

## Single channel high-side driver with analog current sense for 24 V automotive applications

Datasheet – production data



- Overvoltage clamp
- Load current limitation
- Self limiting of fast thermal transients
- Protection against loss of ground and loss of  $V_{CC}$
- Thermal shutdown
- Reverse battery protected with self switch of the PowerMOS
- Electrostatic discharge protection

### Features

Max transient supply voltage	$V_{CC}$	58V
Operating voltage range	$V_{CC}$	8 to 36V
Typ ON-state resistance	$R_{ON}$	16 m $\Omega$
Current limitation (typ)	$I_{LIM}$	60 A
OFF-state supply current	$I_S$	2 $\mu$ A <sup>(1)</sup>

1. Typical value with all loads connected.

- General
  - Very low stand-by current
  - 3.0 V CMOS compatible input
  - Optimized electromagnetic emission
  - Very low electromagnetic susceptibility
  - Compliant with European directive 2002/95/EC
  - Fault reset standby pin (FR\_Stby)
- Diagnostic functions
  - Proportional load current sense
  - Current sense precision for wide range currents
  - Off-state open load detection
  - Output short to  $V_{CC}$  detection
  - Overload and short to ground latch-off
  - Thermal shutdown latch-off
  - Very low current sense leakage
- Protections
  - Undervoltage shutdown

### Applications

- All types of resistive, inductive and capacitive loads

### Description

The VN5T016AH-E is a device made using STMicroelectronics® VIPower® technology, intended for driving resistive or inductive loads with one side connected to ground. Active  $V_{CC}$  pin voltage clamp protects the device against low energy spikes. This device integrates an analog current sense which delivers a current proportional to the load current. Fault conditions such as overload, overtemperature or short to  $V_{CC}$  are reported via the current sense pin.

Output current limitation protects the device in overload condition. The device latches off in case of overload or thermal shutdown.

The device is reset by a low level pass on the fault reset standby pin.

A permanent low level on the inputs and fault reset standby pin disables all outputs and sets the device in standby mode.

# Contents

<b>1</b>	<b>Block diagram and pin description</b>	<b>5</b>
<b>2</b>	<b>Electrical specifications</b>	<b>7</b>
2.1	Absolute maximum ratings	7
2.2	Thermal data	8
2.3	Electrical characteristics	9
2.4	Electrical characteristics curves	19
<b>3</b>	<b>Application information</b>	<b>21</b>
3.1	Load dump protection	21
3.2	MCU I/Os protection	21
3.3	Maximum demagnetization energy ( $V_{CC} = 24\text{ V}$ )	22
<b>4</b>	<b>Package and PCB thermal data</b>	<b>23</b>
4.1	HPAK thermal data	23
<b>5</b>	<b>Package information</b>	<b>26</b>
5.1	HPAK mechanical data	26
5.2	Packing information	28
<b>6</b>	<b>Order codes</b>	<b>29</b>
<b>7</b>	<b>Revision history</b>	<b>30</b>

## List of tables

Table 1.	Pin function . . . . .	5
Table 2.	Suggested connections for unused and not connected pins . . . . .	6
Table 3.	Absolute maximum ratings . . . . .	7
Table 4.	Thermal data . . . . .	8
Table 5.	Power section . . . . .	9
Table 6.	Switching ( $V_{CC} = 24\text{ V}$ ; $T_j = 25\text{ °C}$ ) . . . . .	9
Table 7.	Logic inputs . . . . .	10
Table 8.	Protections and diagnostics . . . . .	11
Table 9.	Current sense ( $8\text{ V} < V_{CC} < 36\text{ V}$ ) . . . . .	11
Table 10.	Open-load detection ( $FR\_Stby = 5\text{ V}$ ) . . . . .	13
Table 11.	Truth table . . . . .	17
Table 12.	Electrical transient requirements (part 1) . . . . .	18
Table 13.	Electrical transient requirements (part 2) . . . . .	18
Table 14.	Electrical transient requirements (part 3) . . . . .	18
Table 15.	Thermal parameters . . . . .	25
Table 16.	HPAK mechanical data . . . . .	27
Table 17.	Device summary . . . . .	29
Table 18.	Document revision history . . . . .	30

## List of figures

Figure 1.	Block diagram . . . . .	5
Figure 2.	Configuration diagram (top view) . . . . .	6
Figure 3.	Current and voltage conventions . . . . .	7
Figure 4.	$T_{\text{reset}}$ definition . . . . .	10
Figure 5.	$T_{\text{stby}}$ definition . . . . .	11
Figure 6.	Output stuck to $V_{\text{CC}}$ detection delay time at $FR_{\text{STBY}}$ activation . . . . .	14
Figure 7.	Current sense delay characteristics . . . . .	14
Figure 8.	Open-load off-state delay timing . . . . .	14
Figure 9.	Switching characteristics . . . . .	15
Figure 10.	Delay response time between rising edge of output current and rising edge of current sense . . . . .	15
Figure 11.	Output voltage drop limitation . . . . .	16
Figure 12.	Device behavior in overload condition . . . . .	16
Figure 13.	Off-state output current . . . . .	19
Figure 14.	High level input current . . . . .	19
Figure 15.	Input clamp voltage . . . . .	19
Figure 16.	Input low level voltage . . . . .	19
Figure 17.	Input high level voltage . . . . .	19
Figure 18.	Input hysteresis voltage . . . . .	19
Figure 19.	On-state resistance vs $T_{\text{case}}$ . . . . .	20
Figure 20.	On-state resistance vs $V_{\text{CC}}$ . . . . .	20
Figure 21.	$I_{\text{LIMH}}$ vs $T_{\text{case}}$ . . . . .	20
Figure 22.	Turn-on voltage slope . . . . .	20
Figure 23.	Turn-off voltage slope . . . . .	20
Figure 24.	Application schematic . . . . .	21
Figure 25.	Maximum turn-off current versus inductance . . . . .	22
Figure 26.	HPAK PC board . . . . .	23
Figure 27.	$R_{\text{thj-amb}}$ vs PCB copper area in open box free air condition (one channel ON) . . . . .	23
Figure 28.	HPAK thermal impedance junction ambient single pulse (one channel ON) . . . . .	24
Figure 29.	Thermal fitting model of a double channel HSD in HPAK . . . . .	24
Figure 30.	HPAK package dimensions . . . . .	26
Figure 31.	HPAK tube shipment (no suffix) . . . . .	28
Figure 32.	HPAK tape and reel (suffix "TR") . . . . .	28

# 1 Block diagram and pin description

Figure 1. Block diagram

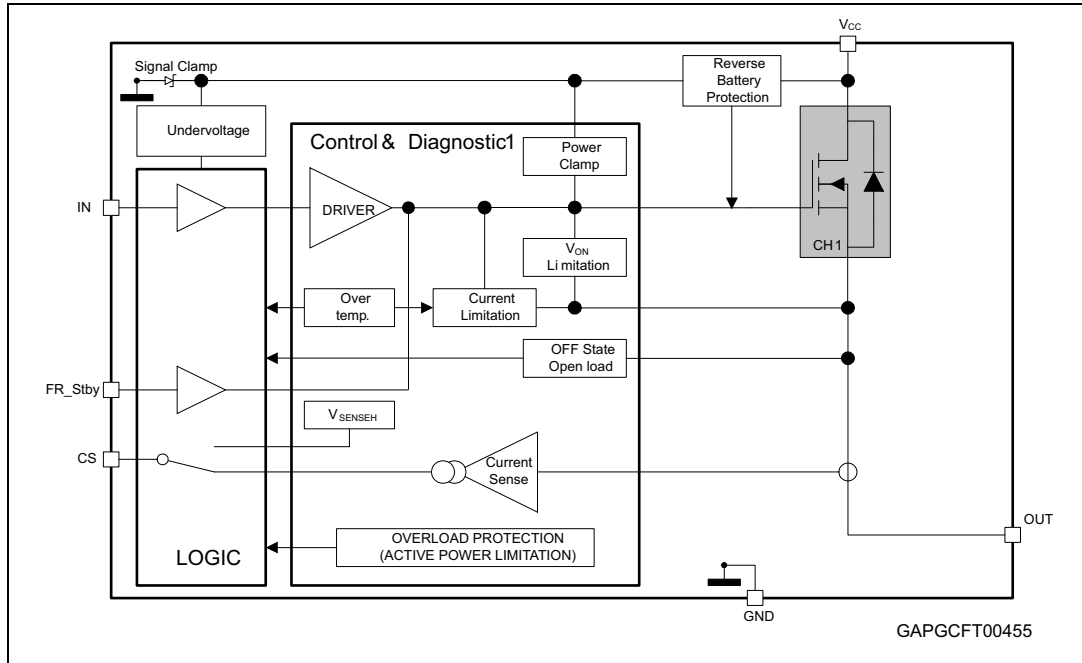


Table 1. Pin function

Name	Function
V <sub>CC</sub>	Battery connection
OUT	Power output
GND	Ground connection
IN	Voltage controlled input pin with hysteresis, CMOS compatible. It controls output switch state
CS	Analog current sense pin, it delivers a current proportional to the load current
FR_Stby	In case of latch-off for overtemperature/overcurrent condition, a low pulse on the FR_Stby pin is needed to reset the channel. The device enters in standby mode if all inputs and the FR_Stby pin are low.

Figure 2. Configuration diagram (top view)

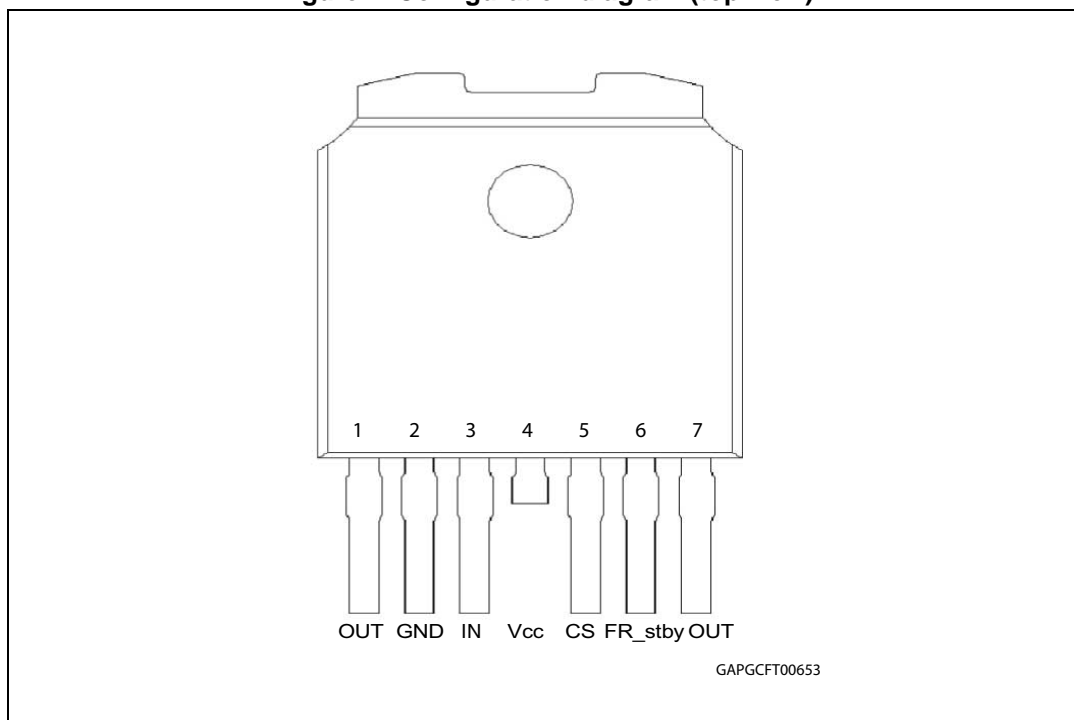


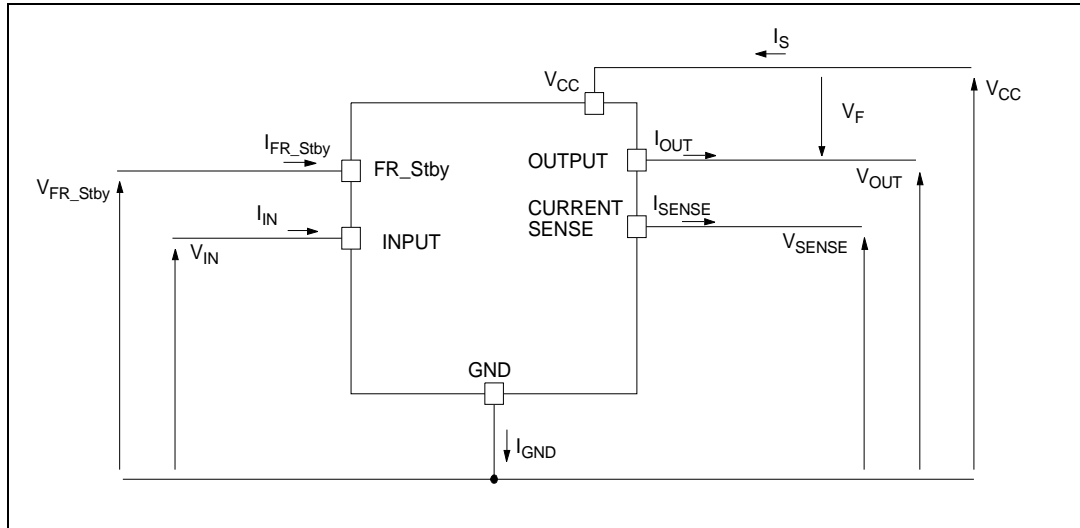
Table 2. Suggested connections for unused and not connected pins

Connection / pin	Current Sense	N.C.	Output	Input	FR_Stby
Floating	Not allowed	X <sup>(1)</sup>	X	X	X
To ground	Through 10 kΩ resistor	X	Not allowed	Through 10 kΩ resistor	Through 10 kΩ resistor

1. X: do not care.

## 2 Electrical specifications

Figure 3. Current and voltage conventions



### 2.1 Absolute maximum ratings

Stressing the device above the ratings 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 the conditions reported in this section for extended periods may affect device reliability.

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
$V_{CC}$	DC supply voltage	58	V
$-V_{CC}$	Reverse DC supply voltage	-32	V
$I_{OUT}$	DC output current	Internally limited	A
$-I_{OUT}$	Reverse DC output current	30	A
$I_{IN}$	DC input current	-1 to 10	mA
$I_{FR\_Stby}$	Fault reset standby DC input current	-1 to 1.5	mA
$V_{CSENSE}$	Current sense maximum voltage	$V_{CC} - 58$ to $+V_{CC}$	V
$E_{MAX}$	Maximum switching energy ( $L = 10$ mH; $V_{bat} = 32$ V; $T_{jstart} = 150^\circ\text{C}$ ; $I_{OUT} = 5.9$ A)	390	mJ
$L_{SMAX}$	Maximum stray inductance in short circuit condition ( $V_{bat} = 32$ V; $R_L = 300$ m $\Omega$ ; $T_{jstart} = 150^\circ\text{C}$ ; $I_{OUT} = I_{limH\_max}$ )	40	$\mu\text{H}$

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
	– FAULT RESET STANDBY PIN	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	Value	Unit
R <sub>thj-case</sub>	Thermal resistance junction-case (max.)	1.5	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient (max.)	See <a href="#">Figure 27</a>	°C/W



## 2.3 Electrical characteristics

$8\text{ V} < V_{CC} < 36\text{ V}$ ;  $-40^\circ\text{C} < T_j < 150^\circ\text{C}$ , unless otherwise specified.

**Table 5. Power section**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{CC}$	Operating supply voltage		8	24	36	V
$V_{USD}$	Undervoltage shutdown			3.5	5	V
$V_{USDhyst}$	Undervoltage shutdown hysteresis			0.5		V
$R_{ON}$	On-state resistance	$I_{OUT} = 5\text{ A}$ ; $T_j = 25^\circ\text{C}$ ; $8\text{ V} < V_{CC} < 36\text{ V}$		16		m $\Omega$
		$I_{OUT} = 5\text{ A}$ ; $T_j = 150^\circ\text{C}$ ; $8\text{ V} < V_{CC} < 36\text{ V}$			32	
$R_{ON REV}$	Reverse battery ON-state resistance	$V_{CC} = -24\text{ V}$ ; $I_{OUT} = -5\text{ A}$ ; $T_j = 25^\circ\text{C}$			16	m $\Omega$
$V_{clamp}$	Clamp voltage	$I_S = 20\text{ mA}$	58	64	70	V
$I_S$	Supply current	Off-state; $V_{CC} = 24\text{ V}$ ; $T_j = 25^\circ\text{C}$ ; $V_{IN} = V_{OUT} = V_{SENSE} = 0\text{ V}$		2 <sup>(1)</sup>	5	$\mu\text{A}$
		On-state; $V_{CC} = 24\text{ V}$ ; $V_{IN} = 5\text{ V}$ ; $I_{OUT} = 0\text{ A}$		2.5	5	mA
$I_{L(off1)}$	Off-state output current	$V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 24\text{ V}$ ; $T_j = 25^\circ\text{C}$	0	0.01	3	$\mu\text{A}$
		$V_{IN} = V_{OUT} = 0\text{ V}$ ; $V_{CC} = 24\text{ V}$ ; $T_j = 125^\circ\text{C}$	0		5	

1. PowerMOS leakage included.

**Table 6. Switching ( $V_{CC} = 24\text{ V}$ ;  $T_j = 25^\circ\text{C}$ )**

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$	Turn-on delay time	$R_L = 4.8\ \Omega$	—	55	—	$\mu\text{s}$
$t_{d(off)}$	Turn-off delay time	$R_L = 4.8\ \Omega$	—	53	—	$\mu\text{s}$
$dV_{OUT}/dt_{(on)}$	Turn-on voltage slope	$R_L = 4.8\ \Omega$		0.59		V/ $\mu\text{s}$
$dV_{OUT}/dt_{(off)}$	Turn-off voltage slope	$R_L = 4.8\ \Omega$		0.54		V/ $\mu\text{s}$
$W_{ON}$	Switching energy losses during $t_{won}$	$R_L = 4.8\ \Omega$	—	2.35	—	mJ
$W_{OFF}$	Switching energy losses during $t_{woff}$	$R_L = 4.8\ \Omega$	—	1.05	—	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		
$V_{FR\_Stby\_L}$	Fault reset standby low level voltage				0.9	V
$I_{FR\_Stby\_L}$	Low level fault reset standby current	$V_{FR\_Stby} = 0.9\text{ V}$	1			$\mu\text{A}$
$V_{FR\_Stby\_H}$	Fault reset standby high level voltage		2.1			V
$I_{FR\_Stby\_H}$	High level fault reset standby current	$V_{FR\_Stby} = 2.1\text{ V}$			10	$\mu\text{A}$
$V_{FR\_Stby(hyst)}$	Fault reset standby hysteresis voltage		0.25			V
$V_{FR\_Stby\_CL}$	Fault reset standby clamp voltage	$I_{FR\_Stby} = 15\text{ mA (10 ms)}$	11		15	V
		$I_{FR\_Stby} = -1\text{ mA}$		-0.7		
$t_{reset}$	Overload latch-off reset time	See <a href="#">Figure 4</a>	2		24	$\mu\text{s}$
$t_{stby}$	Standby delay	See <a href="#">Figure 5</a>	120		1200	$\mu\text{s}$

Figure 4.  $T_{reset}$  definition

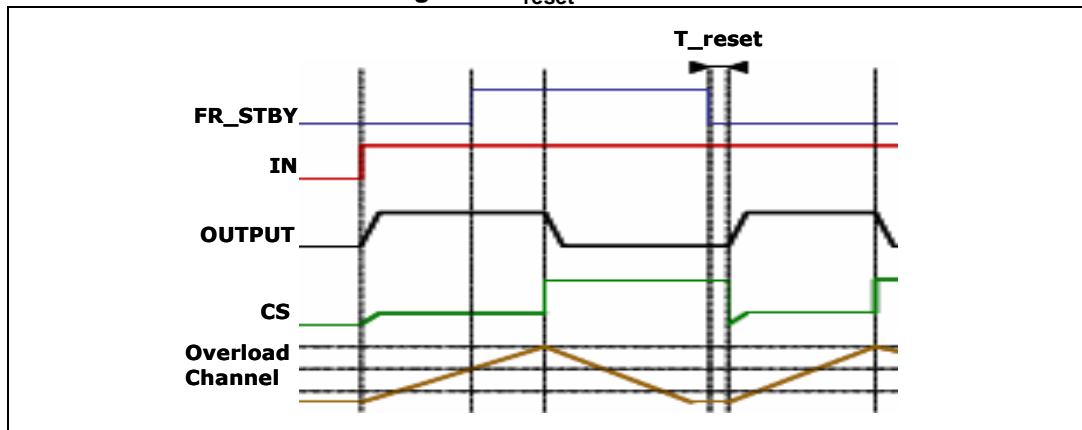


Figure 5.  $T_{stby}$  definition

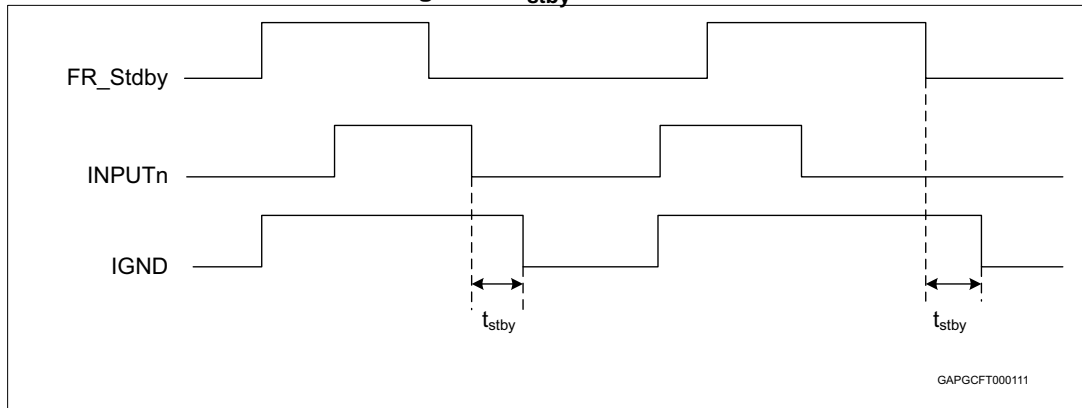


Table 8. Protections and diagnostics

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$I_{limH}$	DC short circuit current	$V_{CC} = 24\text{ V}$	43	60	86	A
		$5\text{ V} < V_{CC} < 36\text{ V}$			86	A
$I_{limL}$	Short circuit current during thermal cycling	$V_{CC} = 24\text{ V}; T_R < T_j < T_{TSD}$		15		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	$I_{OUT} = 5\text{ A}; V_{IN} = 0\text{ V}; L = 6\text{ mH}$	$V_{CC}-58$	$V_{CC}-64$	$V_{CC}-70$	V
$V_{ON}$	Output voltage drop limitation	$I_{OUT} = 500\text{ mA}; T_j = -40^{\circ}\text{C to } 150^{\circ}\text{C}$		25		mV

Table 9. Current sense ( $8\text{ V} < V_{CC} < 36\text{ V}$ )

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$dK_{LED}/K_{LED(TOT)}^{(1)}$	Current sense ratio drift	$I_{OUT} = 12\text{ mA to } 100\text{ mA}; I_{CAL} = 50\text{ mA}; V_{SENSE} = 0.5\text{ V}; T_j = -40^{\circ}\text{C to } 150^{\circ}\text{C}$	-50		50	%
$K_0$	$I_{OUT}/I_{SENSE}$	$I_{OUT} = 100\text{ mA}; V_{SENSE} = 0.5\text{ V}; T_j = -40^{\circ}\text{C to } 150^{\circ}\text{C}$	1333	5600	11884	
$dK_0/K_0^{(1)}$	Current sense ratio drift	$I_{OUT} = 100\text{ mA}; V_{SENSE} = 0.5\text{ V}; T_j = -40^{\circ}\text{C to } 150^{\circ}\text{C}$	-21		32	%
$K_1$	$I_{OUT}/I_{SENSE}$	$I_{OUT} = 0.6\text{ A}; V_{SENSE} = 1\text{ V}; T_j = -40^{\circ}\text{C to } 150^{\circ}\text{C}; T_j = 25^{\circ}\text{C to } 150^{\circ}\text{C}$	2418 3139	5300	9264 7981	
$dK_1/K_1^{(1)}$	Current sense ratio drift	$I_{OUT} = 0.6\text{ A}; V_{SENSE} = 1\text{ V}; T_j = -40^{\circ}\text{C to } 150^{\circ}\text{C}$	-21		23	%

Table 9. Current sense (8 V < V<sub>CC</sub> < 36 V) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
K <sub>2</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 1.6 A; V <sub>SENSE</sub> = 1 V; T <sub>j</sub> = -40°C to 150°C T <sub>j</sub> = 25 °C to 150 °C	2928 3072	4700	7568 6693	
dK <sub>2</sub> /K <sub>2</sub> <sup>(1)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 1.6 A; V <sub>SENSE</sub> = 1 V; T <sub>j</sub> = -40°C to 150°C	-26		21	%
K <sub>3</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 2.4 A; V <sub>SENSE</sub> = 2 V; T <sub>j</sub> = -40°C to 150°C T <sub>j</sub> = 25°C to 150°C	2912 3007	4400	7048 6039	
dK <sub>3</sub> /K <sub>3</sub> <sup>(1)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 2.4 A; V <sub>SENSE</sub> = 2 V; T <sub>j</sub> = -40°C to 150°C	-19		24	%
K <sub>4</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 3 A; V <sub>SENSE</sub> = 4 V; T <sub>j</sub> = -40°C to 150°C T <sub>j</sub> = 25 °C to 150 °C	2843 3142	4300	6686 5634	
dK <sub>4</sub> /K <sub>4</sub> <sup>(1)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 3 A; V <sub>SENSE</sub> = 4 V; T <sub>j</sub> = -40°C to 150°C	-16		22	%
K <sub>5</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 4.2 A; V <sub>SENSE</sub> = 4 V; T <sub>j</sub> = -40°C to 150°C T <sub>j</sub> = 25°C to 150°C	3034 3402	4250	5977 5276	
dK <sub>5</sub> /K <sub>5</sub> <sup>(1)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 4.2 A; V <sub>SENSE</sub> = 4 V; T <sub>j</sub> = -40°C to 150°C	-13		16	%
K <sub>6</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 20 A; V <sub>SENSE</sub> = 4 V; T <sub>j</sub> = -40°C to 150°C	3942	4240	4748	
dK <sub>6</sub> /K <sub>6</sub> <sup>(1)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 20 A; V <sub>SENSE</sub> = 4 V; T <sub>j</sub> = -40°C to 150°C	-5		5	%
dK/K <sub>bulb1(TOT)</sub> <sup>(1)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 1.6 A to 4.2 A; I <sub>OUTCAL</sub> = 3 A; V <sub>SENSE</sub> = 4 V; T <sub>j</sub> = -40°C to 150°C	-17		40	%
dK/K <sub>bulb2(TOT)</sub> <sup>(1)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 0.6 A to 2.4 A; I <sub>OUTCAL</sub> = 1.2 A; V <sub>SENSE</sub> = 2 V; T <sub>j</sub> = -40°C to 150°C	-31		33	%
I <sub>SENSE0</sub>	Analog sense leakage current	I <sub>OUT</sub> = 0 A; V <sub>SENSE</sub> = 0 V; V <sub>IN</sub> = 0 V; T <sub>j</sub> = -40°C to 150°C	0		1	μA
		I <sub>OUT</sub> = 0 A; V <sub>SENSE</sub> = 0 V; V <sub>IN</sub> = 5 V; T <sub>j</sub> = -40°C to 150°C	0		2	
V <sub>SENSE</sub>	Max analog sense output voltage	I <sub>OUT</sub> = 20 A; R <sub>SENSE</sub> = 3.9 kΩ	5			V
V <sub>SENSEH</sub>	Analog sense output voltage in fault condition <sup>(2)</sup>	V <sub>CC</sub> = 24 V; R <sub>SENSE</sub> = 3.9 kΩ		8		V
I <sub>SENSEH</sub>	Analog sense output current in fault condition <sup>(2)</sup>	V <sub>CC</sub> = 24 V; V <sub>SENSE</sub> = 5 V		9	12	mA

Table 9. Current sense ( $8\text{ V} < V_{CC} < 36\text{ V}$ ) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{\text{DSENSE2H}}$	Delay response time from rising edge of INPUT pin	$V_{\text{SENSE}} < 4\text{ V}$ ; $0.5\text{ A} < I_{\text{OUT}} < 20\text{ A}$ ; $I_{\text{SENSE}} = 90\%$ of $I_{\text{SENSE max}}$ (see <a href="#">Figure 7</a> )		300	600	$\mu\text{s}$
$\Delta t_{\text{DSENSE2H}}$	Delay response time between rising edge of output current and rising edge of current sense	$V_{\text{SENSE}} < 4\text{ V}$ ; $I_{\text{SENSE}} = 90\%$ of $I_{\text{SENSEMAX}}$ ; $I_{\text{OUT}} = 90\%$ of $I_{\text{OUTMAX}}$ ; $I_{\text{OUTMAX}} = 5\text{ A}$ (see <a href="#">Figure 10</a> )			450	$\mu\text{s}$
$t_{\text{DSENSE2L}}$	Delay response time from falling edge of INPUT pin	$V_{\text{SENSE}} < 4\text{ V}$ ; $0.5\text{ A} < I_{\text{OUT}} < 20\text{ A}$ ; $I_{\text{SENSE}} = 10\%$ of $I_{\text{SENSE max}}$ (see <a href="#">Figure 7</a> )		3	20	$\mu\text{s}$

- Parameter guaranteed by design; it is not tested.
- Fault condition includes: power limitation, overtemperature and open load in OFF-state condition.

Table 10. Open-load detection ( $\text{FR\_Stby} = 5\text{ V}$ )

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{\text{OL}}$	Openload off-state voltage detection threshold	$V_{\text{IN}} = 0\text{ V}$ ; $8\text{ V} < V_{CC} < 36\text{ V}$	2		4	V
$t_{\text{DSTKON}}$	Output short circuit to $V_{CC}$ detection delay at turn-off	See <a href="#">Figure 8</a>	180		1800	$\mu\text{s}$
$I_{\text{L(off2)}}$	Off-state output current at $V_{\text{OUT}} = 4\text{ V}$	$V_{\text{IN}} = 0\text{ V}$ ; $V_{\text{SENSE}} = 0\text{ V}$ ; $V_{\text{OUT}}$ rising from $0\text{ V}$ to $4\text{ V}$	-120		0	$\mu\text{A}$
$t_{\text{d\_vol}}$	Delay response from output rising edge to $V_{\text{SENSE}}$ rising edge in openload	$V_{\text{OUT}} = 4\text{ V}$ ; $V_{\text{IN}} = 0\text{ V}$ ; $V_{\text{SENSE}} = 90\%$ of $V_{\text{SENSEH}}$ ; $R_{\text{SENSE}} = 3.9\text{ k}\Omega$			20	$\mu\text{s}$
$t_{\text{DFRSTK\_ON}}$	Output short circuit to $V_{CC}$ detection delay at FRSTBY activation	See <a href="#">Figure 8</a> ; Input <sub>1,2</sub> = low			50	$\mu\text{s}$

Figure 6. Output stuck to  $V_{CC}$  detection delay time at  $FR_{STBY}$  activation

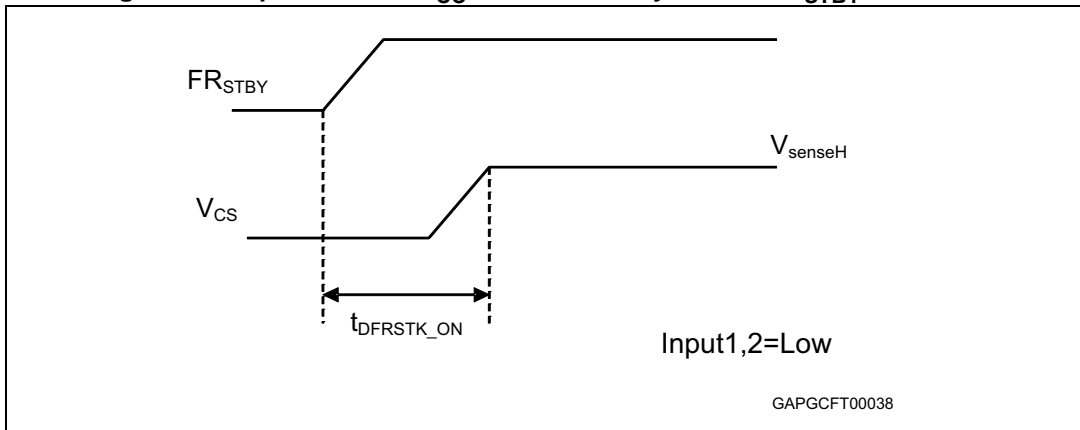


Figure 7. Current sense delay characteristics

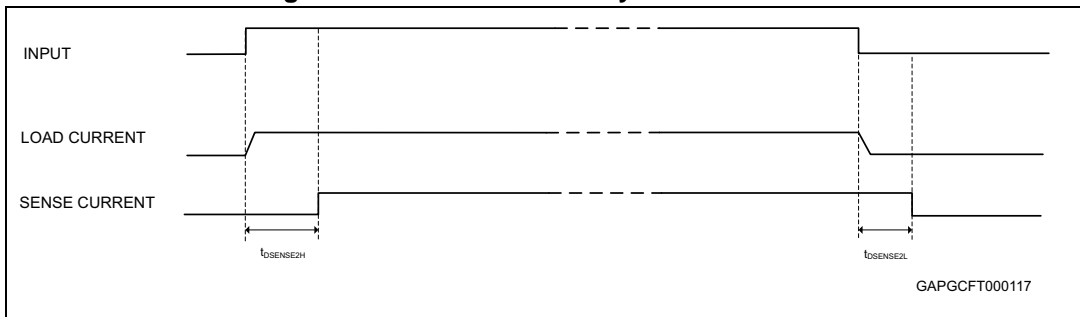
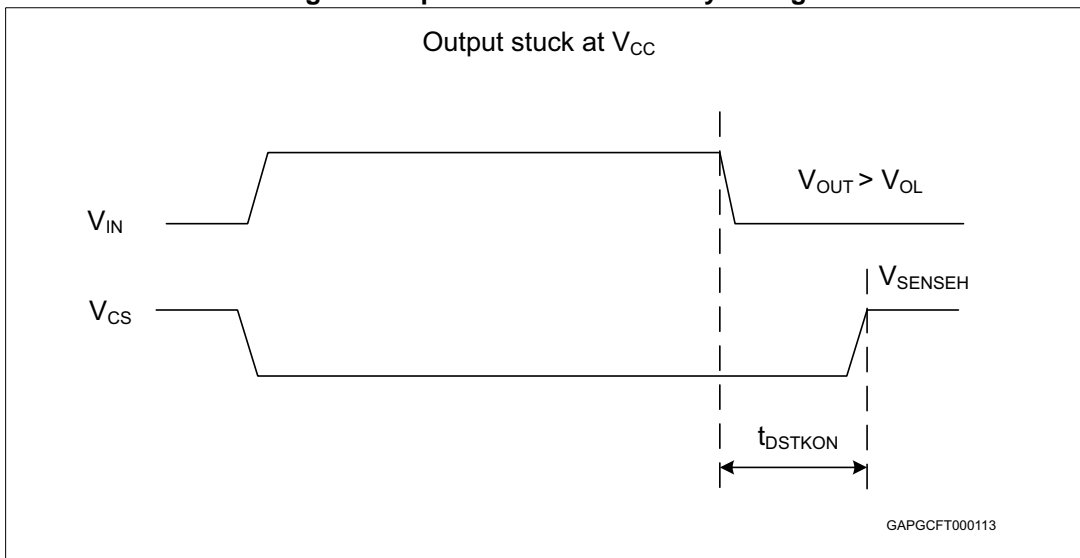
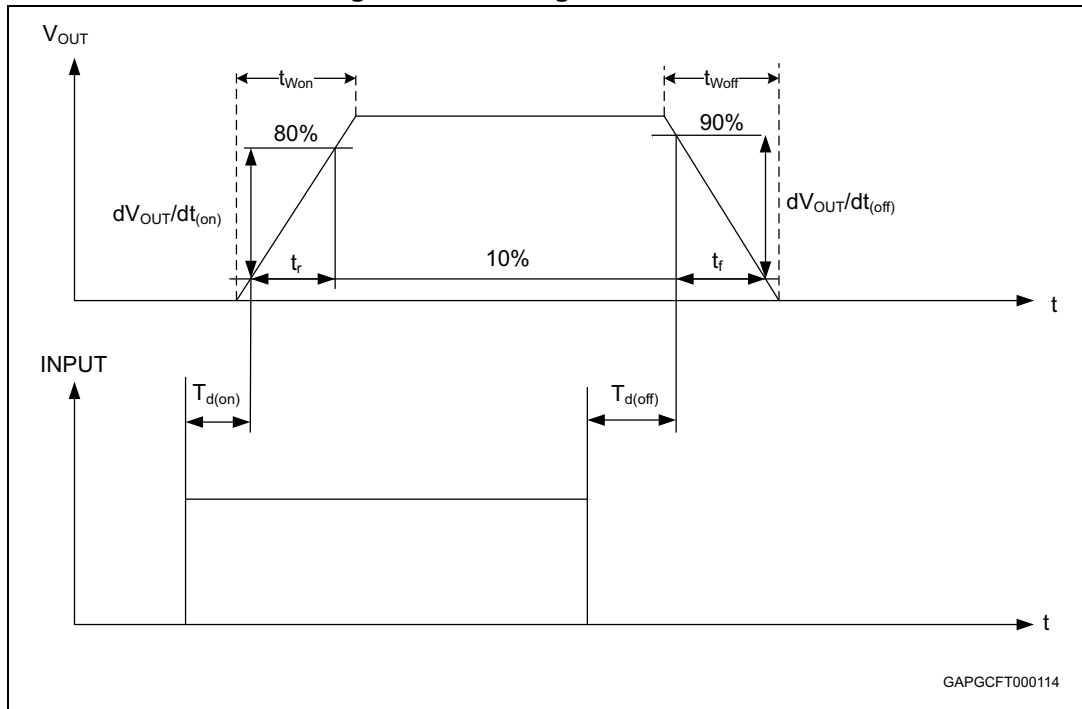


Figure 8. Open-load off-state delay timing



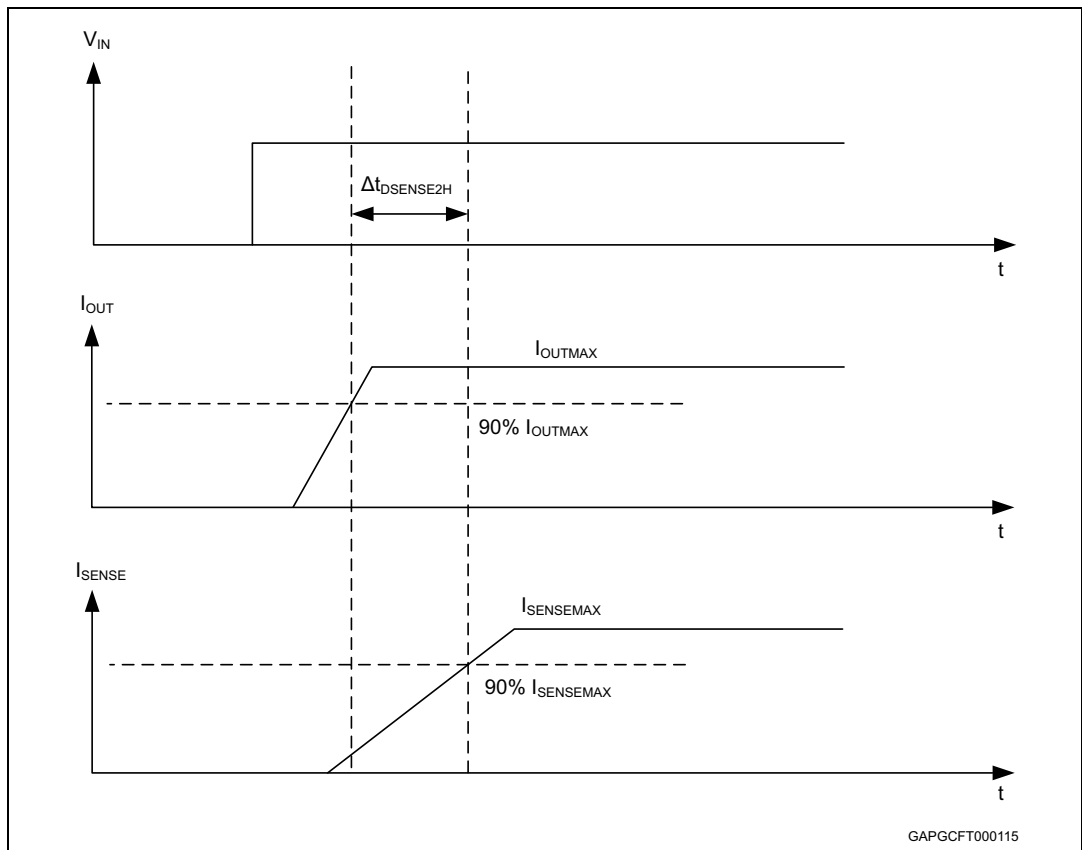
1. With  $FR\_Stby = 5\text{ V}$ .

Figure 9. Switching characteristics



GAPGCFT000114

Figure 10. Delay response time between rising edge of output current and rising edge of current sense



GAPGCFT000115

Figure 11. Output voltage drop limitation

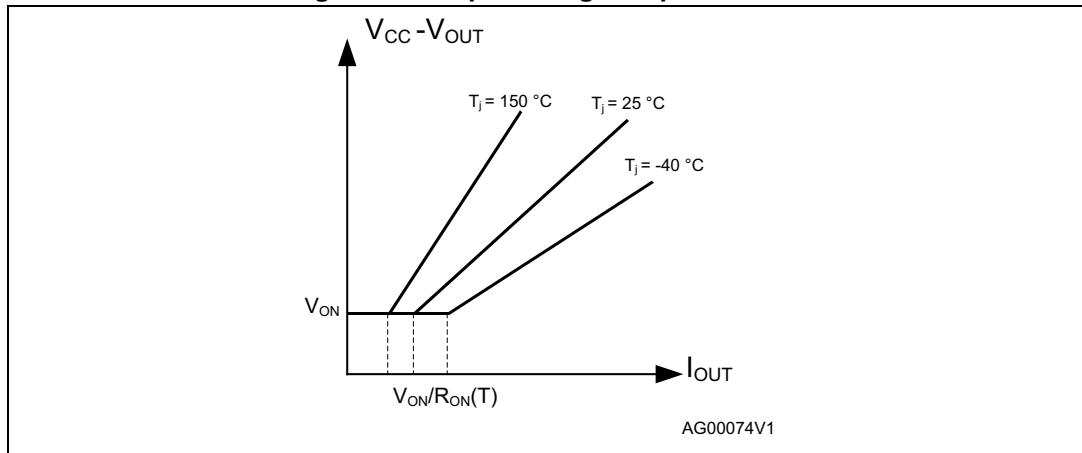


Figure 12. Device behavior in overload condition

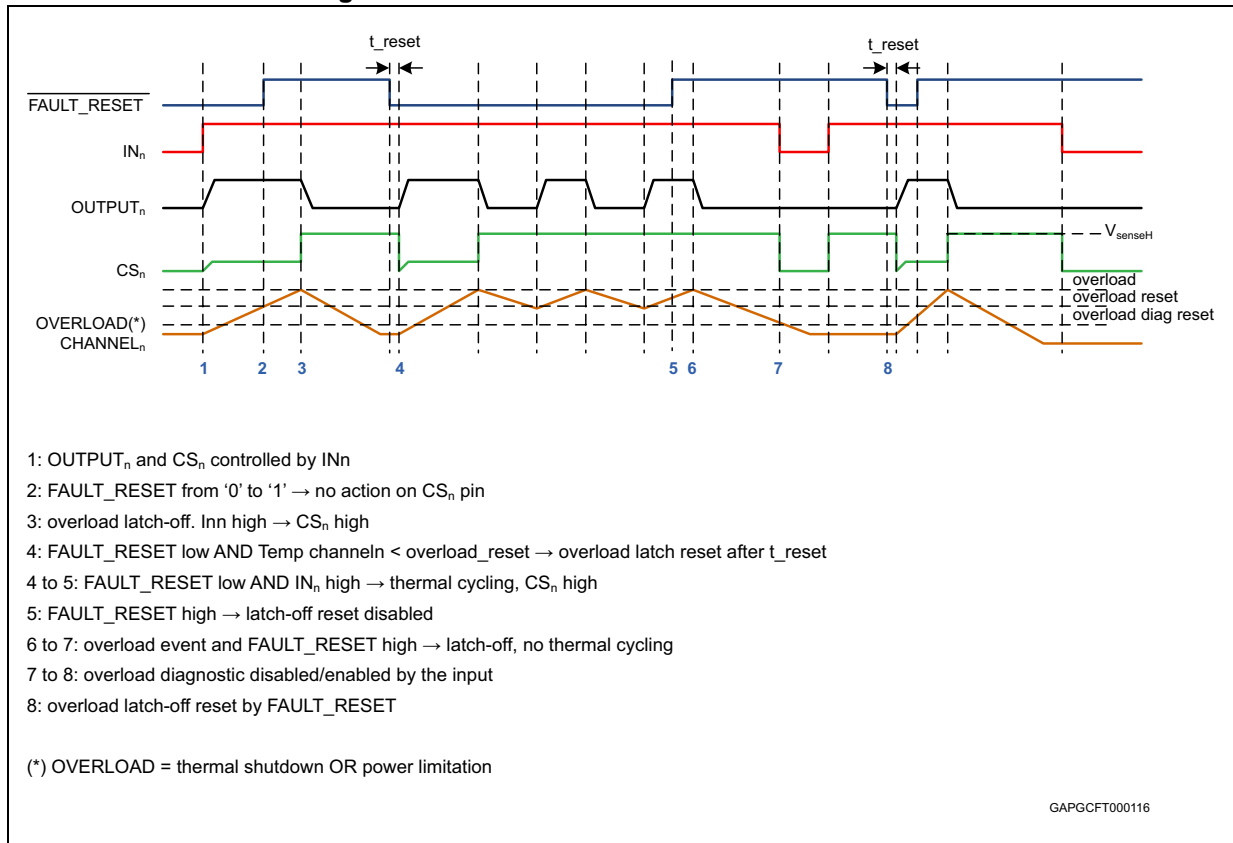




Table 11. Truth table

Conditions	Fault reset standby	Input	Output	Sense
Standby	L	L	X	0
Normal operation	X	L	L	0
	X	H	H	Nominal
Overload	X	L	L	0
	X	H	H	> Nominal
Overtemperature / short to ground	X	L	L	0
	L	H	Cycling	$V_{SENSEH}$
	H	H	Latched	$V_{SENSEH}$
Undervoltage	X	X	L	0
Short to $V_{BAT}$	L	L	H	0
	H	L	H	$V_{SENSEH}$
	X	H	H	< Nominal
Open load off-state (with pull-up)	L	L	H	0
	H	L	H	$V_{SENSEH}$
	X	H	H	0
Negative output voltage clamp	X	L	Negative	0

**Table 12. Electrical transient requirements (part 1)**

ISO 7637-2: 2004(E) Test pulse	Test levels <sup>(1)</sup>		Number of pulses or test times	Burst cycle/pulse repetition time		Delays and impedance
	III	IV				
1	- 450 V	- 600 V	5000 pulses	0.5 s	5 s	1 ms, 50 Ω
2a	+ 37 V	+ 50 V	5000 pulses	0.2 s	5 s	50 μs, 2 Ω
3a	- 150 V	- 200 V	1h	90 ms	100 ms	0.1 μs, 50 Ω
3b	+ 150 V	+ 200 V	1h	90 ms	100 ms	0.1 μs, 50 Ω
4	- 12 V	- 16 V	1 pulse			100 ms, 0.01 Ω
5b <sup>(2)</sup>	+ 123 V	+ 174 V	1 pulse			350 ms, 1 Ω

1. The above test levels must be considered referred to  $V_{CC} = 24.5V$  except for pulse 5b
2. Valid in case of external load dump clamp: 58V maximum referred to ground.

**Table 13. Electrical transient requirements (part 2)**

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

1. With  $R_{load} < 24 \Omega$ .
2. Without capacitor between  $V_{CC}$  and GND.
3. With 10 nF between  $V_{CC}$  and GND.
4. External load dump clamp, 58 V maximum, referred to ground.

**Table 14. 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 Electrical characteristics curves

Figure 13. Off-state output current

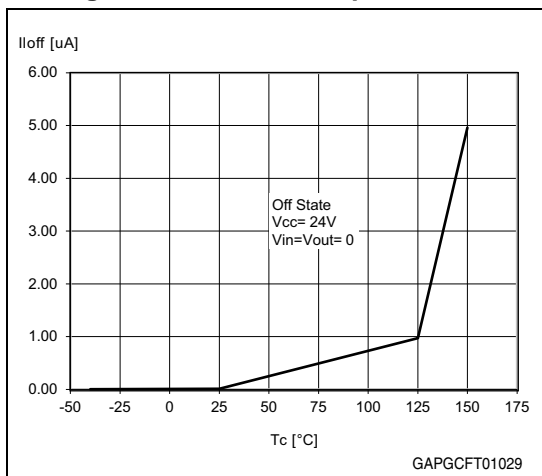


Figure 14. High level input current

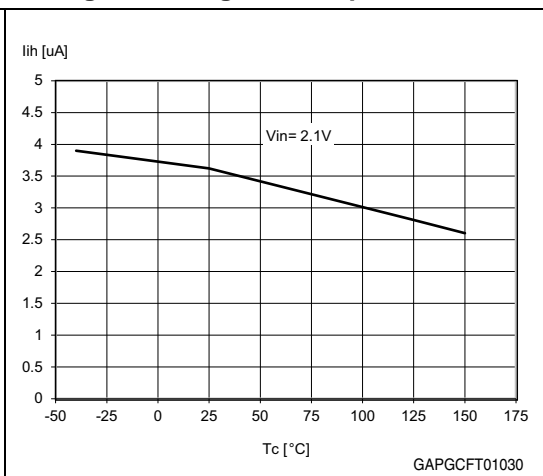


Figure 15. Input clamp voltage

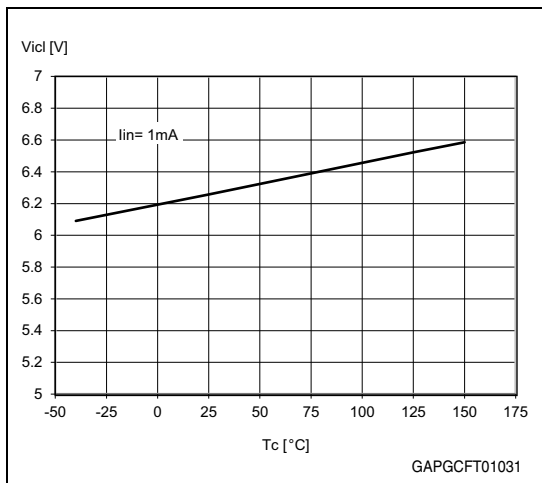


Figure 16. Input low level voltage

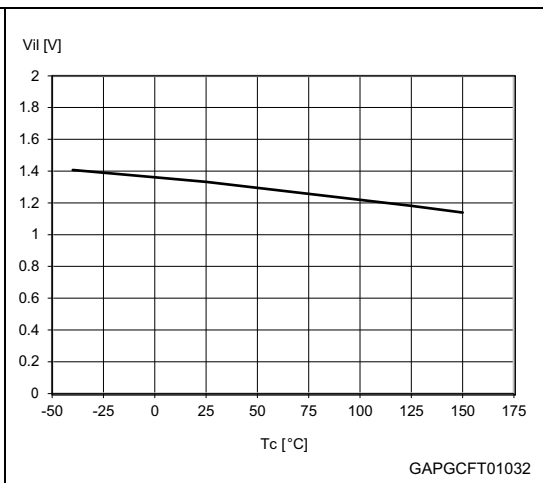


Figure 17. Input high level voltage

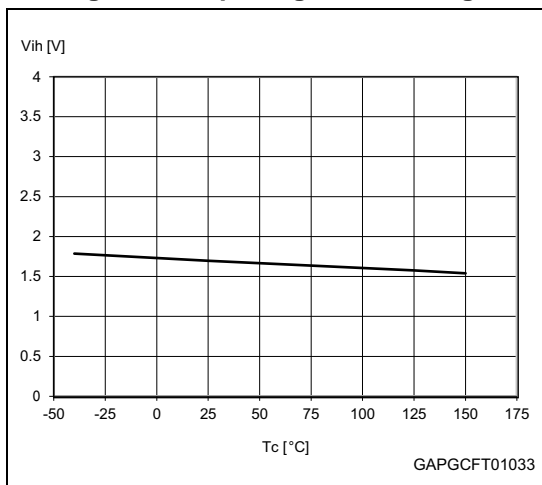


Figure 18. Input hysteresis voltage

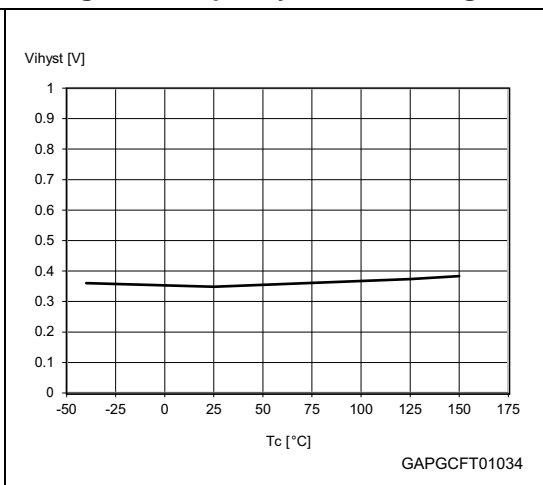


Figure 19. On-state resistance vs  $T_{case}$

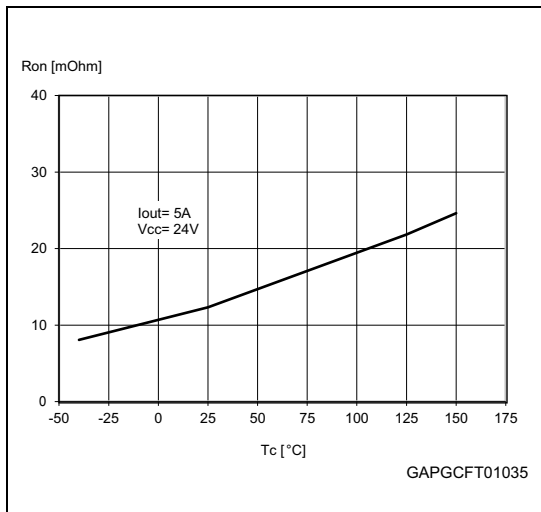


Figure 20. On-state resistance vs  $V_{CC}$

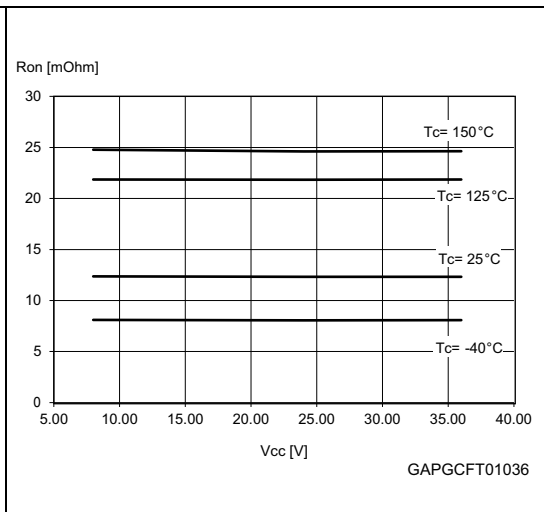


Figure 21.  $I_{LIMH}$  vs  $T_{case}$

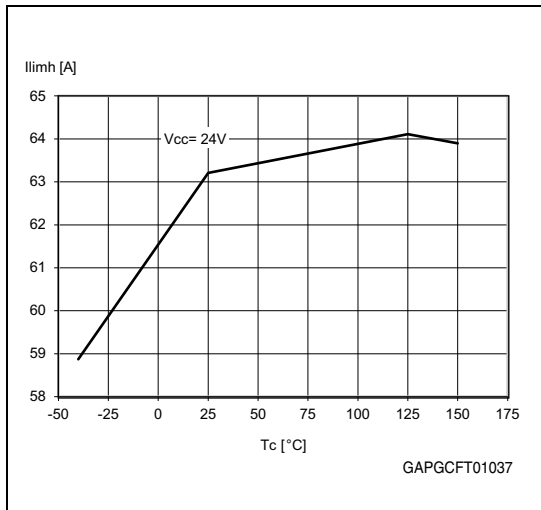


Figure 22. Turn-on voltage slope

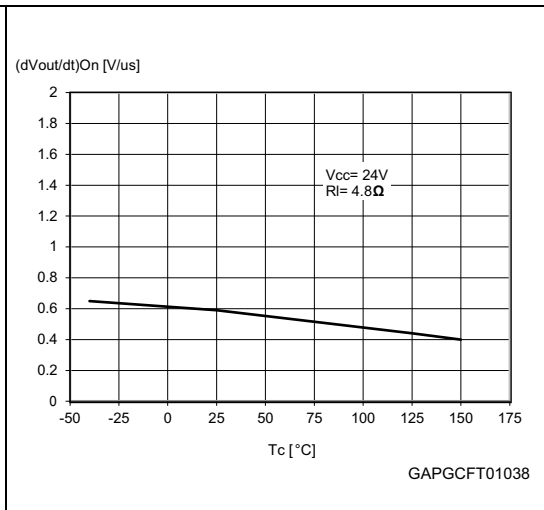
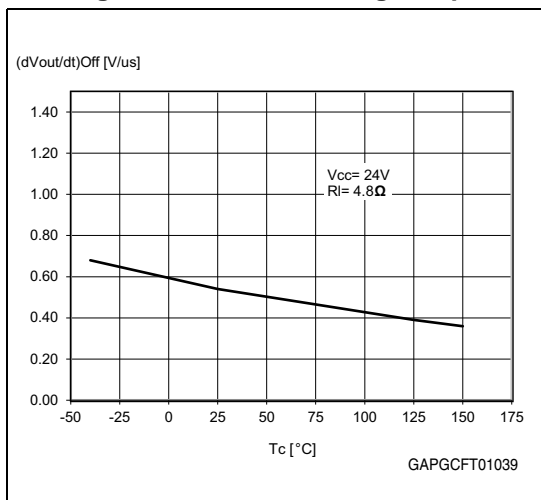
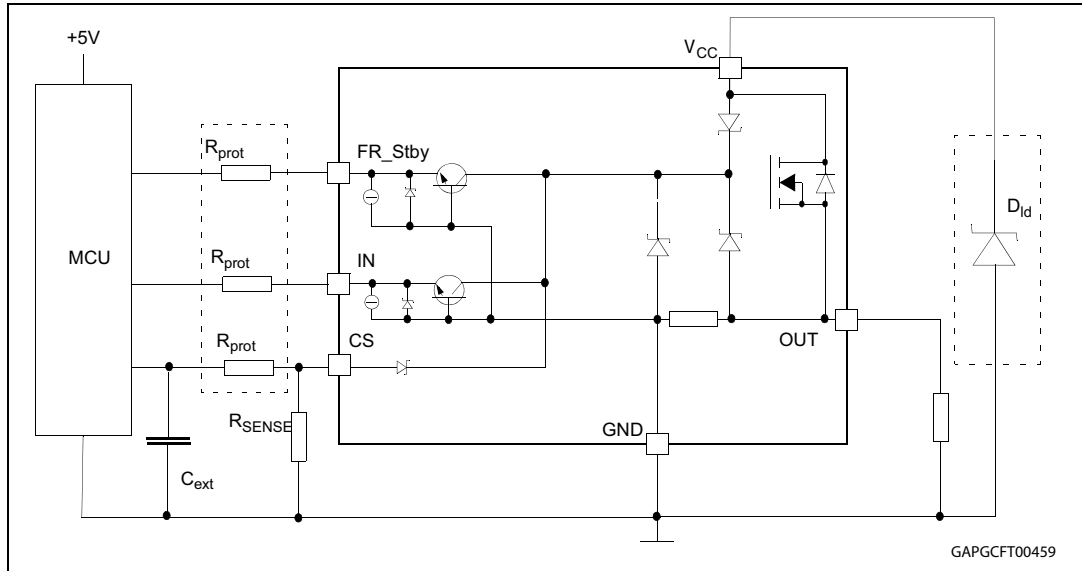


Figure 23. Turn-off voltage slope



### 3 Application information

Figure 24. Application schematic



#### 3.1 Load dump protection

$D_{id}$  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 7637-2 2004 (E) table.

#### 3.2 MCU I/Os protection

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

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

##### Equation 1

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

Calculation example:

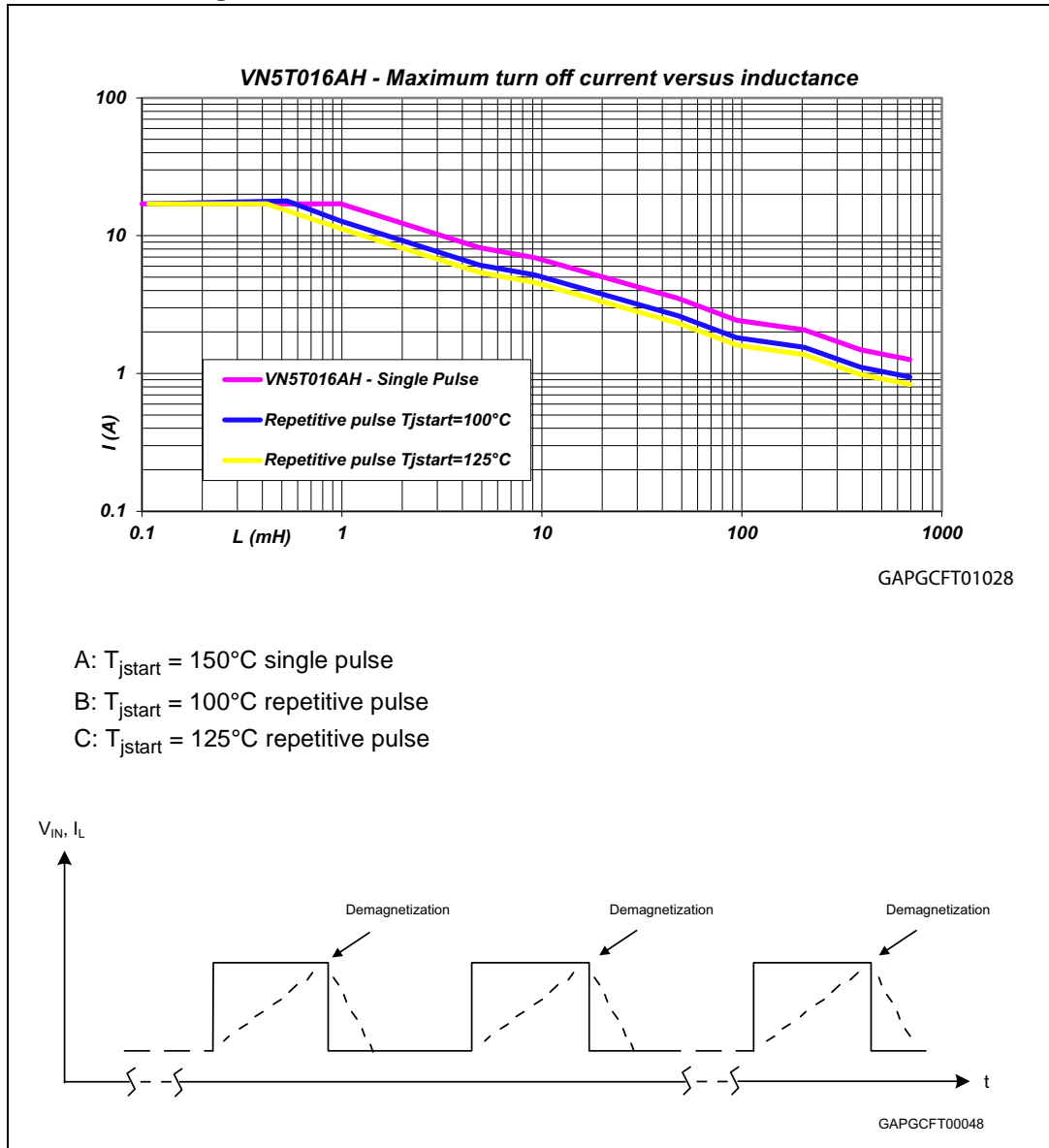
For  $V_{CCpeak} = -600$  V and  $I_{latchup} \geq 20$  mA;  $V_{OH\mu C} \geq 4.5$  V

$30$  k $\Omega \leq R_{prot} \leq 190$  k $\Omega$ .

Recommended value:  $R_{prot} = 56$  k $\Omega$

### 3.3 Maximum demagnetization energy ( $V_{CC} = 24\text{ V}$ )

Figure 25. Maximum turn-off current versus inductance



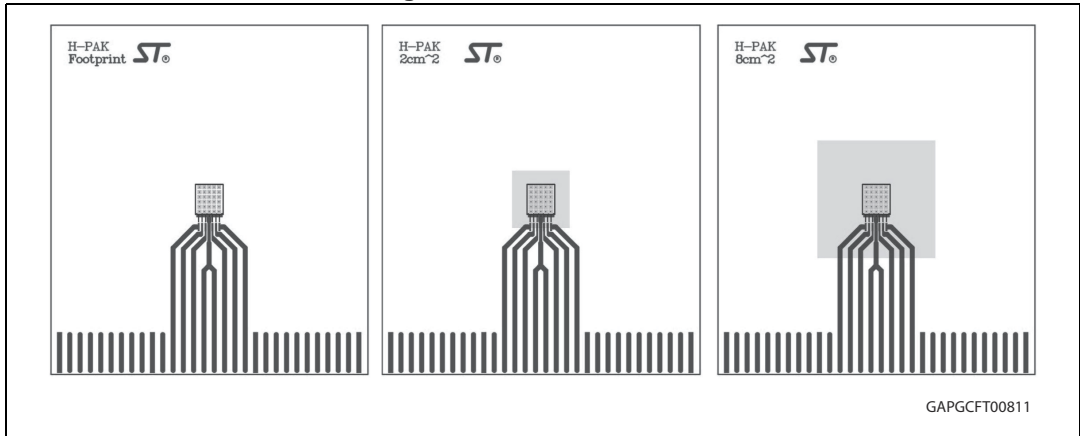
- A:  $T_{jstart} = 150^{\circ}\text{C}$  single pulse
- B:  $T_{jstart} = 100^{\circ}\text{C}$  repetitive pulse
- C:  $T_{jstart} = 125^{\circ}\text{C}$  repetitive pulse

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 PCB thermal data

### 4.1 HPAK thermal data

Figure 26. HPAK PC board



1. Layout condition of  $R_{th}$  and  $Z_{th}$  measurements (Board finish thickness 1.6 mm +/- 10%; Board double layer; Board dimension 78x86; Board Material FR4; Cu thickness 0.070mm (front and back side); Thermal vias separation 1.2 mm; Thermal via diameter 0.3 mm +/- 0.08 mm; Cu thickness on vias 0.025 mm; Footprint dimension 6.4 mm x 7 mm).

Figure 27.  $R_{thj-amb}$  vs PCB copper area in open box free air condition (one channel ON)

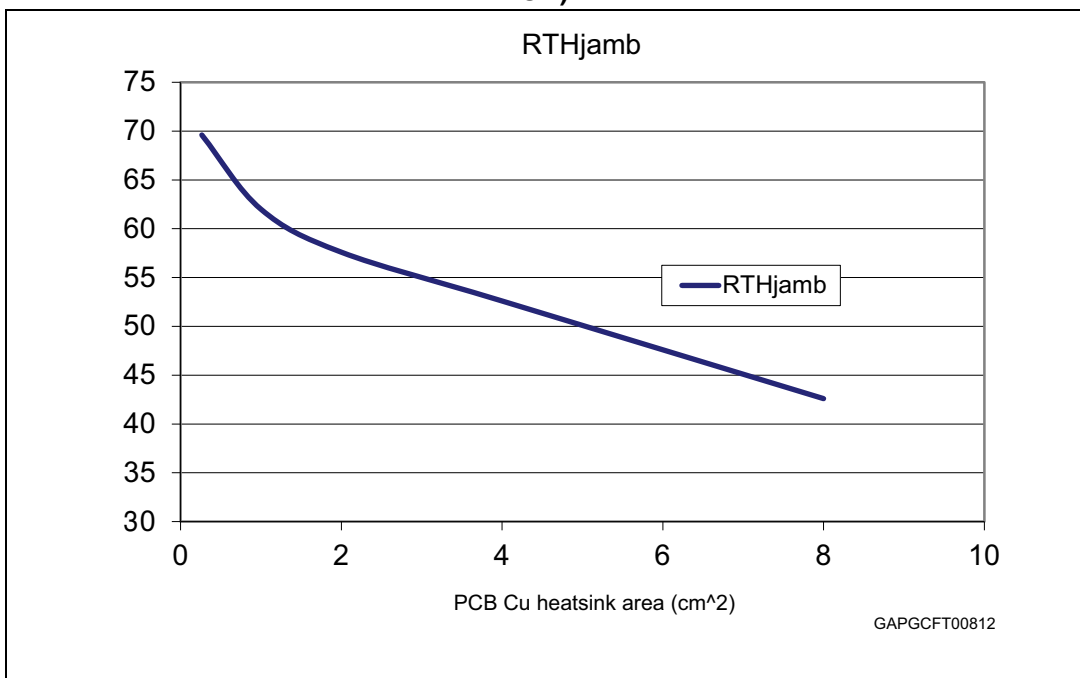


Figure 28. HPAK thermal impedance junction ambient single pulse (one channel ON)

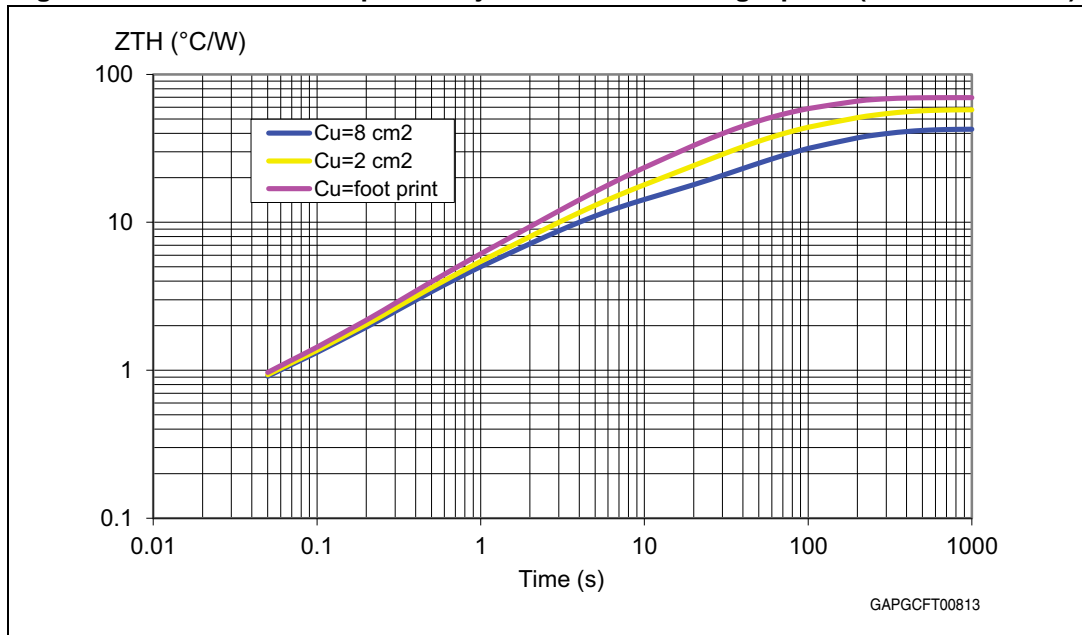
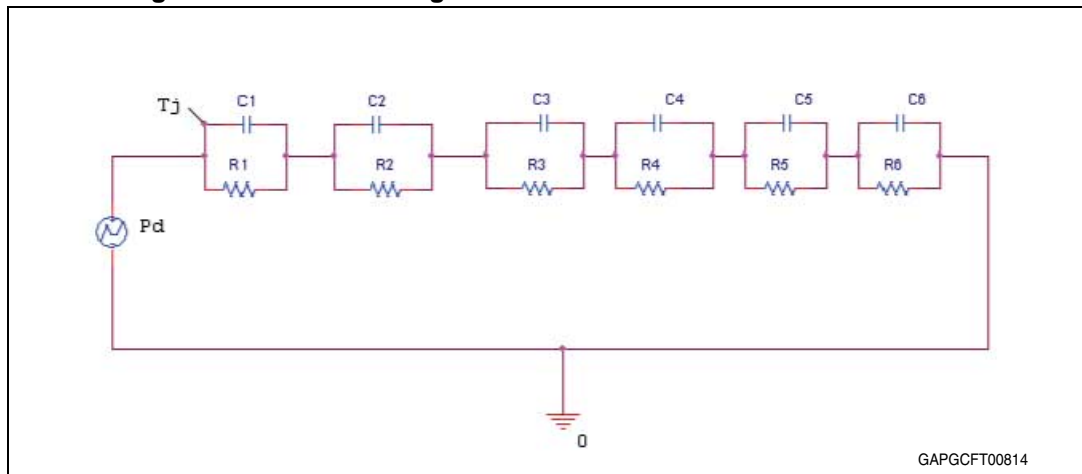


Figure 29. Thermal fitting model of a double channel HSD in HPAK



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.

**Equation 2: pulse calculation formula**

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

where  $\delta = t_p/T$



Table 15. Thermal parameters

Area/island (cm <sup>2</sup> )	Footprint	4	8
R1 (°C/W)	0.1		
R2 (°C/W)	0.5		
R3 (°C/W)	2		
R4 (°C/W)	8		
R5 (°C/W)	28	22	14
R6 (°C/W)	31	25	18
C1 (W.s/°C)	0.01		
C2 (W.s/°C)	0.05		
C3 (W.s/°C)	0.2		
C4 (W.s/°C)	0.4		
C5 (W.s/°C)	0.8	1.4	3
C6 (W.s/°C)	3	6	9

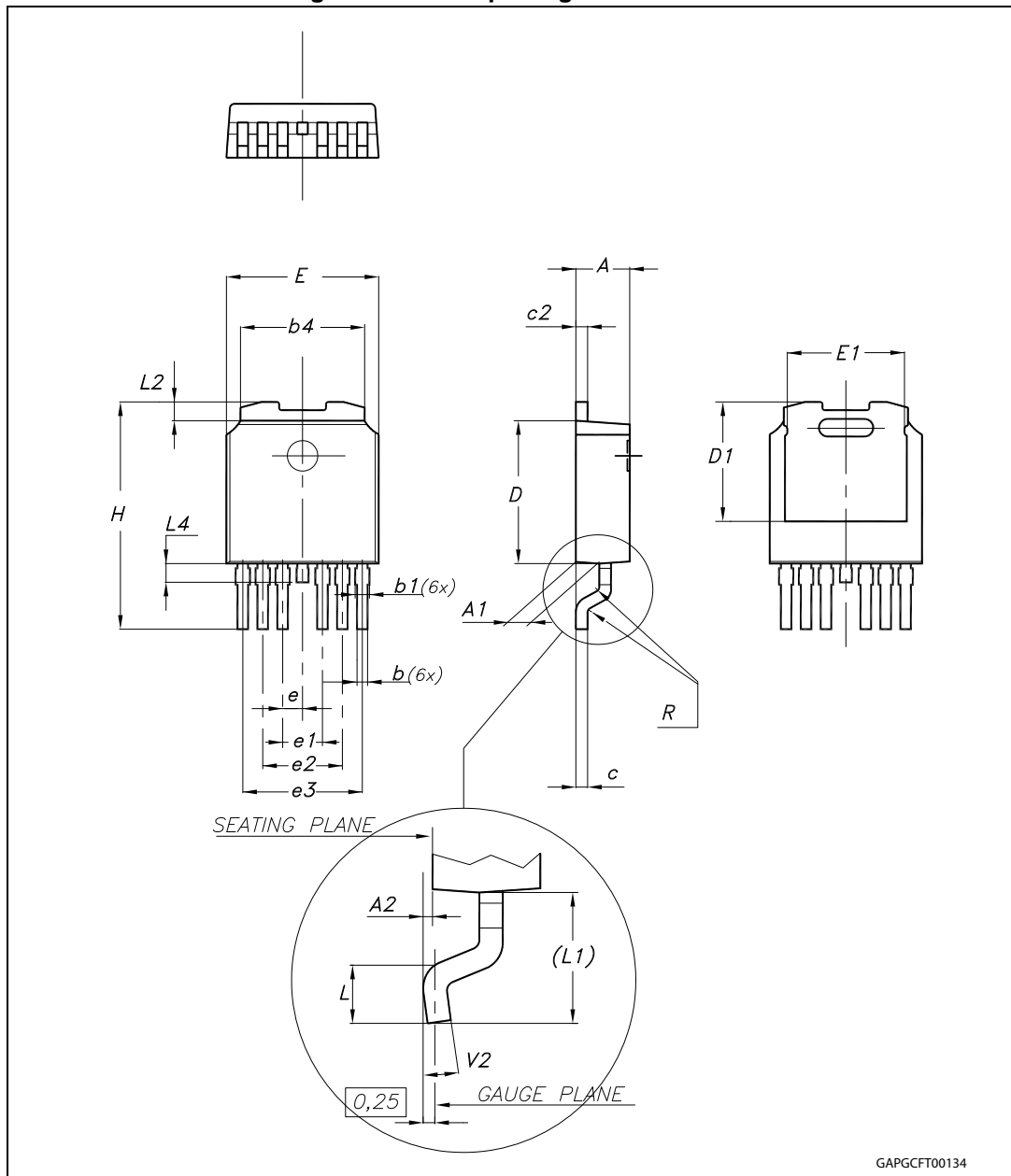
## 5 Package information

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](http://www.st.com).

ECOPACK® is an ST trademark.

### 5.1 HPAK mechanical data

Figure 30. HPAK package dimensions



GAPGCF00134

Table 16. HPAK mechanical data

Ref. dim	Data book mm		
	Min.	Typ.	Max.
A	2.20		2.40
A1	0.90		1.10
A2	0.03		0.23
b	0.40		0.60
b1	0.45		0.65
b4	5.20		5.40
c	0.45		0.60
c2	0.48		0.60
D	6.00		6.20
D1	4.95	5.10	5.25
E	6.40		6.60
E1	5.00	5.20	5.40
e		0.85	
e1	1.60		1.80
e2	3.30		3.50
e3	5.00		5.20
H	9.35		10.10
L	1.00		1.50
(L1)	2.60	2.80	3.00
L2	0.60	0.80	1.00
L4	0.50		1.00
R		0.20	
V2	0°		8°

## 5.2 Packing information

The devices can be packed in tube or tape and reel shipments (see [Table 17: Device summary](#)).

Figure 31. HPAK tube shipment (no suffix)

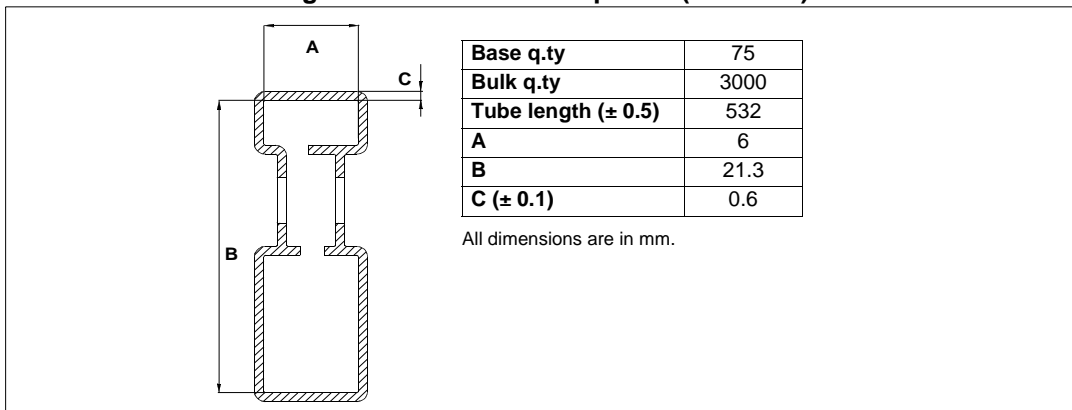
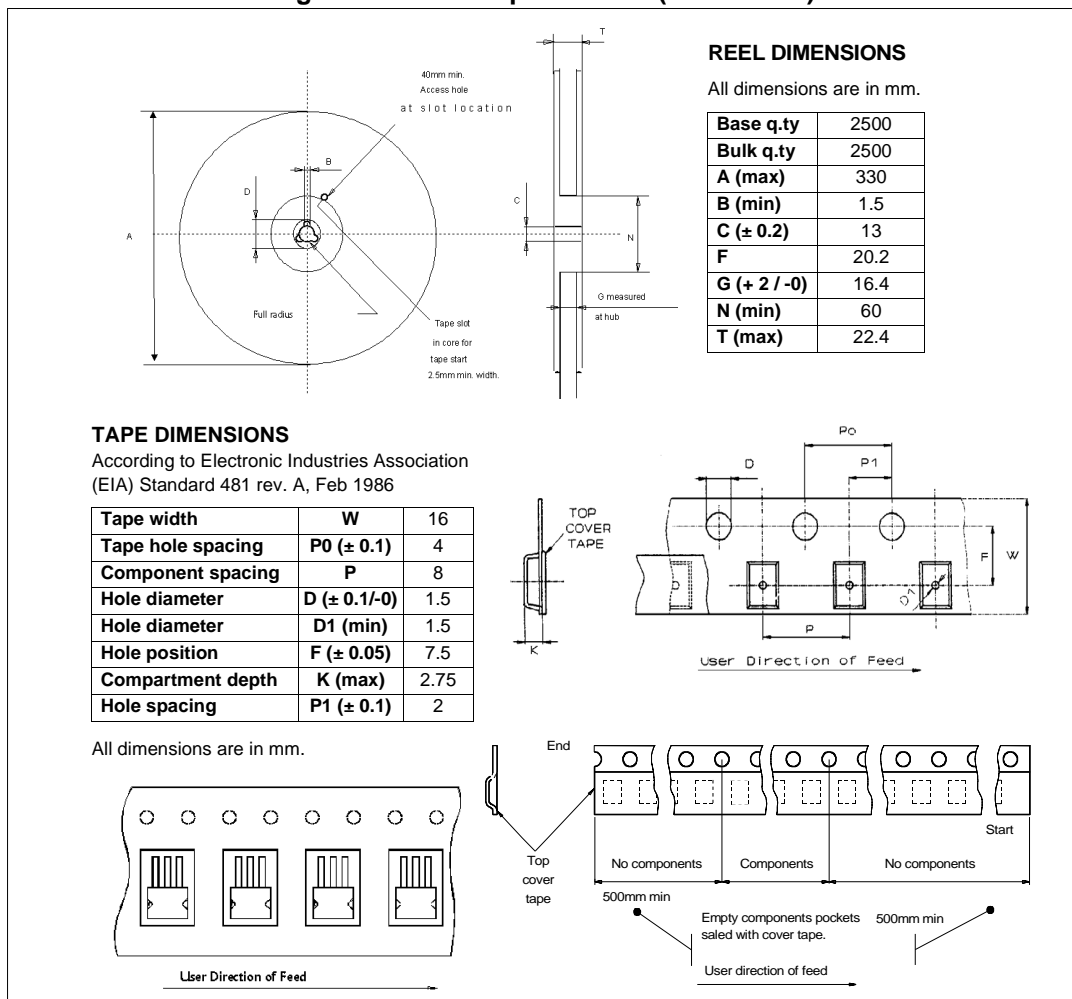


Figure 32. HPAK tape and reel (suffix "TR")



## 6 Order codes

Table 17. Device summary

Package	Order codes	
	Tube	Tape and reel
HPAK	VN5T016AH-E	VN5T016AHTR-E

## 7 Revision history

Table 18. Document revision history

Date	Revision	Changes
01-Oct-2012	1	Initial release.
17-Sep-2013	2	Updated disclaimer.
24-Feb-2016	3	<i>Table 4: Thermal data:</i> – $R_{thj-case}$ : updated value Updated <i>Section 5.1: HPAK mechanical data</i>

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