When Overvoltages Last a Long Time, Use Switching Surge Stoppers

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Abstract

This article discusses the use of switching surge stoppers instead of classic linear ones for overvoltage protection in industrial electronics. With switching surge stoppers, the load will continue running even when surges last for a prolonged time. Classic linear surge stoppers need to cut the current flow by the time the MOSFET in the power path is dissipating more heat than it can handle.

Reliable industrial electronics often have protection circuits to head off any overvoltages on the supply lines and protect the electronics from damage. Overvoltages can arise when fast load changes occur on the power supply line. Parasitic line inductance can result in high voltage spikes. This can be addressed with an input protection circuit such as the one with an LTC4380 from Analog Devices shown in Figure 1. Power switch M1 is in the conductive path. If an overvoltage occurs at V_{IN}, switch M1 is operated in the linear region. This causes M1 to behave as a resistor in the ohmic region, allowing V_{OUT} to be regulated by the voltage drop across MOSFET M1. This prevents the output voltage from rising to excessively high levels, thereby protecting downstream electronics. This method is effective within a certain time limit. This duration is determined by the permissible safe operating area (SOA) of switch M1. However, if the voltage drop across the power MOSFET remains high and the duration exceeds the limit, the MOSFET will heat up beyond its maximum temperature threshold and become damaged. Integrated circuits such as the LTC4380 have built-in timers to protect against overvoltages. The amount of time that the MOSFET is operated in the linear region in an overvoltage situation is set on the timer. This time is usually on the order of a few milli or microseconds. Once this set time has elapsed, switch M1 is completely shut off. As a result, the switch is protected, but the power supply to the system is also shut off.

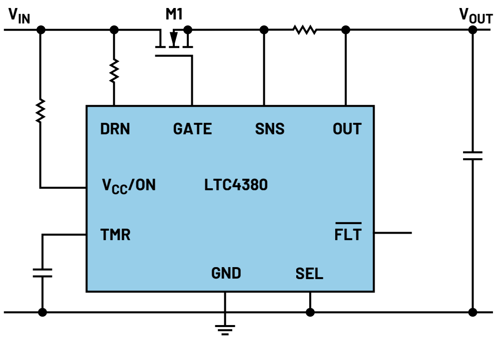

Figure 1. An overvoltage protection with a linear surge protector IC (simplified circuit).

To ensure reliable operation and uninterrupted power supply to industrial electronics under all circumstances, it is crucial to choose a solution that can tolerate overvoltage for extended periods. This includes considering fault scenarios such as incorrectly connected supply lines that may result in overvoltage. By selecting a solution that can handle these situations, the circuit can operate reliably and avoid disruptions to the supply voltage. Such a solution can be realized with a switching surge protector as shown in Figure 2.

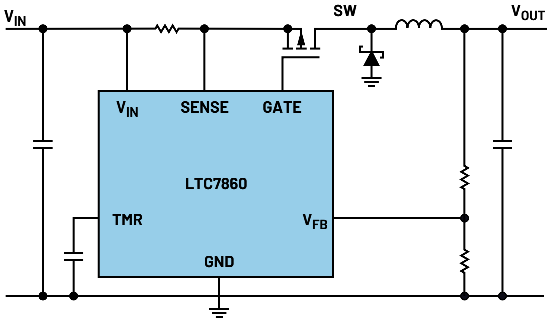

Figure 2. A switching overvoltage protection circuit without a time limit for overvoltage (simplified circuit).

In the circuit in Figure 2, in addition to the surge protector IC, an inductor and an external Schottky diode are used. Basically, a step-down (buck) switching regulator is operated as a protective circuit. However, this switching regulator only begins to work when the input voltage exceeds a set maximum value. Operation in this time period normally does not have to be particularly power efficient. A simple Schottky diode can be used as a flyback diode.

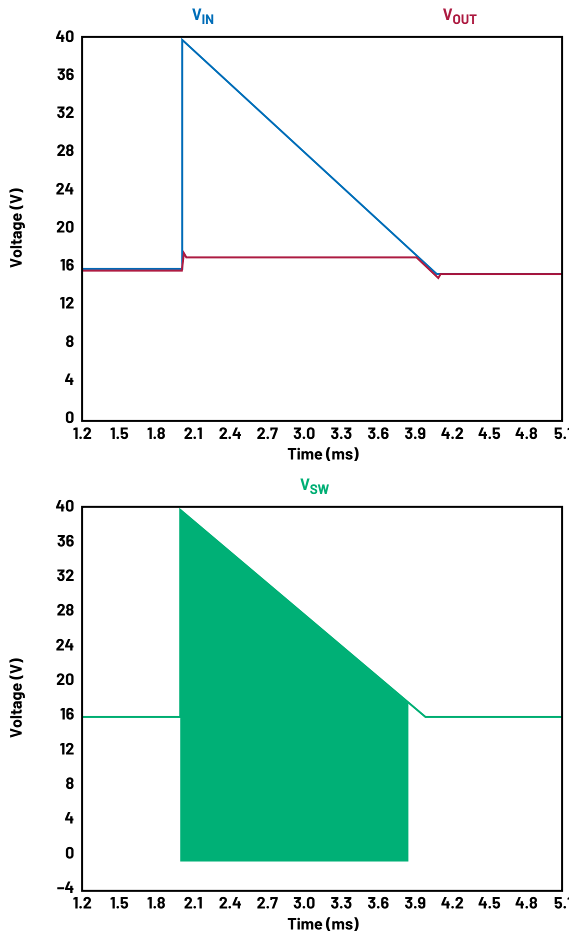

Figure 3. Input voltage and output voltage response to overvoltage (top) and switching at the switching node in the high frequency range (bottom).

Figure 3 shows an input voltage response in blue. The normal input voltage is 16 V. At approximately 2 ms, an overvoltage reaching 40 V occurs. The change in output voltage over time is shown in red. For the duration of the V_{IN} overvoltage, the switching DC-to-DC regulator is activated to regulate the output voltage to 16 V. The switching node voltage (at the node between the MOSFET, the Schottky diode, and the inductor) is shown in green.

An overvoltage protection circuit can thus be designed linearly as shown in Figure 1 or with a special switching (buck) DC-to-DC regulator such as the LTC7860 from Figure 2. A simple step-down switching regulator is not suitable for this application because the N-channel MOSFET cannot be continuously on in this case.

Overvoltage protection circuits include both linear surge protectors and switching surge protector ICs. The latter allows continuous operation of a circuit even during a lengthy overvoltage event. This means that the circuit to be powered is continuously protected and operational, even when overvoltages last a long time.

Conclusion

More and more industrial and instrumentation applications are requiring precision converters to accurately control and measure various processes. Additionally, these end applications are demanding increased flexibility, reliability, and feature sets, while simultaneously reducing costs and board area. Component manufacturers are addressing these challenges and offering a number of products to address the needs of system designers for current and future designs. As can be seen from this article, there are many different approaches in selecting the right components for precision applications, each offering their own associated drawbacks and benefits. As the accuracy of the systems increases, more and more thought needs to be put into the selection of the right component to suit the application needs.

About the Author

Frederik Dostal is a power management expert with more than 20 years of experience in this industry. After his studies of microelectronics at the University of Erlangen, Germany, he joined National Semiconductor in 2001, where he worked as a field applications engineer, gaining experience in implementing power management solutions in customer projects. During his time at National, he also spent four years in Phoenix, Arizona (U.S.A.), working on switch-mode power supplies as an applications engineer. In 2009, he joined Analog Devices, where he has since held a variety of positions working for the product line and European technical support, and currently brings his broad design and application knowledge as a power management expert. Frederik works in the ADI office in Munich, Germany.

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