Application Note

Purpose
Implement remote sensing to compensate for voltage drop in load lines.

Background
As energy is transferred from the power supply to the load by means of load leads, a voltage drop across the load leads occurs and may significantly interfere with load regulation. Remote sensing is a method of compensating for this load lead effect on the output of the power supply.

When to use Remote Sensing
You should use remote sensing in applications where the load is located some distance, typically >10 feet (3 meters), from the power supply output terminals.

You should also use remote sensing if the measured voltage at the load input power terminals is significantly lower than the voltage measured at the power supply output terminals. The difference in voltage is based on the amount of current and the load lead size and length.

CAUTION! Consult the power supply operation manual for maximum voltage drop compensation the sense lines can correct for.

Calculating Voltage Drop

To calculate voltage drop of the load lines, first calculate the resistance of the load leads. Resistance = (Load line length in feet \ 100 ft) * resistivity coefficient in Ohms (Column 3 in the following table). Then apply Ohms law: Volts = Amps * Ohms.

Column 1	Column 2	Column 3	Column 4
Size (AWG)	Amperes (Maximum)	Ohms/100ft (one-way)	IR Drop/100ft (Col. 2x Col. 3)
14	15	0.257	3.85
12	20	0.162	3.24
10	30	0.102	3.06
8	40	0.064	2.56
6	55	0.043	2.36
4	70	0.025	1.75
2	95	0.015	1.42
1/0	125	0.010	1.25
3/0	165	0.006	1.04

Example
Load is 25 feet from the power supply, so total cable length is 50 feet. Load draws 15 Amps through a #12 American Wire Gauge (AWG) line; calculate voltage drop:

Resistance = 50 / 100 * 0.162 » 0.081W
Voltage Drop = 15 * 0.081 » 1.215 volts

Selecting Sense Cables
Sense lines carry very little current due to higher input impedance (typically 1kΩ; refer to operation manual for input impedance of specific supply) than the load lines. Sense line wire gauge should be selected so that there is no greater than a 100 mV drop across the sense lines. Typically #24 - #18 (AWG) is recommended.

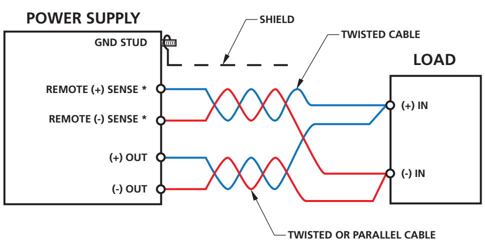
Noise and Impedance Effects
To minimize noise pickup or radiation from load circuits, load wires and remote sense wires should be twisted–pair with minimum lead length. Shielding of the sense leads may be necessary in high noise environments. Even if noise is not a concern, the load and remote sense wires should be twisted–pairs to reduce coupling between them, which could impact the stability of the power supply. If connectors are utilized for the power and sense leads, be careful not to introduce coupling between the leads. Ensure that the connector terminals for the sense leads are in adjacent locations, and minimize the physical loop area of the untwisted portions. Ideally, the sense leads should be separated from the power leads and should have their own connector.

Twisting the load wires provides an additional benefit in reducing the parasitic inductance of the cable. This improves the dynamic response characteristics at the load by maintaining low source impedance at high frequencies. Also, with long load wires, the resultant inductance and resistance could produce high frequency voltage spikes at the load because of current variations in the load itself. The impedance introduced between the output of the power supply and the load could make the ripple/noise at the load worse than the specifications of the power supply (which are valid when measured at the rear panel bus bars). Additional filtering with bypass capacitors at the load terminals may be required to bypass the high frequency load currents.

In addition, when operating with external sense, the recommendation is that it be done with twisted shielded pair, with one end of the shielding connected to ground close to the sense connector. The other end does not need to be connected.

Setup
To use remote voltage sensing, connect the power supply output to the load input terminals. Next, connect the sense lines to the load input as illustrated below.

Remote Sensing Operation at the Load



Remote Sensing

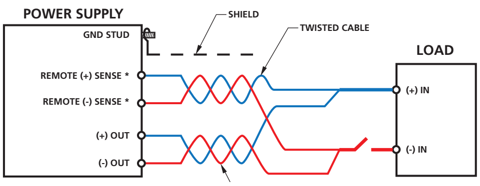
Using a Load Setup

CAUTION!

> Internal power supply damage may occur if the power supply is operated with load power lines disconnected and sensing line connected, which causes the output current to flow through sensing terminals.

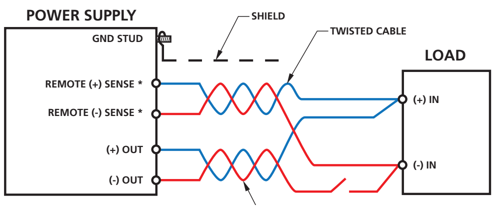
Example of a Good Setup

In the figure below, when the switch opens the power supply output current will drops to zero and the voltage at the output of the supply will decrease by the difference of the line loss of the cables when the load was present.



Example of a Bad Setup

In the figure below, when the switch opens the sense lines are no longer connected to the output of the supply. Sensing no output voltage, the sense attempts to boost the output voltage of the supply. The output voltage being boosted feeds higher current flowing through the sense lines to the load and may eventually cause damage to the supply. The eventual output of the supply may be slightly higher than the maximum rating of the supply (Max output voltage rating + Max sense compensation).



Recommendations

CAUTION!

> Do not perform series operation when using remote sensing, as damage to the power supply may occur