Programmable Hex Voltage Supervisor Featuring the LTC2933 with EEPROM

DESCRIPTION

The DC1633B is a demonstration system that showcases the LTC®2933, a 6-channel I²C/SMBus voltage supervisor with EEPROM. The LTC2933 simultaneously monitors up to six power supply voltages and detects under/overvoltage conditions. In addition the LTC2933 monitors two GPI pins and is able to drive three GPIO pins to indicate OV, UV, system reset, system alert, or other control signal.

The DC1633B is a single circuit board that contains the LTC2933 and support circuitry to provide the ability to demonstrate features and capabilities of the LTC2933 without the need for external power supplies. The DC1633B demo board provides an accurate voltage supervision of six channels and offers over/undervoltage thresholds in various ranges and increments that are digitally programmable.

This demonstration system is supported by the LTpowerPlay™ graphical user interface (GUI) which enables complete control of all the features of the device. Together, the LTpowerPlay software and DC1633B hardware system create a powerful development environment for designing and testing configuration settings of the LTC2933. These settings can be stored in the device's internal EEPROM or in a file. This file can later be used to order pre-programmed devices or to program devices in a production environment. The software displays all of the configuration settings and real time measurements from the system supervisor and peripheral ICs. Telemetry allows easy access and decoding of the fault log created by the LTC2933. The board comes pre-programmed with the EEPROM values appropriate for the six power supply rails on the DC1633B. Just plug and play!

The LTC2933 chip is mounted on the topside of the board with support ADC and DAC circuitry on the back. The ADC provides voltage readings for all six voltage supervisor inputs on the LTC2933 and also reads the GPI and GPIO

voltages. The DAC drives five programmable voltages that are used to emulate the user's system rails. The extra support circuitry allows the user to evaluate the LTC2933 quickly and without the need for external voltmeters or power supplies.

The DC1633B demo board can be powered by an external power supply, such as a +12VDC supply. Communication with the software is provided through the DC1613 USB-to-I²C/SMBus/PMBus controller. The following is a checklist of items which can be obtained from the LTC website or LTC Field Sales.

- USB-to-I²C/SMBus/PMBus Controller (DC1613)
- LTpowerPlay Software

DC1633B Features

- Supervise Six Power Supplies
- Powered from USB Dongle, Power Jack, or V1-V4
- I²C Adjustable OV/UV Trip Points
- Guaranteed Threshold Accuracy ±1%
- I²C/SMBus Serial Interface
- Internal EEPROM
- 256 Programmable Thresholds per Channel
- Up to Three Range Settings per Channel
- Two General Purpose Inputs
- Three General Purpose Inputs/Outputs
- Programmable Output Delays
- Autonomous Operation without Additional Software
- Supported by LTpowerPlay GUI
- LTC2933 Available in 16-Lead DFN and SSOP Packages

Design files for this circuit board are available at http://www.linear.com/demo/DC1633B

PERFORMANCE SUMMARY

COMMON CHARACTERISTICS   **SPECIFICATIONS VALID OVER FULL OPERATING TEMPERATURE RANGE**

PARAMETER	CONDITIONS	VALUE			UNITS
		MIN	TYP	MAX	
Supply Input Voltage Range	V_{IN1}	3.4		13.9	V
	V_{IN2} through V_{IN4}	3.4		5.8	V
V1 Threshold Accuracy				±1.5	%
V1 Monitoring Range	Medium Range	1		5.8	V
	High Range	2.5		13.9	V
V2 to V6 Threshold Accuracy				±1.0	%
V2 to V6 Monitoring Range	Precision Range	0.2		1.2	V
	Low Range	0.5		3.0	V
	Medium Range	1.0		5.8	V

Table 1. Default Thresholds and GPIO Mappings

	Vn_THR_HI	Vn_THR_LO	GPIO1	GPIO2	GPIO3
	Default Thresholds		$\overline{OV}$	$\overline{ALERT}$	$\overline{UV}$
V1	5.5	4.5	Comp_Hi	Comp_Hi	Comp_Lo
V2	2.6V	2.4V	Comp_Hi	Comp_Hi	Comp_Lo
V3	2.1V	1.9V	Comp_Hi	Comp_Hi	Comp_Lo
V4	1.6V	1.4V	Comp_Hi	Comp_Hi	Comp_Lo
V5	1.3V	1.1V	Comp_Hi	Comp_Hi	Comp_Lo
V6	1.05V	0.95V	Comp_Hi	Comp_Hi	Comp_Lo

Table 2. Default GPI Settings

	MANUAL RESET	MARGIN	$\overline{UVDISABLE}$	AUX COMP
GPI1	✓			
GPI2		✓		

GLOSSARY OF TERMS

The following list contains terms used throughout the document.

AUXC: Auxiliary Comparator. A GPI pin may be programmed to this function and map behavior to a GPIO pin. Nominal V_{TH} = 0.5V.

EEPROM: Non-volatile memory (NVM) storage used to retain data after power is removed.

Margin: Term used typically in board level testing that increases/decreases the output voltage to look for sensitivity/marginality problems.

$\overline{MARG}$: Ignore OV and UV faults when active (low). A GPI pin may be programmed to this function and map behavior to a GPIO pin. Nominal V_{TH} = 1.0V.

$\overline{MR}$: Manual Reset, Active Low. A GPI pin may be programmed to this function, map behavior to a GPIO pin, and optionally clear the fault history. Nominal V_{TH} = 1.0V.

NVM: Non-Volatile Memory, See EEPROM.

OV: Overvoltage. The result of a voltage comparison that a pin voltage is above a programmable threshold voltage.

Rail: The final output voltage that the LTC2933 supervises.

Supervise: The act of quickly responding (compared to a fault setting) to a voltage that is compared to pre-programmed values.

UV: Undervoltage. The result of a voltage comparison that a pin voltage is below a programmable threshold voltage.

$\overline{UVDIS}$: UV Disable. Ignore UV faults when the pin is low. A GPI pin may be programmed to this function and map behavior to a GPIO pin. Nominal V_{TH} = 1.0V.

THEORY OF OPERATION

GENERAL DESCRIPTION

The LTC2933 is a hex voltage supervisor which detects an over or undervoltage and signals the system of a fault condition. It does not have a dedicated power supply pin. The chip is powered from the highest voltage applied to V1 through V4, as long as one of these voltages is > 3.4V.

THE CHIP

The LTC2933 integrates six voltage supervisors, two GPIs, and three GPIOs. The V1-V6 supervisors are comprised of OV/UV window comparators that can be programmed to map the detection of a fault to one or more GPIO pin.
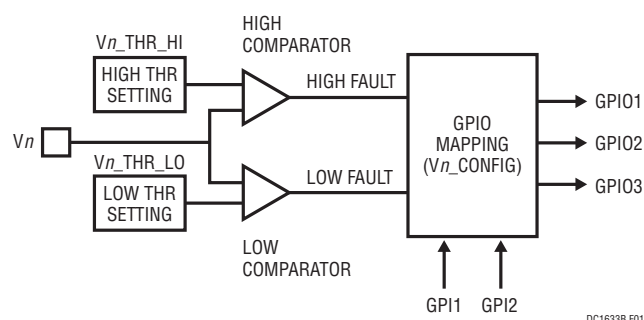
Figure 1. Simplified Block Diagram of Voltage Supervisor Input

In LTpowerPlay, the user programs each voltage supervisor's range, polarity, mapping, and high and low threshold voltages.

Each channel's high/low comparators may be mapped to any GPIO pin, and any comparator may be mapped to multiple GPIO pins. Typically the high comparator is used for the overvoltage condition and the low comparator is used for the undervoltage condition. The high comparator is not dedicated to OV detection nor is the low comparator dedicated for UV detection. For example, both comparators may be configured as OV with the Vn_THR_HI set to indicate an OV Fault and the Vn_THR_LO set for an OV Warning.

The simplified diagram of a GPIO pin shows that the pin may be configured as an active-high or active-low input with optional pullup, or as an active-high or active-low output with optional latched output.
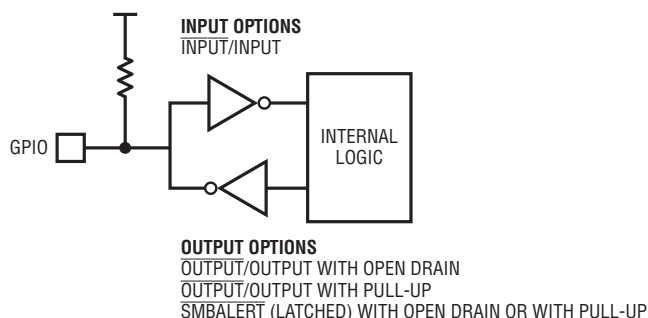
The GPI input pins can be used to override fault conditions by configuring them as $\overline{\text{MARG}}$ or $\overline{\text{UVDIS}}$. The active-low $\overline{\text{MARG}}$ function allows the LTC2933 to ignore OV and UV conditions. The active-low $\overline{\text{UVDIS}}$ function is a special case of the $\overline{\text{MARG}}$ function. It allows the device to ignore UV conditions. The simplified diagram of a GPI pin shows the four configurable options: Manual Reset, Margin, UV Disable, and AUXC. The AUXC option does not provide an internal pull-up.
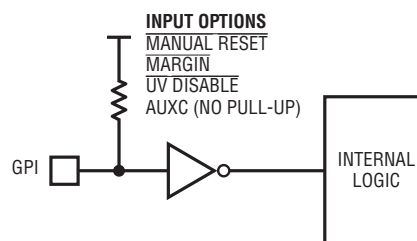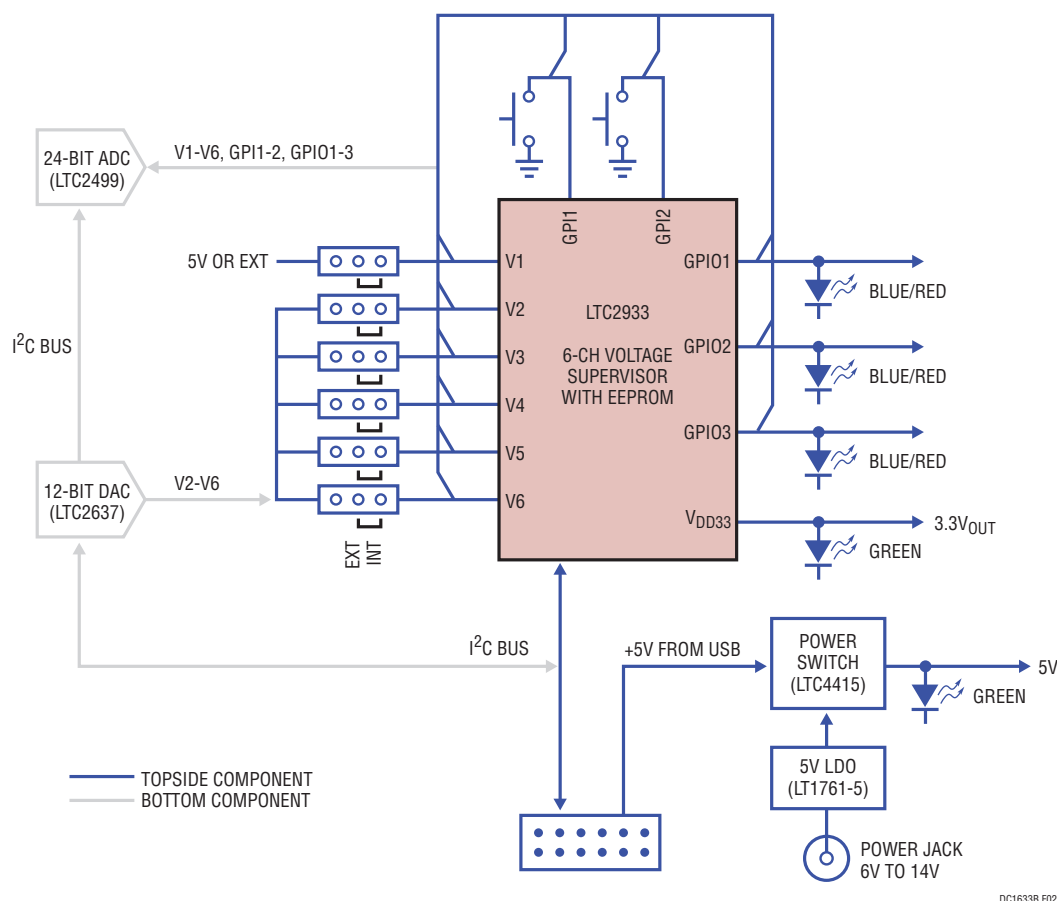
THEORY OF OPERATION

Figure 2. Simplified Block Diagram of the DC1633B

THE BOARD

The LTC2933 chip is mounted on the topside of the board with support ADC and DAC circuitry on the back. The support circuitry is powered from +5V.

The ADC provides voltage readings for all six voltage inputs to the LTC2933 and also reads the GPI and GPIO voltages for a total of eleven. Although the ADC updates at a relatively slow rate, it provides the equivalent of eleven 4½-digit digital multimeters. The simplest demonstration of the DC1633B is to power and control the board via the DC1613 USB controller. The controller provides 5V supply and I²C/SMBus read/write control. This setup provides a quick and easy way to demonstrate the LTC2933's capabilities.

One LTC2499 (ADC) =

One LTC2637 (DAC)

The multi-channel DAC emulates a 5-channel programmable power supply that is used to place "rail" voltages at levels that replicate the user's system rails. This avoids the need for the user to wire actual supply rails to the demo board. However, the board was designed to allow this use case. The DAC output range is 0V to 4V. This is sufficient for demo purposes. Simply place the V2-V6 jumpers to "INT" for internal DAC use, and set to "EXT" if an external supply is provided on the turret.

dc1633bf

THEORY OF OPERATION

POWERING THE BOARD

The DC1633B board can be powered from the DC1613 USB's 5V power or from a wall-powered 12V supply (jack). The LTC2933 hex supervisor can be powered in a number of different ways. The chip itself is powered by any of the inputs V1 through V4, as long as one is above 3.4V. There is a table silk-screened onto the board as a reminder. An internal diode-OR circuit automatically selects the highest voltage of the four inputs. If the USB power or jack power is present, the +5V LED will illuminate. The LTC2933 can then be powered by setting the jumper to "INT 5V". Alternatively set the jumper to "V1 EXT" to connect an external power supply voltage to the V1 EXT turret. The board comes pre-configured with jumpers JP1-JP6 set to the INTERNAL position which allows the on-board 5V LDO regulator to power all circuits.

NOTE: *Turrets V2-V6 are tied directly to the LTC2933 independent of the jumper settings. Turret "V1 EXT" is connected to the V1 pin when the jumper is set to V1 EXT and is not connected to the V1 pin when the jumper is set to "INT 5V". To monitor the V1 pin voltage with a scope probe or DMM, a test point is provided next to the jumper.*

The DC1633B uses a multiplexed ADC that is used to provide voltage readback values. Due to the nature of a multiplexed ADC converter, it has an associated ADC loop time. The total ADC loop time is ~400ms for a given channel. You may notice some lag in the update rate of the displayed voltages.

SELECTING A DEVICE ADDRESS

The DC1633B has a jumper (JP7) labeled ASEL which allows the user to select one of three I^2C addresses. See Table 3.

Table 3. Address Selection of LTC2933

I^2C ADDRESS (7-BIT)	POSITION	DEFAULT
0x1C	L	✓
0x1D	Z	
0x1E	H	

Regardless of the jumper setting, the part will always respond to the I^2C global 7-bit addresses 0x0C and 0x1B.

STATUS_WORD REGISTER

To clear a fault, the user may click the CF icon in the GUI or simply push the RESET pushbutton on the demo board. In both cases, the red (+) on the CF icon and alert LED on the board will be cleared. You will notice that all rails are automatically re-enabled after a programmable retry period. The alert LED may be cleared by clicking the Clear Faults (CF) icon in the GUI. After clearing faults, the system tree may remain "yellow" if any non-volatile fault logs are present.

RESTORING RAM AND GUI FROM LTC2933

To restore the operating memory (RAM) from the LTC2933 EEPROM contents, click the "R" NVM-to-RAM icon in the toolbar. To read the RAM registers into the GUI, click the "R" RAM-to-PC icon in the toolbar.

THEORY OF OPERATION

DC1633B LEDS

The DC1633B board has two green LEDs. When USB power (DC1613 Controller) or external power (6V-14V jack) is applied, the +5V green LED will illuminate. The +5V supply provides power to the support circuitry, not necessarily to the LTC2933. The default setting of jumper JP1 is set to internal 5V and the +3.3V OUT LED will illuminate, indicating the LTC2933 is powered. This LED is not a power good indicator and may falsely indicate proper operation when dimly lit. It may be slightly illuminated if the highest voltage on the V1-V4 inputs are set as low as 1.8V. At this point, the LTC2933 is not in a functioning state, the I^{2}C bus will not communicate with the GUI, and the LTC2933 will be grayed out in the system tree.

DC1633B ToolWindow and GUI Indicators

The ToolWindow displays the ADC readings on the left and DAC voltage settings on the right. The blue/red indicators next to the GPIs and GPIOs display the state (H vs L) and voltage reading from the ADC (LTC2499). Blue indicates a logic high and red indicates a logic low. The ToolWindow is automatically populated when LTpowerPlay detects the DC1633B demo board when it starts.
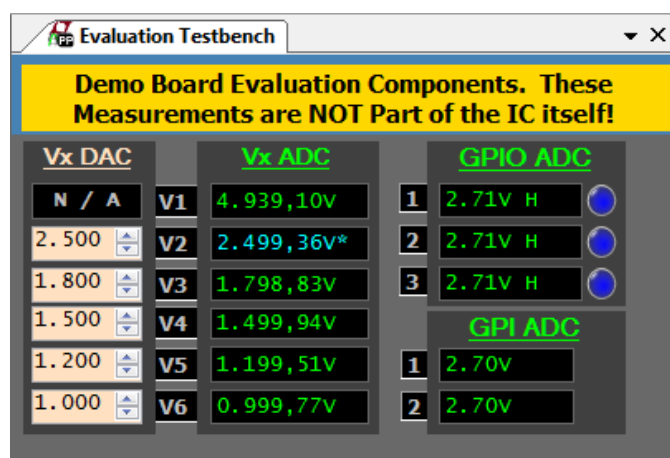
LTpowerPlay GUI SOFTWARE

LTpowerPlay is a powerful Windows-based development environment that supports Linear Technology Power System Management ICs with EEPROM, including the LTC2933 6-channel voltage supervisor. The software supports a variety of different tasks. You can use LTpowerPlay to evaluate Linear Technology ICs by connecting to a demo board system. LTpowerPlay can also be used in an offline mode (with no hardware present) in order to build a multi-chip configuration file that can be saved and reloaded at a later time. LTpowerPlay provides unprecedented system level diagnostic and debug features. It becomes a valuable diagnostic tool during board bring-up to program or tweak the power management scheme in a system or to diagnose power issues when bringing up rails. LTpowerPlay utilizes the DC1613 I^2C/SMBus/PMBus controller to communicate with one of many potential targets, including the DC1633B demo system or a customer board. The software also provides an automatic update feature to keep the software current with the latest set of device drivers and documentation. The LTpowerPlay software can be downloaded from:

http://www.linear.com/ltpowerplay

To access technical support documents for LTC Power System Management Products visit "Help, View Online Help" on the LTpowerPlay menu.
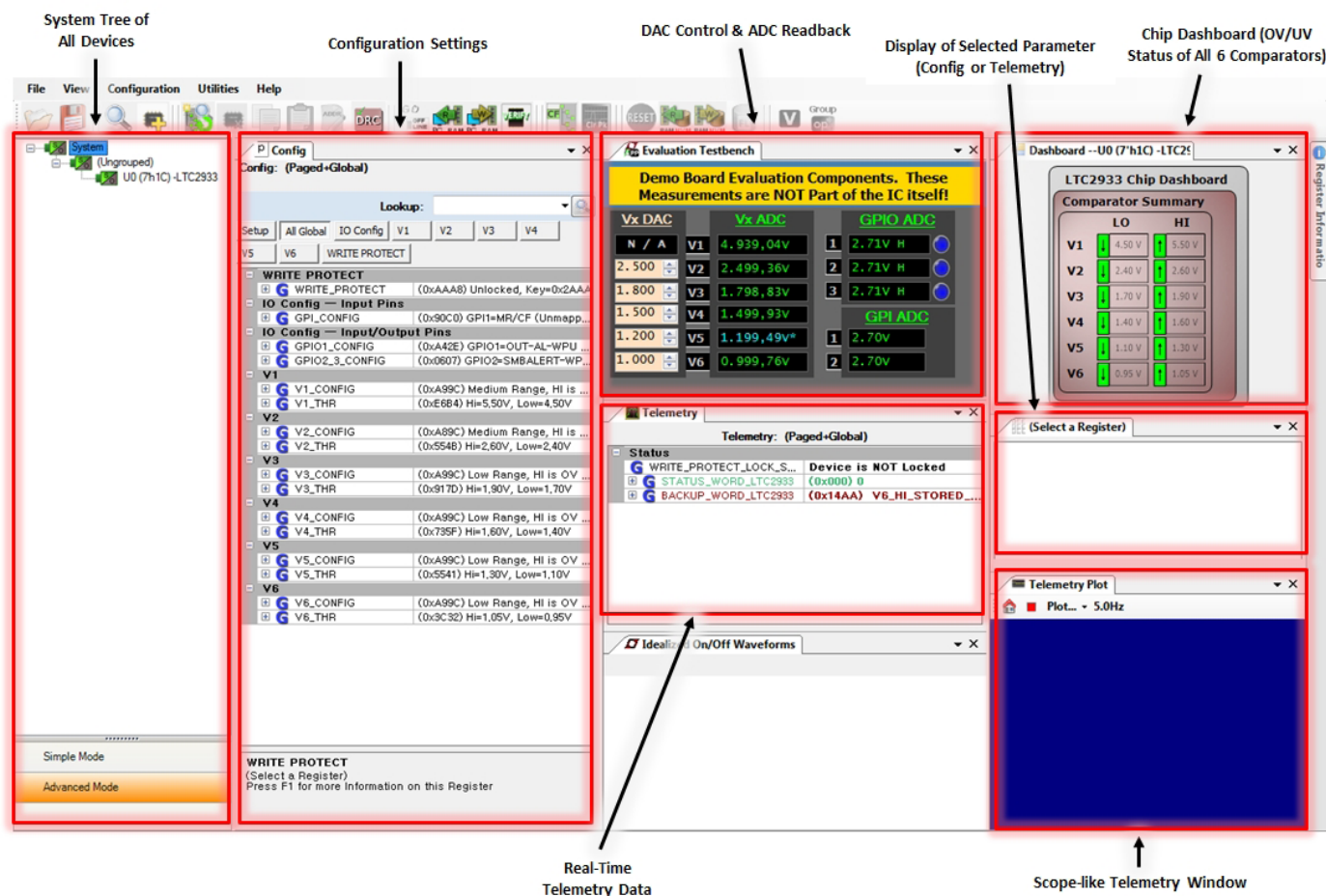
Figure 3. Screenshot of the LTpowerPlay GUI

QUICK START PROCEDURE

The following procedure describes how to set up a DC1633B demo system.

1. Download and install the LTpowerPlay GUI:

   www.linear.com/ltpowerplay

2. Remove the board from the ESD protective bag and place it on a level surface. Connect the DC1613 I^2C/SMBus/PMBus Controller to the DC1633B board using the 12-pin ribbon cable.
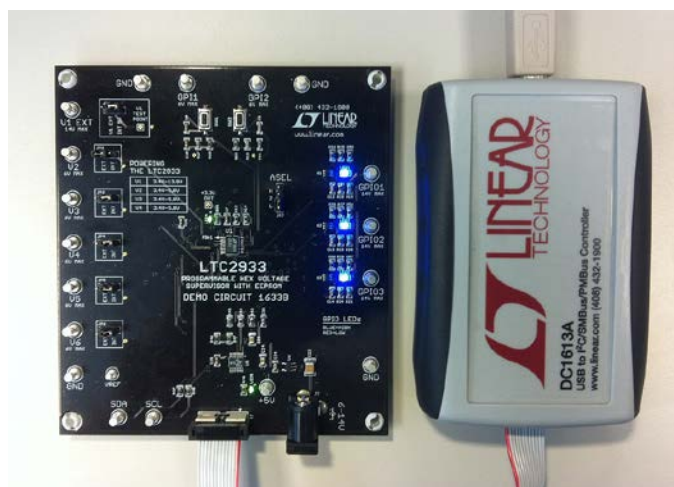
Figure 4. Connecting DC1633B Board and the DC1613 USB to I^2C/SMBus/PMBus Controller

3. Plug the USB-to-I^2C/SMBus/PMBus Controller into a USB port on your PC. The board should power up with +5V and +3.3V OUT LEDs illuminated green. The GPIO LEDs will illuminate blue.

4. Launch the LTpowerPlay GUI.

   a. The GUI automatically identifies the DC1633B and builds a system tree for each I^2C device. The system tree on the left hand side will look like this:
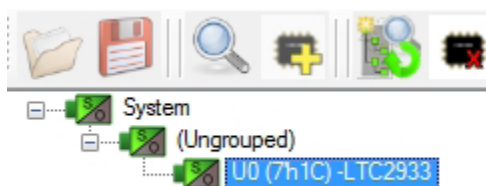
   b. A green message box will be displayed momentarily in the lower left hand corner confirming that the DC1633B is communicating.

5. Load the Demo Configuration.

   In the upper left hand corner of the GUI, select File > Initialize DC1633B Demo > Demo Config (or Factory Defaults). This will load the configuration settings into the working RAM of the LTC2933, set the DAC outputs, clear the status registers, and store the settings into NVM (EEPROM). The 'Demo Config' file is the starting point for the use cases. The 'Factory Defaults' file sets the Vn thresholds that accommodate the initial powerup state of the DAC outputs (2.048V).

SAVING A CONFIGURATION

You can make changes to the LTC2933 register values and DAC settings. Save the demo board configuration to a (*.proj) file by clicking the "Save" icon. This creates a backup file. Name it whatever you like. Note that the DAC settings are saved in the project file.
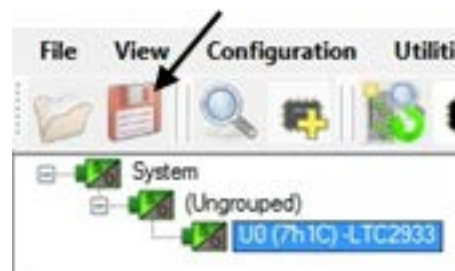
QUICK START VIDEO

There is a Quick Start video that covers the basic features of the LTC2933 chip and DC1633B demo board. The video can be accessed via LTpowerPlay by navigating to the Help menu > DC1633B.
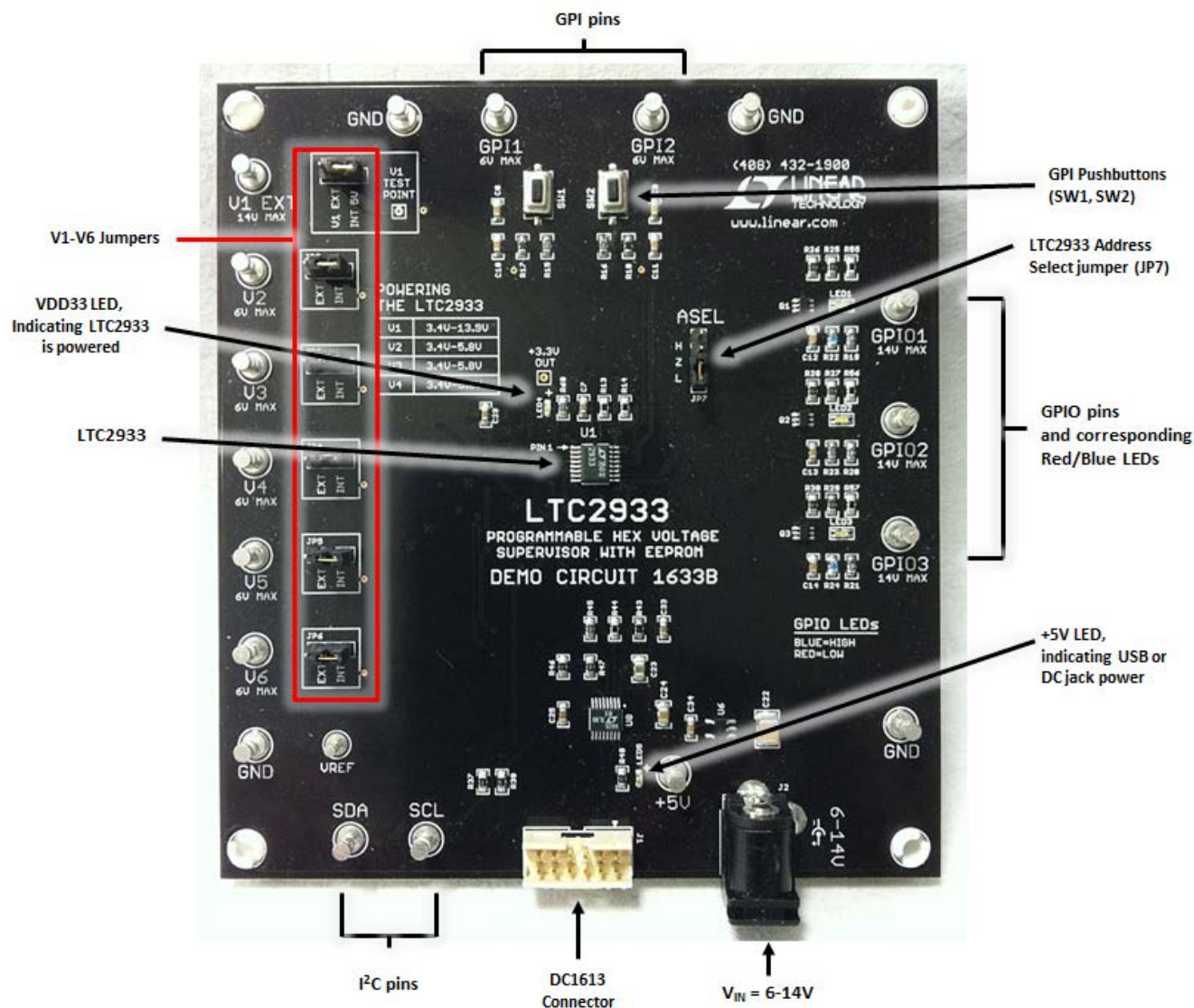
DC1633B DETAILS – TOP SIDE

Figure 5. DC1633B Top Side Details

Table 2. Default Jumper Configuration

REFERENCE DESIGNATOR	SIGNAL NAME	USAGE	DEFAULT
JP1	V1	Selects Internal 5V vs External "V1 EXT" Turret Power	INT 5V
JP2–JP6	V2–V6	Selects Internal vs External Voltage	INT
JP7	ASEL	Selects H/Z/L for LTC2933 Slave Address	L

DEMO BOARD USE CASES

USE CASE #1

A common configuration for the LTC2933 dedicates the V1 pin to the highest supply in the system and uses V2-V6 to monitor other voltages. The V1 pin provides power to the chip and also is used to detect an OV or UV on the V1 pin. For simplicity, the USB controller (DC1613) powers the board and the LTC2933 is powered via the V1 pin with the jumper set to INT 5V.

Each of the high comparator fault outputs is mapped to GPIO1, indicating an active-low OV fault. Each of the low comparator fault outputs are mapped to GPIO3, indicating an active-low UV fault. These OV and UV conditions are indicated in multiple places – LEDs next to the GPIO turrets and also in the GUI. The GPIO2 pin has been mapped as an active-low latched OV indicator. The latched ALERT is cleared by pressing the GPI1 pushbutton. The GPIO pins have a red-blue LED which is red when low and blue when high.

The two GPI inputs are used to detect a Manual Reset (MR) and Margin disable (MARG) and activated when the pushbutton switches are depressed.

GPIO1 → $\overline{\text{OV}}$ fault

GPIO2 → $\overline{\text{ALERT}}$ (latched)

GPIO3 → $\overline{\text{UV}}$ fault

GPI1 → $\overline{\text{MR}}$ (manual reset)

GPI2 → $\overline{\text{MARG}}$ (ignore OV/UV when margining)

Let's margin V5 and V6 low by typing a value of 1V and 0.9V into the respective DAC control boxes. You may also move the DAC output by clicking the up/down arrows on the individual DAC box or by double-clicking the DAC value and entering a new value in the box. V5 and V6 will report a $\overline{\text{UV}}$, turning the LED on

GPIO3 red. The dashboard in the GUI indicates the V5 and V6 voltages are below the LO thresholds of 0.95V

and 1.1V. Also notice in the Telemetry window a STATUS_WORD register, expand it. This register is a live indicator of LO or HI fault conditions. Note the state of LO_FAULT bits when the margin low button is selected. We can demonstrate the effect of the GPI2 pushbutton at this point. The GPI2 pin

has been programmed to function as $\overline{\text{MARG}}$, enabling the LTC2933 to ignore all UV conditions. Notice that when the pushbutton is depressed, GPIO3 returns high (blue). This is useful when the system does not want to be informed of a UV condition during margin low testing. Moving the DAC voltages back to 1.2V and 1V returns GPIO3 to a high state (blue), indicating there is no $\overline{\text{UV}}$ condition.

Let's margin V5 and V6 high by typing a value of 1.4V and 1.1V into the respective DAC control boxes. V5 and V6 will report an $\overline{\text{OV}}$ in the GUI and on the demo board. Both GPIO1 and GPIO2 LEDs will turn red and the dashboard indicates an OV condition and a latched $\overline{\text{ALERT}}$. Note the state of HI_FAULT bits in the STATUS_WORD register. When the GPI2 button is pushed, the GPIO1 (OV) LED is returned to blue and the STATUS_WORD reflects

DEMO BOARD USE CASES

the $\overline{\text{MARG}}$ pin as well, clearing the HI_FAULT bits. We can now change the DACs back to 1.2V and 1.0V. The OV condition is no longer present, however $\overline{\text{ALERT}}$ (GPIO2) remains latched low. Since the GPI1 pin is defined as a Manual Reset, pressing this button clears the latched ALERT, turning GPIO2 LED blue which indicates a deasserted high state.

USE CASE #2

The DC1633B demo board can be configured to supervise external supply voltages. Inputs V2-V6 may be used for this purpose. Simply move the jumper from INT to EXT which disconnects the backside DAC, allowing an external voltage to be applied to the LTC2933. Please ensure the max ratings on the turrets are not exceeded, most of which are 6V. For simplicity, the V1 jumper will remain in the INT 5V position to power the LTC2933. However, in an actual application, the device is powered from the highest voltage on the V1-V4 pins, assuming at least one is above 3.4V.

Apply an external supply voltage to the turret. It is recommended to drive V1-V4 turrets with a low impedance (<10Ω) voltage source. A sensor or other moderate source impedance voltage may be supervised on V5 or V6 inputs. A battery voltage may be supervised on V1-V4 and power the chip since the LTC2933 supply current is <700µA.

For example, a +5V external supply may be connected to turret V2. Notice the GPIO1 and GPIO2 LEDs turn red, indicating $\overline{\text{OV}}$ and $\overline{\text{ALERT}}$ are asserted low. The V2 thresholds need to be changed. Enter 5.5V and 4.5V for the HI and LO threshold settings. The GPIO1 will return high and the LED will change to blue but the GPIO2 remains low (red) since it indicates a latched ALERT. Press the MR pushbutton on GPI1 to release GPIO2 back high (LED blue).

The GPI inputs may also be used to monitor external voltages. These pins can be configured as an auxiliary comparator (AUXC). In this mode, the GPI pin voltage is compared to an internal 0.5V reference. Typically an external voltage divider is provided to obtain the appropriate trip point for the external voltage. The GPI comparators can be mapped to one of the GPIOs to alert the system of an over or undervoltage condition.

# DEMO BOARD USE CASES

USE CASE #3

Another common configuration is one that uses a GPIO pin to drive a system reset. The LTC2933 data sheet shows this feature throughout. The other two GPIOs are configured as previously shown, $\overline{OV}$ and $\overline{ALERT}$. Additionally a manual reset pushbutton (GPI1) asserts the system reset.
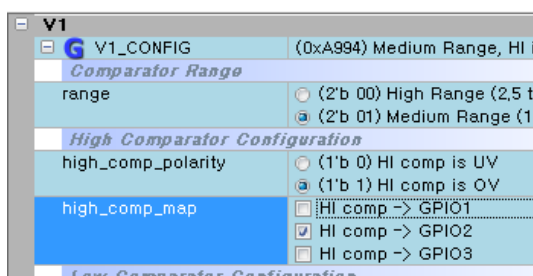
GPIO1 → $\overline{RST}$ (system reset)

GPIO2 → $\overline{OV}$

GPIO3 → $\overline{ALERT}$

GPI1 → $\overline{MR}$ pushbutton
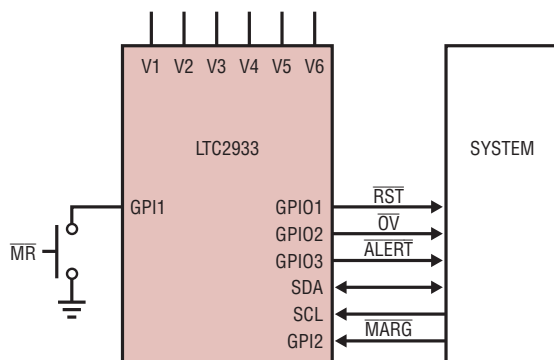
1. To program GPIO1 to system reset function, first uncheck the mapping of all V1-V6 channels to GPIO1.

2. Configure GPI1 as a Manual Reset. Map GPI1 to GPIO1.
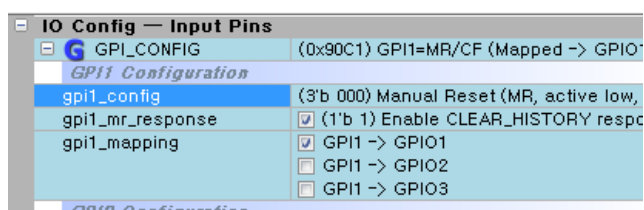
3. Configure GPIO1 as active-low with weak pull-up. To update the changes made in steps 1-3, click the Write All Registers (PC->RAM) icon.
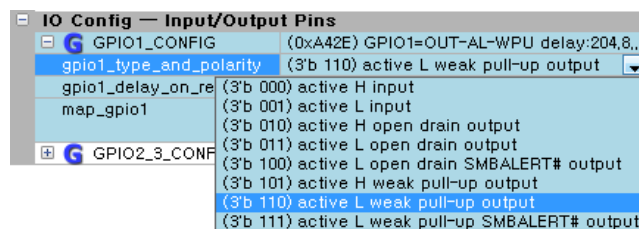
4. You can optionally extend the low time of the system reset by changing the *delay-on-release* setting to ensure a clean release of reset. This provides a time-based debounce of the switch.

When configured in this way, GPIO1 provides a system reset for the host processor and GPI1 can drive a system reset (GPIO1) with a push of a button. You may set the GPIO1 delay-on-release time to 410ms to experience the extended reset firsthand. The UV condition indicator remains on GPIO3. The OV condition is indicated as a latched $\overline{ALERT}$ on GPIO2. When the GPI1 pushbutton is pressed, a system reset is asserted on GPIO1 and the $\overline{ALERT}$ is released if the OV condition is removed.

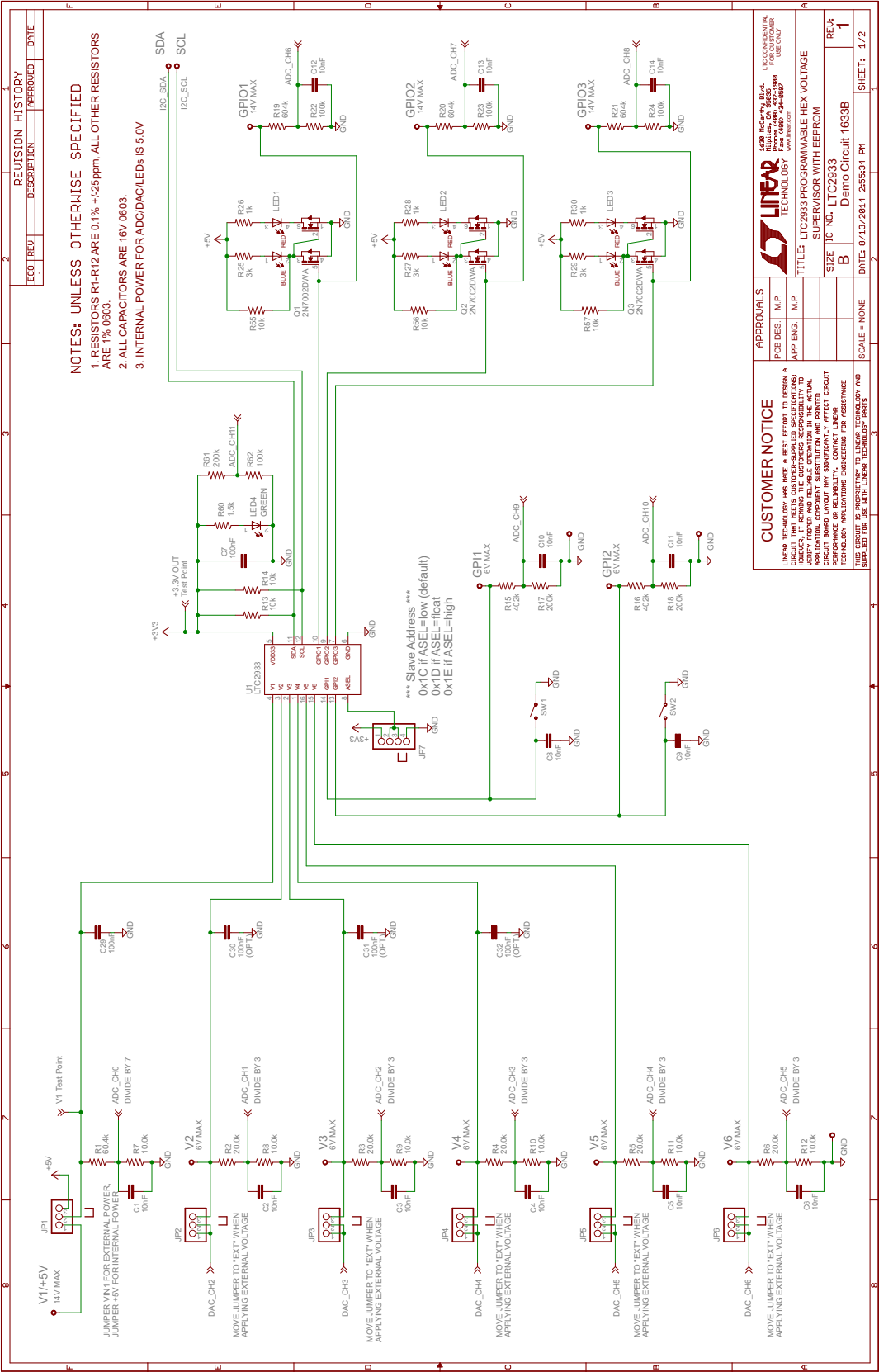# DC1633B DETAILS – TOP
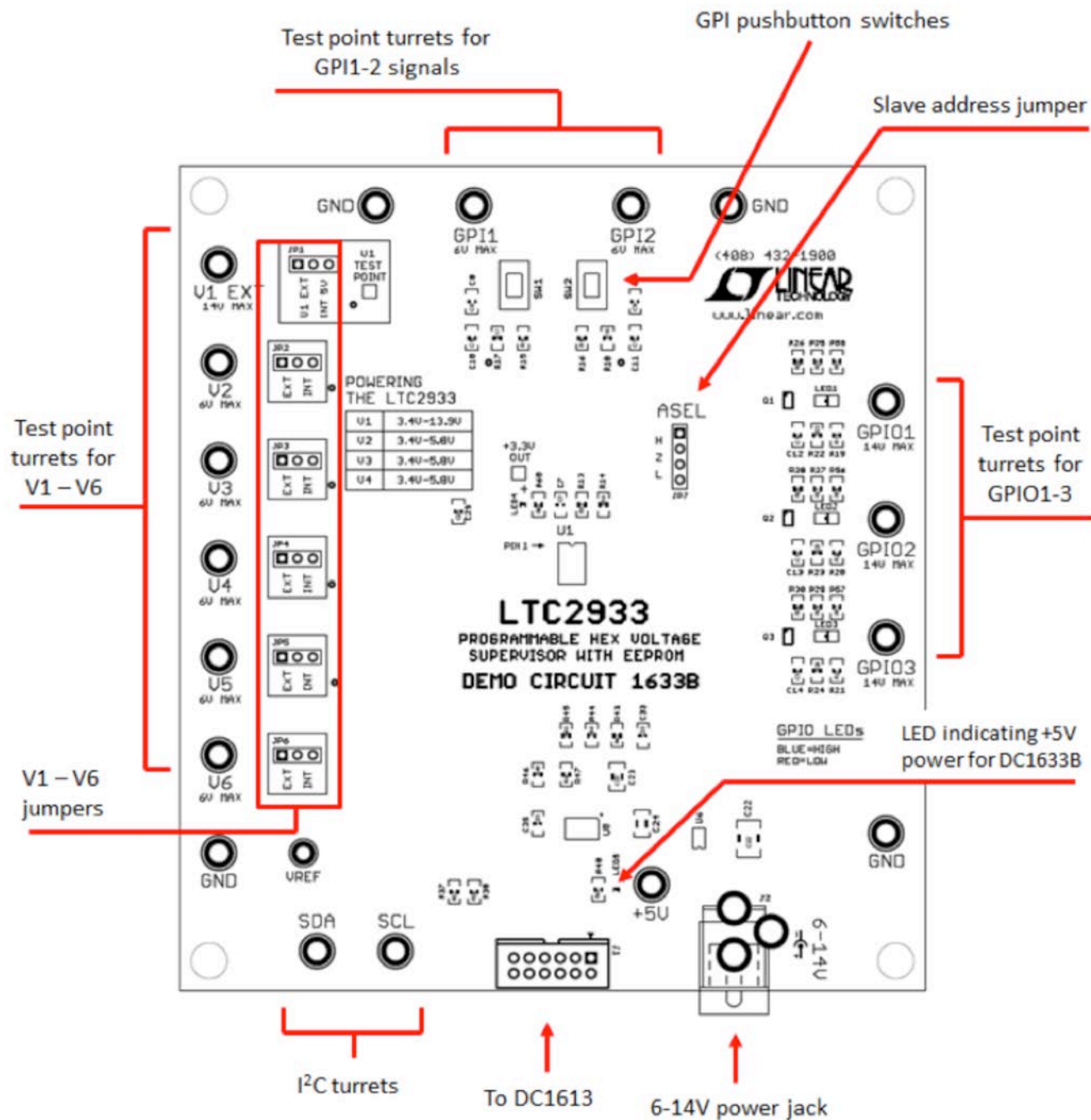
DC1633B DETAILS – BOTTOM
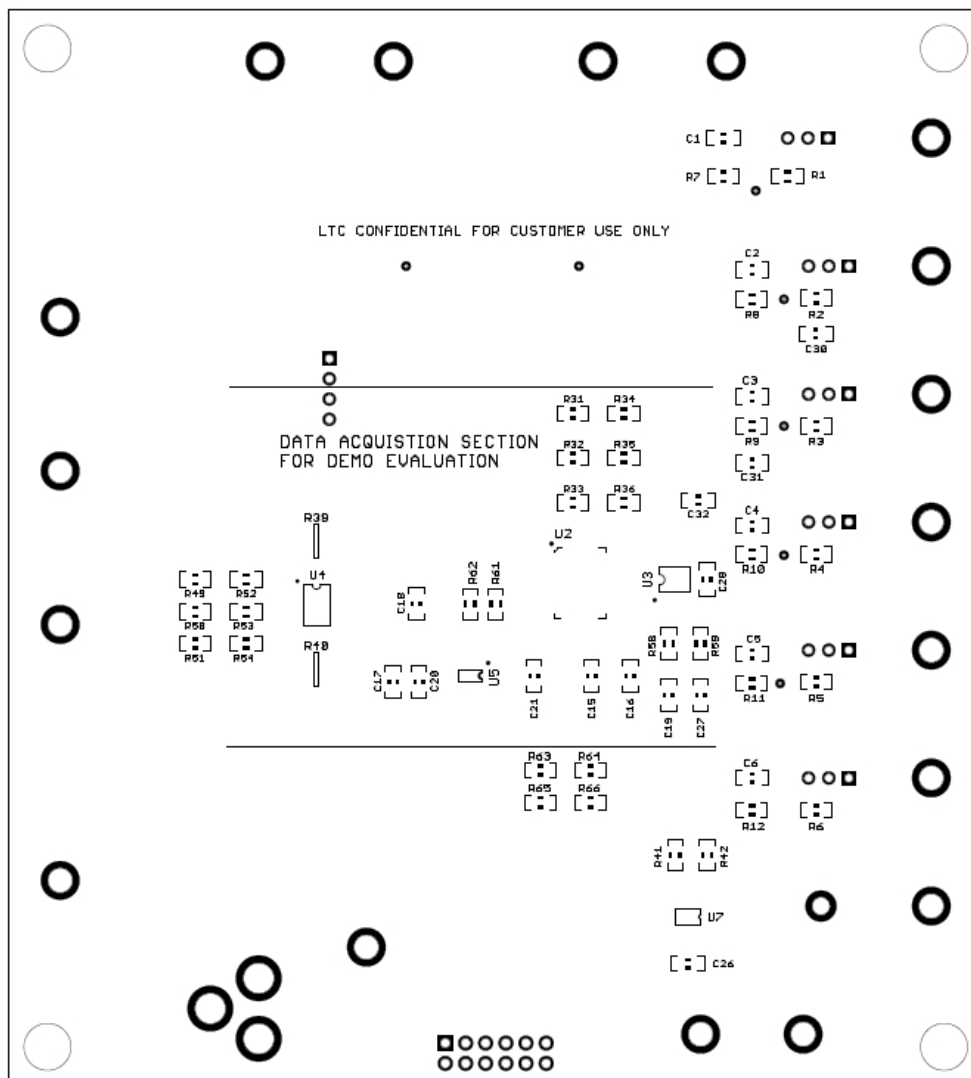
PARTS LIST

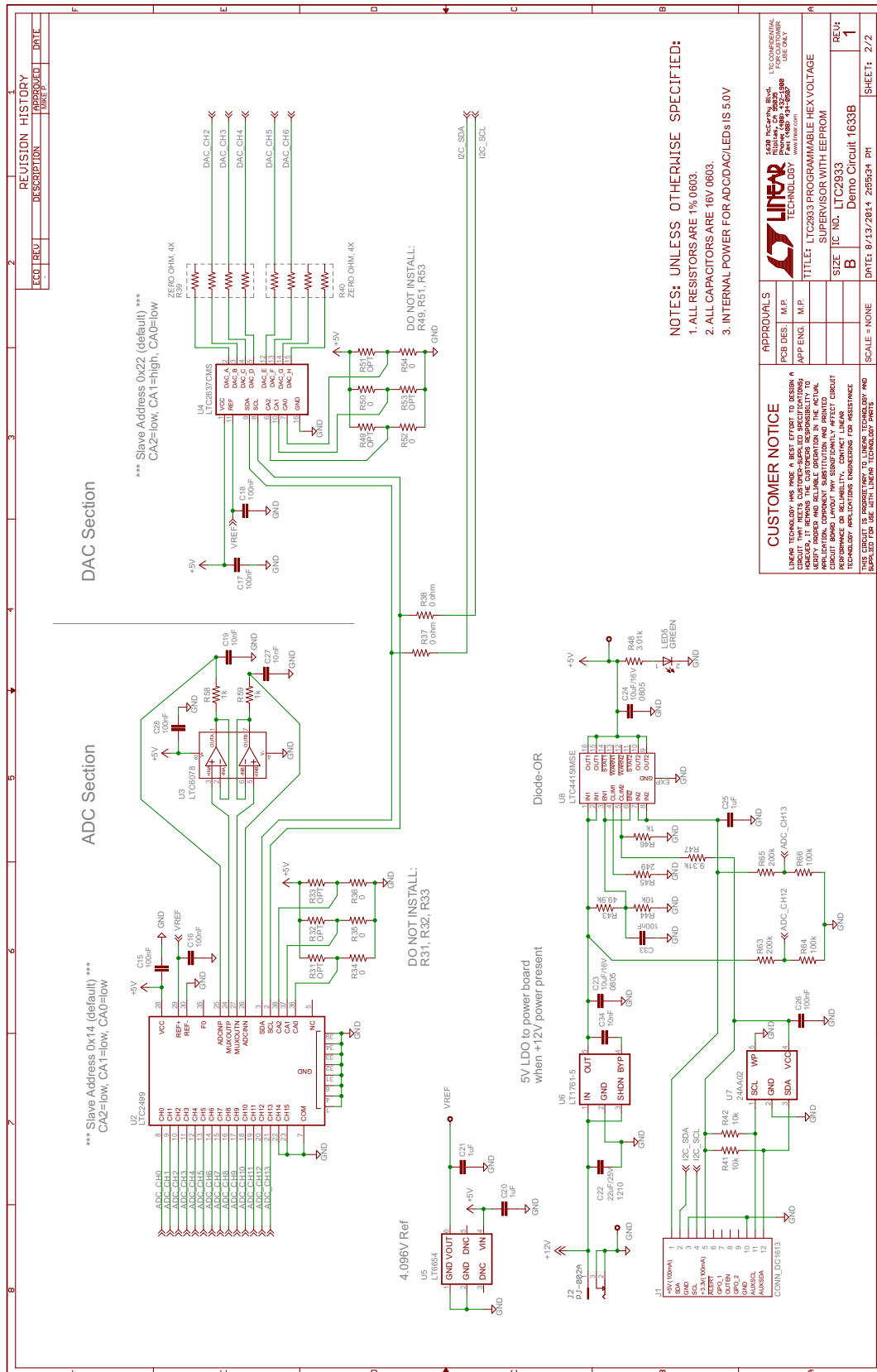| ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Circuit Components				
1	1	U1	IC PROG HEX VOLT SUPERVISOR EEPROM SSOP16	LINEAR: LTC2933CGN#PBF
Additional Demo Board Circuit Components				
2	16	C1, C2, C3, C4, C5, C6, C8, C9, C10, C11, C12, C13, C14, C19, C27, C34	CAP CER 10nF 25V 10% X7R 0603	MURATA: GRM188R71E103KA01D
3	9	C7, C15, C16, C17, C18, C26, C28, C29, C33	CAP CER 100nF 16V 10% X7R 0603	MURATA: GRM188R71C104KA01D
4	3	C20, C21, C25	CAP CER 1µF 16V 10% X7R 0603	MURATA: GRM188R71C105KA12D
5	1	C22	CAP CER 22µF 25V 10% X5R 1210	MURATA: GRM32ER61E226KE15L
6	2	C23, C24	CAP CER 10µF 16V 10% X5R 0805	MURATA: GRM21BR61C106KE15L
7	0	C30, C31, C32 (OPT.)	CAP CER 100nF 16V 10% X7R 0603	
8	3	LED1, LED2, LED3	LED-DUAL-COLOR 1.6mm × 0.8mm RED-BLUE	KINGBRIGHT: APHB1608QBDSURKC
9	2	LED4, LED5	LED GREEN SS TYPE BRIGHT SMD	PANASONIC: LNJ326W83RA
10	3	Q1, Q2, Q3	MOSFET NCH DUAL 60V 180MA	DIODES INC: 2N7002DWA-7
11	1	R1	RES 60.4kΩ 0.1W 0.1% ±25ppm 0603 SMD	PANASONIC: ERA-3AEB6042V
12	5	R2, R3, R4, R5, R6	RES 20.0kΩ 0.1W 0.1% ±25ppm 0603 SMD	PANASONIC: ERA-3AEB203V
13	6	R7, R8, R9, R10, R11, R12	RES 10.0kΩ 0.1W 0.1% ±25ppm 0603 SMD	PANASONIC: ERA-3AEB103V
14	8	R13, R14, R41, R42, R44, R55, R56, R57	RES 10.0kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW060310K0FKEA
15	2	R15, R16	RES 402kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW0603402KFKEA
16	5	R17, R18, R61, R63, R65	RES 200kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW0603200KFKEA
17	3	R19, R20, R21	RES 604kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW0603604KFKEA
18	6	R22, R23, R24, R62, R64, R66	RES 100kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW0603100KFKEA
19	4	R25, R27, R29, R48	RES 3.0kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW06033K00JNEA
20	6	R26, R28, R30, R46, R58, R59	RES 1.0kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW06031K00JNEA
21	0	R31, R32, R33, R49, R51, R53 (OPT.)	RES 0Ω 0603 SMD (OPTIONAL)	
22	8	R34, R35, R36, R37, R38, R50, R52, R54	RES 0Ω 0.1W 0603 SMD	VISHAY: CRCW06030000Z0EA
23	2	R39, R40	0Ω RESISTOR ARRAY, 4 RES, 1206	PANASONIC: EXB-38VR000V
24	1	R43	RES 49.9kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW060349K9FKEA
25	1	R45	RES 249Ω 0.1W 1% 0603 SMD	VISHAY: CRCW0603249RFKEA
26	1	R47	RES 9.31kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW06039K31FKEA
27	1	R60	RES 1.50kΩ 0.1W 1% 0603 SMD	VISHAY: CRCW06031K50JNEA
28	1	U2	IC ADC 24-BIT DELTA SIGMA 16-CH WITH I^{2}C	LINEAR: LTC2499CUHF#PBF
29	1	U3	IC OPAMP DUAL MICROPOWER	LINEAR: LTC6078CMS8
30	1	U4	IC DAC 12BIT OCTAL WITH I^{2}C	LINEAR: LTC2637CMS-HMX12
31	1	U5	IC VREF SERIES PRECISION REFERENCE	LINEAR: LT6654AMPS6-4.096
32	1	U6	FIXED 5V 100mA MICROPOWER LDO	LINEAR: LT1761ES5-5#PBF
33	1	U7	2K-BIT I^{2}C SERIAL EEPROM	MICROCHIP: 24AA02T-I/OT
34	1	U8	DUAL 4A IDEAL DIODES with ADJ CURR LMT	LINEAR: LTC4415IMSE#PBF

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Hardware - For Demo Board Only				
35	1	J1	CONN HEADER 12POS 2MM STR DL PCB	FCI: 98414-G06-12ULF
36	1	J2	CONN PWR JACK 2.1mm × 5.5mm HIGH CUR	CUI INC: PJ-002AH
37	6	JP1-JP6	2mm PIN HEADER 1×3	SULLINS: NRPN031PAEN-RC
38	1	JP7	2mm PIN HEADER 1×4	SULLINS: NRPN041PAEN-RC
39	4	MH1-MH4	SPACER STACKING #4 SCREW NYLON	KEYSTONE: 8831
40	2	SW1, SW2	BLK SWITCH TACTILE SPST-NO 0.05A 12V	C&K: PTS635SL25SMTR LFS
41	18	TP1-TP18	TERM SOLDER TURRET .219"H .109"L	MILL MAX: 2501-2-00-80-00-00-07-0
42	1	TP19	TERM SOLDER TURRET .156"H .084"L	MILL MAX: 2308-2-00-80-00-00-07-0

SCHEMATIC DIAGRAM

dc1633bf

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20 **Linear Technology Corporation**
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com

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Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: info@moschip.ru

Skype отдела продаж:
moschip.ru   moschip.ru_6
moschip.ru_4   moschip.ru_9