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Smart Lowside Power Switch

Features

- Logic Level Input
- Input Protection (ESD)
- Thermal shutdown with latch
- Overload protection
- Short circuit protection
- Overvoltage protection
- Current limitation
- Maximum current adjustable with external resistor
- Current sense
- Status feedback with external input resistor
- Analog driving possible

Application

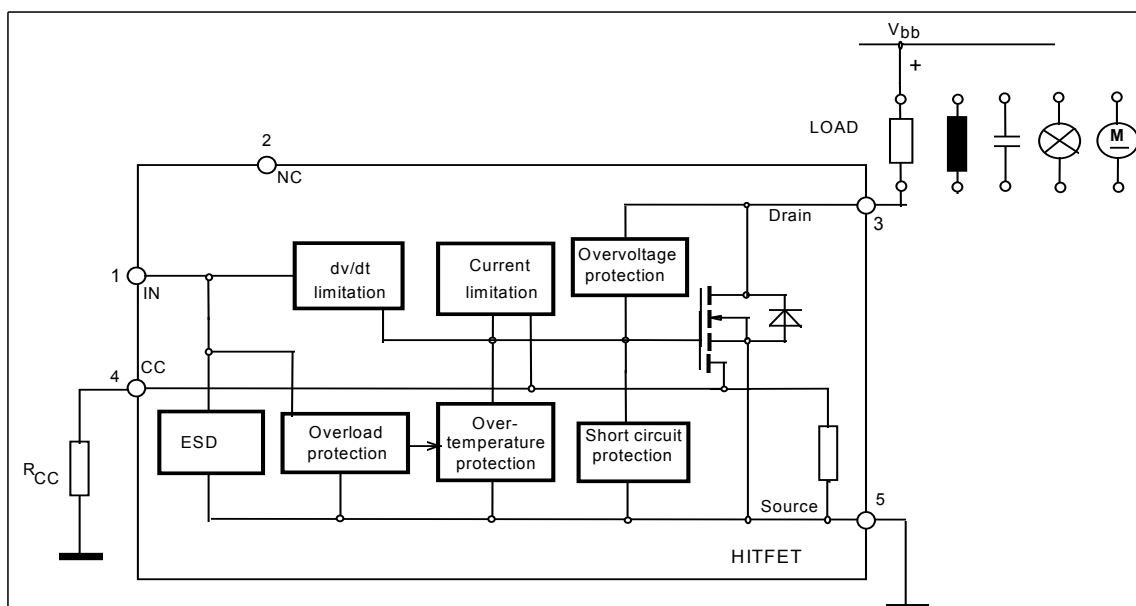
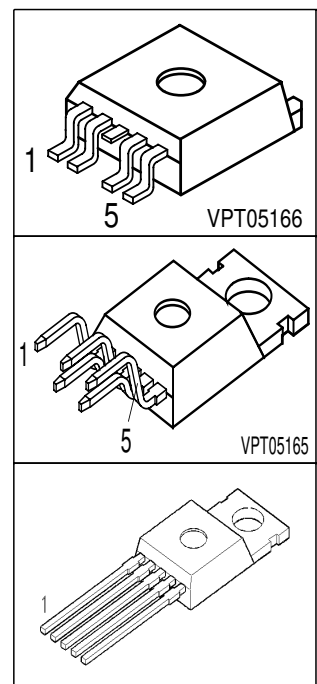
- All kinds of resistive, inductive and capacitive loads in switching or linear applications
- μ C compatible power switch for 12 V and 24 V DC applications
- Replaces electromechanical relays and discrete circuits

General Description

N channel vertical power FET in Smart SIPMOS® chip on chip technology. Fully protected by embedded protected functions.

Product Summary

Drain source voltage	V_{DS}	60	V
On-state resistance	$R_{DS(on)}$	18	m Ω
Current limit	$I_{D(lim)}$	9.5	A
Nominal load current	$I_{D(ISO)}$	19	A
Clamping energy	E_{AS}	6000	mJ



Maximum Ratings at T_j = 25 °C unless otherwise specified

Parameter	Symbol	Value	Unit
Drain source voltage	V _{DS}	60	V
Drain source voltage for short circuit protection R _{CC} = 0 Ω without R _{CC}	V _{DS(SC)}	15 50	
Continuous input current ¹⁾ -0.2V ≤ V _{IN} ≤ 10V V _{IN} < -0.2V or V _{IN} > 10V	I _{IN}	no limit I _{IN} ≤ 2	mA
Operating temperature	T _j	- 40 ... +150	°C
Storage temperature	T _{stg}	- 55 ... +150	
Power dissipation T _C = 25 °C	P _{tot}	240	W
Unclamped single pulse inductive energy I _{D(ISO)} = 19 A	E _{AS}	6000	mJ
Electrostatic discharge voltage (Human Body Model) according to MIL STD 883D, method 3015.7 and EOS/ESD assn. standard S5.1 - 1993	V _{ESD}	3000	V
Load dump protection V _{LoadDump} ²⁾ = V _A + V _S V _{IN} =low or high; V _A =13.5 V t _d = 400 ms, R _I = 2 Ω, I _D =0,5*19A	V _{LD}	110	
t _d = 400 ms, R _I = 2 Ω, I _D = 19A		92	
DIN humidity category, DIN 40 040		E	
IEC climatic category; DIN IEC 68-1		40/150/56	

Thermal resistance

junction - case:	R _{thJC}	0.7	K/W
junction - ambient:	R _{thJA}	75	
SMD version, device on PCB: ³⁾	R _{thJA}	45	

¹In case of thermal shutdown a minimum sensor holding current of 500 µA has to be guaranteed (see also page 3).

²V_{LoadDump} is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839

³ Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm² (one layer, 70µm thick) copper area for drain connection. PCB mounted vertical without blown air.

Electrical Characteristics

Parameter at $T_j=25^\circ\text{C}$, unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
Characteristics					
Drain source clamp voltage $T_j = -40 \dots +150^\circ\text{C}$, $I_D = 10 \text{ mA}$	$V_{DS(AZ)}$	60	-	73	V
Off state drain current $V_{DS} = 32 \text{ V}$, $T_j = -40 \dots +150^\circ\text{C}$, $V_{IN} = 0 \text{ V}$	I_{DSS}	-	-	25	μA
Input threshold voltage $I_D = 3,9 \text{ mA}$	$V_{IN(th)}$	1.3	1.7	2.2	V
Input current - normal operation, $I_D < I_{D(lim)}$: $V_{IN} = 10 \text{ V}$	$I_{IN(1)}$	-	-	100	μA
Input current - current limitation mode, $I_D = I_{D(lim)}$: $V_{IN} = 10 \text{ V}$	$I_{IN(2)}$	-	400	1000	
Input current - after thermal shutdown, $I_D = 0 \text{ A}$: $V_{IN} = 10 \text{ V}$	$I_{IN(3)}$	1500	3000	6000	
Input holding current after thermal shutdown ¹⁾ $T_j = 25^\circ\text{C}$ $T_j = 150^\circ\text{C}$	$I_{IN(H)}$	500 300	- -	- -	
On-state resistance $V_{IN} = 5 \text{ V}$, $I_D = 19 \text{ A}$, $T_j = 25^\circ\text{C}$ $V_{IN} = 5 \text{ V}$, $I_D = 19 \text{ A}$, $T_j = 150^\circ\text{C}$	$R_{DS(on)}$	- -	18 30	22 44	$\text{m}\Omega$
On-state resistance $V_{IN} = 10 \text{ V}$, $I_D = 19 \text{ A}$, $T_j = 25^\circ\text{C}$ $V_{IN} = 10 \text{ V}$, $I_D = 19 \text{ A}$, $T_j = 150^\circ\text{C}$	$R_{DS(on)}$	- -	14 25	18 36	
Nominal load current (ISO 10483) $V_{IN} = 10 \text{ V}$, $V_{DS} = 0.5 \text{ V}$, $T_C = 85^\circ\text{C}$	$I_{D(ISO)}$	19	-	-	A

¹If the input current is limited by external components, low drain currents can flow and heat the device. Auto restart behaviour can occur.

Electrical Characteristics

Parameter at $T_j=25^\circ\text{C}$, unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	

Characteristics

Initial peak short circuit current limit $V_{IN} = 10\text{ V}$, $V_{DS} = 12\text{ V}$	$I_{D(SCp)}$	-	175	-	A
Current limit ¹⁾ $V_{IN} = 10\text{ V}$, $V_{DS} = 12\text{ V}$, $t_m = 350\ \mu\text{s}$, $T_j = -40\dots+150\ ^\circ\text{C}$, without R_{CC} $V_{IN} = 10\text{ V}$, $V_{DS} = 12\text{ V}$, $t_m = 350\ \mu\text{s}$, $T_j = -40\dots+150\ ^\circ\text{C}$, $R_{CC} = 0\ \Omega$	$I_{D(lim)}$	9.5 150	19 220	40 270	

Dynamic Characteristics

Turn-on time V_{IN} to 90% I_D : $R_L = 1\ \Omega$, $V_{IN} = 0$ to 10 V , $V_{bb} = 12\text{ V}$	t_{on}	-	40	100	μs
Turn-off time V_{IN} to 10% I_D : $R_L = 1\ \Omega$, $V_{IN} = 10$ to 0 V , $V_{bb} = 12\text{ V}$	t_{off}	-	70	170	
Slew rate on 70 to 50% V_{bb} : $R_L = 1\ \Omega$, $V_{IN} = 0$ to 10 V , $V_{bb} = 12\text{ V}$	$-dV_{DS}/dt_{on}$	-	1	3	$\text{V}/\mu\text{s}$
Slew rate off 50 to 70% V_{bb} : $R_L = 1\ \Omega$, $V_{IN} = 10$ to 0 V , $V_{bb} = 12\text{ V}$	dV_{DS}/dt_{off}	-	1	3	

Protection Functions

Thermal overload trip temperature	T_{jt}	150	165	-	$^\circ\text{C}$
Unclamped single pulse inductive energy $I_D = 19\text{ A}$, $T_j = 25\ ^\circ\text{C}$, $V_{bb} = 32\text{ V}$ $I_D = 19\text{ A}$, $T_j = 150\ ^\circ\text{C}$, $V_{bb} = 32\text{ V}$	E_{AS}	6000 1800	- -	- -	mJ

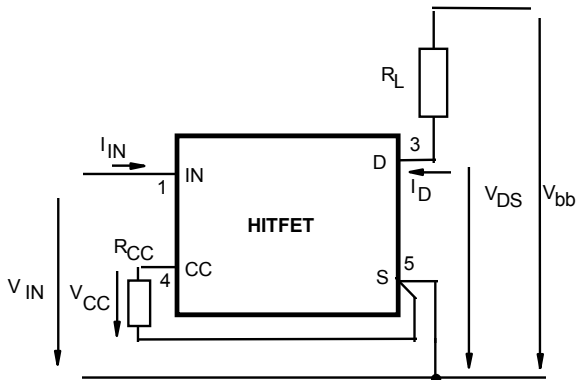
Inverse Diode

Inverse diode forward voltage $I_F = 5 \cdot 19\text{ A}$, $t_m = 300\ \mu\text{s}$, $V_{IN} = 0\text{ V}$	V_{SD}	-	1,1	-	V
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¹Device switched on into existing short circuit (see diagram Determination of $I_{D(lim)}$). If the device is in on condition and a short circuit occurs, these values might be exceeded for max. 50 μs .

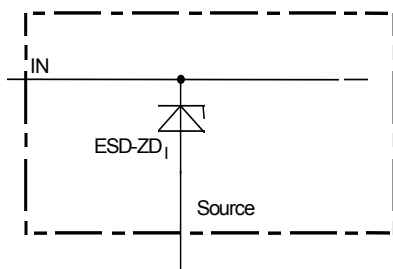
Block Diagramm

Terms



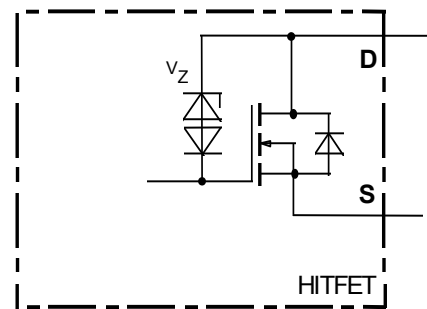
The ground lead impedance of R_{CC} should be as low as possible

Input circuit (ESD protection)

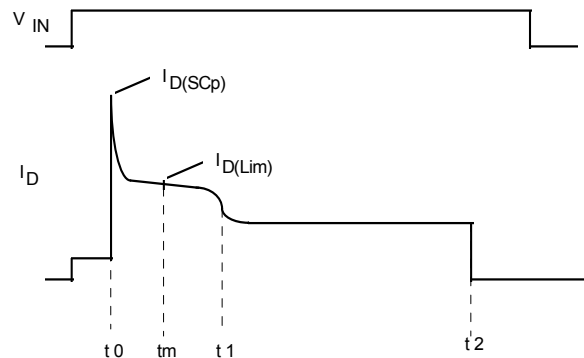


ESD zener diodes are not designed for DC current $> 2 \text{ mA}$ @ $V_{IN} > 10\text{V}$.

Inductive and overvoltage output clamp



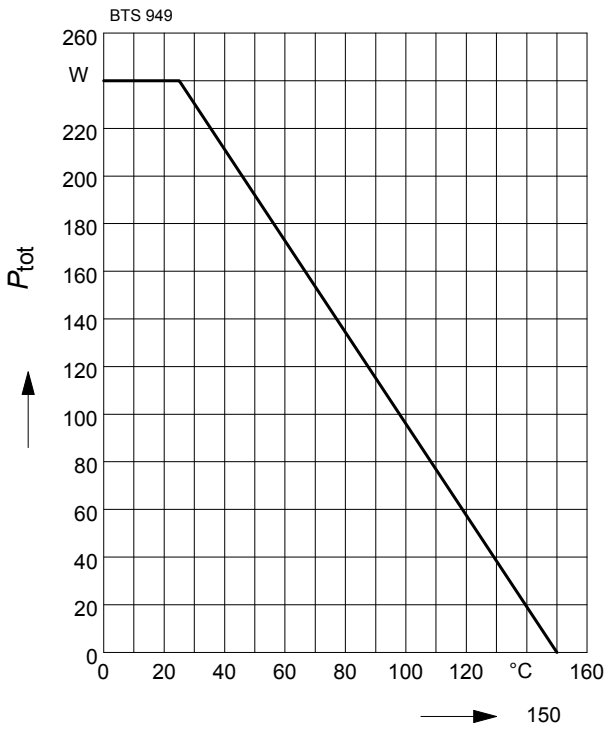
Short circuit behaviour



- t_0 : Turn on into a short circuit
- t_m : Measurementpoint for $I_{D(Lim)}$
- t_1 : Activation of the fast temperature sensor and regulation of the drain current to a level where the junction temperature remains constant.
- t_2 : Thermal shutdown caused by the second temperature sensor, achieved by an integrating measurement.

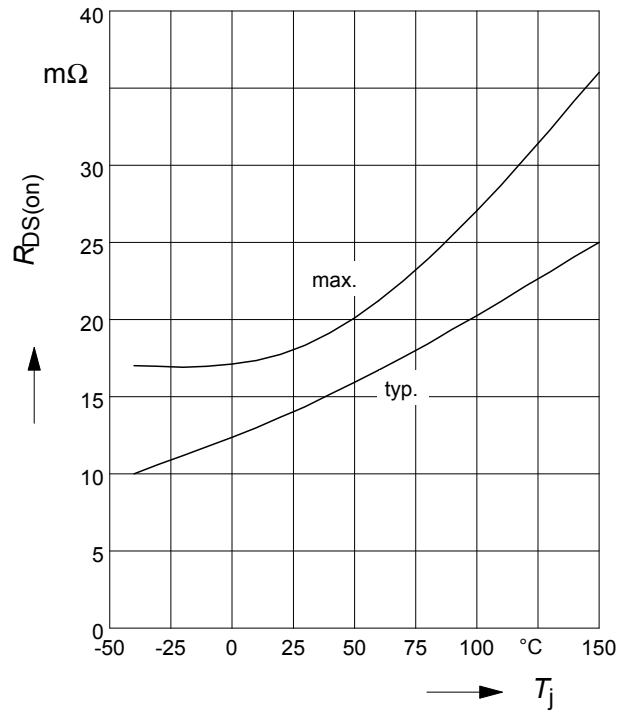
Maximum allowable power dissipation

$P_{tot} = f(T_c)$



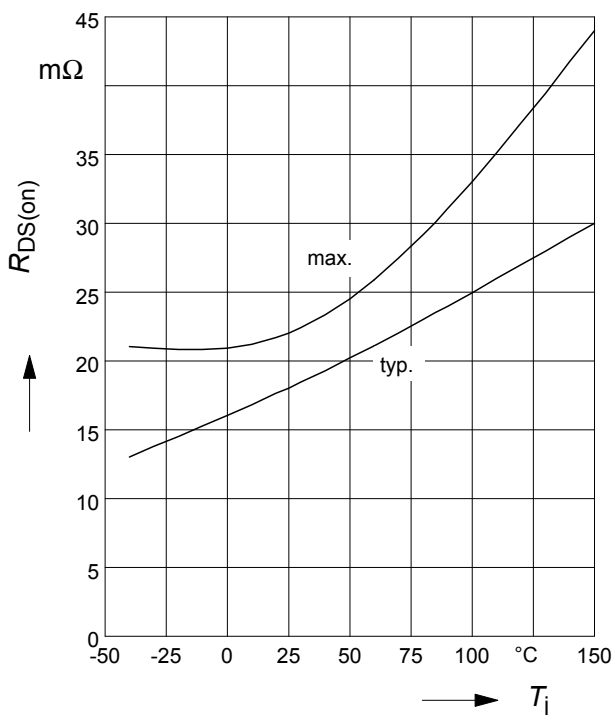
On-state resistance

$R_{ON} = f(T_j); I_D=19A; V_{IN}=10V$



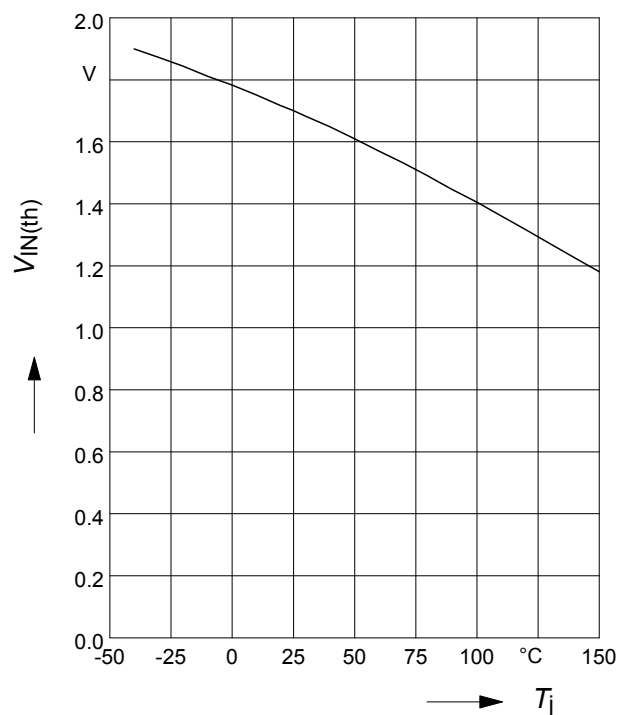
On-state resistance

$R_{ON} = f(T_j); I_D= 19A; V_{IN}=5V$



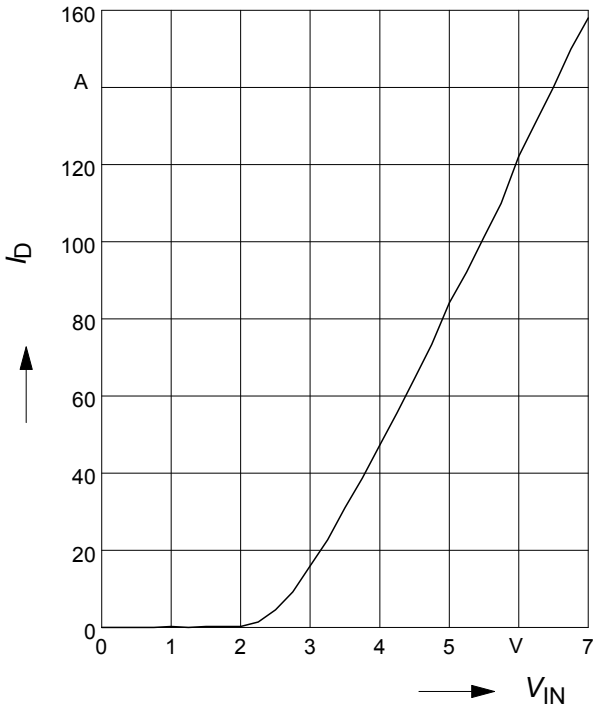
Typ. input threshold voltage

$V_{IN(th)} = f(T_j); I_D=3,9A; V_{DS}=12V$



Typ. transfer characteristics

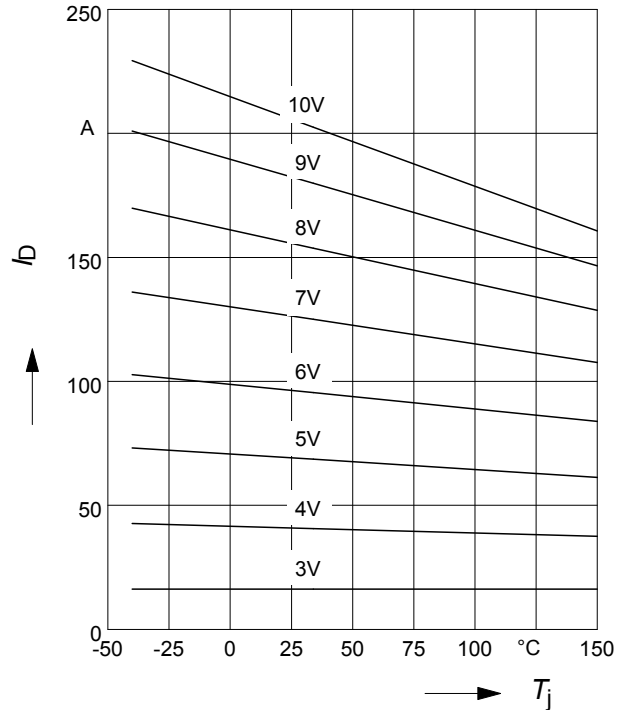
$I_D = f(V_{IN}); V_{DS}=12V; T_j=25^\circ C$



Typ. short circuit current

$I_{Dlim} = f(T_j); R_{CC}=0\Omega, V_{DS}=12V$

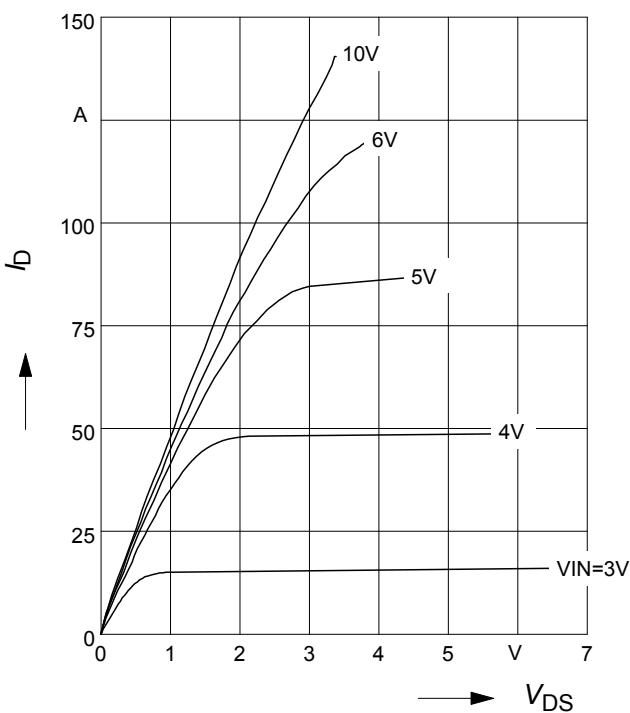
Parameter: V_{IN}



Typ. output characteristic

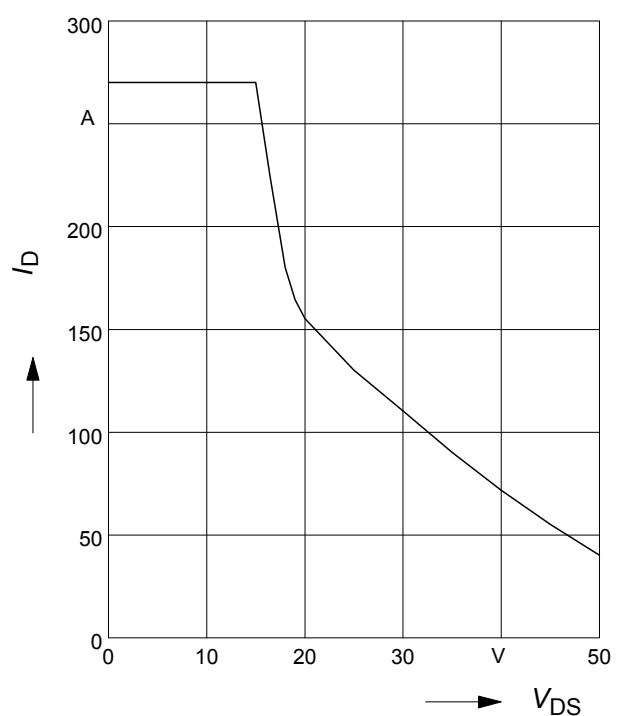
$I_D = f(V_{DS}); T_j=25^\circ C$

Parameter: V_{IN}



Safe Operating Area

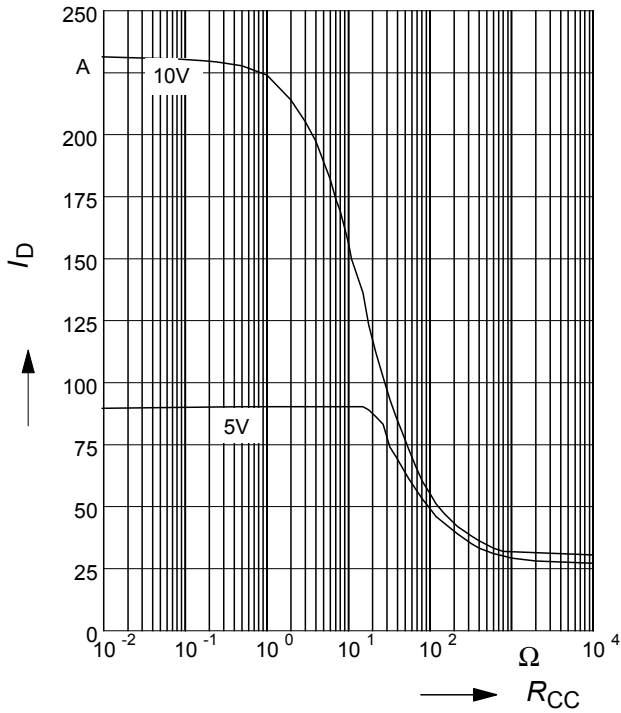
$I_{D(SC)} = f(V_{DS}); T_j=25^\circ C$



Typ. current limit versus R_{CC}

$I_{D(lim)} = f(R_{CC}); T_j=25^\circ\text{C}$

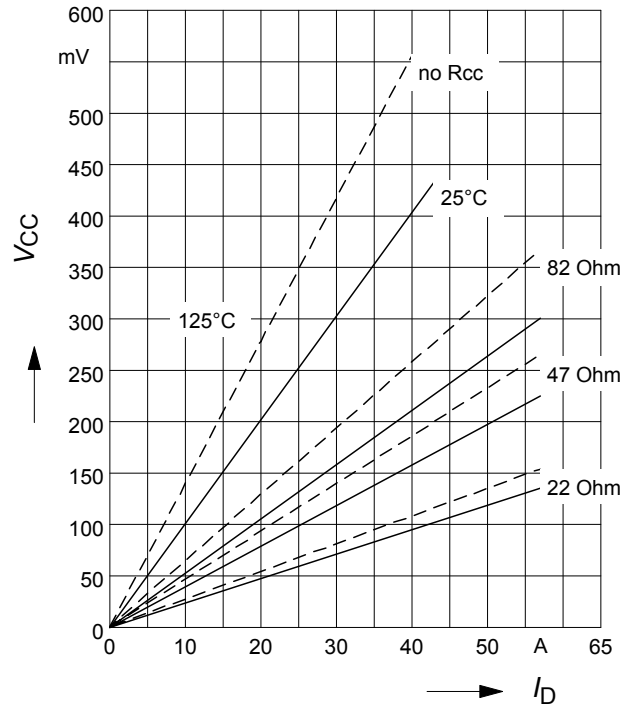
Parameter: V_{IN}



Typ. current sense characteristics

$V_{CC} = f(I_D); V_{IN}=10\text{V}$

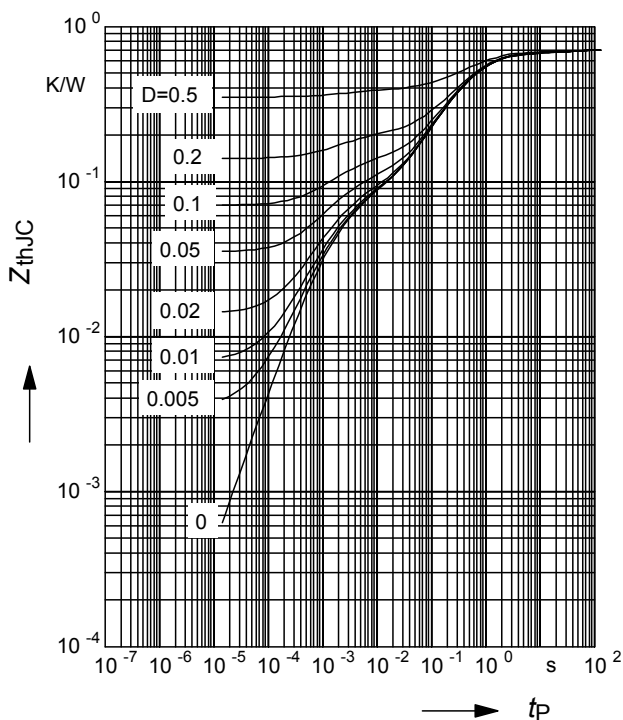
Parameter: R_{CC}, T_j



Transient thermal impedance

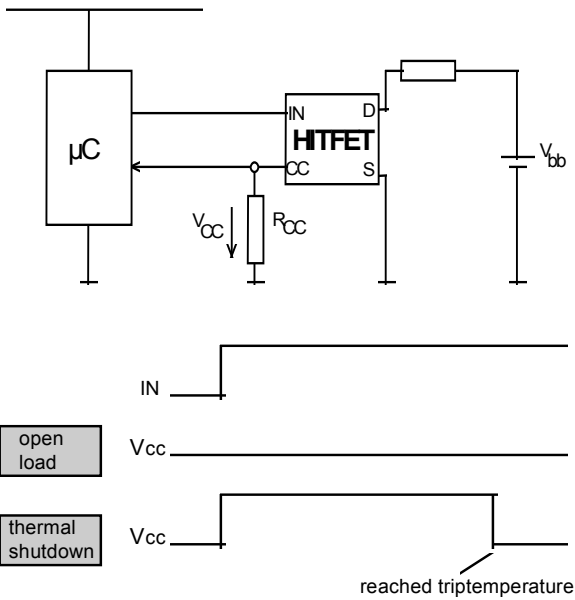
$Z_{thJC} = f(t_p)$

parameter : $D = t_p/T$



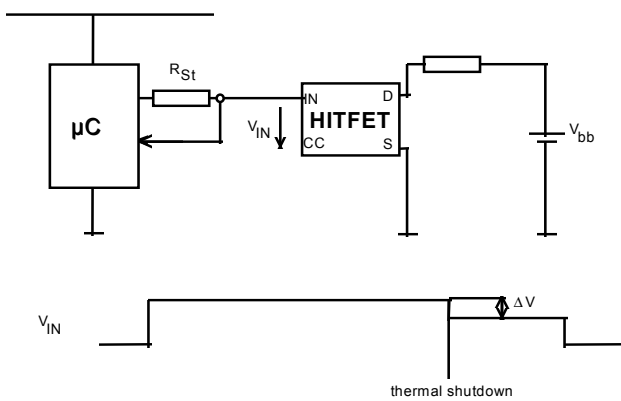
Application examples:

Current Sense Features and Status Signals

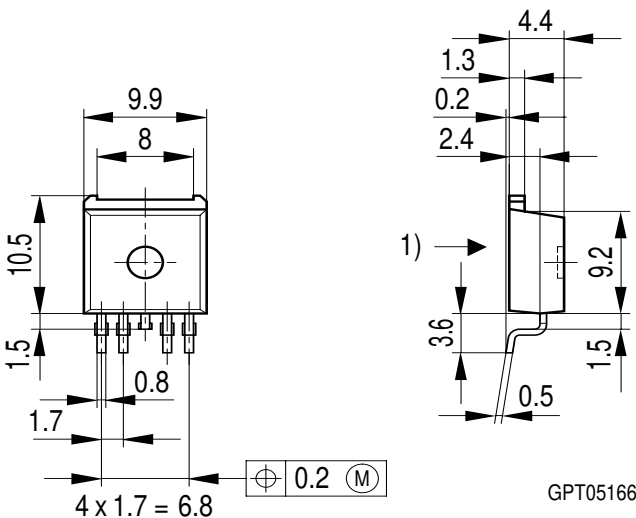
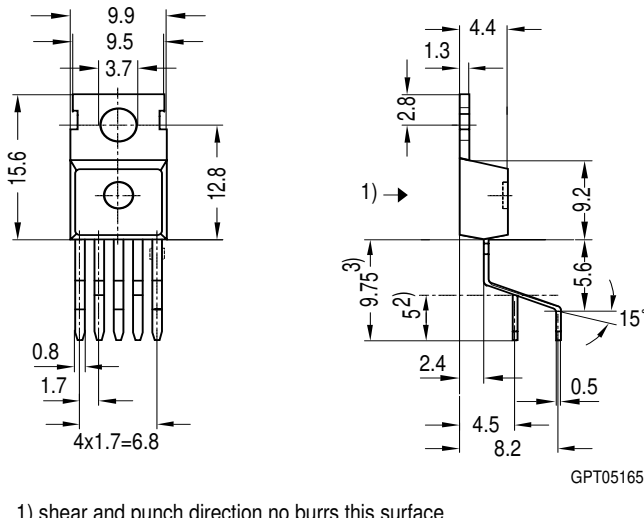


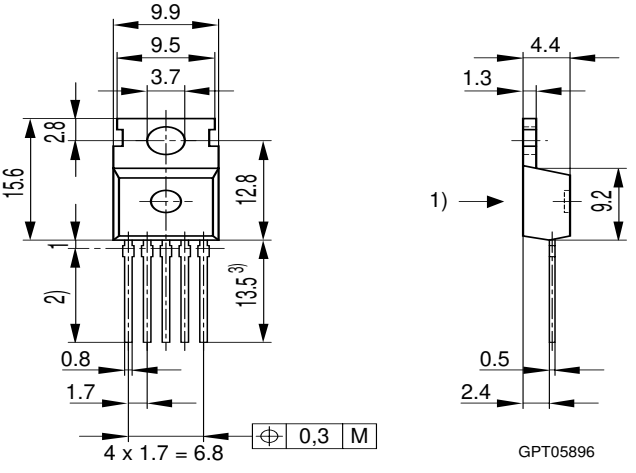
The accuracy of V_{cc} is at each temperature about $\pm 10\%$

Status signal of thermal shutdown by monitoring input current



$$\Delta V = R_{ST} * I_{IN(3)}$$

Package	Ordering Code	Package	Ordering Code
P-TO220-5-62	Q67060-S6703-A4	P-TO220-5-3	Q67060-S6703-A2
 <p>1) shear and punch direction no burrs this surface</p>		 <p>1) shear and punch direction no burrs this surface 2) min. length by tinning 3) max. 11 mm allowable by tinning</p>	

Package	Ordering Code
P-TO220-5-43	On request
 <p>1) Punch direction, burr max. 0.04 2) Dip tinning 3) Max. 14.5 by dip tinning press burr max. 0.05 radii not dimensioned max. 0.2</p>	

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