Technical Article

Precise Voltage Regulation with Dynamic Voltage Scaling

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Abstract

This article discusses the use of dynamic voltage scaling (DVS) to achieve precise voltage regulation. DVS is a process that adjusts the output voltage slightly higher or lower in anticipation of load transients. The article examines how specific ICs can be used for reliable voltage monitoring.

Introduction

When a tightly regulated supply voltage is needed, the DC voltage accuracy specification in a switching regulator's data sheet can be utilized. This value is usually ±1% or ±0.5%. If the voltage converter uses an external resistor voltage divider in the feedback path, then the tolerances of the resistors also must be included in the voltage accuracy calculation. In addition, apart from the DC accuracy, the dynamic voltage accuracy must be considered. If a load transient occurs, that is, if the load suddenly draws a high current, the generated voltage can fall below or rise above the setpoint voltage before settling at the setpoint level. This behavior is dependent on the speed of the control loop. For an application in which the supply voltage must be tightly regulated, an accurate voltage during such load transients is normally also required. Figure 1 shows a typical voltage response in the time domain after a load transient. Here, a load was connected after 100 µs and disconnected after 400 µs.

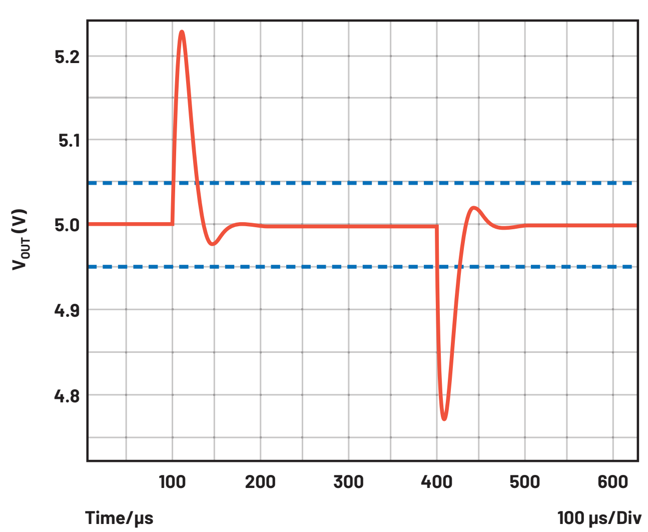

Figure 1. A typical voltage response in a power supply after a load transient.

The Benefits of DVS

DVS offers several benefits that enable precision voltage regulation with increased accuracy. It can be used to adjust the output voltage around a setpoint to compensate for load transients and provide tighter regulation.

The voltage fluctuations following a load transient as shown in Figure 1 are normally many times higher than the DC accuracy limits of a supply voltage. The dashed lines in Figure 1 show the limits for an accuracy of 1%.

In order to contain these sometimes very high voltage fluctuations within a specified accuracy window, it can make sense to use DVS. Here, when the load is low, it is assumed that a load transient to a high load will occur next. The output voltage is therefore increased slightly (for example, to 5.2 V) before this load transient occurs. The amplitude of the voltage dip remains unchanged by this. However, the voltage then does not dip from 5 V to 4.75 V, but rather from 5.2 V to 4.95 V. When there is a high load current, the voltage is lowered slightly because the load is generally expected to decrease again at some point in time. The voltage overshoot is then not as high.

Figure 2 shows the circuit for a step-down switching regulator that implements a simple form of DVS. A signal, for example, from a microcontroller, is applied to the V_{SEL} pin to specify whether or not the generated voltage should be raised slightly. With a simple DVS implementation, the system must generate this command and supply it to the switching regulator. Other switching regulators implement more sophisticated DVS systems. With those, individual load thresholds for DVS switching can be programmed directly.

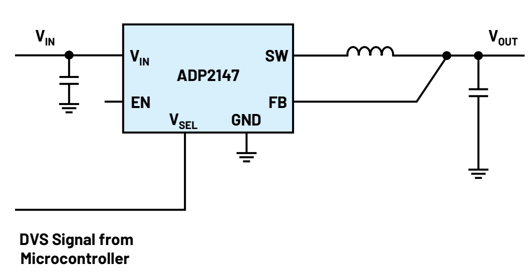

Figure 2. A step-down voltage regulator with simple DVS via a V_{SEL} pin.

In some cases, an application that needs a tightly regulated voltage may require a monitoring IC for checking whether the generated voltage actually lies within the tolerance band. When there are no load transients, a simple supervisory chip is sufficient for checking the DC voltage, which normally lies within a much narrower range. However, this does not work with DVS systems because the DC voltage has two different values: the somewhat higher value and the somewhat lower value of the DVS concept.

Special monitoring ICs such as the MAX20480 power system monitor can also be used with DVS systems for reliable voltage monitoring. The MAX20480 has a digital I^2C interface and, just like the switching regulator in Figure 2, it can be dynamically switched via the V_{SEL} pin to monitor a higher or lower DC voltage when DVS systems are used. Figure 3 shows a block diagram of the DVS switching regulator from Figure 2 with an added DVS-capable voltage monitoring IC.

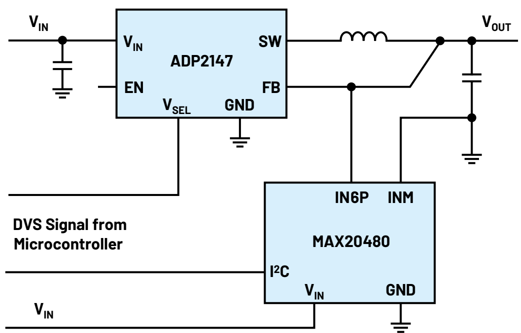

Figure 3. Monitoring with a DVS-capable supervisory controller for highly critical applications.

Conclusion

Interesting solutions are available for generating accurate supply voltages with high DC and dynamic accuracies. DVS can be especially useful. A number of special ICs with DVS support, including the MAX20480 supervisory IC, are available for monitoring the generated voltages. Such ICs improve performance while reducing costs associated with power conversion systems.

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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