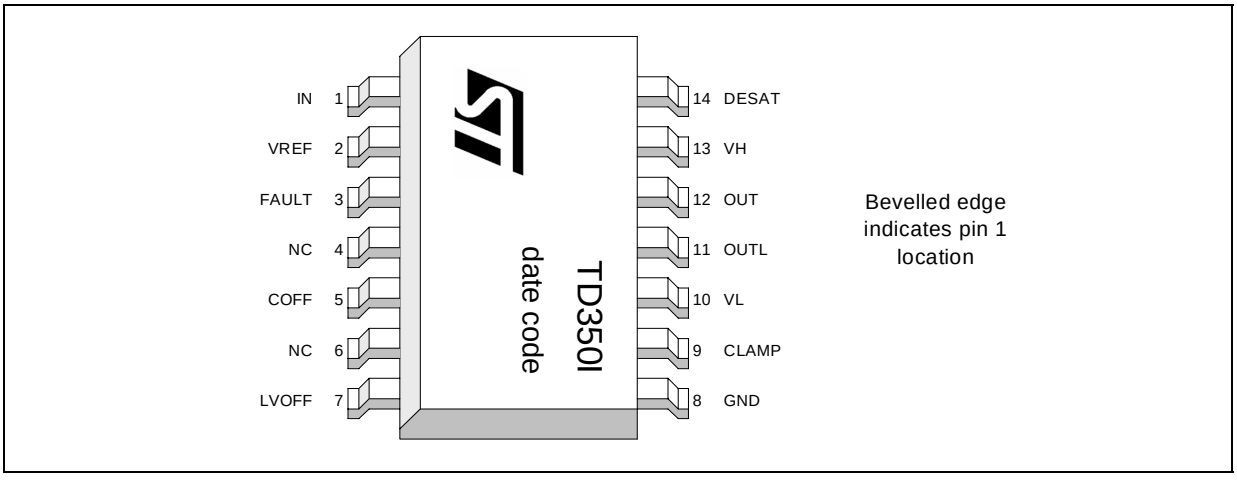
Using the Demoboard for the TD350 Advanced IGBT Driver

1 Introduction

TD350 is an advanced IGBT/MOSFET driver with integrated control and protection functions. Principles of operation and application examples for the TD350 are described extensively in application note AN1944. The present application note concerns the characteristics and use of the demoboard available for testing the TD350.

Figure 1: TD350 pinout



2 Printed circuit board presentation

The demoboard is a 26x35mm double-sided PCB with the TD350 and its peripheral components mounted in a typical configuration (pictured in *Figure 2*). To aid in the understanding and easy modification of the board, the PCB top-side and bottom-side layers, as well as the silk-screen previews are shown in *Figure 3*.

The demoboard electrical schematic is presented on *Figure 4*, and the associated bill of material can be found on *Table 1* on page 5.

Let's study step by step the demoboard original configuration, and the way it can be modified to be adapted to the application.

Figure 2: Demoboard layout

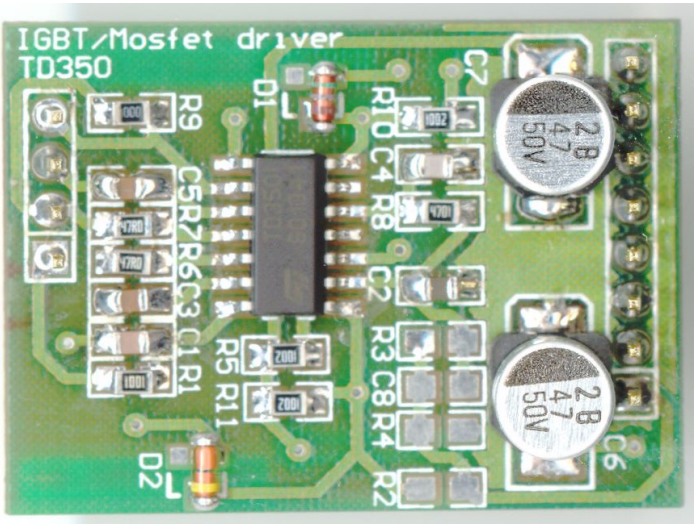
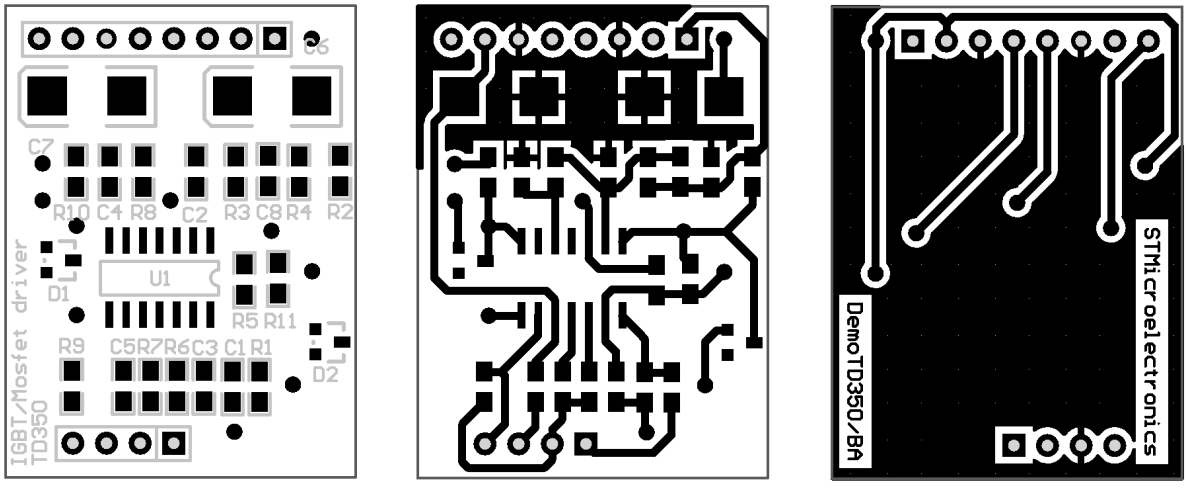


Figure 3: Demoboard PCB: Silk-screen, top-layer and bottom-layer previews



2.1 Input stage

The TD350 can be driven by either a pulse transformer or an optocoupler. The demoboard is set up to use an optocoupler. The TD350 IN pin is clamped to 5V by a zener diode D2 and its bleeding resistor R11=10K (see demoboard schematic on *Figure 4*). To interface the demoboard with the system, the IN1 pin of the input connector can simply be connected to a low-side optocoupler, as show on *Figure 5*. An optional filtering capacitor can be added (for instance 47pF) in the event of a highly noisy environment, although the TD350 already includes a filtering on input signals and rejects signals smaller than 100ns (t_{onmin} specification).

The demoboard can be modified to be driven by a pulse transformer by implementing the optional components R2, R3, R4 and C8. The principle of operation with a pulse transformer is explained in AN1944.

2.2 Output stage

The TD350 uses separate sink and source outputs (OUTL/OUTH) for easy gate driving. The integrated circuit output stage is able to sink/source about 2A/1.5A typical at 25°C, but the IGBT turn-on and turn-off current can be limited independently by the gate resistors R6 and R7 included on the demoboard. The original value for these resistors are R6=R7=47R.

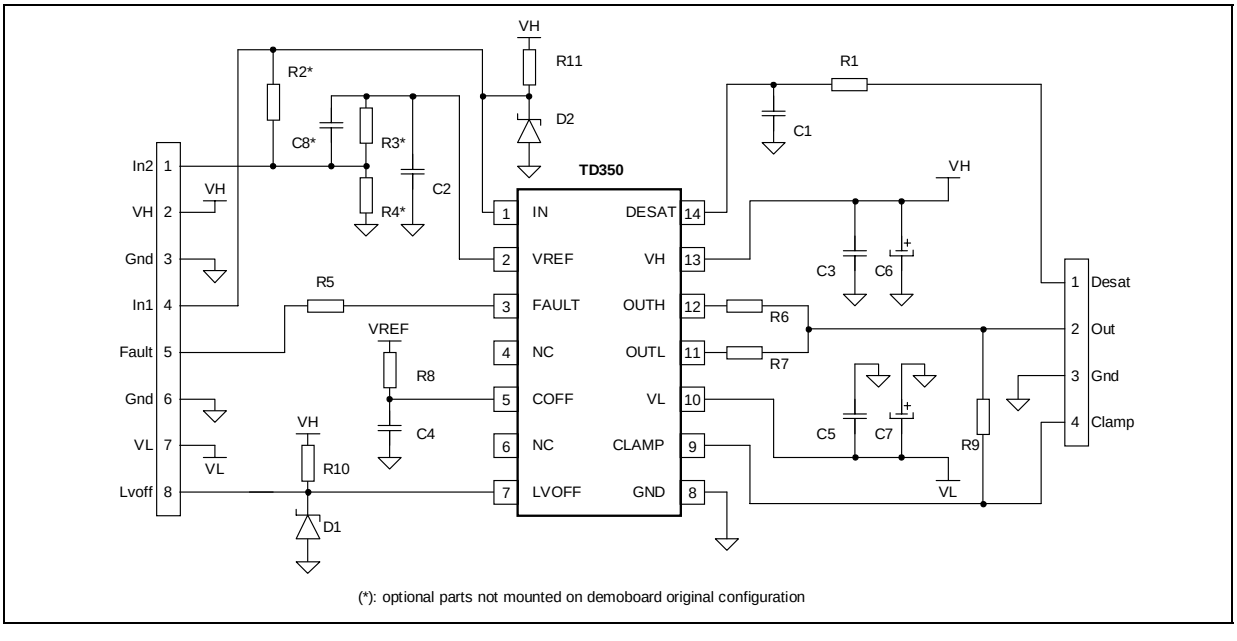
Output current capability can be increased by using an external buffer with two low-cost bipolar transistors. This configuration is described in *Section 4* on page 7.

2.3 Active Miller Clamp

The TD350 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 TD350 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. The CLAMP switch is opened when the input is activated and is closed when the actual gate voltage goes close to the ground level. In this way, the CLAMP function doesn't affect the turn-off characteristic, but only keeps the gate to the low level throughout the off time.

On the demoboard, the CLAMP pin is connected to the IGBT gate by strap R9. This strap can be removed when the clamp feature is not needed, or when an external buffer is used (see reference schematic on *Figure 6*).

Figure 4: Demoboard PCB: Electrical Schematic



2.4 2-level turn-off

In the event of a short-circuit or overcurrent in the load, a large voltage overshoot can occur across the IGBT at turn-off and can exceed the IGBT breakdown voltage. By reducing the gate voltage before turn-off, the IGBT current is limited and the potential overvoltage is reduced. This technique is called 2-level turn-off. Both the level and duration of the intermediate off level are adjustable. Duration is set by the external resistor R8 and capacitor C4 in conjunction with the integrated voltage reference for accurate

timing. The level can be easily set by an external Zener diode D1, and its value is chosen depending on the IGBT characteristics. This 2-level turn-off sequence takes place at each cycle, it has no effect if the current doesn't exceed the normal maximum rated value, but protects the IGBT in case of overcurrent (with a slight increase of conduction losses).

In the demoboard original configuration, Ta (duration of the intermediate level) is set to approximately 1.5µs by R8=4K7 and C4=470pF. The intermediate level is set by 10V Zener diode D1 and bleeding resistor R11=10K.

Tip: *How can you inhibit 2-level turn-off?*
Connect LVOFF to VH by replacing R10 by a short-circuit, remove C4 capacitor and keep COFF pin connected to Vref by R8=4K7.

2.5 Desaturation protection feature

The desaturation function provides a protection against overcurrent events. Voltage across the IGBT is monitored, and the IGBT is turned off if the voltage threshold is reached. A blanking time, t_b, is set using an internal 250mA current source and an external capacitor C1. The DESAT pin is connected to output demoboard connector by R1 resistor. In order to implement the desaturation feature, an external high voltage diode (1kV or more) should be connected between the IGBT collector and the demoboard output connector pin 1 (see *Figure 6* for reference schematic).

The high voltage diode blocks the high voltage during IGBT off state. This diode doesn't need to be fast, a standard 1kV (or more) diode is acceptable.

During operation, the DESAT capacitor is discharged when TD350 output is low (IGBT off). When the IGBT is turned on, the DESAT capacitor starts charging and desaturation protection is effective after the blanking time, t_b, has elapsed:

$$t_b = 7.2V \times \frac{C_1}{250\mu A}$$

With the capacitor used in the demoboard (C1=100pF), the blanking time value will be close to 3ms.

Tip: *What should one do with the DESAT pin when it isn't used?*
Connect DESAT to GND by shorting together pin 1 and pin 3 on the demoboard output connector (see Figure 5).

Table 1: Bill of materials for demoboard

Designator	Description	Value	Package
R1	desaturation resistor	1K-1%	0805
C1	desaturation filtering capacitor	100pF-X7R	0805
C3	positive supply ceramic decoupling capacitor	100nF-X7R	0805
C5	negative supply ceramic decoupling capacitor	100nF-X7R	0805
C6	positive supply electrolytic capacitor	47µF-50V	d6.3 x h7.7
C7	negative supply electrolytic capacitor	47µF-50V	d6.3 x h7.7
R6	turn-on gate drive resistor	47R-1%	0805
R7	turn-off gate drive resistor	47R-1%	0805
R9	strap (optional)	0R	0805
R11	bleeding resistor for Zener diode D2	10K-1%	0805
C2	Vref decoupling capacitor	10nF-X7R	0805
R5	FAULT pin pull-up resistor	10K-1%	0805
R8	2-level turn-off timing resistor	4K7-1%	0805
C4	2-level turn-off timing capacitor	470pF-X7R	0805
R10	bleeding resistor for Zener diode D1	10K-1%	0805
D1	Zener diode for 2-level turn-off intermediate level programming	10V	Melf
D2	Zener diode for IN pin level	5V1	Melf
U1	IGBT/MOSFET driver	TD350	SO-14
J1	Input connector		8-lead
J2	Output connector		4-lead
C8	Vref/2 filtering capacitor	not mounted	0805
R4	Vref/2 divider bridge lower resistor (only with pulse transformer)	not mounted	0805
R3	Vref/2 divider bridge upper resistor (only with pulse transformer)	not mounted	0805
R2	adjustment resistor (only with pulse transformer)	not mounted	0805

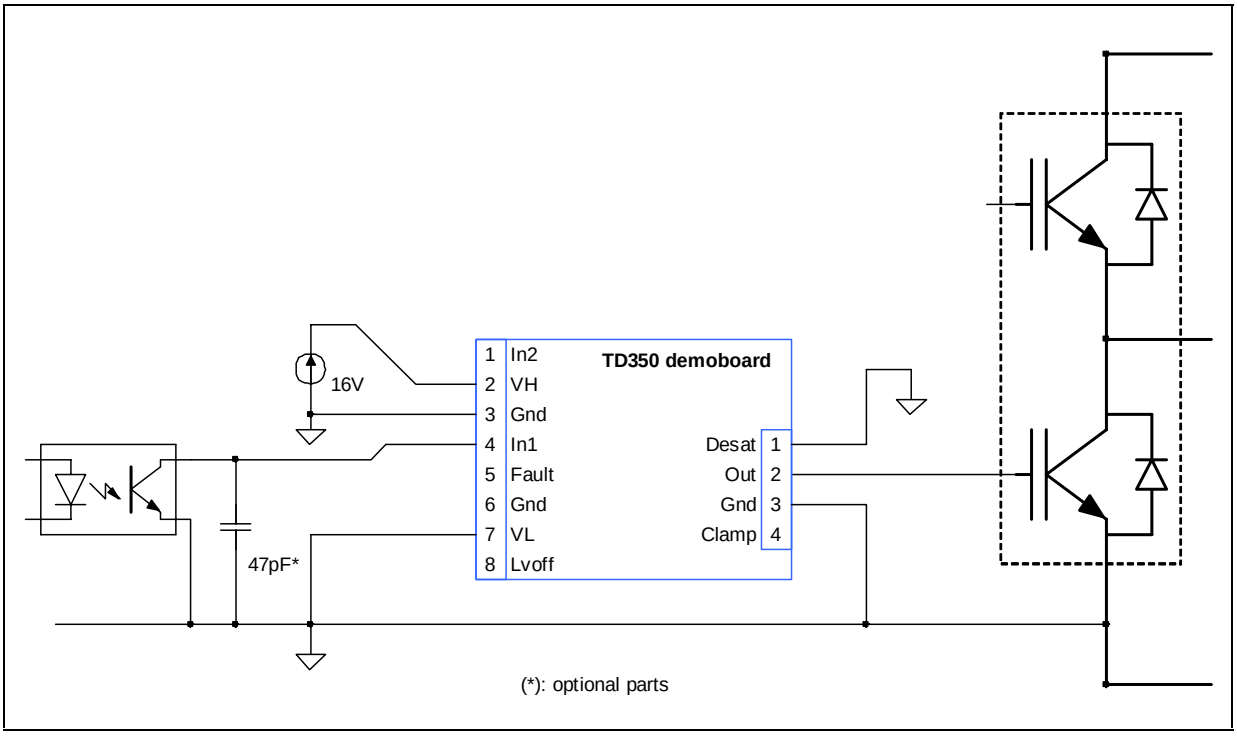
3 Application example no. 1

This first application example demonstrates the typical configuration in which TD350 can be used in low and medium power applications. In this configuration, the TD350 is able to drive IGBTs with current ratings up to about 50A. The schematic showing how to connect the demoboard to the optocoupler, power supply and IGBT module is presented on *Figure 5*. The demoboard doesn't require any modification in order to be used in this configuration. However, it should be noted that C5 and C7 (decoupling capacitors for negative supply) are not needed in this example and they could be removed to optimize application cost and PCB space.

The main characteristics of this example are:

- **Single Supply**: with the benefit of the Active Miller Clamp feature, negative supply isn't needed to avoid mistriggering of the IGBT at turn-off
- **Active Miller Clamp**: the feature is implemented on the demoboard by connecting TD350 CLAMP pin to the IGBT gate with R9=0R resistor
- **2-Step Turn-Off**: at turn-off the gate-to-source voltage will be lowered to 10V during approximately 1.5µs to reduce over-voltage stress on the IGBT in case of over-current event
- **DESAT not used**: to simplify the design DESAT pin is connected to GND to inhibit the function. To implement the desaturation protection, see *Section 2.5*.

Figure 5: TD350 demoboard used in basic application



4 Application example no.2

This second application example shows the typical configuration in which the TD350 can be used in high power applications. With the use of an additional buffer, the TD350 can drive IGBTs with a current rating above 100A. The schematic in *Figure 6* shows how to connect the demoboard with the optocoupler and the power supplies on the input side, and with the IGBT module and the gate buffer circuit on the output side.

The demoboard needs a few modifications with respect to its original configuration to be used as shown in this example:

1) The R9 strap should be removed.

2) The resistors R6 and R7 should be replaced by short-circuits.

The main characteristics of this example are:

- **A dual supply** +16V/-10V is used as often needed in high power applications,
- **Output buffer stage**: considering the high value of the IGBT gate capacitance, the TD350 output is connected to a discrete buffer stage made of two complementary bipolar transistors,
- **CLAMP used as secondary gate discharge**: the CLAMP pin is connected to a external buffer to feature a secondary gate discharge,
- **DESAT feature is implemented**.

Figure 6: TD350 demoboard used in high power applications