

## Smart Lowside Power Switch

### Features

- Logic Level Input
- Input Protection (ESD)
- Thermal Shutdown
- 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

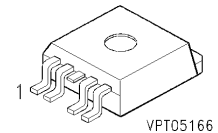
- All kinds of resistive, inductive and capacitive loads in switching or linear applications
- $\mu$ C compatible power switch for 12 V and 24 V DC applications
- Replaces electromechanical relays and discrete circuits

### General Description

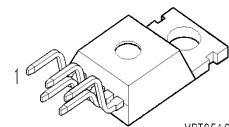
N channel vertical power FET in Smart SIPMOS® chip on chip technology. Fully protected by embedded protected functions.

### Product Summary

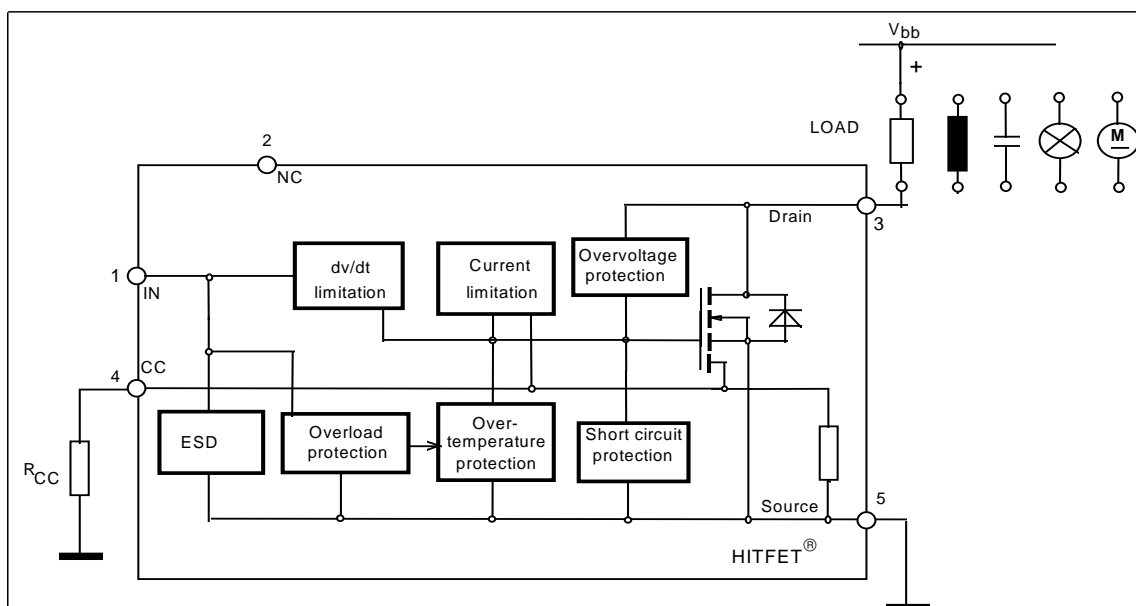
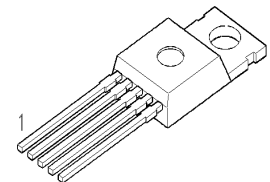
Drain source voltage	$V_{DS}$	60	V
On-state resistance	$R_{DS(on)}$	28	m $\Omega$
Current limit	$I_{D(lim)}$	6	A
Nominal load current	$I_{D(ISO)}$	12	A
Clamping energy	$E_{AS}$	4000	mJ



VPT05166



VPT05165



### Maximum Ratings at T<sub>j</sub> = 25 °C unless otherwise specified

Parameter	Symbol	Value	Unit
Drain source voltage	V <sub>DS</sub>	60	V
Drain source voltage for short circuit protection R <sub>CC</sub> = 0 Ω without R <sub>CC</sub>	V <sub>DS(SC)</sub>	15 50	
Continuous input current <sup>1)</sup> -0.2V ≤ V <sub>IN</sub> ≤ 10V V <sub>IN</sub> < -0.2V or V <sub>IN</sub> > 10V	I <sub>IN</sub>	no limit   I <sub>IN</sub>   ≤ 2	mA
Operating temperature	T <sub>j</sub>	- 40 ... +150	°C
Storage temperature	T <sub>stg</sub>	- 55 ... +150	
Power dissipation T <sub>C</sub> = 25 °C	P <sub>tot</sub>	149	W
Unclamped single pulse inductive energy I <sub>D(ISO)</sub> = 12 A	E <sub>AS</sub>	4000	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 <sub>ESD</sub>	3000	V
Load dump protection V <sub>LoadDump</sub> <sup>2)</sup> = V <sub>A</sub> + V <sub>S</sub> V <sub>IN</sub> =low or high; V <sub>A</sub> =13.5 V t <sub>d</sub> = 400 ms, R <sub>I</sub> = 2 Ω, I <sub>D</sub> =0,5*12A t <sub>d</sub> = 400 ms, R <sub>I</sub> = 2 Ω, I <sub>D</sub> = 12A	V <sub>LD</sub>	100 84	
DIN humidity category, DIN 40 040		E	
IEC climatic category; DIN IEC 68-1		40/150/56	

### Thermal resistance

junction - case:	R <sub>thJC</sub>	0.84	K/W
junction - ambient:	R <sub>thJA</sub>	75	
SMD version, device on PCB: <sup>3)</sup>	R <sub>thJA</sub>	45	

<sup>1</sup>A sensor holding current of 500 µA has to be guaranteed in the case of thermal shutdown (see also page 3)

<sup>2</sup>V<sub>LoadDump</sub> 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 µm thick) copper area for Drain connection. PCB is vertical without blown air.

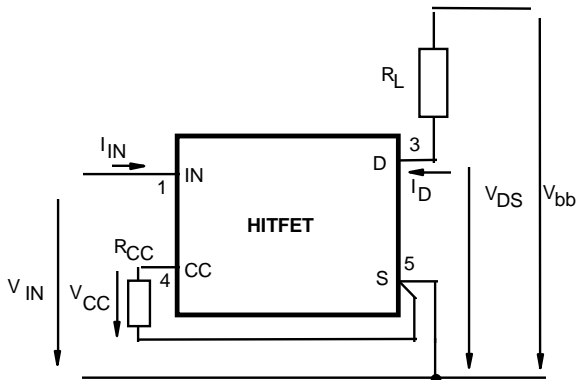
Electrical Characteristics					
Parameter at $T_j=25^\circ\text{C}$ , unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
<b>Characteristics</b>					
Drain source clamp voltage $T_j = -40 \dots +150^\circ\text{C}$ , $I_D = 10 \text{ mA}$	$V_{DS(AZ)}$	60	-	73	V
Off state drain current $V_{DS} = 32 \text{ V}$ , $T_j = -40 \dots +150^\circ\text{C}$ , $V_{IN} = 0 \text{ V}$	$I_{DSS}$	-	-	20	$\mu\text{A}$
Input threshold voltage $I_D = 2,7 \text{ mA}$	$V_{IN(th)}$	1.3	1.7	2.2	V
Input current - normal operation, $I_D < I_{D(lim)}$ : $V_{IN} = 10 \text{ V}$	$I_{IN(1)}$	-	35	100	$\mu\text{A}$
Input current - current limitation mode, $I_D = I_{D(lim)}$ : $V_{IN} = 10 \text{ V}$	$I_{IN(2)}$	-	270	500	
Input current - after thermal shutdown, $I_D = 0 \text{ A}$ : $V_{IN} = 10 \text{ V}$	$I_{IN(3)}$	1000	2500	4000	
Input holding current after thermal shutdown $T_j = 25^\circ\text{C}$ $T_j = 150^\circ\text{C}$	$I_{IN(H)}$	500 300	- -	- -	
On-state resistance $I_D = 12 \text{ A}$ , $V_{IN} = 5 \text{ V}$ , $T_j = 25^\circ\text{C}$ $I_D = 12 \text{ A}$ , $V_{IN} = 5 \text{ V}$ , $T_j = 150^\circ\text{C}$	$R_{DS(on)}$	- -	31 52	34 68	$\text{m}\Omega$
On-state resistance $I_D = 12$ , $V_{IN} = 10 \text{ V}$ , $T_j = 25^\circ\text{C}$ $I_D = 12$ , $V_{IN} = 10$ , $T_j = 150$	$R_{DS(on)}$	- -	25 45	28 56	
Nominal load current (ISO 10483) $V_{IN} = 10 \text{ V}$ , $V_{DS} = 0.5 \text{ V}$ , $T_C = 85^\circ\text{C}$	$I_{D(ISO)}$	12			A

Electrical Characteristics					
Parameter at $T_j=25^\circ\text{C}$ , unless otherwise specified	Symbol	Values			Unit
		min.	typ.	max.	
<b>Characteristics</b>					
Initial peak short circuit current limit $V_{IN} = 10\text{ V}$ , $V_{DS} = 12\text{ V}$	$I_{D(SCP)}$	-	160	-	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 $R_{CC}$ $V_{IN} = 10\text{ V}$ , $V_{DS} = 12\text{ V}$ , $t_m = 350\ \mu\text{s}$ , $T_j = -40\dots+150\ ^\circ\text{C}$ , $R_{CC} = 0\ \Omega$	$I_{D(lim)}$	6 100	12 130	25 170	
<b>Dynamic Characteristics</b>					
Turn-on time $V_{IN}$ to 90% $I_D$ : $R_L = 2,2\ \Omega$ , $V_{IN} = 0$ to $10\text{ V}$ , $V_{bb} = 12\text{ V}$	$t_{on}$	-	40	100	$\mu\text{s}$
Turn-off time $V_{IN}$ to 10% $I_D$ : $R_L = 2,2\ \Omega$ , $V_{IN} = 10$ to $0\text{ V}$ , $V_{bb} = 12\text{ V}$	$t_{off}$	-	70	170	$\mu\text{s}$
Slew rate on 70 to 50% $V_{bb}$ : $R_L = 2,2\ \Omega$ , $V_{IN} = 0$ 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% $V_{bb}$ : $R_L = 2,2\ \Omega$ , $V_{IN} = 10$ to $0\text{ V}$ , $V_{bb} = 12\text{ V}$	$dV_{DS}/dt_{off}$	-	1	3	
<b>Protection Functions</b>					
Thermal overload trip temperature	$T_{jt}$	150	165	-	$^\circ\text{C}$
Unclamped single pulse inductive energy $I_D = 12\text{ A}$ , $T_j = 25\ ^\circ\text{C}$ , $V_{bb} = 32\text{ V}$ $I_D = 12\text{ A}$ , $T_j = 150\ ^\circ\text{C}$ , $V_{bb} = 32\text{ V}$	$E_{AS}$	4000 900	- -	- -	mJ
<b>Inverse Diode</b>					
Inverse diode forward voltage $I_F = 5 \cdot 12\text{ A}$ , $t_m = 300\ \mu\text{s}$ , $V_{IN} = 0\text{ V}$	$V_{SD}$	-	1.13	-	V

<sup>1</sup>Device switched on into existing short circuit (see diagram Determination of  $I_{D(lim)}$ ). Dependant on the application, these values might be exceeded for max. 50  $\mu\text{s}$  in case of short circuit occurs while the device is on condition

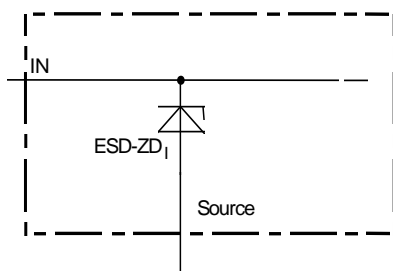
## Block Diagramm

### Terms



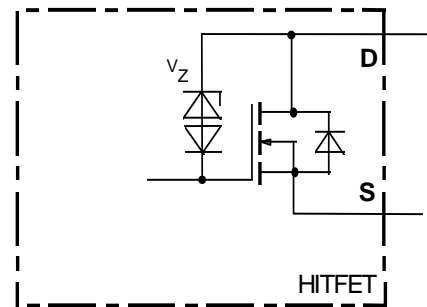
The ground lead impedance of  $R_{CC}$  should be as low as possible

### Input circuit (ESD protection)

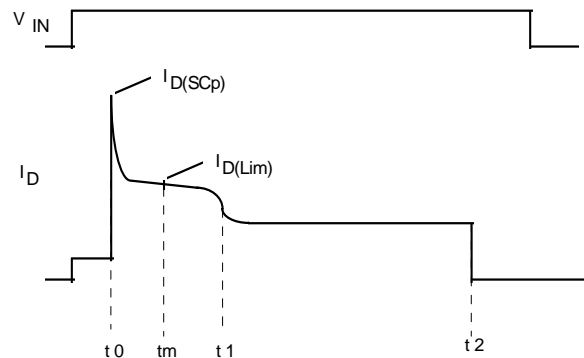


ESD zener diodes are not designed for DC current  $> 2 \text{ mA}$  @  $V_{IN} > 10 \text{ V}$ .

### Inductive and overvoltage output clamp



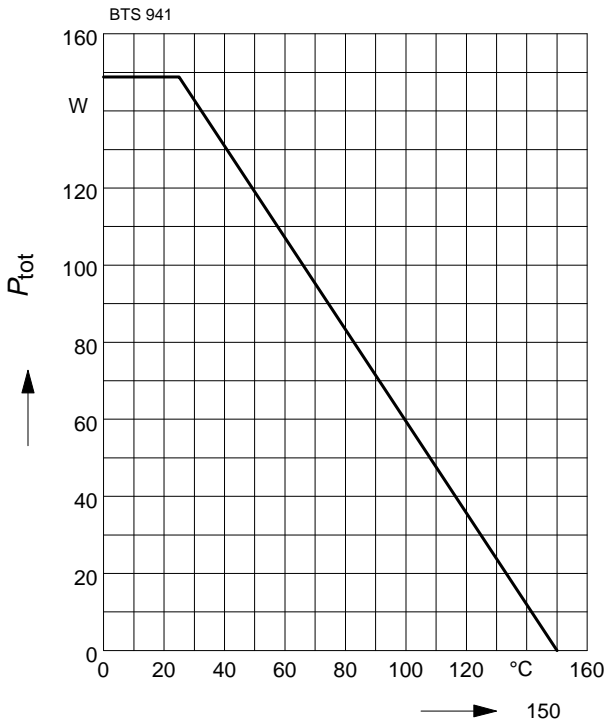
### Short circuit behaviour



- $t_0$ : 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.

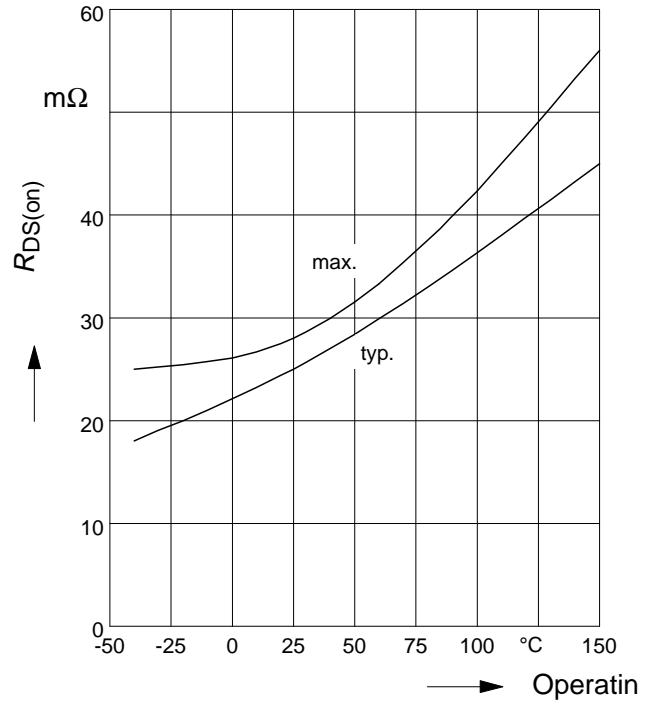
### Maximum allowable power dissipation

$$P_{tot} = f(T_c)$$



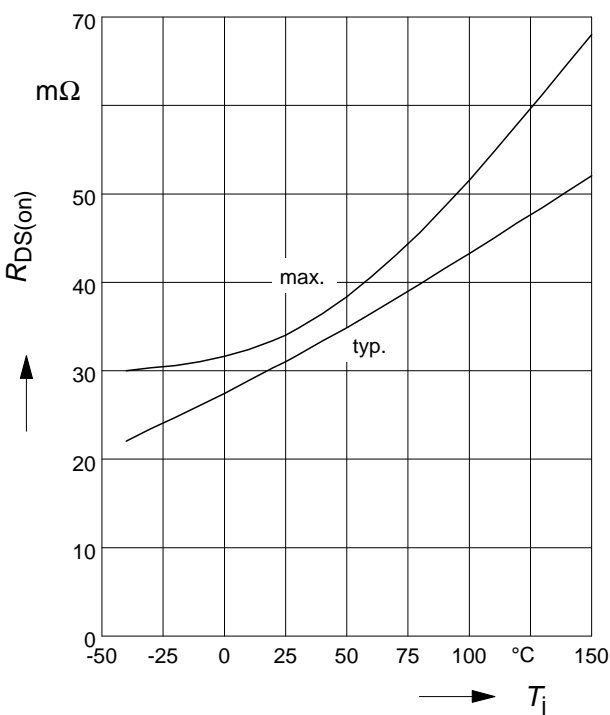
### On-state resistance

$$R_{ON} = f(T_j); I_D=12A; V_{IN}=10V$$



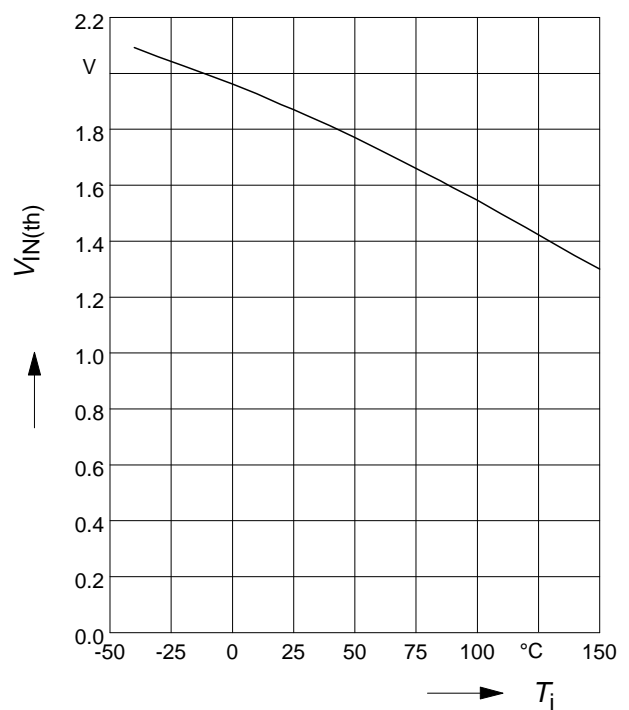
### On-state resistance

$$R_{ON} = f(T_j); I_D= 12A; V_{IN}=5V$$



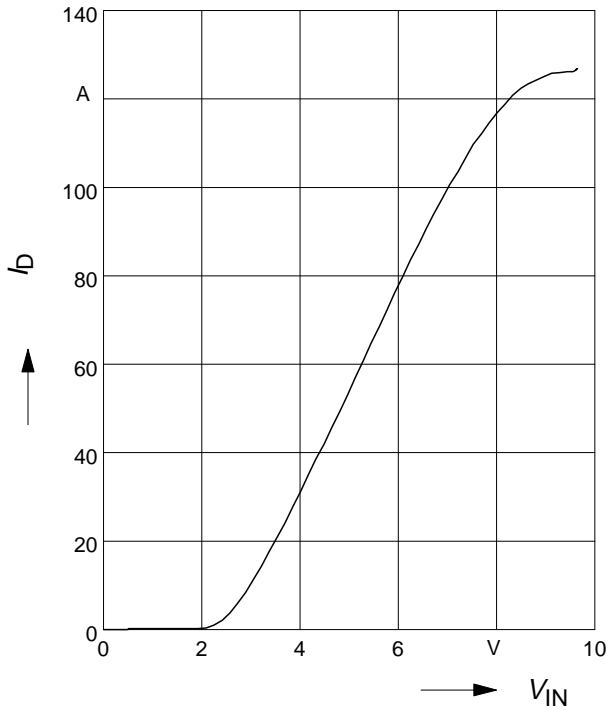
### Typ. input threshold voltage

$$V_{IN(th)} = f(T_j); I_D=2,7A; V_{DS}=12V$$



### Typ. transfer characteristics

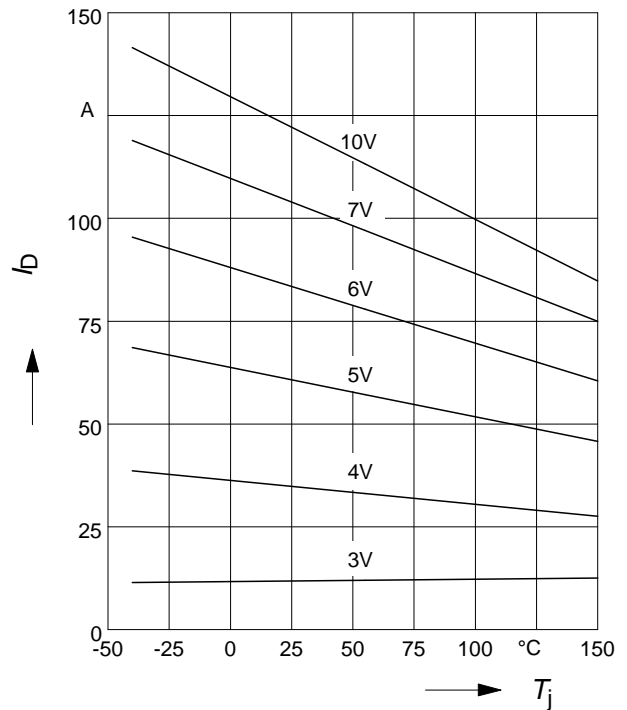
$$I_D = f(V_{IN}); V_{DS}=12V; T_j=25^\circ C$$



### Typ. short circuit current

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

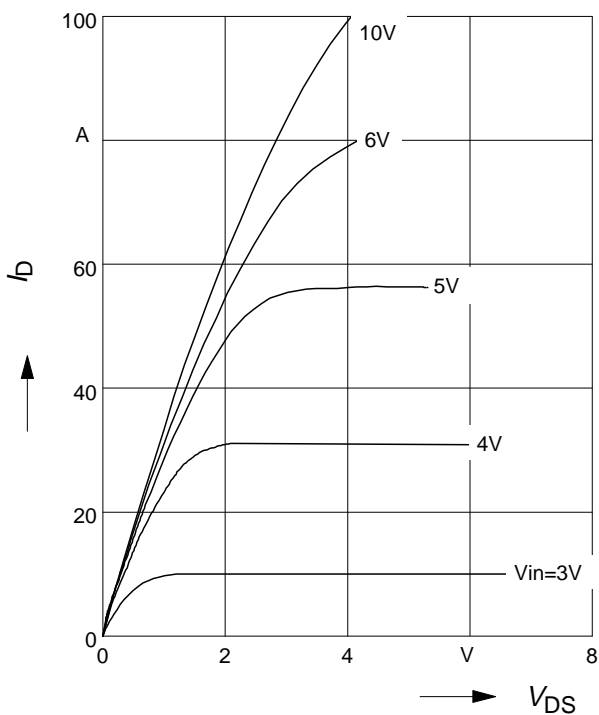
Parameter:  $V_{IN}$



### Typ. output characteristic

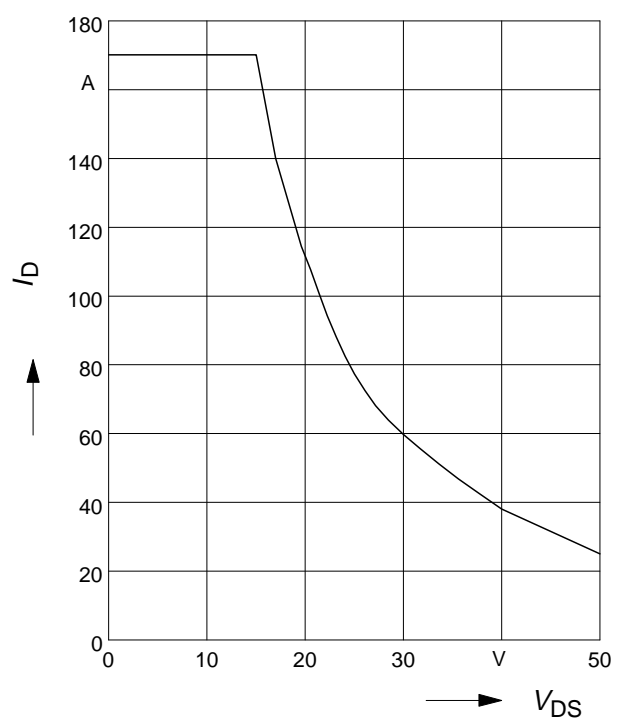
$$I_D = f(V_{DS}); T_j=25^\circ C$$

Parameter:  $V_{IN}$



### Safe Operating Area

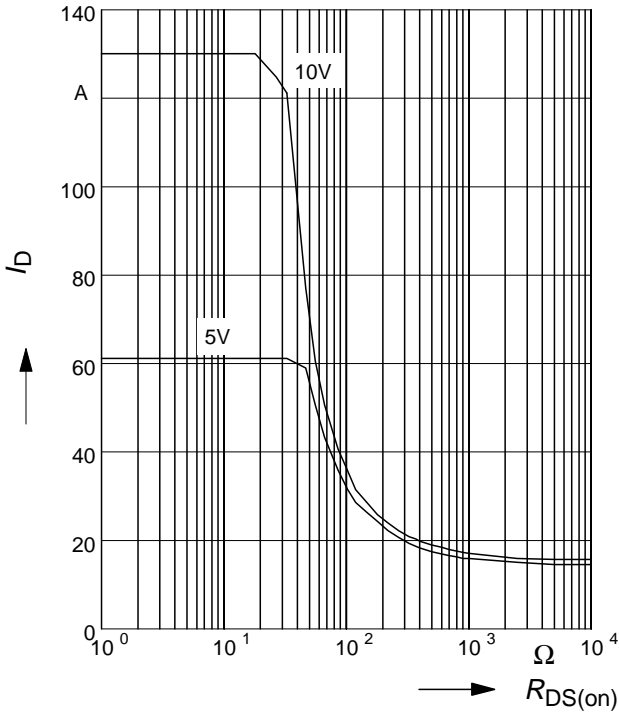
$$I_{D(SC)} = f(V_{DS}); T_j=25^\circ C$$



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

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

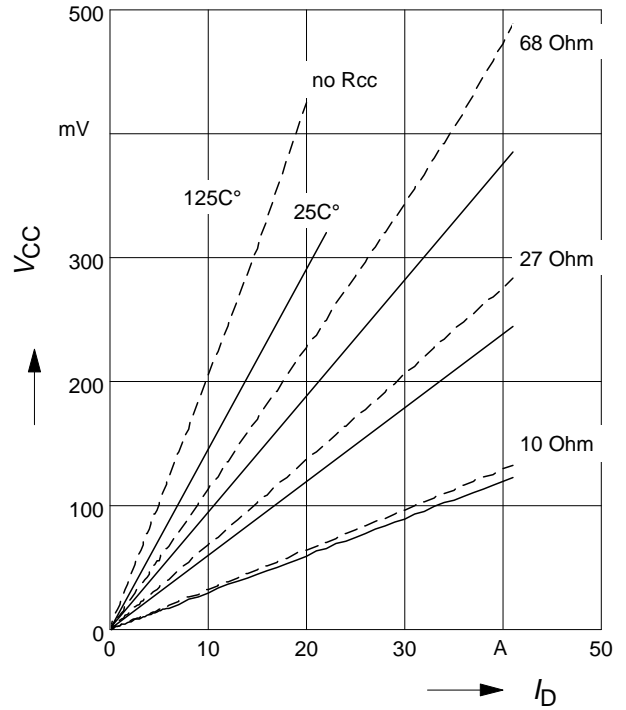
Parameter:  $V_{IN}$



### Typ. current sense characteristics

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

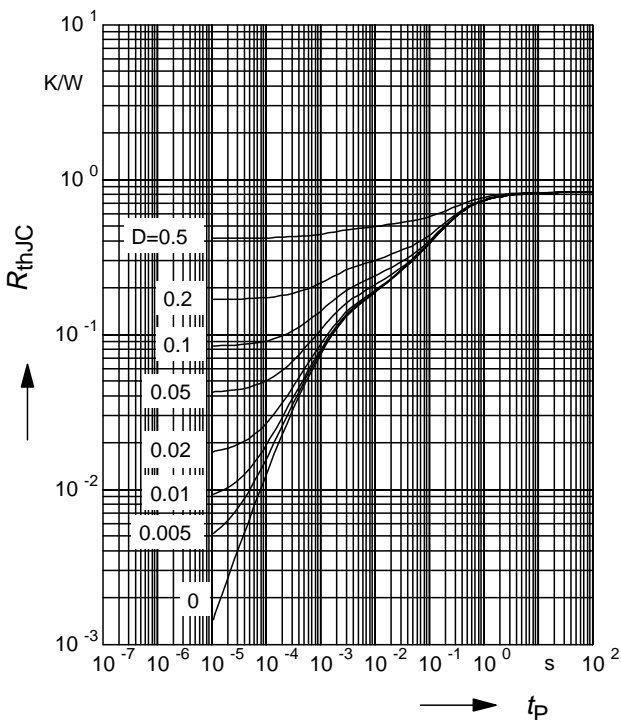
Parameter:  $R_{CC}, T_j$



### Transient thermal impedance

$$Z_{thJC} = f(t_p)$$

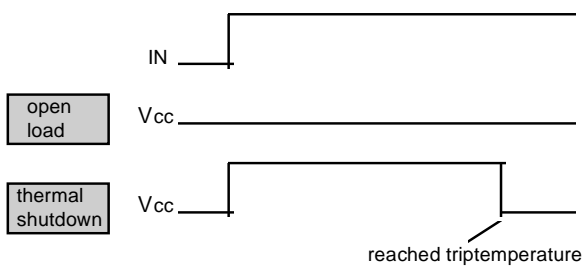
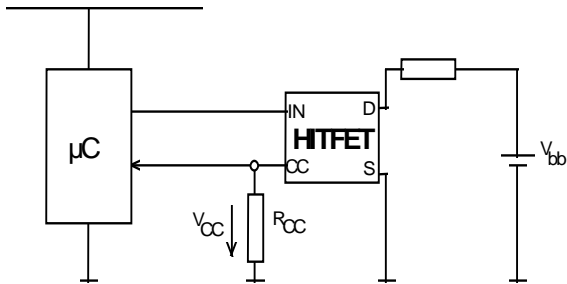
Parameter:  $D = t_p/T$





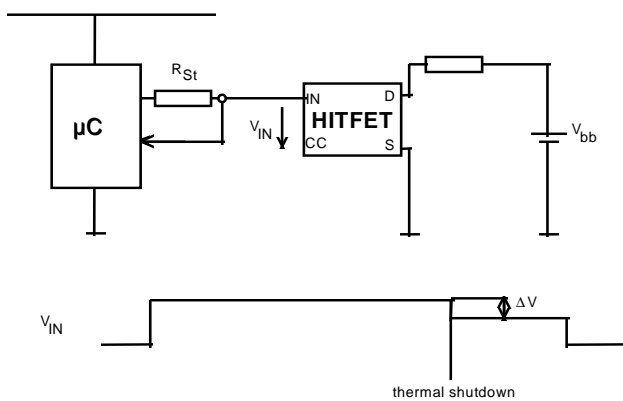
Application examples:

**Current Sense Features and Status Signals**



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

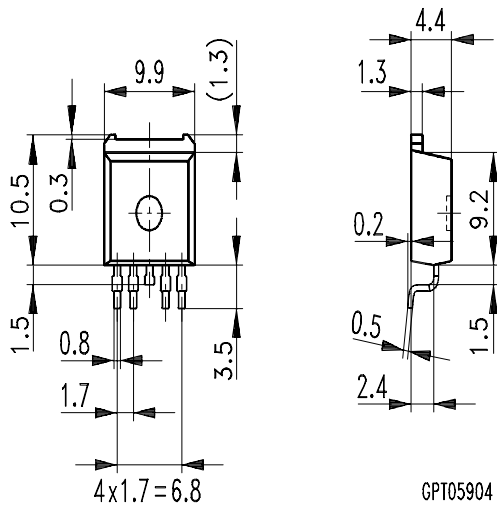
**Status signal of thermal shutdown by monitoring input current**



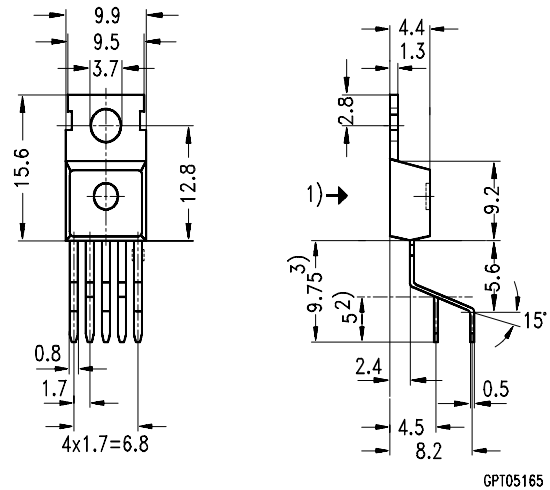
$$\Delta V = R_{ST} * I_{IN(3)}$$

## Package and ordering code all dimensions in mm

Ordering code: Q67060-S6702-A4

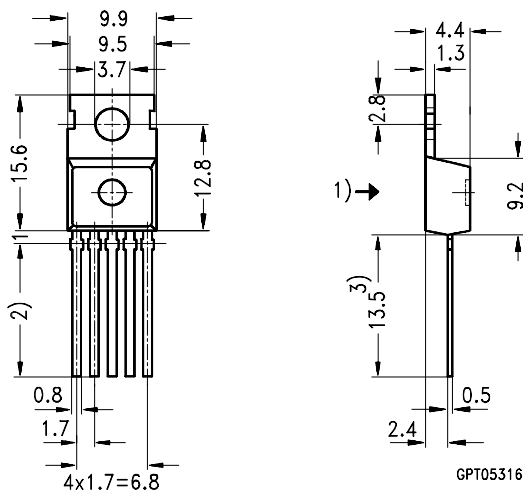


Ordering Code: Q67060-S6702-A2



- 1) shear and punch direction no burrs this surface
- 2) min. length by tinning
- 3) max. 11 mm allowable by tinning

Ordering Code: Q67060-S6702-A3



- 1) punch direction, burr max. 0.04
- 2) dip tinning
- 3) max. 14.5 by dip tinning press burr max. 0.05

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