

# CIPOS™ Micro 600V / 3A

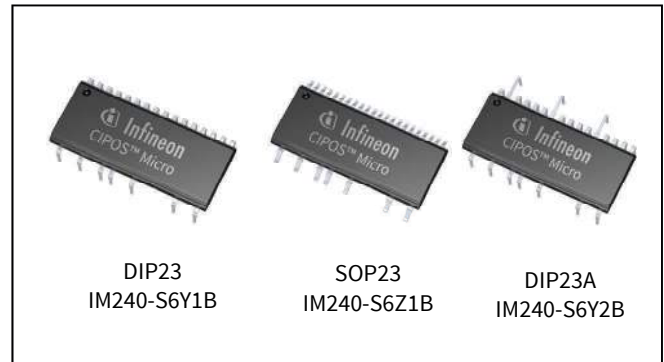
IM240-S6Z1B / IM240-S6Y1B / IM240-S6Y2B

## Description

IM240-M6 Series are 3-phase Intelligent Power Modules (IPM) designed for advanced appliance motor drive applications such as energy efficient fans and pumps. These advanced IPMs offers a combination of low  $V_{CE(sat)}$  RC-DF IGBT technology and the industry benchmark half-bridge high voltage, rugged driver in a familiar package.

## Features

- 600V 3-phase inverter including gate drivers & bootstrap function
- Low 2.1V  $V_{CE(sat)}$  (typ, 25°C, 2.5A) RC-DF IGBT
- UL Certified Temperature Sense (NTC)
- Advanced input filter with shoot-through protection
- Optimized  $dV/dt$  for loss and EMI trade offs
- Open-emitter for single and leg-shunt current sensing
- 3.3V logic compatible
- Driver tolerant to negative voltage (-VS)
- Undervoltage lockout for all channels
- Isolation 1900VRMS, 1min



## Potential Applications

- Air-conditioner fans
- Refrigerator compressors
- Ventilation fans & blower fans
- Low power motor drives

## Product validation

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

**Table1 Part Ordering Table**

| Base part number | Package Type | Standard Pack |          | Orderable Part Number |
|------------------|--------------|---------------|----------|-----------------------|
|                  |              | Form          | Quantity |                       |
| IM240-S6 Series  | DIP23        | Tube          | 240      | IM240-S6Y1B           |
|                  | DIP23A       | Tube          | 240      | IM240-S6Y2B           |
|                  | SOP23        | Tube          | 240      | IM240-S6Z1B           |

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# 1 Internal Electrical Schematic

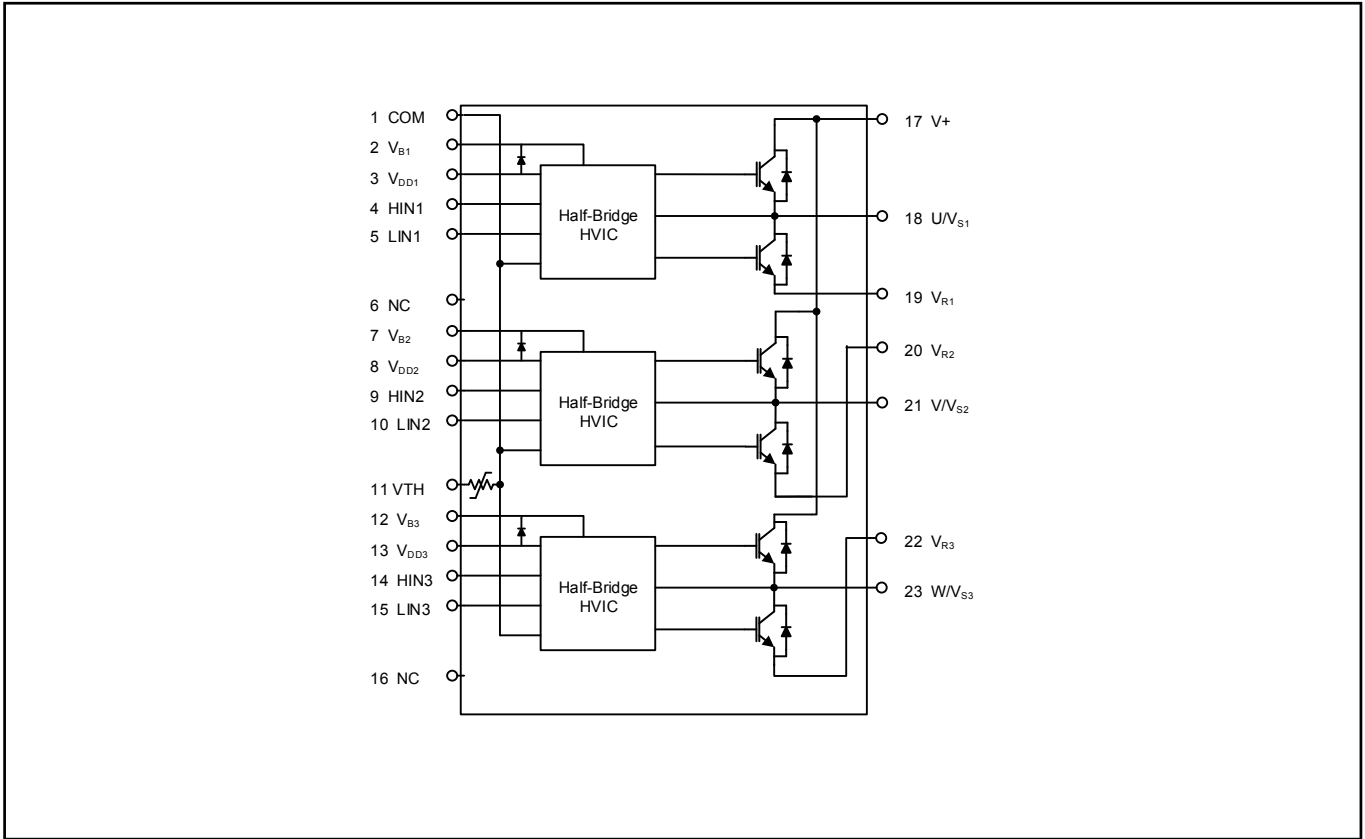


Figure 1 Internal electrical schematic

## 2 Pin Configuration

### 2.1 Pin Assignment

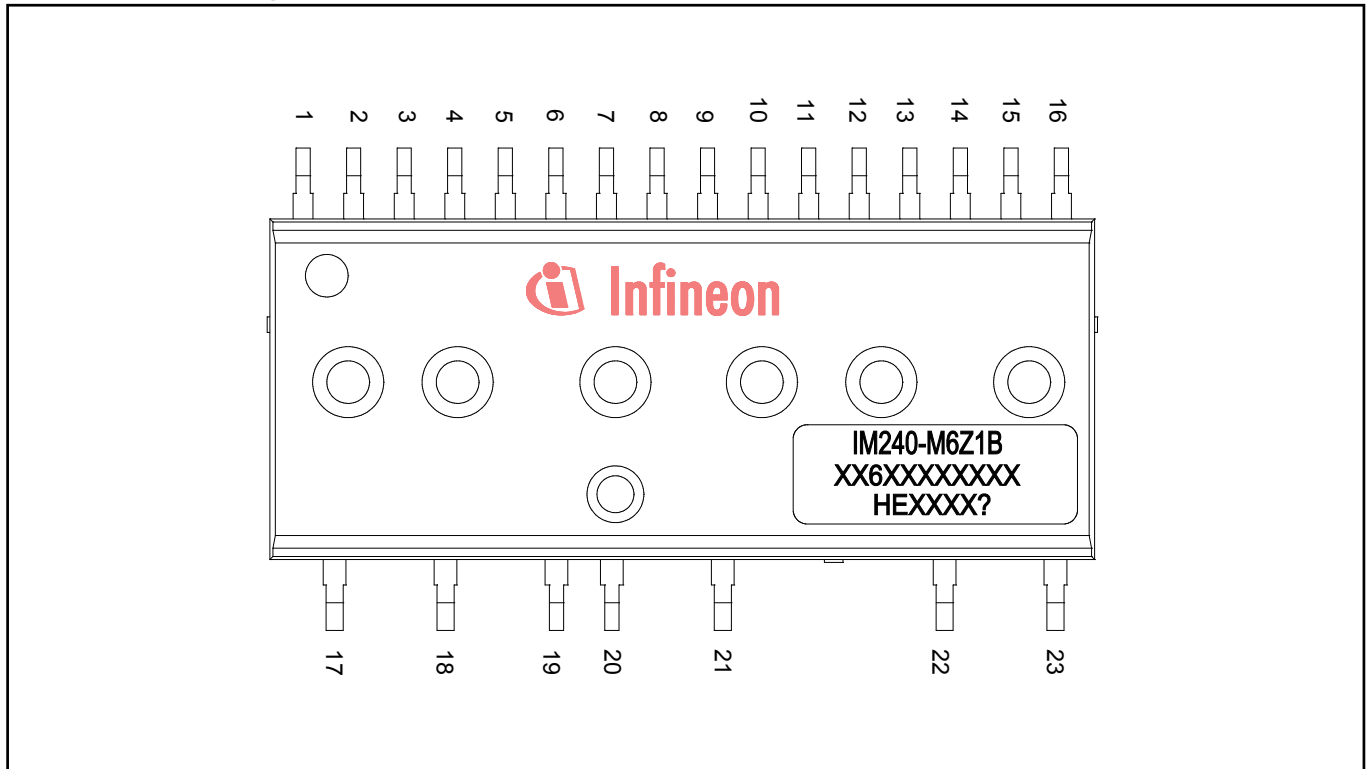


Figure 2 Module pinout

Table 2 Pin Assignment

| Pin | Name             | Description                                     |
|-----|------------------|---|
| 1   | COM              | Logic ground                                    |
| 2   | V <sub>B1</sub>  | High side floating supply voltage 1             |
| 3   | V <sub>DD1</sub> | Low side control supply 1                       |
| 4   | HIN1             | Logic Input for High Side Gate Driver - Phase 1 |
| 5   | LIN1             | Logic Input for Low Side Gate Driver - Phase 1  |
| 6   | NC               | Not connected                                   |
| 7   | V <sub>B2</sub>  | High side floating supply voltage 2             |
| 8   | V <sub>DD2</sub> | Low side control supply 2                       |
| 9   | HIN2             | Logic Input for High Side Gate Driver - Phase 2 |
| 10  | LIN2             | Logic Input for Low Side Gate Driver - Phase 2  |
| 11  | VTH              | Thermistor output                               |
| 12  | V <sub>B3</sub>  | High side floating supply voltage 3             |
| 13  | V <sub>DD3</sub> | Low side control supply 3                       |
| 14  | HIN3             | Logic Input for High Side Gate Driver - Phase 3 |
| 15  | LIN3             | Logic Input for Low Side Gate Driver - Phase 3  |

## Pin Configuration

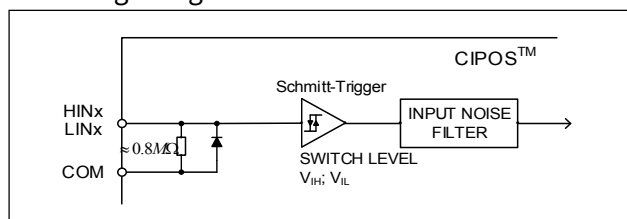
| Pin | Name              | Description   |
|-----|-------------------|---|
| 16  | NC                | Not connected                                       |
| 17  | V+                | Dc bus voltage positive                             |
| 18  | U/V <sub>S1</sub> | Output- phase 1, high side floating supply offset 1 |
| 19  | V <sub>R1</sub>   | Phase 1 low side emitter                            |
| 20  | V <sub>R2</sub>   | Phase 2 low side emitter                            |
| 21  | V/V <sub>S2</sub> | Output- phase 2, high side floating supply offset 2 |
| 22  | V <sub>R3</sub>   | Phase 3 low side emitter                            |
| 23  | W/V <sub>S3</sub> | Output- phase 3, high side floating supply offset 3 |

## 2.2 Pin Descriptions

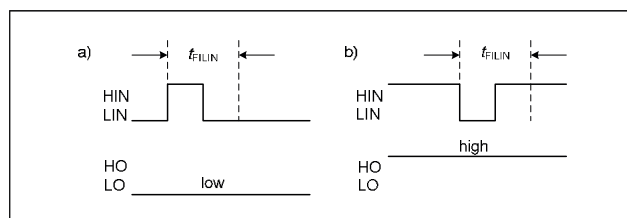
### HIN(1,2,3) and LIN(1,2,3) (Low side and high side control pins)

These pins are positive logic and they are responsible for the control of the integrated IGBT. The Schmitt-trigger input thresholds of them are such to guarantee LSTTL and CMOS compatibility down to 3.3V controller outputs. Pull-down resistor of about 800kΩ is internally provided to pre-bias inputs during supply start-up and an ESD diode is provided for pin protection purposes. Input Schmitt-trigger and noise filter provide beneficial noise rejection to short input pulses.

The noise filter suppresses control pulses which are below the filter time  $T_{FILIN}$ . The filter acts according to Figure 4.



**Figure 3** Input pin structure



**Figure 4** Input filter timing diagram

The integrated gate drive provides additionally a shoot through prevention capability which avoids the simultaneous on-state of the high-side and low-side switch of the same inverter phase. A minimum dead time insertion of typically 300ns is also provided by driver IC, in order to reduce cross-conduction of the external power switches.

### V<sub>DD,COM</sub> (Low side control supply and reference)

V<sub>DD</sub> is the control supply and it provides power both to input logic and to output power stage. Input logic is referenced to COM ground.

The under-voltage circuit enables the device to operate at power on when a supply voltage of at least a typical voltage of  $V_{DDUV+} = 11.1V$  is present.

The IC shuts down all the gate drivers power outputs, when the VDD supply voltage is below  $V_{DDUV-} = 10.9V$ . This prevents the external power switches from critically low gate voltage levels during on-state and therefore from excessive power dissipation.

### V<sub>B(1,2,3)</sub> and V<sub>S(1,2,3)</sub> (High side supplies)

V<sub>B</sub> to V<sub>S</sub> is the high side supply voltage. The high side circuit can float with respect to COM following the external high side power device emitter voltage.

Due to the low power consumption, the floating driver stage is supplied by integrated bootstrap circuit.

The under-voltage detection operates with a rising supply threshold of typical  $V_{BSUV+} = 11.1V$  and a falling threshold of  $V_{BSUV-} = 10.9V$ .

V<sub>S(1,2,3)</sub> provide a high robustness against negative voltage in respect of COM. This ensures very stable designs even under rough conditions.

### V<sub>R(1,2,3)</sub> (Low side emitters)

The low side emitters are available for current measurements of each phase leg. It is recommended to keep the connection to pin COM as short as possible in order to avoid unnecessary inductive voltage drops.

---

**Pin Configuration****VTH (Thermistor output)**

A UL certified NTC is integrated in the module with one terminal of the chip connected to COM and the other to VTH. When pulled up to a rail voltage such as VDD or 3.3V by a resistor, the VTH pin provides an analog voltage signal corresponding to the temperature of the thermistor.

**U/V<sub>S1</sub>, V/V<sub>S2</sub>, W/V<sub>S3</sub> (High side emitter and low side collector)**

These pins are motor U, V, W input pins.

**V+ (Positive bus input voltage, Pin 23)**

The high side IGBTs are connected to the bus voltage. It is noted that the bus voltage does not exceed 450V.

Absolute Maximum Rating

### 3 Absolute Maximum Rating

#### 3.1 Module

**Table 3**

| Parameter                      | Symbol    | Conditions          |           | Units |
|--------------------------------|-----------|---------------------|-----------|-------|
| Storage temperature            | $T_{STG}$ |                     | -40 ~ 150 | °C    |
| Operating case temperature     | $T_C$     |                     | -40 ~ 125 | °C    |
| Operating junction temperature | $T_J$     |                     | -40 ~ 150 | °C    |
| Isolation test voltage         | $V_{ISO}$ | 1min, RMS, f = 60Hz | 1900      | V     |

#### 3.2 Inverter

**Table 4**

| Parameter                       | Symbol            | Conditions   |     | Units         |
|---------------------------------|-------------------|--|-----|---------------|
| Max. blocking voltage           | $V_{CES}/V_{RRM}$ |  | 600 | V             |
| Output current                  | $I_O$             | $T_C = 25^\circ\text{C}$   | 3   | A             |
| Peak output current             | $I_{OP}$          | $T_C = 25^\circ\text{C}, t_p < 1\text{ms}$                           | 6   | A             |
| Peak power dissipation per IGBT | $P_{tot}$         | $T_C = 25^\circ\text{C}$   | 8.4 | W             |
| Short circuit withstand time    | $T_{SC}$          | $V_{DC} = 400\text{V}, T_J = 150^\circ\text{C}, V_{DD} = 15\text{V}$ | 5   | $\mu\text{s}$ |

#### 3.3 Control

**Table 5**

| Parameter   | Symbol   | Conditions |                 | Units |
|---|----------|------------|-----------------|-------|
| Low side control supply voltage                                   | $V_{DD}$ |            | -3 ~ 20         | V     |
| Input voltage LIN, HIN  | $V_{IN}$ |            | -0.3 ~ $V_{DD}$ | V     |
| High side floating supply voltage<br>( $V_B$ reference to $V_S$ ) | $V_{BS}$ |            | -0.3 ~ 20       | V     |

## 4 Thermal Characteristics

**Table 6**

| Parameter                                      | Symbol         | Conditions  | Min. | Typ. | Max. | Units |
|--|----------------|---|------|------|------|-------|
| Single IGBT thermal resistance, junction-case  | $R_{TH(J-C)}$  | Low side V-phase IGBT (See Figure 6 for $T_C$ measurement point)  | -    | 10.1 | 13.1 | °C/W  |
| Single diode thermal resistance, junction-case | $R_{TH(J-C)D}$ | Low side V-phase diode (See Figure 6 for $T_C$ measurement point) | -    | 11.5 | 14.9 | °C/W  |



## 5 Recommended Operating Conditions

**Table 7**

| Parameter                                     | Symbol  | Min. | Typ. | Max. | Units |
|---|---|------|------|------|-------|
| Positive DC bus input voltage                 | V+  | -    | -    | 450  | V     |
| Low side control supply voltage               | V <sub>DD</sub>                                 | 13.5 | -    | 16.5 | V     |
| High side floating supply voltage             | V <sub>BS</sub>                                 | 12.5 | -    | 17.5 | V     |
| Input voltage                                 | V <sub>IN</sub>                                 | 0    | -    | 5    | V     |
| PWM carrier frequency                         | F <sub>PWM</sub>                                | -    | 20   | -    | kHz   |
| External dead time between HIN & LIN          | DT  | 1    | -    | -    | μs    |
| Voltage between COM and V <sub>R(1,2,3)</sub> | V <sub>COMR</sub>                               | -5   | -    | 5    | V     |
| Minimum input pulse width                     | PW <sub>IN(ON)</sub> ,<br>PW <sub>IN(OFF)</sub> | 0.5  | -    | -    | μs    |

## 6 Static Parameters

### 6.1 Inverter

$(V_{DD-COM}) = (V_B - V_S) = 15\text{ V}$ .  $T_C = 25^\circ\text{C}$  unless otherwise specified.

**Table 8**

| Parameter                               | Symbol        | Conditions                                   | Min. | Typ. | Max. | Units         |
|---|---------------|--|------|------|------|---------------|
| Collector-to-emitter saturation voltage | $V_{CE(sat)}$ | $I_C = 1\text{A}$                            | -    | 1.54 | -    | V             |
|   |               | $I_C = 2.5\text{A}$                          | -    | 2.2  | 2.7  | V             |
|   |               | $I_C = 2.5\text{A}, T_J = 150^\circ\text{C}$ | -    | 2.3  | -    | V             |
| Collector emitter leakage current       | $I_{CES}$     | $V_{IN} = 0\text{V}, V_+ = 600\text{V}$      | -    | -    | 40   | $\mu\text{A}$ |
| Diode forward voltage drop              | $V_F$         | $I_C = 1\text{A}$                            | -    | 1.53 | -    | V             |
|   |               | $I_C = 2.5\text{A}$                          | -    | 2.10 | 2.6  | V             |
|   |               | $I_C = 2.5\text{A}, T_J = 150^\circ\text{C}$ | -    | 2.05 | -    | V             |

### 6.2 Control

$(V_{DD-COM}) = (V_B - V_S) = 15\text{ V}$ .  $T_C = 25^\circ\text{C}$  unless otherwise specified. The  $V_{IN}$  and  $I_{IN}$  parameters are referenced to COM and are applicable to all six channels. The  $V_{DDUV}$  parameters are referenced to COM. The  $V_{BSUV}$  parameters are referenced to VS.

**Table 9**

| Parameter   | Symbol                   | Min. | Typ. | Max. | Units         |
|---|--------------------------|------|------|------|---------------|
| Logic "1" input voltage (LIN, HIN)                            | $V_{IN,TH+}$             | 2.2  | -    | -    | V             |
| Logic "0" input voltage (LIN, HIN)                            | $V_{IN,TH-}$             | -    | -    | 0.8  | V             |
| $V_{DD}/V_{BS}$ supply undervoltage, positive going threshold | $V_{DD,UV+}, V_{BS,UV+}$ | 10.0 | 11.1 | 12.2 | V             |
| $V_{DD}/V_{BS}$ supply undervoltage, negative going threshold | $V_{DD,UV-}, V_{BS,UV-}$ | 9.8  | 10.9 | 12.0 | V             |
| $V_{DD}/V_{BS}$ supply undervoltage lock-out hysteresis       | $V_{DDUVH}, V_{BSUVH}$   | -    | 0.2  | -    | V             |
| Quiescent $V_{BS}$ supply current                             | $I_{QBS}$                | -    | -    | 70   | $\mu\text{A}$ |
| Quiescent $V_{DD}$ supply current                             | $I_{QCC}$                | -    | -    | 3.0  | mA            |
| Input bias current $V_{IN} = 5\text{V}$ for LIN, HIN          | $I_{IN+}$                | -    | 5    | 20   | $\mu\text{A}$ |
| Bootstrap resistance  | $R_{BS}$                 | -    | 240  | -    | $\Omega$      |

## 7 Dynamic Parameters

### 7.1 Inverter

$(V_{DD-COM}) = (V_B - V_S) = 15 \text{ V}$ .  $T_C = 25^\circ\text{C}$  unless otherwise specified

**Table 10**

| Parameter                                  | Symbol       | Conditions   | Min. | Typ. | Max. | Units         |
|--|--------------|--|------|------|------|---------------|
| Input to output turn-on propagation delay  | $T_{ON}$     | $I_C = 1\text{A}, V_+ = 300\text{V}$   | -    | 690  | -    | ns            |
| Turn-on rise time                          | $T_R$        |  | -    | 23   | -    | ns            |
| Turn-on switching time                     | $T_{C(on)}$  |  | -    | 132  | -    | ns            |
| Input to output turn-off propagation delay | $T_{OFF}$    | $I_C = 1\text{A}, V_+ = 300\text{V}$   | -    | 770  | -    | ns            |
| Turn-off fall time                         | $T_F$        |  | -    | 101  | -    | ns            |
| Turn-off switching time                    | $T_{C(off)}$ |  | -    | 83   | -    | ns            |
| Turn-on switching energy                   | $E_{ON}$     | $I_C = 1\text{A}, V_+ = 300\text{V}, V_{DD} = 15\text{V}, L = 7\text{mH}$                          | -    | 37   | -    | $\mu\text{J}$ |
| Turn-off switching energy                  | $E_{OFF}$    |  | -    | 8.3  | -    |               |
| Diode reverse recovery energy              | $E_{REC}$    |  | -    | 7.6  | -    |               |
| Diode reverse recovery time                | $T_{RR}$     |  | -    | 41   | -    | ns            |
| Turn-on switching energy                   | $E_{ON}$     | $I_C = 1\text{A}, V_+ = 300\text{V}, V_{DD} = 15\text{V}, L = 7\text{mH}, T_J = 150^\circ\text{C}$ | -    | 62   | -    | $\mu\text{J}$ |
| Turn-off switching energy                  | $E_{OFF}$    |  | -    | 17.6 | -    |               |
| Diode reverse recovery energy              | $E_{REC}$    |  | -    | 19.0 | -    |               |
| Diode reverse recovery time                | $T_{RR}$     |  | -    | 146  | -    | ns            |

### 7.2 Control

$(V_{DD-COM}) = (V_B - V_S) = 15 \text{ V}$ .  $T_C = 25^\circ\text{C}$  unless otherwise specified.

**Table 11**

| Parameter  | Symbol       | Conditions                           | Min. | Typ. | Max. | Units |
|--|--------------|--------------------------------------|------|------|------|-------|
| Input filter time (HIN, LIN)   | $T_{FIL,IN}$ | $V_{IN} = 0$ or $V_{IN} = 5\text{V}$ | -    | 300  | -    | ns    |
| Internal dead time   | $DT_{IC}$    | $V_{IN} = 0$ or $V_{IN} = 5\text{V}$ | -    | 300  | -    | ns    |
| Matching propagation delay time (on and off) for same phase high-side and low-side | $M_T$        | External dead time > 500ns           | -    | -    | 50   | ns    |

## 8 Thermistor Characteristics

Table 12

| Parameter           | Symbol    | Conditions                                     | Min.  | Typ. | Max.  | Units            |
|---------------------|-----------|--|-------|------|-------|------------------|
| Resistance          | $R_{25}$  | $T_c = 25^\circ\text{C}$ , $\pm 5\%$ tolerance | 44.65 | 47   | 49.35 | $\text{k}\Omega$ |
| Resistance          | $R_{125}$ | $T_c = 125^\circ\text{C}$                      | 1.27  | 1.39 | 1.51  | $\text{k}\Omega$ |
| B-constant (25/100) | B         | $\pm 1\%$ tolerance                            | -     | 4006 | -     | K                |
| Temperature Range   |           |  | -40   | -    | 125   | $^\circ\text{C}$ |

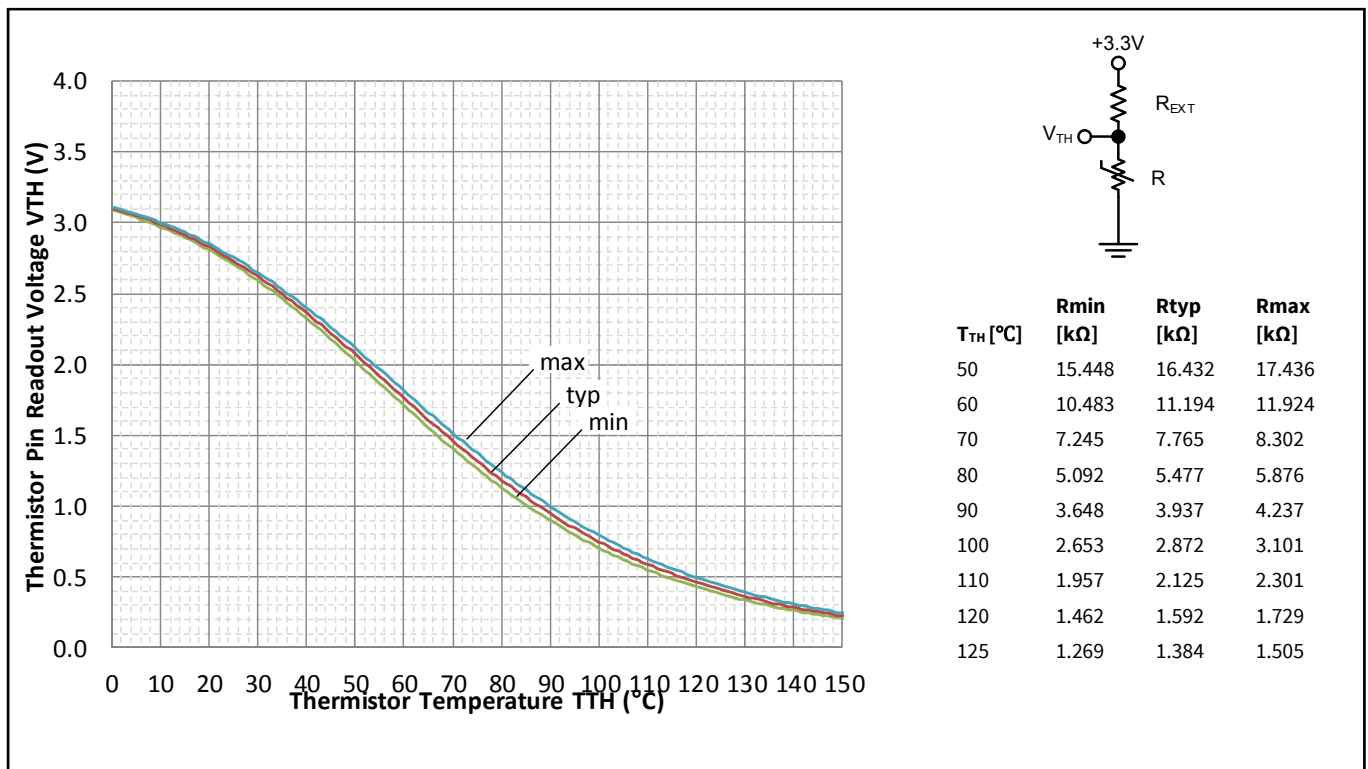


Figure 5 Thermistor resistance - temperature curve, for  $R_{EXT}=9.76\text{k}\Omega$ , and thermistor resistance variation with temperature.

## 9 Mechanical Characteristics and Ratings

**Table 13**

| <b>Parameter</b>             | <b>Symbol</b> | <b>Conditions</b> | <b>Min.</b> | <b>Typ.</b> | <b>Max.</b> | <b>Units</b> |
|------------------------------|---------------|-------------------|-------------|-------------|-------------|--------------|
| Comparative Tracking Index   | CTI           |                   | 550         | -           | -           | V            |
| Curvature of module backside | BC            | See Figure 6      | -50         | -           | 100         | μm           |
| Weight                       | W             |                   | -           | 3.1         | -           | g            |

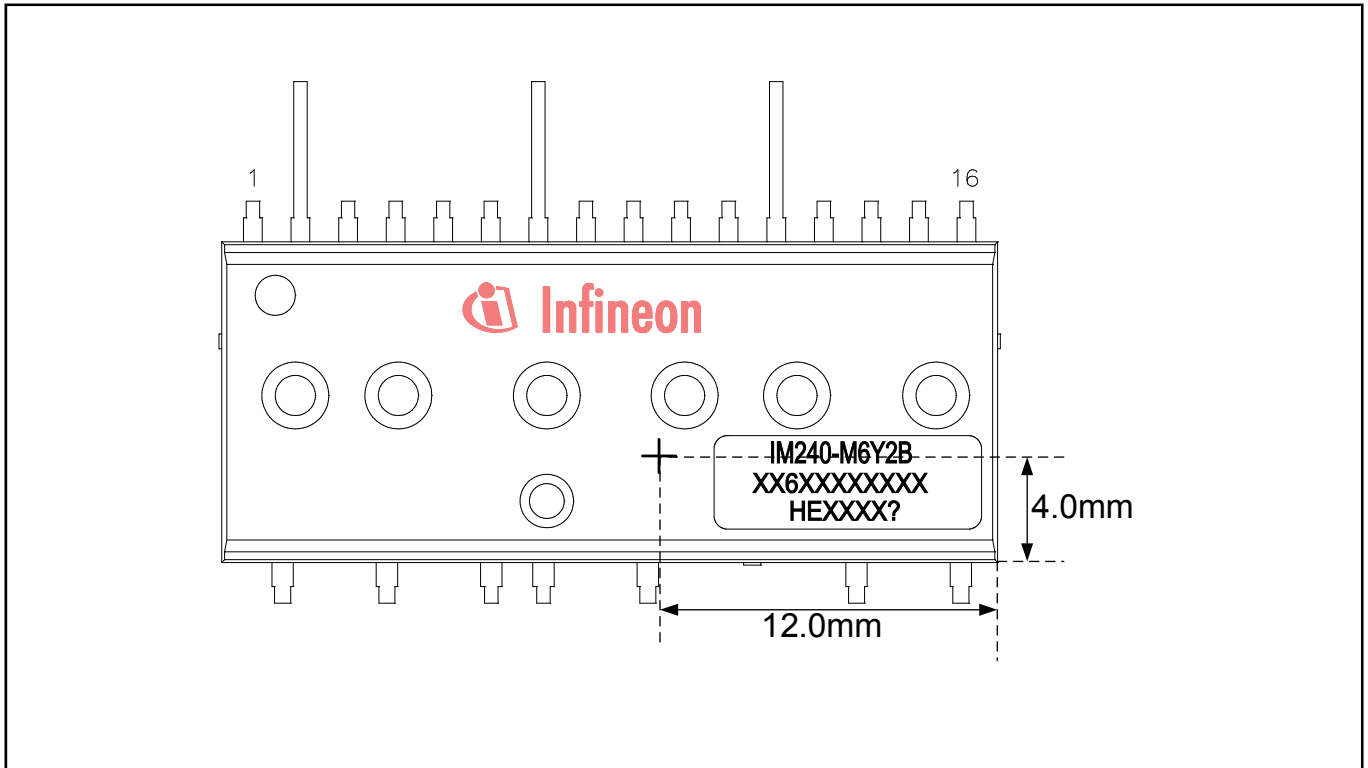
## 10 Qualification Information

**Table 14**

|  |                               |          |
|--|-------------------------------|----------|
| <b>UL Certified</b>                            | File Number E252584 (pending) |          |
| <b>Moisture Sensitivity Level (SOP23 only)</b> | MSL3                          |          |
| <b>RoHS Compliant</b>                          | Yes                           |          |
| <b>ESD</b>                                     | Human Body Model              | Class 2  |
|  | Charge discharge Model        | Class C3 |

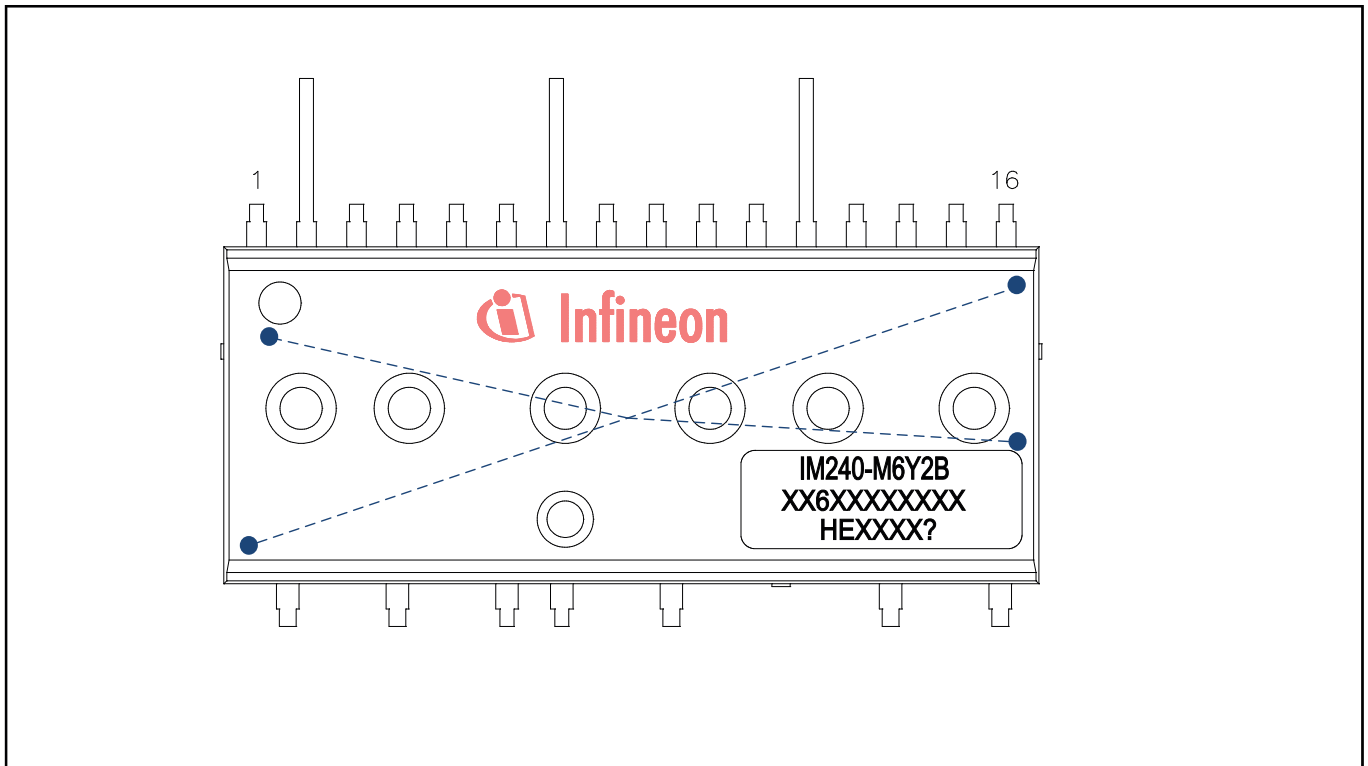
## 11 Diagram & Tables

### 11.1 Tc Measurement Point



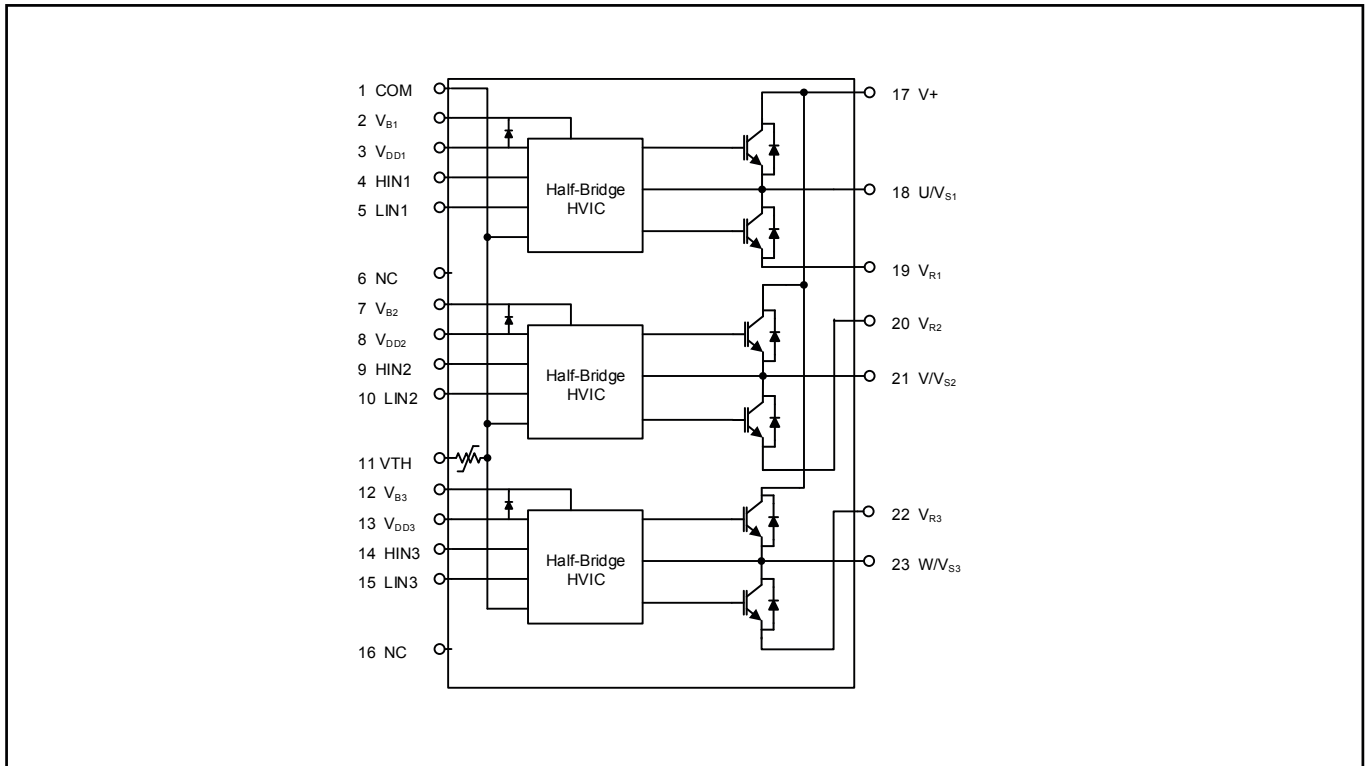
**Figure 6** TC measurement point

### 11.2 Backside Curvature Measurements Points



**Figure 7** Curvature measurement points

### 11.3 Input-Output Logic Table



**Figure 8** Module block diagram

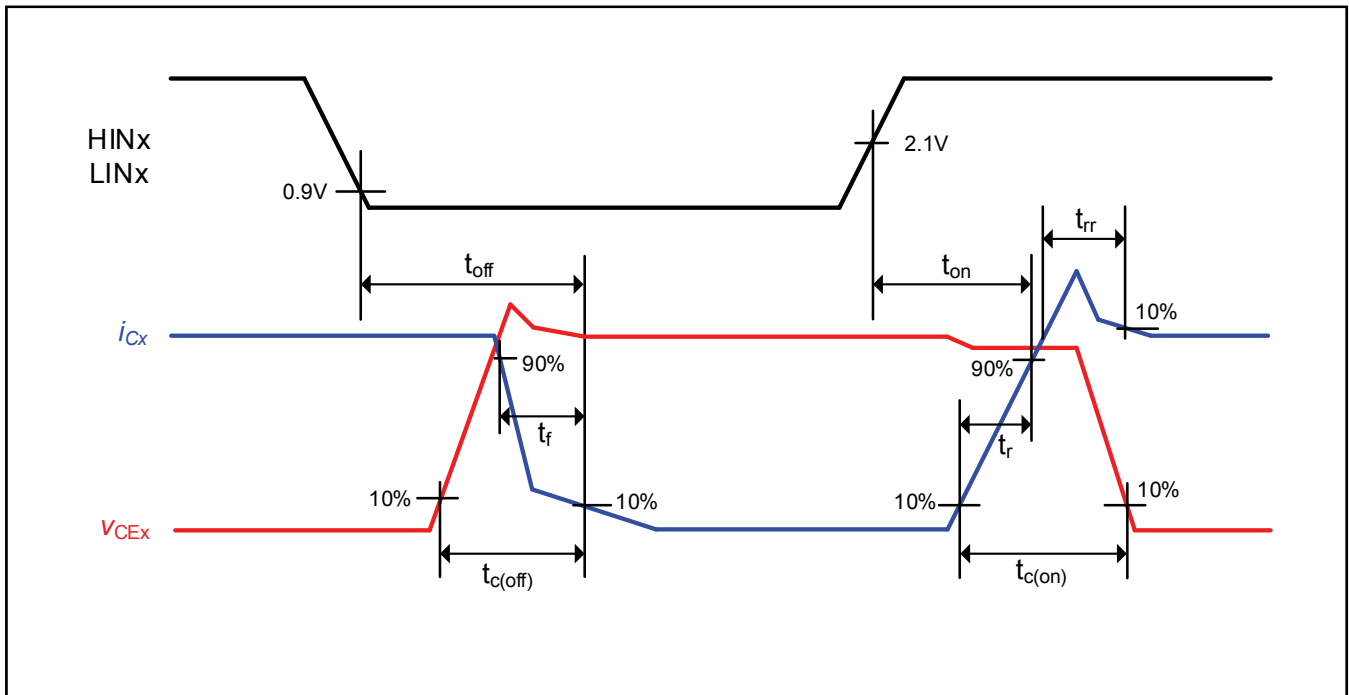
**Table 15**

| HIN 1,2,3 | LIN 1,2,3 | U,V,W |
|-----------|-----------|-------|
| 1         | 0         | V+    |
| 0         | 1         | 0     |
| 0         | 0         | ‡     |
| 1         | 1         | ‡     |

‡ Voltage depends on direction of phase current



### 11.4 Switching Time Definitions



**Figure 9** Switching times definition

## 12 Application Guide

### 12.1 Typical Application Schematic

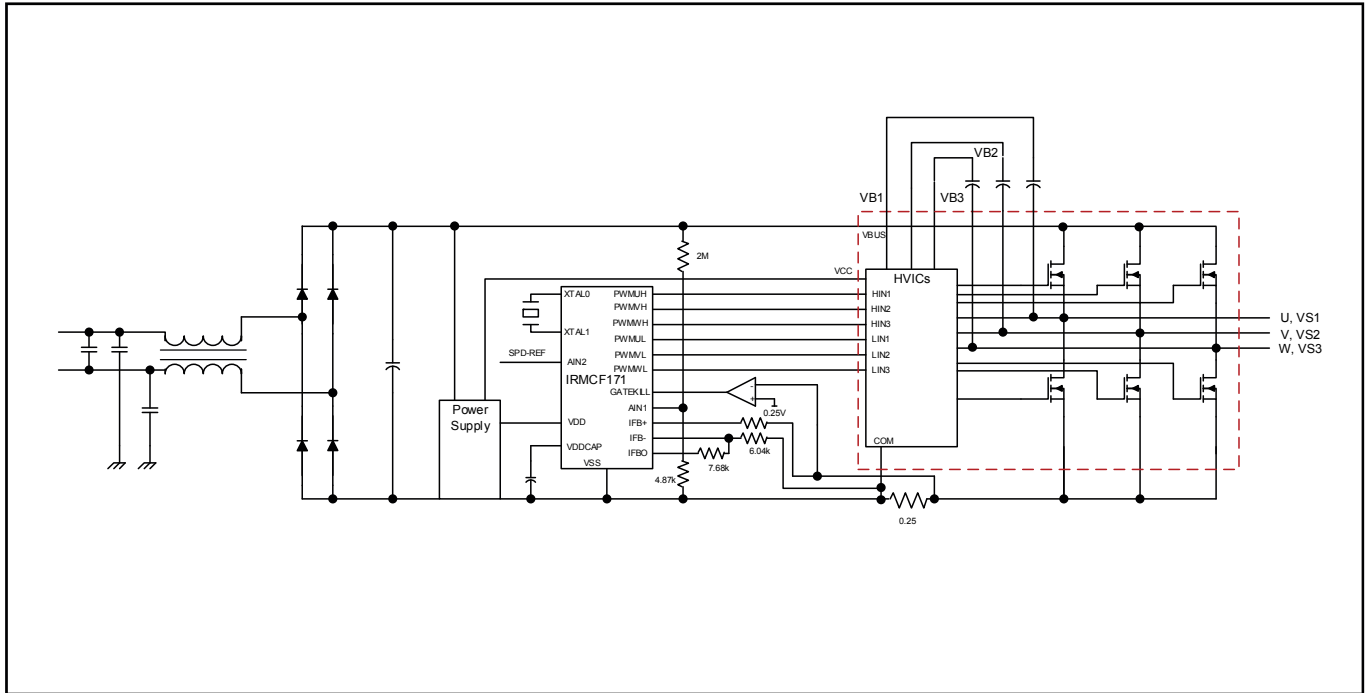


Figure 10 Application Schematic

### 12.2 Performance Charts

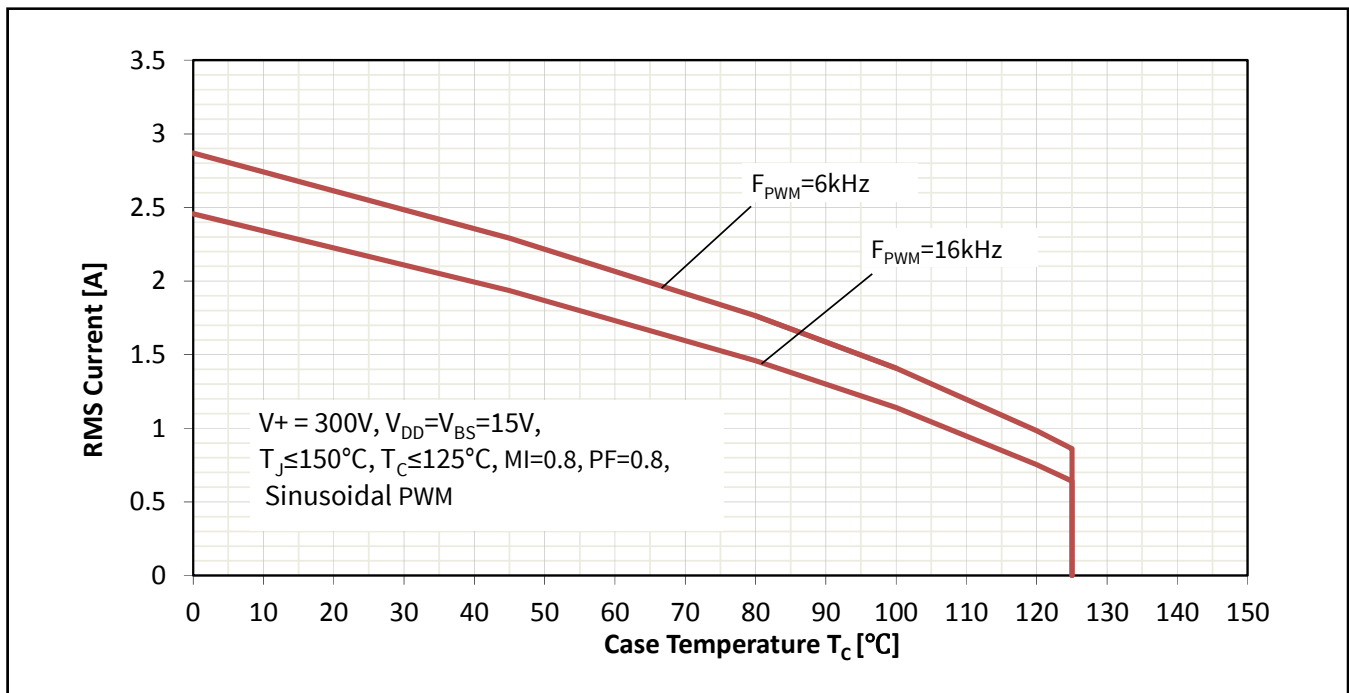
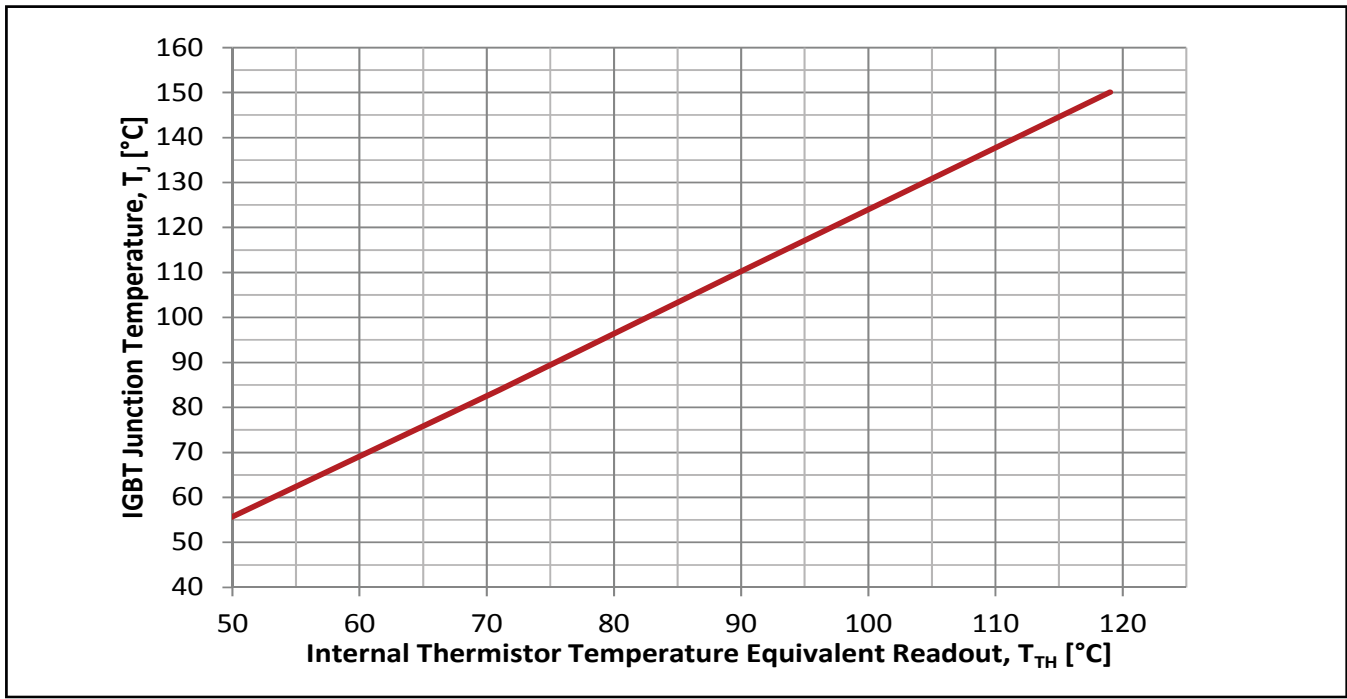


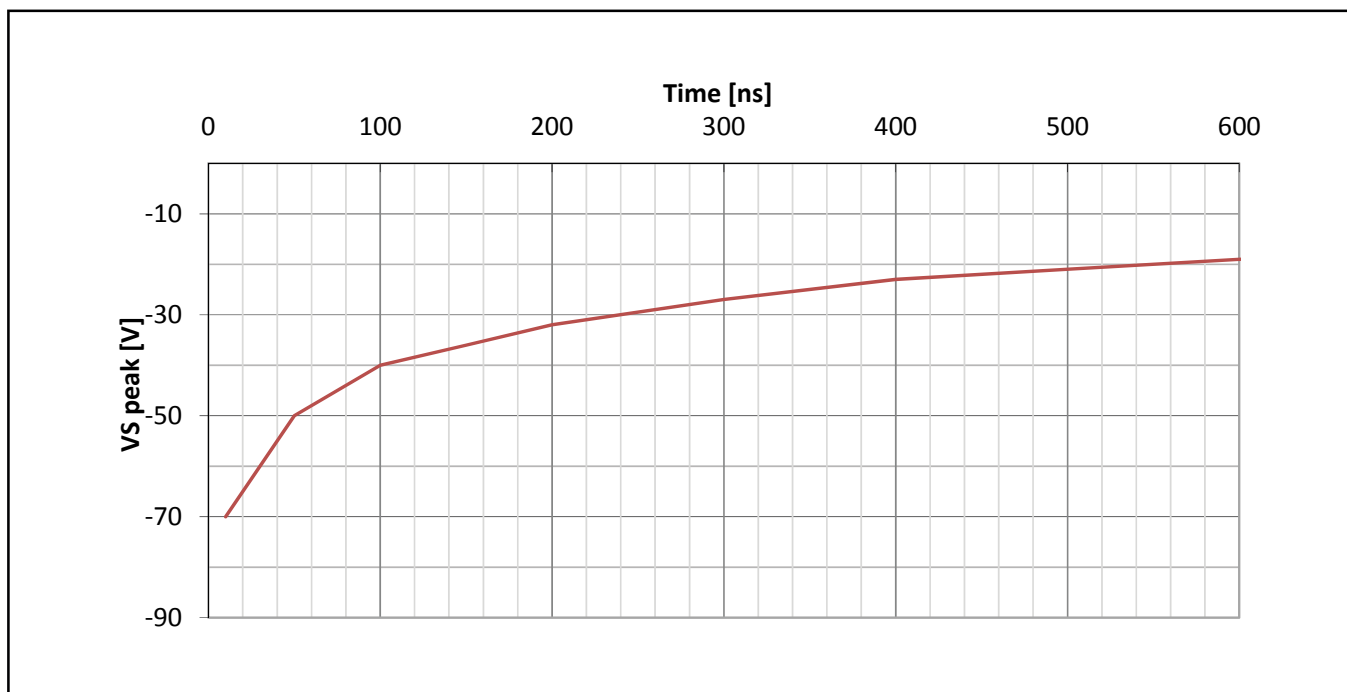
Figure 11 Max continuous current SOA

### 12.3 $T_J$ vs $T_{TH}$



**Figure 12** Typical  $T_J$  vs  $T_{TH}$  correlation

### 12.4 $-V_S$ Immunity

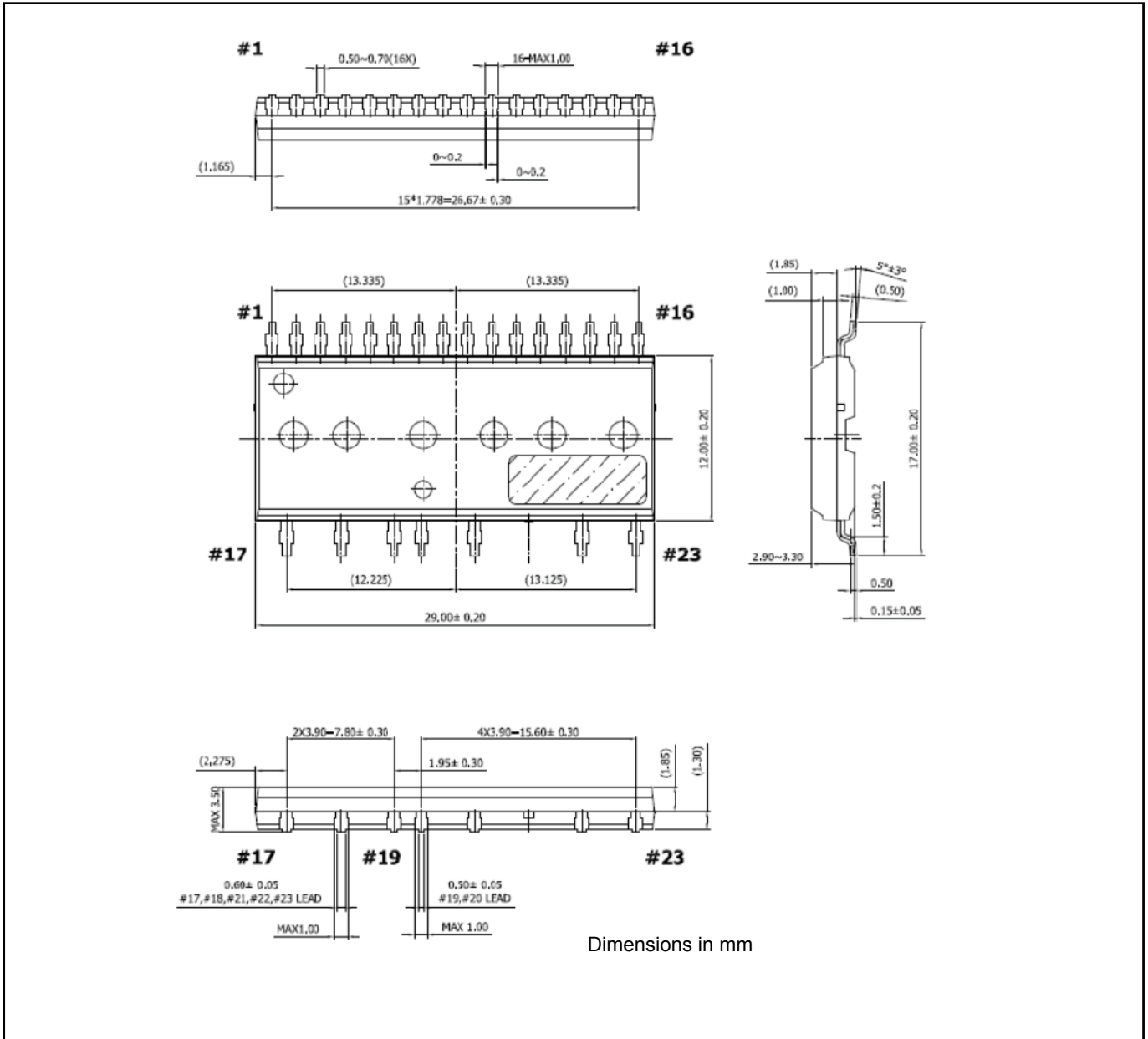


**Figure 13** Negative transient  $V_S$  SOA for integrated gate driver

Package Information

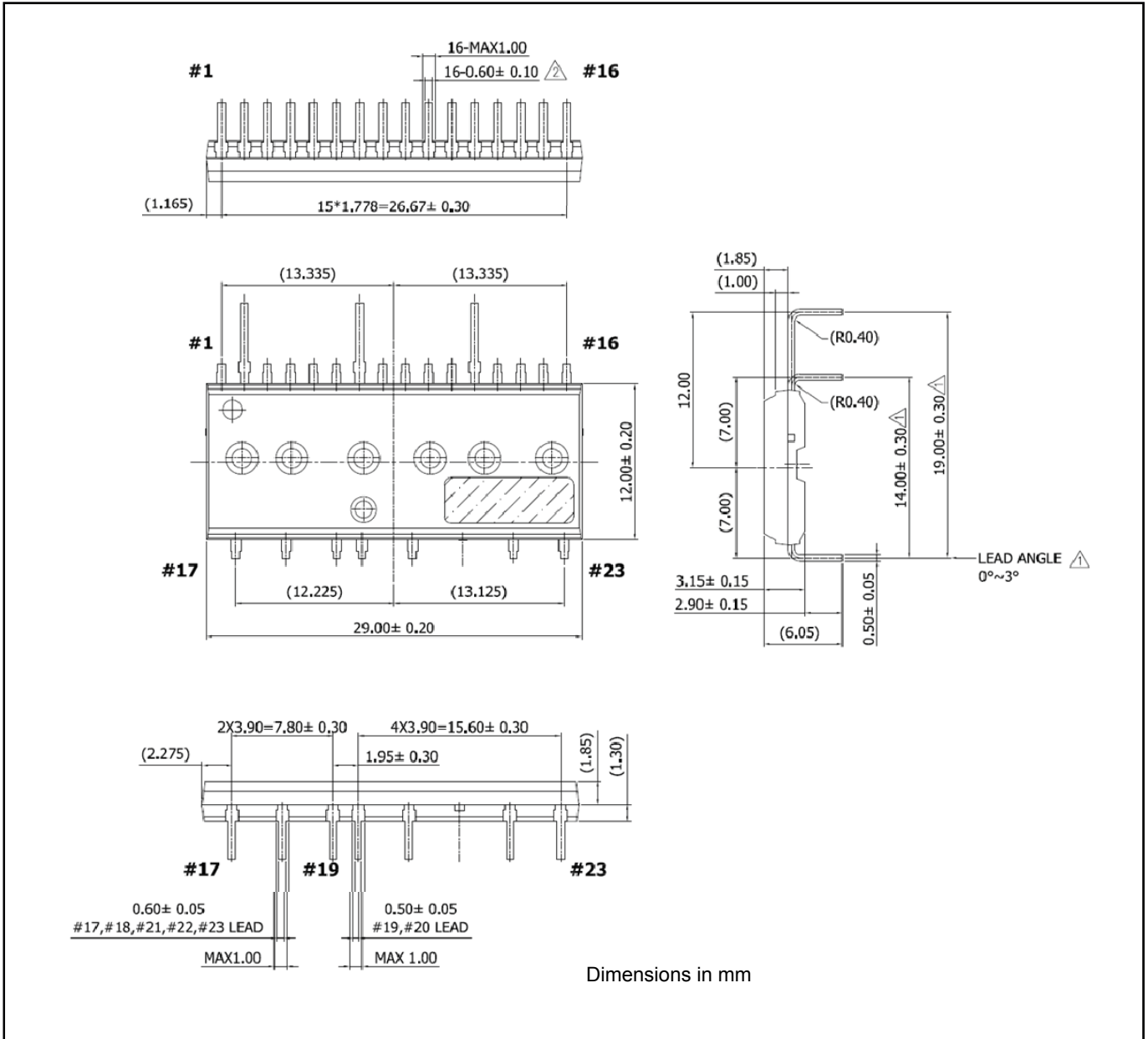
# 13 Package Outline

## 13.1 SOP23



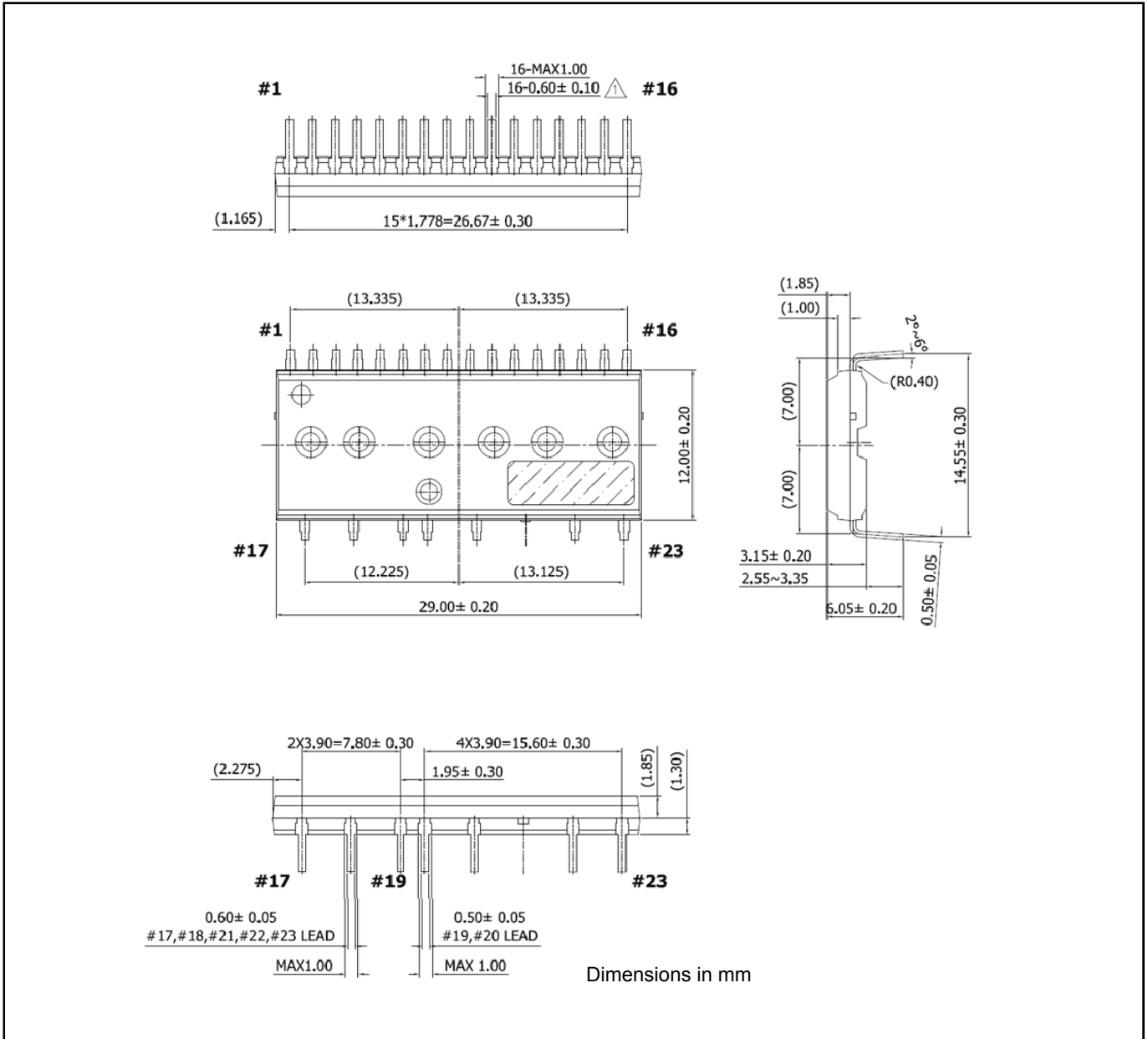
**Package Information**

**13.2 DIP23A**



Package Information

13.3 DIP23



**Revision History**

**Revision History**

**Major changes since the last revision**

| <b>Page or Reference</b> | <b>Revision</b> | <b>Date</b> | <b>Description of changes</b> |
|--------------------------|-----------------|-------------|-------------------------------|
|                          | 2.0             | 10/12/2017  | Final Datasheet               |

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