VNH5250AS-E

Automotive fully integrated H-bridge motor driver

Datasheet - target specification

SO-16N

Features

Type	$R_{DS(on)}$	I_{out}	V_{CCmax}
VNH5250AS-E	250 mΩ typ (per leg)	8 A	41 V

- Output current: 8 A
- 3 V CMOS-compatible inputs
- Undervoltage shutdown
- Overvoltage clamp
- Thermal shutdown
- Cross-conduction protection
- Current and power limitation
- Very low standby power consumption
- Protection against loss of ground and loss of V_{CC}
- Current sense output proportional to motor current
- Output protected against short to ground and short to V_{CC}
- Package: ECOPACK®

Description

The VNH5250AS-E is a full bridge motor driver intended for a wide range of automotive applications. The device incorporates a dual monolithic high-side driver and two low-side switches.

Both switches are designed using STMicroelectronics' well known and proven proprietary VIPower® M0 technology that allows to efficiently integrate on the same die a true Power MOSFET with an intelligent signal/protection circuitry. The three dies are assembled in SO-16N package on electrically isolated leadframes. This package, specifically designed for the harsh automotive environment offers improved thermal performance thanks to exposed die pads. Moreover, its fully symmetrical mechanical design allows superior manufacturability at board level. The input signals IN_A and IN_B can directly interface to the microcontroller to select the motor direction and the brake condition. The $DIAG_A/EN_A$ or $DIAG_B/EN_B$, when connected to an external pull-up resistor, enables one leg of the bridge. Each $DIAG_A/EN_A$ provides a feedback digital diagnostic signal as well. The normal operating condition is explained in the truth table. The CS pin allows to monitor the motor current by delivering a current proportional to its value.

Table 1. Device summary

Package	Order codes	
	Tube	Tape and reel
SO-16N	VNH5250AS-E	VNH5250ASTR-E

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1 Block diagram and pin description

Figure 1. Block diagram

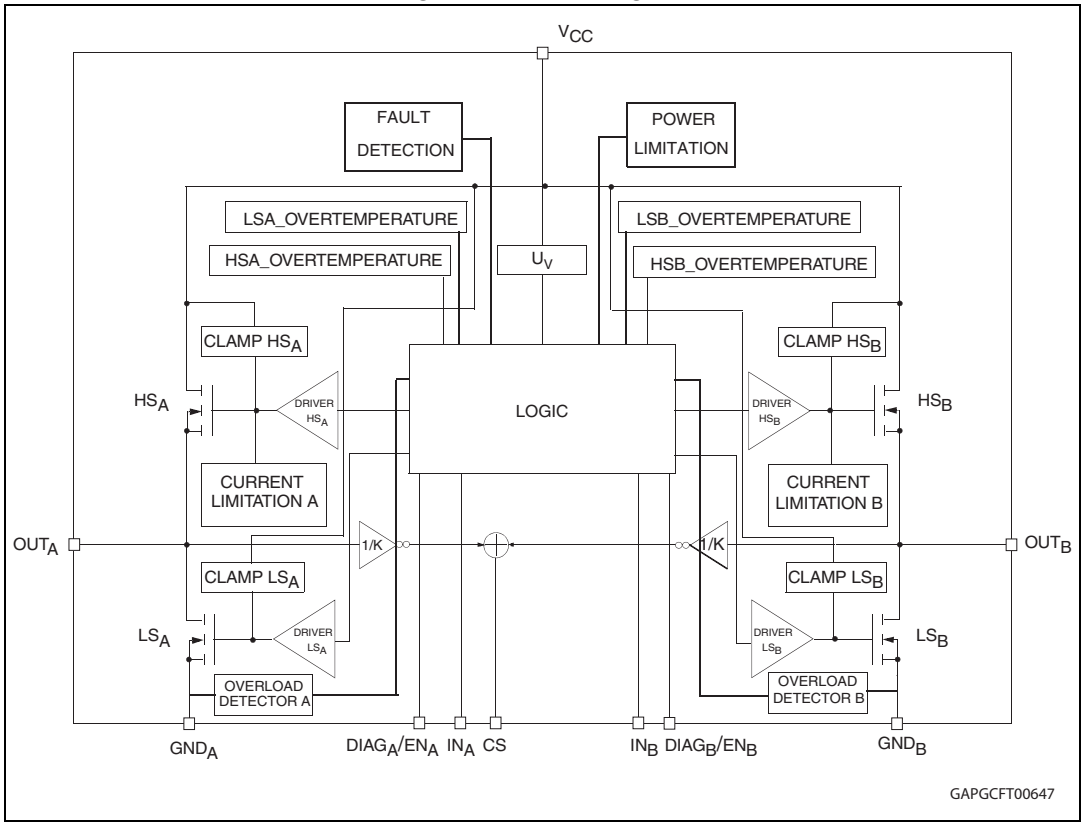


Table 2. Block description

Name	Description
Logic control	Allows the turn-on and the turn-off of the high-side and the low-side switches according to the truth table.
Undervoltage	Shuts down the device for battery voltage lower than 5 V.
High-side and low-side clamp voltage	Protect the high-side and the low-side switches from the high voltage on the battery line.
High-side and low-side driver	Drive the gate of the concerned switch to allow a proper $R_{DS(on)}$ for the leg of the bridge.
Current limitation	Limits the motor current in case of short circuit.
High-side and low-side overtemperature protection	In case of short-circuit with the increase of the junction temperature, it shuts down the concerned driver to prevent degradation and to protect the die.
Low-side overload detector	Detects when low-side current exceeds shutdown current and latches off the concerned low-side.

Table 2. Block description (continued)

Name	Description
Fault detection	Signalizes the abnormal behavior of the switch (output shorted to ground or output shorted to battery) by pulling down the concerned ENx/DIAGx pin.
Power limitation	Limits the power dissipation of the high-side driver inside safe range in case of short to ground condition.

Figure 2. Configuration diagram (top view)

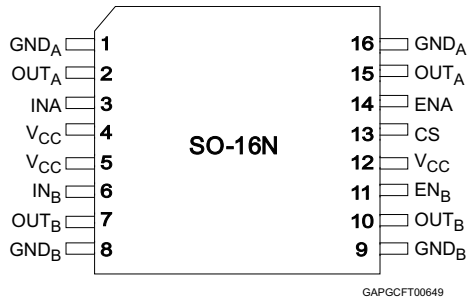


Table 3. Pin definitions and functions

Pin N°	Symbol	Function
1, 16	GND_A	Source of low-side switch A
2, 15	OUT_A	Source of high-side switch A / drain of low-side switch A
3	IN_A	Clockwise input
4, 5, 12	V_{CC}	Power supply voltage
6	IN_B	Counter clockwise input
7, 10	OUT_B	Source of high-side switch B / drain of low-side switch B
8, 9	GND_B	Source of low-side switch B
11	EN_B	Status of high-side and low-side switches B
13	CS	Output of current sense
14	EN_A	Status of high-side and low-side switches A

Table 4. Pin functions description

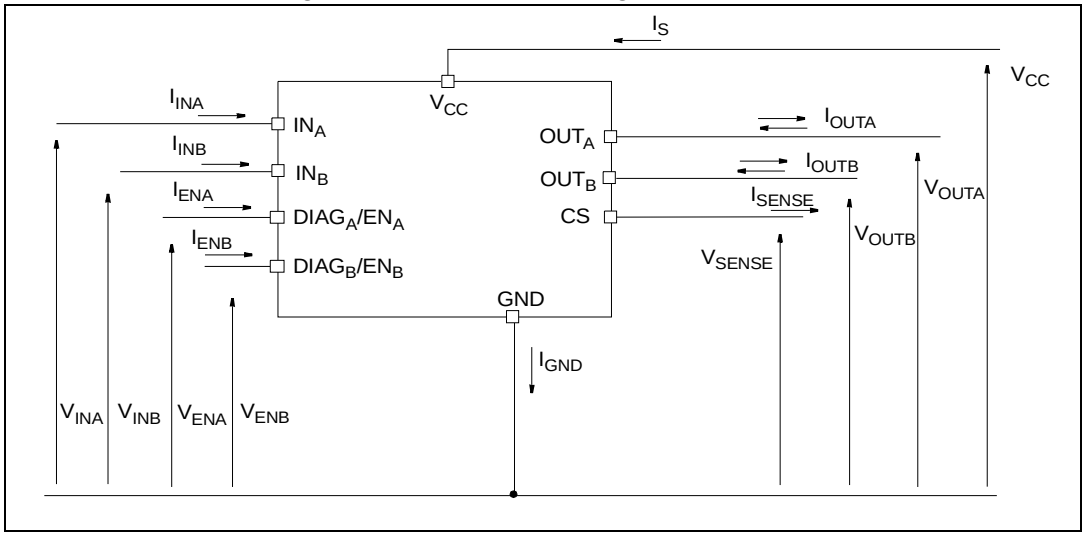
Name	Description
V_{CC}	Battery connection.
GND	Power ground.
OUT_A OUT_B	Power connections to the motor.

Table 4. Pin functions description (continued)

Name	Description
IN_A IN_B	Voltage controlled input pins with hysteresis, CMOS-compatible. These two pins control the state of the bridge in normal operation according to the truth table (brake to V_{CC}, brake to GND, clockwise and counterclockwise).
$EN_A/DIAG_A$ $EN_B/DIAG_B$	Open drain bidirectional logic pins.These pins must be connected to an external pull up resistor. When externally pulled low, they disable half-bridge A or B. In case of fault detection (thermal shutdown of a high-side FET or excessive ON-state voltage drop across a low-side FET), these pins are pulled low by the device (see *Table 13: Truth table in fault conditions (detected on OUTA)*).
CS	Analog current sense output. This output delivers a current proportional to the motor current. The information can be read back as an analog voltage across an external resistor.

2 Electrical specifications

Figure 3. Current and voltage conventions



2.1 Absolute maximum ratings

Stressing the device above the rating listed in *Table 5* may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the Operating sections of this specification is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

Table 5. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	+ 40	V
I_{max}	Maximum output current (continuous)	Internally limited	A
I_R	Reverse output current (continuous)	-15	A
I_{IN}	Input current (IN_A and IN_B pins)	+/- 10	mA
I_{EN}	Enable input current ($DIAG_A/EN_A$ and $DIAG_B/EN_B$ pins)	+/- 10	mA
V_{CS}	Current sense maximum voltage	V_{CC}-40/+V_{CC}	V
V_{ESD}	Electrostatic discharge (Human body model: R=1.5 kΩ, C=100 pF)	2	kV
T_c	Junction operating temperature	-40 to 150	°C
T_{STG}	Storage temperature	-55 to 150	°C
I_{GND}	DC reverse ground pin current	200	mA

2.2 Thermal data

Table 6. Thermal data

Symbol	Parameter	Max. value	Unit
$R_{thj\text{-}case}$	Thermal resistance junction-case (per leg)	TBD	°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient	TBD	°C/W

2.3 Electrical characteristics

Values specified in this section are for V_{CC} = 9 V up to 18 V; -40°C < T_j < 150°C, unless otherwise specified.

Table 7. Power section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{CC}	Operating supply voltage		5.5		18	V
I_S	Supply current	Off-state with all fault cleared and ENx = 0 (standby) IN_A = IN_B = 0; T_j = 25°C; V_{CC} = 13 V		3	6	µA
		Off-state with all fault cleared and ENx = 0 (standby) IN_A = IN_B = 0; V_{CC} = 13 V; T_j = -40°C to 150°C			10	µA
		Off-state (no standby) IN_A = IN_B = 0; ENx = 5 V; T_j = -40°C to 150°C			5	mA
		On-state: IN_A or IN_B = 5 V		3	6	mA
R_{ONHS}	Static high-side resistance	I_{OUT} = 2 A; T_j = -40°C				mΩ
		I_{OUT} = 2 A; T_j = 25°C		125		mΩ
		I_{OUT} = 2 A; T_j = 150°C				mΩ
		I_{OUT} = 2 A; T_j = -40 to 150°C			250	mΩ
R_{ONLS}	Static low-side resistance	I_{OUT} = 2 A; T_j = 25°C		125		mΩ
		I_{OUT} = 2 A; T_j = -40°C to 150°C			250	mΩ
V_f	High-side free-wheeling diode forward voltage	I_{OUT} = -2 A; T_j = 150°C		0.7	0.9	V
$I_{L(off)}$	High-side off-state output current (per channel)	T_j = 25°C; V_{OUTX} = EN_X = 0 V; V_{CC} = 13 V	0		3	µA
		T_j = 125°C; V_{OUTX} = EN_X = 0 V; V_{CC} = 13 V	0		5	µA
I_{RM}	Dynamic cross-conduction current	I_{OUT} = 2.5 A		0.6		A

Table 8. Logic inputs (IN_A, IN_B, EN_A, EN_B, PWM, CS_DIS)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IL}	Input low level voltage	Normal operation ($DIAG_X/EN_X$ pin acts as an input pin)			0.9	V
V_{IH}	Input high level voltage	Normal operation ($DIAG_X/EN_X$ pin acts as an input pin)	2.1			V
V_{IHYST}	Input hysteresis voltage	Normal operation ($DIAG_X/EN_X$ pin acts as an input pin)	0.15			V
V_{ICL}	Input clamp voltage	I_{IN} = 1 mA	5.5	6.3	7.5	V
		I_{IN} = -1 mA	-1.0	-0.7	-0.3	V
I_{INL}	Input current	V_{IN} = 0.9 V	1			µA
I_{INH}	Input current	V_{IN} = 2.1 V			10	µA
V_{DIAG}	Enable output low level voltage	Fault operation ($DIAG_X/EN_X$ pin acts as an output pin); I_{EN} = 1 mA			0.4	V

Table 9. Switching (V_{CC} = 13 V, R_{LOAD} = 6.5 Ω)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	Input rise time < 1µs (see *Figure 4*)		50		µs
$t_{d(off)}$	Turn-off delay time	Input rise time < 1µs (see *Figure 4*)		120		µs
t_r	Rise time			1		µs
t_f	Fall time			40		µs
t_{DEL}	Delay time during change of operating mode		200	400	1600	µs
t_{rr}	High-side free wheeling diode reverse recovery time			400		ns

Table 10. Protections and diagnostics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{USD}	Undervoltage shutdown			3	5	V
$V_{USDhyst}$	Undervoltage shutdown hysteresis			0.5		V
I_{LIM_H}	High-side current limitation		8	12	16	A
I_{SD_LS}	Shutdown LS current		8	15	20	A
V_{CLPH}	High-side clamp voltage (V_{CC} to OUT_A = 0 or OUT_B = 0)	I_{OUT} = 2 A	41	46	52	V
V_{CLPLS}	Low-side clamp voltage (OUT_A = V_{CC} or OUT_B = V_{CC} to GND)	I_{OUT} = 2 A	41	46	52	V
T_{TSD}	Thermal shutdown temperature	V_{IN} = 2.1 V	150	175	200	°C
T_{TR}	Thermal reset temperature		135			°C
T_{HYST}	Thermal hysteresis (T_{SD} - T_R)			7		°C
T_{TSD_LS}	Low-side thermal shutdown temperature	V_{IN} = 2.1 V	150	175	200	°C
V_{CLP}	Total clamp voltage (V_{CC} to GND)	I_{OUT} = 2 A	41	46	52	V
t_{SD_LS}	Time to shutdown for the low-side			10		µs

Table 11. Current sense (9 V < V_{CC} < 18 V)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
K_0	I_{OUT}/I_{SENSE}	I_{OUT} = 0.075 A; V_{SENSE} = 0.5 V; T_j = -40°C to 150°C	-38		38	%
K_1	I_{OUT}/I_{SENSE}	I_{OUT} = 0.25 A; V_{SENSE} = 0.5 V; T_j = -40°C to 150°C	-27		27	%
K_2	I_{OUT}/I_{SENSE}	I_{OUT} = 2 A; V_{SENSE} = 1 V; T_j = -40°C to 150°C	-8		8	%
K_3	I_{OUT}/I_{SENSE}	I_{OUT} = 8 A; V_{SENSE} = 4 V; T_j = -40°C to 150°C	-6		6	%
dK_0/K_0 (1)	Analog sense current drift	I_{OUT} = 0.075 A; V_{SENSE} = 0.5 V; T_j = -40°C to 150°C	-18		18	%
dK_1/K_1 (1)	Analog sense current drift	I_{OUT} = 0.25 A; V_{SENSE} = 0.5 V; T_j = -40°C to 150°C	-12		12	%
dK_2/K_2 (1)	Analog sense current drift	I_{OUT} = 2 A; V_{SENSE} = 1 V; T_j = -40°C to 150°C	-8		8	%
dK_3/K_3 (1)	Analog sense current drift	I_{OUT} = 8 A; V_{SENSE} = 4 V; T_j = -40°C to 150°C	-5		5	%
V_{SENSE}	Max analog sense output voltage	I_{OUT} = 2 A; R_{SENSE} = 2 KΩ	5			V

Table 11. Current sense (9 V < V_{CC} < 18 V) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{SENSE0}	Analog sense leakage current	I_{OUT} = 0 A; V_{SENSE} = 0 V; V_{IN} = 0 V; T_j = -40°C to 150°C	0		5	µA
		V_{IN} = 5 V; T_j = -40°C to.150°C	0			µA
		V_{IN} = 5 V; I_{OUT} = 2.5 A; T_j = -40°C to.150°C	0		5	µA

1. Analog sense current drift is deviation of factor K for a given device over (-40 °C to 150 °C and 9 V < V_{CC} < 18 V) with respect to its value measured at T_J = 25 °C, V_{CC} = 13 V.

Figure 4. Definition of the high-side switching times

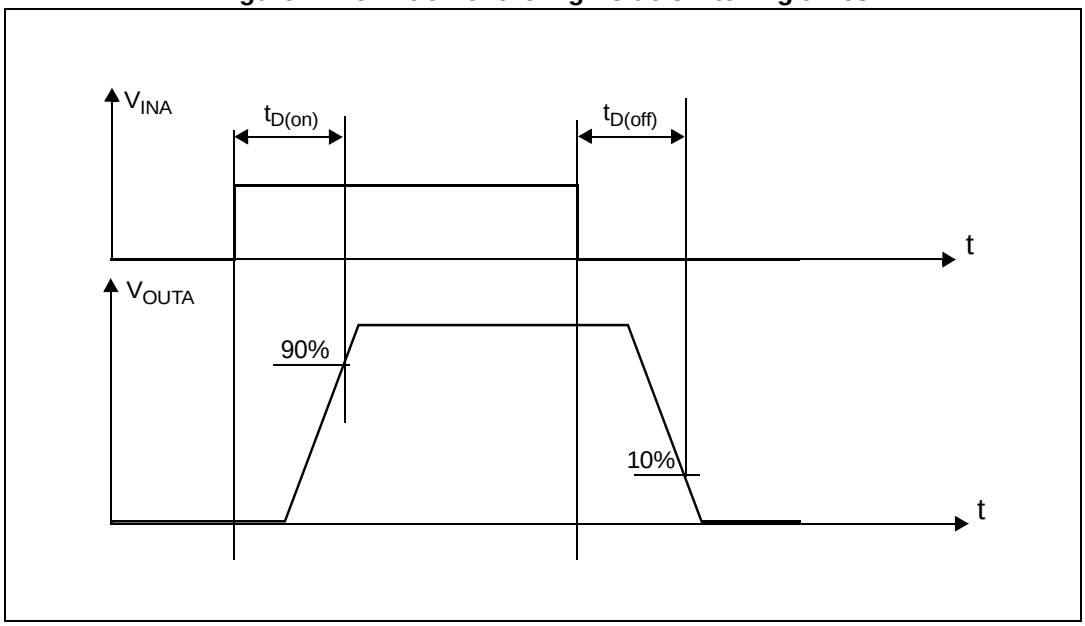


Table 12. Truth table in normal operating conditions

IN_A	IN_B	$DIAG_A/EN_A$	$DIAG_B/EN_B$	OUT_A	OUT_B	CS	Operating mode
1	1	1	1	H	H	High Imp.	Brake to V_{CC}
	0				L	$I_{SENSE} = I_{OUT}/K$	Clockwise (CW)
0	1			L	H		Counterclockwise (CCW)
	0				L	High Imp.	Brake to GND

Table 13. Truth table in fault conditions (detected on OUT_A)

IN_A	IN_B	$DIAG_A/EN_A$	$DIAG_B/EN_B$	OUT_A	OUT_B	CS (V_{CSD}=0V)
1	1	0	1	OPEN	H	High Imp.
	0				L	
0	1				H	I_{OUTB}/K
	0				L	High Imp.
X	X		0		OPEN	
		Fault Information		Protection Action		

Note: In normal operating conditions the $DIAG_X/EN_X$ pin is considered as an input pin by the device. This pin must be externally pulled high.

Table 14. Electrical transient requirements (part 1)

ISO 7637-2: 2004(E) Test pulse	Test levels(1)		Number of pulses or test times	Burst cycle/pulse repetition time		Delays and Impedance
	III	IV		Min.	Max.	
1	-75V	-100V	5000 pulses	0.5s	5s	2 ms, 10Ω
2a	+37V	+50V	5000 pulses	0.2s	5s	50µs, 2Ω
3a	-100V	-150V	1h	90ms	100ms	0.1µs, 50Ω
3b	+75V	+100V	1h	90ms	100ms	0.1µs, 50Ω
4	-6V	-7V	1 pulse			100ms, 0.01Ω
5b(2)	+65V	+87V	1 pulse			400ms, 2Ω

1. The above test levels must be considered referred to V_{CC} = 13.5 V except for pulse 5b.
2. Valid in case of external load dump clamp: 40V maximum referred to ground.

Table 15. Electrical transient requirements (part 2)

ISO 7637-2: 2004(E) Test pulse	Test level results(1)	
	III	IV
1	C	C
2a	C	C
3a	C	C
3b	C	C
4	C	C
5b(2)	C	C

1. The above test levels must be considered referred to V_{CC} = 13.5 V except for pulse 5b.
2. Valid in case of external load dump clamp: 40V maximum referred to ground.

Table 16. Electrical transient requirements (part 3)

Class	Contents
C	All functions of the device are performed as designed after exposure to disturbance.
E	One or more functions of the device are not performed as designed after exposure to disturbance and cannot be returned to proper operation without replacing the device.

3 Package and packing information

3.1 ECOPACK®

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.

3.2 SO-16N mechanical data

Figure 5. SO-16N package dimensions

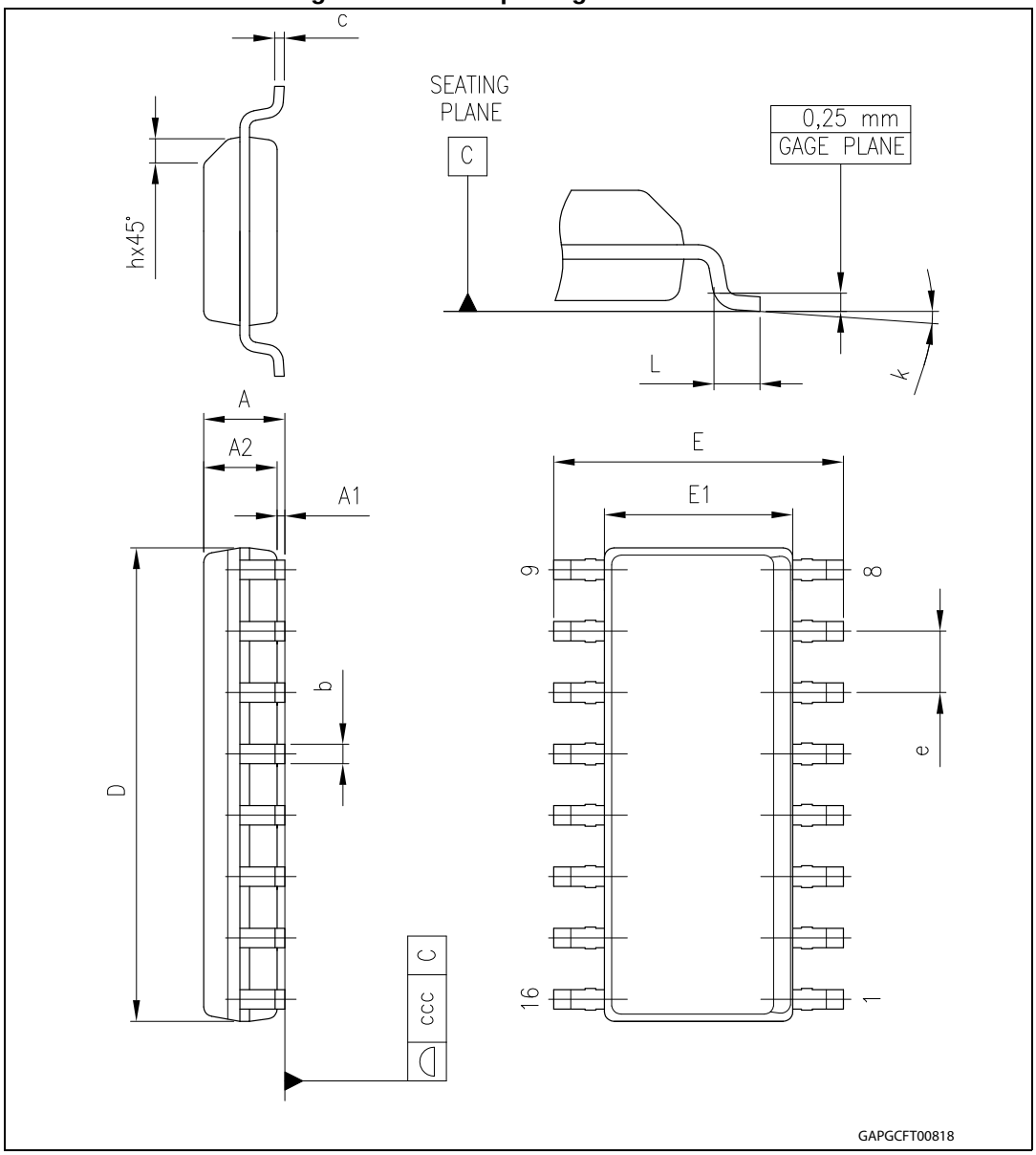


Table 17. SO-16N mechanical data

Symbol	Millimeters		
	Min.	Typ.	Max.
A			1.75
A1	0.10		0.25
A2	1.25		
b	0.31		0.51
c	0.17		0.25
D	9.80	9.90	10.00
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e		1.27	
h	0.25		0.50
L	0.40		1.27
k	0		8
ccc			1.10

4 Revision history

Table 18. Document revision history

Date	Revision	Changes
05-Aug-2013	1	Initial release.
16-Sep-2013	2	Updated disclaimer.

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