

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

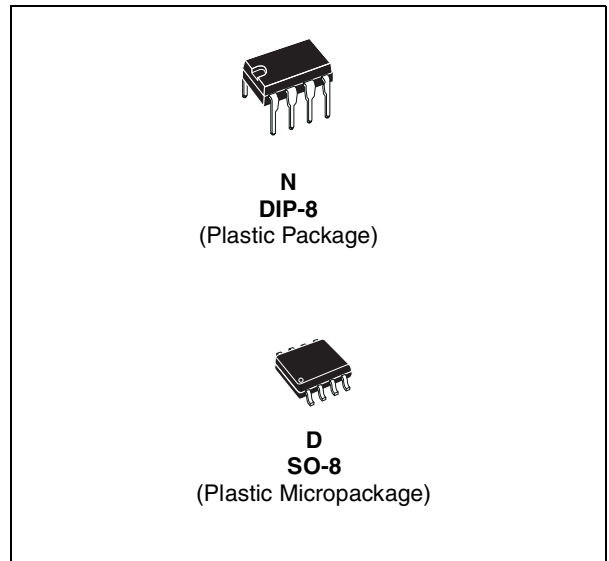
TD352 is an advanced gate driver for IGBT and power MOSFET. Control and protection functions are included and allow the design of high reliability systems.

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.

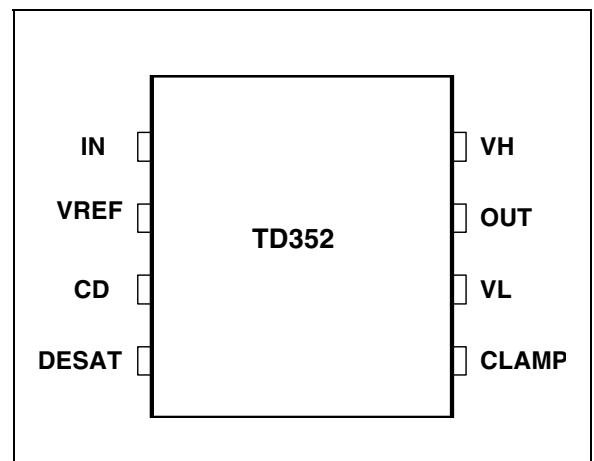
TD352 includes an adjustable turn-on delay. This feature can be used to implement reliable deadtime between high and low sides of a half bridge. External resistor and capacitor are used to provide accurate timing.

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

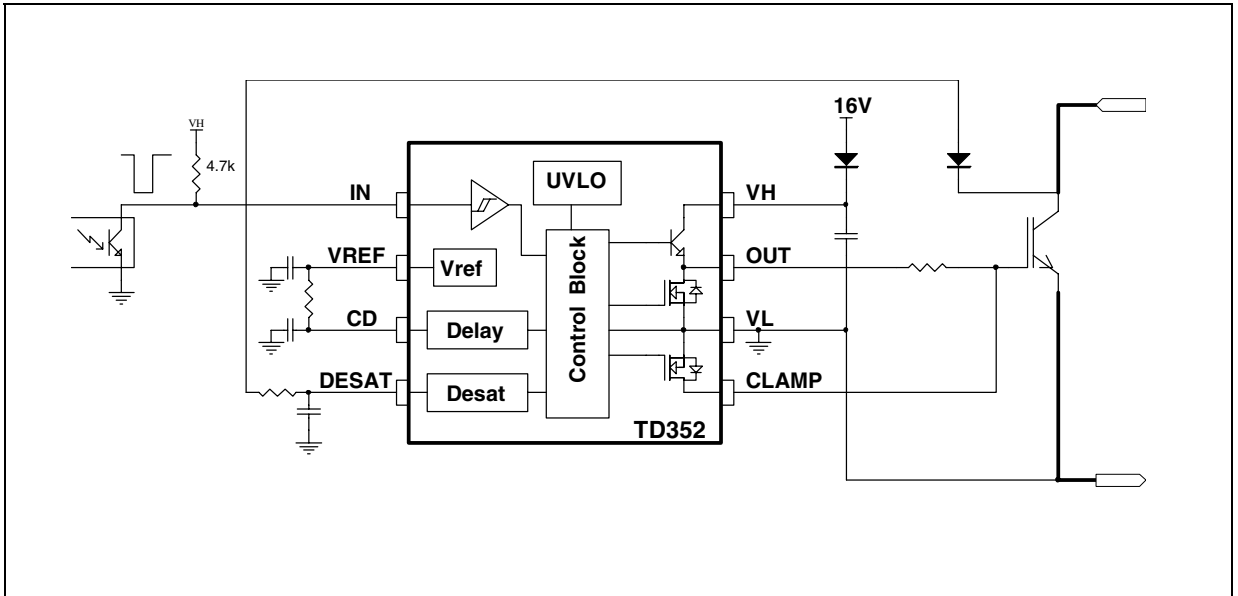


Table 1. Pin Description

| 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 |
| Toper | Operating Free Air Temperature Range | -40 to 125 | °C |

3 Electrical Characteristics

Table 4. $T_{amb} = -20$ to 125°C , $V_H=16\text{V}$ (unless otherwise specified)

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|-------------------------------------|-------------------------------|--|--------|------|------------|---------------------|
| Input | | | | | | |
| 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 | μA |
| Voltage reference - Note 1 | | | | | | |
| Vref | Voltage reference | $T=25^{\circ}\text{C}$ | 4.85 | 5.00 | 5.15 | V |
| Iref | Maximum output current | | 10 | | | mA |
| Clamp | | | | | | |
| Vtclamp | CLAMP pin voltage threshold | | | 2.0 | | V |
| VCL | Clamp low voltage | Icsink=500mA | | | 2.5 | V |
| Delay | | | | | | |
| Vtdel | Voltage threshold | | | 2.5 | | V |
| Rdel | Discharge resistor | I=1mA | | | 500 | Ω |
| Desaturation protection | | | | | | |
| Vdes | Desaturation threshold | | | VH-2 | | ζ |
| I des | Source current | | | 250 | | μA |
| Outputs | | | | | | |
| I sink | Output sink current | Vout=6V | 1000 | 1700 | | mA |
| I src | Output source current | Vout=VH-6V | 750 | 1300 | | 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 μs |
| tdoff | Turn off propagation delay | 10% output change | | | 400 | ns |
| Under Voltage Lockout (UVLO) | | | | | | |
| 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 |
| Supply current | | | | | | |
| Iin | Quiescent current | input low, no load | | | 2.5 | 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

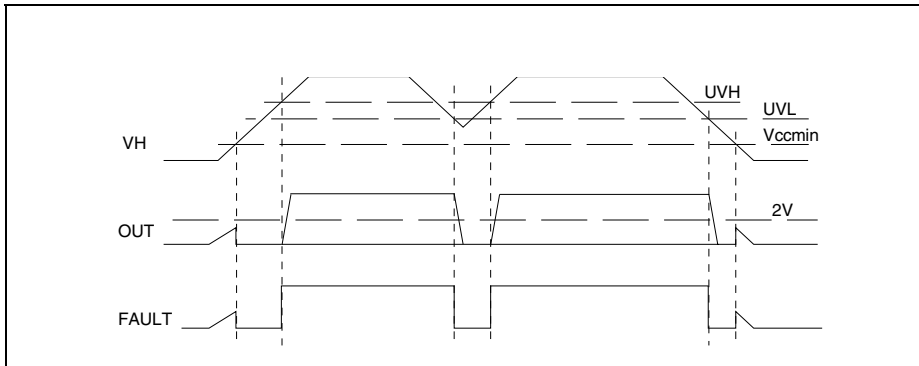
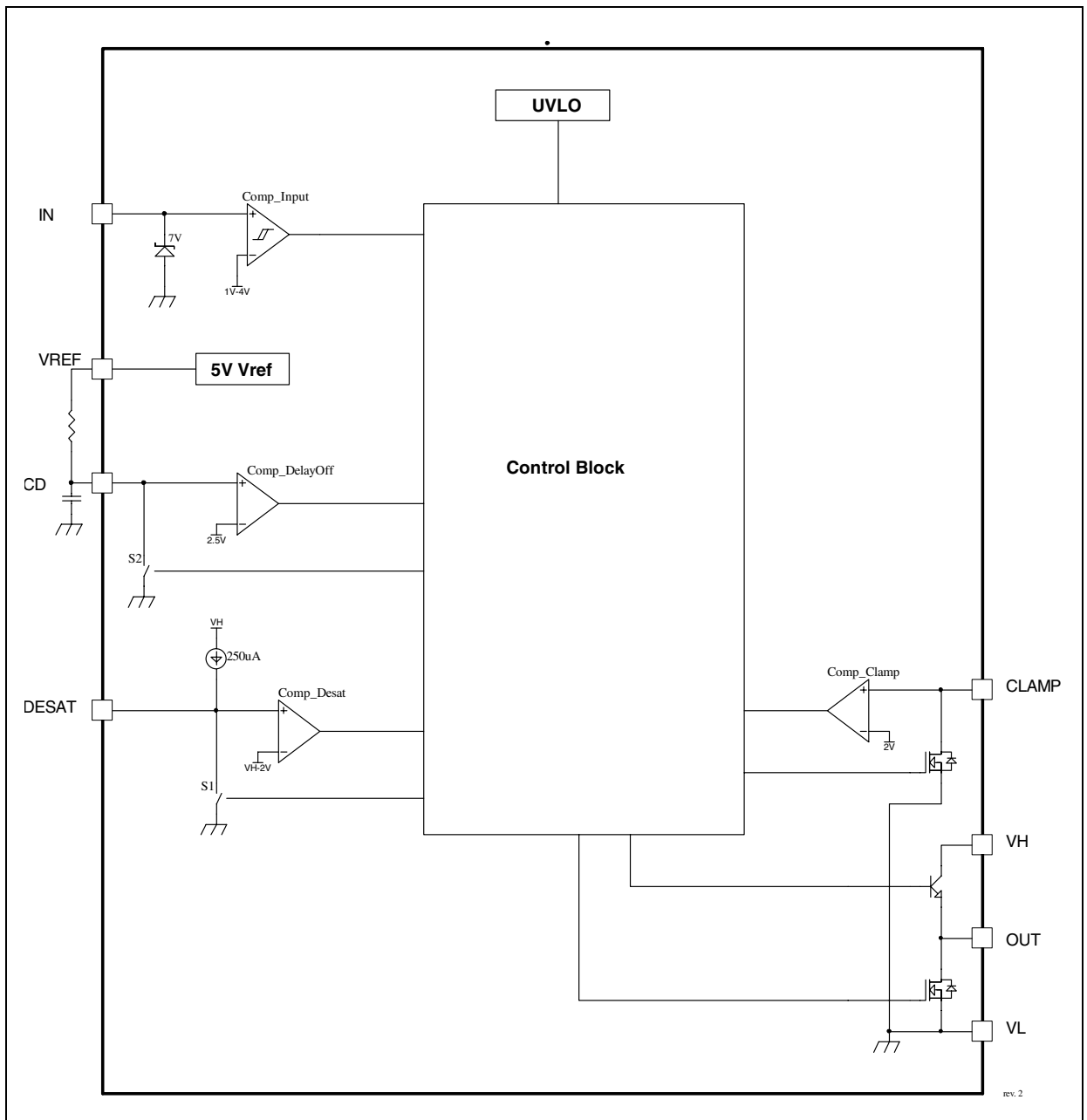


Figure 3. Detailed internal schematic



5 Timing Diagrams

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

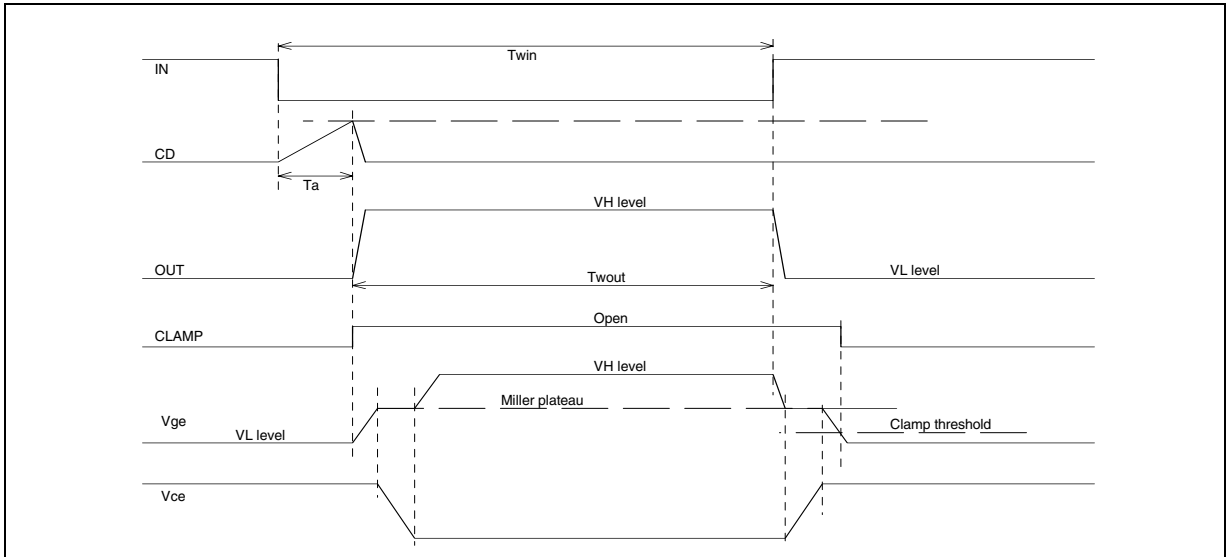


Figure 5. input and output waveform dynamic parameters

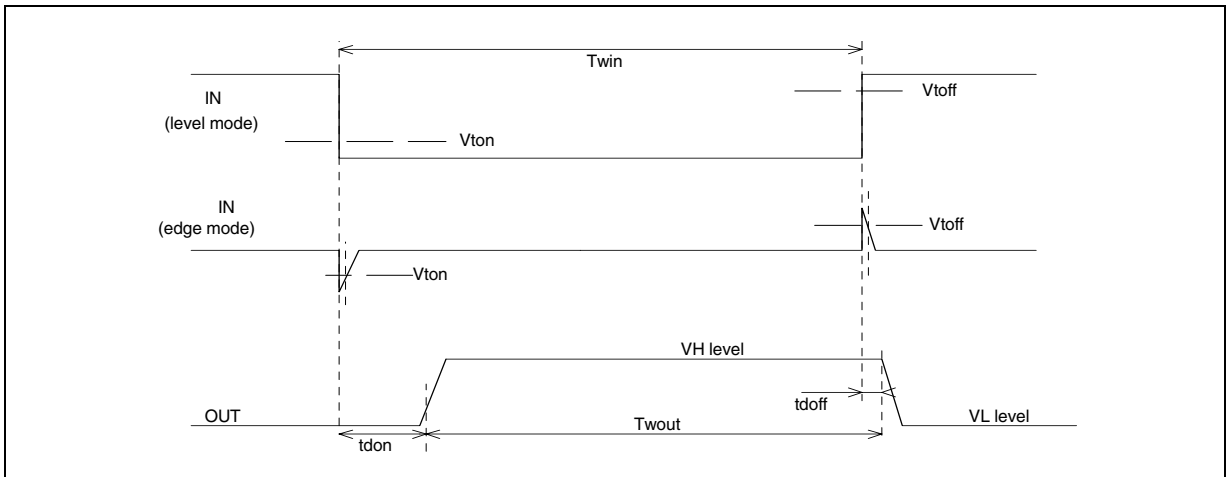
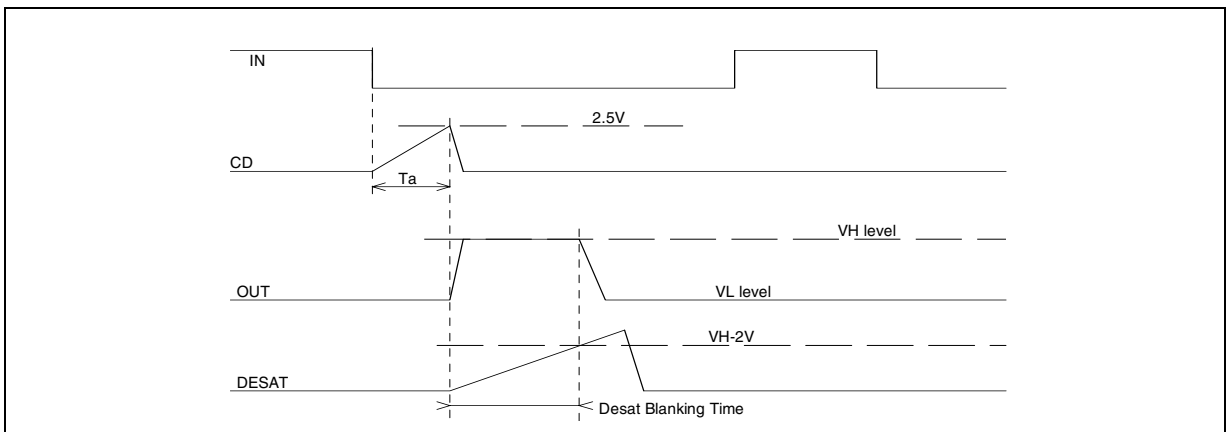


Figure 6. Desaturation fault



6 Typical Performance Curves

Figure 7. Quiescent current vs. temperature

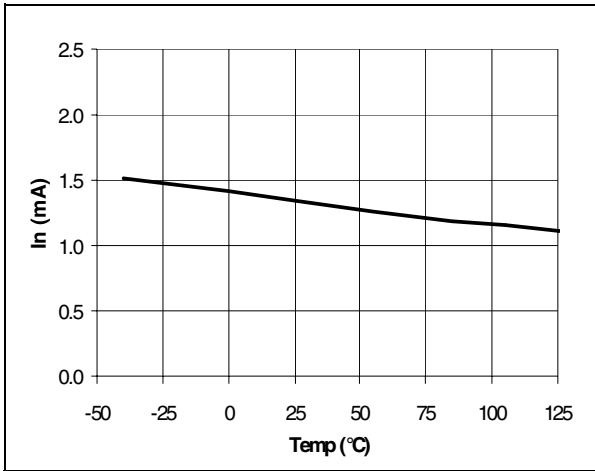


Figure 8. Low level output voltage vs. temperature

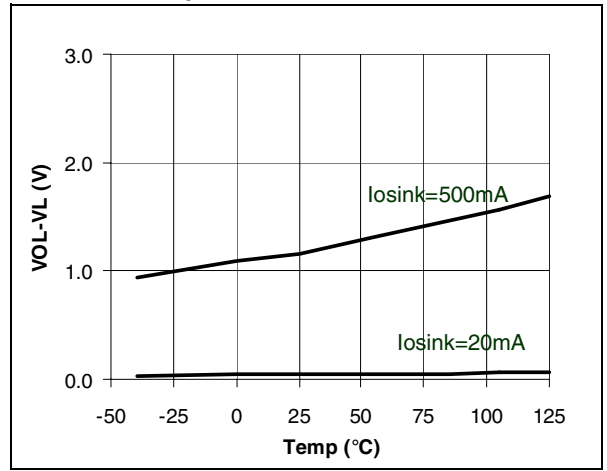


Figure 9. Sink current vs. temperature

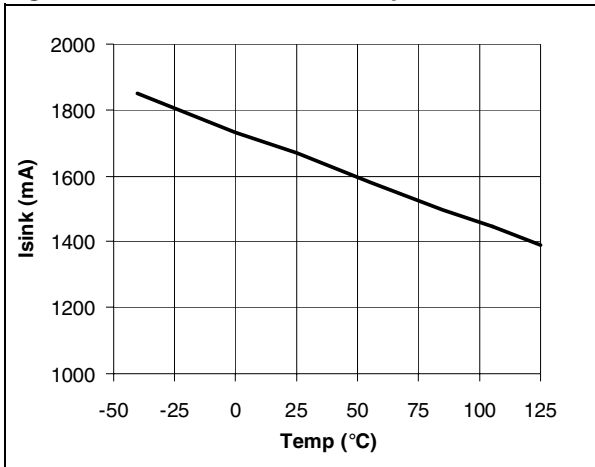


Figure 10. Rdel resistance vs. temperature

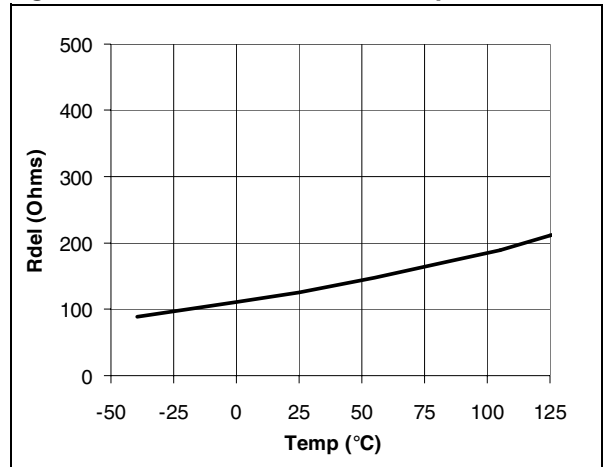


Figure 11. High level output voltage vs. temperature

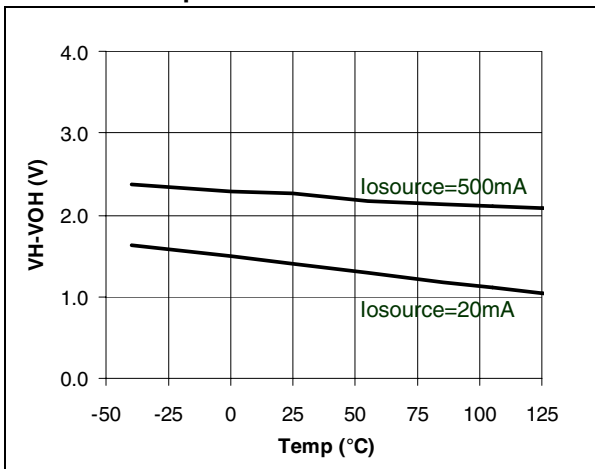
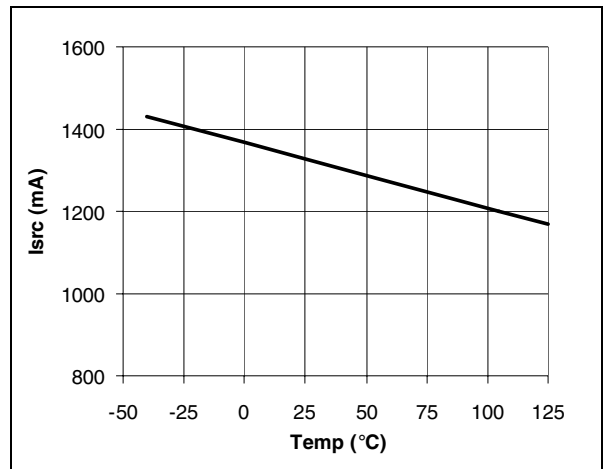


Figure 12. Source current vs. temperature



7 Application Diagrams

Figure 13. Single supply IGBT drive with active Miller clamp

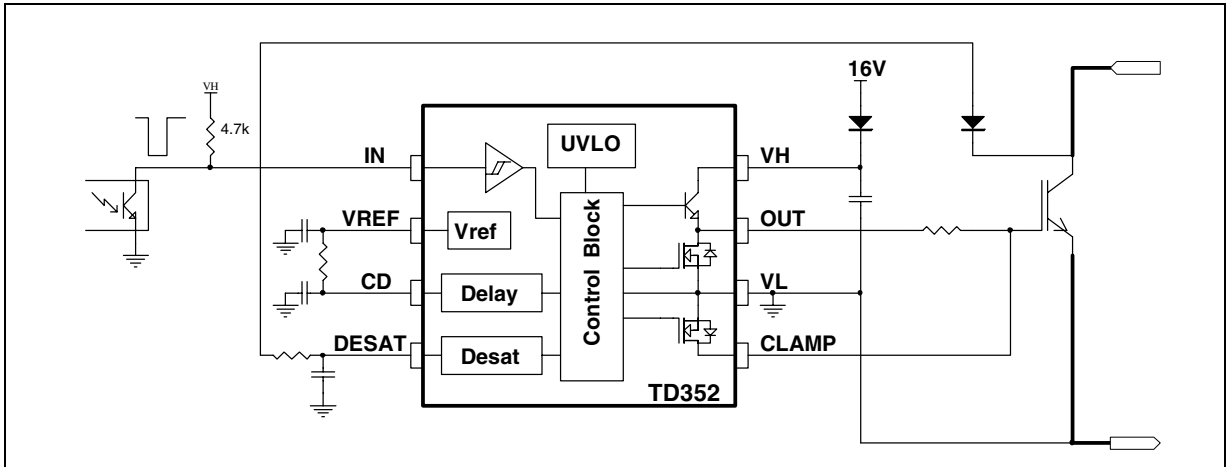


Figure 14. Use of DESAT input for direct overcurrent detection

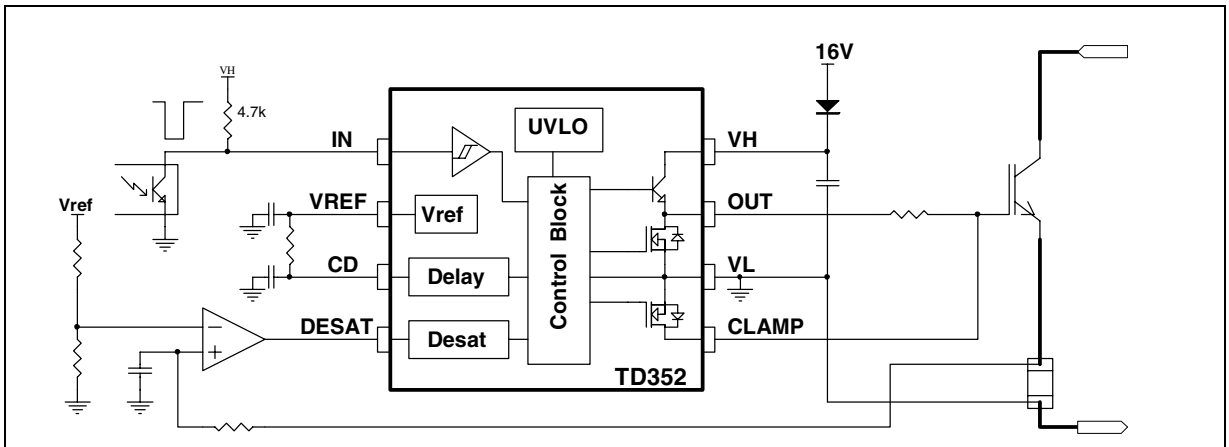
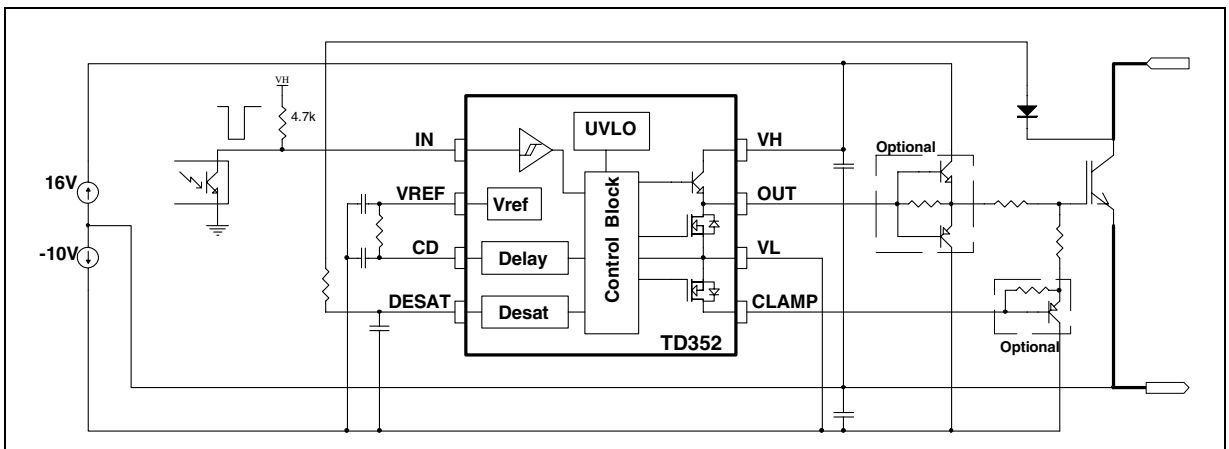


Figure 15. Large IGBT drive with negative voltage gate drive and optional current buffers

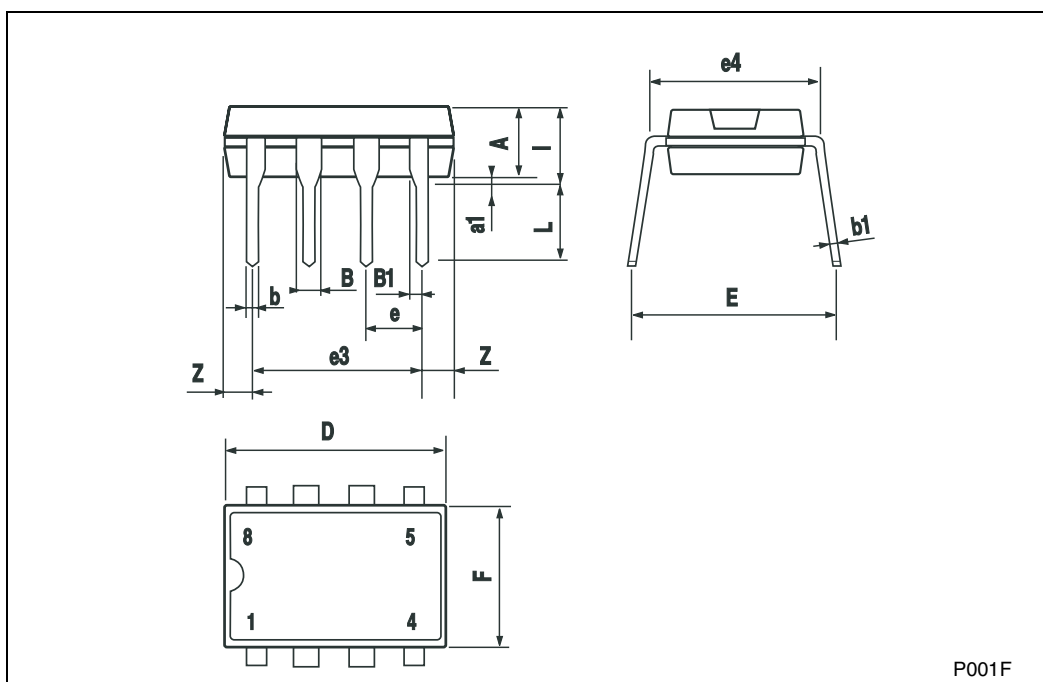


8 Package Mechanical Data

8.1 DIP-8 Package

Plastic DIP-8 MECHANICAL DATA

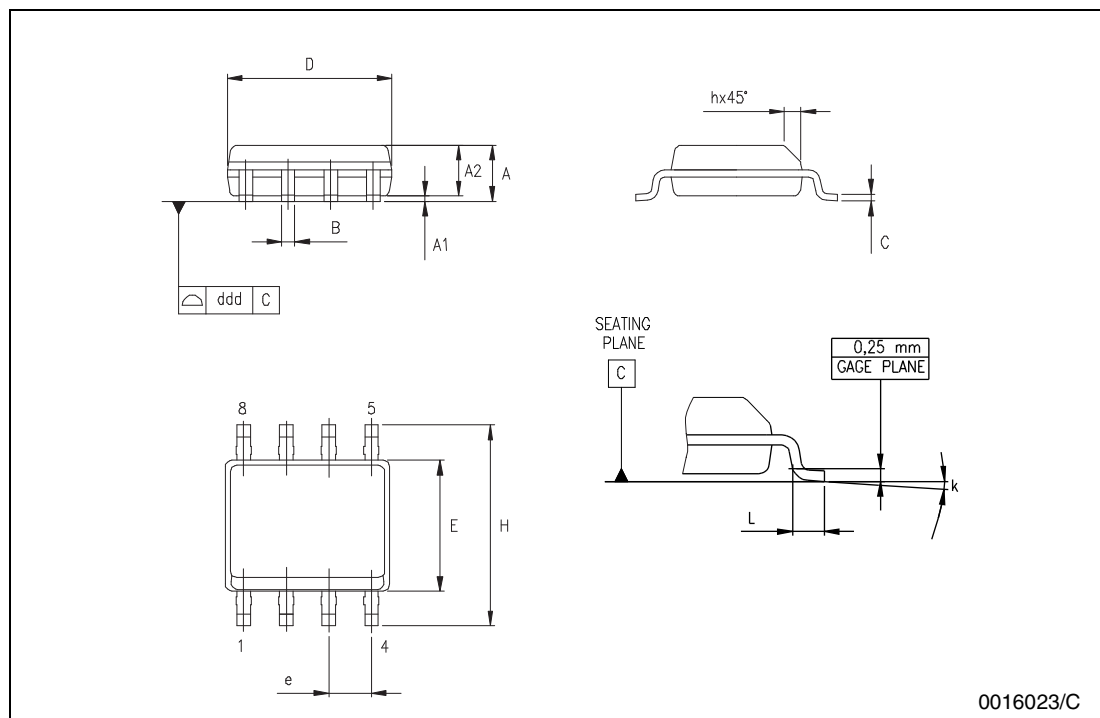
| DIM. | mm. | | | inch | | |
|------|------|------|------|-------|-------|-------|
| | MIN. | TYP | MAX. | MIN. | TYP. | MAX. |
| A | | 3.3 | | | 0.130 | |
| a1 | 0.7 | | | 0.028 | | |
| B | 1.39 | | 1.65 | 0.055 | | 0.065 |
| B1 | 0.91 | | 1.04 | 0.036 | | 0.041 |
| b | | 0.5 | | | 0.020 | |
| b1 | 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 |
| l | | | 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° (max.) | | | | | |
| ddd | | | 0.1 | | | 0.04 |



9 Revision History

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

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