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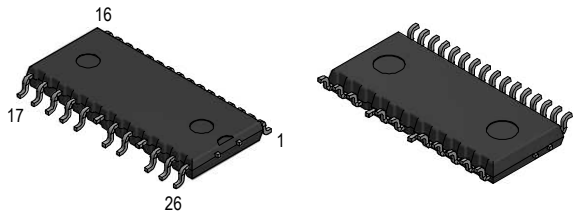
STGIPNS3HD60-H

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

Datasheet - production data



NSDIP-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 interference
- $V_{CE(sat)}$ negative temperature coefficient
- 3.3 V, 5 V, 15 V CMOS/TTL inputs comparators with hysteresis and pull-down/pull-up resistors
- Blanking time t_{dead} ≥ 1 µs
- Undervoltage lockout
- Internal bootstrap diode
- Interlocking function
- Comparator for fault protection against overtemperature and overcurrent
- Op-amp for advanced current sensing
- Optimized pinout for easy board layout
- Moisture sensitivity level (MSL) 3

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 IGBTs 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.

Table 1: Device summary

Order code	Marking	Package	Packing
STGIPN3HD60-H	GIPN3HD60-H	NSDIP-26L	Tape and reel

Contents

1 Internal schematic diagram and pin configuration

Figure 1: Internal schematic diagram

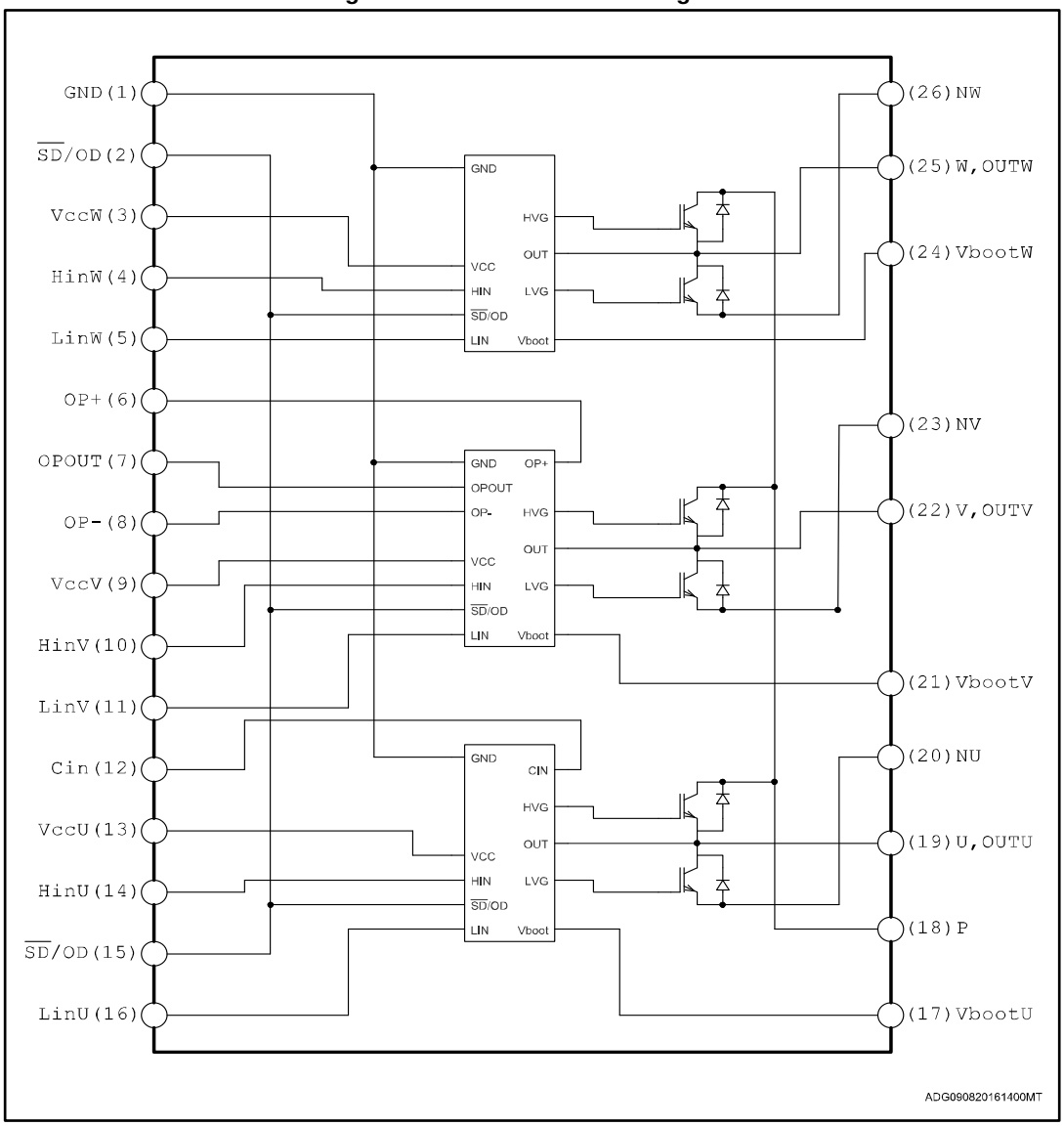
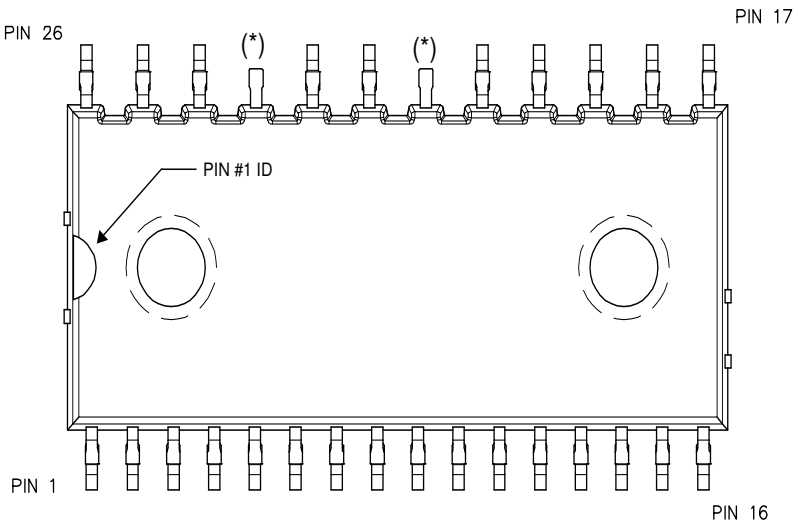


Table 2: Pin description

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	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	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	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)



(*) Dummy pin internally connected to P (positive DC input).

2 Electrical ratings

2.1 Absolute maximum ratings

Table 3: Inverter part

Symbol	Parameter	Value	Unit
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	3	A
± I_{CP}[(3)]	Each IGBT pulsed collector current	18	A
P_{TOT}	Each IGBT total dissipation at T_C = 25°C	7	W

Notes:

(1)Applied between HIN_x, LIN_x and GND for x = 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+}	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, LIN and GND	- 0.3	15	V
$V_{\overline{SD}/OD}$	Open-drain voltage	- 0.3	15	V
$\Delta V_{OUT/dT}$	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 the heatsink plate (AC voltage, t = 60 s)	1000	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_{thJA}	Thermal resistance junction-ambient	44	°C/W

3 Electrical characteristics

3.1 Inverter part

T_J = 25 °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 V, V_{IN}(1) = 0 - 5 V, I_C = 1 A	-	2.15	2.6	V
		V_{CC} = V_{boot} = 15 V, V_{IN}(1) = 0 - 5 V, I_C = 1 A, T_J = 125 °C	-	1.65		
I_{CES}	Collector cut-off current (V_{IN}(1) = 0 “logic state”)	V_{CE} = 550 V, V_{CC} = V_{Boot} = 15 V	-		250	µA
V_F	Diode forward voltage	V_{IN}(1) = 0 “logic state”, I_C = 1 A	-		1.7	V

Notes:

(1)Applied between HIN_x, LIN_x and G_{ND} for x = U,V,W.

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 V, V_{CC} = V_{boot} = 15 V, V_{IN}(2) = 0 - 5 V, I_C = 1 A (see *Figure 4: "Switching time definition"*)	-	158	-	ns
$t_{c(on)}$(1)	Crossover time (on)		-	60	-	
t_{off}(1)	Turn-off time		-	515	-	
$t_{c(off)}$(1)	Crossover time (off)		-	85	-	
t_{rr}	Reverse recovery time		-	82	-	
E_{on}	Turn-on switching energy		-	16	-	µJ
E_{off}	Turn-off switching energy		-	10	-	

Notes:

(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 times of the IGBT itself under the internally given gate driving condition.

(2)Applied between HIN_x, LIN_x and G_{ND} for x = U,V,W.

Figure 3: Switching time test circuit

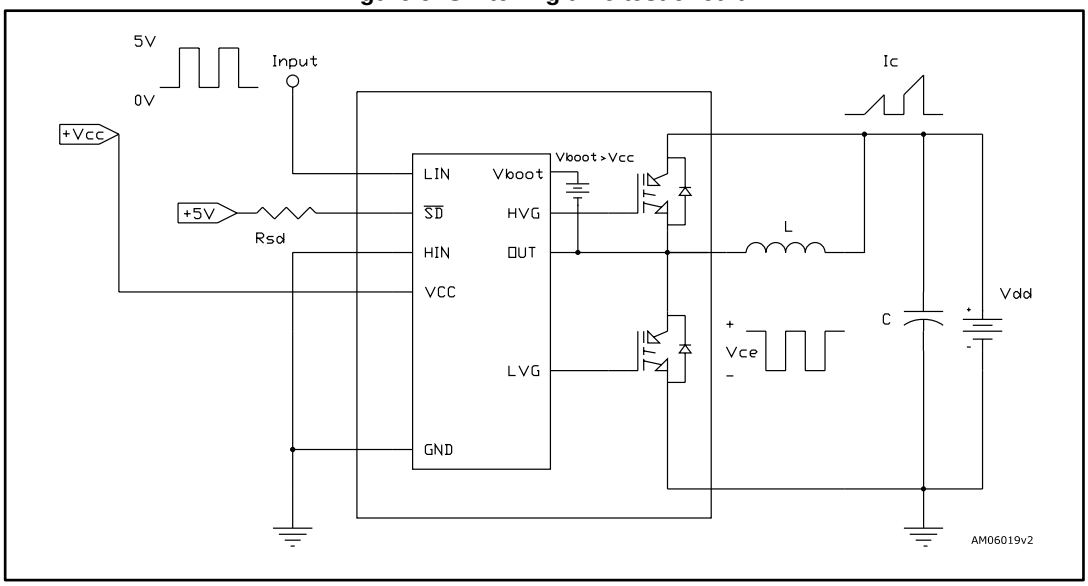


Figure 4: Switching time definition

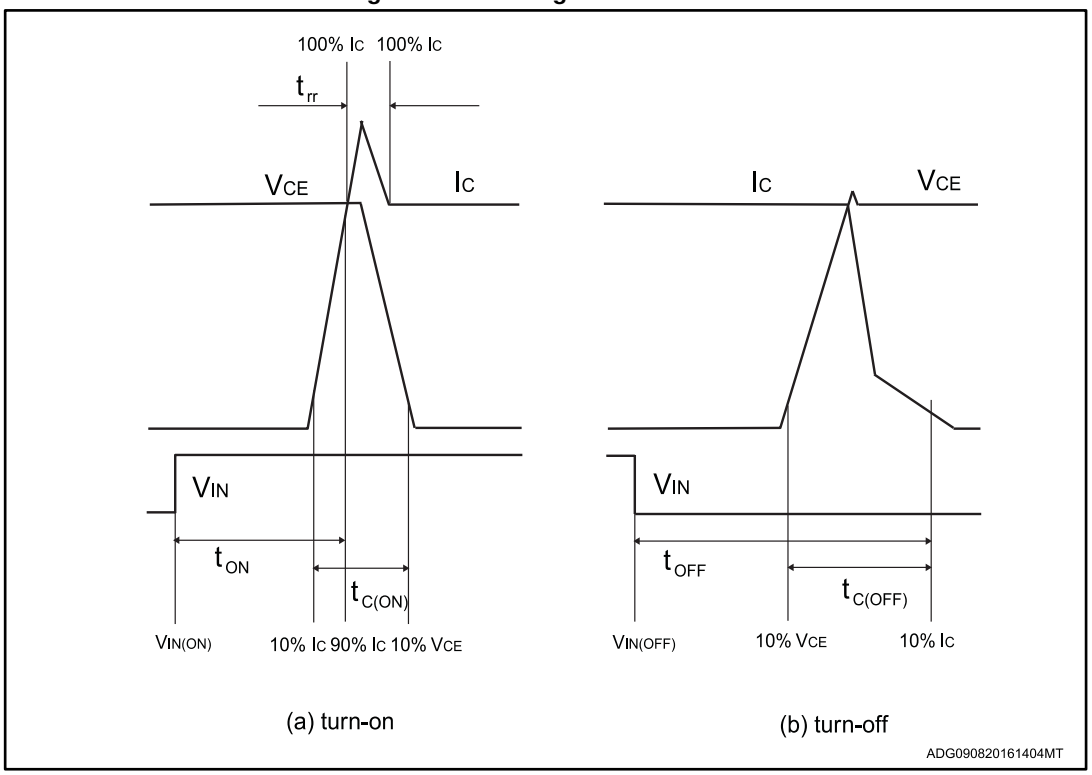


Figure 4: "Switching time definition" refers to the HIN and LIN inputs (active-high).

3.2 Control part

V_{CC} = 15 V unless otherwise specified

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

Table 10: 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 V, $\overline{SD}$ /OD = 5 V, LIN = 0 V 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, LIN = 0 V and HIN = 5 V, C_{IN} = 0		200	300	µA
$R_{DS(on)}$	Bootstrap driver on-resistance	LVG ON		120		Ω

Table 11: Logic inputs

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{il}	Low-logic level voltage				0.8	V
V_{ih}	High-logic level voltage		2.25			V
I_{HINh}	HIN logic “1” input bias current	HIN = 15 V	20	40	100	µA
I_{HINl}	HIN logic “0” input bias current	HIN = 0 V			1	µA
I_{LINl}	LIN logic “0” input bias current	LIN = 0 V			1	µA
I_{LINh}	LIN logic “1” input bias current	LIN = 15 V	20	40	100	µA
I_{SDh}	$\overline{SD}$ logic “0” input bias current	$\overline{SD}$ = 15 V	30	120	300	µA
I_{SDl}	$\overline{SD}$ logic “1” input bias current	$\overline{SD}$ = 0 V			3	µA
Dt	Dead time	See *Figure 5: "Dead time and interlocking waveform definitions"*		360		ns

Table 12: Op-amp characteristics

Symbol	Parameter	Test condition	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_{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/µs
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

Notes:

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

Table 13: Sense comparator characteristics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{ib}	Input bias current	V_{CIN} = 1 V			1	µA
V_{ol}	Open drain low level output voltage	I_{od} = 3 mA			0.5	V
R_{ON_OD}	Open-drain low-level output	I_{od} = 3 mA		166		Ω
R_{PD_SD}	$\overline{SD}$ pull-down resistor (1)			125		kΩ
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 pin CIN	50	200	250	

Notes:

(1)Equivalent values as a result of the resistances of three drivers in parallel.

Table 14: Truth table

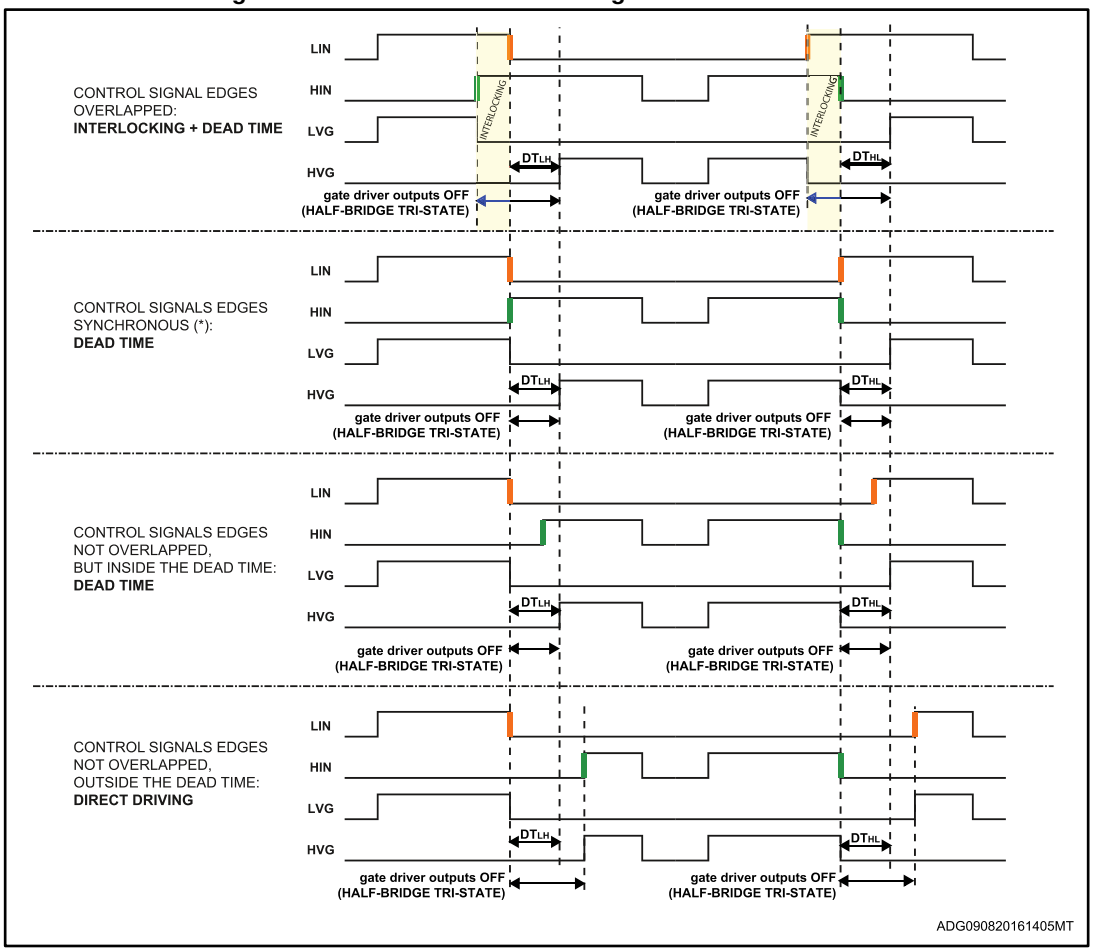
Condition	Logic input (V_I)			Output	
	$\overline{SD}$ /OD	LIN	HIN	LVG	HVG
Shutdown enable half-bridge tri-state	L	X(1)	X(1)	L	L
Interlocking half-bridge tri-state	H	H	H	L	L
0 “logic state” half-bridge tri-state	H	L	L	L	L
1 “logic state” low side direct driving	H	H	L	H	L
1 “logic state” high side direct driving	H	L	H	L	H

Notes:

(1)X: don’t care.

3.3 Waveform definitions

Figure 5: Dead time and interlocking waveform definitions



4 Smart shutdown function

The device integrates a comparator for fault sensing purposes. The comparator has an internal voltage reference (VREF) connected to the inverting input, while the non-inverting input on the pin (CIN) can be connected to an external shunt resistor for simple overcurrent protection.

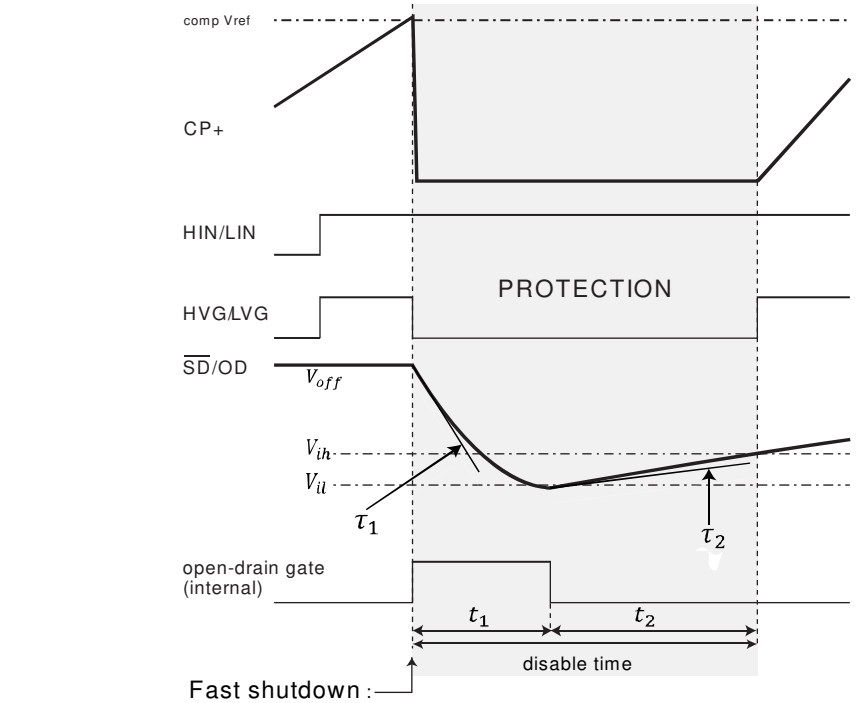
When the comparator triggers, the device is set to the shutdown state and both of its outputs are switched to the low-level setting, causing the half bridge to enter a tri-state.

In common overcurrent protection architectures, the comparator output is usually connected to the shutdown input through an RC network that provides a monostable circuit which implements a protection time following a fault condition.

Our smart shutdown architecture immediately turns off the output gate driver in case of overcurrent along a preferential path for the fault signal which directly switches off the outputs. The time delay between the fault and output shutdown does no longer depend on the RC values of the external network connected to the shutdown pin. At the same time, the DMOS connected to the open-drain output (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).

Moreover, the smart shutdown function allows to increase the real disable time without increasing the constant time of the external RC network.

Figure 6: Smart shutdown timing waveforms

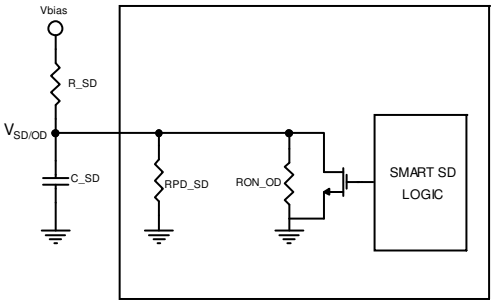


Fast shutdown :
the driver outputs are set to the SD state as soon as the comparator triggers even if the SD signal hasn't reached the lowest input threshold

An approximation of the disable time is given by:

$$t_1 \cong \tau_1 \cdot ln\left(\frac{V_{off} - V_{on}}{V_{il} - V_{on}}\right)$$

SHUTDOWN CIRCUIT



$$t_2 \cong \tau_2 \cdot ln\left(\frac{V_{il} - V_{off}}{V_{ih} - V_{off}}\right)$$

Where:

$$\tau_1 = \left(R_{ON\_OD} // R_{SD} // R_{PD\_SD}\right) \cdot C_{SD} \cong R_{ON\_OD} \cdot C_{SD}$$

$$\tau_2 = \left(R_{SD} // R_{PD\_SD}\right) \cdot C_{SD}$$

$$V_{on} = \frac{R_{ON\_OD} // R_{PD\_SD}}{\left(R_{ON\_OD} // R_{PD\_SD}\right) + R_{SD}} \cdot V_{BIAS} \cong \frac{R_{ON\_OD}}{R_{ON\_OD} + R_{SD}} \cdot V_{BIAS}$$

$$V_{off} = \frac{R_{PD\_SD}}{R_{PD\_SD} + R_{SD}} \cdot V_{BIAS}$$

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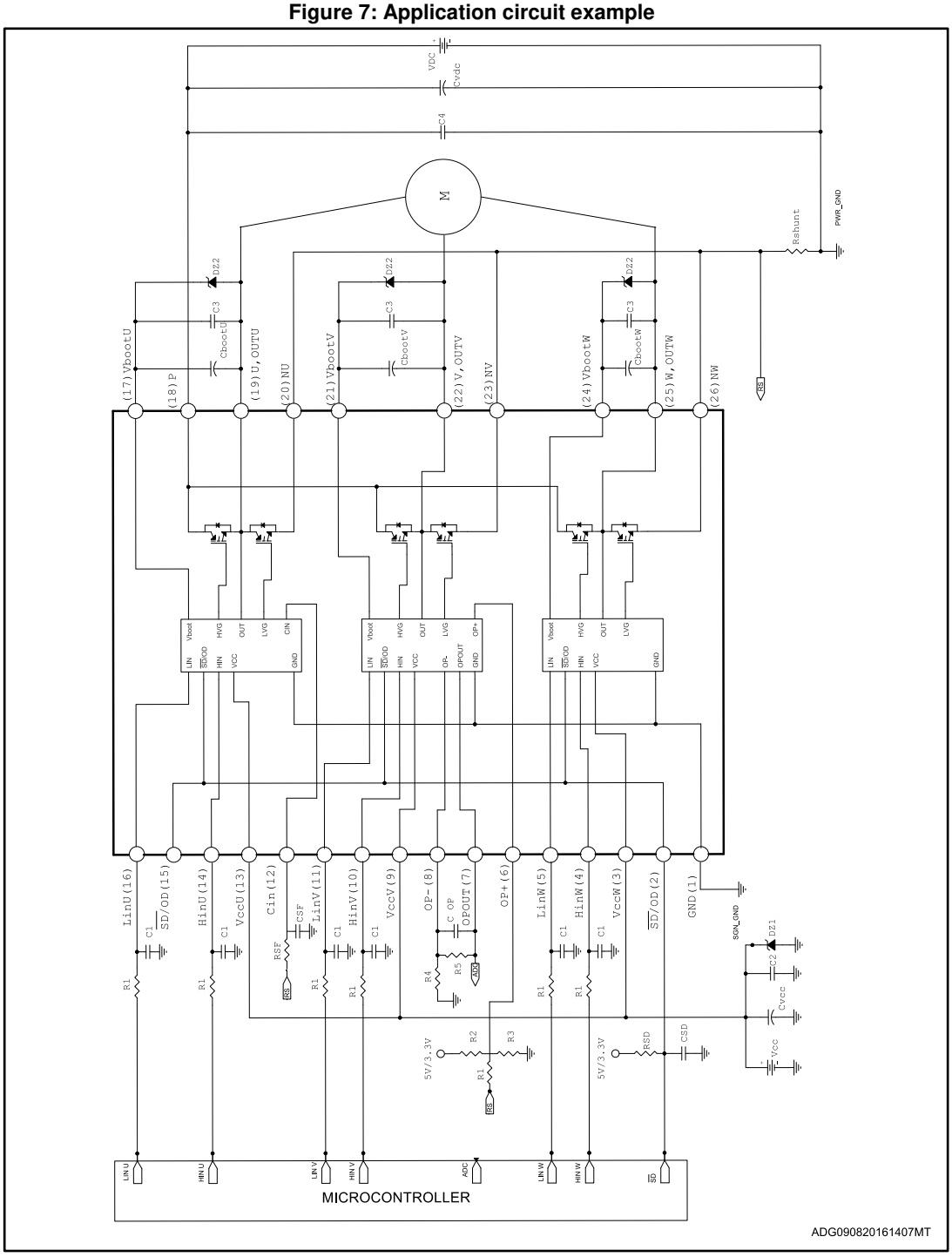
Please refer to *Table 13: "Sense comparator characteristics"* for details on the internal propagation delay time.

5 Application circuit example

Figure 7: Application circuit example



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

5.1 Guidelines

- Input signals HIN, LIN are active-high logic. A 375 kΩ (typ.) pull-down resistor is built-in for each input. To prevent input signal oscillation, the wiring of each input should be as short as possible and the use of RC filters (R1, C1) on each input signal is suggested. The filters should be done within a time constant of about 100 ns and placed as close as possible to the IPM input pins.
- The use of a CVCC bypass capacitor (aluminum or tantalum) can help to reduce the transient circuit demand on the power supply. Also, to reduce any high-frequency switching noise distributed on the power lines, it is suggested to place a C2 decoupling capacitor (100 to 220 nF, with low ESR and low ESL) as close as possible to the Vcc pin and in parallel whit the bypass capacitor.
- The use of an RC filter (RSF, CSF) for preventing protection circuit malfunction is recommended. The time constant (RSF x CSF) should be set to 1 µs and the filter must be placed as close as possible to the CIN pin.
- The $\overline{SD}$ is an input/output pin (open-drain type if used as output). The CSD capacitor of the filter on $\overline{SD}$ should be fixed no higher than 3.3 nF in order to assure an $\overline{SD}$ activation time of $t_{1} \leq 500$ ns, in addition the filter should be placed as close as possible to the $\overline{SD}$ pin.
- The C3 decoupling capacitor (from 100 to 220 nF, ceramic with low ESR and low ESL), in parallel with each C_{boot}, is useful to filter any high-frequency disturbance. Both C_{boot} and C3 (if present) should be placed as close as possible to the U, V, W and Vboot pins. Bootstrap negative electrodes should be connected to U, V, W terminals directly and separated from the main output wires.
- To prevent overvoltage on the Vcc pin, a Zener diode (Dz1) can be used. Similarly, a Zener diode (Dz2) can be placed on the V_{boot} pin in parallel with each C_{boot}.
- The use of the decoupling capacitor C_4 (100 to 220 nF, with low ESR and low ESL) in parallel with the electrolytic capacitor C_{vdc} is useful to prevent surge destruction. Both capacitors C_4 and C_{vdc} should be placed as close as possible to the IPM (C_4 has priority over C_{vdc}).
- By integrating an application-specific type HVIC inside the module, direct coupling to the MCU terminals without an opto-coupler is possible.
- Use low-inductance shunt resistors for phase leg current sensing.
- To avoid any malfunctions, the wiring between the N pins, the shunt resistor and P_{WR_GND} should be as short as possible.
- The connection of SGN_GND to PWR_GND at only one point (close to the shunt resistor terminal) can help to reduce the impact of power ground fluctuation.

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

Table 15: 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 prevent Arm-short	For each input signal	1			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 NSDIP-26L package information

Figure 8: NSDIP-26L package outline

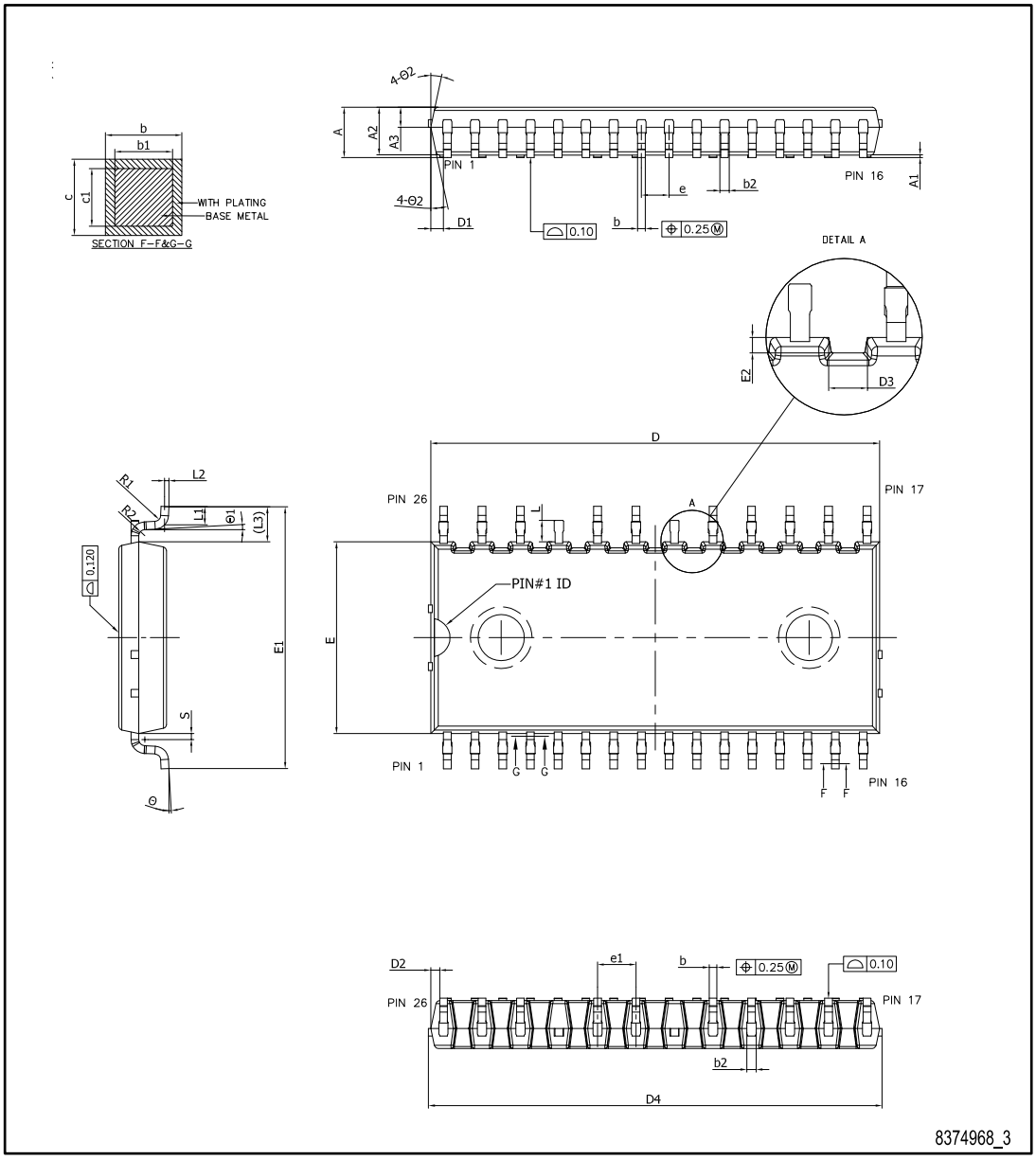
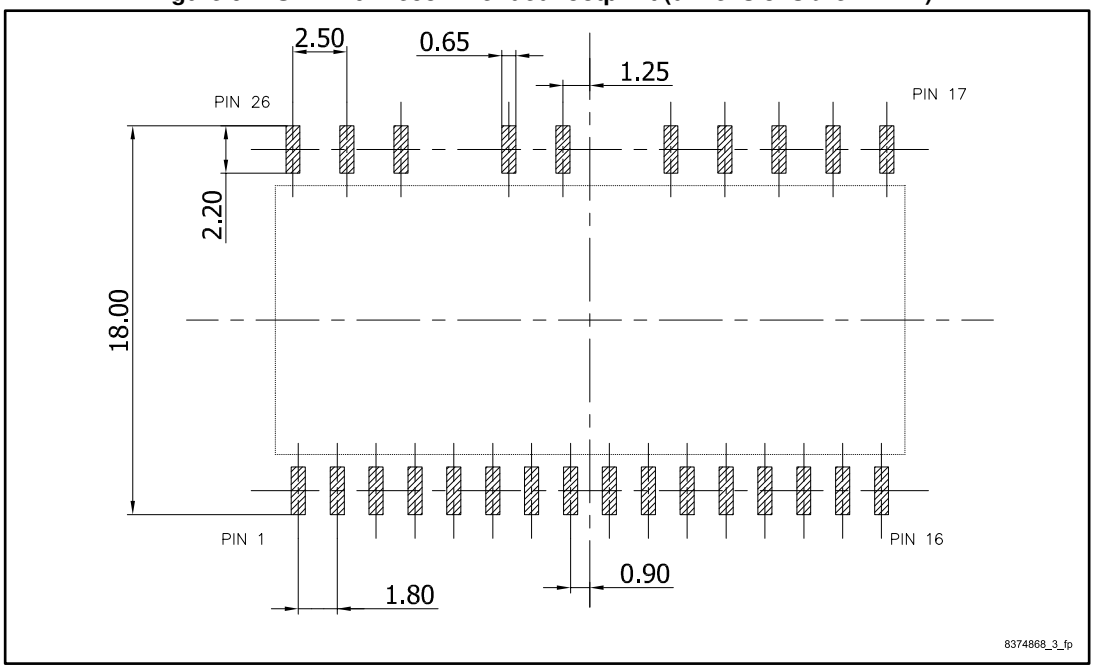


Table 16: NSDIP-26L package mechanical data

Dim.	mm		
	Min.	Typ.	Max.
A			3.45
A1	0.10		0.25
A2	3.00	3.10	3.20
A3	1.70	1.80	1.90
b	0.47		0.57
b1	0.45	0.50	0.55
b2	0.63		0.67
c	0.47		0.57
c1	0.45	0.50	0.55
D	29.05	29.15	29.25
D1	0.70		
D2	0.45		
D3	0.90		
D4			29.65
E	12.35	12.45	12.55
E1	16.70	17.00	17.30
E2	0.35		
e	1.70	1.80	1.90
e1	2.40	2.50	2.60
L	1.24	1.39	1.54
L1	1.00	1.15	1.30
L2	0.25 BSC		
L3	2.275 REF		
R1	0.25	0.40	0.55
R2	0.25	0.40	0.55
S		0.39	0.55
Θ	0°		8°
Θ1	3° BSC		
Θ2	10°	12°	14°

Figure 9: NSDIP-26L recommended footprint (dimensions are in mm)



7 Revision history

Table 17: Document revision history

Date	Revision	Changes
19-Apr-2017	1	Initial release
19-Jan-2018	2	Datasheet status promoted from preliminary to production data. Updated features on cover page. Updated *Table 3: "Inverter part"*, *Table 5: "Total system"*, *Table 6: "Thermal data"*, *Table 9: "Low-voltage power supply"*, *Table 10: "Bootstrapped voltage"* and *Table 13: "Sense comparator characteristics"*. Updated *Figure 6: "Smart shutdown timing waveforms"*. Updated *Section 6.1: "NSDIP-26L package information"*. Minor text changes

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