Preventing Voltage Fluctuations Due to Power Supply Lines

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When power supplies such as step-down regulators or linear regulators are used, they regulate a set voltage to supply a load with electrical energy. In some applications—for example, laboratory power supplies or electronic systems in which various components are connected to longer cables—the regulated voltage is not always particularly accurate at the point where it is needed due to various voltage drops across the interconnection lines. The control accuracy depends on many parameters. One is a dc accuracy for when the load needs a continuous and constant current. There is also the ac accuracy of the voltage generated. This is determined by how the generated voltage behaves with load transients. Effects that play a role in the dc accuracy include the required voltage reference, possibly a resistive voltage divider, and behavior of the error amplifier, as well as some other influences of the power supply. Critical factors for ac accuracy include the selected power level, backup capacitors, and the architecture and design of the control loop.

In addition to all of these influences on the accuracy of a generated supply voltage, however, are other effects that must be considered. If a power supply is spatially separated from the load to be supplied, a voltage drop will exist between the regulated voltage and the location where the electrical energy is needed. This voltage drop depends on the resistance present between the voltage regulator and the load. This can be a cable with plug contacts or a longer trace on a board.

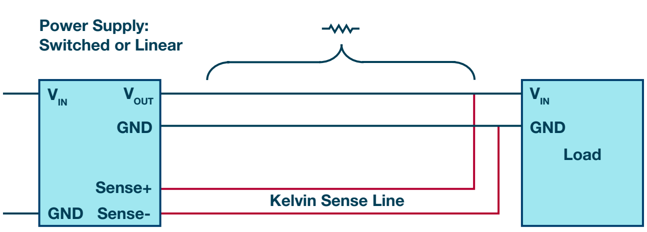

Figure 1. Physical distance between a voltage regulator and the associated load.

Figure 1 shows the resistance present between the power supply and the load. The voltage generated by the supply can be increased slightly to compensate for voltage losses across this resistor. Unfortunately, the resulting voltage drop across the line resistance depends on the load current, that is, the current flowing through the line. A higher current results in a higher voltage drop than does a lower current. The load is thus supplied by a rather inaccurately regulated voltage that depends on the line resistance and the respective current flow.

A solution to this problem was found early on. An additional connection can be run parallel to the actual connection line. Kelvin sense lines measure the voltage on the electrical load side. In Figure 1, these additional lines are shown in red. These measured values are then integrated into the supply voltage control on the power supply side. This concept works quite well, but has the disadvantage of requiring additional sense leads. Such lines can usually have a very small diameter, since they do not carry high currents. Nevertheless, the installation of a measuring line in a connecting cable for higher currents is associated with extra effort and high costs.

It is also possible to compensate for the voltage drop across a connection line between the power supply and load without an additional pair of sense leads. This is of particular interest for applications in which complex cables are elaborate and expensive, and in which the EMC interference generated could easily couple into the voltage test leads. This second possibility consists of the use of a dedicated line drop compensation IC such as the LT6110. This is inserted on the voltage generation side and measures the current before entering the connection line. Based on this measured current, the output voltage of the power supply is then adjusted so that the voltage on the load side is very accurately regulated, regardless of the load current.

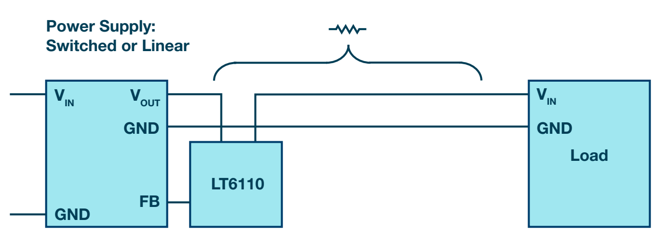

Figure 2. An LT6110 is used to adjust a power supply output voltage to compensate for the voltage drop of a connection line.

For a component such as the LT6110, the power supply voltage can be adjusted depending on the respective load current; however, this adjustment requires information about the line resistance. This information is available in many—but not in all—applications. If a connection line can be exchanged for one that is longer or shorter during the lifetime of a device, then the voltage compensation due to the LT6110 must also be adjusted.

In the case of a possible change in the line resistance during the operation of a device, there are components such as the LT4180 which can use ac signals in the presence of an input capacitor on the load side to make virtual predictions about the resistance of the connection line, and thus can provide a highly accurate voltage at the load.

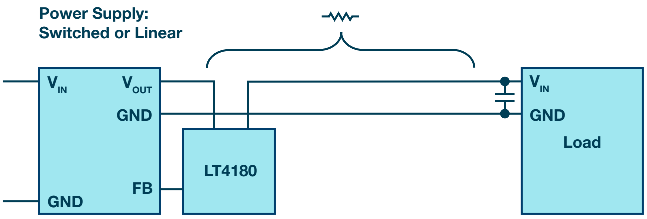

Figure 3. Virtual remote measurement of a line with the LT4180.

Figure 3 shows an application with the LT4180 in which the transmission line resistance is unknown. The line input voltage is adjusted to the respective line resistance. With the LT4180, this is done without Kelvin sense lines through a stepwise changing of the current through the line and measurement of the respective voltage change. The result of this measurement is used to determine the voltage losses in the unknown line. This information is used to make the optimal adjustment of the dc-to-dc converter output voltage.

Such a measurement works well as long as the node on the load side has a low ac impedance. This is the case in many applications, since the load after a long connection line requires a certain amount of energy storage. Due to the low impedance, the output current from the dc-to-dc converter can be modulated and the line resistance is determined using the voltage measurement on the side before the connection line.

Not only is the voltage converter itself relevant to having a successfully regulated supply voltage, but so, too, is the supply line to the load.

Conclusion

The desired dc accuracy can be increased through additional Kelvin sense lines. As an alternative to these additional sense leads, there are also integrated circuits to compensate for voltage drop across a line without requiring a Kelvin sense line. This is useful if the cost of a Kelvin sense line is too high or if existing lines must be used without additional sense leads. With these tips, a higher voltage accuracy can be readily achieved.

About the Author

Frederik Dostal studied microelectronics at the University of Erlangen in Germany. Starting work in the power management business in 2001, he has been active in various applications positions including four years in Phoenix, Arizona, working on switch mode power supplies. He joined Analog Devices in 2009 and works as a field applications engineer for power management at Analog Devices in München. He can be reached at *frederik.dostal@analog.com*.

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