

## Advanced IGBT/MOSFET Driver

- 0.75A source/1.2A sink min gate drive
- Active Miller clamp feature
- Two steps turn-off with adjustable level and delay
- Desaturation detection
- Fault status output
- Negative gate drive ability
- Input compatible with pulse transformer or optocoupler
- Separate sink and source outputs for easy gate drive
- UVLO protection
- 2kV ESD protection

### Description

TD350 is an advanced gate driver for IGBT and power MOSFET. Control and protection functions are included and allow the design of high reliability systems.

Innovative active Miller clamp function avoids the need of negative gate drive in most applications and allows the use of a simple bootstrap supply for the high side driver

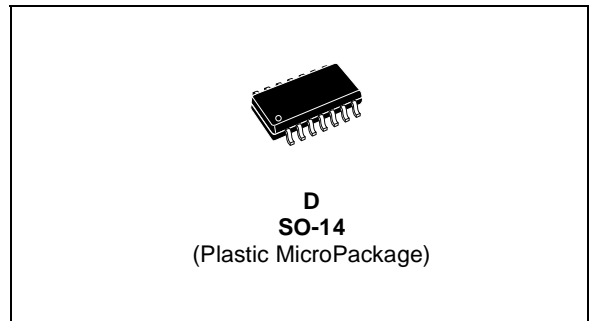
TD350 includes a two-level turn-off feature with adjustable level and delay. This function protects against excessive overvoltage at turn-off in case of overcurrent or short-circuit condition. Same delay is applied at turn-on to prevent pulse width distortion.

TD350 also includes an IGBT desaturation protection and a FAULT status output.

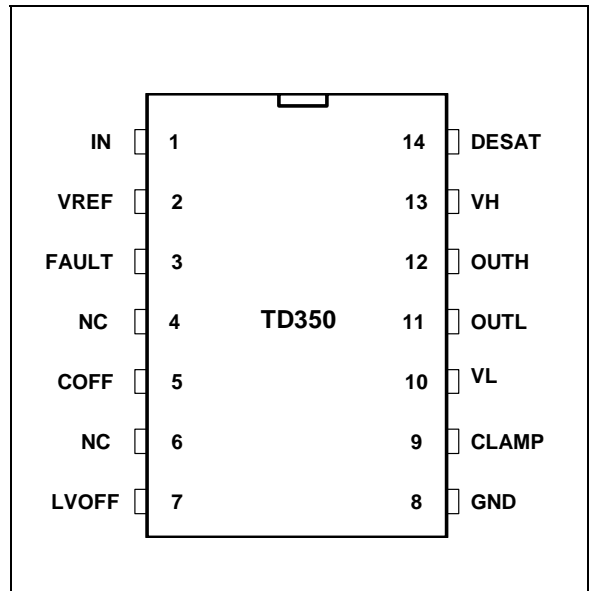
TD350 is compatible with both pulse transformer and optocoupler signals.

### Applications

- 1200V 3-Phase Inverter
- Motor Control
- UPS Systems



### Pin Connections (top view)



### Order Codes

Part Number	Temperature Range	Package	Packaging
TD350ID	-40, +125°C	SO	Tube
TD350IDT			Tape & Reel

## 1 Block Diagram

Figure 1: Schematic block diagram

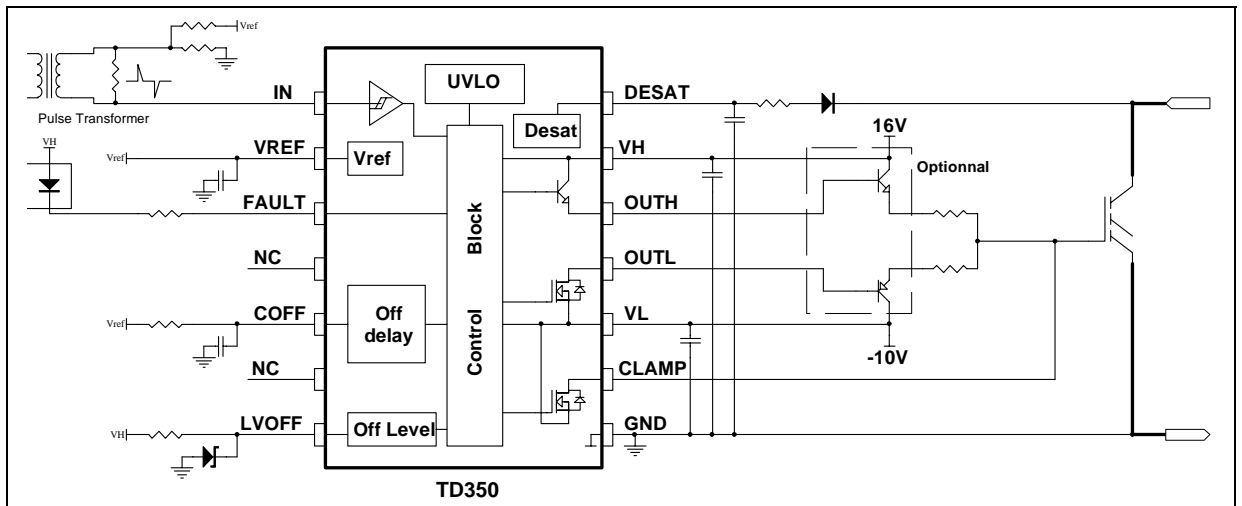


Table 1: Pin description

Name	Pin Number	Type	Function
IN	1	Analog input	Input
VREF	2	Analog output	+5V reference voltage
FAULT	3	Digital output	Fault status output
NC	4	Not connected	
COFF	5	Timing capacitor	Turn off delay
NC	6	Not connected	
LVOFF	7	Analog input	Turn off level
GND	8	Power supply	Signal ground
CLAMP	9	Analog output	Miller clamp
VL	10	Power supply	Negative supply
OUTL	11	Analog output	Gate drive output (sink)
OUTH	12	Analog output	Gate drive output (source)
VH	13	Power supply	Positive supply
DESAT	14	Analog input	Desaturation protection

## 2 Absolute Maximum Ratings

**Table 2: Key parameters and their absolute maximum ratings**

Symbol	Parameter	Value	Unit
VHL	Maximum Supply Voltage (VH - VL)	28	V
VH	Maximum VH voltage vs. GND	28	V
VL	Minimum VL voltage vs. GND	-12	V
Vout	Voltage on OUTH, OUTL, CLAMP pins	VL-0.3 to VH+0.3	V
Vdes	Voltage on DESAT, FAULT, LVOFF pin	-0.3 to VH+0.3	V
Vter	Voltage on other pins (IN, COFF, VREF)	-0.3 to 7	V
Pd	Power dissipation	500	mW
Tstg	Storage temperature	-55 to 150	°C
Tj	Maximum Junction Temperature	150	°C
Rhja	Thermal Resistance Junction-Ambient	125	°C/W
Rhjc	Thermal Resistance Junction-Case	22	°C/W
ESD	Electrostatic discharge	2	kV

**Table 3: Operating conditions**

Symbol	Parameter	Value	Unit
VH	Positive Supply Voltage vs. GND	UVLO to 26	V
VL	Negative Supply Voltage vs. GND	0 to -10	V
VH-VL	Maximum Total Supply Voltage	26	V
Toper	Operating Free Air Temperature Range	-40 to 125	°C

### 3 Electrical Characteristics

Table 4:  $T_{amb} = -20$  to  $125^{\circ}\text{C}$ ,  $V_H=16\text{V}$ ,  $V_L=-10\text{V}$  (unless otherwise specified)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
<b>Input</b>						
Vton	IN turn-on threshold voltage		0.8	1.0		V
Vtoff	IN turn-off threshold voltage			4.0	4.2	V
tonmin	Minimum pulse width		100	135	220	ns
Iinp	IN Input current				1	$\mu\text{A}$
<b>Voltage reference - note <sup>1</sup></b>						
Vref	Voltage reference	$T=25^{\circ}\text{C}$ $T_{min}<T<T_{max}$	4.85 4.77	5.00	5.15 5.22	V V
Iref	Maximum output current		10			mA
<b>Desaturation protection</b>						
Vdes	Desaturation threshold		6.5	7.2	7.9	V
I des	Source current			250		$\mu\text{A}$
<b>Fault output</b>						
tfault	Delay for fault detection				500	ns
VFL	FAULT low voltage	I <sub>fsink</sub> =10mA			1	V
<b>Clamp</b>						
Vtclamp	CLAMP pin voltage threshold			2.0		V
VCL	Clamp low voltage at I <sub>csink</sub> =500mA	$T=25^{\circ}\text{C}$ $T_{min}<T<T_{max}$			V <sub>L</sub> +2.5 V <sub>L</sub> +3.0	V V
<b>Off Delay</b>						
Vtdel	Voltage threshold		2.35	2.50	2.65	V
Rdel	Discharge resistor	I=1mA			500	$\Omega$
<b>Off Levels</b>						
I <sub>blvoff</sub>	LVOFF peak input current (sink)	LVOFF=12V		120	200	$\mu\text{A}$
V <sub>iolv</sub>	Offset voltage	LVOFF=12V	-0.3	-0.15	0	V
<b>Outputs</b>						
VOL1	Output low voltage at I <sub>osink</sub> =20mA				V <sub>L</sub> +0.35	V
VOL2	Output low voltage at I <sub>osink</sub> =200mA	$T=25^{\circ}\text{C}$ $T_{min}<T<T_{max}$			V <sub>L</sub> +1.0 V <sub>L</sub> +1.5	V V
VOL3	Output low voltage at I <sub>osink</sub> =500mA	$T=25^{\circ}\text{C}$ $T_{min}<T<T_{max}$			V <sub>L</sub> +2.5 V <sub>L</sub> +3.0	V V
VOH1	Output high voltage 1	I <sub>osource</sub> =20mA	V <sub>H</sub> -2.5			V
VOH2	Output high voltage 2	I <sub>osource</sub> =200mA	V <sub>H</sub> -3.0			V
VOH3	Output high voltage 3	I <sub>osource</sub> =500mA	V <sub>H</sub> -4.0			V
tr	Rise time	C <sub>L</sub> =1nF, 10% to 90% V <sub>L</sub> =0 V <sub>L</sub> =-10V			130 175	ns ns
tf	Fall time (2 step turn-off disabled)	C <sub>L</sub> =1nF, 90% to 10% V <sub>L</sub> =0 V <sub>L</sub> =-10V			75 90	ns ns
tpd	Input to output propagation delay at turn-on (2 step delay disabled)	10% output change	270		800	ns
$\Delta\text{tw}$	Input to output pulse distortion	10% output change	10	60	110	ns
<b>Under Voltage Lockout (UVLO)</b>						
UVLOH	UVLO top threshold		10	11	12	V
UVLOL	UVLO bottom threshold		9	10	11	V
V <sub>hyst</sub>	UVLO hysteresis	UVH-UVL	0.5	1		V
<b>Supply current</b>						
I <sub>in</sub>	Quiescent current	output=0V, no load			5	mA

1) Recommended capacitor range on VREF pin is 10nF to 100nF.

## 4 Functional Description

### 4.1 Input

The input is compatible with optocouplers or pulse transformers. The input is triggered by the signal edge and allows the use of low-sized, low-cost pulse transformer. Input is active low (output is high when input is low) to ease the use of optocoupler. When driven by a pulse transformer, the input pulse (positive and negative) width must be larger than the minimum pulse width  $t_{onmin}$ .

### 4.2 Voltage reference

A voltage reference is used to create accurate timing for the two-level turn-off with external resistor and capacitor.

### 4.3 Desaturation protection

Desaturation protection ensures the protection of the IGBT in the event of overcurrent. When the DESAT voltage goes higher than 7V, the output is driven low (with 2-level turn-off if applicable). The FAULT output is activated. The FAULT state is exited at the next falling edge of IN input.

A programmable blanking time is used to allow enough time for IGBT saturation. Blanking time is provided by an internal current source and external capacitor.

DESAT input can also be used with an external comparator for overcurrent or over temperature detection.

### 4.4 Active Miller clamp

A Miller clamp allows the control of the Miller current during a high dV/dt situation and can avoid the use of a negative supply voltage.

During turn-off, the gate voltage is monitored and the clamp output is activated when gate voltage goes below 2V (relative to GND). The clamp voltage is VL+3V max for a Miller current up to 500mA. The clamp is disabled when the IN input is triggered again.

### 4.5 Two level turn-off

The two-level turn-off is used to increase the reliability of the application.

During turn-off, gate voltage can be reduced to a programmable level in order to reduce the IGBT current (in the event of over-current). This action avoids both dangerous overvoltage across the IGBT, and RBSOA problems, especially at short circuit turn-off.

Turn-off ( $T_a$ ) delay is programmable through an external resistor and capacitor for accurate timing.

Turn-off delay ( $T_a$ ) is also used to delay the input signal to prevent distortion of input pulse width.

### 4.6 Minimum ON time

In order to ensure the proper operation of the 2-level turn-off function, the input ON time ( $T_{win}$ ) must be greater than the  $T_{winmin}$  value:

$$T_{winmin} = T_a + 2 * R_{del} * C_{off}$$

$R_{del}$  is the internal discharge resistor and  $C_{off}$  is the external timing capacitor.

Input signals smaller than  $T_a$  are ignored. Input signals larger than  $T_{winmin}$  are transmitted to the output stage after the  $T_a$  delay with minimum width distortion ( $\Delta T_w = T_{wout} - T_{win}$ ).

For an input signal width  $T_{win}$  between  $T_a$  and  $T_{winmin}$ , the output width  $T_{wout}$  is reduced below  $T_{win}$  (pulse distortion) and the IGBT could be partially turned on. These input signals should be avoided during normal operation.

### 4.7 Output

The output stage is able to sink 2.3A and source 1.5A typical at 25°C (1.2A/0.75A minimum over the full temperature range). Separated sink and source outputs allow independent gate charge and discharge control without an extra external diode.

### 4.8 Fault status output

Fault output is used to signal a fault event (desaturation, UVLO) to a controller. The fault pin is designed to drive an optocoupler.

### 4.9 Undervoltage protection

Undervoltage detection protects the application in the event of a low  $V_H$  supply voltage (during start-up or a fault situation). During undervoltage, the OUTH pin is open and the OUTL pin is driven low (active pull-down for  $V_H > 2V$ , passive pull-down

for  $V_H < 2V$ ). Fault output signals the undervoltage state and is reset only when undervoltage state disappears.

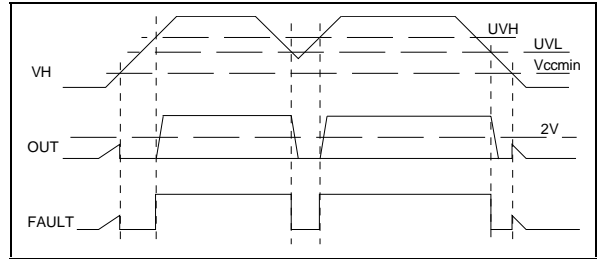
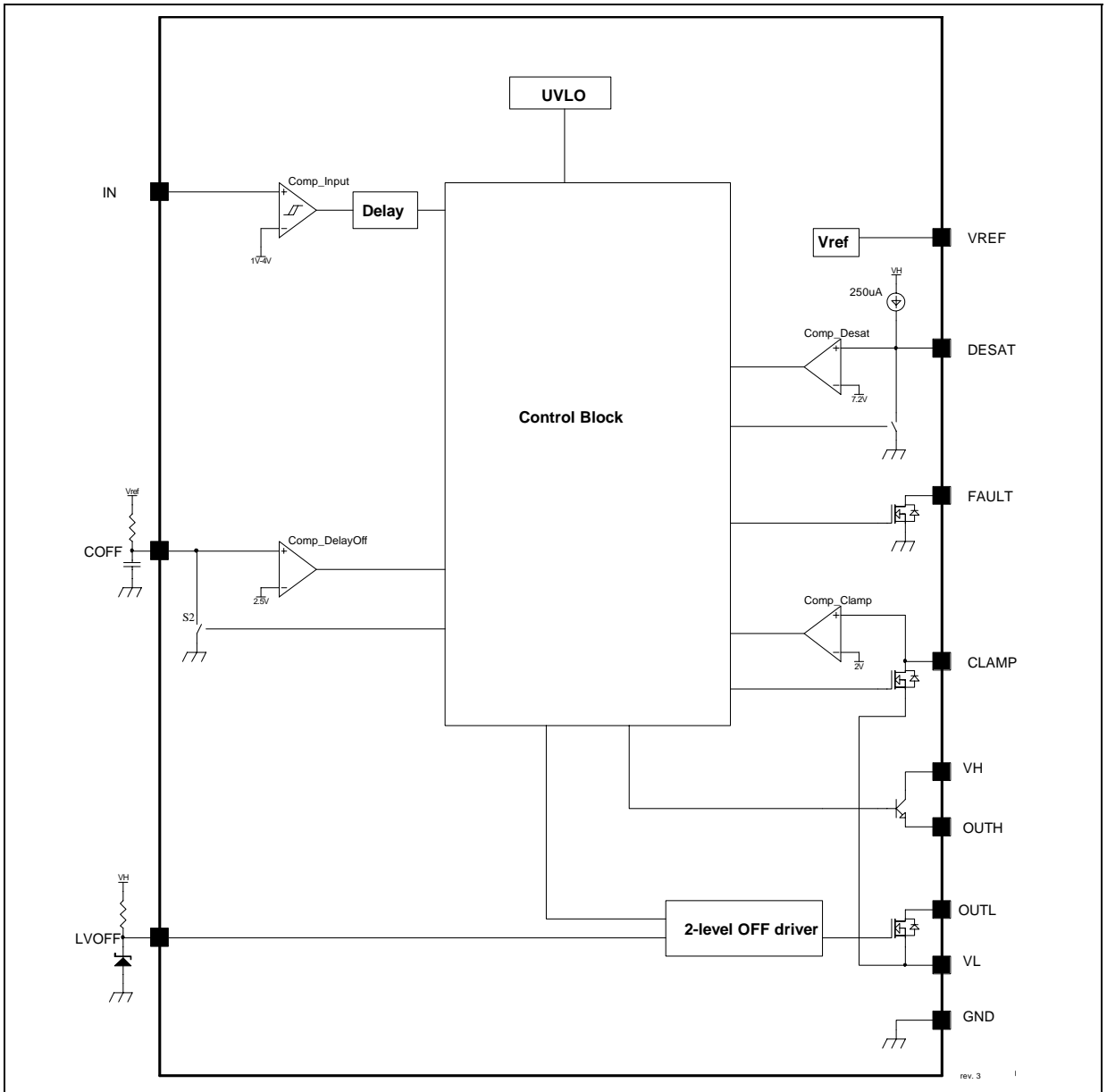


Figure 2: Detailed Internal Schematic



5 Timing Diagrams

Figure 3: Turn-on and turn-off

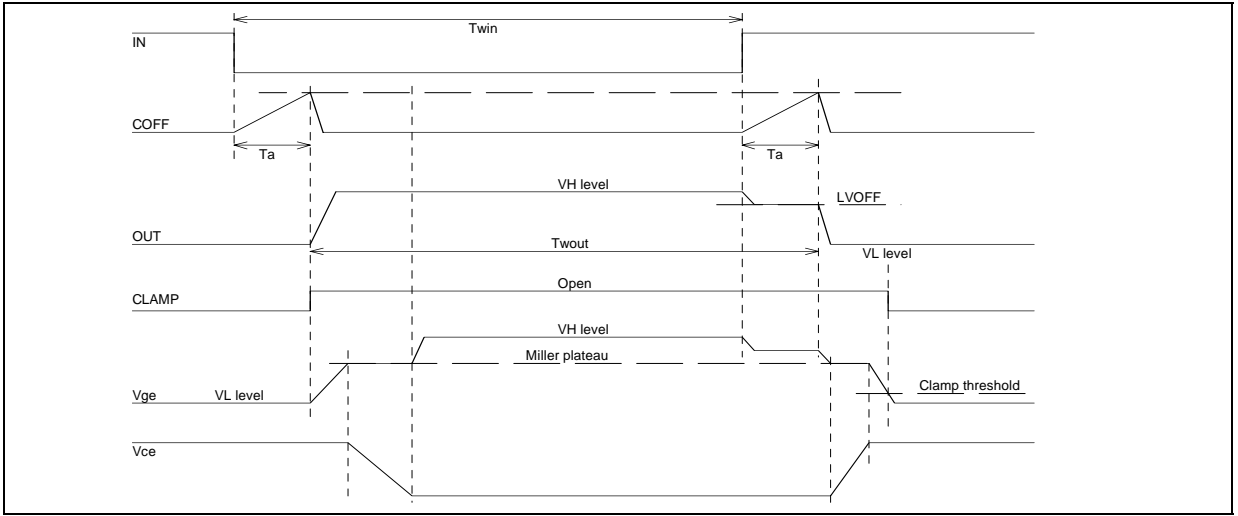


Figure 4: Minimum ON time

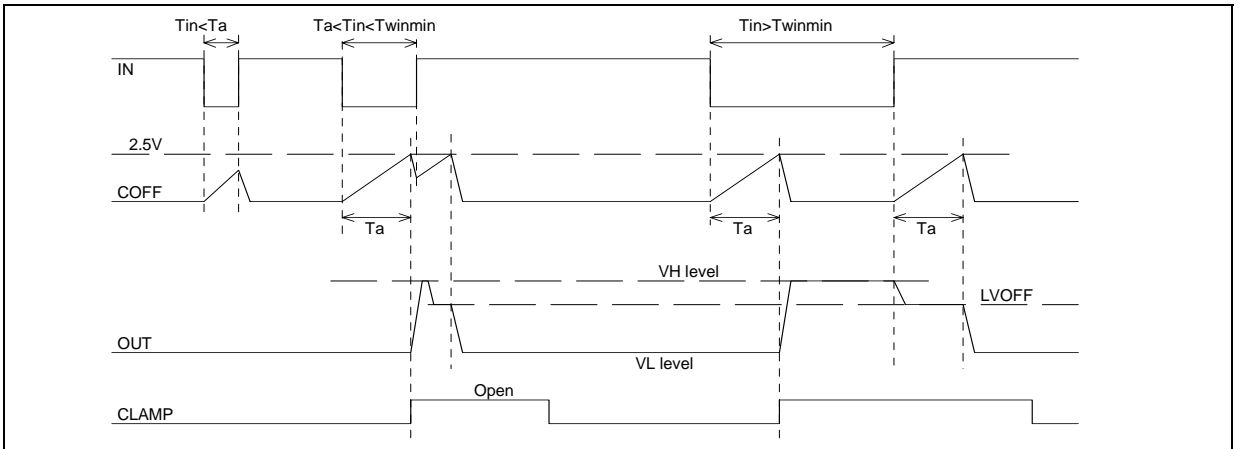
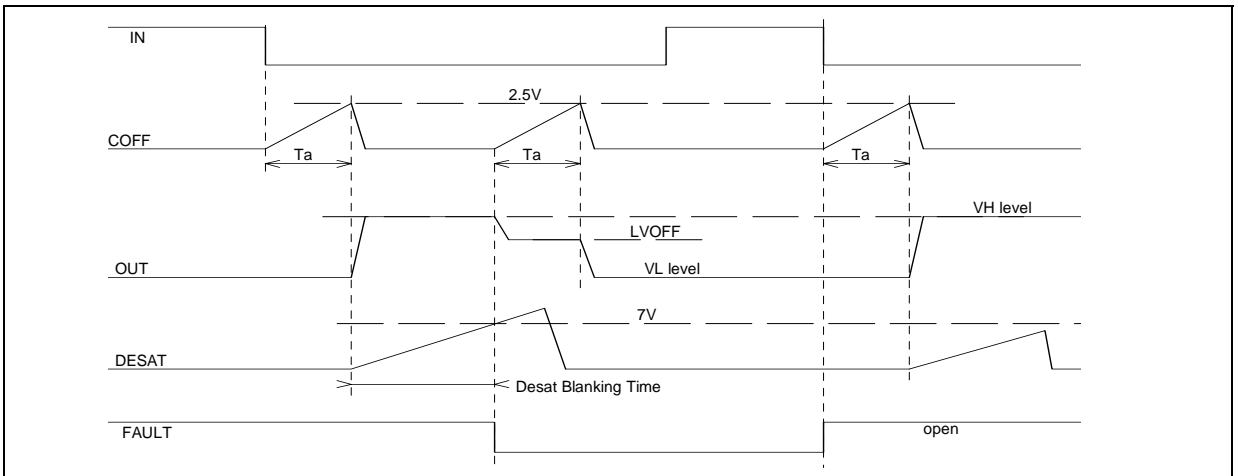


Figure 5: Desaturation fault



## 6 Typical Performance Curves

Figure 6: Supply current vs temperature

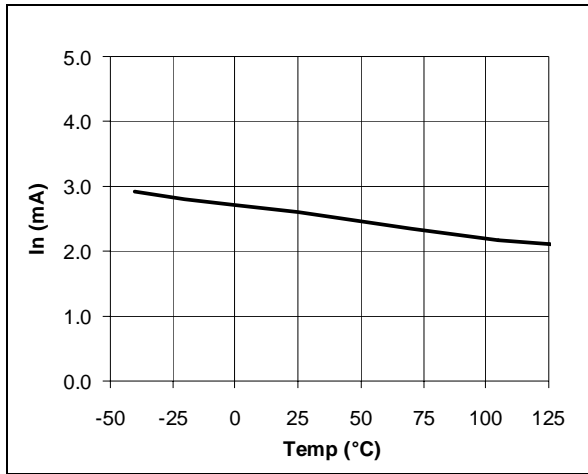


Figure 9: Voltage reference vs temperature

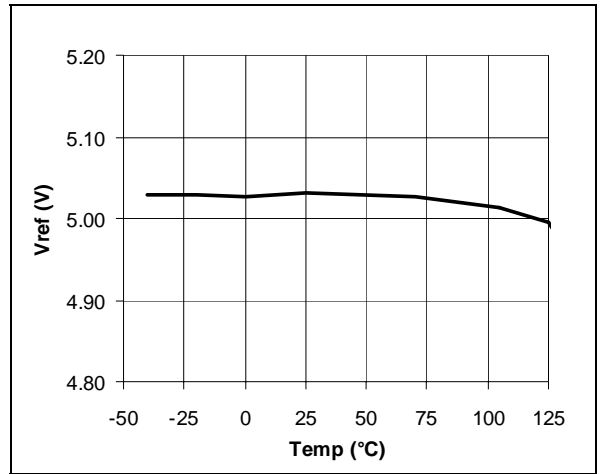


Figure 7: Low level output voltage vs temp.

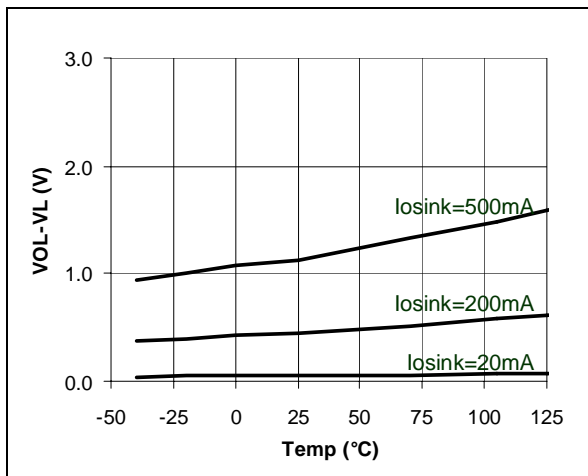


Figure 10: High level output voltage vs temp.

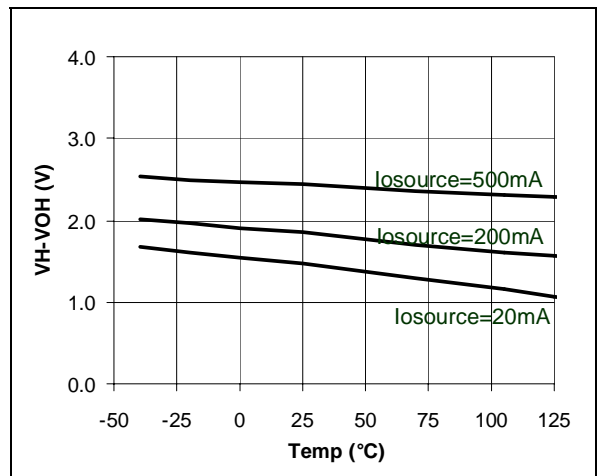


Figure 8: Desaturation threshold vs temperature

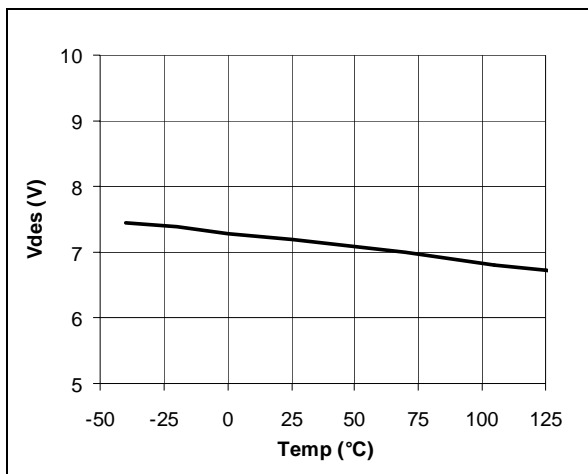
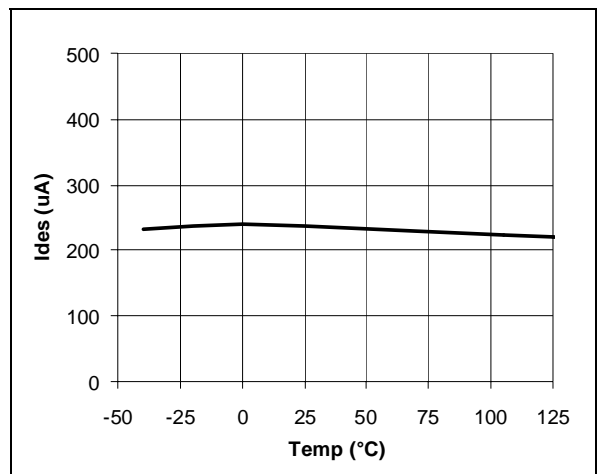


Figure 11: Desaturation source current vs temp.





### 7 Application Diagrams

Figure 12: Single supply IGBT drive with active Miller clamp and 2-level turn-off

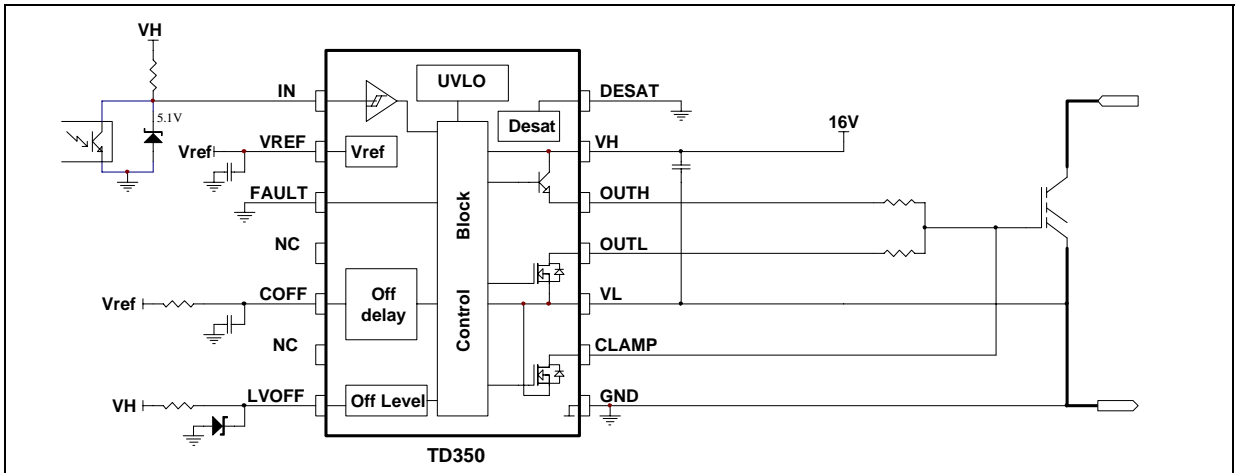


Figure 13: Large IGBT drive with negative gate drive and desaturation detection

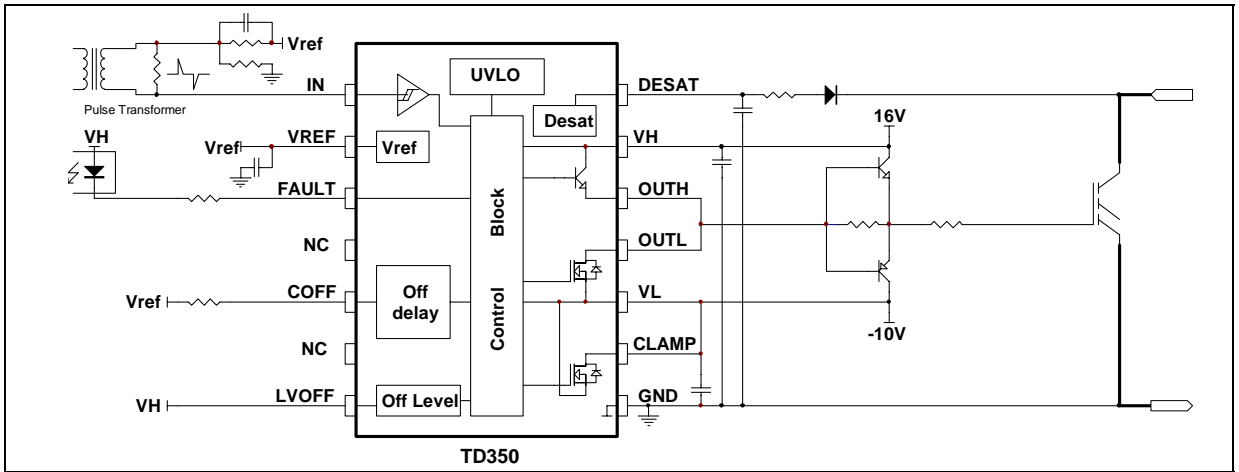
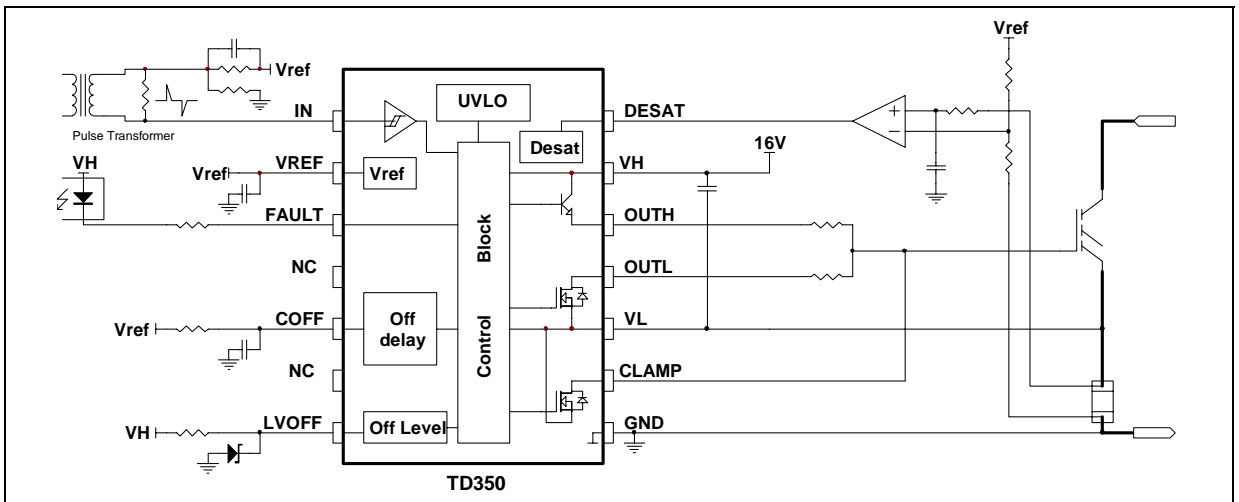
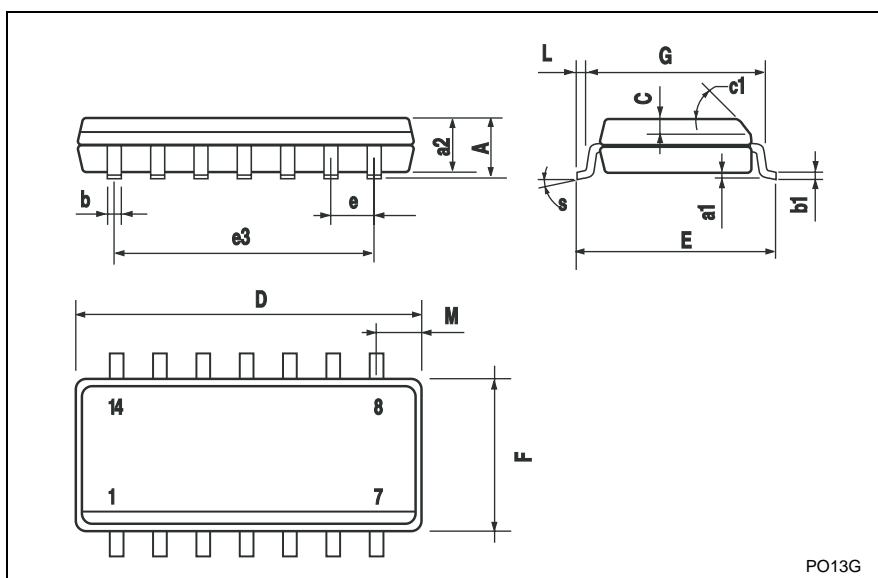


Figure 14: Use of DESAT input for direct overcurrent detection



## 8 PACKAGE MECHANICAL DATA

SO-14 MECHANICAL DATA						
DIM.	mm.			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.2	0.003		0.007
a2			1.65			0.064
b	0.35		0.46	0.013		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.019	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.149		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.019		0.050
M			0.68			0.026
S	8° (max.)					



## 9 Revision History

Date	Revision	Description of Changes
01 August 2004	1	First Release

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