

# 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

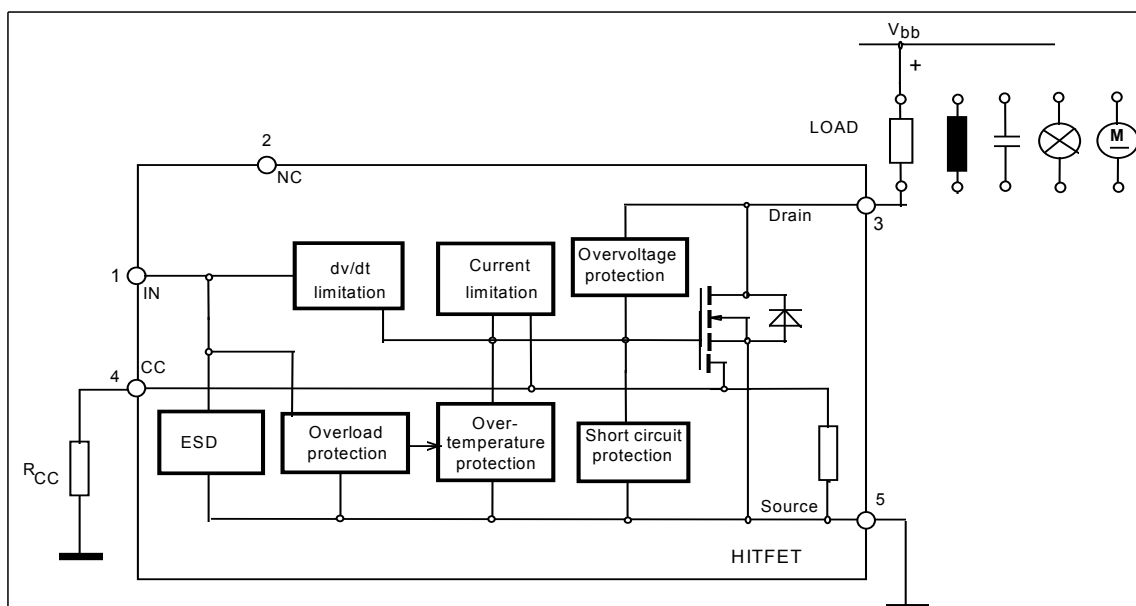
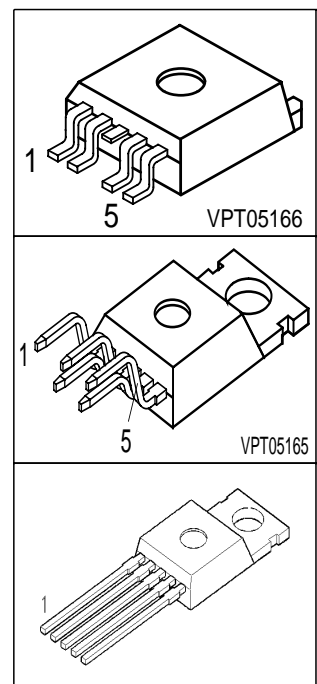
- All kinds of resistive, inductive and capacitive loads in switching or linear applications
- $\mu$ C compatible power switch for 12 V and 24 V DC applications
- Replaces electromechanical relays and discrete circuits

## 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 $\Omega$
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<sub>j</sub> = 25 °C unless otherwise specified**

Parameter	Symbol	Value	Unit
Drain source voltage	$V_{DS}$	60	V
Drain source voltage for short circuit protection $R_{CC} = 0 \Omega$ without $R_{CC}$	$V_{DS(SC)}$	15 50	
Continuous input current <sup>1)</sup> $-0.2V \leq V_{IN} \leq 10V$ $V_{IN} < -0.2V$ or $V_{IN} > 10V$	$I_{IN}$	no limit $ I_{IN}  \leq 2$	mA
Operating temperature	$T_j$	- 40 ... +150	°C
Storage temperature	$T_{stg}$	- 55 ... +150	
Power dissipation $T_C = 25 \text{ °C}$	$P_{tot}$	240	W
Unclamped single pulse inductive energy $I_{D(ISO)} = 19 \text{ A}$	$E_{AS}$	6000	mJ
<b>Electrostatic discharge voltage</b> (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 $V_{LoadDump}^{2)} = V_A + V_S$ $V_{IN} = \text{low or high}; V_A = 13.5 \text{ V}$ $t_d = 400 \text{ ms}, R_l = 2 \Omega, I_D = 0,5 \cdot 19 \text{ A}$ $t_d = 400 \text{ ms}, R_l = 2 \Omega, I_D = 19 \text{ A}$	$V_{LD}$	110 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: <sup>3)</sup>	$R_{thJA}$	45	

<sup>1</sup>In case of thermal shutdown a minimum sensor holding current of 500  $\mu\text{A}$  has to be guaranteed (see also page 3).

<sup>2</sup> $V_{Loaddump}$  is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839

<sup>3</sup> Device on 50mm\*50mm\*1.5mm epoxy PCB FR4 with 6cm<sup>2</sup> (one layer, 70 $\mu\text{m}$  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.	
<b>Characteristics</b>					
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	$\mu\text{A}$
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	$\mu\text{A}$
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 <sup>1)</sup> $T_j = 25^\circ\text{C}$ $T_j = 150^\circ\text{C}$	$I_{IN(H)}$	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

<sup>1</sup>If 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 <sup>1)</sup> $V_{IN} = 10\text{ V}$ , $V_{DS} = 12\text{ V}$ , $t_m = 350\ \mu\text{s}$ , $T_j = -40\dots+150\ ^\circ\text{C}$ , 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 $10\text{ V}$ , $V_{bb} = 12\text{ V}$	$t_{on}$	-	40	100	$\mu\text{s}$
Turn-off time $V_{IN}$ to 10% $I_D$ : $R_L = 1\ \Omega$ , $V_{IN} = 10$ to $0\text{ V}$ , $V_{bb} = 12\text{ V}$	$t_{off}$	-	70	170	
Slew rate on 70 to 50% $V_{bb}$ : $R_L = 1\ \Omega$ , $V_{IN} = 0$ to $10\text{ V}$ , $V_{bb} = 12\text{ V}$	$-dV_{DS}/dt_{on}$	-	1	3	$\text{V}/\mu\text{s}$
Slew rate off 50 to 70% $V_{bb}$ : $R_L = 1\ \Omega$ , $V_{IN} = 10$ to $0\text{ V}$ , $V_{bb} = 12\text{ V}$	$dV_{DS}/dt_{off}$	-	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

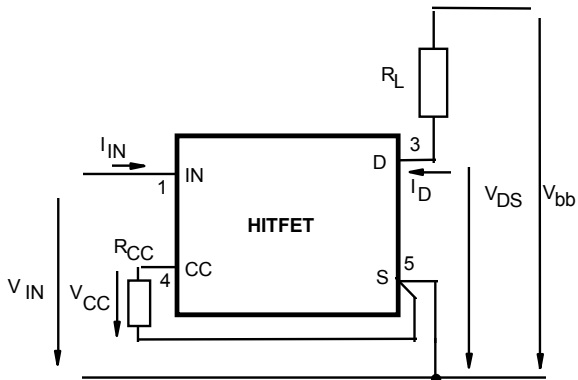
**Inverse Diode**

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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<sup>1</sup>Device 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  $\mu\text{s}$ .

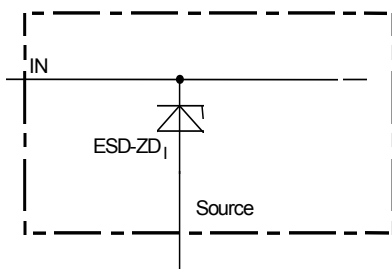
## Block Diagramm

### Terms



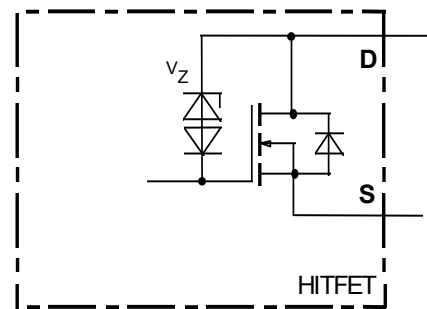
The ground lead impedance of  $R_{CC}$  should be as low as possible

### Input circuit (ESD protection)

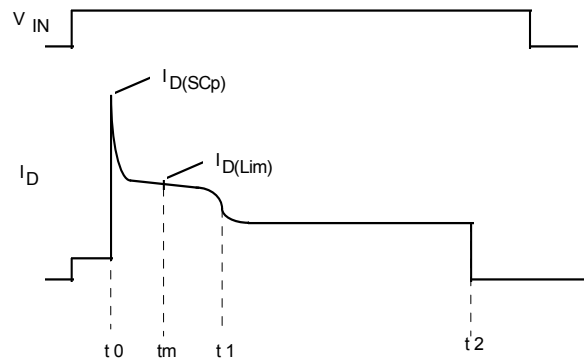


ESD zener diodes are not designed for DC current  $> 2 \text{ mA}$  @  $V_{IN} > 10\text{V}$ .

### Inductive and overvoltage output clamp



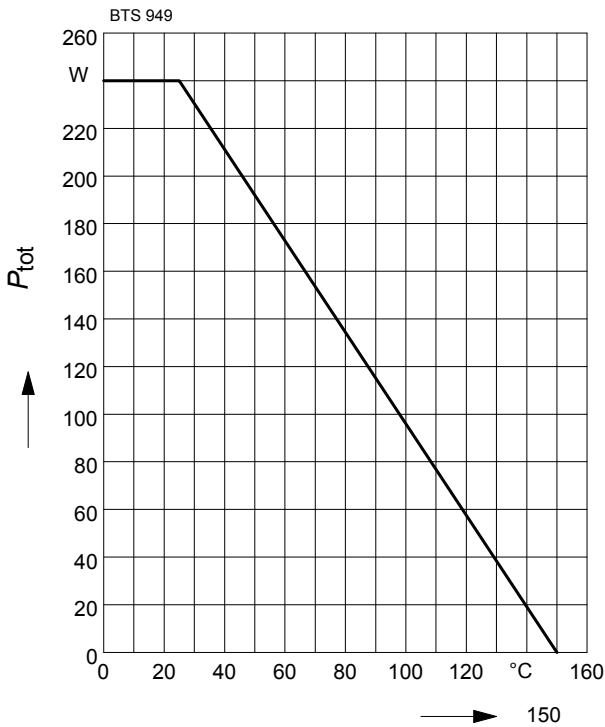
### Short circuit behaviour



- $t_0$ : 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.

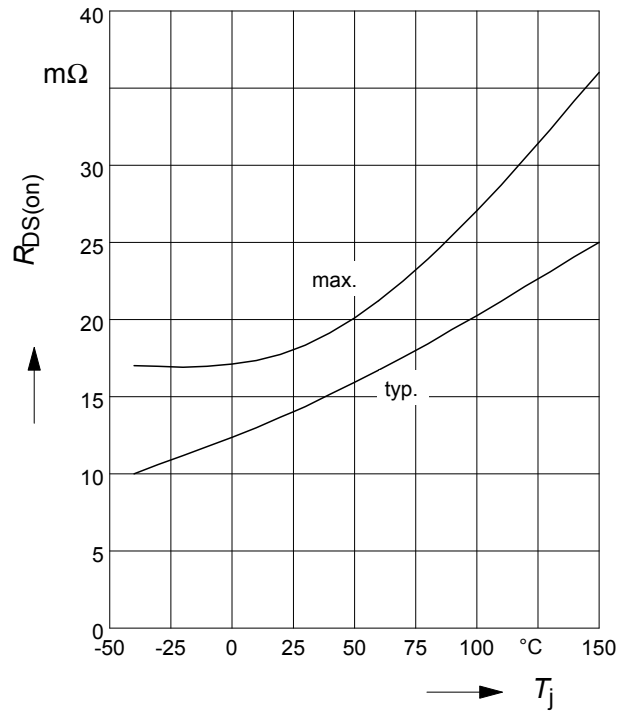
**Maximum allowable power dissipation**

$P_{tot} = f(T_c)$



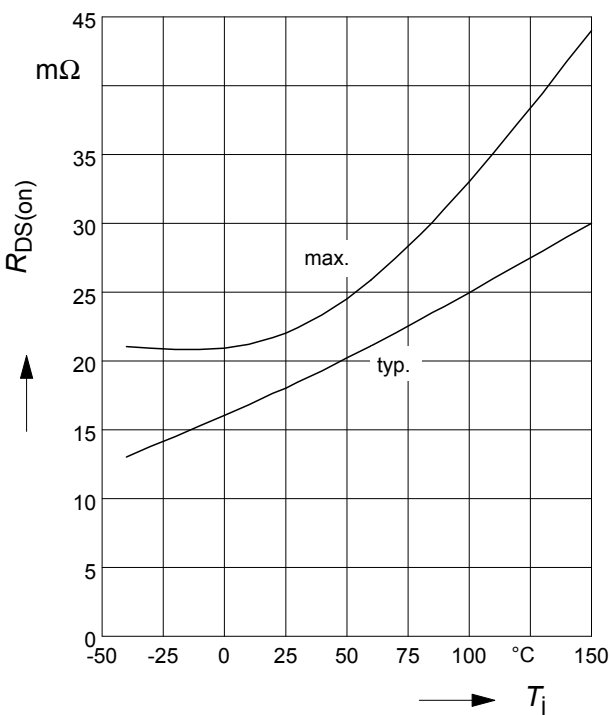
**On-state resistance**

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



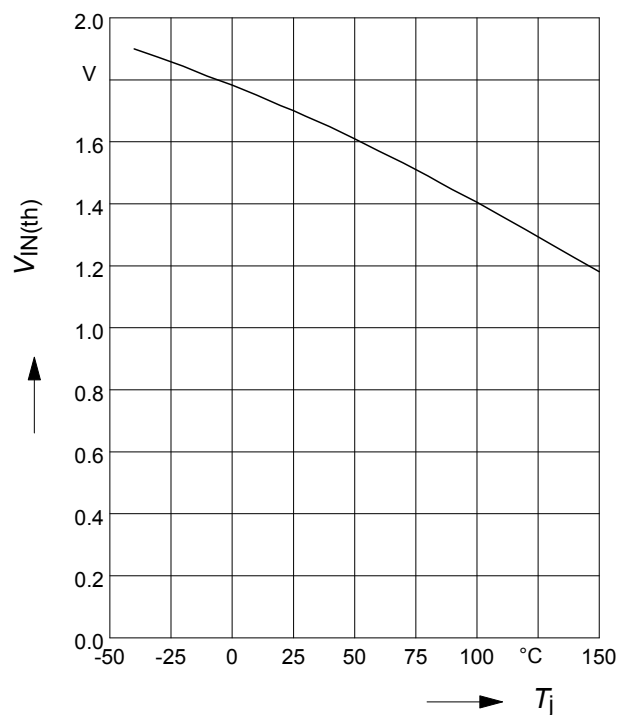
**On-state resistance**

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



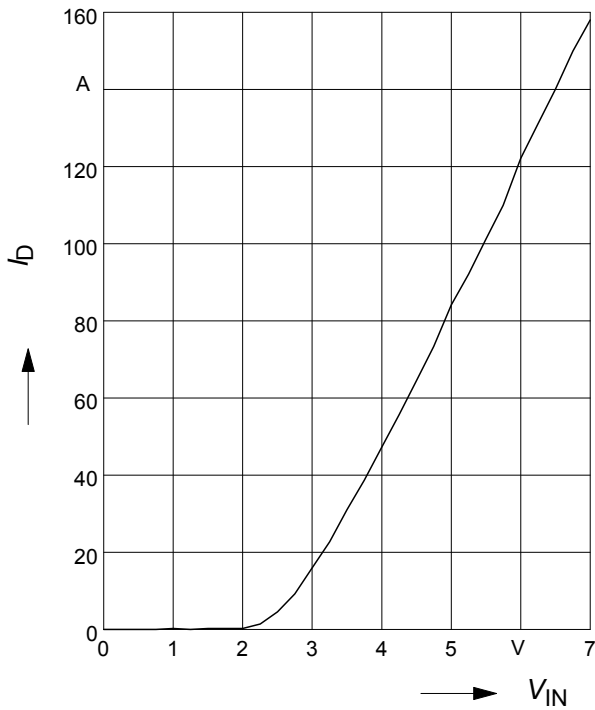
**Typ. input threshold voltage**

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



**Typ. transfer characteristics**

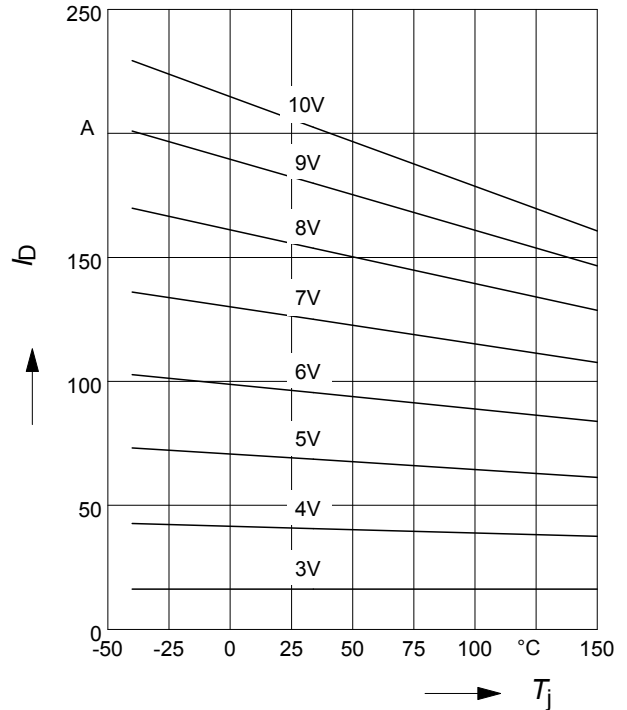
$I_D = f(V_{IN}); V_{DS}=12V; T_j=25^\circ C$



**Typ. short circuit current**

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

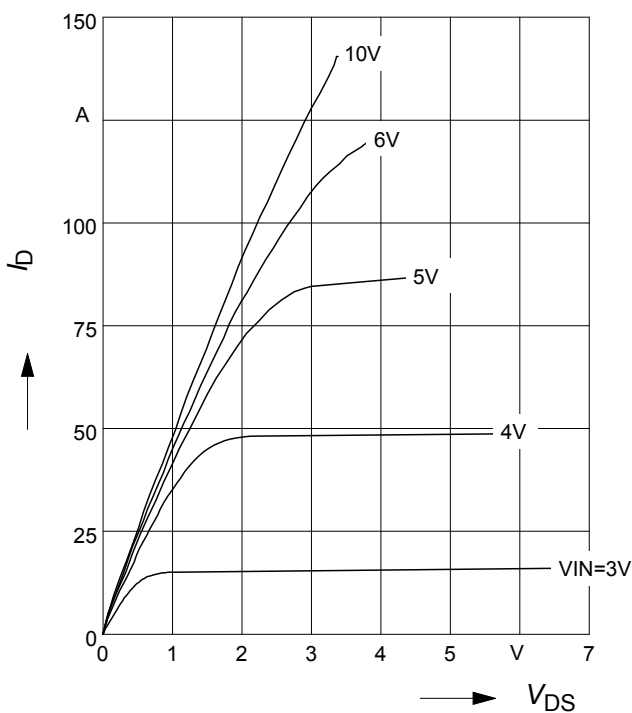
Parameter:  $V_{IN}$



**Typ. output characteristic**

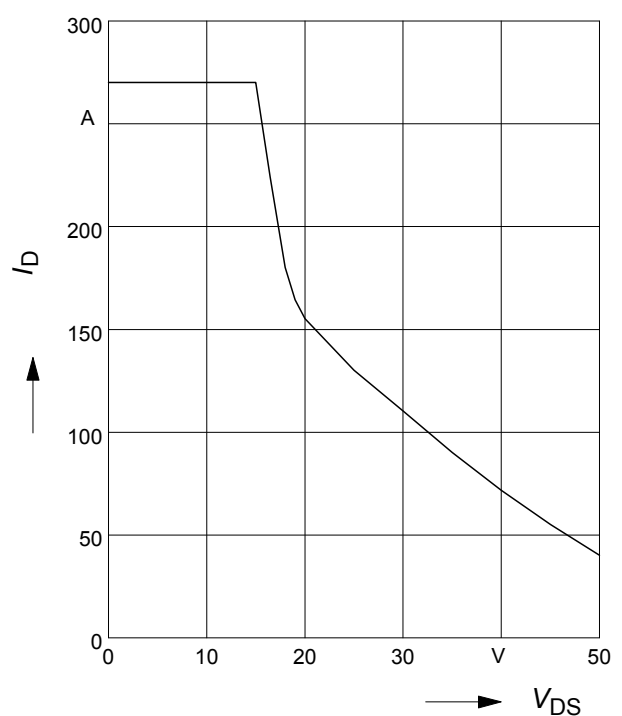
$I_D = f(V_{DS}); T_j=25^\circ C$

Parameter:  $V_{IN}$



**Safe Operating Area**

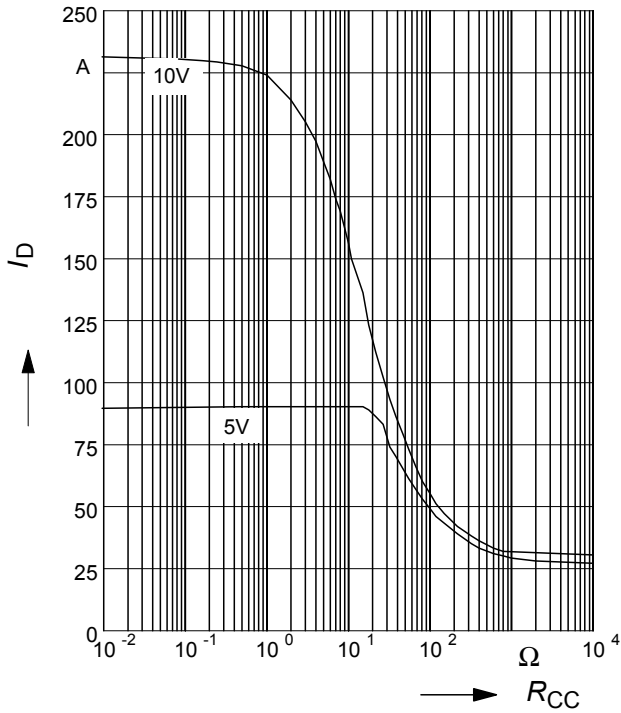
$I_{D(SC)} = f(V_{DS}); T_j=25^\circ C$



**Typ. current limit versus  $R_{CC}$**

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

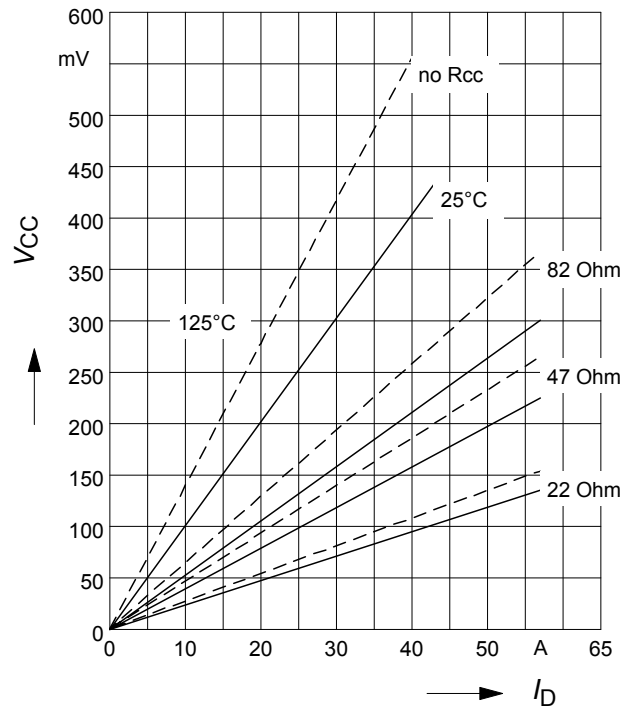
Parameter:  $V_{IN}$



**Typ. current sense characteristics**

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

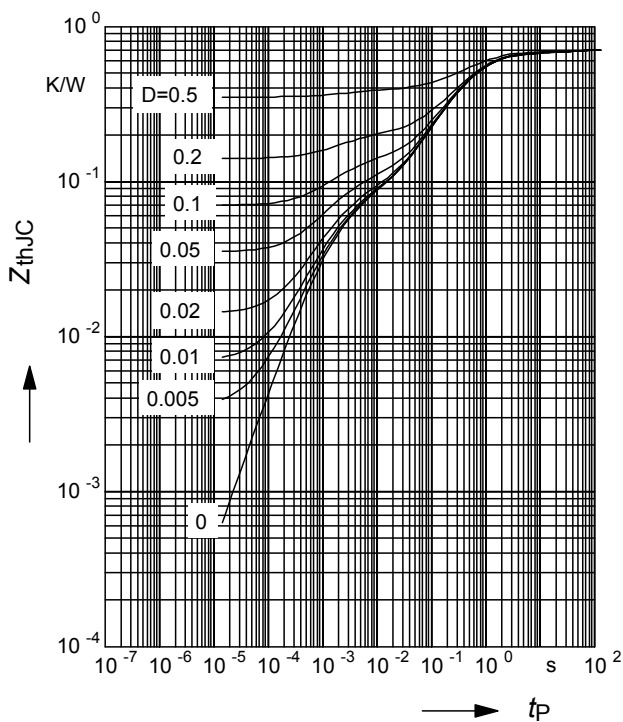
Parameter:  $R_{CC}, T_j$



**Transient thermal impedance**

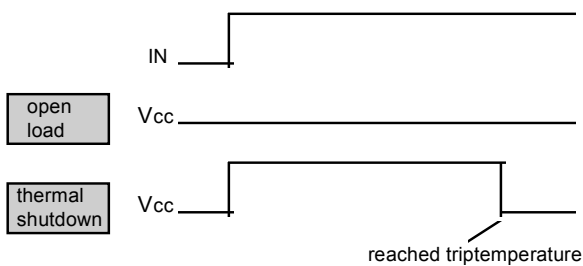
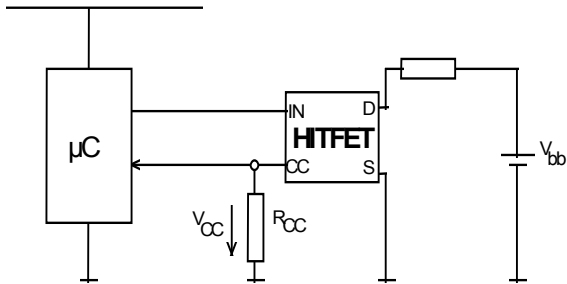
$Z_{thJC} = f(t_p)$

parameter :  $D = t_p/T$



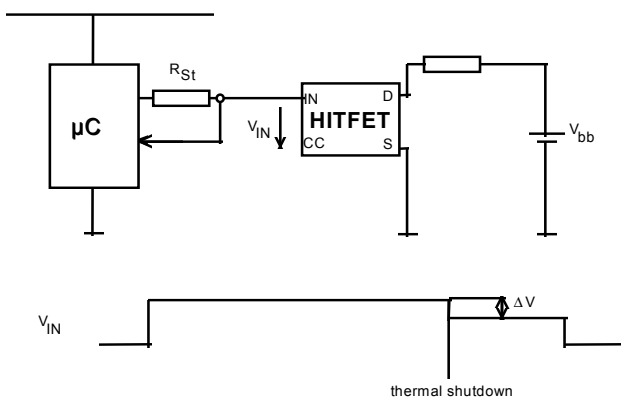
**Application examples:**

**Current Sense Features and Status Signals**

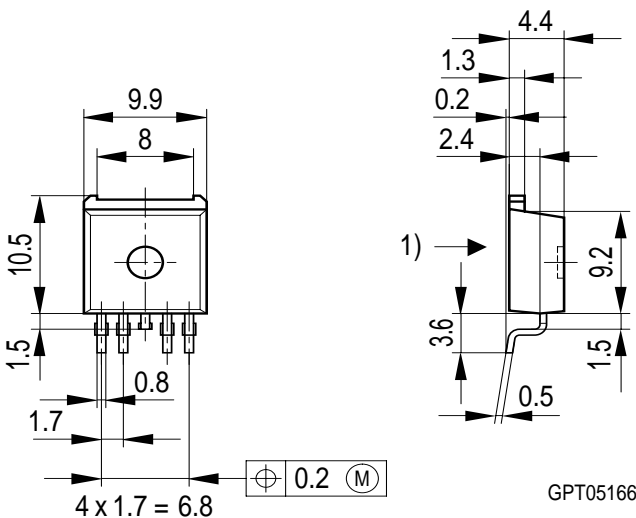
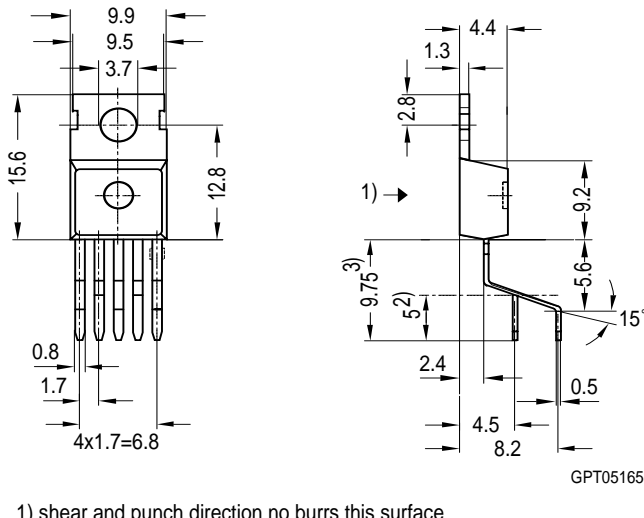


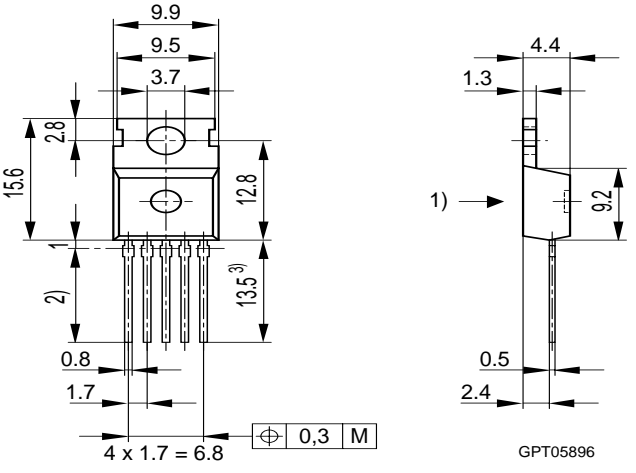
The accuracy of Vcc is at each temperature about ±10 %

**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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