LINEAR TECHNOLOGY

LTC4358

5A Ideal Diode

FEATURES

- **Replaces a Power Schottky Diode**
- **Internal 20mΩ N-Channel MOSFET**
- **0.5µs Turn-Off Time Limits Peak Fault Current**
- **Operating Voltage Range: 9V to 26.5V**
- Smooth Switchover without Oscillation
- No Reverse DC Current
- Available in 14-Pin (4mm × 3mm) DFN and 16-Lead TSSOP Packages

APPLICATIONS

- N+1 Redundant Power Supplies
- High Availability Systems
- Telecom Infrastructure
- Automotive Systems

DESCRIPTION

The LTC®4358 is a 5A ideal diode that uses an internal 20mΩ N-channel MOSFET to replace a Schottky diode when used in diode-OR and high current diode applications. The LTC4358 reduces power consumption, heat dissipation, and PC board area.

The LTC4358 easily ORs power supplies together to increase total system reliability. In diode-OR applications, the LTC4358 regulates the forward voltage drop across the internal MOSFET to ensure smooth current transfer from one path to the other without oscillation. If the power source fails or is shorted, a fast turnoff minimizes reverse current transients.
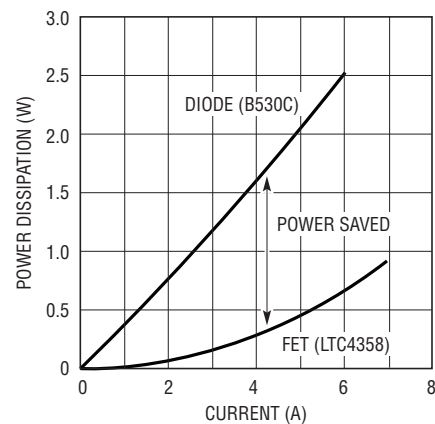
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TYPICAL APPLICATION

12V, 5A Diode-OR
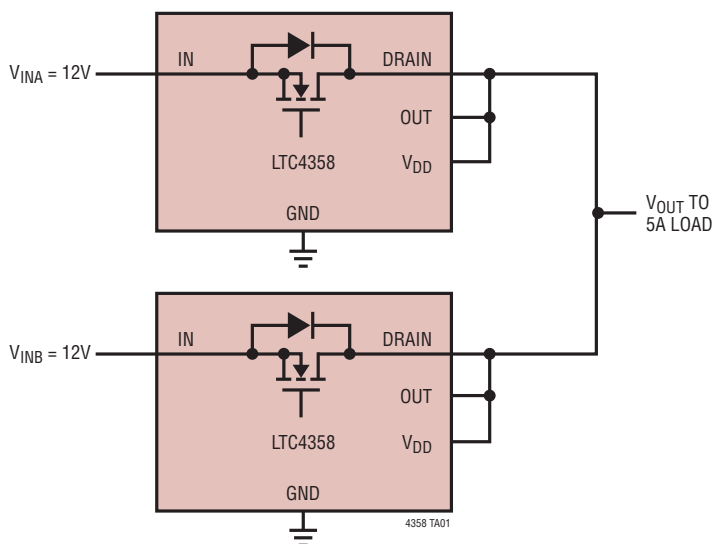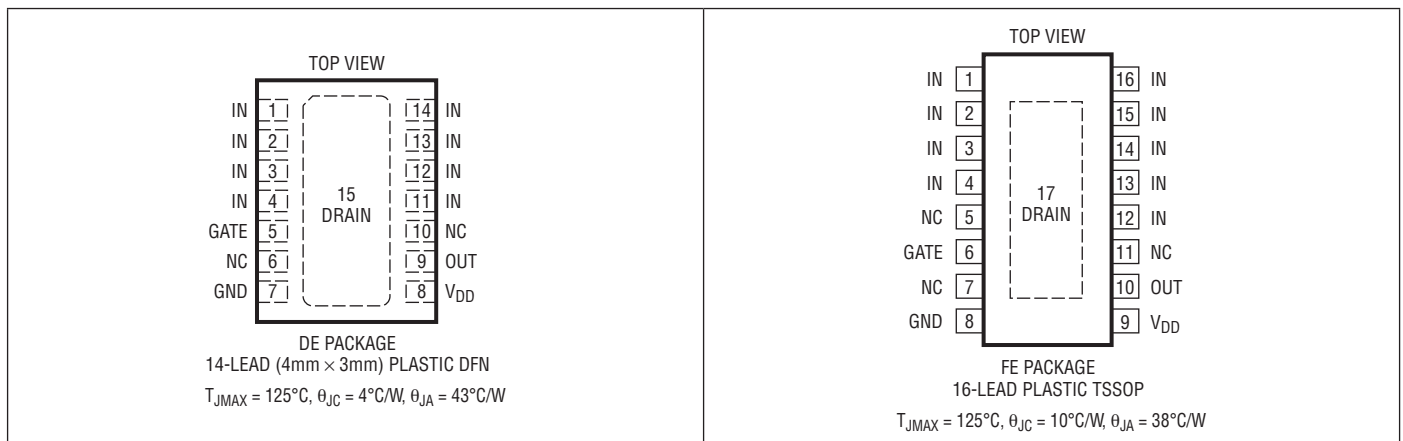

4358 TA01

Power Dissipation vs Load Current

4358 TA01b

ABSOLUTE MAXIMUM RATINGS (Notes 1, 2)

Supply Voltages

    IN, OUT, V_{DD}, DRAIN Voltage .... –0.3V to 28V

Output Voltage

    GATE (Note 3) .... V_{IN} – 0.2V to V_{IN} + 6V

Operating Ambient Temperature Range

    LTC4358C .... 0°C to 70°C

    LTC4358I... –40°C to 85°C

Storage Temperature Range................... –65°C to 150°C

Lead Temperature (Soldering, 10 sec)

    FE Package .... 300°C

PIN CONFIGURATION

TOP VIEW

IN	1	14	IN
IN	2	13	IN
IN	3	12	IN
IN	4	11	IN
GATE	5	10	NC
NC	6	9	OUT
GND	7	8	V_{DD}

15 DRAIN

DE PACKAGE
14-LEAD (4mm × 3mm) PLASTIC DFN
T_{JMAX} = 125°C, θ_{JC} = 4°C/W, θ_{JA} = 43°C/W

TOP VIEW

IN	1	16	IN
IN	2	15	IN
IN	3	14	IN
IN	4	13	IN
NC	5	12	IN
GATE	6	11	NC
NC	7	10	OUT
GND	8	9	V_{DD}

17 DRAIN

FE PACKAGE
16-LEAD PLASTIC TSSOP
T_{JMAX} = 125°C, θ_{JC} = 10°C/W, θ_{JA} = 38°C/W

ORDER INFORMATION

LEAD FREE FINISH	TAPE AND REEL	PART MARKING*	PACKAGE DESCRIPTION	TEMPERATURE RANGE
LTC4358CDE#PBF	LTC4358CDE#TRPBF	4358	14-Lead (4mm × 3mm) Plastic DFN	0°C to 70°C
LTC4358IDE#PBF	LTC4358IDE#TRPBF	4358	14-Lead (4mm × 3mm) Plastic DFN	–40°C to 85°C
LTC4358CFE#PBF	LTC4358CFE#TRPBF	4358FE	16-Lead Plastic TSSOP	0°C to 70°C
LTC4358IFE#PBF	LTC4358IFE#TRPBF	4358FE	16-Lead Plastic TSSOP	–40°C to 85°C

Consult LTC Marketing for parts specified with wider operating temperature ranges. *Temperature grades are identified by a label on the shipping container.
Consult LTC Marketing for information on non-standard lead based finish parts.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/

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ELECTRICAL CHARACTERISTICS

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{OUT} = V_{DD}, V_{DD} = 9V to 26.5V, unless otherwise noted.

SYMBOL	PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
V_{DD}	Operating Supply Range		●	9		26.5	V
I_{DD}	Operating Supply Current		●			0.6	mA
I_{IN}	IN Pin Current	V_{IN} = V_{OUT} ± 1V, No Load	●	150	350	450	µA
I_{OUT}	OUT Pin Current	V_{IN} = V_{OUT} ± 1V, No Load	●		80	160	µA
I_{DRAIN}	DRAIN Pin Current	V_{IN} = 0V, V_{OUT} = V_{DD} = V_{DRAIN} = 26.5V	●			5 150	µA µA
ΔV_{GATE}	N-Channel Gate Drive (V_{GATE} – V_{IN})	V_{DD}, V_{OUT} = 9V to 26.5V	●	4.5		15	V
$I_{GATE(UP)}$	N-Channel Gate Pull Up Current	V_{GATE} = V_{IN}, V_{IN} – V_{OUT} = 0.1V	●	−14	−20	−26	µA
$I_{GATE(DOWN)}$	N-Channel Gate Pull Down Current in Fault Condition	V_{GATE} = V_{IN} + 5V	●	1	2		A
t_{ON}	Turn-On Time	V_{IN} – V_{OUT} = −1V ⌐ 0.1V, V_{DRAIN} = V_{IN}, V_{OUT} = V_{DD}, V_{GATE} – V_{IN} > 4.5V	●		200	500	µs
t_{OFF}	Turn-Off Time	V_{IN} – V_{OUT} = 55mV ⌐ −1V, V_{DRAIN} = V_{IN}, V_{OUT} = V_{DD}, V_{GATE} – V_{IN} < 1V	●		300	500	ns
ΔV_{SD}	Source-Drain Regulation Voltage (V_{IN} – V_{OUT})	1mA < I_{IN} < 100mA	●	10	25	55	mV
ΔV_{SD}	Body Diode Forward Voltage Drop	I_{IN} = 5A, MOSFET Off	●	0.6	0.8	1	V
$R_{DS(ON)}$	Internal N-Channel MOSFET On Resistance	I_{IN} = 5A	●		20	40	mΩ

Note 1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

Note 2: All currents into pins are positive, all voltages are referenced to GND unless otherwise specified.

Note 3: An internal clamp limits the GATE pin to a minimum of 6V above IN. Driving this pin to voltages beyond this clamp may damage the device.

TYPICAL PERFORMANCE CHARACTERISTICS

V_{DD} Current (I_{DD} vs V_{DD})

$V_{IN} = V_{OUT} = V_{DD}$

4358 G01

IN Current (I_{IN} vs V_{IN})

$V_{IN} = V_{OUT} = V_{DD}$

4358 G02

OUT Current (I_{OUT} vs V_{OUT})

$V_{IN} = V_{OUT} = V_{DD}$

4358 G03

MOSFET $R_{DS(ON)}$ vs Temperature

$I_{IN} = 5A$

$V_{OUT} = V_{DD} = 9V$

$V_{OUT} = V_{DD} = 26.5V$

4358 G04

FET Turn-Off Time vs Initial Overdrive

$V_{IN} = 12V$
$\Delta V_{SD} = V_{INITIAL}$ ⌐ -1V

4358 G05

FET Turn-Off Time vs Final Overdrive

$V_{IN} = 12V$
$\Delta V_{SD} = 55mV$ ⌐ V_{FINAL}

4358 G06

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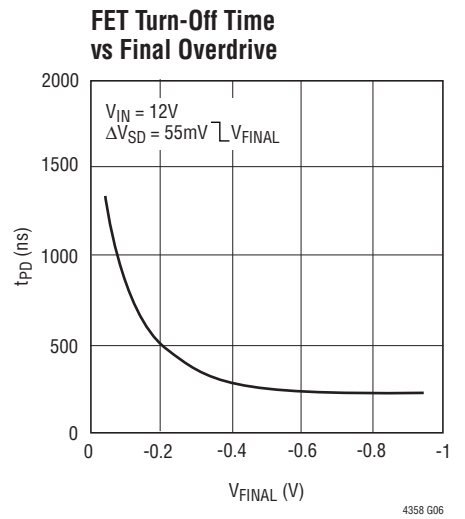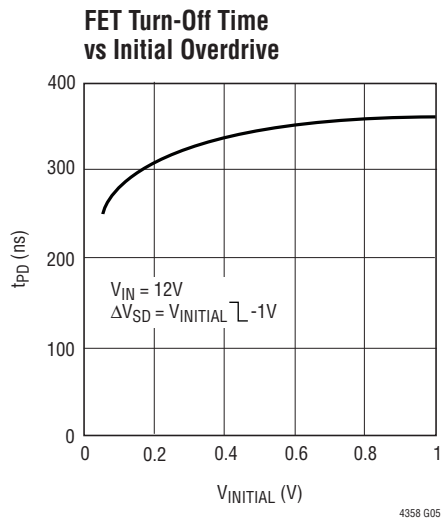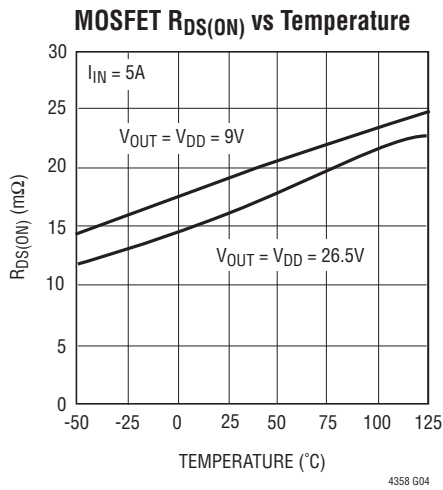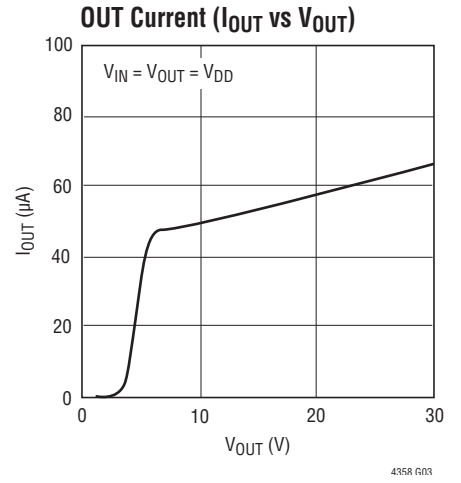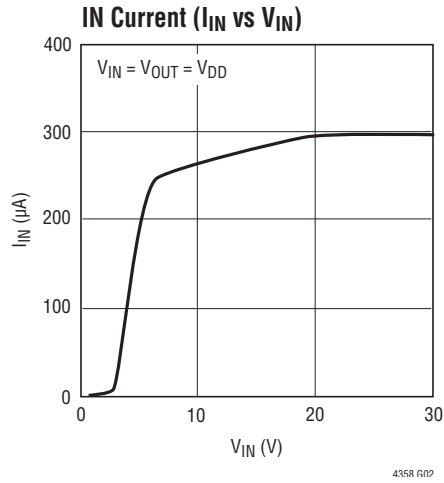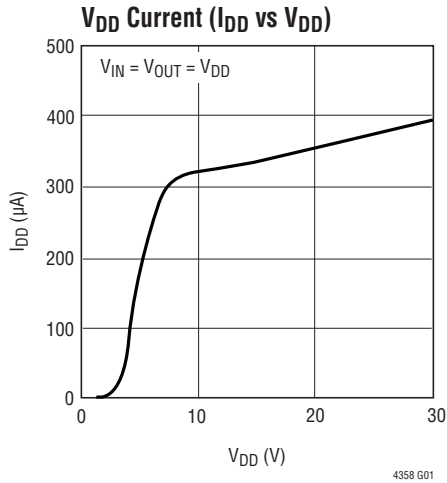
PIN FUNCTIONS (DE/FE PACKAGES)

DRAIN: The exposed pad is the drain of the internal N-channel MOSFET. This pin must be connected to OUT (Pin 9/Pin 10).

GATE: Gate Drive Output. If reverse current flows, a fast pulldown circuit quickly connects the GATE pin to the IN pin, turning off the MOSFET. Leave open if unused.

GND: Device Ground.

IN: Input Voltage and Fast Pulldown Return. IN is the anode of the ideal diode. The voltage sensed at this pin is used to control the source-drain voltage drop across the internal MOSFET. If reverse current starts to flow, a fast pulldown circuit quickly turns off the internal MOSFET. The fast pulldown current is returned through this pin.

NC: No Connection. Not internally connected.

OUT: Output Voltage. The OUT pin is the cathode of the ideal diode and the common output when multiple LTC4358s are configured as an ideal diode-OR. The voltage sensed at this pin is used to control the source-drain voltage drop across the MOSFET. Connect this pin to the drain of the internal N-channel MOSFET (Pin 15/Pin 17).

V_{DD}: Positive Supply Input. The LTC4358 is powered from the V_{DD} pin. Connect this pin to OUT either directly or through an RC hold-up circuit.

BLOCK DIAGRAM

4358 BD
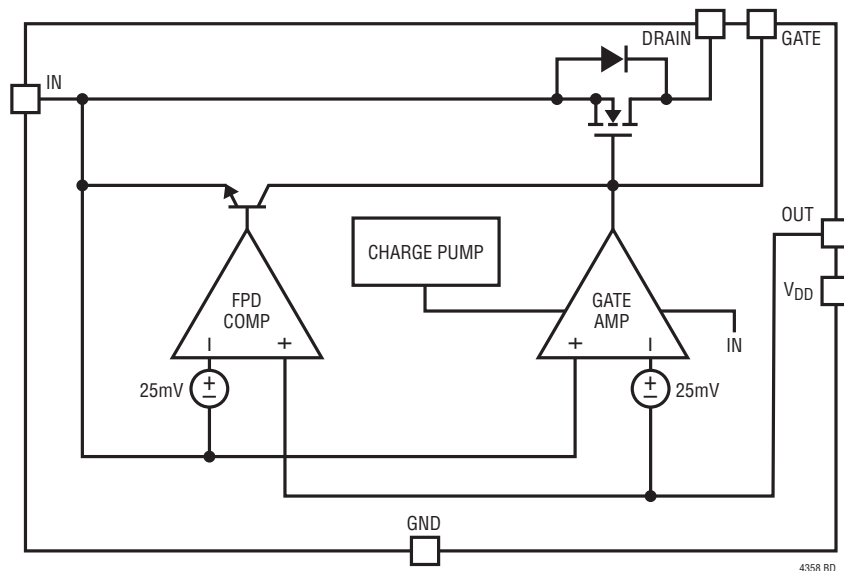
OPERATION

High availability systems often employ parallel-connected power supplies or battery feeds to achieve redundancy and enhance system reliability. ORing diodes have been a popular means of connecting these supplies at the point of load. The disadvantage of this approach is the forward voltage drop and resulting efficiency loss. This drop reduces the available supply voltage and dissipates significant power. Using an N-channel MOSFET to replace a Schottky diode reduces the power dissipation and eliminates the need for costly heat sinks or large thermal layouts in high power applications.

The LTC4358 is a single positive voltage ideal diode controller that drives an internal N-channel MOSFET as a pass transistor to replace a Schottky diode. The IN and DRAIN pins form the anode and cathode of the ideal diode. The input supply is connected to the IN pins, while the DRAIN pin serves as the output. The OUT pin is connected directly to DRAIN and V_{DD}. V_{DD} is the supply for the LTC4358 and is derived from the output either directly or through an RC hold-up circuit.

At power-up, the load current initially flows through the body diode of the internal MOSFET. The internal MOSFET turns on and the amplifier tries to regulate the voltage drop across the IN and OUT connections to 25mV. If the load current causes more than 25mV of drop, the MOSFET is driven fully on and the voltage drop is equal to $R_{DS(ON)} \bullet I_{LOAD}$.

If the load current is reduced causing the forward drop to fall below 25mV, the internal MOSFET is driven lower by a weak pull-down in an attempt to maintain the drop at 25mV. If the load current reverses the MOSFET is turned off with a strong pull-down.

In the event of a power supply failure, such as if the supply that is conducting most or all of the current is shorted to ground, reverse current temporarily flows through the LTC4358 ideal diode that is on. This current is sourced from any load capacitance and from the other supplies. The ideal diode is turned off within 500ns, preventing reverse current from slewing up to a damaging level and minimizing any disturbance on the output.

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APPLICATIONS INFORMATION

ORing Two Supply Outputs

Where LTC4358s are used to combine the outputs of two supplies, the power supply with the highest output voltage sources most or all of the current. If this supply's output is quickly shorted to ground while delivering load current, the current temporarily reverses and flows backwards through the LTC4358. When reverse current flows the LTC4358 ideal diode is quickly turned off.

If the other initially lower supply was not delivering load current at the time of the fault, the output falls until the LTC4358 body diode conducts. Meanwhile, the internal amplifier turns on the MOSFET until the forward drop is reduced to 25mV. If instead this supply was delivering load current at the time of the fault, its ORing MOSFET was already driven at least partially on, and will be driven harder in an effort to maintain a drop of 25mV.

Load Sharing

Figure 1 combines the outputs of multiple, redundant supplies using a simple technique known as droop sharing. Load current is first taken from the highest output, with the low outputs contributing as the output voltage falls under increased loading. The 25mV regulation technique ensures smooth load sharing between outputs without oscillation. The degree of sharing depends on the 20mΩ resistance of the LTC4358 internal MOSFET, the output impedance of the supplies and their initial output voltages.
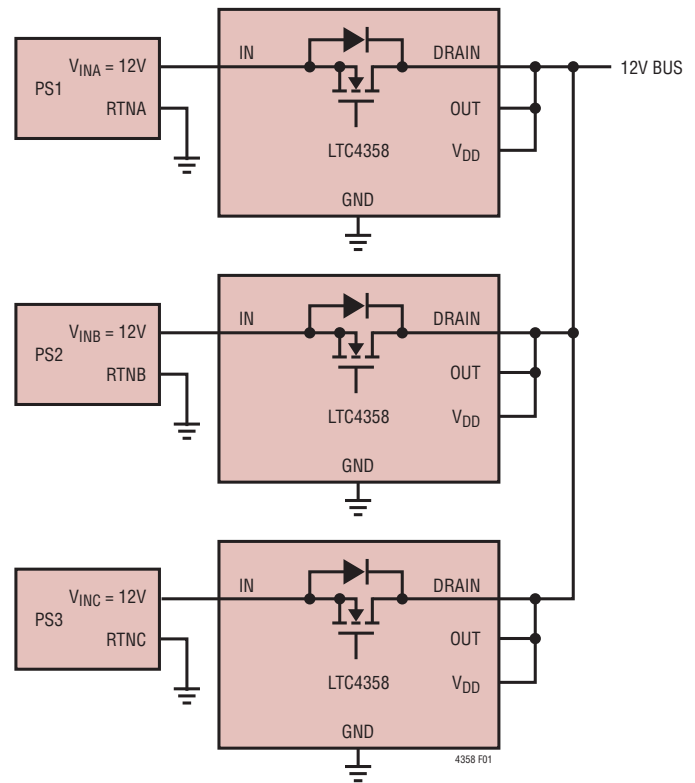

Figure 1. Droop Sharing Redundant Supplies

APPLICATIONS INFORMATION

V_{DD} Hold-Up Circuit

In the event of an input short, parasitic inductance between the input supply of the LTC4358 and the load bypass capacitor may cause V_{DD} to glitch below its minimum operating voltage. This causes the turn-off time (t_{OFF}) to increase. To preserve the fast turn-off time, local output bypassing of 39µF or more is sufficient or a 100Ω, 0.1µF RC hold-up circuit on the V_{DD} pin can be used as shown in Figure 2a and Figure 2b.

Layout Considerations

The following advice should be considered when laying out a printed circuit board for the LTC4358: The OUT pin should be connected as closely as possible to the EXPOSED PAD (drain of the MOSFET) for good accuracy. Keep the traces to the IN and DRAIN wide and short. The PCB traces associated with the power path through the MOSFET should have low resistance. See Figure 4.

The DRAIN acts as a heatsink to remove the heat from the device. For a single layer PCB with the DFN package, use Figure 5 to determine the PCB area needed for a specified maximum current and ambient temperature. If using a two sided PCB, the maximum current is increased by 10%. If the FE package is used, the maximum current is increased by 4%.
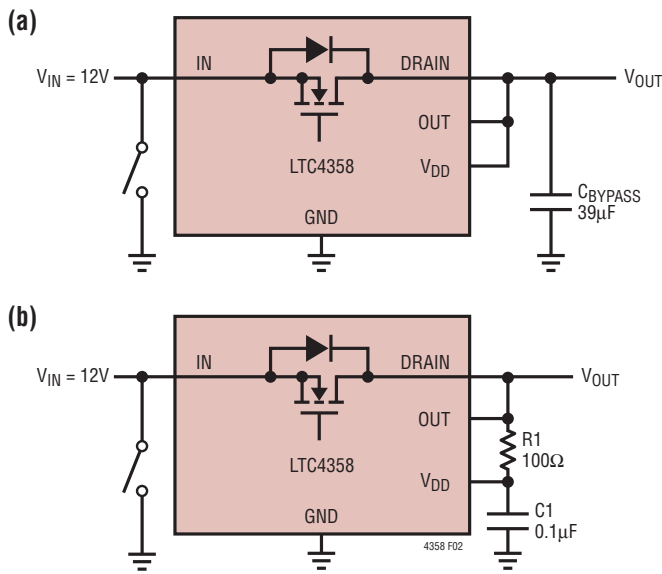

Figure 2. Two Methods of Protecting Against Collapse of V_{DD} From Input Short and Stray Inductance
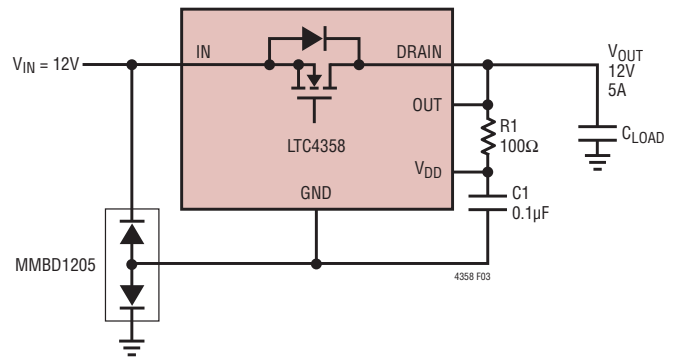
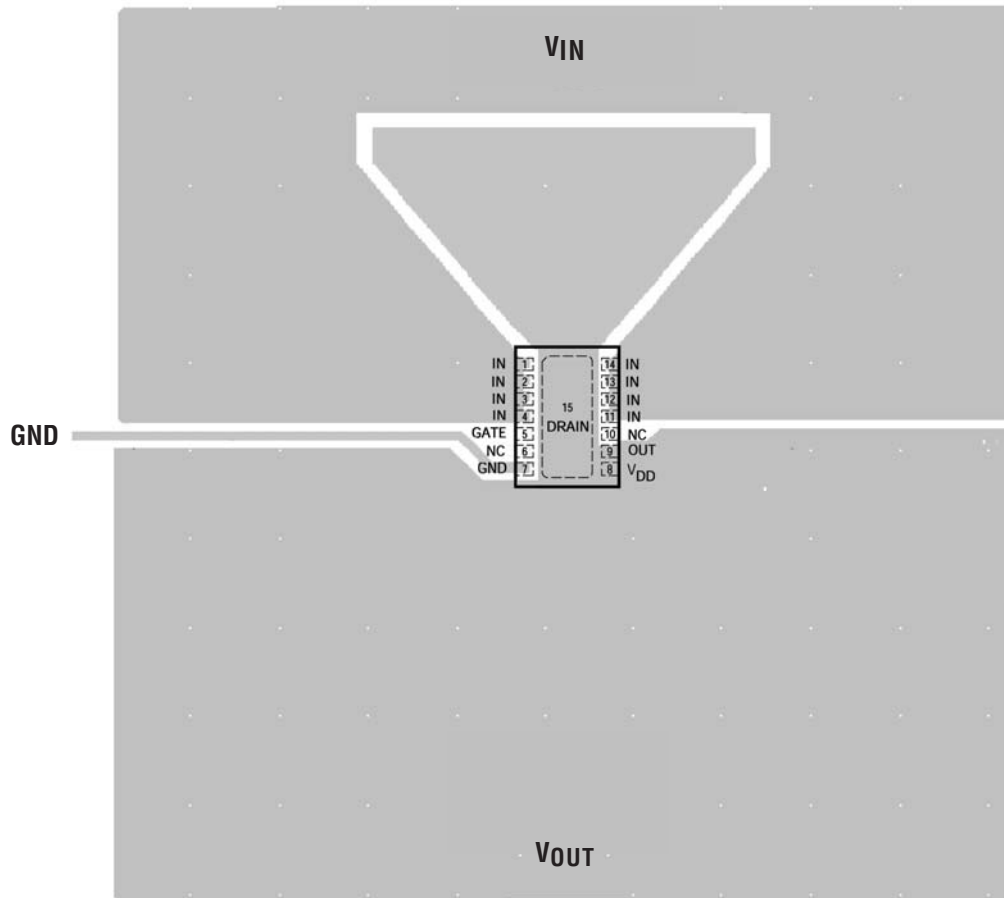

Figure 3. −12V Reverse Input Protection

APPLICATIONS INFORMATION

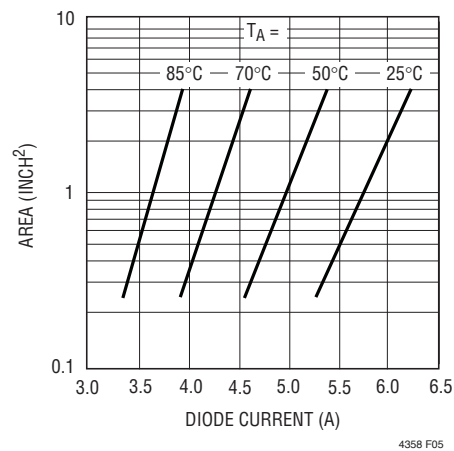**Figure 4. DFN Layout Considerations for 1" × 1" Single Sided PCB**

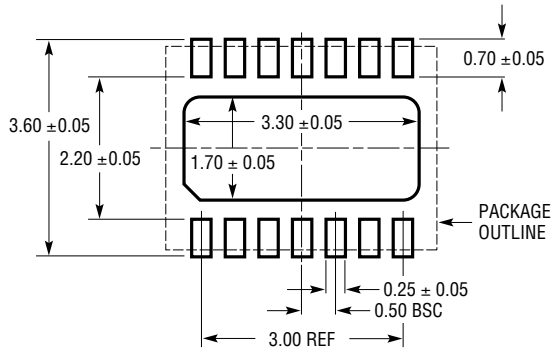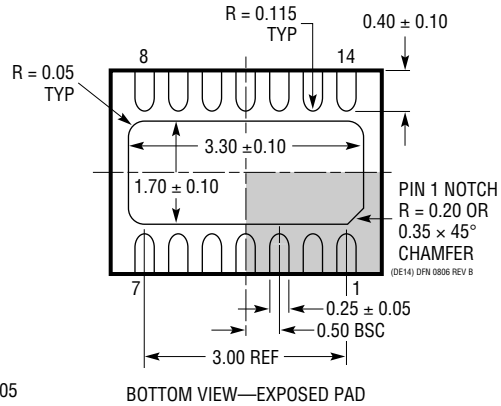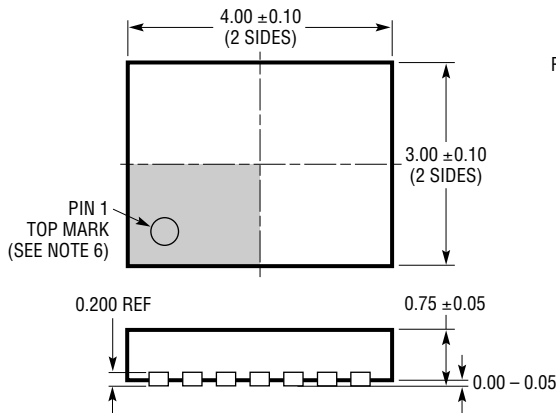**Figure 5. Maximum Diode Current vs PCB Area**

PACKAGE DESCRIPTION

DE Package
**14-Lead Plastic DFN (4mm × 3mm)**
(Reference LTC DWG # 05-08-1708)

3.60 ±0.05

2.20 ±0.05

1.70 ± 0.05

3.30 ±0.05

0.70 ±0.05

PACKAGE OUTLINE

0.25 ± 0.05

0.50 BSC

3.00 REF

RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS
APPLY SOLDER MASK TO AREAS THAT ARE NOT SOLDERED

4.00 ±0.10
(2 SIDES)

3.00 ±0.10
(2 SIDES)

PIN 1
TOP MARK
(SEE NOTE 6)

0.200 REF

0.75 ±0.05

0.00 – 0.05

R = 0.115
TYP

0.40 ± 0.10

R = 0.05
TYP

8

14

3.30 ±0.10

1.70 ± 0.10

PIN 1 NOTCH
R = 0.20 OR
0.35 × 45°
CHAMFER

(DE14) DFN 0806 REV B

7

1

0.25 ± 0.05

0.50 BSC

3.00 REF

BOTTOM VIEW—EXPOSED PAD

NOTE:
1. DRAWING PROPOSED TO BE MADE VARIATION OF VERSION (WGED-3) IN JEDEC
   PACKAGE OUTLINE MO-229
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE
   MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE
   TOP AND BOTTOM OF PACKAGE

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PACKAGE DESCRIPTION

FE Package
16-Lead Plastic TSSOP (4.4mm)
(Reference LTC DWG # 05-08-1663)
Exposed Pad Variation BC

RECOMMENDED SOLDER PAD LAYOUT
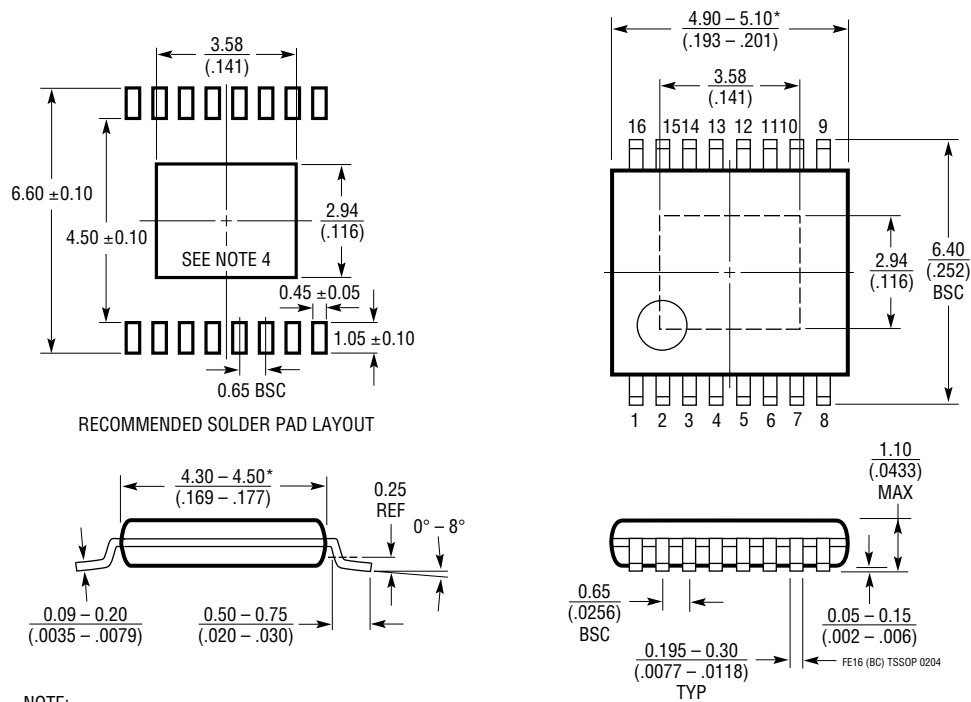
NOTE:
1. CONTROLLING DIMENSION: MILLIMETERS
2. DIMENSIONS ARE IN $\frac{\text{MILLIMETERS}}{\text{(INCHES)}}$
3. DRAWING NOT TO SCALE

4. RECOMMENDED MINIMUM PCB METAL SIZE
   FOR EXPOSED PAD ATTACHMENT
*DIMENSIONS DO NOT INCLUDE MOLD FLASH. MOLD FLASH
 SHALL NOT EXCEED 0.150mm (.006") PER SIDE

FE16 (BC) TSSOP 0204

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TYPICAL APPLICATION

Plug-In Card Input Diode for Supply Hold-Up
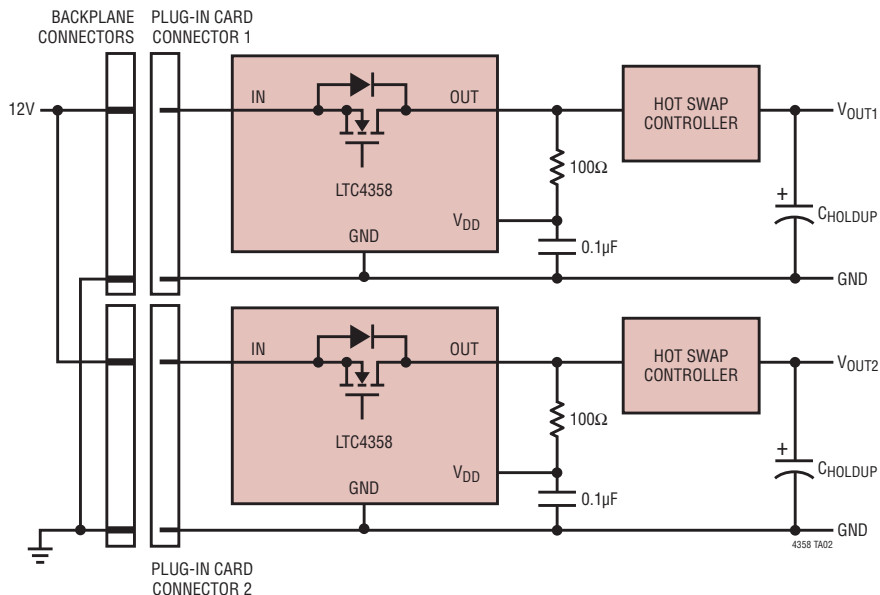
RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1640AH/LT1640AL	Negative High Voltage Hot Swap™ Controllers in SO-8	Negative High Voltage Supplies From –10V to –80V
LT1641-1/LT1641-2	Positive High Voltage Hot Swap Controllers	Active Current Limiting, Supplies From 9V to 80V
LT4250	–48V Hot Swap Controller	Active Current Limiting, Supplies From –20V to –80V
LTC4251/LTC4251-1/LTC4251-2	–48V Hot Swap Controllers in SOT-23	Fast Active Current Limiting, Supplies From –15V
LTC4252-1/LTC4252-2/LTC4252-1A/LTC4252-2A	–48V Hot Swap Controllers in MS8/MS10	Fast Active Current Limiting, Supplies From –15V, Drain Accelerated Response
LTC4253	–48V Hot Swap Controller with Sequencer	Fast Active Current Limiting, Supplies From –15V, Drain Accelerated Response, Sequenced Power Good Outputs
LT4256	Positive 48V Hot Swap Controller with Open-Circuit Detect	Foldback Current Limiting, Open-Circuit and Overcurrent Fault Output, Up to 80V Supply
LTC4260	Positive High Voltage Hot Swap Controller	With I^{2}C and ADC, Supplies from 8.5V to 80V
LTC4261	Negative High Voltage Hot Swap Controller	With I^{2}C and 10-Bit ADC, Adjustable Inrush and Overcurrent Limits
LTC4350	Hot Swappable Load Share Controller	Output Voltage: 1.2V to 20V, Equal Load Sharing
LT4351	MOSFET Diode-OR Controller	External N-Channel MOSFETs Replace ORing Diodes, 1.2V to 20V
LTC4352	Ideal Diode Controller with Monitor	Controls N-Channel MOSFET, 0V to 18V Operation
LTC4354	Negative Voltage Diode-OR Controller and Monitor	Controls Two N-Channel MOSFETs, 1µs Turn-Off, 80V Operation
LTC4355	Positive Voltage Diode-OR Controller and Monitor	Controls Two N-Channel MOSFETs, 0.5µs Turn-Off, 80V Operation
LTC4357	Positive High Voltage Ideal Diode Controller	Controls Single N-Channel MOSFET, 0.5µs Turn-Off, 80V Operation
LTC4223-1/LTC4223-2	Dual Supply Hot Swap Controller for Advanced Mezzanine Cards and µTCA	Controls 12V Main and 3.3V Auxiliary Supplies

Hot Swap is a trademark of Linear Technology Corporation.

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