

LTC2971 High Voltage Two 2-Channel PMBus Power System Managers with Four Power Supply Rails

DESCRIPTION

The DC2875A is a demonstration system for the **LTC®2971** Power System Manager that interfaces to various regulators. The board contains all the circuitry needed to demonstrate a power system that utilizes two 2-channel LTC2971 devices that manage four power supplies. The four power supplies include various switching regulators for the purpose of demonstrating a variety of methods to sense voltage and current. The demo board provides a sophisticated 4-channel digitally programmable power supply system.

The LTC2971 is a 2-channel I²C/SMBus/PMBus Power System Manager that features accurate input current and energy measurement and is capable of managing ±60V supplies. The device monitors input current and input voltage, and calculates input power and energy. The DC2875A demonstrates the ability of the LTC2971 to sequence, trim, margin, supervise, monitor, and log faults for four power supplies. The LTC2971 monitors each channel's output voltage and output current and also monitors each channel's external temperature sensor and its own internal die temperature.

The DC2875A board contains four independent power supply rails. All four rails are based on DC/DC switching regulators. The +36V and +32V channels are managed by an LTC2971 and the ±24V channels are managed by an LTC2971-1. The board is pre-configured with these voltages and may be re-configured with feedback resistors.

The LTpowerPlay® graphical user interface (GUI) supports this demonstration system and enables complete control of all the features of the LTC2971. Together, the LTpowerPlay software and DC2875A hardware system create a powerful development environment for designing and testing configuration settings of the LTC2971. LTpowerPlay stores these settings in the LTC2971 internal EEPROM or in a project file. The software displays all of the configuration settings and real time measurements from the Power System Management IC. Telemetry allows easy access and decoding of the fault log created by the LTC2971. The board comes preprogrammed with the

EEPROM values appropriate for the four power supply rails on the DC2875A. Just plug and play!

Order preprogrammed devices from Analog Devices Express (ADX) using LTpowerPlay: <https://www.analog.com/en/design-center/device-programming.html>

The following items are required:

- +12VDC Power Supply
- USB-to-I²C/SMBus/PMBus Controller (DC1613)
- LTpowerPlay Software

DC2875A FEATURES

- Sequence, Trim, Margin, and Supervise Four Power Supplies
- Manage Faults, Monitor Telemetry, Create Fault Logs
- PMBus Compliant Command Set
- Supported by LTpowerPlay GUI
- Margin or Trim Supplies to 0.25% Accuracy
- Four I_{OUT} and Two I_{IN} Monitors
- Input Power Measurement and Energy Accumulation
- Fast OV/UV Supervisors per Channel
- Multi-Channel Fault Management
- Automatic Fault Logging to Internal EEPROM
- Operates Autonomously without Additional Software
- Monitors: Voltage, Current, Power, Temperature
- 2-Channel Time-Based Output Sequencer
- I²C/SMBus Serial Interface
- Powered from 8V to 18V

Design files for this circuit board are available.

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DEMO MANUAL DC2875A

PERFORMANCE SUMMARY Specifications are at $T_A = 25^\circ\text{C}$

PARAMETER	CONDITIONS	VALUE
V_{PWR} Supply Input Operating Range		4.5V to 60V*
V_{DD33} Supply Input Operating Range		3.13V to 3.47V
ADC V_{SENSE} Total Unadjusted Error (TUE)	$10V \leq V_{SENSE} \leq 60V$	$\pm 0.25\%$
ADC Voltage Sense Input Range	LTC2971 LTC2971-1 (V_{OUT_SNS1})	0V to 60V -60V to 0V
ADC Current Sense Input Range	Differential Current Sense Voltage	-100mV to 100mV
ADC Voltage Sensing Resolution	$0V \leq V_{IN_ADC} \leq 60V$	4.5mV/LSB
ADC Current Sense Resolution	$0mV < V_{IN_ADC} < 16mV$ $16mV < V_{IN_ADC} < 32mV$ $32mV < V_{IN_ADC} < 63.9mV$ $63.9mV < V_{IN_ADC} < 100mV$	15.625 μ A/LSB 31.25 μ A/LSB 62.5 μ A/LSB 125 μ A/LSB
DAC Resolution		10 Bits
DAC Full-Scale Output Voltage	Buffer Gain Setting 0 Buffer Gain Setting 1	1.38V Typ. 2.65V Typ.
Internal Temperature Sensor TUE External Temperature Sensor TUE		$\pm 1^\circ\text{C}$ $\pm 3^\circ\text{C}$
Voltage Supervisor Input Voltage Range (Programmable)	$V_{OUT_SNS[n]}$	0 to 60V (Low Resolution) 0 to 34V (High Resolution)
Voltage Supervisor Sensing Resolution	0V to 60V Range (Low Resolution) 0V to 34V Range (High Resolution)	70.4mV/LSB 35.2mV/LSB
Voltage Supervisor TUE	$9V < V_{IN_VS} < 60V$, Low Resolution Mode $4.5V < V_{IN_VS} < 34V$, High Resolution Mode	$\pm 1.5\%$ $\pm 1.25\%$
I ² C Serial Clock Frequency		10kHz to 400kHz

* Powering the device from input voltages above 25V will create high power dissipation.

DEMO BOARD SYSTEM SPECIFICATIONS

	NOMINAL UNTRIMMED V_{OUT}	REGULATOR PART NUMBER	RESISTORS THAT SET UNTRIMMED V_{OUT}	RDAC	MARGIN RANGE
CH0	+36V $\pm 1\%$	LT7101	R11, R12	R10	$\pm 4\%$
CH1	+32V $\pm 1\%$	LT3991	R20, R21	R19	$\pm 4\%$
CH2	+24V $\pm 1\%$	LT8630	R32, R33	R31	$\pm 5\%$
CH3	-24V $\pm 1\%$	LT3758	R44, R45	R41, R42	$\pm 5\%$

Notes:

- Keep load currents < 300mA on +36V and +32V channels and < 400mA on $\pm 24V$ channels.
- Output voltages can be margined by $\pm 4\%$ or more from nominal with the default resistor values. These values can be easily changed. See section Changing Nominal Output Voltages. Use the LTC2971 Resistor Selection Tool which is accessed from LTpowerPlay.

GLOSSARY OF TERMS

The following list contain terms used throughout the document.

Channel – The collection of functions that monitor, supervise, and trim a given power supply rail.

EEPROM – Nonvolatile 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.

Monitor – The act of measuring voltage, current, and temperature readings.

NVM – Nonvolatile memory, see EEPROM.

OV – Overvoltage, the result of a voltage comparison that a pin voltage is above a programmable threshold voltage.

PMBus – An industry standard power management protocol with a fully defined command language that facilitates communication with power converters and other devices in a power system.

Rail – The final output voltage that the LTC2971 supervises.

Supervise – The act of quickly responding (compared to a fault setting) to a voltage and current condition that is compared to preprogrammed values.

Trim – The act of adjusting the final output voltage. A servo loop is typically used to trim the voltage.

UV – Undervoltage, the result of a voltage comparison that a pin voltage is below a programmable threshold voltage.

WHAT THIS DEMO SYSTEM CAN DO

- *Prototype your system by modifying:* nominal output voltages, range and resolution of margining, sequencing, OV/UV limits, and OC limits.
- *Create your own configuration:* store in the LTC2971 EEPROM or save to a project file. Order preprogrammed parts.
- *Test fault scenarios:* Short outputs to ground, and observe system response and faults.

DEMO SYSTEM HARDWARE

Hardware Required:

1. DC2875A
2. PC + USB Cable
3. 12V, >2A Power Supply
4. USB to I²C/SMBus/PMBus Controller

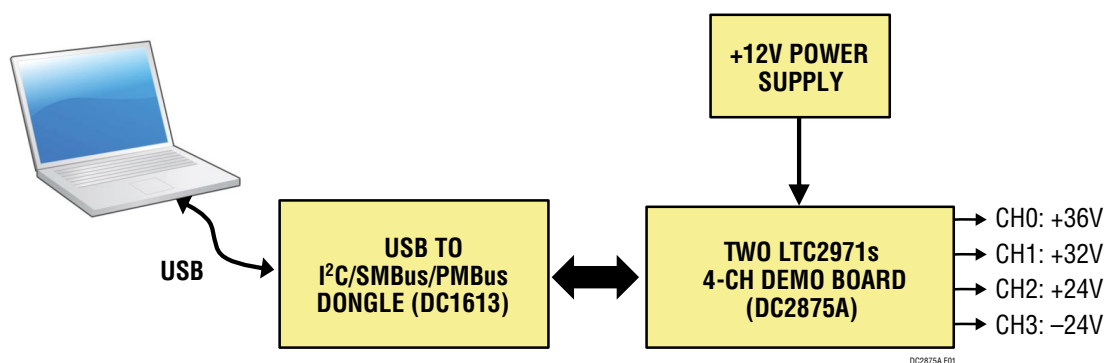


Figure 1. DC2875A Demo Setup

DEMO MANUAL DC2875A

LTpowerPlay GUI SOFTWARE

LTpowerPlay is a powerful Windows-based development environment that supports Analog Devices Power System Management ICs with EEPROM, including the LTC2971 2-Channel Power System Manager. The software supports a variety of different tasks. You can use LTpowerPlay to evaluate Analog Devices ICs by connecting to a demo board system. LTpowerPlay features an offline mode to build a multi-chip configuration file for later use with hardware. 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 I²C/SMBus/PMBus Controller to communicate with one of many potential targets, including the DC2875A 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. Download the software from:

[LTpowerPlay](#)

Select “Help, View Online Help” from the LTpowerPlay menu to access technical documents.

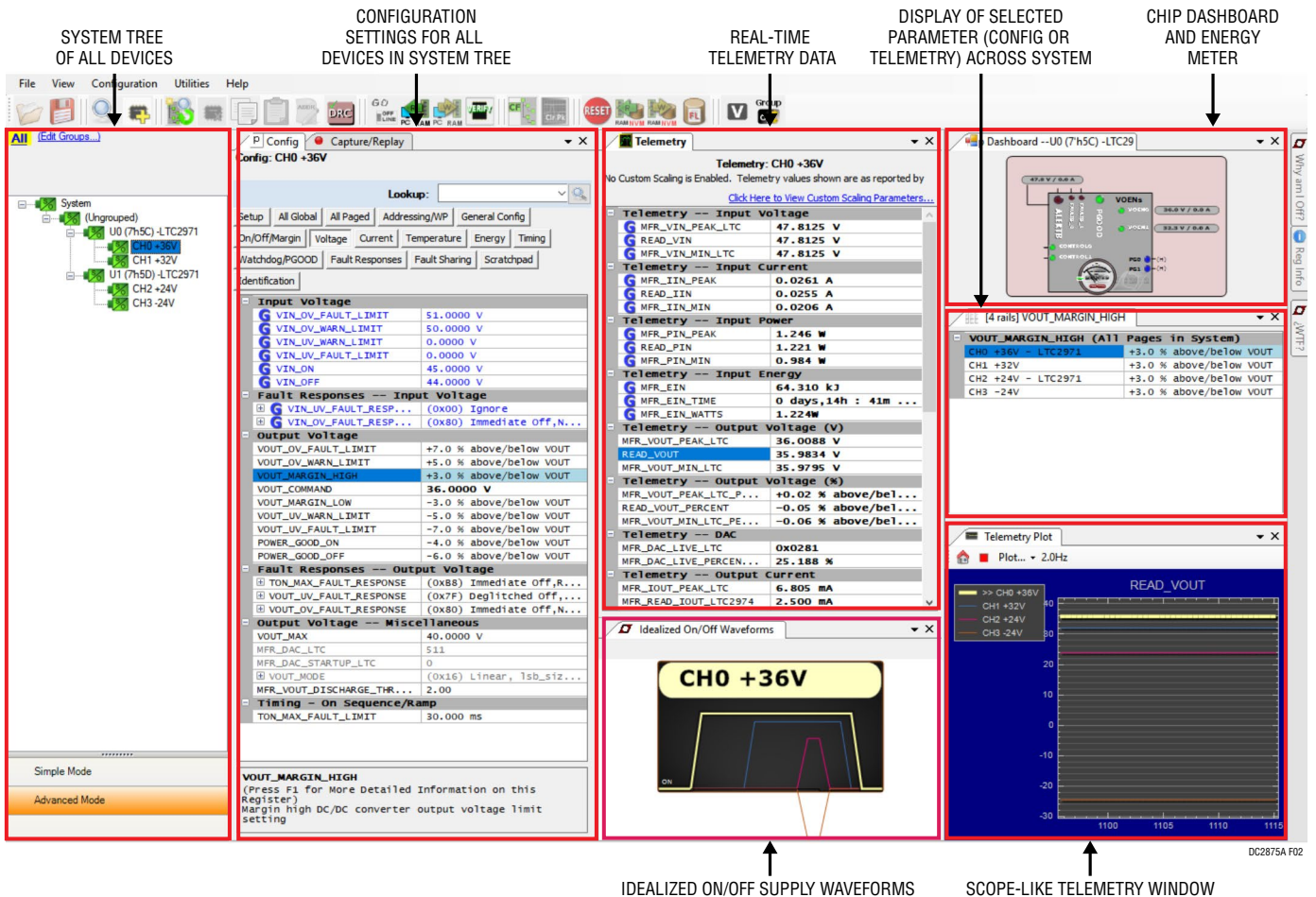


Figure 2. Screenshot of the LTpowerPlay GUI

QUICK START PROCEDURE

The following procedure describes how to set up a DC2875A demo system.

1. Download and install the [LTpowerPlay GUI](#).
2. Remove the board from the ESD protective bag and place it on a level surface. Connect the DC1613 I²C/SMBus/PMBus Controller to the DC2875A board using the 12-pin ribbon cable.

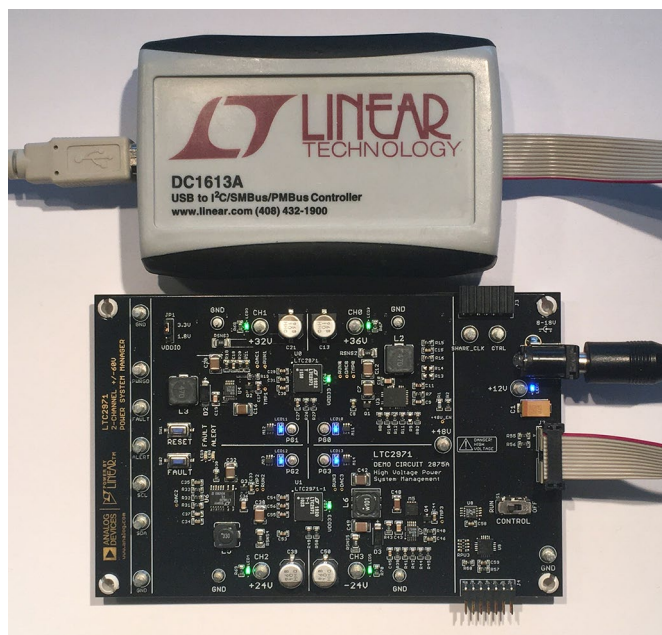
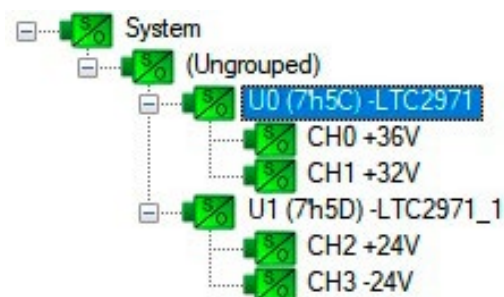


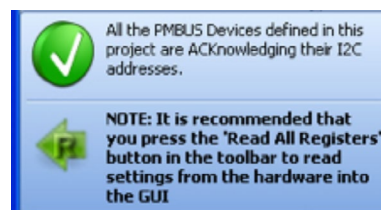
Figure 3. Connecting DC2875A and the DC1613 USB to I²C/SMBus/PMBus Controller

3. Confirm that the RUN switch is set to its OFF position.
4. Plug the USB-to-I²C/SMBus/PMBus Controller into a USB port on your PC. The DC1613's ribbon cable will power up the LTC2971 devices with the LED labeled "VDD33" illuminated green next to each LTC2971. The PG LEDs will illuminate red.
5. Connect a +12VDC power supply with >2A capacity to the V_{IN} input jack of the DC2875A board. The blue LED will illuminate indicating that DC jack power is applied. Move the RUN switch to the ON position. The four outputs will power up and the green LEDs will illuminate.

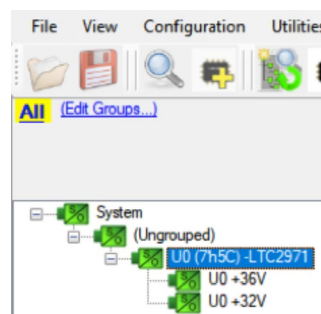
6. Launch the LTpowerPlay GUI.
 - a. The GUI automatically identifies the DC2875A and builds a system tree for each I²C device. The system tree on the left hand side will look like this:



- b. A green message box will be displayed momentarily in the lower left-hand corner confirming that the DC2875A is communicating.



- c. You may make configuration changes. When you update registers in the GUI by using either function key F12 to write an individual register or use the Write All icon to write all registers, you may need these settings for future use. Save the demo board configuration to a (*.proj) file by clicking the "Save" icon. This creates a backup file on your C: drive. Name it whatever you like.



If you need to load the original board default configuration, select the GUI menu pull-down item DEMO → DC2875A_Defaults. This writes

DEMO MANUAL DC2875A

QUICK START PROCEDURE

the board defaults into the RAM and NVM of both LTC2971 devices.

7. The LTC2971 is configured to use the CONTROL switch to sequence on/off the four channels. Slide the switch to RUN to enable, OFF to disable all channels.

LOADING A CONFIGURATION (*.proj) FILE WITH THE GUI

To load a previously saved proj file:

1. In the upper left hand corner of the GUI, File → Open → browse to your *.proj file. This will load the file into the GUI.

2. Click on the “Go Online” icon:



then click on the “PC → RAM” icon:

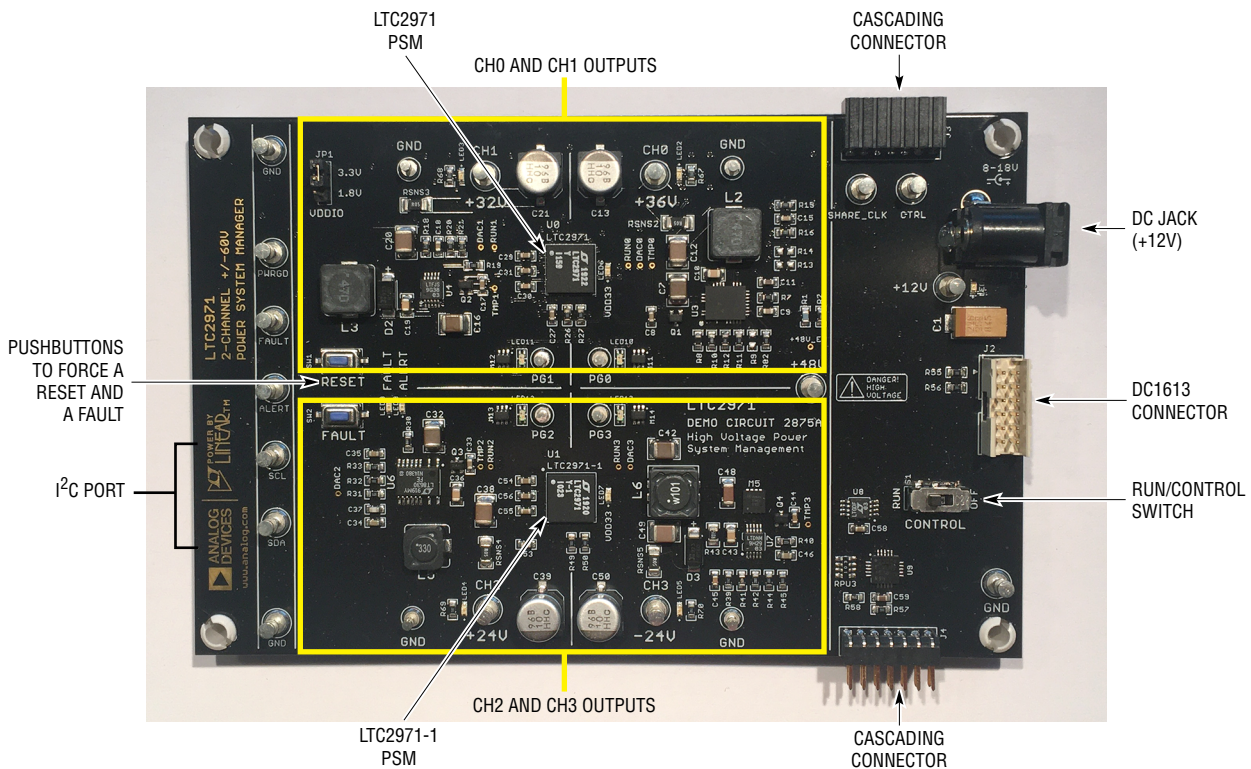


to write all registers. This loads the configuration into the working RAM of the LTC2971 devices.

3. To store the configuration to NVM (EEPROM), click on the “RAM → NVM” icon.



DC2875A DETAILS



COMMON BOARD OPERATIONS

OVERVIEW

A simplified block diagram of the DC2875A is shown in Figure 5. Each LTC2971 measures input current with a 50mΩ sense resistor for their managed channels. Each device also controls, monitors, and supervises its two outputs.

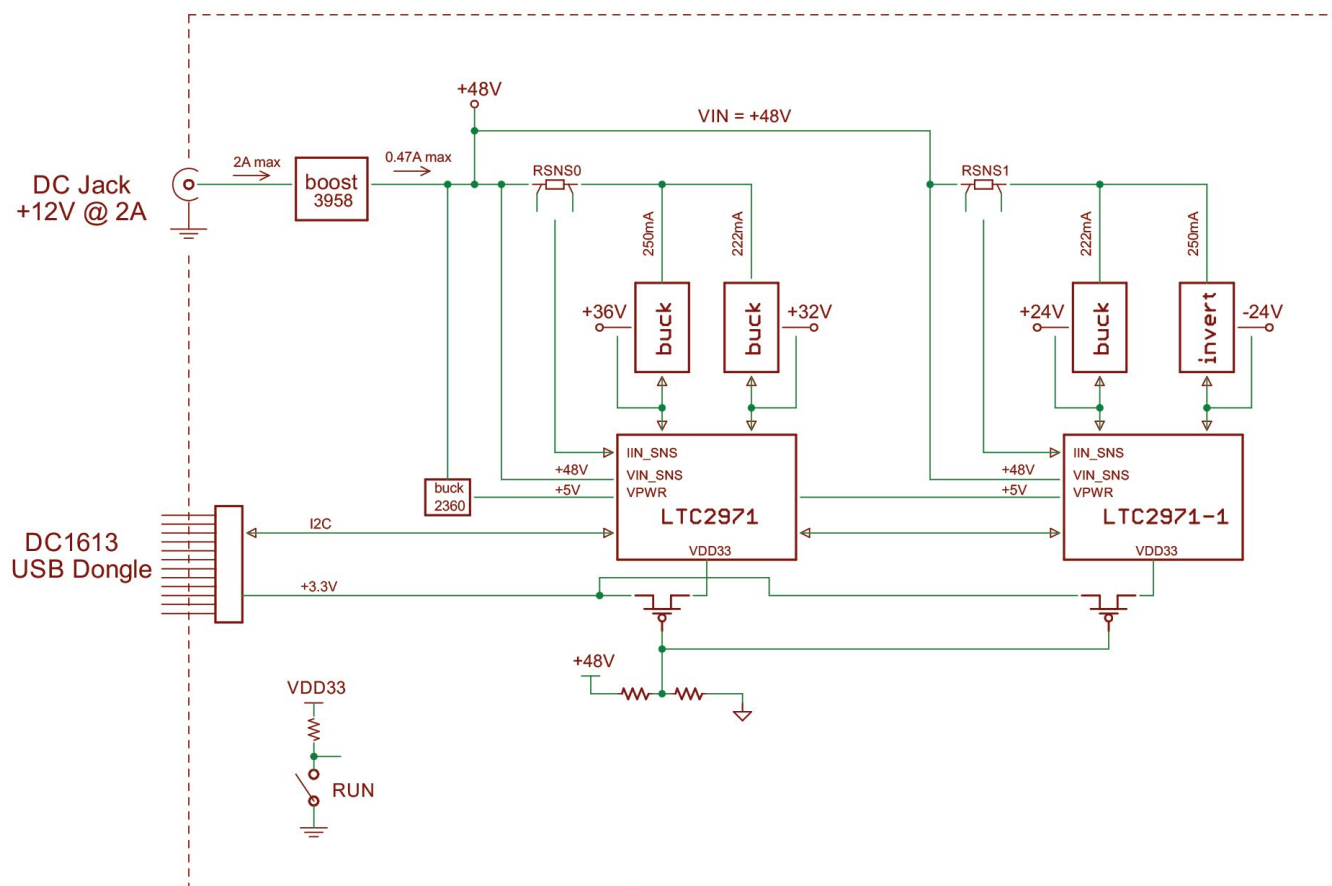


Figure 5. Simplified Block Diagram of the DC2875A

COMMON BOARD OPERATIONS

POWERING THE BOARD

The DC2875A board is powered from a wall-powered 12V supply. The supply must be capable of delivering >2A. If two channels are loaded with the maximum allowable current, the input current may exceed 2A. The LTC2971 devices are powered either from the DC1613's 3.3V power or DC jack power if V_{IN} is applied.

For your convenience, a 12V to 48V boost switching regulator has been designed into the board. The 48V supply acts as the input power supply to the four channels. Each LTC2971 device measures 48V input voltage and input current to the 2 power stages it manages. A 12V wall transformer is much more common than a 48V transformer.

DC2875A LEDs

The blue LED near the power jack indicates that the DC jack has voltage. The green LEDs labeled VDD33 illuminate when the LTC2971 is powered from either the USB controller or the external V_{IN} power. Each channel has its own green LED which indicates that the channel is enabled. The red LEDs on ALERTB and FAULTB indicate a warning or fault has occurred.

RESET THE LTC2971

To reset the LTC2971 and reload the EEPROM contents into operating memory (RAM), press the pushbutton switch SW1 labeled RESET.

PRE-LOAD THE OUTPUTS

Each of the outputs has pre-load resistors that provide 5mA of load current. This ensures that the output voltage decays to GND quickly when the channel is disabled. This is useful when sequencing off then on quickly.

CONTROLLING/SEQUENCING CHANNELS

By default, all four channels on the DC2875A board are controlled by a single CONTROL switch S1.

To demonstrate time-based sequencing, let's use the RUN switch as the master enable. The LTC2971 devices are pre-configured with different TON_DELAY values for each

channel. The TON_DELAY parameter is applied to each of the channels relative to the CONTROL pin or Group operation command to turn all channels "on". The same applies to TOFF_DELAY values. When the CONTROL switch is set to the OFF position, all rails will power down sequentially based on the device's TOFF_DELAY values. Figure 6 shows an oscilloscope screen capture of the four output rails sequencing up.

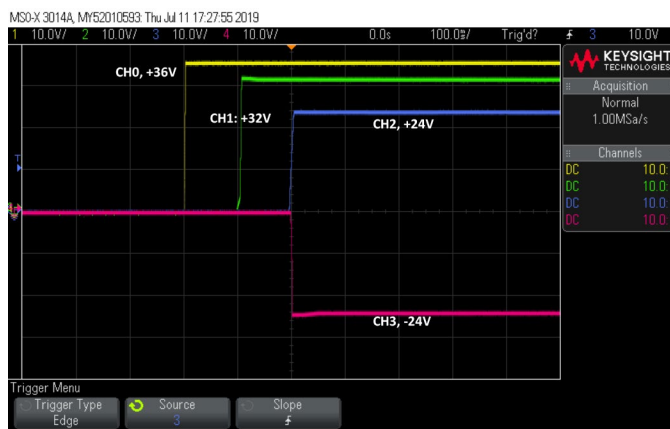


Figure 6. Sequencing Output Channels On

Each channel has an LED that visually indicates if the channel has power. When the CONTROL pin is switched on and off, you will observe the relative on/off timing of the four channels. The timings are intentionally skewed to show the rails ramp times more clearly.

For the LTC2971, the TON_DELAY and TOFF_DELAY values extend to 13.1 seconds, providing a reasonable range for sequencing on and off the power supply rails.

TON_DELAY (All Pages in System)		
CH0 +36V - LTC2971		0.000 ms
CH1 +32V		100.000 ms
CH2 +24V - LTC2971		200.000 ms
CH3 -24V		200.000 ms

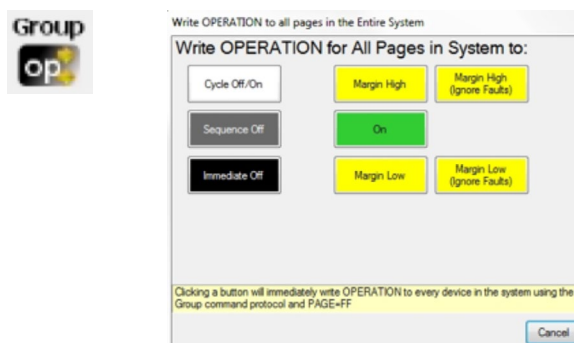
TOFF_DELAY (All Pages in System)		
CH0 +36V - LTC2971		60.000 ms
CH1 +32V		40.000 ms
CH2 +24V - LTC2971		0.000 ms
CH3 -24V		0.000 ms

Figure 7. TON_DELAY and TOFF_DELAY Settings

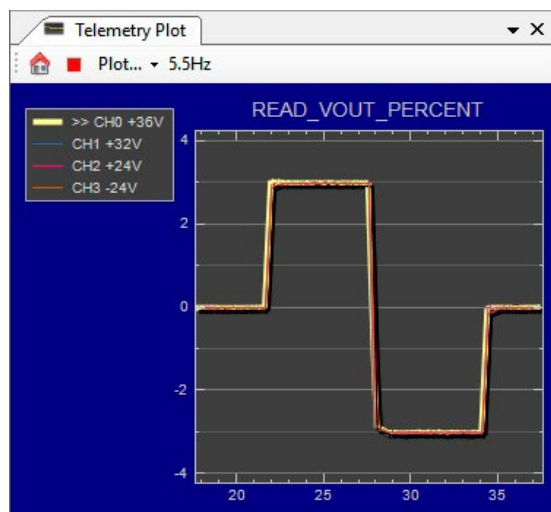
COMMON BOARD OPERATIONS

MARGIN ALL RAILS

The LTC2971 power system manager not only monitors output voltages and currents but can margin the outputs either high or low. Margining is the operation that moves a rail up or down for testing purposes. It allows a system to be fully characterized over supply limits without the use of external hardware or resources. The GUI provides an easy way to margin all rails high or all low by clicking one of four buttons. To invoke the margining dialog, click the GroupOp icon in the toolbar. The buttons labeled “ignore faults” will margin without creating a fault even if the fault limits are exceeded.



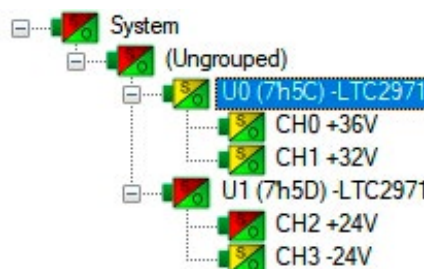
A look at the telemetry window shows the effect of the margin high or margin low operation. This screen shot is a telemetry plot of READ_VOUT_PERCENT showing all rails going from nominal set-points to margin high, margin low, and back to nominal voltages.



The LTC2971 has a multiplexed ADC that is used to provide voltage, current, and temperature readback values. The telemetry plot in the GUI is similar to a multi-channel oscilloscope which is capable of displaying any parameter that is displayed in the telemetry window. Due to the nature of a multiplexed ADC converter, it has an associated ADC loop time of approximately 135ms.

CREATING A FAULT

There is a pushbutton on the DC2875A board that is used to force a fault and demonstrate the demo board’s ability to detect it and respond according to the configuration. When depressed, the FAULT pushbutton (SW2) creates a fault (shorts VOUT_CH2 to ground) on CH2, the +24V output. When faulted, all channels power down immediately and the GUI’s system tree indicates the color red for the Status portion of that channel. You should see all outputs power off, the fault LED momentarily illuminate, the alert LED illuminate continuously, and all rails sequence back on after a retry period. You may also hold the FAULT pushbutton indefinitely to demonstrate the fault behavior and retry timing.



CLEARING A FAULT

To clear a fault, the user can click the CF icon in the GUI or simply push the RESET pushbutton (SW1) on the DC2875A demo board. In both cases, the red (+) on the CF icon and alert LED on the board are both cleared. Notice that all rails are automatically re-enabled after a programmable retry period. A dialog box may pop up after clicking the Clear Faults (CF) icon. If a fault log is present, a dialog will ask if you would like to clear the fault log as well as clear system faults. After clearing faults, the system tree will return to “green” and fault logs re-armed. For further information, see the Working with the Fault Log section.

COMMON BOARD OPERATIONS

“WHY AM I OFF?” TOOL

Use the “Why am I Off” tool in the LTpowerPlay GUI to diagnose the cause for a power supply channel being in an off state. The tool is located in the top right corner of the GUI, above the “Register Information” tab. Hover your cursor over the tab to show the tool.

First select an output channel in the system tree. The tool collects various status information and provides a diagnosis.

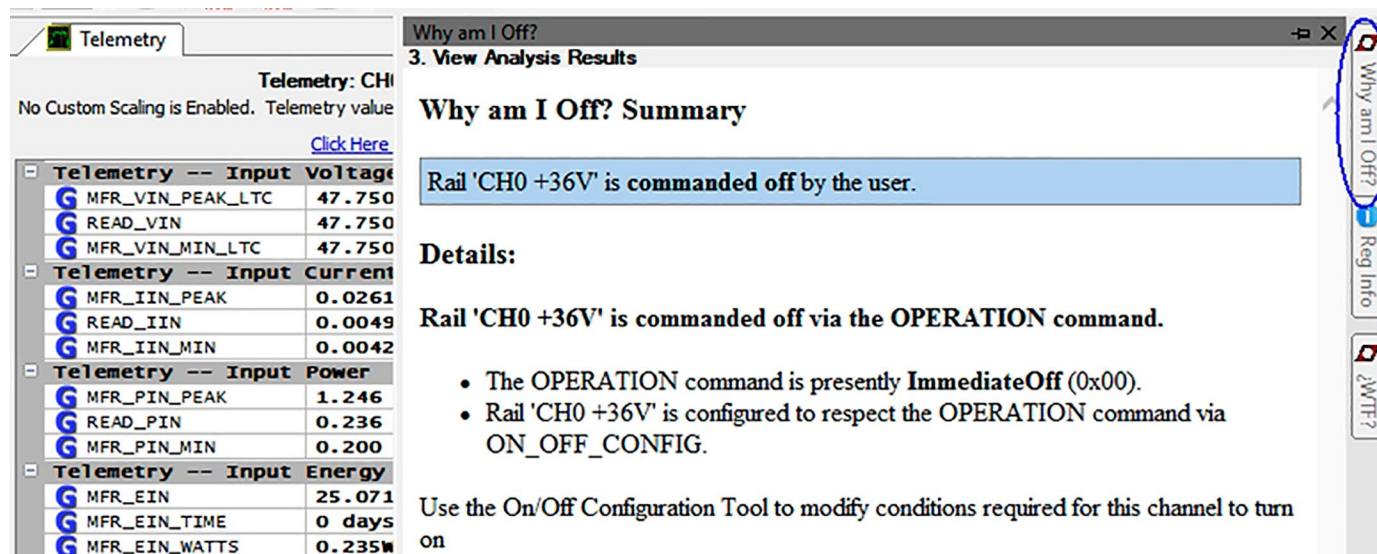


Figure 8. “Why Am I Off” Tool in the LTpowerPlay GUI

ADVANCED DEMO BOARD OPERATIONS

WHAT IS A FAULT LOG?

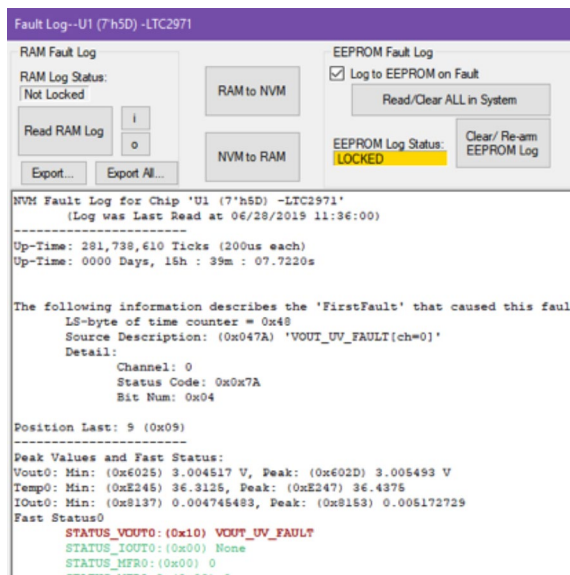
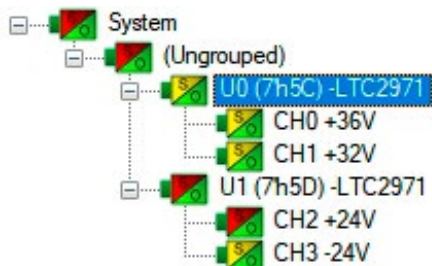
A fault log is a nonvolatile record of the power system leading up to the time of fault. Telemetry data is continuously updated in a circular RAM buffer in the LTC2971. When a fault occurs, the contents of the RAM buffer are

automatically written to NVM. The most recent monitored values (uptime, voltage, current, temperature) provide additional context preceding the fault. It is a powerful diagnostic feature of the LTC2971 on the DC2875A demo board.

ADVANCED DEMO BOARD OPERATIONS

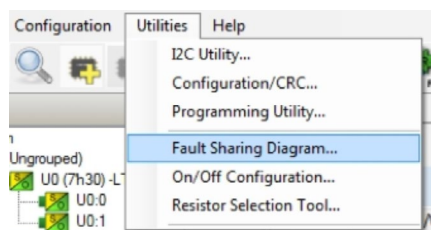
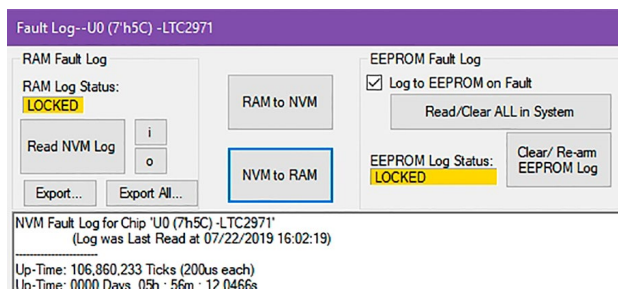
CREATE A FAULT LOG

To create a fault log, check that the *fault_log_enable* bit is set in the MFR_CONFIG_ALL register. Then, create a fault, as described in the section Creating a Fault. If multiple boards are configured, select the appropriate device in the system tree by clicking on the appropriate LTC2971 chip. We are ready to work with the fault log.



WORKING WITH THE FAULT LOG

Once a fault has occurred, the Fault Log (FL) icon will show a red (+) sign on it, indicating that the GUI has detected a fault log in the device. Clicking the icon will bring up a dialog box. Note that it is a context sensitive icon. Be sure to select the desired device in the system tree. Notice that the EEPROM log is locked. The log will not change until it is cleared by the user.



In this case, the fault log will show that channel U0:0 faulted due to a VOUT_UV_FAULT condition. On the previous telemetry loop, the channel voltage reading was a nominal value (+24V). You can save the fault log to a file (.rtf) by clicking the Export button.

It is a 2-step process to read the fault log. First click the “NVM to RAM” button. At this point the RAM Log is locked. Click the “Read NVM Log” button. The fault log data will appear in the text box below.

To clear the fault log, click the “Clear/Rearm EEPROM Log” button. This allows the selected device to be ready for a new fault event. To clear all faults, click the Clear Faults (CF) icon.

ADVANCED DEMO BOARD OPERATIONS

FAULT SHARING SETUP IN THE GUI

Fault sharing provides a means of propagating a fault detected by a power manager to other power managers via FAULT pins. Use the Fault Sharing Setup Tool to configure the fault sharing in the GUI. Select the LTC2971 in the system tree. Go to Utilities → Fault Sharing Diagram. For more details on this topic, please refer to the Fault Management section in the data sheet.

The fault sharing dialog will appear as shown in Figure 9. All Response and all Propagate switches are closed by default. In this configuration, a fault on a channel will shut down not only the faulted channel but all other channels since the Propagate switches are closed.

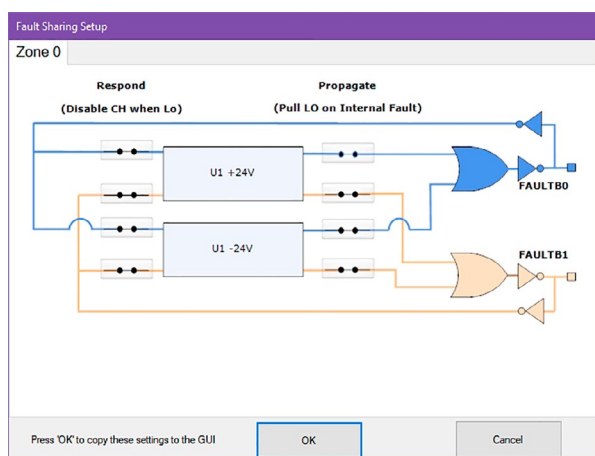


Figure 9. Fault Sharing Utility in LTpowerPlay GUI

There are two types of actions to fault conditions: How a channel responds to another channel’s fault and whether a particular channel propagates its fault to other channels. FAULT pins are bidirectional, meaning the device may drive its fault pin low (output) or may respond to the fault pin when another device drives it low (input). By default, the LTC2971 devices are configured to shut down all channels if the FAULT pin is low and to propagate its own fault to the other channels by driving both FAULT pins low. The FAULT pins are tied together, which effectively creates one fault line. You can think of the “Response” switches as “shut this channel down” when another channel faults, and the “Propagate” switches as “drive the fault pin” to broadcast to other channels that this channel faulted.

FAULT CONFIGURATION EXAMPLE

Let’s explore two different examples. Suppose we do not want channel CH2 (+24V rail) to propagate its fault to the other channels when it faults. And suppose we do not want channel CH3 (–24V rail) to shut down in response to another channel’s fault. We can configure the switches as shown in Figure 10. Simply click the switches to open/close. Click OK to close the dialog box. Click the “PC→RAM” icon to write the changes to the LTC2971.

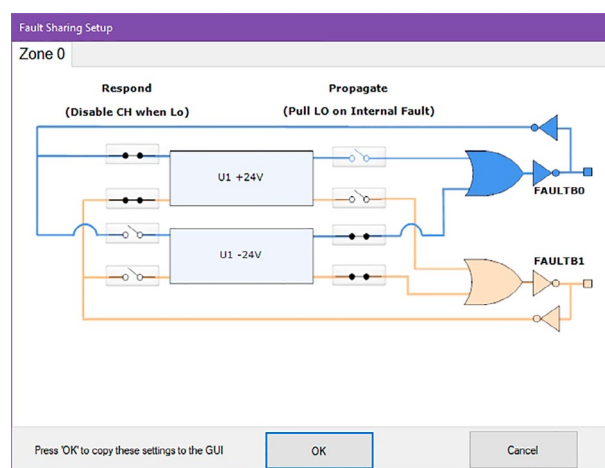


Figure 10. Updated Fault Sharing Configuration

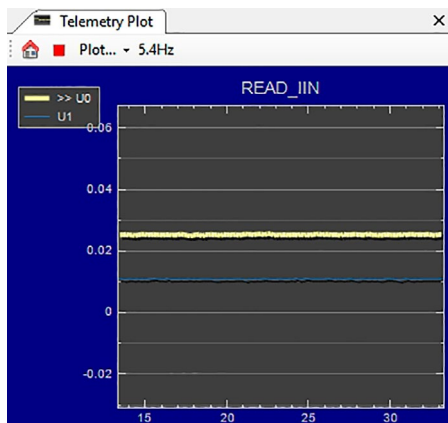
We can now create a fault on CH2 by pressing the FAULT pushbutton. This action shorts the +24V supply to GND through a resistor that dissipates most of the power. You will notice that the channel shuts off but the other channels remain powered up because its fault is not propagated to the other channels. After the retry period, the channel will power back up. We can now observe the effect of changing the response setting on CH3. If you short the FAULT turret to ground, notice that all rails shut down except CH3. This is an example of a keep-alive channel that remains powered up independent of faults to other channels.

CAUTION: It is not recommended to short any of the power supplies directly to GND on this demo board as sparks will fly and damage to components is possible. The energy stored in the output capacitors can generate enough power to cause damage. This is especially important if you change fault responses to “ignore”.

ADVANCED DEMO BOARD OPERATIONS

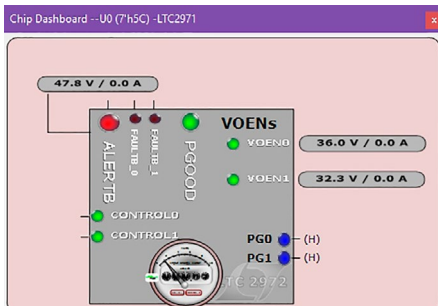
ENERGY METERING

The LTC2971 is capable of high-side current sensing of the input power supply. This feature allows the manager to measure input supply current. Select the READ_IIN register to display the telemetry plot. The input current reading for U0 is ~25mA and for U1 is ~10mA. Notice the input current readings go to zero if you turn all channels off.



The manager also measures input supply voltage and is therefore able to report input power as well. Since energy is the product of power and time, accumulated energy is provided based on the manager’s internal time-base.

The meter displayed in the upper right-hand corner of the GUI provides a number of bits of information. The needle is a real-time indicator of input power and the smaller five dials show the total accumulated energy similar to a home electricity meter. Digital readouts are also provided for convenience.



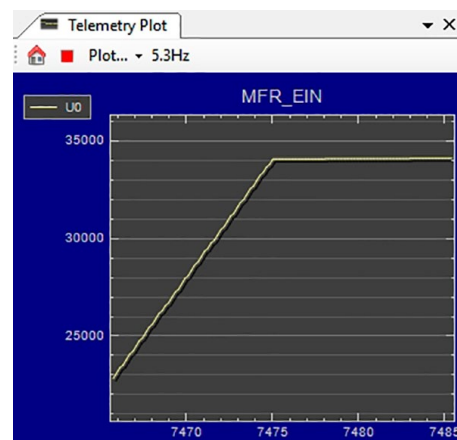
The DC2875A demo board uses two LTC2971 power managers that measure the voltage and current for each pair of outputs. Each LTC2971 is able to monitor and measure two outputs and its input power supply. LTpowerPlay offers a simple and easy to understand interface

that brings together input and output current, voltage, power, and energy readings. To view a chip’s telemetry, simply click U0 or U1 in the system tree.

Telemetry -- Input Voltage	
MFR_VIN_PEAK_LTC	47.8125 V
READ_VIN	47.8125 V
MFR_VIN_MIN_LTC	47.8125 V
Telemetry -- Input Current	
MFR_IIN_PEAK	0.0260 A
READ_IIN	0.0255 A
MFR_IIN_MIN	-0.0001 A
Telemetry -- Input Power	
MFR_PIN	1.242 W

You may also view the input current, input voltage, input power, and input energy together in tabular format. These appear in the telemetry portion of the GUI. The MFR_EIN register holds the accumulated energy value in millijoules. There is also a total time that the energy accumulator has been active and is shown as the MFR_EIN_TIME register. The GUI will automatically update the displayed SI prefix as the units change from mJ to J to kJ.

To demonstrate the meter readings and register values, first select the MFR_EIN register to display the energy in the telemetry plot and select Plot all in Chip from the Plot ... pull-down. Turn off all channels by setting the CONTROL switch to the off position. You will notice that the slope has changed. The accumulated energy rate is the slope. The slope is essentially zero when the channels are off. Note that the input current has changed from about 25mA down to zero as seen in the READ_IIN register. The MFR_EIN_WATTS register displays the input power that is being drawn. This register is the product of the READ_VIN and READ_IIN values. Since the input voltage is 48V, the input power is 48V•25mA or 1.2W. You can confirm this by clicking these three registers one by one and view the telemetry window.



ADVANCED DEMO BOARD OPERATIONS

The MFR_EIN and MFR_EIN_TIME registers may be reset by right-clicking the MFR_EIN register which displays an option menu to “Clear HW Register”. It may also be reset by writing the MFR_EIN_CONFIG register.

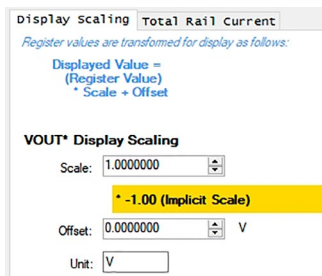
OUTPUT VOLTAGE SENSING

The LTC2971 natively senses voltages up to 60V. The LTC2971-1 can natively sense a positive supply and a negative supply without the need for external divider networks. Voltage sensing employed on the DC2875A is easy. The appropriate VOUT_SNS and GNDSNS pins are connected to all power supplies and ground returns. For the negative voltage channel, the pins called VOUT_SNS1 and GNDSNS1 must be tied to the -24V rail voltage and ground return, respectively. With other/previous PSM devices, one would need to divide down and consider resistor values that might introduce an error.

The LTC2971-1 device has the capability to manage a negative supply. The PMBus register VOUT_COMMAND sets the target output voltage that the chip senses and uses for the servo loop. Likewise, a PMBus register called READ_VOUT is used to read back the output voltage as part of the telemetry. These registers are unsigned float values expressed in an L16 hex format. For positive voltage rails, this is expected. However, for the negative supply on CH1, the user must be aware that a negative sign is inserted to all V_{OUT} related values for CH1.

LTpowerPlay has this inversion built-in. It adds a negative sign to the unsigned values. In the Setup tab, you will see that there is an implicit -1 multiplied by the V_{OUT} Scaling.

Setup Tab



All V_{OUT} related values associated with a negative channel automatically apply this inversion. This is provided as a convenience by LTpowerPlay.

OUTPUT CURRENT SENSING SCHEMES

The load current on all channels is measured by the LTC2971 with a 50mΩ sense resistor in the output path. The IOUT_SNS pins are connected across the sense resistor, a differential voltage is measured, and the PSM translates this voltage as a current. The translation occurs in the LTC2971 via PMBus registers. The feedback resistor for the regulator is tied after the R_{SENSE} which places it within the loop, virtually eliminating any IR drop. The channels are preprogrammed with a value of 50 in the IOUT_CAL_GAIN registers. The units are milliohms.

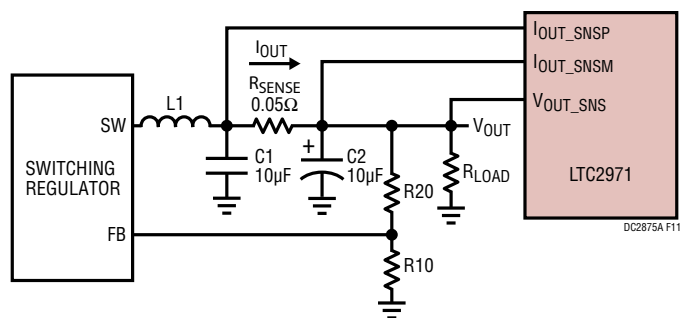


Figure 11. Switcher with Sense Resistor

As an option, zero-ohm SMD resistors may be swapped in order to use CH0 (+36V) regulator’s IMON pin to measure current. This channel uses the IMON pin of the LT7101 regulator to drive a single-ended voltage back to the LTC2971. The IMON pin voltage varies from 0.4V (no load) to 1.3V (full load) and is translated to output current by the LTC2971. The PMBus register values, IOUT_CAL_GAIN and IOUT_CAL_GAIN_OFFSET, are preprogrammed to allow the LTC2971 to report output load current in Amps.

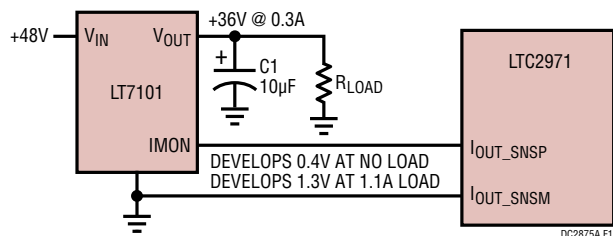


Figure 12. Load Current Measurement with IMON

ADVANCED DEMO BOARD OPERATIONS

The equation below is used to derive the register values:

$$READ_IOUT = \frac{V_{IOUT_SNSPn} - V_{IOUT_SNSMn}}{(IOUT_CAL_GAIN) \cdot T_{CORRECTION}} + IOUT_CAL_OFFSET$$

Rewriting the equation to solve for IOUT_CAL_GAIN,

$$IOUT_CAL_GAIN = \frac{V_{IOUT_SNSP} - V_{IOUT_SNSM}}{READ_IOUT - IOUT_CAL_OFFSET}$$

assuming $T_{CORRECTION} = 1$.

Here's an example calculation. CH0 uses a buck regulator with an IMON pin that has a voltage offset. The LT7101 data sheet provides IMON voltage levels for 1A and 0.25A load currents, 1.21V and 0.603V respectively. Therefore IOUT_CAL_GAIN value is:

$$\frac{1.21V - 0.603V}{1A - 0.25A} = 810m\Omega$$

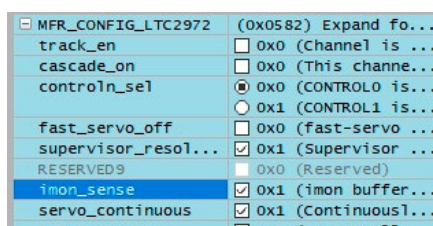
The IOUT_CAL_OFFSET is

$$\frac{0.603V}{0.81\Omega} - 0.25A = -0.495A$$

You may find that the calculated register values need to be adjusted to better correlate with measured load current vs READ_IOUT readings. In general, IMON accuracy on many regulators are not as precise as sense resistors for current measurements.

From the factory, CH0 uses a 50mΩ sense resistor in the output path. You may choose to try IMON sensing method by depopulating zero-ohm resistors R13/R14 and soldering them into the resistor R15/R16 positions.

The *imon_sense* bit must be set in the MFR_CONFIG register on CH0. This allows single-ended voltages up to 6V to be sensed by the IOUT_SNS pins.



The board comes with IOUT_OC_WARN limits set to 0.4A for the +36V/+32V rails and 0.5A for the +24V/-24V rails. If the LTC2971 detects an output current warn limit has

been exceeded, the ALERT pin will be asserted low and the LED will illuminate. The channel will not be shut down.

CAUTION: A channel that uses a high resistance value for the R_{SENSE} is susceptible to damage of the IOUT_SNS pins. This may occur if the channel's output is shorted to GND. The LTC2971 will detect a UV fault condition and shut down the regulator, however a high current will flow instantaneously through the sense resistor, creating a large voltage drop, thereby forcing a large voltage across the IOUT_SNS pins. The absolute maximum ratings on IOUT_SNS pins is ±0.3V on the LTC2971-1 CH1. The series resistors R15/R16 and capacitor C15 between R_{SENSE} and IOUT_SNS pins provide protection against damage to the LTC2971. Any board design that uses high resistance sense resistors are prone to this potential problem.

SERVO CIRCUITS

Each channel has a servo loop that is used to make fine adjustments to its output voltage. The servo loop is intentionally a slow loop so as not to disturb or conflict with the main regulator feedback loop.

The DAC/servo circuits for CH0, CH1, and CH2 are straightforward. The feedback nodes of the switching regulators fall within the LTC2971's DAC range.

The servo circuit for CH3 (-24V) is more challenging. The LT3758's feedback node FBX sits below GND, at -0.8V. The DAC cannot be directly connected to a negative voltage.

In other demo boards (DC2518), we have used a PNP transistor to translate a positive DAC voltage to a current pushing into a node that is below GND (see Figure 13). For this design, a simpler method is used. We can translate a positive voltage to a current by using two resistors. The DAC is tied to the midpoint of a divider, the top of the divider is tied to a positive voltage (VDD33) and the bottom is tied to the feedback node (-0.8V).

With the DAC disconnected, the two resistors feed 10μA prebias current into the feedback node via the two RDAC resistors. It is the prebias current and the 80μA R10 current (0.8V/10k) that sets the floating voltage of the LT3758. The regulator's output voltage moves to keep

ADVANCED DEMO BOARD OPERATIONS

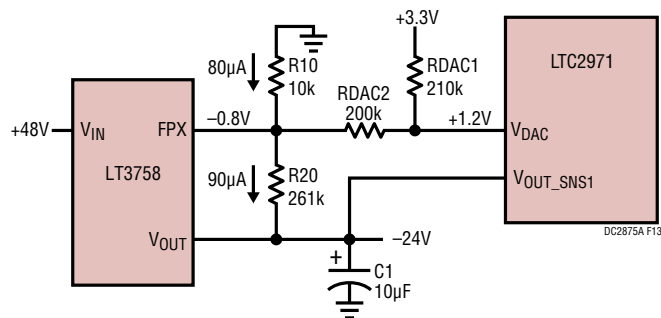


Figure 13. Inverting Switcher with DAC Resistors

FBX at -0.8V , and therefore ensures that R20 resistor current is $90\mu\text{A}$. This creates a 23.5V drop ($90\mu\text{A} \cdot 261\text{k}$) which sets the output voltage to approximately -24.3V . This arrangement allows the DAC to adjust the resistor midpoint, thereby moving the prebias cur-

rent, and therefore the output voltage. When the servo is engaged, the LTC2971 accurately takes an ADC measurement on VOUT_SNS1 and compares it to the target (VOUT_COMMAND), then adjusts the DAC such that the target voltage is reached. VOUT will be accurate to within $\pm 0.25\%$.

When the regulator is first enabled, the LTC2971 DAC is disconnected and VOUT initially goes to its floating voltage which is approximately -24.3V . The DAC soft-connects at the TON_RISE time and connects to the divider which sits $\sim 1.2\text{V}$ above GND. The RDAC1 and RDAC2 resistor values are chosen such that the midpoint is approx. 1.2V , a voltage that is half of the DAC's maximum output in DAC high range mode. Once the DAC finds a suitable voltage, it is connected to the divider and controls this node, making it capable of changing the output voltage by $\pm 1.2\text{V}$.

SETUP PROCEDURE FOR MULTI-BOARD ARRAYS

Multiple demo boards that have the 14-pin cascading connectors can be combined to control as many eight boards. Demo boards that can be cascaded include the DC2875A, DC1962C, DC2022A, DC2023A, DC2028A, DC2198A, DC2518A and DC2619A. The number of boards is limited by an I/O expander chip that has three address pins, allowing 8 different combinations. This setup demonstrates the coordinated fault responses and accurate time base shared across multiple power system managers.

Procedure:

1. Stack the boards side-by-side by plugging J3 of one board into J4 of another DC2875A board.
2. Ensure different slave address settings for each of the boards. The address of each DC2875A board is set by the DIP switch JP2 on the backside of the board. The setting must be unique for each board in the array.
3. Plug in the $+12\text{V}$ V_{IN} power into one of the boards as shown in Figure 14. Only one $+12\text{V}$ power source is allowed.

4. The USB-to-I²C/SMBus/PMBus controller may be plugged into any board. If no demo boards show up in the GUI, click the magnifying glass icon to enumerate the I²C bus and find the addresses of the parts. Go to step #2 to ensure that each board has a unique DIP switch setting.
5. Since the individual CONTROL lines are connected across the boards (CTRL is a common signal across all boards in the array), make sure that all CONTROL switches are set to the RUN position.
6. Relaunch LTpowerPlay. After launching, LTpowerPlay will enumerate the entire board array and build a representative system tree and read all hardware settings into the GUI.

ATTENTION: Once the GUI has launched, click the "RAM \rightarrow NVM" button in the toolbar to ensure that the slave addresses are retained after a power off or reset. Otherwise you may lose communication with the slaves after a power cycle or reset event.

SETUP PROCEDURE FOR MULTI-BOARD ARRAYS

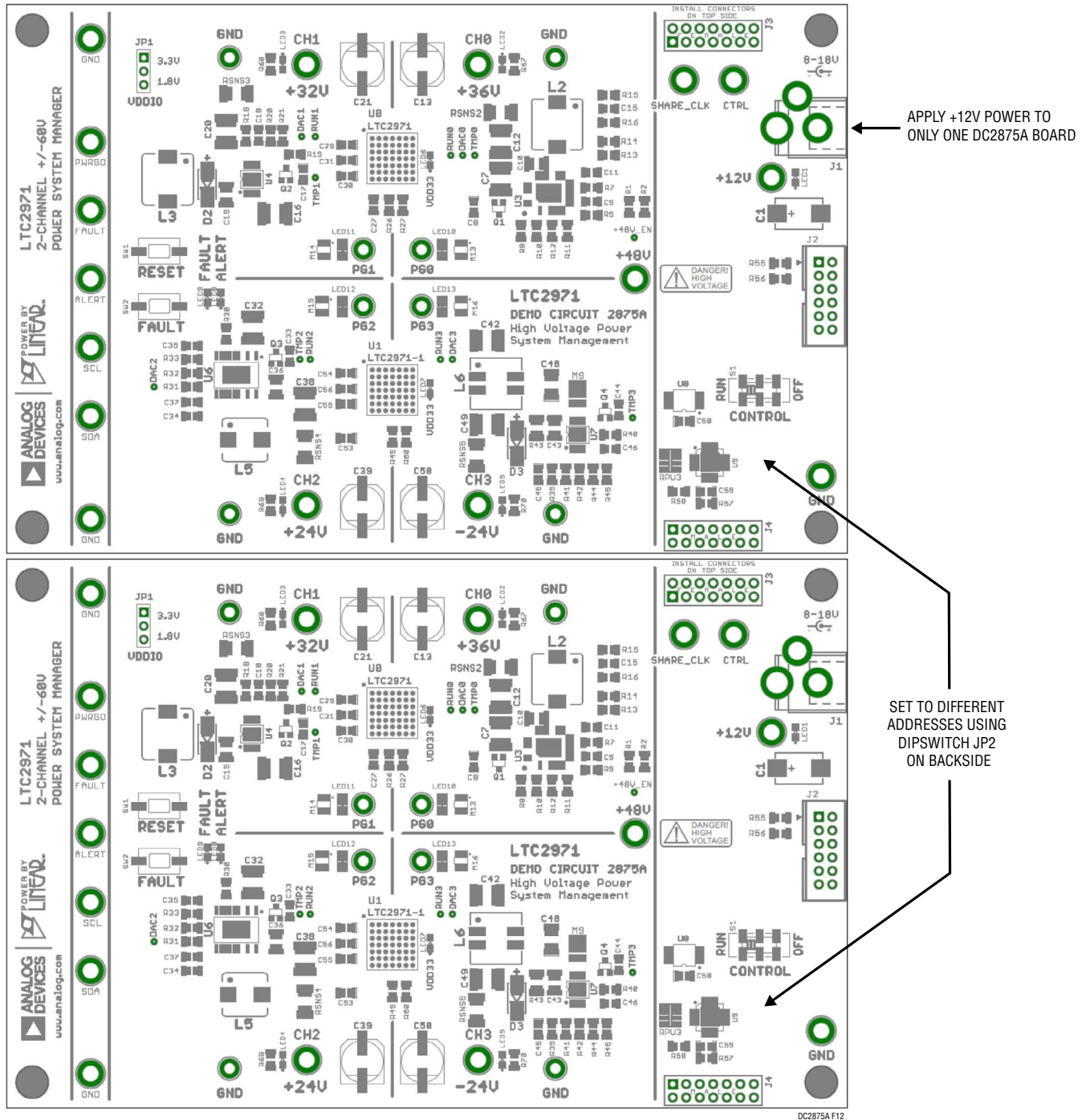


Figure 14. Array of Multiple Board Sets

SETUP PROCEDURE FOR MULTI-BOARD ARRAYS

ENSURING SLAVE ADDRESSES DO NOT CONFLICT

There is a small DIP switch on the backside of the DC2875A. It is used to set the slave address of an I/O expander which allows the addition of multiple boards to a setup. The I/O expander has a base address of 0x20. The DIP switch settings set the offset. The three switches that may be changed are labeled A0, A1, A2. Examples below set the boards to address 0x20 and 0x27.

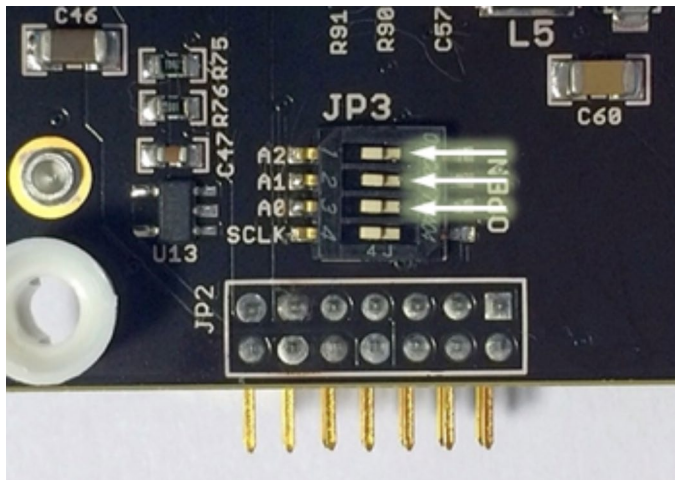


Figure 15. DIP Switch Set to All 0's

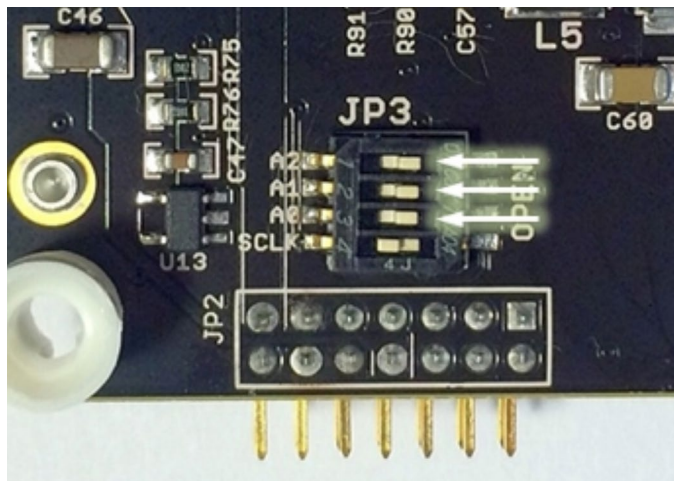


Figure 16. DIP Switch Set to All 1's

DC2875A DETAILS TOP

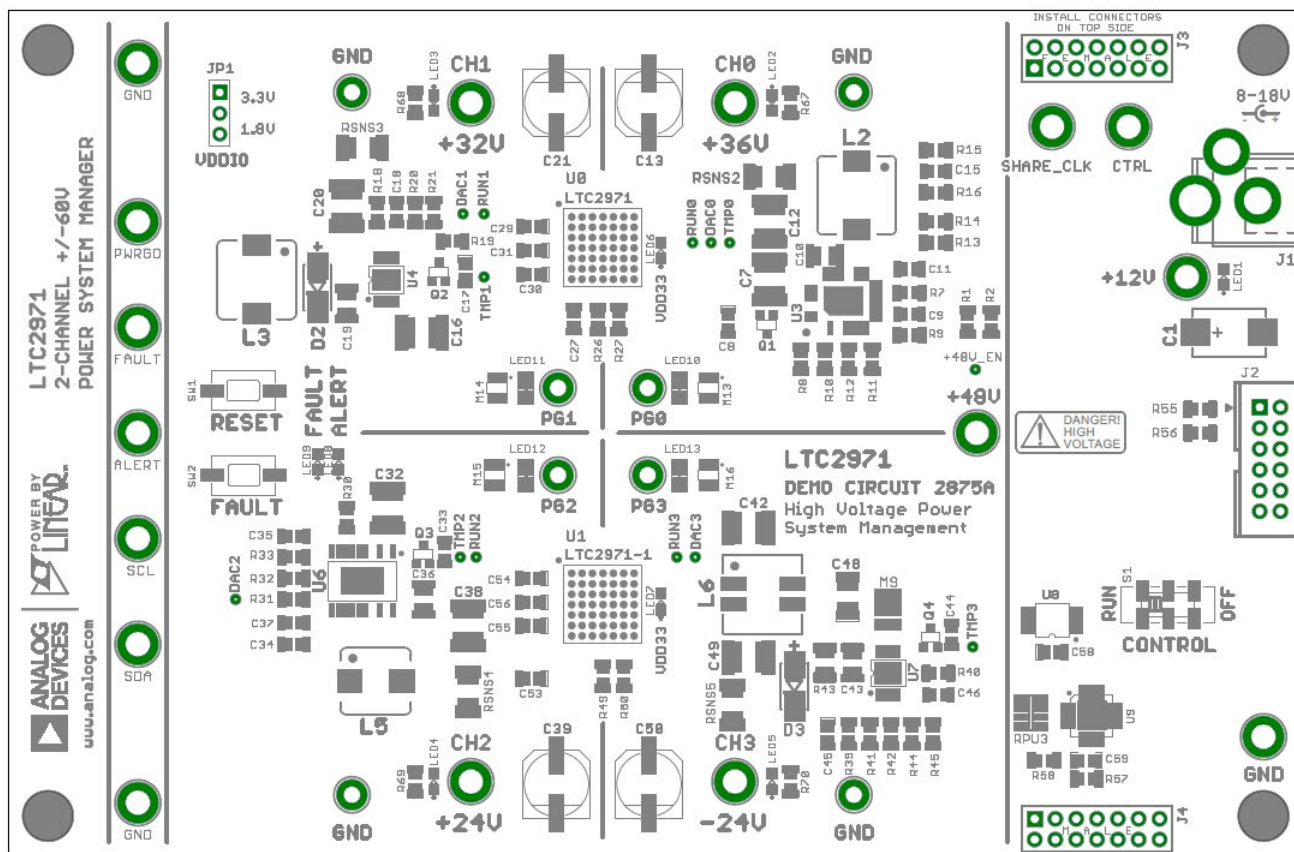
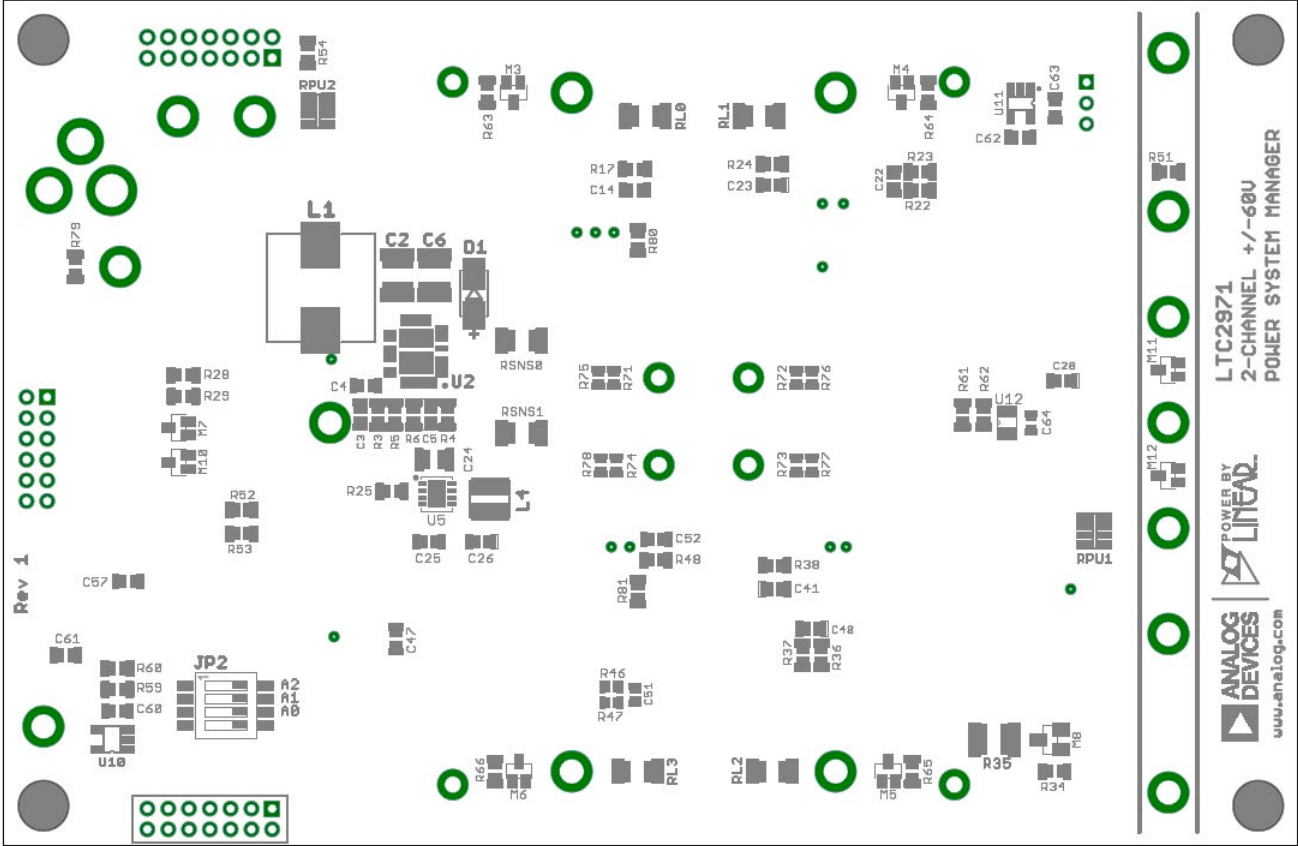


Table 1. DC2875A – Default Switch Configuration

REFERENCE DESIGNATOR	SIGNAL NAME	USAGE	DEFAULT
JP1	VDDIO	Sets I/O Voltage for I ² C and Other Digital Signals	3.3V
JP2 (Bottom)	A0, A1, A2	DIP Switch Used to Set the Address Offset	OPEN
S1	CTRL	Switch Used to Enable/Disable Channels by Pulling the CONTROL Input Pins High/Low of LTC2971	RUN

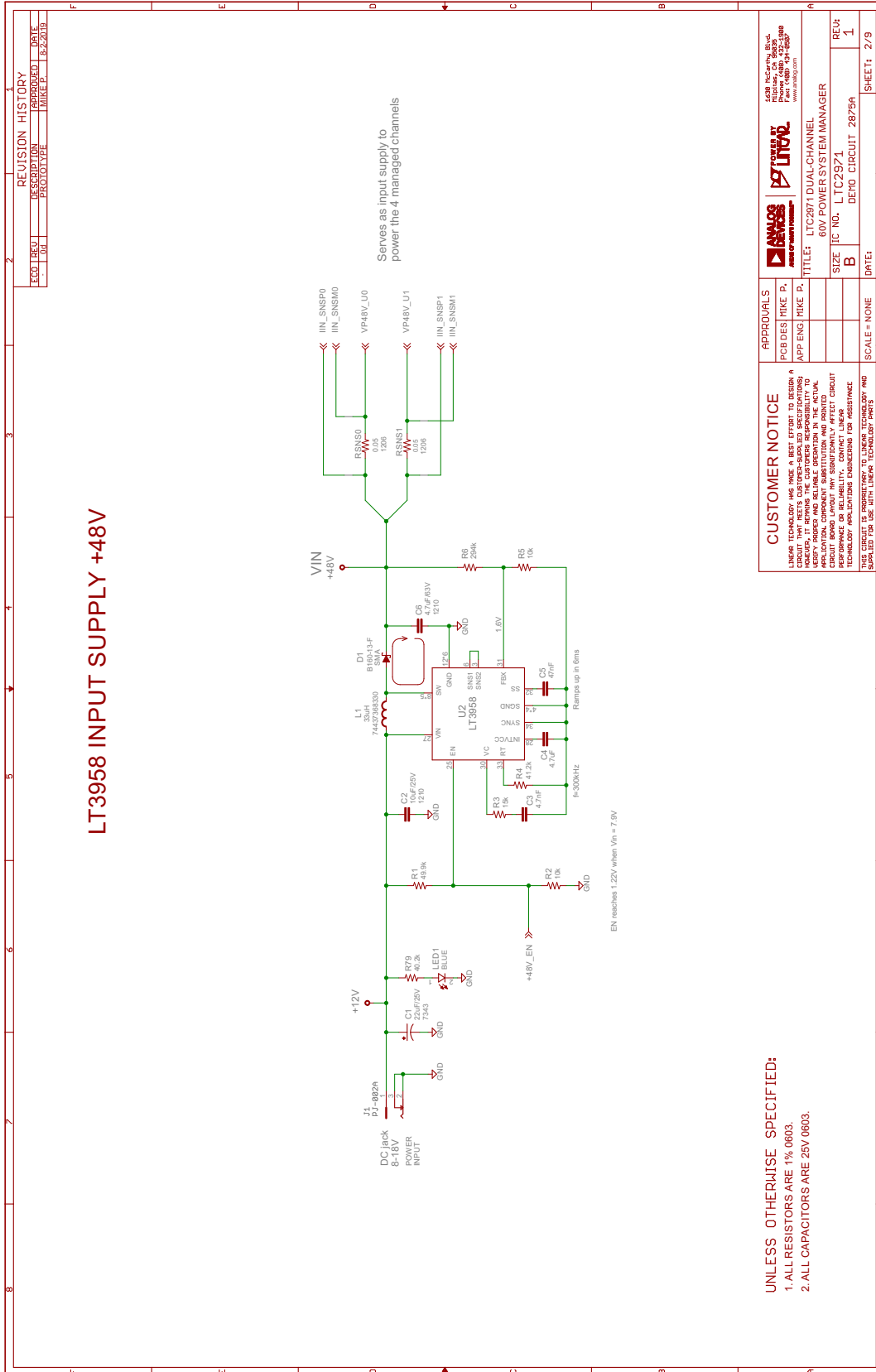
DEMO MANUAL DC2875A

DC2875A DETAILS BOTTOM



DEMO MANUAL DC2875A

DC2875A SCHEMATIC DIAGRAM

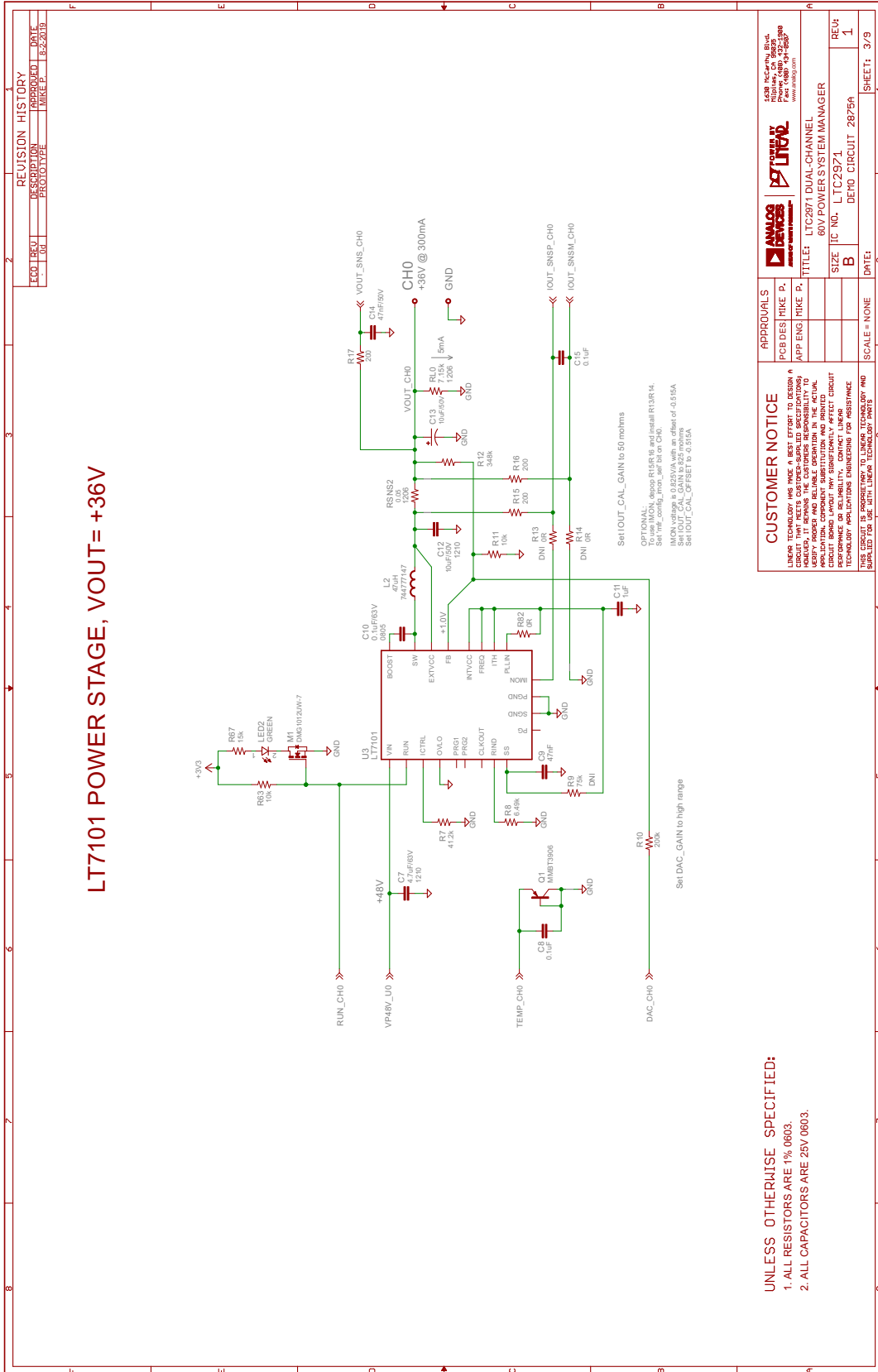


REVISION HISTORY	
DATE	DESCRIPTION
04/18/19	INITIAL RELEASE
08/22/19	REVISED

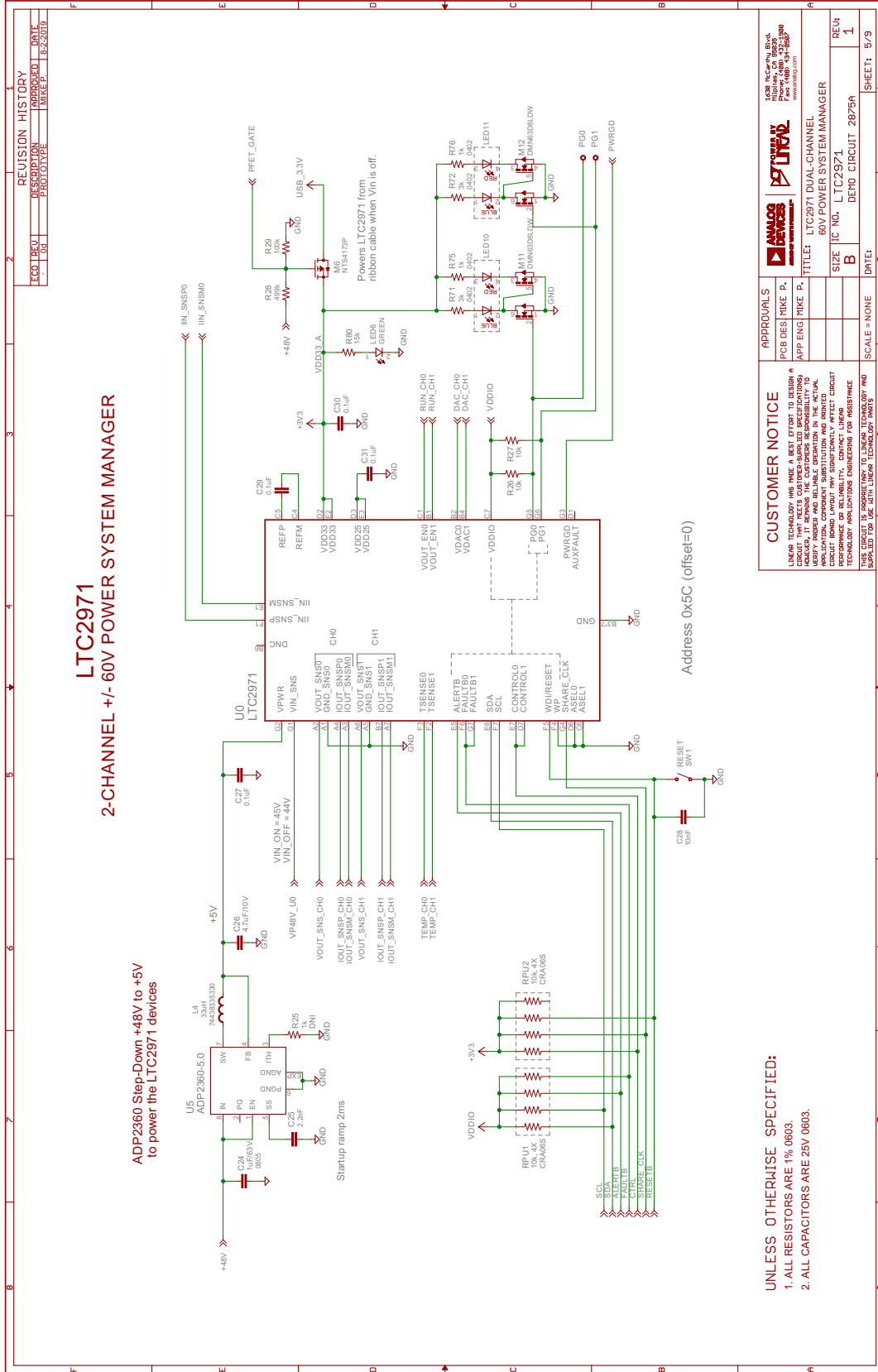
APPROVALS	PCB DESIGNS	APP ENGR	DATE
MIKE P.	MIKE P.	MIKE P.	
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TITLE: L7C2971 DUAL-CHANNEL 60V POWER SYSTEM MANAGER	REV: 1
SIZE: B	IC NO.: L7C2971
SCALE: NONE	DATE: DEMO CIRCUIT 2875A
SHEET: 2/9	

DC2875A SCHEMATIC DIAGRAM



DC2875A SCHEMATIC DIAGRAM



REVISION HISTORY

ECO. NO.	DESCRIPTION	DATE
1	PROTOTYPE	8-25-09
2	MIKE P.	

APPROVALS

PCB DESI	MIKE P.
APP ENGR	MIKE P.

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B	LTC2971	1

DEMO CIRCUIT 2875A

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DRAWN: B

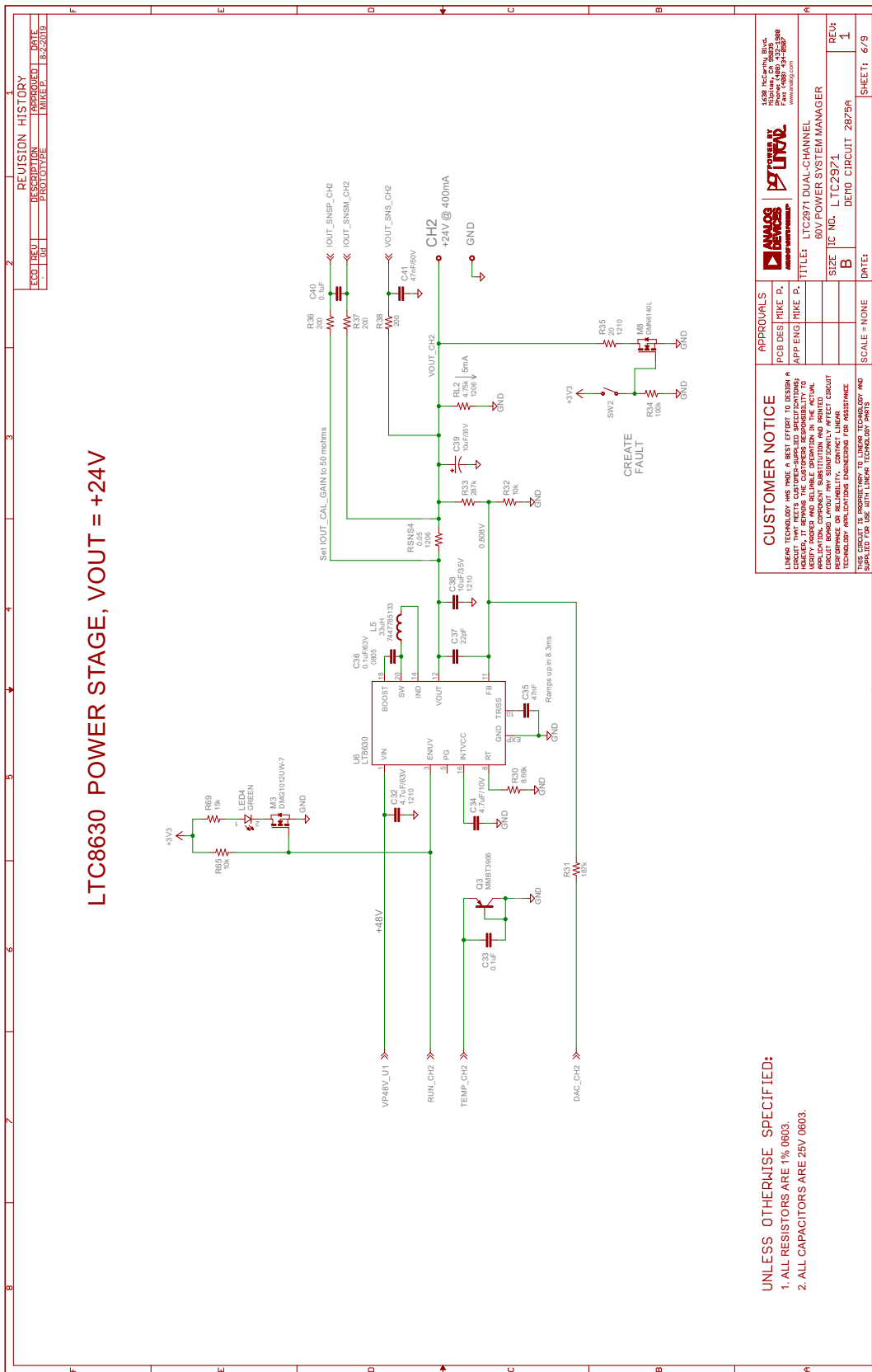
CHECKED: B

DATE: 8-25-09

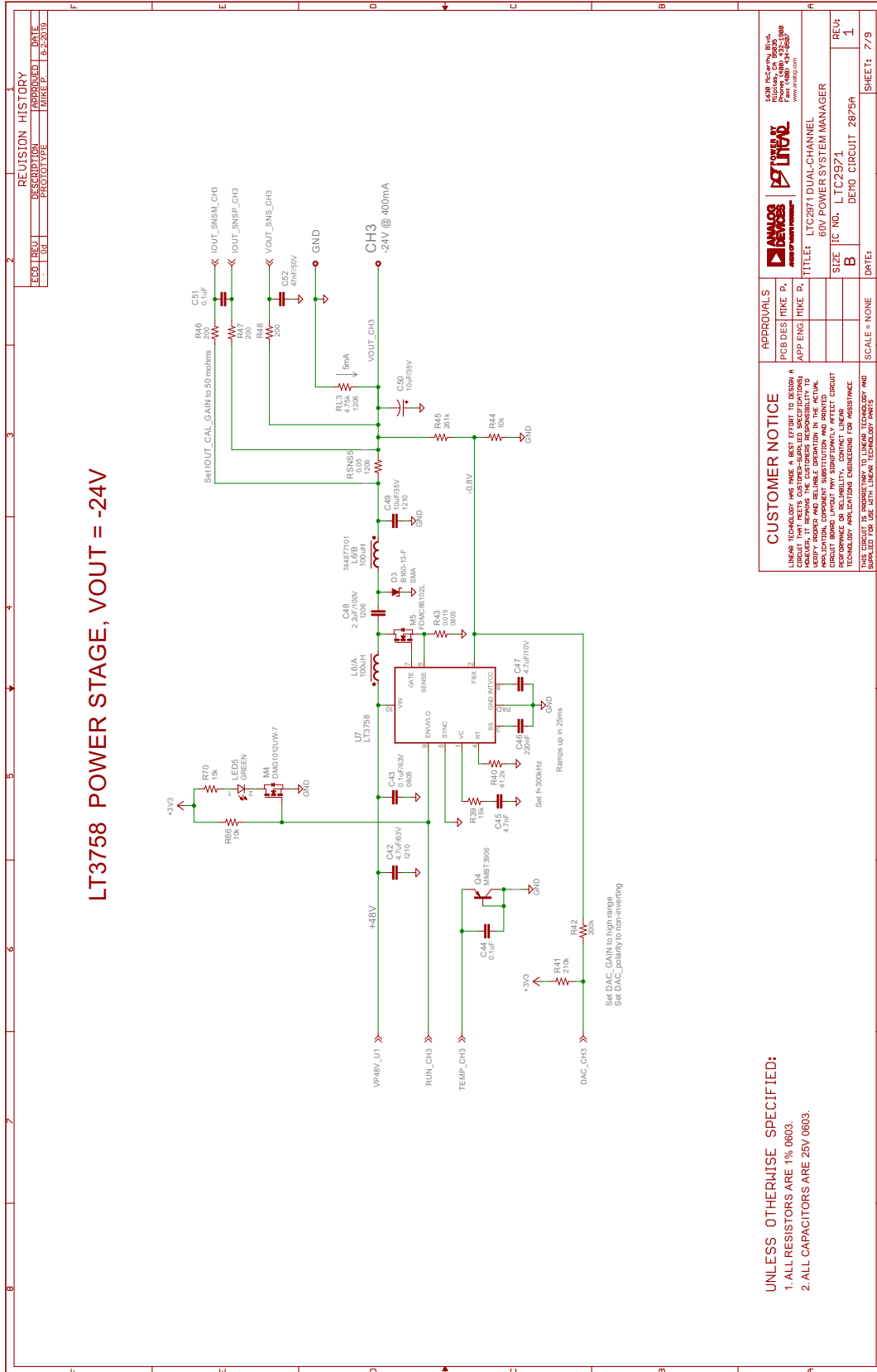
SHEET: 5/9

- UNLESS OTHERWISE SPECIFIED:
1. ALL RESISTORS ARE 1% 0603.
 2. ALL CAPACITORS ARE 25V 0603.

DC2875A SCHEMATIC DIAGRAM

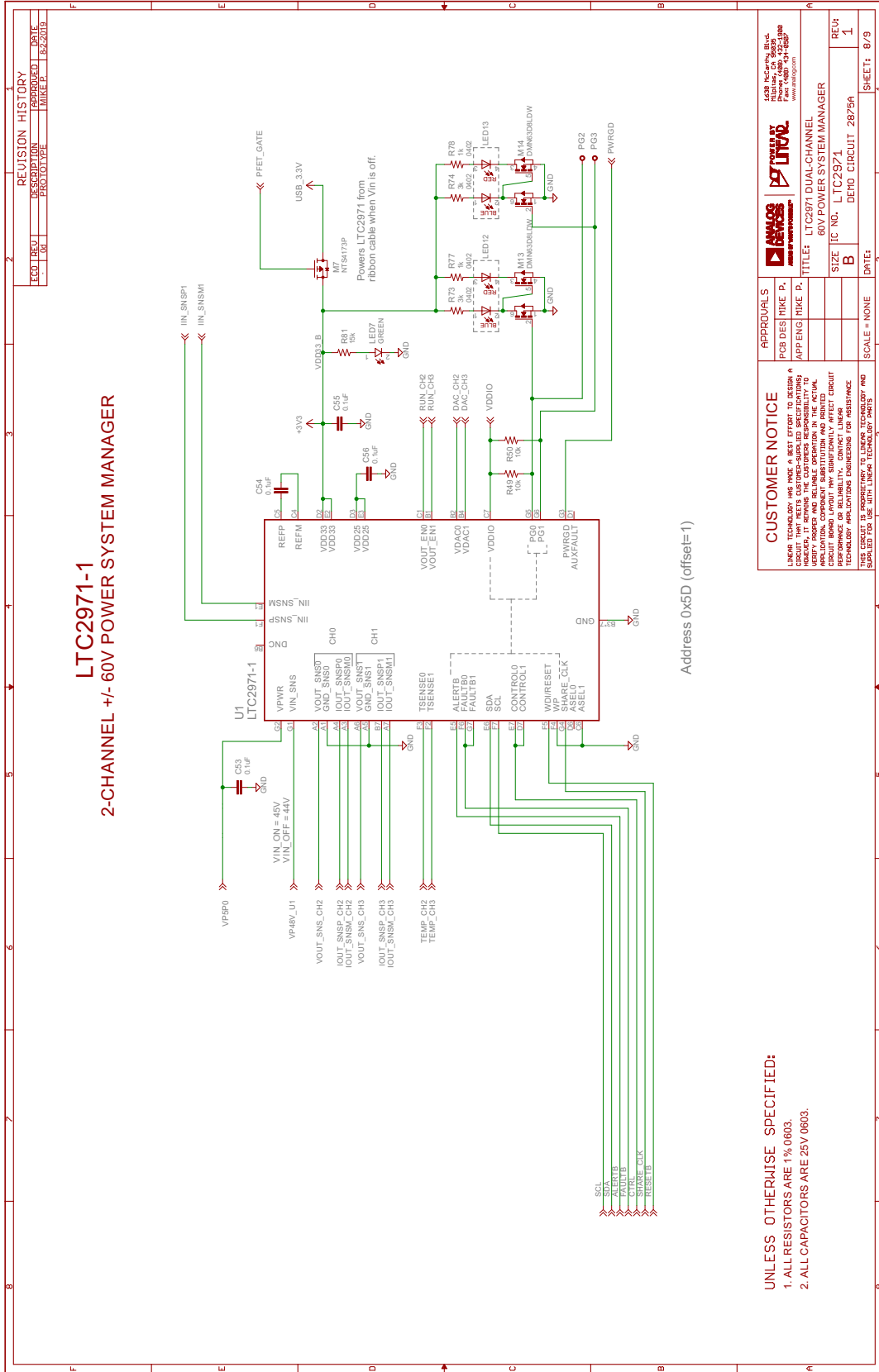


DC2875A SCHEMATIC DIAGRAM

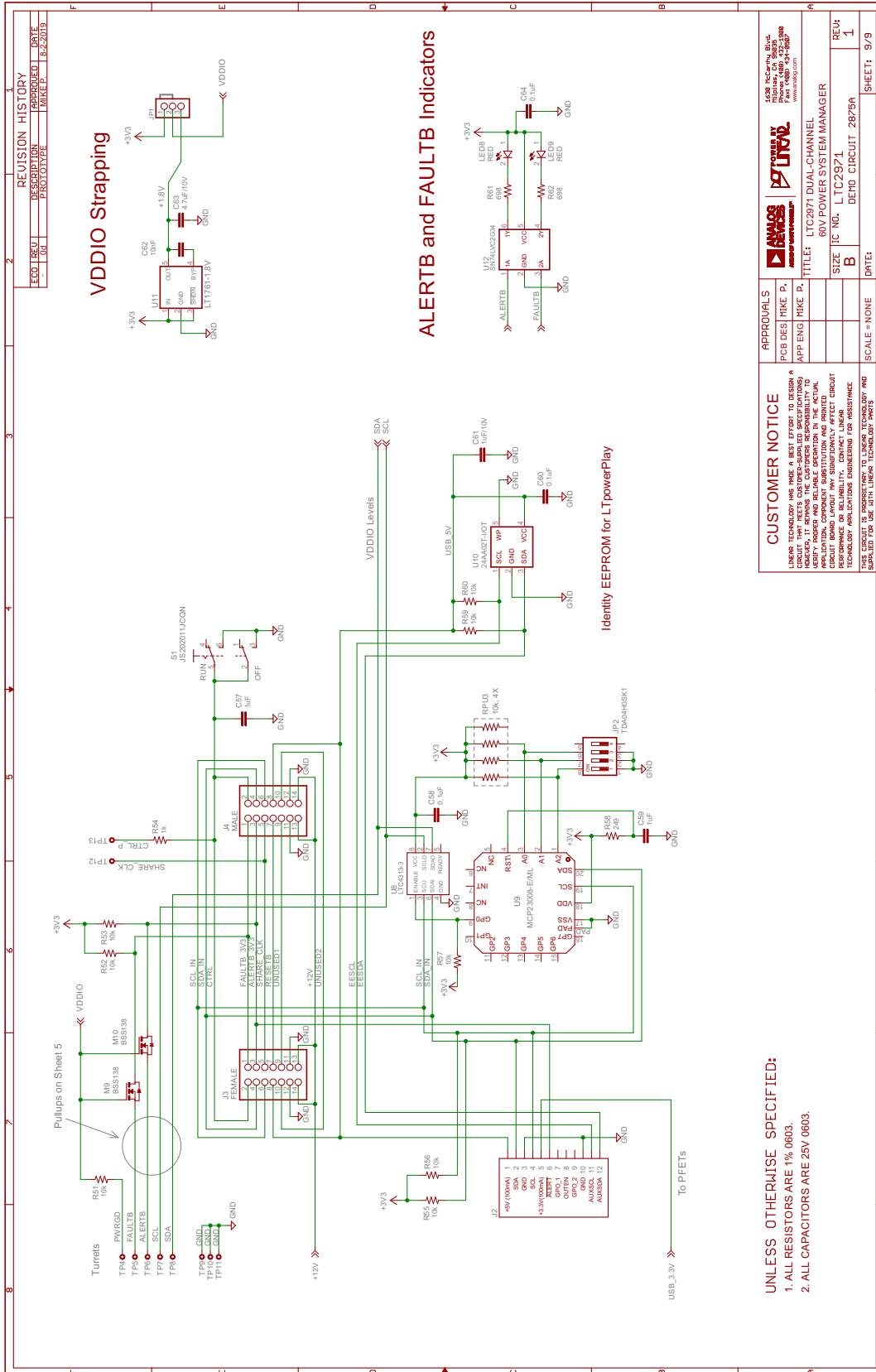


DEMO MANUAL DC2875A

DC2875A SCHEMATIC DIAGRAM



DC2875A SCHEMATIC DIAGRAM



REVISION HISTORY

ECO	DATE	DESCRIPTION	BY
1	04/11/10	INITIAL RELEASE	MMK/EP
2	08/22/10	REVISED FOR PRODUCTION	MMK/EP

APPROVALS

PCB DES	MMK	P.
APP ENG	MMK	P.

TITLE: LTC2971 DUAL-CHANNEL 60V POWER SYSTEM MANAGER

SIZE IC NO. LTC2971

DEMO CIRCUIT 2875A

REVISION 1

SCALE = NONE

DATE: 08/22/10

SHEET: 9/9

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