For best accuracy, the V_{IN} and SENSE pins should be Kelvin-connected to R_{SENSE}.

Four track/hold circuits capture and hold input voltages obtained from R_{SENSE} (due to line current) at times determined by division ratio of the spread spectrum clock. The division ratio depends on the 3-bit code set by DIV2, DIV1 and DIV0. The track/hold circuits include a switch and a storage capacitor. In the track mode, the switch closes thereby coupling the input signal to the specific CHOLD(1, 2, 3, or 4) capacitor, allowing the storage capacitor to track the RSENSE input signal. In the hold mode, the switch opens, isolating the storage capacitor from the input signal and allowing it to hold the amplitude value of the input signal constant.

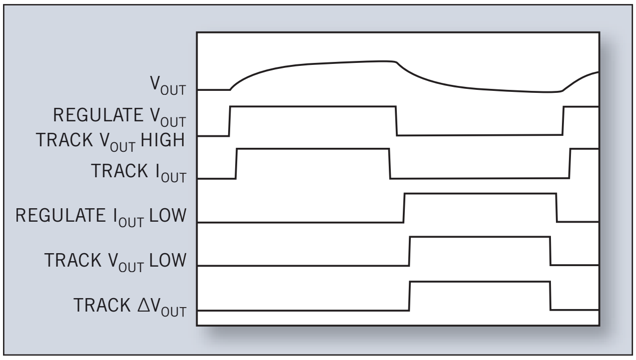

Fig. 4. Timing diagram for virtual remote sensing begins when the power supply and VRS close the loop around V_{OUT}.

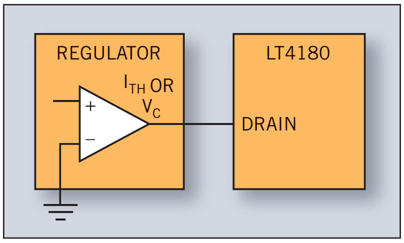

Fig. 5. Working with a non-isolated power supply, the LT4180's drain pin controls virtual remote sensing.

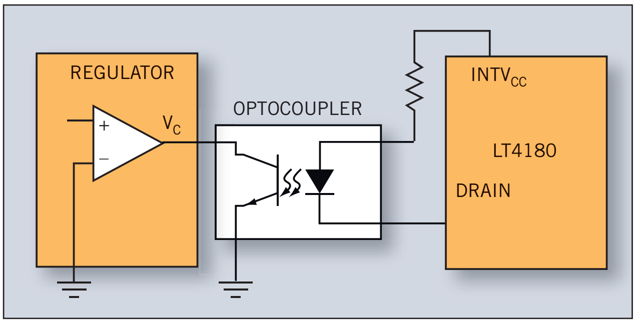

Fig. 6. The LT4180 employs an opto-coupler when working with an isolated power supply.

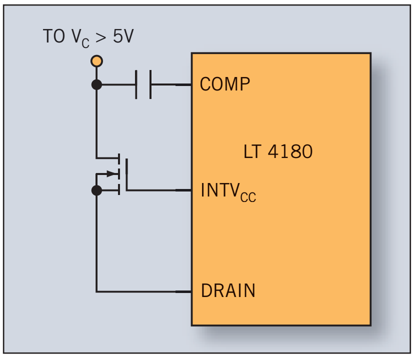

Fig. 7. If the power supply's control pin, VC, exceeds 5V, a cascode circuit can be used to keep the LT4180's DRAIN pin below 5V.

Fig. 4 shows the timing diagram for virtual remote sensing (VRS). A new cycle begins when the power supply and VRS close the loop around V_{OUT} (regulate V_{OUT} = H). Both V_{OUT} and I_{OUT} slew and settle to a new value, and these values are stored in the track-and-hold capacitor (track V_{OUT} high = L and track I_{OUT} = L). The V_{OUT} feedback loop is opened and a new feedback loop is set up commanding the power supply to deliver 90% of the previously measured current (0.9IOUT). V_{OUT} drops to a new value as the power supply reaches a new steady state, and this information is also stored in the track/hold capacitor. At this point, the change in output voltage (ΔV_{OUT}) for a –10% change in output current has been measured and is stored in the track/hold capacitor. It is amplified by a gain of 10 to obtain the total correction to the output. The four track/hold circuits store the amplitude values in sequence to capacitors at CHOLD1, CHOLD2, CHOLD3, and CHOLD4. During the next VRS cycle, the total voltage is fed back to the power supply, which adjusts the voltage at the load to compensate for voltage drops due to line resistance.

To insure orderly start-up, the LT4180 has a soft-correct function. When the RUN pin rising threshold is first exceeded (indicating V_{IN} has crossed its undervoltage lockout threshold), power supply output voltage is set to a value corresponding to zero wiring voltage drop (no correction for wiring). Over a period of time (determined by CHOLD4), the power supply output voltage ramps up to account for wiring voltage drops, optimizing load-end voltage regulation. A new soft-correct cycle is also initiated whenever an overvoltage condition occurs.

The LT4180 will work with either isolated (with an opto) or non-isolated power supplies. A variety of power supplies and regulators having either an external feedback or control pin can be used with the LT4180. Tying the supply's existing inverting input to ground disables its error amplifier (*Fig. 5*). This converts the error amplifier into a simple constant-current source with the output voltage then controlled by the LT4180's drain pin. This method eliminates the regulator error amplifier from the control loop so the control loop with VRS in the LT4180 can control the output.

Isolated power supplies and regulators may also be used by adding an opto-coupler (*Fig. 6*). LT4180 internal regulator (INTVCC) supplies power to the opto-coupler LED. In situations where the control pin V_C of the regulator may exceed 5V, a cascode may be added to keep the DRAIN pin of the LT4180 below 5V (*Fig. 7*).

Three temperature grades are available. They include an extended grade version from -40 to 85°C, an industrial grade version from -40°C to 125°C and a military grade option from -55°C to 125°C. The LT4180 comes in an SSOP-24 package.