

# LTC4380

## Low Quiescent Current Surge Stopper

### DESCRIPTION

Demonstration circuit 2178A showcases the **LTC®4380** low quiescent current surge stopper in an application which can be configured for 12V, 1A or 24V/28V, 0.5A operation. The output voltage is clamped by the LTC4380, permitting the load to operate uninterrupted during transients of up to 250V and load dump surges such as ISO-16750-2 Test A. The output current is limited to 1.25A. In the presence of a sustained input overvoltage or output overcurrent fault the LTC4380 shuts off to prevent damage to the N-channel MOSFET pass element.

The output clamp voltage is selected by jumper JP1 to a value of either 27V or 45V, to suit 12V or 24V/28V systems. DC2178A-A features the LTC4380-1 which latches off after a fault, and DC2178A-B features the LTC4380-2 which automatically retries after a cool down delay.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC2178A>**

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### OPERATING CHARACTERISTICS

System Voltage	12V	24V/28V
Clamp Select	27V	45V
DC Operating (Full Load)*	9V to 20V	9V to 37.5V
DC Survival	80V	80V
Surge Ride-Through**	ISO-16750-2 Test A	ISO-16750-2 Test A
1ms Transient	250V	250V
Onset of Current Limit	1.25A	1.25A
Short Circuit Current	1.55A	1.55A
Maximum Load ( $V_{IN} > 9V$ )	1A	0.5A

\* Initial production boards are marked with more conservative limits of 19V and 35V. Functionality extends to 4.2V at 25°C. All boards are tested to the limits shown in the table above.

\*\* Formerly ISO-7637-2 Test Pulse 5A

## OPERATING CHARACTERISTICS

**DANGER! High voltage testing shall be performed by qualified personnel only. As a safety precaution at least two people shall be present during high voltage testing.**

### Board Layout

DC2178A is a 2 layer board. There are planes for input, output and ground; these are replicated on both layers. There are exposed conductors on the bottom of the board, and any banana plugs present will protrude through the bottom of the board. The underlying surface should be non-conductive and clear of any wire, solder and other conductive debris.

The input plane is designed to have at least 79 mil (2mm) clearance to adjacent conductors, to support 80VDC standoff and transients to 250V. Spikes and surges are withstood by R1, RDRN, CSNUB and Q1. These components are chosen for wide pad spacing, pulse power capability and voltage standoff, but ultimately limit the maximum transient input voltage to approximately 250V. The time spent above 80V is limited by the pulse power capability of Q1 and R1.

### Operation

DC2178A is designed for 12V operation with a load of up to 1A, and 24V or 28V operation with a load of up to 0.5A. JP1 selects an output clamping voltage of either 27V or 45V. For 24V and 28V supplies use a clamping voltage of 45V; 12V supplies may use either 27V or 45V. If the load tolerates the higher voltage, 45V clamping is better than 27V in 12V applications because it reduces the drop across the MOSFET (Q1) and therefore the safe operating area stress, giving longer ride-through time during an overvoltage condition.

Q1 is selected to ride through load dump events (such as ISO 16750-2 Test A) with full load in 12V (1A) and 24V/28V (0.5A) systems. Ride through is also permissible at 1A for a 250V input transient of up to 1ms.

Up to 80VDC can be applied to the input. The circuit will trip off after a delay of approximately 350ms for 1A load and a 27V clamp, or 800ms for a 0.5A load and a 45V clamp. The TMR pin charging current is a function of the power dissipated in Q1 so that the exact delay time is a function of the input voltage, output voltage and load current.

The LTC4380 features current limiting, which is set with RSNS (40m $\Omega$ ) to a value of 1.25A. Current limit does not change with operating voltage or clamping voltage selection. If the output is shorted so that the output voltage falls to 2V or less, current limit increases to 1.55A. In current limit, the LTC4380 trips off after a delay that varies as a function of the dissipation in Q1.

While the LTC4380 is designed to withstand reverse inputs of up to -60V, DC2178A does not tolerate negative-going events because Q1's body diode will pass the negative voltage straight through to the output and load. Negative inputs are easily blocked by the addition of a series input diode, or by adding a second MOSFET as shown in Figures 5 and 7 of the LTC4380 data sheet.

The LTC4380-1/LTC4380-2 V<sub>CC</sub> pin is rated at 80V maximum. Power is applied from the input to the V<sub>CC</sub> pin through a 20k $\Omega$  resistor (R1), filtered by a 2.2 $\mu$ F capacitor (C1A), and clamped by D1 to 68V. This arrangement offers two key benefits. First, C1 filters the V<sub>CC</sub> pin to maintain operation during brief input dropouts and to filter overvoltage spikes. Second, during load dump in 24V/28V applications V<sub>CC</sub> is clamped by D1 to keep the V<sub>CC</sub> pin safely below 80V. D1 is unnecessary in 12V applications because the filtering action provided by C1 is sufficient to keep the V<sub>CC</sub> pin below 80V, even in load dump.

### 12V Cold Crank Operation

An FDB33N25 was chosen for MOSFET Q1 to satisfy two requirements: ability to block load dump (~200V) in 28V systems; and wide safe operating area for uninterrupted operation during load dump events. The penalty for these features is a high threshold voltage of 5V maximum at I<sub>D</sub> = 250 $\mu$ A and 25°C, with no guarantees at temperature extremes. R1 was chosen to limit the peak current in D1 to a safe level with 250V peak input voltage, but it also reduces the V<sub>CC</sub> voltage below the input under normal conditions. Q1 and R1 impact cold crank operation in 12V systems.

The LTC4380 is designed to deliver 10V of gate drive with V<sub>CC</sub> > 8V, and 5V with V<sub>CC</sub> between 4V and 8V, guaranteed over temperature. Thus, the FDB33N25 is incompatible with operation in the 4V to 8V range, although typical DC2178A assemblies can deliver 500mA load current

## OPERATING CHARACTERISTICS

with an input voltage of 4.2V. For full performance in 12V cold crank applications, a logic-level rated MOSFET is necessary for Q1.

### Optional Components

Pads are provided for optional  $V_{CC}$  bypassing at C1B (C1A is stuffed with 2.2 $\mu$ F), and for optional timer capacitance at CTMR2 (CTMR1 is stuffed with 10 $\mu$ F). C1B and CTMR2 are found on the bottom of the board.

An optional GATE pin clamp (D6) is also located on the bottom of the board. This clamp is necessary in applications where a large value gate capacitor ( $C2 \geq 100$ nF) is used. A 15V Zener is recommended for D6, to safely discharge C2 during a hard short circuit.

### Extra Holes

Five through-hole pads are included for the purpose of attaching an off-board power stage comprising a MOSFET, gate suppression resistor, sense resistor and output reservoir capacitor in high current applications, where the components and current levels are not compatible with the layout of DC2178A. The pads are labeled on the bottom of the board and noted on the schematic as INPUT, OUT, GATE, SNS and GND. Remove Q1 and RSNS. Make short, direct connections between the through-hole pads and the external components, and use SNS and OUT to make Kelvin connections to the sense resistor. Depending on the setup and MOSFET used, a snubber may be needed between the MOSFET drain and the ground side of the output reservoir capacitor, or between the MOSFET drain and source terminals to suppress parasitic oscillations.

### Small Turrets

No connection to any of the small turrets is necessary to make the board operate—the LTC4380 defaults to the ON state.

ON is pulled high internally. If this turret is left open, the board will turn on when power is applied. Short this turret to ground to turn off the LTC4380, or pulse low for at least 100 $\mu$ s to restart the LTC4380-1 (DC2178A-A) after a fault.

$\overline{FLT}$  pulls low when the LTC4380 faults off from an overcurrent or overvoltage condition. It is reset by pulling the ON pin low for at least 100 $\mu$ s in the LTC4380-1 (DC2178A-A), or after a cool down interval in the LTC4380-2 (DC2178A-B).  $\overline{FLT}$  can sink up to 3mA.

### Jumpers

Jumper JP1 sets the state of the SEL pin to select between a 27V output clamp (SEL grounded) or a 45V output clamp (SEL connected to OUT). The corresponding clamp voltage at the GATE pin is about 5V higher than these values. Jumper JP2 disables the output LED (DLED) to facilitate measurement of the LTC4380's operating current.

### Basic Test Setup

**DANGER! High voltage testing shall be performed by qualified personnel only. As a safety precaution at least two people shall be present during high voltage testing.**

Set the jumper, JP1, for 12V or 24V/48V operation, connect a power supply to the input, and connect a load to the output as shown in Figure 1. The circuit will turn on automatically when power is applied, and the presence of output power is indicated by the output LED.

To perform surge testing, add a diode (such as a 1N4004) in series with the power supply. Couple the surge generator through a second diode to the input to test the clamping action of DC2178A. The diodes protect the power supply and surge generator against backfeeding.

To measure the operating current, disable the output LED using JP2, and disconnect the load.

OPERATING CHARACTERISTICS

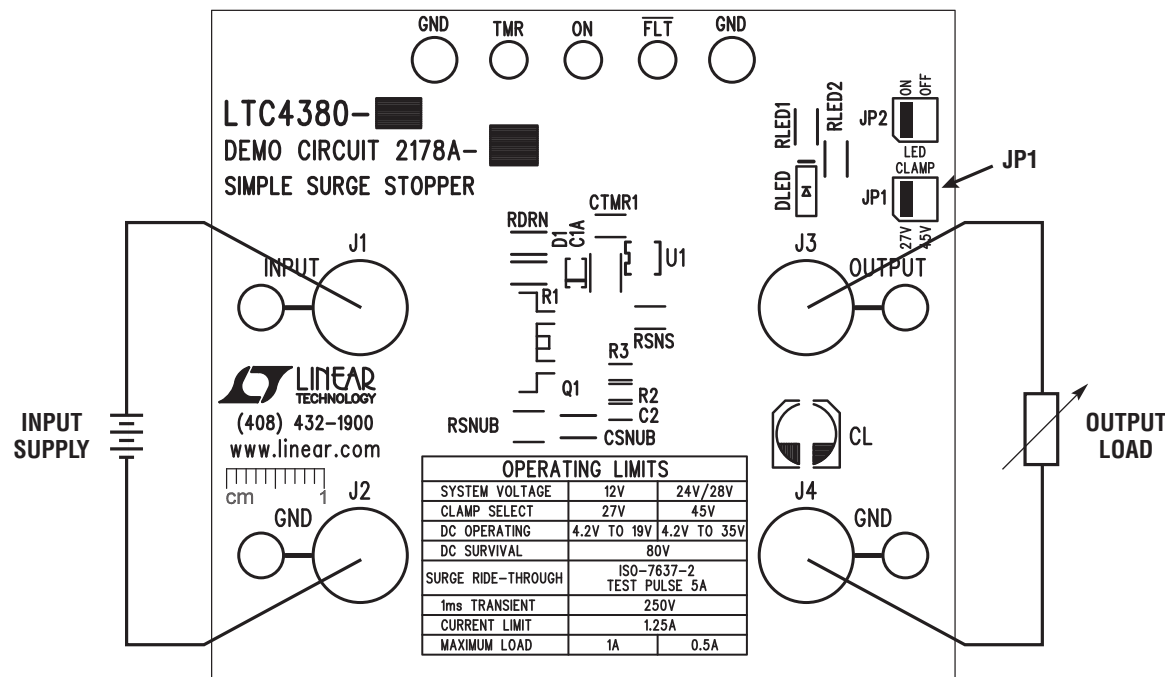
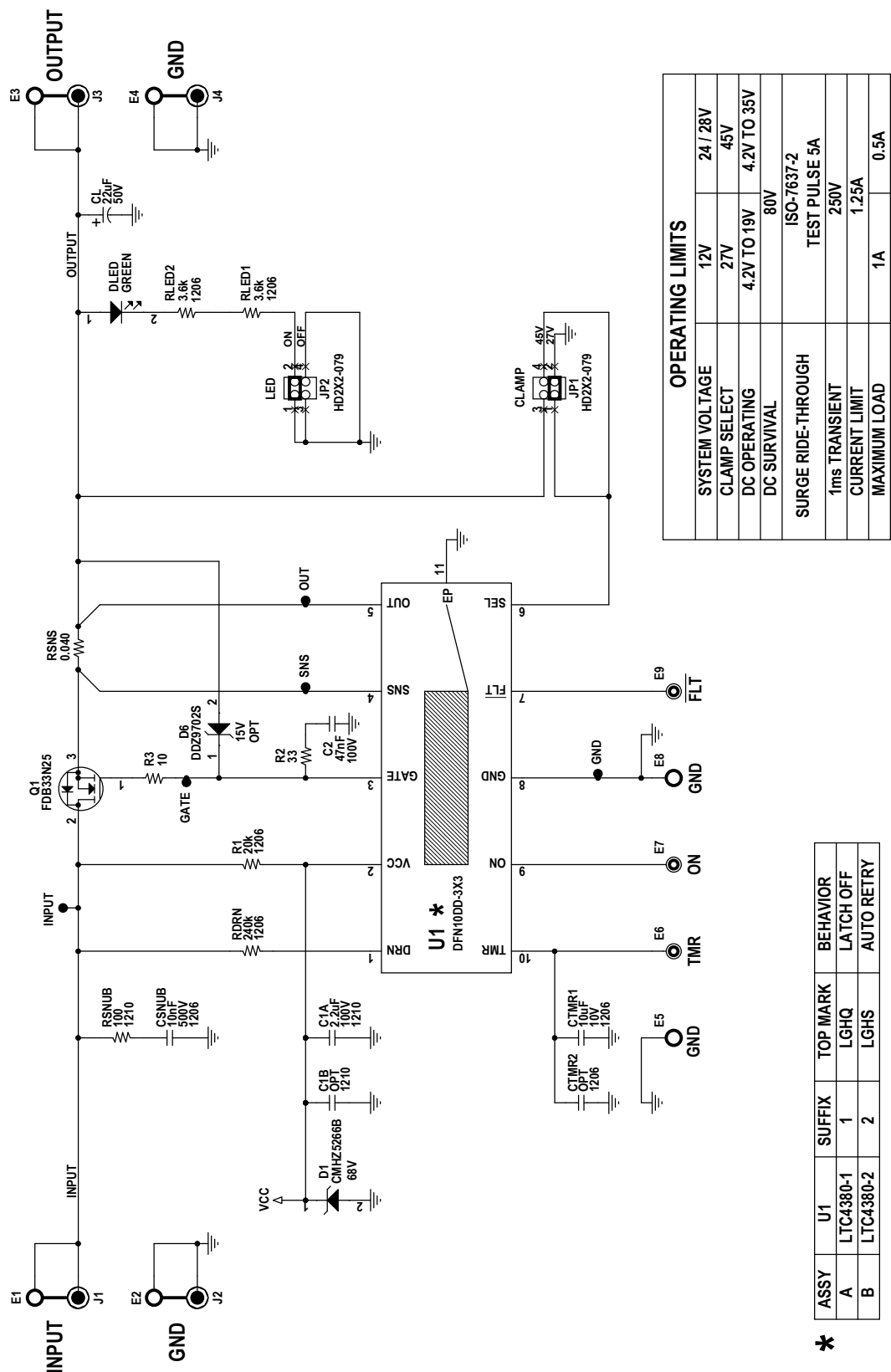


Figure 1. Basic Setup. JP1 Is Set to Match Input Supply, 27V Clamp for 12V Supplies and 45V Clamp for 24V/28V Supplies

SCHEMATIC DIAGRAM



# DEMO MANUAL DC2178A

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