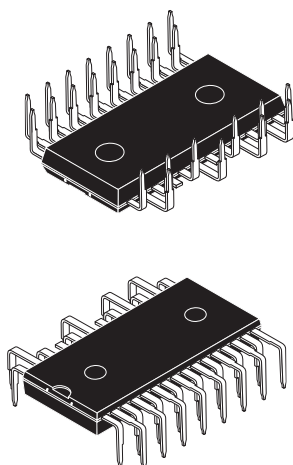


SLLIMM-nano IPM, 3 A, 600 V, 3-phase inverter bridge IGBT



NDIP-26L

Features

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

Applications

- 3-phase inverters for motor drives
- Dish washers
- Refrigerator compressors
- Air-conditioning fans
- Draining and recirculation pumps



Description

This intelligent power module implements a compact, high performance AC motor drive in a simple, rugged design. It is composed of six IGBTs with freewheeling diodes 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.

Product status

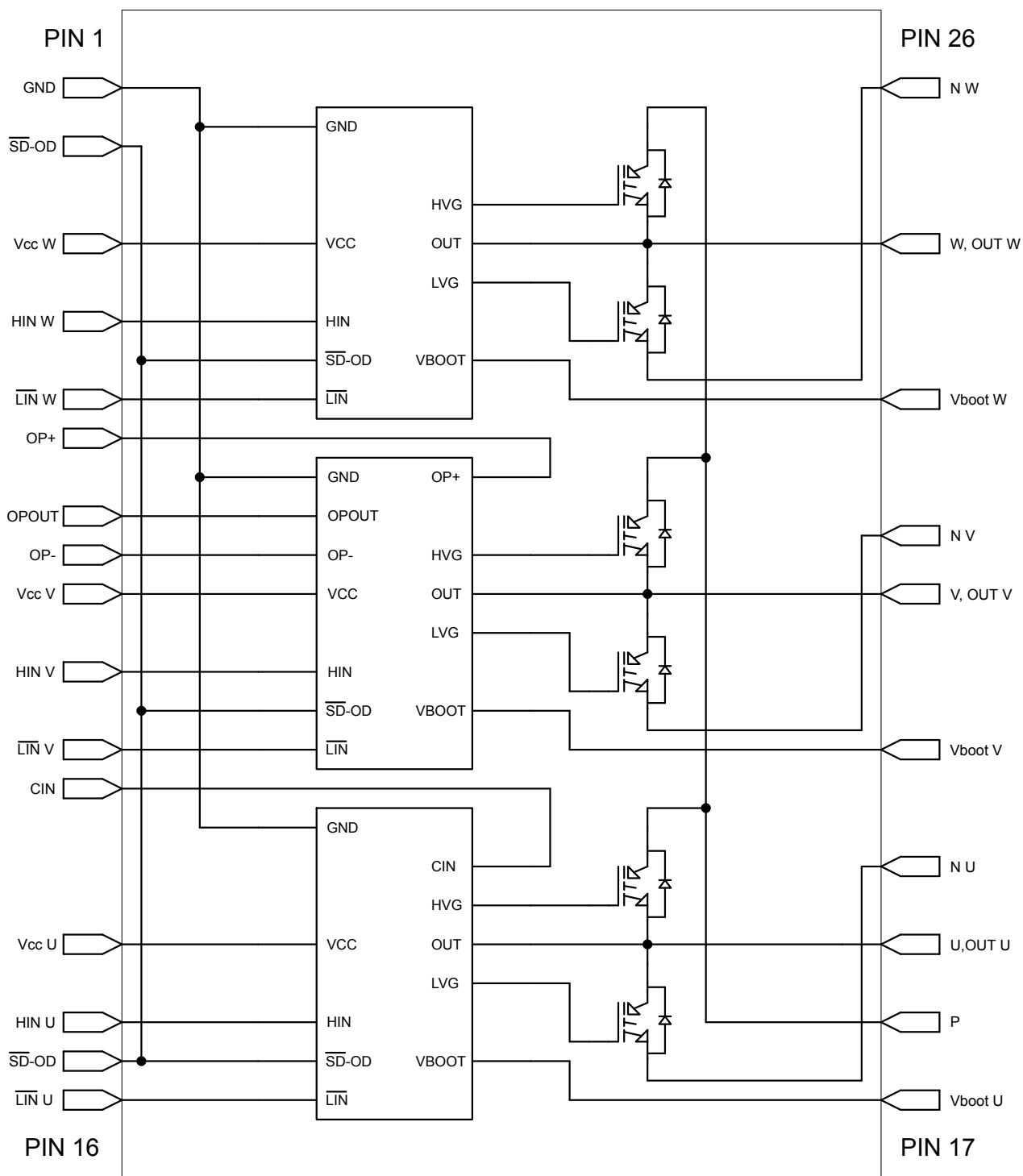
STGIPN3H60

Device summary

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

1 Internal schematic diagram and pin configuration

Figure 1. Internal schematic diagram

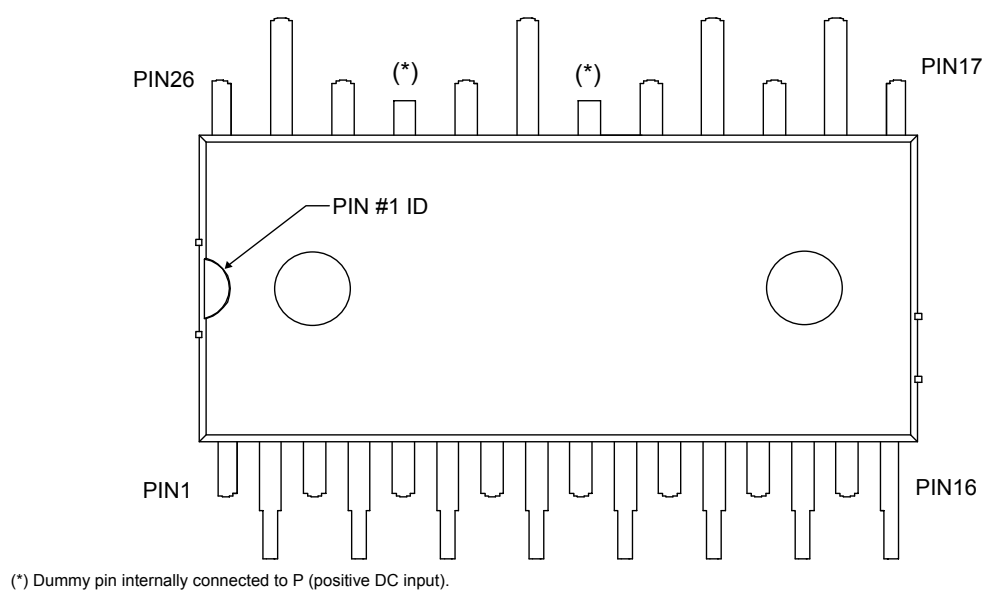


AM09916v1

Table 1. Pin description

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

Figure 2. Pin layout (top view)



2 Electrical ratings

2.1 Absolute maximum ratings

Table 2. Inverter part

Symbol	Parameter	Value	Unit
V_{CES}	Each IGBT collector emitter voltage ($V_{IN}^{(1)} = 0$)	600	V
$\pm I_C$	Continuous collector current each IGBT ($T_C = 25\text{ °C}$)	3	A
$\pm I_{CP}^{(2)}$	Pulsed collector current each IGBT (less than 1 ms)	18	A
P_{TOT}	Total power dissipation each IGBT ($T_C = 25\text{ °C}$)	9.7	W

1. Applied between HIN_i , $\overline{LIN}_i$ and GND for $i = U, V, W$.
2. Pulse width limited by max. junction temperature.

Table 3. 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+}	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
$V_{SD/OD}$	Open-drain voltage	- 0.3	15	V
dV_{out}/dt	Allowed output slew rate		50	V/ns

Table 4. Total system

Symbol	Parameter	Value	Unit
V_{ISO}	Isolation withstand voltage applied between each pin and heat sink plate (AC voltage, $t = 60\text{ s}$)	1000	Vrms
T_J	Power chip operating junction temperature range	-40 to 150	°C
T_C	Module operation case temperature range	-40 to 125	°C

2.2 Thermal data

Table 5. Thermal data

Symbol	Parameter	Value	Unit
$R_{th(j-c)}$	Thermal resistance junction-case single IGBT	12.8	°C/W
	Thermal resistance junction-case single diode	15.5	
$R_{th(j-a)}$	Thermal resistance junction-ambient (per module)	22	

3 Electrical characteristics

3.1 Inverter part

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

Table 6. 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
		$V_{CC} = V_{boot} = 15\text{ V}$, $V_{IN}^{(1)} = 0\text{ to }5\text{ V}$, $I_C = 1\text{ A}$, $T_J = 125\text{ }^{\circ}\text{C}$	-	1.65		
I_{CES}	Collector cut-off current ($V_{IN}^{(1)} = 0$ "logic state")	$V_{CE} = 550\text{ V}$, $V_{CC} = 15\text{ V}$, $V_{BS} = 15\text{ V}$	-		250	μA
V_F	Diode forward voltage	$V_{IN}^{(1)} = 0$ "logic state", $I_C = 1\text{ A}$	-		1.7	V

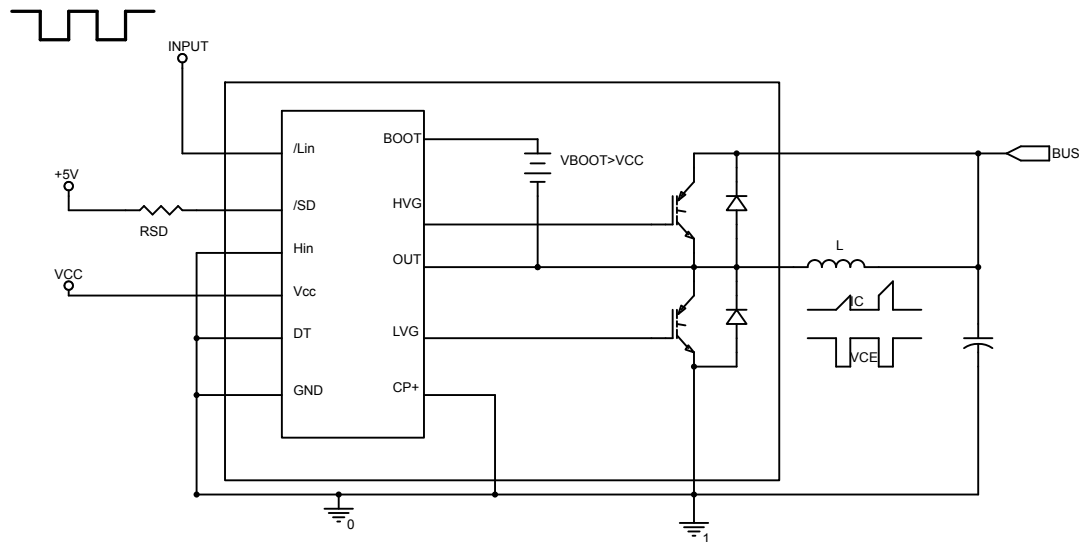
1. Applied between HIN_i , LIN_i and GND for $i = U, V, W$ (LIN inputs are active low).

Table 7. Inductive load switching time and energy

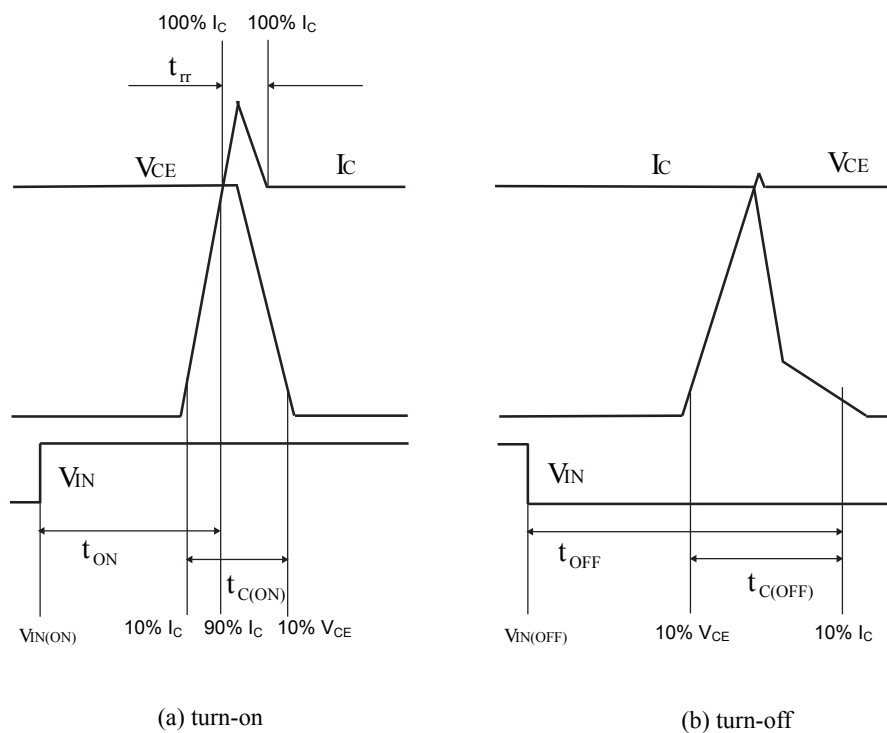
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{on}^{(1)}$	Turn-on time	$V_{DD} = 300\text{ V}$, $V_{CC} = V_{boot} = 15\text{ V}$, $V_{IN}^{(2)} = 0\text{ to }5\text{ V}$, $I_C = 1\text{ A}$ (see Figure 4. Switching time definition)	-	275	-	ns
$t_{c(on)}^{(1)}$	Crossover time (on)		-	90	-	
$t_{off}^{(1)}$	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	-	μJ
E_{off}	Turn-off switching energy		-	13	-	

1. 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 conditions.

2. Applied between HIN_i , LIN_i and GND for $i = U, V, W$ (LIN inputs are active low).

Figure 3. Switching time test circuit


AM09366v1

Figure 4. Switching time definition


AM09223V1

Figure 4. Switching time definition refers to H_{IN} inputs (active high). For $\overline{L}_{IN}$ inputs (active low), V_{IN} polarity must be inverted for turn-on and turn-off.

3.2 Control part

($V_{CC} = 15\text{ V}$ unless otherwise specified).

Table 8. Low voltage power supply

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	$V_{CC} = 15\text{ V}$, $\overline{SD}/OD = 5\text{ V}$, $\overline{LIN} = 5\text{ V}$, $HIN = 0\text{ V}$, $CIN = 0\text{ V}$			150	μA
I_{qcc}	Quiescent current	$V_{CC} = 15\text{ V}$, $\overline{SD}/OD = 5\text{ V}$, $\overline{LIN} = 5\text{ V}$, $HIN = 0\text{ V}$, $CIN = 0\text{ V}$			1	mA
V_{ref}	Internal comparator (CIN) reference voltage		0.5	0.54	0.58	V

Table 9. Bootstrapped voltage

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 $HIN = 5\text{ V}$, $CIN = 0\text{ V}$		70	110	μA
I_{QBS}	V_{BS} quiescent current	$V_{BS} = 15\text{ V}$, $\overline{SD}/OD = 5\text{ V}$, $\overline{LIN}$ and $HIN = 5\text{ V}$, $CIN = 0\text{ V}$		200	300	μA
$R_{DS(on)}$	Bootstrap driver on-resistance	LVG ON		120		Ω

Table 10. Logic inputs

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	$HIN = 15\text{ V}$	110	175	260	μA
I_{HINl}	HIN logic "0" input bias current	$HIN = 0\text{ V}$			1	μA
I_{LINl}	$\overline{LIN}$ logic "1" input bias current	$\overline{LIN} = 0\text{ V}$	3	6	20	μA
I_{LINh}	$\overline{LIN}$ logic "0" input bias current	$\overline{LIN} = 15\text{ V}$			1	μA
I_{SDh}	$\overline{SD}$ logic "0" input bias current	$\overline{SD} = 15\text{ V}$	30	120	300	μA
I_{SDl}	$\overline{SD}$ logic "1" input bias current	$\overline{SD} = 0\text{ V}$			3	μA
Dt	Dead time	see Figure 5. Dead time and interlocking waveform definitions		180		ns

Table 11. Op-amp characteristics

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 ⁽¹⁾			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/ μ 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 the input current is out of the IC.

Table 12. Sense comparator characteristics

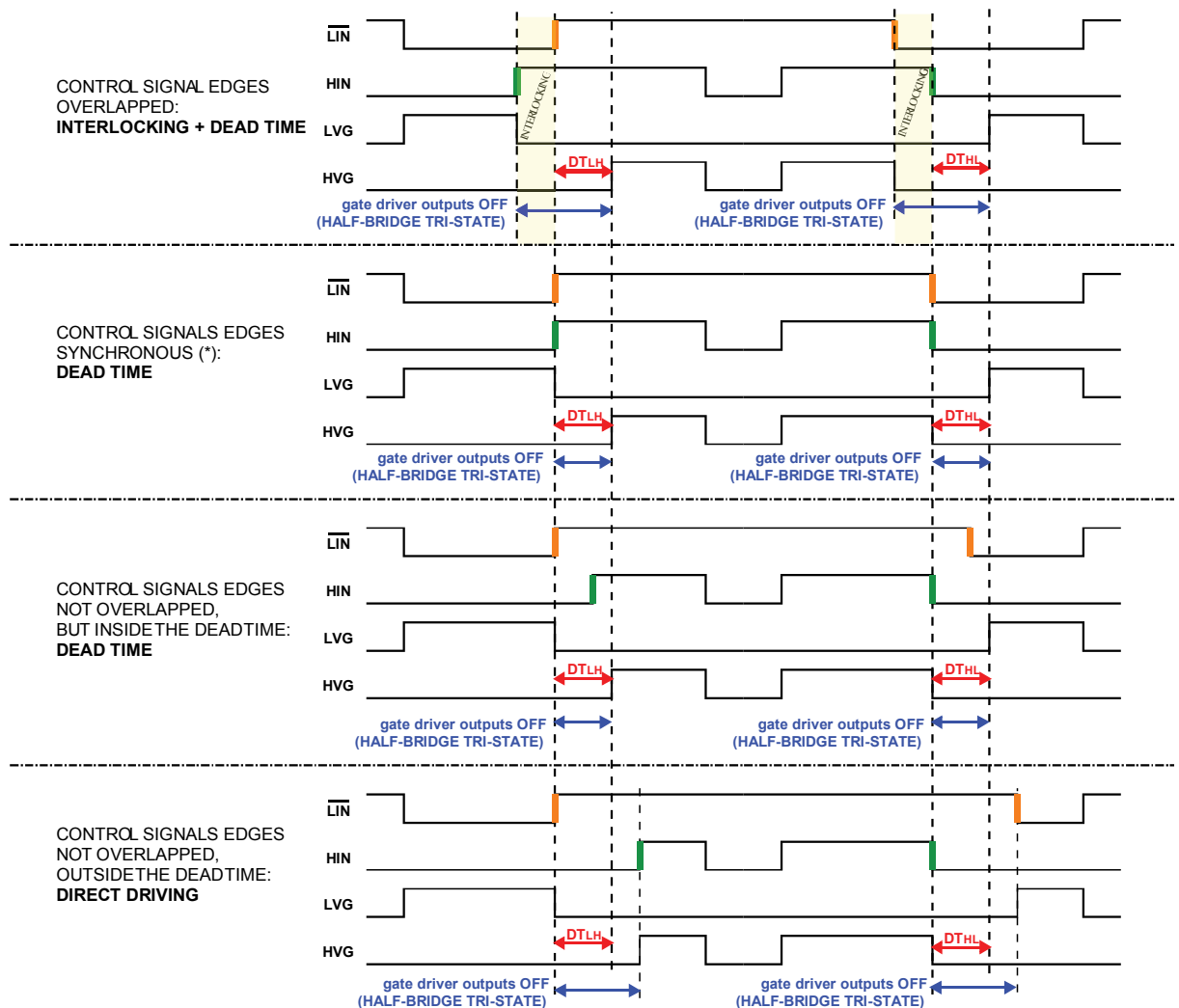
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{ib}	Input bias current	$V_{CIN} = 1\text{ V}$			1	μ A
V_{ol}	Open-drain low level output voltage	$I_{od} = 3\text{ mA}$			0.5	V
t_{d_comp}	Comparator delay	$\overline{SD}/OD$ pulled to 5 V through 100 k Ω resistor		90	130	ns
SR	Slew rate	$C_L = 180\text{ pF}$; $R_{pu} = 5\text{ k}\Omega$		60		V/ μ 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 13. Truth table

Condition	Logic input (V _I)			Output	
	SD/OD	LIN	HIN	LVG	HVG
Shutdown enable half-bridge tri-state	L	X ⁽¹⁾	X ⁽¹⁾	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

1. X: don't care.

3.3 Waveform definitions

Figure 5. Dead time and interlocking waveform definitions


(*) HIN and $\overline{\text{LIN}}$ can be connected together and driven by just one control signal

4 Shutdown function

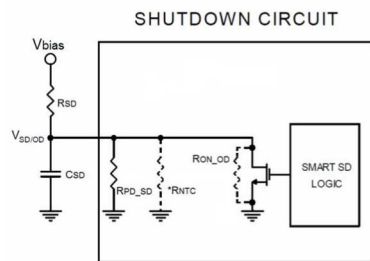
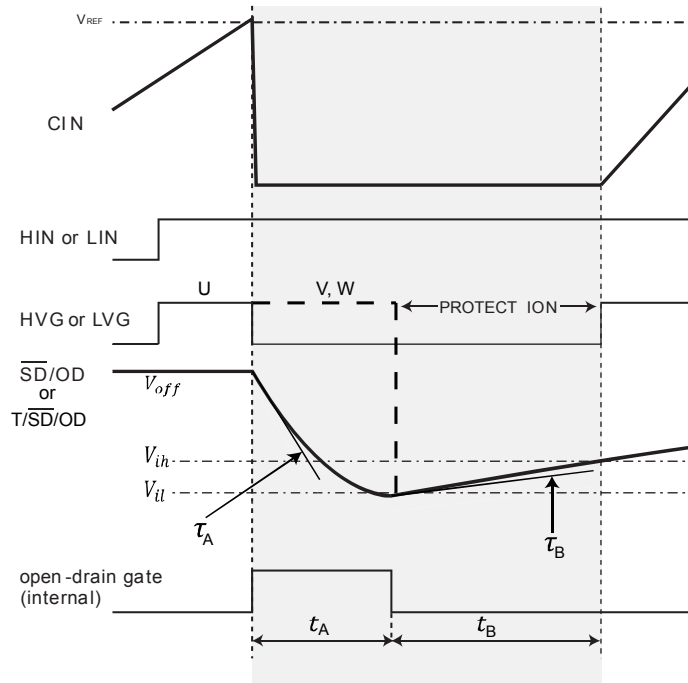
The device is equipped with three half-bridge IC gate drivers and integrates a comparator for fault detection. The comparator has an internal voltage reference V_{REF} connected to the inverting input, while the non-inverting input pin (CIN) can be connected to an external shunt resistor for current monitoring.

Since the comparator is embedded in the U IC gate driver, in case of fault it disables directly the U outputs, whereas the shutdown of V and W IC gate drivers depends on the RC value of the external SD circuitry, which fixes the disabling time.

For an effective design of the shutdown circuit, please refer to Application note AN4966.

Figure 6. Shutdown timing waveforms

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$$t_A \cong \tau_A \cdot \ln \left(\frac{V_{off} - V_{on}}{V_{il} - V_{on}} \right), \quad t_B \cong \tau_B \cdot \ln \left(\frac{V_{il} - V_{off}}{V_{il} - V_{on}} \right)$$

$$\tau_A = (R_{ON_OD} // R_{SD} // R_{PD_SD} // R_{NTC}) \cdot C_{SD} \cong R_{ON_OD} \cdot C_{SD}$$

$$\tau_B = (R_{SD} // R_{PD_SD} // R_{NTC}) \cdot C_{SD}$$

$$V_{on} = \frac{R_{ON_OD} // R_{PD_SD} // R_{NTC}}{(R_{ON_OD} // R_{PD_SD} // R_{NTC}) + R_{SD}} \cdot V_{bias}$$

$$\cong \frac{R_{ON_OD}}{R_{ON_OD} + R_{SD}} \cdot V_{bias}$$

$$V_{off} = \frac{R_{PD_SD} // R_{NTC}}{(R_{PD_SD} // R_{NTC}) + R_{SD}} \cdot V_{bias}$$

R_{SD} and C_{SD} external circuitry must be designed to ensure $V_{on} < V_{il}$ & $V_{off} > V_{ih}$

Please refer to AN4966 for further details.

* R_{NTC} to be considered only when the NTC is internally connected to the T/SD/OD pin.

5.1 Guidelines

- Input signal HIN is active high logic. A pull-down resistor of 85 k Ω (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 k Ω (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 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 14. Recommended operating conditions

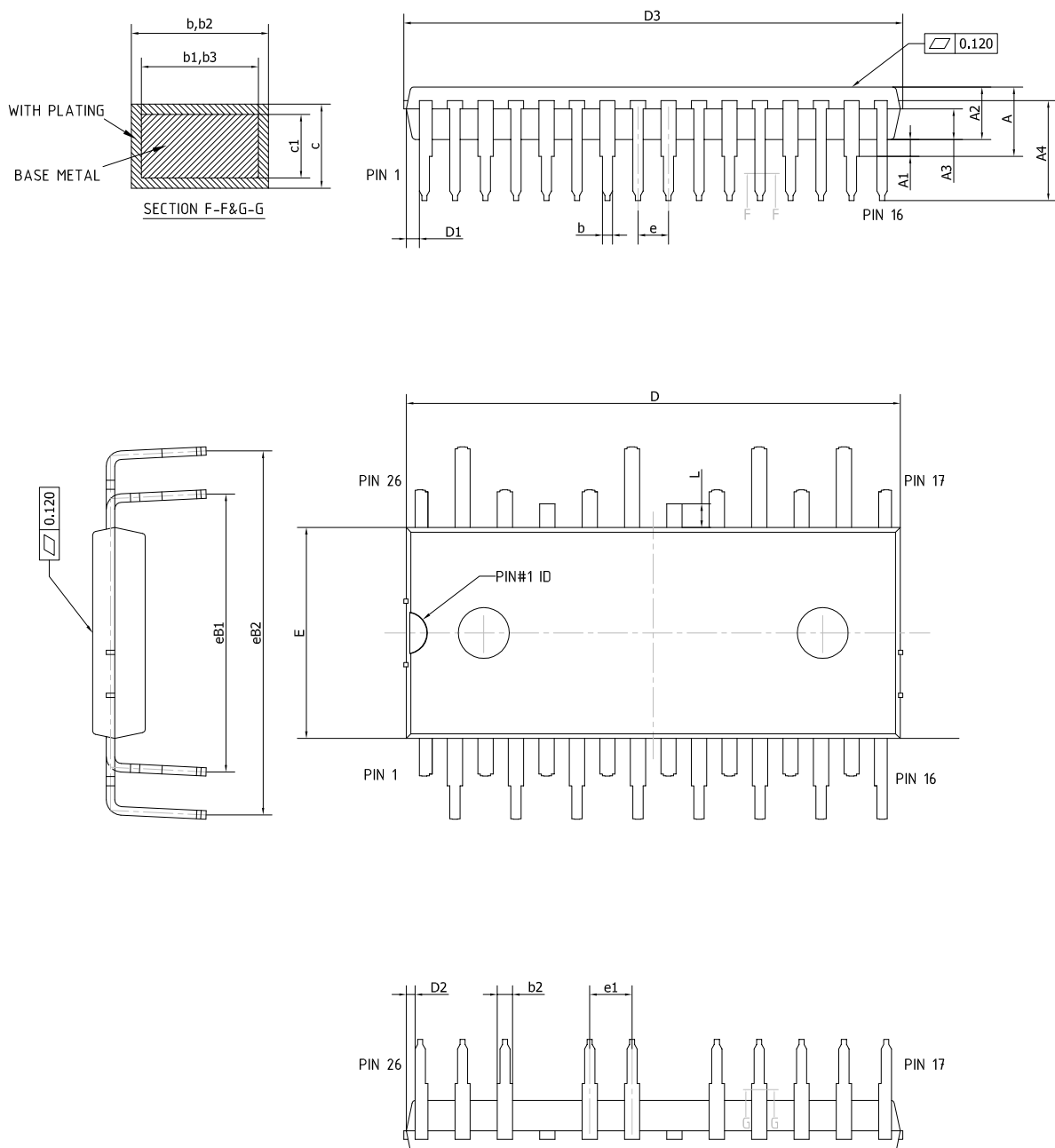
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{PN}	Supply voltage	Applied between P-Nu, Nv, Nw		300	500	V
V_{CC}	Control supply voltage	Applied between V_{CC} -GND	13.5	15	18	V
V_{BS}	High-side bias voltage	Applied between V_{BOOTi} -OUT _i for i = U, V, W	13		18	V
t_{dead}	Blanking time to avoid arm-short	For each input signal	1.5			μs
f_{PWM}	PWM input signal	-40 °C < T_C < 100 °C -40 °C < T_J < 125 °C			25	kHz
T_C	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. ECOPACK is an ST trademark.

6.1 NDIP-26L type C package information

Figure 8. NDIP-26L type C package outline



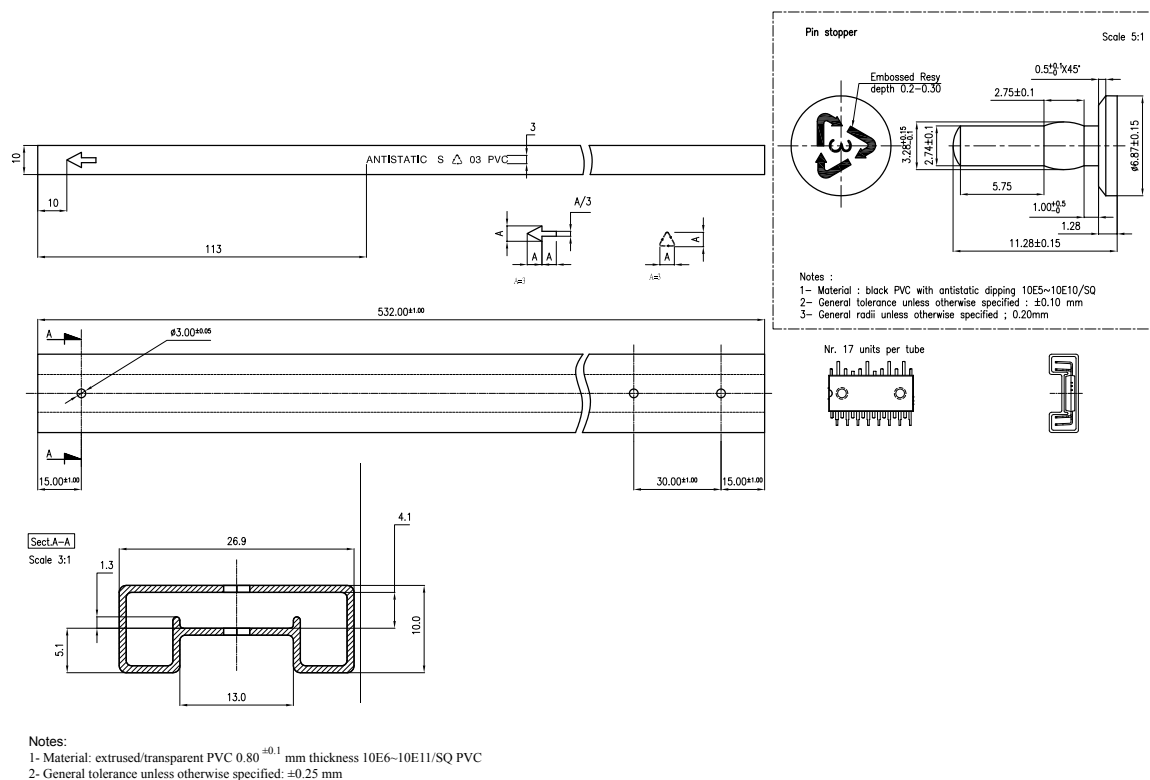
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Table 15. NDIP-26L type C mechanical data

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)



8313150_3

Table 16. Shipping details

Parameter	Value
Base quantity	17 pieces
Bulk quantity	476 pieces

Revision history

Table 17. 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</i> , <i>Figure 6: Smart shutdown timing waveforms</i> . Updated <i>Table 9: Bootstrapped voltage (VCC = 15 V unless otherwise specified)</i> , <i>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.
02-Mar-2020	8	Modified title, applications and description on cover page. Modified <i>Table 2. Inverter part</i> , <i>Table 5. Thermal data</i> , <i>Table 6. , Table 8. Low voltage power supply</i> , <i>Table 12. Sense comparator characteristics</i> , <i>Section 4 Shutdown function</i> . Minor text changes.

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