# TD352

## Advanced IGBT/MOSFET driver

## Features

- 1.7 A sink / 1.3 A source (typ) current capability
- Active Miller clamp feature
- Desaturation detection
- Adjustable turn-on delay
- UVLO protection
- 2k V ESD protection

SO-8

## Applications

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

## Description

This device is an advanced gate driver for IGBTs and power MOSFETs. Control and protection functions are included and allow the design of high reliability systems.

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

The 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. An external resistor and capacitor are used to provide accurate timing.

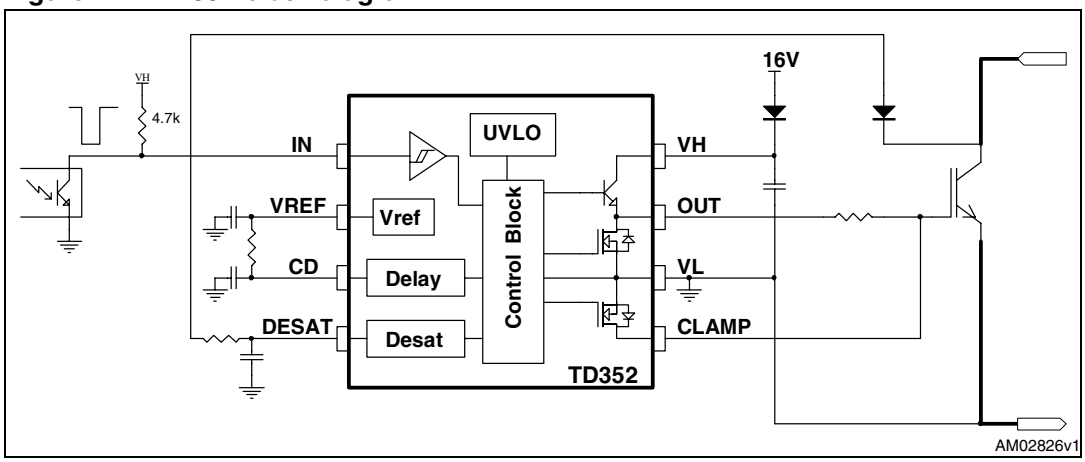
**Table 1. Device summary**

| Order codes | Temperature range | Package | Packaging |
|---|---|---|---|
| TD352ID | -40°C, +125°C | SO-8 | Tube |
| TD352IDT | | | Tape and reel |

# Contents

# 1 Block diagram

**Figure 1. TD352 block diagram**



# 2 Pin connections

**Figure 2. Pin connections (top view)**

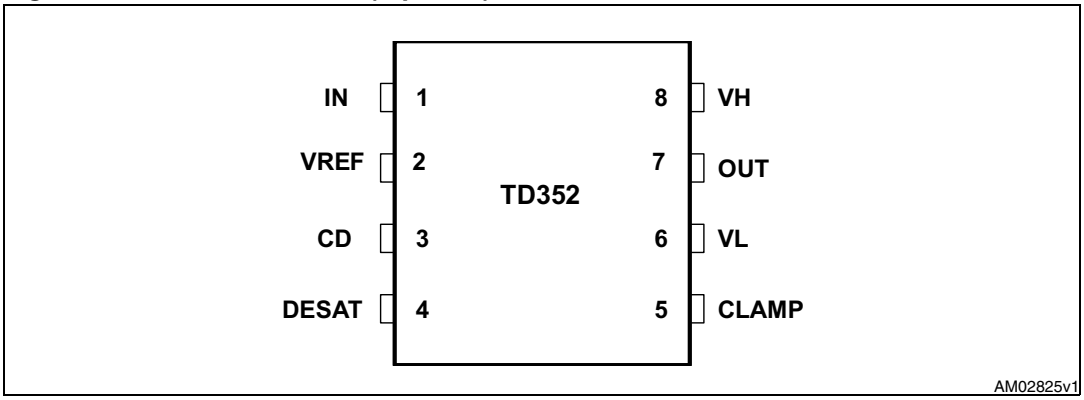



**Table 2. Pin description**

| Pin n° | Name | Type | Function |
|---|---|---|---|
| IN | 1 | Analog input | Input |
| VREF | 2 | Analog output | +5 V 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 |

# 3 Absolute maximum ratings

**Table 3. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| VHL | Maximum supply voltage (VH - VL) | 28 | V |
| $V_{out}$ | Voltage on OUT, CLAMP, DESAT pins | VL-0.3 to VH+0.3 | V |
| $V_{other}$ | Voltage on other pins (IN, CD, VREF) | -0.3 to 7 | V |
| $P_d$ | Power dissipation | 500 | mW |
| $T_{stg}$ | Storage temperature | -55 to 150 | °C |
| $T_j$ | Maximum junction temperature | 150 | °C |
| $R_{thJA}$ | Thermal resistance junction-ambient | 150 | °C/W |
| ESD | Electrostatic discharge (HBM) | 2 | kV |

**Table 4. Operating conditions**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| VH | Positive supply voltage vs. VL | UVLO to 26 | V |
| $T_{oper}$ | Operating free air temperature range | -40 to 125 | °C |

# 4 Electrical characteristics

$T_A$ = -20 to 125 °C, VH = 16 V, unless otherwise specified.

**Table 5. Electrical characteristics**

| Symbol | Parameter | Test condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Input** | | | | | | |
| $V_{ton}$ | IN turn-on threshold voltage | | 0.8 | 1.0 | | V |
| $V_{toff}$ | IN turn-off threshold voltage | | | 4.0 | 4.2 | V |
| $I_{inp}$ | IN input current | IN input voltage < 4.5V | | | 1 | µA |
| **Voltage reference** (1) | | | | | | |
| $V_{ref}$ | Voltage reference | T = 25°C | 4.85 | 5.00 | 5.15 | V |
| $I_{ref}$ | Maximum output current | | 10 | | | mA |
| **Clamp** | | | | | | |
| $V_{tclamp}$ | CLAMP pin voltage threshold | | | 2.0 | | V |
| $V_{CL}$ | Clamp low voltage | $I_{csink}$ = 500mA | | | 2.5 | V |
| **Delay** | | | | | | |
| $V_{tdel}$ | Voltage threshold | | | 2.5 | | V |
| $R_{del}$ | Discharge resistor | I=1mA | | | 500 | Ω |
| **Desaturation protection** | | | | | | |
| $V_{des}$ | Desaturation threshold | | | VH-2 | | V |
| $I_{des}$ | Source current | | | 250 | | µA |
| **Output** | | | | | | |
| $I_{sink}$ | Output sink current | $V_{out}$ = 6V | 1000 | 1700 | | mA |
| $I_{src}$ | Output source current | $V_{out}$ = VH-6V | 750 | 1300 | | mA |
| $V_{OL1}$ | Output low voltage 1 | $I_{osink}$ = 20mA | | | 0.35 | V |
| $V_{OL2}$ | Output low voltage 2 | $I_{osink}$ = 500mA | | | 2.5 | V |
| $V_{OH1}$ | Output high voltage 1 | $I_{osource}$ = 20mA | VH-2.5 | | | V |
| $V_{OH2}$ | Output high voltage 2 | $I_{osource}$ = 500mA | VH-4.0 | | | V |
| $t_r$ | Rise time | $C_L$ = 1nF, 10% to 90% | | | 100 | ns |
| $t_f$ | Fall time | $C_L$ = 1nF, 90% to 10% | | | 100 | ns |
| $t_{don}$ | Turn on propagation delay | 10% OUT change:<br>$R_d$ = 4.7kΩ, no $C_d$<br>$R_d$ = 11kΩ, $C_d$ = 220 pF | <br><br>1.8 | <br><br>2.0 | <br>500<br>2.2 | <br>ns<br>µs |
| $t_{doff}$ | Turn off propagation delay | 10% OUT change | | | 400 | ns |

**Table 5. Electrical characteristics (continued)**

| Symbol | Parameter | Test condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Under voltage lockout (UVLO)** | | | | | | |
| UVLOH | UVLO top threshold | | 10 | 11 | 12 | V |
| UVLOL | UVLO bottom threshold | | 9 | 10 | 11 | V |
| $V_{hyst}$ | UVLO hysteresis | UVLOH-UVLOL | 0.5 | 1 | | V |
| **Supply current** | | | | | | |
| $I_{in}$ | Quiescent current | OUT = 0V; no load | | | 2.5 | mA |

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

# 5 Functional description

## 5.1 Input stage

The TD352 IN input is internally clamped at about 5 V to 7 V. 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=16 V is from 4.7 kΩ to 22 kΩ

## 5.2 Voltage reference

A voltage reference is used to create accurate timing for the turn-on delay with external resistor and capacitor.

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

## 5.3 Active Miller clamp

The TD352 offers an alternative solution to the problem of 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 the 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 the gate voltage goes below 2 V (relative to VL). The clamp voltage is VL+4V max for a Miller current up to 500 mA. The clamp is disabled when the IN input is triggered again.

The CLAMP function does not affect the turn-off characteristic, but only keeps the gate at 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.

## 5.4 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 (see *Figure 5*):

$T_a$ (µs) = 0.7 * $R_d$ (kΩ) * $C_d$ (nF)

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

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

## 5.5 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 exited after a power-down and power-up cycle.

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:

$T_{bdes}$ (µs) = 0.056 * $C_{des}$ (pF)

## 5.6 Output stage

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

## 5.7 Undervoltage protection

Undervoltage detection protects the application in the event of a low VH supply voltage (during startup or a fault situation). During undervoltage, the OUT pin is driven low (active pull-down for VH>2V, and passive pull-down for VH<2V).

**Figure 3. Undervoltage protection**

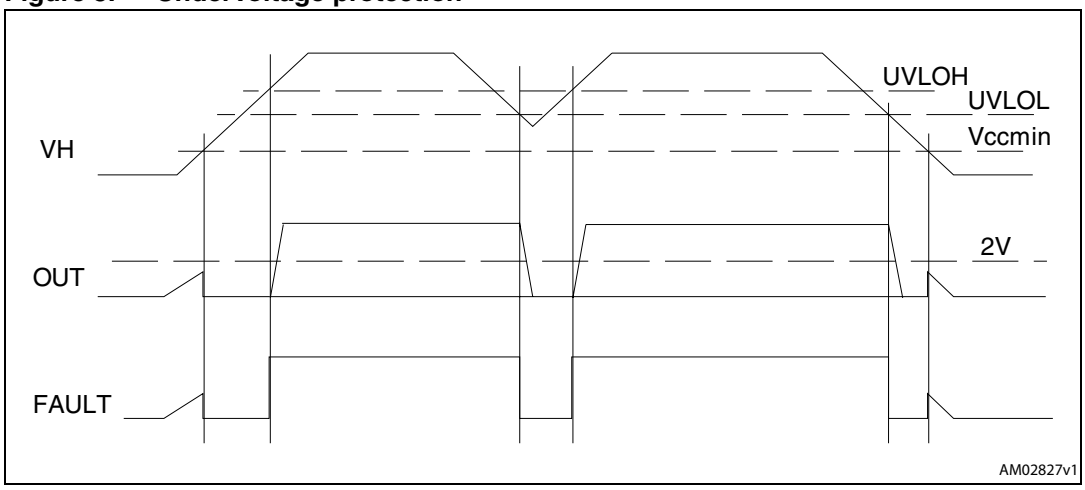
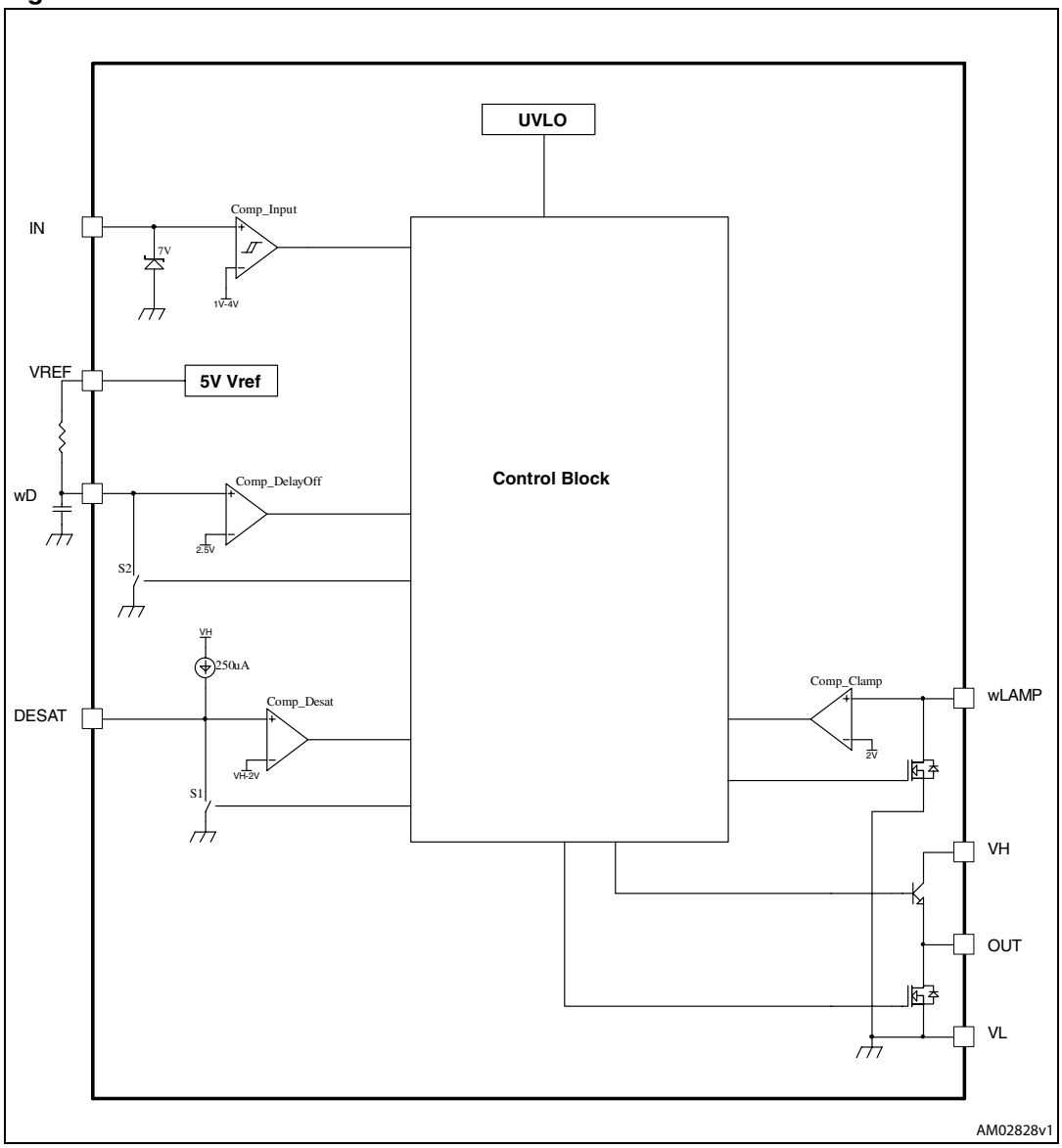


**Figure 4. Detailed internal schematic**



# 6 Timing diagrams

**Figure 5. General turn-on and turn-off sequence**

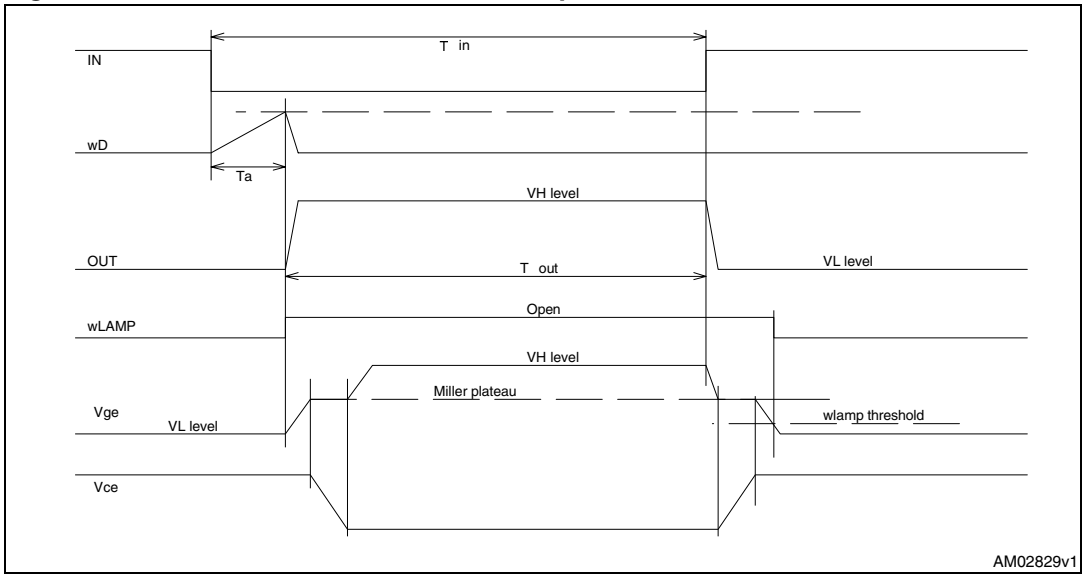



**Figure 6. Input and output waveform dynamic parameters**

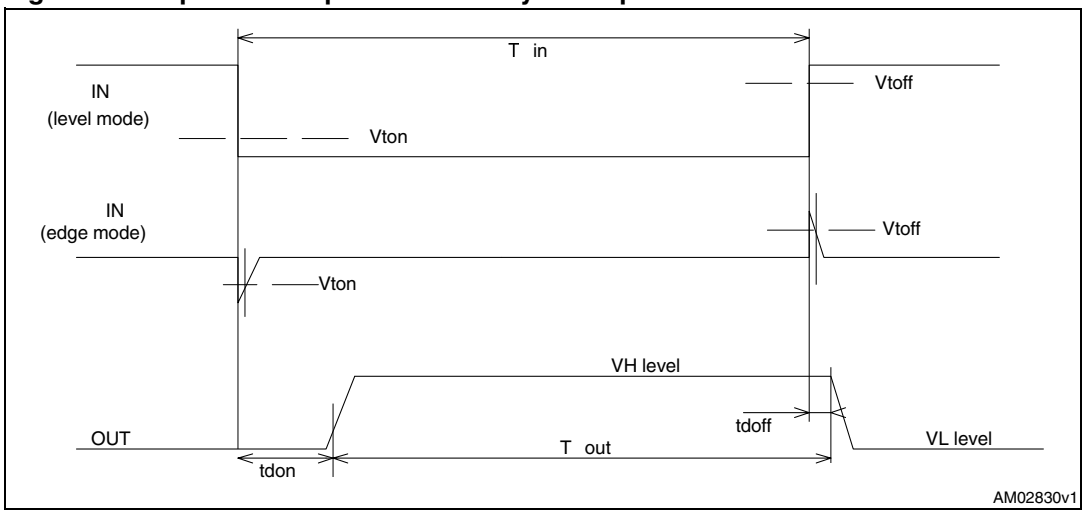
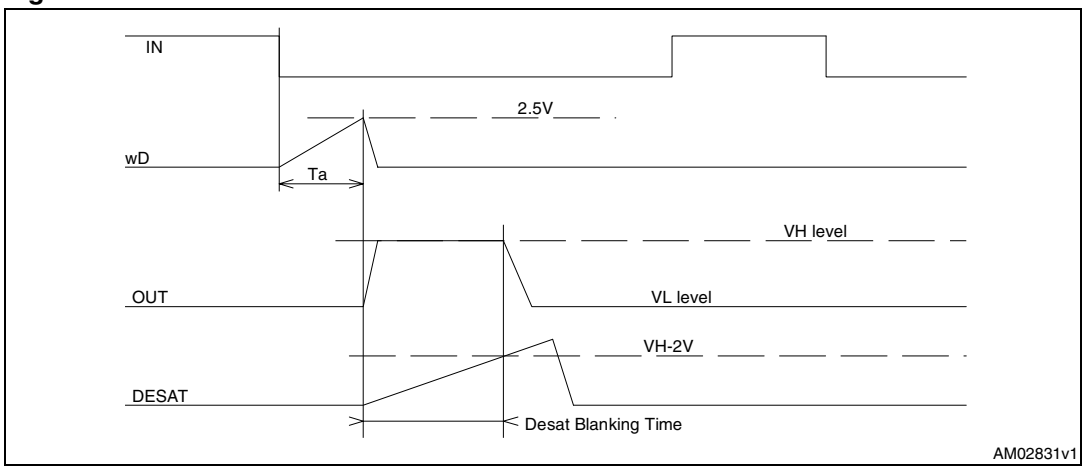


**Figure 7. Desaturation fault**



# 7 Typical performance curves

**Figure 8. Quiescent current vs temperature**

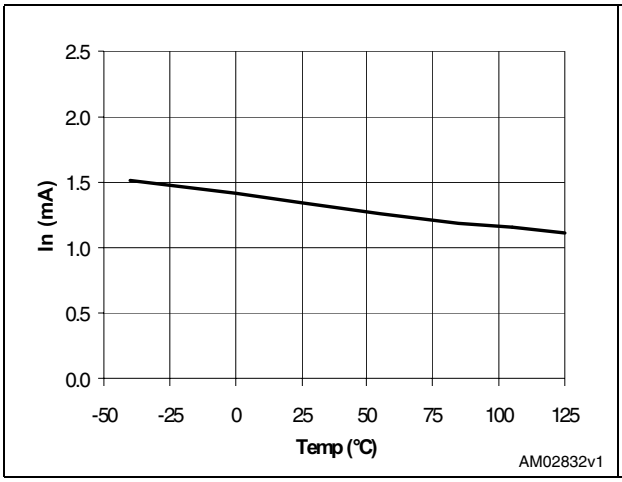



**Figure 9. Rdel resistance vs temperature**

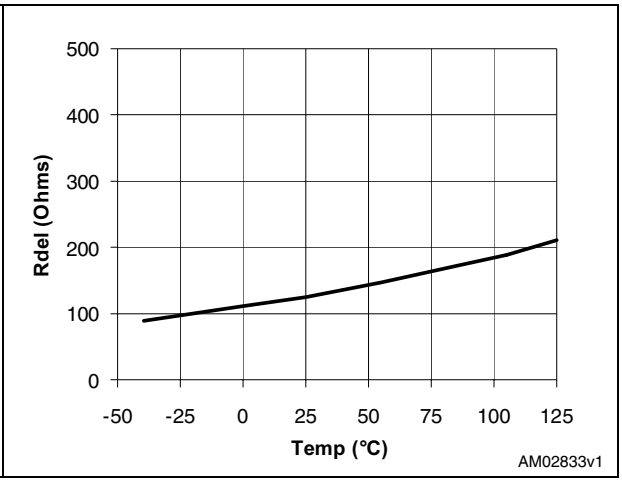



**Figure 10. Low level output voltage vs temp.**

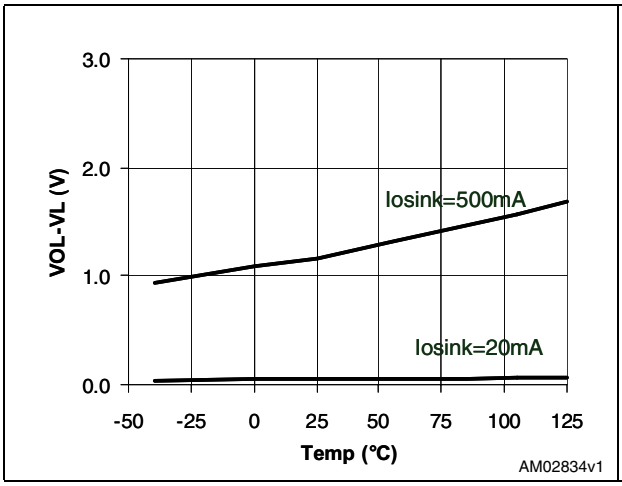



**Figure 11. High level output voltage vs temp.**

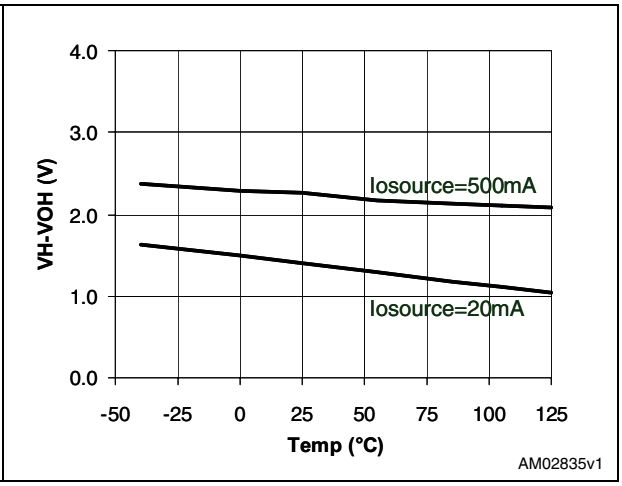


**Figure 12. Sink current vs temperature**

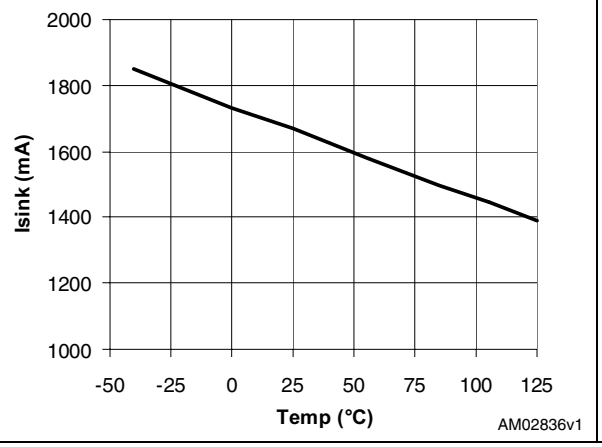
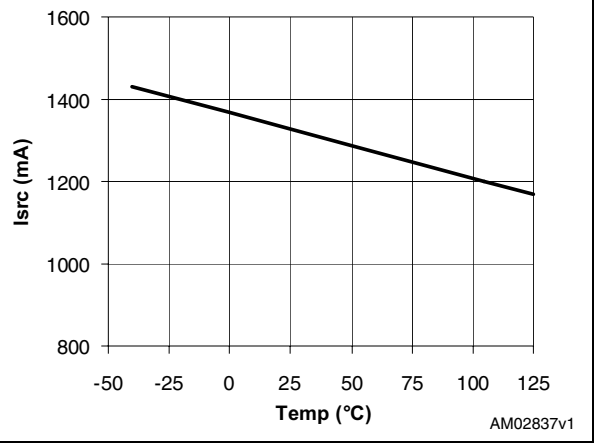



**Figure 13. Source current vs temperature**



# 8 Application diagrams

**Figure 14. Single supply IGBT drive with active Miller clamp and DESAT protection**

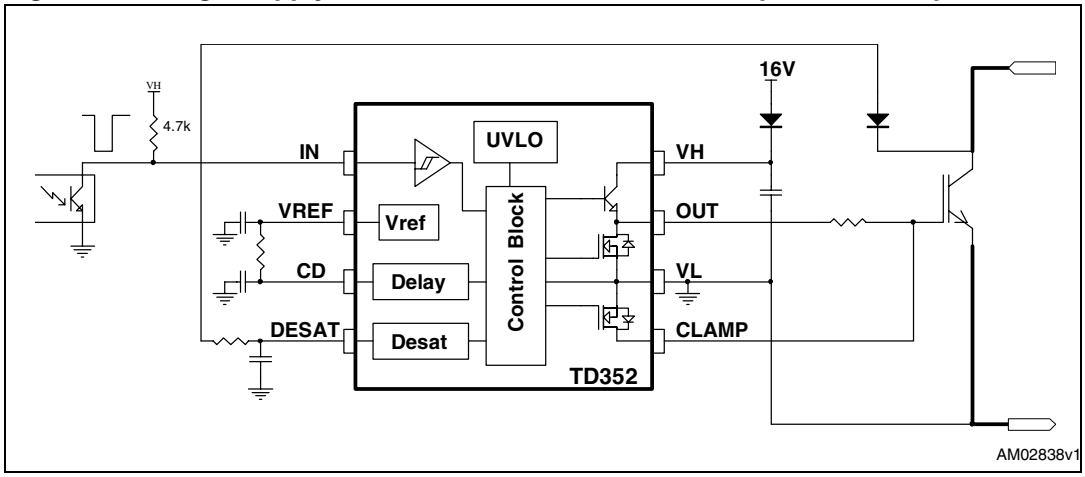



**Figure 15. Use of DESAT input for direct overcurrent detection**

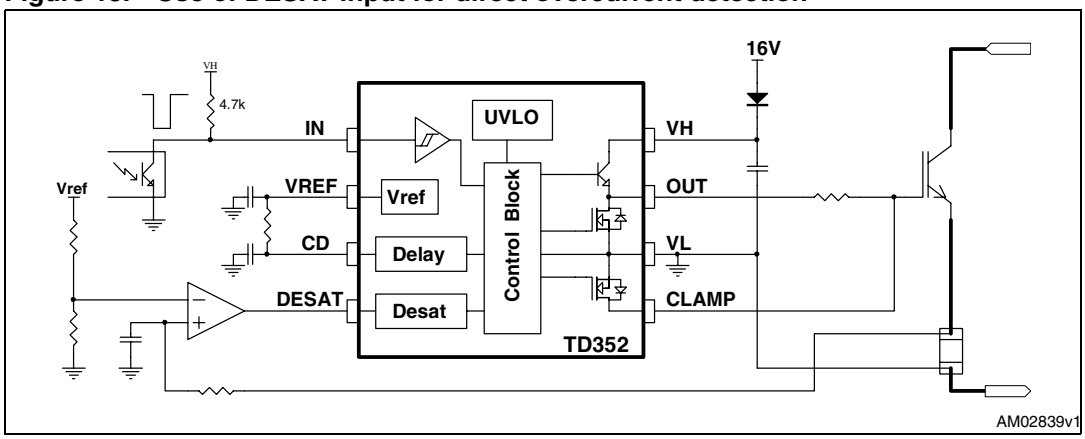
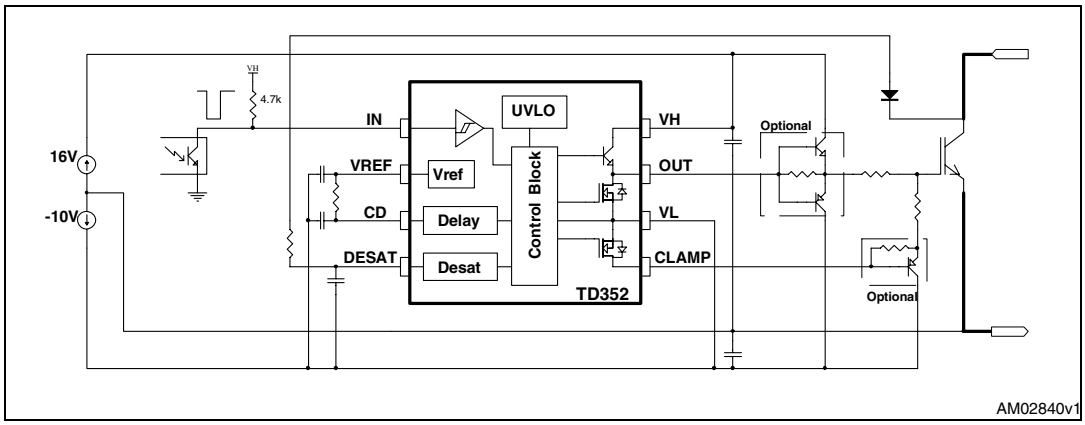



**Figure 16. Large IGBT drive with negative voltage gate drive and optional current buffers**



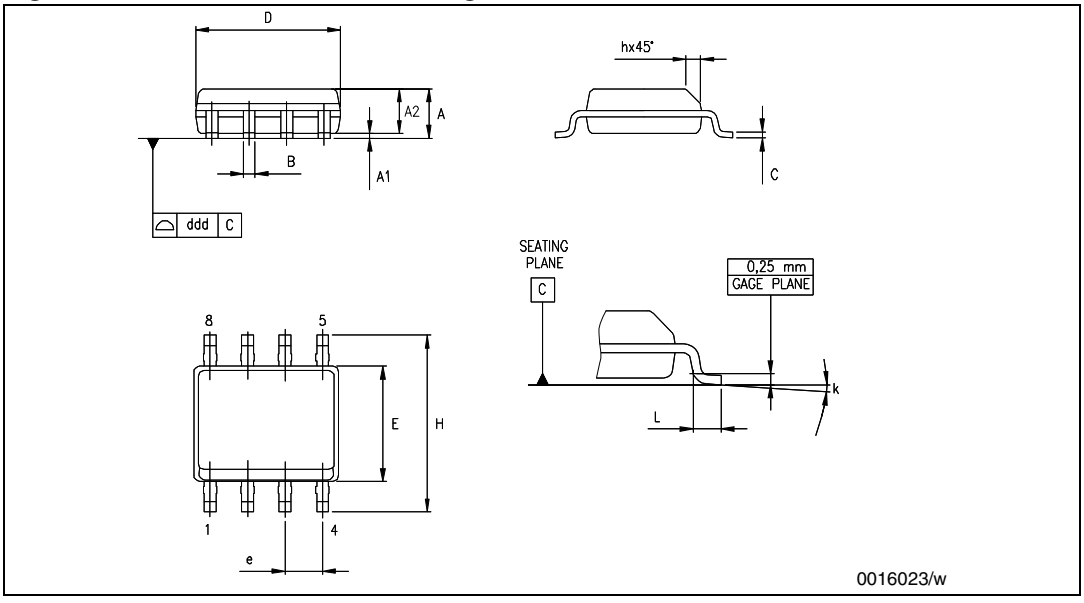
# 9 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: www.st.com. ECOPACK® is an ST trademark.

**Table 6. 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 | (max.) 8 | | | | | |
| ddd | | | 0.1 | | | 0.04 |

**Figure 17. SO-8 mechanical drawing**



# 10 Revision history

**Table 7. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 01-Nov-2004 | 1 | Initial release |
| 13-Jun-2011 | 2 | Deleted order code TD352IN.<br>Content reworked to improve readability. |

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