LTC4238
High Power Hot Swap Controller

DESCRIPTION

DC2914A showcases the LTC®4238, high power, Hot Swap controller. LTC4238 is suited for 12V, 24V and 48V systems and comes loaded with advanced features including SOA timer, COMM pin for scalability, and various operating modes. The board has three variants to showcase the three different staged start topologies of LTC4238. The DC2914A-A showcases the parallel mode of operation for a 48V, 1.5kW application. The DC2914A-B demonstrates the low stress staged start mode for a 48V, 2.5 kW regulated input application. The DC2914A-C showcases the high stress staged start mode with SOA timer for 48V, 2.5kW application with large input steps. Onboard LEDs indicate the presence of input, output as well as power good signaling and any fault if present. High voltage layout rules are followed for best long-term product reliability.

Design files for this circuit board are available.

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	DC2914A-A	DC2914A-B	DC2914A-C
Input Supply Voltage Range		36V to 60V		
Nominal Operating Voltage	Typical	48V		
Overvoltage Limit	Rising	60V		
Undervoltage Limit	Falling	31V		
Power Good Indication	Typical	32V		
Undervoltage Limit	Rising	35V		
Output Current Limit	Typical	50A	63A	60A
Current Limit Timer Period	Typical	550µs	23µs	
Load Capacitance	Typical	2400µF		
FET-Bad Timer Period	Typical	42ms	192ms	42ms

BOARD PHOTO

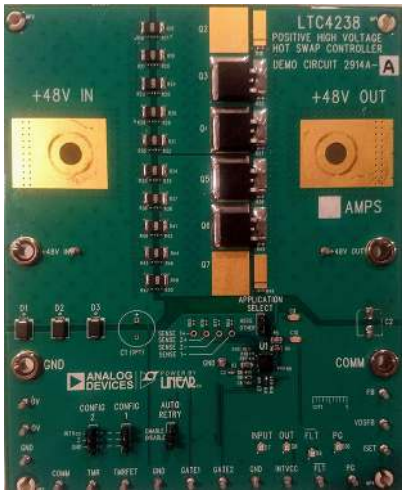

Figure 1. DC2914A Picture

DESCRIPTION

BOARD LAYOUT

The board is divided into several major planes. The 5 main planes are +48V input, +48V output, ground and 2 planes for MOSFET drain. These form the two independent channels in the power path. For power connections, large pads are provided for the input and output plane. The current flows from the input to the output through the MOSFETs but not through the GND of DC2914A; for this reason, only one GND point has been provided with banana jack. For minimum loss, the load and power supply returns should be tied together directly, through the shortest possible length of cable.

Operating Principle

The LTC4238 is a high power Hot Swap controller that has an 6.5V to 80V operating range and 100V absolute maximum at V_{DD} pin. This board is populated to operate at 48V nominal input voltage. LTC4238 showcases three staged start topologies that are discussed below. The DC2914A demo board is designed such that a single board can be modified to run in different staged start modes. The user needs to select the right BOM and choose the right jumper settings for application select, CONFIG 2 and CONFIG 1 pins from Table 5 to select the most suitable mode of operation.

- **Parallel Mode:** The DC2914A-A showcases the parallel mode of operation. The independent gate drive of LTC4238 ensures that SOA stress is shared equally among the two channels. This corresponds to a 2× increase in the effective MOSFET SOA. This mode of operation is suitable for applications with peak power requirements up to 1.5kW. It is suited for systems which expect large input steps or supply surges. Multiple such boards can be tied together using the COMM pin to enhance the SOA capability by 4×, 6×, 8×, or higher.
- **Low Stress Staged Start (LSSS):** The DC2914A-B showcases the LSSS mode of operation. This mode of operation is suited for applications with tightly regulated supply voltages. One channel (controlled by GATE 2) acts as a trickle channel which trickle charges the load capacitor. After FB voltage is high and PG is latched, bypass channel MOSFETs with low $R_{DS(ON)}$ turn on (controlled by Gate 1) and carry the DC load. This mode is best suited for line regulated inputs and cannot ride through large input voltage steps, and hence the most stressful event for such application is the start-up inrush. LTC4238 showcases FET-bad timer which runs during start-up and is kept long enough to ensure that the output capacitors are charged during start-up.* The overcurrent timer is kept short to shut-off the controller quickly during overload.

Table 1. Default Jumper Configuration

JUMPER NAME	DESCRIPTION	DC2914A-A	DC2914A-B	DC2914A-C
Auto Retry	Enable or Disable Auto Retry Functionality	DISABLE	DISABLE	DISABLE
Application Select	Select Application either HSSS or Any Other	OTHER	OTHER	HSSS
Config 2	Select Config 2 Bit for Mode Selection	$INTV_{CC}$	Z	GND
Config 1	Select Config 1 Bit for Mode Selection	$INTV_{CC}$	$INTV_{CC}$	$INTV_{CC}$

Table 2. Power Input and Output Connections

NOMENCLATURE	CONNECTOR	DESCRIPTION
48V IN	E1, E20 (Banana)	48V Power In
48V OUT	E4, E21 (Banana)	48V Power Out
GND	E12 (Banana)	Power Supply Common

*It may be noted that trickle MOSFET should have enough SOA to withstand complete V_{DS} with folded back current limit for FET-bad timer duration in case of startup into short.

DESCRIPTION

- **High Stress Staged Start (HSSS):** The DC2914A-C showcases the HSSS mode of operation. The GATE 1 controls a high SOA MOSFET, whereas GATE 2 drives less expensive bypass MOSFETs with low $R_{DS(ON)}$. The DC load is handled by bypass MOSFETs due to their lower $R_{DS(ON)}$. As soon as there is any stress condition with large V_{DS}, GATE 2 is turned off and GATE 1 remains on. Since stress MOSFET does not carry the full load current , the high SOA stress MOSFET can have higher $R_{DS(ON)}$) without compromising the DC performance.

  DC2914A-C also showcases the SOA Timer mode of the LTC4238 for better protection of the MOSFET. The Timer mode is selected by choosing the right configuration through the CONFIG 1/2 pins. A 3-RC electrical model of the MOSFET controlled by Gate 1 has been connected to the TMR Pin. The timer pin voltage is proportional to the MOSFET junction temperature and hence the timer times out before MOSFET reaches the maximum allowable junction temperature. This makes the timer duration dynamic giving LTC4238 the flexibility to ride through large input voltage steps while still shutting off during severe over current or short circuit conditions much before the MOSFET junction temperature rises beyond allowable limits, thus protecting the MOSFET. For guidance regarding designing the RC network, refer to LTC4238 data sheet

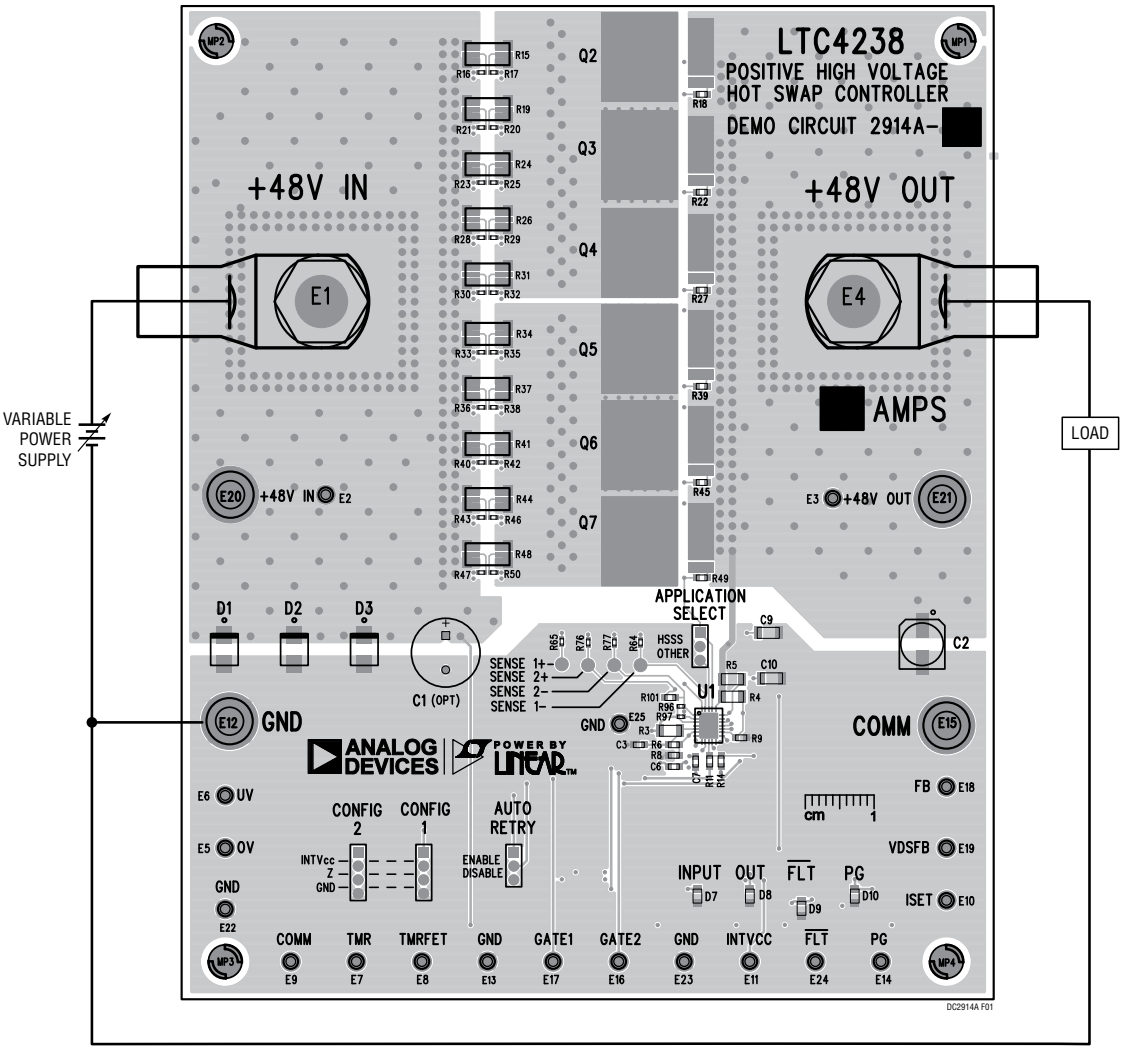

Figure 2. Proper Equipment Setup

DESCRIPTION

Table 3. Test Points, Turrets

NOMENCLATURE	TURRET	DESCRIPTION
48V IN	E2	48V Input Monitor
48V OUT	E3	48V Output Monitor
OV	E5	OV Pin
UV	E6	UV Pin
TMR	E7	Timer Pin
TMRFET	E8	FET BAD Timer Pin
COMM	E9, E15 (Banana)	Communication Pin
ISET	E10	Current Limit Adjustment Pin
$INTV_{CC}$	E11	Internal Vcc Pin
PG	E14	Power Good Indicator Pin
GND	E13, E22, E23, E25	Ground
GATE2	E16	Gate 2 Pin
GATE1	E17	Gate 1 Pin
FB	E18	Power Good Comparator Input
VDSFB	E19	Vds Sense Pin
FLT#	E24	Fault Pin (Active Low)

Table 4. LED Indicators

NOMENCLATURE	CONNECTOR	DESCRIPTION
INPUT	D7 (Green)	Input Power Indicator
OUT	D8 (Green)	Output Power Indicator
FLT#	D9 (Red)	FLT# Pin Low
PG	D10 (Green)	Power Good Indicator

Table 5. LTC4238 Configurations

CONFIGURATION	CONFIG2 PIN	CONFIG1 PIN	DUAL-GATE MODE	CIRCUIT BREAKER TIMER TYPE	FOLDBACK DURING START-UP
1	Ground	Ground	HSSS	Current Limit Timer	30%
2	Ground	Open	HSSS	SOA Timer	10%
3	Ground	$INTV_{CC}$	HSSS	SOA Timer	30%
4	Open	Ground	Parallel	SOA Timer	30%
5	Open	Open	LSSS	SOA Timer	30%
6	Open	$INTV_{CC}$	LSSS	Current Limit Timer	30%
7	IntVCC	Ground	Parallel	SOA Timer	10%
8	IntVCC	Open	Parallel	SOA Timer	30%
9	IntVCC	$INTV_{CC}$	Parallel	Current Limit Timer	30%

QUICK START PROCEDURE

DC2914A is easy to setup to evaluate performance of LTC4238 in various staged start modes. Refer to Figure 2 for proper equipment setup and follow the instructions below.

1. Refer to default jumper configuration in Table 1 to ensure jumpers are in right position. Also verify that the cable connecting the input and load can handle the desired load current of at least 70A. Use 4 AWG ($19mm^2$) cable or higher.
2. With no load, slowly increase the input voltage on the board . Observe the voltage when LED D8 (OUT) illuminates. This voltage should be between 35V and 36V. Continue increasing the voltage and observe when the LED D10 (Power Good) illuminates. This can be used as a signal for downstream converters. If you keep increasing the voltage, LED D8 will extinguish. This should occur between 60V and 60.5V.
3. Place a scope probe to V_{OUT} turret, turn on the controller, and measure the ramp up time with 48V input and no load. This time must be within 20ms for DC2914A-A, 5ms for DC2914A-B and 20ms for DC2914A-C. Notice that after the UV comparator is stable for 40ms, only then gates are allowed to turn on.
4. Connect a typical load capacitor as per Performance Summary and turn on the controller. The controller should be able to turn on for the complete input supply voltage range from 36V to 60V.
5. Connect an electronic load as shown in Figure 2. Set the load to "Constant Current" mode. Start Increasing the load current and observe the current when the part latches off, and generates a fault signal. This value should be very close to the following OC limits:

   DC2914A-A: 50A (25A per channel)

   V_{ISET} = 20mV, R_{SENSE} = 0.8mΩ per channel

   DC2914A-B: 63A (60A for bypass channel and 3A for the trickle channel)

   V_{ISET} = 12mV, R_{SENSE} = 0.2mΩ bypass channel; R_{SENSE} = 4mΩ trickle channel

   DC2914A-C: 60A (bypass channel)

   V_{ISET} = 12 mV, R_{SENSE} = 0.2mΩ bypass channel

Power cycle the part to ensure normal behavior is restored after the overload test.

ADVANCED FEATURES

1. **COMM Pin:** DC2914A showcases COMM pin scalability of LTC4238. Connect multiple DC2914A boards using the COMM pin to ensure they work in tandem as shown in Figure 3. When connected in parallel, only TMR capacitor on master board is required and remaining TMR pins can be grounded while using constant current timer. All boards need their individual FET-bad capacitors (and RC-network for SOA timer if used).
2. **SOA Timer:** DC2914A has the provision for using an SOA timer. In this mode, the TMR current is proportional to power dissipated in the MOSFET. An RC network mimicking the thermal characteristic is required on the TMR pin, such that the TMR pin voltage is proportional to MOSFET die temperature. The mode is configured by Config1/2 voltages and on-board jumpers are provided to set the desired mode. The description to set different modes is provided in Table 5.

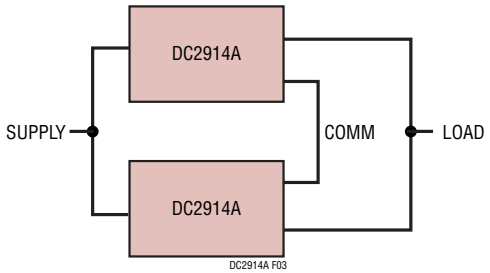

Figure 3. Multiple LTC4238 Connected Using COMM Pin to Share Load

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.

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