Power Supply Sequencing Simplified

Nathan Enger

The challenges in designing a multiple power supply multiply with each additional supply rail. The designer must consider the dynamic environment of coordinated power supply sequencing and timing, generating power-on reset, monitoring for faults and responding appropriately to protect the system. An experienced designer recognizes that flexibility is key to successfully navigating the ebb and flow as a project moves from prototype to production. The ideal solution minimizes the number of hardware and software changes during development.

The ideal multisupply design tool is a single IC that resides in a design from beginning to end, requiring no wiring changes through the life cycle of the product. It autonomously supervises and sequences multiple power rails, cooperating with other ICs to seamlessly supervise many power regulators in the system, and provides fault and reset management. The designer can use powerful PC-based software to configure, visualize and debug system behavior in real time when connected to an I²C bus.

The LTC®2937 fits this bill. It is a 6-channel voltage sequencer and high accuracy supervisor with EEPROM. Each of the six channels has two dedicated comparators to accurately monitor over- and undervoltage conditions to within ±0.75%. The comparator thresholds are individually programmable over a range of 0.2V to 6V with 8-bit resolution. The comparators are fast, with deglitched propagation delays of 10µs. Each sequencer channel has an enable output that can control an external regulator, or the gate of a pass FET. All aspects of supervisor voltage and sequencer timing are individually configurable, including up- and down-sequence order, sequence timing parameters, and fault response. The built-in EEPROM makes the part completely autonomous and able to power-up in the correct state to control the system. In addition, multiple LTC2937s can cooperate to autonomously sequence up to 300 supplies in a system, all using a single-wire communication bus.

Power supply faults are controllable, visible and manageable through the LTC2937's autonomous fault response behaviors, and through debug registers. The LTC2937 automatically detects fault conditions and can power down the system in a coordinated manner. It can remain off, or attempt to resequence the supplies after the fault. In a system with a microcontroller and an I²C/SMBus, the LTC2937 provides detailed information regarding the type and cause of the fault, and the state of the system. The microcontroller can make decisions about how to respond, or allow the LTC2937 to respond on its own.

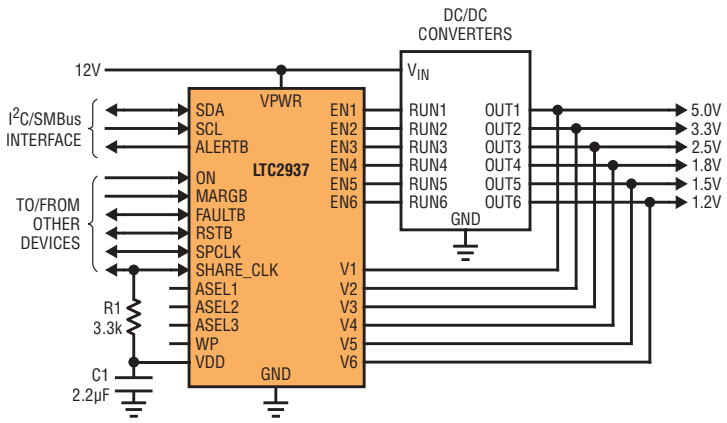


Figure 1. LTC2937 sequencing six supplies

Three Steps of Power Supply Control

A power supply cycle has three operating steps: sequence-up, monitoring and sequence-down. Figure 2 shows these phases for a typical system. During up-sequencing, each power supply must wait its turn, and then power up to the correct voltage in a designated amount of time. During the monitoring phase each power supply must remain within designated over- and undervoltage

Each of the LTC2937's six channels has two dedicated comparators to accurately monitor over- and undervoltage conditions to within ±0.75%. The comparator thresholds are individually programmable over a range of 0.2V to 6V with 8-bit resolution.

limits. During down-sequencing, each supply must wait its turn (often in a different order from up-sequencing), then power down within a configured time limit. At any point, something can go wrong, causing a fault in the system. The design challenge is to create a system in which all of these steps, and all of the variables, are easily configurable, but carefully controlled.

Sequence-up begins when the ON input transitions to active. The LTC2937 advances through its up-sequence, enabling each supply in turn, and monitoring to ensure that the supply voltage rises above the configured threshold before the configured time. Any supply that fails to meet its assigned timing triggers a sequencing fault.

A unique benefit of the LTC2937 is its sequence position clock. Each channel is assigned to a sequence position (1–1023), and receives its enable signal when the LTC2937 counts to the given number in the sequence. A channel with sequence position 1 is always enabled before a channel with sequence position 2. If a system specification changes, requiring these

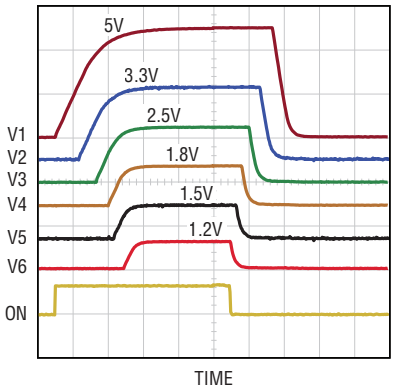


Figure 2. Power supply sequencing waveforms

two channels to sequence in a different order, then the sequence positions can be swapped, powering the second channel in sequence position 1, and the first in position 2. Multiple LTC2937s can share sequence position information, so that sequence position N happens at the same time for all LTC2937 chips, and channels controlled by different chips can participate in the same sequence (see Figure 3).

The monitoring phase begins when the last channel sequences up and crosses its undervoltage threshold. During monitoring, the LTC2937 uses its high accuracy comparators to continuously monitor the voltage at each input against over- and undervoltage thresholds. It ignores minor glitches on the inputs, only triggering if the voltage crosses the threshold with sufficient magnitude for sufficient time. When the LTC2937 detects a fault, it responds immediately according to its configured supervisor fault response. In a typical scenario, it shuts down all supplies simultaneously, asserting RESETB to the system, then it attempts to resequence up according to the normal start-up sequence. This prevents the supplies from powering parts of the system while others are unpowered, or executing an uncoordinated recovery after the fault. Multiple LTC2937s in a system can share fault state, and respond to each other's faults, maintaining complete coherence between cooperating channels during fault recovery. The LTC2937 offers numerous programmable fault response behaviors to satisfy many different system configurations.

The sequence-down phase begins when the ON input transitions low. The sequence position clock begins its count

Table 1. Programmable 6-channel sequencer and supervisors with EEPROM

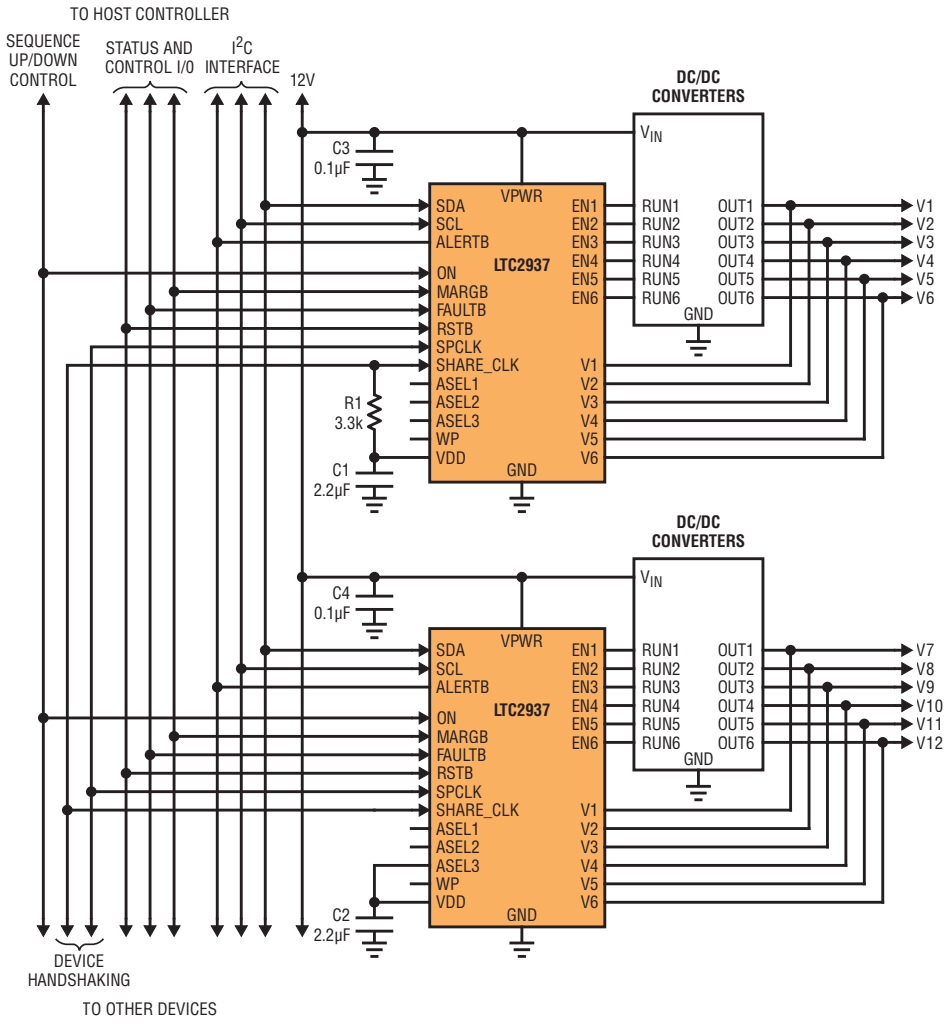
	LTC2933	LTC2936	LTC2937
Sequencer	No	No	Yes
Comparator Outputs	No	Yes	No
Threshold Range	1V to 13.9V (1×) 0.2V to 5.8V (5×)	0.2V to 5.8V (6×)	0.2V to 6V (6×)
Threshold Accuracy	±1%	±1%	±0.75%
Power Supply	3.4V to 13.9V	3.13V to 13.9V	2.9V to 16.5V
Package (mm × mm)	5×4 DFN-16, SSOP-16	4×5 QFN-24, SSOP-24	5×6 QFN-28

The LTC2937's extensive register set is powerful, yet mastering it is simple. The LTpowerPlay graphical user interface (GUI) displays all of the status and debug register information in one convenient interface.

again to bring the supplies down, but all of the sequence-down parameters are independent from the sequence-up parameters. Channels can sequence down in any order, and multiple LTC2937 chips coordinate sequencing of all controlled supplies. During the down-sequence, each supply must fall below its discharge threshold within its configured time limit, or trigger a sequencing fault. The LTC2937 can pull down on the supply with an optional current source to actively discharge slow moving supplies.

The sequence position clock enforces event-based sequence order, with each event waiting for preceding events before it can continue. The LTC2937 also allows time-based sequencing, and can participate in systems that enable supply rails at predetermined time points. Reconfigurable registers function in either time-based or event-based mode.

Figure 3. Typical connections between multiple LTC2937s



LTpowerPlay Makes it Simple

The LTC2937's extensive register set is powerful, yet mastering it is simple. The LTpowerPlay® graphical user interface (GUI) displays all of the status and debug register information in one convenient interface. The GUI communicates with any Linear Technology power system management IC (including the LTC2937) on the I²C/SMBus. Configuring one or more LTC2937s is as simple as a few clicks of the mouse.

LTpowerPlay saves settings on the PC, and can write them into the LTC2937 EEPROM. The GUI also shows all of the debug information for system malfunctions. LTpowerPlay can show when any supply is over- or undervoltage, or if a supply has failed sequence timing. After a fault, the GUI allows complete control over restarting the system. In every stage of the design—start-up, configuration, debug, and operation—LTpowerPlay is an indispensable window into system performance.

Conclusion

The LTC2937 simplifies power system sequencing and supervision. It requires very little board real estate for a complete system. It is flexible and reconfigurable, yet autonomous through its EEPROM memory. It can operate on its own, or in concert with other chips in a large system, seamlessly orchestrating the operations of up to 300 power supplies. ■

The LTC2937 simplifies power system sequencing and supervision. It requires very little board real estate for a complete system. It is flexible and reconfigurable, yet autonomous through its EEPROM memory. It can operate on its own, or in concert with other chips in a large system, seamlessly orchestrating the operations of up to 300 power supplies.

Figure 4. LTpowerPlay graphical user interface (GUI) displays all of the status and debug register information in one convenient interface. Configuring one or more LTC2937s is as simple as a few clicks of the mouse. LTpowerPlay saves settings on the PC, and can write them into the LTC2937 EEPROM.