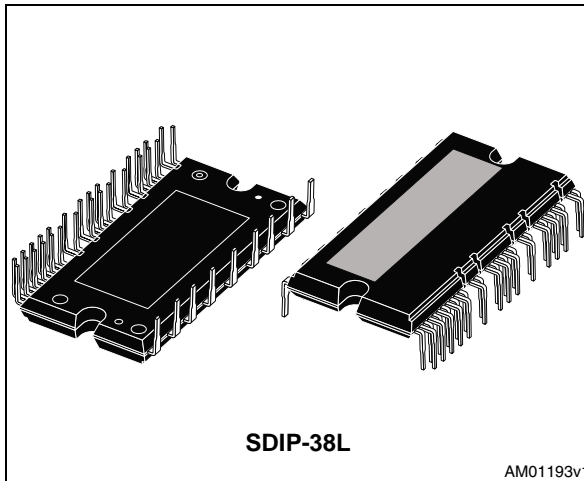


## SLLIMM™ (small low-loss intelligent molded module) IPM, 3-phase inverter - 20 A, 600 V short-circuit rugged IGBT

Datasheet - production data



- Isolation rating of 2500 V<sub>rms</sub>/min
- 5 kΩ NTC for temperature control
- UL Recognized: UL1557 file E81734

### Applications

- 3-phase inverters for motor drives
- Home appliances, such as washing machines, refrigerators, air conditioners and sewing machines

### Description

This intelligent power module provides a compact, high performance AC motor drive in a simple, rugged design. Combining ST proprietary control ICs with the most advanced short-circuit-rugged IGBT system technology, this device is ideal for 3-phase inverters in applications such as home appliances and air conditioners. SLLIMM™ is a trademark of STMicroelectronics.

### Features

- IPM 20 A, 600 V 3-phase IGBT inverter bridge including control ICs for gate driving and free-wheeling diodes
- Short-circuit rugged IGBTs
- V<sub>CE(sat)</sub> negative temperature coefficient
- 3.3 V, 5 V, 15 V CMOS/TTL inputs comparators with hysteresis and pull down/pull up resistors
- Undervoltage lockout
- Internal bootstrap diode
- Interlocking function
- Smart shutdown function
- Comparators for fault protection against overtemperature and overcurrent
- Op amps for advanced current sensing
- DBC substrate leading to low thermal resistance

**Table 1. Device summary**

Order code	Marking	Package	Packaging
STGIPL20K60	GIPL20K60	SDIP-38L	Tube

# Contents

- 1 Internal schematic diagram and pin configuration . . . . . 3**
- 2 Electrical ratings . . . . . 6**
  - 2.1 Absolute maximum ratings . . . . . 6
  - 2.2 Thermal data . . . . . 7
- 3 Electrical characteristics . . . . . 8**
  - 3.1 Control part . . . . . 10
    - 3.1.1 NTC thermistor . . . . . 12
  - 3.2 Waveform definitions . . . . . 14
- 4 Smart shutdown function . . . . . 15**
- 5 Application information . . . . . 17**
  - 5.1 Recommendations . . . . . 18
- 6 Package mechanical data . . . . . 19**
- 7 Revision history . . . . . 23**

# 1 Internal schematic diagram and pin configuration

Figure 1. Internal schematic diagram

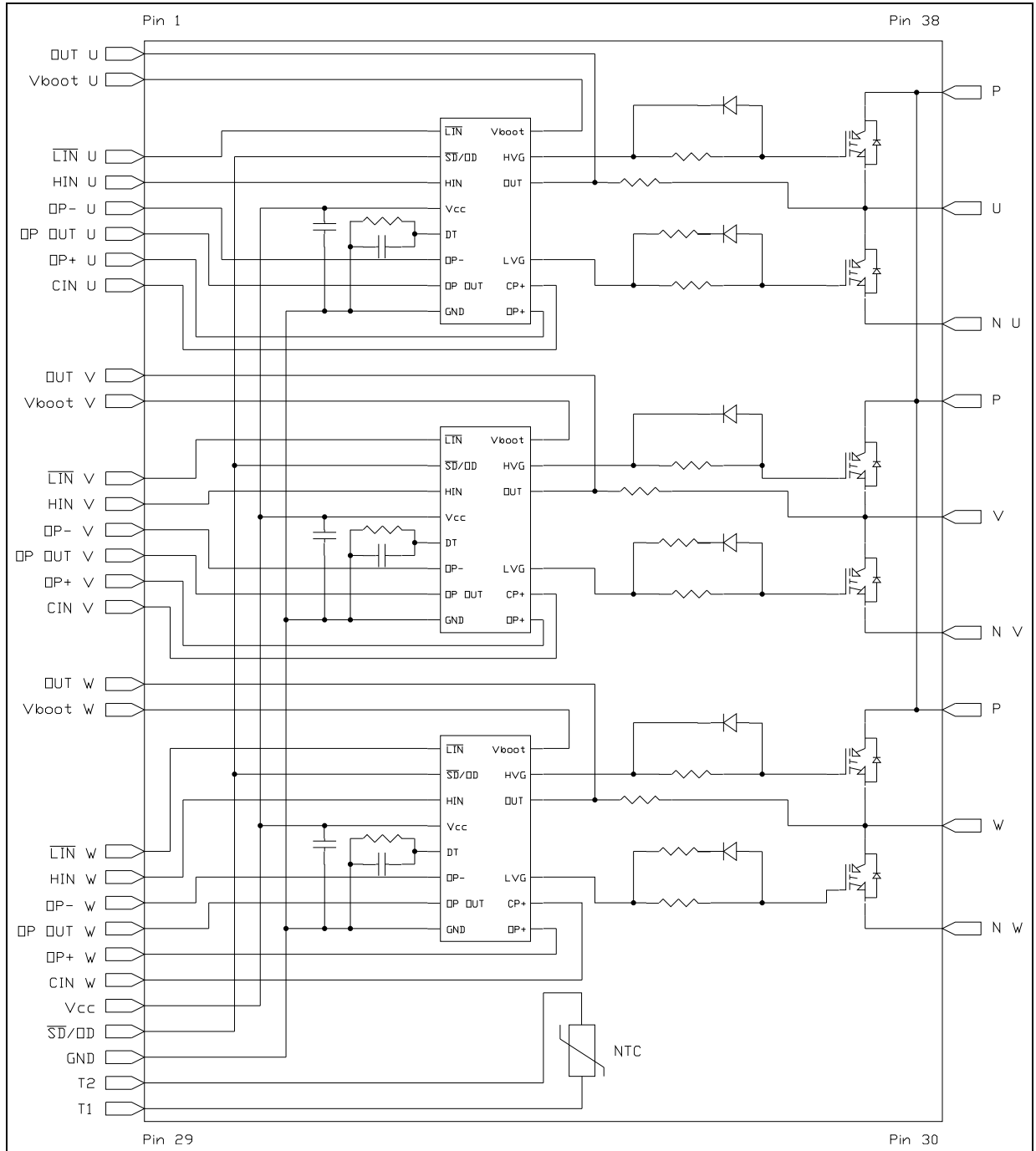


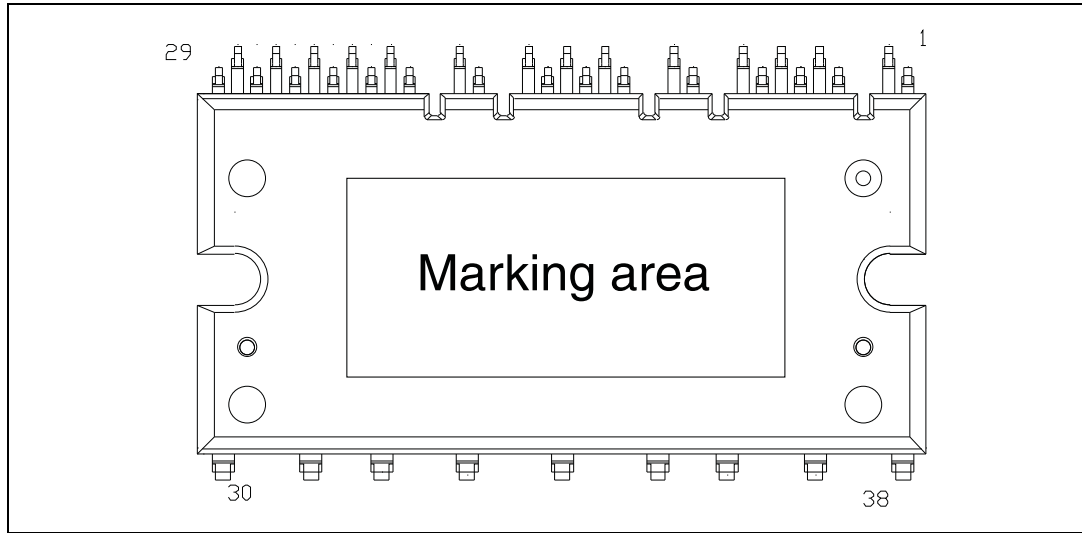
Table 2. Pin description

Pin	Symbol	Description
1	OUT <sub>U</sub>	High side reference output for U phase
2	V <sub>boot U</sub>	Bootstrap voltage for U phase
3	$\overline{\text{LIN}}_{\text{U}}$	Low side logic input for U phase
4	HIN <sub>U</sub>	High side logic input for U phase
5	OP <sup>-</sup> <sub>U</sub>	Op amp inverting input for U phase
6	OP <sub>OUT U</sub>	Op amp output for U phase
7	OP <sup>+</sup> <sub>U</sub>	Op amp non inverting input for U phase
8	CIN <sub>U</sub>	Comparator input for U phase
9	OUT <sub>V</sub>	High side reference output for V phase
10	V <sub>boot V</sub>	Bootstrap voltage for V phase
11	$\overline{\text{LIN}}_{\text{V}}$	Low side logic input for V phase
12	HIN <sub>V</sub>	High side logic input for V phase
13	OP <sup>-</sup> <sub>V</sub>	Op amp inverting input for V phase
14	OP <sub>OUT V</sub>	Op amp output for V phase
15	OP <sup>+</sup> <sub>V</sub>	Op amp non inverting input for V phase
16	CIN <sub>V</sub>	Comparator input for V phase
17	OUT <sub>W</sub>	High side reference output for W phase
18	V <sub>boot W</sub>	Bootstrap voltage for W phase
19	$\overline{\text{LIN}}_{\text{W}}$	Low side logic input for W phase
20	HIN <sub>W</sub>	High side logic input for W phase
21	OP <sup>-</sup> <sub>W</sub>	Op amp inverting input for W phase
22	OP <sub>OUT W</sub>	Op amp output for W phase
23	OP <sup>+</sup> <sub>W</sub>	Op amp non inverting input for W phase
24	CIN <sub>W</sub>	Comparator input for W phase
25	V <sub>CC</sub>	Low voltage power supply
26	$\overline{\text{SD}} / \text{OD}$	Shutdown logic input (active low) / open drain (comparator output)
27	GND	Ground
28	T <sub>2</sub>	NTC thermistor terminal 2
29	T <sub>1</sub>	NTC thermistor terminal 1
30	N <sub>W</sub>	Negative DC input for W phase
31	W	W phase output
32	P	Positive DC input
33	N <sub>V</sub>	Negative DC input for V phase
34	V	V phase output

Table 2. Pin description (continued)

Pin	Symbol	Description
35	P	Positive DC input
36	N <sub>U</sub>	Negative DC input for U phase
37	U	U phase output
38	P	Positive DC input

Figure 2. Pin layout (bottom view)



## 2 Electrical ratings

### 2.1 Absolute maximum ratings

Table 3. Inverter part

Symbol	Parameter	Value	Unit
$V_{PN}$	Supply voltage applied between P- $N_U$ , $N_V$ , $N_W$	450	V
$V_{PN(surge)}$	Supply voltage (surge) applied between P- $N_U$ , $N_V$ , $N_W$	500	V
$V_{CES}$	Each IGBT collector emitter voltage ( $V_{IN}^{(1)} = 0$ )	600	V
$\pm I_C^{(2)}$	Each IGBT continuous collector current at $T_C = 25\text{ }^\circ\text{C}$	20	A
$\pm I_{CP}^{(3)}$	Each IGBT pulsed collector current	40	A
$P_{TOT}$	Each IGBT total dissipation at $T_C = 25\text{ }^\circ\text{C}$	56	W
$t_{scw}$	Short circuit withstand time, $V_{CE} = 0.5 V_{(BR)CES}$ , $T_j = 125\text{ }^\circ\text{C}$ , $V_{CC} = V_{boot} = 15\text{ V}$ , $V_{IN(1)} = 0 - 5\text{ V}$	5	$\mu\text{s}$

1. Applied between  $HIN_i$ ,  $\overline{LIN}_i$  and GND for  $i = U, V, W$
2. Calculated according to the iterative formula:

$$I_C(T_C) = \frac{T_{j(max)} - T_C}{R_{thj-c} \times V_{CE(sat)(max)}(T_{j(max)}, I_C(T_C))}$$

3. Pulse width limited by max junction temperature

Table 4. Control part

Symbol	Parameter	Min.	Max.	Unit
$V_{OUT}$	Output voltage applied between $OUT_U$ , $OUT_V$ , $OUT_W$ - GND	$V_{boot} - 21$	$V_{boot} + 0.3$	V
$V_{CC}$	Low voltage power supply	- 0.3	21	V
$V_{CIN}$	Comparator input voltage	- 0.3	$V_{CC} + 0.3$	V
$V_{op+}$	OPAMP non-inverting input	- 0.3	$V_{CC} + 0.3$	V
$V_{op-}$	OPAMP inverting input	- 0.3	$V_{CC} + 0.3$	V
$V_{boot}$	Bootstrap voltage	- 0.3	620	V
$V_{IN}$	Logic input voltage applied between $HIN$ , $\overline{LIN}$ and GND	- 0.3	15	V
$V_{SD/OD}$	Open drain voltage	- 0.3	15	V
$dV_{OUT}/dt$	Allowed output slew rate		50	V/ns

Table 5. Total system

Symbol	Parameter	Value	Unit
$V_{ISO}$	Isolation withstand voltage applied between each pin and heatsink plate (AC voltage, $t = 60$ sec.)	2500	V
$T_j$	Power chips operating junction temperature	-40 to 150	°C
$T_C$	Module case operation temperature	-40 to 125	°C

## 2.2 Thermal data

Table 6. Thermal data

Symbol	Parameter	Value	Unit
$R_{thJC}$	Thermal resistance junction-case single IGBT	2.2	°C/W
	Thermal resistance junction-case single diode	4.5	°C/W

### 3 Electrical characteristics

$T_j = 25\text{ °C}$  unless otherwise specified.

**Table 7. Inverter part**

Symbol	Parameter	Test condition	Value			Unit
			Min.	Typ.	Max.	
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{CC} = V_{Boot} = 15\text{ V}$ , $V_{IN}^{(1)} = 0 - 5\text{ V}$ , $I_C = 12\text{ A}$	-	2.2	2.75	V
		$V_{CC} = V_{Boot} = 15\text{ V}$ , $V_{IN}^{(1)} = 0 - 5\text{ V}$ , $I_C = 12\text{ A}$ , $T_j = 125\text{ °C}$	-	1.8		
$I_{CES}$	Collector-cut off current ( $V_{IN}^{(1)} = 0$ "logic state")	$V_{CE} = 550\text{ V}$ $V_{CC} = V_{boot} = 15\text{ V}$	-		150	$\mu\text{A}$
$V_F$	Diode forward voltage	$V_{IN}^{(1)} = 0$ "logic state", $I_C = 12\text{ A}$	-	1.7	2.1	V
<b>Inductive load switching time and energy</b>						
$t_{on}$	Turn-on time	$V_{DD} = 300\text{ V}$ , $V_{CC} = V_{boot} = 15\text{ V}$ , $V_{IN}^{(1)} = 0 - 5\text{ V}$ , $I_C = 12\text{ A}$ (see <a href="#">Figure 3</a> )	-	915		ns
$t_{c(on)}$	Crossover time (on)		-	155		
$t_{off}$	Turn-off time		-	375		
$t_{c(off)}$	Crossover time (off)		-	120		
$t_{rr}$	Reverse recovery time		-	75		
$E_{on}$	Turn-on switching losses		-	300		$\mu\text{J}$
$E_{off}$	Turn-off switching losses		-	170		

1. Applied between HINi  $\overline{LINi}$  and GND for  $i = U, V, W$  ( $\overline{LIN}$  inputs are active-low).

**Note:**  $t_{on}$  and  $t_{off}$  include the propagation delay time of the internal drive.  $t_{C(ON)}$  and  $t_{C(OFF)}$  are the switching time of IGBT itself under the internally given gate driving condition.



Figure 3. Switching time test circuit

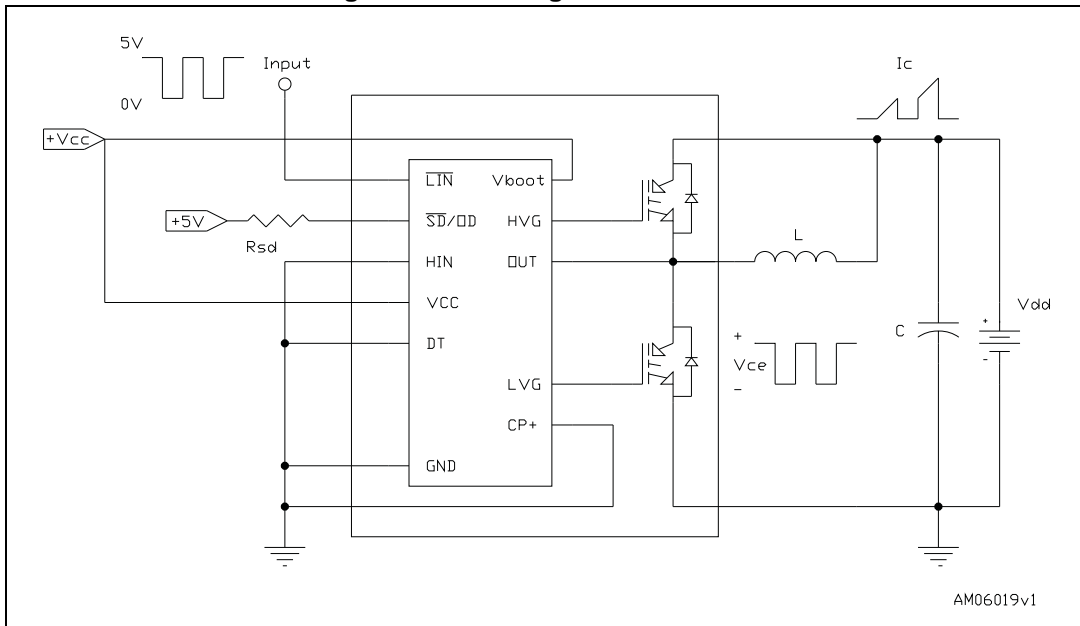


Figure 4. Switching time definition

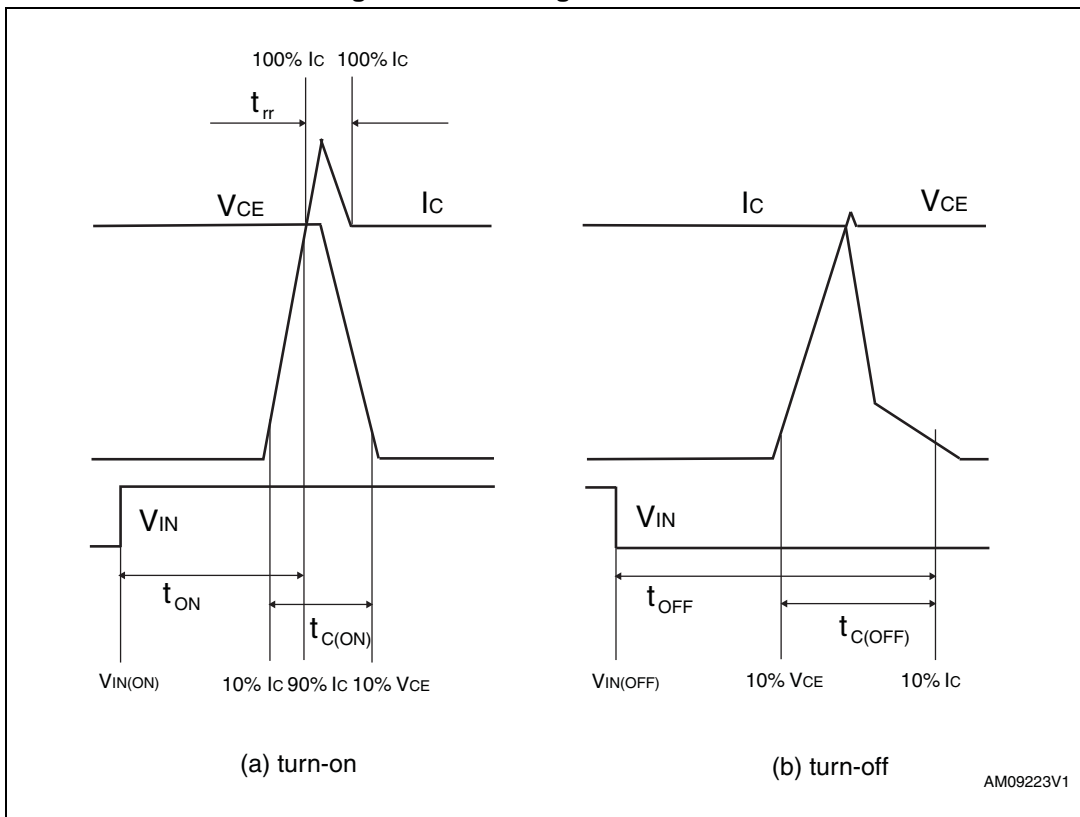


Figure 4 "Switching time definition" refers to HIN inputs (active high). For LIN inputs (active low), VIN polarity must be inverted for turn-on and turn-off.

### 3.1 Control part

**Table 8. Low voltage power supply ( $V_{CC} = 15\text{ V}$  unless otherwise specified)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{CC\_hys}$	$V_{CC}$ UV hysteresis		1.2	1.5	1.8	V
$V_{CC\_thON}$	$V_{CC}$ UV turn ON threshold		11.5	12	12.5	V
$V_{CC\_thOFF}$	$V_{CC}$ UV turn OFF threshold		10	10.5	11	V
$I_{qccu}$	Undervoltage quiescent supply current	$V_{CC} = 10\text{ V}$ $\overline{SD}/\overline{OD} = 5\text{ V}$ ; $\overline{LIN} = 5\text{ V}$ ; $H_{IN} = 0$ , $C_{IN} = 0$			450	$\mu\text{A}$
$I_{qcc}$	Quiescent current	$V_{CC} = 15\text{ V}$ $\overline{SD}/\overline{OD} = 5\text{ V}$ ; $\overline{LIN} = 5\text{ V}$ $H_{IN} = 0$ , $C_{IN} = 0$			3.5	mA
$V_{ref}$	Internal comparator (CIN) reference voltage		0.5	0.54	0.58	V

**Table 9. Bootstrapped voltage ( $V_{CC} = 15\text{ V}$  unless otherwise specified)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{BS\_hys}$	$V_{BS}$ UV hysteresis		1.2	1.5	1.8	V
$V_{BS\_thON}$	$V_{BS}$ UV turn ON threshold		11.1	11.5	12.1	V
$V_{BS\_thOFF}$	$V_{BS}$ UV turn OFF threshold		9.8	10	10.6	V
$I_{QBSU}$	Undervoltage $V_{BS}$ quiescent current	$V_{BS} < 9\text{ V}$ $\overline{SD}/\overline{OD} = 5\text{ V}$ ; $\overline{LIN}$ and $H_{IN} = 5\text{ V}$ ; $C_{IN} = 0$		70	110	$\mu\text{A}$
$I_{QBS}$	$V_{BS}$ quiescent current	$V_{BS} = 15\text{ V}$ $\overline{SD}/\overline{OD} = 5\text{ V}$ ; $\overline{LIN}$ and $H_{IN} = 5\text{ V}$ ; $C_{IN} = 0$		200	300	$\mu\text{A}$
$R_{DS(on)}$	Bootstrap driver on resistance	LVG ON		120		W

**Table 10. Logic inputs ( $V_{CC} = 15\text{ V}$  unless otherwise specified)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{il}$	Low logic level voltage		0.8		1.1	V
$V_{ih}$	High logic level voltage		1.9		2.25	V
$I_{HINh}$	HIN logic "1" input bias current	$H_{IN} = 15\text{ V}$	110	175	260	$\mu\text{A}$
$I_{HINl}$	HIN logic "0" input bias current	$H_{IN} = 0\text{ V}$			1	$\mu\text{A}$
$I_{LINl}$	$\overline{LIN}$ logic "1" input bias current	$\overline{LIN} = 0\text{ V}$	3	6	20	$\mu\text{A}$
$I_{LINh}$	$\overline{LIN}$ logic "0" input bias current	$\overline{LIN} = 15\text{ V}$			1	$\mu\text{A}$
$I_{SDh}$	$\overline{SD}$ logic "0" input bias current	$\overline{SD} = 15\text{ V}$	30	120	300	$\mu\text{A}$
$I_{SDl}$	$\overline{SD}$ logic "1" input bias current	$\overline{SD} = 0\text{ V}$			3	$\mu\text{A}$
Dt	Dead time	see <a href="#">Figure 9</a>		600		ns

Table 11. Op amp characteristics ( $V_{CC} = 15\text{ V}$  unless otherwise specified)

Symbol	Parameter	Test condition	Min.	Typ.	Max.	Unit
$V_{io}$	Input offset voltage	$V_{ic} = 0\text{ V}$ , $V_o = 7.5\text{ V}$			6	mV
$I_{io}$	Input offset current	$V_{ic} = 0\text{ V}$ , $V_o = 7.5\text{ V}$		4	40	nA
$I_{ib}$	Input bias current <sup>(1)</sup>			100	200	nA
$V_{icm}$	Input common mode voltage range		0			V
$V_{OL}$	Low level output voltage	$R_L = 10\text{ k}\Omega$ to $V_{CC}$		75	150	mV
$V_{OH}$	High level output voltage	$R_L = 10\text{ k}\Omega$ to GND	14	14.7		V
$I_o$	Output short circuit current	Source, $V_{id} = +1$ ; $V_o = 0\text{ V}$	16	30		mA
		Sink, $V_{id} = -1$ ; $V_o = V_{CC}$	50	80		mA
SR	Slew rate	$V_i = 1 - 4\text{ V}$ ; $C_L = 100\text{ pF}$ ; unity gain	2.5	3.8		V/ $\mu\text{s}$
GBWP	Gain bandwidth product	$V_o = 7.5\text{ V}$	8	12		MHz
$A_{vd}$	Large signal voltage gain	$R_L = 2\text{ k}\Omega$	70	85		dB
SVR	Supply voltage rejection ratio	vs. $V_{CC}$	60	75		dB
CMRR	Common mode rejection ratio		55	70		dB

1. The direction of input current is out of the IC.

Table 12. Sense comparator characteristics ( $V_{CC} = 15\text{ V}$  unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{ib}$	Input bias current	$V_{CIN} = 1\text{ V}$	-		3	$\mu\text{A}$
$V_{ol}$	Open-drain low-level output voltage	$I_{od} = 3\text{ mA}$	-		0.5	V
$t_{d\_comp}$	Comparator delay	$\overline{SD}/OD$ pulled to 5 V through 100 k $\Omega$ resistor	-	90	130	ns
SR	Slew rate	$C_L = 180\text{ pF}$ ; $R_{pu} = 5\text{ k}\Omega$	-	60		V/ $\mu\text{sec}$
$t_{sd}$	Shutdown to high / low side driver propagation delay	$V_{OUT} = 0$ , $V_{boot} = V_{CC}$ ; $V_{IN} = 0$ to 3.3 V	50	125	200	ns
$t_{isd}$	Comparator triggering to high / low side driver turn-off propagation delay	Measured applying a voltage step from 0 V to 3.3 V to pin $CIN_i$	50	200	250	

Table 13. Truth table

Condition	Logic input (V <sub>I</sub> )			Output	
	$\overline{\text{SD/OD}}$	LIN	HIN	LVG	HVG
Shutdown enable half-bridge 3-state	L	X	X	L	L
Interlocking half-bridge 3-state	H	L	H	L	L
0 "logic state" half-bridge 3-state	H	H	L	L	L
1 "logic state" low side direct driving	H	L	L	H	L
1 "logic state" high side direct driving	H	H	H	L	H

Note: X: don't care.

Figure 5. Maximum I<sub>C(RMS)</sub> current vs. switching frequency (1)

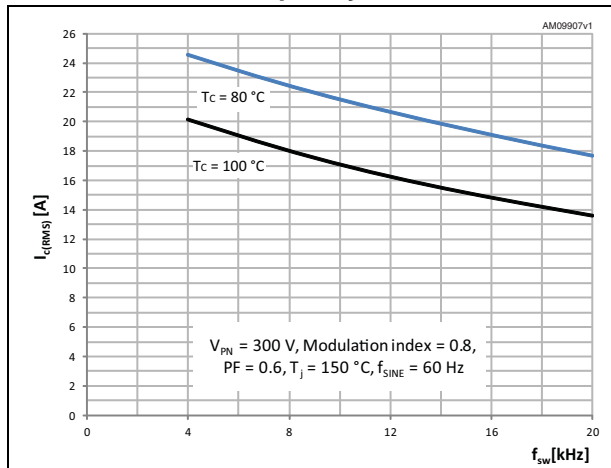
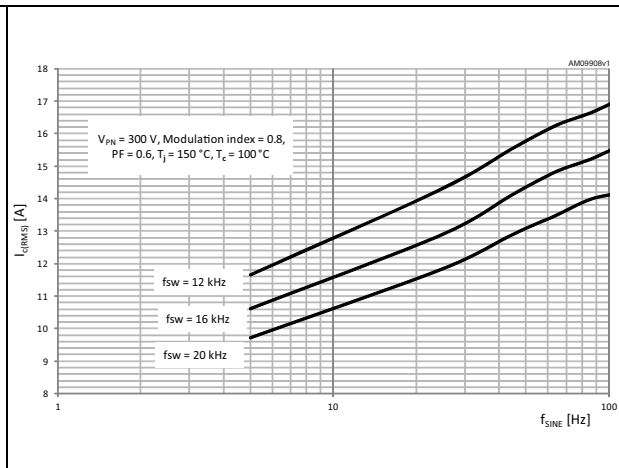


Figure 6. Maximum I<sub>C(RMS)</sub> current vs. fsine (1)



1. Simulated curves refer to typical IGBT parameters and maximum R<sub>thj-c</sub>.

### 3.1.1 NTC thermistor

Table 14. NTC thermistor

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit.
R <sub>25</sub>	Resistance	T <sub>NTC</sub> = 25°C to 85°C		5		kΩ
R <sub>125</sub>	Resistance	T <sub>NTC</sub> = 125°C		300		Ω
B	B-constant	T <sub>C</sub> = 25°C to 85°C		3340		K
T	Operating temperature		-40		125	°C

Equation 1: resistance variation vs. temperature

$$R(T) = R_{25} \cdot e^{B\left(\frac{1}{T} - \frac{1}{298}\right)}$$

Where T are temperatures in Kelvin

Figure 7. NTC resistance vs. temperature

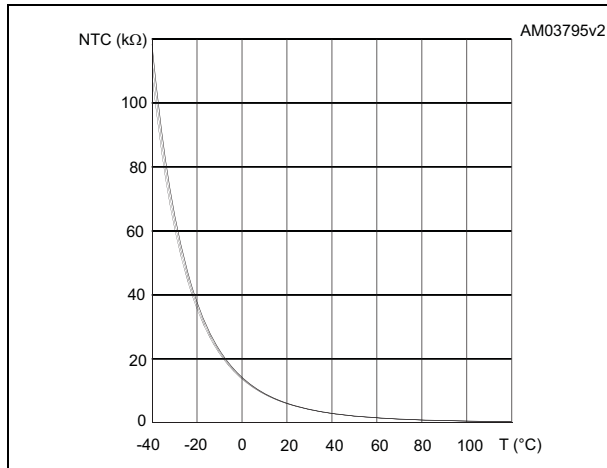
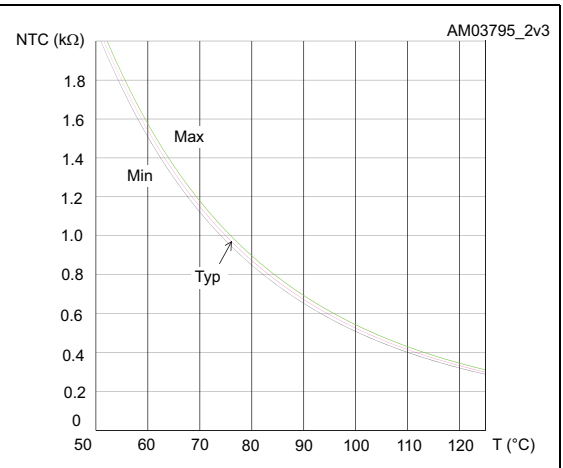
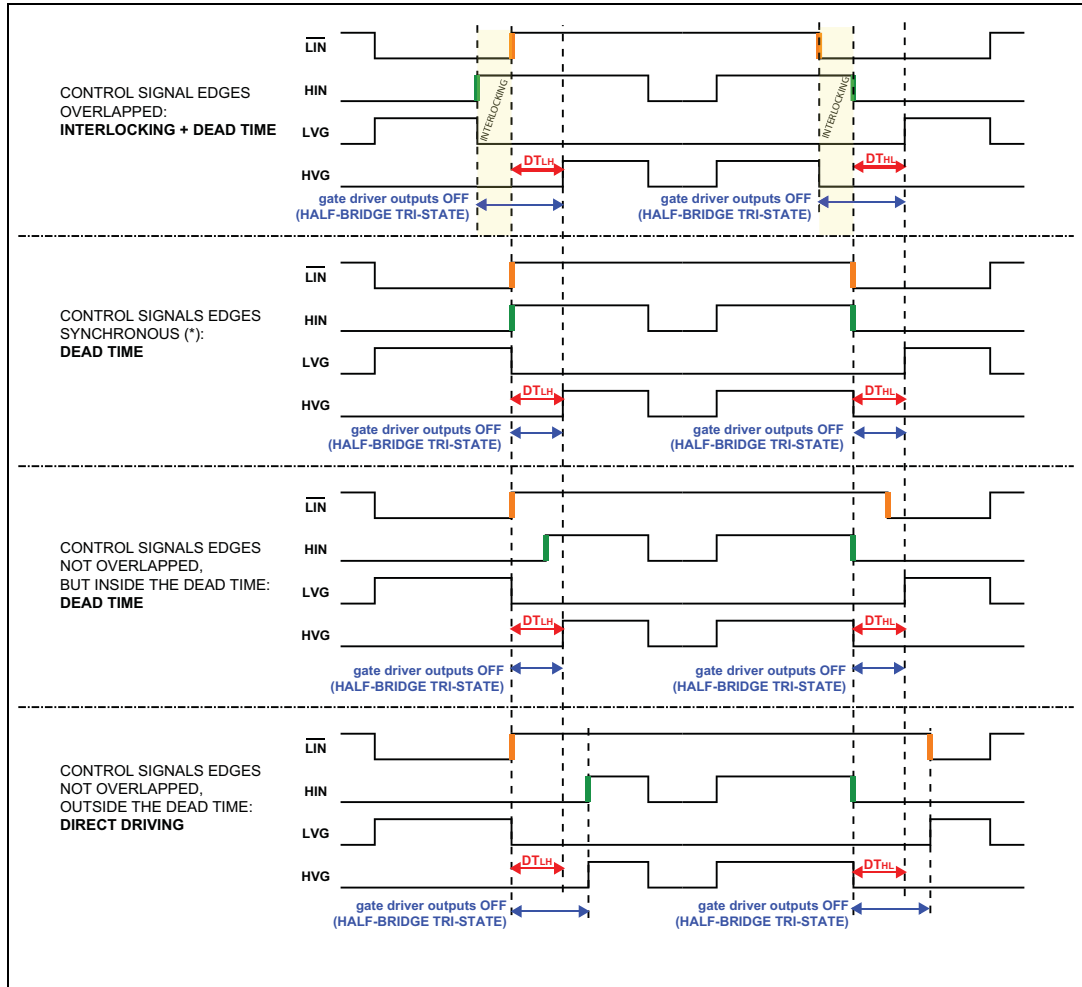


Figure 8. NTC resistance vs. temperature zoom



### 3.2 Waveform definitions

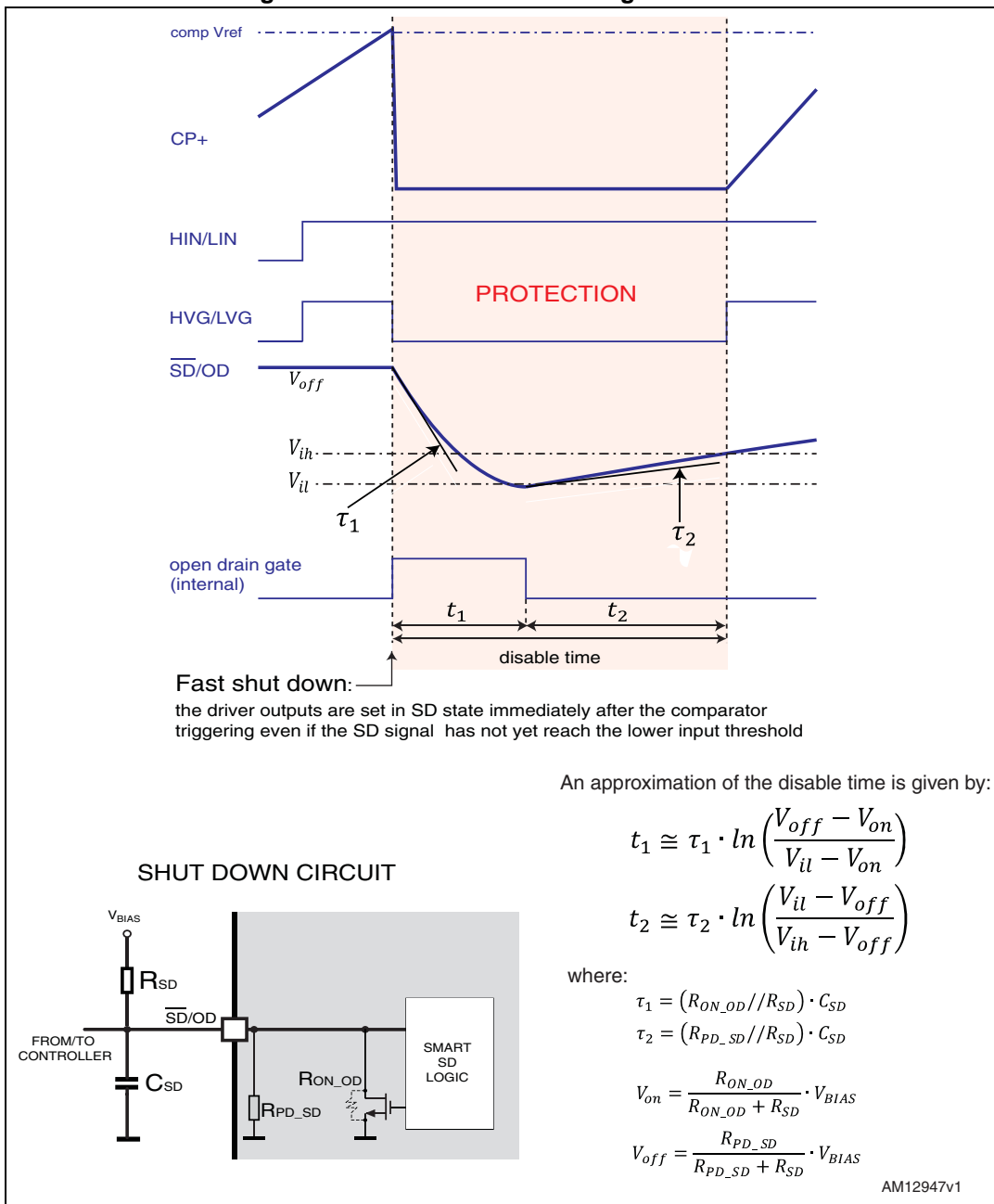
Figure 9. Dead time and interlocking waveforms definitions



## 4 Smart shutdown function

The STGIPL20K60 integrates a comparator for fault sensing purposes. The comparator non-inverting input (CIN) can be connected to an external shunt resistor in order to implement a simple overcurrent protection function. When the comparator triggers, the device is set in shutdown state and both its outputs are set to low-level leading the half-bridge in 3-state. In the common overcurrent protection architectures the comparator output is usually connected to the shutdown input through a RC network, in order to provide a mono-stable circuit, which implements a protection time that follows the fault condition. Our smart shutdown architecture allows to immediately turn-off the output gate driver in case of overcurrent, the fault signal has a preferential path which directly switches off the outputs. The time delay between the fault and the outputs turn-off is no more dependent on the RC values of the external network connected to the shutdown pin. At the same time the internal logic turns on the open-drain output and holds it on until the shutdown voltage goes below the logic input lower threshold. Finally the smart shutdown function provides the possibility to increase the real disable time without increasing the constant time of the external RC network.

Figure 10. Smart shutdown timing waveforms

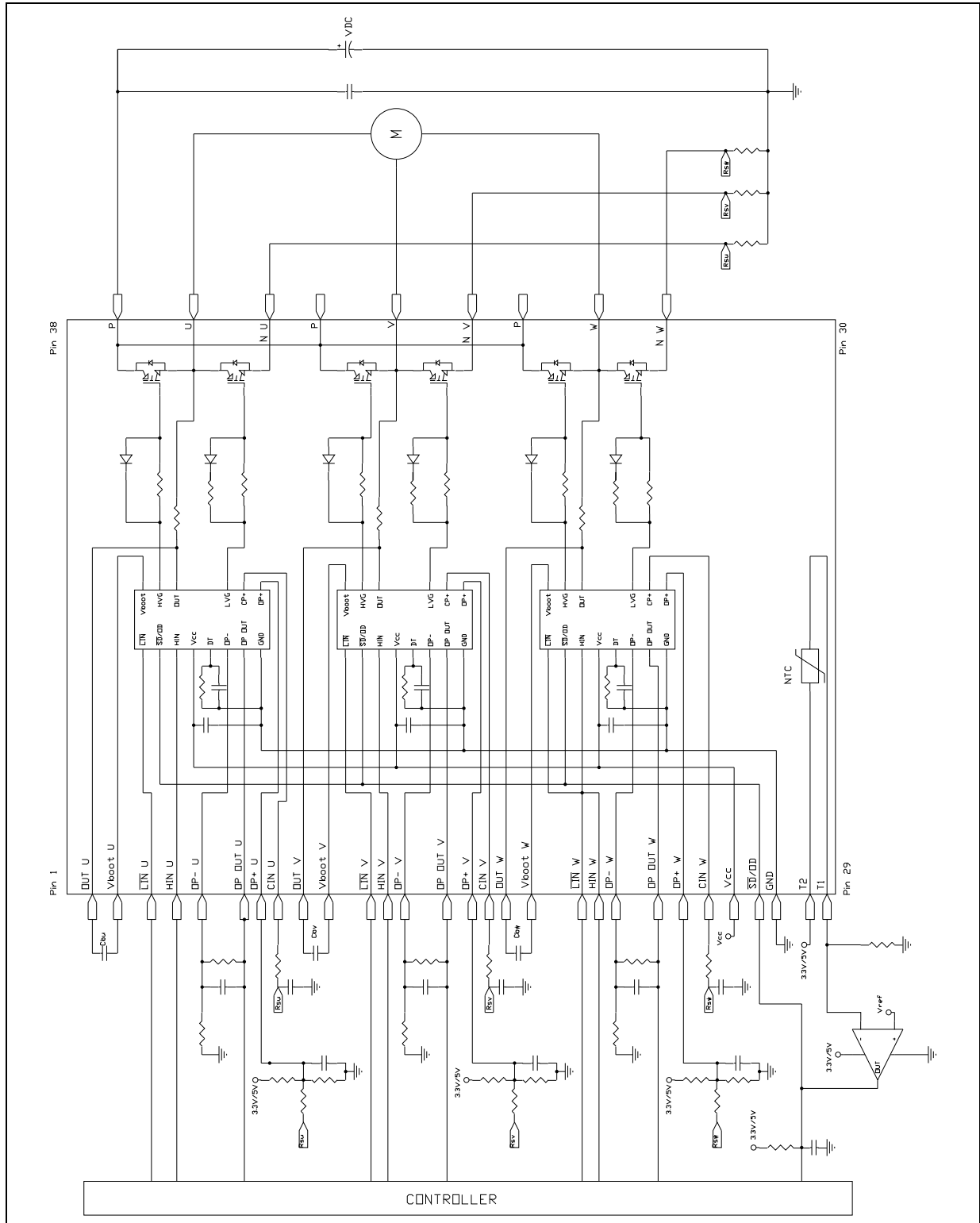


Pls refer to Table 12 for internal propagation delay time details.



# 5 Application information

Figure 11. Typical application circuit



## 5.1 Recommendations

- Input signal HIN is active high logic. A 85 k $\Omega$  (typ.) pull down resistor is built-in for each high side input. If an external RC filter is used, for noise immunity, pay attention to the variation of the input signal level.
- Input signal  $\overline{\text{LIN}}$  is active low logic. A 720 k $\Omega$  (typ.) pull-up resistor, connected to an internal 5 V regulator through a diode, is built-in for each low side input.
- To prevent the input signals oscillation, the wiring of each input should be as short as possible.
- By integrating an application specific type HVIC inside the module, direct coupling to MCU terminals without any opto-coupler is possible.
- Each capacitor should be located as nearby the pins of IPM as possible.
- Low inductance shunt resistors should be used for phase leg current sensing.
- Electrolytic bus capacitors should be mounted as close to the module bus terminals as possible. Additional high frequency ceramic capacitor mounted close to the module pins will further improve performance.
- The  $\overline{\text{SD/OD}}$  signal should be pulled up to 5 V / 3.3 V with an external resistor (see [Section 4: Smart shutdown function](#) for detailed info).

**Table 15. Recommended operating conditions**

Symbol	Parameter	Conditions	Value			Unit
			Min.	Typ.	Max.	
V <sub>PN</sub>	Supply voltage	Applied between P-Nu, Nv, Nw		300	400	V
V <sub>CC</sub>	Control supply voltage	Applied between V <sub>CC</sub> -GND	13.5	15	18	V
V <sub>BS</sub>	High side bias voltage	Applied between V <sub>BOOT</sub> -OUT <sub>i</sub> for i = U, V, W	13		18	V
t <sub>dead</sub>	Blanking time to prevent Arm-short	For each input signal	1			$\mu\text{s}$
f <sub>PWM</sub>	PWM input signal	-40°C < T <sub>C</sub> < 100°C -40°C < T <sub>J</sub> < 125°C			20	kHz
T <sub>C</sub>	Case operation temperature				100	°C

For further details refer to AN3338.

## 6 Package mechanical data

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK is an ST trademark.

Please refer to dedicated technical note TN0107 for mounting instructions.

**Table 16. SDIP-38L mechanical data**

Dimensions	mm.		
	Min.	Typ.	Max.
A	49.10	49.60	50.10
A1	1.10	1.30	1.50
A2	1.40	1.60	1.80
A3	44.10	44.60	45.10
B	24.00	24.50	25.00
B1	11.25	11.85	12.45
B2	27.10	27.60	28.10
B3	28.60	29.10	29.60
C	5.00	5.40	6.00
C1	6.50	7.00	7.50
C2	10.35	10.85	11.35
e	1.10	1.30	1.50
e1	3.20	3.40	3.60
e2	5.80	6.00	6.20
e3	4.60	4.80	5.00
e4	5.60	5.80	6.00
e5	6.30	6.50	6.70
e6	4.50	4.70	4.90
D		38.10	
D1		5.75	
E		11.80	
E1		2.15	
F	0.85	1.00	1.15
F1	0.35	0.50	0.65
R	1.55	1.75	1.95

Table 16. SDIP-38L mechanical data (continued)

T	0.45	0.55	0.65
V	0°		6°

Figure 12. SDIP-38L package dimensions

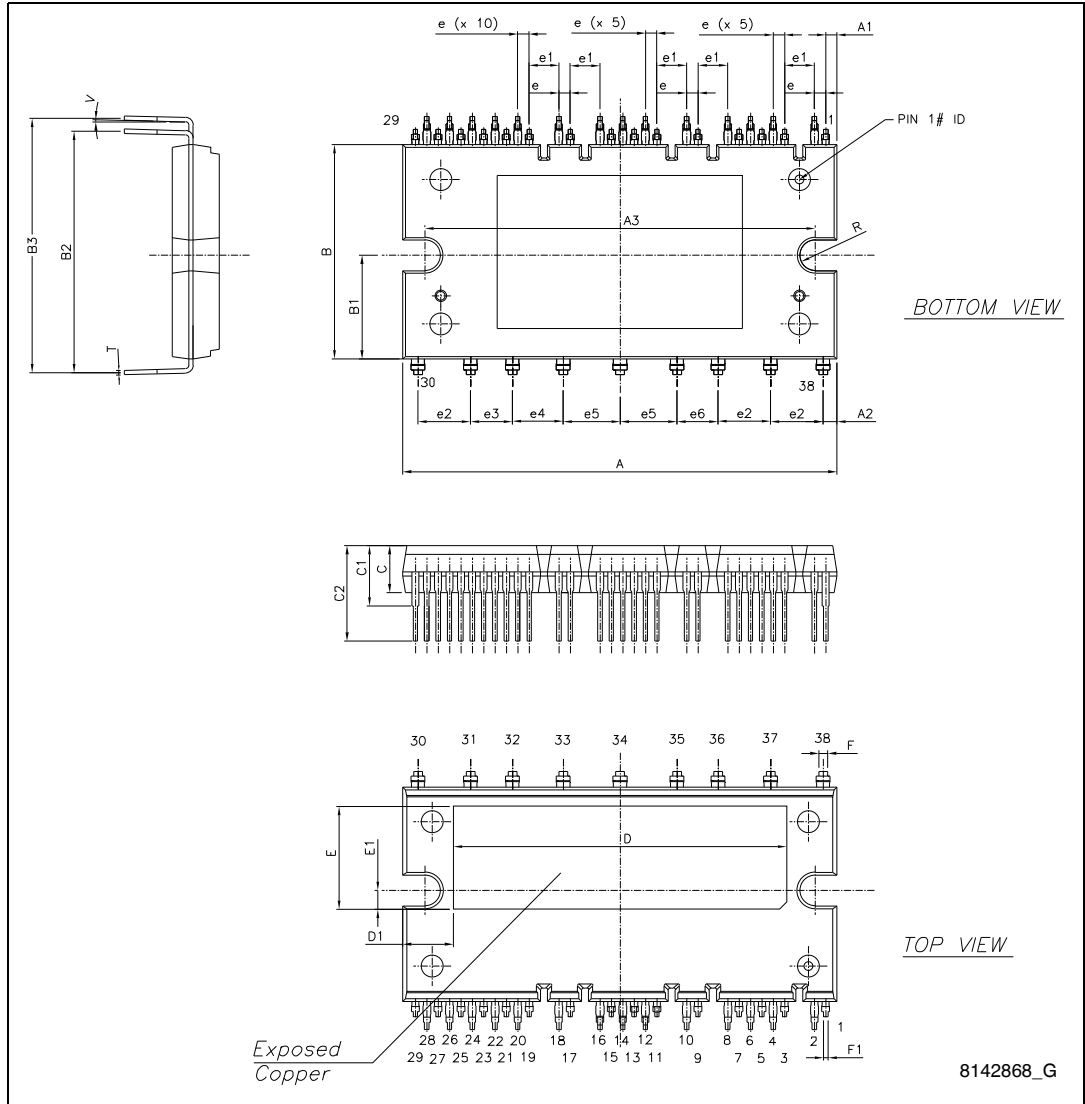


Figure 13. SDIP-38L shipping tube type A (dimensions are in mm.)

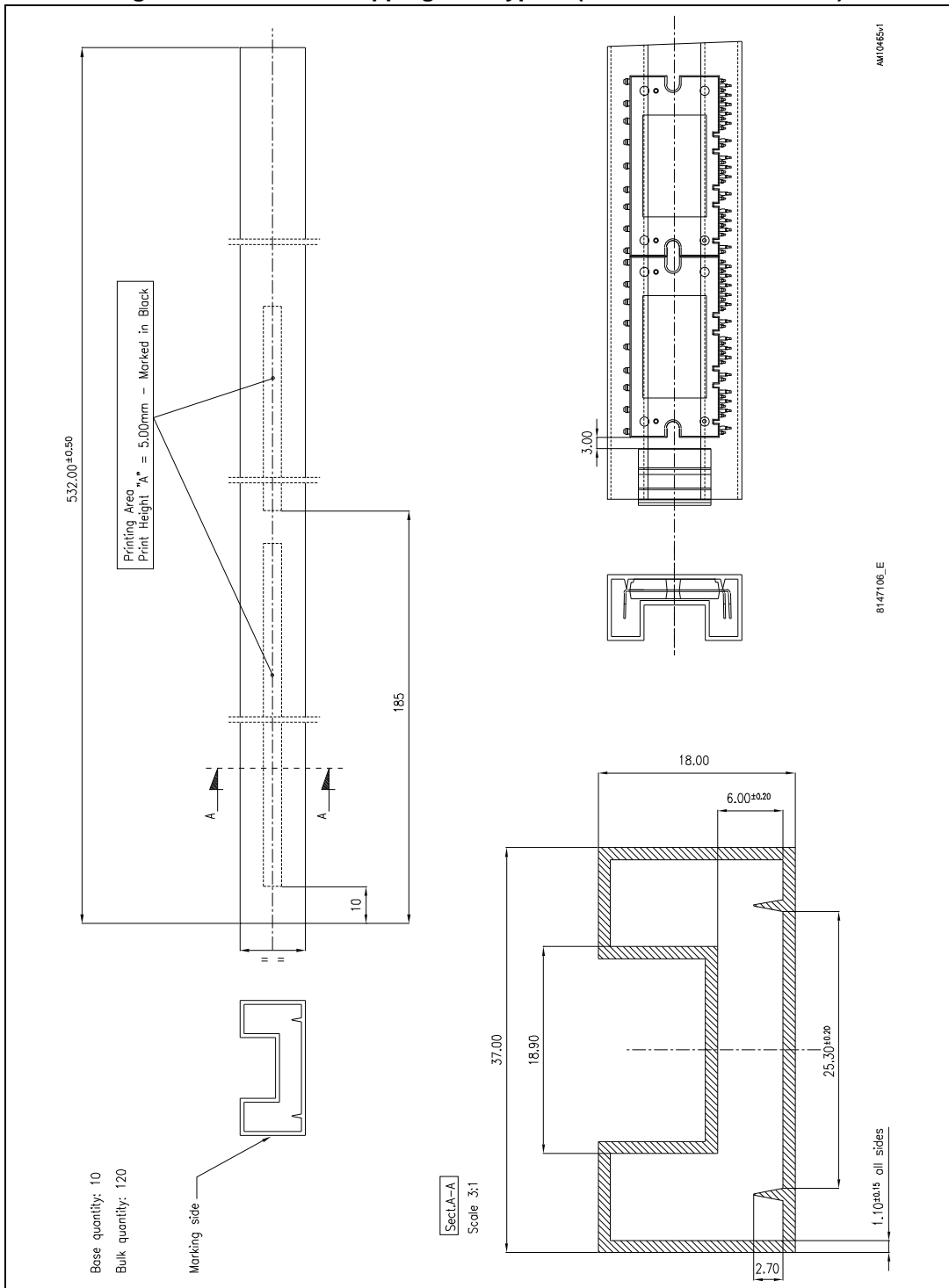
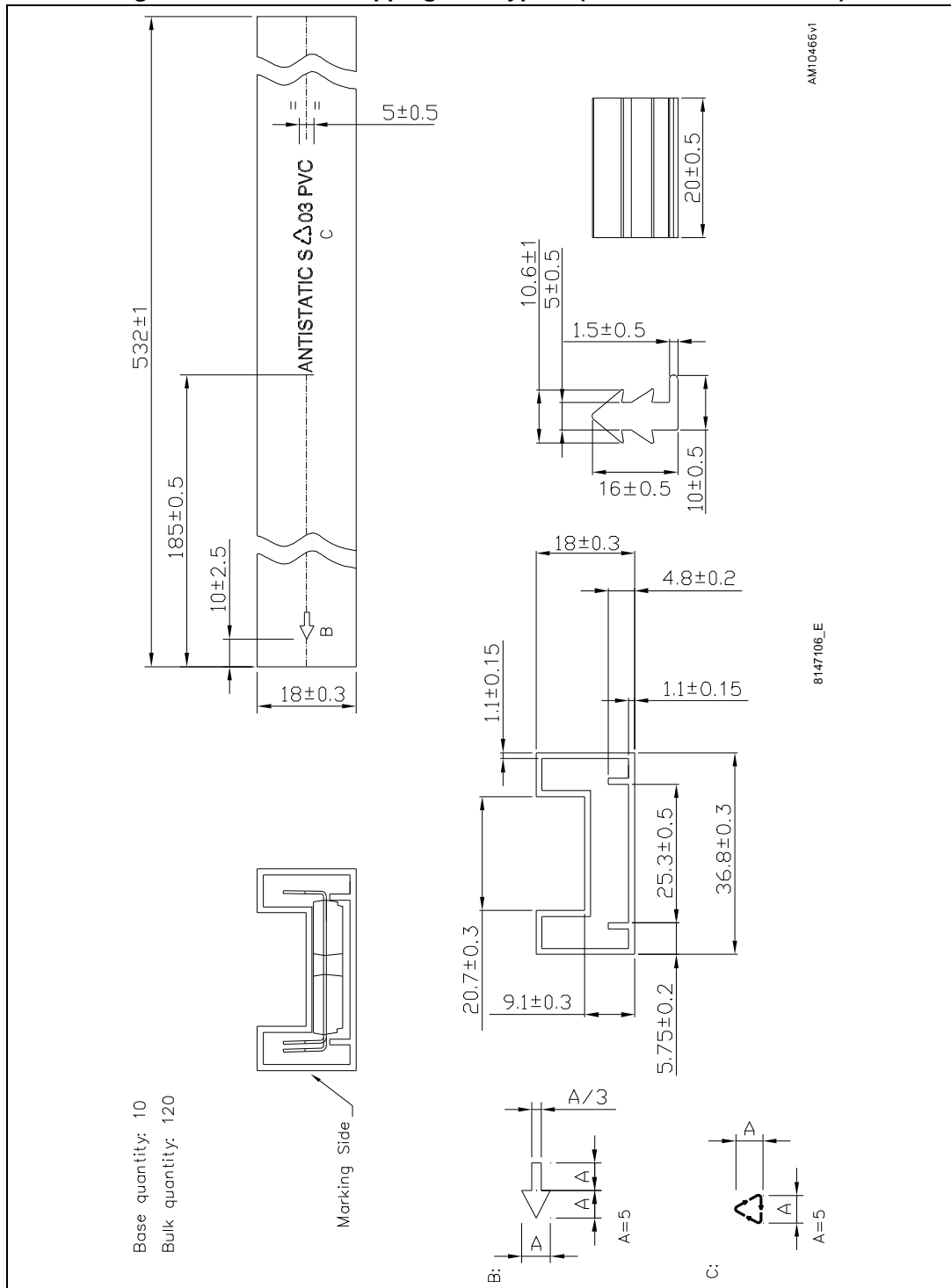


Figure 14. SDIP-38L shipping tube type B (dimensions are in mm.)



## 7 Revision history

Table 17. Document revision history

Date	Revision	Changes
16-Jun-2011	1	Initial release
28-Aug-2012	2	Modified: Min. and Max. value <a href="#">Table 4 on page 6</a> . Updated: <a href="#">Figure 13 on page 21</a> . Added: <a href="#">Figure 14 on page 22</a> .
17-Jun-2013	3	Updated <a href="#">Figure 9: Dead time and interlocking waveforms definitions</a> .

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