

## SLLIMM™ -nano small low-loss intelligent molded module IPM, 3 A, 600 V, 3-phase IGBT inverter bridge

Datasheet - production data



### Applications

- 3-phase inverters for motor drives
- Dish washers, refrigerator compressors, heating systems, air-conditioning fans, draining and recirculation pumps

### Description

This SLLIMM (small low-loss intelligent molded module) nano provides a compact, high performance AC motor drive in a simple, rugged design. It is composed of six MOSFETs and three half-bridge HVICs for gate driving, providing low electromagnetic interference (EMI) characteristics with optimized switching speed. The package is optimized for thermal performance and compactness in built-in motor applications, or other low power applications where assembly space is limited. This IPM includes an operational amplifier, completely uncommitted, and a comparator that can be used to design a fast and efficient protection circuit. SLLIMM™ is a trademark of STMicroelectronics.

### Features

- IPM 3 A, 600 V, 3-phase IGBT inverter bridge including control ICs for gate driving and freewheeling diodes
- Optimized for low electromagnetic interference
- $V_{CE(sat)}$  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
- Comparator for fault protection against overtemperature and overcurrent
- Op-amp for advanced current sensing
- Optimized pinout for easy board layout

Table 1: Device summary

Order code	Marking	Package	Packing
STGIPN3H60	GIPN3H60	NDIP-26L	Tube

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# 1 Internal schematic diagram and pin configuration

Figure 1: Internal schematic diagram

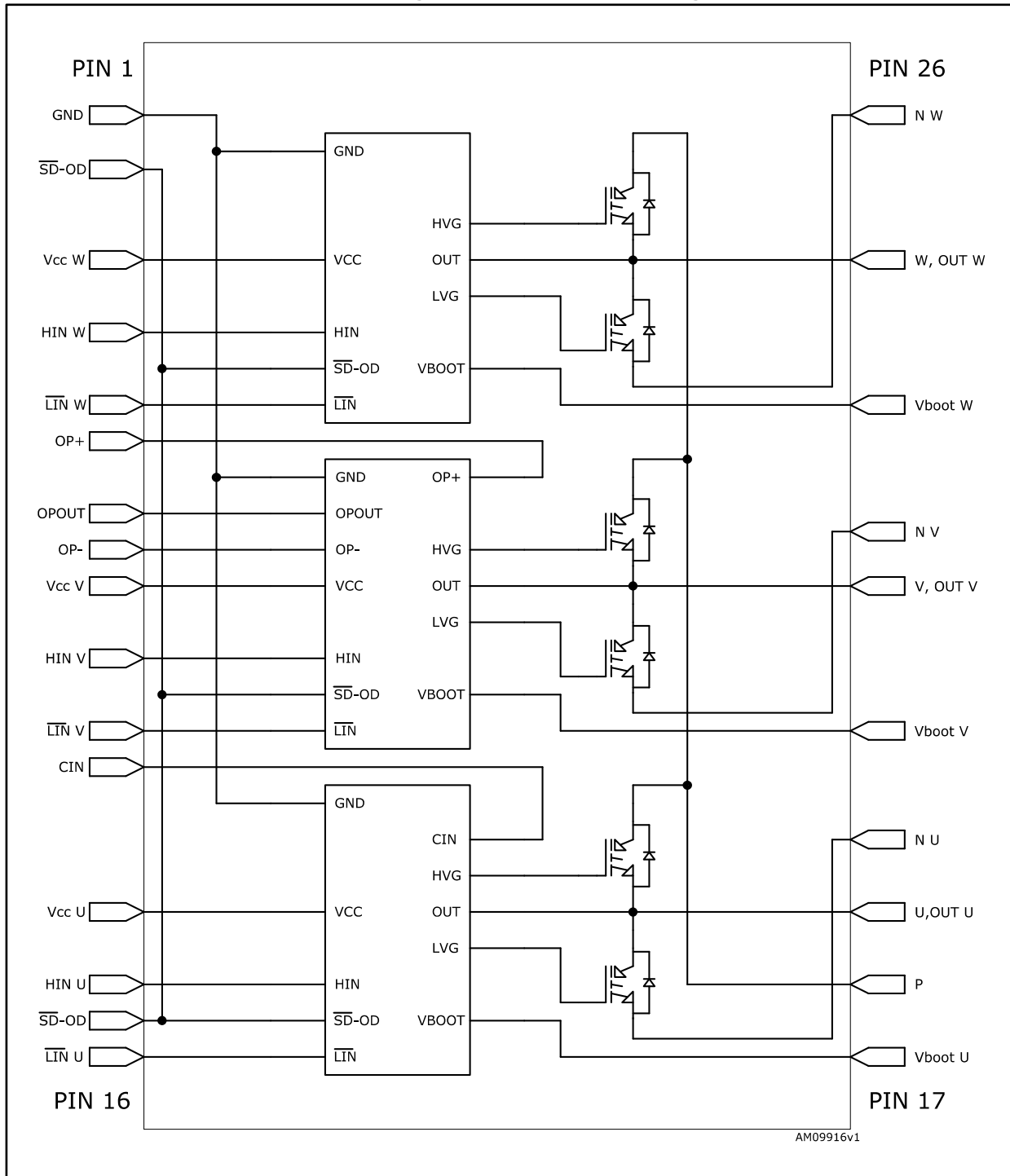


Table 2: Pin description

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

Figure 2: Pin layout (top view)



## 2 Electrical ratings

### 2.1 Absolute maximum ratings

Table 3: Inverter part

Symbol	Parameter	Value	Unit
V <sub>CES</sub>	Each IGBT collector emitter voltage (V <sub>IN</sub> <sup>(1)</sup> = 0)	600	V
± I <sub>C</sub> <sup>(2)</sup>	Each IGBT continuous collector current at T <sub>C</sub> = 25 °C	3	A
± I <sub>CP</sub> <sup>(3)</sup>	Each IGBT pulsed collector current	18	A
P <sub>TOT</sub>	Each IGBT total dissipation at T <sub>C</sub> = 25 °C	8	W

**Notes:**

<sup>(1)</sup>Applied among HIN<sub>i</sub>,  $\overline{\text{LIN}}_i$  and GND for i = U, V, W.

<sup>(2)</sup>Calculated according to the iterative formula:

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

<sup>(3)</sup>Pulse width limited by max. junction temperature.

Table 4: Control part

Symbol	Parameter	Min.	Max.	Unit
V <sub>OUT</sub>	Output voltage applied among OUT <sub>U</sub> , OUT <sub>V</sub> , OUT <sub>W</sub> - GND	V <sub>boot</sub> - 21	V <sub>boot</sub> + 0.3	V
V <sub>CC</sub>	Low voltage power supply	- 0.3	21	V
V <sub>CIN</sub>	Comparator input voltage	- 0.3	V <sub>CC</sub> + 0.3	V
V <sub>op+</sub>	Op-amp non-inverting input	- 0.3	V <sub>CC</sub> + 0.3	V
V <sub>op-</sub>	Op-amp inverting input	- 0.3	V <sub>CC</sub> + 0.3	V
V <sub>boot</sub>	Bootstrap voltage	- 0.3	620	V
V <sub>IN</sub>	Logic input voltage applied among HIN, $\overline{\text{LIN}}$ and GND	- 0.3	15	V
V <sub><math>\overline{\text{SD}}</math>/OD</sub>	Open-drain voltage	- 0.3	15	V
ΔV <sub>OUT/dT</sub>	Allowed output slew rate		50	V/ns

Table 5: Total system

Symbol	Parameter	Value	Unit
V <sub>ISO</sub>	Isolation withstand voltage applied among each pin and heatsink plate (AC voltage, t = 60 s)	1000	V
T <sub>j</sub>	Power chip operating junction temperature range	-40 to 150	°C
T <sub>C</sub>	Module operation case temperature range	-40 to 125	°C

## 2.2 Thermal data

Table 6: Thermal data

Symbol	Parameter	Value	Unit
R <sub>thJA</sub>	Thermal resistance junction-ambient	50	°C/W

## 3 Electrical characteristics

### 3.1 Inverter part

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

**Table 7: Static**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{CE(sat)}$	Collector-emitter saturation voltage	$V_{CC} = V_{boot} = 15\text{ V}$ , $V_{IN}^{(1)} = 0\text{ to }5\text{ V}$ , $I_C = 1\text{ A}$	-	2.15	2.6	V
		$V_{CC} = V_{boot} = 15\text{ V}$ , $V_{IN}^{(1)} = 0\text{ to }5\text{ V}$ , $I_C = 1\text{ A}$ , $T_J = 125\text{ °C}$	-	1.65		
$I_{CES}$	Collector cut-off current ( $V_{IN}^{(1)} = 0$ "logic state")	$V_{CE} = 550\text{ V}$ , $V_{CC} = V_{Boot} = 15\text{ V}$	-		250	$\mu\text{A}$
$V_F$	Diode forward voltage	$V_{IN}^{(1)} = 0$ "logic state", $I_C = 1\text{ A}$	-		1.7	V

**Notes:**

<sup>(1)</sup>Applied among  $HIN_i$ ,  $\overline{LIN}_i$  and  $GND$  for  $i = U, V, W$  ( $\overline{LIN}_i$  inputs are active low).

**Table 8: Inductive load switching time and energy**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{on}^{(1)}$	Turn-on time	$V_{DD} = 300\text{ V}$ , $V_{CC} = V_{boot} = 15\text{ V}$ , $V_{IN}^{(2)} = 0 - 5\text{ V}$ , $I_C = 1\text{ A}$ (see <a href="#">Figure 4: "Switching time definition"</a> )	-	275	-	ns
$t_{c(on)}^{(1)}$	Crossover time (on)		-	90	-	
$t_{off}^{(1)}$	Turn-off time		-	890	-	
$t_{c(off)}^{(1)}$	Crossover time (off)		-	125	-	
$t_{rr}$	Reverse recovery time		-	50	-	
$E_{on}$	Turn-on switching energy		-	18	-	$\mu\text{J}$
$E_{off}$	Turn-off switching energy		-	13	-	

**Notes:**

<sup>(1)</sup> $t_{ON}$  and  $t_{OFF}$  include the propagation delay time of the internal drive.  $t_{c(ON)}$  and  $t_{c(OFF)}$  are the switching time of MOSFET itself under the internally given gate driving conditions.

<sup>(2)</sup>Applied among  $HIN_i$ ,  $\overline{LIN}_i$  and  $GND$  for  $i = U, V, W$  ( $\overline{LIN}_i$  inputs are active low).



Figure 3: Switching time test circuit

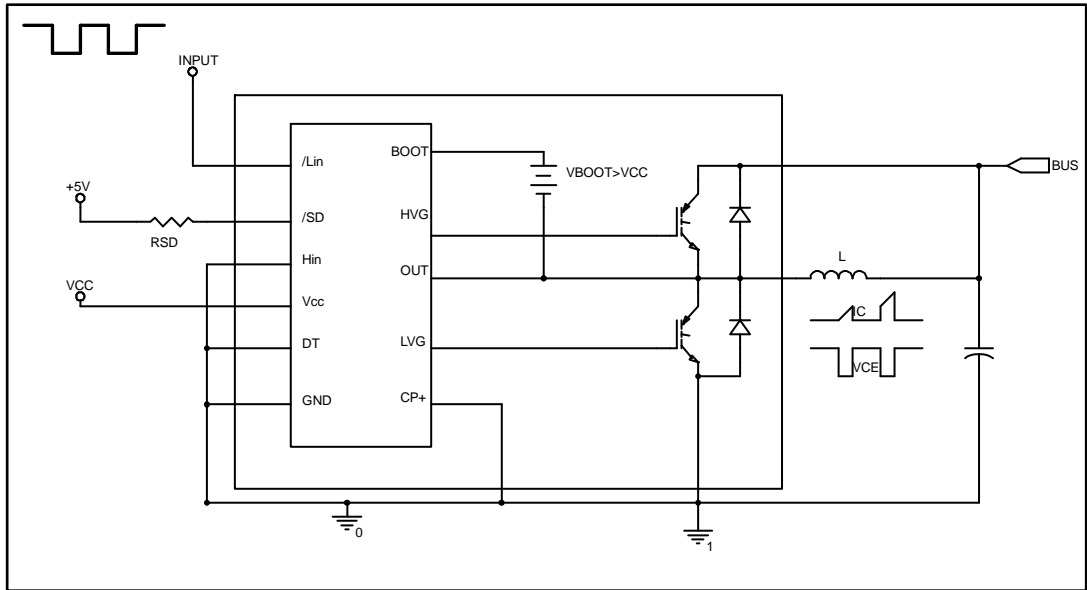


Figure 4: Switching time definition

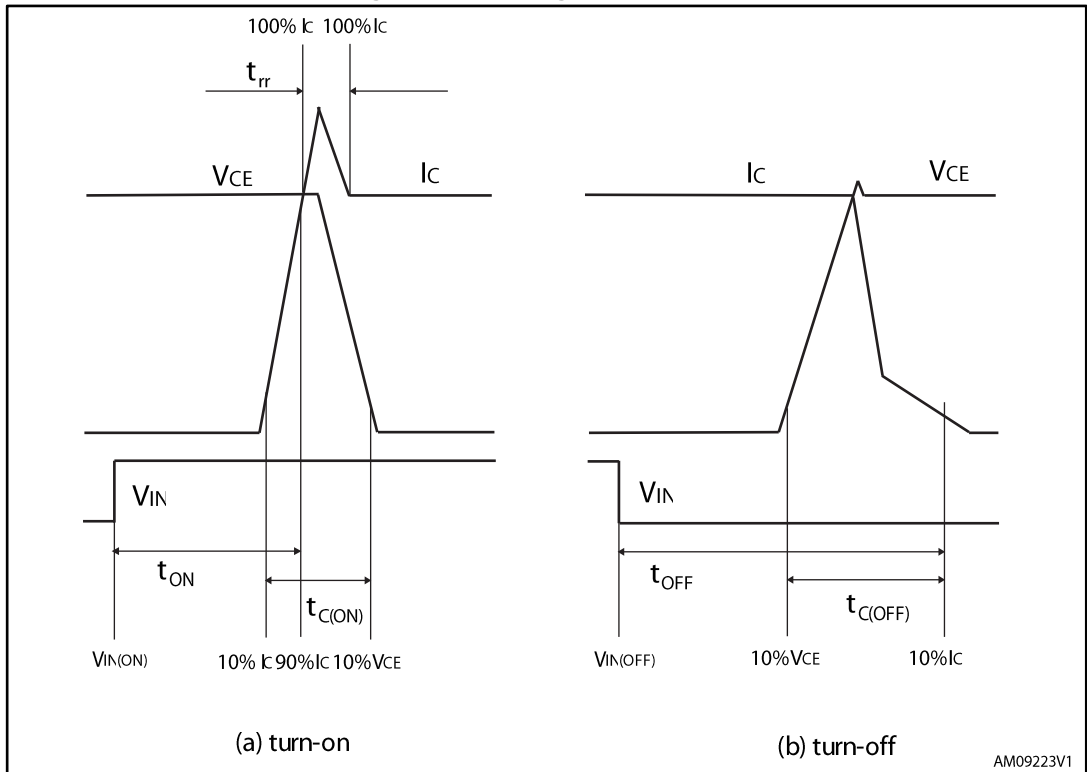


Figure 4: "Switching time definition" refers to HIN inputs (active high). For  $\overline{\text{LIN}}$  inputs (active low), VIN polarity must be inverted for turn-on and turn-off.

### 3.2 Control part

**Table 9: 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	$V_{CC} = 10\text{ V}$ , $\overline{SD} / OD = 5\text{ V}$ , $\overline{LIN} = 5\text{ V}$ , $H_{IN} = 0$ , $C_{IN} = 0\text{ V}$			150	$\mu\text{A}$
$I_{qcc}$	Quiescent current	$V_{CC} = 15\text{ V}$ , $\overline{SD} / OD = 5\text{ V}$ , $\overline{LIN} = 5\text{ V}$ , $H_{IN} = 0$ , $C_{IN} = 0\text{ V}$			1	mA
$V_{ref}$	Internal comparator (CIN) reference voltage		0.5	0.54	0.58	V

**Table 10: 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	$V_{BS} < 9\text{ V}$ $\overline{SD} / OD = 5\text{ V}$ , $\overline{LIN}$ and $H_{IN} = 5\text{ V}$ , $C_{IN} = 0\text{ V}$		70	110	$\mu\text{A}$
$I_{qBS}$	$V_{BS}$ quiescent current	$V_{BS} = 15\text{ V}$ $\overline{SD} / OD = 5\text{ V}$ , $\overline{LIN}$ and $H_{IN} = 5\text{ V}$ , $C_{IN} = 0\text{ V}$		200	300	$\mu\text{A}$
$R_{DS(on)}$	Bootstrap driver on-resistance	LVG ON		120		$\Omega$

**Table 11: 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	$\mu\text{A}$
$I_{HINI}$	HIN logic "0" input bias current	$H_{IN} = 0\text{ V}$			1	$\mu\text{A}$
$I_{LINI}$	$\overline{LIN}$ logic "1" input bias current	$\overline{LIN} = 0\text{ V}$	3	6	20	$\mu\text{A}$

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{LINh}$	$\overline{LIN}$ 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 5: "Dead time and interlocking waveform definitions"</a>		180		ns

Table 12: Op-amp characteristics ( $V_{CC} = 15\text{ V}$  unless otherwise specified)

Symbol	Parameter	Test conditions	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, $V_{id} = +1\text{ V}$ ; $V_o = 0\text{ V}$	16	30		mA
		Sink, $V_{id} = -1\text{ V}$ ; $V_o = V_{CC}$	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

**Notes:**

<sup>(1)</sup>The direction of the input current is out of the IC.

Table 13: 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/ $\mu\text{s}$
$t_{sd}$	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	50	200	250	

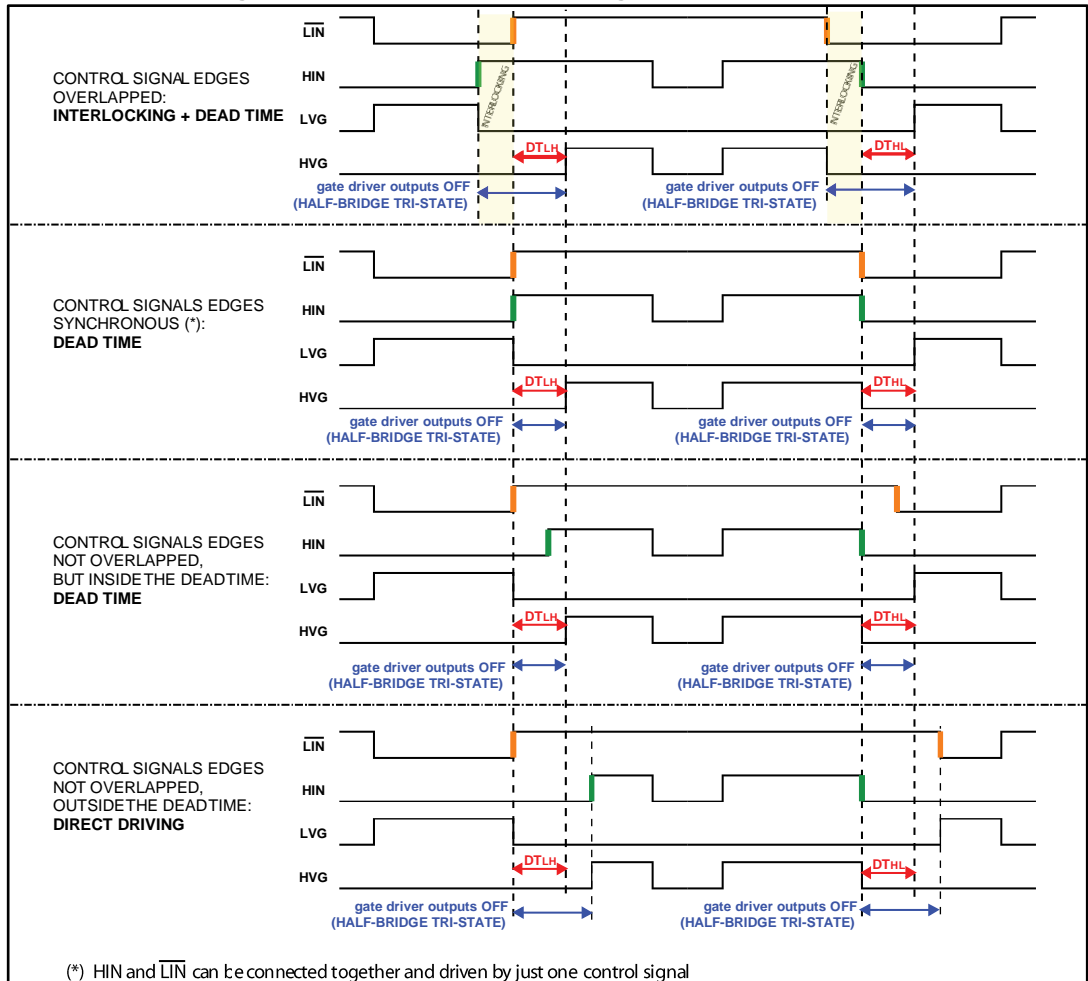
Table 14: Truth table

Condition	Logic input ( $V_i$ )			Output	
	$\overline{SD}$ /OD	LIN	HIN	LVG	HVG
Shutdown enable half-bridge tri-state	L	X <sup>(1)</sup>	X <sup>(1)</sup>	L	L
Interlocking half-bridge tri-state	H	L	H	L	L
0 "logic state" half-bridge tri-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

**Notes:**<sup>(1)</sup>X: don't care.

### 3.3 Waveform definitions

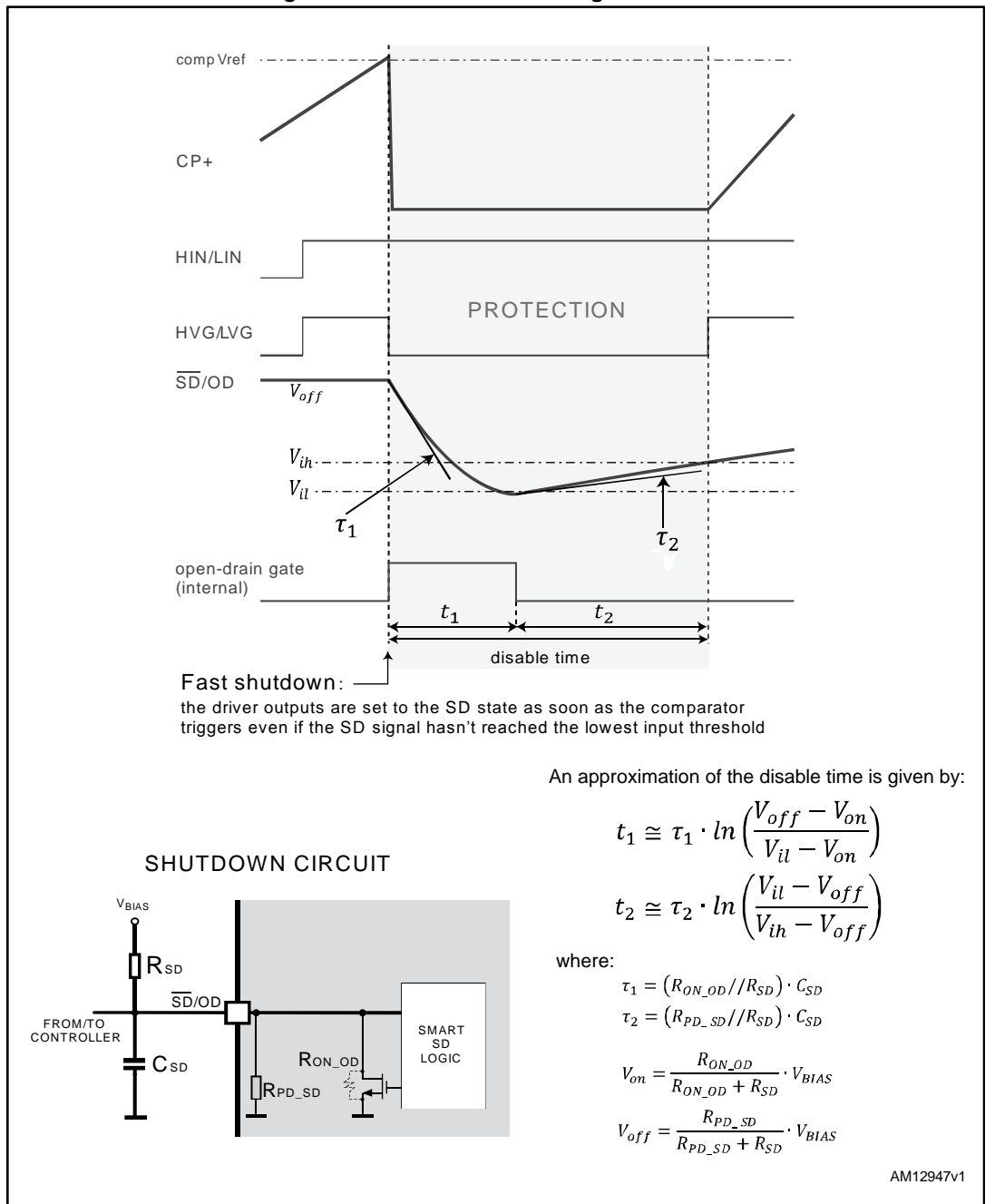
Figure 5: Dead time and interlocking waveform definitions



## 4 Smart shutdown function

The STGIPN3H60 integrates a comparator for fault sensing purposes. The comparator non-inverting input ( $C_{IN}$ ) can be connected to an external shunt resistor so to implement a simple overcurrent protection function. When the comparator triggers, the device is set in shutdown state and both of its outputs are set to low level to lead the half-bridge to tri-state. In common overcurrent protection architectures, the comparator output is usually connected to the shutdown input through an RC network, to provide a mono-stable circuit, which implements a protection time following to the fault condition. Our smart shutdown architecture allows the output gate driver to immediately turn off 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 output 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 threshold. Finally the smart shutdown function increases the real disable time without increasing the constant time of the external RC network.

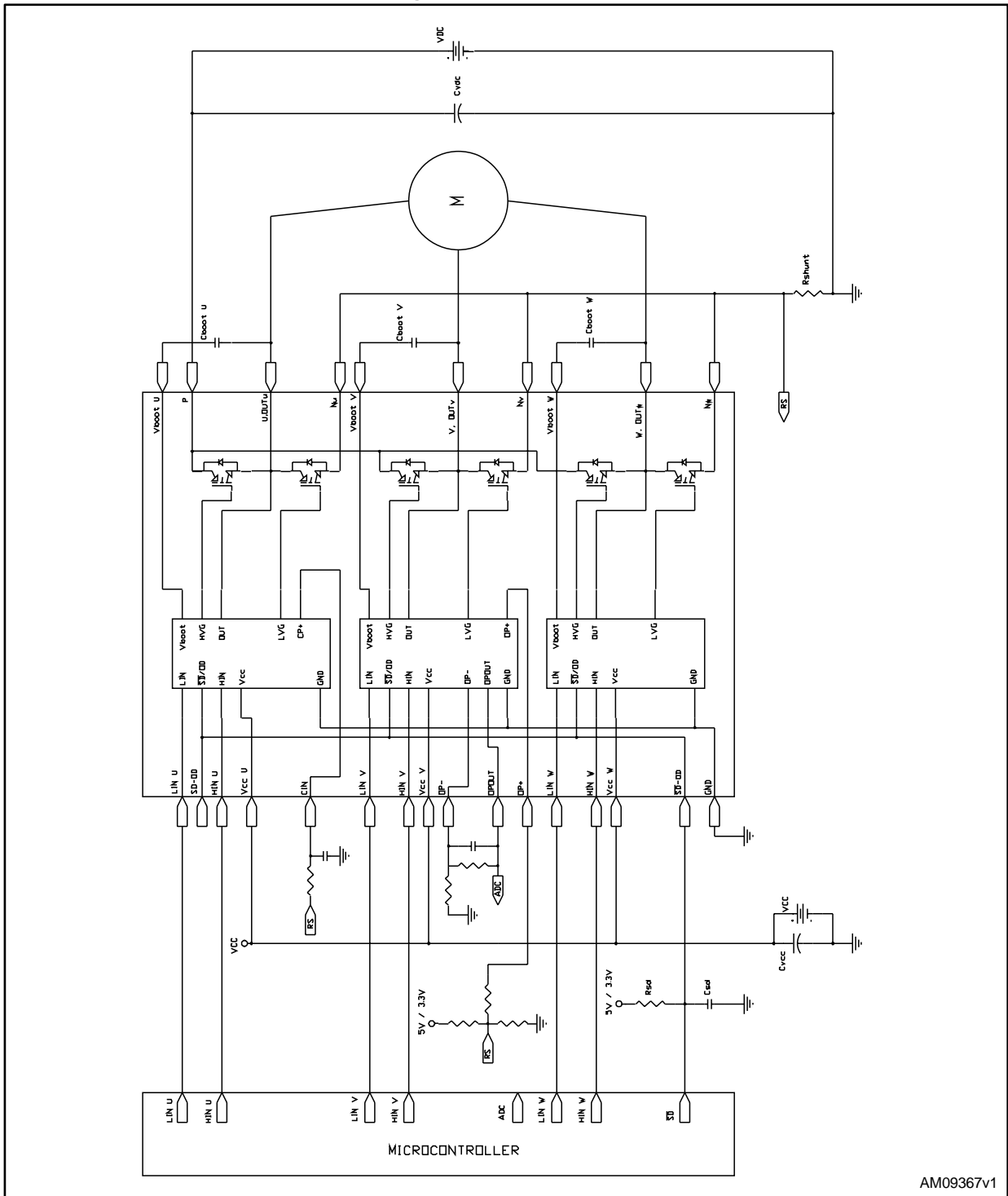
Figure 6: Smart shutdown timing waveforms



Please refer to [Table 13: "Sense comparator characteristics \(VCC = 15 V unless otherwise specified\)"](#) for internal propagation delay time details.

## 5 Application circuit example

Figure 7: Application circuit example



AM09367v1

Application designers are free to use a different scheme according to the specifications of the device.



## 5.1 Guidelines

- Input signal HIN is active high logic. A pull-down resistor of 85 kΩ (typ.) is built-in for each high-side input. If an external RC filter is used for noise immunity, attention should be given 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 input signal 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 the MCU terminals without an optocoupler is possible.
- Each capacitor should be located as close as possible to pins of IPM.
- 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 capacitors mounted close to the module pins improve the 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).

These guidelines ensure the specifications of the device for application designs. For further details, please refer to the relevant application note AN4043.

Table 15: Recommended operating conditions

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>PN</sub>	Supply voltage	Applied among P-Nu, Nv, Nw		300	500	V
V <sub>CC</sub>	Control supply voltage	Applied to V <sub>CC</sub> -GND	13.5	15	18	V
V <sub>BS</sub>	High-side bias voltage	Applied to V <sub>BOOTi</sub> -OUT <sub>i</sub> for i = U, V, W	13		18	V
t <sub>dead</sub>	Blanking time to avoid arm-short	For each input signal	1.5			μs
f <sub>PWM</sub>	PWM input signal	-40 °C < T <sub>c</sub> < 100 °C -40 °C < T <sub>j</sub> < 125 °C			25	kHz
T <sub>C</sub>	Case operation temperature				100	°C

## 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](http://www.st.com). ECOPACK® is an ST trademark.

### 6.1 NDIP-26L type C package information

Figure 8: NDIP-26L type C package outline

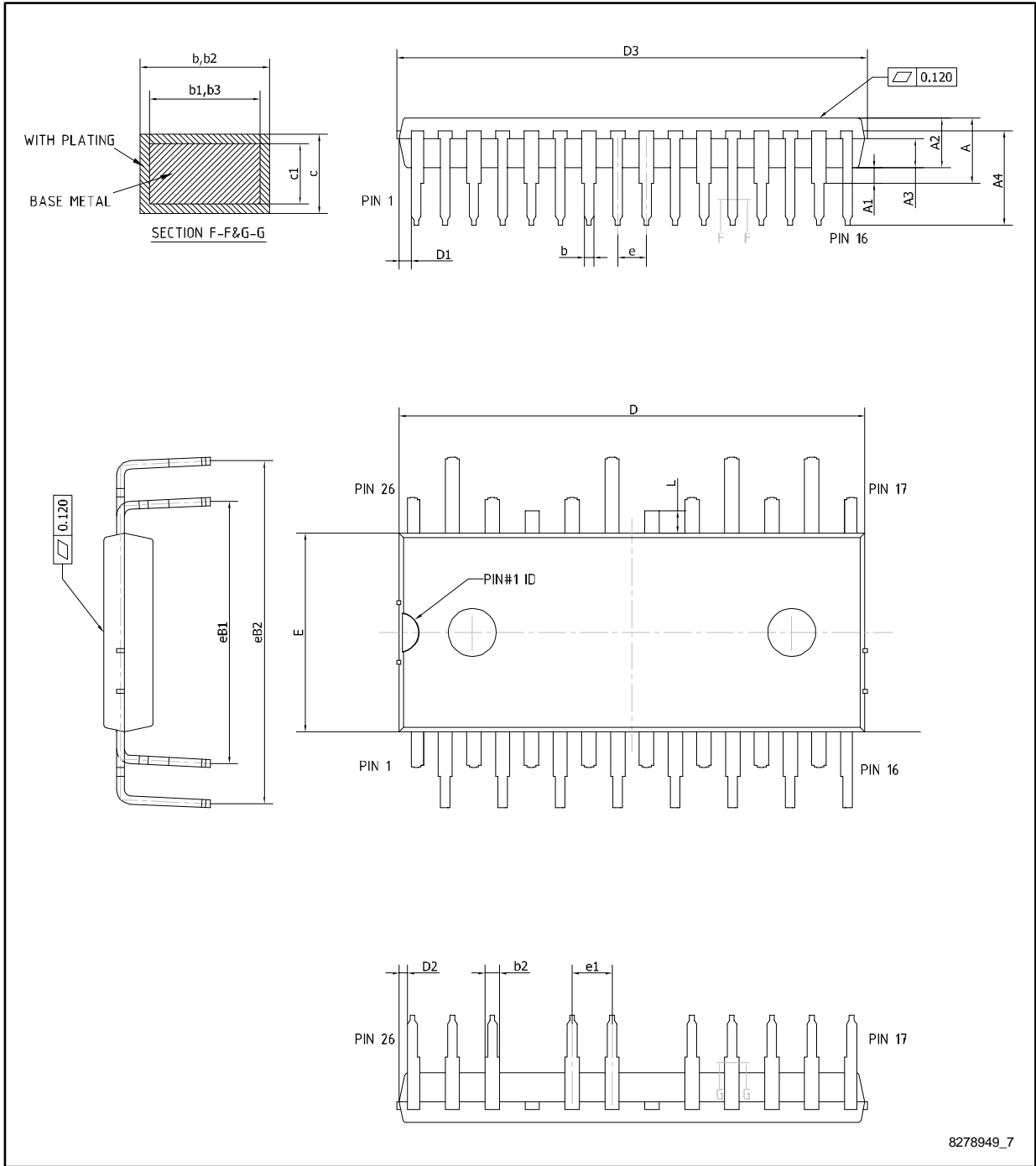


Table 16: NDIP-26L type C mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			4.40
A1	0.80	1.00	1.20
A2	3.00	3.10	3.20
A3	1.70	1.80	1.90
A4	5.70	5.90	6.10
b	0.53		0.72
b1	0.52	0.60	0.68
b2	0.83		1.02
b3	0.82	0.90	0.98
c	0.46		0.59
c1	0.45	0.50	0.55
D	29.05	29.15	29.25
D1	0.50	0.77	1.00
D2	0.35	0.53	0.70
D3			29.55
E	12.35	12.45	12.55
e	1.70	1.80	1.90
e1	2.40	2.50	2.60
eB1	16.10	16.40	16.70
eB2	21.18	21.48	21.78
L	1.24	1.39	1.54

## 6.2 NDIP-26L packing information

Figure 9: NDIP-26L tube (dimensions are in mm)

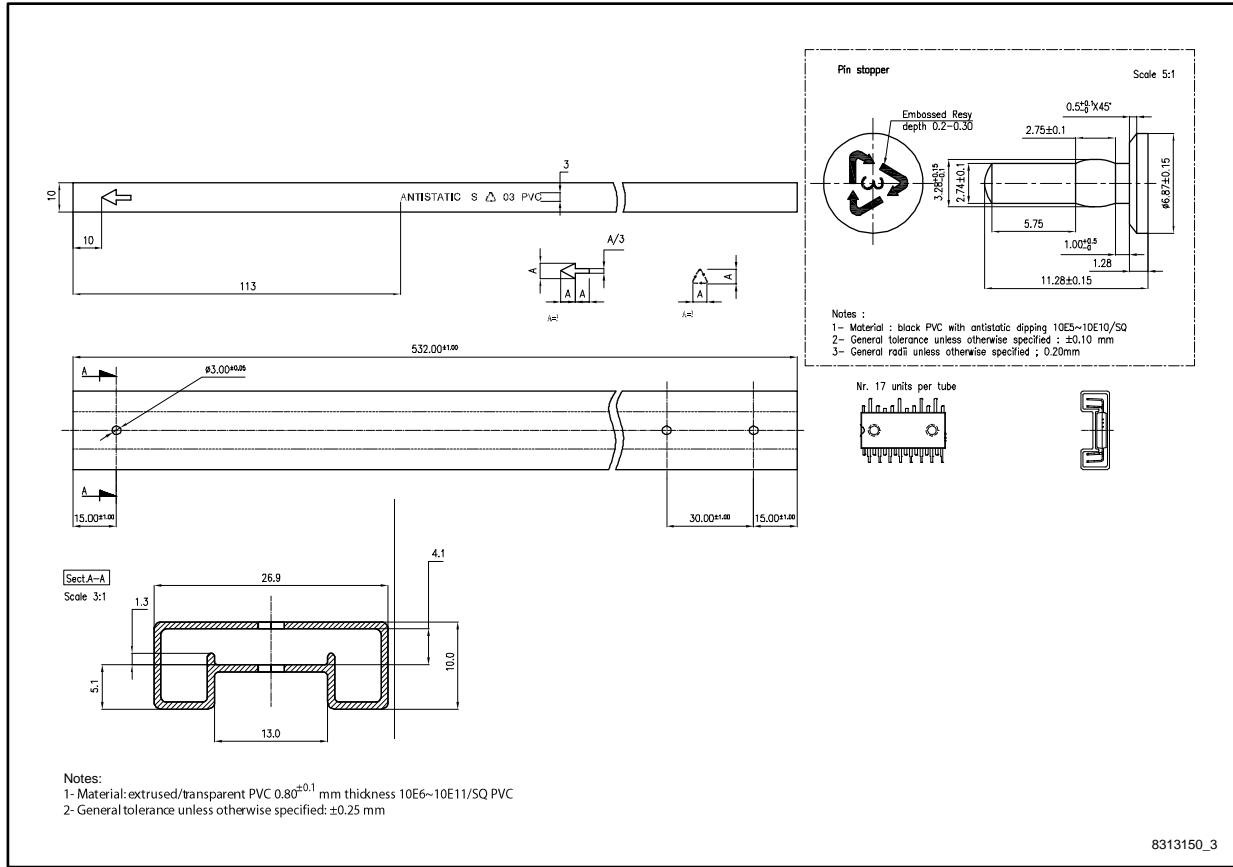


Table 17: Shipping details

Parameter	Value
Base quantity	17 pieces
Bulk quantity	476 pieces

## 7 Revision history

**Table 18: Document revision history**

Date	Revision	Changes
23-Jun-2011	1	Initial release.
23-Dec-2011	2	Document status promoted from preliminary data to datasheet. Added <i>Figure 9 on page 20</i> .
03-Jul-2012	3	Modified: Min. and Max. value <i>Table 4 on page 6</i> . Added: <i>Table 14 on page 17</i> .
14-Mar-2014	4	Updated <i>Figure 3: Switching time test circuit, Figure 6: Smart shutdown timing waveforms</i> . Updated <i>Table 9: Bootstrapped voltage (VCC = 15 V unless otherwise specified), Table 10: Logic inputs (VCC = 15 V unless otherwise specified)</i> . Updated <i>Section 6: Package mechanical data</i> .
28-Aug-2014	5	Updated unit in <i>Table 9: Bootstrapped voltage (VCC = 15 V unless otherwise specified)</i>
12-Nov-2014	6	Updated unit for Slew rate parameter in <i>Table 11.: OPAMP characteristics (VCC = 15 V unless otherwise specified)</i> Updated <i>6: Package mechanical data</i> .
16-Mar-2017	7	Updated <i>Section 6.1: "NDIP-26L type C package information"</i> and <i>Section 6.2: "NDIP-26L packing information"</i> . Minor text changes.

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