



**THE DATASHEET OF
1EDI20I12MFXUMA1**



EiceDRIVER™ 1EDI Compact (1ED-MF)

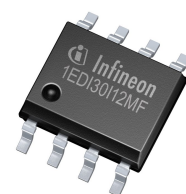
Single channel isolated gate driver IC with clamp

Features

- Single channel isolated gate driver
- For 600 V/650 V/1200 V IGBTs, MOSFETs, and SiC MOSFETs
- Up to 6 A typical peak current at rail-to-rail output
- Active Miller clamp
- Galvanically isolated coreless transformer driver
- Wide input voltage operating range
- Suitable for operation at high ambient temperature and in fast switching applications
- Small and cost optimized DSO-8 150 mil package with 4 mm creepage
- 20 V absolute maximum output supply voltage

Potential applications

- AC and brushless DC motor drives
- High voltage DC/DC-converter and DC/AC-inverter
- Induction heating resonant application
- UPS-systems
- Commercial air-conditioning (CAC)
- Server and telecom switched mode power supplies (SMPS)
- Solar



| Product type | Typical output current and configuration | UVLO | Propagation delay | Package marking |
|-----------------------------|--|------|-------------------|-----------------|
| 1EDI10I12MF | 2.3 A with 1.0 A Miller clamp | 12 V | 300 ns | 1I10I12M |
| 1EDI20I12MF | 4.4 A with 2.0 A Miller clamp | 12 V | 300 ns | 1I20I12M |
| 1EDI30I12MF | 6.2 A with 3.0 A Miller clamp | 12 V | 300 ns | 1I30I12M |

Product validation

Qualified for industrial applications according to the relevant tests of JEDEC47/20/22.

Description

Description

The 1EDixx12MF are galvanically isolated single channel gate driver in a DSO-8 narrow body package that provide output currents up to 6.2 A and an integrated active Miller clamp circuit with the same current rating to protect against parasitic turn on.

The input logic pins operate on a wide input voltage range from 3 V to 15 V using scaled CMOS threshold levels to support even 3.3 V microcontrollers.

Data transfer across the isolation barrier is realized by the coreless transformer technology.

Every driver family member comes with logic input and driver output undervoltage lockout (UVLO) and active shutdown.

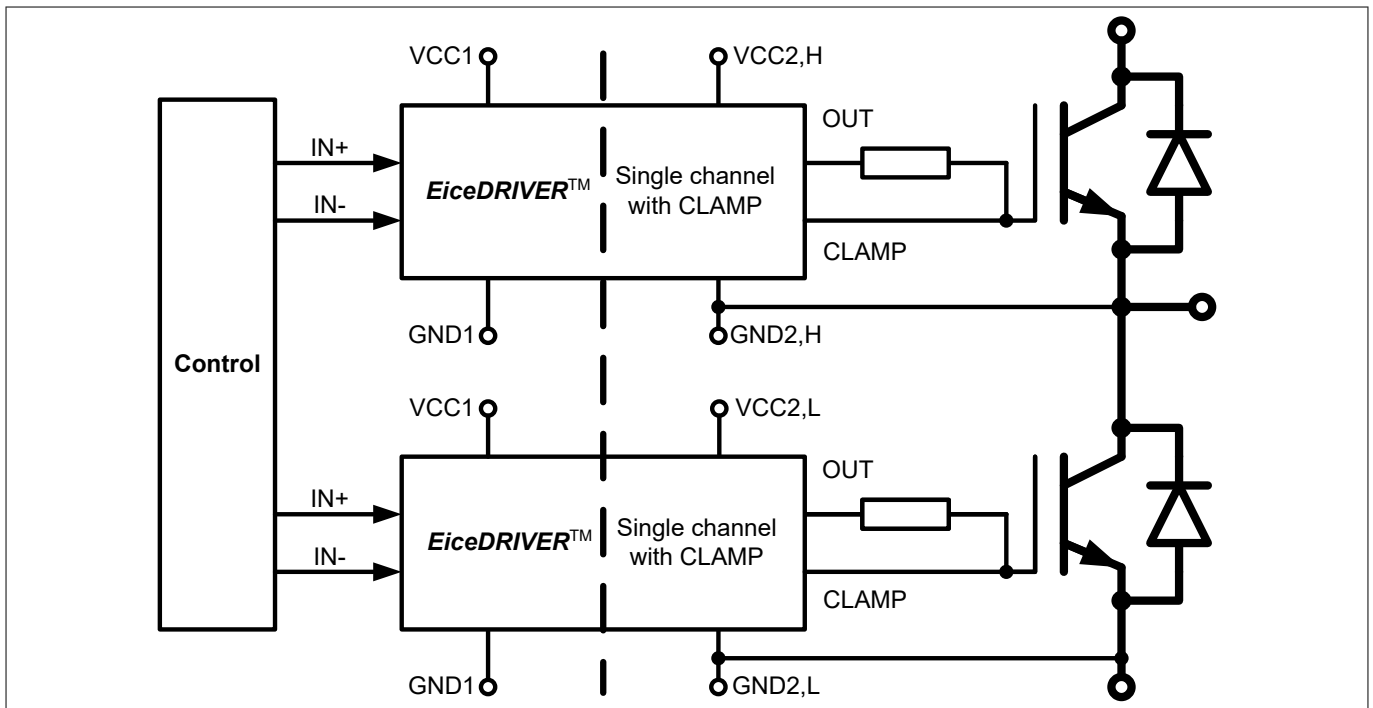


Figure 1 Typical application

Table of contents

| | | |
|----------|--|----|
| | Table of contents | 3 |
| 1 | Block diagram | 4 |
| 2 | Pin configuration and functionality | 5 |
| 2.1 | Pin configuration | 5 |
| 2.2 | Pin functionality | 5 |
| 3 | Functional description | 7 |
| 3.1 | Supply | 7 |
| 3.2 | Protection features | 8 |
| 3.2.1 | Undervoltage lockout (UVLO) | 8 |
| 3.2.2 | Active shut-down | 8 |
| 3.2.3 | Short circuit clamping | 8 |
| 3.2.4 | Active Miller clamp | 8 |
| 3.3 | Non-inverting and inverting inputs | 9 |
| 3.4 | Driver output | 9 |
| 4 | Electrical parameters | 10 |
| 4.1 | Absolute maximum ratings | 10 |
| 4.2 | Operating parameters | 11 |
| 4.3 | Electrical characteristics | 11 |
| 4.3.1 | Voltage supply | 11 |
| 4.3.2 | Logic input | 12 |
| 4.3.3 | Gate driver | 13 |
| 4.3.4 | Short circuit clamping | 14 |
| 4.3.5 | Active Miller clamp | 14 |
| 4.3.6 | Dynamic characteristics | 15 |
| 4.3.7 | Active shut down | 15 |
| 5 | Package outline | 16 |
| 6 | Application notes | 17 |
| 6.1 | Reference layout for thermal data | 17 |
| 6.2 | Printed circuit board guidelines | 17 |
| | Revision history | 17 |
| | Disclaimer | 18 |

Block diagram

1 Block diagram

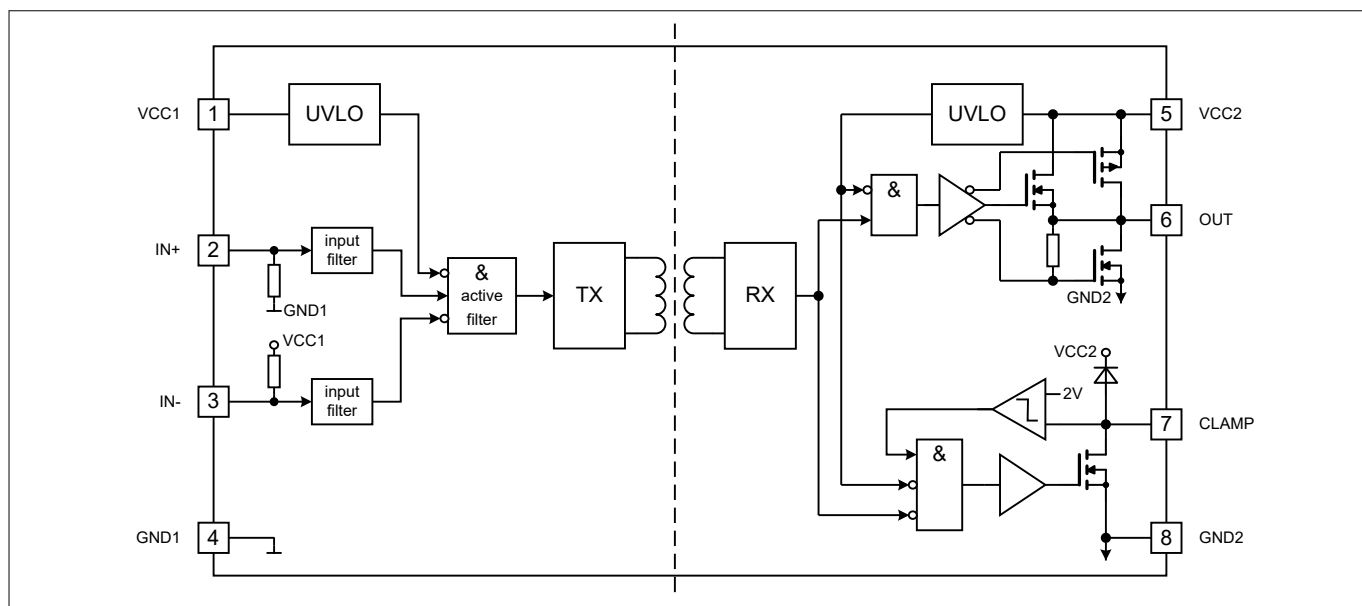


Figure 2 Block diagram

2 Pin configuration and functionality

2.1 Pin configuration

Table 1 Pin configuration

| Pin No. | Name | Function |
|---------|-------|---|
| 1 | VCC1 | Positive logic supply |
| 2 | IN+ | Non-inverted driver input (active high) |
| 3 | IN- | Inverted driver input (active low) |
| 4 | GND1 | Logic ground |
| 5 | VCC2 | Positive power supply voltage |
| 6 | OUT | Driver output |
| 7 | CLAMP | Active Miller clamp |
| 8 | GND2 | Power ground |

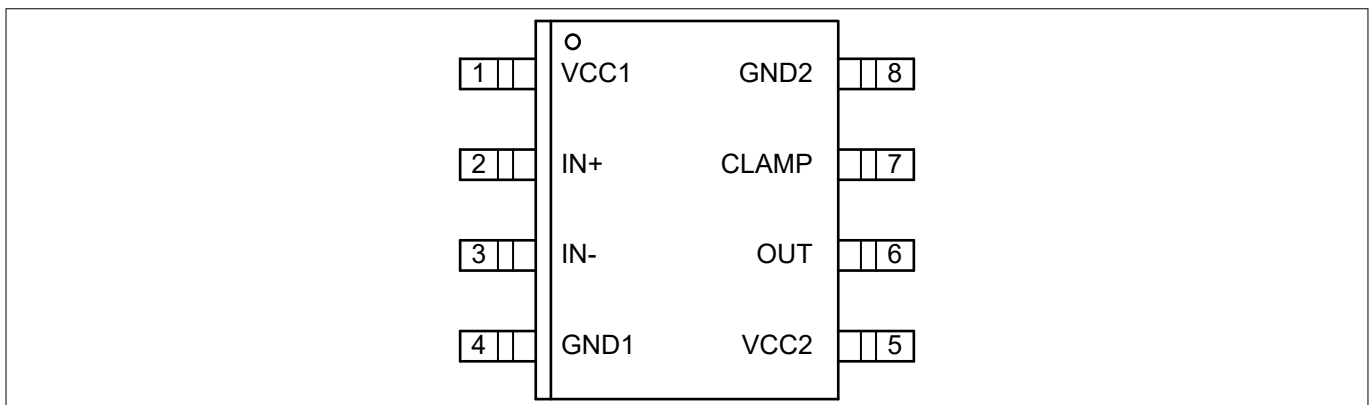


Figure 3 DSO-8 narrow body (top view)

2.2 Pin functionality

VCC1

Logic input supply voltage of 3.3 V up to 15 V wide operating range.

IN+ non inverting driver input

IN+ non-inverted control signal for driver output if IN- is set to low. (Output sourcing active at IN+ = high and IN- = low)

Due to internal filtering a minimum pulse width is defined to ensure robustness against noise at IN+. An internal weak pull-down-resistor favors off-state.

IN- inverting driver input

IN- inverted control signal for driver output if IN+ is set to high. (Output sourcing active at IN- = low and IN+ = high)

Due to internal filtering a minimum pulse width is defined to ensure robustness against noise at IN-. An internal weak pull-up-resistor favors off-state.

Pin configuration and functionality

GND1

Ground connection of input circuit.

GND2 reference ground

Reference ground of the output driving circuit.

VCC2

Positive power supply pin of output driving circuit. A proper blocking capacitor has to be placed close to this supply pin.

OUT driver output

Combined source and sink output pin to external IGBT. The output voltage will be switched between *VCC2* and *GND2* and is controlled by *IN+* and *IN-*. In case of an UVLO event this output will be switched off and an active shut down keeps the output voltage at a low level.

CLAMP active Miller clamp

Connect gate of external IGBT directly to this pin. As soon as the gate voltage has dropped below 2 V referred to *GND2* during turn off state the Miller clamp function ties its output to *GND2* to avoid parasitic turn on of the connected IGBT.

Functional description

3 Functional description

The 1EDIxxI12MF is a general purpose isolated gate driver. Basic control and protection features support fast and easy design of highly reliable systems.

The integrated galvanic isolation between control input logic and driving output stage grants additional safety. Its wide input voltage supply range supports the direct connection of various signal sources like DSPs and microcontrollers.

With the rail-to-rail output and the additional active Miller clamp, dynamic turn on due to Miller capacitance is suppressed.

3.1 Supply

The driver can operate over a wide supply voltage range.

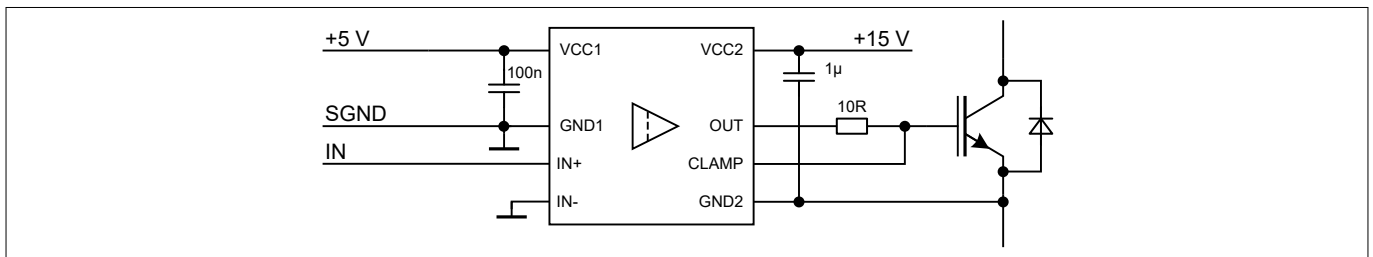


Figure 4 Application example

The typical positive supply voltage for the driver is 15 V at VCC2. Erratical dynamic turn on of the IGBT can be prevented with the active Miller clamp function, in which the CLAMP output is directly connected to the IGBT gate.

3.2 Protection features

3.2.1 Undervoltage lockout (UVLO)

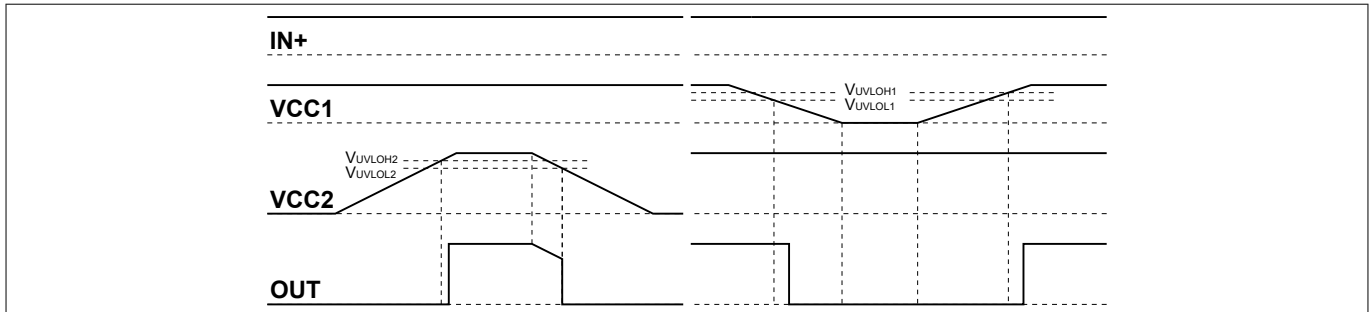


Figure 5 UVLO behavior

To ensure correct switching of IGBTs the device is equipped with an undervoltage lockout for input and output independently. Operation starts only after both VCC levels have increased beyond the respective V_{UVLOH} levels

If the power supply voltage V_{VCC1} of the input chip drops below V_{UVLOL1} a turn-off signal is sent to the output chip before power-down. The IGBT is switched off and the signals at $IN+$ and $IN-$ are ignored until V_{VCC1} reaches the power-up voltage V_{UVLOH1} again.

If the power supply voltage V_{VCC2} of the output chip goes down below V_{UVLOL2} the IGBT is switched off and signals from the input chip are ignored until V_{VCC2} reaches the power-up voltage V_{UVLOH2} again.

3.2.2 Active shut-down

The active shut-down feature ensures a safe IGBT off-state if the output chip is not connected to the power supply or an undervoltage lockout is in effect. The IGBT gate is clamped at OUT to $GND2$.

3.2.3 Short circuit clamping

During short circuit the IGBT's gate voltage tends to rise because of the feedback via the Miller capacitance. An additional protection circuit connected to OUT and $CLAMP$ limits this voltage to a value slightly higher than the supply voltage. A maximum current of 500 mA may be fed back to the supply through one of these paths for 10 μ s. If higher currents are expected or tighter clamping is desired external Schottky diodes may be added.

3.2.4 Active Miller clamp

In a half bridge configuration the switched off IGBT tends to dynamically turn on during turn on phase of the opposite IGBT. A Miller clamp allows sinking the Miller current across a low impedance path in this high dV/dt situation. Therefore in many applications, the use of a negative supply voltage can be avoided. During turn-off, the gate voltage is monitored and the clamp output is activated when the gate voltage drops below typical 2 V (referred to $GND2$). The clamp is designed for a Miller current in the same range as the nominal output current.

Functional description

3.3 Non-inverting and inverting inputs

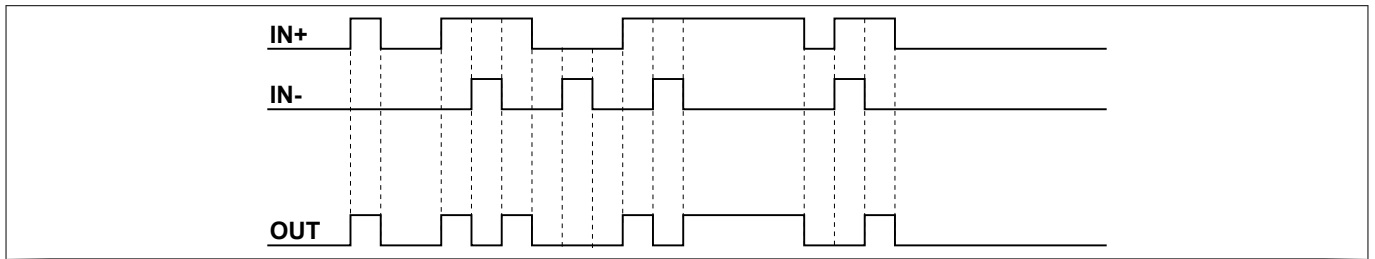


Figure 6 Logic input to output switching behavior

There are two possible input modes to control the IGBT. At non-inverting mode $IN+$ controls the driver output while $IN-$ is set to low. At inverting mode $IN-$ controls the driver output while $IN+$ is set to high. A minimum input pulse width is defined to filter occasional glitches.

3.4 Driver output

The output driver section uses MOSFETs to provide a rail-to-rail output. This feature permits that tight control of gate voltage during on-state and short circuit can be maintained as long as the driver's supply is stable. Due to the low internal voltage drop, switching behavior of the IGBT is predominantly governed by the gate resistor. Furthermore, it reduces the power to be dissipated by the driver.

Electrical parameters

4 Electrical parameters

4.1 Absolute maximum ratings

Note: Absolute maximum ratings are defined as ratings, which when being exceeded may lead to destruction of the integrated circuit. Unless otherwise noted all parameters refer to GND1

Table 2 Absolute maximum ratings

| Parameter | Symbol | Values | | Unit | Note or Test Condition |
|--|-----------------|----------------|------------------------------|------|------------------------------------|
| | | Min. | Max. | | |
| Power supply output side | V_{VCC2} | -0.3 | 20 ¹⁾ | V | 2) |
| Gate driver output | V_{OUT} | $V_{GND2}-0.3$ | $V_{VCC2}+0.3$ | V | 2) |
| Maximum short circuit clamping time | t_{CLP} | – | 10 | μs | $I_{CLAMP/OUT} = 500 \text{ mA}$ |
| Positive power supply input side | V_{VCC1} | -0.3 | 18.0 | V | – |
| Logic input voltages (I_{N+}, I_{N-}) | $V_{LogicIN}$ | -0.3 | 18.0 | V | – |
| Pin CLAMP voltage | V_{CLAMP} | -0.3 | $V_{VCC2}+0.3$ ¹⁾ | V | 2) |
| Input to output isolation voltage ($GND2$) | V_{GND2} | -1200 | 1200 | V | $GND2 - GND1$ |
| Junction temperature | T_J | -40 | 150 | °C | – |
| Storage temperature | T_S | -55 | 150 | °C | – |
| Comparative tracking index | CTI | 600 | – | | IEC 60601-1: Material group II |
| Power dissipation (Input side) | $P_{D, IN}$ | – | 25 | mW | 3) @ $T_A = 25^\circ\text{C}$ |
| Power dissipation (Output side) | $P_{D, OUT}$ | – | 400 | mW | 3) @ $T_A = 25^\circ\text{C}$ |
| Thermal resistance (Input side) | $R_{THJA, IN}$ | – | 145 | K/W | 3) @ $T_A = 85^\circ\text{C}$ |
| Thermal resistance (Output side) | $R_{THJA, OUT}$ | – | 165 | K/W | 3) @ $T_A = 85^\circ\text{C}$ |
| ESD capability | $V_{ESD, HBM}$ | – | 2 | kV | Human body model ⁴⁾ |
| | $V_{ESD, CDM}$ | – | 1 | kV | Charged device model ⁵⁾ |

¹ May be exceeded during short circuit clamping.

² With respect to GND2.

³ See Figure 10 for reference layouts for these thermal data. Thermal performance may change significantly with layout and heat dissipation of components in close proximity.

⁴ According to ANSI/ESDA/JEDEC-JS-001-2017 (discharging a 100 pF capacitor through a 1.5 kΩ series resistor).

⁵ According to ANSI/ESDA/JEDEC-JS-002-2014 (TC = test condition in volt)

Electrical parameters

4.2 Operating parameters

Note: Within the operating range the IC operates as described in the functional description. Unless otherwise noted all parameters refer to GND1.

Table 3 Operating parameters

| Parameter | Symbol | Values | | Unit | Note or Test Condition |
|---|-----------------|----------------|--------------------------|-------------------|-------------------------------|
| | | Min. | Max. | | |
| Power supply output side | V_{VCC2} | 13 | 18 | V | 6) |
| Power supply input side | V_{VCC1} | 3.1 | 17 | V | – |
| Logic input voltages (I_{N+}, I_{N-}) | $V_{LogicIN}$ | -0.3 | 17 | V | – |
| Pin CLAMP voltage | V_{CLAMP} | $V_{GND2}-0.3$ | V_{VCC2} ⁷⁾ | V | 6) |
| Switching frequency | f_{sw} | – | 1.0 | MHz | 8)9) |
| Ambient temperature | T_A | -40 | 125 | °C | – |
| Thermal coefficient, junction-top | $\Psi_{th,jt}$ | – | 4.8 | K/W | 9) @ $T_A = 85^\circ\text{C}$ |
| Common mode transient immunity | $ dV_{ISO}/dt $ | – | 100 | kV/ μs | 9) @ 1000 V |

4.3 Electrical characteristics

Note: The electrical characteristics include the spread of values in supply voltages, load and junction temperatures given below. Typical values represent the median values at $T_A = 25^\circ\text{C}$. Unless otherwise noted all voltages are given with respect to their respective GND (GND1 for pins 1 to 3, GND2 for pins 5 to 7).

4.3.1 Voltage supply

Table 4 Voltage supply

| Parameter | Symbol | Values | | | Unit | Note or Test Condition |
|--|--------------|--------|------|------|------|------------------------|
| | | Min. | Typ. | Max. | | |
| UVLO threshold input chip | V_{UVLOH1} | – | 2.85 | 3.1 | V | – |
| | V_{UVLOL1} | 2.55 | 2.75 | – | V | – |
| UVLO hysteresis input chip ($V_{UVLOH1} - V_{UVLOL1}$) | V_{HYS1} | 0.09 | 0.10 | – | V | – |
| UVLO threshold output chip (IGBT supply) | V_{UVLOH2} | – | 11.9 | 12.7 | V | 10) |
| | V_{UVLOL2} | 10.5 | 11.0 | – | V | 10) |

(table continues...)

⁶ With respect to GND2.
⁷ May be exceeded during short circuit clamping.
⁸ do not exceed max. power dissipation
⁹ Parameter is not subject to production test - verified by design/characterization
¹⁰ With respect to GND2.

Electrical parameters

Table 4 (continued) Voltage supply

| Parameter | Symbol | Values | | | Unit | Note or Test Condition |
|--|------------|--------|------|------|------|--|
| | | Min. | Typ. | Max. | | |
| UVLO hysteresis output chip ($V_{UVLOH1} - V_{UVLOL1}$) | V_{HYS2} | 0.7 | 0.85 | – | V | – |
| Quiescent current input chip | I_{Q1} | – | 0.6 | 1 | mA | $V_{VCC1} = 5\text{ V}$ $IN+ = \text{High}, IN- = \text{Low}$ $\Rightarrow OUT = \text{High}$ |
| Quiescent current output chip | I_{Q2} | – | 1.2 | 2 | mA | $V_{VCC2} = 15\text{ V}$ $IN+ = \text{High}, IN- = \text{Low}$ $\Rightarrow OUT = \text{High}$ |

4.3.2 Logic input

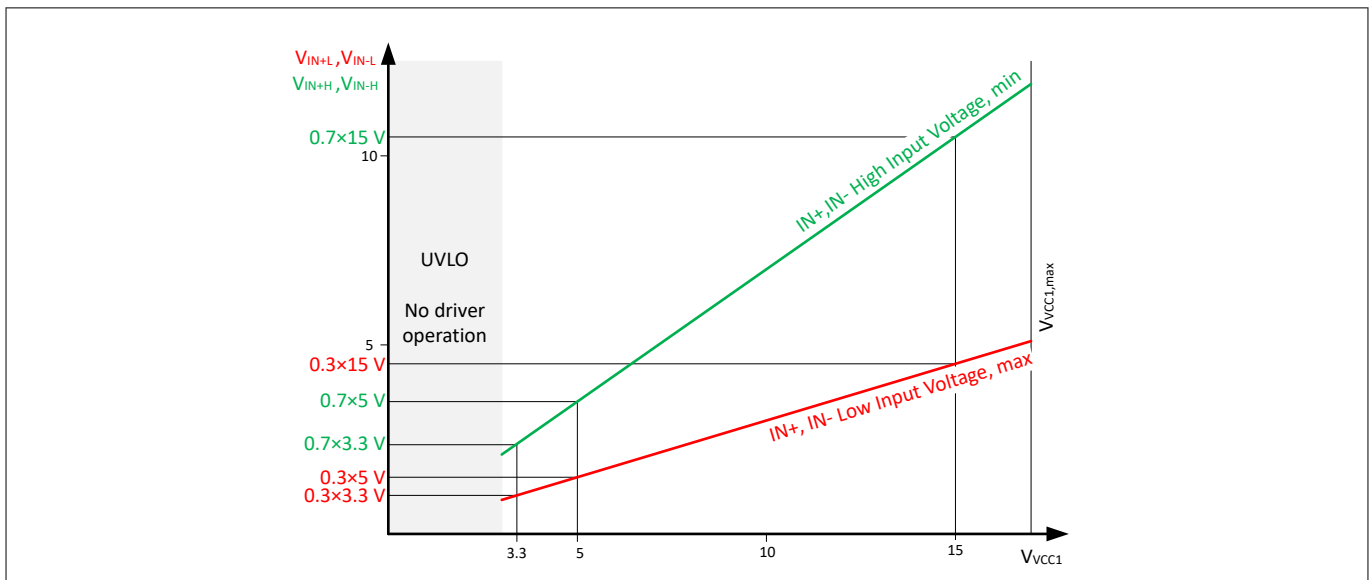


Figure 7 V_{CC1} scaled input threshold voltage of $IN+$ and $IN-$

Beginning from the input undervoltage lockout level, threshold levels for $IN+$ and $IN-$ are scaled to V_{CC1} . The high input threshold is 70% of V_{CC1} and the low input threshold is at 30% of V_{CC1} .

Table 5 Logic input

| Parameter | Symbol | Values | | | Unit | Note or Test Condition |
|-------------------------------|---------------------------|-----------------------|------|-----------------------|------|--|
| | | Min. | Typ. | Max. | | |
| $IN+, IN-$ low input voltage | $V_{IN+L},$ V_{IN-L} | – | – | $0.3 \times V_{VCC1}$ | | ¹¹⁾ $3.1\text{ V} \leq V_{VCC1} \leq 17\text{ V}$ |
| $IN+, IN-$ high input voltage | $V_{IN+H},$ V_{IN-H} | $0.7 \times V_{VCC1}$ | – | – | | |

(table continues...)

¹¹ Parameter is not subject to production test - verified by design/characterization

Electrical parameters

Table 5 (continued) Logic input

| Parameter | Symbol | Values | | | Unit | Note or Test Condition |
|-------------------------------------|---------------------------|--------|------|------|---------------|---|
| | | Min. | Typ. | Max. | | |
| I_{N+}, I_{N-} low input voltage | $V_{IN+L},$ V_{IN-L} | – | – | 1.5 | V | $V_{VCC1} = 5.0\text{ V}$ |
| I_{N+}, I_{N-} high input voltage | $V_{IN+H},$ V_{IN-H} | 3.5 | – | – | V | |
| I_{N-} input current | I_{IN-} | – | 70 | 200 | μA | $V_{VCC1} = 5.0\text{ V}, V_{IN-} = GND1$ |
| I_{N+} input current | I_{IN+} | – | 70 | 200 | μA | $V_{VCC1} = 5.0\text{ V}, V_{IN+} = V_{VCC1}$ |

4.3.3 Gate driver

Note: minimum Peak current rating valid over temperature range!

Table 6 Gate driver

| Parameter | Symbol | Values | | | Unit | Note or Test Condition |
|---|------------------|--------|------|------|------|---|
| | | Min. | Typ. | Max. | | |
| High level output peak current (source) | $I_{OUT,H,PEAK}$ | | | – | A | ^{12) 13)} $I_{N+} = \text{High},$ $I_{N-} = \text{Low},$ $V_{VCC2} = 15\text{ V}$ |
| 1EDI10I12MF | | 1.0 | 2.2 | | | |
| 1EDI20I12MF | | 2.0 | 4.4 | | | |
| 1EDI30I12MF | | 3.0 | 5.9 | | | |
| Low level output peak current (sink) | $I_{OUT,L,PEAK}$ | | | – | A | ^{12) 13)} $I_{N+} = \text{Low},$ $I_{N-} = \text{Low},$ $V_{VCC2} = 15\text{ V}$ |
| 1EDI10I12MF | | 1.0 | 2.3 | | | |
| 1EDI20I12MF | | 2.0 | 4.1 | | | |
| 1EDI30I12MF | | 3.0 | 6.2 | | | |

¹² specified min. output current is forced; voltage across the device $V_{(VCC2-OUT)}$ or $V_{(OUT-GND2)} < V_{VCC2}$.

¹³ Parameter is not subject to production test - verified by design/characterization

Electrical parameters

4.3.4 Short circuit clamping

Table 7 Short circuit clamping

| Parameter | Symbol | Values | | | Unit | Note or Test Condition |
|--|-----------------|--------|------|------|------|--|
| | | Min. | Typ. | Max. | | |
| Clamping voltage (<i>OUT</i>) ($V_{OUT} - V_{VCC2}$) | V_{CLPout} | – | 0.9 | 1.3 | V | ¹⁴⁾ $I_{N+} = \text{High}$, $I_{N-} = \text{Low}$, $I_{OUT} = 500 \text{ mA}$ (pulse test $t_{CLPmax} = 10 \mu\text{s}$) |
| Clamping voltage (<i>CLAMP</i>) ($V_{VCLAMP} - V_{VCC2}$) | $V_{CLPclamp1}$ | – | 1.3 | – | V | ¹⁴⁾ $I_{N+} = \text{High}$, $I_{N-} = \text{Low}$, $I_{CLAMP} = 500 \text{ mA}$ (pulse test $t_{CLPmax} = 10 \mu\text{s}$) |
| Clamping voltage (<i>CLAMP</i>) | $V_{CLPclamp2}$ | – | 0.7 | 1.1 | V | ¹⁴⁾ $I_{N+} = \text{High}$, $I_{N-} = \text{Low}$, $I_{CLAMP} = 20 \text{ mA}$ |

4.3.5 Active Miller clamp

Table 8 Active Miller clamp

| Parameter | Symbol | Values | | | Unit | Note or Test Condition |
|--|------------------|-------------------|------|------|------|--|
| | | Min. | Typ. | Max. | | |
| Low level clamp current 1EDI10I12MF 1EDI20I12MF 1EDI30I12MF | $I_{CLAMP,PEAK}$ | 1.0 2.0 3.0 | – | – | A | ¹⁵⁾ $I_{N+} = \text{Low}$, $I_{N-} = \text{Low}$, $V_{CLAMP} = 15 \text{ V}$ pulsed $t_{pulse} = 2 \mu\text{s}$ |
| Clamp threshold voltage | V_{CLAMP} | 1.6 | 2.0 | 2.4 | V | ¹⁶⁾ |

¹⁴⁾ With respect to *GND2*.

¹⁵⁾ Parameter is not subject to production test - verified by design/characterization

¹⁶⁾ With respect to *GND2*.

Electrical parameters

4.3.6 Dynamic characteristics

Dynamic characteristics are measured with $V_{VCC1} = 5\text{ V}$ and $V_{VCC2} = 15\text{ V}$.

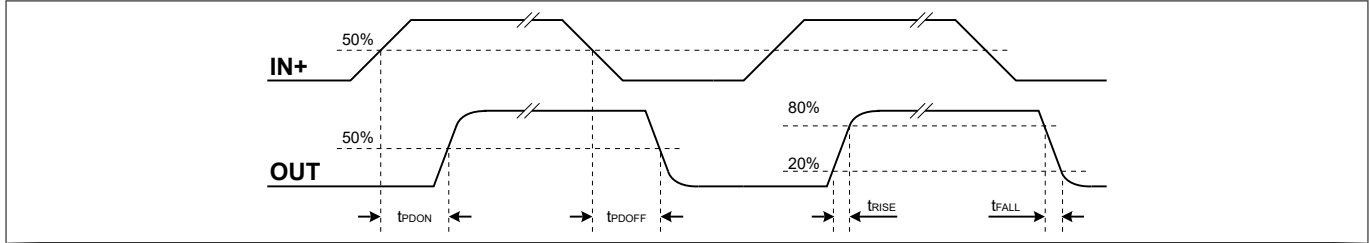


Figure 8 Propagation delay, rise and fall time

Table 9 Dynamic characteristics

| Parameter | Symbol | Values | | | Unit | Note or Test Condition |
|--|--------------------------------|--------|------|------|------|---|
| | | Min. | Typ. | Max. | | |
| Input IN to output propagation delay ON | t_{PDON} | 270 | 300 | 330 | ns | $C_{LOAD} = 100\text{ pF}$ $V_{IN+} = 50\%$, $V_{OUT} = 50\%$ @ 25°C |
| Input IN to output propagation delay OFF | t_{PDOFF} | 270 | 300 | 330 | ns | |
| Input IN to output propagation delay distortion ($t_{PDOFF} - t_{PDON}$) | t_{PDISTO} | -30 | 5 | 40 | ns | |
| Input pulse suppression time $IN+$, $IN-$ | t_{MININ+} , t_{MININ-} | 230 | 240 | - | ns | |
| IN input to output propagation delay ON variation due to temp | t_{PDONt} | - | - | 14 | ns | ¹⁷⁾ $C_{LOAD} = 100\text{ pF}$ $V_{IN+} = 50\%$, $V_{OUT} = 50\%$ |
| IN input to output propagation delay OFF variation due to temp | t_{PDOFFt} | - | - | 14 | ns | |
| IN input to output propagation delay distortion variation due to temp ($t_{PDOFF} - t_{PDON}$) | $t_{PDISTOt}$ | - | - | 8 | ns | |
| Rise time | t_{RISE} | - | 10 | 20 | ns | $C_{LOAD} = 1\text{ nF}$ $V_L 20\%$, $V_H 80\%$ |
| Fall time | t_{FALL} | - | 9 | 19 | ns | |

4.3.7 Active shut down

Table 10 Active shut down

| Parameter | Symbol | Values | | | Unit | Note or Test Condition |
|--------------------------|-------------|--------|------|------|------|--|
| | | Min. | Typ. | Max. | | |
| Active shut down voltage | V_{ACTSD} | - | 2.0 | 2.3 | V | ¹⁸⁾ $I_{OUT}/I_{OUT,PEAK} = 0.1$, VCC2 open |

¹⁷⁾ Parameter is not subject to production test - verified by design/characterization

¹⁸⁾ With respect to GND2.

Package outline

5 Package outline

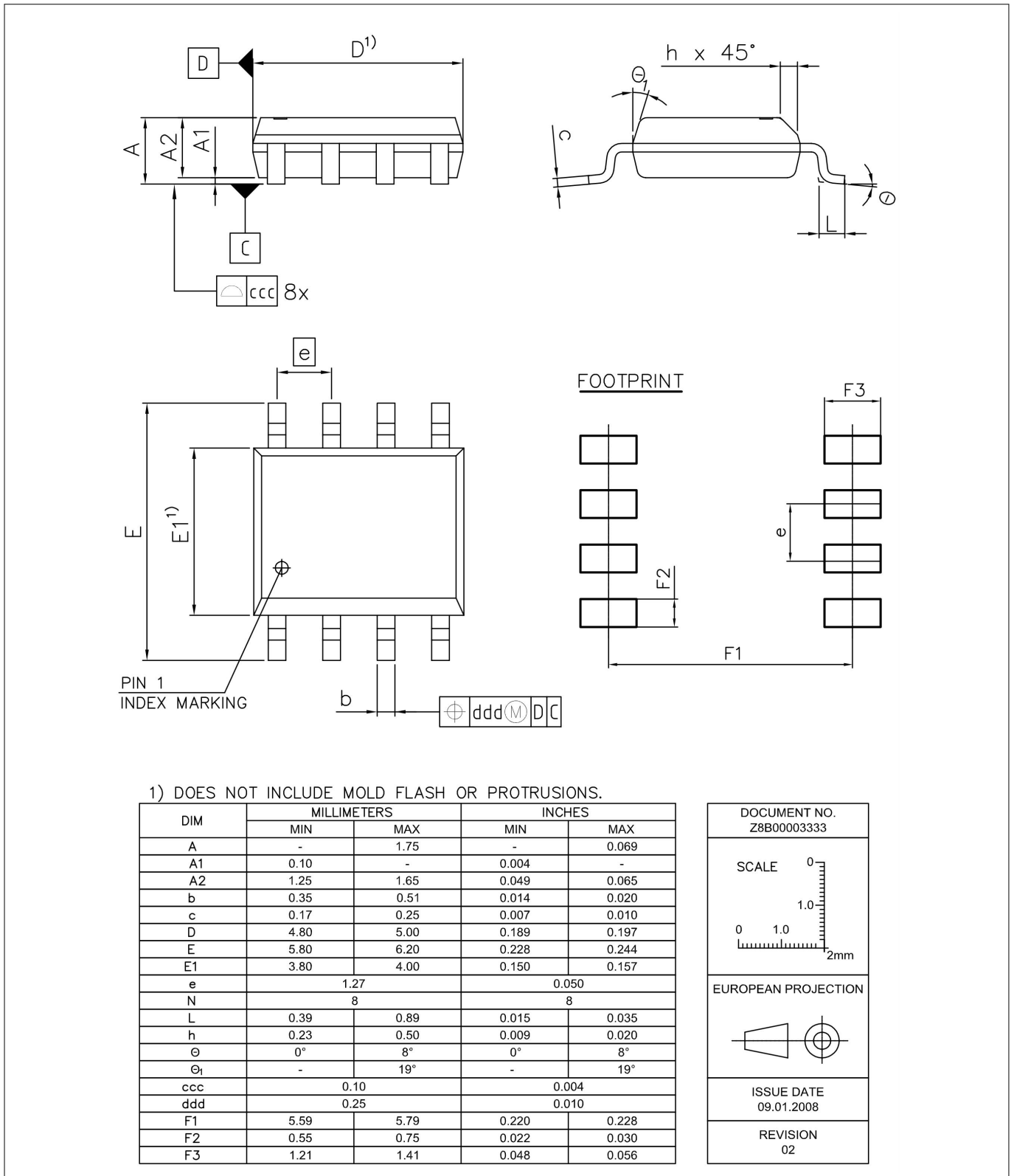


Figure 9 DSO-8 narrow body (Plastic (green) dual small outline package)

6 Application notes

6.1 Reference layout for thermal data

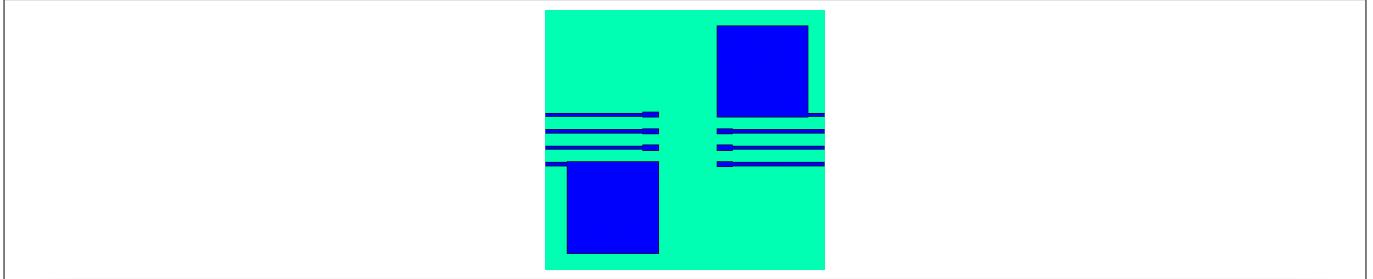


Figure 10 Reference layout for thermal data (Copper thickness 35 μm)

This PCB layout represents the reference layout used for the thermal characterization.

Pin 4 (GND1) and pin 8 (GND2) require each a ground plane of 100 mm² for achieving maximum power dissipation. The package is built to dissipate most of the heat generated through these pins.

The thermal coefficient junction-top ($\Psi_{th,jt}$) can be used to calculate the junction temperature at a given top case temperature and driver power dissipation:

$$T_j = \Psi_{th,jt} \cdot P_D + T_{top}$$

6.2 Printed circuit board guidelines

The following factors should be taken into account for an optimum PCB layout.

- Sufficient spacing should be kept between high voltage isolated side and low voltage side circuits.
- The same minimum distance between two adjacent high-side isolated parts of the PCB should be maintained to increase the effective isolation and to reduce parasitic coupling.
- In order to ensure low supply ripple and clean switching signals, bypass capacitor trace lengths should be kept as short as possible.

Revision history

| Document version | Date of release | Description of changes |
|------------------|-----------------|---|
| 1.10 | 2023-06-23 | Change of template, general layout, and version numbering system minimum value of t_{RISE} and t_{FALL} removed Added footnote for gate driver output current |
| 2.0 | 2014-11-10 | Parameter finalized, editorial changes |
| 1.02 | 2014-10-14 | Parameter list completed |

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