Evaluating the LT4200 12 V, 100 A Hot Swap E-Fuse

GENERAL DESCRIPTION

The EVAL-LT4200-AZ circuit board enables evaluation of two parallel LT4200 50 A hot swap E-fuses in a 100 A application. The LT4200 protects the backplane supply from glitches and sparks by controlling the inrush current during hot plug. During an output overload, the LT4200 shuts off after a delay to protect the internal power MOSFET and the backplane supply. The EVAL-LT4200-AZ includes resistive dividers for undervoltage and overvoltage protection and output power good. Turrets are provided for monitoring current, power good, fault status, and input and output voltages. Several test points allow probing of other circuit nodes.

Design files for this circuit board are available at the Analog Devices, Inc. website.

ELECTRICAL CHARACTERISTICS

Specifications are at T_A = 25°C.

Table 1.

Parameter	Typical Value	Units
Input Operating Voltage	12	V
Maximum Input Voltage for DC Survival	16	V
Undervoltage Lockout Release (Input Rising)	9.91	V
Undervoltage Lockout (Input Falling)	9.27	V
Power Good Threshold (Output Rising)	10.5	V
Overvoltage Lockout (Input Rising)	15.1	V
Current Limit	114	A
Electronic Circuit Breaker Delay	1.2	ms
Maximum Load Capacitance (CGATE and RGATE Not Installed)	7666	µF

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REVISION HISTORY

6/2023—Revision 0: Initial Version

QUICK START PROCEDURE

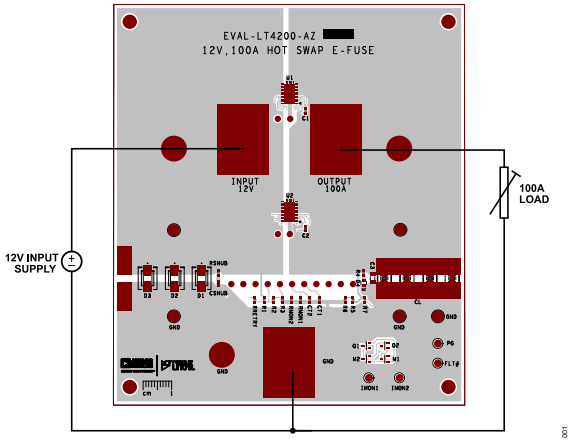

Figure 1. Measurement Equipment Setup

The EVAL-LT4200-AZ is easily set up to evaluate the performance of dual LT4200 for 100 A applications. Refer to Figure 1 for proper equipment setup. Note that any high current connectors and banana plugs present protrude through the bottom of the EVAL-LT4200-AZ. Even though the EVAL-LT4200-AZ is equipped with standoffs, the underlying surface must be non-conductive and clear of any wire, solder, and other conductive debris.

CL has pads to fit many different sizes of capacitors, from 0603 to 2220 size ceramic or electrolytic capacitors.

Load current can be monitored on the IMON1 and IMON2 turrets, which have a value of 0.04 V/A determined by the installed RMON1 and RMON2 of 20 kΩ.

A simple demonstration of the nominal operation of the EVAL-LT4200-AZ is as follows:

1. Use a power supply that can provide up to 14 V and 120 A, and a load that can dissipate up to 1600 W.
2. Connect a power supply, initially off, to the INPUT and a load to OUTPUT, as shown in Figure 1. If testing with a high current load, use an equivalent #6 gauge or larger wire and high current rated connectors for the input and output connector pads. The small turrets located in the middle left (INPUT) and right (OUTPUT) and bottom right (PG, FLT#, IMON1, IMON2) are only for monitoring purposes. They do not need any connections.
3. Applying input voltage greater than 10 V powers up the output, as indicated by the green LED, D4. See Figure 2 for typical start up when hot swapping the input. If loading 100 A, the INPUT to OUTPUT voltage drop is around 60 mV and each LT4200 temperature rises to around 80°C in a 23°C ambient without air flow when using #4 gauge wires for input and output connections (see Figure 3).

In Figure 2, when hot plugging, the debounce feature ensures that the internal MOSFET turns on after the input is stable for 48 ms. Because there is no gate capacitor, the output rises in 34 ms. In Figure 3, a #4-gauge wire was used for input and output connections. A thermal camera was used to measure the LT4200 package temperature. Each point was recorded after 20 minutes of steady state operation.

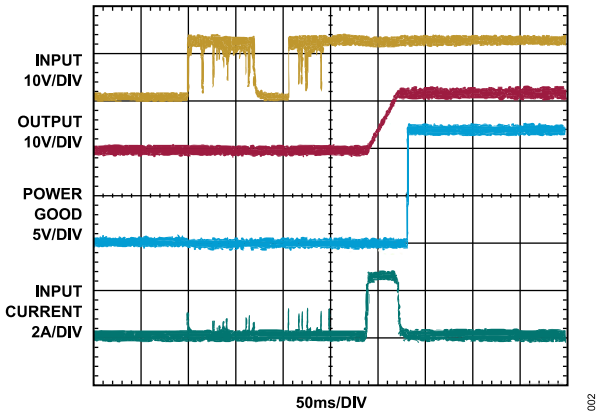

Figure 2. EVAL-LT4200-AZ Startup Into 7650 µF Load Capacitor After Input Hot Plug

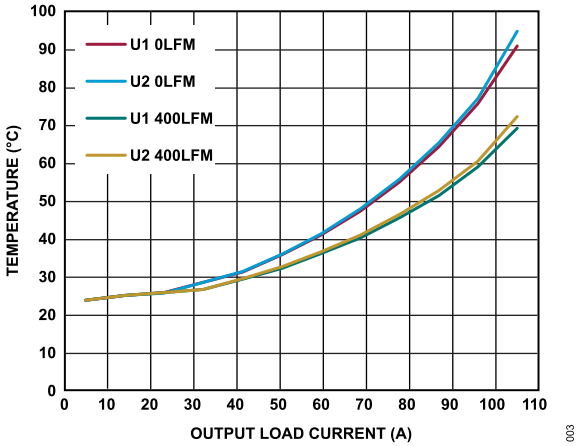

Figure 3. LT4200 Temperature (U1 and U2) vs. Load Current in a 23°C Ambient with No Air Flow and with 400 Linear Feet Per Minute (LFM) Air Flow

BOARD DESCRIPTION

OVERVIEW

The EVAL-LT4200-AZ is an 8-layer board with 2 oz copper on the top and bottom layers and 1 oz copper on the inner layers. There are large planes for input, output, and ground on the top three layers. The two LT4200 devices are placed symmetrically around the input and output connections, 1.5" apart to minimize thermal coupling, especially because each LT4200 dissipates 3 W at 50 A. Large planes of the bottom five layers are connected to the LT4200 SENSE− pads to conduct heat towards the back side of the EVAL-LT4200-AZ.

To ease probing, turrets are provided for the INPUT, OUTPUT, IMON, FLT#, and PG pins. Note that even a 10 MΩ probe or voltmeter affects measurements of high impedance nodes, such as GATE and TIMER. Be careful not to short TIMER to ground because it prevents the LT4200 from shutting down in the event of an overcurrent condition, potentially damaging the internal metal-oxide semiconductor field effect transistor (MOSFET).

U1 AND U2: HOT SWAP CONTROLLERS

Refer to the LT4200 data sheet for details on its operation and electrical specifications. The quiescent current of the EVAL-LT4200-AZ at a 12 V input is 3.46 mA.

D4: OUTPUT VOLTAGE INDICATOR

A green LED, D4, indicates the presence of output voltage. If the LT4200 MOSFETs switch off, D4 turns off.

OPTIONAL CL: OUTPUT CAPACITOR PADS

A large copper pad (CL) is provided on the right side of the EVAL-LT4200-AZ for stuffing 0603 to 2220 sized ceramics and electrolytic capacitors for different applications. When using the internal gate ramp rate (CGATE and RGATE not populated), the maximum guaranteed operating CL is 7666 µF. For applications that require higher CL capacitance values, add a CGATE and RGATE. See the CGATE and RGATE: Adjustable Inrush Current section for more details.

R1 TO R3, R5, AND R7 UV/OV/PG THRESHOLDS

Set the input supply to zero and ramp the voltage slowly. At greater than 10 V, the circuit is out of UV lockout and the output ramps up, turning on the green LED, D4. At greater than 10.5 V, the FB pin is above its threshold, releasing the PG pin high. Increasing the supply past 15.1 V engages OV lockout. D4 turns off and PG asserts low.

CGATE AND RGATE: ADJUSTABLE INRUSH CURRENT

The EVAL-LT4200-AZ comes with two uninstalled gate RC networks (RGATE and CGATE). By default, the gate voltage ramps up at a rate of 0.35 V/ms during normal operation. This corresponds to 34 ms ramp time for 12 V input voltage. Adding a capacitor and a 100 kΩ resistor from GATE to GND lowers the inrush current below the default rate. Note that when RGATE and CGATE are being used, it is necessary to compensate the current limit regulation loop with a 3.3 nF capacitor at CCOMP. The GATE pin is charged with a 24 µA current. Therefore, the voltage slope of the GATE pin is equal to 24 µA/CGATE and the supply inrush current follows Equation 1.

$$I_{INRUSH} = \frac{C_L}{C_{GATE}} \times 24 \quad \mu A \tag{1}$$

where:
C_L is the CL value.
C_{GATE} is the CGATE value.

RRETRY: SELECT AUTORETRY

By default, the EVAL-LT4200-AZ comes with 0 Ω at RRETRY, setting the EVAL-LT4200-AZ to autoretry by connecting FLT# to UV. When there is an overload event, the LT4200 turns off the internal MOSFET and enters a 414 ms long cooldown state followed by a 48 ms debounce delay before attempting to turn on the MOSFET again. If autoretry is not needed, remove the RRETRY resistor to disconnect UV from FLT#.

TIMER

When an overcurrent event occurs, the TIMER capacitor begins to charge up at a rate of 12 ms/µF before the switch is turned off. By default, each LT4200 is equipped with a 0.1 µF capacitor value. Therefore, the turn off delay for each LT4200 is 1.2 ms. The presence of the cross-coupled timer circuit gives priority to the slower LT4200 timer that triggers when both LT4200 devices can turn off (see the M1, M2, Q1, and Q2: Cross-Coupled Timer Circuit section for more information).

M1, M2, Q1, AND Q2: CROSS-COUPLED TIMER CIRCUIT

These cross-coupled transistors prevent any one LT4200 TIMER pin from ramping up to its threshold and shutting off its gate before the other LT4200 also hits its current limit threshold. This ensures that the current limit of the EVAL-LT4200-AZ can reach twice the 57 A of each LT4200. Note that this circuit only works when PG is high, for example, when the output voltage is greater than 10.5 V.

D1, RSNUB, AND CSNUB: INPUT CLAMP AND SNUBBER

During an overload, the internal MOSFET of the LT4200 shuts off after a delay set by the TIMER capacitor. The sudden stop to current flow induces a high input voltage spike that reacts with the parasitic inductance (of the input supply cable) and capacitance, creating an oscillation. The transient voltage suppressor (TVS) absorbs the amplitude of the spike to protect the LT4200, while the snubber dampens the oscillation.

NOTES

ESD Caution
ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.