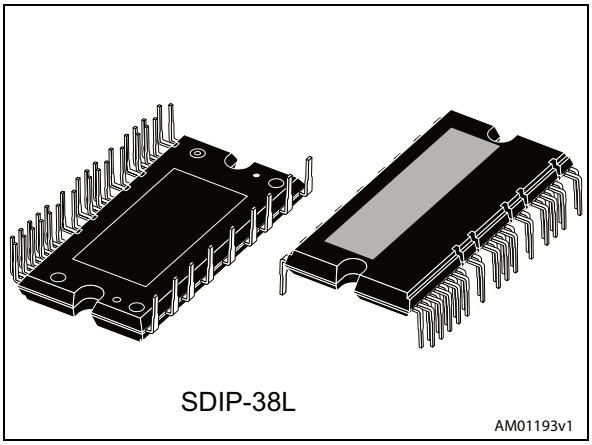
STGIPL10C60

SLLIMM™ (small low-loss intelligent molded module) IPM, 3-phase inverter, 10 A, 600 V short-circuit rugged IGBT

Datasheet - production data



SDIP-38L

Features

- IPM 10 A, 600 V 3-phase IGBT inverter bridge including control ICs for gate driving and freewheeling diodes
- Short-circuit rugged IGBT
- $V_{CE(sat)}$ negative temperature coefficient
- 3.3 V, 5 V, 15 V CMOS/TTL input 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
- Isolation rating of 2500 V_{rms}/min.
- 5 kΩ NTC for temperature control
- UL recognized: UL1557 file
- 3-phase inverter for motor drives
- Home appliance such as: washing machines, refrigerators, air conditioners and sewing machines

Description

These intelligent power modules provide compact, high performance AC motor drives 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.

Table 1. Device summary

Order code	Marking	Package	Packaging
STGIPL10C60	GIPL10C60	SDIP-38L	Tube

Contents

1 Internal block diagram and pin configuration

Figure 1. Internal block diagram

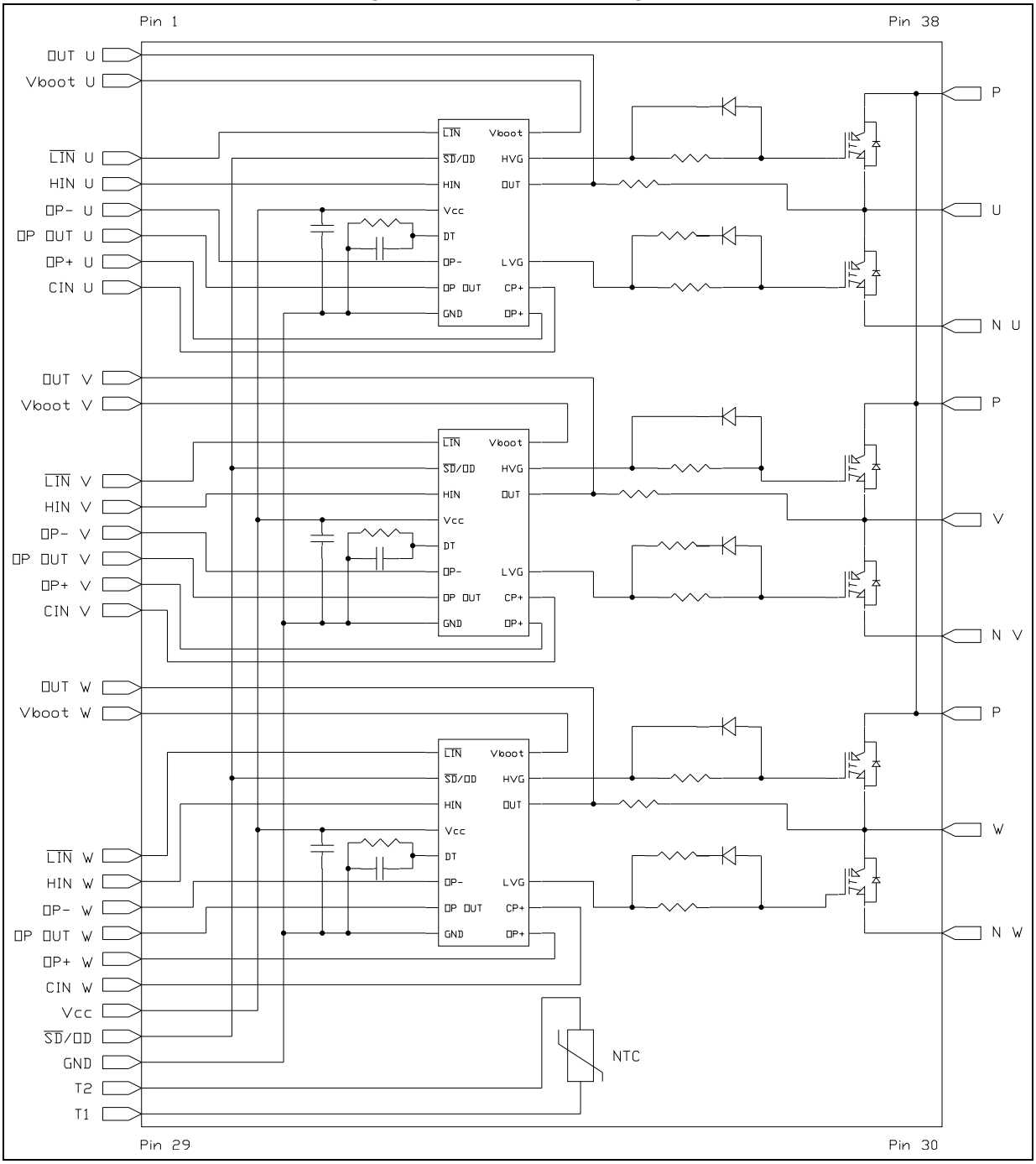


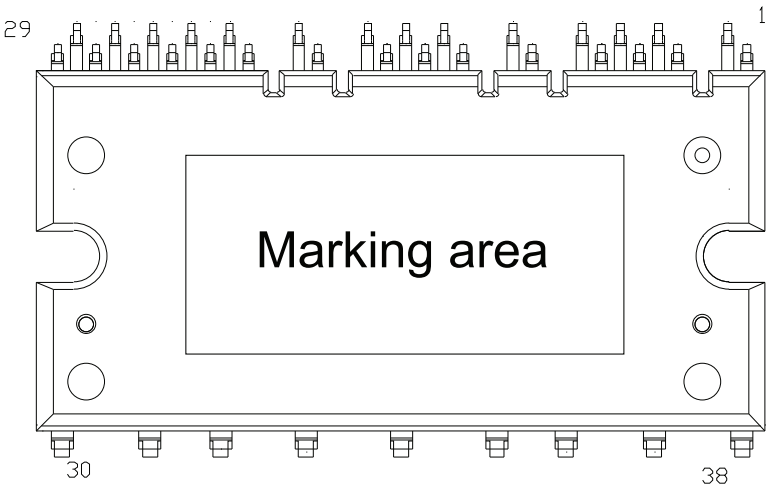
Table 2. Pin description

Pin	Symbol	Description
1	OUT_U	High-side reference output for U phase
2	$V_{boot\ U}$	Bootstrap voltage for U phase
3	$\overline{LIN}_U$	Low-side logic input for U phase
4	HIN_U	High-side logic input for U phase
5	$OP\text{-}_U$	Op amp inverting input for U phase
6	$OP_{OUT\ U}$	Op amp output for U phase
7	$OP+_U$	Op amp non-inverting input for U phase
8	CIN_U	Comparator input for U phase
9	OUT_V	High-side reference output for V phase
10	$V_{boot\ V}$	Bootstrap voltage for V phase
11	$\overline{LIN}_V$	Low-side logic input for V phase
12	HIN_V	High-side logic input for V phase
13	$OP\text{-}_V$	Op amp inverting input for V phase
14	$OP_{OUT\ V}$	Op amp output for V phase
15	$OP+_V$	Op amp non-inverting input for V phase
16	CIN_V	Comparator input for V phase
17	OUT_W	High-side reference output for W phase
18	$V_{boot\ W}$	Bootstrap voltage for W phase
19	$\overline{LIN}_W$	Low-side logic input for W phase
20	HIN_W	High-side logic input for W phase
21	$OP\text{-}_W$	Op amp inverting input for W phase
22	$OP_{OUT\ W}$	Op amp output for W phase
23	$OP+_W$	Op amp non-inverting input for W phase
24	CIN_W	Comparator input for W phase
25	V_{CC}	Low voltage power supply
26	$\overline{SD}$ / OD	Shutdown logic input (active low) / open drain (comparator output)
27	GND	Ground
28	T_2	NTC thermistor terminal 2
29	T_1	NTC thermistor terminal 1
30	N_W	Negative DC input for W phase
31	W	W phase output
32	P	Positive DC input
33	N_V	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_U	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 among P-N_U, N_V, N_W	450	V
$V_{PN(surge)}$	Supply voltage (surge) applied among P-N_U, N_V, N_W	500	V
V_{CES}	Each IGBT collector emitter voltage (V_{IN}(1) = 0)	600	V
± I_C(2)	Each IGBT continuous collector current at T_C = 25 °C	10	A
± I_{CP} (3)	Each IGBT pulsed collector current	20	A
P_{TOT}	Each IGBT total dissipation at T_C = 25 °C	35	W
t_{scw}	Short-circuit withstand time, V_{CE} = 0.5 $V_{(BR)CES}$ T_j = 125 °C, V_{CC} = V_{boot} = 15 V, $V_{IN\,(1)}$= 0÷5 V	5	µs

1. Applied to 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 among 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+}	Op amp non-inverting input	- 0.3	V_{CC} + 0.3	V
V_{op-}	Op amp inverting input	- 0.3	V_{CC} + 0.3	V
V_{boot}	Bootstrap voltage	- 0.3	620	V
V_{IN}	Logic input voltage applied among HIN, $\overline{LIN}$ and GND	- 0.3	15	V
$V_{\overline{SD}/OD}$	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 to each pin and heatsink plate (AC voltage, t = 60 seconds)	2500	V
T_j	Power chip 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
$R_{th(j-c)}$	Thermal resistance junction-case single IGBT	3.6	°C/W
	Thermal resistance junction-case single diode	5	°C/W

Figure 3. Maximum $I_{C(RMS)}$ current vs switching frequency(1)

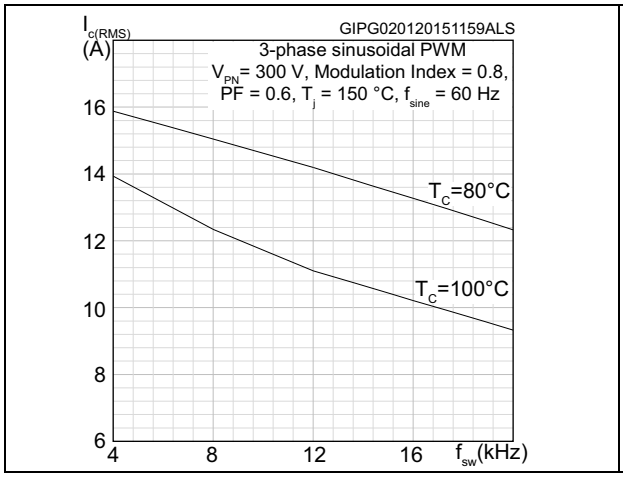
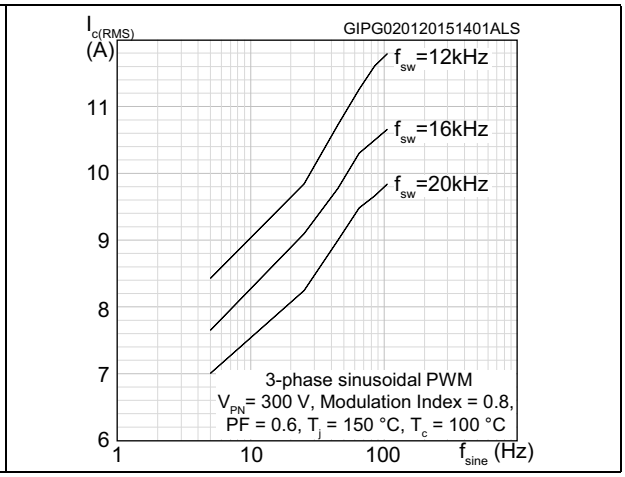


Figure 4. Maximum $I_{C(RMS)}$ current vs f_{sine}(1)



1. Simulated curves refer to typical IGBT parameters and maximum R_{thj-c}

3 Electrical characteristics

T_j = 25 °C unless otherwise specified.

Table 7. Inverter part

Symbol	Parameter	Test conditions	Value			Unit
			Min.	Typ.	Max.	
$V_{CE(sat)}$	Collector-emitter saturation voltage	V_{CC} = V_{boot} = 15 V, V_{IN}(1) = 0 to 5 V, I_C = 10 A	-	1.6	1.95	V
		V_{CC} = V_{boot} = 15 V, V_{IN}(1) = 0 to 5 V, I_C = 10 A, T_j= 125 °C	-	1.7		
I_{CES}	Collector cut-off current (V_{IN}(1) = 0 “logic state”)	V_{CE} = 550 V, V_{CC} = V_{boot} = 15 V	-		150	µA
V_F	Diode forward voltage	V_{IN}(1) = 0 “logic state”, I_C = 10 A	-		2.2	V
Inductive load switching time and energy						
t_{on}	Turn-on time	V_{DD} = 300 V, V_{CC} = V_{boot} = 15 V, V_{IN}(1) = 0 to 5 V, I_C = 10 A (see *Figure 5*)	-	410		ns
$t_{c(on)}$	Crossover time (on)		-	215		
t_{off}	Turn-off time		-	360		
$t_{c(off)}$	Crossover time (off)		-	90		
t_{rr}	Reverse recovery time		-	230		
E_{on}	Turn-on switching losses		-	346		µJ
E_{off}	Turn-off switching losses		-	94		

1. Applied to HIN_i $\overline{LIN_i}$ 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 IGBT switching time under the internally given gate driving conditions.

Figure 5. Switching time test circuit

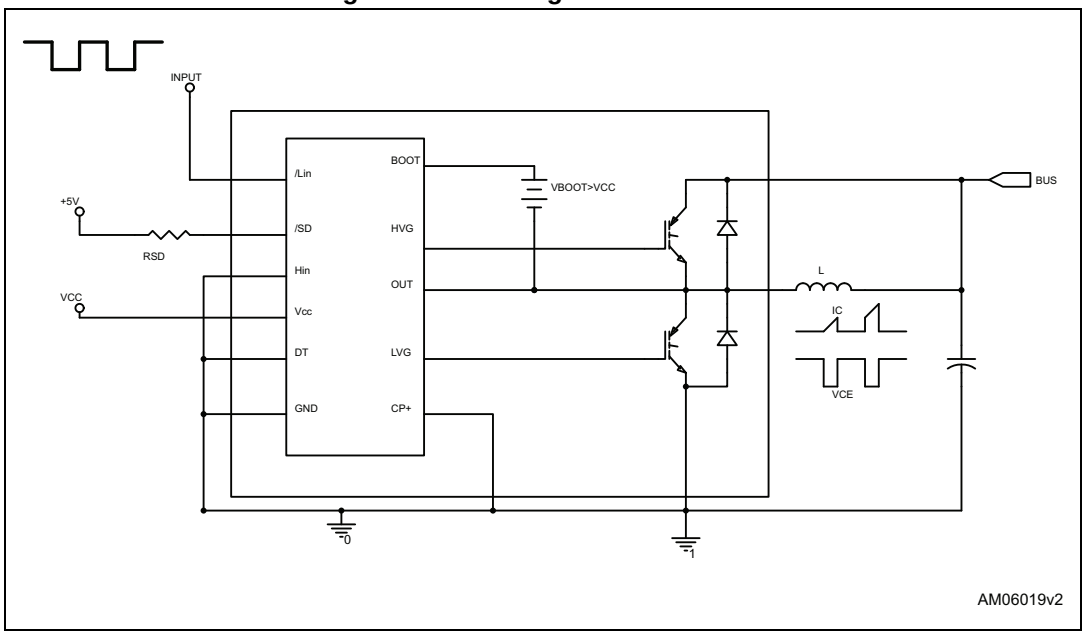


Figure 6. Switching time definition

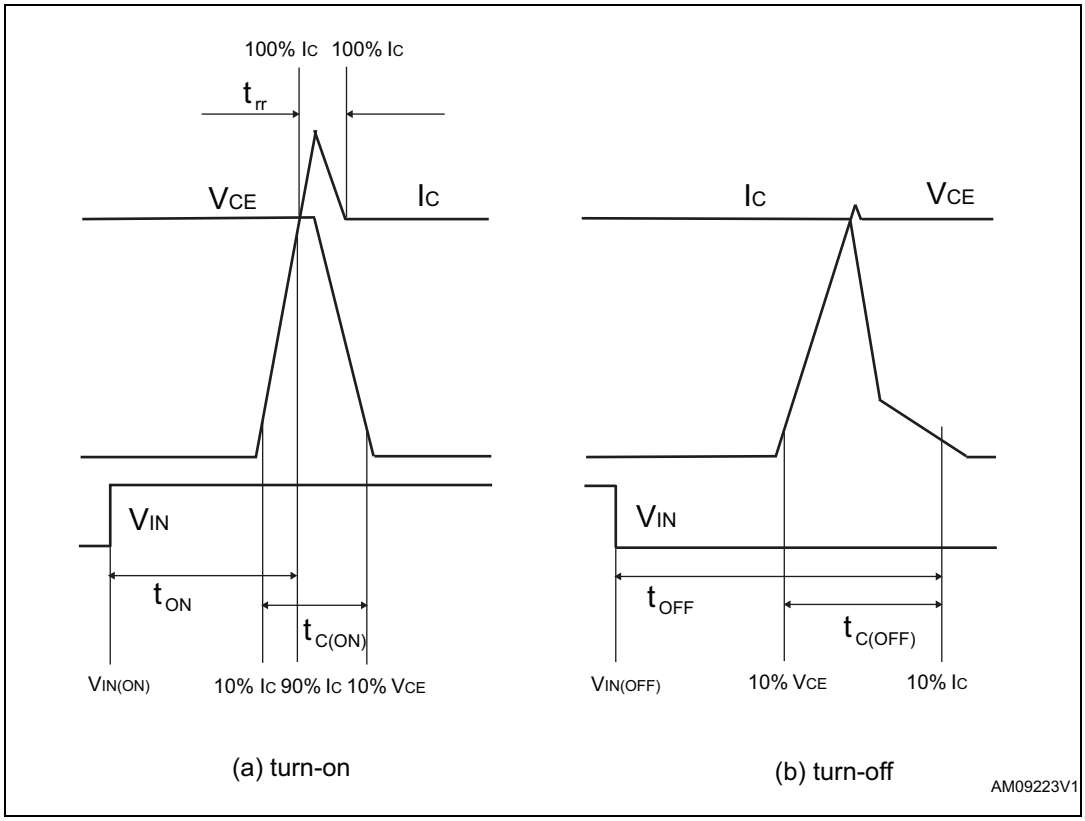


Figure 6 refers to HIN inputs (active high). For $\overline{\text{LIN}}$ inputs (active low), V_{IN} polarity has to be inverted for turn-on and turn-off.

3.1 Control part

Table 8. Low voltage power supply (V_{CC} = 15 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 V $\overline{SD}$/OD = 5 V; $\overline{LIN}$ = 5 V; H_{IN} = 0, C_{IN} = 0			450	µA
I_{qcc}	Quiescent current	V_{CC} = 15 V $\overline{SD}$/OD = 5 V; $\overline{LIN}$ = 5 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 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 V $\overline{SD}$/OD = 5 V; $\overline{LIN}$ and HIN = 5 V; C_{IN} = 0		70	110	µA
I_{QBS}	V_{BS} quiescent current	V_{BS} = 15 V $\overline{SD}$/OD = 5 V; $\overline{LIN}$ and HIN = 5 V; C_{IN} = 0		200	300	µA
$R_{DS(on)}$	Bootstrap driver on-resistance	LVG on		120		Ω

Table 10. Logic inputs (V_{CC} = 15 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	HIN = 15 V	110	175	260	µA
I_{HINl}	HIN logic “0” input bias current	HIN = 0 V			1	µA
I_{LINl}	$\overline{LIN}$ logic “1” input bias current	$\overline{LIN}$ = 0 V	3	6	20	µA
I_{LINh}	$\overline{LIN}$ logic “0” input bias current	$\overline{LIN}$ = 15 V			1	µA
I_{SDh}	$\overline{SD}$ logic “0” input bias current	$\overline{SD}$ = 15 V	30	120	300	µA

Table 10. Logic inputs (V_{CC} = 15 V unless otherwise specified) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{SDl}	$\overline{SD}$ logic “1” input bias current	$\overline{SD}$ = 0 V			3	µA
Dt	Dead time	see *Figure 9* and *Table 15*		600		ns

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

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{io}	Input offset voltage	V_{ic} = 0 V, V_o = 7.5 V			6	mV
I_{io}	Input offset current	V_{ic} = 0 V, V_o = 7.5 V		4	40	nA
I_{ib}	Input bias current (1)			100	200	nA
V_{icm}	Input common mode voltage range		0			V
V_{OL}	Low level output voltage	R_L = 10 kΩ to V_{CC}		75	150	mV
V_{OH}	High level output voltage	R_L = 10 kΩ to GND	14	14.7		V
I_o	Output short-circuit current	Source, V_{id} = 1 V; V_o = 0 V	16	30		mA
		Sink, V_{id} = 1 V; V_o = V_{CC}	50	80		mA
SR	Slew rate	V_i = 1 , 4 V; C_L = 100 pF; unity gain	2.5	3.8		V/ms
GBWP	Gain bandwidth product	V_o = 7.5 V	8	12		MHz
A_{vd}	Large signal voltage gain	R_L = 2 kΩ	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 IC.

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

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{ib(i)}$	Input bias current	$V_{CIN(i)}$ = 1 V, i = U, V o W	-		3	µA
V_{ol}	Open drain low level output voltage	I_{od} = 3 mA	-		0.5	V
t_{d_comp}	Comparator delay	$\overline{SD}$/OD pulled to 5 V through 100 kΩ resistor	-	90	130	ns
SR	Slew rate	C_L = 180 pF; R_{pu} = 5 kΩ	-	60		V/µs
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 CIN_i pin	50	200	250	

Table 13. Truth table

Conditions	Logic input (V_I)			Output	
	$\overline{SD}$/OD	$\overline{LIN}$	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

3.1.1 NTC thermistor

Table 14. NTC thermistor

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
R_{25}	Resistance	T = 25 °C		5		kΩ
R_{125}	Resistance	T = 125 °C		300		Ω
B	B-constant	T = 25 °C to 85 °C		3340		K
T	Operating temperature		-40		125	°C

Equation 1

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

where T is Kelvin temperature.

Figure 7. NTC resistance vs. temperature

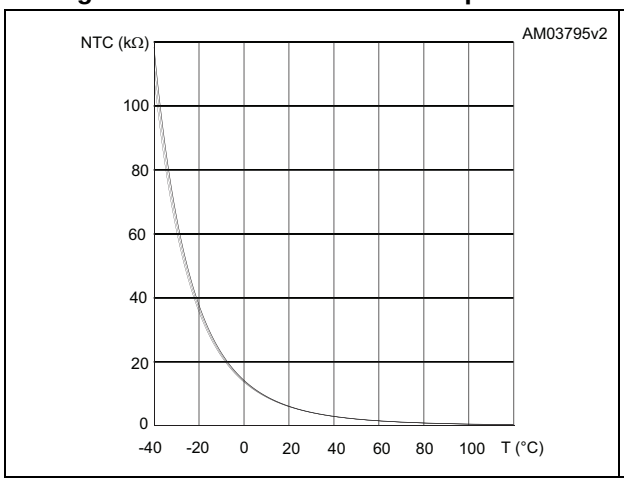
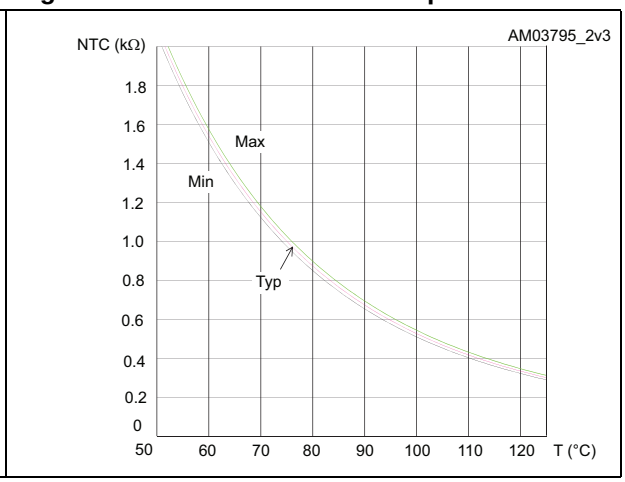
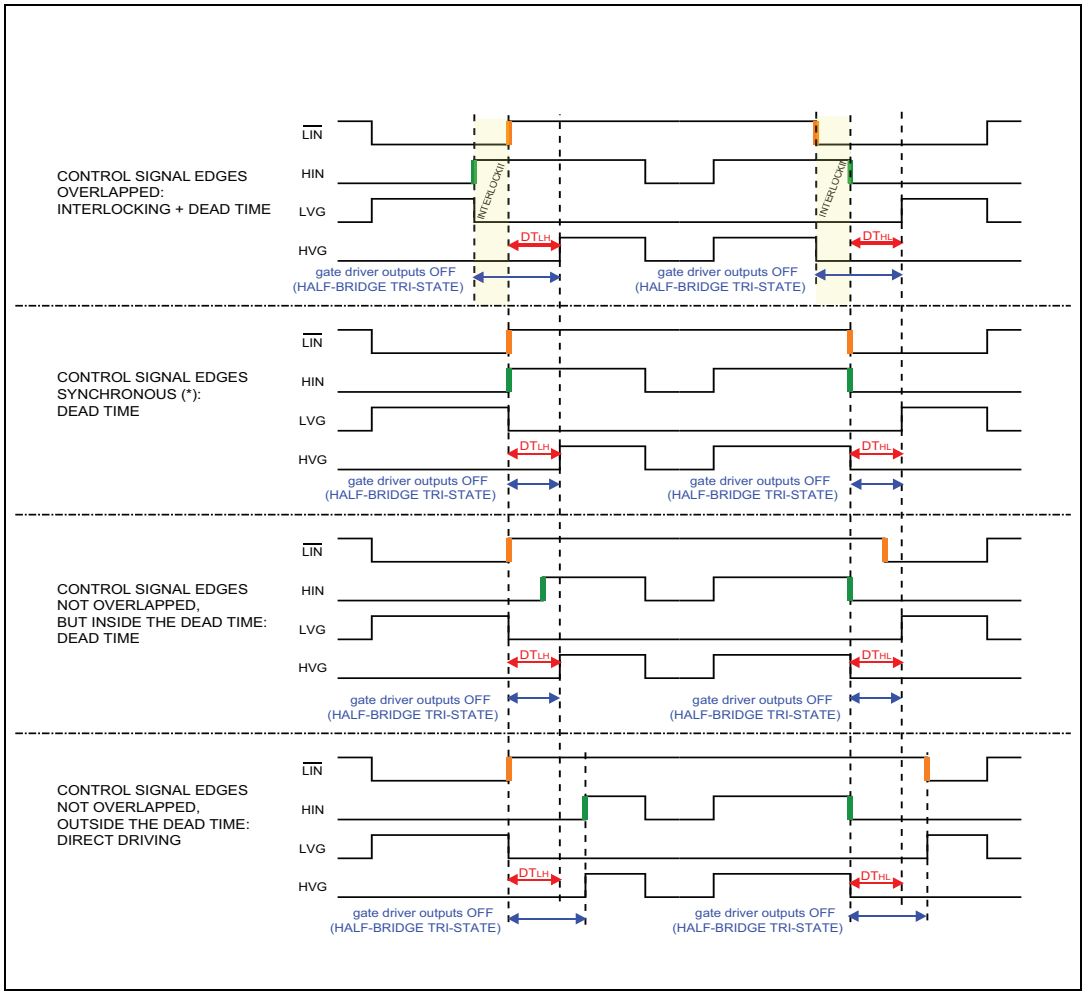


Figure 8. NTC resistance vs. temperature zoom



3.2 Waveform definitions

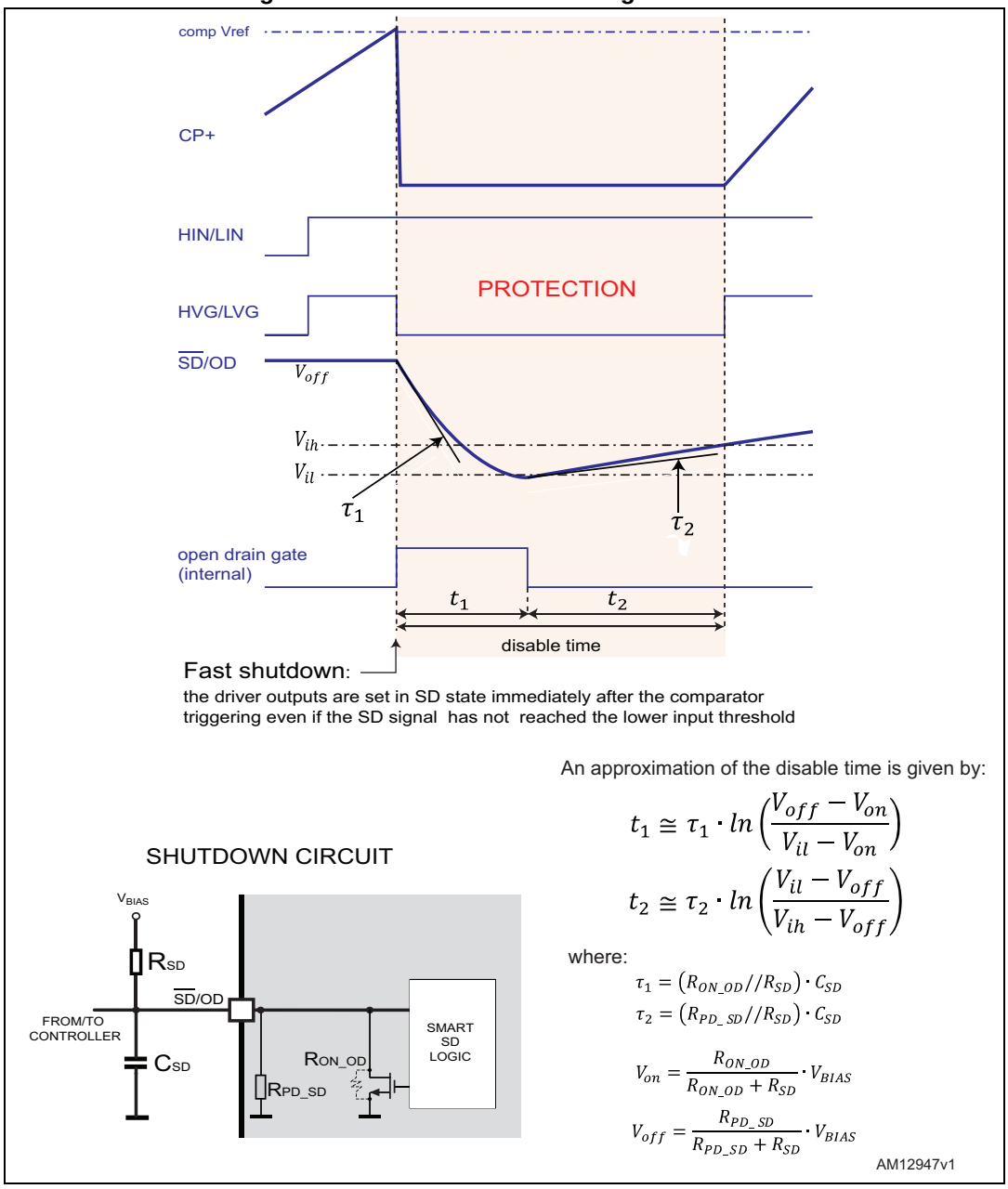
Figure 9. Dead time and interlocking waveform definitions



4 Smart shutdown function

These devices integrate a comparator for fault sensing purposes. The comparator has an internal voltage reference, V_{REF}, connected to the inverting input, while the non-inverting input available on the CIN pin can be connected to an external shunt resistor to implement the overcurrent protection function. When the comparator triggers, the device is in shutdown state and both of its outputs are set to low, leading the half-bridge to a tri-state. In overcurrent protection architectures, the comparator output is usually connected to the shutdown input through an RC network so as to provide a mono-stable circuit which implements a protection time following the fault condition. This smart shutdown architecture allows the output gate driver to be turned off immediately 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 turn-off of outputs isn't dependent on the RC values of the external network connected to the shutdown pin. At the same time, DMOS connected to the open drain output ($\overline{SD}$/OD pin) is turned on by the internal logic, which holds it on until the shutdown voltage is lower than the logic input lower threshold (Vil). Finally, the smart shutdown function can increase the real disable time without increasing the constant time of the external RC network.

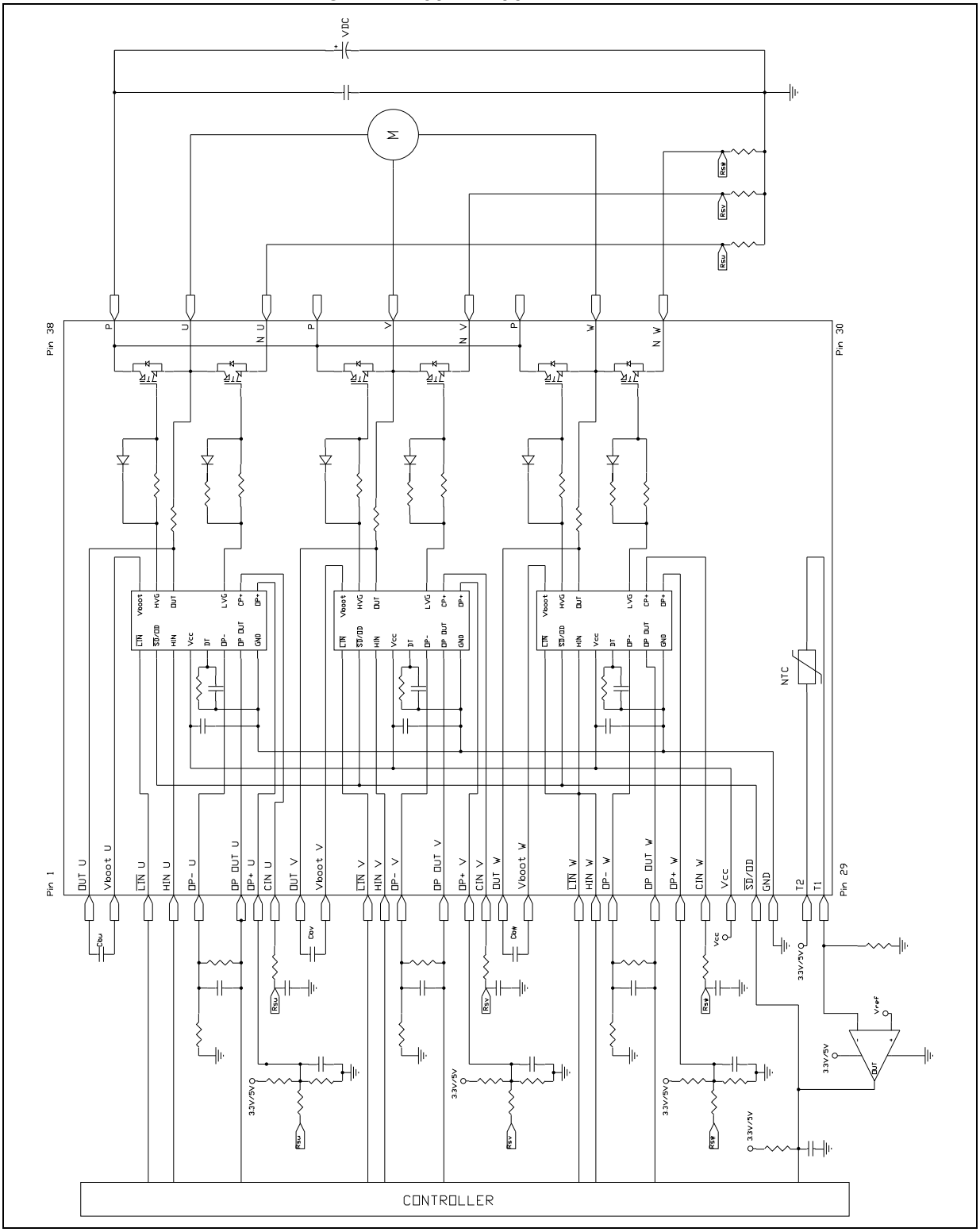
Figure 10. Smart shutdown timing waveforms



Please 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 kΩ (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 kΩ (typ.) pull-up resistor, connected to an internal 5 V regulator through a diode, is built-in for each low-side input.
- To avoid the input signal oscillation, the wiring of each input should be as short as possible.
- By integrating HVIC application inside the module, direct coupling to MCU terminals without any opto-coupler is possible.
- Each capacitor should be very close to IPM pins.
- Low inductance shunt resistors should be used for phase lag current sensing.
- Electrolytic bus capacitors should be mounted on the module bus terminals as closer as possible. Additional high frequency ceramic capacitors, mounted on module pins, improve the performance.
- $\overline{\text{SD}}$/OD signal should be pulled up 5 V / 3.3 V with an external resistor (see *Section 4: Smart shutdown function* for detailed information).

Table 15. Recommended operating conditions

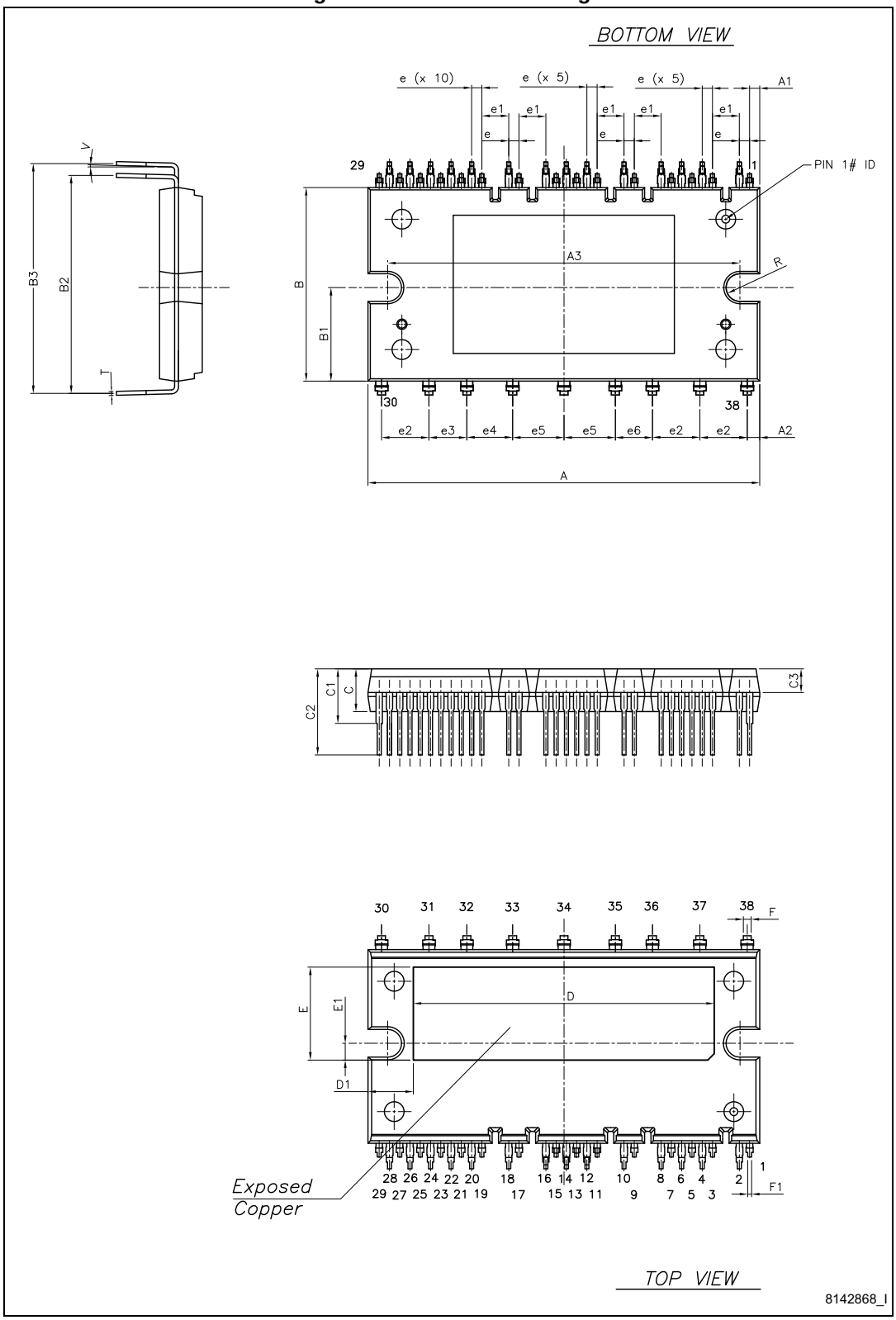
Symbol	Parameter	Conditions	Value			Unit
			Min.	Typ.	Max.	
V_{PN}	Supply voltage	Applied among P-N_U, N_V, N_W		300	400	V
V_{CC}	Control supply voltage	Applied to V_{CC}, GND	13.5	15	18	V
V_{BS}	High-side bias voltage	Applied between V_{BOOTi}, OUT_i for i = U, V, W	13		18	V
t_{dead}	Blanking time to prevent arm shortage	For each input signal	1			µs
f_{PWM}	PWM input signal	-40 °C < T_c < 100 °C -40 °C < T_j < 125 °C			20	kHz
T_C	Case operation temperature				100	°C

Note: For further details refer to AN3338.

6 Package information

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

Figure 12. SDIP-38L drawings



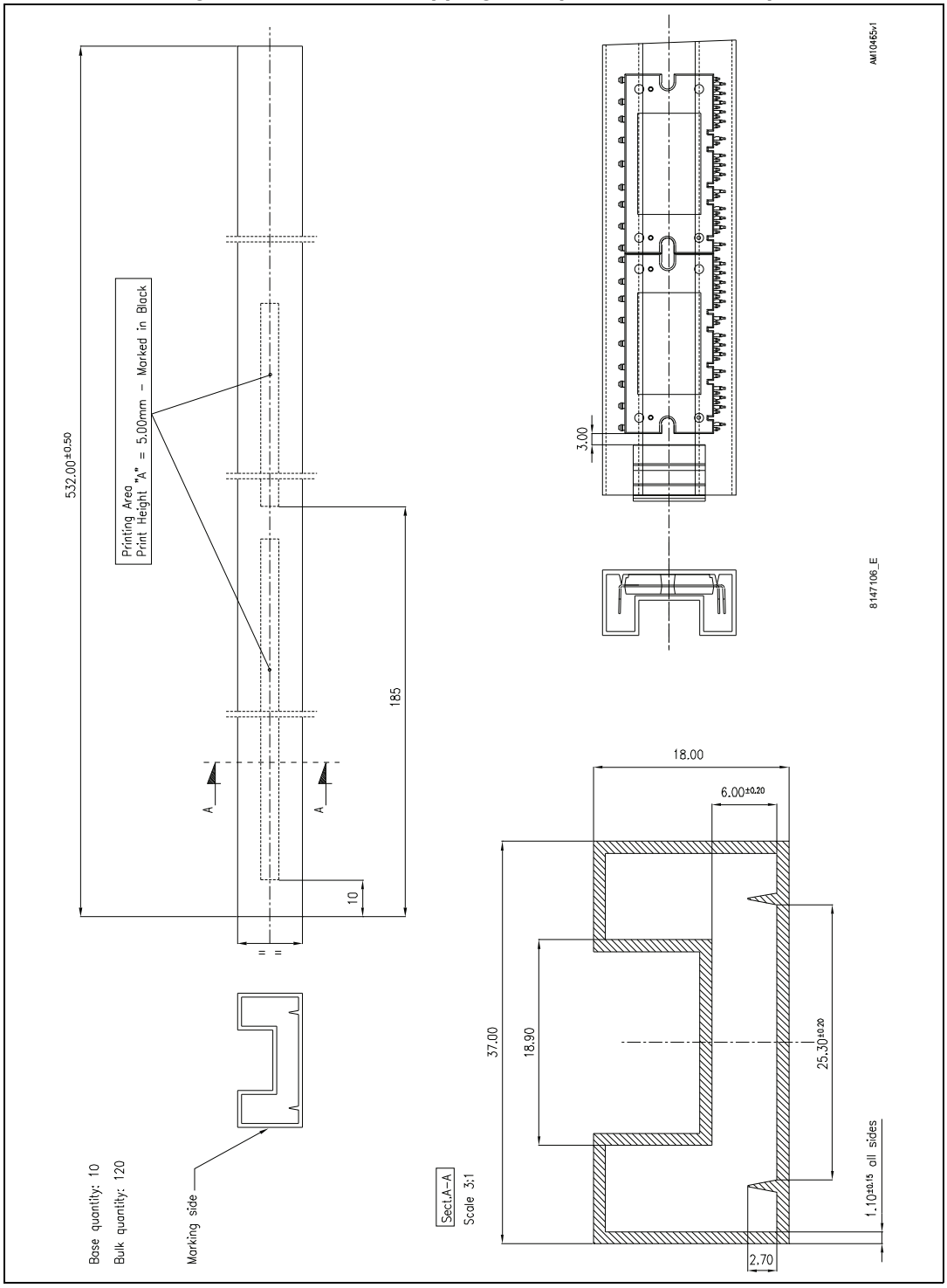
Note: Please refer to dedicated technical note TN0107 for mounting instructions.

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
C3	2.90	3.00	3.10
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
T	0.45	0.55	0.65
V	0°		6°

7 Packaging mechanical data

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



8 Revision history

Table 17. Document revision history

Date	Revision	Changes
16-May-2014	1	Initial release.
07-Jan-2015	2	Text edits throughout document In Section 2.1, updated Table 3: Inverter part In Section 2.2, – updated Table 3: Inverter part – added Figure 3: Maximum IC(RMS) current vs switching frequency – added Figure 4: Maximum IC(RMS) current vs fsine(1) In Section 3, updated Table 7: Inverter part. Updated Section 6: Package information.
21-Oct-2015	3	Document status promoted from target to preliminary data.