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ON Semiconductor®

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# FOD8318

## 2.5 A Output Current, IGBT Drive Optocoupler with Active Miller Clamp, Desaturation Detection, and Isolated Fault Sensing

### Features

- High noise immunity characterized by common mode rejection
  - 35 kV /  $\mu$ s Minimum Common Mode Rejection ( $V_{cm} = 1500 V_{peak}$ )
- 2.5 A peak output current driving capability for most 1200 V / 150 A IGBT
- Optically isolated fault sensing feedback
- Active Miller clamp to shut off the IGBT during high dv/dt without needing a negative supply voltage
- “Soft” IGBT turn-off
- Built-in IGBT protection
  - Desaturation detection
  - Under-voltage lock out (UVLO) protection
- Wide supply voltage range from 15 V to 30 V
  - Use of P-Channel MOSFETs at output stage enables output voltage swing close to the supply rail (rail-to-rail output)
- 3.3 V / 5 V, CMOS/TTL-compatible inputs
- High Speed
  - 250 ns max. propagation delay over full operating temperature range
- Extended industrial temperature range, -40°C to 100°C temperature range
- Safety and regulatory approvals
  - UL1577, 4,243  $V_{RMS}$  for 1 min.
  - DIN EN/IEC 60747-5-5, 1,414  $V_{peak}$  working insulation voltage, 8000  $V_{peak}$  transient isolation voltage ratings
- $R_{DS(ON)}$  of 1  $\Omega$  (typ.) offers lower power dissipation
- User configurable: inverting, non-inverting, auto-reset, auto-shutdown
- 8 mm creepage and clearance distances

### Applications

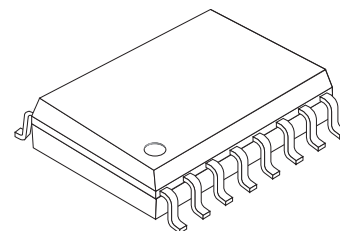
- Industrial inverter
- Induction heating
- Isolated IGBT drive

### Description

The FOD8318 is an advanced 2.5 A output current IGBT drive optocoupler capable of driving most 1200 V / 150 A IGBTs. It is ideally suited for fast-switching driving of power IGBTs and MOSFETs used in motor control inverter applications and high-performance power systems. It consists of an integrated gate drive optocoupler featuring low  $R_{DS(ON)}$  CMOS transistors to drive the IGBT from rail to rail and an integrated high-speed isolated feedback for fault sensing. The FOD8318 has an active Miller clamp function to shut off the IGBT during a high dv/dt situation without the need of a negative supply voltage. It offers critical protection features necessary for preventing fault conditions that lead to destructive thermal runaway of IGBTs.

It utilizes ON's proprietary Optoplanar® coplanar packaging technology and optimized IC design to achieve high noise immunity, characterized by high common mode rejection and power supply rejection specifications.

The device is housed in a compact 16-pin small outline plastic package that meets the 8 mm creepage and clearance requirements.



FOD8318 — 2.5 A Output Current, IGBT Drive Optocoupler with Active Miller Clamp, Desaturation Detection, and Isolated Fault Sensing

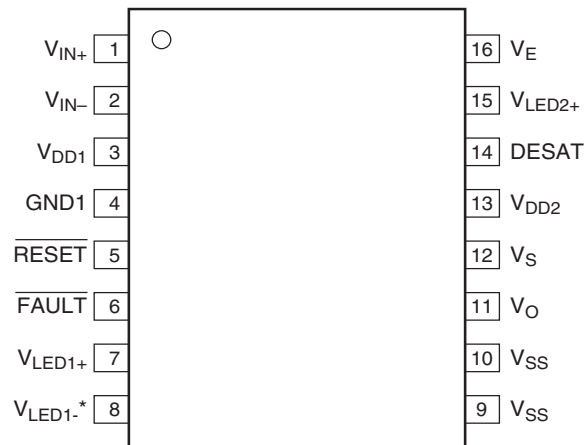
### Truth Table

$V_{IN+}$	$V_{IN-}$	UVLO ( $V_{DD2} - V_E$ )	DESAT Detected?	$\overline{\text{FAULT}}$	$V_{OUT}^*$
X	X	Active	X	X	LOW
X	X	X	Yes	LOW	LOW
LOW	X	X	X	X	LOW
X	HIGH	X	X	X	LOW
HIGH	LOW	Not Active	No	HIGH	HIGH

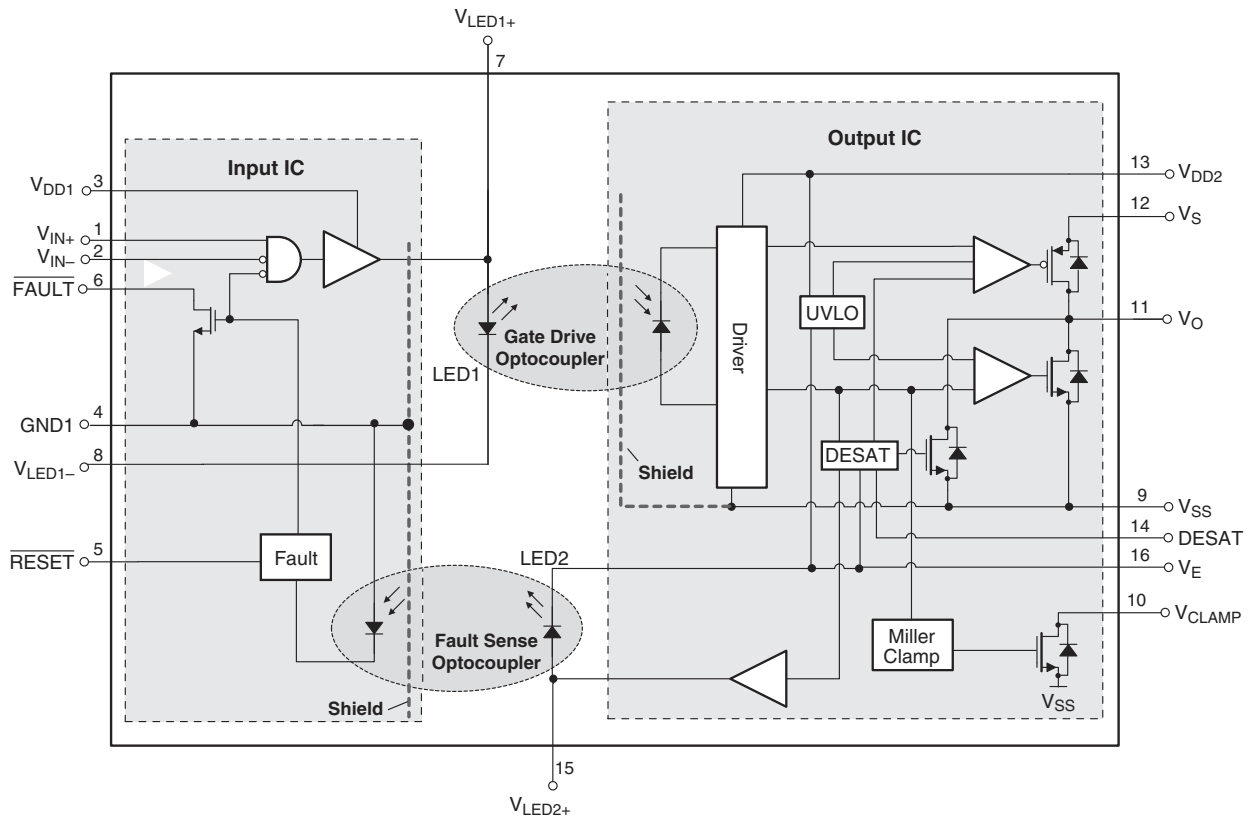
\* $V_{OUT}$  is always LOW with 'clamp' being active (gate voltage < 2 V above  $V_{SS}$ ).

### Pin Definitions

Pin #	Name	Description
1	$V_{IN+}$	Non-inverting gate drive control input
2	$V_{IN-}$	Inverting gate drive control input
3	$V_{DD1}$	Positive input supply voltage (3 V to 5.5 V)
4	GND1	Input ground
5	$\overline{\text{RESET}}$	Fault reset input
6	$\overline{\text{FAULT}}$	Fault output
7	$V_{LED1+}$	LED 1 anode (must be left unconnected)
8	$V_{LED1-}$	LED 1 cathode (must be connected to ground)
9	$V_{SS}$	Output supply voltage (negative)
10	$V_{CLAMP}$	Active Miller clamp supply voltage
11	$V_O$	Gate drive output voltage
12	$V_S$	Source of pull-up PMOS transistor
13	$V_{DD2}$	Positive output supply voltage
14	DESAT	Desaturation voltage input
15	$V_{LED2+}$	LED 2 anode (must be left unconnected)
16	$V_E$	Output supply voltage / IGBT emitter



### Block Diagram



## Safety and Insulation Ratings

As per DIN EN/IEC 60747-5-5. This optocoupler is suitable for “safe electrical insulation” only within the safety limit data. Compliance with the safety ratings shall be ensured by means of protective circuits.

Symbol	Parameter	Min.	Typ.	Max.	Unit
	Installation Classifications per DIN VDE 0110/1.89 Table 1				
	For Rated Mains Voltage < 150 Vrms		I-IV		
	For Rated Mains Voltage < 300 Vrms		I-IV		
	For Rated Mains Voltage < 450 Vrms		I-IV		
	For Rated Mains Voltage < 600 Vrms		I-IV		
	For Rated Mains Voltage < 1000 Vrms		I-III		
	Climatic Classification		40/100/21		
	Pollution Degree (DIN VDE 0110/1.89)		2		
CTI	Comparative Tracking Index	175			
V <sub>PR</sub>	Input to Output Test Voltage, Method b, V <sub>IORM</sub> × 1.875 = V <sub>PR</sub> , 100 % Production Test with t <sub>m</sub> = 1 s, Partial Discharge < 5 pC	2,651			V <sub>peak</sub>
	Input to Output Test Voltage, Method a, V <sub>IORM</sub> × 1.5 = V <sub>PR</sub> , Type and Sample Test with t <sub>m</sub> = 60 s, Partial Discharge < 5 pC	2,121			V <sub>peak</sub>
V <sub>IORM</sub>	Maximum Working Insulation Voltage	1,414			V <sub>peak</sub>
V <sub>IOTM</sub>	Highest Allowable Over Voltage	8,000			V <sub>peak</sub>
	External Creepage	8			mm
	External Clearance	8			mm
	Insulation Thickness	0.5			mm
T <sub>Case</sub>	Safety Limit Values – Maximum Values Allowed in the Event of a Failure				
	Case Temperature	150			°C
P <sub>S,INPUT</sub>	Input Power	100			mW
P <sub>S,OUTPUT</sub>	Output Power	600			mW
R <sub>IO</sub>	Insulation Resistance at T <sub>S</sub> , V <sub>IO</sub> = 500 V	10 <sup>9</sup>			Ω

### Absolute Maximum Ratings ( $T_A = 25\text{ }^\circ\text{C}$ unless otherwise specified)

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter	Value	Units
$T_{STG}$	Storage Temperature	-40 to +125	$^\circ\text{C}$
$T_{OPR}$	Operating Temperature	-40 to +100	$^\circ\text{C}$
$T_J$	Junction Temperature	-40 to +125	$^\circ\text{C}$
$T_{SOL}$	Lead Wave Solder Temperature (no solder immersion) <i>Refer to page 28 for reflow temperature profile.</i>	260 for 10 s	$^\circ\text{C}$
$I_{FAULT}$	Fault Output Current	15	mA
$I_{O(PEAK)}$	Peak Output Current <sup>(1)</sup>	3	A
$V_E - V_{SS}$	Negative Output Supply Voltage <sup>(2)</sup>	0 to 15	V
$V_{DD2} - V_E$	Positive Output Supply Voltage	-0.5 to 35 – ( $V_E - V_{SS}$ )	V
$V_{O(peak)}$	Gate Drive Output Voltage	-0.5 to 35	V
$V_{DD2} - V_{SS}$	Output Supply Voltage	-0.5 to 35	V
$V_{DD1}$	Positive Input Supply Voltage	-0.5 to 6	V
$V_{IN+}$ , $V_{IN-}$ and $V_{RESET}$	Input Voltages	-0.5 to $V_{DD1}$	V
$V_{FAULT}$	Fault Pin Voltage	-0.5 to $V_{DD1}$	V
$V_S$	Source of Pull-up PMOS Transistor Voltage	$V_{SS} + 6.5$ to $V_{DD2}$	V
$V_{DESAT}$	DESAT Voltage	$V_E$ to $V_E + 25$	V
$I_{CLAMP}$	Peaking Clamping Sinking Current	1.7	A
$V_{CLAMP}$	Miller Clamping Voltage	-0.5 to $V_{DD2}$	V
$PD_I$	Input Power Dissipation <sup>(3)(5)</sup>	100	mW
$PD_O$	Output Power Dissipation <sup>(4)(5)</sup>	600	mW

#### Notes:

- Maximum pulse width = 10  $\mu\text{s}$ , maximum duty cycle = 0.2 %.
- This negative output supply voltage is optional. It's only needed when negative gate drive is implemented. A schottky diode is recommended to be connected between  $V_E$  and  $V_{SS}$  to protect against a reverse voltage greater than 0.5 V. Refer to application information, "6. Active Miller Clamp Function" on page 25.
- No derating required across temperature range.
- Derate linearly above 64  $^\circ\text{C}$ , free air temperature at a rate of 10.2 mW/ $^\circ\text{C}$
- Functional operation under these conditions is not implied. Permanent damage may occur if the device is subjected to conditions outside these ratings.

## Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. ON does not recommend exceeding them or designing to absolute maximum ratings.

Symbol	Parameter	Min.	Max.	Unit
$T_A$	Ambient Operating Temperature	-40	+100	°C
$V_{DD1}$	Input Supply Voltage <sup>(6)</sup>	3	5.5	V
$V_{DD2} - V_{SS}$	Total Output Supply Voltage	15	30	V
$V_E - V_{SS}$	Negative Output Supply Voltage	0	15	V
$V_{DD2} - V_E$	Positive Output Supply Voltage <sup>(6)</sup>	15	$30 - (V_E - V_{SS})$	V
$V_S$	Source of Pull-up PMOS Transistor Voltage	$V_{SS} + 7.5$	$V_{DD2}$	V

### Note:

- During power up or down, it is important to ensure that VIN+ remains LOW until both the input and output supply voltages reach the proper recommended operating voltage to avoid any momentary instability at the output state. Refer to "Time to Good Power" section on page 25.

## Isolation Characteristics

Apply over all recommended conditions, typical value is measured at  $T_A = 25\text{ °C}$

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
$V_{ISO}$	Input-Output Isolation Voltage	$T_A = 25\text{ °C}$ , R.H. < 50 %, $t = 1.0\text{ min}$ , $I_{I-O} \leq 10\text{ }\mu\text{A}$ , 50 Hz <sup>(7)(8)(9)</sup>	4,243			$V_{RMS}$
$R_{ISO}$	Isolation Resistance	$V_{I-O} = 500\text{ V}^{(7)}$		$10^{11}$		$\Omega$
$C_{ISO}$	Isolation Capacitance	$V_{I-O} = 0\text{ V}$ , freq = 1.0 MHz <sup>(7)</sup>		1		pF

### Notes:

- Device is considered a two terminal device: pins 1 to 8 are shorted together and pins 9 to 16 are shorted together.
- 4,243  $V_{RMS}$  for 1-minute duration is equivalent to 5,091  $V_{RMS}$  for 1-second duration.
- The Input-Output Isolation Voltage is a dielectric voltage rating as per UL1577. It should not be regarded as an input-output continuous voltage rating. For the continuous working voltage rating, refer to the equipment level safety specification or *DIN EN/IEC 60747-5-5 Safety and Insulation Ratings Table* on page 4.

## Electrical Characteristics

Apply over all recommended conditions; typical value is measured at  $V_{DD1} = 5\text{ V}$ ,  $V_{DD2} - V_{SS} = 30\text{ V}$ ,  $V_E - V_{SS} = 0\text{ V}$ ,  $T_A = 25\text{ °C}$  unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units	Figure
$V_{IN+L}$ , $V_{IN-L}$ , $V_{RESETL}$	Logic Low Input Voltages				0.8	V	
$V_{IN+H}$ , $V_{IN-H}$ , $V_{RESETH}$	Logic High Input Voltages		2.0			V	
$I_{IN+L}$ , $I_{IN-L}$ , $I_{RESETL}$	Logic Low Input Currents	$V_{IN} = 0.4\text{ V}$	-0.5	-0.001		mA	
$I_{FAULTL}$	$\overline{\text{FAULT}}$ Logic Low Output Current	$V_{\overline{\text{FAULT}}} = 0.4\text{ V}$	5.0	12.0		mA	1, 35
$I_{FAULTH}$	$\overline{\text{FAULT}}$ Logic High Output Current	$V_{\overline{\text{FAULT}}} = V_{DD1}$	-40	0.002		$\mu\text{A}$	35

### Electrical Characteristics (Continued)

Apply over all recommended conditions; typical value is measured at  $V_{DD1} = 5\text{ V}$ ,  $V_{DD2} - V_{SS} = 30\text{ V}$ ,  $V_E - V_{SS} = 0\text{ V}$ ,  $T_A = 25\text{ }^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units	Figure
$I_{OH}$	High Level Output Current	$V_O = V_{DD2} - 3\text{ V}$	-1	-2.5		A	2, 7, 36
		$V_O = V_{DD2} - 6\text{ V}^{(10)}$	-2.5			A	
$I_{OL}$	Low Level Output Current	$V_O = V_{SS} + 3\text{ V}$	1	3		A	3, 37
		$V_O = V_{SS} + 6\text{ V}^{(11)}$	2.5			A	
$I_{OLF}$	Low Level Output Current During Fault Condition	$V_O - V_{SS} = 14\text{ V}$	70	125	170	mA	4, 41
$V_{OH}$	High Level Output Voltage	$I_O = -100\text{ mA}$ (12)(13)(14)	$V_S - 1.0\text{ V}$	$V_S - 0.5\text{ V}$		V	5, 7, 38
$V_{OL}$	Low Level Output Voltage	$I_O = 100\text{ mA}$		0.1	0.5	V	6, 8, 38
$I_{DD1H}$	High Level Supply Current	$V_{IN+} = V_{DD1} = 5.5\text{ V}$ , $V_{IN-} = 0\text{ V}$		14	17	mA	9, 39
$I_{DD1L}$	Low Level Supply Current	$V_{IN+} = V_{IN-} = 0\text{ V}$ , $V_{DD1} = 5.5\text{ V}$		2	3	mA	
$I_{DD2H}$	High Level Output Supply Current	$V_O = \text{Open}^{(14)}$		1.7	3	mA	10, 11, 40
$I_{DD2L}$	Low Level Output Supply Current	$V_O = \text{Open}$		1.8	2.8	mA	
$I_{SH}$	High Level Source Current	$I_O = 0\text{ mA}$		0.65	1.5	mA	40
$I_{SL}$	Low Level Source Current	$I_O = 0\text{ mA}$		0.6	1.4	mA	40
$I_{EL}$	$V_E$ Low Level Supply Current		-0.8	-0.5		mA	13, 40
$I_{EH}$	$V_E$ High Level Supply Current		-0.5	-0.25		mA	
$I_{CHG}$	Blanking Capacitor Charge Current	$V_{DESAT} = 2\text{ V}^{(14)(15)}$	-0.13	-0.25	-0.33	mA	12, 41
$I_{DSCHG}$	Blanking Capacitor Discharge Current	$V_{DESAT} = 7\text{ V}$	10	36		mA	41
$V_{UVLO+}$	Under-Voltage Lockout Threshold <sup>(14)</sup>	$V_O > 5\text{ V}$ at $25\text{ }^\circ\text{C}$	10.8	11.7	12.7	V	15, 29, 42
$V_{UVLO-}$		$V_O < 5\text{ V}$ at $25\text{ }^\circ\text{C}$	9.8	10.7	11.7	V	
$UVLO_{HYS}$	Under-Voltage Lockout Threshold Hysteresis	At $25\text{ }^\circ\text{C}$	0.4	1.0		V	
$V_{DESAT}$	DESAT Threshold <sup>(14)</sup>	$V_{DD2} - V_E > V_{UVLO-}$ , $V_O < 5\text{ V}$	6.0	6.5	7.2	V	16, 41
$V_{CLAMP\_THRES}$	Clamping Threshold Voltage			2.2		V	33, 52
$I_{CLAMPL}$	Clamp Low Level Sinking Current	$V_O = V_{SS} + 2.5\text{ V}$	0.35	1.2		A	32, 51

#### Notes:

10. Maximum pulse width =  $10\text{ }\mu\text{s}$ , maximum duty cycle = 0.2 %.
11. Maximum pulse width = 4.99 ms, maximum duty cycle = 99.8 %.
12.  $V_{OH}$  is measured with the DC load current in this testing (maximum pulse width = 1 ms, maximum duty cycle = 20 %). When driving capacitive loads,  $V_{OH}$  approaches  $V_{DD}$  as  $I_{OH}$  approaches zero units.
13. Positive output supply voltage ( $V_{DD2} - V_E$ ) should be at least 15 V. This ensures adequate margin in excess of the maximum under-voltage lockout threshold  $V_{UVLO+}$  of 13.5 V.
14. When  $V_{DD2} - V_E > V_{UVLO}$  and output state  $V_O$  of the FOD8318 is allowed to go HIGH, the DESAT detection feature is active and provides the primary source of IGBT protection. UVLO is needed to ensure DESAT detection is functional.



15. The blanking time,  $t_{BLANK}$ , is adjustable by an external capacitor ( $C_{BLANK}$ ) where  $t_{BLANK} = C_{BLANK} * (V_{DESAT} / I_{CHG})$ .

### Switching Characteristics

Apply over all recommended conditions; typical value is measured at  $V_{DD1} = 5\text{ V}$ ,  $V_{DD2} - V_{SS} = 30\text{ V}$ ,  $V_E - V_{SS} = 0\text{ V}$ ,  $T_A = 25\text{ }^\circ\text{C}$  unless otherwise specified.

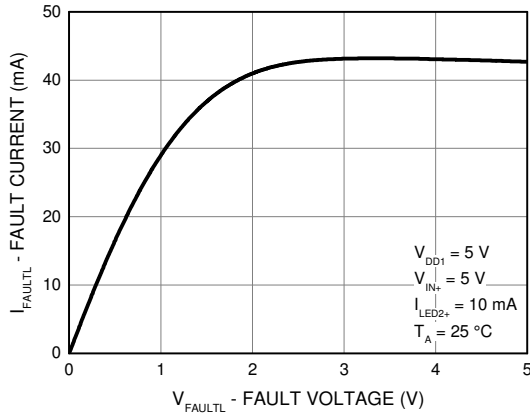
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units	Figure	
$t_{PHL}$	Propagation Delay Time to Logic Low Output <sup>(17)</sup>	Rg = 10 $\Omega$ , Cg = 10 nF, f = 10 kHz, Duty Cycle = 50 % <sup>(16)</sup>		140	250	ns	17, 18, 19, 20, 21, 22, 43, 51	
$t_{PLH}$	Propagation Delay Time to Logic High Output <sup>(18)</sup>			160	250	ns		
PWD	Pulse Width Distortion,   $t_{PHL} - t_{PLH}$   <sup>(19)</sup>			20	100	ns		
PDD Skew	Propagation Delay Difference Between Any Two Parts or Channels, ( $t_{PHL} - t_{PLH}$ ) <sup>(20)</sup>			-150		150	ns	
$t_R$	Output Rise Time (10 % – 90 %)				25		ns	43, 53
$t_F$	Output Fall Time (90 % – 10 %)				25		ns	
$t_{DESAT(90\%)}$	DESAT Sense to 90 % $V_O$ Delay <sup>(21)</sup>	Rg = 10 $\Omega$ , Cg = 10 nF, $V_{DD2} - V_{SS} = 30\text{ V}$		450	700	ns	23, 44	
$t_{DESAT(10\%)}$	DESAT Sense to 10 % $V_O$ Delay <sup>(21)</sup>			2.7	4.0	$\mu\text{s}$	24, 26, 27, 44	
$t_{DESAT(\overline{FAULT})}$	DESAT Sense to Low Level $\overline{FAULT}$ Signal Delay <sup>(22)</sup>			1.4	5.0	$\mu\text{s}$	25, 44, 54	
$t_{DESAT(Low)}$	DESAT Sense to DESAT Low Propagation Delay <sup>(23)</sup>			250		ns	44	
$t_{RESET(\overline{FAULT})}$	$\overline{RESET}$ to High Level $\overline{FAULT}$ Signal Delay <sup>(24)</sup>			3	6	20	$\mu\text{s}$	28, 45, 54
$t_{DESAT(MUTE)}$	DESAT Input Mute			10	22	35	$\mu\text{s}$	
$PW_{\overline{RESET}}$	$\overline{RESET}$ Signal Pulse Width			1.2			$\mu\text{s}$	
$t_{UVLO ON}$	UVLO Turn On Delay <sup>(25)</sup>		$V_{DD2} = 20\text{ V}$ in 1.0ms Ramp		4		$\mu\text{s}$	29, 46
$t_{UVLO OFF}$	UVLO Turn Off Delay <sup>(26)</sup>				3		$\mu\text{s}$	
$t_{GP}$	Time to Good Power <sup>(27)</sup>		$V_{DD2} = 0$ to 30 V in 10 $\mu\text{s}$ Ramp		2.5		$\mu\text{s}$	30, 31, 46
$CM_H$	Common Mode Transient Immunity at Output High	$T_A = 25\text{ }^\circ\text{C}$ , $V_{DD1} = 5\text{ V}$ , $V_{DD2} = 25\text{ V}$ , $V_{SS} = \text{Ground}$ , $V_{CM} = 1500\text{ V}_{peak}$ <sup>(28)</sup>	35	50		kV/ $\mu\text{s}$	48, 49	
$CM_L$	Common Mode Transient Immunity at Output Low	$T_A = 25\text{ }^\circ\text{C}$ , $V_{DD1} = 5\text{ V}$ , $V_{DD2} = 25\text{ V}$ , $V_{SS} = \text{Ground}$ , $V_{CM} = 1500\text{ V}_{peak}$ <sup>(29)</sup>	35	50		kV/ $\mu\text{s}$	47, 50	

#### Notes:

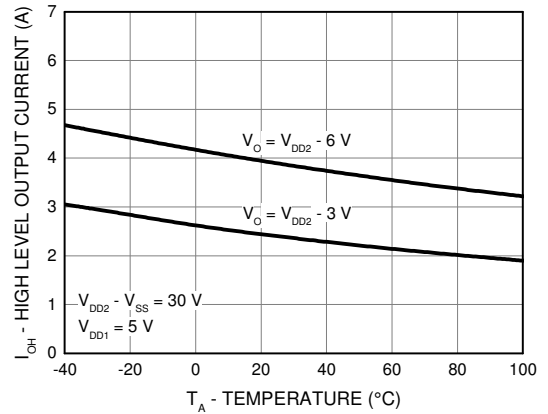
16. This load condition approximates the gate load of a 1200 V / 150 A IGBT.
17.  $t_{PHL}$  propagation delay is measured from the 50 % level on the falling edge of the input pulse ( $V_{IN+}$ ,  $V_{IN-}$ ) to the 50 % level of the falling edge of the  $V_O$  signal. Refer to Figure 53.
18.  $t_{PLH}$  propagation delay is measured from the 50 % level on the rising edge of the input pulse ( $V_{IN+}$ ,  $V_{IN-}$ ) to the 50 % level of the rising edge of the  $V_O$  signal. Refer to Figure 53.
19. PWD is defined as |  $t_{PHL} - t_{PLH}$  | for any given device.

20. The difference between  $t_{PHL}$  and  $t_{PLH}$  between any two FOD8318 parts under same operating conditions, with equal loads.
21. This is the amount of time the DESAT threshold must be exceeded before  $V_O$  begins to go LOW. This is supply voltage dependent. *Refer to Figure 54.*
22. This is the amount of time from when the DESAT threshold is exceeded, until the  $\overline{FAULT}$  output goes LOW. *Refer to Figure 54.*
23. This is the amount of time the DESAT threshold must be exceeded before  $V_O$  begins to go LOW and the  $\overline{FAULT}$  output to go LOW. *Refer to Figure 54.*
24. This is the amount of time from when  $\overline{RESET}$  is asserted LOW, until  $\overline{FAULT}$  output goes HIGH. *Refer to Figure 54.*
25.  $t_{UVLO\ ON}$  UVLO turn-on delay is measured from  $V_{UVLO+}$  threshold voltage of the output supply voltage ( $V_{DD2}$ ) to the 5 V level of the rising edge of the  $V_O$  signal.
26.  $t_{UVLO\ OFF}$  UVLO turn-off delay is measured from  $V_{UVLO-}$  threshold voltage of the output supply voltage ( $V_{DD2}$ ) to the 5 V level of the falling edge of the  $V_O$  signal.
27.  $t_{GP}$  time to good power is measured from 13.5 V level of the rising edge of the output supply voltage ( $V_{DD2}$ ) to the 5 V level of the rising edge of the  $V_O$  signal.
28. Common mode transient immunity at output HIGH state is the maximum tolerable negative  $dV_{cm}/dt$  on the trailing edge of the common mode pulse,  $V_{CM}$ , to assure that the output remains in HIGH state (i.e.,  $V_O > 15\text{ V}$  or  $\overline{FAULT} > 2\text{ V}$ ).
29. Common mode transient immunity at output LOW state is the maximum positive tolerable  $dV_{cm}/dt$  on the leading edge of the common mode pulse,  $V_{CM}$ , to assure that the output remains in a LOW state (i.e.,  $V_O < 1.0\text{ V}$  or  $\overline{FAULT} < 0.8\text{ V}$ ).

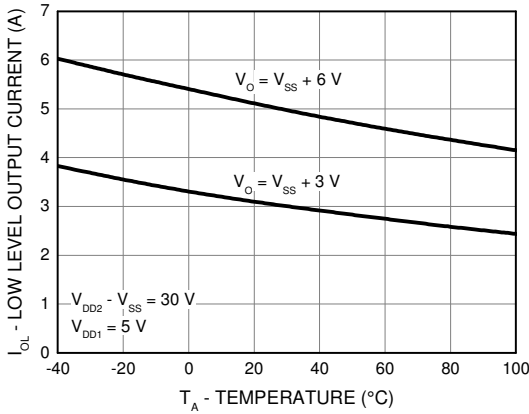
### Typical Performance Characteristics



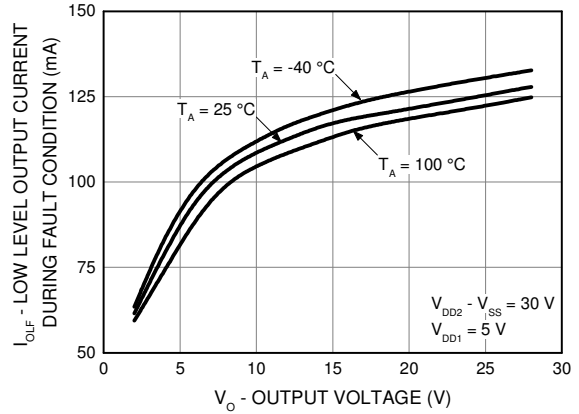
**Figure 1. FAULT Logic Low Output Current ( $I_{\text{FAULTL}}$ ) vs. FAULT Logic Low Output Voltage ( $V_{\text{FAULTL}}$ )**



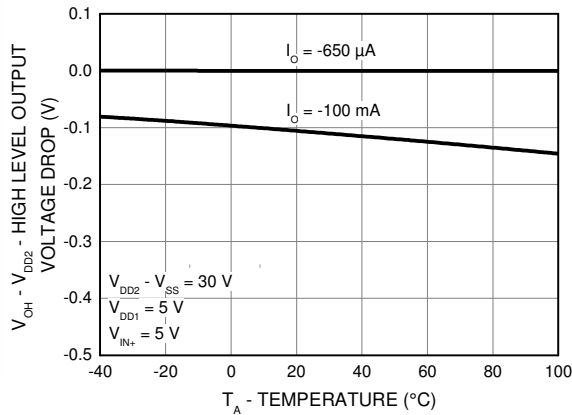
**Figure 2. High Level Output Current ( $I_{\text{OH}}$ ) vs. Temperature**



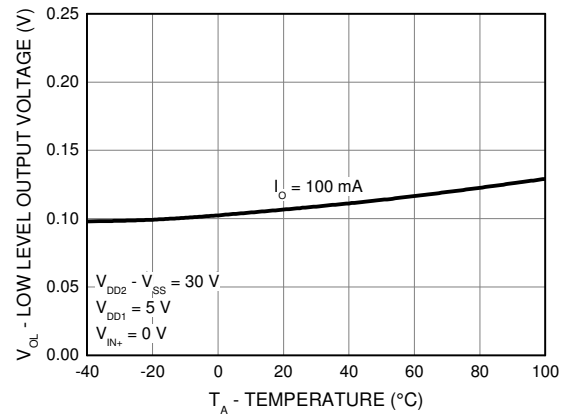
**Figure 3. Low Level Output Current ( $I_{\text{OL}}$ ) vs. Temperature**



**Figure 4. Low Level Output Current During Fault Condition ( $I_{\text{OLF}}$ ) vs. Output Voltage ( $V_{\text{O}}$ )**

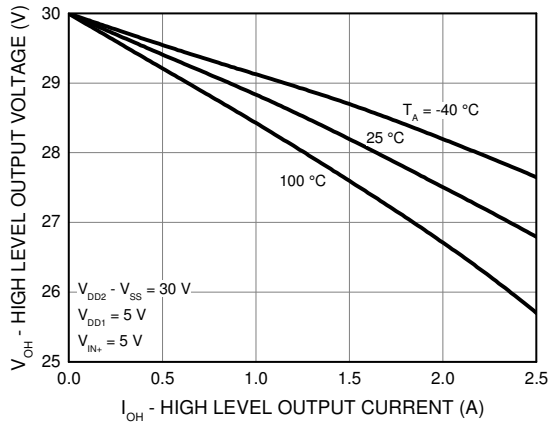


**Figure 5. High Level Output Voltage Drop ( $V_{\text{OH}} - V_{\text{DD}}$ ) vs. Temperature**

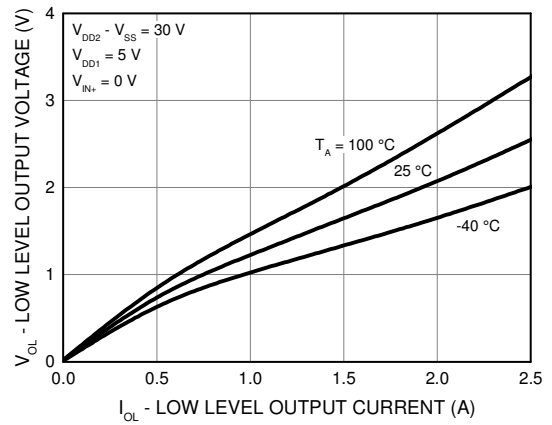


**Figure 6. Low Level Output Voltage ( $V_{\text{OL}}$ ) vs. Temperature**

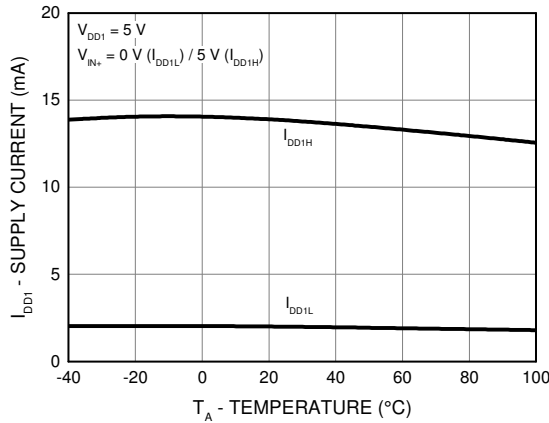
**Typical Performance Characteristics (Continued)**



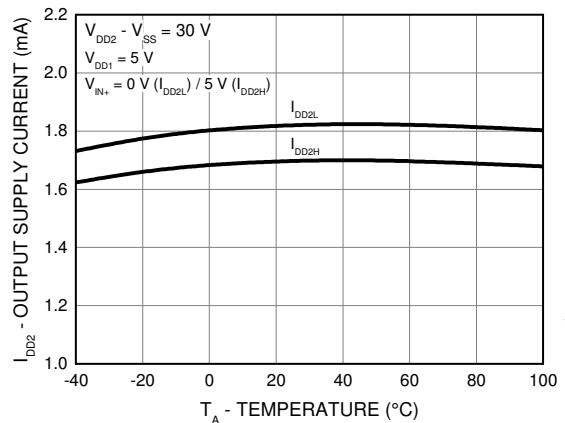
**Figure 7. High Level Output Voltage ( $V_{OH}$ ) vs. High Level Output Current ( $I_{OH}$ )**



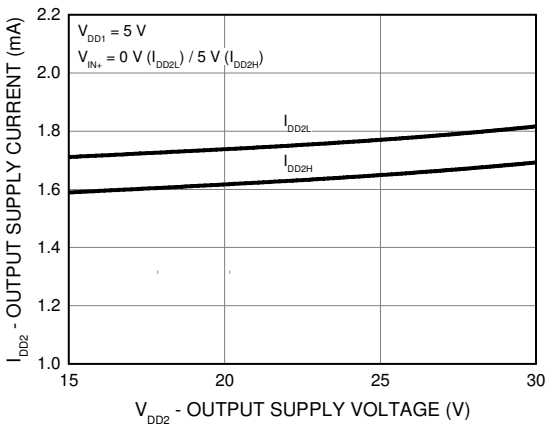
**Figure 8. Low Level Output Voltage ( $V_{OL}$ ) vs. Low Level Output Current ( $I_{OL}$ )**



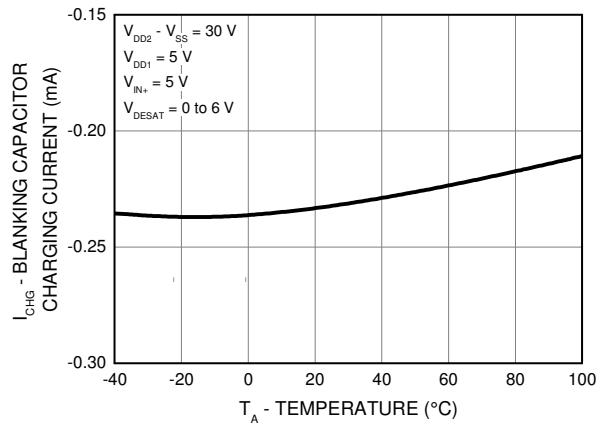
**Figure 9. Supply Current ( $I_{DD1}$ ) vs. Temperature**



**Figure 10. Output Supply Current ( $I_{DD2}$ ) vs. Temperature**

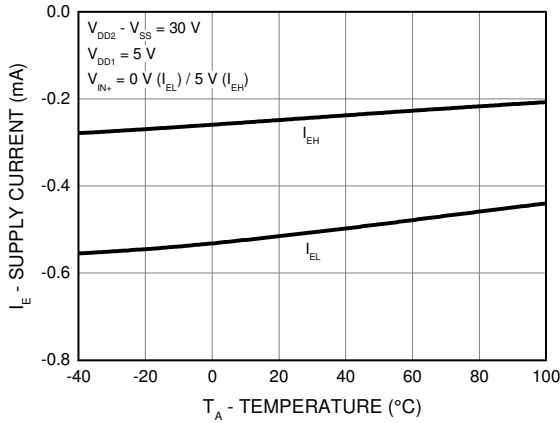


**Figure 11. Output Supply Current ( $I_{DD2}$ ) vs. Output Supply Voltage ( $V_{DD2}$ )**

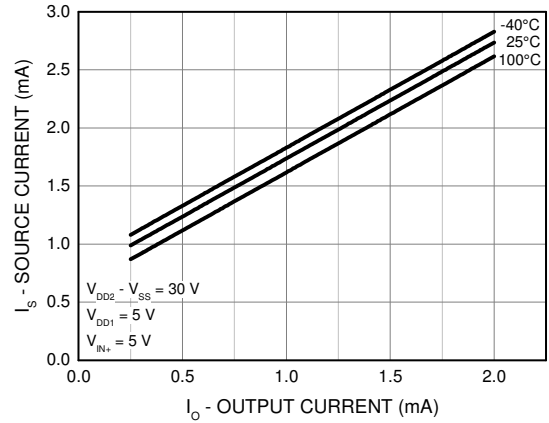


**Figure 12. Blanking Capacitor Charge Current ( $I_{CHG}$ ) vs. Temperature**

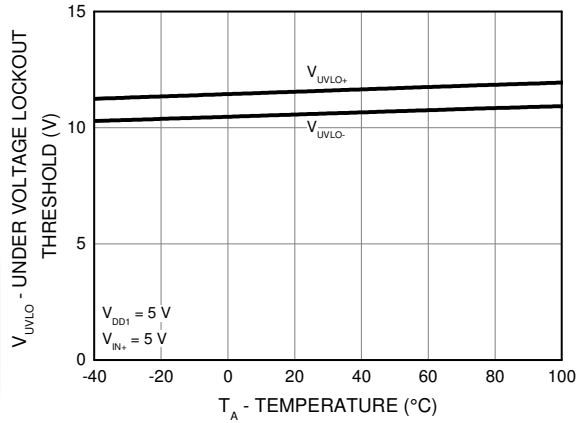
**Typical Performance Characteristics (Continued)**



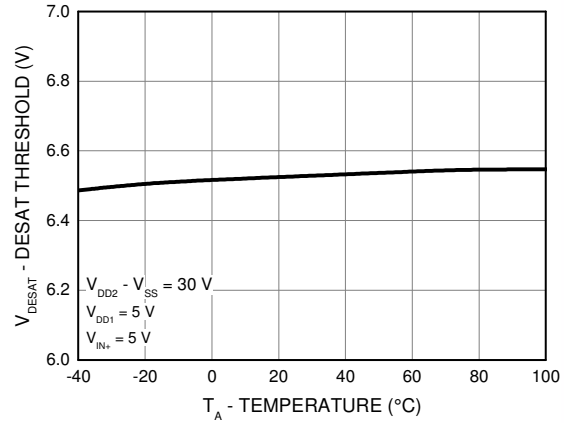
**Figure 13. Supply Current ( $I_E$ ) vs. Temperature**



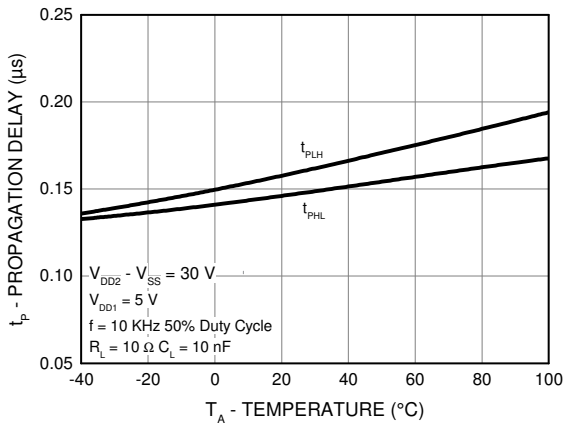
**Figure 14. Source Current ( $I_S$ ) vs. Output Current ( $I_O$ )**



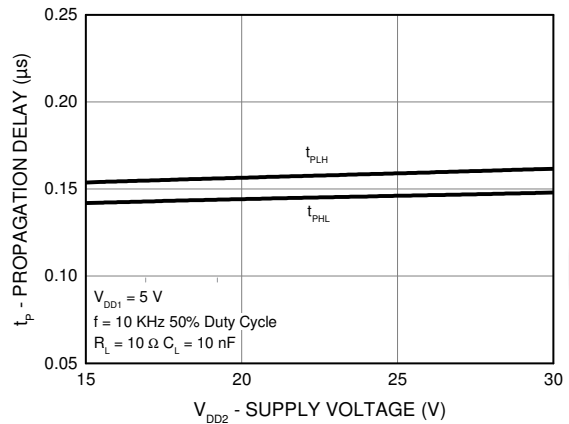
**Figure 15. Under Voltage Lockout Threshold ( $V_{UVLO}$ ) vs. Temperature**



**Figure 16. DESAT Threshold ( $V_{DESAT}$ ) vs. Temperature**

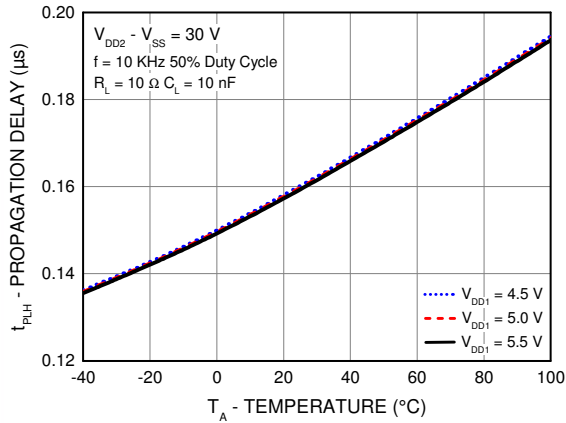


**Figure 17. Propagation Delay ( $t_P$ ) vs. Temperature**

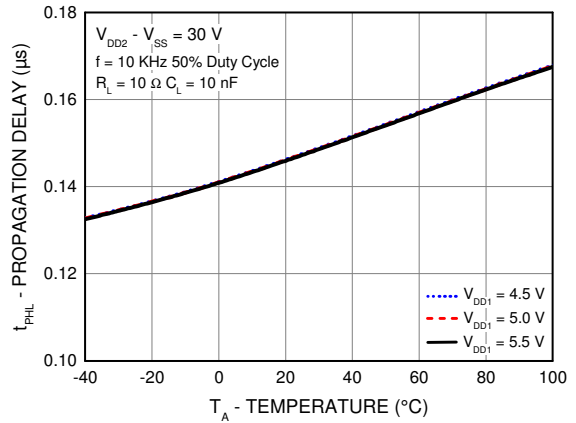


**Figure 18. Propagation Delay ( $t_P$ ) vs. Supply Voltage ( $V_{DD2}$ )**

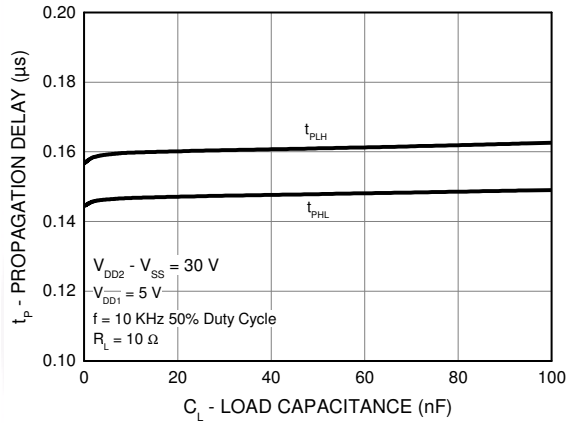
**Typical Performance Characteristics (Continued)**



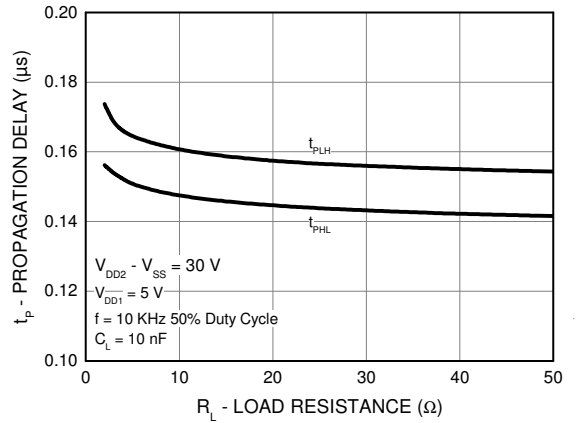
**Figure 19. Propagation Delay Time to Logic High Output ( $t_{PLH}$ ) vs. Temperature**



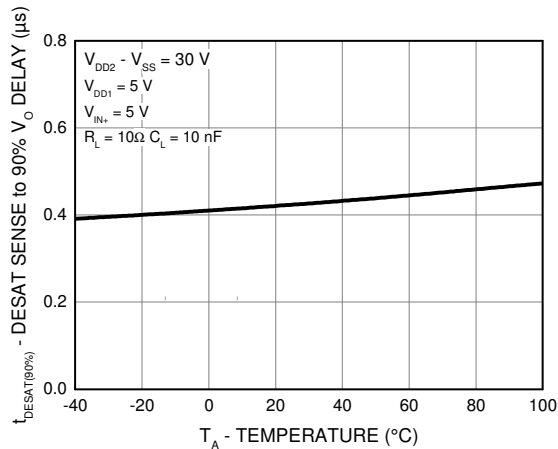
**Figure 20. Propagation Delay Time to Logic Low Output ( $t_{PHL}$ ) vs. Temperature**



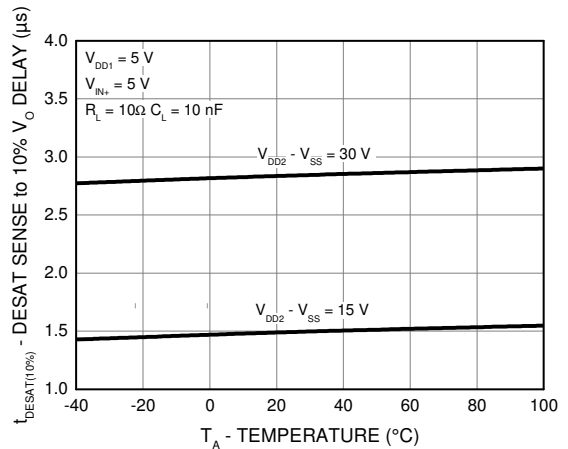
**Figure 21. Propagation Delay ( $t_P$ ) vs. Load Capacitance ( $C_L$ )**



**Figure 22. Propagation Delay ( $t_P$ ) vs. Load Resistance ( $R_L$ )**

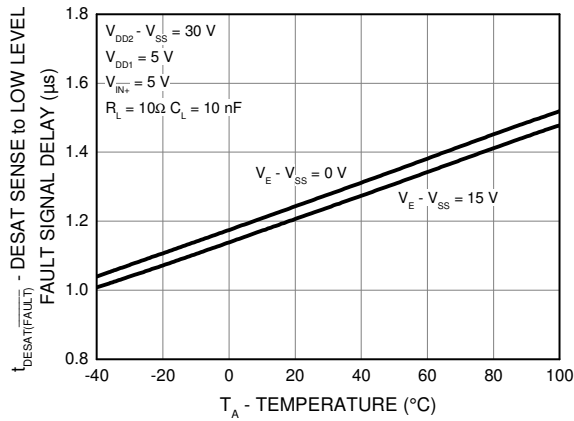


**Figure 23. DESAT Sense to 90%  $V_O$  Delay ( $t_{DESAT(90\%)}$ ) vs. Temperature**

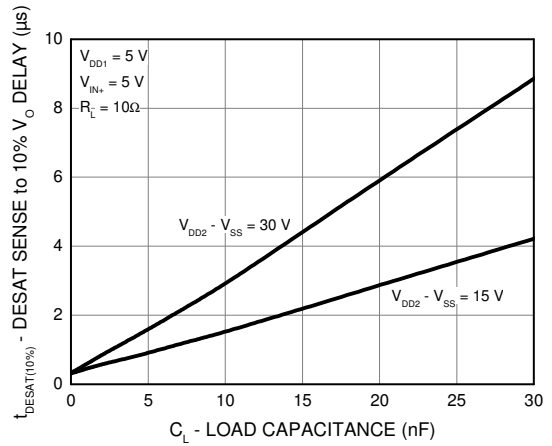


**Figure 24. DESAT Sense to 10%  $V_O$  Delay ( $t_{DESAT(10\%)}$ ) vs. Temperature**

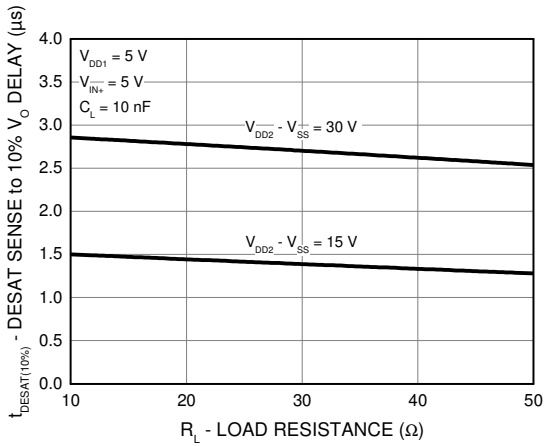
**Typical Performance Characteristics (Continued)**



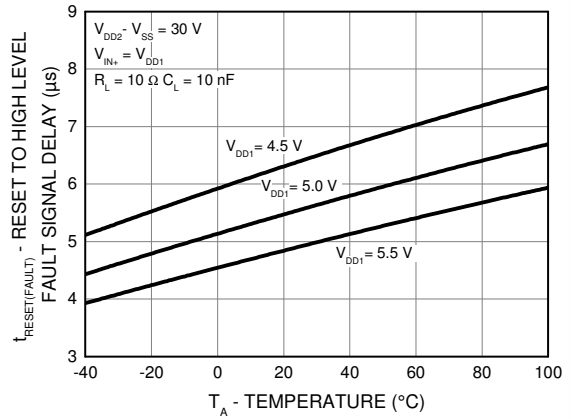
**Figure 25. DESAT Sense to Low Level FAULT Signal Delay ( $t_{\text{DESAT(FAULT)}}$ ) vs. Temperature**



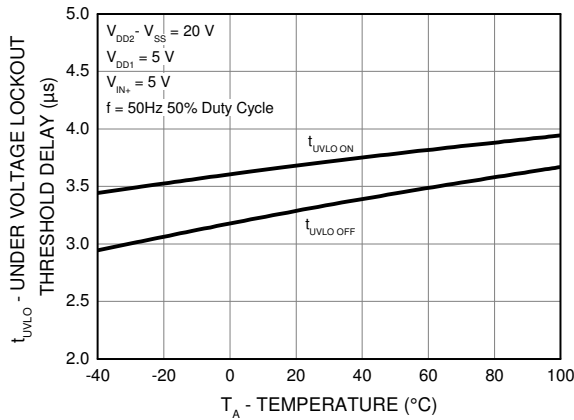
**Figure 26. DESAT Sense to 10%  $V_O$  Delay ( $t_{\text{DESAT(10%)}}$ ) vs. Load Capacitance ( $C_L$ )**



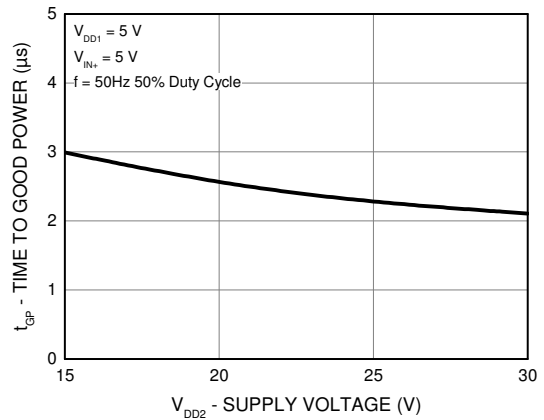
**Figure 27. DESAT Sense to 10%  $V_O$  Delay ( $t_{\text{DESAT(10%)}}$ ) vs. Load Resistance ( $R_L$ )**



**Figure 28. RESET to High Level FAULT Signal Delay ( $t_{\text{RESET(FAULT)}}$ ) vs. Temperature**

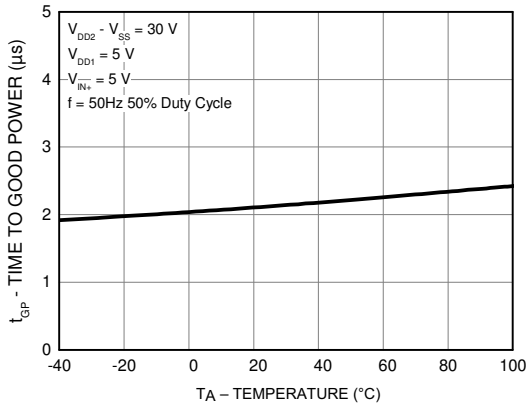


**Figure 29. Under Voltage Lockout Threshold Delay ( $t_{\text{UVLO}}$ ) vs. Temperature**

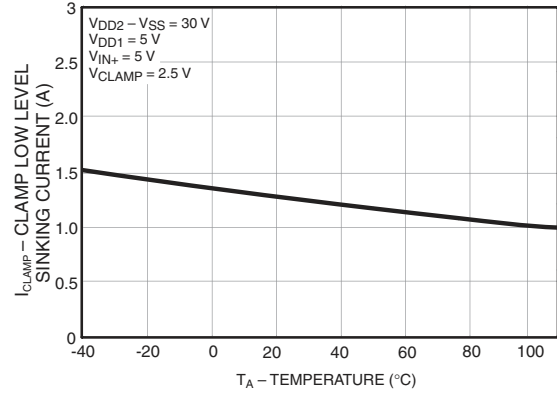


**Figure 30. Time to Good Power ( $T_{\text{GP}}$ ) vs. Supply Voltage ( $V_{\text{DD2}}$ )**

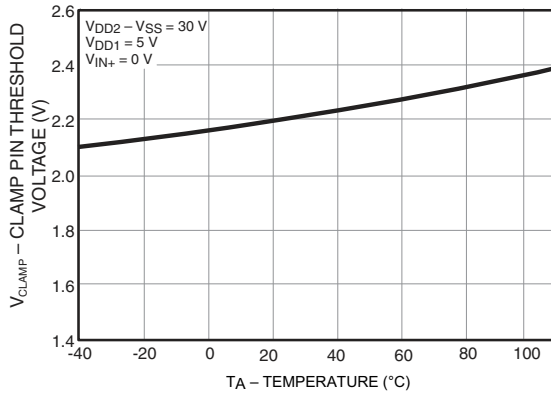
**Typical Performance Characteristics (Continued)**



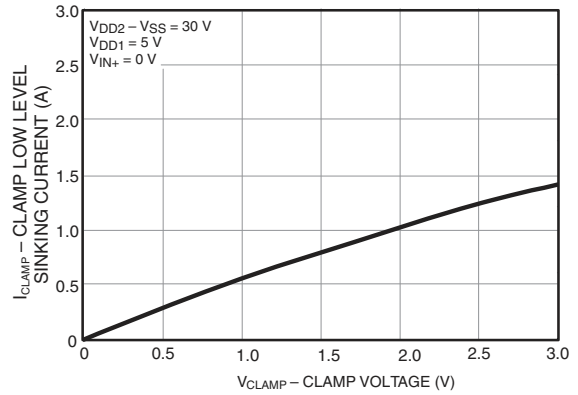
**Figure 31. Time to Good Power (t<sub>GP</sub>) vs. Temperature**



**Figure 32. Clamp Low Level Sinking Current (I<sub>CLAMP</sub>) vs. Temperature**



**Figure 33. Clamping Threshold Voltage (V<sub>CLAMP</sub>) vs. Temperature**



**Figure 34. Clamp Low Level Sinking Current (I<sub>CLAMP</sub>) vs. Clamp Voltage (V<sub>CLAMP</sub>)**



### Test Circuits

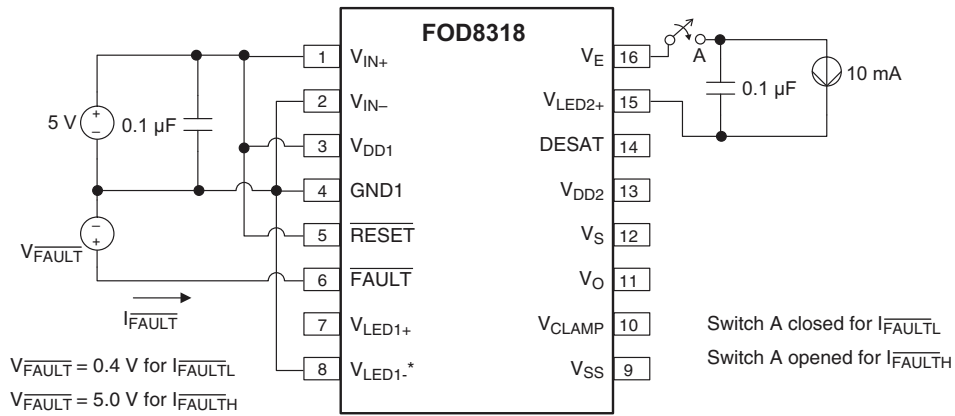


Figure 35. Fault Output Current ( $I_{\overline{FAULTL}}$ ) and ( $I_{\overline{FAULTH}}$ ) Test Circuit

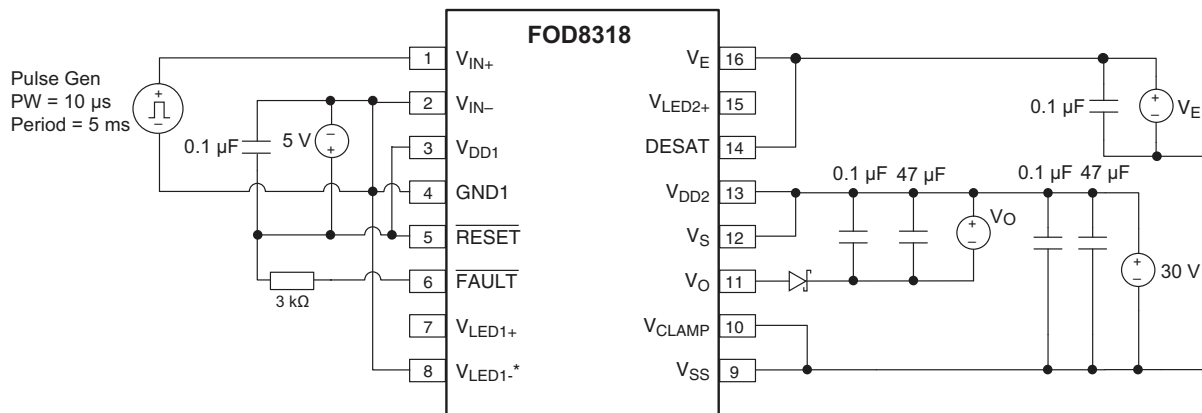


Figure 36. High Level Output Current ( $I_{OH}$ ) Test Circuit

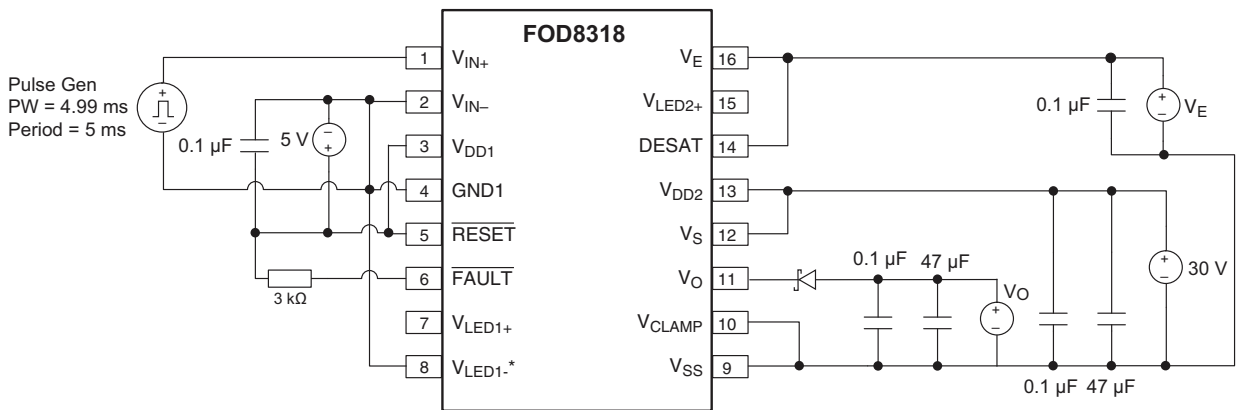
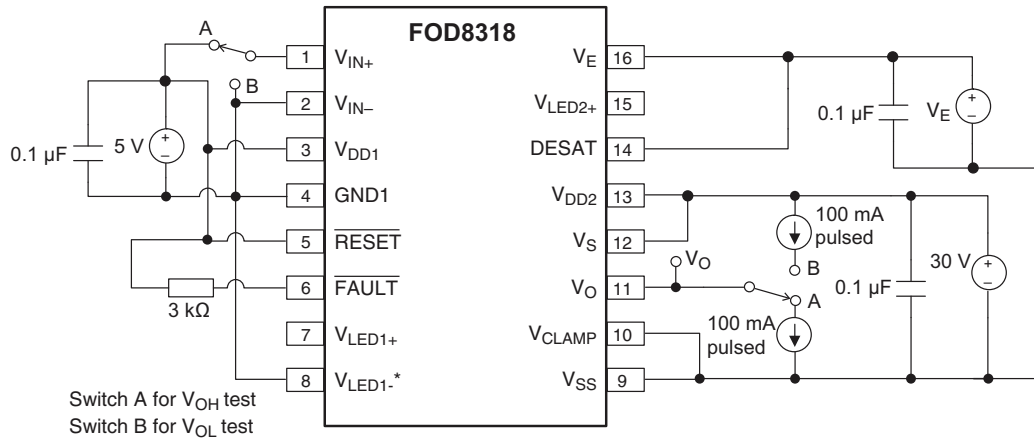
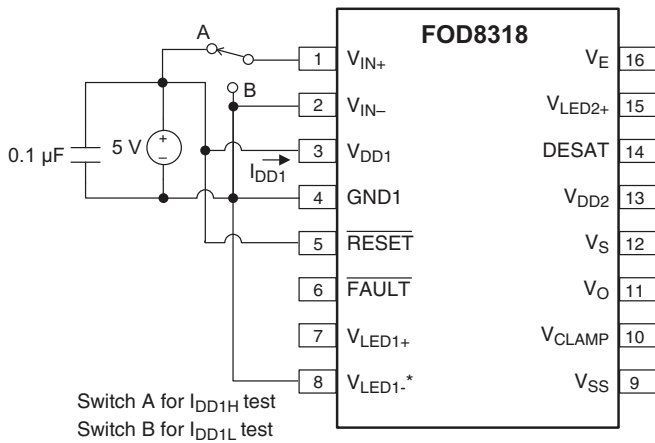


Figure 37. Low Level Output Current ( $I_{OL}$ ) Test Circuit

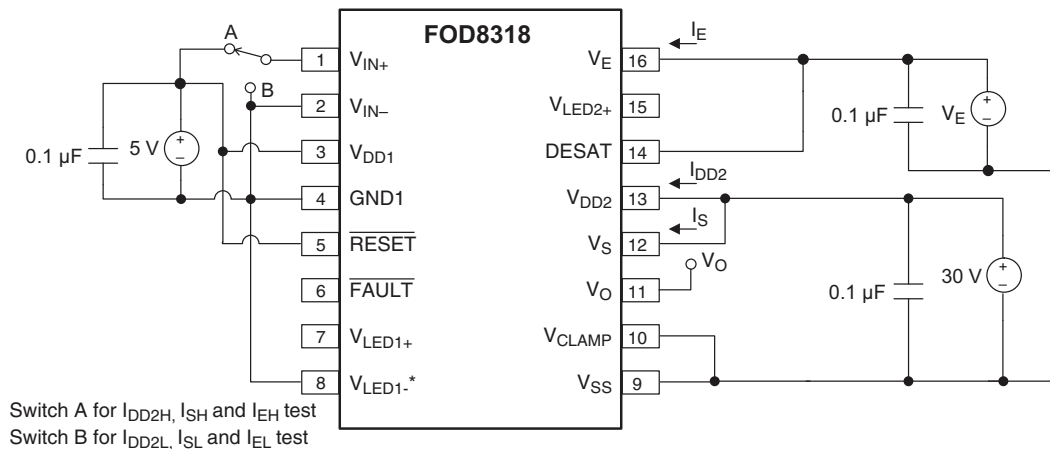
**Test Circuits** (Continued)



**Figure 38. High Level ( $V_{OH}$ ) and Low Level ( $V_{OL}$ ) Output Voltage Test Circuit**

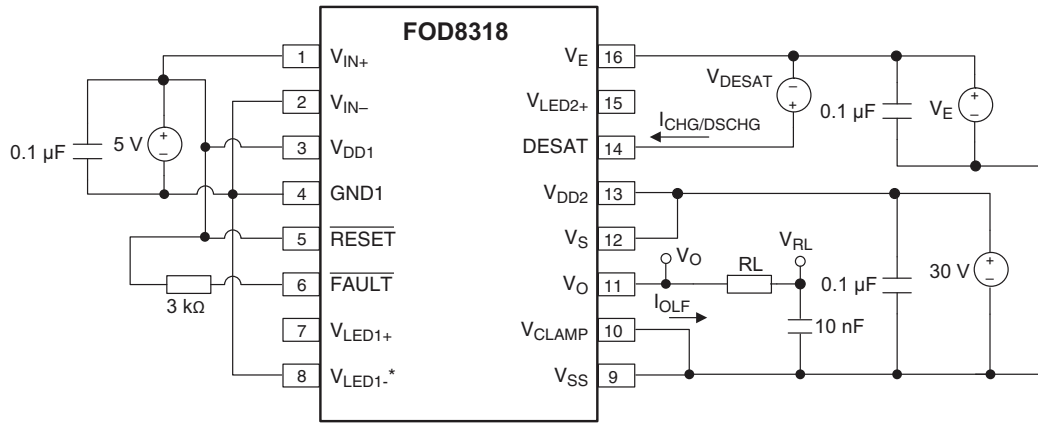


**Figure 39. High Level ( $I_{DD1H}$ ) and Low Level ( $I_{DD1L}$ ) Supply Current Test Circuit**

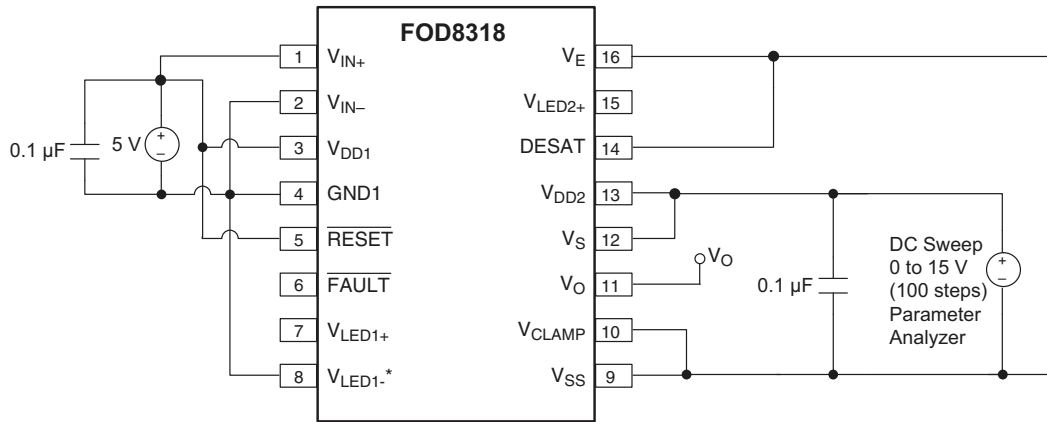


**Figure 40. High Level ( $I_{DD2H}$ ), Low Level ( $I_{DD2L}$ ) Output Supply Current, High Level ( $I_{SH}$ ), Low Level ( $I_{SL}$ ) Source Current,  $V_E$  High Level ( $I_{EH}$ ), and  $V_E$  Low Level ( $I_{EL}$ ) Supply Current Test Circuit**

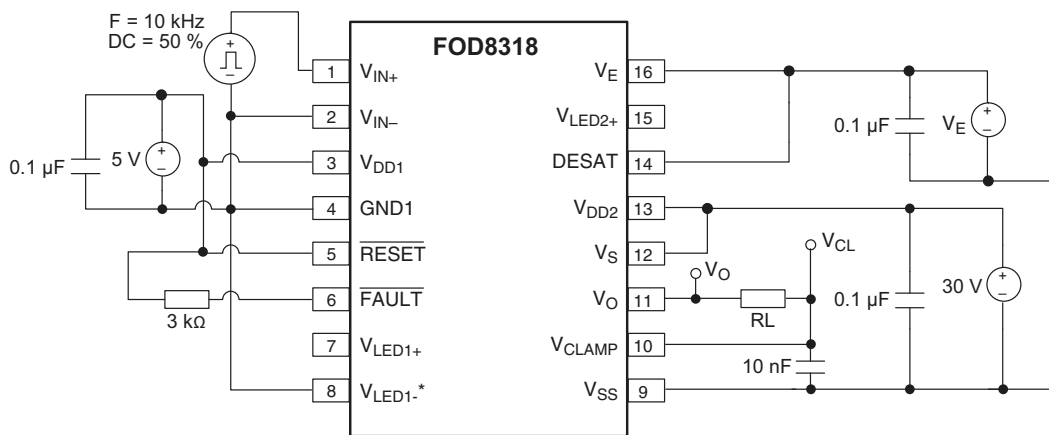
**Test Circuits** (Continued)



**Figure 41. Low Level Output Current During Fault Conditions ( $I_{OLF}$ ), Blanking Capacitor Charge Current ( $I_{CHG}$ ), Blanking Capacitor Discharging Current ( $I_{DSCHG}$ ), and DESAT Threshold ( $V_{DESAT}$ ) Test Circuit**

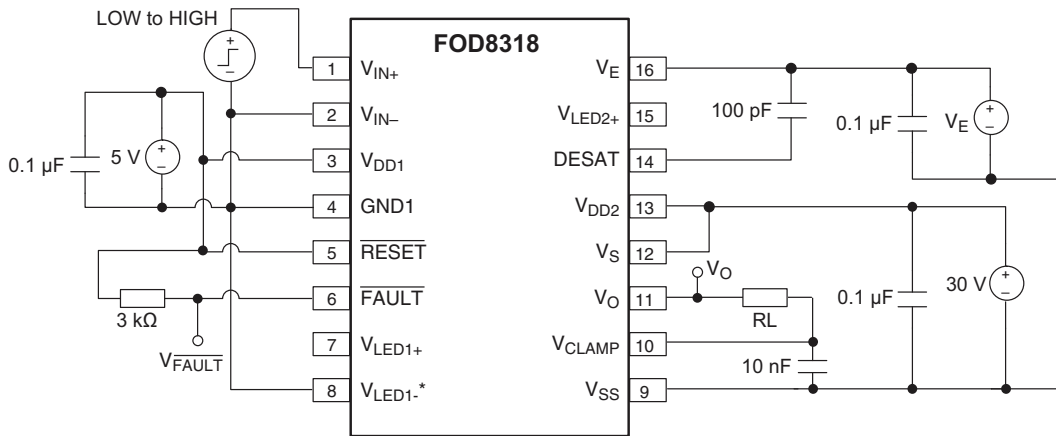


**Figure 42. Under-Voltage Lockout Threshold ( $V_{UVLO}$ ) Test Circuit**

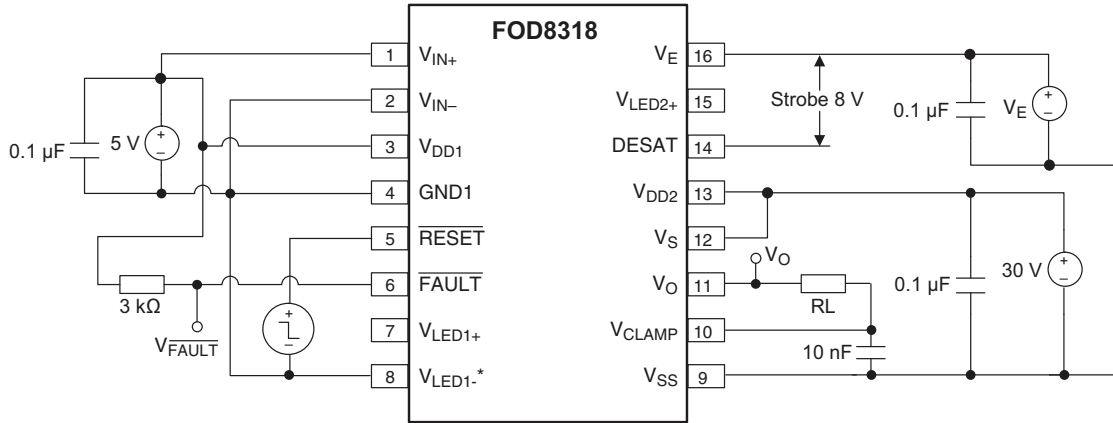


**Figure 43. Propagation Delay ( $t_{PLH}$ ,  $t_{PHL}$ ), Pulse Width Distortion (PWD), Rise Time ( $t_r$ ), and Fall Time ( $t_f$ ) Test Circuit**

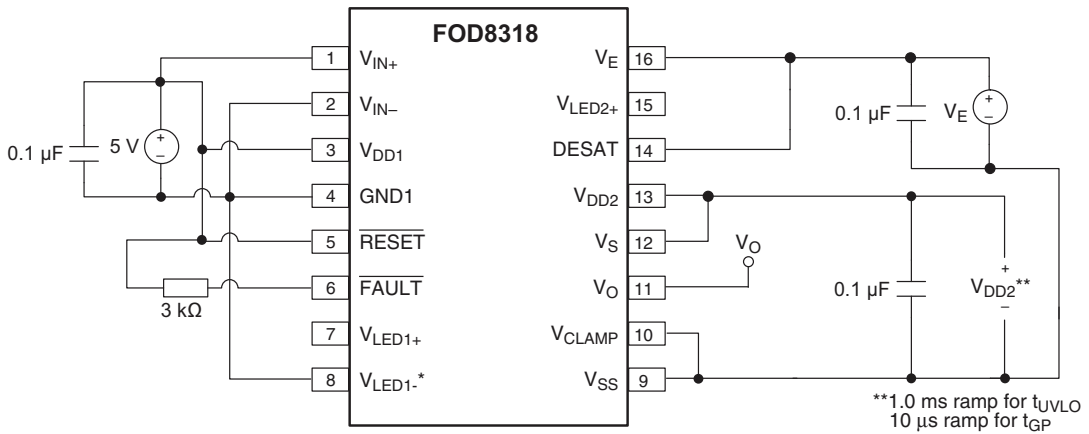
**Test Circuits** (Continued)



**Figure 44.** DESAT Sense ( $t_{DESAT(90\%)}$ ,  $t_{DESAT(10\%)}$ ), DESAT Fault ( $t_{DESAT(\overline{FAULT})}$ ), and ( $t_{DESAT(LOW)}$ ) Test Circuit

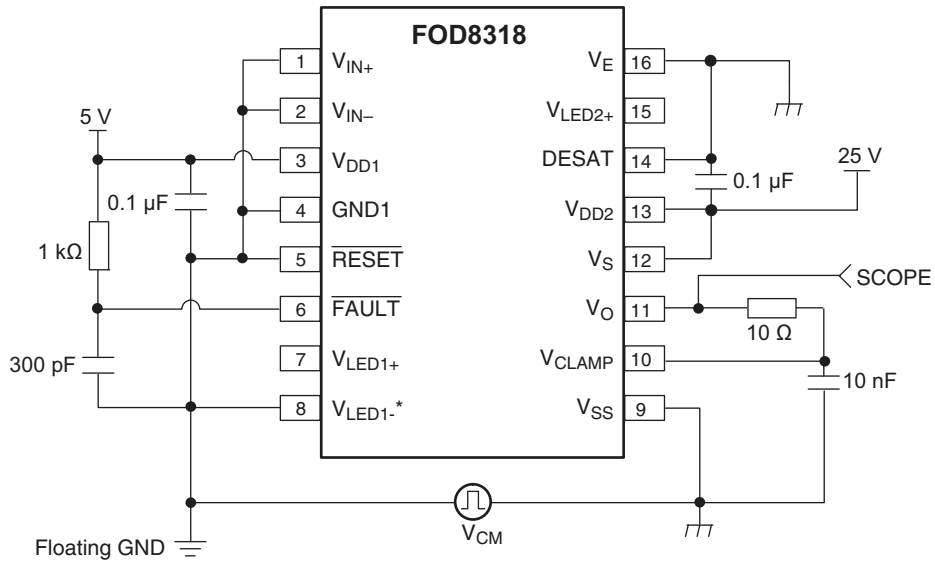


**Figure 45.** Reset Delay ( $t_{RESET(\overline{FAULT})}$ ) Test Circuit

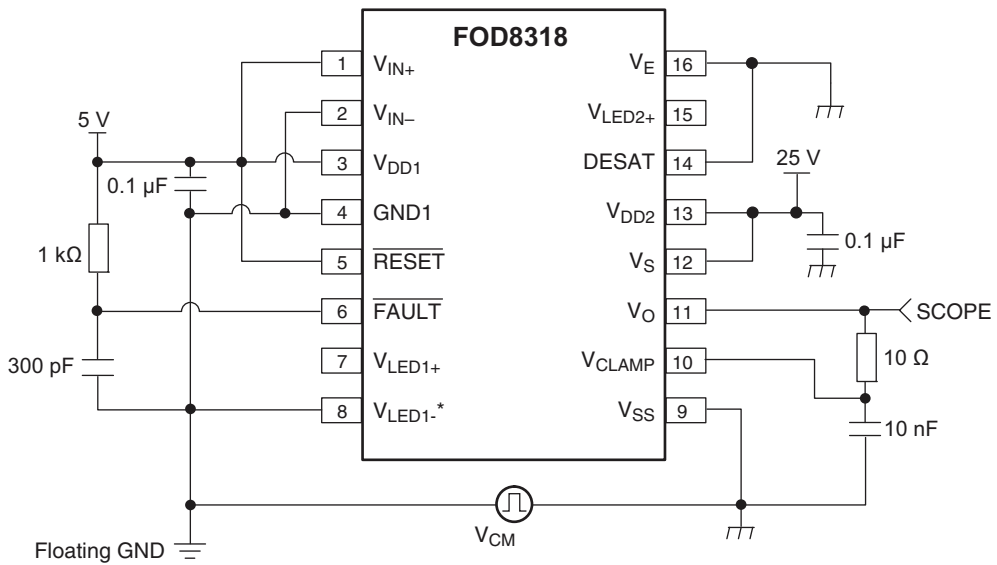


**Figure 46.** Under-Voltage Lockout Delay ( $t_{UVLO}$ ) and Time to Good Power ( $t_{GP}$ ) Test Circuit

**Test Circuits** (Continued)

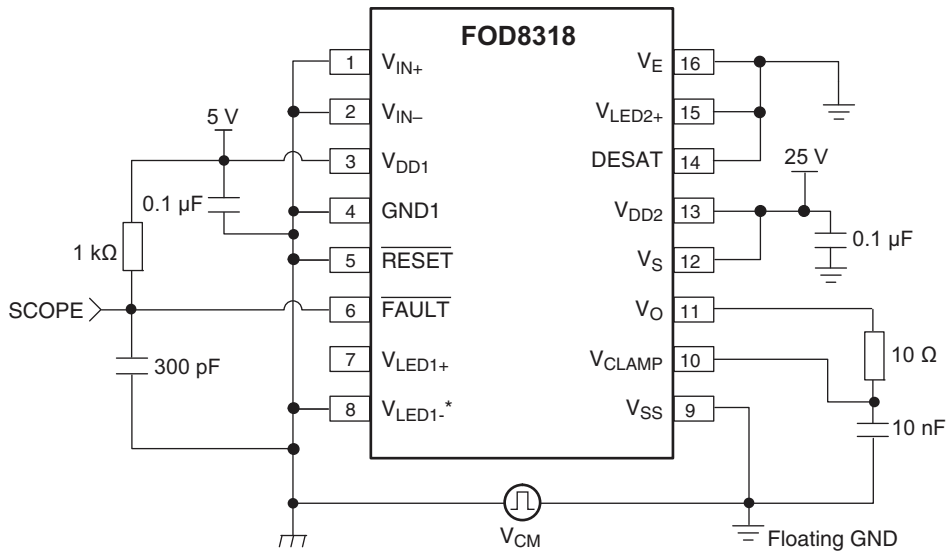


**Figure 47. Common Mode Low (CM<sub>L</sub>) Test Circuit at LED1 Off**

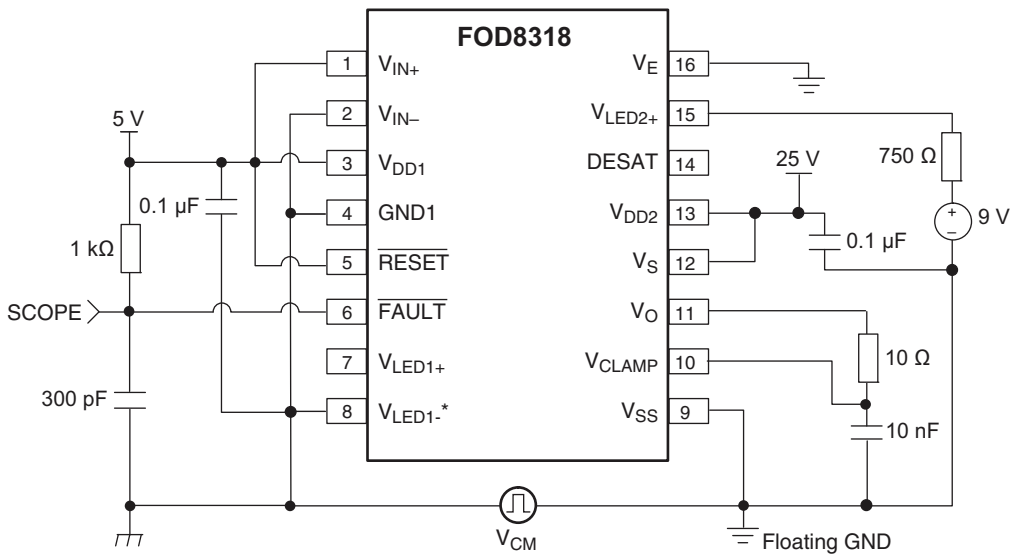


**Figure 48. Common Mode High (CM<sub>H</sub>) Test Circuit at LED1 On**

**Test Circuits** (Continued)

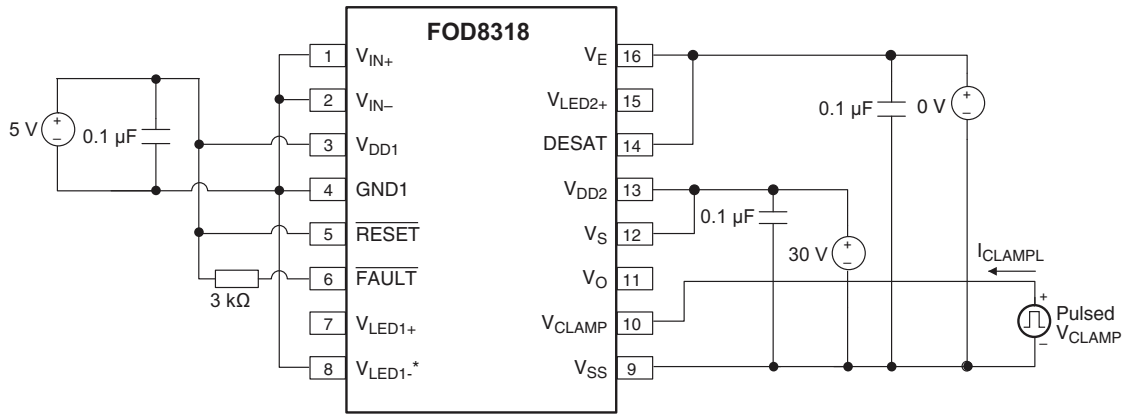


**Figure 49. Common Mode High (CM<sub>H</sub>) Test Circuit at LED2 Off**

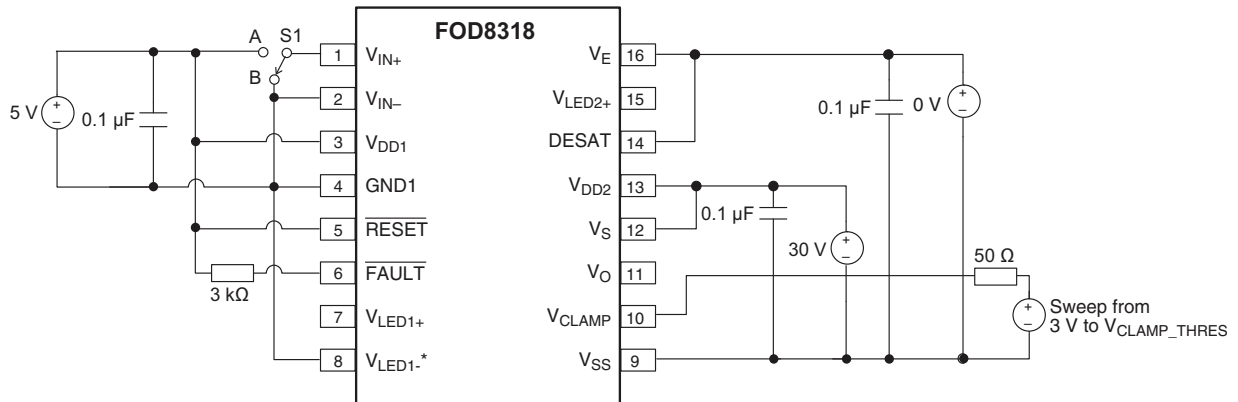


**Figure 50. Common Mode Low (CM<sub>L</sub>) Test Circuit at LED2 On**

**Test Circuits** (Continued)



**Figure 51. Clamp Low Level Sinking Current ( $I_{CLAMP}$ )**



Initially set S1 to A before connecting 3 V to clamp pin. Then switch to B before sweeping down to get the  $V_{CLAMP\_THRES}$ , clamping threshold voltage.

**Figure 52. Clamp Pin Threshold Voltage ( $V_{CLAMP}$ )**

### Timing Diagrams

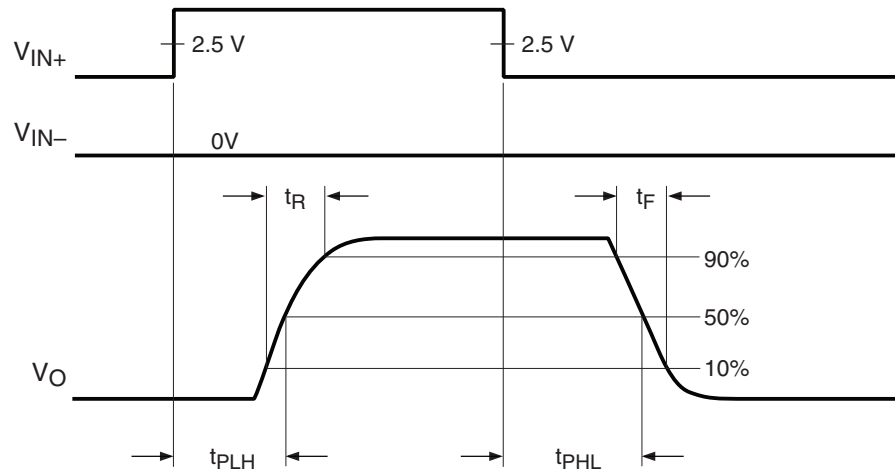


Figure 53. Propagation Delay ( $t_{PLH}$ ,  $t_{PHL}$ ), Rise Time ( $t_R$ ), and Fall Time ( $t_F$ ) Timing Diagram

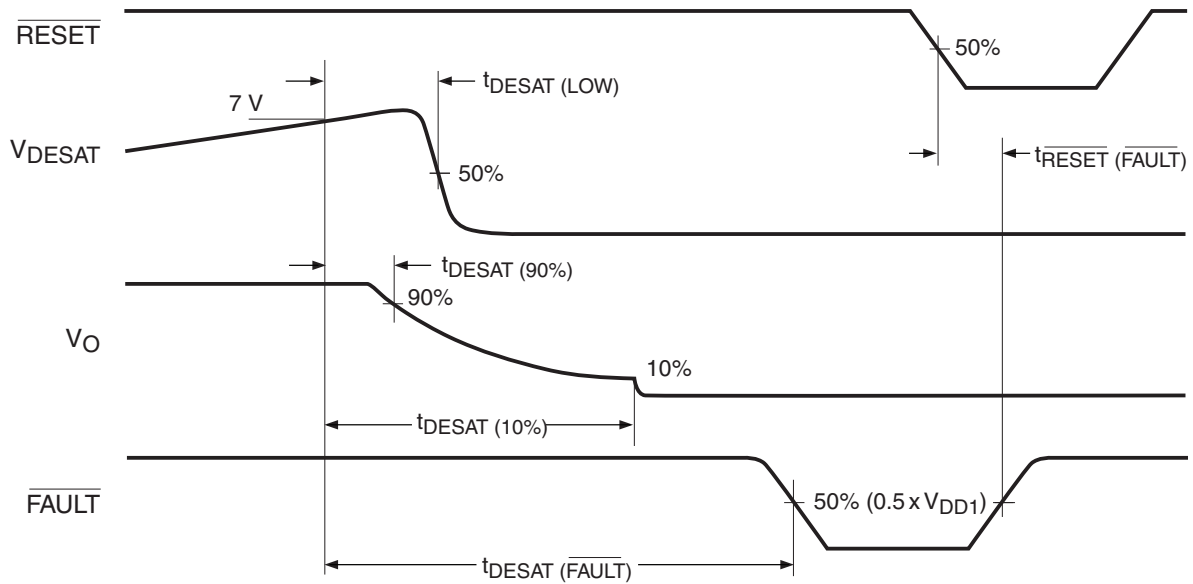


Figure 54. Definitions for Fault Reset Input ( $\overline{RESET}$ ), Desaturation Voltage Input (DESAT), Output Voltage ( $V_O$ ), and Fault Output ( $\overline{FAULT}$ ) Timing Waveforms



## Application Information

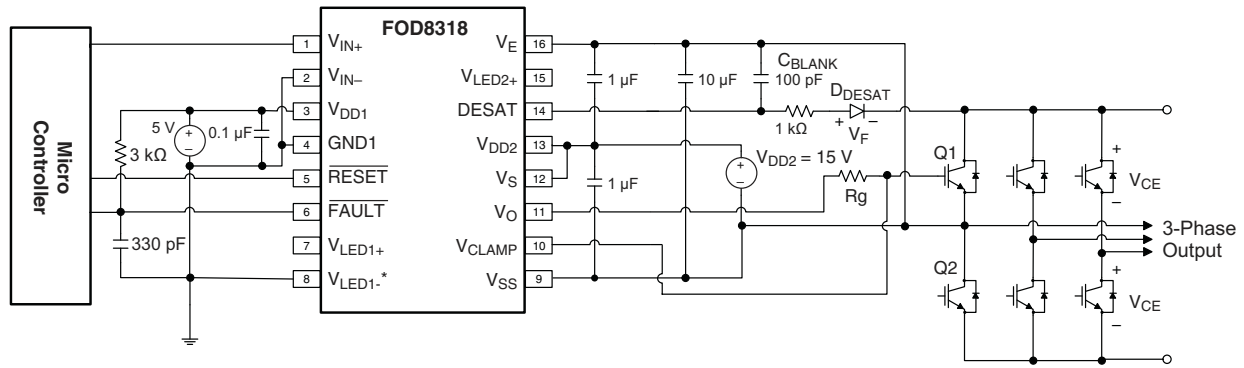


Figure 55. Recommended Application Circuit

### Functional Description

The functional behavioral of FOD8318 is illustrated by the detailed internal schematic shown in Figure 56. This explains the interaction and sequence of internal and external signals, together with the timing diagrams.

#### 1. Non-Inverting and Inverting Inputs

There are two CMOS/TTL-compatible inputs,  $V_{IN+}$  and  $V_{IN-}$ , to control the IGBT in non-inverting and inverting configurations, respectively. When  $V_{IN-}$  is set to LOW state,  $V_{IN+}$  controls the driver output,  $V_O$ , in non-inverting configuration. When  $V_{IN+}$  is set to HIGH state,  $V_{IN-}$  controls the driver output in inverting configuration.

The relationship between the inputs and output are illustrated in the Figure 57.

During normal operation, when no fault is detected, the  $\overline{\text{FAULT}}$  output, which is an open-drain configuration, is latched to HIGH state. This allows the gate driver to be controlled by the input logic signal.

When a fault is detected, the  $\overline{\text{FAULT}}$  output is latched to LOW state. This condition remains until the input logic is pulled to LOW and the  $\overline{\text{RESET}}$  pin is also pulled LOW for a period longer than  $PW_{\overline{\text{RESET}}}$ .

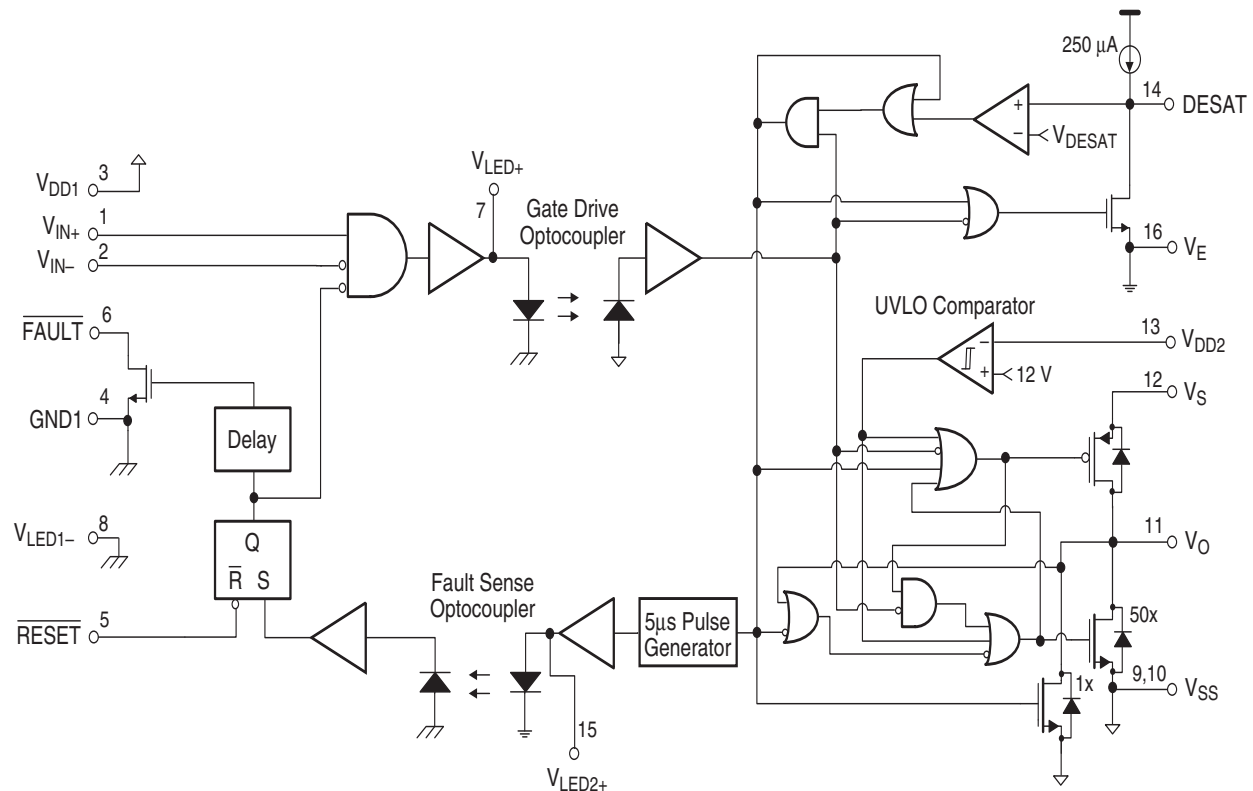


Figure 56. Detailed Internal Schematic

## 2. Gate Driver Output

A pair of PMOS and NMOS comprise the output driver stage, which facilitates close to rail-to-rail output swing. This feature allows a tight control of gate voltage during on-state and short-circuit condition. The output driver is typically to sink 2 A and source 2 A at room temperature. Due to the low  $R_{DS(ON)}$  of the MOSFETs, the power dissipation is reduced as compared to those bipolar-type driver output stages. The absolute maximum rating of the output peak current,  $I_{O(PEAK)}$ , is 3 A; therefore the careful selection of the gate resistor,  $R_g$ , is required to limit the short-circuit current of the IGBT.

As shown in Figure 56, gate driver output is influenced by signals from the photodetector circuitry, the UVLO comparator, and the DESAT signals. Under no-fault condition, normal operation resumes while the supply voltage is above the UVLO threshold, the output of the photodetector drives the MOSFETs of the output stage.

The logic circuitry of the output stage ensures that the push-pull devices are never “ON” simultaneously. When the output of the photodetector is HIGH, the output,  $V_O$ , is pulled to HIGH state by turning on the PMOS. When the output of the photodetector is LOW,  $V_O$  is pulled to LOW state by turning on the NMOS.

When  $V_{DD2}$  supply goes below  $V_{UVLO}$ , which is the designated UVLO threshold at the comparator,  $V_O$  is pulled down to LOW state regardless of photodetector output.

When desaturation is detected,  $V_O$  turns off slowly as it is pulled LOW by the 1XNMOS device. The input to the fault sense circuitry is latched to HIGH state and turns on the LED. When  $V_O$  goes below 2 V, the 50XNMOS device turns on again, clamping the IGBT gate firmly to  $V_{SS}$ . The Fault Sense signal remains latched in the HIGH state until the LED of the gate driver circuitry turns off.

## 3. Desaturation Protection, FAULT Output

Desaturation detection protection ensures the protection of the IGBT at short-circuit by monitoring the collector-emitter voltage of the IGBT in the half bridge. When the DESAT voltage goes up and reaches above the threshold voltage, a short-circuit condition is detected and the driver output stage executes a “soft” IGBT turn-off and is eventually driven LOW, as illustrated in Figure 58. The FAULT open-drain output is triggered active LOW to report a desaturation error. It is only cleared by activating active LOW by the external controller to the  $\overline{RESET}$  input with the input logic is pulled to LOW.

The DESAT fault detector should be disabled for a short period (blanking time) before the IGBT turns on to allow the collector voltage to fall below DESAT threshold. This blanking period protects against false trigger of the DESAT while the IGBT is turning on.

The blanking time is controlled by the internal DESAT charge current, the DESAT voltage threshold, and the external DESAT capacitor (capacitor between DESAT and  $V_E$  pin). The nominal blanking time can be calcu-

lated using external capacitance ( $C_{BLANK}$ ), FAULT threshold voltage ( $V_{DESAT}$ ), and DESAT charge current ( $I_{CHG}$ ) as:

$$t_{BLANK} = C_{BLANK} \times V_{DESAT} / I_{CHG}$$

With a recommended 100 pF DESAT capacitor, the nominal blanking time is:

$$100 \text{ pF} \times 7 \text{ V} / 250 \text{ } \mu\text{A} = 2.8 \text{ } \mu\text{s}$$

## 4. “Soft” Turn-Off

The soft turn-off feature ensures the safe turn off of the IGBT under fault conditions. This reduces the voltage spike on the collector of the IGBT. Without this, the IGBT would see a heavy spike on the collector and result in permanent damage to the device.

## 5. Under-Voltage Lockout

Under-voltage detection prevents the application of insufficient gate voltage to the IGBT. This could be dangerous, as it would drive the IGBT out of saturation and into the linear operation where the losses are very high and quickly overheated. This feature ensures the proper operating of the IGBTs. The output voltage,  $V_O$ , remains LOW regardless of the inputs as long as the supply voltage,  $V_{DD2} - V_E$ , is less than  $V_{UVLO+}$ . When the supply voltage falls below  $V_{UVLO-}$ ,  $V_O$  goes LOW, as illustrated in Figure 59.

## 6. Active Miller Clamp Function

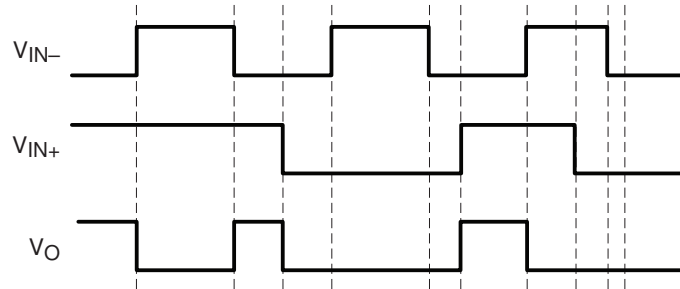
An active Miller clamp feature allows the sinking of the Miller current to the ground or emitter of the IGBT during a high-dV/dt situation. Instead of driving the IGBT gate to a negative supply voltage to increase the safety margin, the device has a dedicated  $V_{CLAMP}$  pin to control the Miller current. During turn-off, the gate voltage of the IGBT is monitored and the  $V_{CLAMP}$  output is activated when the gate voltage goes below 2 V (relative to  $V_{SS}$ ). The Miller clamp NMOS transistor is then turned on and provides a low resistive path for the Miller current. This helps prevent a self-turn-on due to the parasitic Miller capacitor in power switches. The clamp voltage is  $V_{OL} + 2.5 \text{ V}$  maximum for a Miller current up to 1200 mA. In this way, the  $V_{CLAMP}$  function does not affect the turn-off characteristic. It helps to clamp the gate to the LOW level throughout the turn-off time. During turn-on, where the input of the driver is activated, the  $V_{CLAMP}$  function is disabled or opened.

## 7. Time to Good Power

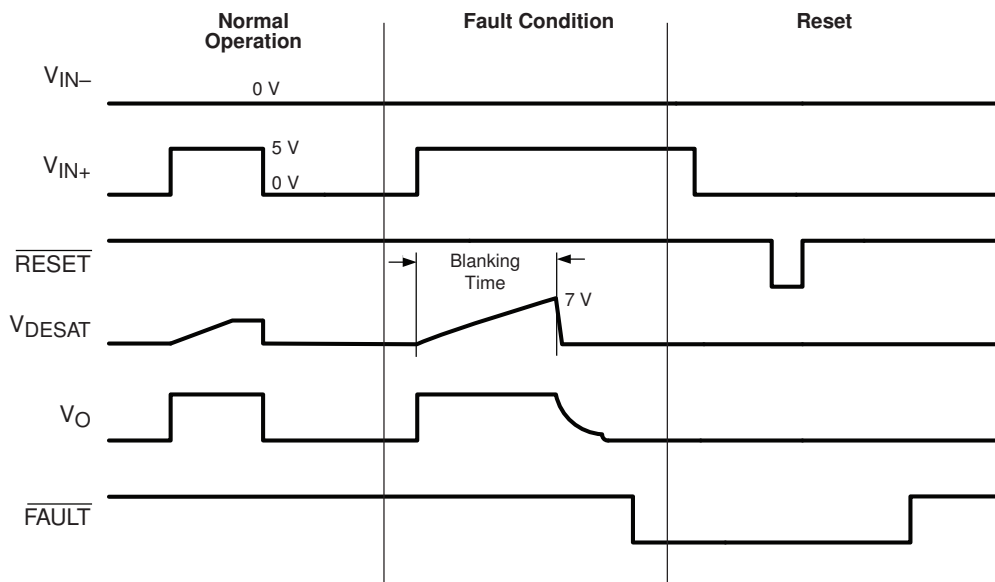
At initial power up, the LED is off and the output of the gate driver should be in the LOW state. Sometimes race conditions exist that causes the output to follow the  $V_E$  (assuming  $V_{DD2}$  and  $V_E$  are connected externally), until all of the circuits in the output IC have stabilized. This condition can result in output transitions or transients that are coupled to the driven IGBT. These glitches can cause the high-side and low-side IGBTs to conduct shoot-through current that may result in destructive damage to the power semiconductor devices. ON has introduced a initial turn-on delay, generally called “time-

to-good power". This delay, typically 2.5  $\mu$ s, is only present during the initial power-up of the device. Once powered, the "time-to-good power" delay is determined by the delay of the UVLO circuitry. If the LED is "ON" during

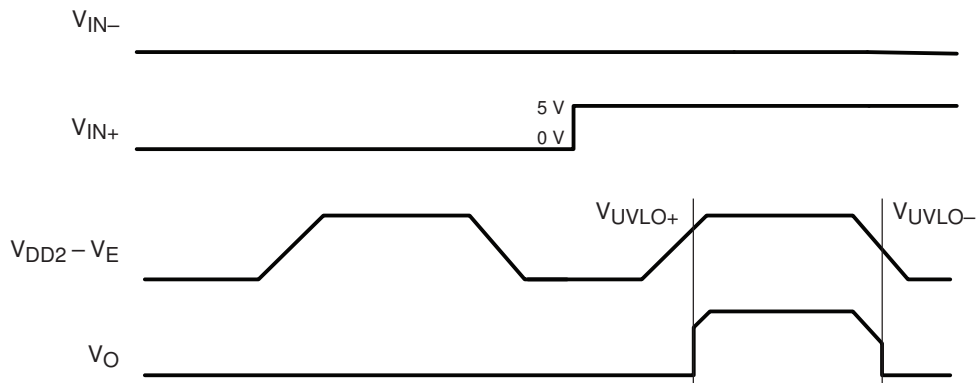
the initial turn-on activation, LOW-to-HIGH transition at the output of the gate driver only occurs 2.5  $\mu$ s after the  $V_{DD2}$  power is applied.



**Figure 57. Input/Output Relationship**




**Figure 58. Timing Relationship Among DESAT, FAULT, and RESET**



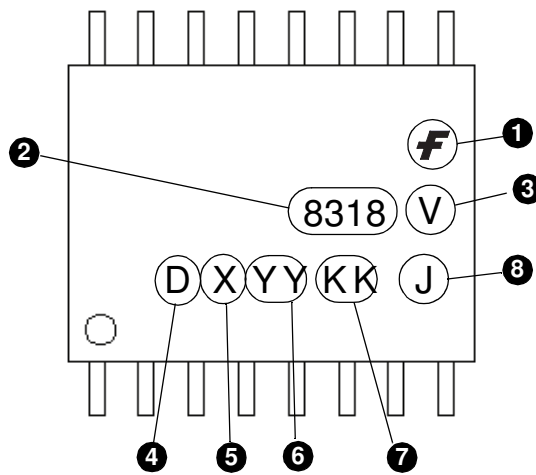
**Figure 59. UVLO for Output Side**

## Ordering Information

Part Number	Package	Packing Method
FOD8318	SO 16-Pin	Tube (50 units per tube)
FOD8318R2	SO 16-Pin	Tape and Reel (750 units per reel)
FOD8318V	SO 16-Pin, DIN EN/IEC 60747-5-5 Option	Tube (50 units per tube)
FOD8318R2V	SO 16-Pin, DIN EN/IEC 60747-5-5 Option	Tape and Reel (750 units per reel)

 All packages are lead free per JEDEC: J-STD-020B standard.

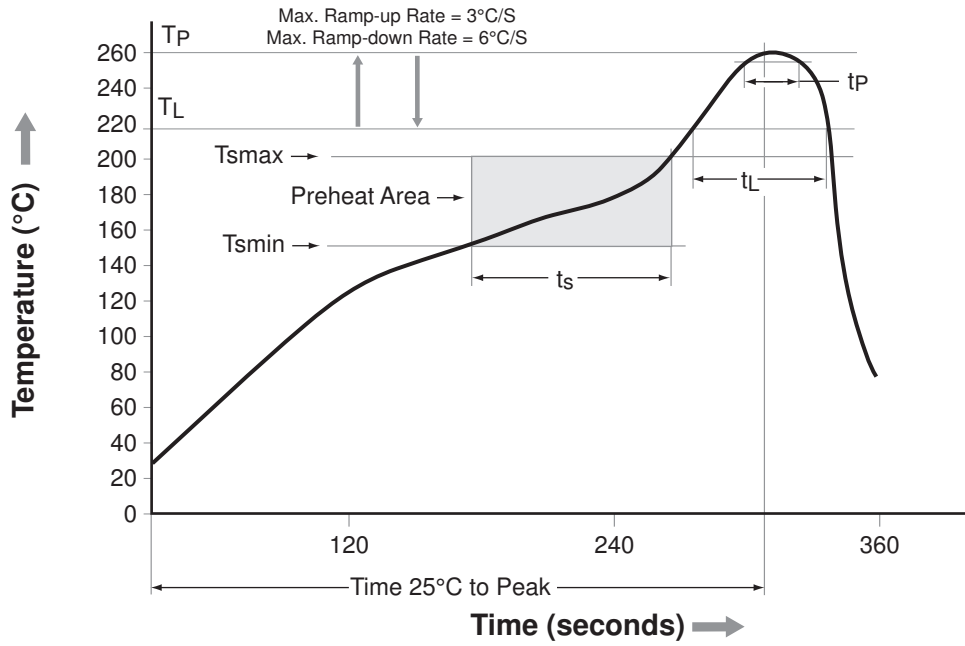
## Marking Information



### Definitions

1	Company logo
2	Device number, e.g., '8318' for FOD8318
3	DIN EN/IEC60747-5-5 option (only appears on component ordered with this option)
4	Plant code, e.g., 'D'
5	Last-digit year code, e.g., 'B' for 2011
6	Two-digit work week ranging from '01' to '53'
7	Lot traceability code
8	Package assembly code, J

## Reflow Profile



Profile Feature	Pb-Free Assembly Profile
Temperature Minimum ( $T_{smin}$ )	150 °C
Temperature Maximum ( $T_{smax}$ )	200 °C
Time ( $t_s$ ) from ( $T_{smin}$ to $T_{smax}$ )	60–120 seconds
Ramp-up Rate ( $t_L$ to $t_P$ )	3 °C/second max.
Liquidous Temperature ( $T_L$ )	217 °C
Time ( $t_L$ ) Maintained Above ( $T_L$ )	60–150 seconds
Peak Body Package Temperature	260 °C +0 °C / –5 °C
Time ( $t_P$ ) within 5 °C of 260 °C	30 seconds
Ramp-down Rate ( $T_P$ to $T_L$ )	6 °C/second max.
Time 25 °C to Peak Temperature	8 minutes max.



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