

## Advanced IGBT/MOSFET Driver

- 1A sink / 0.75A source min. gate drive
- Active Miller clamp feature
- Desaturation detection
- Adjustable and accurate turn-on delay
- UVLO protection
- 2kV ESD protection

### Description

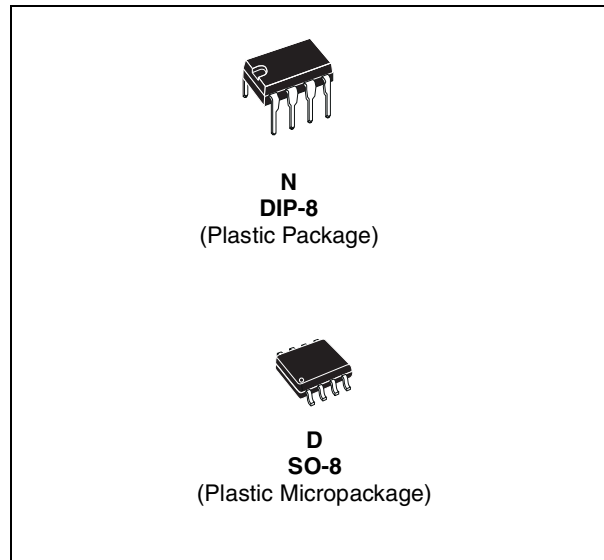
TD352 is an advanced gate driver for IGBT and power MOSFET. Control and protection functions are included and allow the design of high reliability systems.

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.

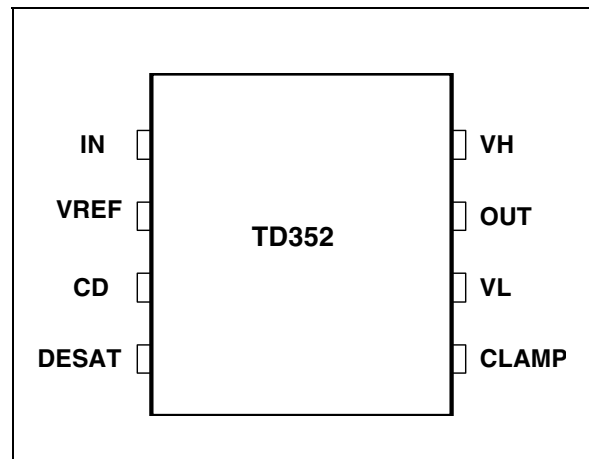
TD352 includes an adjustable turn-on delay. This feature can be used to implement reliable deadtime between high and low sides of a half bridge. External resistor and capacitor are used to provide accurate timing.

### Applications

- 1200V 3-phase inverter
- Motor control systems
- UPS



### Pin Connections (top view)



### Order Codes

Part Number	Temperature Range	Package	Packaging	Marking
TD352IN	-40°C, +125°C	DIP	Tube	TD352I
TD352ID		SO		TD352I
TD352IDT			Tape & Reel	TD352I

## 1 Block Diagram

Figure 1. System and internal block diagram

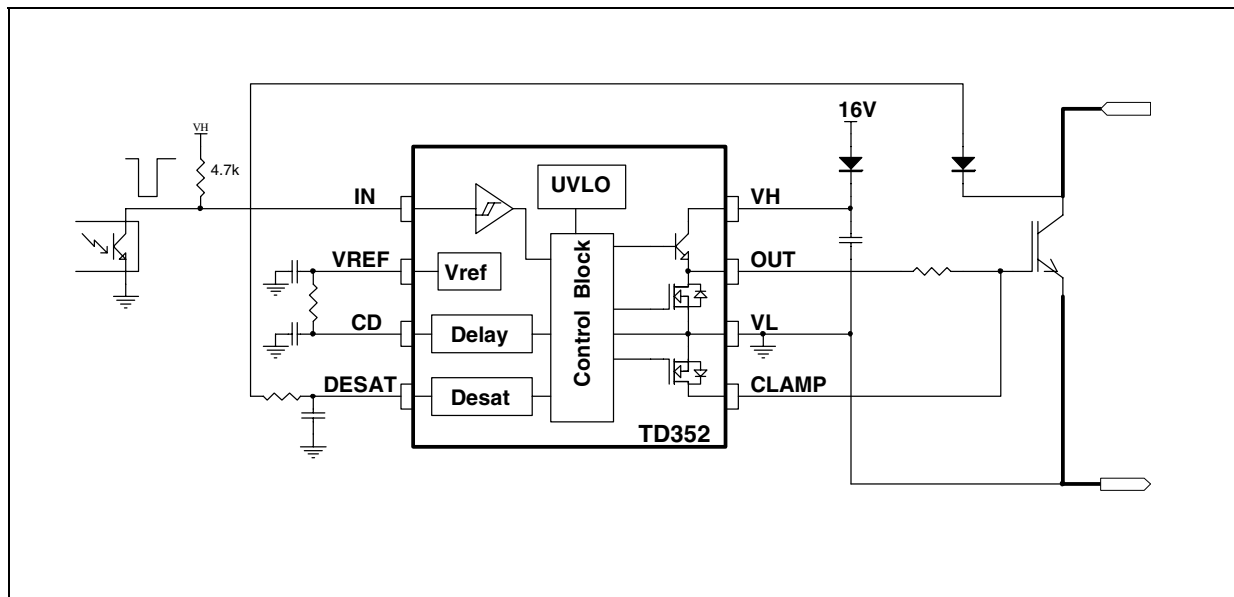


Table 1. Pin Description

Name	Pin Number	Type	Function
IN	1	Analog input	Input
VREF	2	Analog output	+5V reference voltage
CD	3	Timing capacitor	Turn on delay
DESAT	4	Analog input	Desaturation protection
CLAMP	5	Analog output	Miller clamp
VL	6	Power supply	Signal ground
OUT	7	Analog output	Gate drive output
VH	8	Power supply	Positive supply

## 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
Vout	Voltage on OUT, CLAMP, LVOFF pins	VL-0.3 to VH+0.3	V
Vter	Voltage on other pins (IN, CD, 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	150	°C/W
ESD	Electrostatic discharge	2	kV

**Table 3. Operating Conditions**

Symbol	Parameter	Value	Unit
VH	Positive Supply Voltage vs. VL	UVLO to 26	V
Tope	Operating Free Air Temperature Range	-40 to 125	°C

### 3 Electrical Characteristics

Table 4.  $T_{amb} = -20$  to  $125^{\circ}\text{C}$ ,  $V_H=16\text{V}$  (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
linp	IN Input current	IN input voltage < 4.5V			1	$\mu\text{A}$
<b>Voltage reference - Note 1</b>						
Vref	Voltage reference	$T=25^{\circ}\text{C}$	4.85	5.00	5.15	V
Iref	Maximum output current		10			$\text{mA}$
<b>Clamp</b>						
Vtclamp	CLAMP pin voltage threshold			2.0		V
VCL	Clamp low voltage	Icsink=500mA			2.5	V
<b>Delay</b>						
Vtdel	Voltage threshold			2.5		V
Rdel	Discharge resistor	I=1mA			500	$\Omega$
<b>Desaturation protection</b>						
Vdes	Desaturation threshold			VH-2		$\zeta$
I des	Source current			250		$\mu\text{A}$
<b>Outputs</b>						
Isink	Output sink current	Vout=6V	1000	1700		$\text{mA}$
Isrc	Output source current	Vout=VH-6V	750	1300		$\text{mA}$
VOL1	Output low voltage 1	Iosink=20mA			0.35	V
VOL2	Output low voltage 2	Iosink=500mA			2.5	V
VOH1	Output high voltage 1	Iosource=20mA	VH-2.5			V
VOH2	Output high voltage 2	Iosource=500mA	VH-4.0			V
tr	Rise time	CL=1nF, 10% to 90%			100	ns
tf	Fall time	CL=1nF, 90% to 10%			100	ns
tdon	Turn on propagation delay	10% output change: Rd=4.7k, no Cd Rd=11k, Cd=220pF	1.8	2.0	500 2.2	ns $\mu\text{s}$
tdoff	Turn off propagation delay	10% output change			400	ns
<b>Under Voltage Lockout (UVLO)</b>						
UVLOH	UVLO top threshold		10	11	12	V
UVLOL	UVLO bottom threshold		9	10	11	V
Vhyst	UVLO hysteresis	Vhyst=UVLOH-UVLOL	0.5	1		V
<b>Supply current</b>						
lin	Quiescent current	input low, no load			2.5	$\text{mA}$

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

## 4 Functional Description

### 4.1 Input stage

TD352 IN input is clamped at about 5V to 7V. The input is triggered by the signal edge. When using an open collector optocoupler, the resistive pull-up resistor can be connected to either VREF or VH. Recommended pull-up resistor value with VH=16V are from 4.7k to 22k.

### 4.2 Voltage reference

A voltage reference is used to create accurate timing for the turn-on delay with external resistor and capacitor. The same circuitry is also used for the two-level turn-off delay.

A decoupling capacitor (10nF to 100nF) on VREF pin is required to ensure good noise rejection.

### 4.3 Active Miller clamp:

The TD352 offers an alternative solution to the problem of the Miller current in IGBT switching applications. Instead of driving the IGBT gate to a negative voltage to increase the safety margin, the TD352 uses a dedicated CLAMP pin to control the Miller current. When the IGBT is off, a low impedance path is established between IGBT gate and emitter to carry the Miller current, and the voltage spike on the IGBT gate is greatly reduced.

During turn-off, the gate voltage is monitored and the clamp output is activated when gate voltage goes below 2V (relative to VL). The clamp voltage is VL+4V max for a Miller current up to 500mA. The clamp is disabled when the IN input is triggered again.

The CLAMP function doesn't affect the turn-off characteristic, but only keeps the gate to the low level throughout the off time. The main benefit is that negative voltage can be avoided in many cases, allowing a bootstrap technique for the high side driver supply.

### 4.4 Turn-on delay

Turn-on ( $T_a$ ) delay is programmable through external resistor  $R_d$  and capacitor  $C_d$  for accurate timing.  $T_a$  is approximately given by:

$$T_a (\mu s) = 0.7 * R_d (\text{kohms}) * C_d (\text{nF})$$

The turn-on delay can be disabled by connecting the CD pin to VREF with a 4.7k resistor.

Input signals with ON-time smaller than  $T_a$  are ignored.

### 4.5 Desaturation protection

Desaturation protection ensures the protection of the IGBT in the event of overcurrent. When the DESAT voltage goes higher than VH-2V, the TD352 OUT pin is driven low. The fault state is only exit after power-down and power-up.

A programmable blanking time is used to allow enough time for IGBT saturation. Blanking time is provided by an internal current source and external  $C_{des}$  capacitor, the  $T_{bdes}$  blanking time value is given by:

$$T_{bdes} = V_{des} * C_{des} / I_{des}$$

At VH=16V,  $T_{bdes}$  is approximately given by:

$$T_{bdes} (\mu s) = 0.056 * C_{des} (\text{pF})$$

### 4.6 Output stage

The output stage is able to sink/source 1.7A/1.3A typical at 25°C and 1.0A/0.75A min. over the full temperature range. This current capability is specified near the usual IGBT Miller plateau.

### 4.7 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 OUT pin is driven low (active pull-down for  $V_H > 2V$ , passive pull-down for  $V_H < 2V$ ).

**Figure 2. Undervoltage protection**

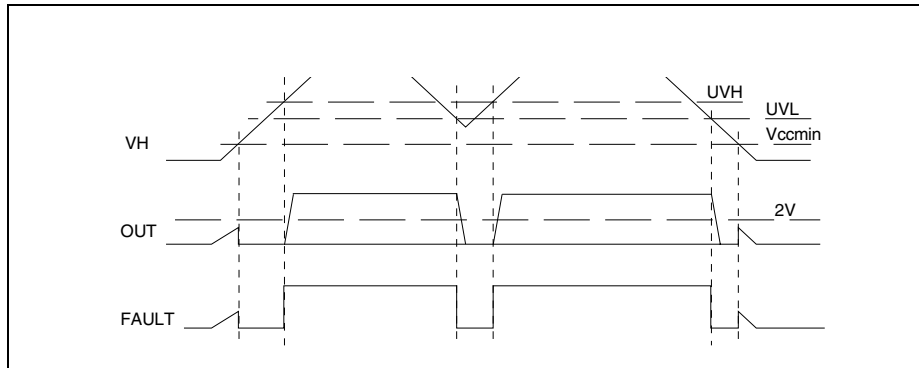
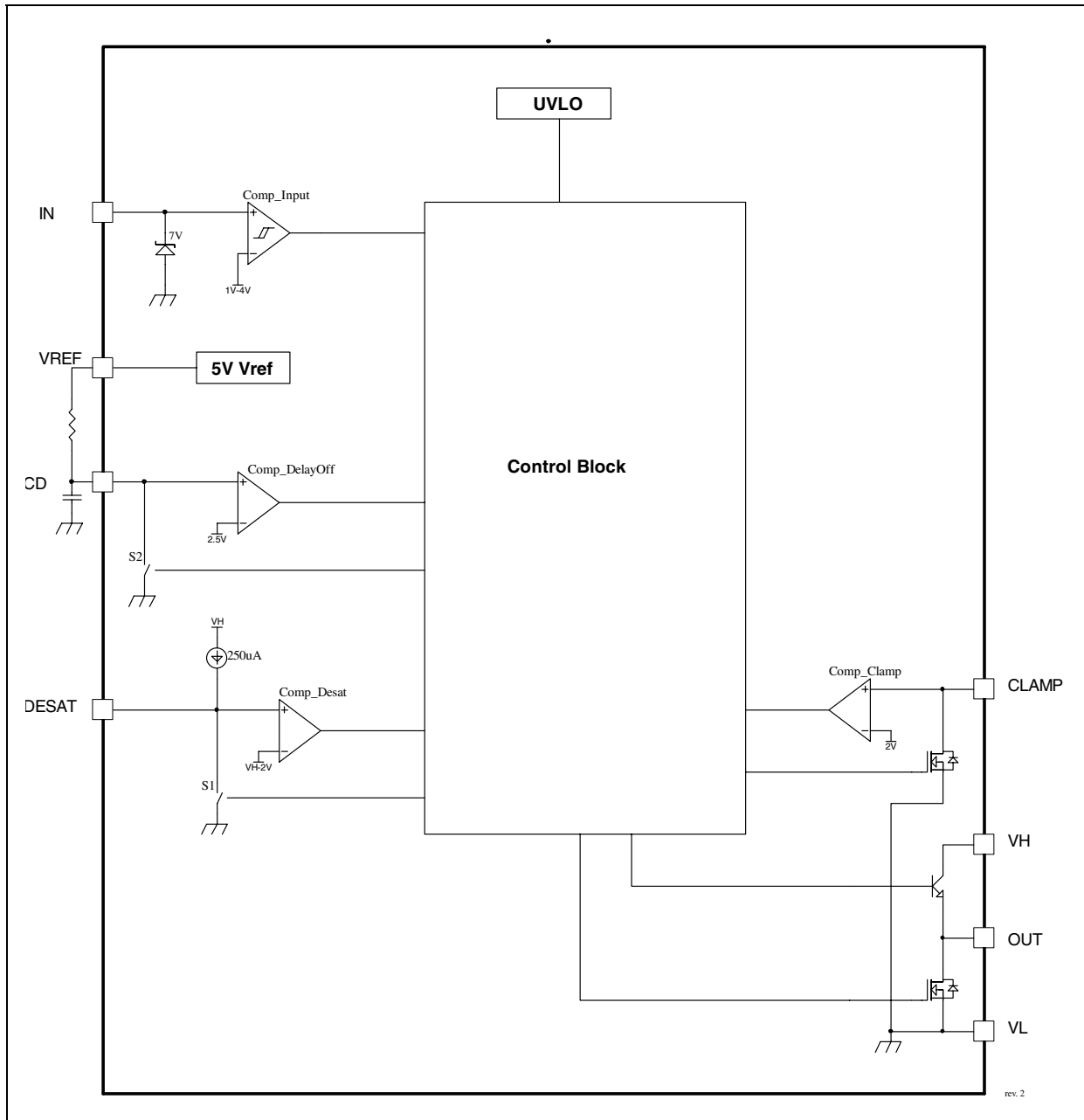


Figure 3. Detailed internal schematic



### 5 Timing Diagrams

Figure 4. General turn-on and turn-off sequence

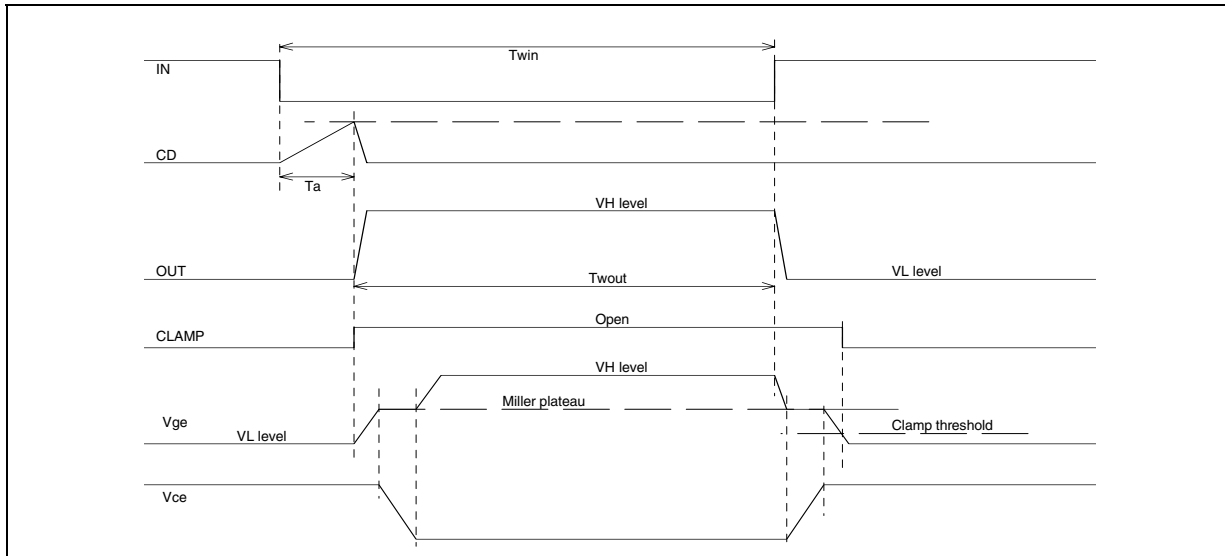


Figure 5. input and output waveform dynamic parameters

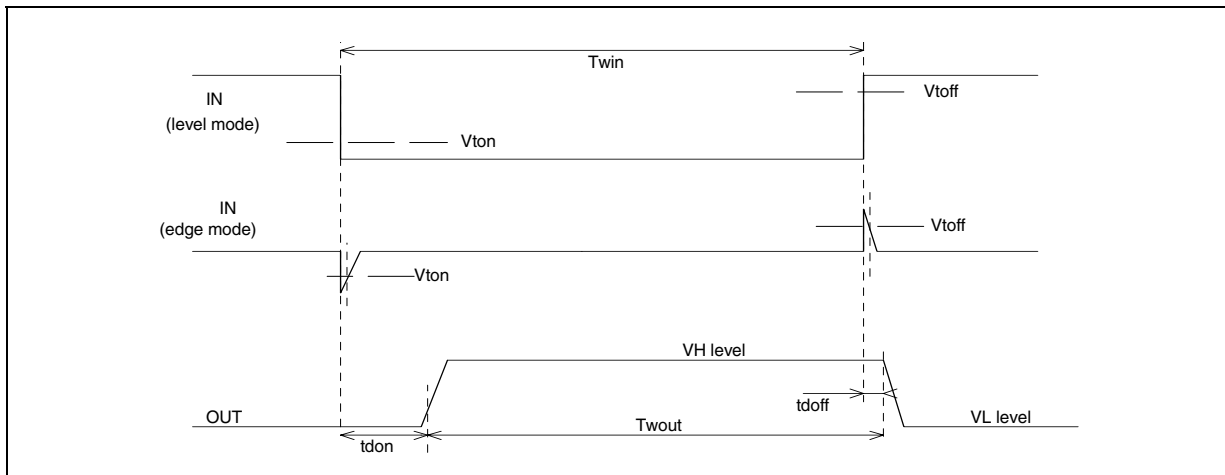
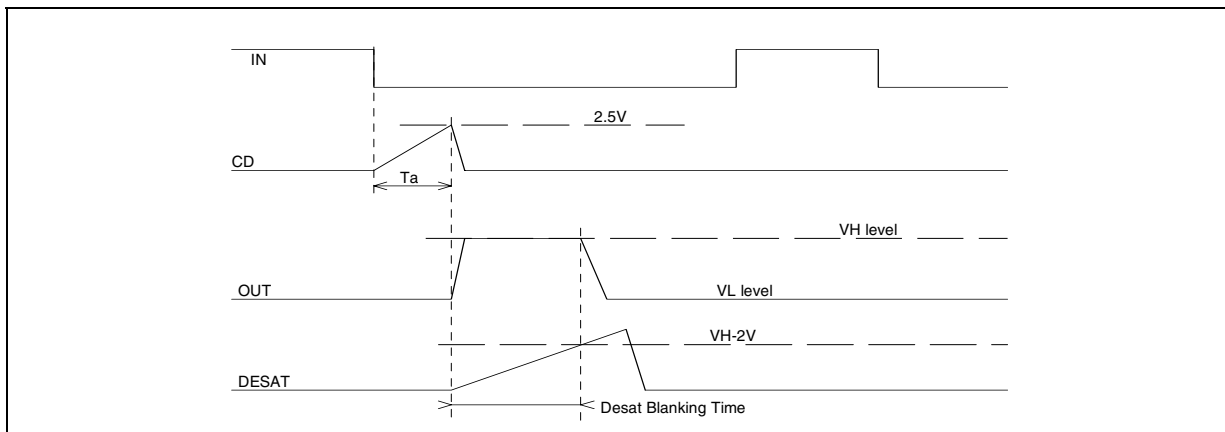


Figure 6. Desaturation fault





## 6 Typical Performance Curves

Figure 7. Quiescent current vs. temperature

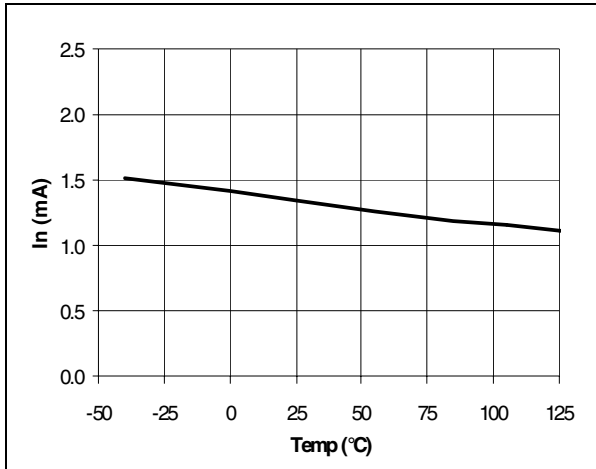


Figure 8. Low level output voltage vs. temperature

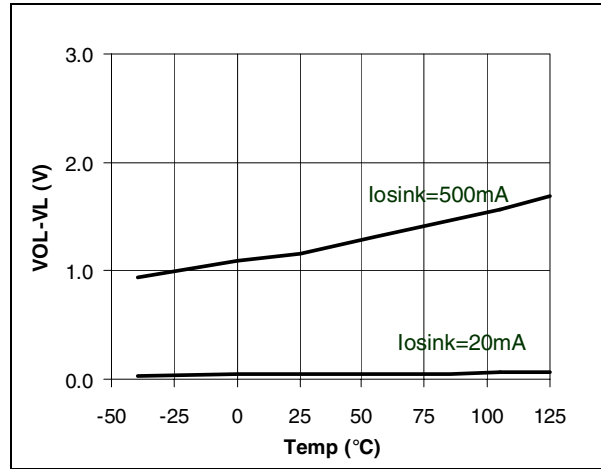


Figure 9. Sink current vs. temperature

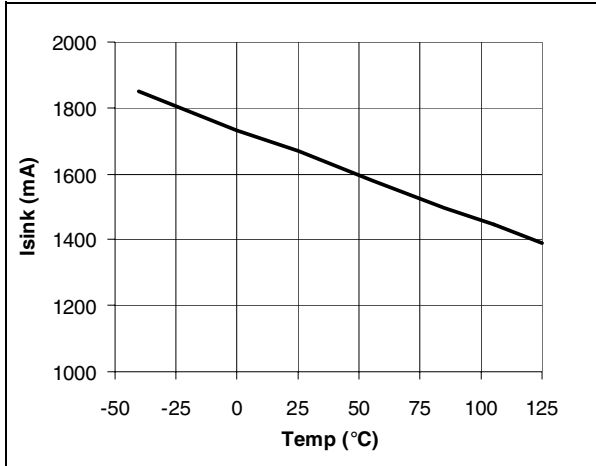


Figure 10. Rdel resistance vs. temperature

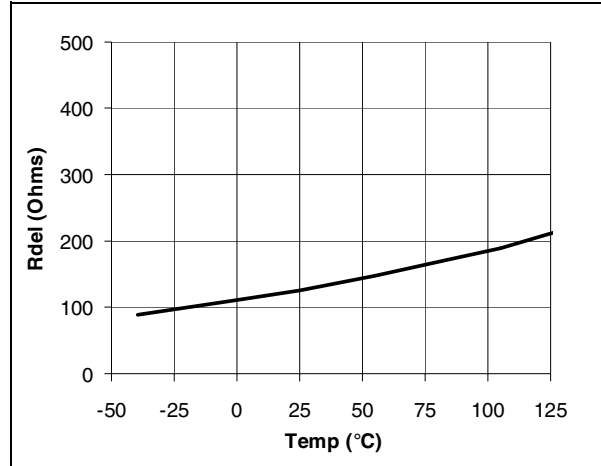


Figure 11. High level output voltage vs. temperature

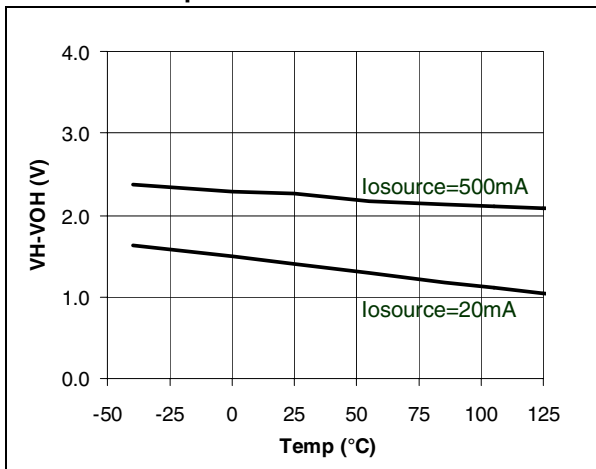
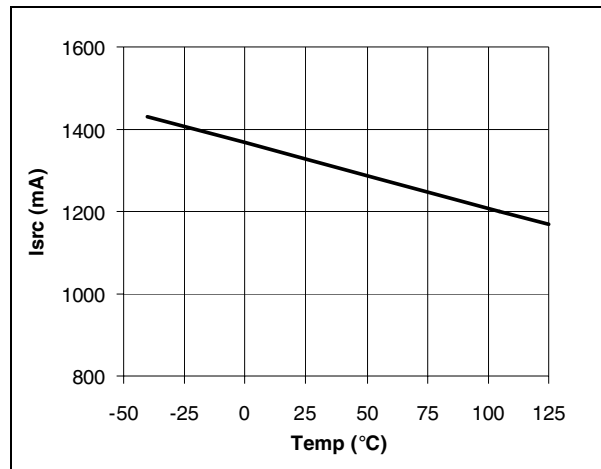


Figure 12. Source current vs. temperature



## 7 Application Diagrams

Figure 13. Single supply IGBT drive with active Miller clamp

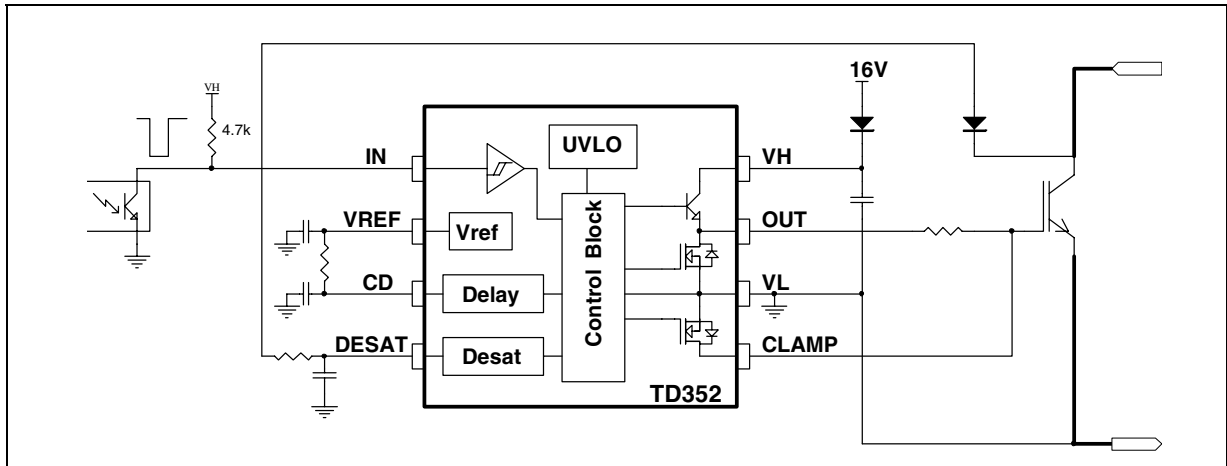


Figure 14. Use of DESAT input for direct overcurrent detection

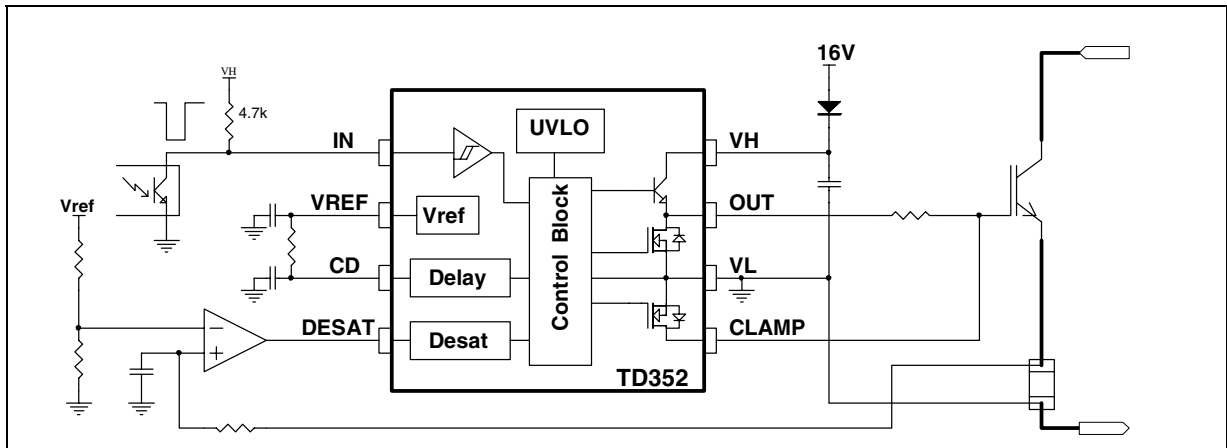
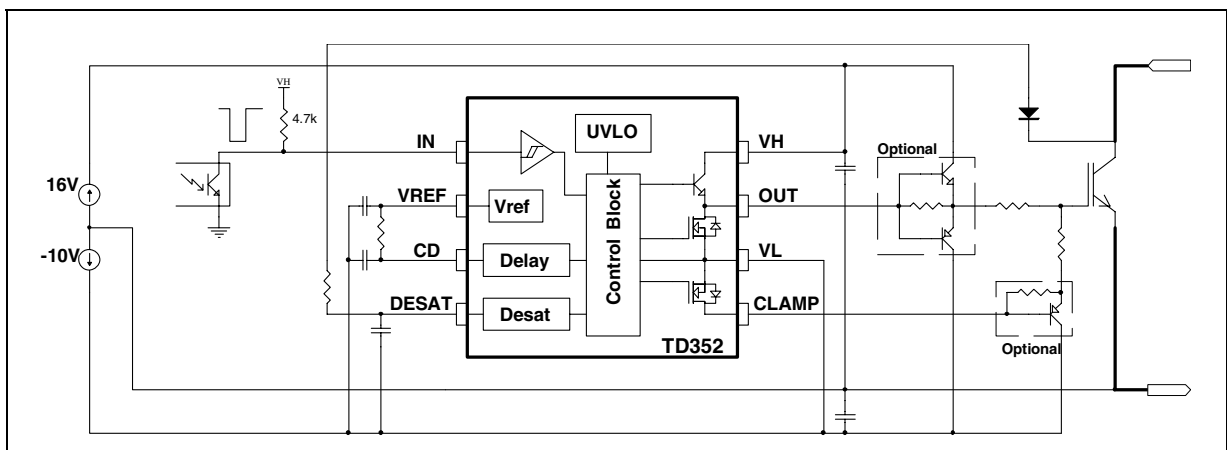


Figure 15. Large IGBT drive with negative voltage gate drive and optional current buffers

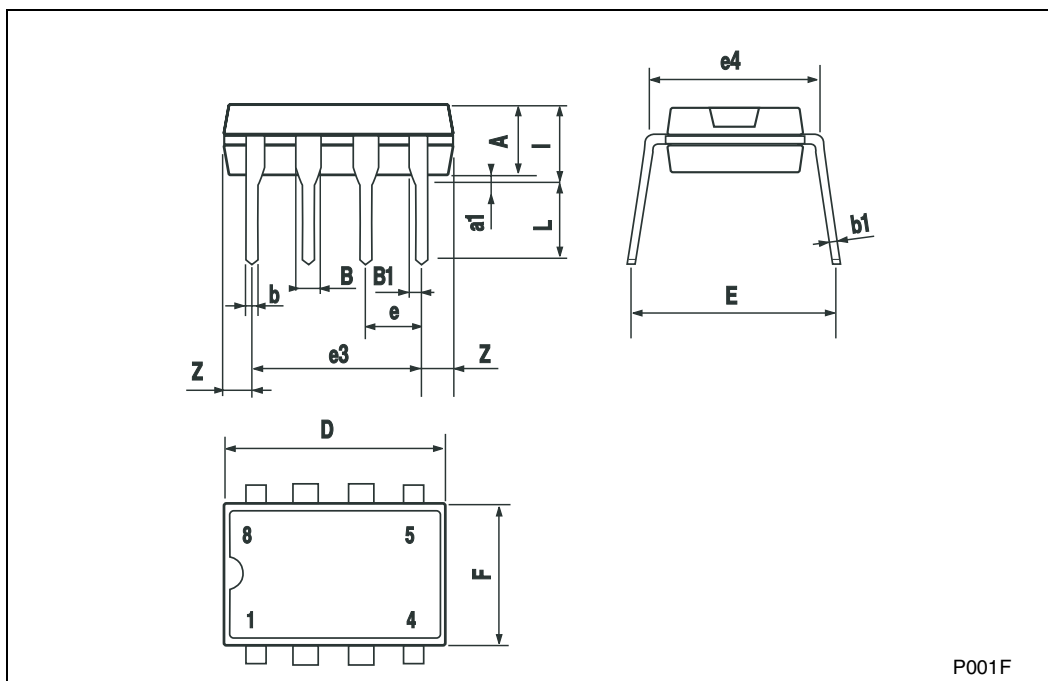


## 8 Package Mechanical Data

### 8.1 DIP-8 Package

**Plastic DIP-8 MECHANICAL DATA**

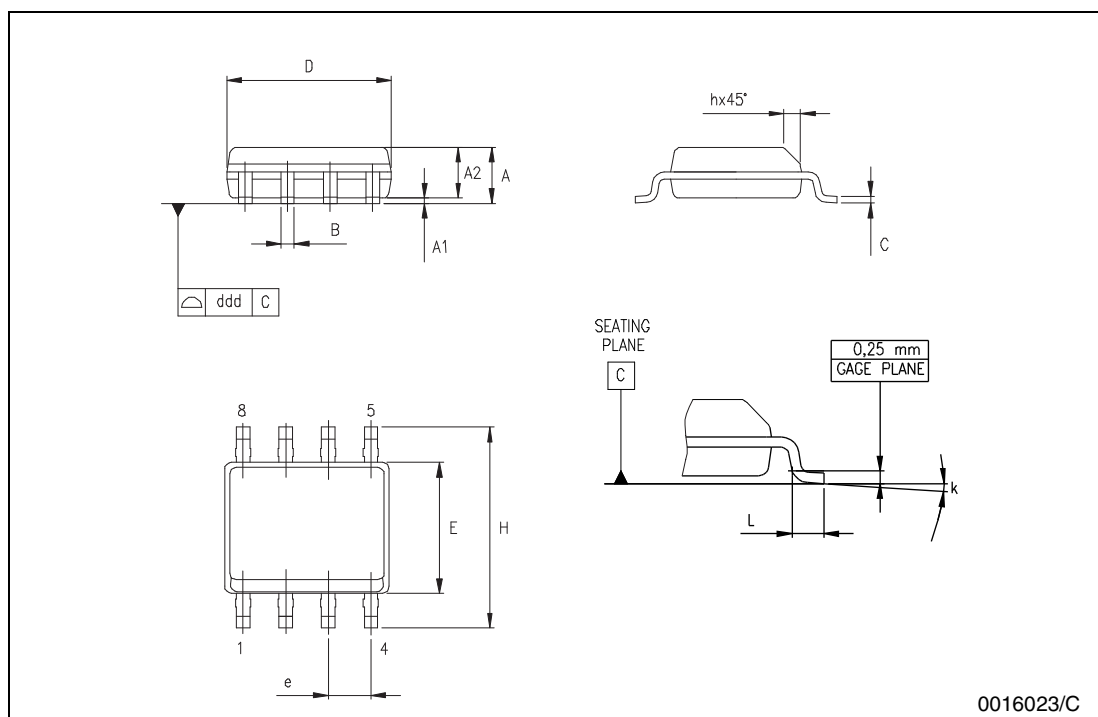
DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A		3.3			0.130	
a1	0.7			0.028		
B	1.39		1.65	0.055		0.065
B1	0.91		1.04	0.036		0.041
b		0.5			0.020	
b1	0.38		0.5	0.015		0.020
D			9.8			0.386
E		8.8			0.346	
e		2.54			0.100	
e3		7.62			0.300	
e4		7.62			0.300	
F			7.1			0.280
I			4.8			0.189
L		3.3			0.130	
Z	0.44		1.6	0.017		0.063



## 8.2 SO-8 Package

## SO-8 MECHANICAL DATA

DIM.	mm.			inch		
	MIN.	TYP	MAX.	MIN.	TYP.	MAX.
A	1.35		1.75	0.053		0.069
A1	0.10		0.25	0.04		0.010
A2	1.10		1.65	0.043		0.065
B	0.33		0.51	0.013		0.020
C	0.19		0.25	0.007		0.010
D	4.80		5.00	0.189		0.197
E	3.80		4.00	0.150		0.157
e		1.27			0.050	
H	5.80		6.20	0.228		0.244
h	0.25		0.50	0.010		0.020
L	0.40		1.27	0.016		0.050
k	$8^{\circ}$ (max.)					
ddd			0.1			0.04



## 9 Revision History

Date	Revision	Description of Changes
01 Dec. 2004	1	First Release

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