LTC4284
High Power Negative Voltage Hot Swap Controller with I²C Energy Monitor and EEPROM

DESCRIPTION

Demonstration circuit 2470A showcases the LTC®4284 high power, negative Hot Swap controller with I²C energy monitor and EEPROM in a 2.5kW, –48V application. DC2470A is configured for low stress staged start, which offers the lowest cost hot plug solution for high power systems.

Included on the board is isolation for power good control pins to enable downstream power converters. LEDs indicate the presence of –48V input and output as well as the state of both supply feeds and power good signaling. High voltage layout rules are followed throughout for best long term product reliability.

Headers are provided for all three LTC evaluation interfaces, providing instant access to voltage, current and power measurements, fault logging, and board temperature.

Design files for this circuit board are available.

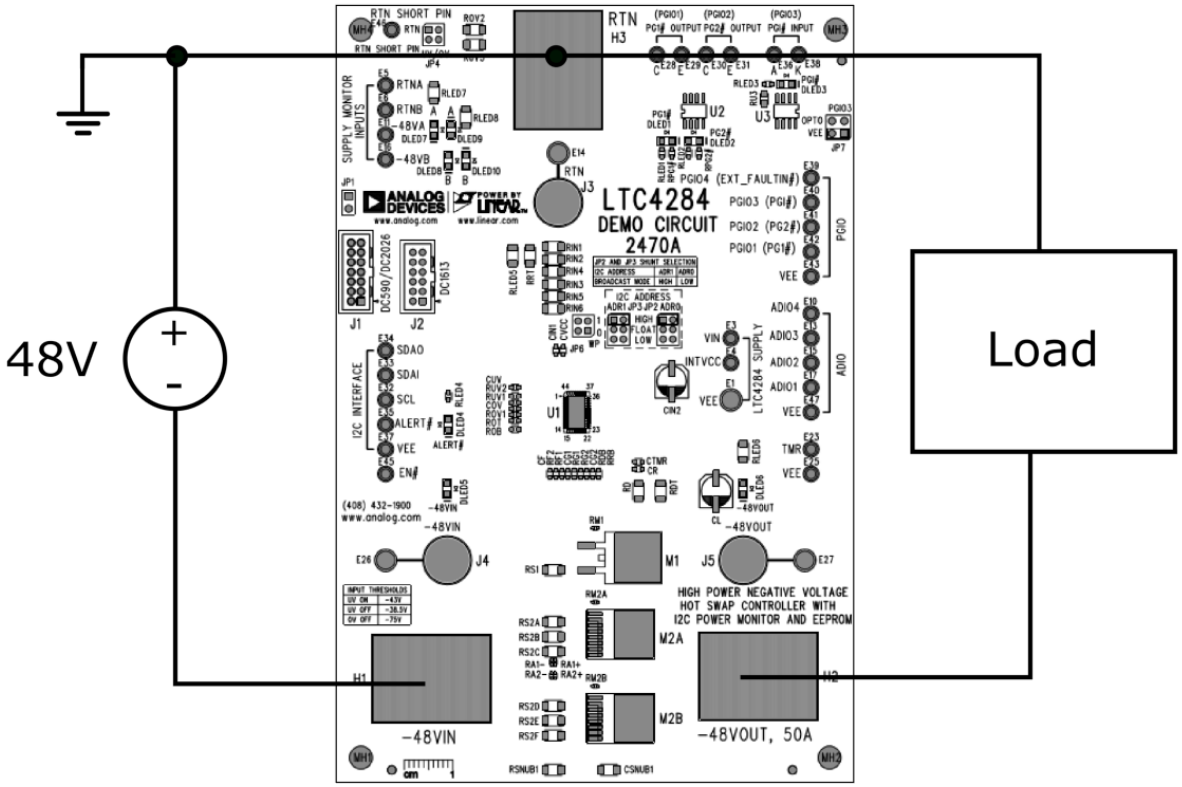

Figure 1. LTC4284 Setup

QUICK START PROCEDURE

Board Layout

The board is divided into several planes, each separated by a 60-mil gap for DC standoff up to 100V. In addition to the basic planes (RTN, $-48V_{IN}$, V_{EE}, and $-48V_{OUT}$), there are small sub planes for the MOSFET sources. Other isolated regions include the areas around the supply monitor inputs, RTN short pin, and the power good opto-isolators.

Power Connections

Use 4 AWG ($19mm^2$) welding cable for power supply and load connections. Suitable welding cable is available from Anixter [(877) 467-9473]. Order ToughFlex #4 heavy duty welding cable, part number WC4BK.

The resistance of 4 AWG welding cable is 263µΩ per foot, resulting in a power dissipation of 658mW and a voltage drop of 13.2mV per foot at 50A. While the voltage drop may be negligible in a 48V system, the power dissipation will cause a noticeable temperature rise in the cable and can also contribute to board heating.

For power connections to the PCB, large pads are provided with Panduit S4-14R ring terminals. These are designed for use with 4 AWG welding cable. Crimp all ring terminals using a Thomas & Betts WT115 or equivalent compression crimper. Do not solder.

The ring terminals are attached to the board with stainless ¼-28 mounting hardware. To prevent damage to the PCB, do not exceed a torque of 5 ft-lbs (6.8Nm). The cap screws require a 3/16" Allen wrench, and the nuts require a 7/16" nut driver. Stainless hardware is subject to galling; lubricate the threads with Lucas Oil Products white lithium grease (product number 10533) or with an equivalent product that meets the NLGI #2 specification.

Power flows through DC2470A from the $-48V_{IN}$ terminal to $-48V_{OUT}$, through the load, and hence returns to the positive terminal of the power supply. It is not necessary for power to flow through DC2470A in the return path; for this reason, there is only one RTN connection on the PCB. Surprisingly, the PCB's return connection can be made with a small test lead to either the load or the power supply.

For minimum loss, the load and power supply returns should be connected together directly, through the shortest possible length of cable. Nevertheless, a high current RTN pad is included to provide a convenient point at which the load and power supply returns can be joined together, in the case where separate cables present themselves.

Power Good Control

DC2470A includes two power good outputs, as well as a power good input, using the PGIO1, PGIO2, and PGIO3 pins of the LTC4284. Initially, 256ms after a successful power up, Power Good 1 ($\overline{PG1}$) goes low. 256ms later Power Good 2 ($\overline{PG2}$) goes low. The intent of these two outputs is to sequentially enable downstream DC-DC converters, after the MOSFETs are fully on. $\overline{PG1}$ and $\overline{PG2}$ outputs are the photo transistors of U2. These pull low in the "power good" condition and can sink up to 1mA.

Power good input ($\overline{PGI}$ INPUT, implemented with the PGIO3 pin) must be asserted within 512ms after $\overline{PG2}$ goes low, as verification that the secondary supplies have successfully reached regulation. If $\overline{PGI}$ INPUT is not asserted in time, the LTC4284 will shut down.

Normally the $\overline{PGI}$ INPUT signal is obtained from a supply monitor, or just simply tied to a secondary supply output. $\overline{PGI}$ INPUT (turrets A and K) drives a green indicator LED and the LED in opto isolator U3, each through a 1kΩ resistor, so that $\overline{PGI}$ INPUT can be tied directly to a 3.3V or 5V supply (A = +, K = –) to assert a power good condition.

Higher supplies can be monitored with the addition of 500Ω/V in series with $\overline{PGI}$ INPUT's A and K turrets. To avoid the need for $\overline{PGI}$ feedback during initial testing, jumper JP7 is provided so that PGIO3 can be forced low (PGIO3 set to V_{EE} position).

J1, J2 Digital Interface

The LTC4284 features an I^2C interface to control the device and to retrieve measurements, status and fault information. Because the LTC4284 uses $-48V_{IN}$ as its "ground" reference, the I^2C lines must be isolated in order to communicate with a truly ground-referred control processor. This isolation is not included on DC2470A.

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Instead, headers are made available for DC590, DC1613 and DC2026 interface boards, all of which feature full galvanic isolation and USB communication with a host computer. A ribbon cable connects J1 or J2 to the interface board; do not use J1 and J2 simultaneously.

An LTpowerPlay® GUI is available. This GUI operates with DC1613, supplied separately. A 24LC025 EEPROM (U4) located on DC2470A communicates with LTpowerPlay, permitting it to load the corresponding GUI without user input.

Jumpers

JP1: 24LC025 (U4) WP. This jumper is not installed. It is used to enable writes to the 24LC025 EEPROM that stores demo board information for use by LTpowerPlay, to select the corresponding GUI. Do not short the JP1 terminals, otherwise the memory contents may be corrupted, and the software will no longer recognize the board or load the proper GUI.

JP3, JP2: I^2C Address. These jumpers program the LTC4284's address at the ADR1 and ADR0 pins. Default FLOAT-FLOAT stuffing selects address 2Ah. HIGH-LOW selects broadcast mode (see data sheet for information on broadcast mode).

JP4: UV/OV. The UV and OV divider strings are joined together and serve as an RTN short pin input. For testing purposes, the short pin function can be bypassed by moving the jumper to the RTN position. To avoid permanent connector damage, high power applications must use a short pin for on/off control during insertion and extraction.

JP6: WP. This write protect blocks writes (position 1) to the LTC4284 on-chip EEPROM. 0 enables writes. WP does not block fault logging.

JP7: PGIO3. PGIO3 is configured as a $\overline{PGI}$ input (power good input) and is controlled by the $\overline{PGI}$ INPUT via opto isolator U3. JP7 bypasses the $\overline{PGI}$ function when the jumper is set to the V_{EE} position. Doing so ties PGIO3 low, indicating "power is good" and allowing the LTC4284 to remain on after a successful power-up.

Supply Monitor Inputs

The ADIN1-4 pins are used to measure the individual supply feed terminal voltages relative to the V_{REF} pin (and ultimately, V_{EE}), in a two-supply system. ADIO3 is configured to measure the chassis voltage, also relative to V_{REF}. Thus, in a redundant feed system, a total of five connections between DC2470A and RTNA, RTNB, $–48V_A$, $–48V_B$ and CHASSIS are necessary to use this feature. Precision 101:1 dividers connect to each of these potentials, to measure their respective voltages. The bottom of the dividers is connected to V_{REF}, allowing measurement of up to ±100V relative to V_{EE}. Feed voltage is inferred by subtracting associated –48V and RTN readings. Absolute terminal voltages, relative to chassis, are obtained by subtracting the chassis reading (ADIO3) from the individual terminal readings (ADIN1-4). LTpowerPlay takes care of calculations and shows the differential voltage of the two feeds, and the individual feed terminal voltages relative to ground. The operation of the feed monitor circuit is explained in the data sheet and illustrated in Figure 23, Feed Voltage and Open Fuse Monitoring. If unused, these connections may be simply left open.

Board Temperature

An NTC thermistor (RTHA) and linearizing circuit is connected to the LTC4284's ADIO4 pin, to measure board temperature. The ADIO4 pin is configured as an ADC input. The LTpowerPlay GUI calculates temperature using the ADC measurement of ADIO4's voltage.

Altered Register Values

The following changes have been made to the default register values as they are listed in the data sheet:

I_{LIM}	0011	18mV
FB	01	50%
F_{TBD_DL}	01	512ms

QUICK START PROCEDURE

Basic Operation

Set JP4 to RTN, and JP7 to V_{EE}. These are the default stuffing positions. Connect an interface cable to DC1613 via J2 and connect a PC to DC1613 via its USB interface.

After first verifying that the supply is off, and the load is disabled, connect a 48V supply capable of at least 60A to $-48V_{IN}$ and RTN, and connect a load across $-48V_{OUT}$ and RTN. As previously described, the load RTN may be connected directly to the supply, and DC2470A's RTN terminal connected through a small test lead.

Turn on the supply. The LTC4284 is configured to turn on autonomously after application of power. Once the output is up, as indicated by the $-48V_{OUT}$ LED (DLED6) and the $\overline{PGI}$ and $\overline{PG2}$ LEDs (DLED1 and DLED2), the load may be enabled. The LTpowerPlay GUI may be started at any time.

If two supplies are available, the supply monitor inputs may be connected to the appropriate terminals ahead of the ORing diodes. The matching negative side diode OR is DC2180A, which features the LTC4371.

A Note About Grounding

"Ground" reference for DC2470A is $-48V_{IN}$ and the attached V_{EE} plane, whereas in an actual system RTN closely tracks earth and chassis ground. For bench testing where the input supply is floating, $-48V_{IN}$ and V_{EE} can serve as the reference ground, such as for oscilloscope probing.

The DC590, DC1613 and DC2026 interface boards are fully isolated and can be used regardless of whether $-48V_{IN}$ or RTN is ground referenced.