

# LTC4232 and LTC4232-1: 5A Integrated Hot Swap Controller

## DESCRIPTION

Demonstration circuit 1886B features the [LTC4232](#) and the [LTC4232-1](#) 5A integrated Hot Swap™ controllers. The LTC4232 is ideally suited for demanding power distribution control in 2.9V to 15V applications for hot board insertion protection, high side power switching, and electronic circuit breaker functions. The LTC4232 provides a rich set of features to support Hot Swap applications including:

- 2% accurate undervoltage and overvoltage comparators
- Thermal protection
- Adjustable inrush current control
- Adjustable, 10% accurate current limit with programmable cutout time
- Foldback current limiting
- Programmable output voltage ramp rate
- Configurable auto-retry or latchoff on overcurrent faults
- Power good and fault outputs
- Debounce time during supply turn-on

The LTC4232 debounce time is 100ms, while the LTC4232-1 is 16ms. Both are available in a 16-lead 5mm × 3mm DFN package. The LTC4232 is showcased on demonstration circuit 1886B-A. The LTC4232-1 is installed on DC1886B-B. Both demo boards are configured for 12V application. By changing a few passive components, 2.9V to 15V applications can be easily evaluated.

The LTC4232 has limited output voltage slew rate with a typical value of 300V/s, while the LTC4232-1 does not have a special circuit to limit this parameter. The natural (maximum) gate voltage slew rate ( $S_N$ ) of the LTC4232-1 is defined by the internal MOSFET  $C_{RSS}$  (reverse transfer capacitance) value and gate driver current capability. It is 48000V/s as a typical value.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC1886B>**

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## PERFORMANCE SUMMARY (T<sub>A</sub> = 25°C)

| SYMBOL                     | PARAMETER                             | CONDITIONS                                                                                                              | MIN               | TYP               | MAX               | UNITS        |
|----------------------------|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------|-------------------|-------------------|--------------|
| V <sub>DD</sub>            | Board Input Supply Range              | Min Is UV, Max Is OV                                                                                                    | 9.2               | 12                | 15.1              | V            |
| dV <sub>GATE</sub> /dt     | GATE Pin Turn-On Ramp Rate            | LTC4232<br>LTC4232-1 with 10nF GATE Capacitor                                                                           | 0.15<br>1.7       | 0.3<br>2.4        | 0.55<br>3.5       | V/ms<br>V/ms |
| R <sub>ON</sub>            | MOSFET + Sense Resistor On-Resistance |                                                                                                                         | 15                | 33                | 50                | mΩ           |
| I <sub>LIM(TH)</sub>       | Current Limit Threshold               | V <sub>FB</sub> = 1.23V, No R <sub>SET</sub><br>V <sub>FB</sub> = 0V<br>V <sub>FB</sub> = 1.23V, R <sub>SET</sub> = 20k | 5.0<br>1.2<br>2.6 | 5.6<br>1.5<br>2.9 | 6.1<br>1.8<br>3.3 | A<br>A<br>A  |
| V <sub>TH</sub>            | OV, UV, FB Pin Threshold Voltage      | V <sub>IN</sub> Rising                                                                                                  | 1.21              | 1.235             | 1.26              | V            |
| V <sub>UV(RTH)</sub>       | UV Pin Reset Threshold Voltage        | V <sub>UV</sub> Falling                                                                                                 | 0.55              | 0.62              | 0.7               | V            |
| V <sub>FB(HYST)</sub>      | FB Pin Power Good Hysteresis          |                                                                                                                         | 10                | 20                | 30                | mV           |
| t <sub>D(AUTO-RETRY)</sub> | Auto-Retry Turn-On Delay (Internal)   | LTC4232<br>LTC4232-1                                                                                                    | 50<br>8           | 100<br>16         | 150<br>24         | ms<br>ms     |
| T <sub>ADJUST</sub>        | Timer Period for ADJUSTABLE Option    | LTC4232<br>LTC4232-1                                                                                                    | 9.5<br>0.95       | 12.3<br>1.23      | 16.8<br>1.68      | ms<br>ms     |

## JUMPERS AND LEDS

Two demo board jumpers, JP1 and JP2, allow selection of controller operation:

- JP1 TIMER DURATION: Set to FIXED 2ms position for the internal 2ms timer period (FIXED 2ms not recommended for LTC4232-1 during auto-retry) or ADJUSTABLE determined by TIMER capacitor C1 (12ms for LTC4232 and 1.2ms for LTC4232-1). (Default position: ADJUSTABLE)
- JP2 AUTORETRY: Set to ON for auto-retry or OFF for latchoff on overcurrent fault. (Default position: OFF)

When selecting AUTORETRY option for the circuit with a predominantly resistive load, particularly for LTC4232-1, pay special attention to the power MOSFET thermal condition. The initial low current limit (due to the foldback characteristic) can power the load only during a very short time, and the MOSFET will experience the maximum current limit for almost all of the remaining power up period. This may exceed the MOSFET SOA, if allowed to autoretry.

Four LEDs indicate the state of the hot swap circuit. Red LEDs, D3 and D5, provide fault status and low output voltage (it is a NOT power good signal). Two green LEDs, D2 and D4, signal the presence of valid input and output voltages.

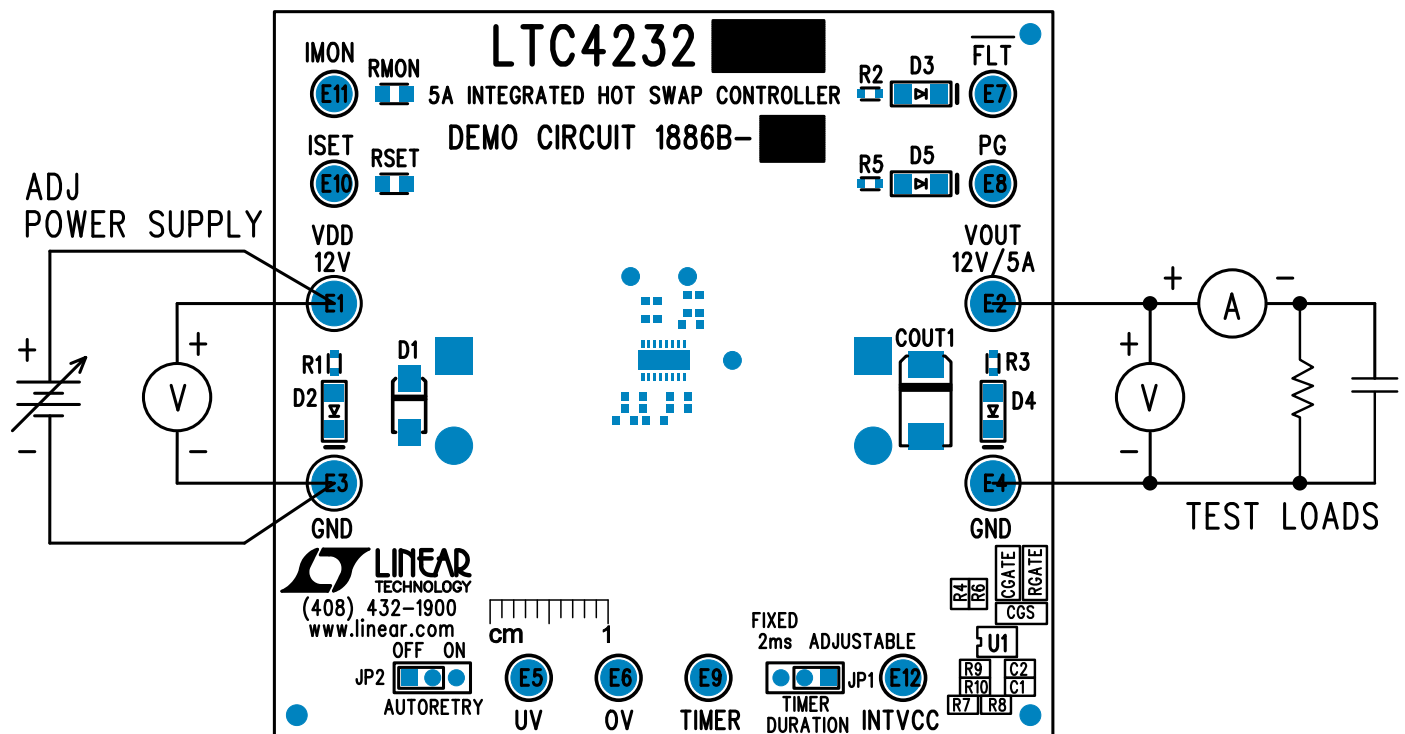


Figure 1. Proper Measurement Equipment Setup

## QUICK START PROCEDURE

Demonstration circuit 1886B is easy to set up to evaluate the performance of the LTC4232 or LTC4232-1. Refer to Figure 1 for the proper measurement equipment setup and follow the procedure below.

1. Place jumpers in the following positions:

**JP1**    TIMER DURATION    FIXED 2ms

**JP2**    AUTORETRY    OFF

2. With power off, connect 12V power supply terminals to the VDD (E1) and GND (E3) turrets.
3. Turn on the 12V power supply and verify the output voltage between the V<sub>OUT</sub> (E2) and GND (E4) turrets. Two green LEDs, D2 and D4 should light up.
4. Check the current limit using an electronic or resistive load. It should be in the range of 5A to 6.1A if an overcurrent condition occurs while the output is high (after powering up properly). If the output is shorted initially, the load current will be limited in the range of 1.2A to 1.8A due to the foldback characteristic. Current may be monitored on the IMON turret. The IMON signal scale is 0.4V/A.

An overcurrent condition is indicated by the red LED FLT(D3) and red LED PG (D5).

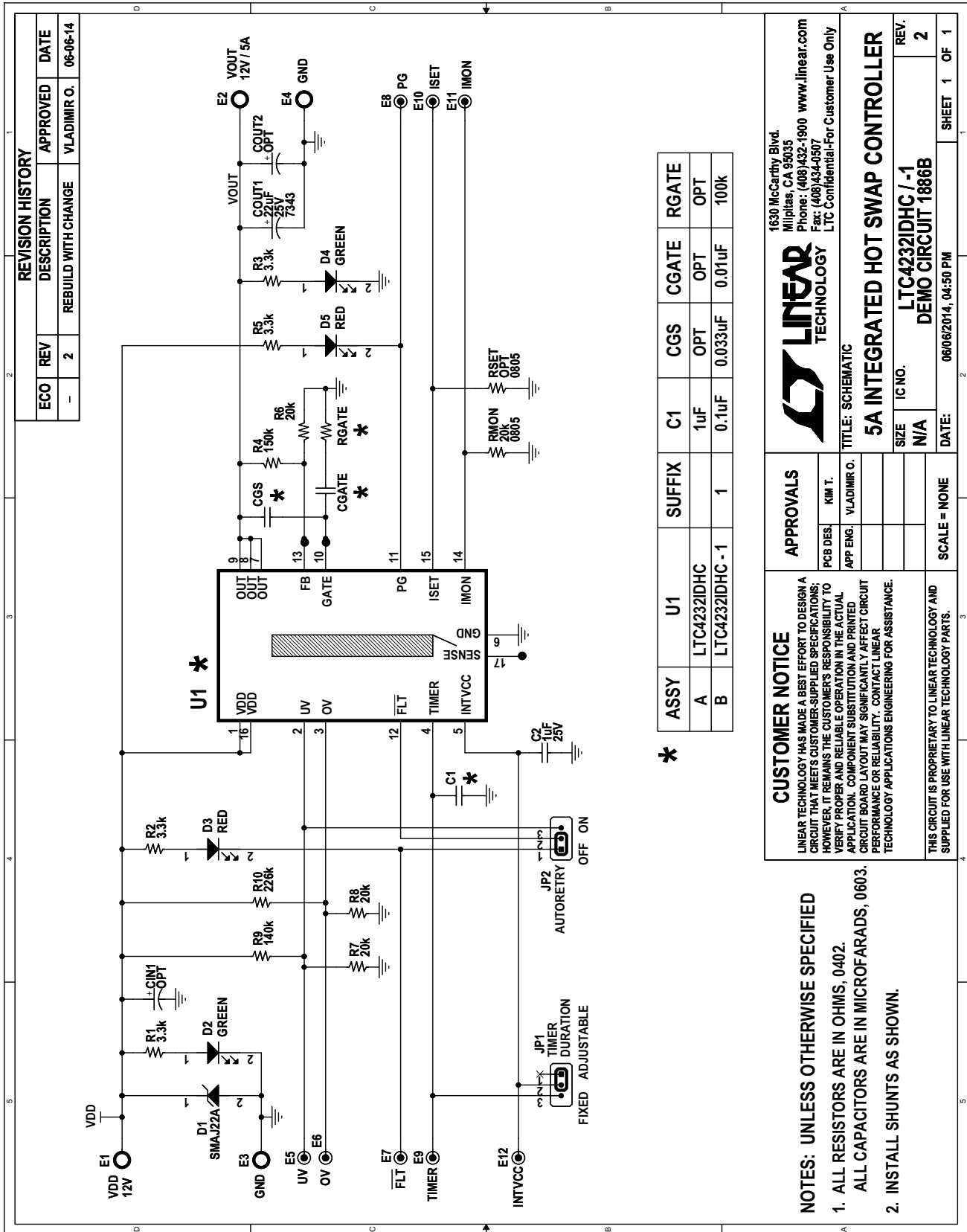
5. Check the output voltage slew rate with an oscilloscope, without a load connected. It should take from 22ms to 80ms for LTC4232, and from 3.0ms to 7.0ms for LTC4232-1.
6. For DC1886B-A (LTC4232) use a 2000 $\mu$ F capacitive load to demonstrate that power up mode completes successfully. Use a current probe to verify that inrush current is limited initially by the foldback characteristic and later by the low output voltage slew rate.
7. For DC1886B-A use a 6000 $\mu$ F capacitive load to demonstrate that the part not only enters into the current limit state but operates in this state until the timer period expires. It is not a successful power up.
8. For DC1886B-B use a 800 $\mu$ F capacitive load to demonstrate a successful power up mode. The controller will operate in current limit almost all of the timer period.
9. For DC1886B-B use a 3000 $\mu$ F capacitive load to demonstrate an unsuccessful power up transient. The operating point does not leave current limit during the whole timer period. It will then time out and turn off.

# DEMO MANUAL DC1886B

## PARTS LIST

| ITEM                                         | QTY | REFERENCE      | PART DESCRIPTION                                    | MANUFACTURER/PART NUMBER          |
|----------------------------------------------|-----|----------------|-----------------------------------------------------|-----------------------------------|
| <b>Required Circuit Components</b>           |     |                |                                                     |                                   |
| 1                                            | 0   | CIN1, COUT2    | CAP, SANYO\16X25\H                                  | OPT                               |
| 2                                            | 1   | COUT1          | CAP, TANT, 22 $\mu$ F 25V, 20%, 7343                | AVX, TPSD226M025R0200             |
| 3                                            | 1   | C2             | CAP, X5R, 1 $\mu$ F 25V, 0603                       | AVX, 06033D105KAT2A               |
| 4                                            | 1   | D1             | DIODE, 400W TRANSIENT VOLTAGE SUPPRESSOR, SMA-DIODE | DIODES INC., SMAJ22A-13-F         |
| 5                                            | 2   | D2, D4         | LED, GREEN, LED-ROHM-SML-010FT                      | ROHM, SML-010FTT86L               |
| 6                                            | 2   | D3, D5         | LED, RED, LED-ROHM-SML-010VT                        | ROHM, SML-010VTT86L               |
| 7                                            | 4   | E1, E2, E3, E4 | TURRET, TEST PIN, 0.094"                            | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 8                                            | 8   | E5-E12         | TURRET, TEST PIN, 0.064"                            | MILL-MAX, 2308-2-00-80-00-00-07-0 |
| 9                                            | 2   | JP1, JP2       | JMP, HD1X3, 0.079CC                                 | SULLIN, NRPN031PAEN-RC            |
| 10                                           | 1   | RMON           | RES., CHIP, 20k, 1/8W, 5%, 0805                     | YAGEO, RC0805JR-0720KL            |
| 11                                           | 0   | RSET           | RES., CHIP, 0805                                    | OPT                               |
| 12                                           | 4   | R1, R2, R3, R5 | RES., CHIP, 3.3k, 1/16W, 5%, 0603                   | YAGEO, RC0603JR-073K3L            |
| 13                                           | 1   | R4             | RES., CHIP, 150k, 1/16W, 5%, 0603                   | YAGEO, RC0603JR-07150KL           |
| 14                                           | 3   | R6, R7, R8     | RES., CHIP, 20k, 1/16W, 5%, 0603                    | YAGEO, RC0603JR-0720KL            |
| 15                                           | 1   | R9             | RES., CHIP, 140k, 1/16W, 5%, 0603                   | YAGEO, RC0603JR-07140KL           |
| 16                                           | 1   | R10            | RES., CHIP, 226k, 1/16W, 5%, 0603                   | YAGEO, RC0603JR-07226KL           |
| 17                                           | 2   |                | SHUNT, 0.079" CENTER                                | SAMTEC, 2SN-BK-G                  |
| <b>DC1886B-A Required Circuit Components</b> |     |                |                                                     |                                   |
|                                              | 1   |                | DC1886B-GENERAL BOM                                 |                                   |
|                                              | 1   | C1             | CAP, X5R, 1 $\mu$ F 25V, 0603                       | AVX, 06033D105KAT2A               |
|                                              | 0   | CGS, CGATE     | CAP, 0603                                           | OPT                               |
|                                              | 0   | RGATE          | RES., 0603                                          | OPT                               |
|                                              | 1   | U1             | I.C., LTC4232IDHC, DFN16DHC                         | LINEAR TECH., LTC4232IDHC         |
| <b>DC1886B-B Required Circuit Components</b> |     |                |                                                     |                                   |
|                                              | 1   |                | DC1886B-GENERAL BOM                                 |                                   |
|                                              | 1   | C1             | CAP, X5R, 0.1 $\mu$ F 25V, 0603                     | AVX, 06033D104KAT2A               |
|                                              | 0   | CGS            | CAP, X7R, 3300pF 100V, 5%, 0603                     | AVX, 06031C332JAT2A               |
|                                              | 1   | CGATE          | CAP, X7R, 0.01 $\mu$ F 100V, 5%, 0603               | AVX, 06031C103JAT2A               |
|                                              | 1   | RGATE          | RES., CHIP, 100k, 1/10W, 1% 0603                    | NIC, NRC06F1003TRF                |
|                                              | 1   | U1             | I.C., LTC4232IDHC-1, DFN16DHC                       | LINEAR TECH., LTC4232IDHC-1       |

# SCHEMATIC DIAGRAM



# DEMO MANUAL DC1886B

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