VNH7100AS

Automotive fully integrated H-bridge motor driver

Datasheet - production data

SO-16N

Features

Type	$R_{DS(on)}$	I_{out}	V_{CCmax}
VNH7100AS	100 mΩ typ (per leg)	12 A	41 V

- Automotive qualified
- Output current: 15 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}
- PWM operation up to 20 kHz
- MultiSense diagnostic functions
  - Analog motor current feedback
  - Output short to ground detection
  - Thermal shutdown indication
  - OFF-state open-load detection
  - Output short to V_{CC} detection
- Output protected against short to ground and short to V_{CC}
- Standby Mode
- Half Bridge Operation
- Package: ECOPACK®

Description

The device 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.

Moreover, its fully symmetrical mechanical design allows superior manufacturability at board level. The input signals IN_A and IN_B can directly interface the microcontroller to select the motor direction and the brake condition. A SEL0 pin is available to address the information available on the MultiSense to the microcontroller. The MultiSense pin allows to monitor the motor current by delivering a current proportional to the motor current value.

The PWM, up to 20 kHz, allows to control the speed of the motor in all possible conditions. In all cases, a low level state on the PWM pin turns off both the LS_A and LS_B switches.

Table 1. Device summary

Package	Order codes	
	Tube	Tape and reel
SO-16N	—	VNH7100ASTR

Contents

List of tables

List of figures

1 Block diagram and pin description

Figure 1. Block diagram

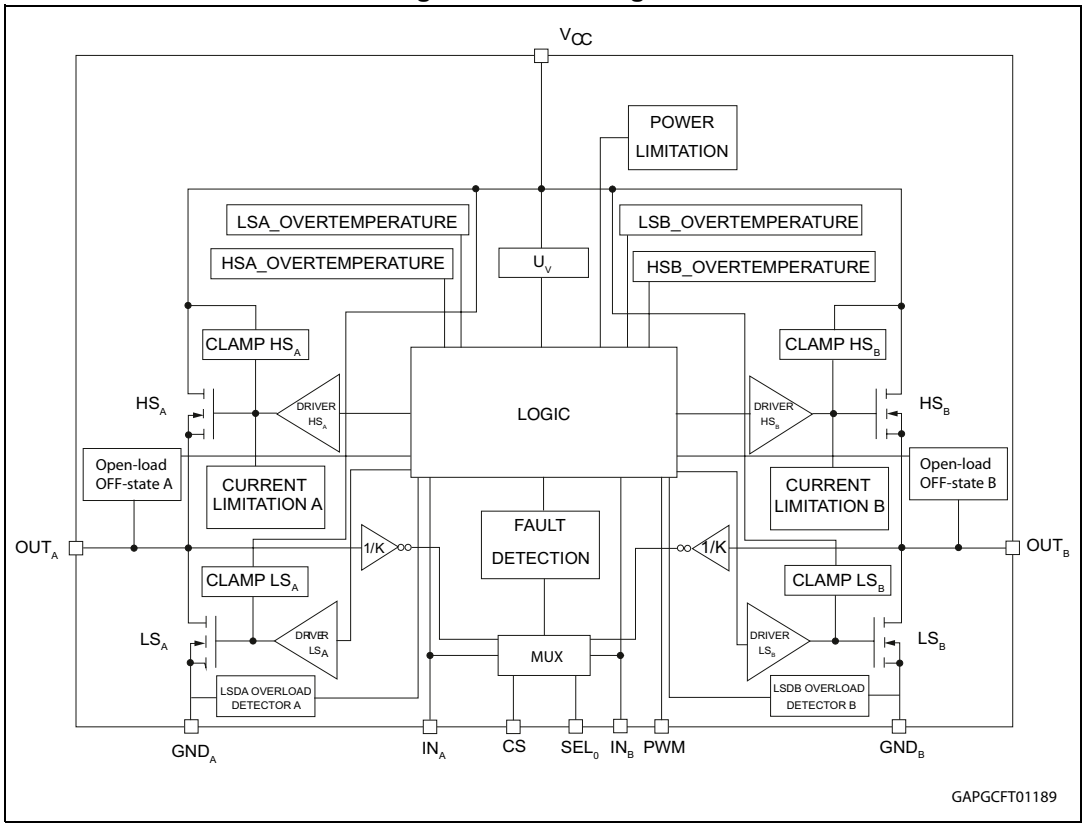


Table 2. Block description

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 4 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_{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 through MultiSense 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)

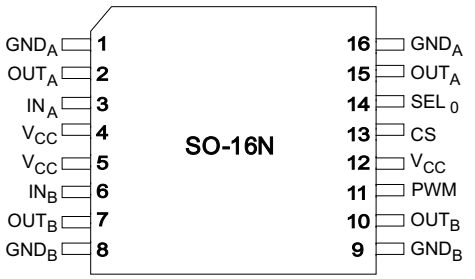
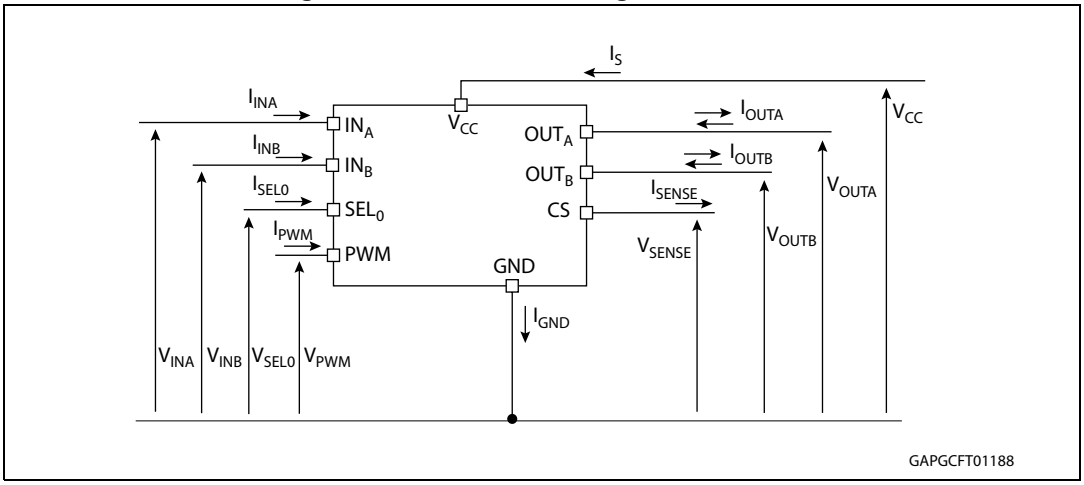


Table 3. Pin definitions and functions

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	PWM	Voltage controlled input pin with hysteresis, CMOS compatible. Gates of low-side FETS get modulated by the PWM signal during their on phase allowing speed control of the motor. Active high.
13	CS	Multiplexed analog sense output pin; it delivers a current proportional to the motor current.
14	SEL_0	Active high compatible with 3 V and 5 V CMOS outputs pin; in combination with IN_A, IN_B, it addresses the CurrentSense information delivered to the micro according to the operative truth table.

2 Electrical specifications

Figure 3. Current and voltage conventions



2.1 Absolute maximum ratings

Stressing the device above the rating listed in *Table 4: Absolute maximum ratings* 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 4. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	38	V
$-V_{CC}$	Reverse DC Supply Voltage	0.3	V
I_{max}	Maximum output current (continuous)	Internally limited	A
I_R	Reverse output current (continuous)	-15	A
V_{CCPK}	Maximum transient supply voltage (ISO 16750-2:2010 Test B clamped to 40 V; R_L = 4 Ω)	40	V
V_{CCJS}	Maximum jump start voltage for single pulse short circuit protection	28	V
I_{IN}	Input current (IN_A and IN_B pins)	-1 to 10	mA
I_{SEL0}	SEL_0 DC input current	-1 to 10	mA
I_{PWM}	PWM input current	-1 to 10	mA
I_{SENSE}	CS pin DC output current (V_{GND} = V_{CC} and V_{SENSE} < 0 V)	10	mA
	CS pin DC output current in reverse (V_{CC} < 0 V)	-20	

Table 4. Absolute maximum ratings (continued)

Symbol	Parameter	Value	Unit
V_{ESD}	Electrostatic discharge (Human body model: R = 1.5 kΩ; C = 100 pF) – IN_A,IN_B, PWM – SEL_0 – CS – V_{CC} – Output	 2 2 2 4 4	kV
V_{ESD}	Charge device model (CDM-AEC-Q100-011)	750	V
T_c	Junction operating temperature	-40 to 150	°C
T_{STG}	Storage temperature	-55 to 150	°C

2.2 Thermal data

Table 5. Thermal data

Symbol	Parameter		Max. value	Unit
$R_{thj\text{-}pin}$	Thermal resistance junction-pin	HSD	32	°C/W
		LSD	45	°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient (JEDEC JESD 51-2)(1)		See *Figure 24*	°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient (JEDEC JESD 51-2)(2)	HSD	40.7	°C/W
		LSD	55.4	°C/W

1. Device mounted on two-layers 2s0p PCB.
2. Device mounted on four-layers 2s2p PCB.

2.3 Electrical characteristics

Values specified in this section are for V_{CC} = 7 V up to 28 V; -40°C < T_j < 150°C, unless otherwise specified.

Table 6. Power section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{CC}	Operating supply voltage		4		28	V
I_S	Supply current	Off-state (standby) IN_A = IN_B = 0; SEL_0 = 0; PWM = 0; T_j = 25 °C; V_{CC} = 13 V;			1	µA
		Off-state (standby) IN_A = IN_B = 0; SEL_0 = 0; PWM = 0; V_{CC} = 13 V; T_j = 85°C			1	µA
		Off-state (standby) IN_A = IN_B = 0; SEL_0 = 0; PWM = 0; V_{CC} = 13 V; T_j = 125 °C			3	µA
		Off-state (no standby) IN_A = IN_B = 0; SEL_0 = 5 V; PWM= 0		2	4	mA
		On-state: IN_A or IN_B = 5 V; PWM = 0 or PWM = 5; SEL_0 = X		3.5	6	mA
t_{D_STBY}(1)	Standby mode blanking time	V_{CC} = 13 V; IN_A = IN_B = PMW = 0 V; V_{SEL0} from 5 V to 0 V	0.2	1	1.8	ms
R_{ONHS}	Static high-side resistance	I_{OUT} = 2.5 A; T_j = 25°C		60		mΩ
		I_{OUT} = 2.5 A; T_j = -40 to 150°C			120	mΩ
R_{ONLS}	Static low-side resistance	I_{OUT} = 2.5 A; T_j = 25°C		40		mΩ
		I_{OUT} = 2.5 A; T_j = -40°C to 150°C			80	mΩ
V_f	Free-wheeling diode forward voltage	I_{OUT} = -2.5 A; T_j = 150°C		0.7	0.9	V
$I_{L(off)}$	Off-state output current of one leg	IN_A = IN_B = 0; PWM = 0; V_{CC} = 13 V; T_j = 25 °C	0		0.5	µA
		IN_A = IN_B = 0; PWM = 0; V_{CC} = 13 V; T_j = 125 °C	0		3	µA
$I_{L(off\_h)}$	Off-state output current of one leg with other HSD on	IN_A = 0; IN_B = 5 V; PWM = 0; V_{CC} = 13 V	20		60	µA

1. To power on the device from the standby, it is recommended to:
— toggle INA or INB from 0 to 1 first to come out from STBY mode
— toggle PWM from 0 to 1 with a delay of 20 µs
this avoids any over-stress on the device in case of existing short-to-battery.

Table 7. Logic inputs (IN_A, IN_B, PWM) (V_{CC} = 7 V up to 28 V; -40°C < T_j < 150°C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{IL}	Input low level voltage				0.9	V
V_{IH}	Input high level voltage		2.1			V
V_{IHYST}	Input hysteresis voltage		0.2			V
V_{ICL}	Input clamp voltage	I_{IN} = 1 mA	5.3		7.2	V
		I_{IN} = -1 mA		-0.7		V
I_{INL}	Input current	V_{IN} = 0.9 V	1			µA
I_{INH}	Input current	V_{IN} = 2.1 V			10	µA
SEL_0 (V_{CC} = 7 V up to 18 V; -40°C < T_j < 150°C)						
V_{SELL}	Input low level voltage				0.9	V
I_{SELL}	Low level input current	V_{SEL} = 0.9 V	1			µA
V_{SELH}	Input high level voltage		2.1			V
I_{SELH}	High level input current	V_{SEL} = 2.1 V			10	µA
$V_{SEL(hyst)}$	Input hysteresis voltage		0.2			V
V_{SELCL}	Input clamp voltage	I_{SEL} = 1 mA	5.3		7.5	V
		I_{SEL} = -1 mA		-0.8		V
PWM (V_{CC}= 7 V up to 28 V; -40°C < T_j < 150°C)						
V_{PWM}	Input low level voltage				0.9	V
I_{PWM}	Low level input current	V_{PWM} = 0.9 V	1			µA
V_{PWM}	Input high level voltage		2.1			V
I_{PWMH}	High level input current	V_{PWM} = 2.1 V			10	µA
$V_{PWM(hyst)}$	Input hysteresis voltage		0.2			V
V_{PMWCL}	Input clamp voltage	I_{PWM} = 1 mA	5.3		7.2	V
		I_{PWM} = -1 mA		-0.7		V

Table 8. Switching (V_{CC} = 13 V; R_{LOAD} = 5.2 Ω)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$f^{(1)}$	PWM frequency		0		20	kHz
$t_{d(on)}$	Turn-on delay time	Input rise time < 1µs (see *Figure 6*)		20		µs
$t_{d(off)}$	Turn-off delay time	Input rise time < 1µs (see *Figure 6*)		13		µs
t_r	Rise time	See *Figure 5*		0.7	1.5	µs
t_f	Fall time	See *Figure 5*		0.2	0.5	µs
t_{cross}	Low-side turn-on delay time	Input rise time < 1 µs (see *Figure 7*)	40	150	350	µs

1. Parameter guaranteed by design and characterization; not subjected to production test.

Table 9. Protections and diagnostics (V_{CC} = 7 V up to 18 V; -40°C < T_j < 150°C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{USD}	Undervoltage shutdown				4	V
$V_{USDreset}$	Undervoltage shutdown reset				5	V
$V_{USDHyst}$	Undervolatge shutdown Hysteresis			0.4		V
I_{LIM_H}	High-side current limitation		12	18	24	A
I_{SD_LS}	Shutdown LS current		14	22	30	A
t_{SD_LS}	Time to shutdown for the low-side	V_{INA} = V_{INB} = 0 V; PWM = 5 V (see *Figure 8*)		5		µs
V_{CL_HSD}	High-side clamp voltage (V_{CC} to OUT_A = 0 or OUT_B = 0)	I_{OUT} = 100 mA; t_{CLAMP} = 1 ms	38	46		V
V_{CL_LSD}	Low-side clamp voltage (OUT_A = V_{CC} or OUT_B = V_{CC} to GND)	I_{OUT} = 100 mA; t_{CLAMP} = 1 ms	38	46		V
T_{TSD_HS}	High-side thermal shutdown temperature	IN_x = 2.1 V	150	175	200	°C
T_{TR_HS}	High-side thermal reset temperature		135			°C
T_{HYST_HS}	High-side thermal hysteresis (T_{SD_HS} - T_{R_HS})			7		°C
T_{TSD_LS}	Low-side thermal shutdown temperature	IN_x = 0 V	150	175	200	°C
V_{CL}	Total clamp voltage (V_{CC} to GND)	I_{OUT} = 100 mA; t_{CLAMP} = 1 ms	38	46	52	V
V_{OL}	OFF-state open-load voltage detection threshold	IN_A = IN_B = 0; PWM = 0; V_{SEL0} = 5 V for CHA; V_{SEL0} = 0 V and within t_{D_STBY} for CHB	2	3	4	V
$I_{L(off2)}$	OFF-state output sink current	IN_A = IN_B = 0; V_{OUTx} = V_{OL}; PWM = 0 V; V_{SEL0} = 5 V for CHA; V_{SEL0} = 0 V and within t_{D_STBY} for CHB	-100		-15	µA
t_{DSTKON}	OFF-state diagnostic delay time from falling edge of INPUT (see *Figure 4*)	IN_A = 5 V to 0 V; IN_B = 0 V; V_{SEL0} = 5 V; I_{OUT} = 0 A; V_{OUTA} = 4 V; PWM = 0 V	40	150	350	µs
t_{D_VOL} (1)	OFF-state diagnostic delay time from rising edge of V_{OUT} (see *Figure 11*)	IN_A = IN_B = 0 V; PWM = 0 V; V_{OUTx} = 0 V to 4 V; V_{SEL0} = 5 V for CHA; V_{SEL0} = 0 V and within t_{D_STBY} for CHB		5	30	µs

Table 9. Protections and diagnostics (V_{CC} = 7 V up to 18 V; -40°C < T_j < 150°C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{Latch\_RST\_HD}$(1)	Input reset time for high-side fault unlatch (see *Figure 9*)	V_{INx} = 5 V to 0 V; HSDx faulting	3	10	20	µs
$t_{Latch\_RST\_LS}$(1)	Input reset time for low-side fault unlatch (see *Figure 10*)	V_{INx} = 0 V to 5 V; LSDx faulting	3	10	20	µs

1. Parameter guaranteed by design and characterization; not subjected to production test.

Table 10. CS (7 V < V_{CC} < 18 V; -40 °C < T_j < 150 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{SENSE_CL}	MultiSense clamp voltage	V_{CC} = 18 V; I_{SENSE} = -5 mA		11		V
		V_{CC} = 18 V; I_{SENSE} = 5 mA	-13		-9	V
K_0	I_{OUT}/I_{SENSE}	I_{OUT} = 0.05 A; V_{SENSE} = 0.5 V; T_j = -40°C to 150°C	420			
K_1	I_{OUT}/I_{SENSE}	I_{OUT} = 0.2 A; V_{SENSE} = 0.5 V; T_j = -40°C to 150°C	710	1190	1670	
K_2	I_{OUT}/I_{SENSE}	I_{OUT} = 2.5 A; V_{SENSE} = 4 V; T_j = -40°C to 150°C	980	1120	1247	
K_3	I_{OUT}/I_{SENSE}	I_{OUT} = 4 A; V_{SENSE} = 4 V; T_j = -40°C to 150°C	990	1120	1235	
dK_0/K_0(1)(2)	Analog sense current drift	I_{OUT} = 0.05 A; V_{SENSE} = 0.5 V; T_j = -40°C to 150°C	-25		25	%
dK_1/K_1(1)(2)	Analog sense current drift	I_{OUT} = 0.2 A; V_{SENSE} = 0.5 V; T_j = -40°C to 150°C	-21		21	%
dK_2/K_2(1)(2)	Analog sense current drift	I_{OUT} = 2.5 A; V_{SENSE} = 4 V; T_j = -40°C to 150°C	-5		5	%
dK_3/K_3(1)(2)	Analog sense current drift	I_{OUT} = 4 A; V_{SENSE} = 4 V; T_j = -40°C to 150°C	-4		4	%
V_{SENSE_SAT}	Max analog sense output voltage	V_{CC} = 7 V; R_{SENSE} = 10 kΩ; V_{SEL0} = 5 V; I_{OUTA} = 4 A; V_{INA} = 5 V; PWM = 0; T_j = 150 °C	5			V
I_{SENSE0}	MultiSense leakage current	I_{OUT} = 0 A; V_{SENSE} = 0 V; IN_x = 0 V; SEL_0 = 0; T_j = -40°C to 150°C (standby)	0		0.5	µA
		I_{OUT} = 0 A; V_{SENSE} = 0 V; IN_x = 0 V; SEL_0 = 5 V; T_j = -40°C to 150°C (no standby)	0		0.5	µA
		IN_x = 5 V; PWM = 5 V: T_j = -40°C to 150°C; I_{OUT} = 0 A	0		5	µA

Table 10. CS (7 V < V_{CC} < 18 V; -40 °C < T_j < 150 °C) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{SENSEH}	MultiSense output voltage in fault condition	V_{CC} = 13 V; R_{SENSE} = 1 kΩ – E.g: OUT_A in open-load IN_A = 0 V; I_{OUTA} = 0 A; V_{OUTA} = 4 V; V_{SEL0} = 5 V	5		7	V
V_{OUT_MSD}(2)	Output Voltage for MultiSense shutdown	V_{INA} = 5 V; V_{INB} = 0 V; V_{SEL0} = 5 V; R_{SENSE} = 2.7 kΩ I_{OUT} = 2.5 A		5		V
I_{SENSE_SAT}(2)	MultiSense saturation current	V_{CC} = 13 V; V_{SENSE} = 4 V; V_{INA} = 5 V; V_{INB} = 0 V; V_{SEL0} = 5 V; T_j = 150 °C	5.8			mA
I_{OUT_SAT}(2)	Output saturation current	V_{CC} = 13 V; V_{SENSE} = 4 V; V_{INA} = 5 V; V_{INB} = 0 V; V_{SEL0} = 5 V; I_{OUT} = 7 A; T_j = 150°C	7			A
I_{SENSEH}	MultiSense output voltage in fault condition	V_{CC} = 13 V; V_{SENSE} = V_{SENSEH}	7	20	30	mA

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.
2. Parameter guaranteed by design and characterization; not subjected to production test.

Figure 4. T_{DSTKON}

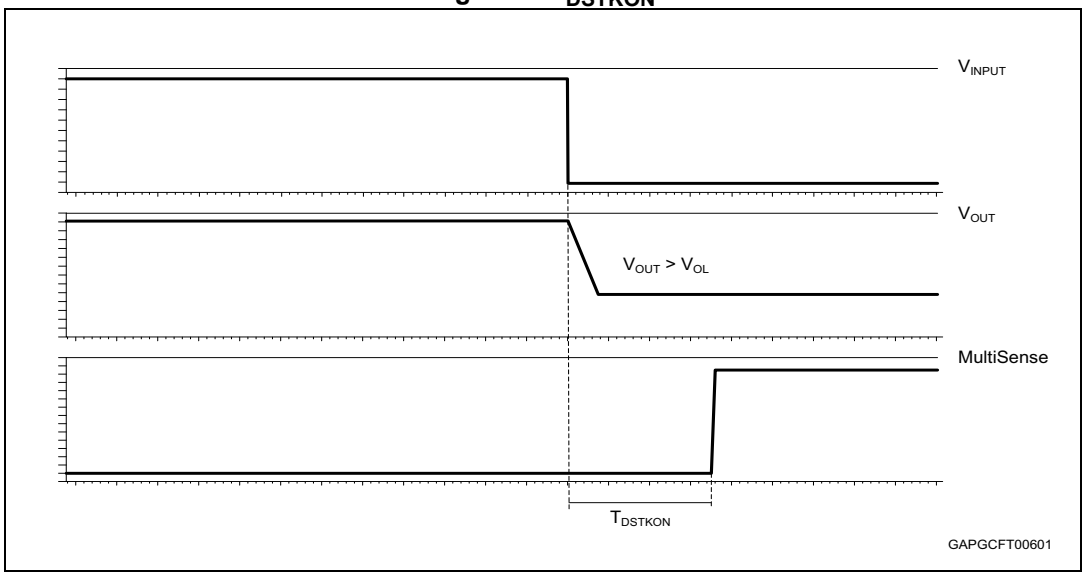


Figure 5. Definition of the low-side switching times

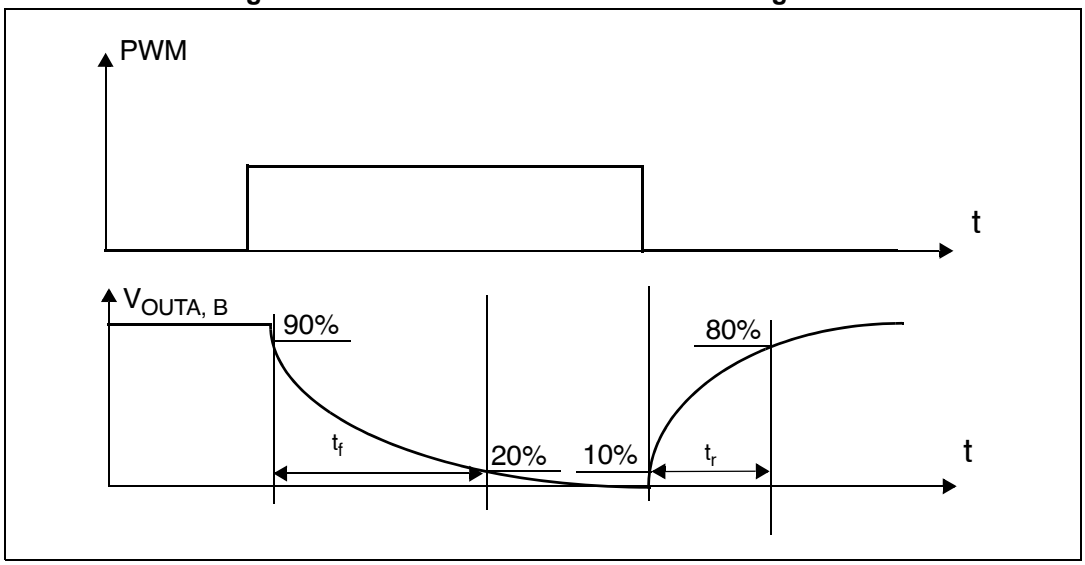


Figure 6. Definition of the high-side switching times

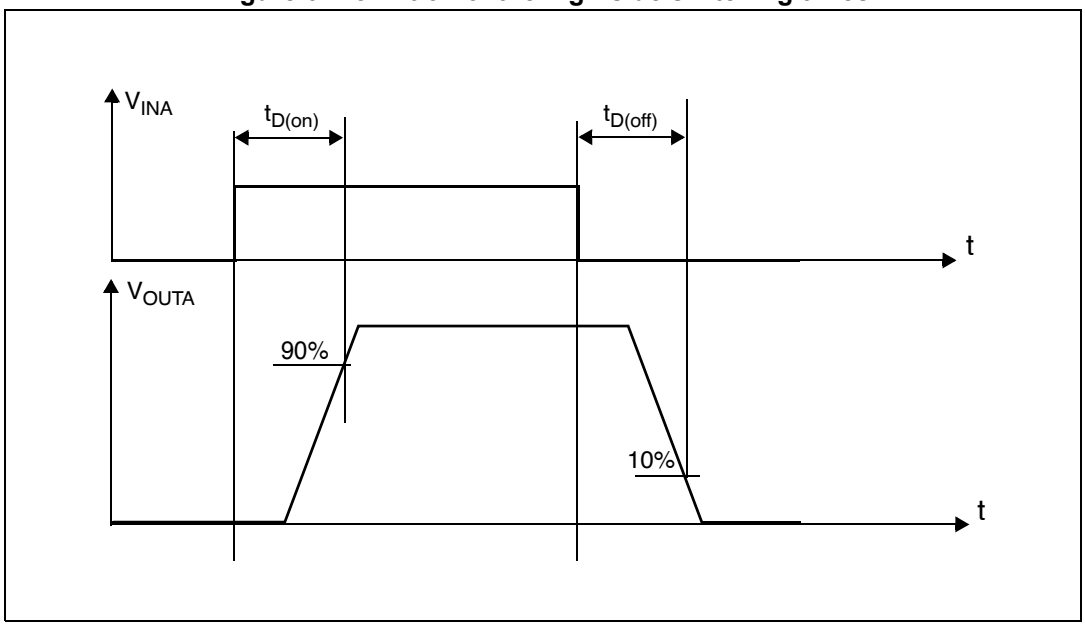


Figure 7. Low-side turn-on delay time

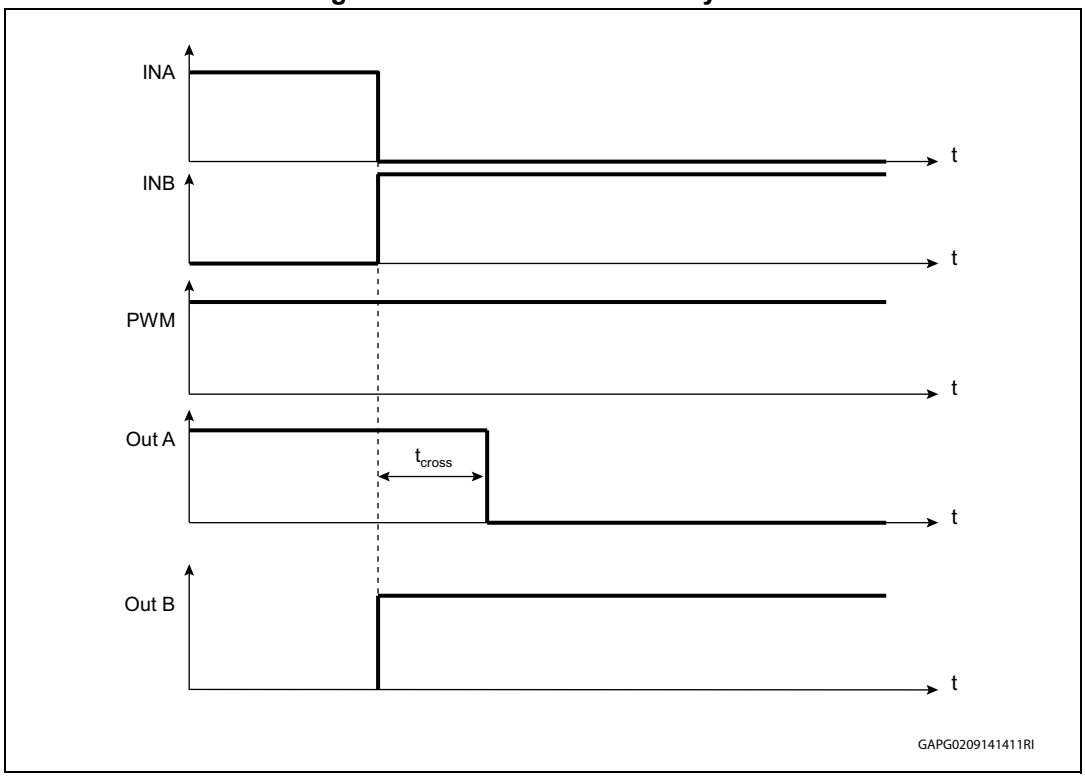


Figure 8. Time to shutdown for the low-side driver

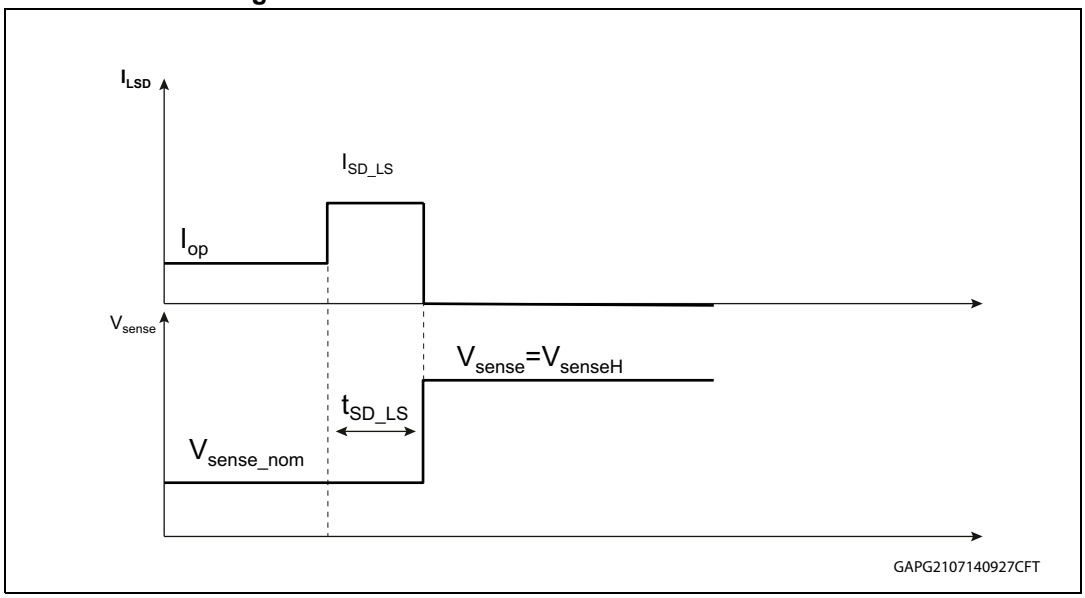


Figure 9. Input reset time for HSD - fault unlatch

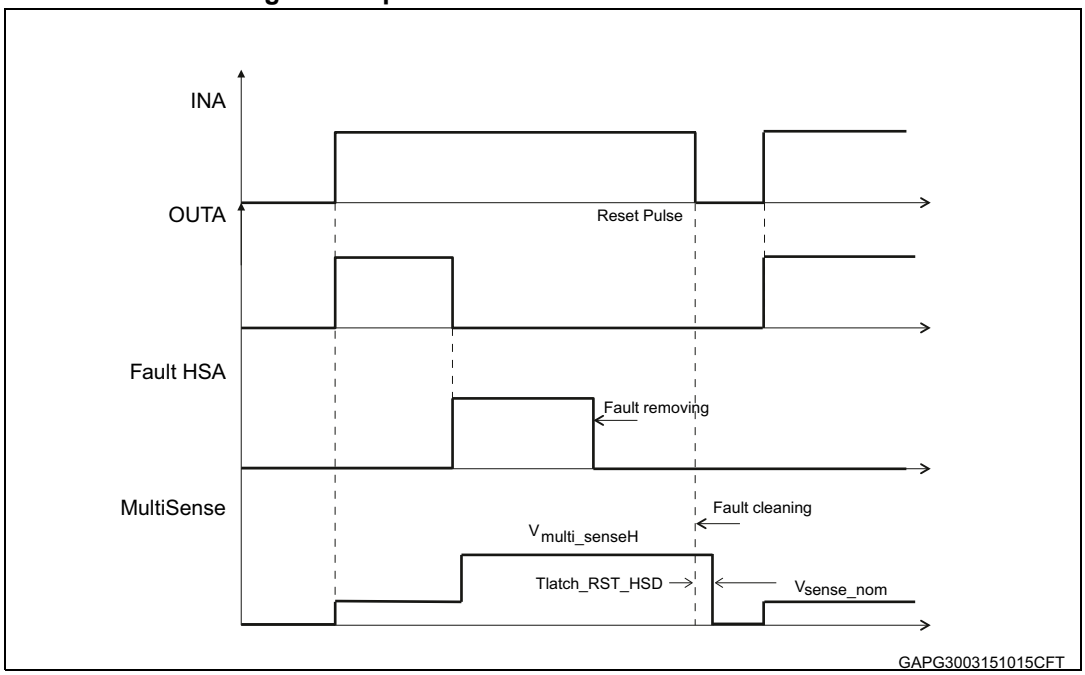


Figure 10. Input reset time for LSD - fault unlatch

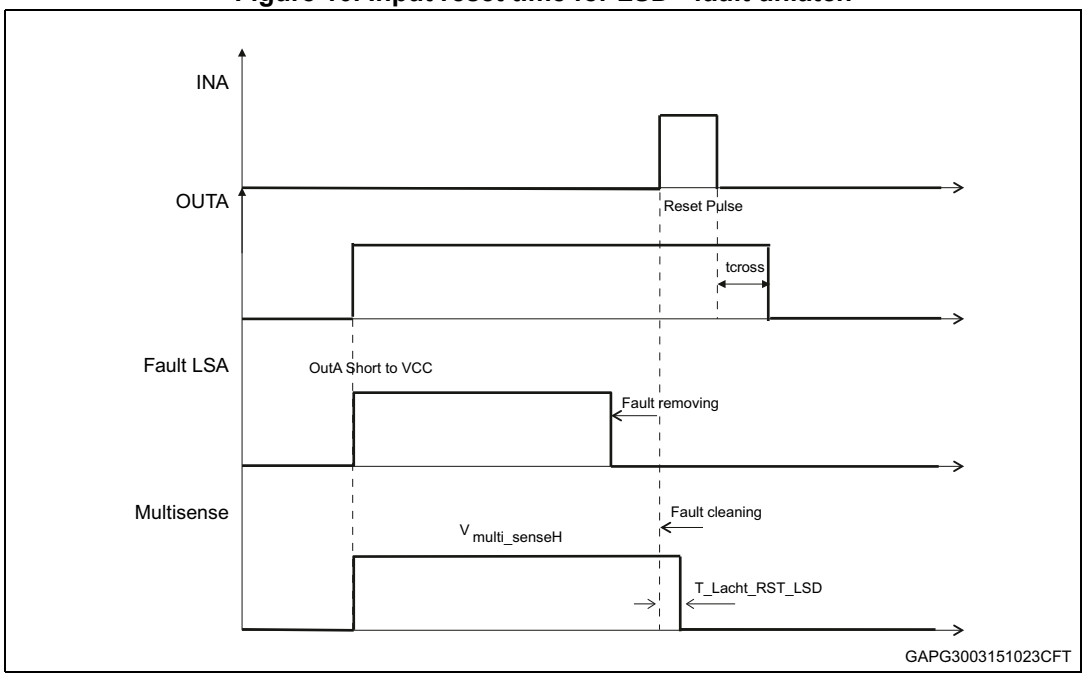


Figure 11. OFF-state diagnostic delay time from rising edge of V_{OUT} (t_{D_VOL})

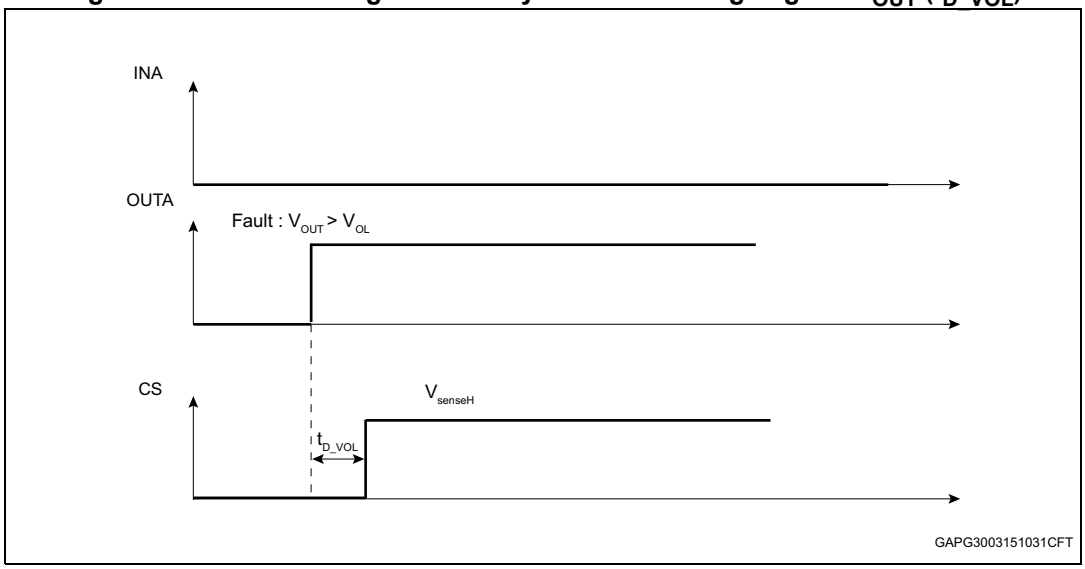


Table 11. Operative condition - truth table

Pin status					HSDs and LDSs Status			
IN_A	IN_B	SEL_0	PWM	CS	HSDA	LSDA	HSDB	LSDB
1	1	1	x	Current Monitoring HSDA	On	Off	On	Off
		0		Current Monitoring HSDB				
1	0	1	1	Current Monitoring HSDA	On	Off	Off	On
			0		On	Off	Off	Off
1	0	0	1	Hi-Z	On	Off	Off	On
			0		On	Off	Off	Off
0	1	1	1	Hi-Z	Off	On	On	Off
			0		Off	Off	On	Off
0	1	0	1	Current Monitoring HSDB	Off	On	On	Off
			0		Off	Off	On	Off
0	0	1	1	Hi-Z	Off	On	Off	On
		0						
0	0	1	0	x(1)	Off	Off	Off	Off
		0(2)			Off	Off	Off	Off

1. Refer to *Table 13: Off-state - truth table*
2. For IN_A =IN_B=SEL_0 = PWM = 0, the device enters in standby after t_{D_STBY}

Table 12. On-state fault conditions - truth table

Digital Input pins				CS	Comment
INA	INB	PWM	SEL0		
0	0	1	0	VsenseH	LSB protection triggered; LSB latched off
0	0	1	1	VsenseH	LSA protection triggered; LSA latched off
0	1	X	0	VsenseH	HSB protection triggered; HSB latched off
0	1	1	1	VsenseH	LSA protection triggered; LSA latched off
1	0	1	0	VsenseH	LSB protection triggered; HSB latched off
1	0	X	1	VsenseH	HSA protection triggered; HSA latched off
1	1	X	0	Hi-Z	HSB protection triggered; HSB latched off
1	1	X	1	Hi-Z	HSA protection triggered; HSA latched off

Note: Other logic combinations on digital input pins not reported on the above table don't allow to detect a latched off channel.

Table 13. Off-state - truth table

IN_A	IN_B	SEL_0	PWM	Out_A	Out_B	CS	Description
Off-state diagnostic							
0	0	1	0	$V_{outA}>V_{OL}$	x	V_{SENSEH}	Case 1. Out_A shorted to V_{CC} if no pull-up is applied Case 2. No open-load in full bridge configuration with an external pull-up on Out_B Case 3. open-load in half bridge configuration with an external pull-up on Out_A(motor connected between Out_A and Ground)
				$V_{outA}<V_{OL}$	x	Hi-Z	Case 1. Open-load in full Bridge configuration with an external pull-up on Out_B Case 2. No open-load in half Bridge configuration with external pull-up on Out_A (motor connected between Out_A and Ground)
		0(1)(2)		X	$V_{outB}>V_{OL}$	V_{SENSEH}	Case 1. Out_B shorted to V_{CC} if no pull-up is applied Case 2. No open-load in full bridge configuration with external pull-up on Out_A Case 3. Open-load in half bridge configuration with external pull-up on Out_B (motor connected between Out_B and Ground)
				X	$V_{outB}<V_{OL}$	Hi-Z	Case1. Open-load in full Bridge configuration with an external pull-up on Out_A Case 2. No open-load in half Bridge configuration with external pull-up on Out_B (motor connected between Out_B and Ground)

1. The device enters standby mode after t_{D_STBY}
2. To power on the device from the standby, it is recommended to toggle IN_A or IN_B from 0 to 1 first and then PWM from 0 to 1 to avoid any over-stress on the device in case of short-to-battery.

2.4 Waveforms

Figure 12. Normal operative conditions

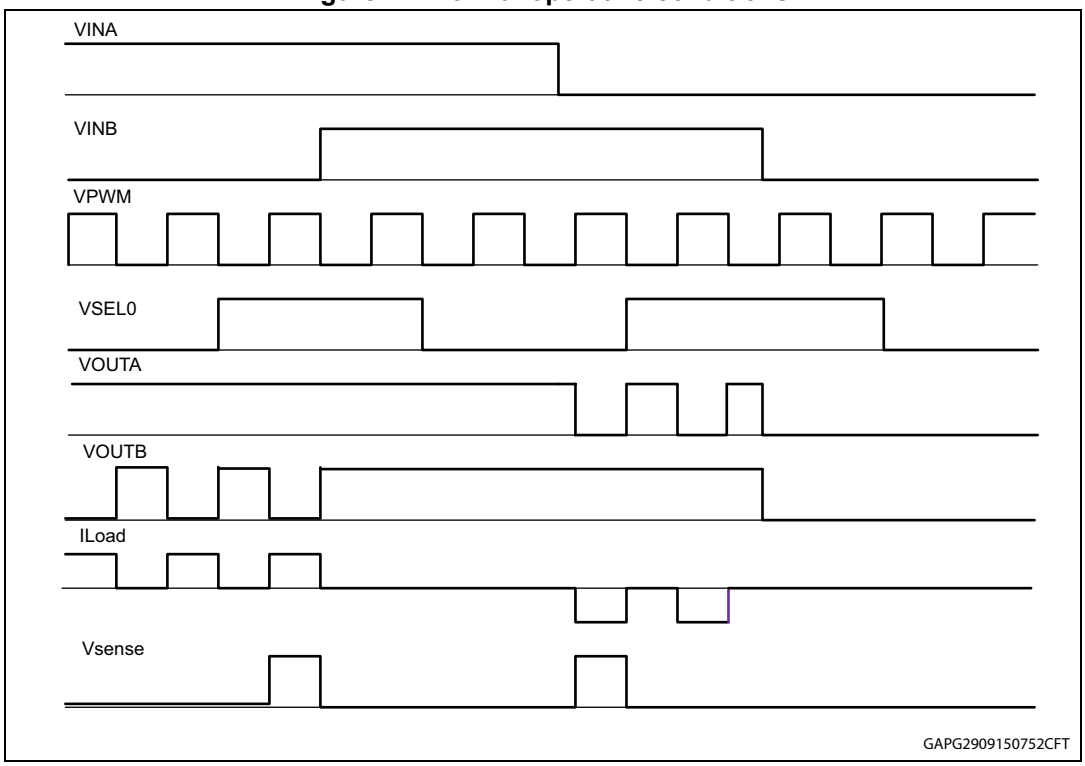


Figure 13. OUT shorted to ground and short clearing

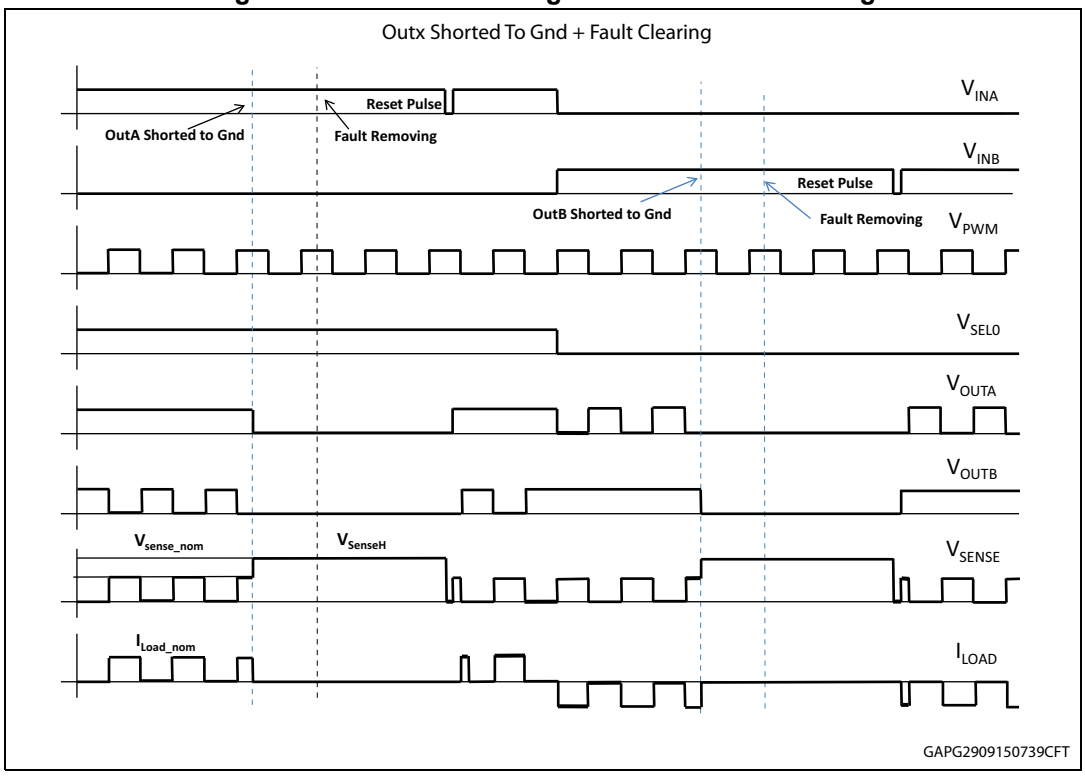
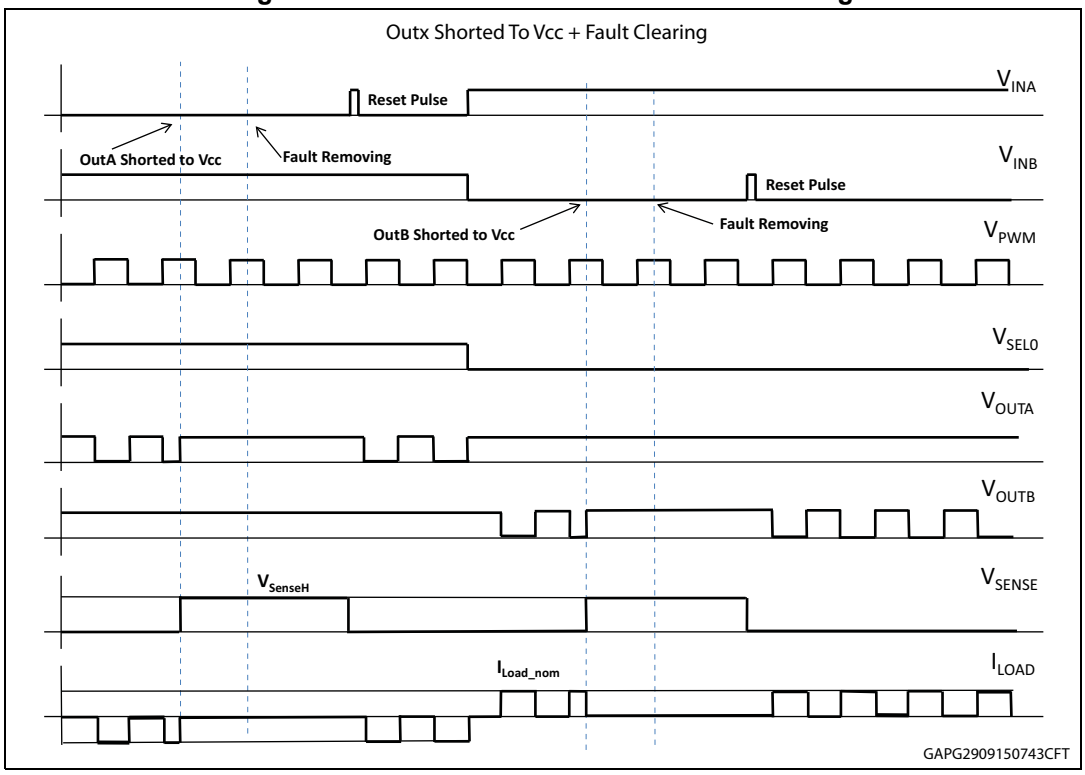


Figure 14. OUT shorted to Vcc and short clearing



3 Application information

Here following there is the typical application schematic suggested for a proper operation of the device in DC or PWM conditions.

Figure 15. Application schematic with reverse battery protection connected to Vbatt

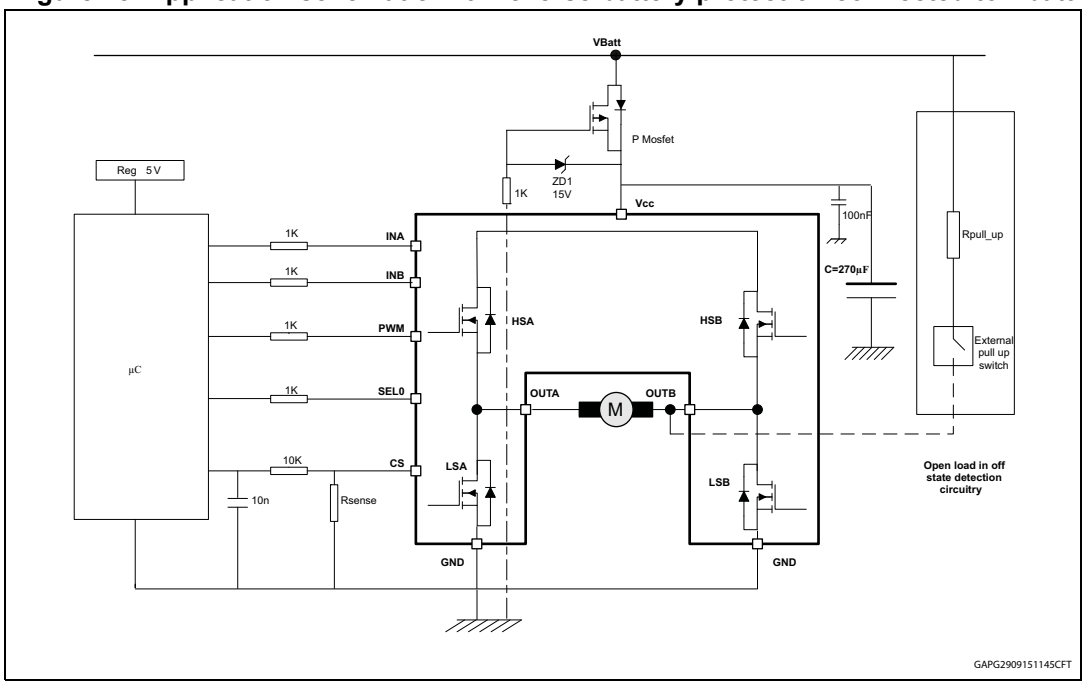


Figure 16. Application schematic with reverse battery protection connected to GND

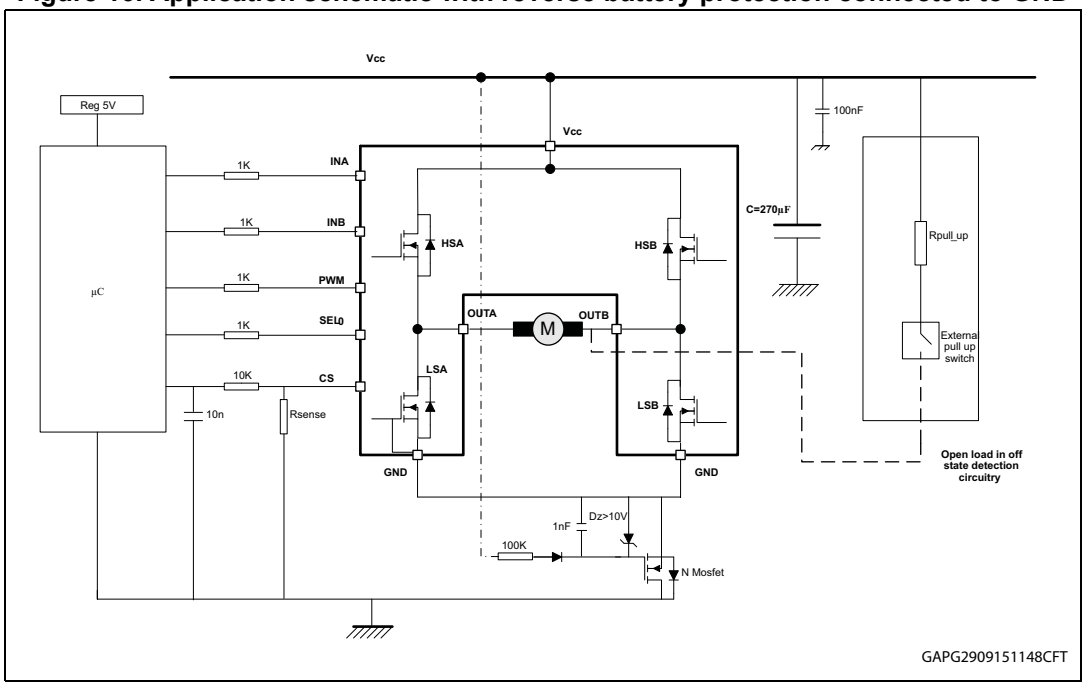
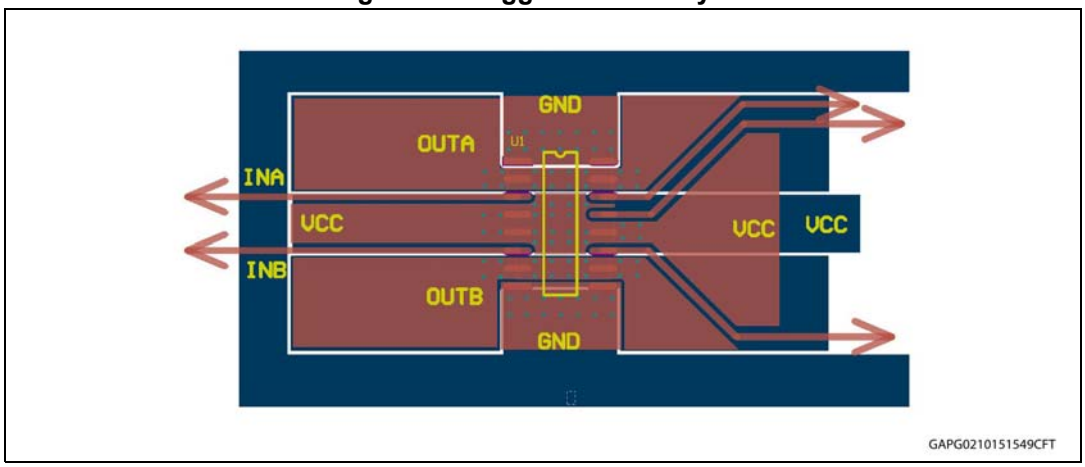


Figure 17. Suggested PCB layout



Note: PCB layout recommendation:
Optimized connection (short) between Drain LSD and Source HSD
Optimized GNDa and GNDb connection (symmetric connection)

3.1 Reverse battery protection

Three possible solutions can be considered:

- A Schottky diode D connected to V_{CC} pin
- An N-channel MOSFET connected to the GND pin
- A P-channel MOSFET connected to the V_{CC} pin

In case the reverse battery protection is not present, the device sustains no more than -15 A because of the two Body diodes of the Power MOSFETs. Additionally, in reverse battery condition the I/Os of the device is pulled down to the V_{CC} line (approximately -1.5 V).

Series resistor must be inserted to limit the current sunk from the microcontroller I/Os. If I_{Rmax} is the maximum target reverse current through microcontroller I/Os, series resistor is:

$$R = \frac{V_{IOs} - V_{CC}}{I_{Rmax}}$$

3.2 OFF-state open-load detection – External circuitry dimensioning

The detection of an open-load in off state requires an external circuitry to be connected between Output and V_{BATT}.

For the detection it is necessary to put one network on each leg in case of Half Bridge operation or one network on one of the output in case of full bridge (see *Table 13: Off-state - truth table*).

The external circuitry is made up by an external pull-up resistor R_{pull_up} connecting the output to a positive supply voltage V_{PU} (V_{Batt}).

It is preferable to switch-off V_{PU} by using an external pull_up switch to reduce the overall standby current during he module standby mode.

R_{pull_up} must be dimensioned to ensure that in normal operative conditions $V_{OUT} > V_{OLmax}$.

To satisfy this condition the R_{pull_up} must be selected according to:

- if the device is used in half bridge configuration, the equation is:

$$R_{pull\_up} < \frac{V_{BATTmin} - V_{OLmax}}{I_{L(off2)min[@VOLmax]}}$$

- if the device is used in H-bridge configuration, the equation is:

$$R_{pull\_up} < \frac{V_{BATTmin} - V_{OLmax}}{2 \times I_{L(off2)min[@VOLmax]}}$$

3.3 Immunity against transient electrical disturbances

The immunity of the device against transient electrical emissions, conducted along the supply lines and injected into the V_{CC} pin, is tested in accordance with ISO7637-2:2011 (E) and ISO 16750-2:2010.

The related function performance status classification is shown in *Table 14*.

Test pulses are applied directly to DUT (Device Under Test) both in ON and OFF-state and in accordance to ISO 7637-2:2011(E), chapter 4. The DUT is intended as the present device only, without components and accessed through V_{CC} and GND terminals.

Status II is defined in ISO 7637-1 Function Performance Status Classification (FPSC) as follows: “The function does not perform as designed during the test but returns automatically to normal operation after the test”.

Table 14. ISO 7637-2 - electrical transient conduction along supply line

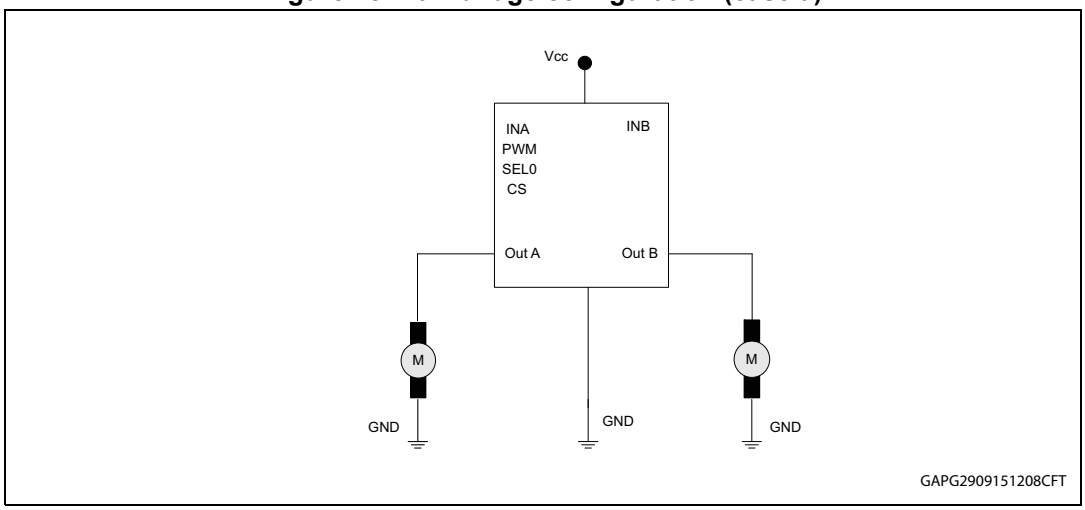
Test Pulse 2011(E)	Test pulse severity level with Status II functional performance status		Minimum number of pulses or test time	Burst cycle / pulse repetition time		Pulse duration and pulse generator internal impedance
	Level	U_S[1]		min	max	
1	III	-112 V	500 pulses	0,5 s		2ms, 10 Ω
2a	III	+55 V	500 pulses	0,2 s	5 s	50µs, 2 Ω
3a	IV	-220 V	1h	90 ms	100 ms	0.1µs, 50 Ω
3b	IV	+150 V	1h	90 ms	100 ms	0.1µs, 50 Ω
4[2]	IV	-7 V	1 pulse			100ms, 0.0 1Ω
Load dump according to ISO 16750-2:2010						
Test B[3]		40 V	5 pulse	1 min		400 ms, 2 Ω

1. U_S is the peak amplitude as defined for each test pulse in ISO 7637-2:2011(E), chapter 5.6.

2. Test pulse from ISO 7637-2:2004(E).
3. With 40 V external suppressor referred to ground (-40°C < T_j < 150°C).

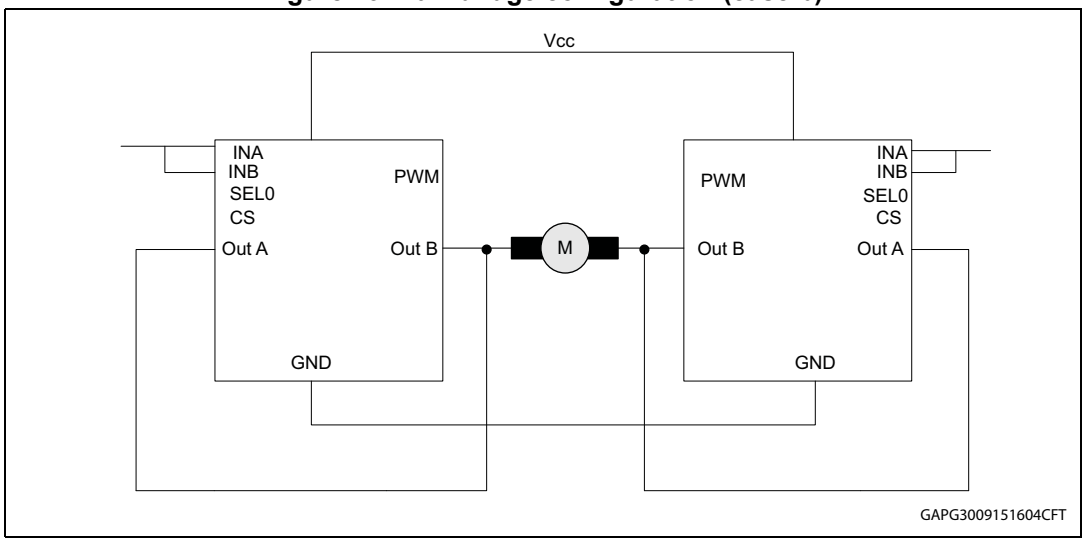
3.4 Device configurations

Figure 18. Half-bridge configuration (case a)



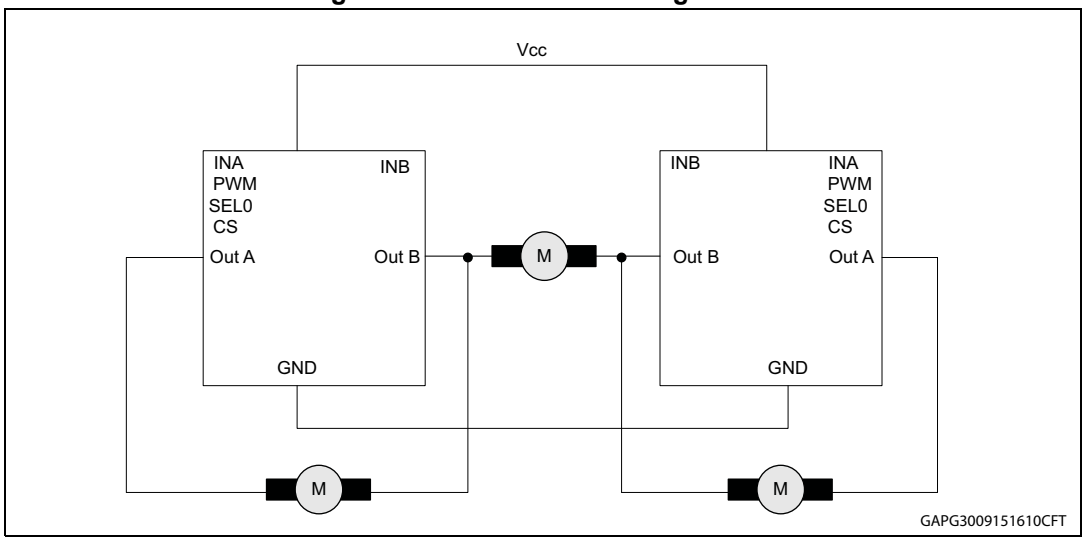
Note: The VNH7100AS can be used in half bridge configuration as the two legs can be independently driven. The SEL0 pin can be used to address the diagnostic on the CS according to the operative truth table.

Figure 19. Half-bridge configuration (case b)



Note: The VNH7100AS can be used in applications where an half-bridge with a resistance of 50 mΩ per leg is needed.

Figure 20. Multi-motors configuration



Note: The VNH7100AS can easily be designed in multi motor driving configuration in the applications where only one motor at a time must be activated. The SEL0 pin can be used to read the diagnostic on the CS according to the operative truth table.

4 Package and PCB thermal data

4.1 SO16-N thermal data

Figure 21. PCB layout (top and bottom): footprint, 2+2+2 cm^2, 8+8+8 cm^2

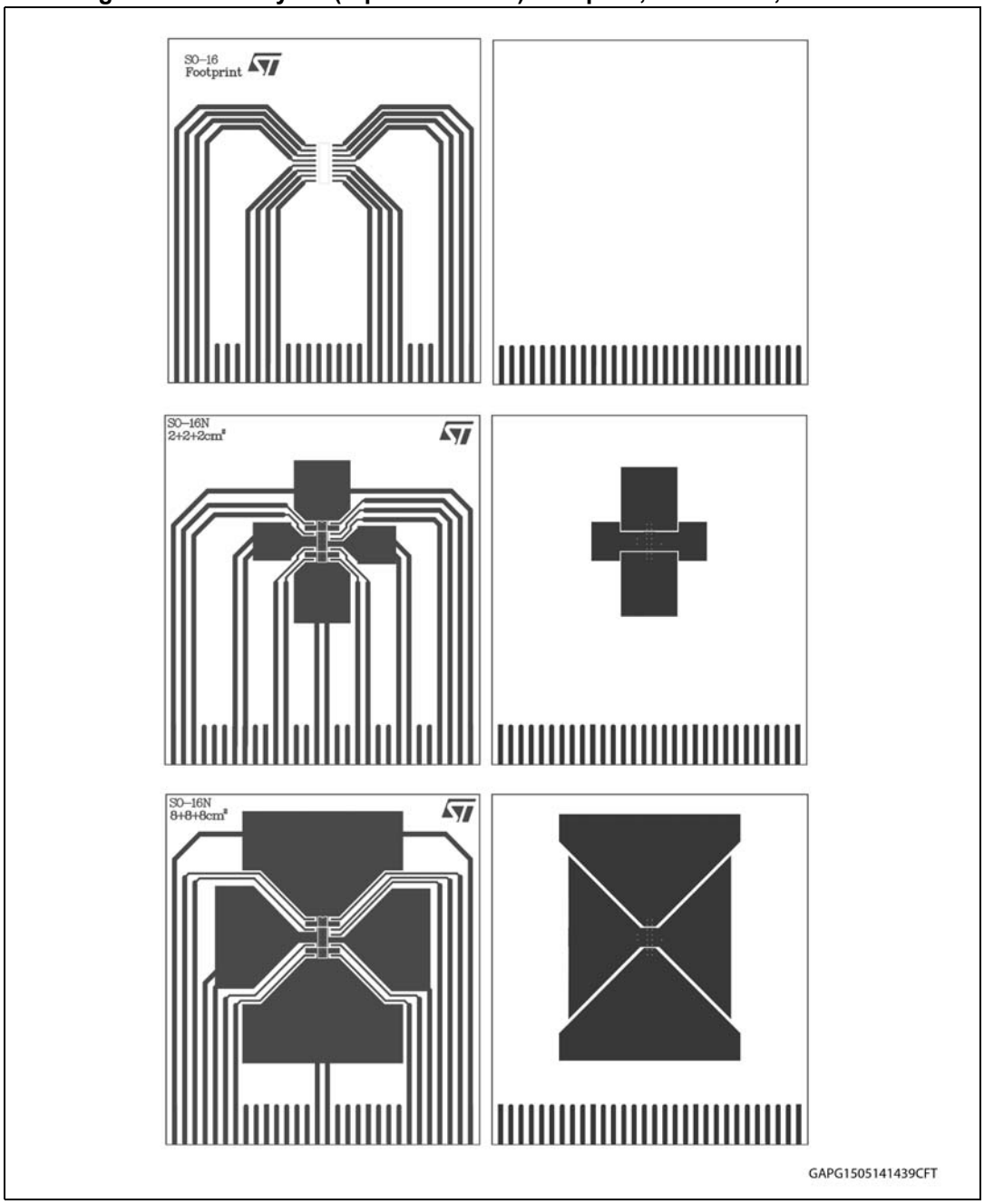
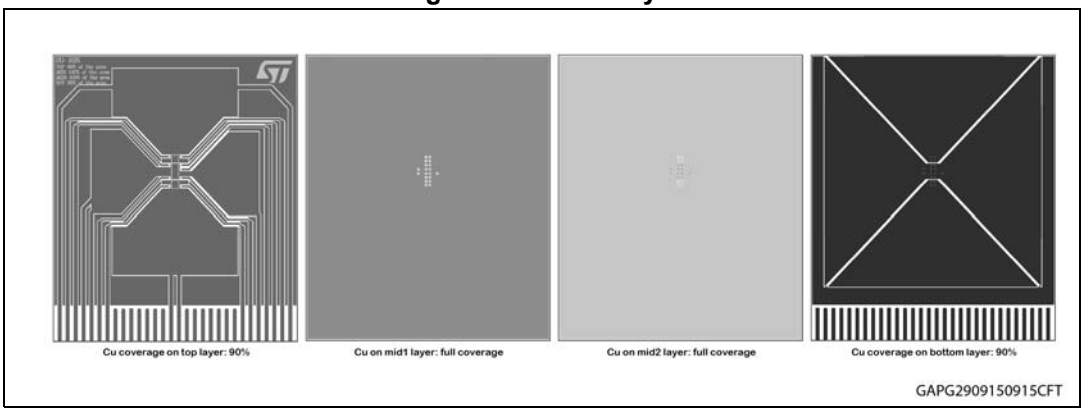


Figure 22. PCB 4 layer



Note: Board finish thickness 1.6 mm +/- 10%; Board double layer and four layers; Board dimension 77x86 mm; Board Material FR4; Cu thickness 0.070mm (outer layers); Cu thickness 0.035mm (inner layers); Thermal vias separation 1.2 mm; Thermal via diameter 0.3 mm +/- 0.08 mm; Cu thickness on vias 0.025 mm.

4.2 Package thermal data

4.2.1 Thermal characterization in steady state conditions

Figure 23. Chipset configuration configuration in steady state conditions

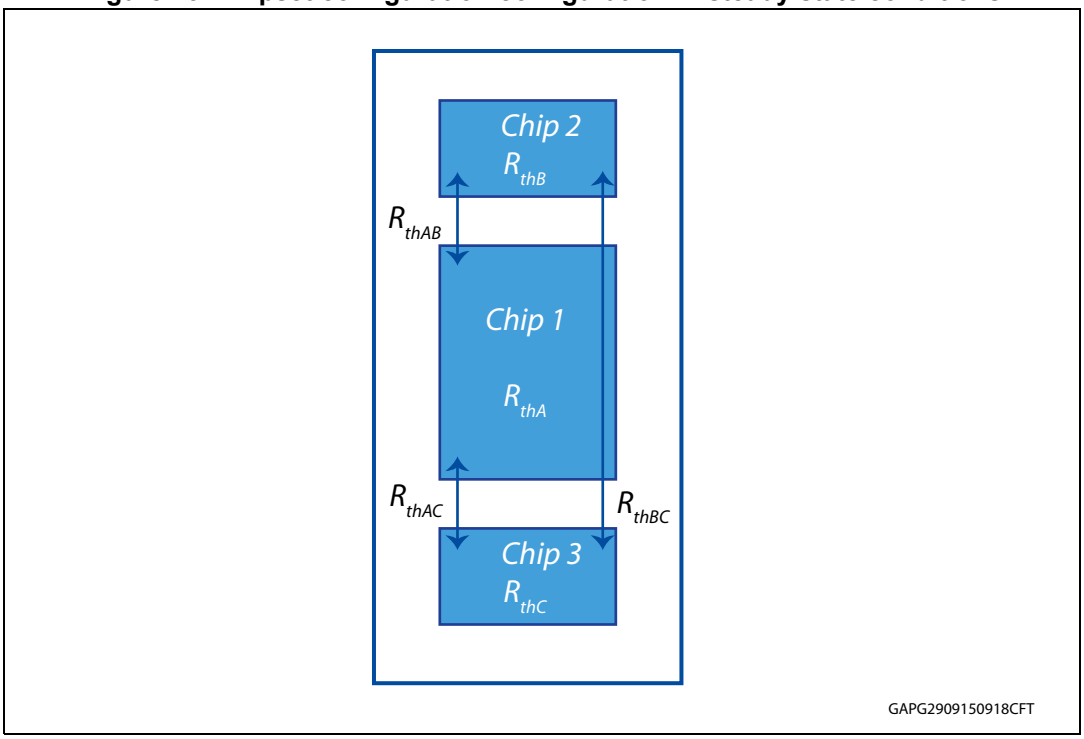


Figure 24. Auto and mutual $R_{thj\text{-}amb}$ vs. PCB heat-sink area in open box free air condition

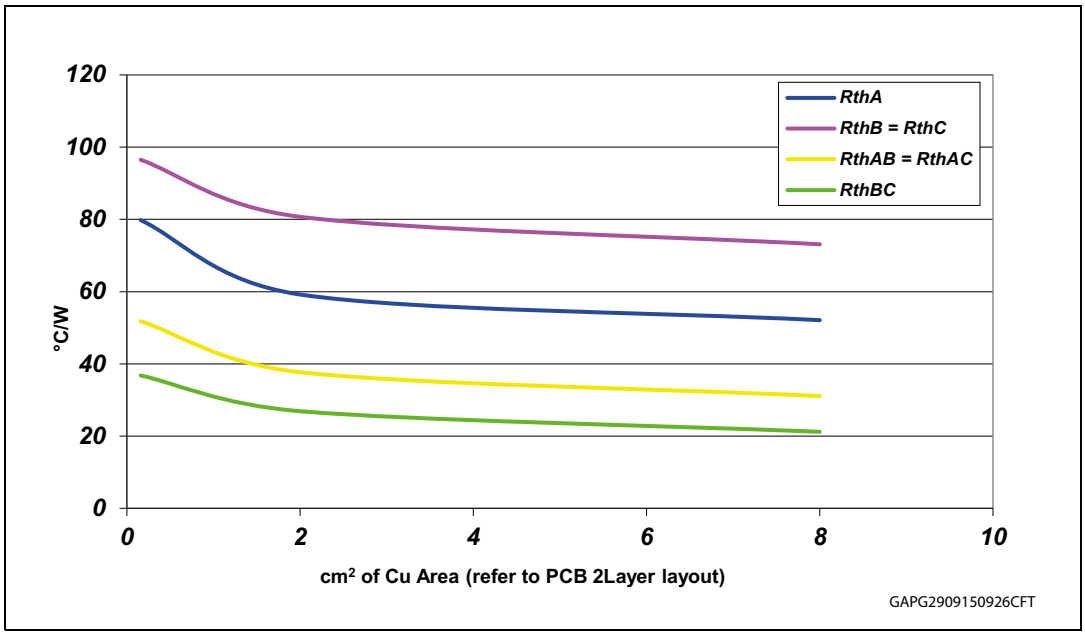


Table 15. Thermal model for junction temperature calculation in steady-state conditions

Chip 1	Chip 2	Chip 3	Tjchip1	Tjchip2	Tjchip3
ON	OFF	ON	$P_{dchip1} \cdot R_{thA} + P_{dchip3} \cdot R_{thAC} + T_{amb}$	$P_{dchip1} \cdot R_{thAB} + P_{dchip3} \cdot R_{thBC} + T_{amb}$	$P_{dchip1} \cdot R_{thAC} + P_{dchip3} \cdot R_{thC} + T_{amb}$
ON	ON	OFF	$P_{dchip1} \cdot R_{thA} + P_{dchip2} \cdot R_{thAB} + T_{amb}$	$P_{dchip1} \cdot R_{thAB} + P_{dchip2} \cdot R_{thB} + T_{amb}$	$P_{dchip1} \cdot R_{thAC} + P_{dchip2} \cdot R_{thBC} + T_{amb}$
ON	OFF	OFF	$P_{dchip1} \cdot R_{thA} + T_{amb}$	$P_{dchip1} \cdot R_{thAB} + T_{amb}$	$P_{dchip1} \cdot R_{thAC} + T_{amb}$
ON	ON	ON	$P_{dchip1} \cdot R_{thA} + (P_{dchip2} + P_{dchip3}) \cdot R_{thAB} + T_{amb}$	$P_{dchip2} \cdot R_{thB} + P_{dchip1} \cdot R_{thAB} + P_{dchip3} \cdot R_{thBC} + T_{amb}$	$P_{dchip1} \cdot R_{thAB} + P_{dchip2} \cdot R_{thBC} + P_{dchip3} \cdot R_{thC} + T_{amb}$

4.2.2 Thermal characterization during transients

$T_{hs} = Pd_{hs} \cdot Z_{hs} + Z_{hsls} \cdot (Pd_{lsA} + Pd_{lsB}) + T_{amb}$

$T_{lsA} = Pd_{lsA} \cdot Z_{ls} + Pd_{hs} \cdot Z_{hsls} + Pd_{lsB} \cdot Z_{lsls} + T_{amb}$

$T_{lsB} = Pd_{lsB} \cdot Z_{ls} + Pd_{hs} \cdot Z_{hsls} + Pd_{lsA} \cdot Z_{lsls} + T_{amb}$

Figure 25. HSD thermal impedance junction ambient single pulse

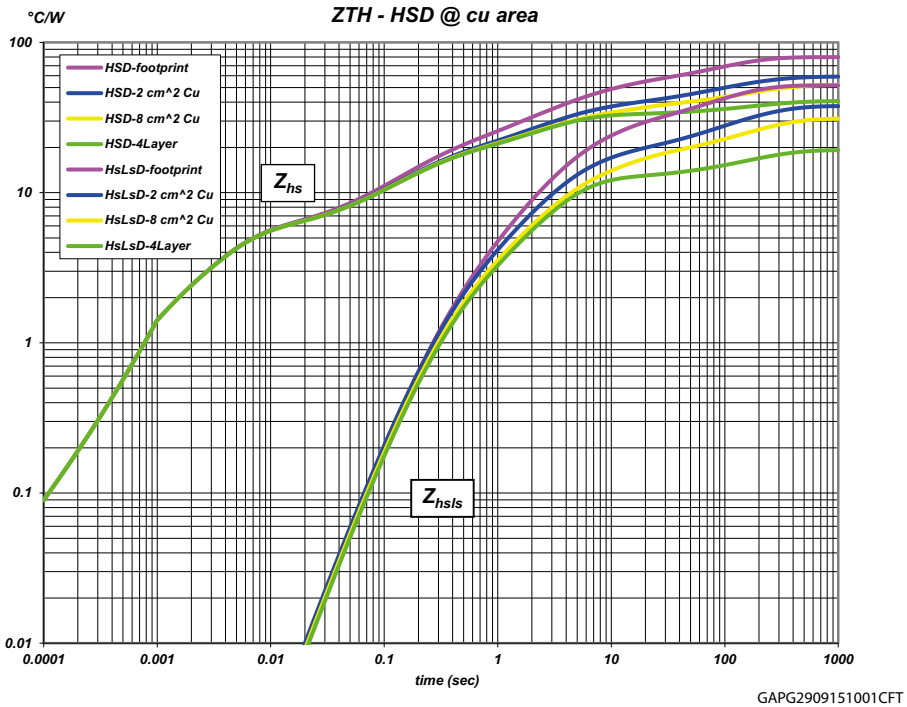


Figure 26. LSD thermal impedance junction ambient single pulse

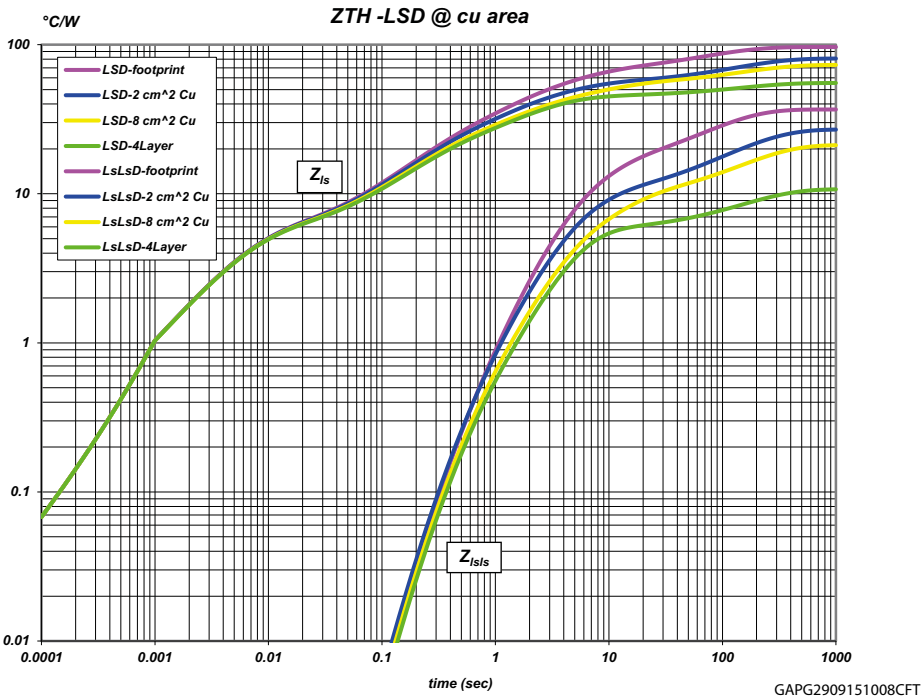


Figure 27. Electrical equivalent model

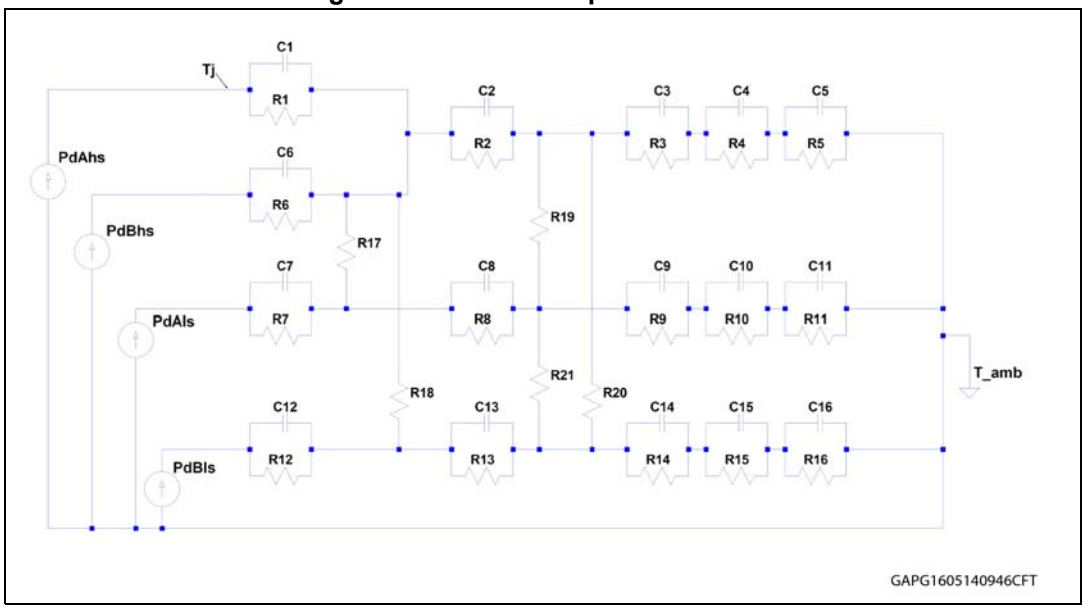


Table 16. Thermal parameters

Area/island (cm^2)	FP	2	8	4L
R1 (°C/W)	5.3	5.3	5.3	5.3
R2 (°C/W)	12	12	12	12
R3 (°C/W)	30	25	25	30
R4 (°C/W)	42	12	12	2
R5 (°C/W)	85	45	30	17
R6 (°C/W)	5.3	5.3	5.3	5.3
R7 (°C/W)	5.1	5.1	5.1	5.1
R8 (°C/W)	12	12	12	12
R9 (°C/W)	30	30	30	42
R10 (°C/W)	68	52	48	10
R11 (°C/W)	75	80	60	26
R12 (°C/W)	5.1	5.1	5.1	5.1
R13 (°C/W)	12	12	12	12
R14 (°C/W)	30	30	30	42
R15 (°C/W)	68	52	48	10
R16 (°C/W)	75	80	60	26
R17 (°C/W)	120	100	100	100
R18 (°C/W)	120	100	100	100
R19 (°C/W)	180	170	170	170
R20 (°C/W)	180	170	170	170

Table 16. Thermal parameters (continued)

Area/island (cm^2)	FP	2	8	4L
C1 (W·s/°C)	0.00065	0.00065	0.00065	0.00065
C2 (W·s/°C)	0.018	0.018	0.018	0.018
C3 (W·s/°C)	0.08	0.1	0.1	0.1
C4 (W·s/°C)	0.2	0.5	1	2
C5 (W·s/°C)	1.5	2	6	12
C6 (W·s/°C)	0.00065	0.00065	0.00065	0.00065
C7 (W·s/°C)	0.001	0.001	0.001	0.001
C8 (W·s/°C)	0.02	0.02	0.02	0.02
C9 (W·s/°C)	0.06	0.06	0.06	0.06
C10 (W·s/°C)	0.08	0.1	0.2	0.5
C11 (W·s/°C)	1	2.5	3	6
C12 (W·s/°C)	0.00065	0.00065	0.00065	0.00065
C13 (W·s/°C)	0.02	0.02	0.02	0.02
C14 (W·s/°C)	0.06	0.06	0.06	0.06
C15 (W·s/°C)	0.08	0.1	0.2	0.5
C16 (W·s/°C)	1	2.5	3	6

5 Package and packing 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.

5.1 SO-16N mechanical data

Figure 28. SO-16N package dimensions

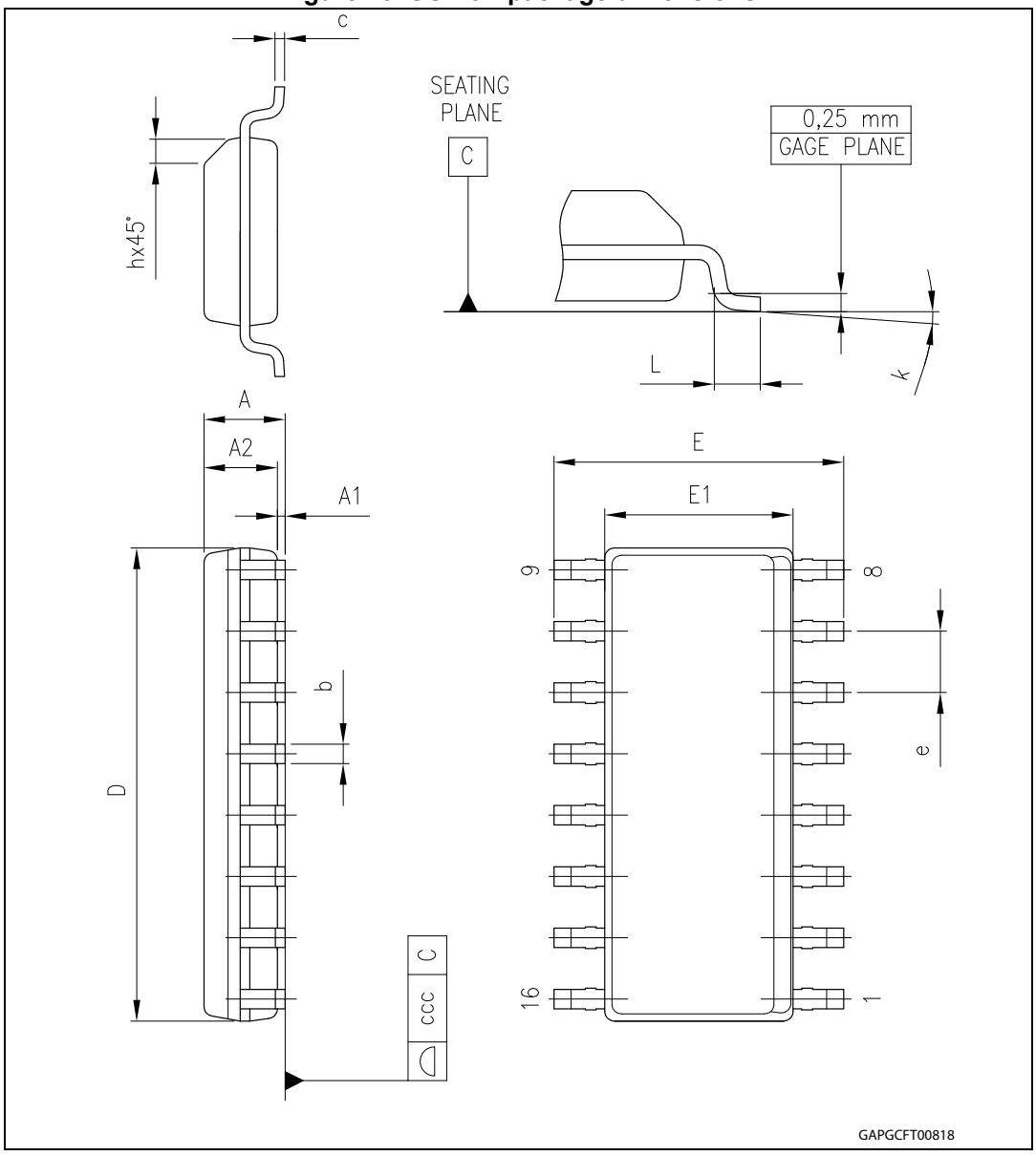


Table 17. SO-16N mechanical data

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			0.10

5.2 SO-16N packing information

Figure 29. SO-16N reel 13”

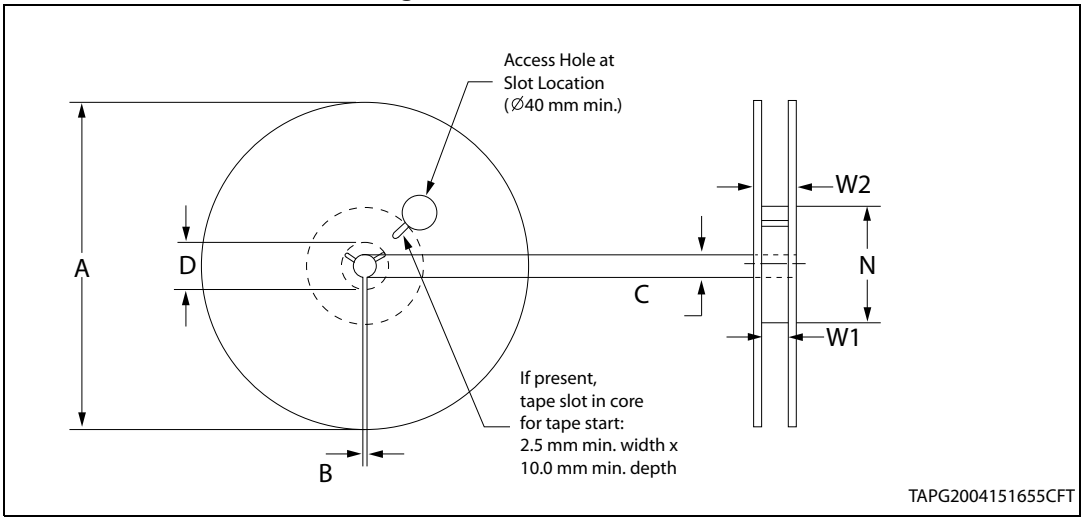


Table 18. Reel dimensions

Description	Value(1)
Base quantity	2500
Bulk quantity	2500
A (max)	330
B (min)	1.5
C (+0.5, -0.2)	13
D (min)	20.2
N	100
W1 (+2 /-0)	16.4
W2 (max)	22.4

1. All dimensions are in mm.

Figure 30. SO-16N carrier tape

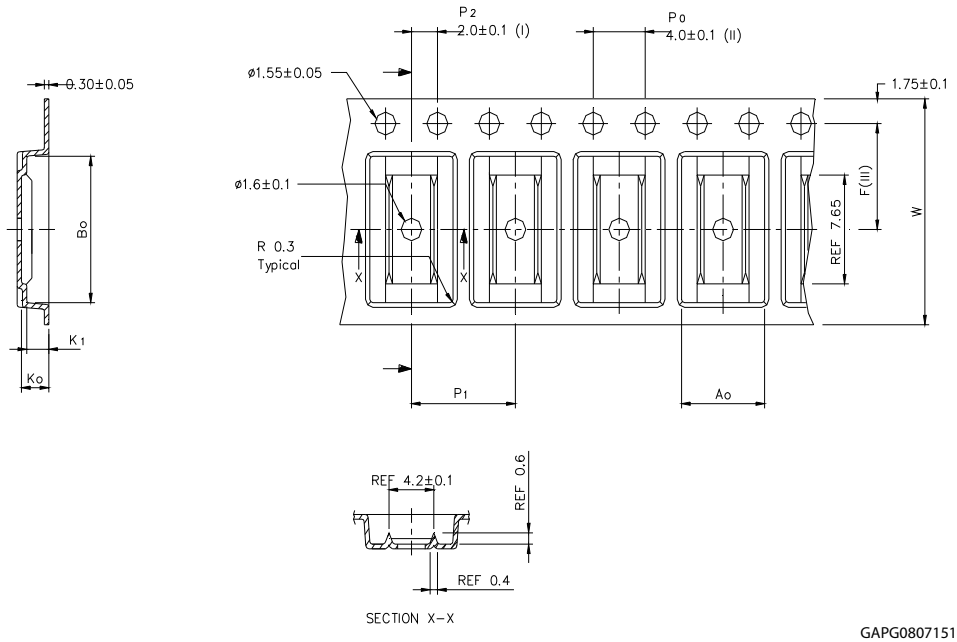


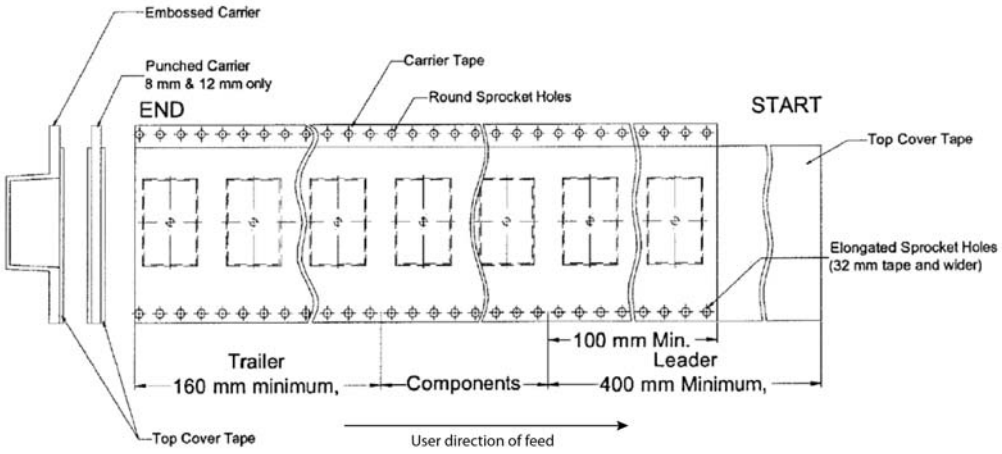
Table 19. SO-16N carrier tape dimensions

Description	Value
A_0	6.55 ± 0.1
B_0	10.38 ± 0.1
K_0	2.10 ± 0.1
K_1	1.80 ± 0.1
F	7.50 ± 0.1

Table 19. SO-16N carrier tape dimensions (continued)

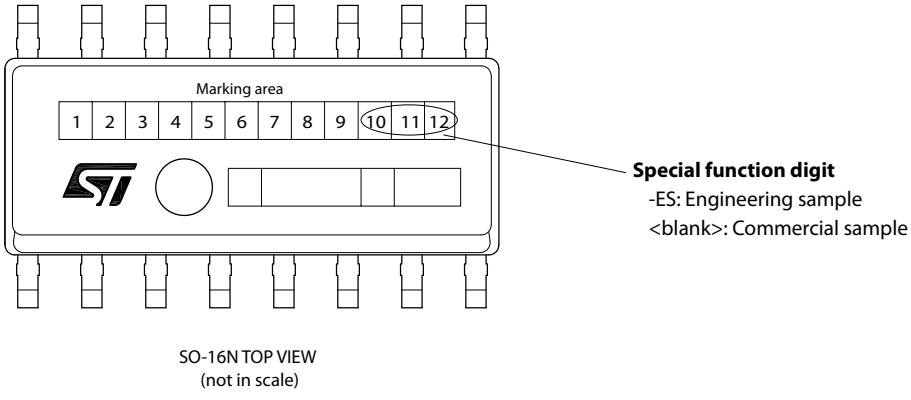
Description	Value
P_1	8.00 ± 0.1
W	16.00 ± 0.3

Figure 31. SO-16N schematic drawing of leader and trailer tape



5.3 SO-16N marking information

Figure 32. SO-16N marking information



Note: Engineering Samples: these samples can be clearly identified by a dedicated special symbol in the marking of each unit. These samples are intended to be used for electrical compatibility evaluation only; usage for any other purpose may be agreed only upon written authorization by ST. ST is not liable for any customer usage in production and/or in reliability qualification trials.

Commercial Samples: fully qualified parts from ST standard production with no usage restrictions.

6 Revision history

Table 20. Document revision history

Date	Revision	Changes
16-Jul-2015	1	Initial release.
01-Sep-2015	2	*Table 8: Switching (VCC = 13 V; RLOAD = 5.2 Ω)*: – t_{cross}: updated values *Table 9: Protections and diagnostics (VCC = 7 V up to 18 V; -40°C < Tj < 150°C)*: – I_{SD_LS}, t_{DSTKON}: updated values *Table 10: CS (7 V < VCC < 18 V; -40 °C < Tj < 150 °C)*: – K_2, K_3, I_{SENSE_SAT}: updated values
04-Sep-2015	3	*Table 4: Absolute maximum ratings*: – I_R: updated value
07-Oct-2015	4	*Table 4: Absolute maximum ratings*: – $-I_{GND}$: removed row Updated *Table 5: Thermal data* *Table 6: Power section*: – V_f: updated parameter Updated *Figure 9: Input reset time for HSD - fault unlatch* and *Figure 10: Input reset time for LSD - fault unlatch* Added *Section 2.4: Waveforms* and *Chapter 4: Package and PCB thermal data* Updated *Chapter 3: Application information*
21-Oct-2015	5	Updated *Table 12: On-state fault conditions - truth table*
23-May-2016	6	*Table 8: Switching (VCC = 13 V; RLOAD = 5.2 Ω)*: – T_r, T_f: updated maximum values Updated *Table 12: On-state fault conditions - truth table*