Precise & Flexible Supply Voltage Supervision for Multirail Digital Boards

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Introduction

Circuit boards with FPGAs, microprocessors (µP), ASICs, and DSPs have multiple power supply rails, ranging from sub-1V point-of-loads (POL) to 12V intermediate bus, requiring voltage supervision to ensure reliable and error-free system operation. As silicon process technology has scaled to tens of nanometers, not only has the lowest POL output voltage (usually powering the core) trended below 1V but the processor core's accuracy specification has also tightened to 3% and better. These accuracy specifications translate to tight tolerances both on the power supply voltage and the voltage supervisor monitoring such a supply.

Over the same period, the number of supply rails has proliferated as they are needed to power the FPGA/µP/ASIC/DSP core and I/O, memory, PLLs and other analog circuits, making ten or more rails not uncommon. Frequently, it is also the case that the exact supply voltage levels are not known till late in the design or even after the board is fabricated and assembled. Optimizing supply voltages to lower board power consumption entails customized trimming of the supply voltage and a corresponding adjustment to the supervision threshold based on each individual board's performance. The voltage levels may also change with a revision of the FPGA/µP/ASIC/DSP. Traditionally, supervisor threshold changes are implemented by reworking resistive dividers or setting jumpers, but the adjustment granularity is limited and the procedure is cumbersome, time consuming, and prone to errors.

Why Is Voltage Supervision Accuracy Important?

Let's consider an example involving the setting of a voltage supervisor threshold. Assume a microprocessor specifies a (conveniently rounded) 1V±3% voltage for its core power supply input, implying the valid operational range to be from 0.97V to 1.03V. For enhanced reliability, an external voltage supervisor is employed to monitor this supply instead of just relying on the µP's internal power-on-reset. In an ideal world, with no variations, the undervoltage supervisor threshold is set exactly at 0.97V such that a reset is signaled as soon as the supply voltage drops below 0.97V shown in Figure 1. In reality, voltage supervisors are built out of analog reference voltages and comparators, each of which has a tolerance band contributing to the supervision threshold variation. For a 0.97V supervisor threshold with ±1% accuracy, the threshold varies from 0.96V to 0.98V. When the threshold is at the low end (0.96V), the supply could be outside the µP core's valid voltage range but the supervisor will not be signaling a reset, leading to a malfunctioning µP. To remedy this, the nominal supervisor threshold is set 1% above the 0.97V end of the valid range, i.e., at 0.98V. The downside is that when the supply voltage is below 0.99V, a reset could be signaled due to a high supervisor threshold. Therefore, the supply voltage needs to stay above 0.99V or 1V−1%, i.e., the supervisor threshold accuracy eats in to the power supply operating range.

The same analysis applies to the overvoltage threshold which will be nominally set to 1.02V, restricting the upper end of the supply voltage range to 1.01V or 1V+1%. Therefore, a ±3% specification on the µP coupled with a ±1% supervisor threshold accuracy yields a power supply tolerance requirement of ±1%. Note that a ±1.5% supervisor accuracy yields an impossible power supply tolerance of 0%. If overvoltage protection is not needed, the supply voltage can range from 0.99V to 1.03V; a 1.01V±2% power supply works for this case. In summary, supervisor accuracy plays an important role in determining the tolerance and cost for the required power supply.

Flexible Supervision

To solve the voltage supervision challenges mentioned in the introduction section, Linear Technology offers programmable six-supply voltage supervisors—LTC2933 (see Figure 2) and LTC2936—with integrated EEPROM, 0.2V to 13.9V threshold adjustment range, and 8-bit (256 choices) threshold registers set through an I^2C/SMBus digital interface. Both devices offer ±1% accuracy for thresholds in the 0.6V to 5.8V range with two adjustable-polarity thresholds per monitor input. For example, one of the thresholds can be configured as an undervoltage (UV) detector for reset generation while the other threshold can be employed either for overvoltage (OV) detection, protecting expensive board electronics against damage, or as a higher UV threshold for an early power-fail warning, providing valuable time for the processor to backup data. Threshold adjustment through the I^2C/SMBus interface gets rid of external resistive dividers, freeing up board space and eliminating accuracy degradation due to resistor tolerances. Last minute threshold changes are quickly achieved by writing to configuration registers instead of reworking boards, reducing time-to-market. Volatile memory holds instantaneous fault status while internal EEPROM stores register configuration and backs up fault history, speeding debug and reducing development time. To minimize nuisance resets from supply noise, the supervisors respond to input glitches based on comparator overdrive as shown in Figure 3.

Two general purpose inputs (GPI) can be configured as a manual reset input, UV or UV/OV fault disable input (e.g., during board margin testing), write protect input (LTC2936 only), or auxiliary comparator inputs. The GPI auxiliary comparator's fixed 0.5V threshold is ±2% accurate, extending monitoring to a total of eight supplies with external resistive dividers. Three general purpose input/outputs (GPIO) can be configured either as inputs or as reset, fault, or SMBus alert outputs. Any GPI, GPIO, or UV/OV fault inputs can be mapped to any of the GPIO outputs. The GPIO pins are programmable for their delay-on-release time (1µs to 1.64s), output type (open-drain or weak pull-up), and polarity (active high or low). To achieve this flexibility, no software coding is needed as the LTpowerPlay™ development environment shown in Figure 4 configures devices through an intuitive graphical interface. The LTC2933 and LTC2936 also monitor negative supplies, such as those powering analog circuits, with a resistive divider to the negative supply from a 2% accurate 3.3V linear regulator output.

The differences between the LTC2933 and LTC2936 are shown in Table 1. One of the LTC2933 inputs directly monitors a 12V intermediate bus while the other five inputs monitor supplies in the 0.2V to 5.8V range with thresholds adjustable in 4mV steps on the 0.2V to 1.2V precision range setting. The LTC2936 brings out each monitor's comparator outputs to a pin, enabling a cascade sequencing application in which a supply is started up after the previous supply in sequence has reached its valid operating range.

Conclusion

Modern digital boards with multiple power supply rails present a host of challenges to the power system designer. One among these is to precisely monitor a wide variety of supply voltages, some with levels not known until the last minute, in order to generate a reset for the processor system when the supplies power-up or brownout. The LTC2933 and LTC2936 tackle these challenges head-on, offering a simple and flexible solution for monitoring and supervising six rails with programmable, accurate thresholds, speeding time-to-market, and meeting the accuracy demands of modern processors without the need to procure and maintain inventory on multiple supervisor devices.

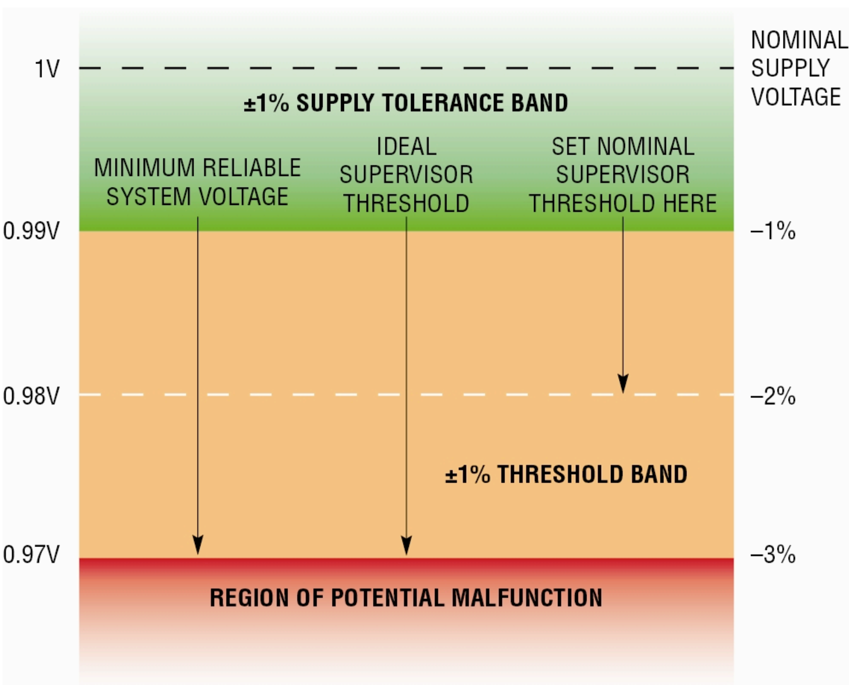

Figure 1. Setting Supervisor Threshold

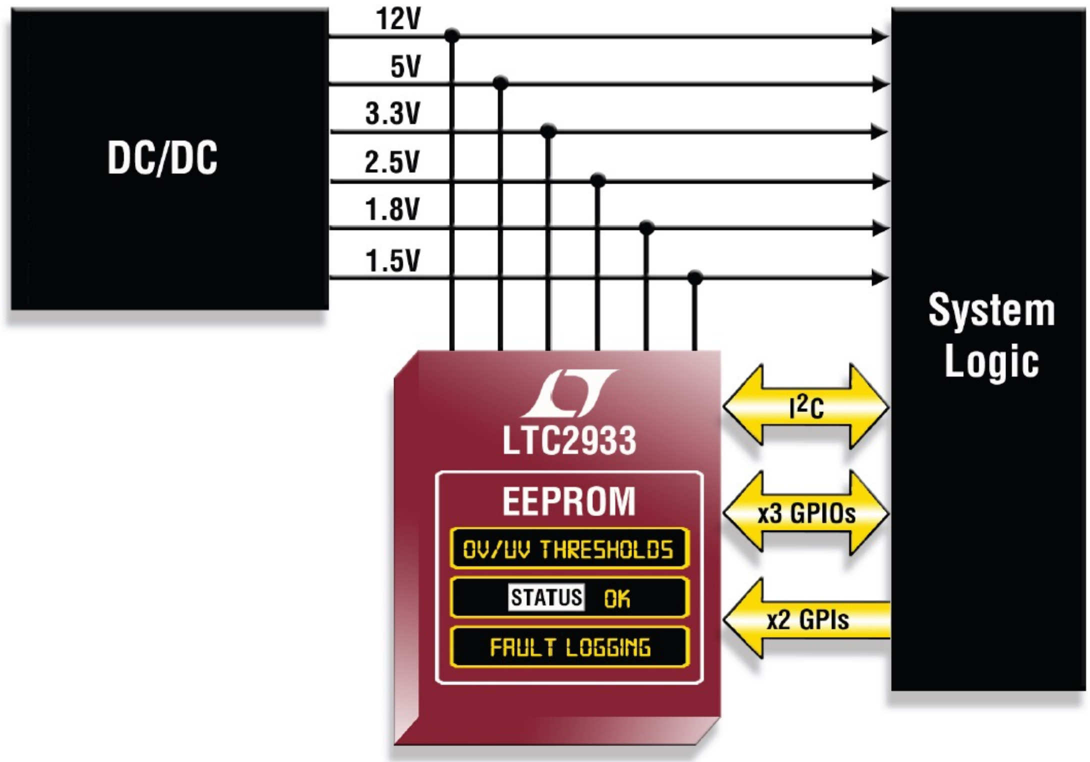

Figure 2. LTC2933 Programmable Hex Voltage Supervisor with EEPROM & I^2C/SMBus

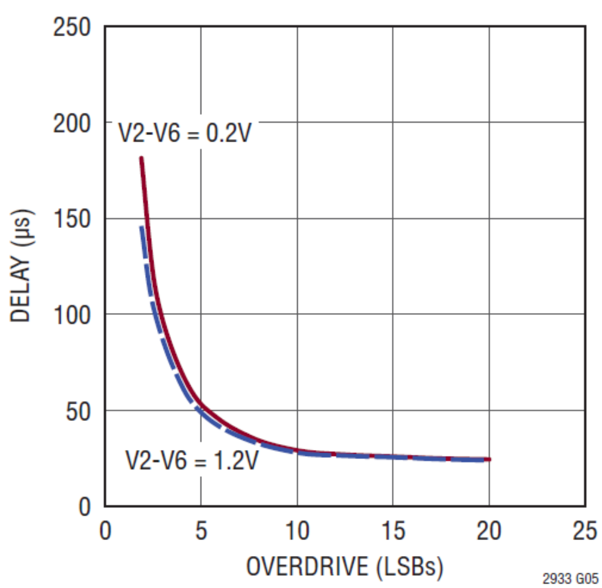

Figure 3. LTC2933 Response Time vs. Overdrive on V2 to V6 Monitor InputS

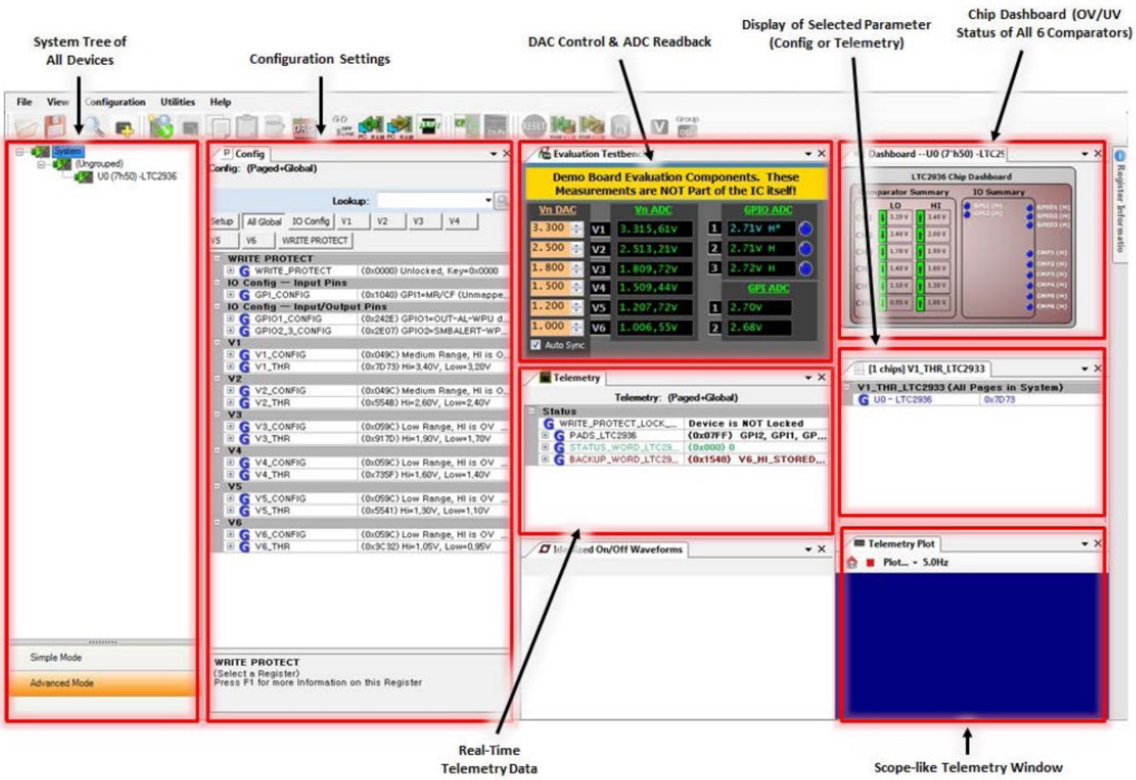

Figure 4. LTpowerPlay Software Graphical Interface for Configuring LTC2933 & LTC2936 (shown)

	Power Supply	Separate Supply Input	Threshold Range	Comparator Outputs	Response Time	I²C Addresses	Package
LTC2933	3.4V to 13.9V	No	0.2V to 13.9V	None	25µs	3	SSOP-16, 5mm × 4mm DFN-16
LTC2936	3.13V to 13.9V	Yes	0.2V to 5.8V	6	7.5µs	9	SSOP-24, 4mm × 5mm QFN-24

Table 1. Differences between LTC2933 & LTC2936, Hex Voltage Supervisors with EEPROM