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NIS5431 Series

+3.3 Volt Electronic Fuse

The NIS5431 series is a cost effective, resettable fuse. It is designed to buffer the load device from excessive input voltage which can damage sensitive circuits. It also includes an overvoltage clamp circuit that limits the output voltage during transients but does not shut the unit down, thereby allowing the load circuit to continue operation.

Features

- Integrated Power Device
- 33 mΩ Typical
- Internal Charge Pump
- Internal Undervoltage Lockout Circuit
- Internal Overvoltage Clamp
- These are Pb−Free Devices and are RoHS Compliant

Typical Applications

- Mother Board
- Hard Drives
- Fan Drives

ON Semiconductor®

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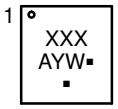
5.0 AMP, 3.3 VOLT ELECTRONIC FUSE

WDFN10
CASE 522AA

MARKING DIAGRAM

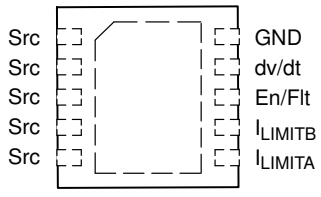


Pin	Function
1–5	SOURCE
6	I_{LIMITA}
7	I_{LIMITB}
8	Enable/Fault
9	dv/dt
10	GND
11 (flag)	VCC

XXX = Specific Device Code
A = Assembly Location
Y = Year
W = Work Week
▪ = Pb−Free Package

(Note: Microdot may be in either location)

PIN ASSIGNMENTS



(Top View)

ORDERING INFORMATION

Device	Features	Marking	Package	Shipping†
NIS5431MT1TXG	Thermal Latching	31	WDFN10 (Pb−Free)	3000 / Tape & Reel
NIS5431MT1TWG	Thermal Latching	31W	WDFN10 (Pb−Free)	3000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

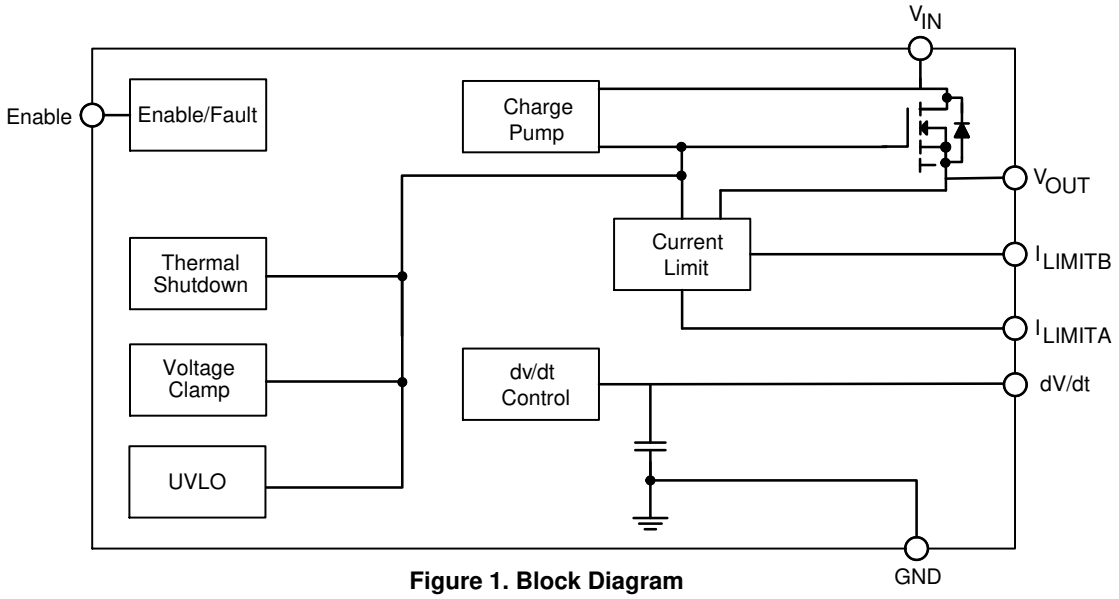


Figure 1. Block Diagram

FUNCTIONAL PIN DESCRIPTION

Pin	Function	Description
1–5	Source	This pin is the source of the internal power FET and the output terminal of the fuse.
6	I_{LIMITA}	A resistor between this pin and the I_{LIMITB} pin sets the overload and short circuit current limit levels.
7	I_{LIMITB}	A resistor between this pin and the I_{LIMITA} pin sets the overload and short circuit current limit levels.
8	Enable/Fault	The enable/fault pin is a tri–state, bidirectional interface. It can be used to enable or disable the output of the device by pulling it to ground using an open drain or open collector device. If a thermal fault occurs, the voltage on this pin will go to an intermediate state to signal a monitoring circuit that the device is in thermal shutdown. It can also be connected to another device in this family to cause a simultaneous shutdown during thermal events.
9	dv/dt	The internal dv/dt circuit controls the slew rate of the output voltage at turn on. It has an internal capacitor that allows it to ramp up over a period of 1.4 ms. An external capacitor can be added to this pin to increase the ramp time. If an additional time delay is not required, this pin should be left open.
10	Ground	Negative input voltage to the device. This is used as the internal reference for the IC.
11 (belly pad)	V_{CC}	Positive input voltage to the device.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Input Voltage, operating, steady–state (V_{CC} to GND, Note 1)	V_{IN}	–0.6 to 14	V
Thermal Resistance, Junction–to–Air 0.1 in^2 copper (Note 2) 0.5 in^2 copper (Note 2) JESD51–7 4–layer board	θ_{JA}	 154 93 50	°C/W
Thermal Resistance, Junction–to–Lead (Pin 1)	θ_{JL}	49	°C/W
Thermal Resistance, Junction–to–Case	θ_{JC}	20	°C/W
Total Power Dissipation @ T_A = 25°C (operating)	P_{max}	2.5	W
Operating Temperature Range (Notes 3 and 4)	T_J	–40 to 150	°C
Nonoperating Temperature Range	T_J	–55 to 155	°C
Lead Temperature, Soldering (10 Sec)	T_L	260	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Negative voltage will not damage device provided that the power dissipation is limited to the rated allowable power for the device.
2. 1 oz copper, double–sided FR4.
3. Thermal limit is set above the maximum thermal rating. It is not recommended to operate this device at temperatures greater than the maximum ratings for extended periods of time.
4. Exceeding T_J will thermally destroy the FET. See AND9042/D.

ELECTRICAL CHARACTERISTICS

(Unless otherwise noted: V_{CC} = 3.3 V, C_{in} = 2.2 μF, C_L = 70 μF, dv/dt pin open, T_A = 25°C unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
POWER FET					
Delay Time (enabling of chip to I_D = 100 mA with 1 A resistive load) (Note 9)	T_{dly}		200		μs
ON Resistance (Note 5) T_J = 140°C (Note 6)	$R_{DS(on)}$	25	33 60	50	mΩ
Off State Output Voltage (V_{CC} = 8 V_{dc}, V_{GS} = 0 V_{dc}, R_L = 100 kΩ) (Note 9)	V_{off}		10	200	mV
Output Capacitance (V_{DS} = 3.3 V_{DC}, V_{GS} = 0 V_{DC}, R_L = ∞)	C_{out}		230		pF
Continuous Current (T_A = 25°C, 0.5 in^2 pad) (Note 6) (T_A = 25°C, JESD51−7 4−layer board) (T_A = 80°C, minimum copper)	I_D I_D I_D		4.2 5.0 2.3		A
THERMAL LATCH					
Shutdown Temperature (Note 6)	T_{SD}	150	175	200	°C
Thermal Hysteresis (Decrease in die temperature for turn on, does not apply to latching parts)	T_{Hyst}		45		°C
UNDER/OVERVOLTAGE PROTECTION					
V_{OUT} Maximum (V_{CC} = 8 V) NIS5431	$V_{out-clamp}$	3.6	3.85	4.1	V
Undervoltage Lockout (Turn on, Voltage Going High)	V_{UVLO}	1.91	2.35	2.5	V
UVLO Hysteresis (Note 9)	V_{Hyst}		0.145		V
CURRENT LIMIT					
Kelvin Short Circuit Current Limit (Note 7) (R_{Limit} = 10 Ω)	I_{LIM}	1.35	1.90	2.45	A
Overload Current Limit (Note 7) (R_{Limit} = 10 Ω)	I_{LIM}		6.0		A
dv/dt CIRCUIT					
Output Voltage Ramp Time (Enable to V_{OUT} = 3.0 V) (Note 9)	t_{slew}	0.3	0.6	1.2	ms
Maximum Capacitor Voltage	V_{max}			V_{CC}	V
ENABLE/FAULT					
Logic Level Low (Output Disabled)	V_{in-low}	0.35	0.58	0.81	V
Logic Level Mid (Thermal Fault, Output Disabled)	V_{in-mid}	0.82	1.4	1.95	V
Logic Level High (Output Enabled) (Note 9)	$V_{in-high}$	1.96	2.2	2.50	V
High State Maximum Voltage	V_{in-max}	2.51	3.3	5.2	V
Logic Low Sink Current (V_{enable} = 0 V)	I_{in-low}		−12	−20	μA
Logic High Leakage Current for External Switch (V_{enable} = 3.3 V)	$I_{in-leak}$			1.0	μA
Maximum Fanout for Fault Signal (Total number of chips that can be connected to this pin for simultaneous shutdown)	Fan			3.0	Units
TOTAL DEVICE					
Bias Current (Operational) (Note 9)	I_{Bias}		400	750	μA
Bias Current (Shutdown) (Note 9)	I_{Bias}		80		μA
Minimum Operating Voltage (Notes 6 and 8)	V_{min}			2.5	V

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

5. Pulse test: Pulse width 300 μs, duty cycle 2%.
6. Verified by design.
7. Refer to explanation of short circuit and overload conditions in application note AND8140/D.
8. Device will shut down prior to reaching this level based on actual UVLO trip point.
9. Guaranteed by characterization or design.

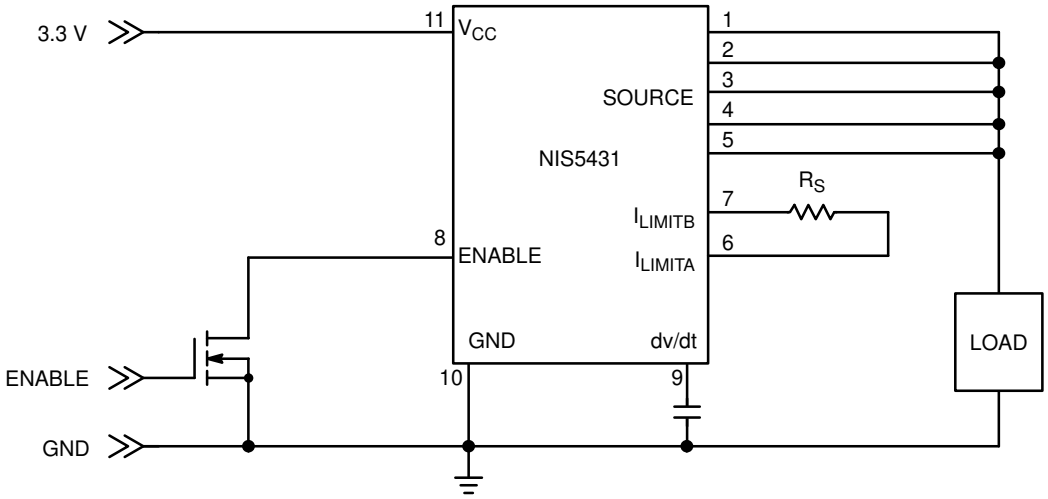


Figure 2. Typical Application Circuit

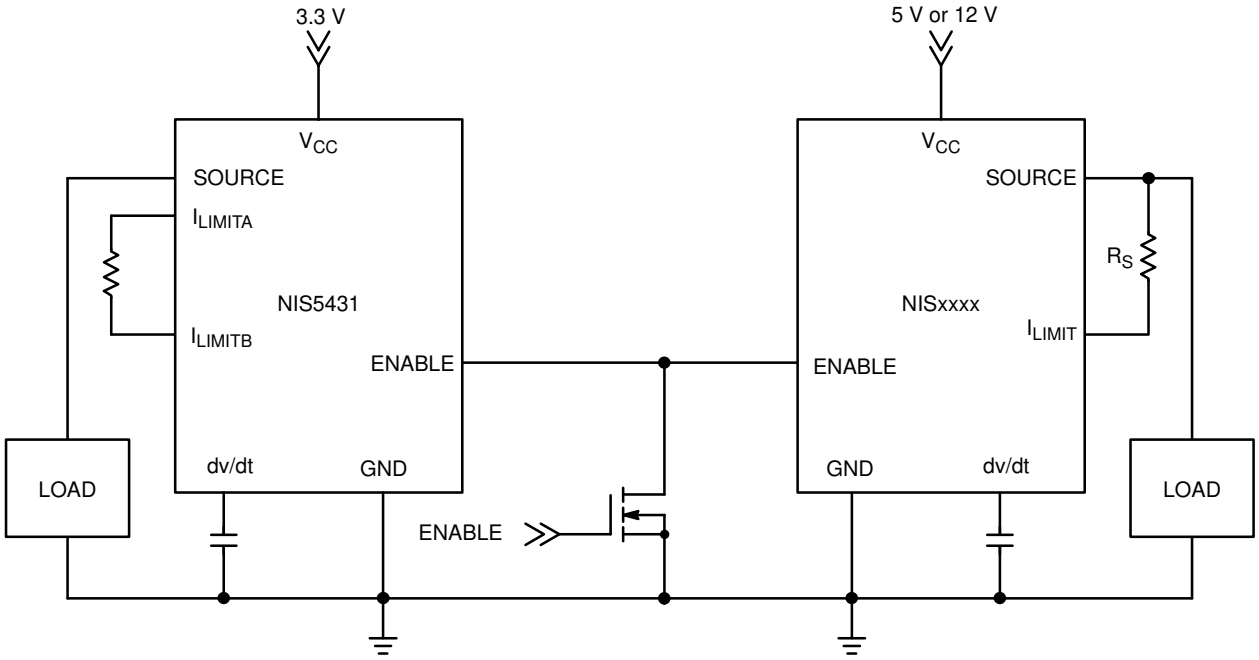


Figure 3. Common Thermal Shutdown

APPLICATION INFORMATION

Basic Operation

This device is a self−protected, resettable, electronic fuse. It contains circuits to monitor the input voltage, output voltage, output current and die temperature.

On application of the input voltage, the device will apply the input voltage to the load based on the restrictions of the controlling circuits. The dv/dt of the output voltage will be controlled by the internal dv/dt circuit. The output voltage will slew from 0 V to the rated output voltage in 0.6 ms, unless additional capacitance is added to the dv/dt pin.

The device will remain on as long as the temperature does not exceed the 175°C limit that is programmed into the chip. The current limit circuit does not shut down the part but will reduce the conductivity of the FET to maintain a constant current at the internally set current limit level. The input overvoltage clamp also does not shutdown the part, but will limit the output voltage to the V_{out}−clamp value in the event that the input exceeds that level.

An internal charge pump provides bias for the gate voltage of the internal n−channel power FET and also for the current limit circuit. The remainder of the control circuitry operates between the input voltage (V_{CC}) and ground.

Application Information

It is recommended to connect an input decoupling capacitor and an output filtering capacitor to the device to

attenuate the power supply noise and the possible voltage spikes caused by inductive loads. The values of these capacitors depend on the characteristics of the power supply and the inductance observed by the device at its input and output, however, minimum values of 1 μF for the input capacitor and 22 μF for the output capacitor are recommended for most applications.

Power Limit

Refer to Application Note AND9042/D for I_{LIMSE} limitations.

Current Limit

The current limit circuit uses a SENSEFET along with a reference and amplifier to control the peak current in the device. The SENSEFET allows for a small fraction of the load current to be measured, which has the advantage of reducing the losses in the sense resistor as well as increasing the value and decreasing the power rating of the sense resistor. Sense resistors are typically in the tens of ohms range with power ratings of several milliwatts making them very inexpensive chip resistors.

The current limit circuit has two limiting values, one for overload events which are defined as the mode of operation in which the gate is high and the FET is fully enhanced. The short circuit mode of operation occurs when the device is actively limiting the current and the gate is at an intermediate level. For a more detailed description of this circuit please refer to application note AND8140.

Overvoltage Clamp

The overvoltage clamp consists of an amplifier and reference. It monitors the output voltage and if the input voltage exceeds the specified Vout maximum for the device, the gate drive of the main FET is reduced to limit the output. This is intended to allow operation through transients while protecting the load. If an overvoltage condition exists for many seconds, the device may overheat due to the voltage drop across the FET combined with the load current. In this event, the thermal protection circuit would shut down the device.

Undervoltage Lockout

The undervoltage lockout circuit uses a comparator with hysteresis to monitor the input voltage. If the input voltage drops below the specified level, the output switch will be switched to a high impedance state.

dv/dt Circuit

The dv/dt circuit brings the output voltage up under a linear, controlled rate regardless of the load impedance characteristics. An internal ramp generator creates a linear ramp, and a control circuit forces the output voltage to follow that ramp, scaled by a factor.

The default ramp time is approximately 0.6 ms. This can be modified by adding an external capacitor at the dv/dt pin. This pin includes an internal current source of approximately 1 μA. Since the current level is very low, it is important to use a ceramic cap or other low leakage capacitor. Aluminum electrolytic capacitors are not recommended for this circuit.

The ramp time from 0 to the nominal output voltage can be determined by the following equation, where *t* is in seconds:

$$t_{0-3} = 8.25\ E5 \cdot C_{ext}$$

Where:
C is in Farads
t is in Seconds

Any time that the unit shuts down due to a fault, enable shut−down, or recycling of input power, the timing capacitor will be discharged and the output voltage will ramp from 0 at turn on.

Enable/Fault

The Enable/Fault Pin is a multi−function, bidirectional pin that can control the output of the chip as well as send information to other devices regarding the state of the chip. When this pin is low, the output of the fuse will be turned off. When this pin is high the output of the fuse will be turned−on. If a thermal fault occurs, this pin will be pulled low to an intermediate level by an internal circuit.

To use as a simple enable pin, an open drain or open collector device should be connected to this pin. Due to its tri−state operation, it should not be connected to any type of logic with an internal pullup device.

If the chip shuts down due to the die temperature reaching its thermal limit, this pin will be pulled down to an intermediate level. This signal can be monitored by an external circuit to communicate that a thermal shutdown has occurred. If this pin is tied to another device in this family, a thermal shutdown of one device will cause both devices to disable their outputs. Both devices will turn on once the fault is removed for the auto−retry devices.

For the latching thermal device, the outputs will be enabled after the enable pin has been pulled to ground with an external switch and then allowed to go high or after the input power has been recycled. For the auto retry devices, both devices will restart as soon as the die temperature of the device in shutdown has been reduced to the lower thermal limit. The thermal options are listed in the ordering table.

Thermal Protection

The NIS5431 includes an internal temperature sensing circuit that senses the temperature on the die of the power FET. If the temperature reaches 175°C, the device will shut down, and remove power from the load. Output power can be restored by either recycling the input power or toggling the enable pin. Power will automatically be reapplied to the load for auto−retry devices once the die temperature has been reduced by 45°C.

The thermal limit has been set high intentionally, to increase the trip time during high power transient events. It is not recommended to operate this device above 150°C for extended periods of time.

TYPICAL CHARACTERISTICS

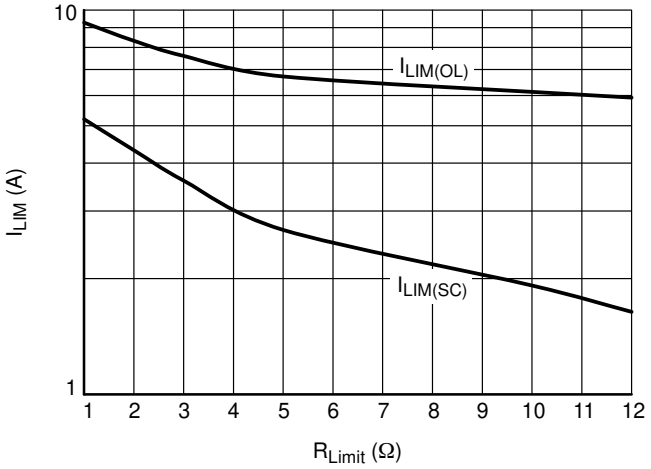


Figure 4. Current Limit vs. R_{Limit}

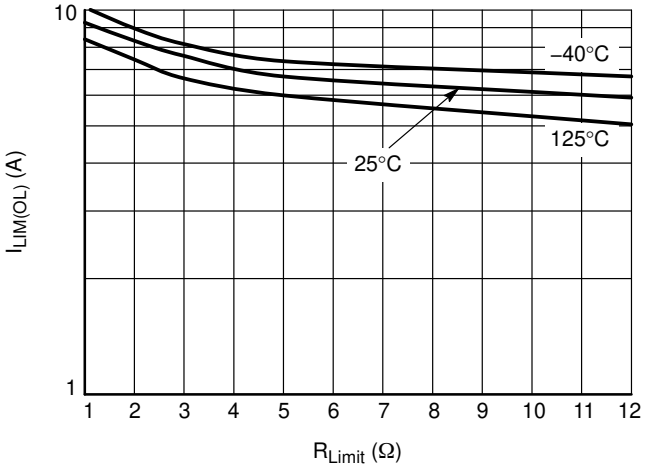


Figure 5. Overload Current Limit vs. R_{Limit} over Ambient Temperature

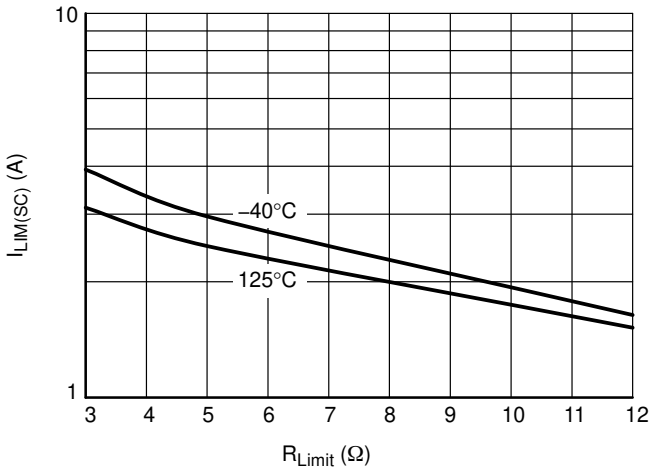


Figure 6. Short Circuit Current Limit vs. R_{Limit} over Ambient Temperature

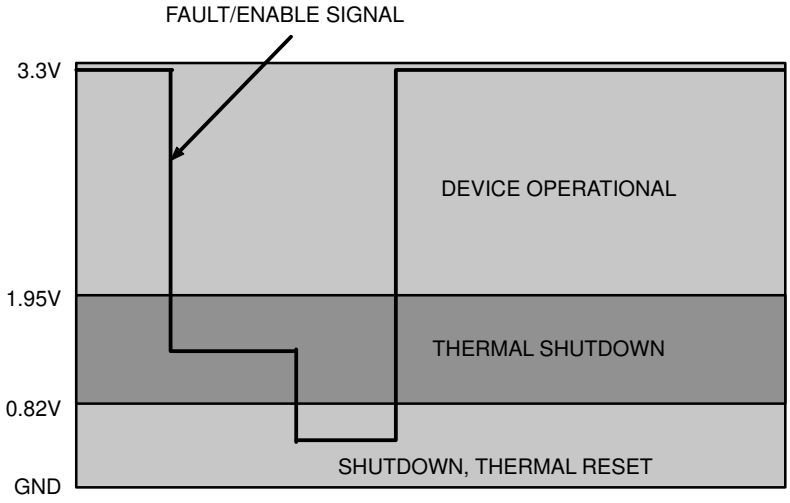


Figure 7. Enable/Fault Signal Levels

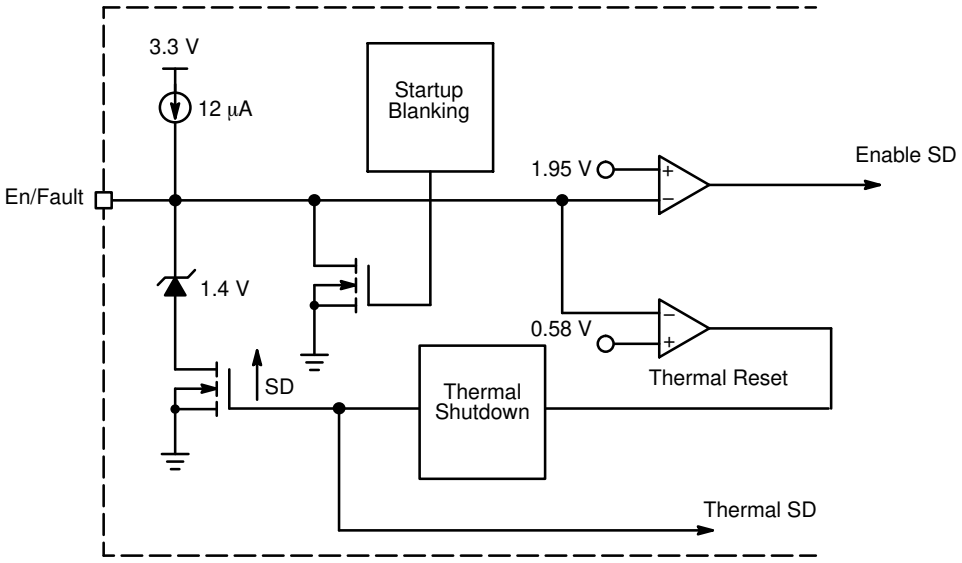
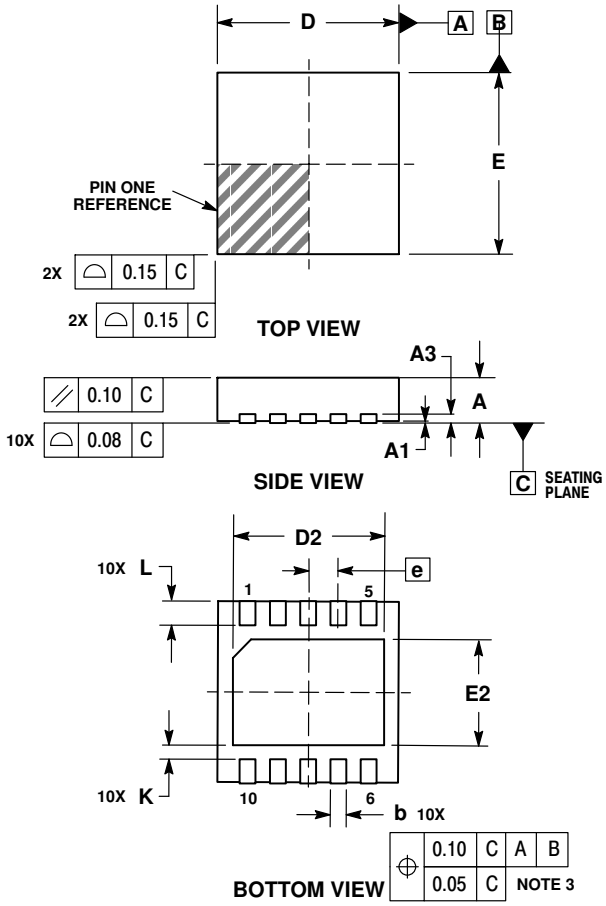


Figure 8. Enable/Fault Simplified Circuit

PACKAGE DIMENSIONS

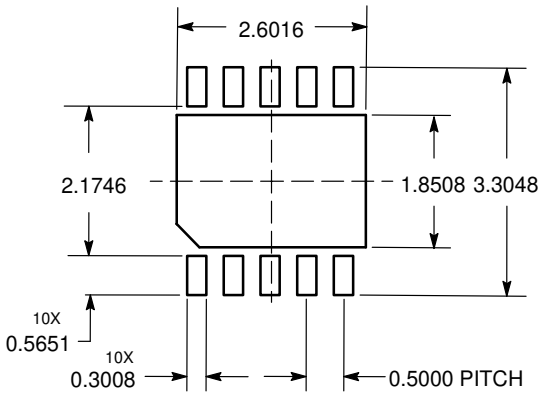
WDFN10, 3x3, 0.5P
CASE 522AA
ISSUE A



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

	MILLIMETERS		
DIM	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.03	0.05
A3		0.20 REF	
b	0.18	0.24	0.30
D		3.00 BSC	
D2	2.45	2.50	2.55
E		3.00 BSC	
E2	1.75	1.80	1.85
e		0.50 BSC	
K		0.19 TYP	
L	0.35	0.40	0.45

SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

*For additional information on our Pb–Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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