

# 16 mΩ high-side driver with analog current sense for automotive applications

Datasheet - production data



- Self limiting of fast thermal transients
- Protection against loss of ground and loss of  $V_{CC}$
- Overtemperature shutdown with auto restart (thermal shutdown)
- Reverse battery protected
- Electrostatic discharge protection

## Features

Max supply voltage	$V_{CC}$	41 V
Operating voltage range	$V_{CC}$	4.5 to 28 V
Max on-state resistance (per ch.)	$R_{ON}$	16 mΩ
Current limitation (typ)	$I_{LIMH}$	73 A
Off-state supply current	$I_S$	2 μA <sup>(1)</sup>

1. Typical value with all loads connected.

- General
  - Inrush current active management by power limitation
  - Very low standby current
  - 3.0 V CMOS compatible inputs
  - Optimized electromagnetic emissions
  - Very low electromagnetic susceptibility
  - In compliance with the 2002/95/EC European directive
- Diagnostic functions
  - Proportional load current sense
  - High current sense precision for wide current range
  - Current sense disable
  - Overload and short to ground (power limitation) indication
  - Thermal shutdown indication
- Protections
  - Undervoltage shutdown
  - Overvoltage clamp
  - Load current limitation

## Applications

- All types of resistive, inductive and capacitive loads
- Suitable as LED driver

## Description

The VN5E016MH-E is a single channel high-side driver manufactured in the ST proprietary VIPower™ M0-5 technology and housed in the tiny HPak package. The VN5E016MH-E is designed to drive 12 V automotive grounded loads delivering protection, diagnostics and easy 3 V and 5 V CMOS compatible interface with any microcontroller.

The device integrates advanced protective functions such as load current limitation, inrush and overload active management by power limitation, overtemperature shut-off with auto restart and overvoltage active clamp.

A dedicated analog current sense pin is associated with every output channel in order to provide enhanced diagnostic functions including fast detection of overload and short-circuit to ground through power limitation indication and overtemperature indication.

The current sensing and diagnostic feedback of the whole device can be disabled by pulling the CS\_DIS pin high to allow sharing of the external sense resistor with other similar devices.

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Figure 2. Configuration diagram (top view) not in scale

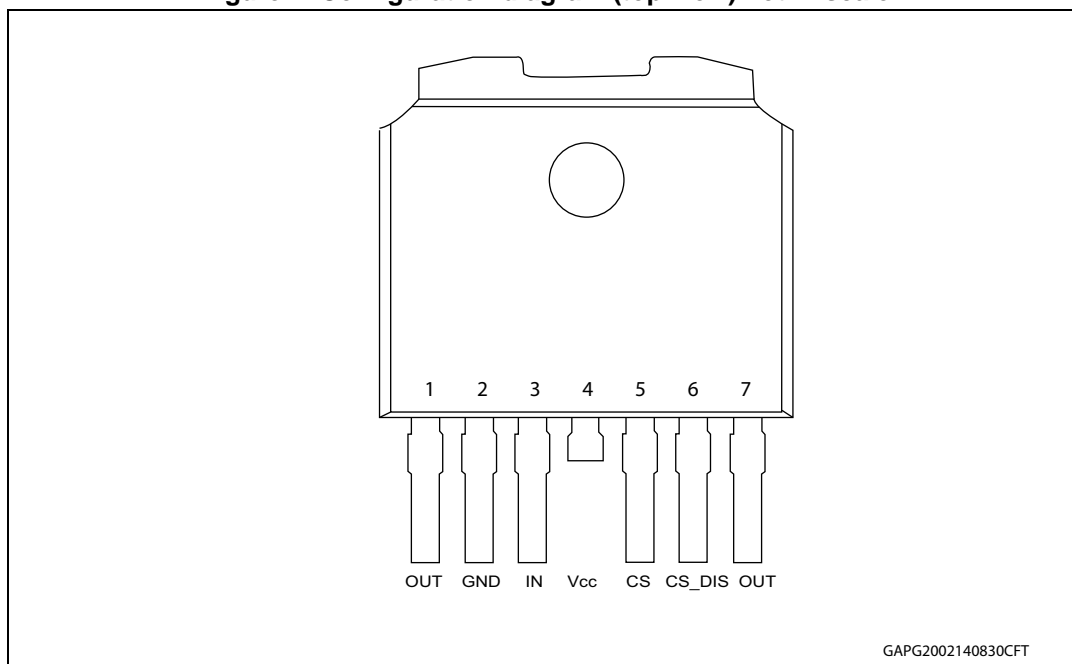
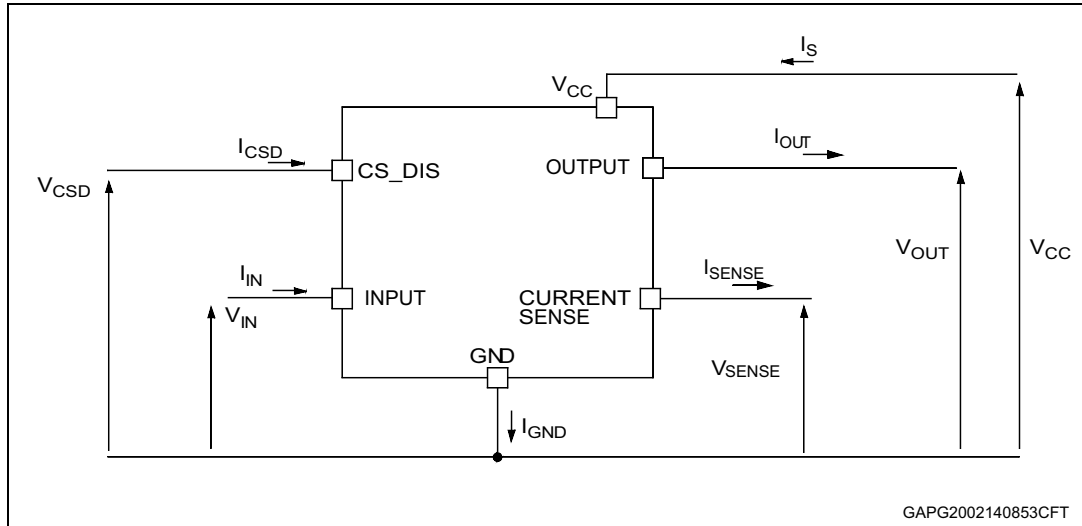


Table 2. Suggested connections for unused and not connected pins

Connection / pin	Current sense	Output	Input	CS_DIS
Floating	Not allowed	X	X	X
To ground	Through 1 k $\Omega$ resistor	Through 22 k $\Omega$ resistor	Through 10 k $\Omega$ resistor	Through 10 k $\Omega$ resistor

## 2 Electrical specifications

Figure 3. Current and voltage conventions



### 2.1 Absolute maximum ratings

Stressing the device above the rating listed in [Table 3](#) 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 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
$V_{CC}$	DC supply voltage	41	V
$-V_{CC}$	Reverse DC supply voltage	0.3	V
$I_{GND}$	DC reverse ground pin current	200	mA
$I_{OUT}$	DC output current	Internally limited	A
$-I_{OUT}$	Reverse DC output current	20	A
$I_{IN}$	DC input current	-1 to 10	mA
$I_{CSD}$	DC current sense disable input current	-1 to 10	mA
$V_{CSENSE}$	Current sense maximum voltage ( $V_{CC} > 0$ )	$V_{CC}-41$ $+V_{CC}$	V V
$E_{MAX}$	Maximum switching energy (single pulse) ( $L = 1.55\text{ mH}$ ; $R_L = 0\ \Omega$ ; $V_{bat} = 13.5\text{ V}$ ; $T_{jstart} = 150\text{ }^\circ\text{C}$ ; $I_{OUT} = I_{limL}(\text{Typ.})$ )	350	mJ

Table 3. Absolute maximum ratings (continued)

Symbol	Parameter	Value	Unit
V <sub>ESD</sub>	Electrostatic discharge (human body model: R = 1.5 KΩ; C = 100 pF)		
	– Input	4000	V
	– Current sense	2000	V
	– CS_DIS	4000	V
	– Output	5000	V
	– V <sub>CC</sub>	5000	V
V <sub>ESD</sub>	Charge device model (CDM-AEC-Q100-011)	750	V
T <sub>j</sub>	Junction operating temperature	-40 to 150	°C
T <sub>stg</sub>	Storage temperature	-55 to 150	°C

## 2.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	Max. value	Unit
R <sub>thj-case</sub>	Thermal resistance junction-case	0.63	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient	69.3	°C/W



## 2.3 Electrical characteristics

Values specified in this section are for  $8\text{ V} < V_{CC} < 28\text{ V}$ ,  $-40\text{ °C} < T_j < 150\text{ °C}$ , unless otherwise specified.

**Table 5. Power section**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{CC}$	Operating supply voltage		4.5	13	28	V
$V_{USD}$	Undervoltage shutdown			3.5	4.5	V
$V_{USDhyst}$	Undervoltage shutdown hysteresis			0.5		V
$R_{ON}$	On-state resistance	$I_{OUT} = 5\text{ A}$ ; $T_j = 25\text{ °C}$			16	m $\Omega$
		$I_{OUT} = 5\text{ A}$ ; $T_j = 150\text{ °C}$			32	m $\Omega$
		$I_{OUT} = 5\text{ A}$ ; $V_{CC} = 5\text{ V}$ ; $T_j = 25\text{ °C}$			20	m $\Omega$
$V_F$	Output - $V_{CC}$ diode voltage	$-I_{OUT} = 5\text{ A}$ ; $T_j = 150\text{ °C}$			0.7	V
$V_{clamp}$	Clamp voltage	$I_{CC} = 20\text{ mA}$ ; $I_{OUT} = 0\text{ A}$	41	46	52	V
$I_S$	Supply current	Off-state; $V_{CC} = 13\text{ V}$ ; $T_j = 25\text{ °C}$ ; $V_{IN} = V_{OUT} = V_{SENSE} = 0\text{ V}$		2	5	$\mu\text{A}$
		On-state; $V_{CC} = 13\text{ V}$ ; $V_{IN} = 5\text{ V}$ ; $I_{OUT} = 0\text{ A}$		1.5	3	mA
$I_{L(off1)}$	Off-state output current	$V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 13\text{ V}$ ; $T_j = 25\text{ °C}$	0	0.01	3	$\mu\text{A}$
		$V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 13\text{ V}$ ; $T_j = 125\text{ °C}$	0		5	$\mu\text{A}$

**Table 6. Switching ( $V_{CC} = 13\text{ V}$ ,  $T_j = 25\text{ °C}$ )**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$R_L = 2.6\ \Omega$ (see <a href="#">Figure 5</a> )	—	15	—	$\mu\text{s}$
$t_{d(off)}$	Turn-off delay time	$R_L = 2.6\ \Omega$ (see <a href="#">Figure 5</a> )	—	45	—	$\mu\text{s}$
$(dV_{OUT}/dt)_{on}$	Turn-on voltage slope	$R_L = 2.6\ \Omega$	—	0.2	—	V/ $\mu\text{s}$
$(dV_{OUT}/dt)_{off}$	Turn-off voltage slope	$R_L = 2.6\ \Omega$	—	0.2	—	V/ $\mu\text{s}$
$W_{ON}$	Switching energy losses at turn-on ( $t_{won}$ )	$R_L = 2.6\ \Omega$ (see <a href="#">Figure 5</a> )	—	1.4	—	mJ
$W_{OFF}$	Switching energy losses at turn-off ( $t_{won}$ )	$R_L = 2.6\ \Omega$ (see <a href="#">Figure 5</a> )	—	0.8	—	mJ

Table 7. Logic inputs

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{IL}$	Input low level voltage				0.9	V
$I_{IL}$	Low level input current	$V_{IN} = 0.9\text{ V}$	1			$\mu\text{A}$
$V_{IH}$	Input high level voltage		2.1			V
$I_{IH}$	High level input current	$V_{IN} = 2.1\text{ V}$			10	$\mu\text{A}$
$V_{I(hyst)}$	Input hysteresis voltage		0.25			V
$V_{ICL}$	Input clamp voltage	$I_{IN} = 1\text{ mA}$	5.5		7	V
		$I_{IN} = -1\text{ mA}$		-0.7		V
$V_{CSDL}$	CS_DIS low level voltage				0.9	V
$I_{CSDL}$	Low level CS_DIS current	$V_{CSD} = 0.9\text{ V}$	1			$\mu\text{A}$
$V_{CSDH}$	CS_DIS high level voltage		2.1			V
$I_{CSDH}$	High level CS_DIS current	$V_{CSD} = 2.1\text{ V}$			10	$\mu\text{A}$
$V_{CSD(hyst)}$	CS_DIS hysteresis voltage		0.25			V
$V_{CSCL}$	CS_DIS clamp voltage	$I_{CSD} = 1\text{ mA}$	5.5		7	V
		$I_{CSD} = -1\text{ mA}$		-0.7		V

Table 8. Protection and diagnostics (1)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{limH}$	Short circuit current	$V_{CC} = 13\text{ V}$	54	73	108	A
		$5\text{ V} < V_{CC} < 28\text{ V}$			108	A
$I_{limL}$	Short circuit current during thermal cycling	$V_{CC} = 13\text{ V};$ $T_R < T_j < T_{TSD}$		18		A
$T_{TSD}$	Shutdown temperature		150	175	200	$^{\circ}\text{C}$
$T_R$	Reset temperature		$T_{RS} + 1$	$T_{RS} + 5$		$^{\circ}\text{C}$
$T_{RS}$	Thermal reset of status		135			$^{\circ}\text{C}$
$T_{HYST}$	Thermal hysteresis ( $T_{TSD} - T_R$ )			7		$^{\circ}\text{C}$
$V_{DEMAG}$	Turn-off output voltage clamp	$I_{OUT} = 2\text{ A}; V_{IN} = 0;$ $L = 6\text{ mH}$	$V_{CC} - 41$	$V_{CC} - 46$	$V_{CC} - 52$	V
$V_{ON}$	Output voltage drop limitation	$I_{OUT} = 0.5\text{ A};$ $T_j = -40\text{ }^{\circ}\text{C}$ to $150\text{ }^{\circ}\text{C}$		25		mV

1. To ensure long term reliability under heavy overload or short circuit conditions, protection and related diagnostic signals must be used together with a proper software strategy. If the device is subjected to abnormal conditions, this software must limit the duration and number of activation cycles.

Table 9. Current sense ( $8\text{ V} < V_{CC} < 18\text{ V}$ )

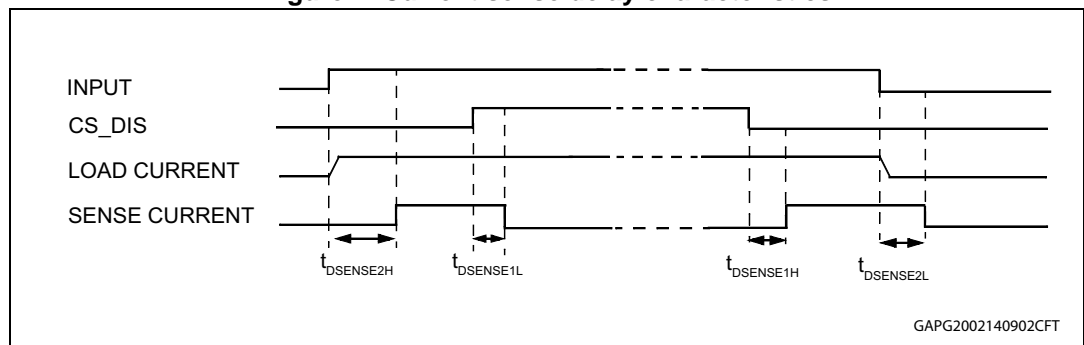
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$K_0$	$I_{OUT}/I_{SENSE}$	$I_{OUT} = 0.25\text{ A}$ ; $V_{SENSE} = 0.5\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$	2836	6200	10444	
$K_1$	$I_{OUT}/I_{SENSE}$	$I_{OUT} = 5\text{ A}$ ; $V_{SENSE} = 0.5\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$ $T_j = 25\text{ °C}$ to $150\text{ °C}$	4306 4358	5200 5200	7004 6106	
$dK_1/K_1^{(1)}$	Current sense ratio drift	$I_{OUT} = 5\text{ A}$ ; $V_{SENSE} = 0.5\text{ V}$ ; $V_{CSD} = 0\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$	- 11		+ 11	%
$K_2$	$I_{OUT}/I_{SENSE}$	$I_{OUT} = 10\text{ A}$ ; $V_{SENSE} = 4\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$ $T_j = 25\text{ °C}$ to $150\text{ °C}$	4608 4501	5040 5040	5926 5502	
$dK_2/K_2^{(1)}$	Current sense ratio drift	$I_{OUT} = 10\text{ A}$ ; $V_{SENSE} = 4\text{ V}$ ; $V_{CSD} = 0\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$	- 8		+ 8	%
$K_3$	$I_{OUT}/I_{SENSE}$	$I_{OUT} = 25\text{ A}$ ; $V_{SENSE} = 4\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$ $T_j = 25\text{ °C}$ to $150\text{ °C}$	4612 4566	4930 4930	5367 5168	
$dK_3/K_3^{(1)}$	Current sense ratio drift	$I_{OUT} = 25\text{ A}$ ; $V_{SENSE} = 4\text{ V}$ ; $V_{CSD} = 0\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$	- 4		+ 4	%
$I_{SENSE0}$	Analog sense leakage current	$I_{OUT} = 0\text{ A}$ ; $V_{SENSE} = 0\text{ V}$ ; $V_{CSD} = 5\text{ V}$ ; $V_{IN} = 0\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$	0		1	$\mu\text{A}$
		$V_{CSD} = 0\text{ V}$ ; $V_{IN} = 5\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$	0		2	$\mu\text{A}$
		$I_{OUT} = 2\text{ A}$ ; $V_{SENSE} = 0\text{ V}$ ; $V_{CSD} = 5\text{ V}$ ; $V_{IN} = 5\text{ V}$ ; $T_j = -40\text{ °C}$ to $150\text{ °C}$			1	$\mu\text{A}$
$I_{OL}$	Openload ON-state current detection threshold	$V_{IN} = 5\text{ V}$ ; $I_{SENSE} = 5\text{ }\mu\text{A}$	5		70	mA
$V_{SENSE}$	Max analog sense output voltage	$I_{OUT} = 18\text{ A}$ ; $R_{SENSE} = 3.9\text{ K}\Omega$	5			V
$V_{SENSEH}^{(2)}$	Analog sense output voltage in fault condition	$V_{CC} = 13\text{ V}$ ; $R_{SENSE} = 3.9\text{ K}\Omega$		8		V
$I_{SENSEH}^{(2)}$	Analog sense output current in fault condition	$V_{CC} = 13\text{ V}$ ; $V_{SENSE} = 5\text{ V}$		9		mA
$t_{DSENSE1H}$	Delay response time from falling edge of CS_DIS pin	$V_{SENSE} < 4\text{ V}$ ; $1.5\text{ A} < I_{OUT} < 25\text{ A}$ ; $I_{SENSE} = 90\%$ of $I_{SENSE\text{ max}}$ (see <a href="#">Figure 4</a> )		50	100	$\mu\text{s}$
$t_{DSENSE1L}$	Delay response time from rising edge of CS_DIS pin	$V_{SENSE} < 4\text{ V}$ ; $1.5\text{ A} < I_{OUT} < 25\text{ A}$ ; $I_{SENSE} = 10\%$ of $I_{SENSE\text{ max}}$ (see <a href="#">Figure 4</a> )		5	20	$\mu\text{s}$

**Table 9. Current sense (8 V < V<sub>CC</sub> < 18 V) (continued)**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
t <sub>DSENSE2H</sub>	Delay response time from rising edge of INPUT pin	V <sub>SENSE</sub> < 4 V; 1.5 A < I <sub>OUT</sub> < 25 A; I <sub>SENSE</sub> = 90 % of I <sub>SENSE max</sub> (see Figure 4)		270	600	μs
Δt <sub>DSENSE2H</sub>	Delay response time between rising edge of output current and rising edge of current sense	V <sub>SENSE</sub> < 4V; I <sub>SENSE</sub> = 90 % of I <sub>SENSEMAX</sub> ; I <sub>OUT</sub> = 90 % of I <sub>OUTMAX</sub> ; I <sub>OUTMAX</sub> = 3 A (see Figure 7)			280	μs
t <sub>DSENSE2L</sub>	Delay response time from falling edge of INPUT pin	V <sub>SENSE</sub> < 4 V; 1.5 A < I <sub>OUT</sub> < 25 A; I <sub>SENSE</sub> = 10 % of I <sub>SENSE max</sub> (see Figure 4)		100	250	μs

1. Parameter guaranteed by design, it is not tested.
2. Fault condition includes: power limitation and overtemperature.

**Figure 4. Current sense delay characteristics**



**Figure 5. Switching characteristics**

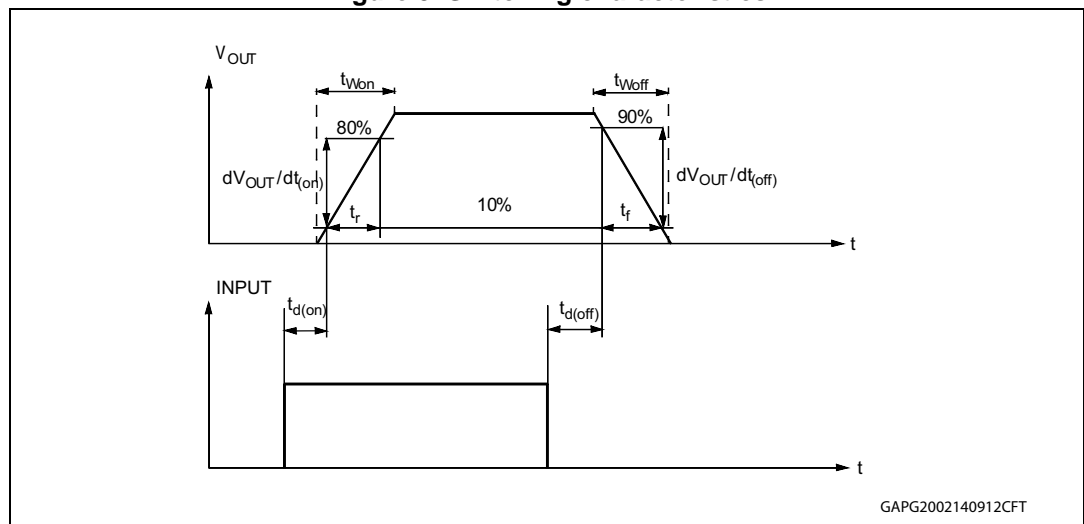


Figure 6. Output voltage drop limitation

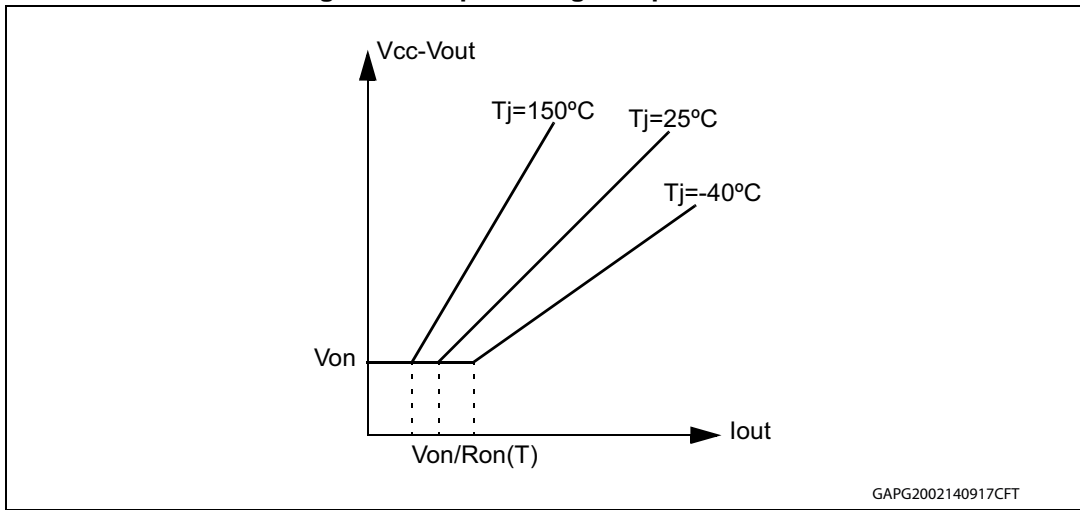


Figure 7. Delay response time between rising edge of output current and rising edge of current sense (CS enabled)

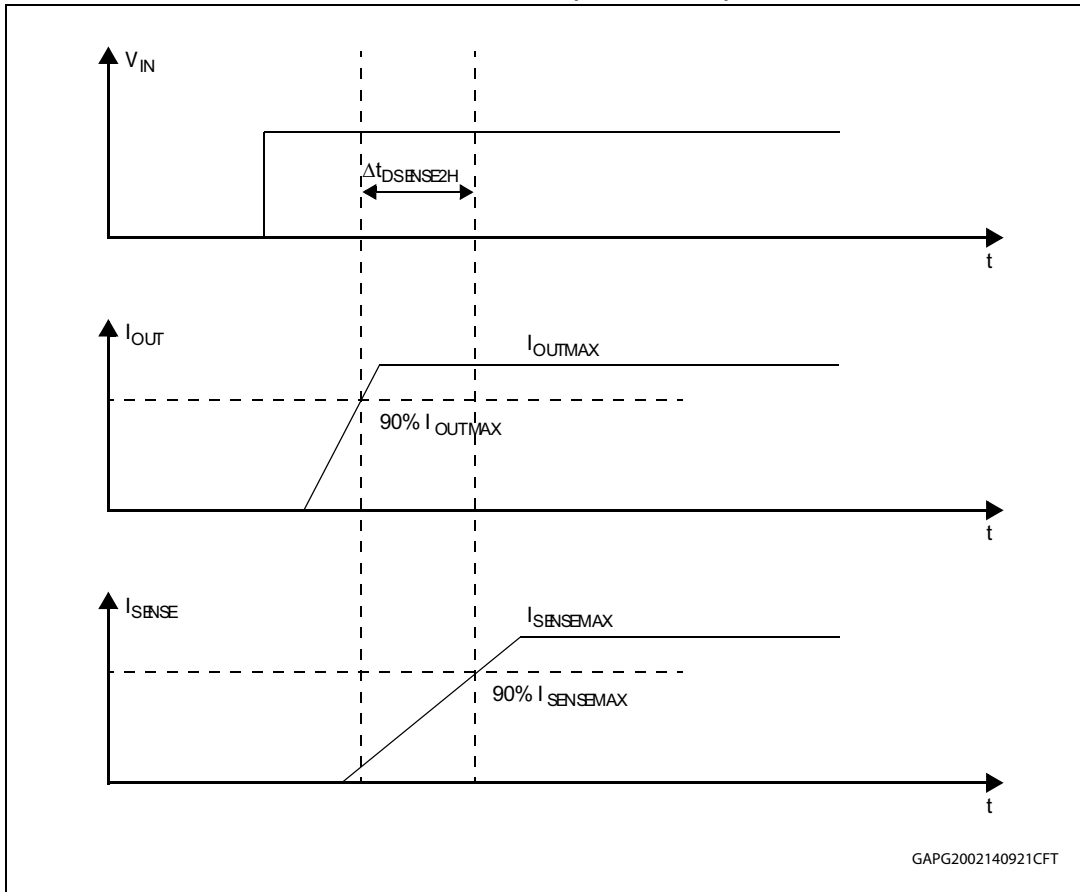


Figure 8.  $I_{OUT}/I_{SENSE}$  vs  $I_{OUT}$

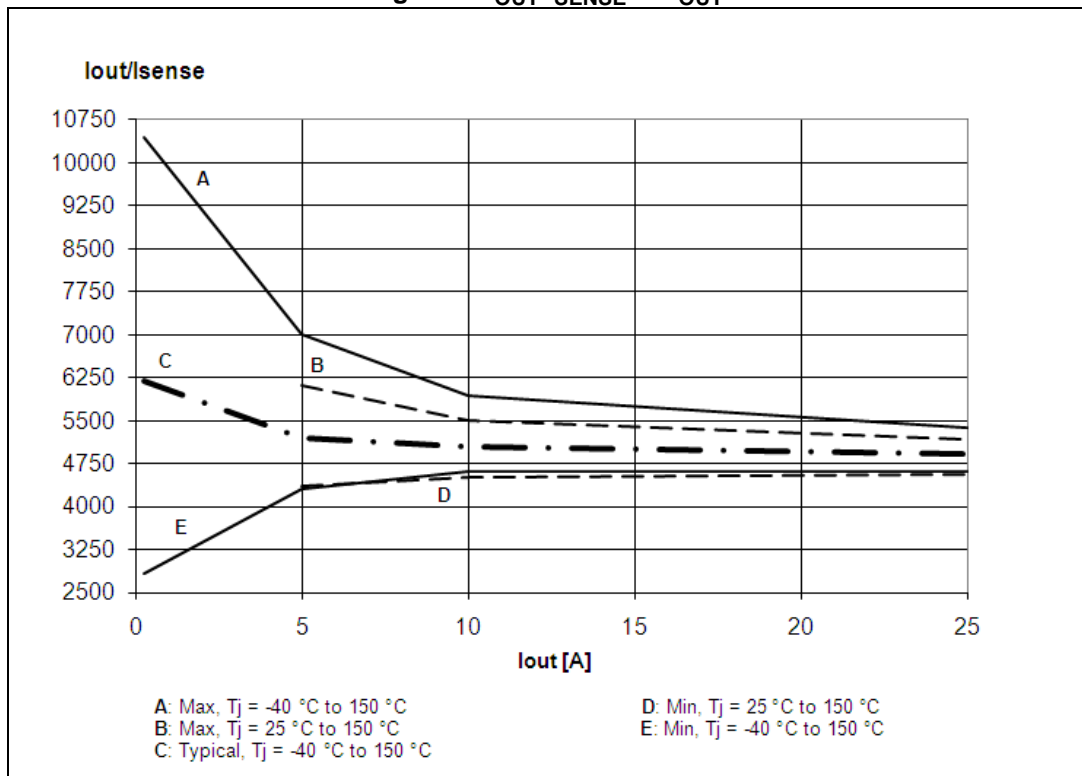


Figure 9. Maximum current sense ratio drift vs load current

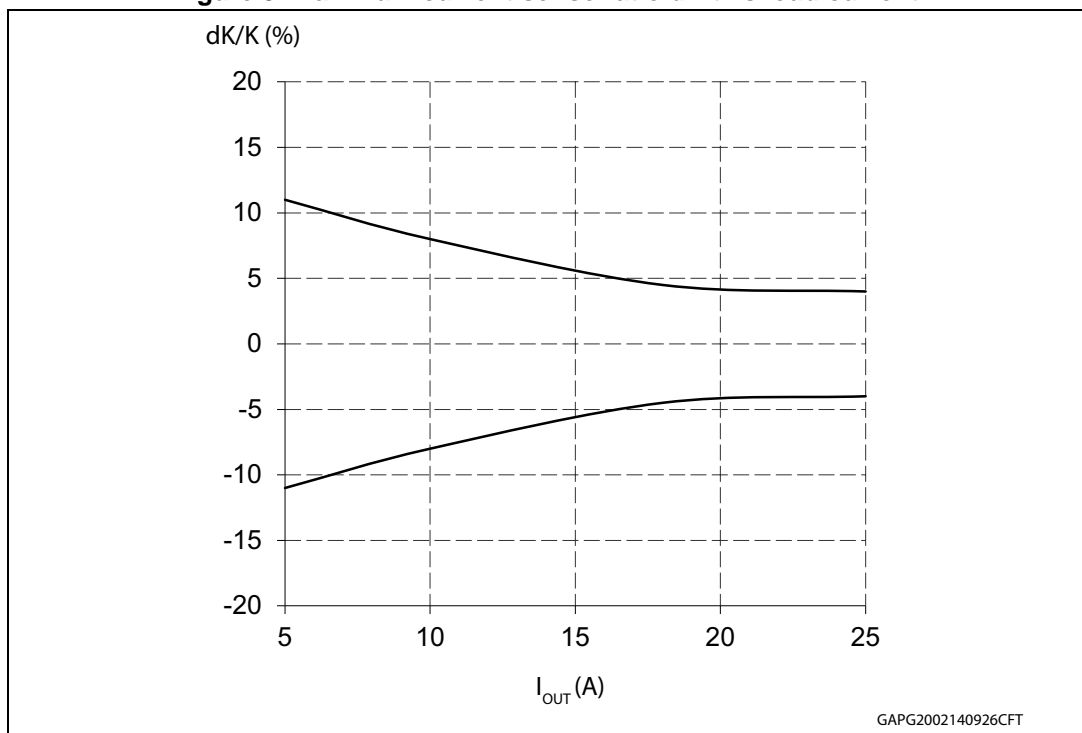


Table 10. Truth table

Conditions	Input	Output	Sense ( $V_{CSD} = 0\text{ V}$ ) <sup>(1)</sup>
Normal operation	L	L	0
	H	H	Nominal
Overtemperature	L	L	0
	H	L	$V_{SENSEH}$
Undervoltage	L	L	0
	H	L	0
Overload	H	X (no power limitation)	Nominal
	H	Cycling (power limitation)	$V_{SENSEH}$
Short circuit to GND (power limitation)	L	L	0
	H	L	$V_{SENSEH}$
Negative output voltage clamp	L	L	0

1. If the  $V_{CSD}$  is high, the SENSE output is at a high impedance, its potential depends on leakage currents and external circuit.

**Table 11. Electrical transient requirements (part 1)**

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

1. Valid in case of external load dump clamp: 40 V maximum referred to ground.

**Table 12. Electrical transient requirements (part 2)**

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

1. The above test levels must be considered referred to V<sub>CC</sub> = 13.5 V except for pulse 5b

2. Valid in case of external load dump clamp: 40 V maximum referred to ground.

**Table 13. 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.



## 2.4 Waveforms

Figure 10. Normal operation

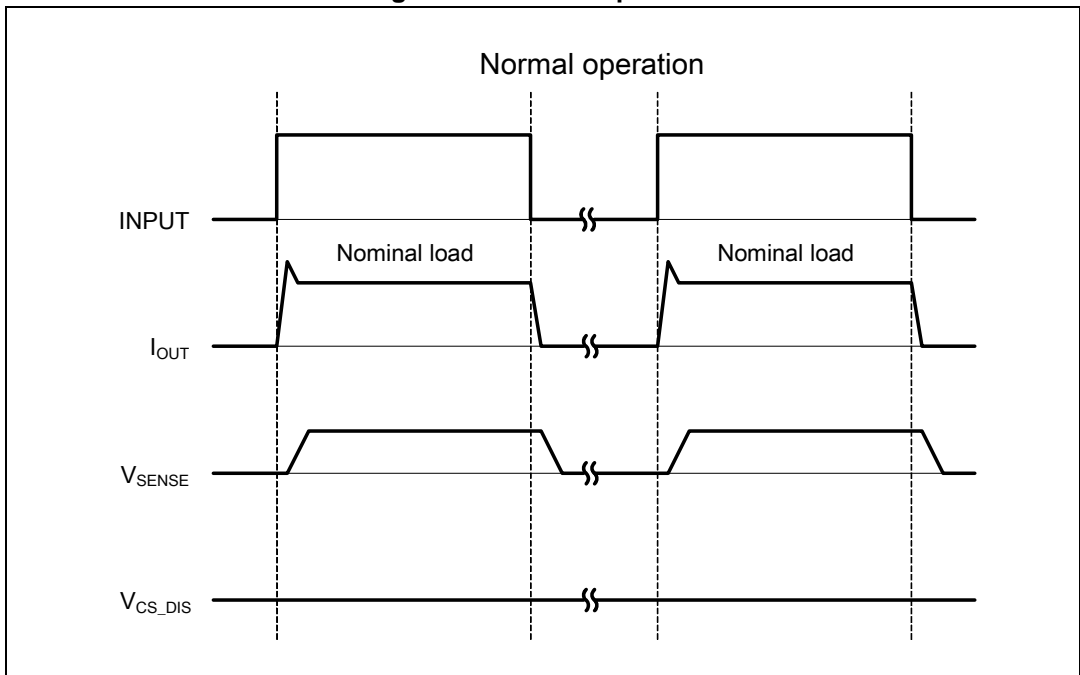


Figure 11. Overload or short to GND

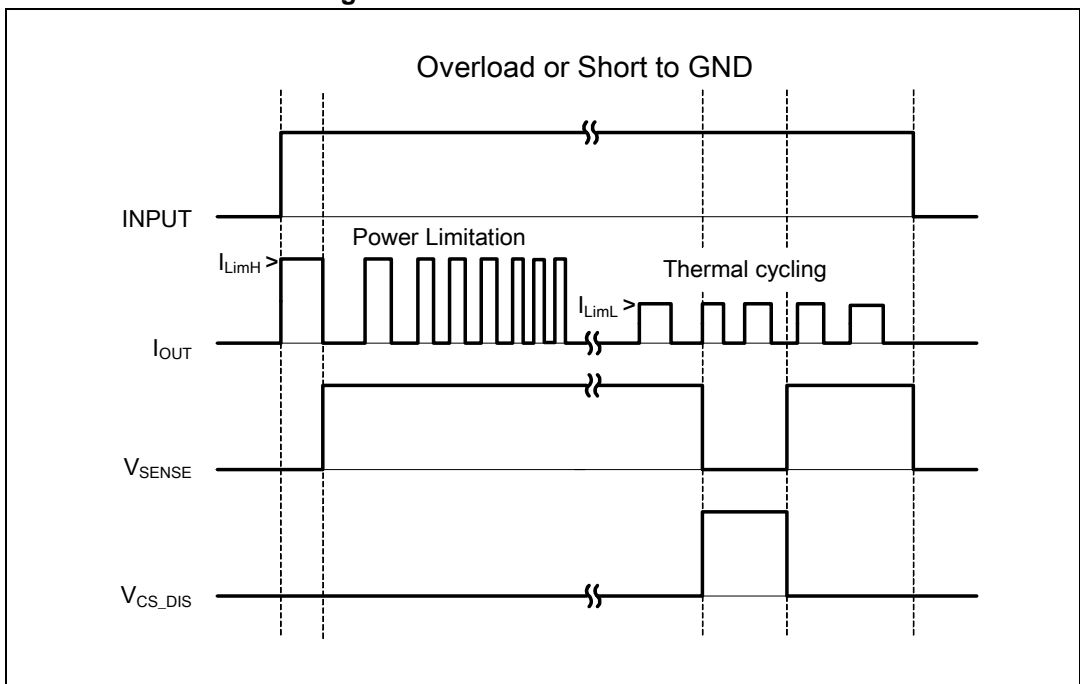


Figure 12. Intermittent overload

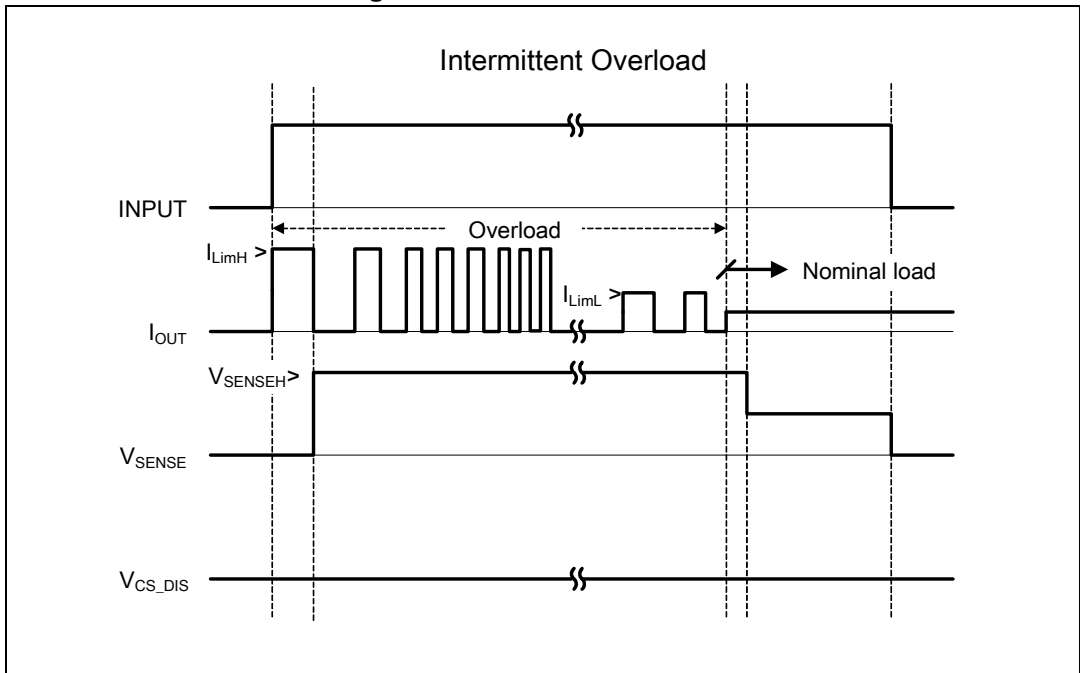
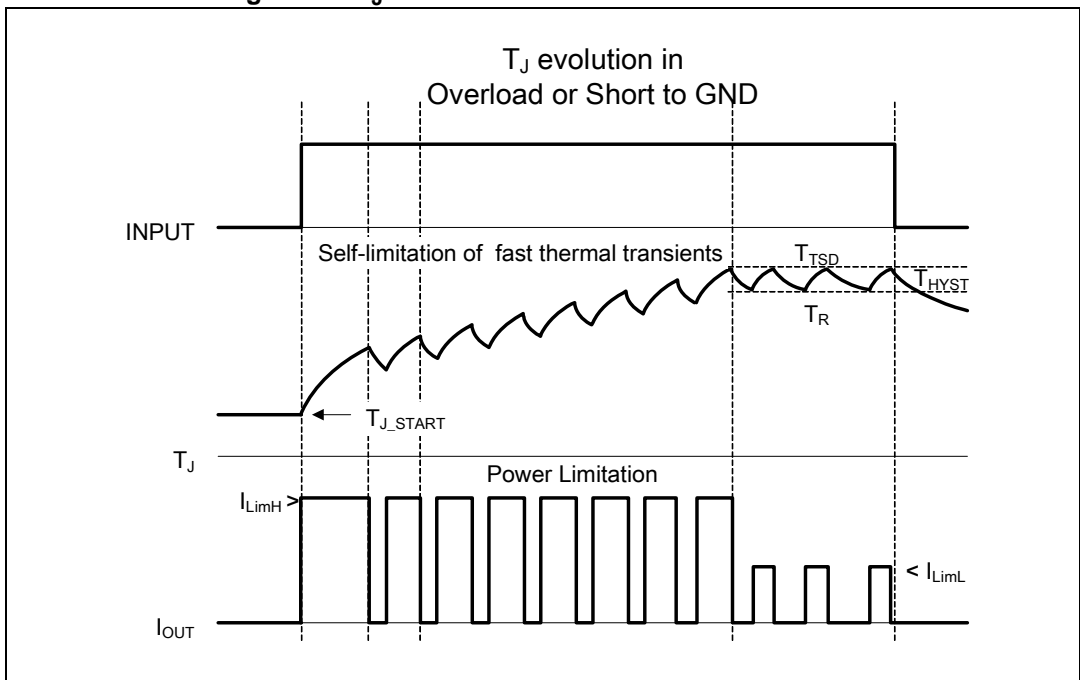


Figure 13. T<sub>J</sub> evolution in overload or short to GND



## 2.5 Electrical characteristics curves

Figure 14. Off-state output current

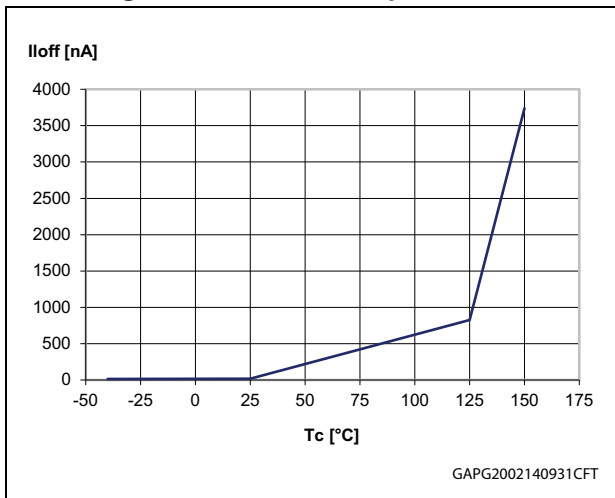


Figure 15. High level input current

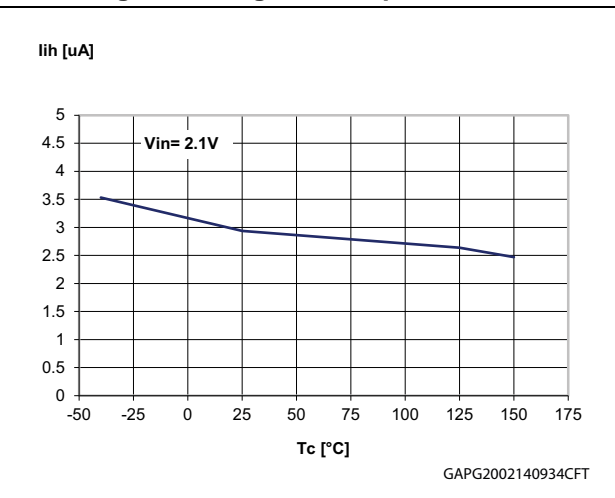


Figure 16. Input clamp level

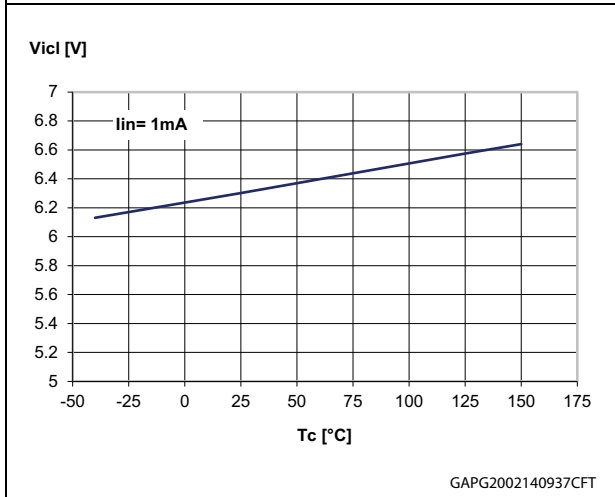


Figure 17. Input low level

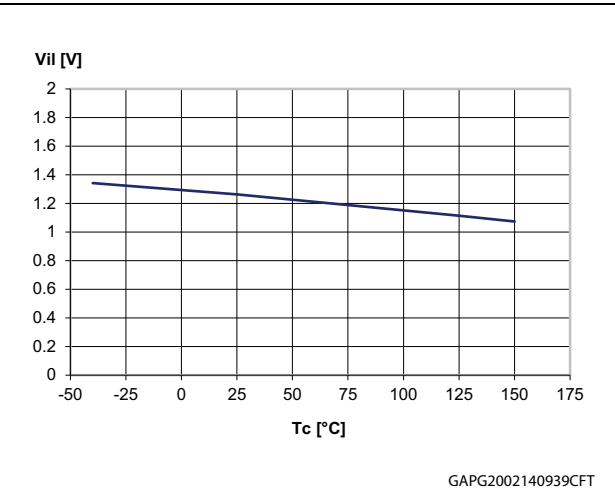


Figure 18. Input high level

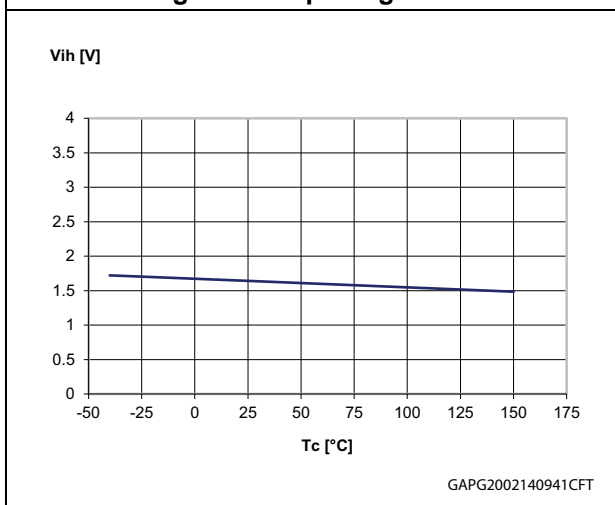
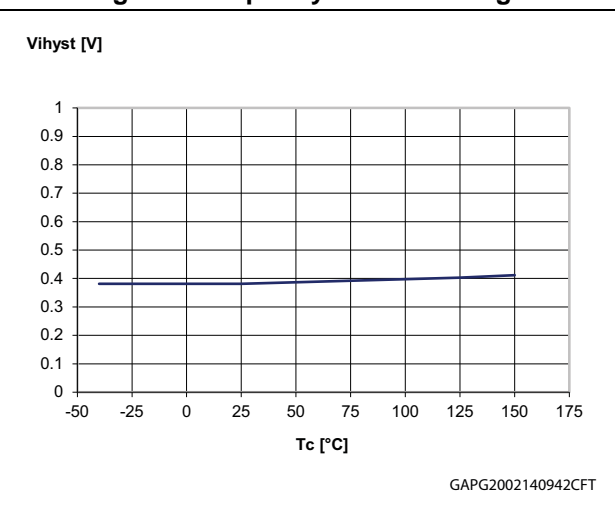


Figure 19. Input hysteresis voltage



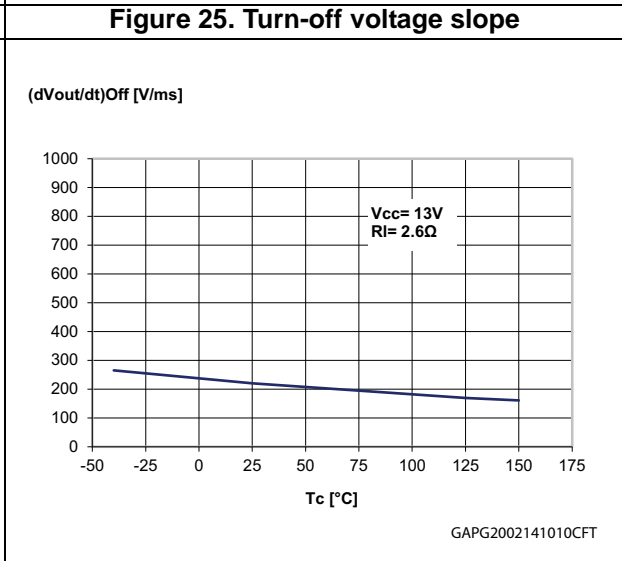
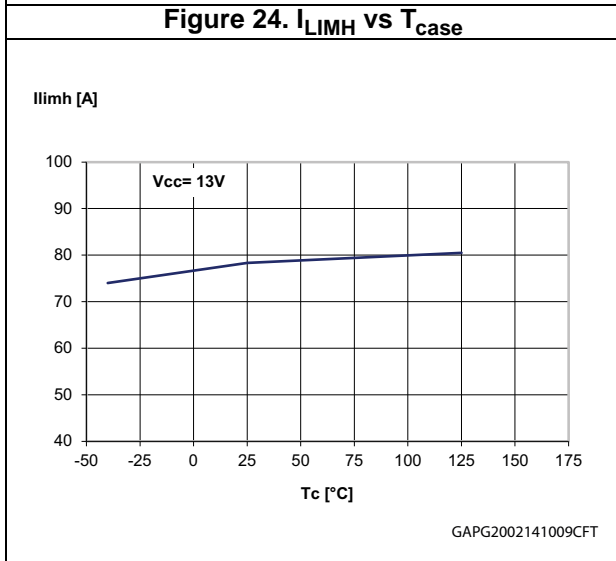
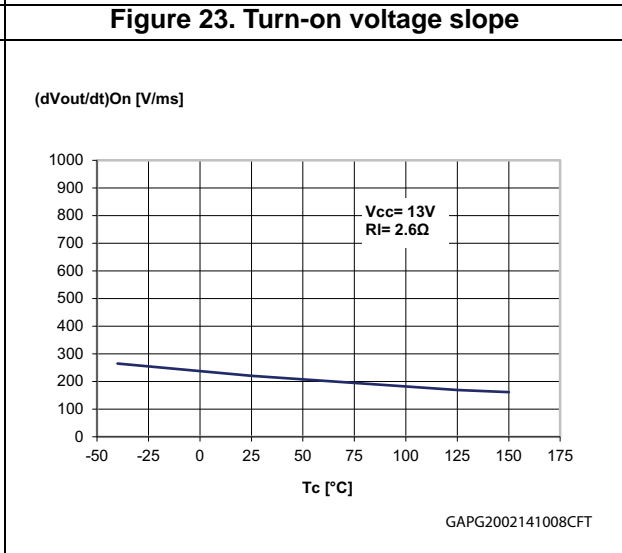
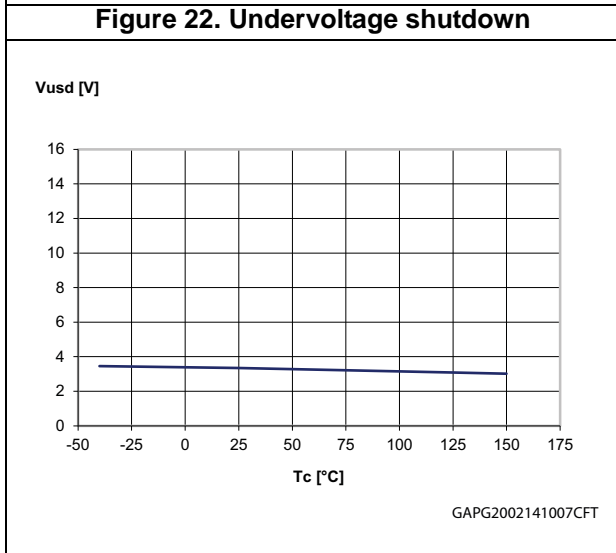
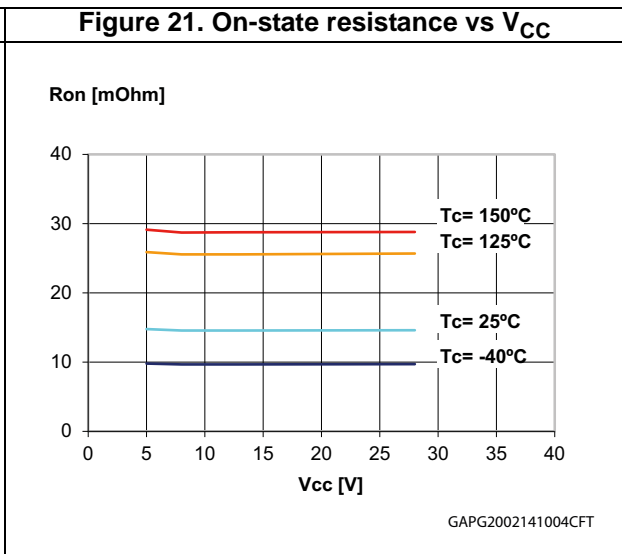
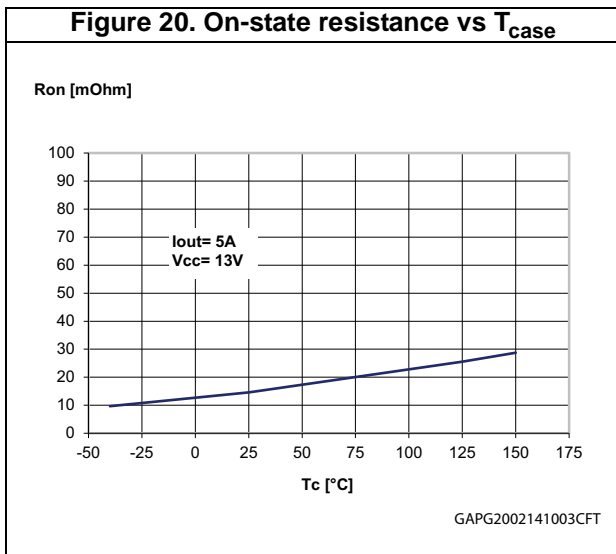


Figure 26. CS\_DIS high level voltage

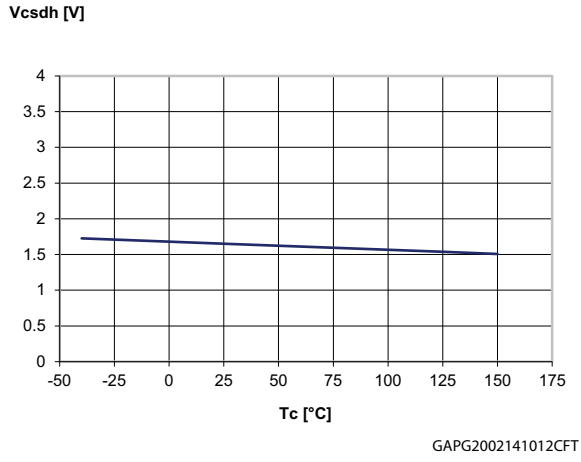


Figure 27. CS\_DIS clamp voltage

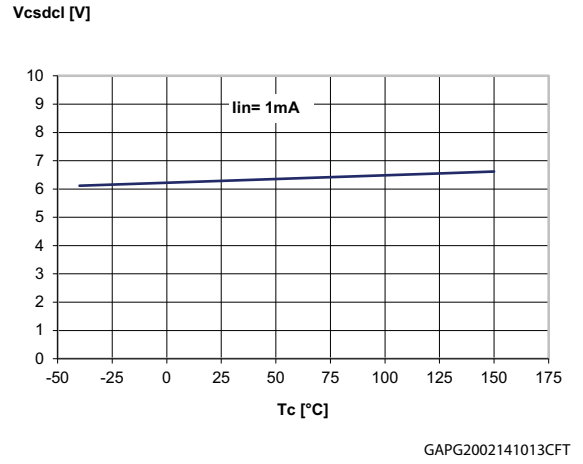
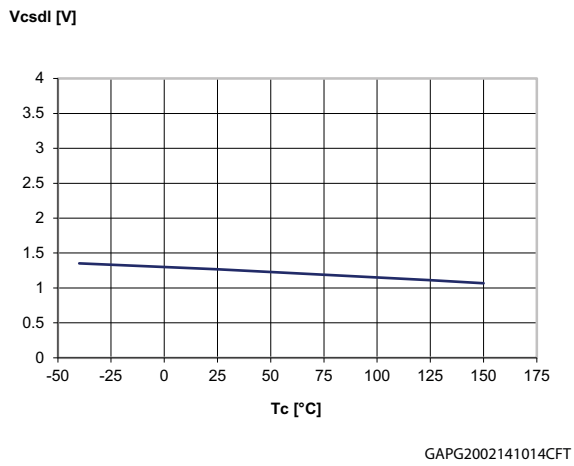
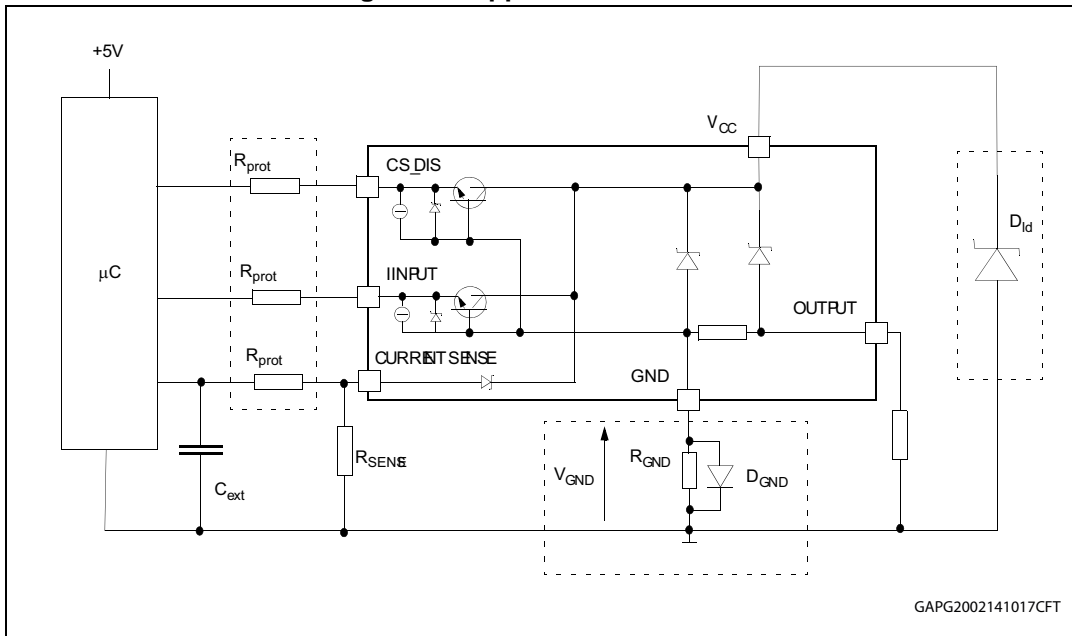


Figure 28. CS\_DIS low level voltage



### 3 Application information

Figure 29. Application schematic



GAPG2002141017CFT

#### 3.1 GND protection network against reverse battery

##### 3.1.1 Solution 1: resistor in the ground line (R\_GND only)

This can be used with any type of load.

The following is an indication on how to set the dimension of R\_GND resistor.

$$1) R_{GND} \leq 600 \text{ mV} / (I_{S(on)max})$$

$$2) R_{GND} \geq (-V_{CC}) / (-I_{GND})$$

where  $-I_{GND}$  is the DC reverse ground pin current and can be found in the absolute maximum rating section of the device datasheet.

Power dissipation in R\_GND (when  $V_{CC} < 0$ : during reverse battery situations) is:

##### Equation 1

$$P_D = (-V_{CC})^2 / R_{GND}$$

This resistor can be shared amongst several different HSDs. Please note that the value of this resistor should be calculated with formula (1) where  $I_{S(on)max}$  becomes the sum of the maximum on-state currents of the different devices.

Please note that if the microprocessor ground is not shared by the device ground then the R\_GND produces a shift ( $I_{S(on)max} * R_{GND}$ ) in the input thresholds and the status output values. This shift varies depending on how many devices are ON in the case of several high side drivers sharing the same R\_GND.

If the calculated power dissipation leads to a large resistor or several devices have to share the same resistor then ST suggests to utilize Solution 2 (see below).

### 3.1.2 Solution 2: a diode ( $D_{GND}$ ) in the ground line

A resistor ( $R_{GND} = 1 \text{ k}\Omega$ ) should be inserted in parallel to  $D_{GND}$  if the device drives an inductive load.

This small signal diode can be safely shared amongst several different HSDs. Also in this case, the presence of the ground network produces a shift ( $\approx 600 \text{ mV}$ ) in the input threshold and in the status output values if the microprocessor ground is not common to the device ground. This shift not varies if more than one HSD shares the same diode/resistor network.

## 3.2 Load dump protection

$D_{ld}$  is necessary (voltage transient suppressor) if the load dump peak voltage exceeds the  $V_{CC}$  max DC rating. The same applies if the device is subject to transients on the  $V_{CC}$  line that are greater than the ones shown in the ISO T/R 7637/1 table.

## 3.3 MCU I/Os protection

If a ground protection network is used and negative transients are present on the  $V_{CC}$  line, the control pins are pulled negative. ST suggests to insert a resistor ( $R_{prot}$ ) in line to prevent the MCU I/O pins from latching-up.

The value of these resistors is a compromise between the leakage current of MCU and the current required by the HSD I/Os (Input levels compatibility) with the latch-up limit of MCU I/Os.

### Equation 2

$$-V_{CCpeak}/I_{latchup} \leq R_{prot} \leq (V_{OH\mu C} - V_{IH} - V_{GND}) / I_{IHmax}$$

Calculation example:

For  $V_{CCpeak} = -100 \text{ V}$  and  $I_{latchup} \geq 20 \text{ mA}$ ;  $V_{OH\mu C} \geq 4.5 \text{ V}$

$$5 \text{ k}\Omega \leq R_{prot} \leq 65 \text{ k}\Omega.$$

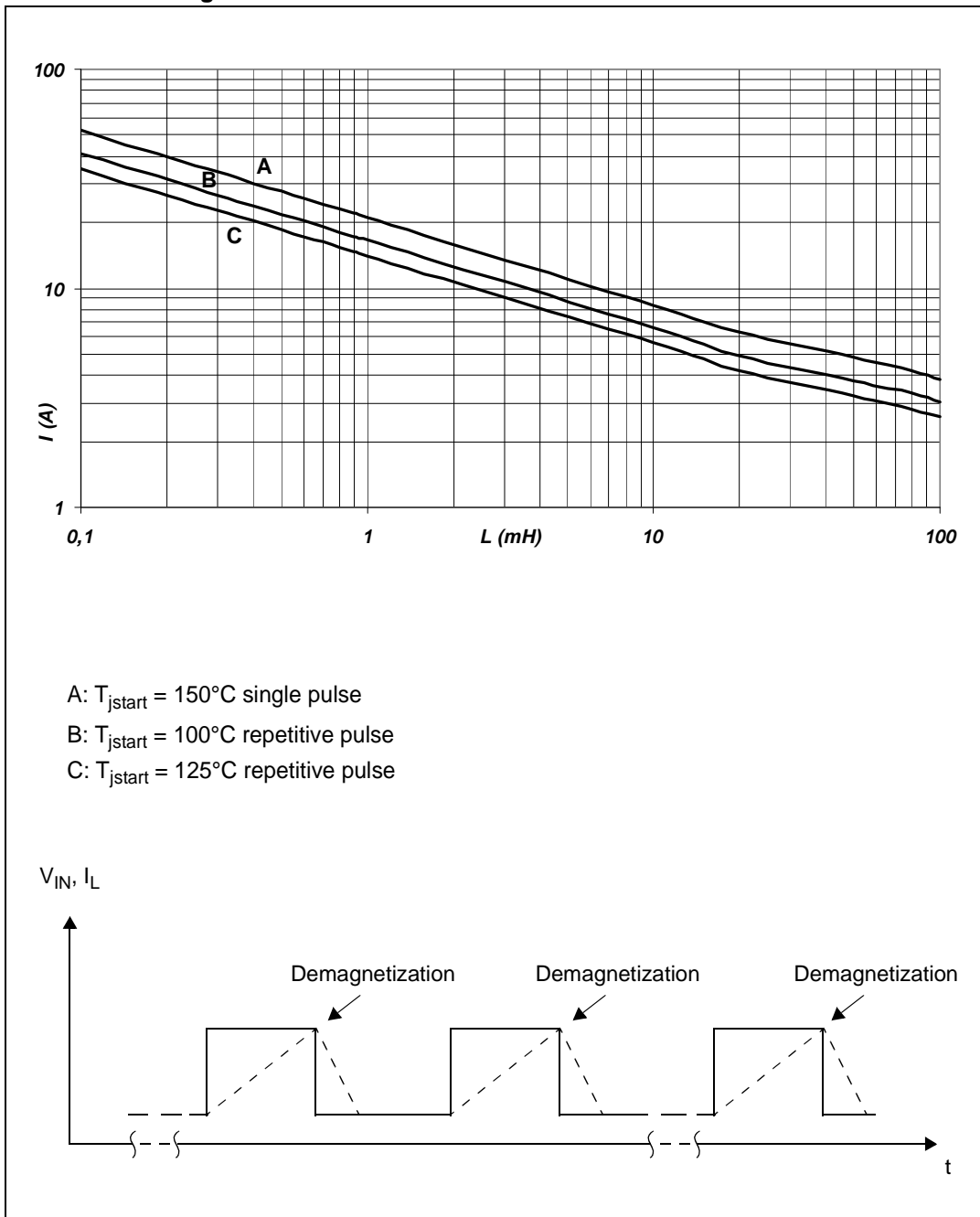
Recommended values:  $R_{prot} = 10 \text{ k}\Omega$ ,  $C_{EXT} = 10 \text{ nF}$ .





### 3.5 Maximum demagnetization energy ( $V_{CC} = 13.5\text{ V}$ )

Figure 31. Maximum turn-off current versus inductance

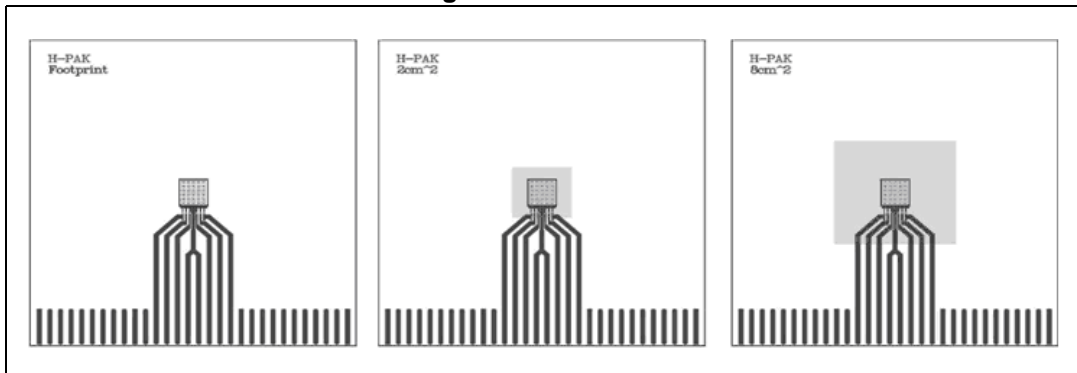


1. Values are generated with  $R_L = 0\ \Omega$ . In case of repetitive pulses,  $T_{jstart}$  (at the beginning of each demagnetization) of every pulse must not exceed the temperature specified above for curves A and B.

## 4 Package and PC board thermal data

### 4.1 HPak thermal data

Figure 32. PC board



1. Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (PCB FR4 area = 58 mm x 58 mm, PCB thickness = 1.8 mm, Cu thickness = 70  $\mu$ m, Copper areas: from minimum pad lay-out to 8 cm<sup>2</sup>).

Figure 33.  $R_{thj-amb}$  vs PCB copper area in open box free air condition

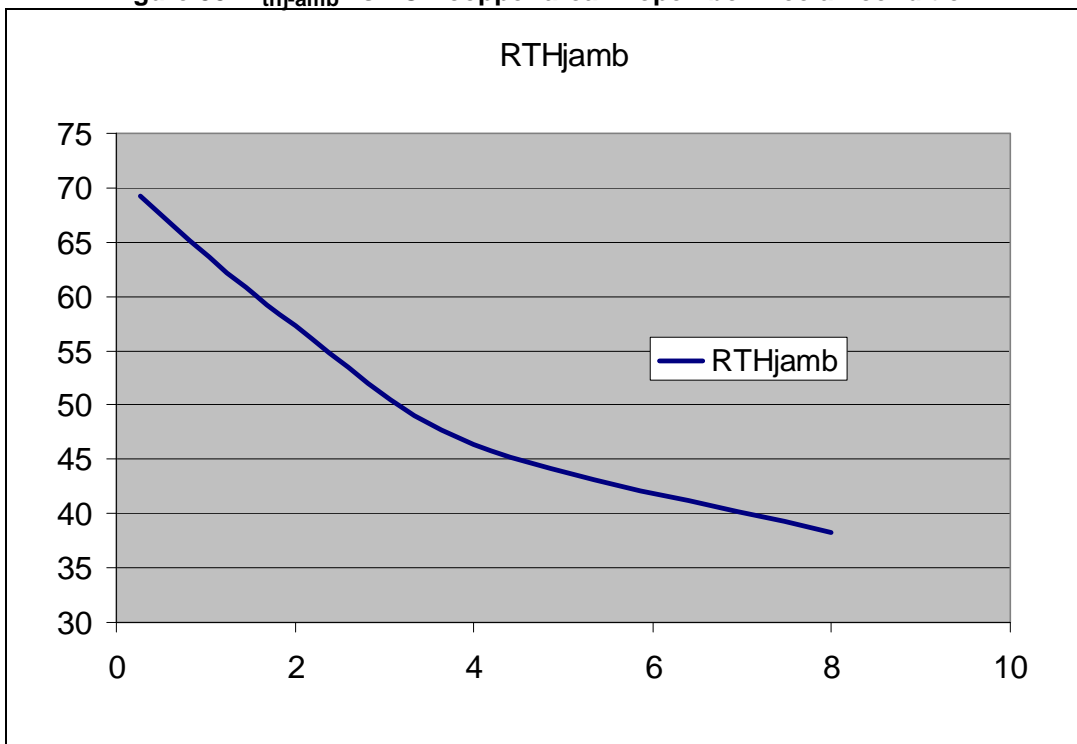
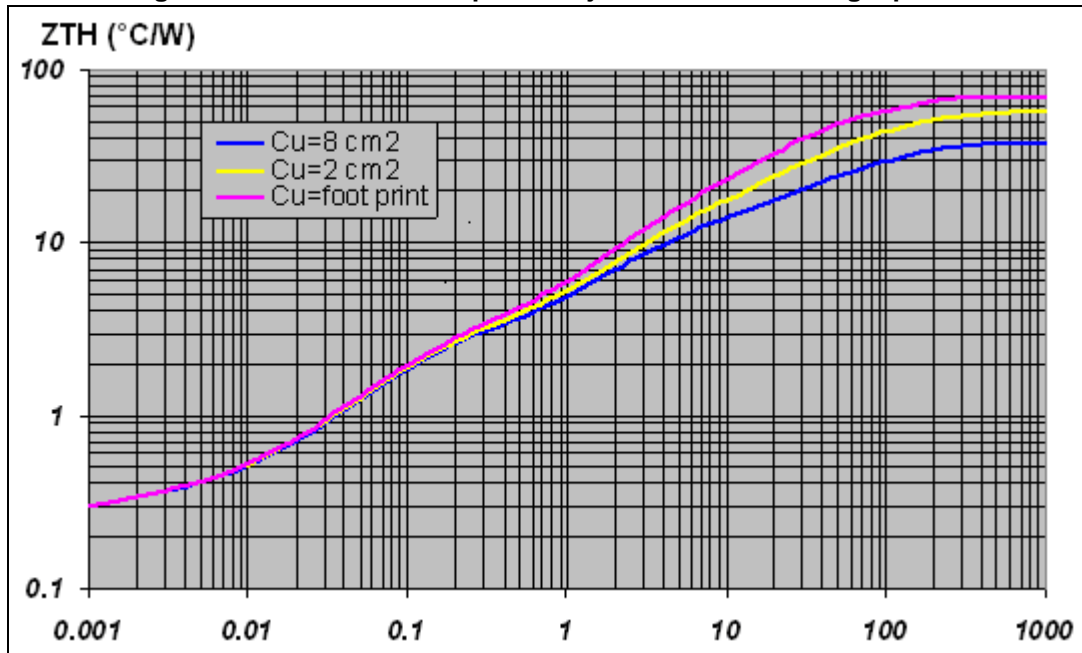


Figure 34. HPak thermal impedance junction ambient single pulse

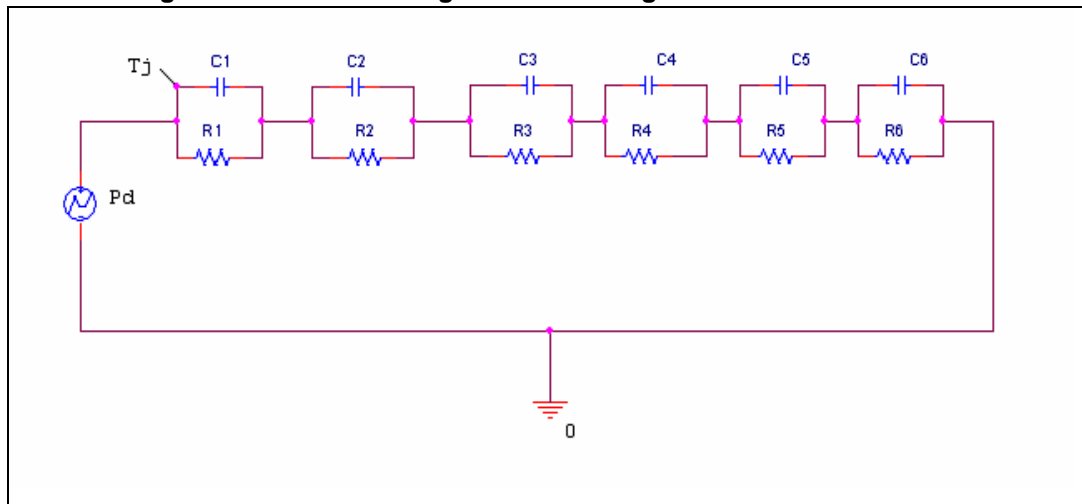


Equation 3: pulse calculation formula:

$$Z_{TH\delta} = R_{TH} \cdot \delta + Z_{THtp}(1 - \delta)$$

where  $\delta = t_p/T$

Figure 35. Thermal fitting model of a single channel HSD in HPak



1. The fitting model is a simplified thermal tool and is valid for transient evolutions where the embedded protections (power limitation or thermal cycling during thermal shutdown) are not triggered.

Table 14. Thermal parameter

Area/island (cm <sup>2</sup> )	Footprint	4	8
R1 (°C/W)	0.1	-	-
R2 (°C/W)	0.2	-	-
R3 (°C/W)	2	-	-
R4 (°C/W)	8	-	-
R5 (°C/W)	28	22	12
R6 (°C/W)	31	25	16
C1 (W.s/°C)	0.0001	-	-
C2 (W.s/°C)	0.002	-	-
C3 (W.s/°C)	0.05	-	-
C4 (W.s/°C)	0.4	-	-
C5 (W.s/°C)	0.8	1.4	3
C6 (W.s/°C)	3	6	9

## 5 Package and packing information

### 5.1 ECOPACK® packages

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.

### 5.2 HPak mechanical data

Figure 36. KPak package dimension

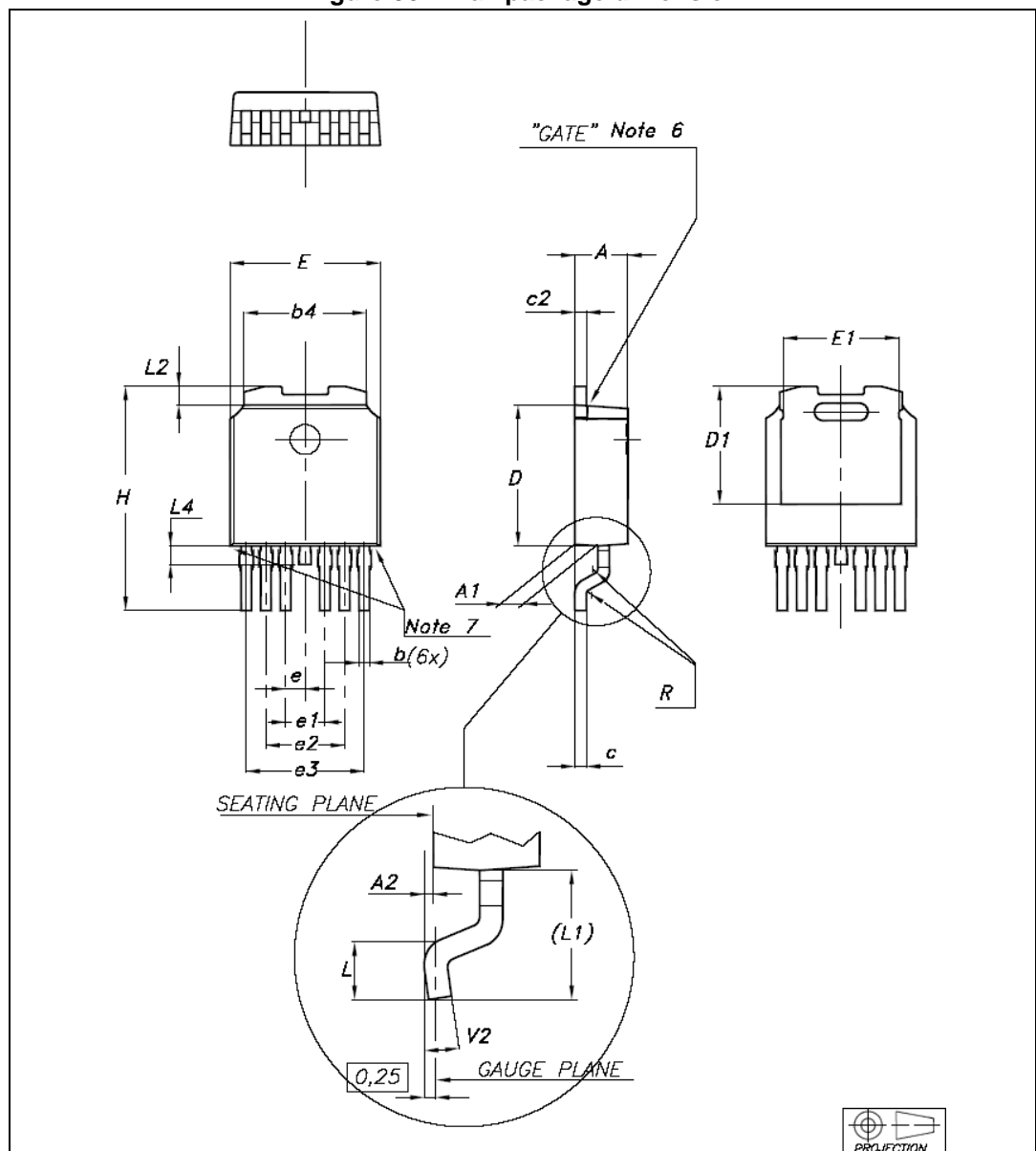


Table 15. HPak mechanical data

Ref. dim	Data book mm		
	Nom.	Min.	Max.
A		2.20	2.40
A1		0.90	1.10
A2		0.03	0.23
b		0.45	0.60
b4		5.20	5.40
c		0.45	0.60
c2		0.48	0.60
D		6.00	6.20
D1	5.10		
E		6.40	6.60
E1	5.20		
e	0.85		
e1		1.60	1.80
e2		3.30	3.50
e3		5.00	5.20
H		9.35	10.10
L		1	
(L1)	2.80		
L2	0.80		
L4		0.60	1.00
R	0.20		
V2		0°	8°

### 5.3 HPak packing information

The devices can be packed in tube or tape and reel shipments (see [Table 16: Device summary](#)).

Figure 37. HPak tube shipment (no suffix)

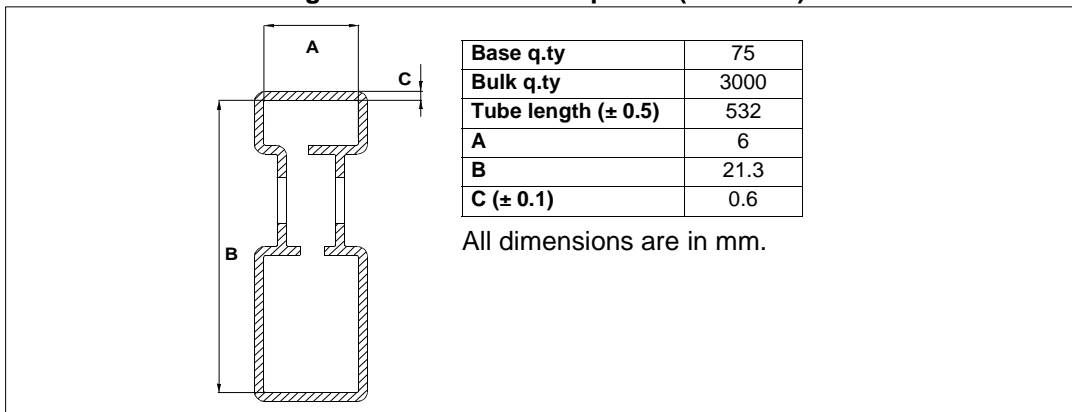
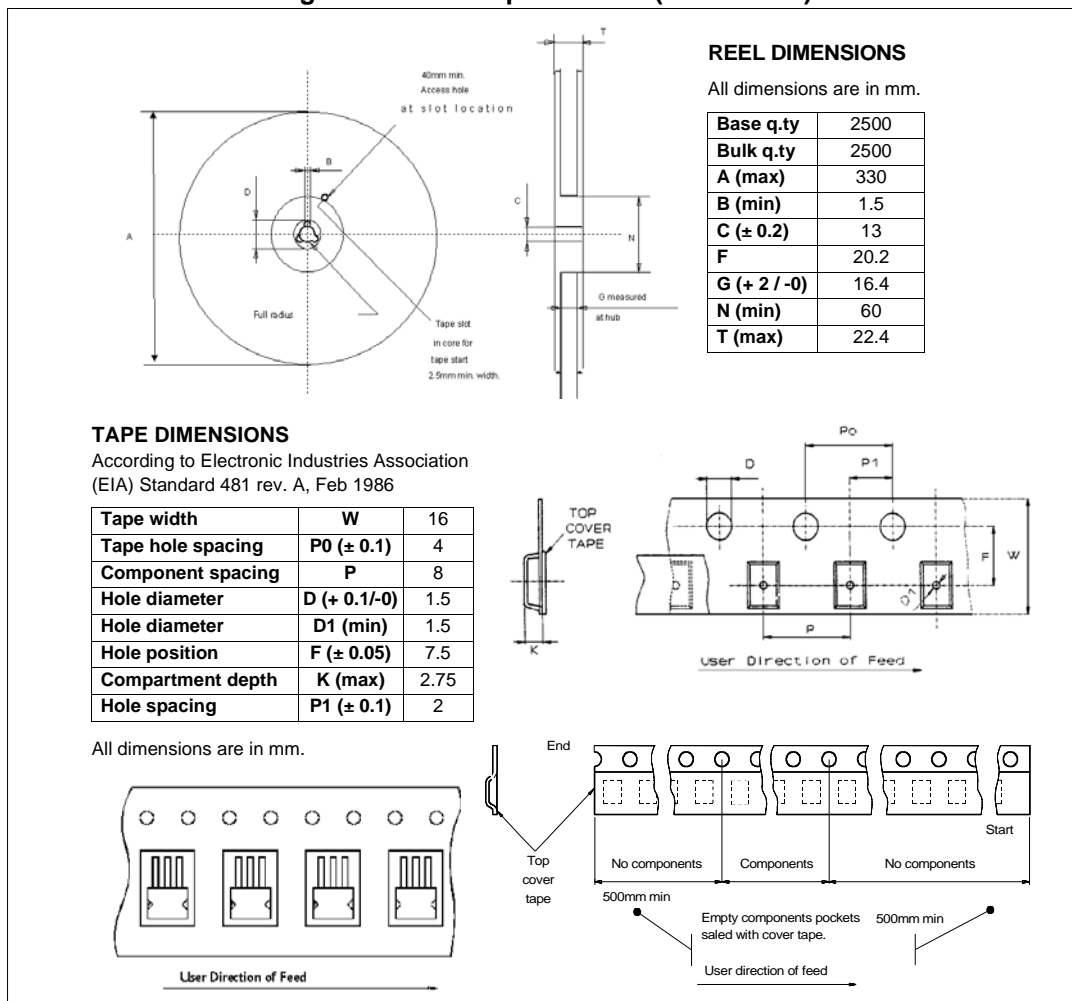


Figure 38. HPak tape and reel (suffix "TR")



## 6 Order codes

Table 16. Device summary

Package	Order codes	
	Tube	Tape and reel
7 pins H-pack	Root part number 1	VN5E016MHTR-E



## 7 Revision history

**Table 17. Document revision history**

Date	Revision	Changes
29-Jun-2010	1	Initial release.
30-Jun-2010	2	Changed status from target specification to preliminary data.
29-Jul-2010	3	<i>Table 9: Current sense (8 V &lt; VCC &lt; 18 V):</i> – Updated K1 maximum value for $T_j = 25\text{ °C} \dots 150\text{ °C}$
04-Aug-2010	4	<i>Table 9: Current sense (8 V &lt; VCC &lt; 18 V):</i> – Updated K1, K2 and K3 typical values for $T_j = -40\text{ °C} \dots 150\text{ °C}$ – Updated $dK_1/K_1$ test conditions Updated <i>Figure 8: IOUT/ISENSE vs IOUT</i> .
19-Feb-2014	5	Changed document status from “Preliminary data” to “Production data”
07-May-2014	6	Updated <i>Figure 2: Configuration diagram (top view) not in scale</i>

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