

# Control Integrated POver System (CIPOS™)

IFCM15S60GD

Datasheet

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## CIPOS™

# Control Integrated POver System

*Dual In-Line PFC integrated Intelligent Power Module  
3 $\phi$ -bridge 600V/15A, Single phase PFC 650V/30A*

### Features

#### Package

- Dual In-Line molded module
- Lead-free terminal plating; RoHS compliant
- Very low thermal resistance due to DCB

#### Inverter

- TRENCHSTOP™ IGBT3
- Rugged SOI gate driver technology with stability against transient and negative voltage
- Allowable negative VS potential up to -11V for signal transmission at VBS=15V
- Integrated bootstrap functionality
- Over current shutdown
- Temperature monitor
- Under-voltage lockout at all channels
- Low side common emitter
- Cross-conduction prevention
- All of 6 switches turn off during protection

#### PFC

- TRENCHSTOP™ IGBT3
- Rapid switching emitter controlled diode

### Target Applications

- Home appliances
- Low power motor drives

### Description

The CIPOS™ module family 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 with single phase PFC in variable speed drives for applications like an air conditioning and low power motor drives. The package concept is specially adapted to power applications, which need good thermal conduction and electrical isolation, but also EMI-save control and overload protection.

TRENCHSTOP™ IGBT3 and anti-parallel diodes are combined with an optimized SOI gate driver for excellent electrical performance.

### System Configuration

- 3 half bridges with TRENCHSTOP™ IGBT3 and anti parallel diodes
- 3 $\phi$  SOI gate driver
- Single phase PFC with TRENCHSTOP™ IGBT3 and Rapid switching emitter controlled diode
- Thermistor
- Pin-to-heatsink clearance distance typ. 1.6mm

## Pin Configuration

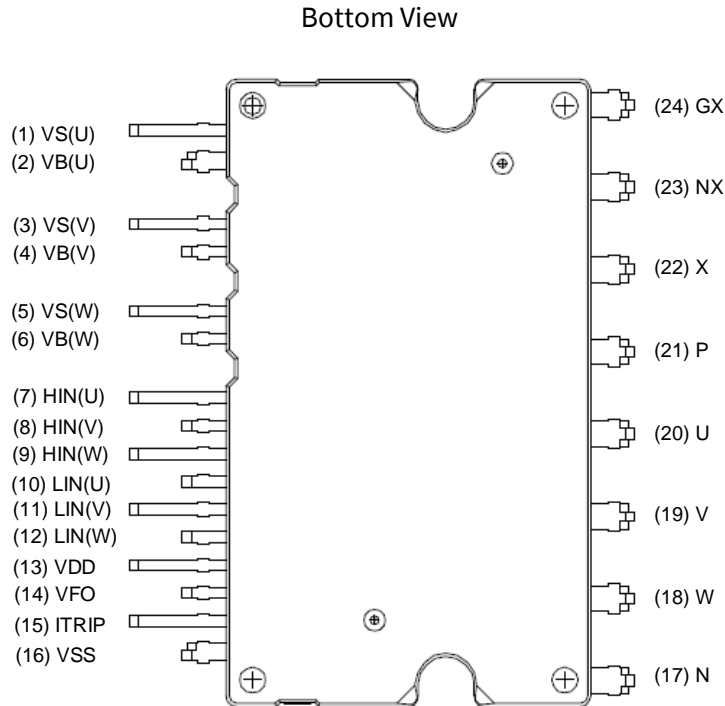


Figure 1 Pin configuration

## Internal Electrical Schematic

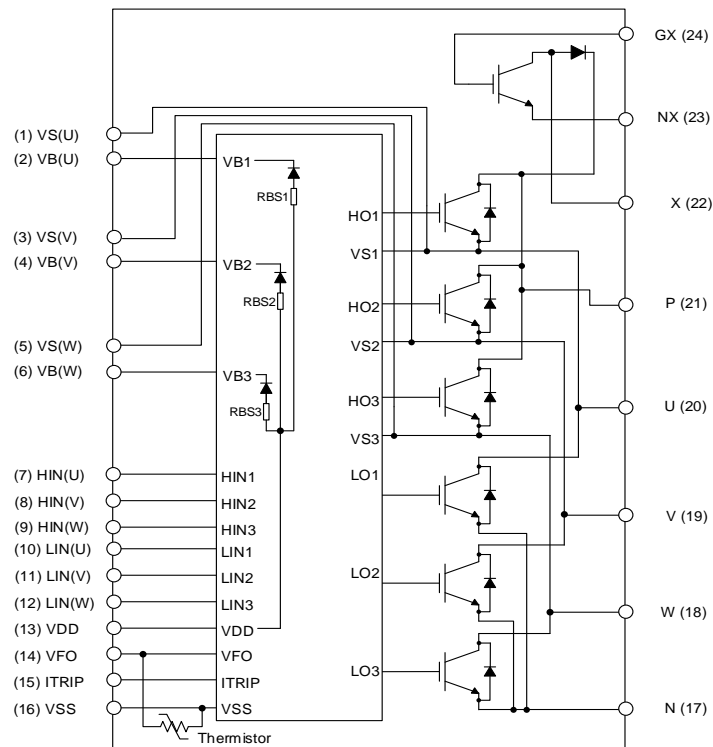


Figure 2 Internal schematic

## Pin Assignment

Pin Number	Pin Name	Pin Description
1	VS(U)	U-phase high side floating IC supply offset voltage
2	VB(U)	U-phase high side floating IC supply voltage
3	VS(V)	V-phase high side floating IC supply offset voltage
4	VB(V)	V-phase high side floating IC supply voltage
5	VS(W)	W-phase high side floating IC supply offset voltage
6	VB(W)	W-phase high side floating IC supply voltage
7	HIN(U)	U-phase high side gate driver input
8	HIN(V)	V-phase high side gate driver input
9	HIN(W)	W-phase high side gate driver input
10	LIN(U)	U-phase low side gate driver input
11	LIN(V)	V-phase low side gate driver input
12	LIN(W)	W-phase low side gate driver input
13	VDD	Low side control supply
14	VFO	Fault output / Temperature monitor
15	ITRIP	Over current shutdown input
16	VSS	Low side control negative supply
17	N	Low side emitter
18	W	Motor W-phase output
19	V	Motor V-phase output
20	U	Motor U-phase output
21	P	Positive output voltage / Positive bus input voltage
22	X	PFC IGBT collector
23	NX	PFC IGBT emitter
24	GX	PFC IGBT gate

## Pin Description

### HIN(U,V,W) and LIN(U,V,W) (Low side and high side control pins, Pin 7 - 12)

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 5kΩ is internally provided to pre-bias inputs during supply start-up and a zener clamp 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.

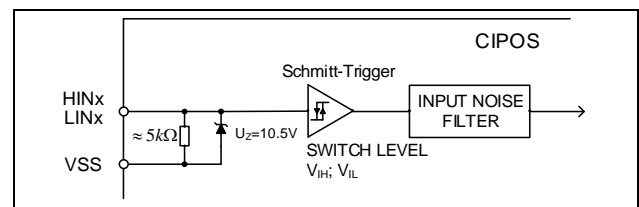


Figure 3 Input pin structure

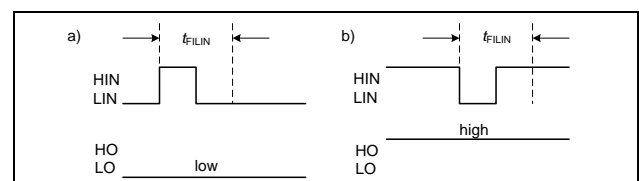


Figure 4 Input filter timing diagram

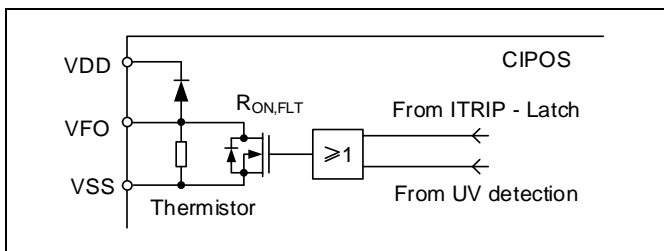
It is recommended for proper work of this product not to provide input pulse-width lower than 1 $\mu$ s.

The integrated gate drive provides additionally a shoot through prevention capability which avoids the simultaneous on-state of two gate drivers of the same leg (i.e. HO1 and LO1, HO2 and LO2, HO3 and LO3). 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 380ns is also provided by driver IC, in order to reduce cross-conduction of the external power switches.

**VFO (Fault-output and NTC, Pin 14)**

The VFO pin indicates a module failure in case of under voltage at pin VDD or in case of triggered over current detection at ITRIP. A pull-up resistor is externally required to bias the NTC.



**Figure 5 Internal circuit at pin VFO**

The same pin provides direct access to the NTC, which is referenced to VSS. An external pull-up resistor connected to +5V ensures that the resulting voltage can be directly connected to the microcontroller.

**ITRIP (Over current detection function, Pin 15)**

CIPOS™ provides an over current detection function by connecting the ITRIP input with the motor current feedback. The ITRIP comparator threshold (typ. 0.47V) is referenced to VSS ground. An input noise filter (typ:  $t_{ITRIPMIN} = 530ns$ ) prevents the driver to detect false over-current events.

Over current detection generates a shut down of all outputs of the gate driver after the shutdown propagation delay of typically 1000ns.

**VDD, VSS (Low side control supply and reference, Pin 13, 16)**

VDD is the low side supply and it provides power both to input logic and to low side output power stage. Input logic is referenced to VSS ground.

The under-voltage circuit enables the device to operate at power on when a supply voltage of at least a typical voltage of  $V_{DDUV+} = 12.1V$  is present.

The IC shuts down all the gate drivers' power outputs, when the VDD supply voltage is below  $V_{DDUV-} = 10.4V$ . This prevents the external power switches from critically low gate voltage levels during on-state and therefore from excessive power dissipation.

**VB(U,V,W) and VS(U,V,W) (High side supplies, Pin 1 - 6)**

VB to VS is the high side supply voltage. The high side circuit can float with respect to VSS 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  $V_{BSUV+} = 12.1V$  and a falling threshold of  $V_{BSUV-} = 10.4V$ .

VS(U,V,W) provide a high robustness against negative voltage in respect of VSS of -50V transiently. This ensures very stable designs even under rough conditions.

**N (Low side emitter, Pin 17)**

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

**W, V, U (High side emitter and low side collector, Pin 18 - 20)**

These pins are motor U, V, W input pins

**P (Positive bus input voltage, Pin 21)**

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

**X, NX, GX (Single boost PFC, Pins 22-24)**

These pins are emitter, collector and gate of IGBT for single boost PFC.

## Absolute Maximum Ratings

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

### Module Section

Description	Condition	Symbol	Value		Unit
			min	max	
Storage temperature range		$T_{stg}$	-40	125	$^\circ C$
Isolation test voltage	RMS, $f = 60Hz$ , $t = 1min$	$V_{ISOL}$	2000	-	V
Operating case temperature range	Refer to Figure 6	$T_C$	-40	125	$^\circ C$

### Inverter Section

Description	Condition	Symbol	Value		Unit
			min	max	
Max. blocking voltage	$I_C = 250\mu A$	$V_{CES}$	600	-	V
DC link supply voltage of P-N	Applied between P-N	$V_{PN}$	-	450	V
DC link supply voltage (surge) of P-N	Applied between P-N	$V_{PN(surge)}$	-	500	V
Output current	$T_C = 25^\circ C$ , $T_J < 150^\circ C$	$I_C$	-15	15	A
Maximum peak output current	less than 1ms	$I_{C(peak)}$	-30	30	A
Short circuit withstand time <sup>1</sup>	$V_{DC} \leq 400V$ , $T_J = 150^\circ C$	$t_{SC}$	-	5	$\mu s$
Power dissipation per IGBT		$P_{tot}$	-	49.8	W
Operating junction temperature range		$T_J$	-40	150	$^\circ C$
Single IGBT thermal resistance, junction-case		$R_{thJC}$	-	2.51	K/W
Single diode thermal resistance, junction-case		$R_{thJCD}$	-	4.67	K/W

### Control Section

Description	Condition	Symbol	Value		Unit
			min	max	
Module supply voltage		$V_{DD}$	-1	20	V
High side floating supply voltage (VB vs. VS)		$V_{BS}$	-1	20	V
Input voltage	LIN, HIN, ITRIP	$V_{IN}$ $V_{ITRIP}$	-1 -1	10 10	V
Inverter switching frequency		$f_{PWM}$	-	20	kHz
PFC switching frequency		$f_{PWM(PFC)}$	-	40	kHz

<sup>1</sup> Allowed number of short circuits: <1000; time between short circuits: > 1s.

## PFC Section

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

Description	Condition	Symbol	Value		Unit
			min	max	
Max. blocking voltage	$I_C = 250\mu A$	$V_{CES}$	650	-	V
Repetitive peak reverse voltage	$I_R = 250\mu A$	$V_{RRM}$	650	-	V
Gate-emitter voltage		$V_{GE}$	-20	20	V
Input RMS current	$T_J \leq 150^\circ C, T_C = 25^\circ C$	$I_i$	-	30	A
Maximum peak input current	$T_J \leq 150^\circ C, T_C = 25^\circ C$ less than 1ms, non-repetitive	$I_{i(peak)}$	-	60	A
Short circuit withstand time <sup>1</sup>	$V_{DC} \leq 400V, T_J = 150^\circ C$	$t_{SC}$	-	5	$\mu s$
Power dissipation		$P_{tot}$	-	105.9	W
Operating junction temperature range		$T_J$	-40	150	$^\circ C$
Single IGBT thermal resistance, junction-case		$R_{thJC}$	-	1.18	K/W
Single diode thermal resistance, junction-case		$R_{thJCD}$	-	2.76	K/W

## 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	-	450	V
High side floating supply voltage ( $V_B$ vs. $V_S$ )	$V_{BS}$	13.5	-	18.5	V
Low side supply voltage	$V_{DD}$	14.5	16	18.5	V
Control supply variation	$\Delta V_{BS}$ ,	-1	-	1	V/ $\mu s$
	$\Delta V_{DD}$	-1	-	1	
Logic input voltages LIN,HIN,ITRIP	$V_{IN}$	0	-	5	V
	$V_{ITRIP}$	0	-	5	
Between $V_{SS}$ - N and NX(including surge)	$V_{SS}$	-5	-	5	V
PFC IGBT gate-emitter voltage	$V_{GE}$	14	-	18	V
PFC IGBT external gate parameters	$R_G$	-	10	-	$\Omega$
	$C_{GE}$	-	4.7	-	nF
	$R_{GE}$	-	10	-	k $\Omega$

<sup>1</sup> Allowed number of short circuits: <1000; time between short circuits: > 1s.



## Static Parameters

### Inverter Section

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

Description	Condition	Symbol	Value			Unit
			min	typ	max	
Collector-Emitter saturation voltage	$I_C = 10A$ $T_J = 25^\circ C$ $150^\circ C$	$V_{CE(sat)}$	- -	1.55 1.8	2.05 -	V
Emitter-Collector forward voltage	$I_F = 10A$ $T_J = 25^\circ C$ $150^\circ C$	$V_F$	- -	1.75 1.8	2.45 -	V
Collector-Emitter leakage current	$V_{CE} = 600V$	$I_{CES}$	-	-	1	mA
Logic "1" input voltage (LIN,HIN)		$V_{IH}$	-	2.1	2.5	V
Logic "0" input voltage (LIN,HIN)		$V_{IL}$	0.7	0.9	-	V
ITRIP positive going threshold		$V_{IT,TH+}$	400	470	540	mV
ITRIP input hysteresis		$V_{IT,HYS}$	40	70	-	mV
VDD and VBS supply under voltage positive going threshold		$V_{DDUV+}$ $V_{BSUV+}$	10.8	12.1	13.0	V
VDD and VBS supply under voltage negative going threshold		$V_{DDUV-}$ $V_{BSUV-}$	9.5	10.4	11.2	V
VDD and VBS supply under voltage lockout hysteresis		$V_{DDUVH}$ $V_{BSUVH}$	1.0	1.7	-	V
Quiescent VBx supply current (VBx only)	$H_{IN} = 0V$	$I_{QBS}$	-	300	500	$\mu A$
Quiescent VDD supply current (VDD only)	$L_{IN} = 0V, H_{INX} = 5V$	$I_{QDD}$	-	370	900	$\mu A$
Input bias current	$V_{IN} = 5V$	$I_{IN+}$	-	1	1.5	mA
Input bias current	$V_{IN} = 0V$	$I_{IN-}$	-	2	-	$\mu A$
ITRIP input bias current	$V_{ITRIP} = 5V$	$I_{ITRIP+}$	-	65	150	$\mu A$
VFO input bias current	$VFO = 5V, V_{ITRIP} = 0V$	$I_{FO}$	-	60	-	$\mu A$
VFO output voltage	$I_{FO} = 10mA, V_{ITRIP} = 1V$	$V_{FO}$	-	0.5	-	V

## PFC Section

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

Description	Condition	Symbol	Value			Unit
			min	typ	max	
Collector-Emitter saturation voltage	$I_C = 30A$ , $T_J = 25^\circ C$ $150^\circ C$	$V_{CE(sat)}$	- -	2.0 2.55	2.4 -	V
Diode forward voltage	$I_F = 30A$ , $T_J = 25^\circ C$ $150^\circ C$	$V_F$	- -	1.75 1.65	2.3 -	V
Gate-Emitter threshold voltage	$I_C = 0.43mA$ , $V_{GE} = V_{CE}$	$V_{GE(th)}$	4.1	5.1	5.7	V
Collector-Emitter leakage current	$V_{CE} = 650V$ , $V_{GE} = 0V$	$I_{CES}$	-	-	1	mA
Gate-Emitter leakage current	$V_{CE} = 0V$ , $V_{GE} = 20V$	$I_{GES}$	-	-	1	$\mu A$
Diode reverse leakage current	$V_R = 650V$	$I_R$	-	-	1	mA

## Bootstrap Parameters

( $T_J = 25^\circ C$ , if not stated otherwise)

Description	Condition	Symbol	Value			Unit
			min	typ	max	
Repetitive peak reverse voltage		$V_{RRM}$	600	-	-	V
Bootstrap diode resistance	Between $V_F = 4V$ and $V_F = 5V$	$R_{BSD}$	-	40	-	$\Omega$
Reverse recovery time	$I_F = 0.6A$ , $di/dt = 80A/\mu s$	$t_{rr\_BSD}$	-	50	-	ns
Bootstrap diode forward voltage	$I_F = 0.5mA$	$V_{F\_BSD}$	-	1	-	V

## Dynamic Parameters

### Inverter Section

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

Description	Condition	Symbol	Value			Unit
			min	typ	max	
Turn-on propagation delay time	$V_{LIN,HIN} = 5V,$ $I_C = 10A,$ $V_{DC} = 300V$	$t_{on}$	-	680	-	ns
Turn-on rise time		$t_r$	-	30	-	ns
Turn-on switching time		$t_{c(on)}$	-	220	-	ns
Reverse recovery time		$t_{rr}$	-	60	-	ns
Turn-off propagation delay time	$V_{LIN,HIN} = 0V,$ $I_C = 10A,$ $V_{DC} = 300V$	$t_{off}$	-	950	-	ns
Turn-off fall time		$t_f$	-	55	-	ns
Turn-off switching time		$t_{c(off)}$	-	120	-	ns
Short circuit propagation delay time	From $V_{IT,TH+}$ to 10% $I_{SC}$	$t_{SCP}$	-	1250	-	ns
Input filter time ITRIP	$V_{ITRIP} = 1V$	$t_{ITRIPmin}$	-	530	-	ns
Input filter time at LIN, HIN for turn on and off	$V_{LIN,HIN} = 0V \text{ \& } 5V$	$t_{FILIN}$	-	290	-	ns
Fault clear time after ITRIP-fault	$V_{ITRIP} = 1V$	$t_{FLTCLR}$	40	-	-	$\mu s$
Deadtime between low side and high side		$DT_{PWM}$	1.5	-	-	$\mu s$
Deadtime of gate drive circuit		$DT_{IC}$	-	380	-	ns
IGBT turn-on energy (includes reverse recovery of diode)	$V_{DC} = 300V, I_C = 10A$ $T_J = 25^\circ C$ $150^\circ C$	$E_{on}$	-	400	-	$\mu J$
			-	490	-	
IGBT turn-off energy	$V_{DC} = 300V, I_C = 10A$ $T_J = 25^\circ C$ $150^\circ C$	$E_{off}$	-	190	-	$\mu J$
			-	290	-	
Diode recovery energy	$V_{DC} = 300V, I_C = 10A$ $T_J = 25^\circ C$ $150^\circ C$	$E_{rec}$	-	55	-	$\mu J$
			-	70	-	

### PFC Section

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

Description	Condition	Symbol	Value			Unit
			min	typ	max	
Input capacitance	$V_{CE} = 25V, V_{GE} = 0V,$ $f = 1MHz$	$C_{ies}$	-	1900	-	pF
Output capacitance		$C_{oes}$	-	107	-	
Reverse transfer capacitance		$C_{res}$	-	55	-	
Gate charge	$V_{DC} = 520V, I_C = 30A,$ $V_{GE} = 15V$	$Q_G$	-	165	-	nC
Turn-on delay time	$V_{DC} = 400V, I_C = 30A,$ $R_G = 10\Omega, C_{GE} = 4.7nF,$ $R_{GE} = 10k\Omega, T_J = 25^\circ C$	$t_{d(on)}$	-	20	-	ns
Turn-on rise time		$t_r$	-	90	-	ns
Turn-off delay time		$t_{d(off)}$	-	205	-	ns
Turn-off fall time		$t_f$	-	30	-	ns
Reverse recovery time		$t_{rr}$	-	100	-	ns
Turn-on energy	$V_{DC} = 400V, I_C = 30A, R_G = 10\Omega,$ $C_{GE} = 4.7nF, R_{GE} = 10k\Omega$ $T_J = 25^\circ C$ $150^\circ C$	$E_{on}$	-	1540	-	$\mu J$
Turn-off energy	$V_{DC} = 400V, I_C = 30A, R_G = 10\Omega,$ $C_{GE} = 4.7nF, R_{GE} = 10k\Omega$ $T_J = 25^\circ C$ $150^\circ C$	$E_{off}$	-	510	-	
Diode recovery energy	$V_{DC} = 400V, I_C = 30A, R_G = 10\Omega,$ $C_{GE} = 4.7nF, R_{GE} = 10k\Omega$ $T_J = 25^\circ C$ $150^\circ C$	$E_{rec}$	-	50	-	$\mu J$
			-	120	-	

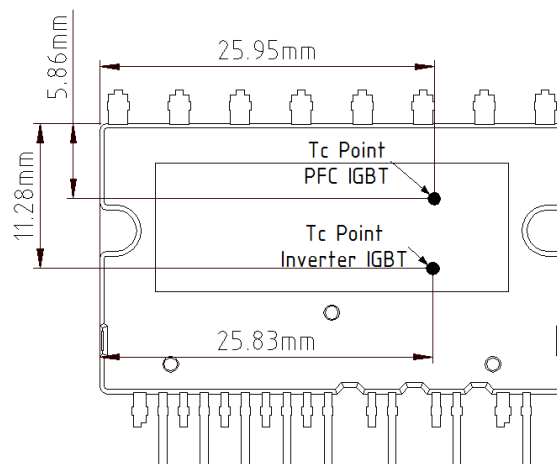
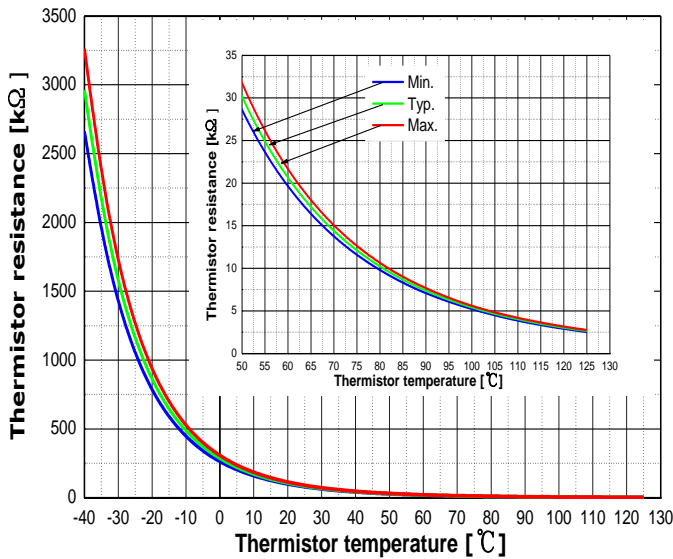


Figure 6 T<sub>c</sub> measurement point<sup>1</sup>

<sup>1</sup> Any measurement except for the specified point in figure 6 is not relevant for the temperature verification and brings wrong or different information.

## Thermistor

Description	Condition	Symbol	Value			Unit
			min	typ	max	
Resistor	$T_{NTC} = 25^{\circ}\text{C}$	$R_{NTC}$	-	85	-	$k\Omega$
B-constant of NTC (Negative temperature coefficient)		$B(25/100)$	-	4092	-	K



T [°C]	Rmin. [kΩ]	Rtyp. [kΩ]	Rmax. [kΩ]
50	28.400	29.972	31.545
60	19.517	20.515	21.514
70	13.670	14.315	14.960
80	9.745	10.169	10.593
90	7.062	7.345	7.628
100	5.199	5.388	5.576
110	3.856	4.009	4.163
120	2.900	3.024	3.149
125	2.527	2.639	2.751

Figure 7 Thermistor resistance – temperature curve and table

(For more information, please refer to the application note ‘AN CIPOS™-Mini 1 Technical description’)

## Mechanical Characteristics and Ratings

Description	Condition	Value			Unit
		min	typ	max	
Mounting torque	M3 screw and washer	0.49	-	0.78	Nm
Flatness	Refer to Figure 8	-50	-	100	$\mu\text{m}$
Weight		-	6.83	-	g

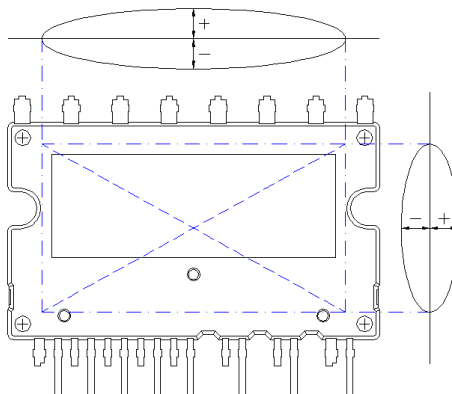
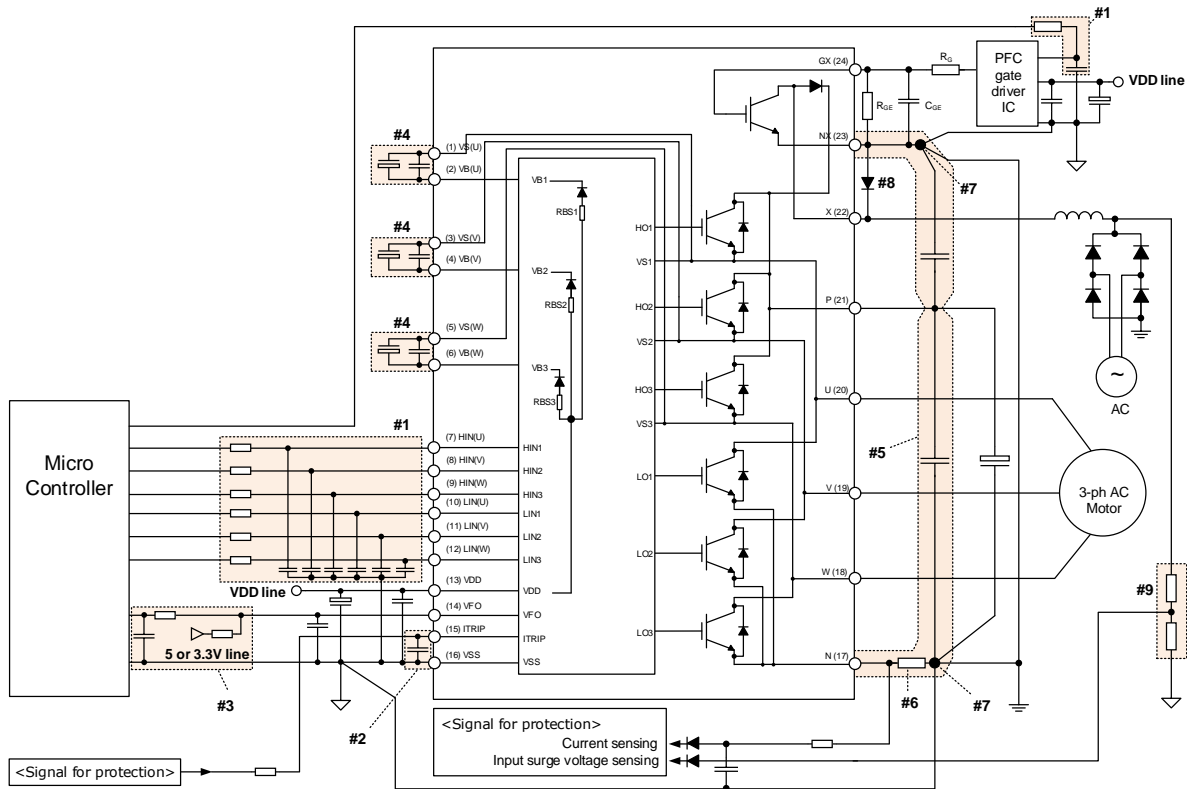


Figure 8 Flatness measurement position

## Circuit of a Typical Application



**Figure 9 Application circuit**

Because PFC IGBT inside this product has very high speed switching characteristics, considerable large surge voltage between P and NX terminals and switching noise on signaling path are generated easily. Please pay attention to the below items for optimized application circuit design.

1. Input circuit
  - To reduce input signal noise by high speed switching, the RIN and CIN filter circuit should be mounted. (100Ω, 1nF)
  - CIN should be placed as close to VSS pin as possible.
2. Itrip circuit
  - To prevent protection function errors, CITRIP should be placed as close to Itrip and VSS pins as possible.
3. VFO circuit
  - VFO output is an open drain output. This signal line should be pulled up to the positive side of the 5V/3.3V logic power supply with a proper resistor RPU. It is recommended that RC filter be placed as close to the controller as possible.
4. VB-VS circuit
  - Capacitor for high side floating supply voltage should be placed as close to VB and VS pins as possible.
5. Snubber capacitor
  - The wiring between CIPOS™ Mini and snubber capacitor including shunt resistor should be as short as possible.
6. Shunt resistor
  - Each shunt resistor of SMD type should be used for reducing its stray inductance.
7. Ground pattern
  - Each ground pattern should be separated at only one point of shunt resistor as short as possible.
  - Power ground pattern between PFC and Inverter should be connected as short as possible.
8. Anti parallel diode
  - It's mandatory to connect anti-parallel diode (2A, voltage rating higher than 650V) to PFC IGBT.
9. Input surge voltage protection circuit
  - This protection circuit is necessary for PFC IGBT to be protected from excessive surge voltage.

### Switching Times Definition

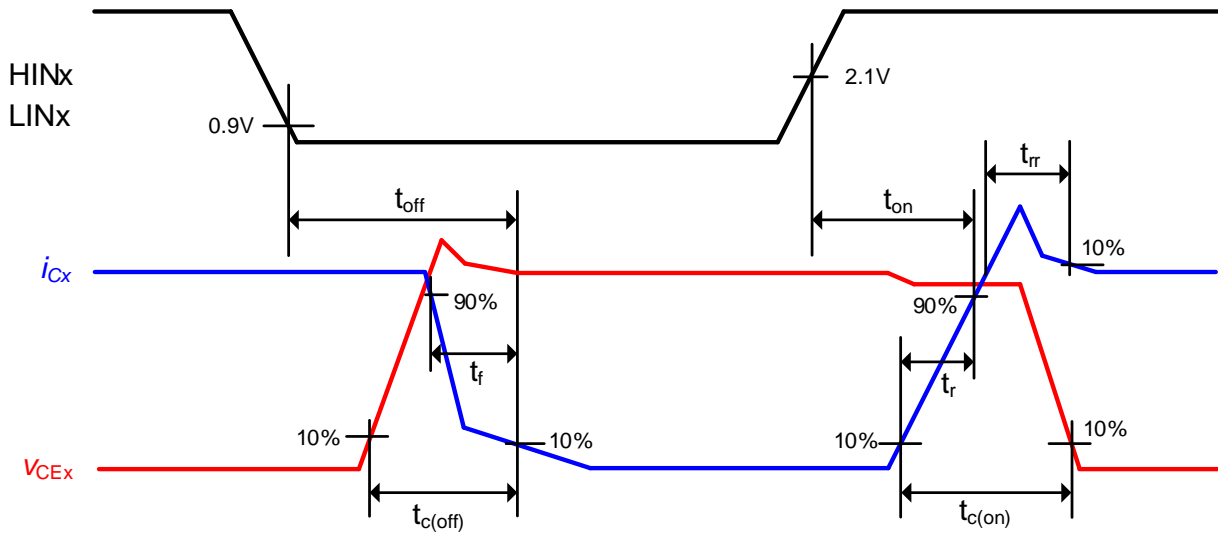


Figure 10 Switching times definition of inverter

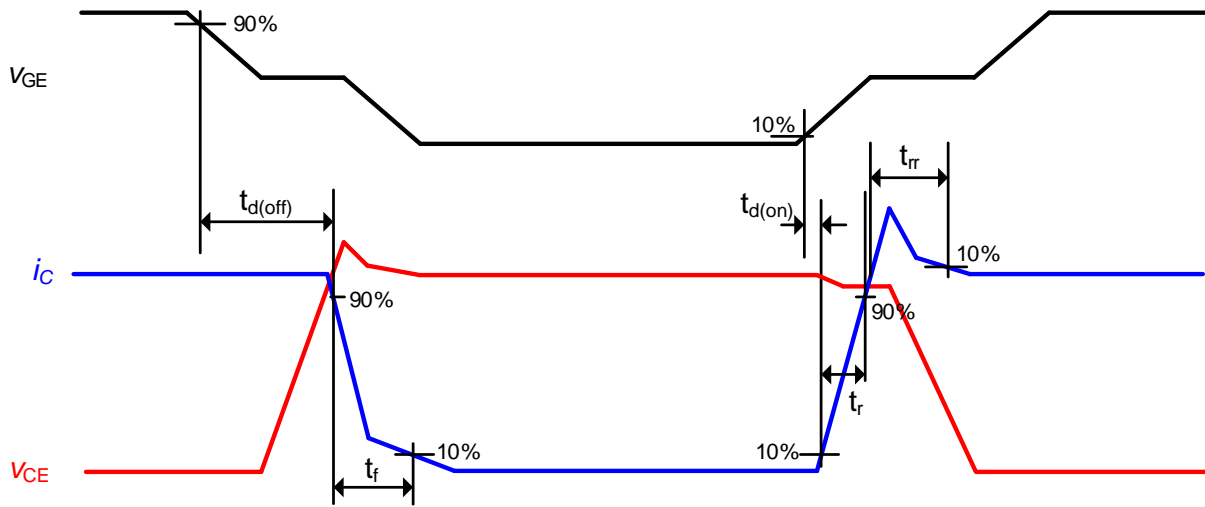
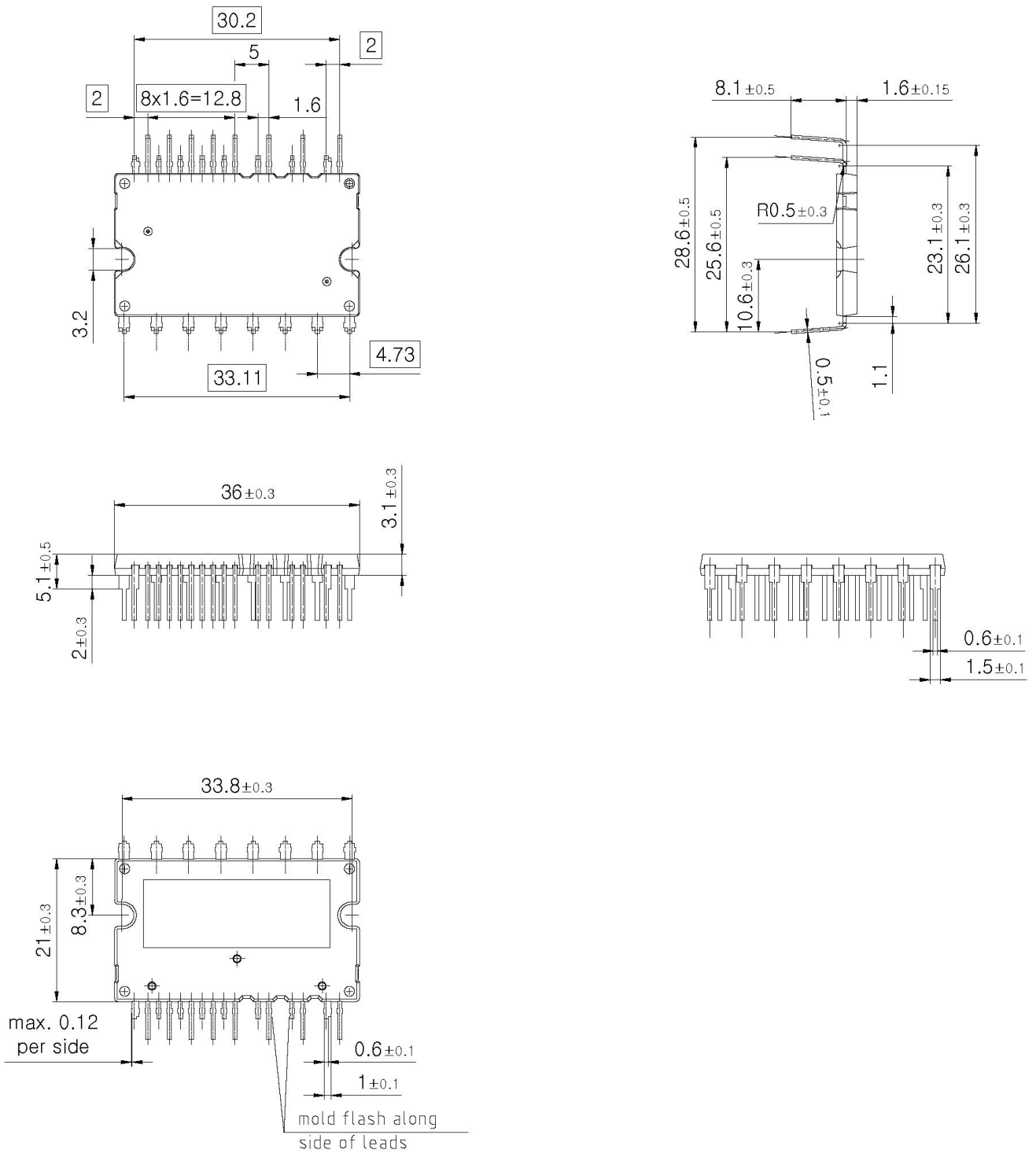


Figure 11 Switching times definition of PFC

## Package Outline





## Revision history

Document version	Date of release	Description of changes
V 2.1	Aug. 2017	Package outline update Fig.9 Application circuit
V 2.2	Sep. 2017	Maximum operating case temperature, Tc= 125°C

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