

Using the LTC2937

A Step-by-Step Guide to Sequencing and Supervision

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Introduction

The **LTC[®]2937** is a power supply sequencer and supervisor with features that make it ideal for power supply management. It has features that enable seamless cooperation between any number of rails, including timing and sequencing, fast voltage supervision, fault handling, and debugging. Its EEPROM memory enables complete autonomy, and the I²C/SMBus interface allows it to be interactive in real time. With flexibility, however, comes some complexity, and there are design choices that need to be made in order to achieve success. This article walks through common scenarios and how to apply the features of the LTC2937 successfully.

This document is broken into the following sections:

- A Minimalist Circuit
- Adding Circuit Features
- Programming LTC2937
- The LTpowerPlay[®] GUI
- More Circuit Enhancements

We begin with a most basic hardware configuration, then expand to cover various improvements that take advantage of the features of the LTC2937 and add flexibility.

A MINIMALIST CIRCUIT

It is possible to achieve power supply management with very few external components. The LTC2937 is programmed to be completely autonomous, handling sequencing up and down, voltage supervision, and fault management. A minimal number of external pull-up resistors and bypass capacitors are needed, but nothing else is required.

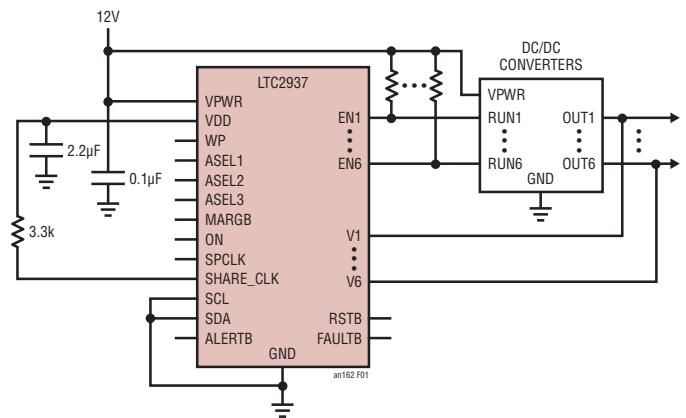


Figure 1. A Minimalist LTC2937 Circuit

Schematic Connections

- Connect SHARE_CLK to VDD through a 3.3k pull-up resistor. The sequencer won't advance if this open-drain pin doesn't toggle.
- Connect the open-drain ENn lines through pull-up resistors to a suitable voltage (up to 16.5V). Some DC/DC converters contain their own pull-ups, and may not require an external resistor.
- Connect SCL and SDA to GND, or optionally to VDD through 10k pull-up resistors. We are not using them in this configuration, but they should not be left floating.
- All other pins can take care of themselves – leave them floating. ON, MARGB, WP, ALERTB, FAULTB, RSTB, and SPCLK all have their own built-in weak pull-ups. The ASEL1,2,3 pins will float to set the (7-bit) device I²C address to 0x44, and WP pulls itself to the write-protected state, but that doesn't matter because the I²C bus is unused here.

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Basic Functions

In this minimalist configuration the LTC2937 will derive power from the 12V input and power-up its VDD LDO regulator. When VDD rises above the undervoltage lockout threshold the LTC2937 will load settings from EEPROM into operating memory (a process that takes about 2ms), then, because the ON pin pulls itself high, immediately begin sequencing up. All supplies will execute a coordinated sequence according to the pre-programmed rules stored in EEPROM¹.

After the supplies are up the LTC2937 monitors for voltage excursions outside of the programmed OV and UV limits, and will detect a fault within less than 35µs of any excursion (ignoring short glitches).

When the LTC2937 detects a fault it can (depending on configuration) automatically bring down all supplies and, after a delay, try to sequence up again. It does this with no external intervention, protecting the system from damage. Note that many control behaviors are fully configurable in the EEPROM memory.

ADDING FEATURES TO THE MINIMALIST CIRCUIT

The minimalist circuit is very functional, but it does not take advantage of all of the features that the LTC2937 offers.

In the minimalist circuit the LTC2937 is not connected to the I²C bus, so it will only follow the programming contained in its EEPROM. It is not configured to reprogram the parts on the board, so pre-programmed parts are required. If the LTC2937 contains factory default programming, it will do nothing (do no harm).

Connecting the LTC2937 to the I²C/SMBus means that advanced features, like updating voltage and sequence rules, re-programming the EEPROM, LTpowerPlay support, fault debugging, single-stepping, and firmware control become available. More on this later.

In the basic circuit, there is nothing to tell the LTC2937 when to sequence down. Neither the ON pin nor the I²C bus command are used. When 12V falls the ENn outputs remain high because the LTC2937 does not pull them low. The sequencer does not sequence down, so the supervised output regulators are on their own as far as shutting down.

Note 1. EEPROM memory can be programmed through the I²C/SMBus, either at the factory, in a dedicated programmer, or on a system board that uses I²C bus to communicate with LTC2937.

Adding VPWR Monitoring

Because the minimalist circuit simply sequences up as soon as it can, and remains up until the 12V supply collapses, the likely result is an un-sequenced, unpredictable ordering of supply power-down.

There are several ways to overcome this challenge. At a minimum, we can implement a control mechanism using one of the supervisor channels to monitor the 12V voltage through a resistor divider, and cause a fault when it falls too low. The fault condition, while not ideal, at least causes all ENn pins to pull low simultaneously, shutting-off the supplies before the 12V voltage collapses. This is a (minimal) improvement on uncoordinated collapse.

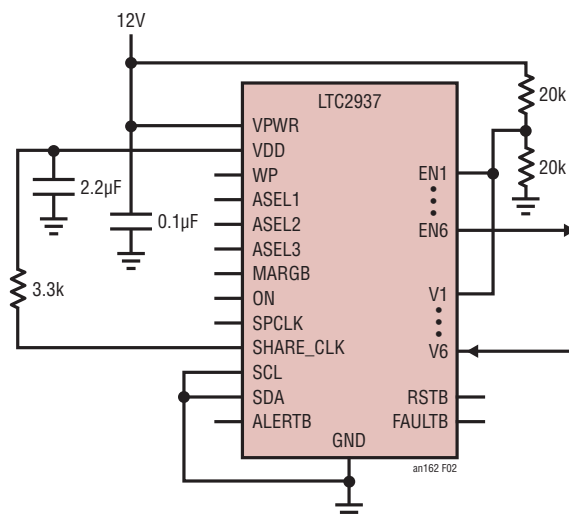


Figure 2. LTC2937 VPWR Detect

In this case, the LTC2937's fault retry delay should be programmed longer than the expected time that it takes the 12V supply to collapse. This prevents the LTC2937 from trying to start again while the supply is falling. Setting `FAULT_RESPONSE[7:5] = 3'b111` (13.1 seconds) will accomplish this.

To implement a full down-sequence there are several options. The best option is to use the ON pin to command the sequencer up or down. The ON pin controls when the supplies should be on or off with its logic level. Alternatively, an I²C command can force sequencing up and down, if there is a bus master to send that command. Both of these options require additional circuitry to command the LTC2937. More on this later.

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When the 12V supply is present, it supplies power to the LTC2937. When 12V is absent, the 3.3V supply may provide alternate power to the LTC2937 and the SCL/SDA bus lines. The LTC2937 has power, and can communicate over the I²C bus, but even if it attempts to sequence-up the supplies, no harm can be done without main board power.

Write Protect

The LTC2937 WP pin normally pulls itself up to VDD and prevents any changes to RAM or EEPROM. To enable writing, tie the WP pin to GND. Note that when the I²C bus is active write protection prevents any writes to memory, which will prevent features such as in-system programming and function control over the I²C bus.

The LTC2937 also honors the WRITE_PROTECTION register (0x00). If bit0 = 1 then the device is write protected. Use the read-modify-write technique to set the bit to 0. First read the register, which contains a key in bits 15 - 2. Then modify only bit0 → 0, maintaining the key value. Finally, write the modified contents back to the register. After the memory is unlocked the key value can be changed, if desired.

Note that BOTH the WP pin and the WRITE_PROTECTION register must be unlocked to enable writing to the LTC2937. Include a PCB option to (temporarily) pull the WP pin to GND to allow writing to the part during in-system programming, board bring-up, and debug.

PROGRAMMING THE LTC2937

After the circuit schematic is configured, the LTC2937 requires register settings to set the rules of operation. With factory default register settings the LTC2937 will not sequence up. For programming purposes, the registers can be grouped into functional sets, and it is simple to program a working system with a basic understanding of the register groups.

The following example shows how to program the LTC2937 for a particular set of voltages and timings. These settings will be similar, but not the same, for other applications. The LTC2937 data sheet gives a full explanation of registers and configuration bits.

Configuring RAM and EEPROM

The overall procedure for configuring the LTC2937 registers involves setting TIMING parameters, setting VOLTAGE parameters, and configuring FAULT CONTROL and OTHER functions. The following register settings show an example of the LTC2937's sequencer configuration – a good place to start. Remember that the LTC2937 data sheet contains a complete discussion of all of these registers and their functions.

Note that the easiest way to program and observe registers in the LTC2937 (and many other Linear Technology parts) is to use LTpowerPlay. More on this topic later in this article.

Sequence Up Control

Refer to Figure 5. There are several timing parameters to set for each channel. First is SEQ_UP_POSITION. Find this parameter in the SEQ_UP_POSITION_n registers. It can take values between 0 and 1023, with 0 meaning do not sequence. Each sequencer event happens at a specified delay with a given sequence position. Multiple events can occupy one sequence position.

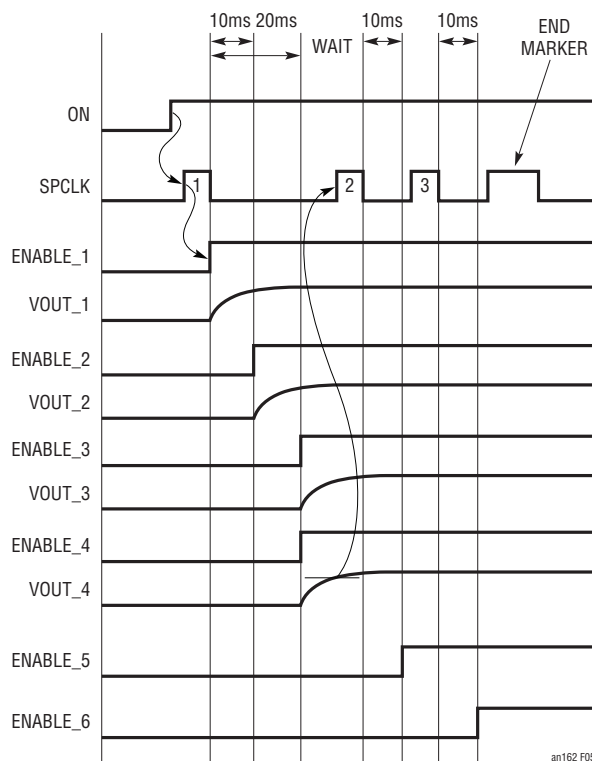


Figure 5. Example Sequence Up Timing

SEQ_UP_POSITION_1	1 (0x01)
SEQ_UP_POSITION_2	1 (0x01)
SEQ_UP_POSITION_3	1 (0x01)
SEQ_UP_POSITION_4	1 (0x01)
SEQ_UP_POSITION_5	2 (0x02)
SEQ_UP_POSITION_6	3 (0x03)

The second timing parameter is TON_DELAY (wait before enabling within a sequence position). Find this parameter in the TON_TIMERS_n registers. It can take values between 0µs and 655ms in 80µs increments.

TON_DELAY_1	0 (0x000)
TON_DELAY_2	10ms (0x07D)
TON_DELAY_3	20ms (0x0FA)
TON_DELAY_4	20ms (0x0FA)
TON_DELAY_5	10ms (0x07D)
TON_DELAY_6	10ms (0x07D)

The third timing parameter is TON_MAX (allow this long for voltage to rise above its UV threshold after enable before declaring a sequence fault). Find this parameter in the TON_TIMERS_n registers. It can take values between 160µs and 655ms, or infinity.

TON_MAX_1	2.6ms (011b)
TON_MAX_2	2.6ms (011b)
TON_MAX_3	2.6ms (011b)
TON_MAX_4	2.6ms (011b)
TON_MAX_5	160µs (001b)
TON_MAX_6	160µs (001b)

Sequence Down Control

Refer to Figure 6. Sequence down timing is very similar to, but independent from, sequence up timing. There are several sequence down timing parameters to set for each channel. First is SEQ_DOWN_POSITION. Find this parameter in the SEQ_DOWN_POSITION_n registers. It can take values between 0 and 1023.

SEQ_DOWN_POSITION_1	1 (0x01)
SEQ_DOWN_POSITION_2	1 (0x01)
SEQ_DOWN_POSITION_3	1 (0x01)
SEQ_DOWN_POSITION_4	1 (0x01)
SEQ_DOWN_POSITION_5	1 (0x01)
SEQ_DOWN_POSITION_6	1 (0x01)

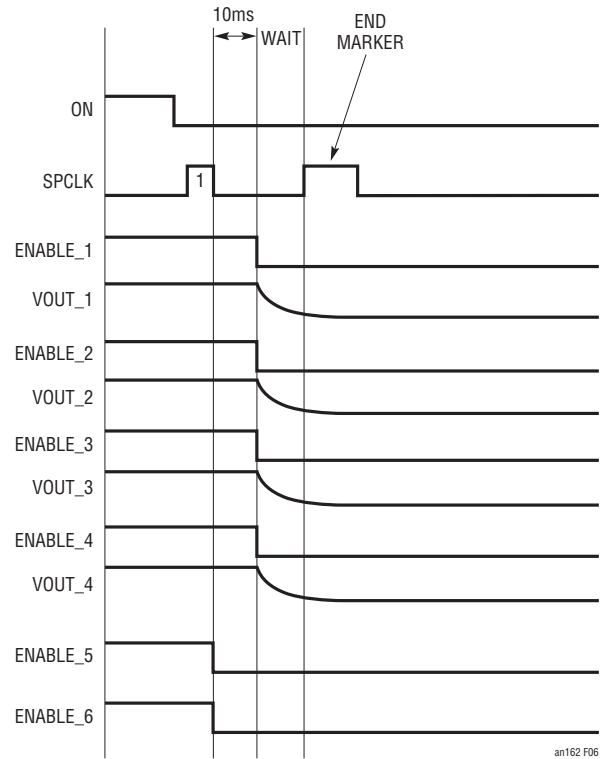


Figure 6. Sequence Down Timing

The second timing parameter is TOFF_DELAY (wait before disabling a channel within a sequence position). Find this parameter in the TOFF_TIMERS_n registers. It can take values between 0µs and 655ms in 80µs increments.

TOFF_DELAY_1	10ms (0x07D)
TOFF_DELAY_2	10ms (0x07D)
TOFF_DELAY_3	10ms (0x07D)
TOFF_DELAY_4	10ms (0x07D)
TOFF_DELAY_5	0 (0x000)
TOFF_DELAY_6	0 (0x000)

The third timing parameter is TOFF_MAX (allow this long for voltage to fall after disable before declaring a fault). Find this parameter in the TOFF_TIMERS_n registers. It can take values between 2.6ms and 10.5s, or infinity.

TOFF_MAX_1	41ms (011b)
TOFF_MAX_2	41ms (011b)
TOFF_MAX_3	41ms (011b)
TOFF_MAX_4	41ms (011b)
TOFF_MAX_5	2.6ms (001b)
TOFF_MAX_6	2.6ms (001b)

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Voltage Supervisor Control

Voltage limits come in two flavors: overvoltage (OV), and undervoltage (UV). The UV limit is used during sequencing to determine when a supply is up. Both limits are used during supervision to monitor supply health.

To set voltage limits, choose the V_RANGE for each channel (1V to 6V, 0.5V to 3V, or 0.2V to 1.2V), then select OV and UV thresholds in the range.

For supplies that reside above ground, selecting voltage settings is simple. Here are some example settings:

CHANNEL	V_RANGE	OV	UV
VOUT_1 (+3.3V Nominal)	HIGH (00b)	3.63V (0x88)	2.97V (0x67)
VOUT_2 (+1.8V Nominal)	LOW (01b)	1.98V (0x99)	1.62V (0x75)
VOUT_3 (+5V Nominal)	HIGH (00b)	5.5V (0xE6)	4.5V (0xB4)
VOUT_4 (0.8V Nominal)	ADJUSTABLE (10b)	0.88V (0xAF)	0.72V (0x87)

A clever use for sequencer channels is as logic handshaking during sequencing. For example, a channel may command a microprocessor to initialize before proceeding. The ENn output starts the initialization, and the returning ready signal tells the LTC2937 sequencer to proceed with the sequence.

For the voltage monitors connected to logic (handshaking) pins, the voltage limits can be very loose. This is because we only care to detect whether the voltages are logic 1 or not.

CHANNEL	V_RANGE	OV	UV
VOUT_5 (+3.3V)	HIGH (00b)	3.63V (0x88)	2.0V (0x37)
VOUT_6 (+3.3V)	HIGH (00b)	3.63V (0x88)	2.0V (0x37)

Fault Control

A fault happens when an expectation is violated (voltage or timing). There are several types of faults, but the two main types are SEQUENCE faults and SUPERVISOR faults. A sequence fault happens during sequencing, and cannot be masked with the MARGB pin (margin function). A

supervisor fault happens when the supplies are up (done sequencing), and these can be masked by MARGB.

The LTC2937 can perform one of several actions when it encounters a fault, including turning off and staying off, or turning off and trying again. Note that turn off means all enables go down at once; there is no down sequence during a fault.

For example we program the LTC2937 to go off, wait 13.1s after all supplies discharge, then try again.

FAULT_RESPONSE	0x00FF
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If a fault occurs, such as a voltage exceeding its programmed overvoltage limit, the LTC2937 will immediately shut down all ENn outputs, disabling all supplies simultaneously (no sequence down when a fault occurs).

Other Configuration Registers

These configuration registers collect all of the remaining control and debug features. They include ON/OFF control, which faults to honor, and write protection.

ON_OFF_CONTROL	0x0004
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This ON_OFF_CONTROL setting instructs the LTC2937 to sequence up when the ON input pin is high, and sequence down when it is low. Other bits in this register can provide additional functionality. Refer to the data sheet.

RSTB_CONFIG	0xBFFF
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This RSTB_CONFIG instructs the LTC2937 to honor all OV and UV faults, and to de-assert the RSTB output 200ms after all supplies become valid upon sequence up. Alternatively, we could set CH5 and CH6 to ignore OV faults, since we are using them as logic handshaking signals in this case. Set RSTB_CONFIG = 0xB3FF.

WRITE_PROTECTION	0xNNNN
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The WRITE_PROTECTION register contains one bit to control write protection (bit 0), and 14 bits of key value. Write protection cannot be unlocked unless the keys match. In order to unlock the write protection bit, first read the register, then modify only bit 0, then write the register with the same key. Once the register is unlocked you may write a new key value.

THE LTpowerPlay GUI

Overview

LTpowerPlay is the best way to interface with the LTC2937 over the I²C bus. It provides an intuitive, flexible, and complete view of the configuration and status registers inside of many different Linear Technology parts, including the LTC2937, and provides help documentation, configuration files, and support for the LTC2937 on your MS Windows PC. Figure 7 shows the LTpowerPlay tool connected to the LTC2937.

Use LTpowerPlay to:

- Program all of the registers in the LTC2937.
- Save and restore LTC2937 register settings in a project file, preserving configuration settings.
- Program the non-volatile EEPROM memory of the LTC2937.

- Read status information and graphically visualize what the LTC2937 is doing in real time.
- Debug faults and single-step the sequencer through its up or down sequence.
- Read and write configuration registers.
- Get help from on-line documents, videos, or a live support person.

The LTpowerPlay GUI organizes the configuration registers in groups by channel and by function (timing, voltage, etc.) Each register in the Config window pane is selectable and editable. Clicking the PC→RAM button in the button bar at the top writes changes to the LTC2937 RAM. Status registers are displayed in real-time in the telemetry pane. A condensed form of status information is also available in the Chip Dashboard in the upper right corner.

Much more information, including FAQs, documentation, and videos, are available in the Help menu.

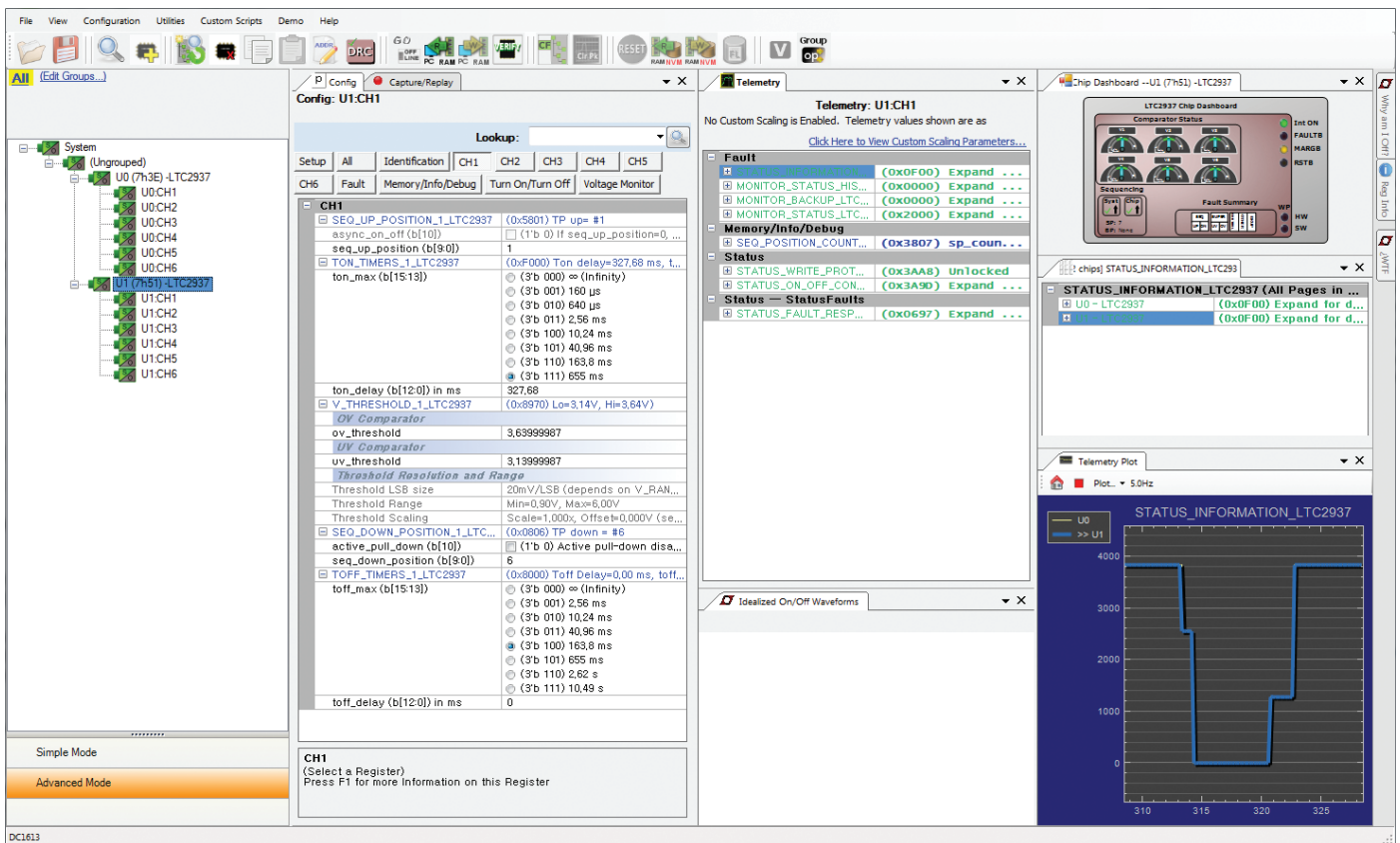


Figure 7. LTpowerPlay

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MORE CIRCUIT ENHANCEMENTS

No two designs are alike, and each one calls for some departure from the basic arrangement. There are tricks that allow the LTC2937 to fit into a wide variety of environments with just a few simple adjustments. Here are some examples.

I²C/SMBus Addresses

There are two different ways to express an I²C bus address. The address is expressed in one 8-bit byte, sent on the serial bus most-significant bit first, but the LSB in the address byte is always the read/write bit. This means that adjacent 8-bit addresses (odd/even) are the same address: even number for WRITE, and odd number for READ. For this reason the least-significant bit is often neglected in documentation, and only the most-significant 7-bits are given. This is called a 7-bit address. For example:

ADDR TYPE	HEX VALUE	BINARY VALUE	COMMENT
8-bit	0xB8	8'b1011_1000	r/w = 0 (write)
	0xB9	8'b1011_1001	r/w = 1 (read)
7-bit	0x5C	7'b101_1100_	r/w bit neglected

All addresses in this document are given in 7-bit format.

The LTC2937 can answer to a programmable address on the I²C bus. If there are other devices on the bus then it is important to consider which addresses the LTC2937 uses. There are three different kinds of addresses:

Slave Address	The primary address to which each LTC2937 answers. Each device on the bus must have a unique slave address. This address is programmable by pin-strapping the ADDR0,1,2 pins.
Global Address 0x36	The one address to which ALL LTC2937s answer. Other parts on the bus may have their own global addresses.
ARA 0x0C	"Alert Response Address". This is the SMBus protocol for answering an alert, and all SMBus parts on the bus must answer to it.

The ASEL0,1,2 pins set the slave I²C address for each LTC2937. The address can be selected from one of 27 possibilities by pulling each pin to VDD or GND, or by leaving it floating. A good approach for flexibility is to place both a pull-up and a pull-down resistor on each ASELn pin, then only populate these as necessary to set the address.

I²C Bus Buffers

Often there are multiple I²C bus voltage levels in a system. If an existing I²C bus master operates on a 2.5V or 1.8V domain, it should not be connected to the 3.3V I²C bus levels at the LTC2937 pins. The part may be damaged, or may not accept the same logic levels. Additionally, there are cases where a bus segment may be un-powered, pulling-down the SCL and SDA lines, while the remaining bus segments must continue to operate. The solution is a bus buffer such as the LTC4313 (Figure 8).

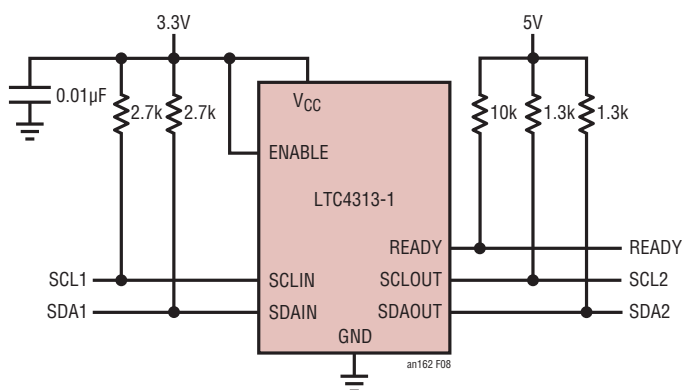


Figure 8. LTC4313 I²C Bus Buffer

This allows the scenario where a DC1613 dongle can communicate with the LTC2937 while the microprocessor or FPGA that normally serves as bus master is unpowered.

Better On/Off Control

We have already seen a poor-man's solution to sequencing control using one of the LTC2937's supervisor channels to monitor the 12V input voltage. This is not an ideal solution because it does not permit a proper down sequence, it simply detects a voltage fault and shuts down everything all at once. A more robust approach uses the LTC2955 to drive the LTC2937 ON pin high or low in response to defined 12V voltage levels. This solution has the added advantage of a pushbutton for manual control. Also notice in Figure 9 that VPWR has a 10µF hold-up capacitor to power the LTC2937 while the sequencer is sequencing down. The diode prevents the hold-up capacitor from bleeding charge into the falling 12V supply.

This ON/OFF circuit can also be used with the dongle power circuit in Figure 4. It will try to hold the ON pin low as long as the 12V power supply is low.

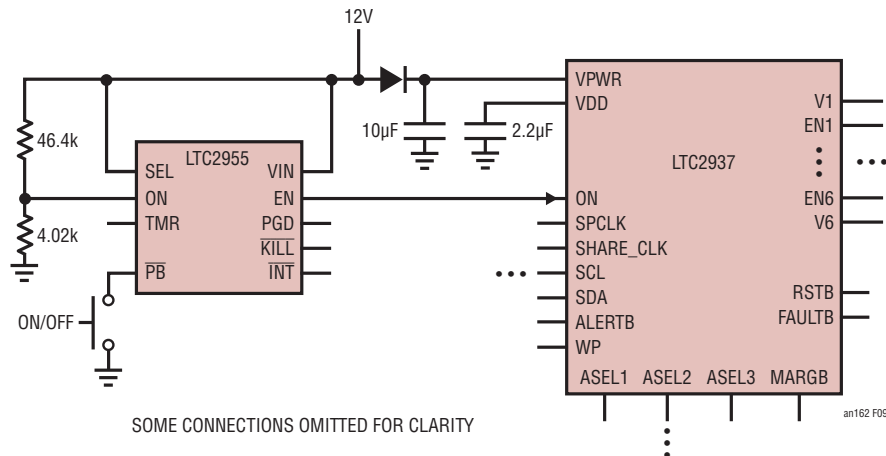


Figure 9. LTC2955 On/Off Circuit

More Channels, More LTC2937s

A single LTC2937 can sequence and supervise six channels. In a system with more than six supplies, adding more LTC2937s simplifies sequencing because the sequencers communicate timing, sequence, and fault information and respond together.

Figure 10 shows the connections between LTC2937s. The following rules should be applied.

- Connect SHARE_CLK to all LTC2937s in the system. One 3.3kΩ to one VDD is sufficient. All of the LTC2937s will take timing cues from the shared clock line. Do not connect SHARE_CLK to any other points in the system.
- Connect SPCLK to all LTC2937s. No pull-up is needed. All LTC2937s will take sequencing cues from the shared line. Do not connect SPCLK to any other points in the system.
- Connect FAULTB to all LTC2937s in the system. No pull-up is necessary, since each LTC2937 pulls up to its own VDD. Each LTC2937 can be programmed to respond to the FAULTB line going low.
- Connect all ON pins to all LTC2937s in the system. No pull-up is necessary, since each LTC2937 pulls up to its own VDD. Connecting them together helps maintain consistent state across multiple sequencers. Control this pin to command up and down sequencing.
- Each LTC2937 in the system requires a unique I²C slave address for communicating on the bus. Connect ASEL1,2,3 lines to GND or VDD (local to the chip), or leave floating to select unique addresses. Note that

every LTC2937 responds to the global 7-bit address 0x36, and to the SMBus ARA 0x0C, regardless of ASEL setting.

Logic Handshake

It is possible to use one LTC2937 channel (EN_n output and V_n input) as a logic handshake, instead of a power supply sequencer/supervisor. Use EN_n to send a signal to a CPLD, FPGA, or other logic in the system, and use V_n to receive a logic signal when the process is complete. This is useful for devices that contain their own internal start-up circuitry that needs an undetermined time delay in the power-up sequence. The LTC2937 can simply shake hands with that device in the sequence.

Unused Channels

Tie unused V_n inputs to GND. Set the unused channel sequence position to 0 (SEQ_UP_POSITION_n = 0x0000) so it will not attempt to enable during sequencing, and set vn_ov_enable = 0 and vn_uv_enable = 0 in the RSTB_CONFIG register to prevent these OV and UV conditions from factoring into the fault decisions.

Before leaving a channel unused, consider that unused channels offer additional capability that could be used in other ways. In a sense these pins can function as general purpose inputs and outputs. Each EN_n pin can provide a logic indication of a programmed register bit, and each comparator input can monitor any voltage or logic pin in the system. The I²C bus provides access to all of these functions.

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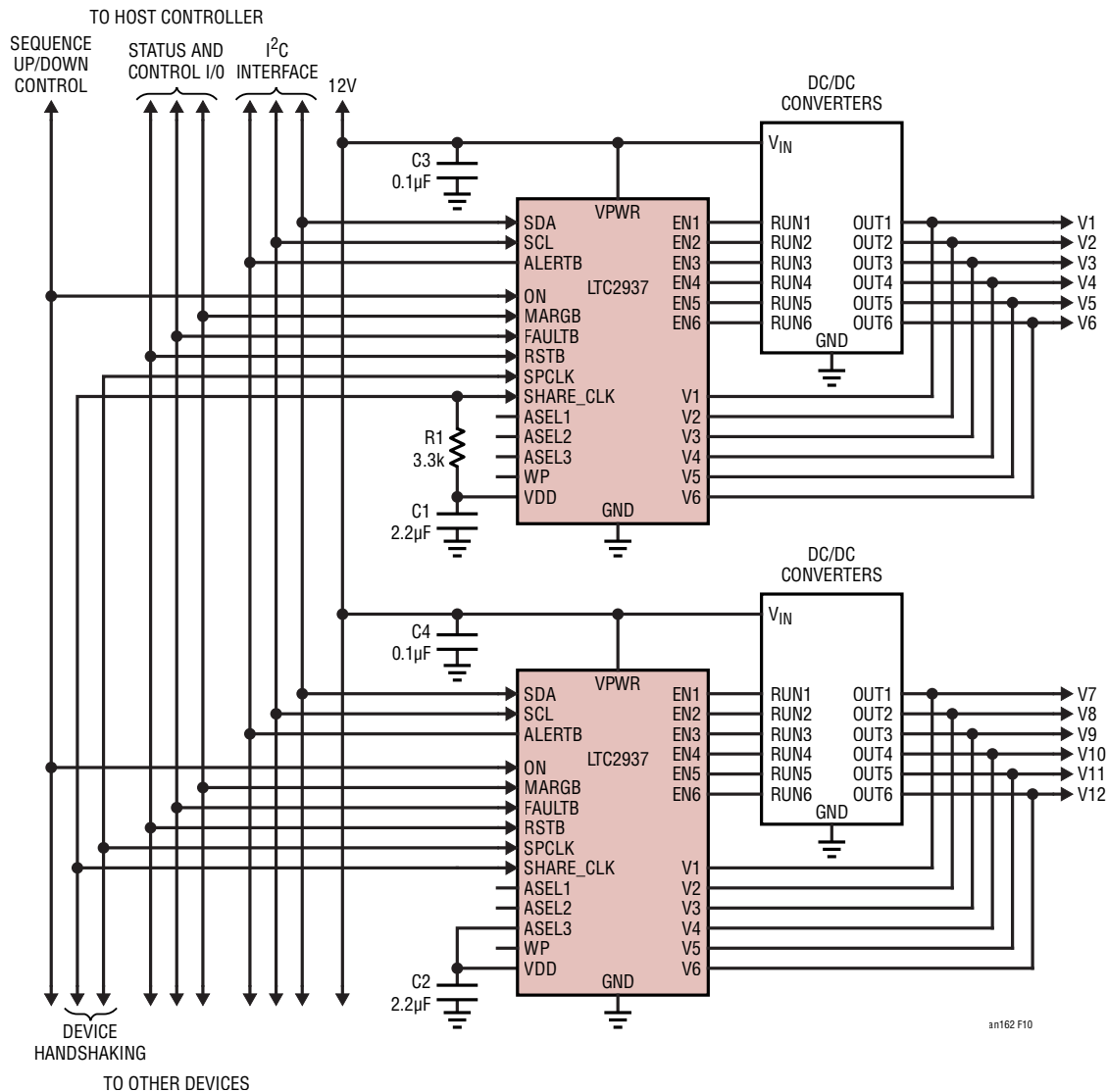


Figure 10. Connecting Multiple LTC2937s Together in a System

Reset and Power Good

Often a system needs a reset signal that activates only when one or more power rails are not good. The LTC2937, using its many comparators, monitors the status of all of its input voltages, and releases the RSTB pin when all of the supplies are within their specified ranges (power is good). RSTB can be programmed to monitor any combination of OV and UV limits at the inputs, and can also be programmed to delay its release for a time after all supplies are good.

Use the RSTB output to reset other components of the system. The RSTB pin is not an input to the LTC2937, but its state can be read in the MONITOR_STATUS (0x30) register.

Supervising Current

The LTC2937 is a voltage sensing device. It detects voltage at its inputs. In some cases a system may need to also make sure that current is staying within prescribed limits, and respond to overcurrent conditions. With a little help from the LTC6101 the LTC2937 can do just that.

The LTC6101 is a high-side current sense amplifier that measures the differential voltage across a current sense resistor and produces a scaled, ground referenced voltage. Once the current signal is in this form, the LTC2937 can monitor for overcurrent just like it monitors for any other voltage.

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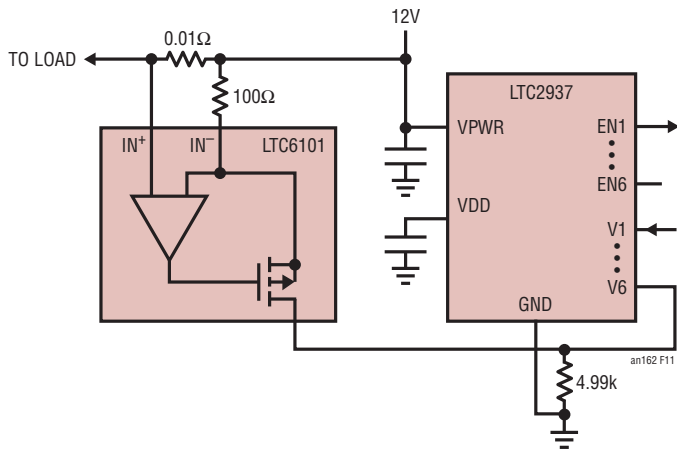


Figure 11. LTC2937 Supervising Current with LTC6101

Program the LTC2937 as follows (assuming CH6 is monitoring current, and 1.0A is the limit):

SEQ_UP_POSITION_6	0x0000	Don't Sequence CH6
SEQ_DOWN_POSITION_6	0x0000	Don't Sequence CH6
RSTB_CONFIG[11]	1'b1	Monitor for OV Faults
RSTB_CONFIG[5]	1'b0	Don't Monitor UV
V_RANGE[11:10]	2'b10	Adjustable Range
V_THRESHOLD_6[15:8]	0x50	Only OV Threshold Matters
V_THRESHOLD_6[7:0]	0x05	

The LTC2937 will not sequence the current monitor channel, but it will respond if the current goes above 1.0A. Using the adjustable range gives the best resolution up to 1.2V at the V6 pin.

Decide on the best settings (V_RANGE and $V_THRESHOLD$) based upon the gain of the LTC6101 circuit. In Figure 11 the circuit gain is:

$$\text{Gain} = 5000\Omega \cdot \frac{0.01\Omega}{100\Omega} = 0.5 \left[\frac{\text{Volts}}{\text{Amps}} \right]$$

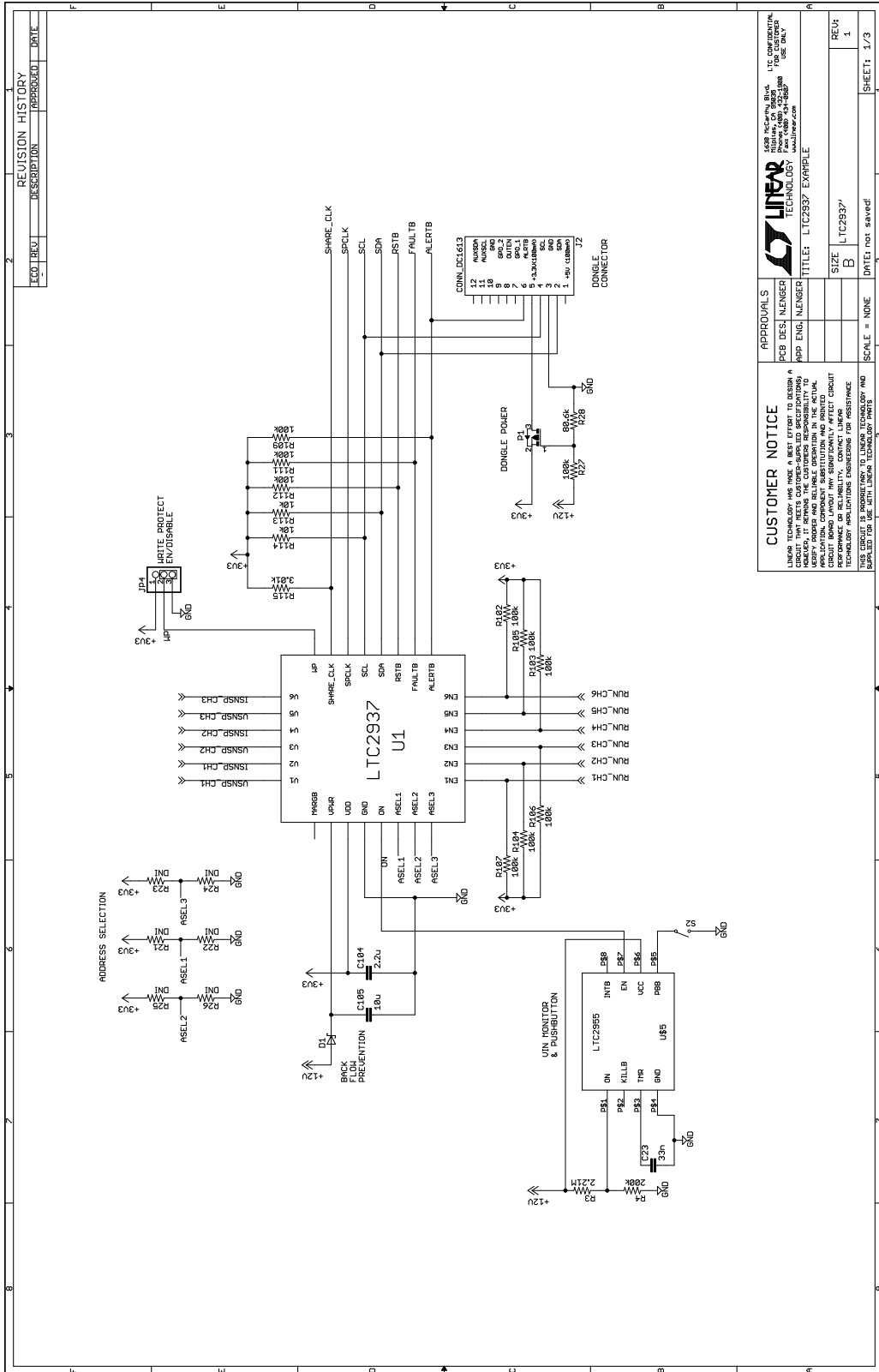
Conclusion

The LTC2937 is flexible, powerful, and easy to use. Connecting it to a system is simple, and requires few external components. It can stand alone in a completely autonomous system, and take advantage of a few simple techniques to add powerful capabilities to any power delivery system, whether there are a handful of power supplies, or hundreds. The powerful LTpowerPlay software provides comprehensive support, from initial design-in, to EEPROM configuration, to board bring-up and debugging. With these capabilities the LTC2937 gives you advanced control over your power system with one integrated platform.

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APPENDIX A

Complete Schematic



REV	DESCRIPTION	DATE
1.001	REVU	10/28/2004

REV	DESCRIPTION	DATE
1.001	REVU	10/28/2004

REV	DESCRIPTION	DATE
1.001	REVU	10/28/2004

REV	DESCRIPTION	DATE
1.001	REVU	10/28/2004

REV	DESCRIPTION	DATE
1.001	REVU	10/28/2004

APPROVALS	PCB DES. MEMBER	APP. ENG. MEMBER

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APPENDIX B

Be a Debug Ninja

Anyone who has ever brought up a complex board knows the soul crushing smell of burning plastic upon first power-up. Something unexpectedly goes haywire on the brand new board, and now it is time to break out the soldering iron and replace parts. The subsequent debug effort wastes time and distracts from the main development task. The LTC2937 is a fast, agile tool for debugging, making it much easier to avoid these situations, prevent damage to costly components, and turn a lengthy debug process into a quick audit of reported faults.

The LTC2937 detects several types of faults, and can be programmed to respond in helpful, protective ways. It can also capture information about what went wrong, pointing the way to the solution. Using The DC1613 I²C/SMBus/PMBus adapter and LTpowerPlay enable all of this.

Here are several common fault scenarios that the LTC2937 easily handles:

A Rail Shorted to Ground

Sometimes a board assembly error, manufacturing defect, or part malfunction causes one power supply rail to short to ground, preventing it from coming up at initial power-up. In this case, the power supply will not sequence up at all, and the LTC2937 will stop the sequence before anything else happens. Several bad things can be avoided. First, the failed power supply can be disabled before it damages itself or something else on the board. Second, the power supply sequencer can be halted before additional power supplies are enabled, avoiding out-of-order sequencing, which could potentially damage other devices.

Sometimes an older board will encounter a defect that shorts an operating power supply rail to ground. In this case, the LTC2937 can point-out the failed supply in one easy step, even if the failure is intermittent. The status registers capture the failure information, and can be read easily to see which supply failed.

A Rail Shorted to a High Voltage

One of the worst things that can happen to a power supply is overvoltage. If the supply is misconfigured, shorted to

another that pulls it up, or if it fails in such a way that it pulls itself up to a high voltage, the result can be damage to sensitive components, and expensive board rework.

The LTC2937 detects these overvoltage conditions, and immediately shuts down all supplies under its control. As long as the system is designed to respond effectively, the overvoltage fault can be contained and quickly mitigated. The LTC2937 also indicates which supply was overvoltage, even after all supplies have been disabled. This can protect the board and still provide debug information after the fact.

Too Much Load Current

In the event that a supply cannot deliver enough current to a load, the result may be a transient brownout; the supply dips momentarily below its operating specification. Transient conditions can be tough to debug, but the LTC2937 captures momentary phenomena and stores them for later. Because the STATUS_HISTORY register flags the first thing that went wrong, even if more bad things happen later, we can focus on what started the cascade instead of wasting time chasing elusive downstream effects of a supply glitch.

Rail Sequencing Dependencies

A common board configuration involves one or more intermediate bus voltages on a board, powering downstream regulators. A cascade of regulators must power up in order so that downstream devices can derive power from those up stream. If sequencing dependencies are not met, there may be no power available when a downstream regulator tries to start. In this case, the LTC2937 is very handy because not only does it make the sequence clear, it also makes it configurable and debuggable.

The LTC2937 can catch the fact that the upstream supply is not up in time, and prevent the downstream devices from enabling. It can also be programmed to force the downstream regulators to wait until the upstream regulator is up. Fault information is readily available in the status registers. When the problem is understood, fixing it is a simple matter of reconfiguring the LTC2937 registers – either changing sequence order, or changing sequence timing. No software or system design changes are necessary.

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Sequence Out of Order

There are any number of reasons that a power supply sequence may need to change after a board is assembled. Because the LTC2937 makes the sequence order and timing a matter of register configuration it is trivial to change at any point in the process. LTpowerPlay further simplifies the process by making it visual and user-friendly.

The LTC2937 has an advanced feature that enables single-stepping through the up and down sequences as they happen, making it easy to watch the system in slow motion and measure what it is doing as it comes up or goes down. The BREAK_POINT register controls this operation.

Trying to Sequence Up Before the Supplies have Discharged

A common worry in hot-swap cards is the possibility of removing power and quickly restoring it during a plug or un-plug event, either by contact bounce, or user action. This can cause the sequencer to try to go down, then up, then down again in rapid succession. If one or more supply rails on the card are not down when the sequencer tries to sequence up again, damage can occur.

The LTC2937 features the ability to force a complete down sequence before it tries to sequence up again. The ON_OFF_CONTROL[5] bit tells the sequencer to wait for discharge before sequencing up.

Discharge power supply output capacitance quickly by enabling the active discharge feature. Each of the six Vn inputs to the LTC2937 contains an optional active pull-down current source that is useful for bleeding off charge when the power supplies are disabled. Select this feature by setting SEQ_DOWN_POSITION_n[10] = 1'b1.

Configuring Registers for Debugging

The LTC2937 can operate completely autonomously, but when something goes wrong, it is good to stop the autonomous behavior and allow the operator to gather information. LTpowerPlay makes this easy. The appropriate response settings are contained in the FAULT_RESPONSE register.

Set FAULT_RESPONSE[4:3] = 2'b01 to immediate off and bits [2:0] = 3'b000, no retry. Alternatively, if it is better to keep the supplies enabled in the event of a fault, select bits

[4:3] = 2'b00, continue instead of immediate off. Because the LTC2937 clears much of its fault information when it restarts after a fault, it is usually best to stop and wait for the user to interact before proceeding.

With the DC1613 dongle attached to the I²C bus LTpowerPlay can read and write registers in the LTC2937. The visuals make it very easy to see what the system is doing³. In addition to directly reading and writing registers, the LTpowerPlay Chip Dashboard view presents most of the LTC2937 device status in one simple graphic, showing each comparator status and fault details in a cluster, showing the sequencer state, and a showing summary of fault and status bits. The user can use this information to quickly determine system health and operational status before parsing the specific status registers individually. Figure 12 shows an example in which all of the power supply channels are sequenced up, and the voltages are good, but there is historical fault information about a past undervoltage event on channel 4. All of this information is immediately visible on the dashboard.

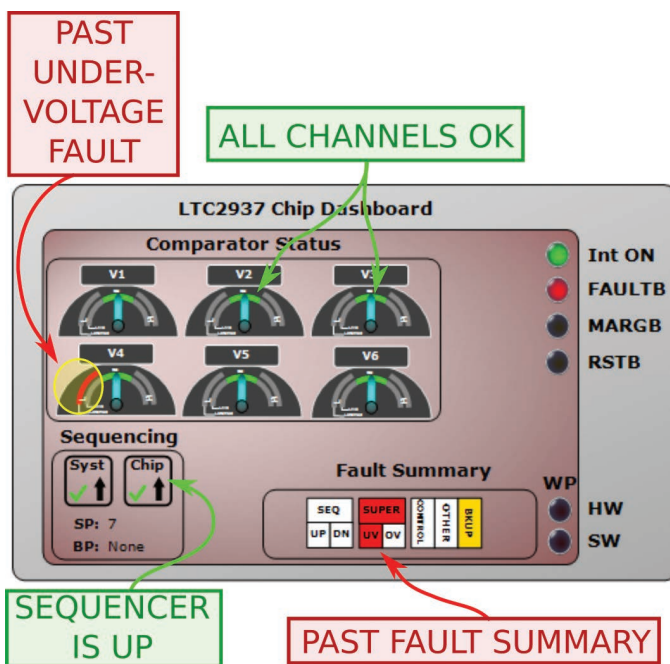


Figure 12. LTpowerPlay Chip Dashboard Showing Historical Fault Status Information in Red

Note 3. Together with LTpowerPlay, the LTC2937 makes debugging system power supply problems much easier and more effective, reducing costly board rework, and time to market.