

**600V ACTIVE OR'ING MOSFET CONTROLLER IN SO7**

**Description**

The ZXGD3114N7 is a 600V active ORing MOSFET controller designed for driving a very-low  $R_{DS(ON)}$  power MOSFET as an ideal diode. This replaces the standard rectifier to reduce the forward voltage drop and overall increase the power transfer efficiency.

The ZXGD3114N7 can be used on both high-side and low-side power supply units (PSU) with rails up to  $\pm 600V$ . It enables very-low  $R_{DS(ON)}$  MOSFETs to operate as ideal diodes as the turn-off threshold is only  $-3mV$  with  $\pm 2mV$  tolerance. In the typical 48V configuration, the standby power consumption is  $<50mW$  as the low quiescent supply current is  $<1mA$ . During PSU fault condition, the ORing controller detects the power reduction and rapidly turns off the MOSFET in  $<600ns$  to block reverse current flow and avoid the common bus voltage drooping.

**Applications**

Active ORing Controller in:

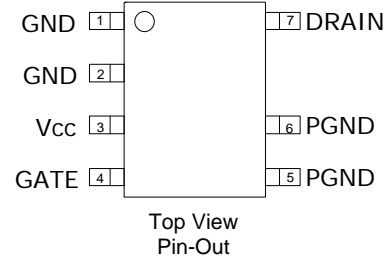
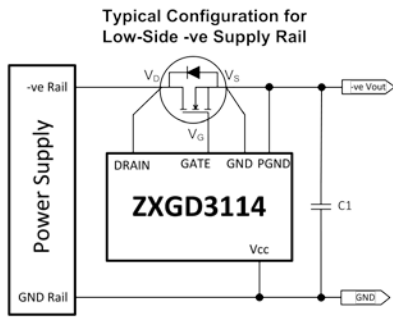
- (N + 1) Redundant Power Supplies
- Telecom and Networking
- Data Centers and Servers

**Features**

- Active ORing MOSFET Controller for High- or Low-Side PSU
- Ideal Diode to Reduce Forward Voltage Drop
- $-3mV$  Typical Turn-Off Threshold with  $\pm 2mV$  Tolerance
- 600V Drain Voltage Rating
- 25V  $V_{CC}$  Rating
- $<50mW$  Standby Power with Quiescent Supply Current  $<1mA$
- $<600ns$  Turn-Off Time to Minimize Reverse Current
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

**Mechanical Data**

- Case: SO-7
- Case Material: Molded Plastic. "Green" Molding Compound. UL Flammability Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish—Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 <sup>Ⓔ</sup>
- Weight: 0.074 grams (Approximate)

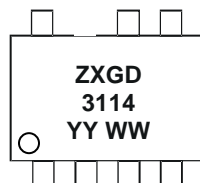


**Ordering Information (Note 4)**

| Product      | Marking  | Reel Size (inches) | Tape Width (mm) | Quantity per Reel |
|--------------|----------|--------------------|-----------------|-------------------|
| ZXGD3114N7TC | ZXGD3114 | 13                 | 12              | 2500              |

- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
  2. See <https://www.diodes.com/quality/lead-free/> for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
  3. Halogen- and Antimony-free "Green" products are defined as those which contain  $<900ppm$  bromine,  $<900ppm$  chlorine ( $<1500ppm$  total Br + Cl) and  $<1000ppm$  antimony compounds.
  4. For packaging details, go to our website at <http://www.diodes.com/products/packages.html>.

**Marking Information**



ZXGD = Product Type Marking Code, Line 1  
 3114 = Product Type Marking Code, Line 2  
 YY = Year (ex: 17 = 2017)  
 WW = Week (01 to 53)



**Pin Functions**

| Pin Number | Pin Name        | Pin Function and Description  |
|------------|-----------------|---|
| 1, 2       | GND             | <b>Ground</b><br>Connect this pin to the MOSFET source terminal and ground reference point.   |
| 3          | V <sub>CC</sub> | <b>Power Supply</b><br>This supply pin should be closely decoupled to ground with a X7R type capacitor.   |
| 4          | GATE            | <b>Gate Drive</b><br>This pin sources (I <sub>SOURCE</sub> ) and sinks (I <sub>SINK</sub> ) current into the MOSFET gate. If V <sub>CC</sub> > 12V, then the GATE-to-GND will clamp at 12V. The turn on time of the MOSFET can be programmed through an external gate resistor (R <sub>G</sub> ). |
| 5, 6       | PGND            | <b>Power Ground</b><br>Connect this pin to the MOSFET source terminal and ground reference point.   |
| 7          | DRAIN           | <b>Drain Sense</b><br>Connect this pin to the MOSFET drain terminal to detect the change in drain-source voltage.   |

**Absolute Maximum Ratings** (Voltage relative to GND, @ T<sub>A</sub> = +25°C, unless otherwise specified.)

| Characteristic                  | Symbol              | Value                     | Unit |
|---------------------------------|---------------------|---------------------------|------|
| Supply Voltage                  | V <sub>CC</sub>     | 25                        | V    |
| Drain Pin Voltage               | V <sub>D</sub>      | -3 to 600                 | V    |
| Gate Output Voltage**           | V <sub>G</sub>      | -3 to V <sub>CC</sub> + 3 | V    |
| Gate Driver Peak Source Current | I <sub>SOURCE</sub> | 2                         | A    |
| Gate Driver Peak Sink Current   | I <sub>SINK</sub>   | 5                         | A    |

\*\*Gate voltage is clamped to 12V.

**Thermal Characteristics**

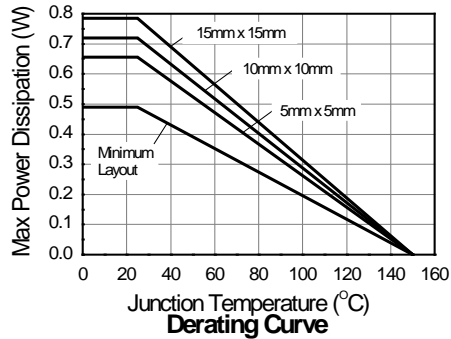
| Characteristic                              | Symbol                            | Value       | Unit        |      |
|---|-----------------------------------|-------------|-------------|------|
| Power Dissipation<br>Linear Derating Factor | P <sub>D</sub>                    | 490         | mW<br>mW/°C |      |
|   |                                   | (Note 5)    |             | 3.92 |
|   |                                   | (Note 6)    |             | 655  |
|   |                                   | (Note 7)    |             | 5.24 |
|   |                                   | (Note 8)    |             | 720  |
| Thermal Resistance, Junction to Ambient     | R <sub>θJA</sub>                  | 785         | °C/W        |      |
|   |                                   | (Note 5)    |             | 6.28 |
|   |                                   | (Note 6)    |             | 255  |
|   |                                   | (Note 7)    |             | 191  |
| (Note 8)                                    | 173                               |             |             |      |
| (Note 9)                                    | 159                               |             |             |      |
| Thermal Resistance, Junction to Lead        | R <sub>θJL</sub>                  | 135         | °C/W        |      |
| Operating and Storage Temperature Range     | T <sub>J</sub> , T <sub>STG</sub> | -50 to +150 | °C          |      |

**ESD Ratings** (Note 10)

| Characteristic                           | Symbol  | Value | Unit | JEDEC Class |
|--|---------|-------|------|-------------|
| Electrostatic Discharge—Human Body Model | ESD HBM | 2000  | V    | 3A          |
| Electrostatic Discharge—Machine Model    | ESD MM  | 200   | V    | B           |

- Notes:
- For a device surface mounted on minimum recommended pad layout FR-4 PCB with high coverage of single sided 1oz copper, in still air conditions; the device is measured when operating in a steady-state condition.
  - Same as Note 5, except pin 3 (V<sub>CC</sub>) and pins 5 & 6 (PGND) are both connected to separate 5mm × 5mm 1oz copper heat-sinks.
  - Same as Note 6, except both heat-sinks are 10mm × 10mm.
  - Same as Note 6, except both heat-sinks are 15mm × 15mm.
  - Thermal resistance from junction to solder-point at the end of each lead on pins 2 & 3 (GND) and pins 5 & 6 (V<sub>CC</sub>).
  - Refer to JEDEC specification JESD22-A114 and JESD22-A115.

## Thermal Derating Curve



## Electrical Characteristics (@ $V_{CC} = 12V$ , $T_A = +25^\circ C$ , unless otherwise specified.)

| Characteristic                     | Symbol        | Min  | Typ   | Max | Unit    | Test Condition   |
|------------------------------------|---------------|------|-------|-----|---------|--|
| <b>Input Supply</b>                |               |      |       |     |         |  |
| Operating Supply Voltage           | $V_{CC}$      | 4    | —     | 20  | V       | —  |
| Quiescent Current                  | $I_Q$         | —    | 260   | 400 | $\mu A$ | $-0.6V \leq V_{DRAIN} \leq 600V$   |
| Drain Low Input Current            | $I_{DL}$      | -100 | -15   | —   | nA      | $V_D = -0.1V$  |
| Drain High Input Current           | $I_{DH}$      | —    | 0.85  | 10  | $\mu A$ | $V_D = 600V$   |
| <b>Gate Driver</b>                 |               |      |       |     |         |  |
| Gate Peak Source Current           | $I_{SOURCE}$  | —    | 0.66  | —   | A       | $C_L = 47nF$   |
| Gate Peak Sink Current             | $I_{SINK}$    | —    | 3.3   | —   |         |  |
| Gate Peak Source Current (Note 11) | $I_{SOURCE}$  | 1    | —     | —   | A       | $V_{GATE} = 5V$ & $V_{DRAIN} = -1V$  |
| Gate Peak Sink Current (Note 11)   | $I_{SINK}$    | 1.8  | —     | —   | A       | $V_{GATE} = 5V$ & $V_{DRAIN} = 1V$   |
| <b>Detector Under DC Condition</b> |               |      |       |     |         |  |
| Turn-Off Threshold Voltage         | $V_T$         | -5   | -3    | -1  | mV      | $V_G \leq 1V$  |
| Gate Output Voltage                | $V_{G(OFF)}$  | —    | 0.1   | 0.3 | V       | $V_{DRAIN} \geq 0mV$ &<br>$V_{CC} = 12V$   |
|                                    | $V_G$         | 10.5 | 10.85 | —   |         | $V_{DRAIN} = -8mV$ &<br>$V_{CC} = 12V$   |
|                                    | $V_{G(OFF)}$  | —    | 0.1   | 0.3 |         | $V_{DRAIN} \geq 0mV$ &<br>$V_{CC} = 4V$  |
|                                    | $V_G$         | 2.5  | 2.85  | —   |         | $V_{DRAIN} = -8mV$ &<br>$V_{CC} = 4V$  |
|                                    | $V_{G(OFF)}$  | —    | 0.1   | 0.3 |         | $V_{DRAIN} \geq 0mV$ &<br>$V_{CC} = 20V$   |
|                                    | $V_G$         | 10.5 | 11.2  | —   |         | $V_{DRAIN} = -8mV$ &<br>$V_{CC} = 20V$   |
| <b>Switching Performance</b>       |               |      |       |     |         |  |
| Turn-On Propagation Delay          | $t_{D(RISE)}$ | —    | 400   | —   | ns      | $C_L = 47nF$<br>Rise and Fall Measured 10% to 90%<br>Refer to Application Test Circuit Below |
| Gate Rise Time                     | $t_R$         | —    | 695   | —   |         |  |
| Turn-Off Propagation Delay         | $t_{D(FALL)}$ | —    | 400   | —   |         |  |
| Gate Fall Time                     | $t_F$         | —    | 131   | —   |         |  |

Note: 11. Measured under pulsed conditions. Pulse width = 300 $\mu s$ . Duty cycle  $\leq 2\%$ .

## Layout Considerations

The GATE pin should be close to the MOSFET gate to minimize trace resistance and inductance to maximize switching performance. While the  $V_{CC}$  to GND pin requires an X7R type capacitor closely decoupling the supply. Trace widths should be maximized in the high current paths through the MOSFET and ground return in order to minimize the effects of circuit resistance and inductance. Also, the ground return loop should be as short as possible. For thermal consideration, the main heat path is from pin 3 ( $V_{CC}$ ) and pins 5 & 6 (PGND). For best thermal performance, the copper area connected to pin 3 ( $V_{CC}$ ) and pins 5 & 6 (PGND) should be maximized.

## Active ORing or (N+1) Redundancy Application

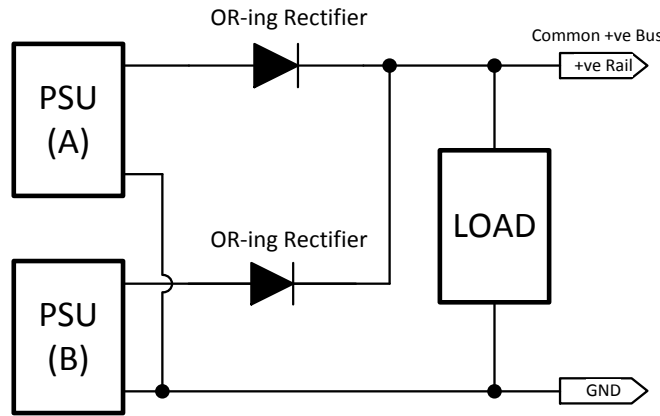


Figure 1

Critical systems require fault-tolerant power supplies that can be achieved by paralleling two or more PSUs into (N+1) redundancy configuration. During normal operation, usually all PSUs equally share the load for maximum reliability. If one of the PSU is unplugged or fails, the other PSUs fully support the load. To avoid the faulty PSU from affecting the common bus, an ORING rectifier blocks the reverse current flow into the faulty PSU. Likewise during hot-swapping, the ORING rectifiers isolate a PSU's discharged output capacitors from the common bus.

As the load current is in the tens of amps then a standard rectifier has a significant forward voltage drop. This both wastes power and significantly drops the potential on low voltage rails. Hence, very low  $R_{DS(ON)}$  power MOSFETs can replace the standard rectifiers and the ZXGD3114 controls the MOSFET as an ideal diode.

## Functional Block Diagram

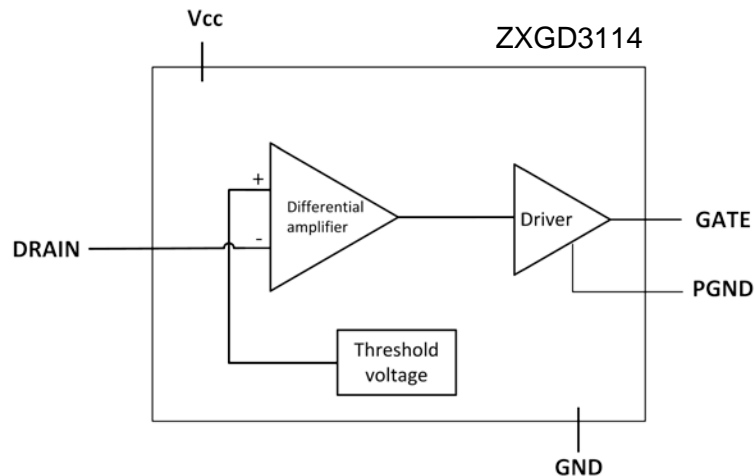


Figure 2

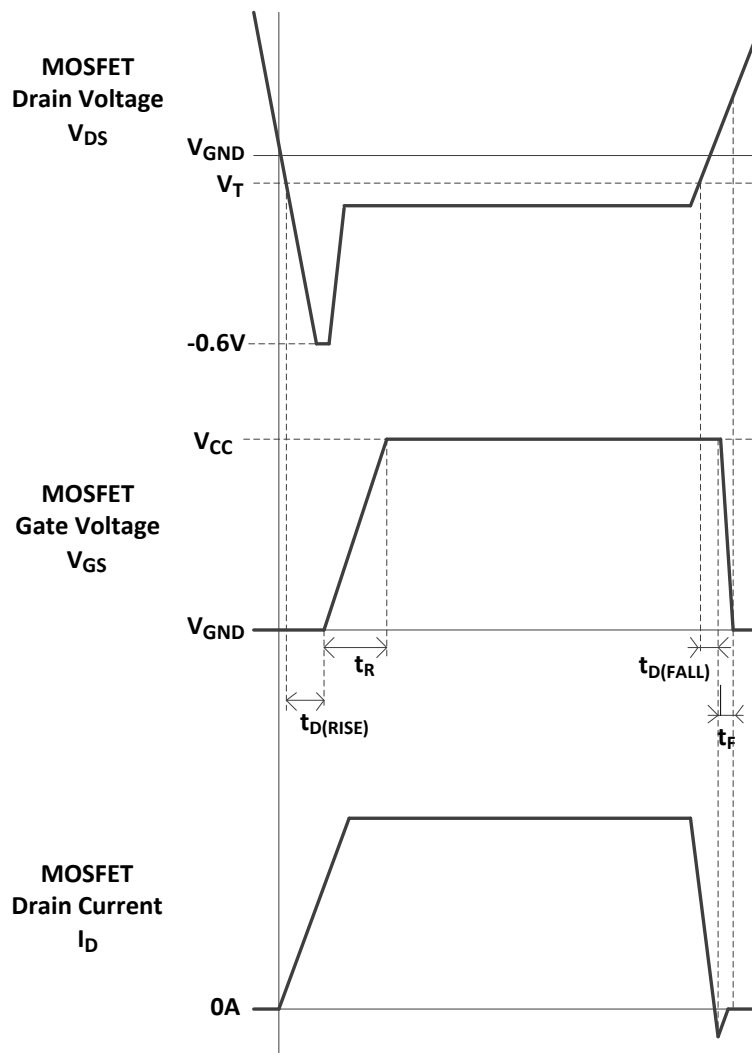
The device is comprised of a differential amplifier and high current driver. The differential amplifier acts as a detector and monitors the DRAIN-to-GND pin voltage difference. When this difference is less than the threshold voltage ( $V_T$ ), a positive output voltage approaching  $V_{CC}$  is given on the GATE pin. If  $V_{CC} > 12V$ , the GATE-to-GND clamps at 12V. Conversely, when the DRAIN-to-GND pin voltage difference is greater than  $V_T$ , the GATE pin voltage rapidly reduces towards the GND voltage.



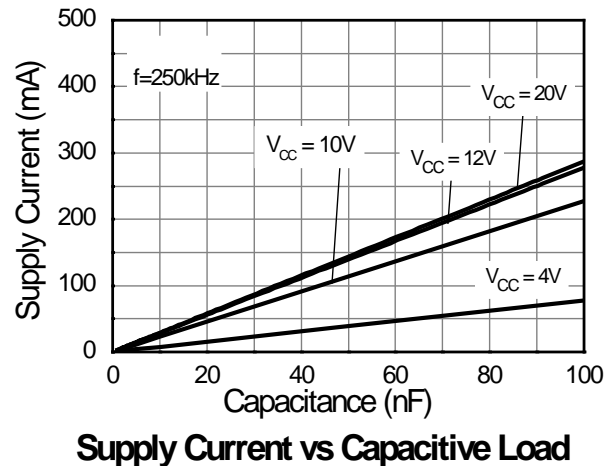
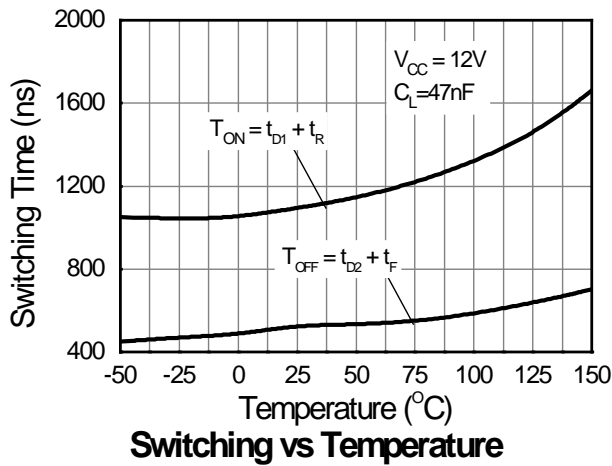
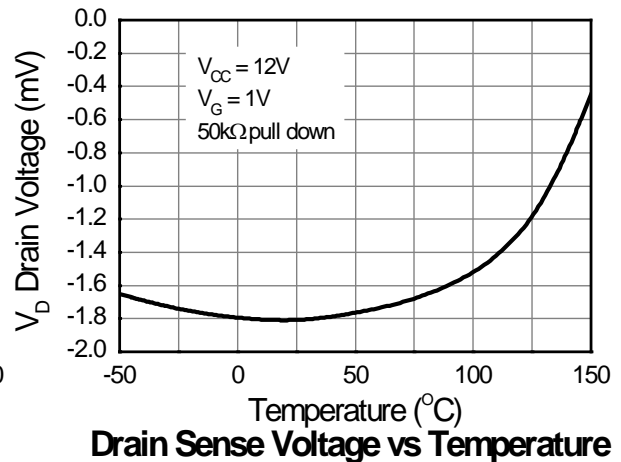
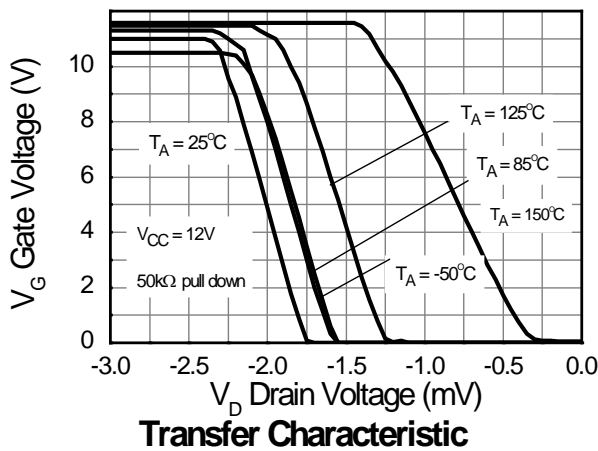
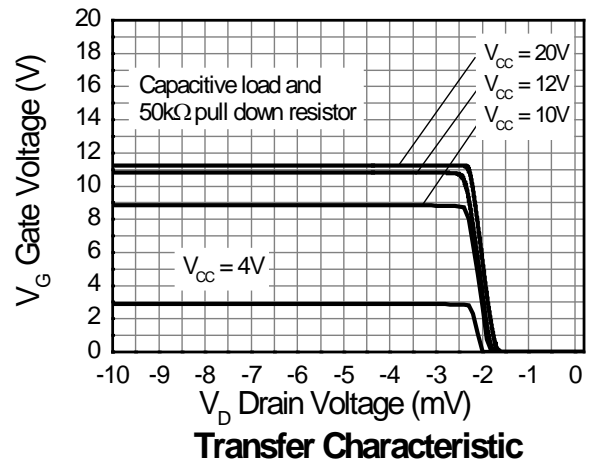
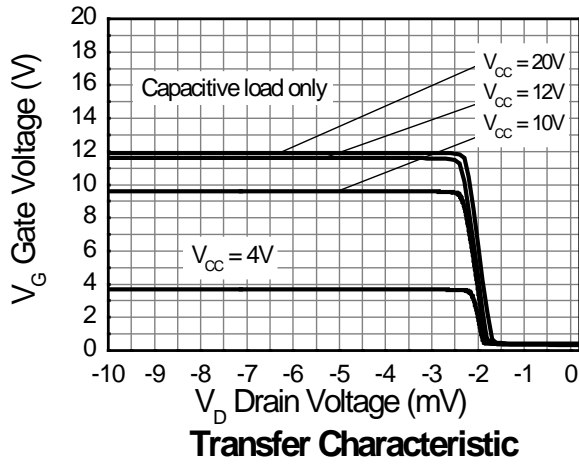
## Operation in Typical Application

The ZXGD3114 operation is described step-by-step with reference to the typical application circuits and the timing diagram below:

1. The ZXGD3114 differential amplifier monitors the MOSFET's drain-source voltage ( $V_{DS}$ ).
2. At system start up, the MOSFET body diode is forced to conduct current from the input PSU to the load, and  $V_{DS}$  is approximately  $-0.6V$  as measured by the differential amplifier between DRAIN-to-GND pins.
3.  $V_{DS} < V_T$  (threshold voltage), the differential amplifier, outputs a positive voltage approaching  $V_{CC}$  with respect to GND. This feeds the driver stage where the GATE pin voltage rises towards  $V_{CC}$ . If  $V_{CC} > 12V$ , then the GATE-to-GND clamps at  $12V$ .
4. The sourcing current out of the GATE pin drives the MOSFET gate to enhance the channel and turns it on.
5. If a short condition occurs on the input PSU, it causes the MOSFET  $V_{DS}$  to increase.
6. When  $V_{DS} > V_T$ , the differential amplifier's output goes to GND, and the driver stage rapidly pulls the GATE pin voltage to GND turning off the MOSFET channel. This prevents high reverse current flow from the load to the PSU, which could pull down the common bus voltage causing catastrophic system failure.

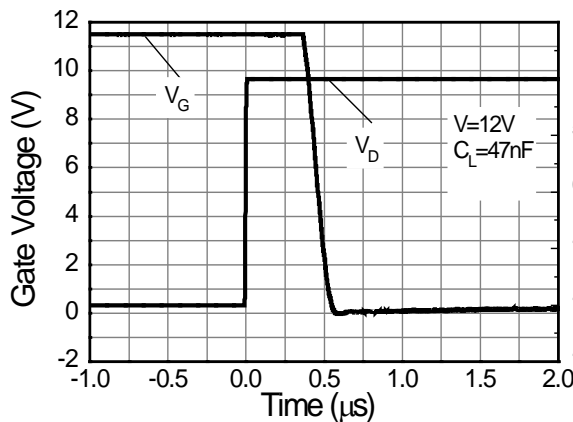


**Typical Electrical Characteristics**

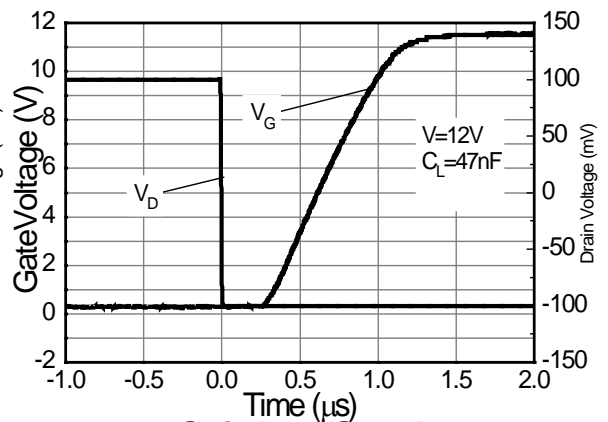




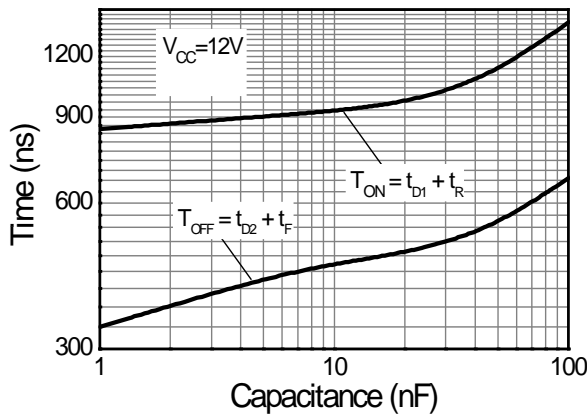
**Typical Electrical Characteristics** (continued)



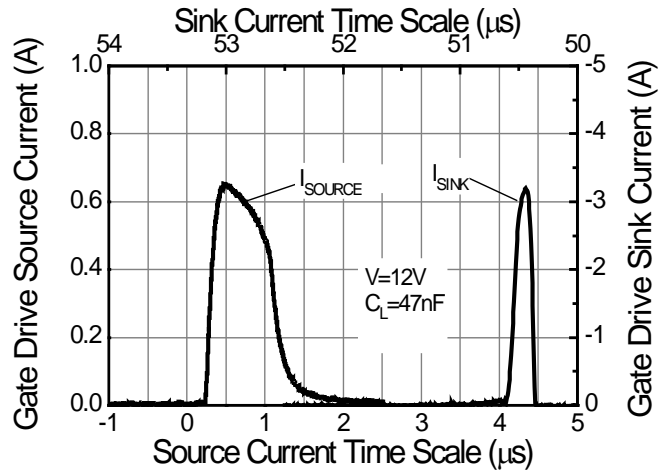
**Switch Off Speed**



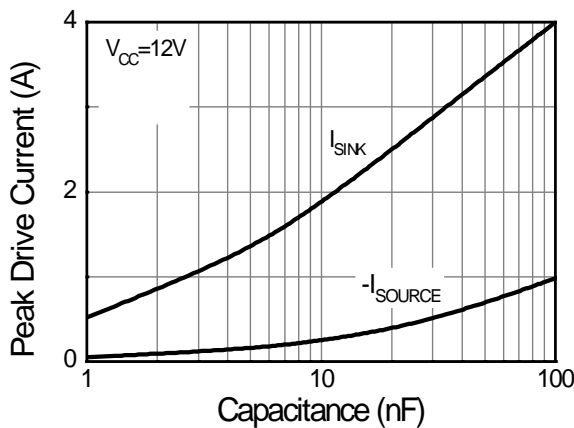
**Switch On Speed**



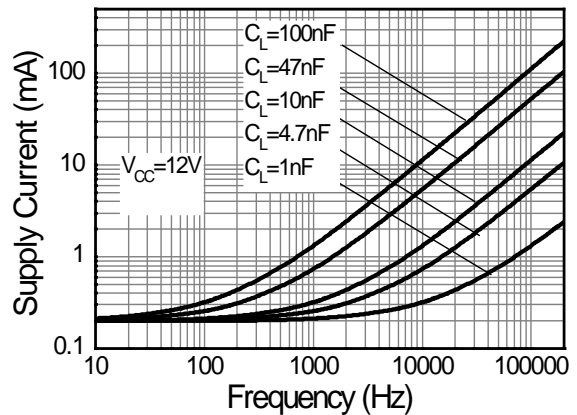
**Switching vs Capacitive Load**



**Gate Drive Current**



**Gate Current vs Capacitive Load**

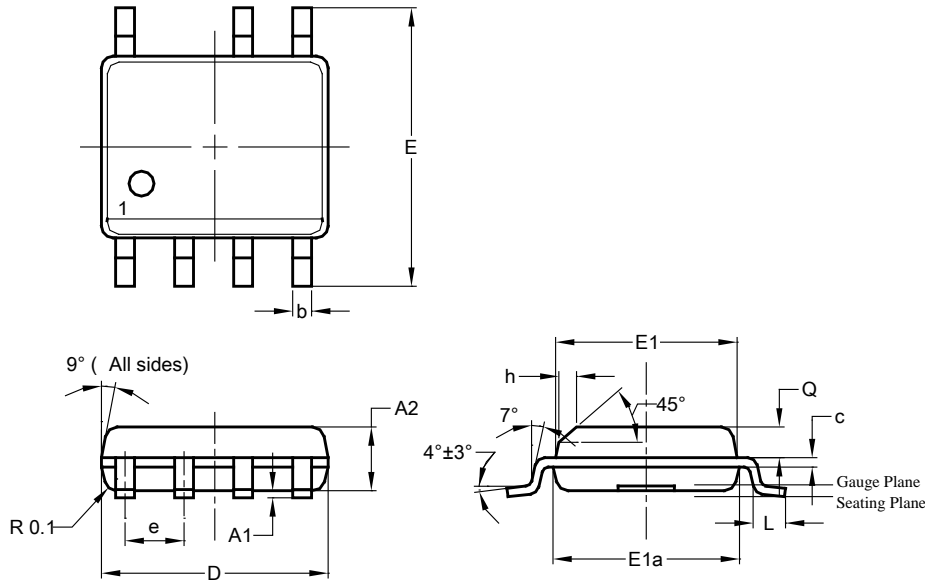


**Supply Current vs Frequency**

**Package Outline Dimensions**

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**SO-7**

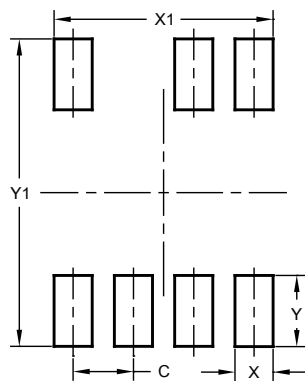


| SO-7                        |      |      |      |
|-----------------------------|------|------|------|
| Dim                         | Min  | Max  | Typ  |
| A2                          | 1.40 | 1.50 | 1.45 |
| A1                          | 0.10 | 0.20 | 0.15 |
| b                           | 0.30 | 0.50 | 0.40 |
| c                           | 0.15 | 0.25 | 0.20 |
| D                           | 4.85 | 4.95 | 4.90 |
| E                           | 5.90 | 6.10 | 6.00 |
| E1                          | 3.80 | 3.90 | 3.85 |
| E1a                         | 3.85 | 3.95 | 3.90 |
| e                           | —    | —    | 1.27 |
| h                           | —    | —    | 0.35 |
| L                           | 0.62 | 0.82 | 0.72 |
| Q                           | 0.60 | 0.70 | 0.65 |
| <b>All Dimensions in mm</b> |      |      |      |

**Suggested Pad Layout**

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**SO-7**



| Dimensions | Value (in mm) |
|------------|---------------|
| C          | 1.270         |
| X          | 0.802         |
| X1         | 4.612         |
| Y          | 1.505         |
| Y1         | 6.500         |

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