

# CIPOS™ Tiny IM323

## IM323-L6G/IM323-L6G2

### Description

The CIPOS™ Tiny IM323 product group offers the chance for integrating various power and control components to increase reliability, optimize PCB size and system costs. It is designed to control three phase AC motors and permanent magnet motors in variable speed drives for application like an air conditioning and refrigerator. The package concept is specially adapted to power application, which need good thermal conduction and electrical isolation, also EMI-save control and overload protection. The reverse conducting IGBTs are combined with an optimized SOI gate driver for excellent electrical performance.

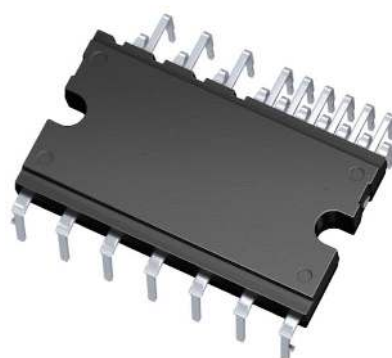
### Features

#### Package

- Fully isolated Dual In-Line molded module
- Applied full-package
- Lead-free terminal plating; RoHS compliant

#### Inverter

- 600V Reverse conducting, RCD2 IGBT
- Rugged SOI gate driver technology with stability against transient and negative voltage
- Allowable negative  $V_S$  potential up to -11 V for signal transmission at  $V_{BS} = 15$  V
- Integrated bootstrap functionality
- Over current shutdown
- Built-in NTC thermistor for temperature monitoring
- Under-voltage lockout at all channels
- Low-side emitter pins accessible for phase current monitoring (open emitter)
- Sleep function
- Cross-conduction prevention
- All of 6 switches turn off during protection



### Potential applications

Air conditioning and Home appliances

Industrial drives

**Product validation**

**Product validation**

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

**Table 1**      **Product information**

Base part number	Package type	Standard pack		Remark
		Form	MOQ	
IM323-L6G	DIP 33x19	15 pcs / Tube	240 pcs	
IM323-L6G2	DIP 33x19	15 pcs / Tube	240 pcs	Short lead

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Internal electrical schematic

1 Internal electrical schematic

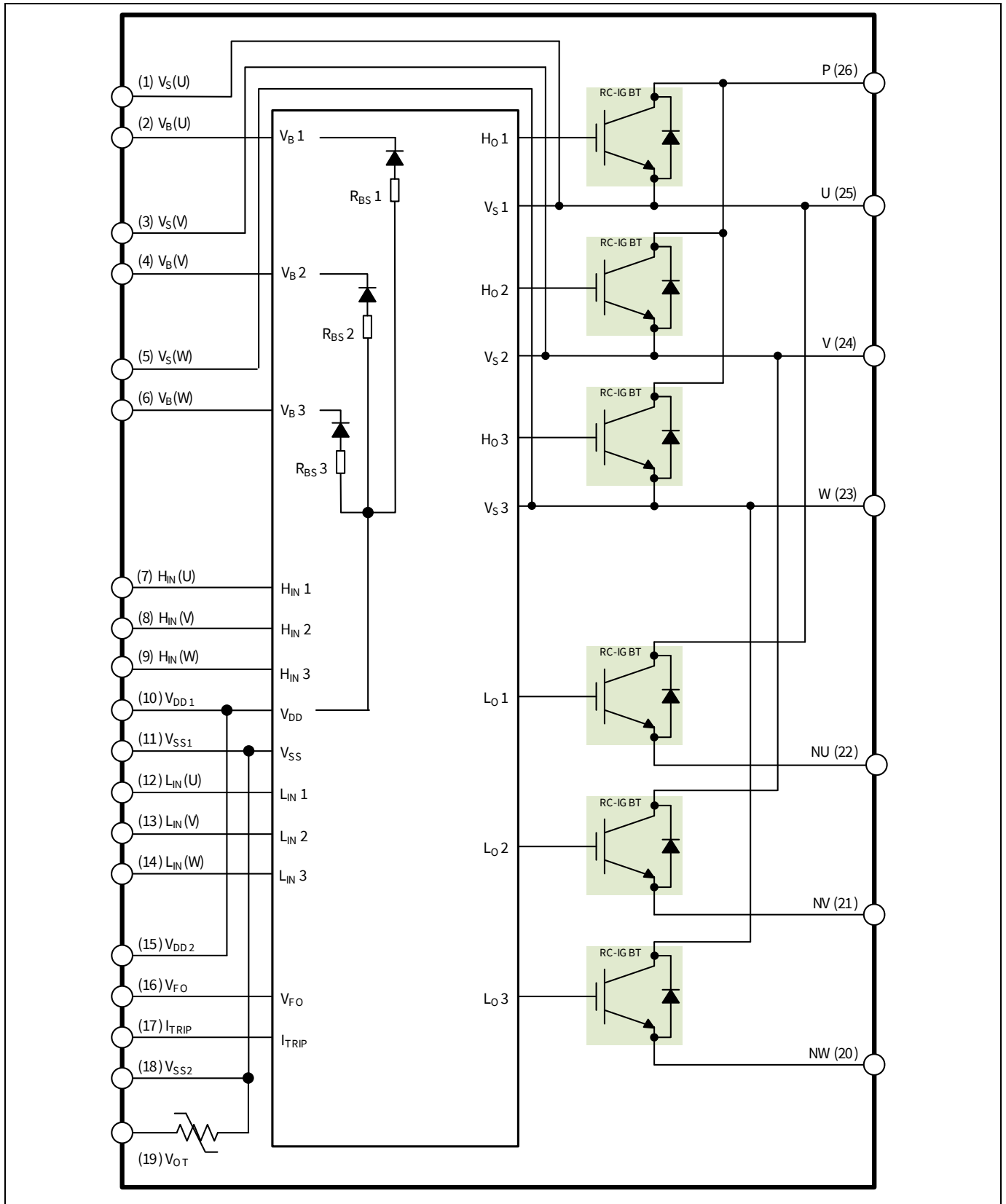


Figure 1 Internal electrical schematic

Pin description

## 2 Pin description

### 2.1 Pin assignment

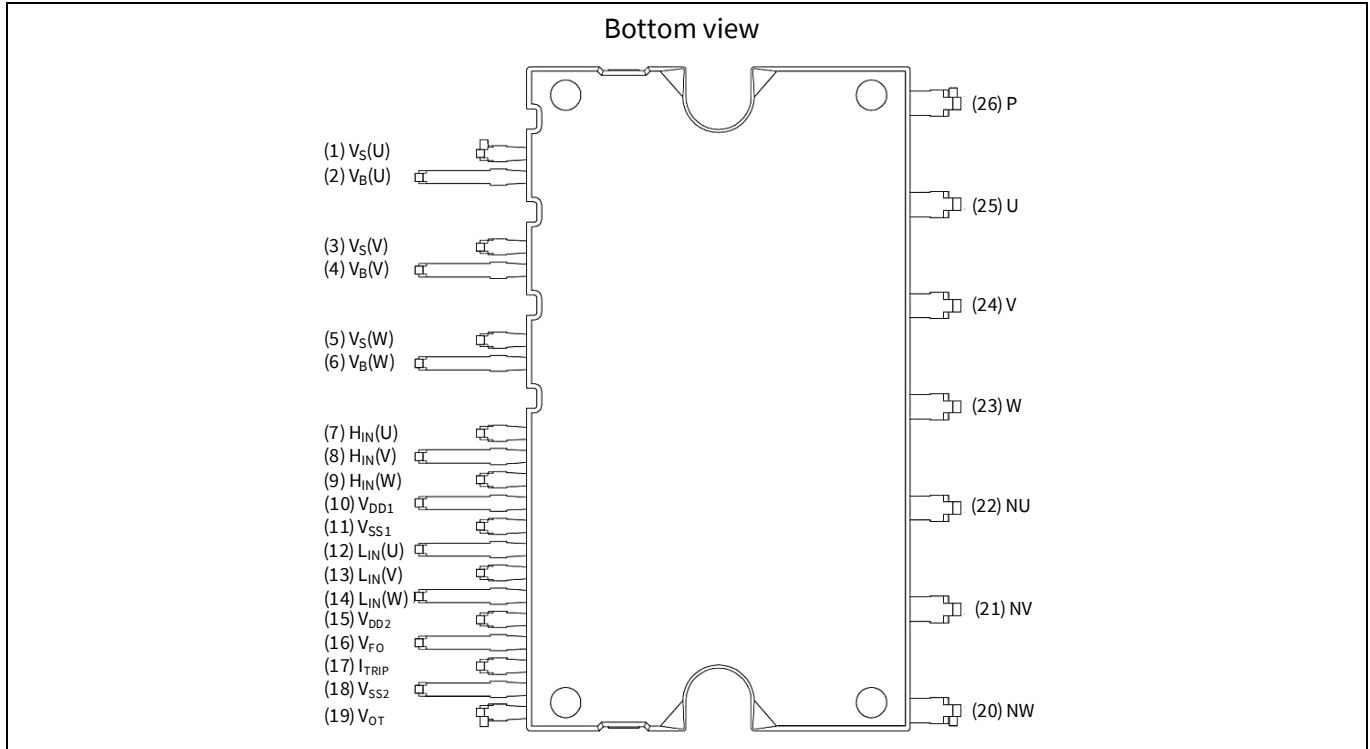


Figure 2 Pin configuration

Table 2 Pin assignment

Pin number	Pin name	Pin description
1	$V_S(U)$	U-phase high-side floating IC supply offset voltage
2	$V_B(U)$	U-phase high-side floating IC supply voltage
3	$V_S(V)$	V-phase high-side floating IC supply offset voltage
4	$V_B(V)$	V-phase high-side floating IC supply voltage
5	$V_S(W)$	W-phase high-side floating IC supply offset voltage
6	$V_B(W)$	W-phase high-side floating IC supply voltage
7	$H_{IN}(U)$	U-phase high-side gate driver input
8	$H_{IN}(V)$	V-phase high-side gate driver input
9	$H_{IN}(W)$	W-phase high-side gate driver input
10	$V_{DD1}$	Low-side control supply
11	$V_{SS1}$	Low-side control negative supply
12	$L_{IN}(U)$	U-phase low-side gate driver input
13	$L_{IN}(V)$	V-phase low-side gate driver input
14	$L_{IN}(W)$	W-phase low-side gate driver input
15	$V_{DD2}$	Low-side control supply
16	$V_{FO}$	Fault-output
17	$I_{TRIP}$	Over-current shutdown input

Pin description

Pin number	Pin name	Pin description
18	V <sub>SS2</sub>	Low-side control negative supply
19	V <sub>OT</sub>	Temperature output
20	NW	W-phase low-side emitter
21	NV	V-phase low-side emitter
22	NU	U-phase low-side emitter
23	W	Motor W-phase output
24	V	Motor V-phase output
25	U	Motor U-phase output
26	P	Positive bus input voltage

2.2 Pin description

**H<sub>IN</sub> (U, V, W) and L<sub>IN</sub> (U, V, W) (High-side pins, Pin 7 - 9 and Low-side pins, Pin 12 - 14)**

These pins are positive logic and they are responsible for the control of the integrated IGBTs. The schmitt-trigger input thresholds of them are such to guarantee LSTTL and CMOS compatibility down to 3.3 V controller outputs. Pull-down resistor of about 5 kΩ is internally provided to pre-bias inputs during supply start-up. 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  $t_{FIL,IN}$ . The filter acts according to Figure 4. It is not recommended for proper work to provide input pulse-width lower than 1 μs.

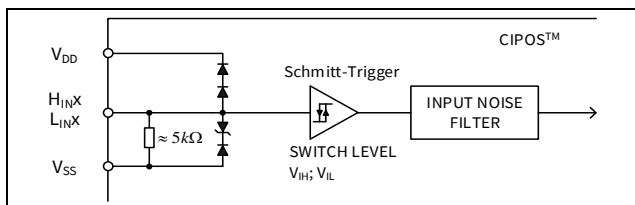


Figure 3 Input pin structure

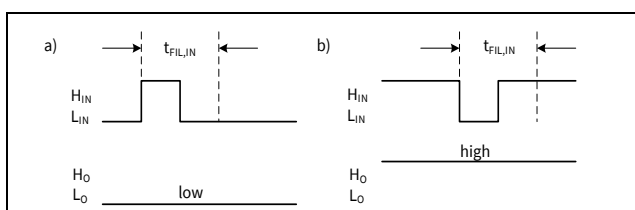


Figure 4 Input filter timing diagram

The integrated gate driver provides additionally a shoot through prevention capability which avoids the simultaneous on-state of two gate drivers of the same leg (i.e. H<sub>o1</sub> and L<sub>o1</sub>, H<sub>o2</sub> and L<sub>o2</sub>, H<sub>o3</sub> and L<sub>o3</sub>). When two inputs of a same leg are activated, only former activated one is activated so that the leg is kept steadily in a safe state.

A minimum deadtime insertion of typically 360 ns is also provided by driver IC, in order to reduce cross-conduction of the external power switches.

**V<sub>FO</sub> (Fault-output, Pin 16)**

The V<sub>FO</sub> pin indicates a module failure in case of under-voltage at pin V<sub>DD</sub> or in case of triggered over-current detection at I<sub>TRIP</sub>. An external pull-up resistor is required.

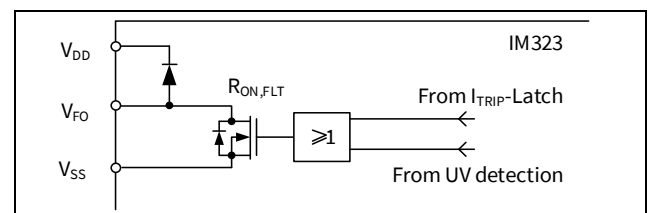


Figure 5 Internal circuit at pin V<sub>FO</sub>

The sleep function is activated after each trigger of I<sub>TRIP</sub> or under-voltage lockout. A new edge input signals is mandatory to activate gate drives after fault-clear time as shown in Figure 10.

**I<sub>TRIP</sub> (Over-current detection function, Pin 17)**

The IM323 product group provides an over-current detection function by connecting the I<sub>TRIP</sub> input with the IGBT current feedback. The I<sub>TRIP</sub> comparator

## Pin description

threshold (typical = 0.525 V) is referenced to  $V_{SS}$ . An input noise filter ( $t_{TRIP} = \text{typ. } 530 \text{ ns}$ ) prevents the driver to detect false over-current events.

Over-current detection generates a shutdown of outputs of the gate driver. Fast track shutdown function allows low-side outputs to be turned off faster than high-side outputs about 200 ns. The fault-clear time is set to minimum 100  $\mu\text{s}$ .

### **$V_{DDX}$ , $V_{SSX}$ (Control supply and reference, Pin 10(15) and reference, Pin 11(18))**

$V_{DD}$  is the control supply and it provides power both to input logic and to output power stage. Input logic is referenced to  $V_{SS}$  ground.

The under-voltage circuit enables the device to operate at power on when a supply voltage of at least a typical voltage of  $V_{DDUV+} = 12.4 \text{ V}$  is present.

The IC shuts down all the gate drivers power outputs, when the  $V_{DD}$  supply voltage is below  $V_{DDUV-} = 11.5 \text{ V}$ . This prevents the external power switches from critically low gate voltage levels during on-state and therefore from excessive power dissipation.

### **$V_B$ (U, V, W) and $V_S$ (U, V, W) (High-side supplies, Pin 1 - 6)**

$V_B$  to  $V_S$  is the high-side supply voltage. The high-side circuit can float with respect to  $V_{SS}$  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  $V_{BSUV+} = 11.5 \text{ V}$  and a falling threshold of  $V_{BSUV-} = 10.7 \text{ V}$ .

$V_S$  (U, V, W) provide a high robustness against negative voltage in respect of  $V_{SS}$  of -50 V transiently. This ensures very stable designs even under rough conditions.

### **NW, NV, NU (Low-side emitter, Pin 20 - 22)**

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

### **W, V, U (High-side emitter and low-side collector, Pin 23 - 25)**

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

### **P (Positive bus input voltage, Pin 26)**

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

**Absolute maximum ratings**

### 3 Absolute maximum ratings

( $V_{DD} = 15\text{ V}$  and  $T_J = 25^\circ\text{C}$ , if not stated otherwise)

#### 3.1 Module section

Description	Symbol	Condition	Value	Unit
Storage temperature range	$T_{STG}$		-40 ~ 125	$^\circ\text{C}$
Operating case temperature	$T_C$	Refer to Figure 7	-40 ~ 125	$^\circ\text{C}$
Operating junction temperature	$T_J$		-40 ~ 150	$^\circ\text{C}$
Maximum junction temperature <sup>1</sup>	$T_{J, \text{switch}, \text{max}}$		175	$^\circ\text{C}$
Isolation voltage	$V_{ISO}$	1 min, RMS, $f = 60\text{ Hz}$	2000	V

#### 3.2 Inverter section

Description	Symbol	Condition	Value	Unit
Maximum blocking voltage	$V_{CES}$	$I_C = 250\ \mu\text{A}$	600	V
DC link supply voltage of P - N	$V_{PN}$	Applied between P - N	450	V
DC link supply voltage (surge) of P - N	$V_{PN(\text{Surge})}$	Applied between P - N	500	V
Collector current <sup>2</sup>	$I_C$	$T_C = 25^\circ\text{C}$ , $T_J < 150^\circ\text{C}$	$\pm 15$	A
Maximum peak collector current	$I_{CP}$	$T_C = 25^\circ\text{C}$ , $T_J < 150^\circ\text{C}$ , less than 1 ms	$\pm 30$	A
Power dissipation per IGBT	$P_{\text{tot}}$		27	W
Short circuit withstand time	$t_{SC}$	$V_{DD} = 15\text{ V}$ , $V_{DC} \leq 400\text{ V}$ , $T_J \leq 150^\circ\text{C}$	3	$\mu\text{s}$

#### 3.3 Control section

Description	Symbol	Condition	Value	Unit
High-side offset voltage	$V_S$		600	V
Repetitive peak reverse voltage of bootstrap diode	$V_{RRM}$		600	V
Module control supply voltage	$V_{DD}$	Applied between $V_{DD} - V_{SS}$	-1 ~ 20	V
High-side floating supply voltage ( $V_B$ reference to $V_S$ )	$V_{BS}$	Applied between $V_B - V_S$	-1 ~ 20	V
Input voltage ( $L_{IN}$ , $H_{IN}$ , $I_{TRIP}$ )	$V_{IN}$		-1 ~ $V_{DD} + 0.3$	V
Fault-output voltage	$V_{FO}$		-1 ~ $V_{DD} + 0.3$	V

<sup>1</sup>The maximum junction temperature rating of built in power chips is  $175^\circ\text{C}$  under condition: max. 10 sec, every 10 min, max. 1 hrs cumulative over lifetime.

<sup>2</sup>Limited by junction temperature.



## 4 Thermal characteristics

Description	Symbol	Condition	Value			Unit
			Min.	Typ.	Max.	
Single IGBT thermal resistance, junction-case	$R_{thJC}$	Low-side U-phase (See Figure 7 for $T_c$ measurement point)	-	-	4.7	K/W
Single diode thermal resistance, junction-case	$R_{thJC,D}$		-	-	7.4	K/W

Recommended operation conditions

## 5 Recommended operation conditions

All voltages are absolute voltages referenced to  $V_{SS}$ -potential unless otherwise specified.

Description	Symbol	Value			Unit
		Min.	Typ.	Max.	
DC link supply voltage of P - N	$V_{PN}$	0	300	450	V
Low-side supply voltage	$V_{DD}$	13	15	17.5	V
High-side floating supply voltage ( $V_B$ vs. $V_S$ )	$V_{BS}$	13	-	17.5	V
Logic input voltages $L_{IN}$ , $H_{IN}$ , $I_{TRIP}$	$V_{IN}$ $V_{ITRIP}$	0	-	5	V
Inverter PWM carrier frequency	$f_{PWM}$	-	-	20	kHz
External dead time between $H_{IN}$ & $L_{IN}$	DT	1	-	-	$\mu s$
Voltage between $V_{SS}$ - N (including surge)	$V_{COMP}$	-5	-	5	V
Minimum input pulse width	$PW_{IN(ON)}$ , $PW_{IN(OFF)}$	0.7	-	-	$\mu s$
Control supply variation	$\Delta V_{BS}$	-1	-	1	V/ $\mu s$
	$\Delta V_{DD}$	-1	-	1	

Static parameters

## 6 Static parameters

( $V_{DD} = 15\text{ V}$  and  $T_J = 25^\circ\text{C}$ , if not stated otherwise)

### 6.1 Inverter section

Description	Symbol	Condition	Value			Unit
			Min.	Typ.	Max.	
Collector-emitter saturation voltage	$V_{CE(\text{Sat})}$	$I_C = 12\text{ A}, T_J = 25^\circ\text{C}$ $I_C = 12\text{ A}, T_J = 150^\circ\text{C}$	-	2.00	2.40	V
			-	2.35	-	
Collector-emitter leakage current	$I_{CES}$	$V_{CE} = 600\text{ V}$	-	-	1	mA
Diode forward voltage	$V_F$	$I_C = 12\text{ A}, T_J = 25^\circ\text{C}$ $I_C = 12\text{ A}, T_J = 150^\circ\text{C}$	-	1.95	2.30	V
			-	2.00	-	

### 6.2 Control section

Description	Symbol	Condition	Value			Unit
			Min.	Typ.	Max.	
Logic "1" input voltage ( $L_{IN}, H_{IN}$ )	$V_{IH}$		1.7	2.0	2.3	V
Logic "0" input voltage ( $L_{IN}, H_{IN}$ )	$V_{IL}$		0.7	0.9	1.1	V
$I_{TRIP}$ positive going threshold	$V_{IT, TH+}$		475	525	570	mV
$I_{TRIP}$ input hysteresis	$V_{IT, HYS}$		45	70	-	mV
$V_{DD}$ and $V_{BS}$ supply under-voltage positive going threshold	$V_{DDUV+}$		11.5	12.4	13.1	V
	$V_{BSUV+}$		10.6	11.5	12.2	
$V_{DD}$ and $V_{BS}$ supply under-voltage negative going threshold	$V_{DDUV-}$		10.6	11.5	12.3	V
	$V_{BSUV-}$		9.7	10.7	11.7	
$V_{DD}$ and $V_{BS}$ supply under-voltage lockout hysteresis	$V_{DDUVH}, V_{BSUVH}$		0.5	0.9	-	V
Quiescent $V_{BSx}$ supply current ( $V_{BSx}$ only)	$I_{QBS}$	$V_{HIN} = 0\text{ V}$	-	-	300	$\mu\text{A}$
Quiescent $V_{DD}$ supply current ( $V_{DD}$ only)	$I_{QDD}$	$V_{LIN} = 0\text{ V}, V_{HINX} = 5\text{ V}$	-	-	1.1	mA
Input bias current for $L_{IN}, H_{IN}$	$I_{IN+}$	$V_{IN} = 5\text{ V}$	-	1.1	1.7	mA
Input bias current for $I_{TRIP}$	$I_{ITRIP+}$	$V_{ITRIP} = 5\text{ V}$	-	68	185	$\mu\text{A}$
Input bias current for $V_{FO}$	$I_{FO}$	$V_{FO} = 5\text{ V}, V_{ITRIP} = 0\text{ V}$	-	60	-	$\mu\text{A}$
$V_{FO}$ output voltage	$V_{FO}$	$I_{FO} = 10\text{ mA}, V_{ITRIP} = 1\text{ V}$	-	0.35	-	V
Bootstrap diode forward voltage	$V_{F, BSD}$	$I_F = 0.3\text{ mA}$	-	1.0	-	V
Bootstrap diode resistance	$R_{BSD}$	Between $V_F = 4\text{ V}$ and $V_F = 5\text{ V}$	-	37	-	$\Omega$

Dynamic parameters

## 7 Dynamic parameters

( $V_{DD} = 15\text{ V}$  and  $T_J = 25^\circ\text{C}$ , if not stated otherwise)

### 7.1 Inverter section

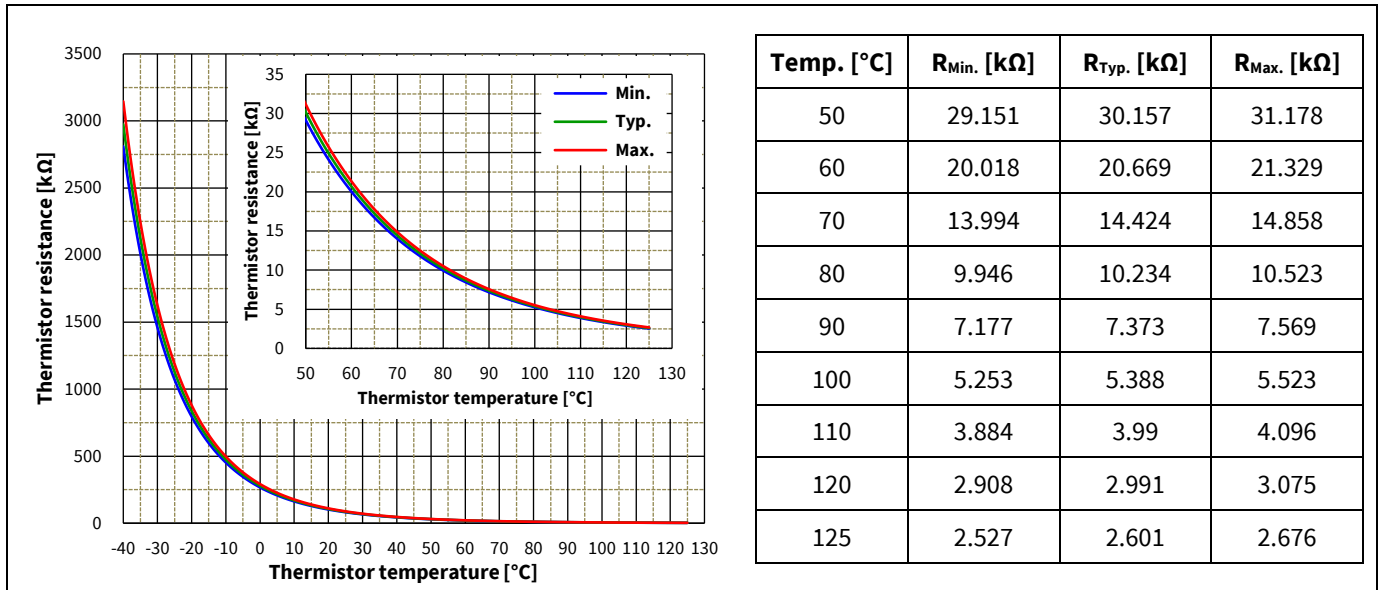
Description	Symbol	Condition	Value			Unit
			Min.	Typ.	Max.	
Turn-on propagation delay time	$t_{on}$	$V_{LIN, HIN} = 5\text{ V}$ , $I_C = 15\text{ A}$ , $V_{DC} = 300\text{ V}$	-	720	-	ns
Turn-on rise time	$t_r$		-	40	-	ns
Turn-on switching time	$t_{c(on)}$		-	130	-	ns
Reverse recovery time	$t_{rr}$		-	135	-	ns
Turn-off propagation delay time	$t_{off}$	$V_{LIN, HIN} = 0\text{ V}$ , $I_C = 15\text{ A}$ , $V_{DC} = 300\text{ V}$	-	805	-	ns
Turn-off fall time	$t_f$		-	25	-	ns
Turn-off switching time	$t_{c(off)}$		-	60	-	ns
Short circuit propagation delay time	$t_{SCP}$	From $V_{IT, TH+}$ to 10% $I_{SC}$	-	1250	-	ns
IGBT turn-on energy (includes reverse recovery of diode)	$E_{on}$	$V_{DC} = 300\text{ V}$ , $I_C = 15\text{ A}$ $T_J = 25^\circ\text{C}$ $150^\circ\text{C}$	-	365	-	$\mu\text{J}$
			-	515	-	
IGBT turn-off energy	$E_{off}$	$V_{DC} = 300\text{ V}$ , $I_C = 15\text{ A}$ $T_J = 25^\circ\text{C}$ $150^\circ\text{C}$	-	170	-	$\mu\text{J}$
			-	230	-	
Diode recovery energy	$E_{rec}$	$V_{DC} = 300\text{ V}$ , $I_C = 15\text{ A}$ $T_J = 25^\circ\text{C}$ $150^\circ\text{C}$	-	60	-	$\mu\text{J}$
			-	120	-	

### 7.2 Control section

Description	Symbol	Condition	Value			Unit
			Min.	Typ.	Max.	
Input filter time $I_{TRIP}$	$t_{ITRIP}$	$V_{ITRIP} = 1\text{ V}$	-	530	-	ns
Input filter time at $L_{IN}$ , $H_{IN}$ for turn on and off	$t_{FIL, IN}$	$V_{LIN, HIN} = 0\text{ V}$ or $5\text{ V}$	-	290	-	ns
Fault clear time after $I_{TRIP}$ -fault	$t_{FLT, CLR}$	$V_{ITRIP} = 1\text{ V}$ , $V_{pull-up} = 5\text{ V}$ ( $R = 1\text{ M}\Omega$ , $C = 2\text{ nF}$ )	100	280	-	$\mu\text{s}$
$I_{TRIP}$ to fault propagation delay	$t_{FLT}$	$V_{LIN, HIN} = 0\text{ V}$ or $5\text{ V}$ , $V_{ITRIP} = 1\text{ V}$	-	680	1000	ns
Internal deadtime	$DT_{IC}$	$V_{IN} = 0\text{ V}$ or $V_{IN} = 5\text{ V}$	-	360	-	ns
Matching propagation delay time (On & Off) all channels	$M_T$	External dead time > 500 ns	-	20	-	ns

## 8 Thermistor characteristics

Description	Symbol	Condition	Value			Unit
			Min.	Typ.	Max.	
Resistance	$R_{NTC}$	$T_{NTC} = 25^{\circ}\text{C}$	-	85	-	k $\Omega$
B-constant of NTC (Negative Temperature Coefficient) thermistor	B (25/100)		-	4092	-	K



**Figure 6 Thermistor resistance - temperature curve and table**  
(For more information, please refer to application note 'AN2021-04 CIPOS™ Tiny IM323 application note'.)

## 9 Mechanical characteristics and ratings

Description	Condition		Value			Unit
			Min.	Typ.	Max.	
Mounting torque	M3 screw and washer		0.59	0.69	0.78	N·m
Terminal strength pull	Control terminal: Load 5 N Power terminal: Load 10 N	JEITA-ED-4701	10	-	-	s
Terminal strength bending	Control terminal: Load 2.5 N Power terminal: Load 5 N 90degree bend	JEITA-ED-4701	2	-	-	times
Backside curvature	Refer to Figure 8		0	-	110	µm
Weight			-	5.6	-	g

Qualification information

## 10 Qualification information

<b>UL certification</b>	File number: E314539	
<b>Moisture sensitivity level</b>	-	
<b>RoHS compliant</b>	Yes (Lead-free terminal plating)	
<b>ESD (Electrostatic Discharge)</b>	HBM (Human body model) class	2
	CDM (Charged device model) class	C2A

Diagrams and tables

# 11 Diagrams and tables

## 11.1 T<sub>c</sub> measurement point

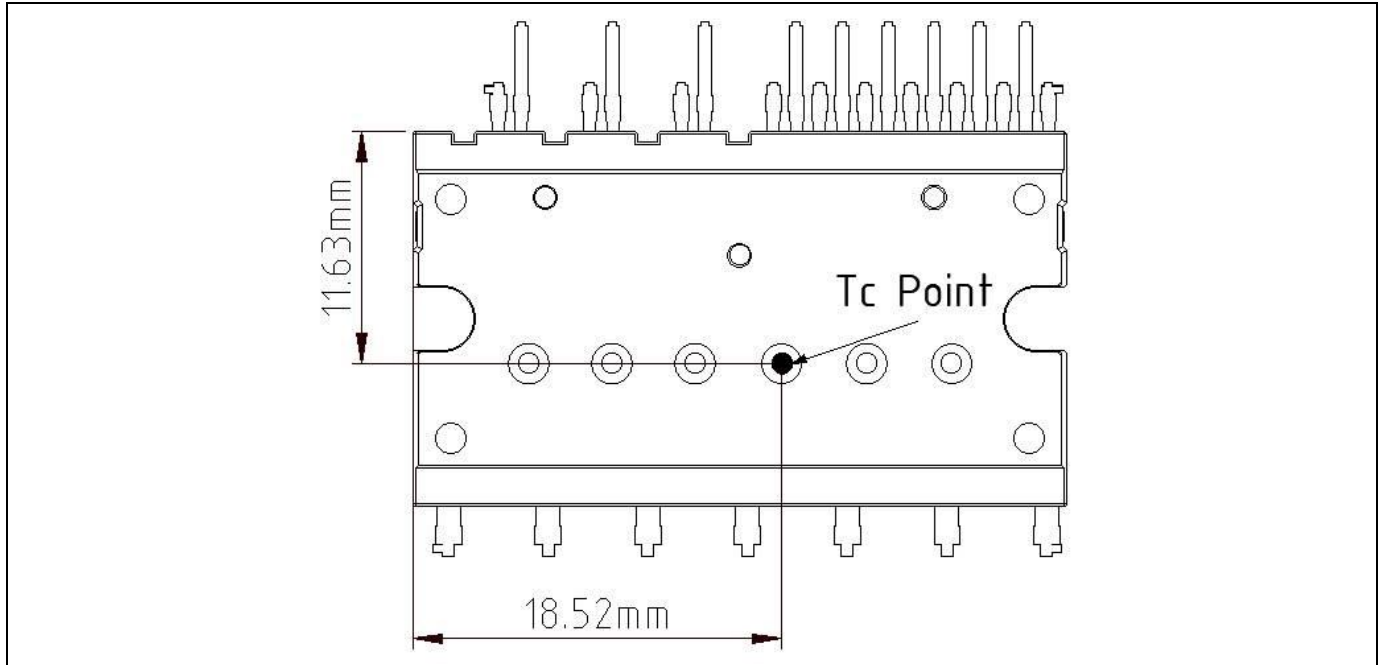


Figure 7 T<sub>c</sub> measurement point<sup>1</sup>

## 11.2 Backside curvature measurement point

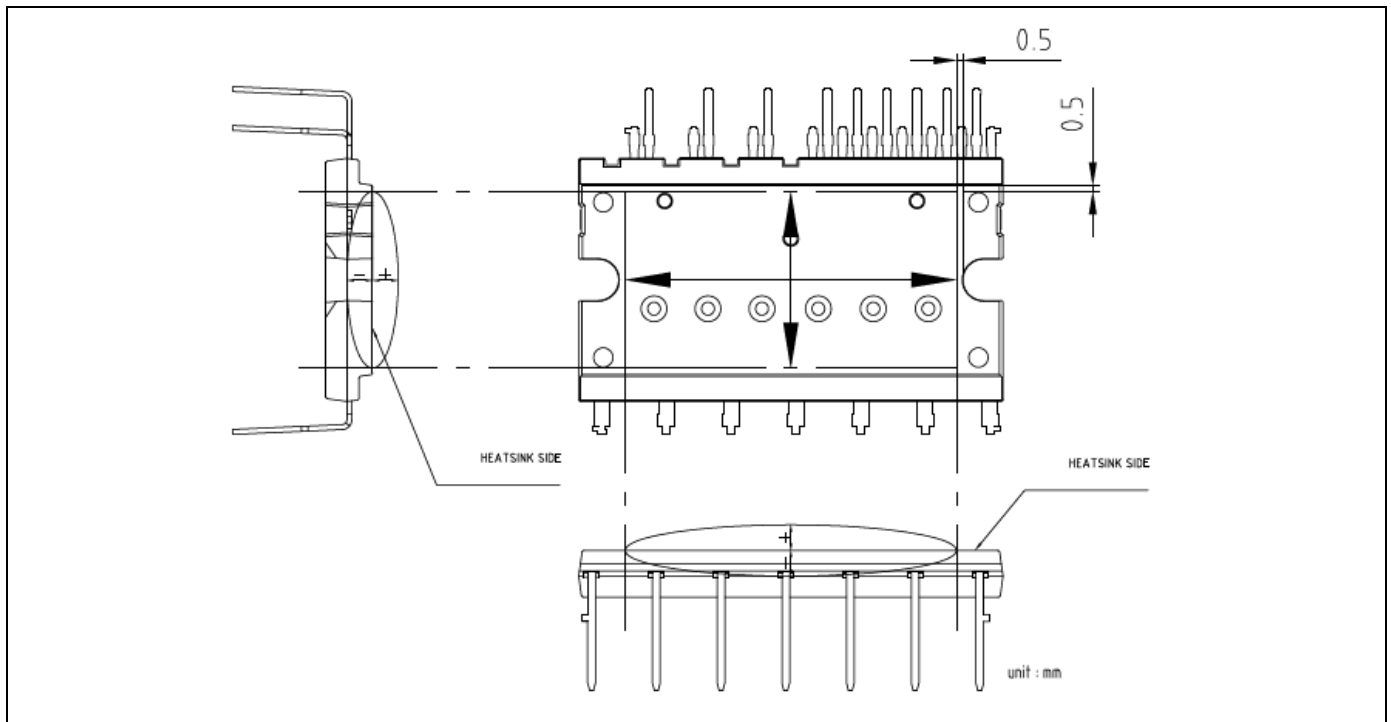


Figure 8 Backside curvature measurement position

<sup>1</sup>Any measurement except for the specified point in Figure 7 is not relevant for the temperature verification and brings wrong or different information.



Diagrams and tables

11.3 Switching time definition

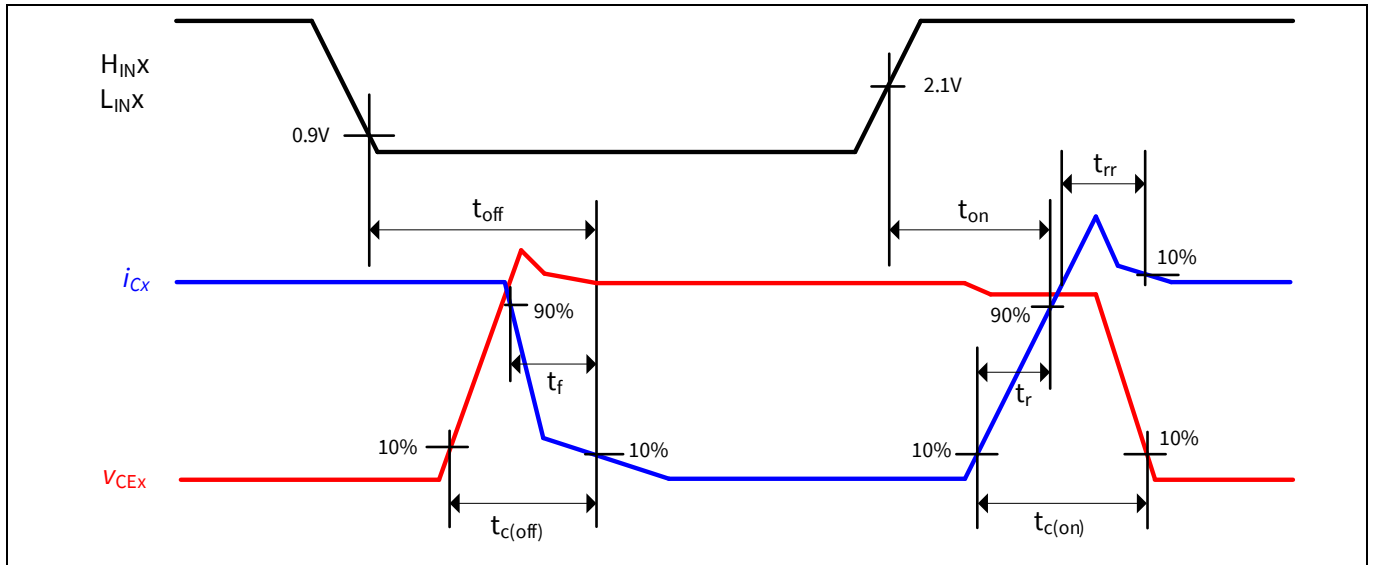


Figure 9 Switching times definition

11.4 Sleep function timing diagram

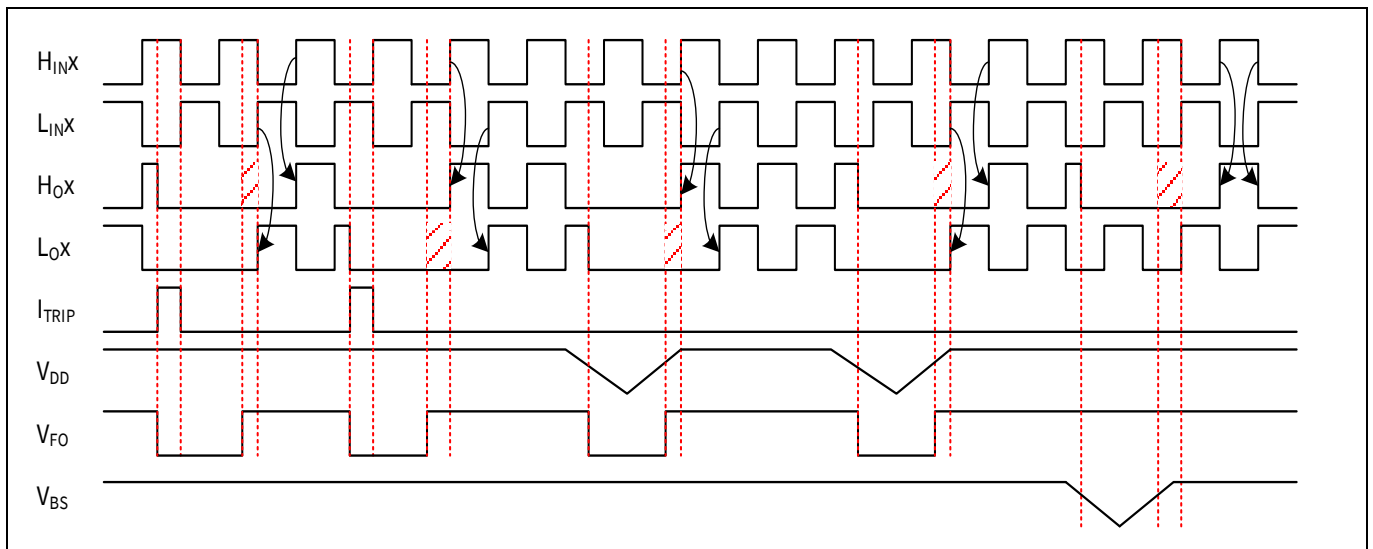


Figure 10 Sleep function timing diagram

Application guide

12 Application guide

12.1 Typical application schematic

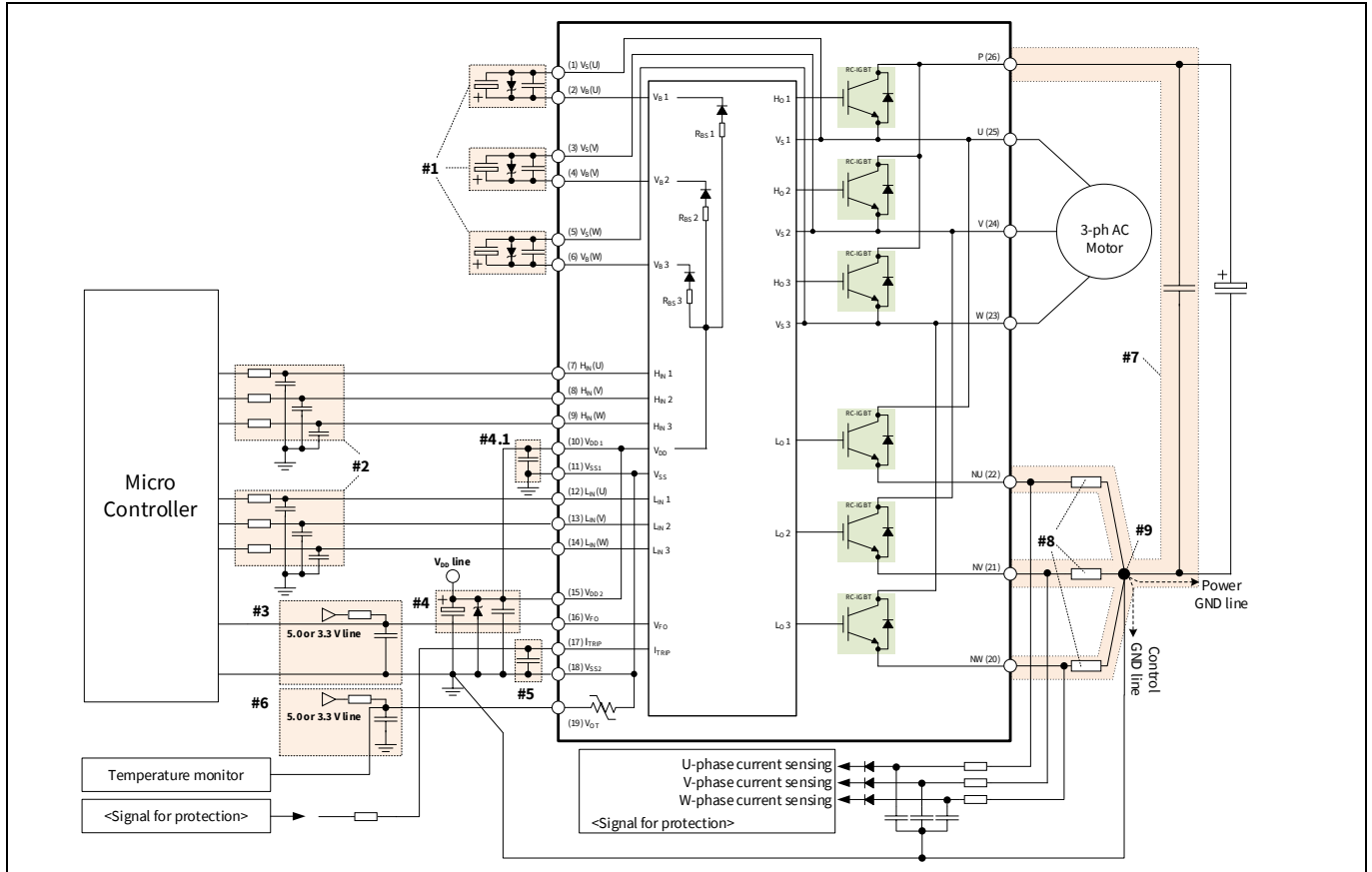


Figure 11 Typical application circuit

1.  $V_B$ - $V_S$  circuit
  - Capacitor and Zener diode for high-side floating supply voltage should be placed as close to  $V_B$  and  $V_S$  pins as possible.
2. Input circuit
  - To reduce input signal noise by high speed switching, the  $R_{IN}$  and  $C_{IN}$  filter circuit should be mounted. (100  $\Omega$ , 1 nF)
  - $C_{IN}$  should be placed as close to  $V_{SS}$  pin as possible.
3.  $V_{FO}$  circuit
  - $V_{FO}$  pin is open drain configuration. This terminal should be pulled up to the bias voltage of the 5.0 V/3.3 V through a proper resistor.
  - It is recommended that RC filter is placed close to the controller.
4.  $V_{DD}$ - $V_{SS}$  circuit
  - Capacitor and Zener diode for control supply voltage should be placed as close to  $V_{DD2}$  and  $V_{SS2}$  pins as possible.
5.  $I_{TRIP}$  circuit
  - To prevent protection function errors,  $C_{ITRIP}$  should be placed as close to  $I_{TRIP}$  and  $V_{SS2}$  pins as possible.
6.  $V_{OT}$  circuit
  - Capacitor should be placed as close to  $V_{OT}$  and  $V_{SS}$  pins as possible due to  $V_{OT}$  voltage is analog voltage.
7. Snubber capacitor
  - The wiring between IPM and snubber capacitor including shunt resistor should be as short as possible.
8. Shunt resistor
  - The shunt resistor of SMD type should be used for reducing its stray inductance.
9. Ground pattern
  - Ground pattern should be separated at only one point of shunt resistor as short as possible.

Package outline

13 Package outline

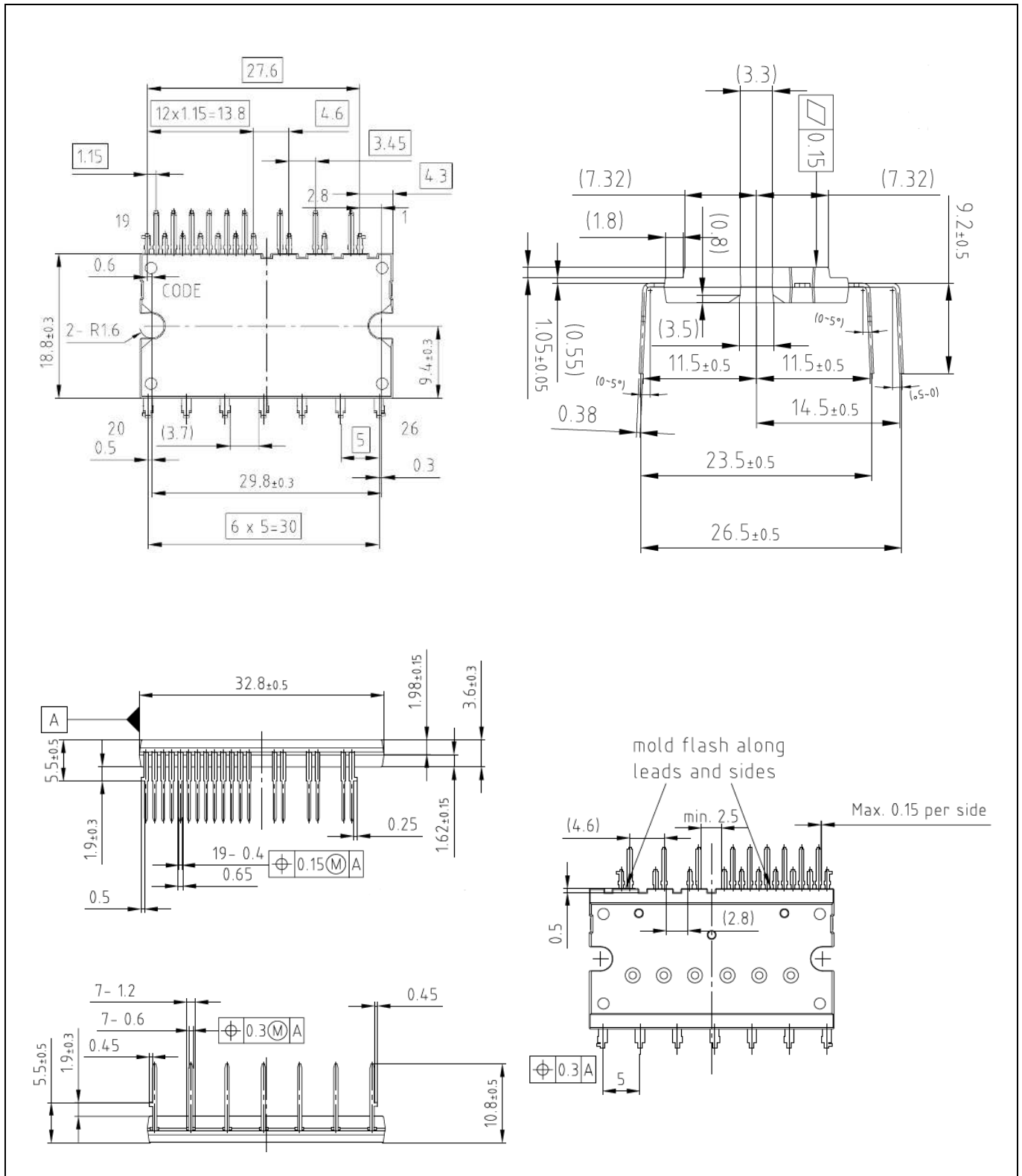


Figure 12 IM323-L6G

Package outline

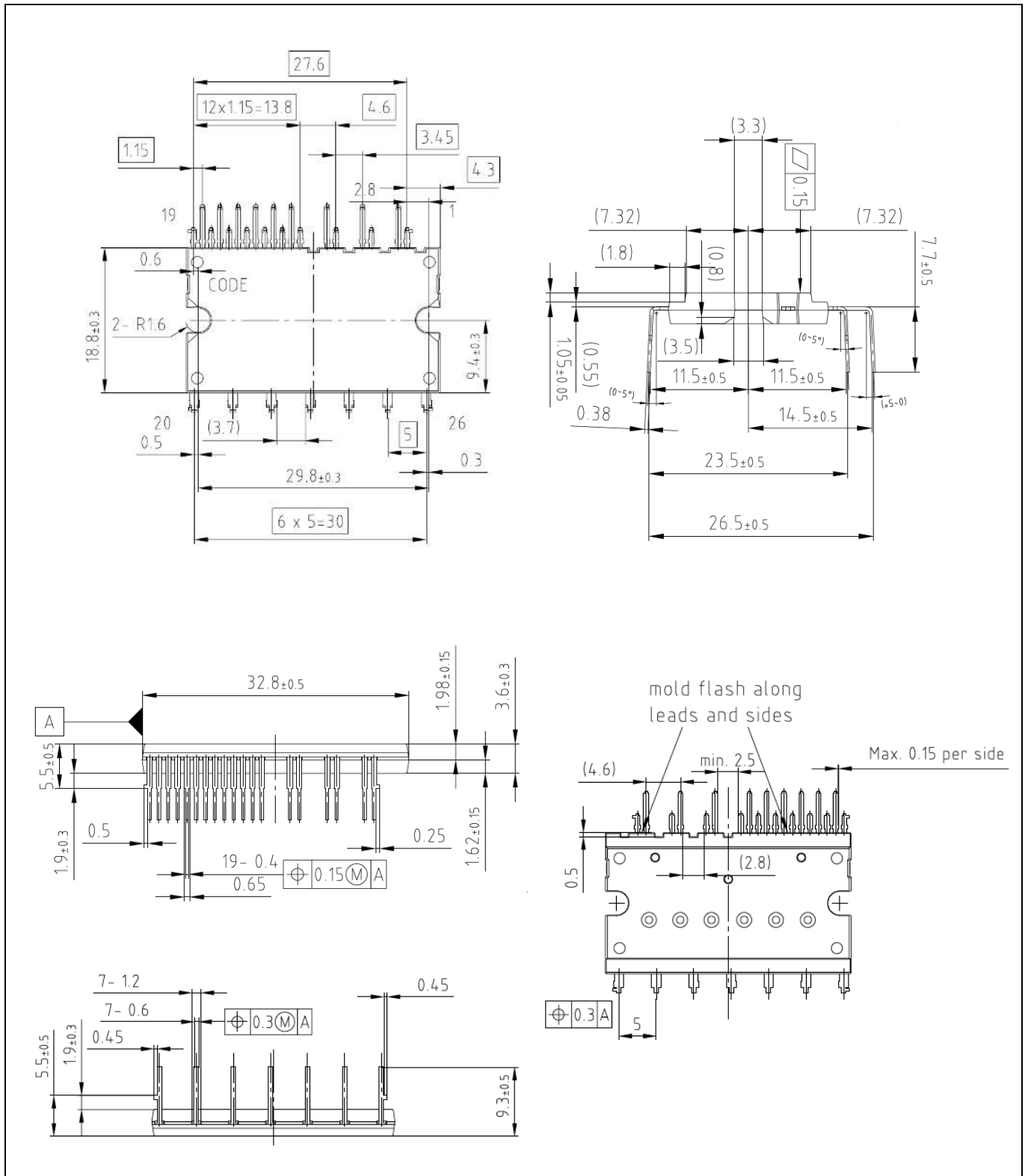


Figure 13 IM323-L6G2

Revision history

Revision history

Document version	Date of release	Description of changes
V 2.0	2021-12-09	Initial release
V 2.1	2022-01-28	UL certification updated
V 2.2	2022-11-16	ESD class updated

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