VN7004SLHTR Datasheet

DiGi Electronics Part Number	VN7004SLHTR-DG
Manufacturer	STMicroelectronics
Manufacturer Product Number	VN7004SLHTR
Description	HIGH-SIDE DRIVER WITH CURRENTSEN
Detailed Description	Power Switch/Driver 1:1 N-Channel 135A OctaPAK 7+1

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Purchase and inquiry

Manufacturer Product Number:	Manufacturer:
VN7004SLHTR	STMicroelectronics
Series:	Product Status:
-	Active
Switch Type:	Number of Outputs:
General Purpose	1
Ratio - Input:Output:	Output Configuration:
1:1	High Side
Output Type:	Interface:
N-Channel	Logic
Voltage - Load:	Voltage - Supply (Vcc/Vdd):
-	4V ~ 28V
Current - Output (Max):	Rds On (Typ):
135A	4mOhm
Input Type:	Features:
Non-Inverting	Load Discharge, Status Flag
Operating Temperature:	Mounting Type:
-40°C ~ 150°C (TJ)	Surface Mount
Supplier Device Package:	Package / Case:
OctaPAK 7+1	OctaPAK (7 leads + Tab)
Base Product Number:	
VN7007	

Environmental & Export classification

RoHS Status:	Moisture Sensitivity Level (MSL):
ROHS3 Compliant	3 (168 Hours)
REACH Status:	ECCN:
REACH Unaffected	EAR99
HTSUS:	
8542.39.0001	

life.augmented

VN7004SLH

Datasheet

High-side driver with CurrentSense analog feedback for automotive seat heating systems

Octapak

Features

Max transient supply voltage	V_{CC}	40 V
Operating voltage range	V_{CC}	4 to 28 V
Typ. on-state resistance (per Ch)	R_{ON}	4 mΩ
Current limitation (typ.)	I_{LIMH}	135 A
Stand-by current (max.)	I_{STBY}	0.5 µA

- AEC-Q100 qualified
- General
  - Single channel smart high-side driver with CurrentSense analog feedback
  - Very low standby current
  - Compatible with 3.0 V and 5 V CMOS outputs
- Diagnostic functions
  - Overload and short to ground (power limitation) indication
  - Thermal shutdown indication
  - OFF-state open-load detection
  - Output short to V_{CC} detection
- Protections
  - Undervoltage shutdown
  - Overvoltage clamp
  - Load current limitation
  - Self limiting of fast thermal transients
  - Loss of ground and loss of V_{CC}
  - Configurable latch-off on overtemperature or power limitation
  - Reverse battery
  - Electrostatic discharge protection

Product status link
VN7004SLH

Product summary	
Order code	VN7004SLHTR
Package	Octapak
Packing	Tape and reel

Application

Specially intended for Automotive seat heating systems.

Description

The device is a single channel high-side driver manufactured using ST proprietary VIPower technology and housed in the Octapak package. The device is designed to drive 12 V automotive grounded loads through a 3 V and 5 V CMOS-compatible interface, and to provide protection and diagnostics.

The device integrates advanced protective functions such as load current limitation, overload active management by power limitation and overtemperature shutdown.

A combination of INPUT and FR_DIAG pins latches the output in case of fault, disables the latch-off functionality and enables OFF-state diagnostic.

1 Block diagram and pin description

Figure 1. Block diagram

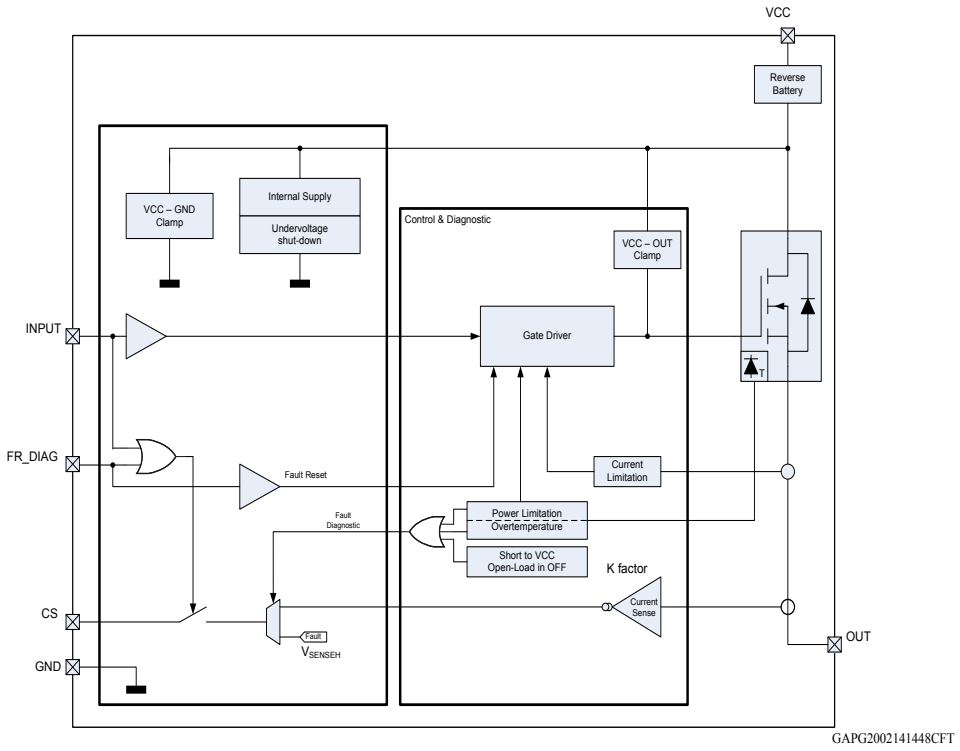


Table 1. Pin functions

Name	Function
V_{CC}	Battery connection.
OUTPUT	Power outputs. All the pins must be connected together.
GND	Ground connection.
INPUT	Voltage controlled input pin with hysteresis. Compatible with 3 V and 5 V CMOS outputs. It controls output switch state.
CS	Analog current sense output pin delivers a current proportional to the load current.
FR_DIAG	It sets auto-restart and latch-off protection. Moreover, it enables OFF-state diagnostic.

Figure 2. Configuration diagram (top view)

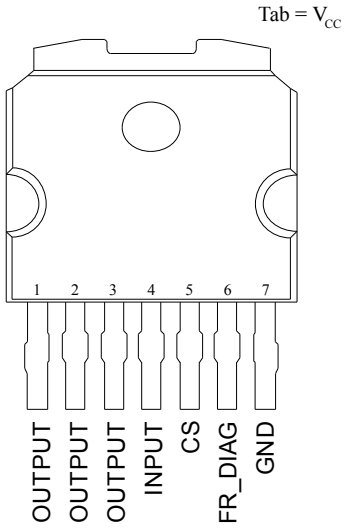


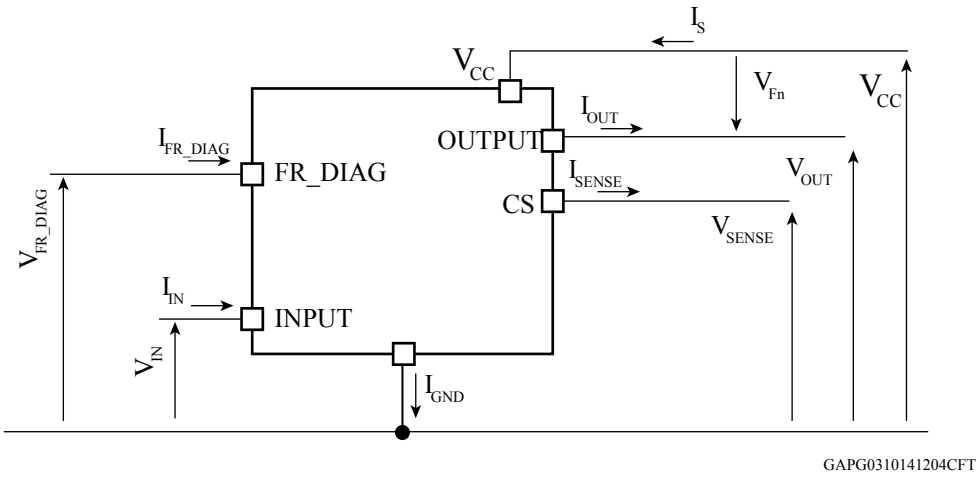
Table 2. Suggested connections for unused and not connected pins

Connection / pin	CS	N.C.	Output	Input	FR_DIAG
Floating	Not allowed	X (1)	X	X	X
To ground	Through 1 kΩ resistor	X	Not allowed	Through 15 kΩ resistor	Through 15 kΩ resistor

1. *X: do not care.*

2 Electrical specification

Figure 3. Current and voltage conventions



Note: $V_F = V_{OUT} - V_{CC}$ when $V_{OUT} > V_{CC}$ and INPUT = LOW

2.1 Absolute maximum ratings

Stressing the device above the rating listed in Table 3. 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 the conditions in the table below for extended periods may affect device reliability.

Table 3. Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	DC supply voltage	38	V
$-V_{CC}$	Reverse DC supply voltage	16	
V_{CCPK}	Maximum transient supply voltage (ISO7637-2:2004 Pulse 5b level IV clamped to 40 V; R_L = 4 Ω)	40	
$-I_{GND}$	DC reverse ground pin current	200	mA
I_{OUT}	OUTPUT DC output current	Internally limited	A
$-I_{OUT}$	Reverse DC output current	38	
I_{IN}	INPUT DC input current	-1 to 10	mA
I_{FR_DIAG}	FR_DIAG DC input current		
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	
E_{MAX}	Maximum switching energy (single pulse) (T_{DEMAG} = 0.13 ms; T_{jstart} = 150 °C)	105	mJ

Symbol	Parameter	Value	Unit
V_{ESD}	Electrostatic discharge (JEDEC 22A-114F) • INPUT • CurrentSense • FR_DIAG • OUTPUT • V_{CC}	4000 2000 4000 4000 4000	V V V V V
V_{ESD}	Charge device model (CDM-AEC-Q100-011)	750	V
T_j	Junction operating temperature	-40 to 150	°C
T_{stg}	Storage temperature	-55 to 150	

2.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	Typ. value	Unit
$R_{thj\text{-}case}$	Thermal resistance junction-case (1)	1.45	°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient (JEDEC JESD 51-5) (2)	58.1	
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient (JEDEC JESD 51-7) (1)	15.6	

1. *Device mounted on four-layers 2s2p PCB*
2. *Device mounted on two-layers 2s0p PCB with 2 cm^2 heatsink copper trace*

2.3 Main electrical characteristics

7 V < V_{CC} < 28 V; -40°C < T_j < 150°C, unless otherwise specified.

All typical values refer to V_{CC} = 13 V; T_j = 25°C, unless otherwise specified.

Table 5. Power section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{CC}	Operating supply voltage		4	13	28	V
V_{USD}	Undervoltage shutdown				4	V
$V_{USDReset}$	Undervoltage shutdown reset				5	V
$V_{USDhyst}$	Undervoltage shutdown hysteresis			0.3		V
R_{ON}	On-state resistance	I_{OUT} = 15 A; T_j = 25°C		4		mΩ
		I_{OUT} = 15 A; T_j = 150°C			8	mΩ
		I_{OUT} = 15 A; V_{CC} = 4 V; T_j = 25°C			6	mΩ
R_{ON_Rev}	R_{DSON} in reverse battery condition	V_{CC} = -13 V; I_{OUT} = -15 A; T_j = 25°C		4		mΩ
V_{clamp}	Clamp voltage	I_S = 20 mA; T_j = -40°C	38			V
		I_S = 20 mA; 25°C < T_j < 150°C	41	46	52	V
I_{STBY}	Supply current in standby at V_{CC} = 13 V (1)	V_{CC} = 13 V; V_{IN} = V_{OUT} = V_{FR_DIAG} = 0 V; T_j = 25°C			0.5	µA
		V_{CC} = 13 V; V_{IN} = V_{OUT} = V_{FR_DIAG} = 0 V; T_j = 85°C (2)			1.4	µA

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{STBY}	Supply current in standby at V_{CC} = 13 V (1)	V_{CC} = 13 V; V_{IN} = V_{OUT} = V_{FR_DIAG} = 0 V; T_j = 125°C			11	µA
t_{D_STBY}	Standby mode blanking time	V_{CC} = 13 V; V_{IN} = 5 V; V_{FR_DIAG} = 0 V; I_{OUT} = 0 A	200	1150	2000	µs
$I_{S(ON)}$	Supply current	V_{CC} = 13 V; V_{FR_DIAG} = 0 V; V_{IN} = 5 V; I_{OUT} = 0 A		4	6.5	mA
$I_{GND(ON)}$	Control stage current consumption in ON state. All channels active.	V_{CC} = 13 V; V_{FR_DIAG} = 5 V; V_{IN} = 5 V; I_{OUT} = 15 A			9	mA
$I_{L(off)}$	Off-state output current at V_{CC} = 13 V	V_{IN} = V_{OUT} = 0 V; V_{CC} = 13 V; T_j = 25°C	0	0.01	0.5	µA
		V_{IN} = V_{OUT} = 0 V; V_{CC} = 13 V; T_j = 125°C	0		11	
V_F	Output - V_{CC} diode voltage	I_{OUT} = -15 A; T_j = 150°C			0.7	V

1. *PowerMOS leakage included.*
2. *Parameter specified by design; not subject to production test.*

Table 6. Switching

V_{CC} = 13 V; -40°C < T_j < 150°C, unless otherwise specified						
Symbol	**Parameter**	**Test conditions**	**Min.**	**Typ.**	**Max.**	**Unit**
$t_{d(on)}$ (1)	Turn-on delay time	R_L = 1.8 Ω	290	640	1100	µs
$t_{d(off)}$ (1)	Turn-off delay time		160	330	510	
$(dV_{OUT}/dt)_{on}$ (1)	Turn-on voltage slope	R_L = 1.8 Ω	0.015	0.023	0.041	V/µs
$(dV_{OUT}/dt)_{off}$ (1)	Turn-off voltage slope		0.018	0.031	0.056	
W_{ON}	Switching energy losses at turn-on (t_{won})	R_L = 1.8 Ω	—	11.5	18 (2)	mJ
W_{OFF}	Switching energy losses at turn-off (t_{woff})	R_L = 1.8 Ω	—	8	12 (2)	mJ
t_{SKEW} (1)	Differential Pulse skew (t_{PHL} - t_{PLH})	R_L = 1.8 Ω	-780	-410	-40	µs

1. *See Figure 6. Switching times and Pulse skew.*
2. *Parameter guaranteed by design and characterization; not subject to production test.*

Table 7. Logic inputs

7 V < V_{CC} < 28 V; -40°C < T_j < 150°C						
Symbol	**Parameter**	**Test conditions**	**Min.**	**Typ.**	**Max.**	**Unit**
INPUT characteristics						
V_{IL}	Input low level voltage				0.9	V
I_{IL}	Low level input current	V_{IN} = 0.9 V	1			µA
V_{IH}	Input high level voltage		2.1			V
I_{IH}	High level input current	V_{IN} = 2.1 V			10	µA
$V_{I(hyst)}$	Input hysteresis voltage		0.2			V
V_{ICL}	Input clamp voltage	I_{IN} = 1 mA	5.3		7.5	V
		I_{IN} = -1 mA		-0.7		
FR_DIAG characteristics (7 V < V_{CC} < 18 V)						
V_{FR_DIAGL}	Input low level voltage				0.9	V

7 V < V_{CC} < 28 V; -40°C < T_j < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{FR_DIAGL}	Low level input current	V_{IN} = 0.9 V	1			µA
V_{FR_DIAGH}	Input high level voltage		2.1			V
I_{FR_DIAGH}	High level input current	V_{IN} = 2.1 V			10	µA
$V_{FR\_DIAG(hyst)}$	Input hysteresis voltage		0.2			V
V_{FR_DIAGCL}	Input clamp voltage	I_{IN} = 1 mA	5.3		7.5	V
		I_{IN} = -1 mA		-0.7		

Table 8. Protections

7 V < V_{CC} < 18 V; -40°C < T_j < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I_{LIMH} (1)	DC short circuit current	V_{CC} = 13 V	80	135	175	A
		4 V < V_{CC} < 18 V (2)			175	
I_{LIML}	Short circuit current during thermal cycling	V_{CC} = 13 V; T_R < T_j < T_{TSD}		38		A
T_{TSD}	Shutdown temperature		150	175	200	°C
T_R	Reset temperature(2)		T_{RS} + 1	T_{RS} + 7		°C
T_{RS}	Thermal reset of fault diagnostic indication	V_{FR_DIAG} = 5 V;	135			°C
T_{HYST}	Thermal hysteresis (T_{TSD} - T_R)(2)			7		°C
ΔT_{J_SD}	Dynamic temperature	V_{CC} = 13 V		60		K
t_{LATCH_RST}	Fault reset time for output unlatch(2)	V_{FR_DIAG} = 5 V to 0 V; V_{IN} = 5 V	3	10	20	µs
V_{DEMAG}	Turn-off output voltage clamp	I_{OUT} = 2 A; L = 6 mH; T_j = -40°C	V_{CC} - 38			V
		I_{OUT} = 2 A; L = 6 mH; T_j = 25°C to 150°C	V_{CC} - 41	V_{CC} - 46	V_{CC} - 52	

1. *Parameter guaranteed by an indirect test sequence.*
2. *Parameter guaranteed by design and characterization; not subject to production test.*

Table 9. CurrentSense

7 V < V_{CC} < 18 V; -40°C < T_j < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{SENSE_CL}	CurrentSense clamp voltage	V_{FR_DIAG} = 0 V; I_{SENSE} = 1 mA	-17		-12	V
		V_{FR_DIAG} = 0 V; I_{SENSE} = -1 mA		7		V
CurrentSense characteristics						
K_0	I_{OUT}/I_{SENSE}	I_{OUT} = 1 A; V_{SENSE} = 0.5 V	9000	16650	24500	
dK_0/K_0 (1) (2)	Current sense ratio drift	I_{OUT} = 1 A; V_{SENSE} = 0.5 V	-30		30	%

7 V < V_{CC} < 18 V; -40°C < T_j < 150°C						
Symbol	**Parameter**	**Test conditions**	**Min.**	**Typ.**	**Max.**	**Unit**
K_1	I_{OUT}/I_{SENSE}	I_{OUT} = 7 A; V_{SENSE} = 4 V	13150	16450	19750	
dK_1/K_1 (1) (2)	Current sense ratio drift	I_{OUT} = 7 A; V_{SENSE} = 4 V	-10		10	%
K_2	I_{OUT}/I_{SENSE}	I_{OUT} = 12 A; V_{SENSE} = 4 V	14200	16450	19100	
dK_2/K_2 (1) (2)	Current sense ratio drift	I_{OUT} = 12 A; V_{SENSE} = 4 V	-7		7	%
K_3	I_{OUT}/I_{SENSE}	I_{OUT} = 45 A; V_{SENSE} = 4 V	14760	16450	18670	
dK_3/K_3 (1) (2)	Current sense ratio drift	I_{OUT} = 45 A; V_{SENSE} = 4 V	-5		5	%
$I_{SENSE\ 0}$	CurrentSense leakage current	CurrentSense disabled: V_{FR_DIAG} = 0 V	0		0.5	µA
		CurrentSense disabled: -1 V < V_{SENSE} < 5 (1)	-0.5		0.5	µA
		CurrentSense enabled: V_{IN} = 5 V; I_{OUT} = 0 A	0		25	µA
V_{OUT_CSD} (1)	Output Voltage for CurrentSense shutdown	V_{FR_DIAG} = 5 V; R_{SENSE} = 2.7 kΩ; V_{IN} = 5 V; I_{OUT} = 15 A		5		V
V_{SENSE_SAT}	Multisense saturation voltage	V_{CC} = 7 V; R_{SENSE} = 10 kΩ; V_{FR_DIAG} = 5 V; V_{IN} = 5 V; I_{OUT} = 15 A; T_j = -40°C	5			V
I_{SENSE_SAT} (1)	CS saturation current	V_{CC} = 7 V; V_{SENSE} = 4 V; V_{IN} = 5 V; V_{FR_DIAG} = 5 V; T_j = 150°C	4			mA
I_{OUT_SAT} (1)	Output saturation current	V_{CC} = 7 V; V_{SENSE} = 4 V; V_{IN} = 5 V; V_{FR_DIAG} = 5 V; T_j = -150°C	75			A
OFF-state diagnostic						
V_{OL}	OFF-state open-load voltage detection threshold	V_{IN} = 0 V; V_{FR_DIAG} = 5 V	2	3	4	V
$I_{L(off2)}$	OFF-state output sink current	V_{IN} = 0 V; V_{OUT} = V_{OL}; T_j = -40°C to 125°C	-100		-15	µA
t_{DSTKON}	OFF-state diagnostic delay time from falling edge of INPUT (see Figure 7. T_{DSTKON})	V_{IN} = 5 V to 0 V; V_{FR_DIAG} = 5 V; I_{OUT} = 0 A; V_{OUT} = 4 V	400	1480	2500	µs
$t_{D\_OL\_V}$	Settling time for valid OFF-state open load diagnostic indication from rising edge of FR_DIAG	V_{IN} = 0 V; V_{FR} = 0 V; V_{OUT} = 4 V; V_{FR_DIAG} = 0 V to 5 V			60	µs
t_{D_VOL}	OFF-state diagnostic delay time from rising edge of V_{OUT}	V_{IN} = 0 V; V_{FR_DIAG} = 5 V; V_{OUT} = 0 V to 4 V		5	30	µs
Fault diagnostic feedback (see Table 10. Truth table)						
V_{SENSEH}	CurrentSense output voltage in fault condition	V_{CC} = 13 V; V_{IN} = 0 V; V_{FR_DIAG} = 5 V; I_{OUT} = 0 A; V_{OUT} = 4 V; R_{SENSE} = 1 kΩ	5		6.6	V
I_{SENSEH}	CurrentSense output current in fault condition	V_{CC} = 13 V; V_{SENSE} = 5 V	7	20	30	mA
CurrentSense timings (current sense mode)(3)						
$t_{DSENSE2H}$	Current sense settling time from rising edge of INPUT	V_{IN} = 0 V to 5 V; V_{FR_DIAG} = 5 V; R_{SENSE} = 1 kΩ; R_L = 0.87 Ω		1200	3750	µs

7 V < V_{CC} < 18 V; -40°C < T_j < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$\Delta t_{DSENSE2H}$	Current sense settling time from rising edge of I_{OUT} (dynamic response to a step change of I_{OUT})	V_{IN} = 5 V; V_{FR_DIAG} = 5 V; R_{SENSE} = 1 kΩ; I_{SENSE} = 90 % of $I_{SENSEMAX}$; R_L = 0.87 Ω			690	µs
$t_{DSENSE2L}$	Current sense turn-off delay time from falling edge of INPUT	V_{IN} = 5 V to 0 V; V_{FR_DIAG} = 5 V; R_{SENSE} = 1 kΩ; R_L = 0.87 Ω		510	880	µs

1. *Parameter guaranteed by design and characterization; not subject to production test.*
2. *All values refer to V_{CC} = 13 V; T_j = 25°C, unless otherwise specified.*
3. *Transition delay is measured up to ±10% of final conditions.*

Figure 4. I_{OUT}/I_{SENSE} versus I_{OUT}

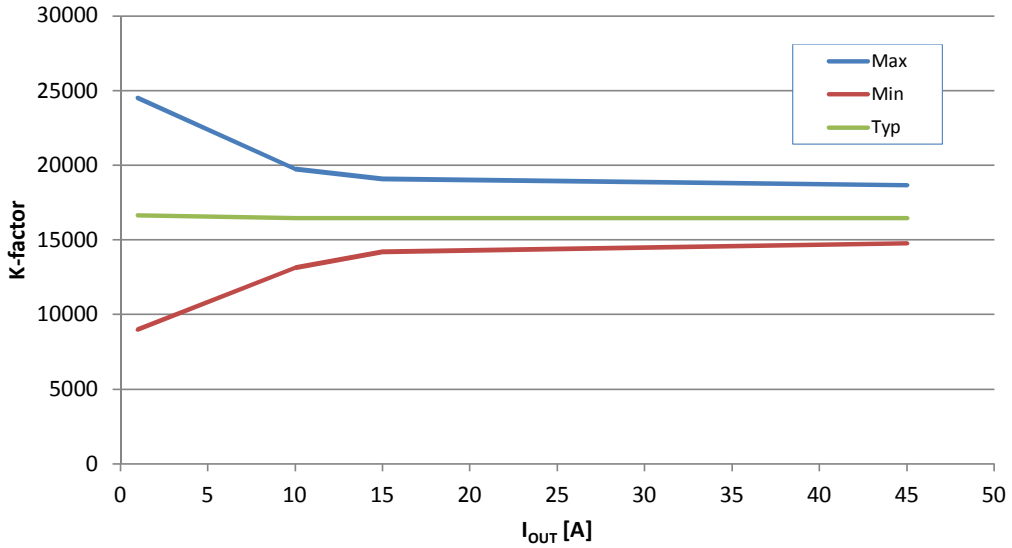


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Figure 5. **Current sense precision vs. I_{OUT}**

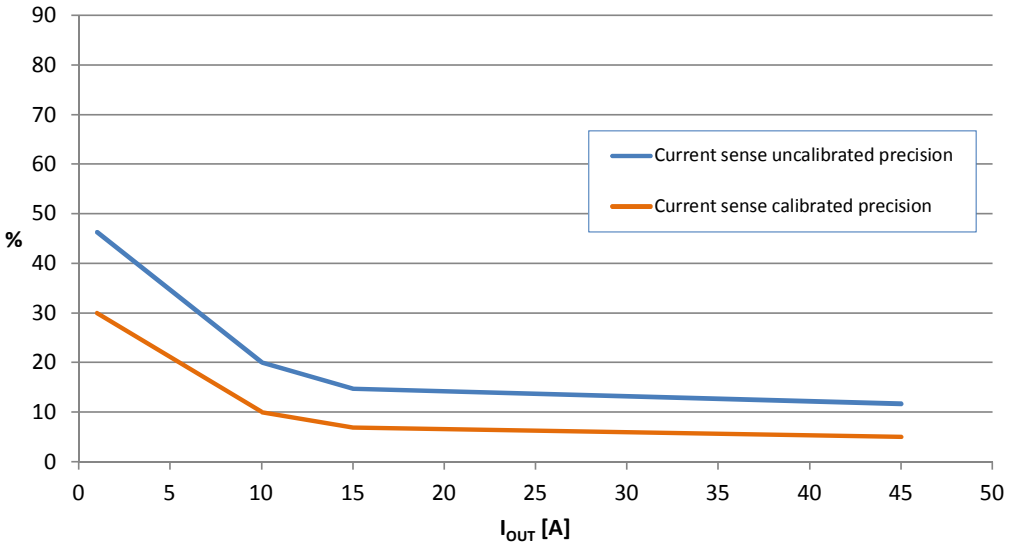

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Figure 6. **Switching times and Pulse skew**

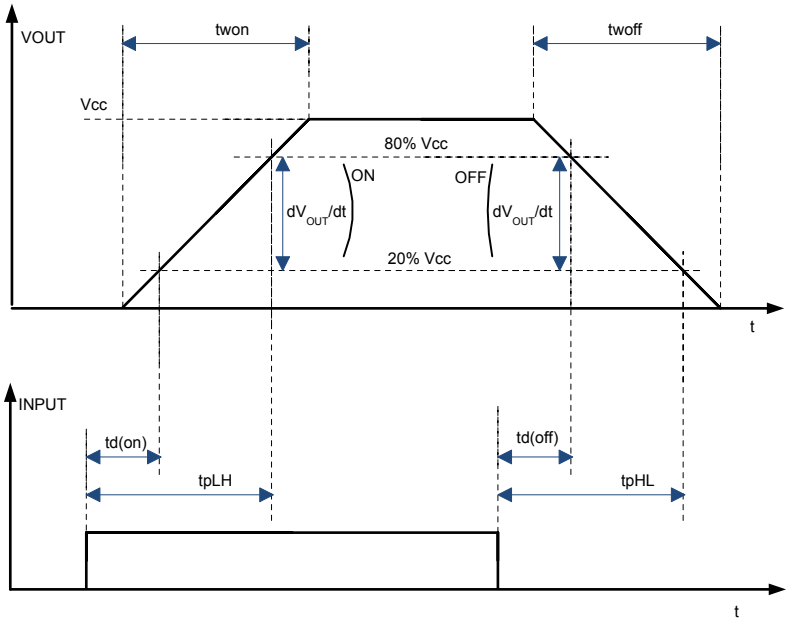


Figure 7. T_{DSTKON}

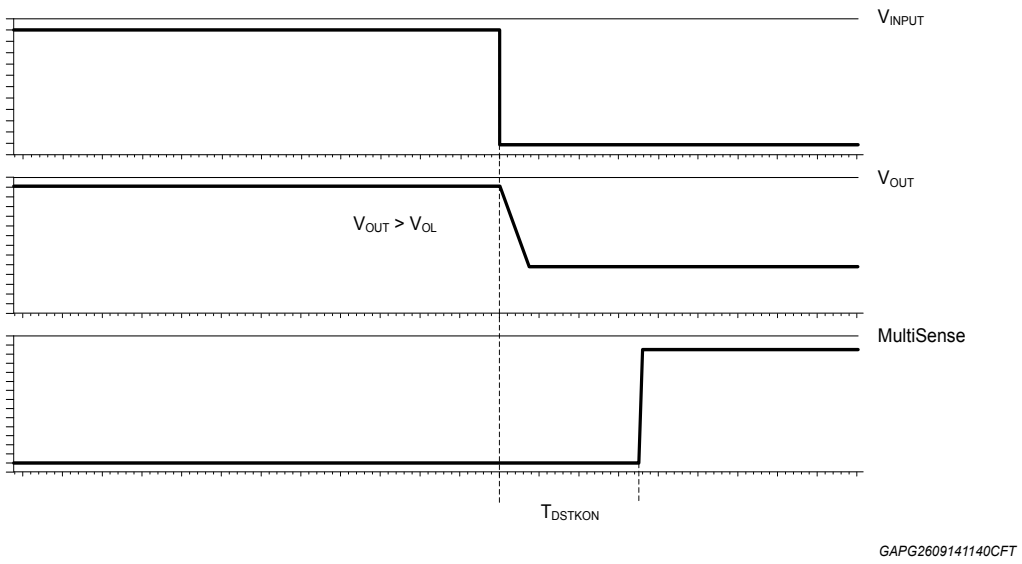


Table 10. Truth table

Mode	Conditions	IN	FR_DIAG	OUT	Current Sense	Comments
Stand by	All logic inputs low	L	L	L	Hi-Z	Low quiescent current consumption
Normal	Nominal load connected; T_j < 150°C	L	H	L	0	OFF-state diagnostic enabled
		H	L	H	I_{SENSE} = 1/ K * I_{OUT}	Autorestart mode
		H	H	H	I_{SENSE} = 1/K * I_{OUT}	Latch-off mode
Overload	Overload or short to GND causing: $T_j > T_{TSD}$ or $\Delta T_j > \Delta T_{j\_SD}$	H	L	H	V_{SENSEH}	Autorestart mode
		H	H	H	V_{SENSEH}	Latch-off mode
Under-voltage	$V_{CC} < V_{USD}$ (falling)	X	X	L	Hi-Z	Re-start when $V_{CC} > V_{USD} + V_{USDhyst}$ (rising)
OFF-state diagnostics	Short to V_{CC}	L	H	H	V_{SENSEH}	
	Open-load	L	H	H		External pull-up
Negative output voltage	Inductive loads turn-off	L	X	< 0 V	0	

Table 11. FR_DIAG functionality

FR_DIAG	Input	Diagnostic	Overload protection
0	0	Disabled	X (1)
0	1	Enabled	Auto-restart
1	0	Enabled (OFF-state diagnostic)	X(1)
1	1	Enabled	Latch-off

1. *X: do not care.*

2.4 Electrical characteristics curves

Figure 8. OFF-state output current

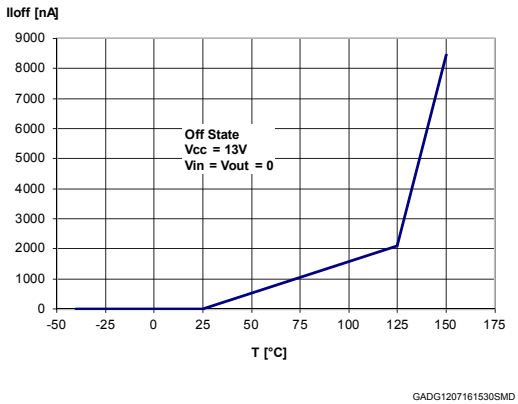


Figure 9. Standby current

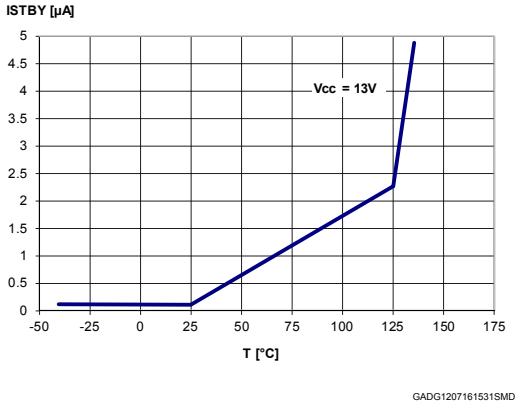


Figure 10. $I_{GND(ON)}$ vs. I_{out}

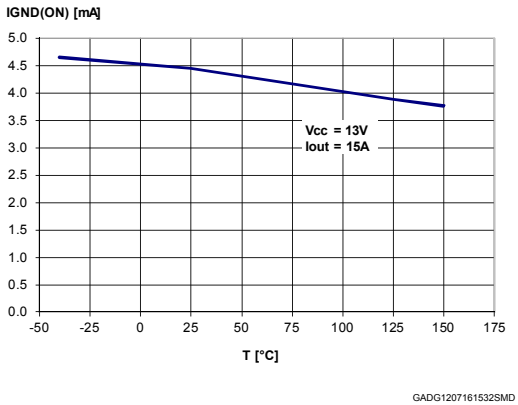


Figure 11. Logic input high level voltage

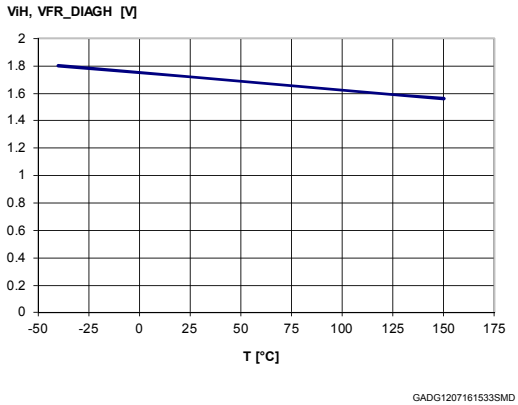


Figure 12. Logic input low level voltage

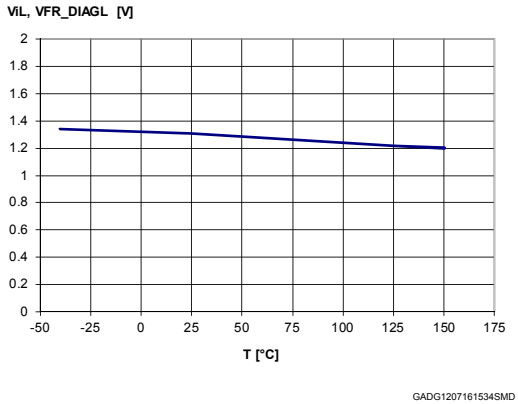


Figure 13. High level logic input current

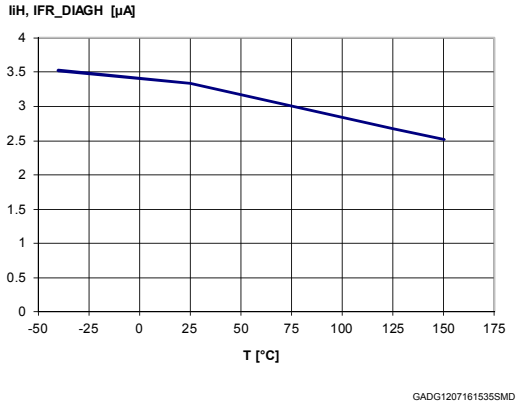


Figure 14. Low level logic input current

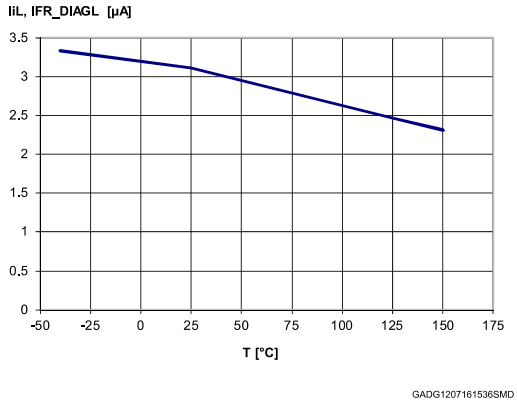


Figure 15. Logic input hysteresis voltage

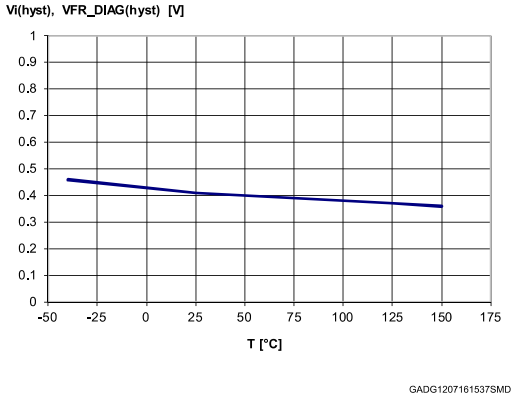


Figure 16. Undervoltage shutdown

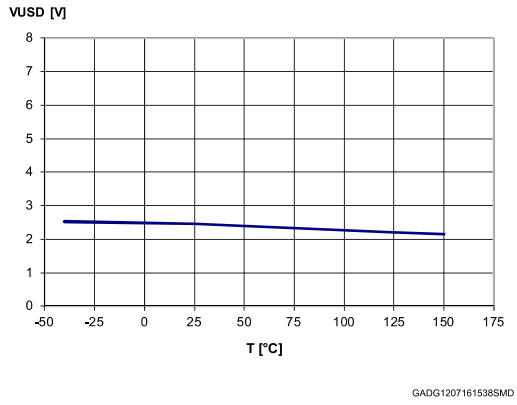


Figure 17. On-state resistance vs. T_{case}

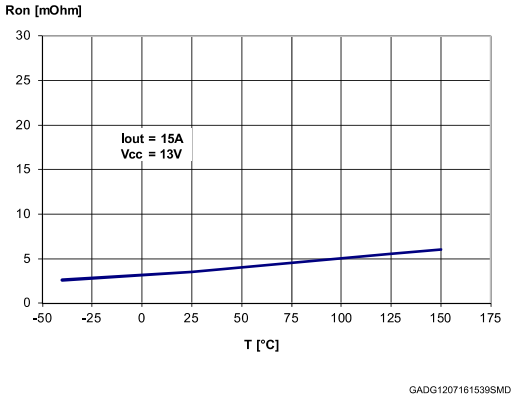


Figure 18. On-state resistance vs. V_{CC}

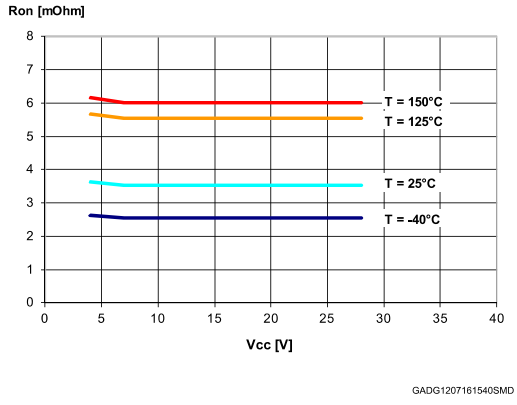


Figure 19. Turn-on voltage slope

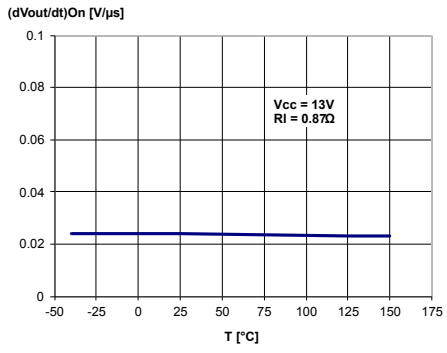


Figure 20. Turn-off voltage slope

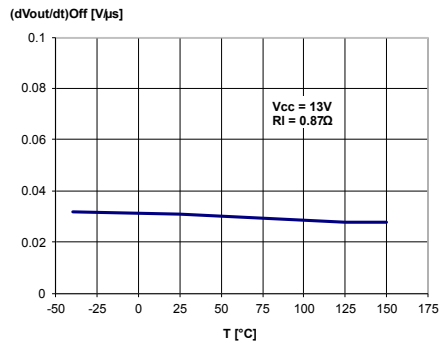


Figure 21. Won vs. T_{case}

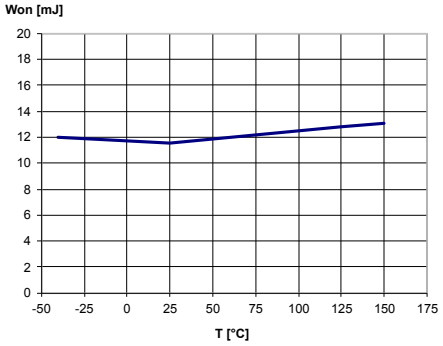


Figure 22. Woff vs. T_{case}

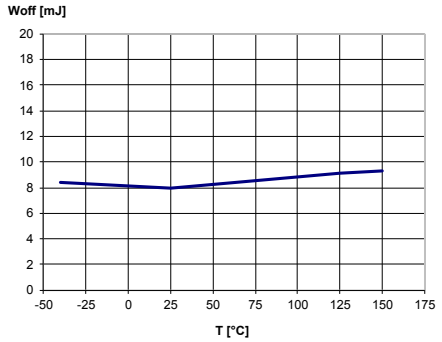


Figure 23. I_{LIMH} vs. T_{case}

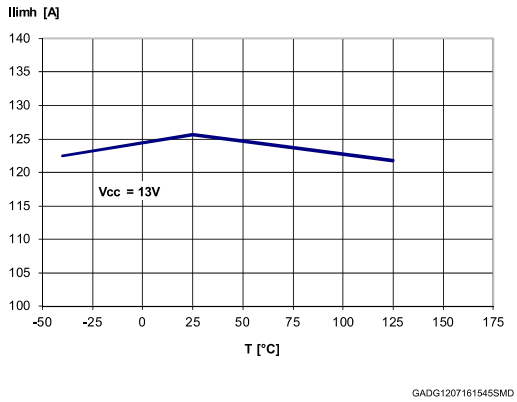


Figure 24. Turn-off output voltage clamp

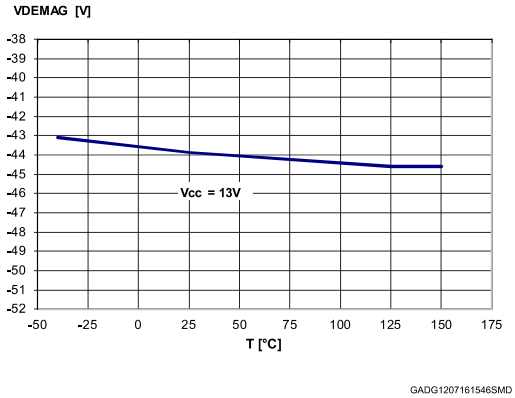


Figure 25. OFF-state open-load voltage detection threshold

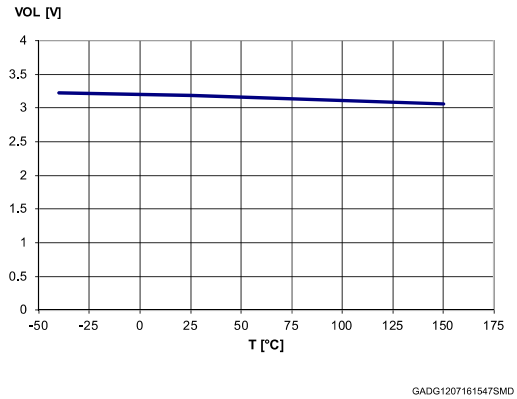


Figure 26. Vs clamp vs. T_{case}

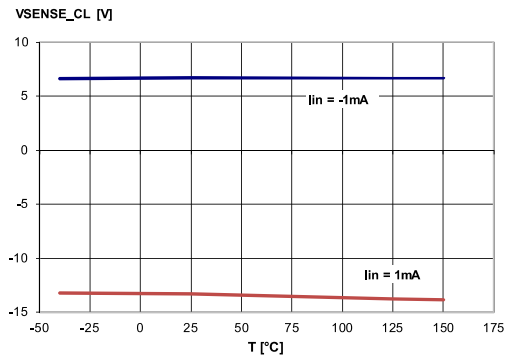
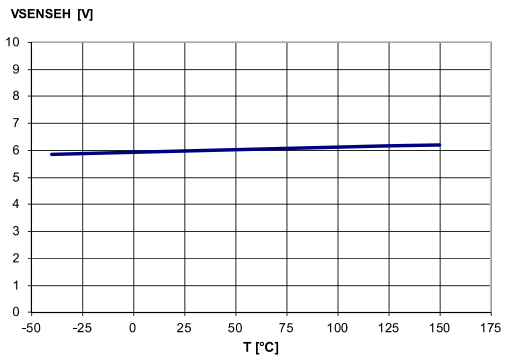


Figure 27. V_{senseh} vs. T_{case}



3 Protections

3.1 Power limitation

The basic working principle of this protection consists of an indirect measurement of the junction temperature swing ΔT_j through the direct measurement of the spatial temperature gradient on the device surface in order to automatically shut off the output MOSFET as soon as ΔT_j exceeds the safety level of ΔT_{j_SD}. According to the voltage level on the FR_DIAG pin, the output MOSFET switches on and cycles with a thermal hysteresis according to the maximum instantaneous power which can be handled (FR_DIAG = Low) or remains off (FR_DIAG = High). The protection prevents fast thermal transient effects and, consequently, reduces thermo-mechanical fatigue.

3.2 Thermal shutdown

In case the junction temperature of the device exceeds the maximum allowed threshold (typically 175°C), it automatically switches off and the diagnostic indication is triggered. According to the voltage level on the FR_DIAG pin, the device switches on again as soon as its junction temperature drops to T_R (FR_DIAG = Low) or remains off (FR_DIAG = High).

3.3 Current limitation

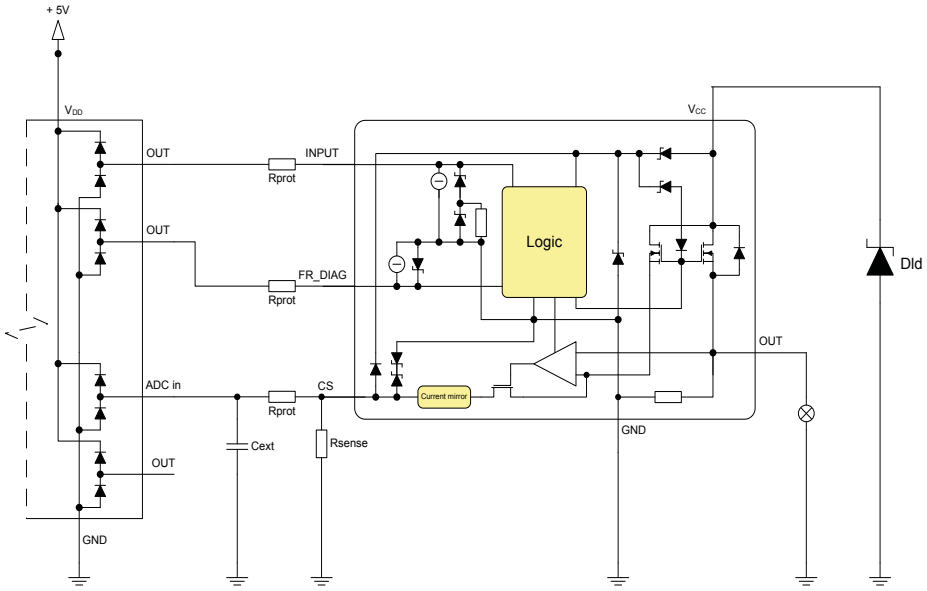
The device is equipped with an output current limiter in order to protect the silicon as well as the other components of the system (e.g. bonding wires, wiring harness, connectors, loads, etc.) from excessive current flow. Consequently, in case of short-circuit, overload or during load power-up, the output current is clamped to a safety level, I_{LIMH}, by operating the output power MOSFET in the active region.

3.4 Negative voltage clamp

In case the device drives inductive load, the output voltage reaches negative values during turn off. A negative voltage clamp structure limits the maximum negative voltage to a certain value, V_{DEMAG}, allowing the inductor energy to be dissipated without damaging the device.

4 Application information

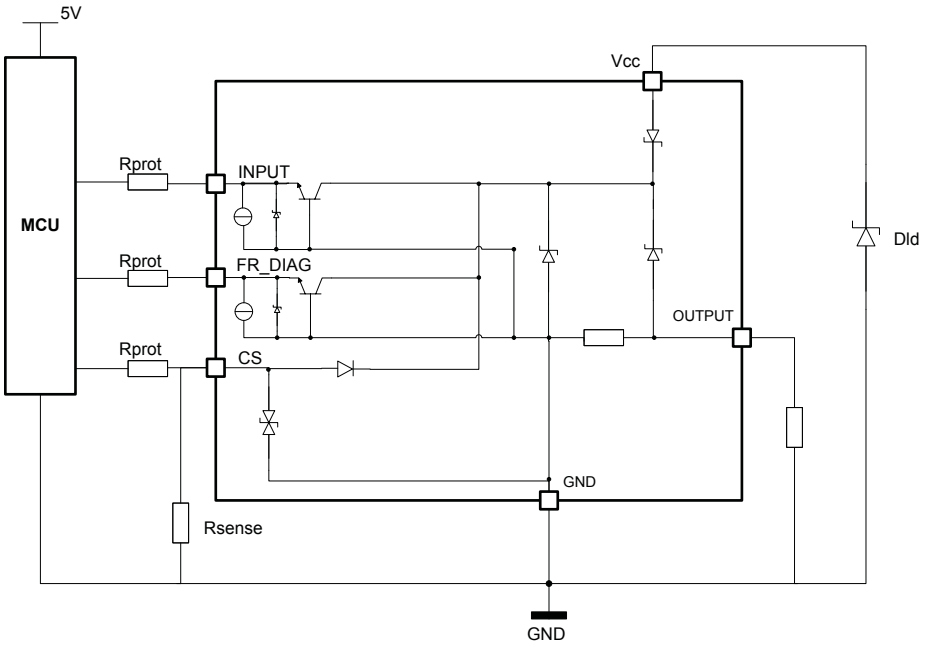
Figure 28. **Application diagram**



GAPG1607150817CFT

4.1 GND protection network against reverse battery

Figure 29. **Simplified internal structure**



GAPG1606150821CFT

The device does not need any external components to protect the internal logic in case of a reverse battery condition. The protection is provided by internal structures.

In addition, due to the fact that the output MOSFET turns on even in reverse battery mode, thus providing the same low ohmic path as in regular operating conditions, no additional power dissipation has to be considered.

4.2 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 12. ISO 7637-2 - electrical transient conduction along supply line.

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 12. 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	-112V	500 pulses	0,5 s		2ms, 10Ω
2a	III	+55V	500 pulses	0,2 s	5 s	50µs, 2Ω
3a	IV	-220V	1h	90 ms	100 ms	0.1µs, 50Ω
3b	IV	+150V	1h	90 ms	100 ms	0.1µs, 50Ω
4 (2)	IV	-7V	1 pulse			100ms, 0.01Ω
Load dump according to ISO 16750-2:2010						
Test B (3)		40V	5 pulse	1 min		400ms, 2Ω

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).*

4.3 MCU I/Os protection

If a ground protection network is used and negative transients are present on the V_{CC} line, the control pins will be pulled negative. ST suggests to insert a resistor (R_{prot}) in line both to prevent the microcontroller I/O pins from latch-up and to protect the HSD inputs.

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:

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

Calculation example:

For V_{CCpeak} = -150 V; $I_{latchup} \geq$ 20mA; $V_{OH\,\mu\,C} \geq$ 4.5V

7.5 kΩ ≤ R_{prot} ≤ 140 kΩ.

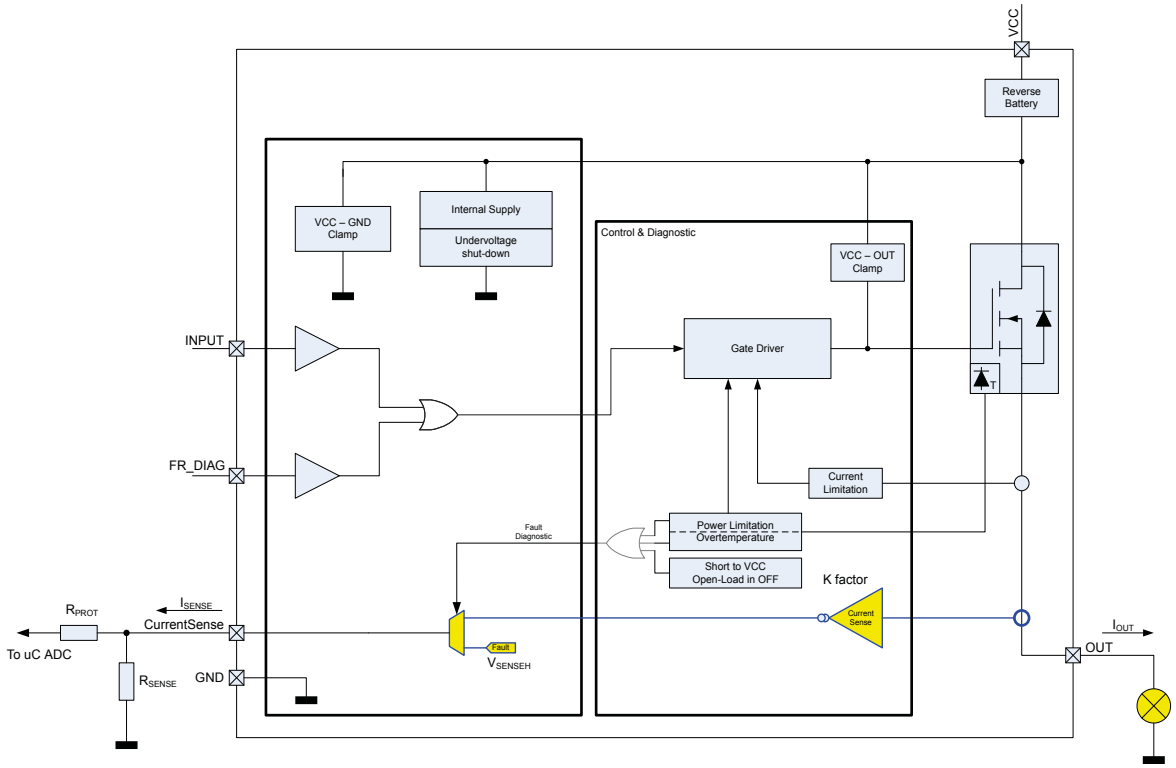
Recommended values: R_{prot} = 15 kΩ

4.4 CS - analog current sense

Diagnostic information on device and load status are provided by an analog output pin (CS) delivering the following signal:

- Current monitor: current monitor of channel output current

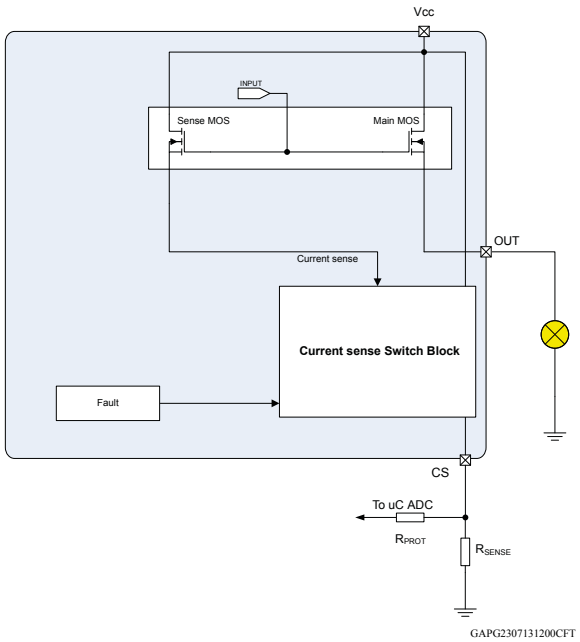
Figure 30. CurrentSense and diagnostic - block diagram



GAPG2704161550CFT

4.4.1 Principle of CurrentSense signal generation

Figure 31. CurrentSense block diagram



Current sense

This output is capable of providing:

- **Current mirror proportional to the load current in normal operation**, delivering current proportional to the load according to a known ratio named **K**
- **Diagnostics flag in fault conditions** delivering fixed voltage V_{SENSEH}

The current delivered by the current sense circuit, I_{SENSE}, can be easily converted to a voltage V_{SENSE} by using an external sense resistor, R_{SENSE}, allowing continuous load monitoring and abnormal condition detection.

Normal operation (channel ON, no fault)

While the device is operating in normal conditions (no fault intervention), V_{SENSE} calculation can be done using simple equations

Current provided by CurrentSense output: $I_{SENSE} = I_{OUT}/K$

Voltage on R_{SENSE}: $V_{SENSE} = R_{SENSE} \cdot I_{SENSE} = R_{SENSE} \cdot I_{OUT}/K$

Where :

- V_{SENSE} is the voltage measurable on R_{SENSE} resistor
- I_{SENSE} is the current provided from the CS pin in current output mode
- I_{OUT} is the current flowing through output
- K factor represents the ratio between PowerMOS cells and SenseMOS cells; its spread includes geometric factor spread, current sense amplifier offset and process parameters spread of the overall circuitry specifying the ratio between I_{OUT} and I_{SENSE}.

Failure flag indication

In case of power limitation/overtemperature, the fault is indicated by the CS pin which is switched to a “current limited” voltage source, V_{SENSEH}.

In any case, the current sourced by the CS in this condition is limited to I_{SENSEH}.

Figure 32. Analogue HSD – open-load detection in off-state

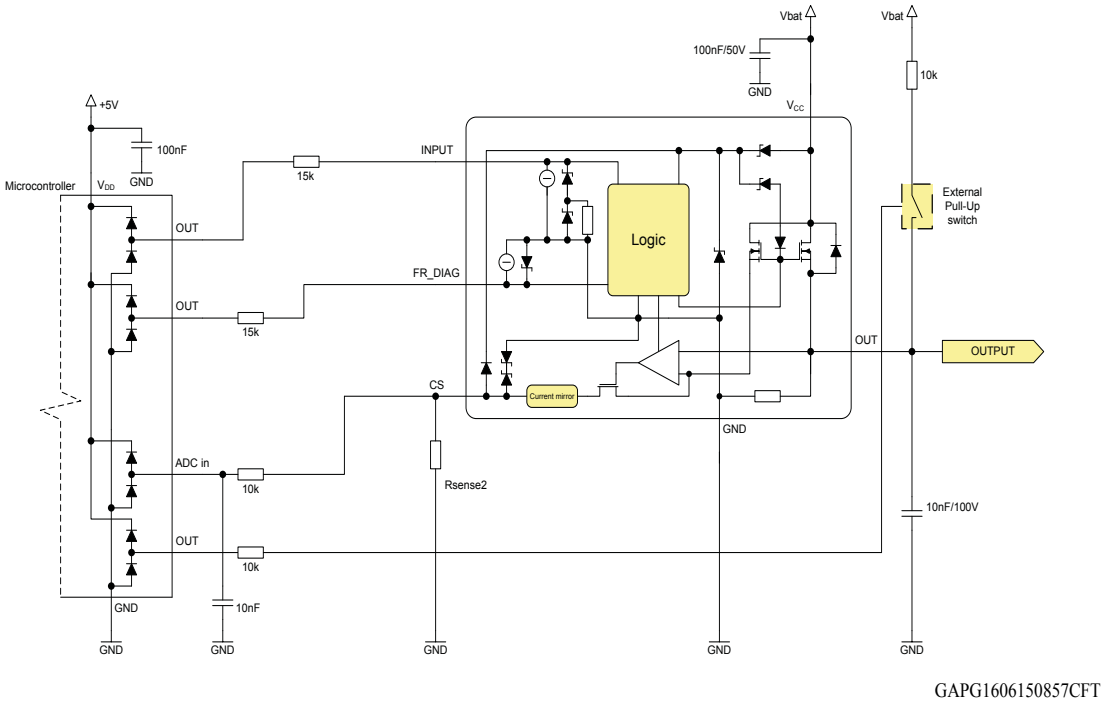


Figure 33. Open-load / short to V_{CC} condition

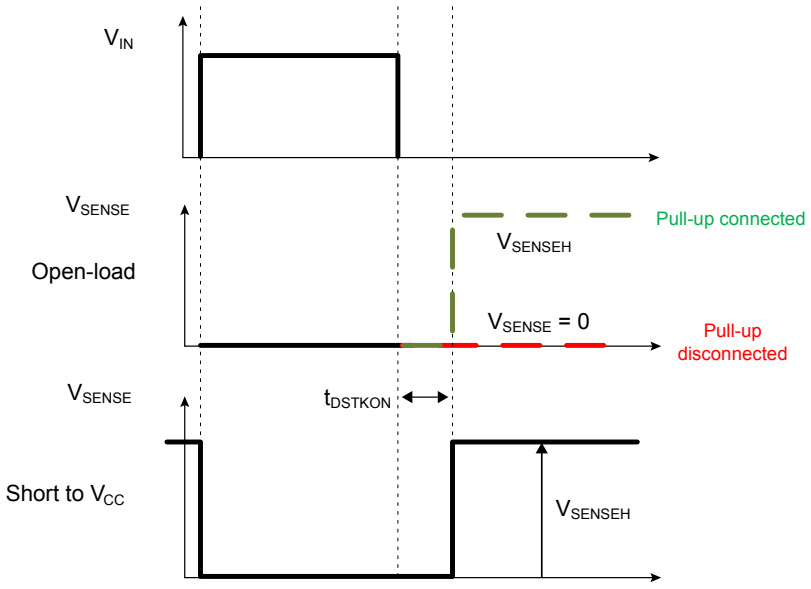


Table 13. **CurrentSense pin levels in off-state**

Condition	Output	CurrentSense	FR_DIAG
Open-load	$V_{OUT} > V_{OL}$	Hi-Z	L
		V_{SENSEH}	H
	$V_{OUT} < V_{OL}$	Hi-Z	L
		0	H
Short to V_{CC}	$V_{OUT} > V_{OL}$	Hi-Z	L
		V_{SENSEH}	H
Nominal	$V_{OUT} < V_{OL}$	Hi-Z	L
		0	H

4.4.2 Short to VCC and OFF-state open-load detection

Short to V_{CC}

A short circuit between V_{CC} and output is indicated by the relevant current sense pin set to V_{SENSEH} during the device off-state. Small or no current is delivered by the current sense during the on-state depending on the nature of the short circuit.

OFF-state open-load with external circuitry

Detection of an open-load in off mode requires an external pull-up resistor R_{PU} connecting the output to a positive supply voltage V_{PU}.

It is preferable V_{PU} to be switched off during the module standby mode in order to avoid the overall standby current consumption to increase in normal conditions, i.e. when load is connected.

R_{PU} must be selected in order to ensure $V_{OUT} > V_{OLmax}$ in accordance with the following equation:

$$R_{PU} < \frac{V_{PU} - 4}{I_{L(off2)min\ @\ 4V}}$$

5 Package and PCB thermal data

5.1 Octapak thermal data

Figure 34. **Octapak on two-layer PCB (2s0p to JEDEC JESD 51-5)**

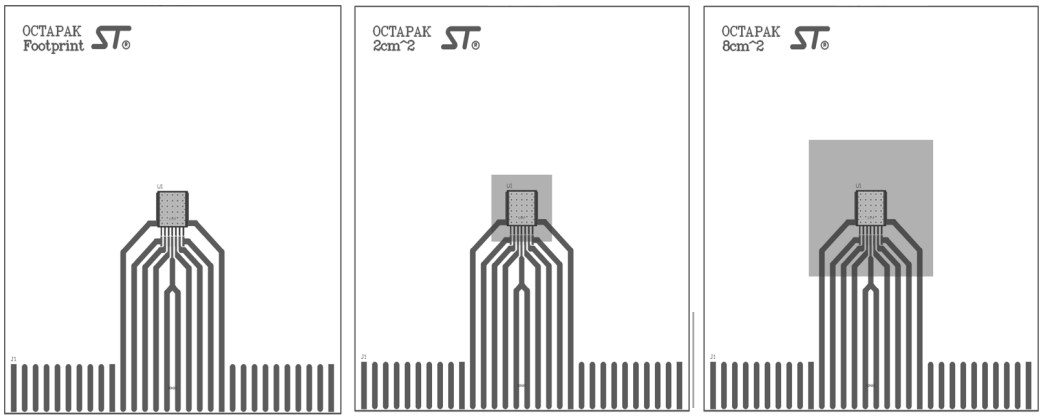


Figure 35. **Octapak on four-layer PCB (2s2p to JEDEC JESD 51-7)**

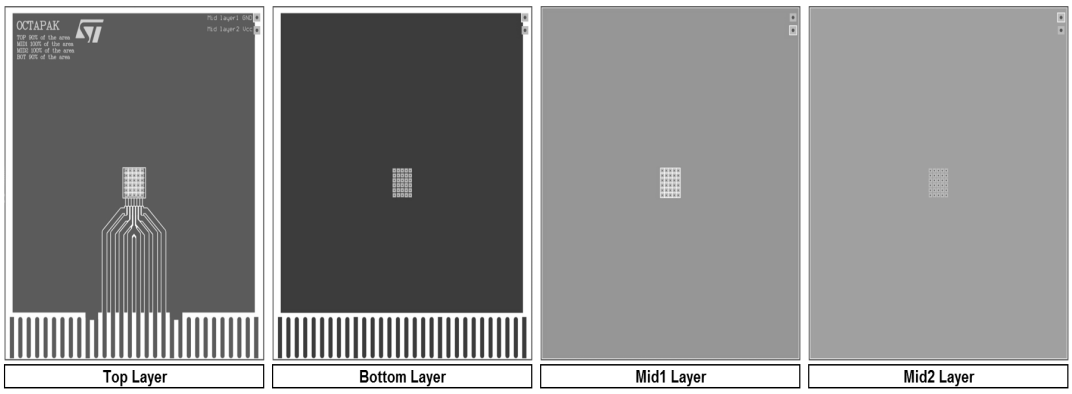


Table 14. **PCB properties**

Dimension	Value
Board finish thickness	1.6 mm +/- 10%
Board dimension	77 mm x 86 mm
Board Material	FR4
Copper thickness (top and bottom layers)	0.070 mm
Copper thickness (inner layers)	0.035 mm
Thermal vias separation	1.2 mm
Thermal via diameter	0.3 mm +/- 0.08 mm
Copper thickness on vias	0.025 mm
Footprint dimension (top layer)	6.4 mm x 7 mm

Dimension	Value
Heatsink copper area dimension (bottom layer)	Footprint, 2 cm^2 or 8 cm^2

Figure 36. $R_{thj-amb}$ vs PCB copper area in open box free air conditions

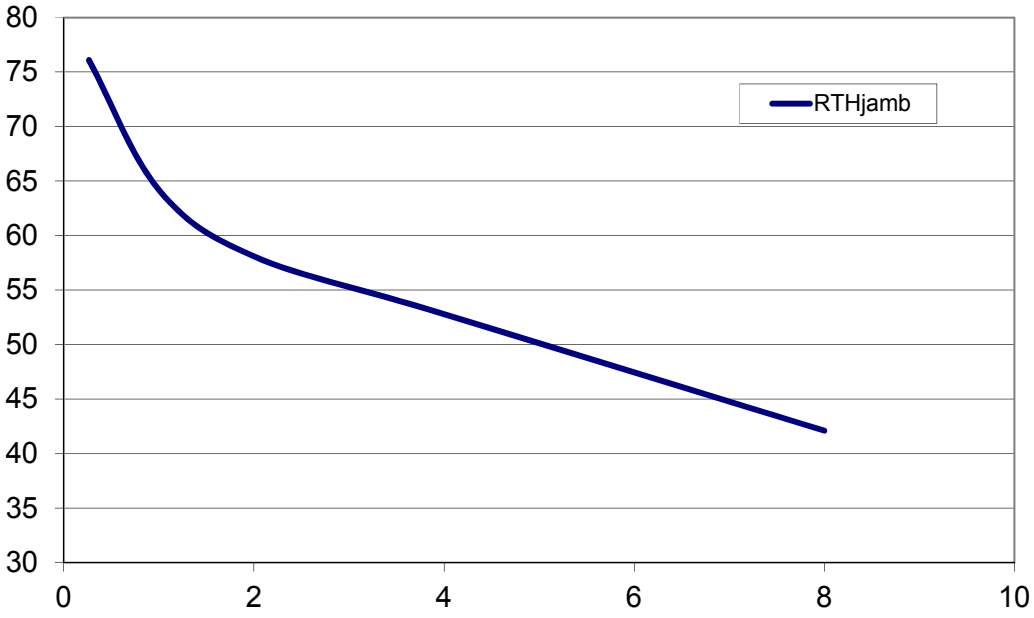
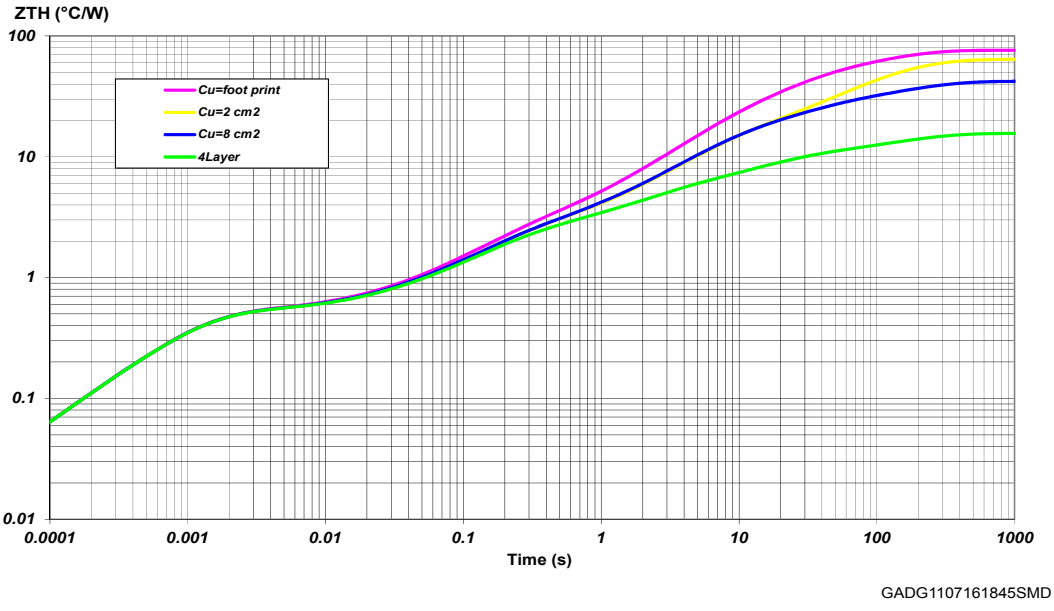


Figure 37. Octapak thermal impedance junction ambient single pulse



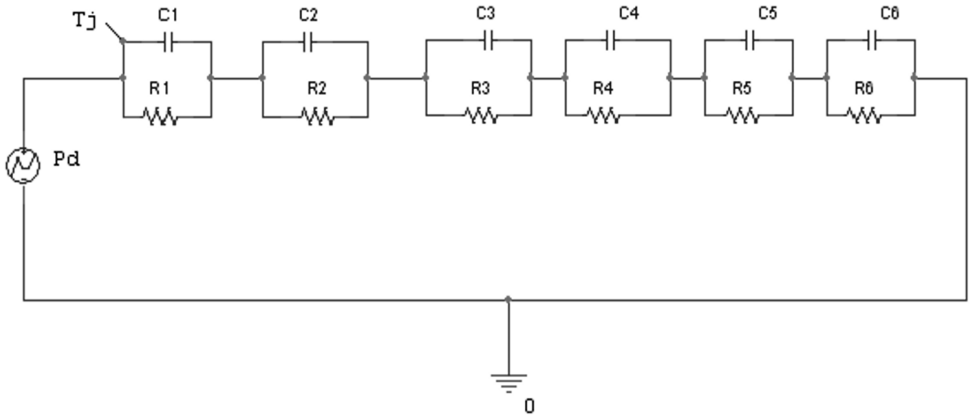
Pulse calculation formula

Equation:

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

where $δ = t_P/T$

Figure 38. Thermal fitting model for Octapak



Note: 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 15. Thermal parameters

Area/island (cm^2)	Footprint	2	8	4L
R1 (°C/W)	0.01	0.01	0.01	0.01
R2 (°C/W)	0.5	0.5	0.5	0.5
R3 (°C/W)	1.6	1.6	1.6	1.6
R4 (°C/W)	10	10	10	2.5
R5 (°C/W)	28	20	12	5
R6 (°C/W)	36	26	18	6
C1 (W.s/°C)	0.001	0.001	0.001	0.001
C2 (W.s/°C)	0.0018	0.0018	0.0018	0.0018
C3 (W.s/°C)	0.11	0.11	0.11	0.11
C4 (W.s/°C)	0.6	0.6	0.6	0.8
C5 (W.s/°C)	0.8	1.4	2.2	3
C6 (W.s/°C)	3	6	9	25

6 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

6.1 Octapak package information

Figure 39. Octapak package dimensions

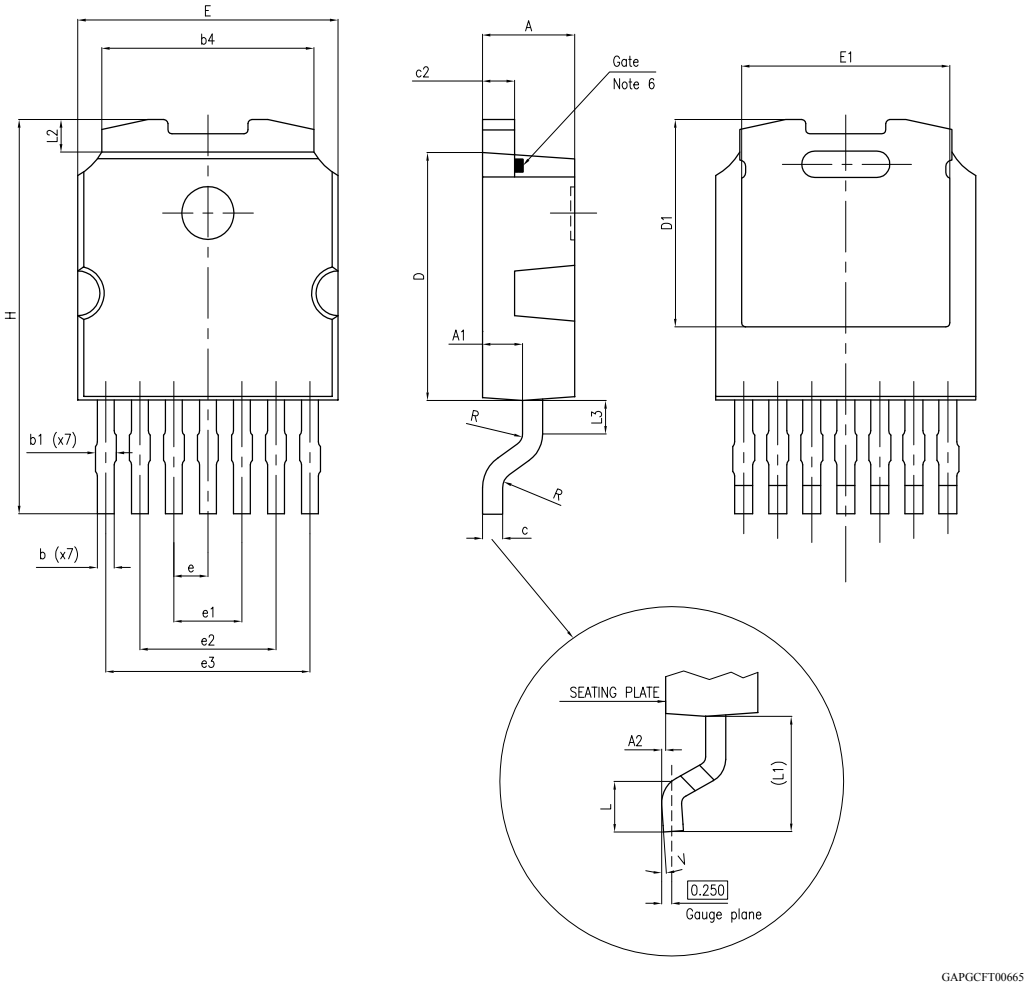


Table 16. **Octapak mechanical data**

Symbol	Millimeters		
	Min.	Typ.	Max.
A	2.20	2.30	2.40
A1	0.90	1.00	1.10
A2	0.03		0.15
b	0.38	0.45	0.52
b1			0.70
b4	5.20	5.30	5.40
c	0.45	0.50	0.60
c2	0.75	0.80	0.90
D	6.00	6.10	6.20
D1		5.15	
E	6.40	6.50	6.60
E1		5.30	
e		0.85 BSC	
e1	1.60	1.70	1.80
e2	3.30	3.40	3.50
e3	5.00	5.10	5.20
H	9.35	9.70	10.10
L	1.00		—
(L1)		2.80	
L2		0.80	
L3		0.85	
R		0.40 BSC	
V2	0°		8°

6.2 Octapak packing information

Figure 40. **Octapack reel 13"**

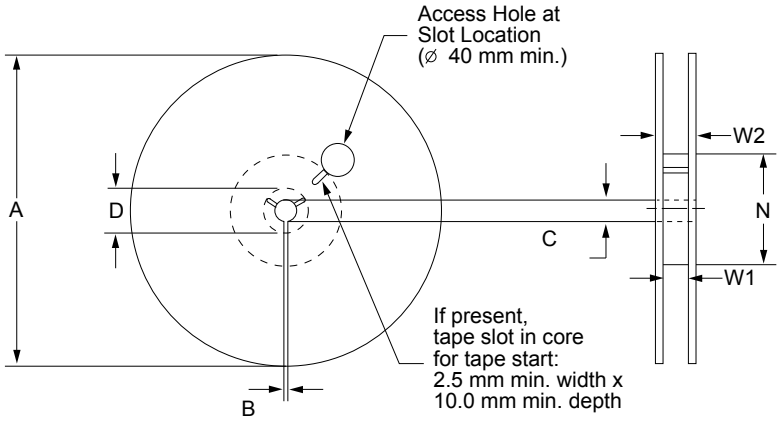


Table 17. **Reel dimensions**

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

1. *All dimensions are in mm.*

Figure 41. Octapak carrier tape

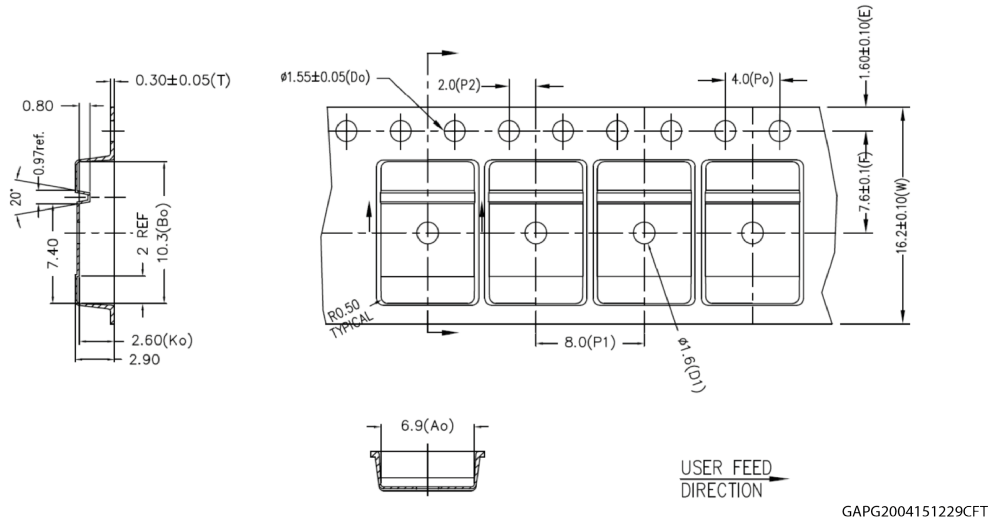
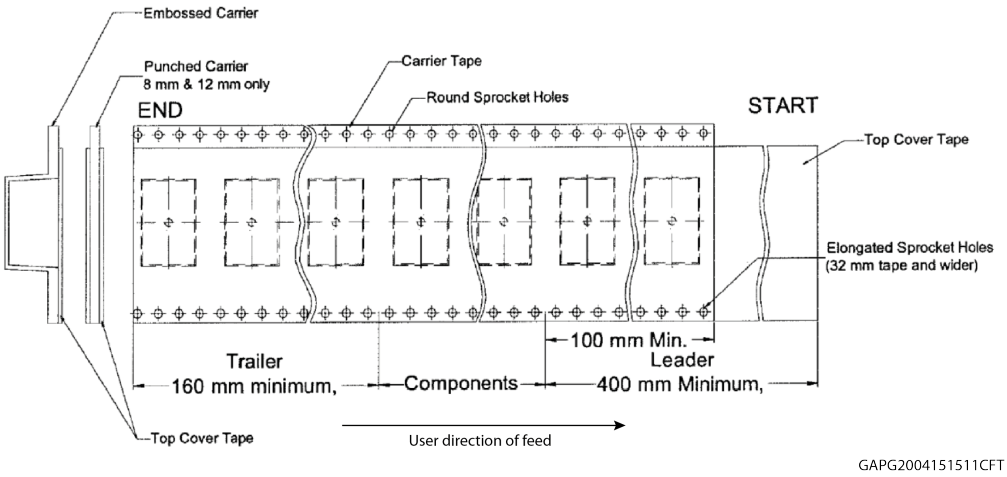
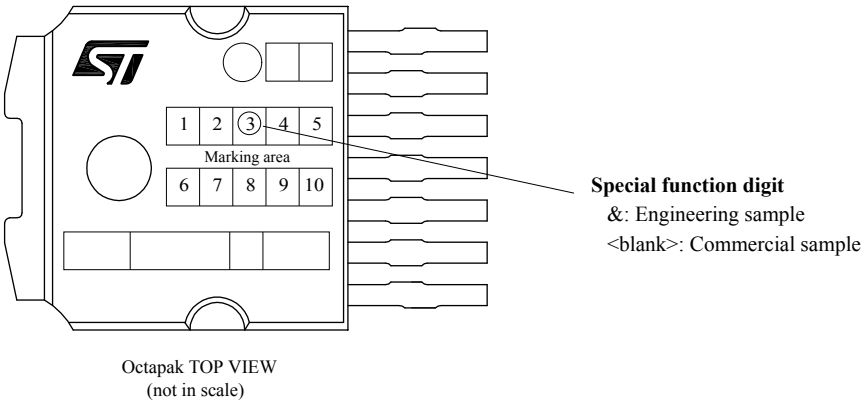


Figure 42. Octapak schematic drawing of leader and trailer tape



6.3 Octapak marking information

Figure 43. **Octapak marking information**



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Revision history

Table 18. **Document revision history**

Date	Version	Changes
15-Mar-2021	1	Initial release.
28-Oct-2021	2	Updated features in cover page. Updated Table 5. Power section and Table 9. CurrentSense. Added Section 2.4 Electrical characteristics curves.

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