

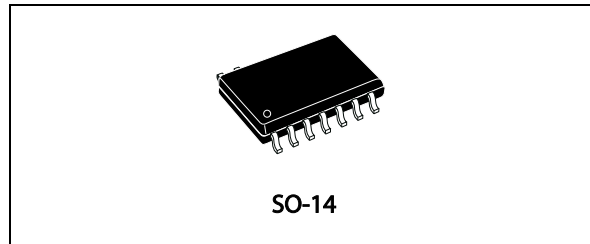
Advanced IGBT/MOSFET driver

Features

- 1.5 A source/2.3 A sink typ 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
- 2 kV ESD protection (HBM)

Applications

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



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.

Table 1. Device summary

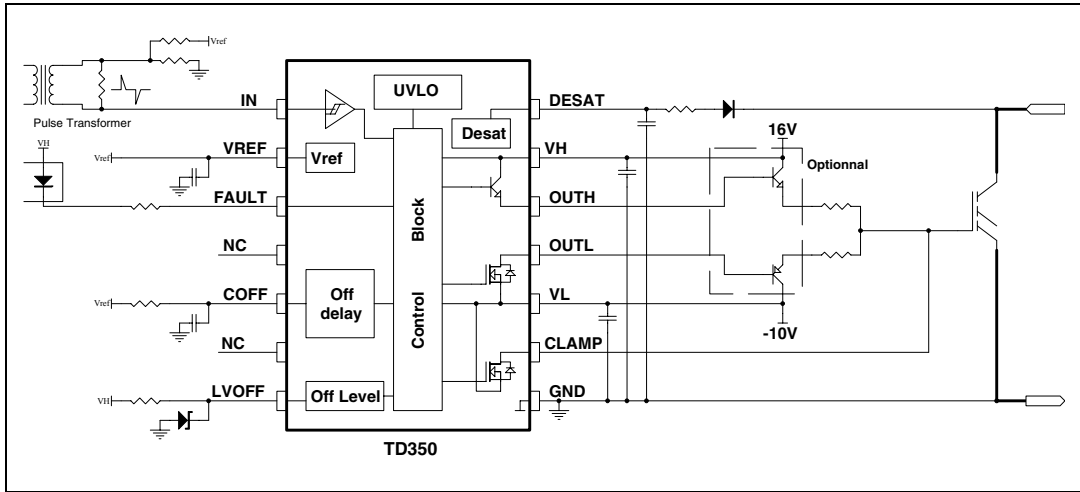
| Order codes | Temperature range | Package | Packaging |
|-------------|-------------------|---------|---------------|
| TD350ID | -40, +125°C | SO-14 | Tube |
| TD350IDT | | | Tape and reel |

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1 Block diagram

Figure 1. Schematic block diagram



2 Pin connections

Figure 2. Pin connections (top view)

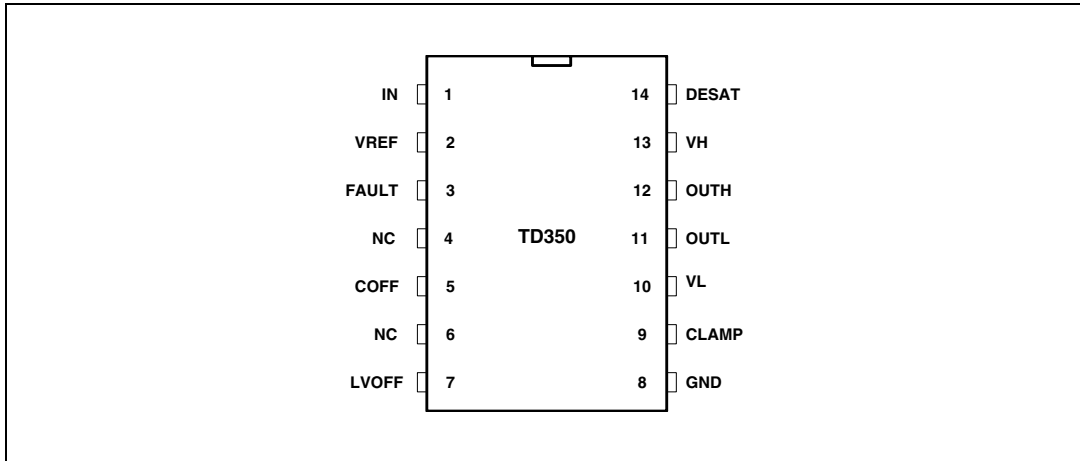


Table 2. Pin description

| 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 |

3 Absolute maximum ratings

Table 3. 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 |
| V _{out} | Voltage on OUTH, OUTL, CLAMP pins | VL-0.3 to VH+0.3 | V |
| V _{des} | Voltage on DESAT, FAULT, LVOFF pin | -0.3 to VH+0.3 | V |
| V _{other} | Voltage on other pins (IN, COFF, 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 | 125 | °C/W |
| R _{thjc} | Thermal resistance junction-case | 22 | °C/W |
| ESD | Electrostatic discharge (HBM) | 2 | kV |

Table 4. 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 |
| T _{oper} | Operating free air temperature range | -40 to 125 | °C |

4 Electrical characteristics

$T_A = -20$ to 125 °C, $V_H=16$ V, $V_L=-10$ 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 |
| t_{onmin} | Minimum pulse width | | 100 | 135 | 220 | ns |
| I_{inp} | IN input current | | | | 1 | μ A |
| Voltage reference ⁽¹⁾ | | | | | | |
| V_{ref} | Voltage reference | $T=25^\circ\text{C}$ $T_{min}<T<T_{max}$ | 4.85 4.77 | 5.00 | 5.15 5.22 | V V |
| I_{ref} | Maximum output current | | 10 | | | mA |
| Desaturation protection | | | | | | |
| V_{des} | Desaturation threshold | | 6.5 | 7.2 | 7.9 | V |
| I_{des} | Source current | | | 250 | | μ A |
| Fault output | | | | | | |
| t_{fault} | Delay for fault detection | | | | 500 | ns |
| V_{FL} | FAULT low voltage | $I_{FLsink}=10\text{mA}$ | | | 1 | V |
| Clamp | | | | | | |
| V_{tclamp} | CLAMP pin voltage threshold | | | 2.0 | | V |
| V_{CL} | Clamp low voltage | $T=25^\circ\text{C}; I_{CLsink}=500\text{mA}$ $T_{min}<T<T_{max}; I_{CLsink}=500\text{mA}$ | | | VL+2.5 VL+3.0 | V V |
| Off delay | | | | | | |
| V_{tdel} | Voltage threshold | | 2.35 | 2.50 | 2.65 | V |
| R_{del} | Discharge resistor | $I=1\text{mA}$ | | | 500 | Ω |
| Off levels | | | | | | |
| I_{blvoff} | LVOFF peak input current (sink) | LVOFF=12V | | 120 | 200 | μ A |
| V_{iolv} | Offset voltage | LVOFF=12V | -0.3 | -0.15 | 0 | V |
| Outputs | | | | | | |
| V_{OL1} | Output low voltage at $I_{osink}=20\text{mA}$ | | | | VL+0.35 | V |
| V_{OL2} | Output low voltage at $I_{osink}=200\text{mA}$ | $T=25^\circ\text{C}$ $T_{min}<T<T_{max}$ | | | VL+1.0 VL+1.5 | V V |

Table 5. Electrical characteristics (continued)

| Symbol | Parameter | Test condition | Min | Typ | Max | Unit |
|-------------------------------------|---|--|--------|-----|--------|------|
| V _{OL3} | Output low voltage at I _{osink} =500mA | T=25°C | | | VL+2.5 | V |
| | | T _{min} <T<T _{max} | | | VL+3.0 | V |
| V _{OH1} | Output high voltage 1 | I _{osource} =20mA | VH-2.5 | | | V |
| V _{OH2} | Output high voltage 2 | I _{osource} =200mA | VH-3.0 | | | V |
| V _{OH3} | Output high voltage 3 | I _{osource} =500mA | VH-4.0 | | | V |
| t _r | Rise time | C _L =1nF, 10% to 90% | | | 130 | ns |
| | | VL=0 VL=-10V | | | 175 | ns |
| t _f | Fall time ⁽²⁾ | C _L =1nF, 90% to 10% | | | 75 | ns |
| | | VL=0 VL=-10V | | | 90 | ns |
| t _{pd_on} | Turn-on propagation delay | 10% output change; T=25°C | 400 | 500 | 600 | ns |
| | | 10% output change; T _{min} <T<T _{max} | 350 | | 650 | ns |
| t _{pd_off} | Turn-off propagation delay | 10% output change; T=25°C | 350 | 450 | 570 | ns |
| | | 10% output change; T _{min} <T<T _{max} | 300 | | 620 | ns |
| Δtw | Input to output pulse distortion | 10% output change | 25 | 50 | 120 | ns |
| 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 | Output=0V, no load | | | 5 | mA |

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

2. 2 step turn-off disabled

5 Functional description

5.1 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} .

5.2 Voltage reference

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

5.3 Desaturation protection

Desaturation protection ensures the protection of the IGBT in the event of overcurrent. When the DESAT voltage goes higher than 7 V, 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.

5.4 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 2 V (relative to GND). The clamp voltage is V_L+3 V max for a Miller current up to 500 mA. The clamp is disabled when the IN input is triggered again.

5.5 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.

5.6 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.

5.7 Output

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

5.8 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.

5.9 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 $V_H > 2$ V, passive pull-down for $V_H < 2$ V). Fault output signals the undervoltage state and is reset only when undervoltage state disappears.

Figure 3. Undervoltage protection

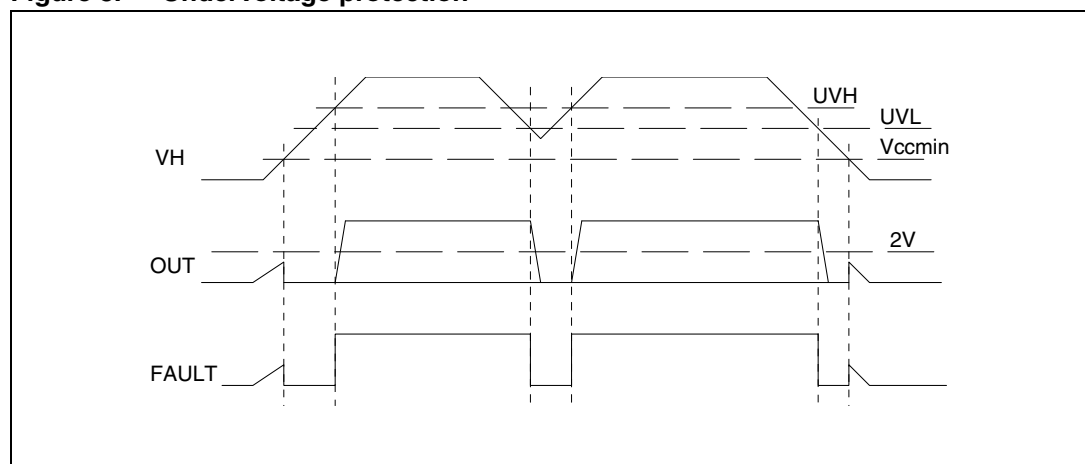
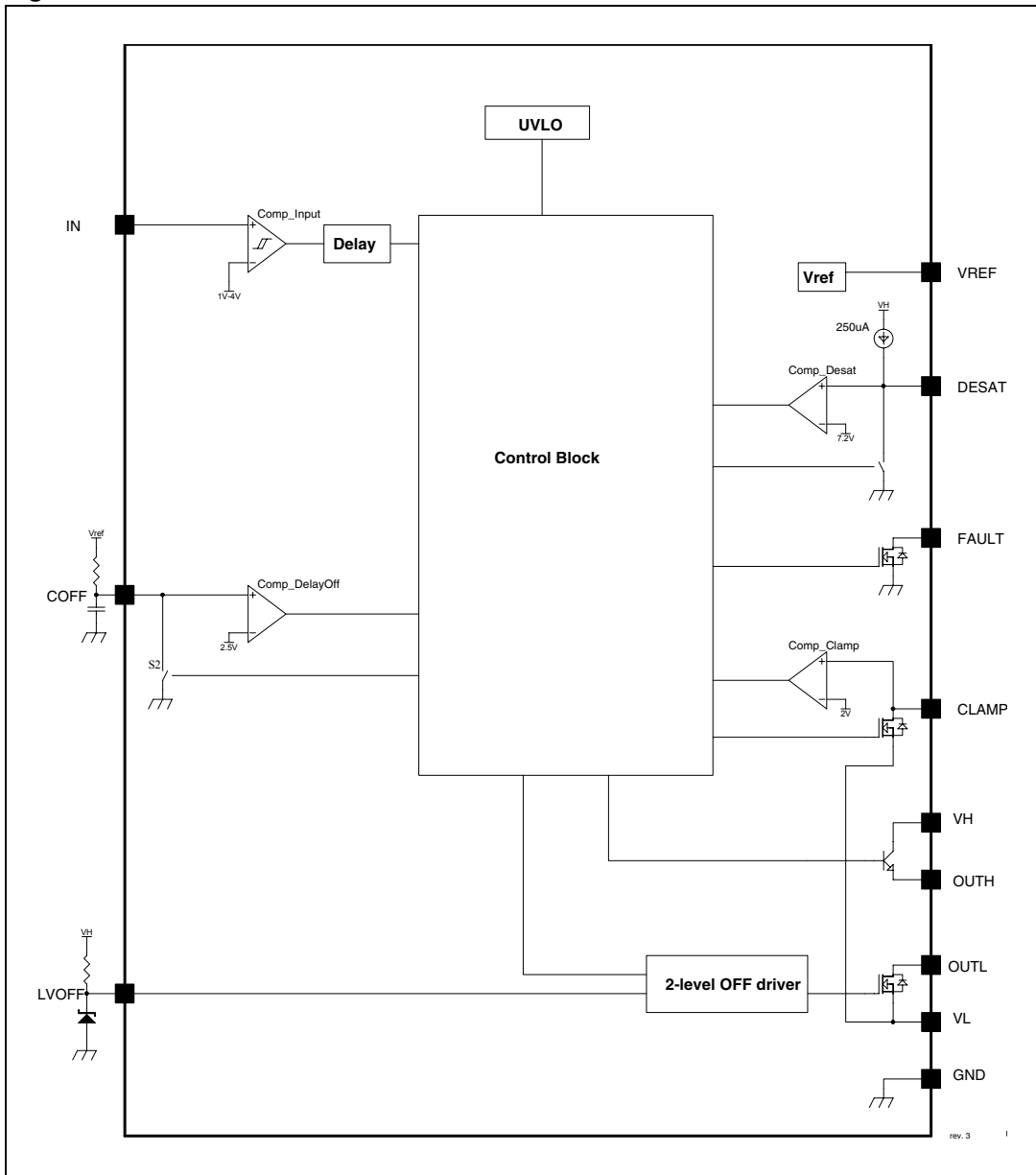


Figure 4. Detailed internal schematic



6 Timing diagrams

Figure 5. Turn-on and turn-off

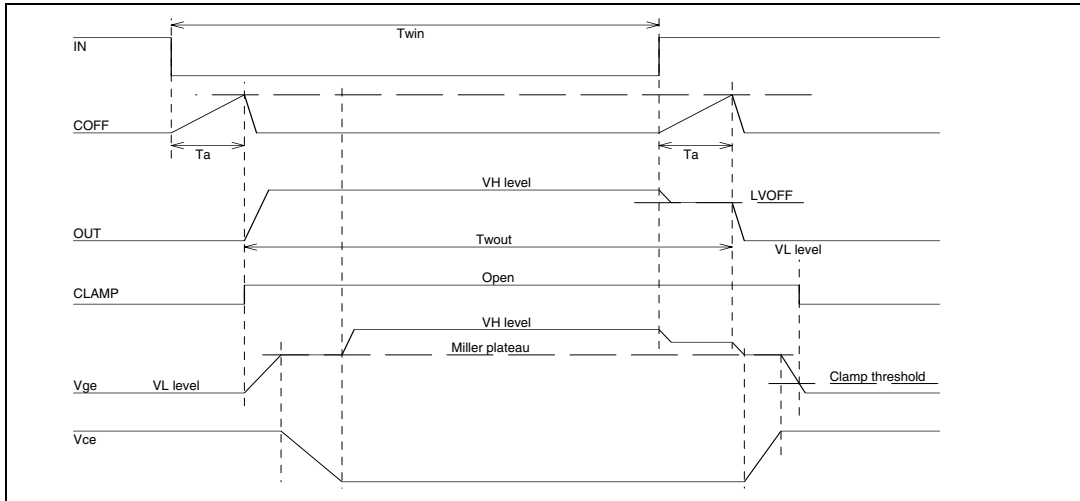


Figure 6. Minimum ON time

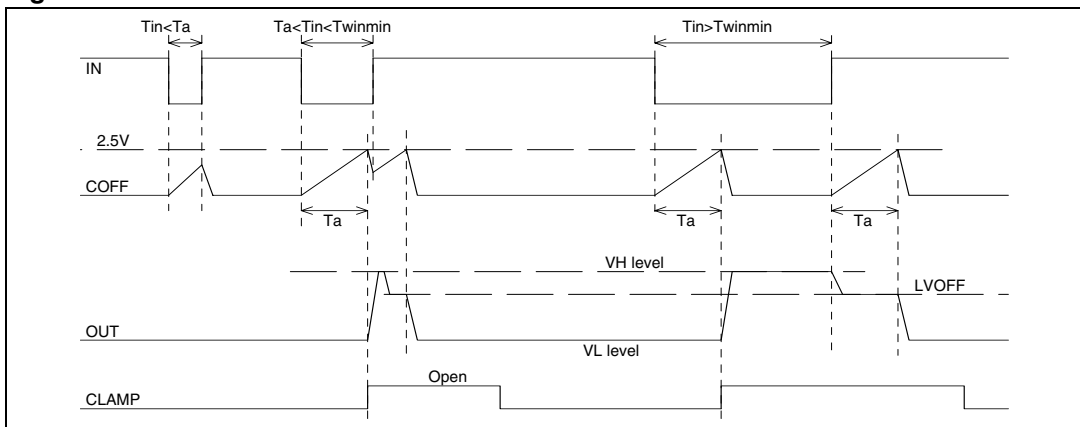
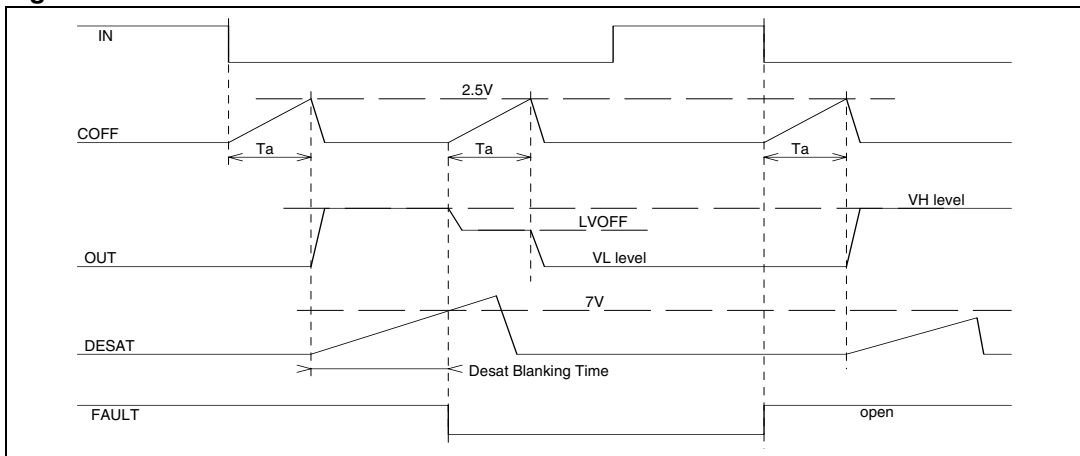


Figure 7. Desaturation fault



7 Typical performance curves

Figure 8. Supply current vs temperature

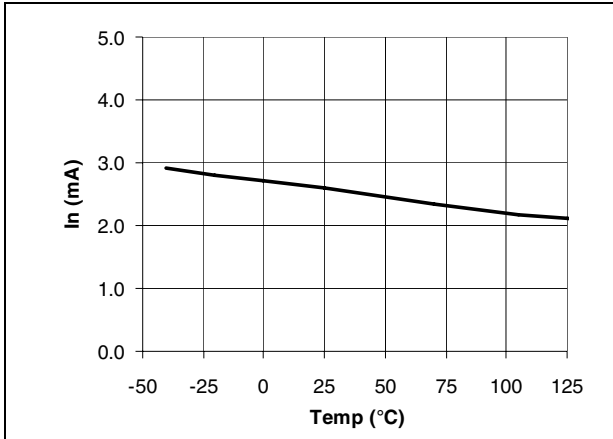


Figure 9. Low level output voltage vs temp.

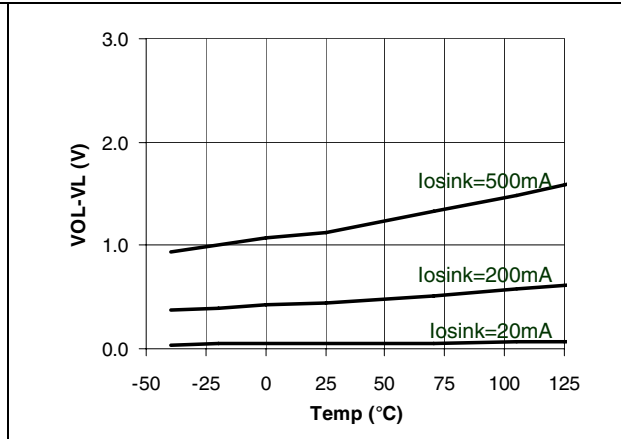


Figure 10. Desaturation threshold vs temp.

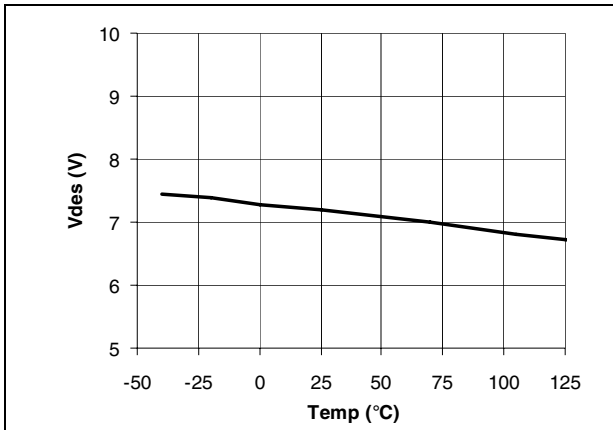


Figure 11. Voltage reference vs temp.

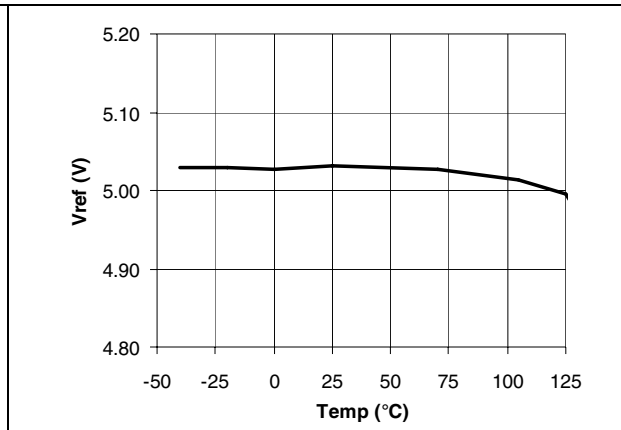


Figure 12. High level output voltage vs temp.

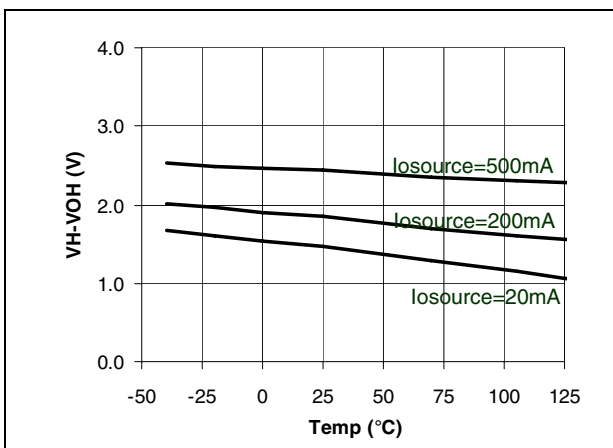
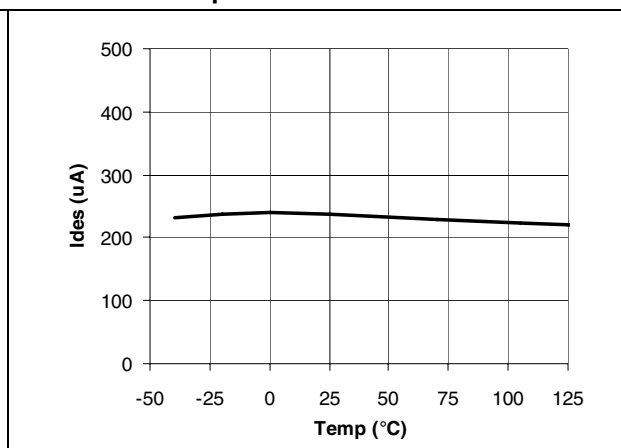


Figure 13. Desaturation source current vs temp.



8 Application diagrams

Figure 14. Single supply IGBT drive with active Miller clamp and 2-level turn-off

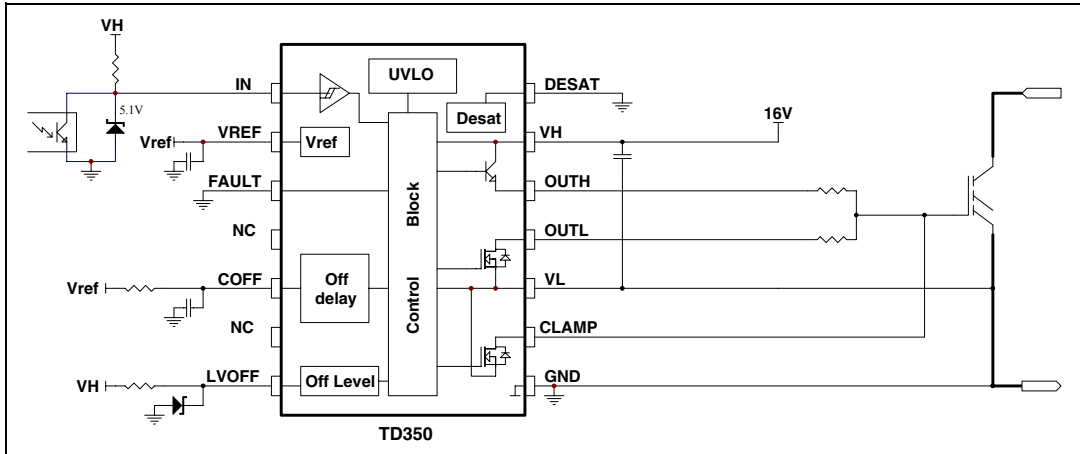


Figure 15. Large IGBT drive with negative gate drive and desaturation detection

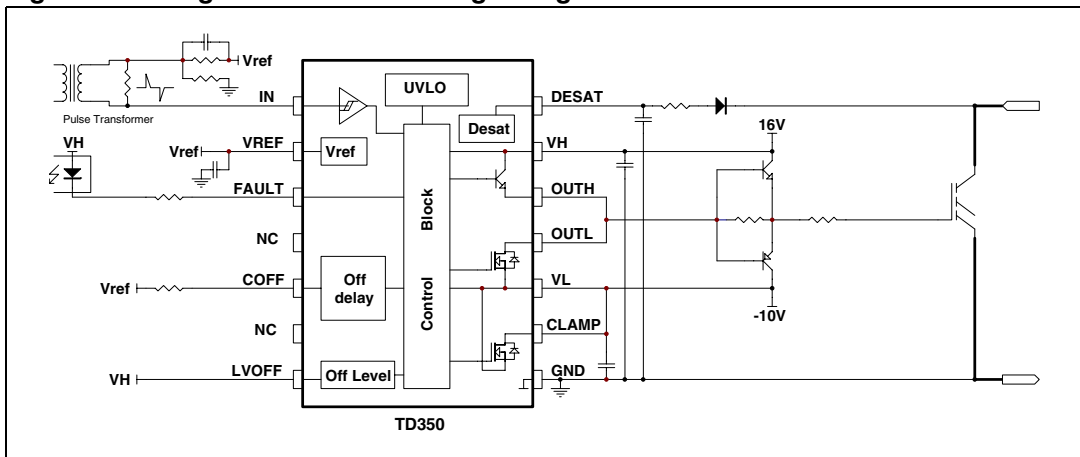
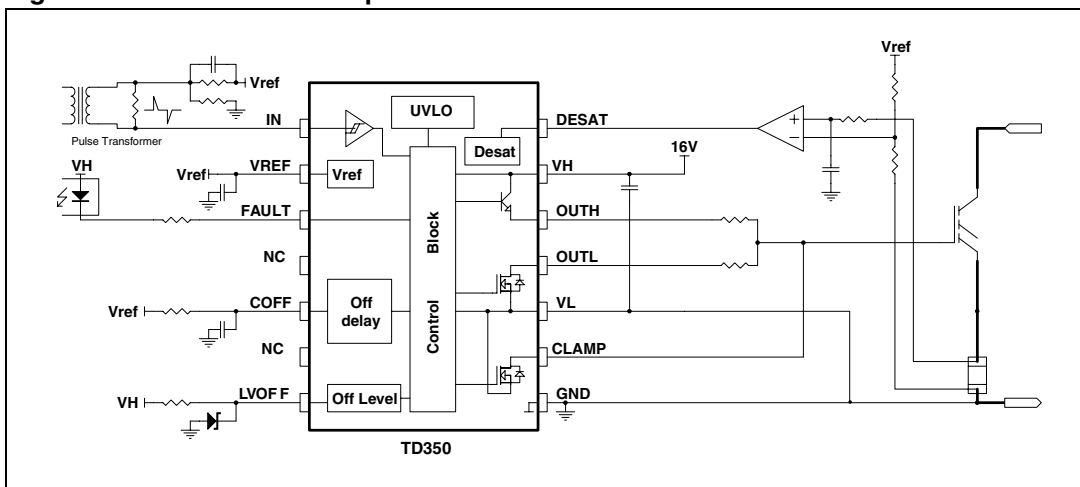


Figure 16. Use of DESAT input for direct overcurrent detection



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-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.) | | | | | |

10 Revision history

Table 7. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| | 3 | No history because migration |
| 01-Aug-2004 | 4 | Updated: Coverpage and Figure 7 |
| 17-Feb-2010 | 5 | Updated: Coverpage, Table 3 , Table 5 and Figure 16 |
| 28-Apr-2010 | 6 | Updated: Table 5 |

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