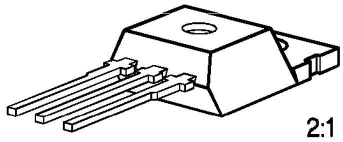
SIEMENS

TEMPFET® BTS 100

- P channel
- Enhancement mode
- Temperature sensor with thyristor characteristic
- The drain pin is electrically shorted to the tab



Pin	1	2	3
	G	D	S

Refer to circuit design hints (see chapter Technical Information)

Type	V_{DS}	I_D	$R_{DS(on)}$	Package	Ordering Code
BTS 100	– 50 V	– 8 A	0.3 Ω	TO-220AB	C67078-A5007-A2

Maximum Ratings

Parameter	Symbol	Values	Unit
Drain-source voltage	V_{DS}	– 50	V
Drain-gate voltage, R_{GS} = 20 kΩ	V_{DGR}	– 50	
Gate-source voltage	V_{GS}	± 20	
Continuous drain current, T_C = 30 ˚C	I_D	– 8.0	A
ISO drain current T_C = 85 ˚C, V_{GS} = 10 V, V_{DS} = 0.5 V	$I_{D\text{-}ISO}$	– 1.5	
Pulsed drain current, T_C = 25 ˚C	$I_{D\ puls}$	– 32	
Short circuit current, T_j = – 55 ... + 150 ˚C	I_{SC}	– 25	
Short circuit dissipation, T_j = – 55 ... + 150 ˚C	P_{SCmax}	500	W
Power dissipation	P_{tot}	40	
Operating and storage temperature range	T_j, T_{stg}	– 55 ... + 150	˚C
DIN humidity category, DIN 40 040	–	E	–
IEC climatic category, DIN IEC 68-1	–	55/150/56	
Thermal resistance Chip-case Chip-ambient	 $R_{th\ JC}$ $R_{th\ JA}$	 ≤ 3.1 ≤ 75	K/W

Electrical Characteristics
at T_j = 25 °C, unless otherwise specified.

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Static Characteristics					
Drain-source breakdown voltage V_{GS} = 0, I_D = – 0.25 mA	$V_{(BR)DSS}$	– 50	–	–	V
Gate threshold voltage V_{GS} = V_{DS}, I_D = – 1 mA	$V_{GS(th)}$	– 2.5	– 3.0	– 3.5	
Zero gate voltage drain current V_{GS} = 0 V, V_{DS} = – 50 V	I_{DSS}				µA
T_j = 25 °C		–	– 1	– 10	
T_j = 150 °C		–	– 100	– 300	
Gate-source leakage current V_{GS} = – 20 V, V_{DS} = 0	I_{GSS}				
T_j = 25 °C		–	– 10	– 100	nA
T_j = 150 °C		–	– 2	– 4	µA
Drain-source on-state resistance V_{GS} = – 10 V, I_D = – 5 A	$R_{DS(on)}$	–	0.25	0.3	Ω
Dynamic Characteristics					
Forward transconductance $V_{DS} \geq 2 \times I_D \times R_{DS(on)max}$, I_D = – 5 A	g_{fs}	1.5	2.3	4.0	S
Input capacitance V_{GS} = 0, V_{DS} = – 25 V, f = 1 MHz	C_{iss}	–	900	1200	pF
Output capacitance V_{GS} = 0, V_{DS} = – 25 V, f = 1 MHz	C_{oss}	–	350	550	
Reverse transfer capacitance V_{GS} = 0, V_{DS} = – 25 V, f = 1 MHz	C_{rss}	–	130	230	
Turn-on time t_{on}, ($t_{on} = t_{d(on)} + t_r$) V_{CC} = – 30 V, V_{GS} = – 10 V, I_D = – 2.9 A, R_{GS} = 50 Ω	$t_{d(on)}$	–	20	30	ns
	t_r	–	60	95	
Turn-off time t_{off}, ($t_{off} = t_{d(off)} + t_f$) V_{CC} = – 30 V, V_{GS} = – 10 V, I_D = – 2.9 A, R_{GS} = 50 Ω	$t_{d(off)}$	–	70	90	
	t_f	–	55	75	

Electrical Characteristics (cont'd)
at T_j = 25 ˚C, unless otherwise specified.

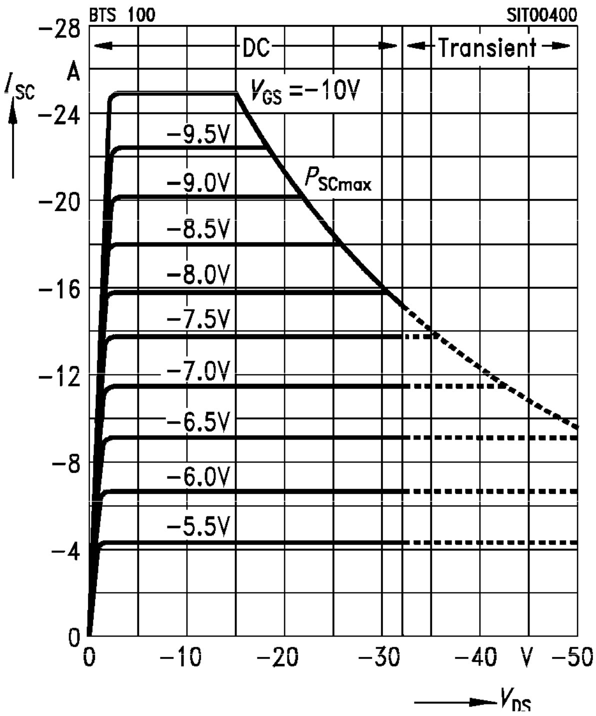
Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Reverse Diode					
Continous source current	I_S	–	–	– 8.0	A
Pulsed source current	I_{SM}	–	–	– 32	
Diode forward on-voltage I_F = – 16 A, V_{GS} = 0	V_{SD}	–	– 1.0	– 1.7	V
Reverse recovery time I_F = I_S, di_F/dt = – 100 A/µs, V_R = – 30 V	t_{rr}	–	90	–	ns
Reverse recovery charge I_F = I_S, di_F/dt = – 100 A/µs, V_R = – 30 V	Q_{rr}	–	0.23	–	µC
Temperature Sensor					
Forward voltage $I_{TS(on)}$ = – 10 mA, T_j = – 55 ... + 150 ˚C Sensor override, $t_p \leq$ 100 µs T_j = – 55 ... + 160 ˚C	$V_{TS(on)}$	– –	– 1.4 –	– 1.5 – 10	V
Forward current T_j = – 55 ... + 150 ˚C Sensor override, $t_p \leq$ 100 µs T_j = – 55 ... + 160 ˚C	$I_{TS(on)}$	– –	– –	– 10 – 600	mA
Holding current, $V_{TS(off)}$ = – 5 V, T_j = 25 ˚C T_j = 150 ˚C	I_H	– 0.05 – 0.05	– 0.1 – 0.2	– 0.5 – 0.3	
Switching temperature V_{TS} = – 5 V	$T_{TS(on)}$	150	–	–	˚C
Turn-off time V_{TS} = – 5 V, $I_{TS(on)}$ = – 2 mA	t_{off}	0.5	–	2.5	µs

Examples for short-circuit protection

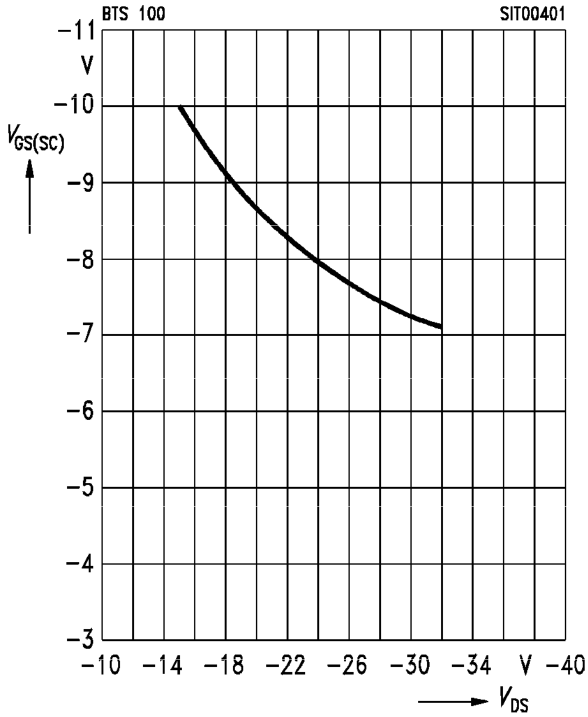
at T_j = – 55 ... + 150 ˚C, unless otherwise specified.

Parameter	Symbol	Example			Unit
		1	2	–	
Drain-source voltage	V_{DS}	– 15	– 30	–	V
Gate-source voltage	V_{GS}	– 10	– 8.2	–	
Short-circuit current	I_{SC}	≤ – 25	≤ – 16	–	A
Short-circuit dissipation	P_{SC}	375	480	–	W
Response time T_j = 25 ˚C, before short circuit	$t_{SC(off)}$	55	55	–	ms

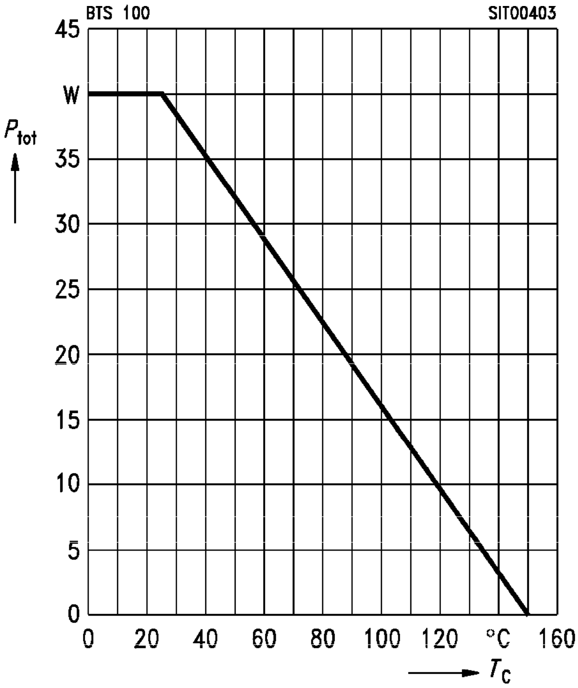
Short-circuit protection $I_{SC} = f(V_{DS})$
Parameter: V_{GS}
Diagram to determine I_{SC} for T_j = –55 ... + 150 ˚C



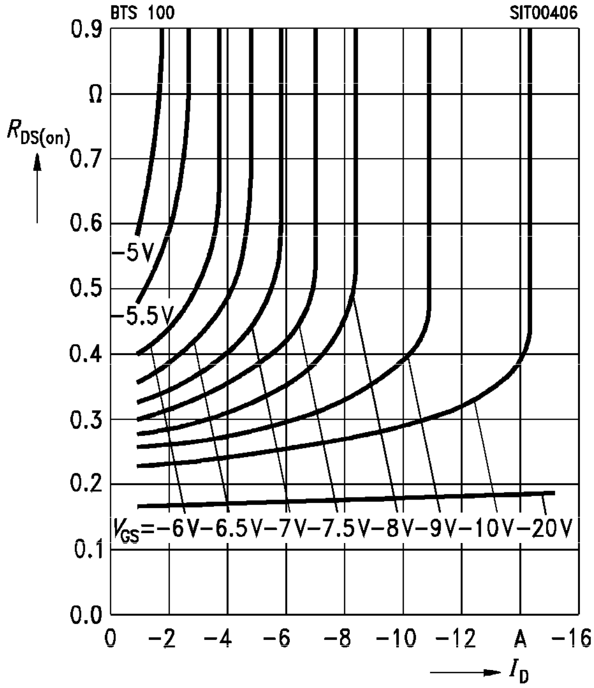
Max. gate voltage $V_{GS(SC)} = f(V_{DS})$
Parameter: T_j = – 55 ... + 150 ˚C



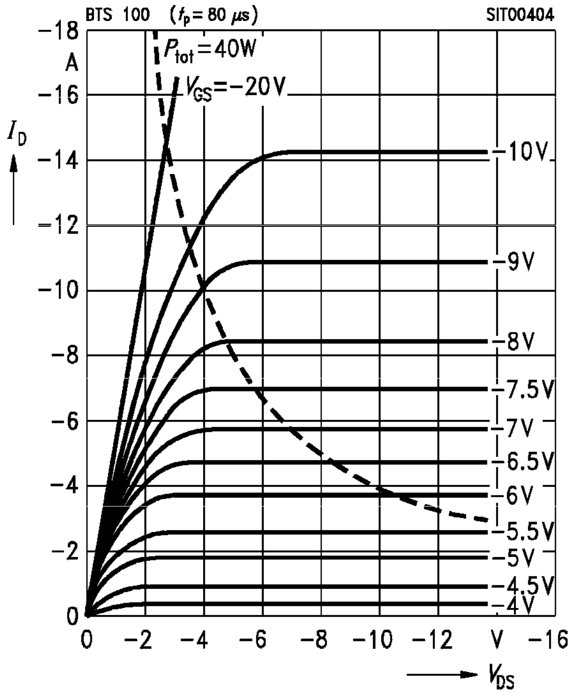
Max. power dissipation $P_{tot} = f(T_C)$



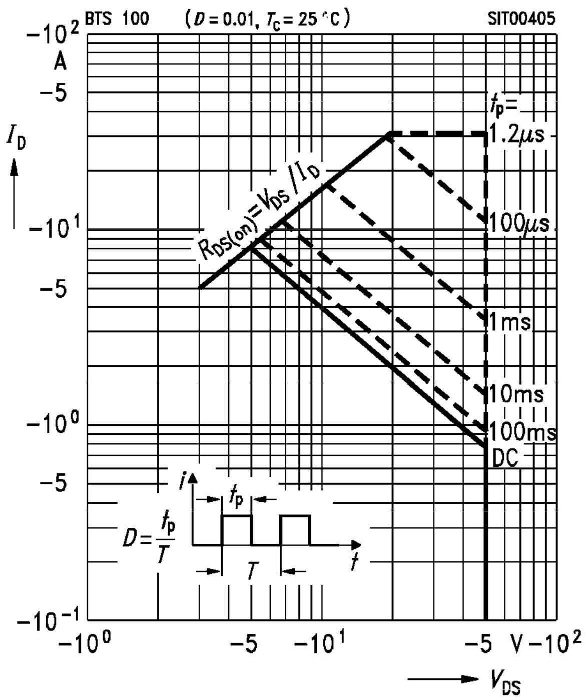
Typ. drain-source on-state resistance
$R_{DS(on)} = f(I_D)$
Parameter: V_{GS}



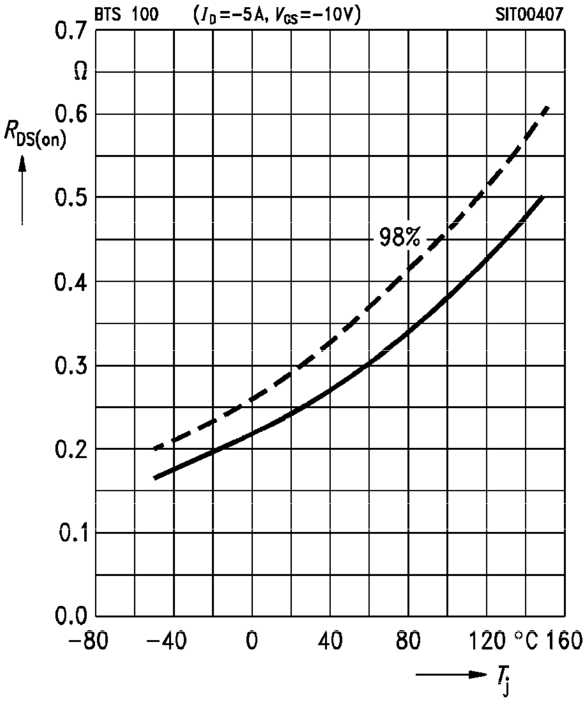
Typical output characteristics $I_D = f(V_{DS})$
Parameter: t_p = 80 µs



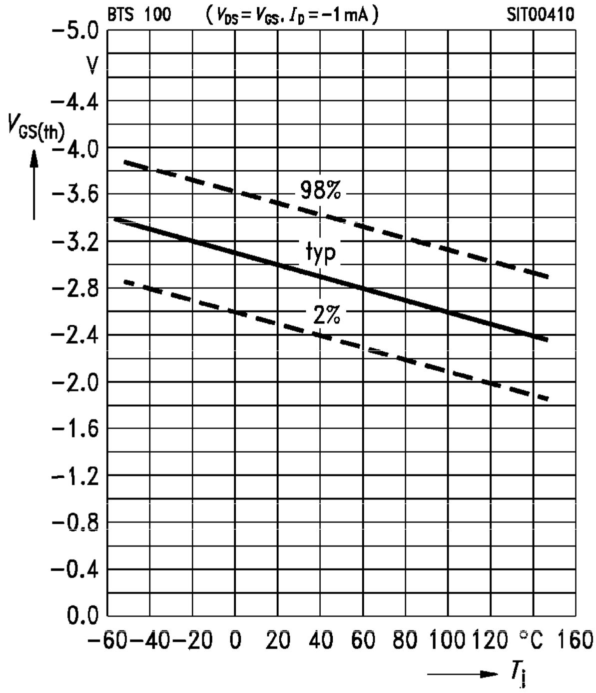
Safe operating area $I_D = f(V_{DS})$
Parameter: D = 0.01, T_C = 25 °C



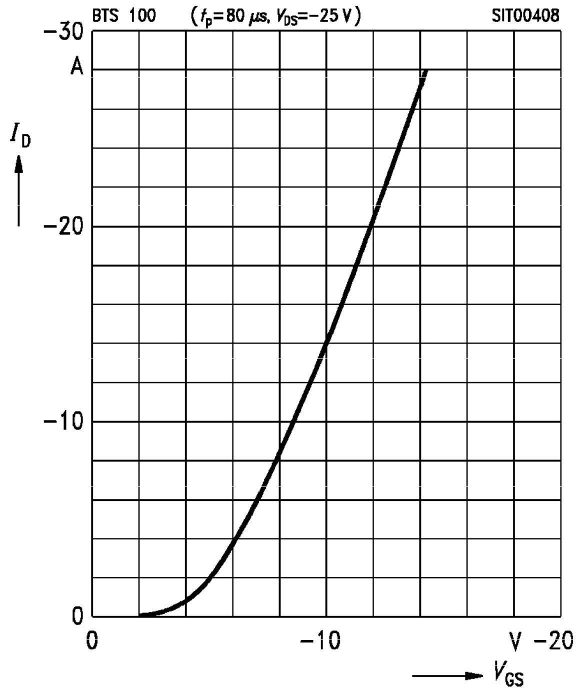
Drain-source on-state resistance
$R_{DS(on)} = f(T_j)$
Parameter: I_D = – 5 A, V_{GS} = – 10 V



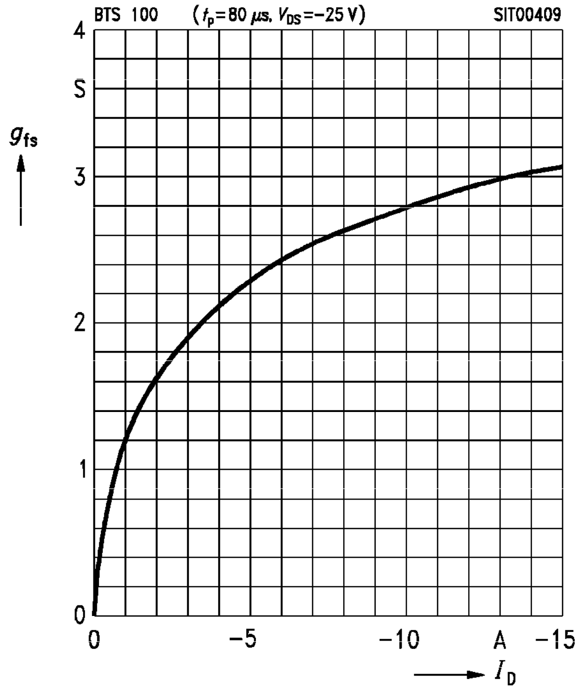
Gate threshold voltage $V_{GS(th)} = f(T_j)$
Parameter: V_{DS} = V_{GS}, I_D = – 1 mA



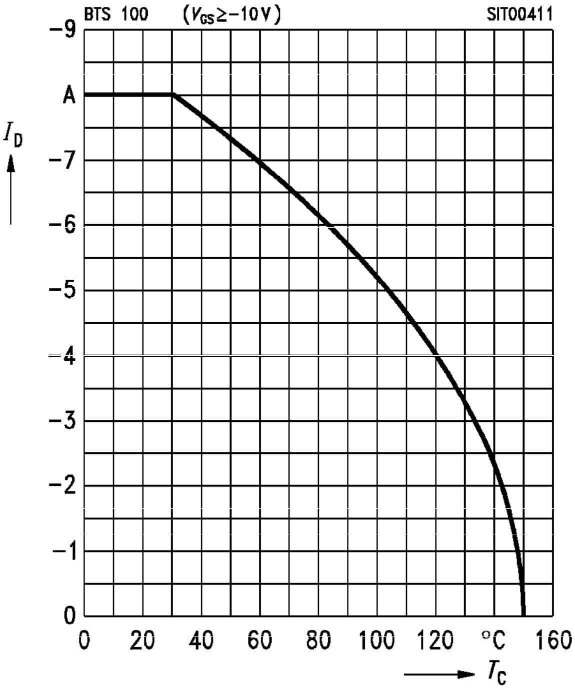
Typ. transfer characteristic
$I_D = f(V_{GS})$
Parameter: t_p = 80 µs, V_{DS} = – 25 V



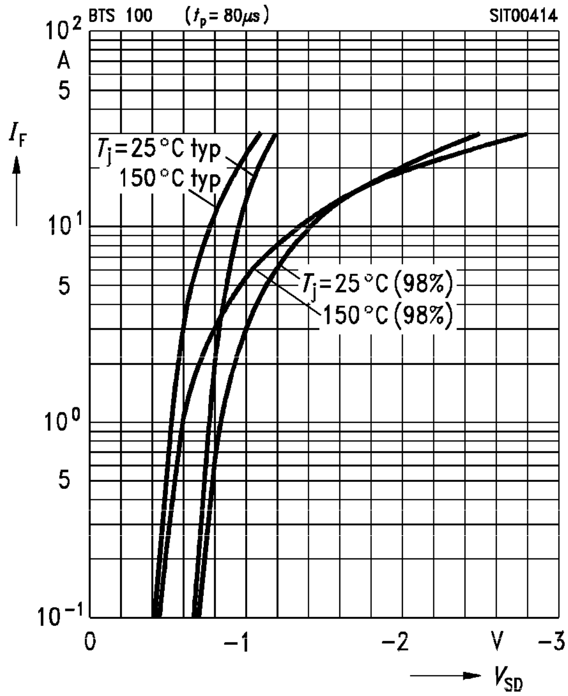
Typ. transconductance $g_{fs} = f(I_D)$
Parameter: t_p = 80 µs, V_{DS} = – 25 V



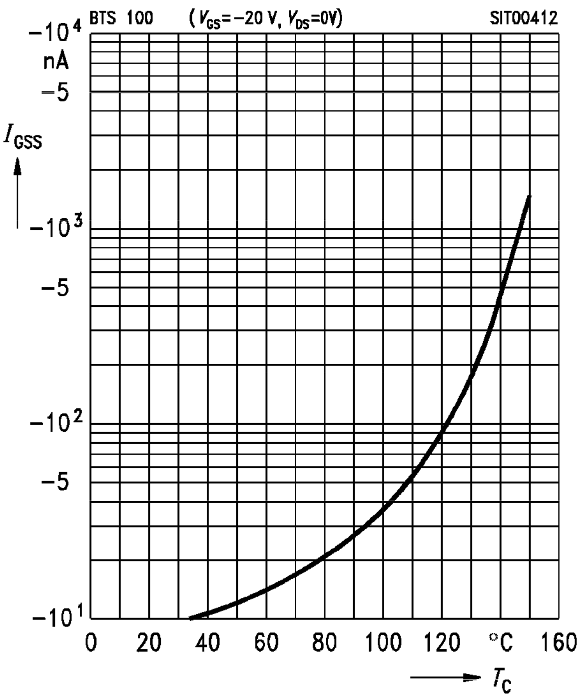
Continous drain current $I_D = f(T_C)$
Parameter: $V_{GS} \geq -10$ V



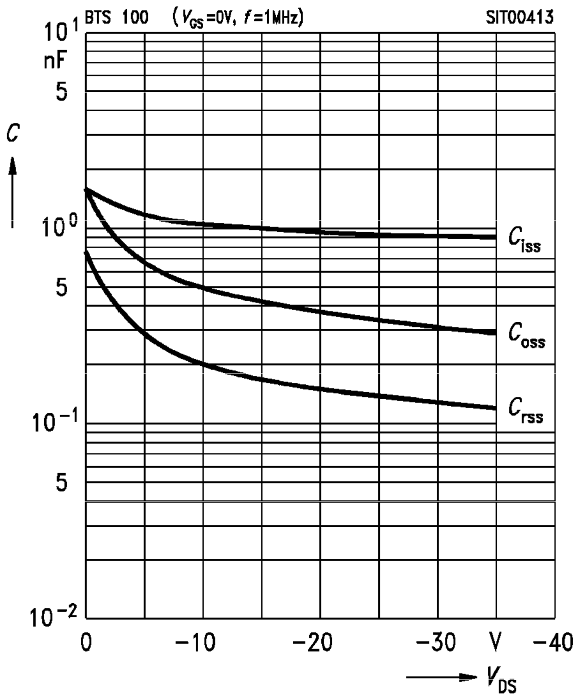
Forward characteristics of reverse diode
$I_F = f(V_{SD})$
Parameter: T_j, t_p = 80 µs



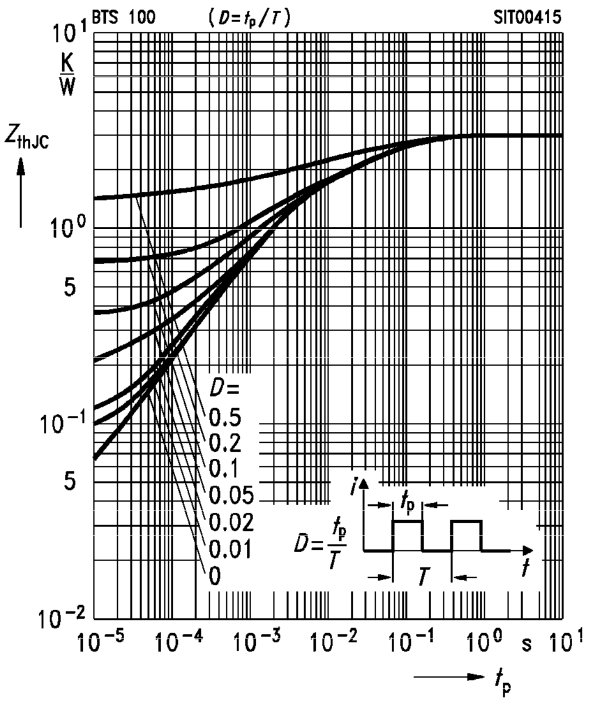
Typ. gate-source leakage current
$I_{GSS} = f(T_C)$
Parameter: V_{GS} = – 20 V, V_{DS} = 0



Typ. capacitances $C = f(V_{DS})$
Parameter: V_{GS} = 0, f = 1 MHz

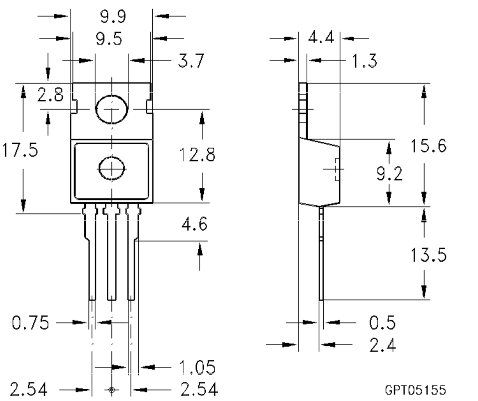


Transient thermal impedance $Z_{thJC} = f(t_p)$
Parameter: $D = t_p/T$



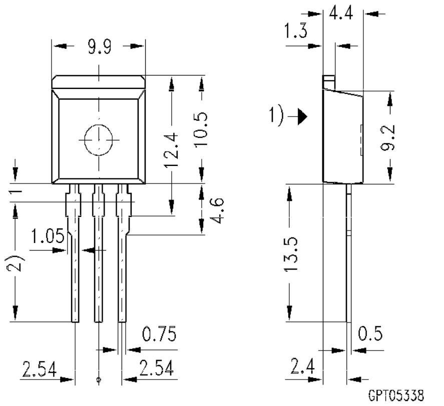
TO 220 AB Standard

Ordering Code C67078-A5007-A2



TO 220 AB Option E 3046

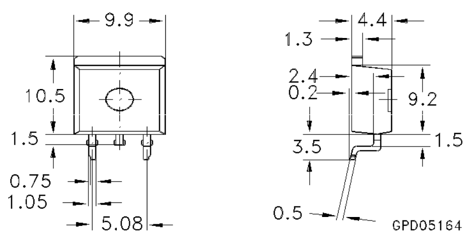
Ordering Code C67078-A5007-A4



1) shear and punch direction no burrs this surface
2) dip tinning

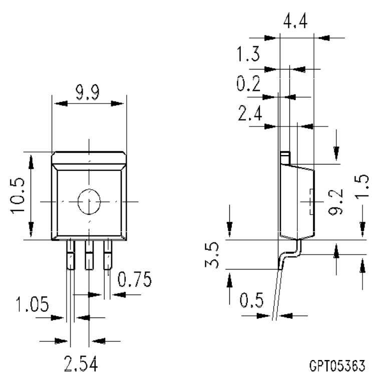
TO 220 AB SMD version E3045

Ordering Code C67078-A5007-A7



TO 220 AB SMD version E3044

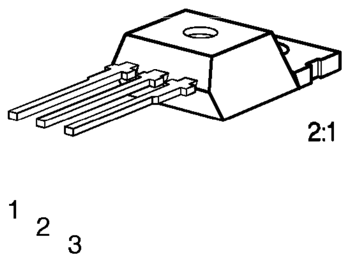
Ordering Code C67078-A5007-A9



SIEMENS

TEMPFET® BTS 114A

- N channel
- Enhancement mode
- Temperature sensor with thyristor characteristic
- The drain pin is electrically shorted to the tab



Pin	1	2	3
	G	D	S

Refer to circuit design hints (see chapter Technical Information)

Type	V_{DS}	I_D	$R_{DS(on)}$	Package	Ordering Code
BTS 114A	50 V	17 A	0.10 Ω	TO-220AB	C67078-S5000-A2

Maximum Ratings

Parameter	Symbol	Values	Unit
Drain-source voltage	V_{DS}	50	V
Drain-gate voltage, R_{GS} = 20 kΩ	V_{DGR}	50	
Gate-source voltage	V_{GS}	± 20	
Continuous drain current, T_C = 27 ˚C	I_D	17	A
ISO drain current T_C = 85 ˚C, V_{GS} = 10 V, V_{DS} = 0.5 V	$I_{D\text{-}ISO}$	3.8	
Pulsed drain current, T_C = 25 ˚C	$I_{D\ puls}$	68	
Short circuit current, T_j = – 55 ... + 150 ˚C	I_{SC}	37	
Short circuit dissipation, T_j = – 55 ... + 150 ˚C	P_{SCmax}	550	W
Power dissipation	P_{tot}	50	
Operating and storage temperature range	T_j, T_{stg}	– 55 ... + 150	˚C
DIN humidity category, DIN 40 040	–	E	–
IEC climatic category, DIN IEC 68-1	–	55/150/56	
Thermal resistance Chip-case Chip-ambient	 $R_{th\ JC}$ $R_{th\ JA}$	 ≤ 2.5 ≤ 75	K/W

Electrical Characteristics
at T_j = 25 ˚C, unless otherwise specified.

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Static Characteristics					
Drain-source breakdown voltage V_{GS} = 0, I_D = 0.25 mA	$V_{(BR)DSS}$	50	–	–	V
Gate threshold voltage V_{GS} = V_{DS}, I_D = 1.0 mA	$V_{GS(th)}$	2.5	3.0	3.5	
Zero gate voltage drain current V_{GS} = 0 V, V_{DS} = 50 V T_j = 25 ˚C T_j = 125 ˚C	I_{DSS}	 – –	 0.1 10	 1.0 100	µA
Gate-source leakage current V_{GS} = 20 V, V_{DS} = 0 T_j = 25 ˚C T_j = 150 ˚C	I_{GSS}	 – –	 10 2	 100 4	 nA µA
Drain-source on-state resistance V_{GS} = 10 V, I_D = 9.0 A	$R_{DS(on)}$	–	0.08	0.10	Ω
Dynamic Characteristics					
Forward transconductance $V_{DS} \geq 2 \times I_D \times R_{DS(on)max}$, I_D =9 A	g_{fs}	5.0	8.0	–	S
Input capacitance V_{GS} = 0, V_{DS} = 25 V, f = 1 MHz	C_{iss}	–	450	600	pF
Output capacitance V_{GS} = 0, V_{DS} = 25 V, f = 1 MHz	C_{oss}	–	220	350	
Reverse transfer capacitance V_{GS} = 0, V_{DS} = 25 V, f = 1 MHz	C_{rss}	–	85	150	
Turn-on time t_{on}, ($t_{on} = t_{d(on)} + t_r$) V_{CC} = 30 V, V_{GS} = 10 V, I_D = 3.0 A, R_{GS} = 50 Ω	$t_{d(on)}$	–	20	30	ns
	t_r	–	40	60	
Turn-off time t_{off}, ($t_{off} = t_{d(off)} + t_f$) V_{CC} = 30 V, V_{GS} = 10 V, I_D = 3.0 A, R_{GS} = 50 Ω	$t_{d(off)}$	–	55	70	
	t_f	–	40	60	

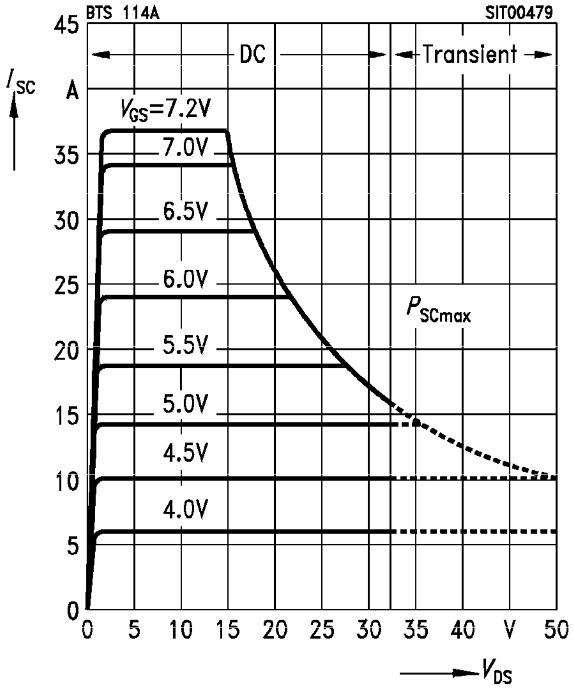
Electrical Characteristics (cont'd)
at T_j = 25 °C, unless otherwise specified.

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Reverse Diode					
Continuous source current	I_S	–	–	17	A
Pulsed source current	I_{SM}	–	–	68	
Diode forward on-voltage I_F = 30 A, V_{GS} = 0	V_{SD}	–	1.5	1.8	V
Reverse recovery time I_F = I_S, di_F/dt = 100 A/µs, V_R = 30 V	t_{rr}	–	60	–	ns
Reverse recovery charge I_F = I_S, di_F/dt = 100 A/µs, V_R = 30 V	Q_{rr}	–	0.10	–	µC
Temperature Sensor					
Forward voltage $I_{TS(on)}$ = 10 mA, T_j = – 55 ... + 150 °C Sensor override, $t_p \leq$ 100 µs T_j = – 55 ... + 160 °C	$V_{TS(on)}$	– –	1.4 –	1.5 10	V
Forward current T_j = – 55 ... + 150 °C Sensor override, $t_p \leq$ 100 µs T_j = – 55 ... + 160 °C	$I_{TS(on)}$	– –	– –	10 600	mA
Holding current, $V_{TS(off)}$ = 5.0 V, T_j = 25 °C T_j = 150 °C	I_H	0.05 0.05	0.1 0.2	0.5 0.3	
Switching temperature V_{TS} = 5.0 V	$T_{TS(on)}$	–	–	–	°C
Turn-off time V_{TS} = 5.0 V, $I_{TS(on)}$ = 2 mA	t_{off}	0.5	–	2.5	µs

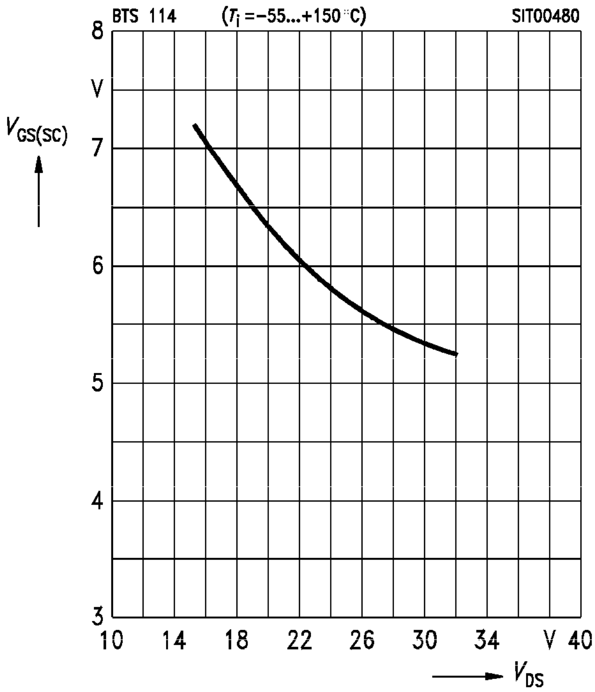
Examples for short-circuit protection
at T_j = – 55 ... + 150 ˚C, unless otherwise specified

Parameter	Symbol	Examples			Unit
		1	2	–	
Drain-source voltage	V_{DS}	15	30	–	V
Gate-source voltage	V_{GS}	7.2	5.2	–	
Short-circuit current	I_{SC}	37	17	–	A
Short-circuit dissipation	P_{SC}	550	510	–	W
Response time T_j = 25 ˚C, before short circuit	$t_{SC(off)}$	25	25	–	ms

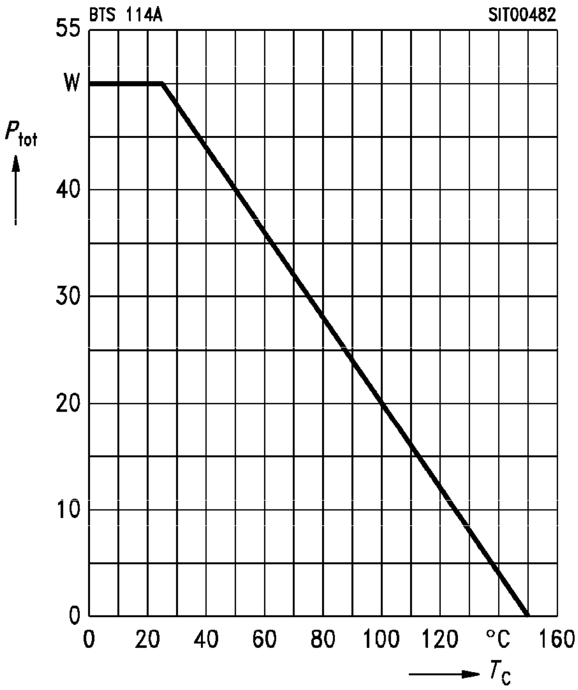
Short-circuit protection $I_{SC} = f(V_{DS})$
Parameter: V_{GS}
Diagram to determine I_{SC} for T_j = –55 ... + 150 ˚C



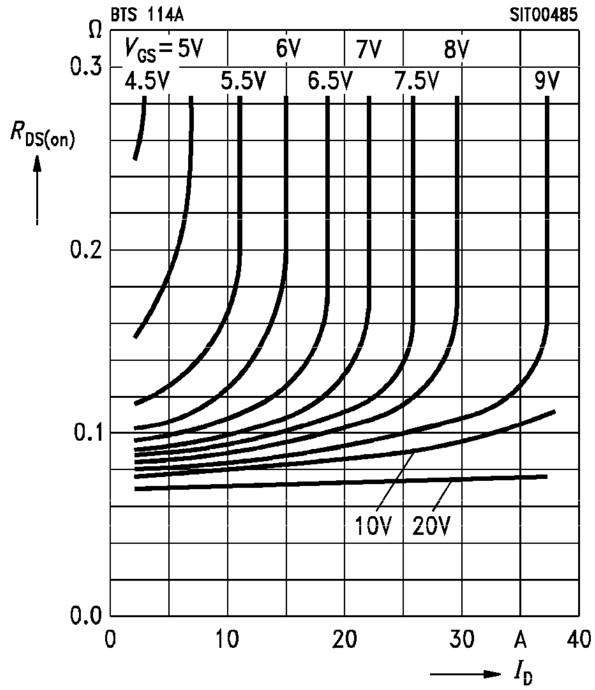
Max. gate voltage $V_{GS(SC)} = f(V_{DS})$
Parameter: T_j = – 55 ... + 150 ˚C



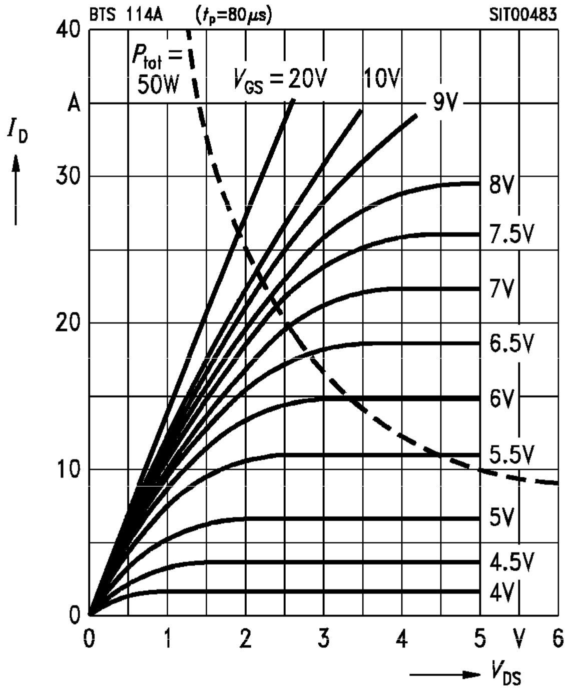
Max. power dissipation $P_{tot} = f(T_C)$



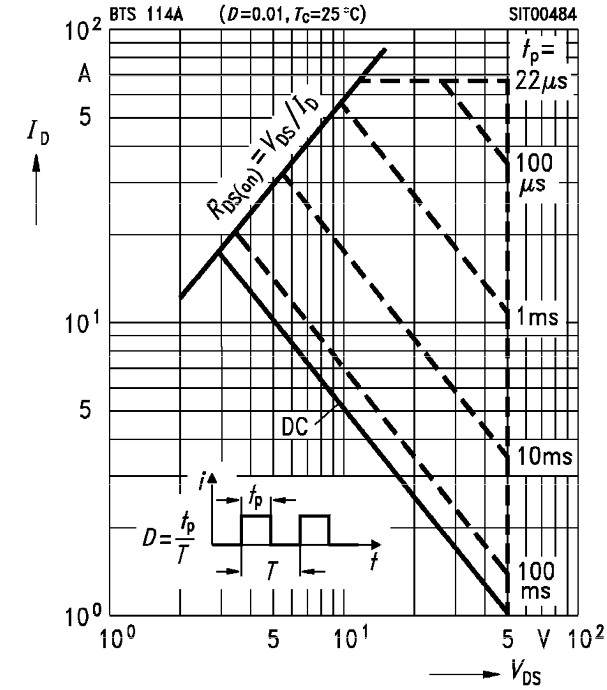
Typ. drain-source on-state resistance
$R_{DS(on)} = f(I_D)$
Parameter: V_{GS}



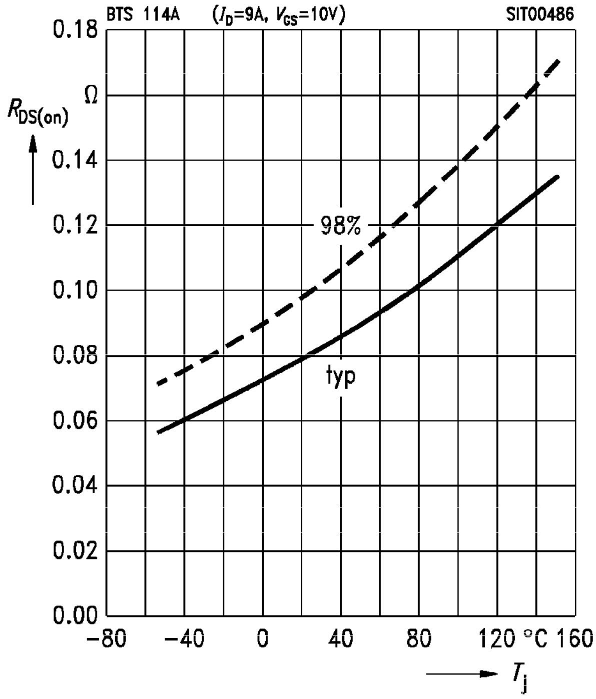
Typical output characteristics $I_D = f(V_{DS})$
Parameter: t_p = 80 µs



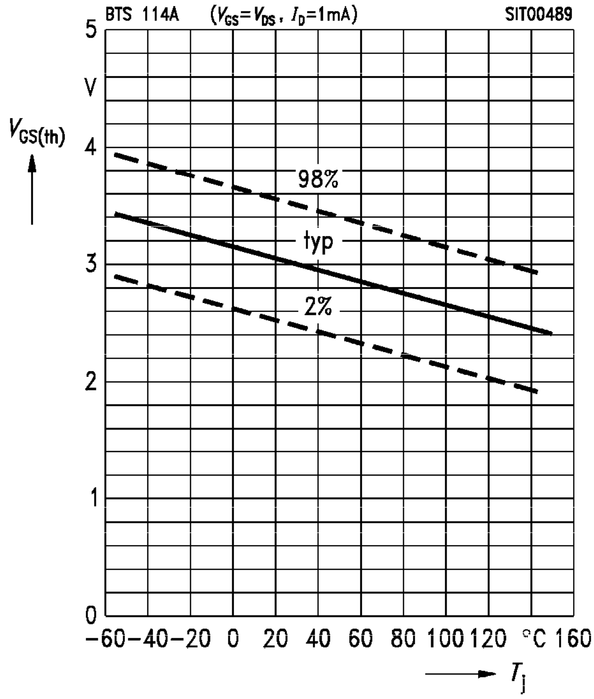
Safe operating area $I_D = f(V_{DS})$
Parameter: D = 0.01, T_C = 25 °C



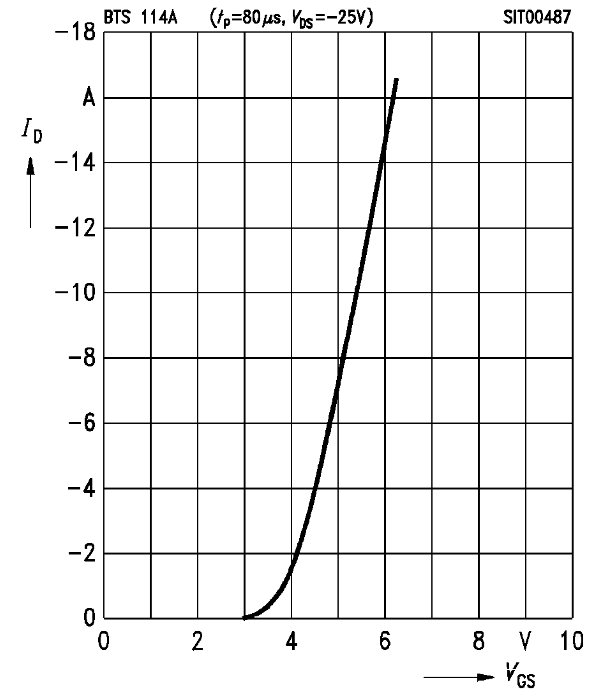
Drain-source on-state resistance
$R_{DS(on)} = f(T_j)$
Parameter: I_D = 9 A, V_{GS} = 10 V



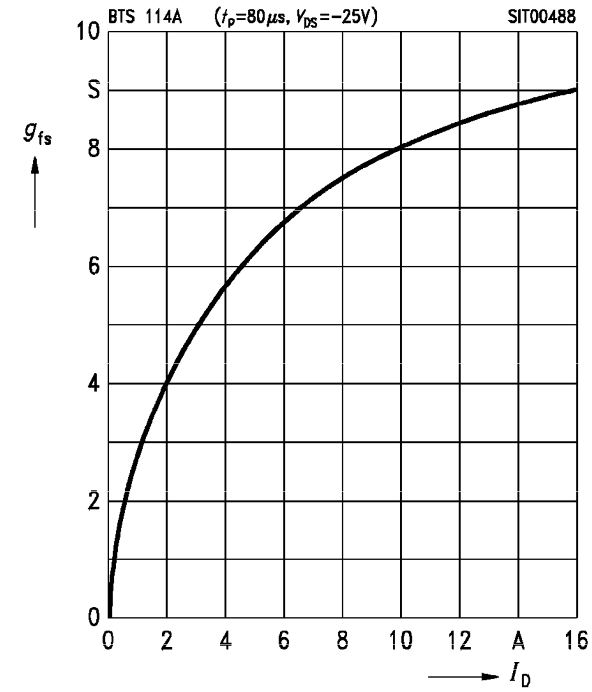
Gate threshold voltage $V_{GS(th)} = f(T_j)$
Parameter: V_{DS} = V_{GS}, I_D = – 1 mA (spread)



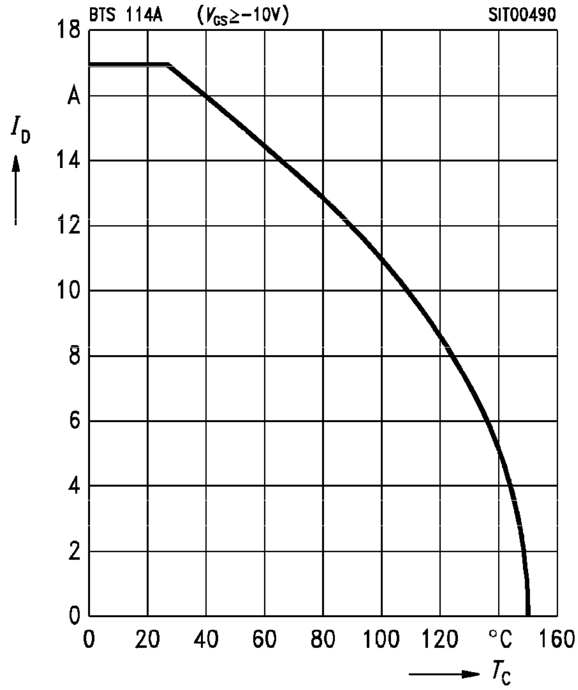
Typ. transfer characteristic
$I_D = f(V_{GS})$
Parameter: t_p = 80 µs, V_{DS} = – 25 V



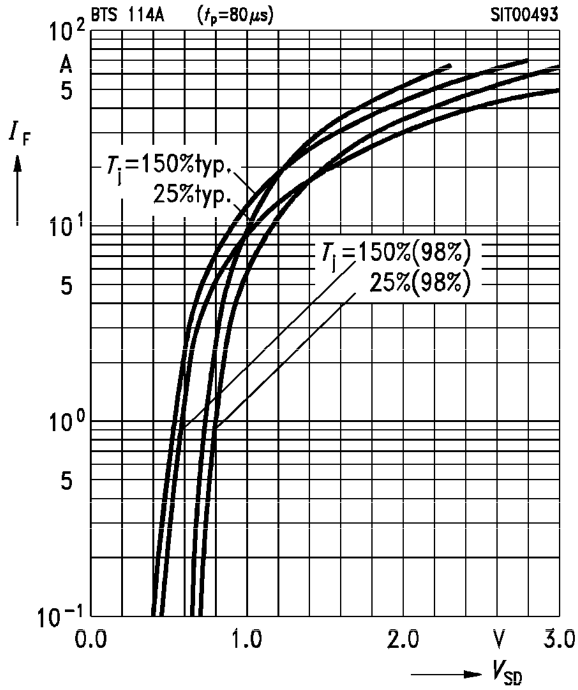
Typ. transconductance $g_{fs} = f(I_D)$
Parameter: t_p = 80 µs, V_{DS} = – 25 V



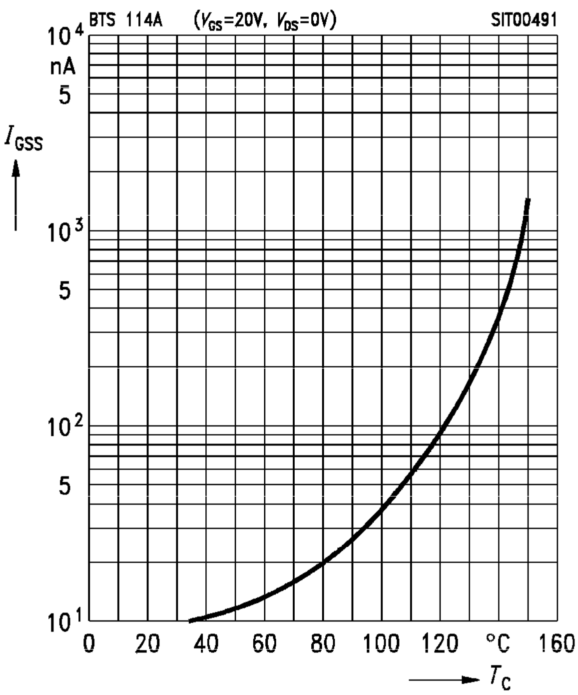
Continous drain current $I_D = f(T_C)$
Parameter: $V_{GS} \geq -10$ V



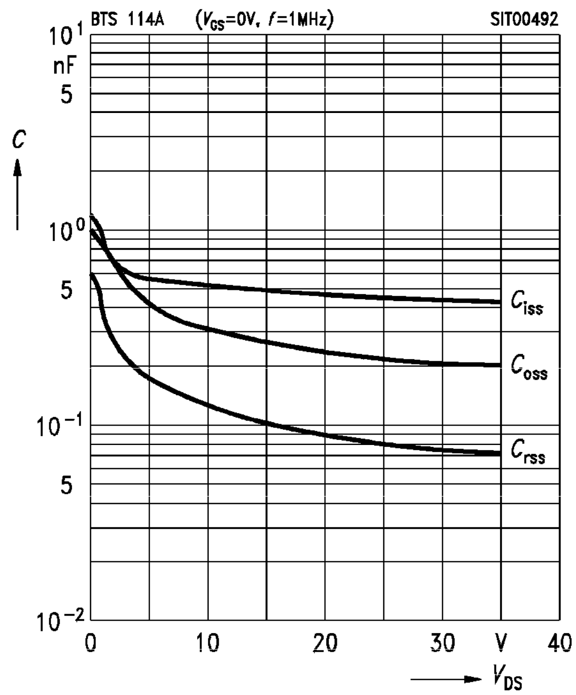
Forward characteristics of reverse diode
$I_F = f(V_{SD})$
Parameter: T_j, t_p = 80 µs (spread)



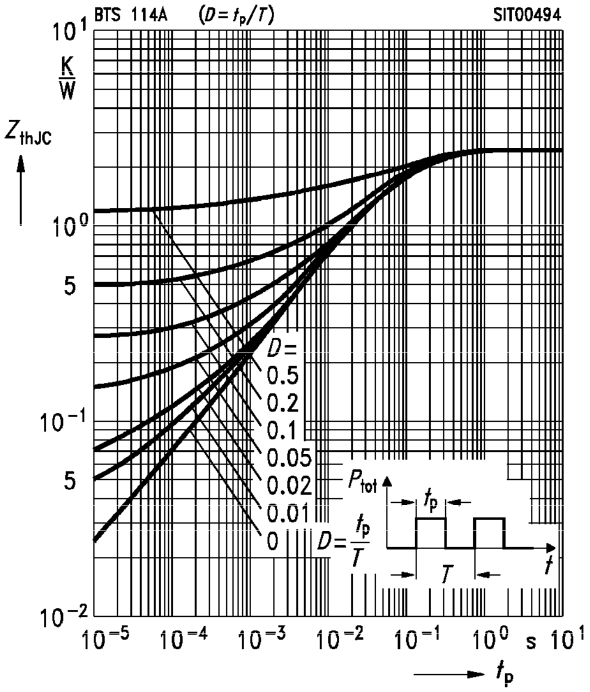
Typ. gate-source leakage current
$I_{GSS} = f(T_C)$
Parameter: V_{GS} = 20 V, V_{DS} = 0



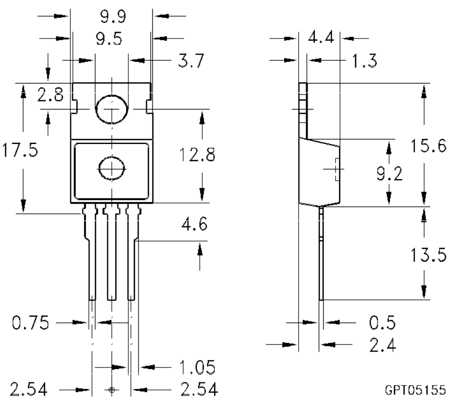
Typ. capacitances $C = f(V_{DS})$
Parameter: $V_{GS} = 0$, f = 1 MHz



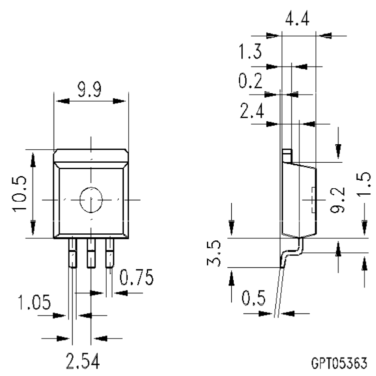
Transient thermal impedance $Z_{thJC} = f(t_p)$
Parameter: $D = t_p/T$



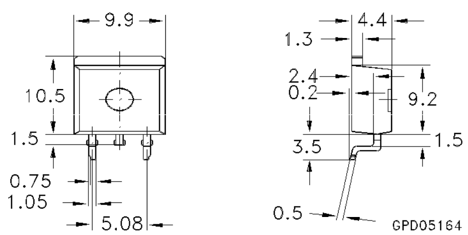
TO 220 AB **Ordering Code**
Standard C67078-S5000-A2



TO 220 AB **Ordering Code**
SMD Version E3044 C67078-S5000-A8



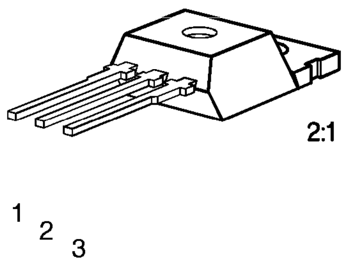
TO 220 AB **Ordering Code**
Tape & reel E3045 A C67078-S5000-A11



SIEMENS

TEMPFET® BTS 121A

- N channel
- Logic level
- Enhancement mode
- Temperature sensor with thyristor characteristic
- The drain pin is electrically shorted to the tab



Pin	1	2	3
	G	D	S

Refer to circuit design hints (see chapter Technical Information)

Type	V_{DS}	I_D	$R_{DS(on)}$	Package	Ordering Code
BTS 121A	100 V	22 A	0.1 Ω	TO-220AB	C67078-S5010-A2

Maximum Ratings

Parameter	Symbol	Values	Unit
Drain-source voltage	V_{DS}	100	V
Drain-gate voltage, R_{GS} = 20 kΩ	V_{DGR}	100	
Gate-source voltage	V_{GS}	± 10	
Continuous drain current, T_C = 25 ˚C	I_D	22	A
ISO drain current T_C = 85 ˚C, V_{DS} = 10 V, V_{DS} = 0.5 V	$I_{D\text{-}ISO}$	3.5	
Pulsed drain current, T_C = 25 ˚C	$I_{D\ puls}$	88	
Short circuit current, T_j = – 55 ... + 150 ˚C	I_{SC}	68	
Short circuit dissipation, T_j = – 55 ... + 150 ˚C V_{DS} ≤ 50 V / V_{DS} ≤ 15 V	P_{SCmax}	800 / 1000	W
Power dissipation	P_{tot}	95	
Operating and storage temperature range	T_j, T_{stg}	– 55 ... + 150	˚C
DIN humidity category, DIN 40 040	–	E	–
IEC climatic category, DIN IEC 68-1	–	55/150/56	
Thermal resistance Chip-case Chip-ambient	 $R_{th\ JC}$ $R_{th\ JA}$	 ≤ 1.32 ≤ 75	K/W

Electrical Characteristics
at T_j = 25 °C, unless otherwise specified.

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Static Characteristics					
Drain-source breakdown voltage V_{GS} = 0, I_D = 0.25 mA	$V_{(BR)DSS}$	100	–	–	V
Gate threshold voltage V_{GS} = V_{DS}, I_D = 1 mA	$V_{GS(th)}$	1.5	2.0	2.5	
Zero gate voltage drain current V_{GS} = 0 V, V_{DS} = 100 T_j = 25 °C T_j = 125 °C	I_{DSS}	 – –	 0.1 10	 1.0 100	µA
Gate-source leakage current V_{GS} = ± 20 V, V_{DS} = 0 T_j = 25 °C T_j = 150 °C	I_{GSS}	 – –	 10 2	 100 4	 nA µA
Drain-source on-state resistance V_{GS} = 4.5 V, I_D = 9.5 A	$R_{DS(on)}$	–	0.085	0.1	Ω
Dynamic Characteristics					
Forward transconductance $V_{DS} \geq 2 \times I_D \times R_{DS(on)max}$, I_D = 9.5 A	g_{fs}	8	14	–	S
Input capacitance V_{GS} = 0, V_{DS} = 25 V, f = 1 MHz	C_{iss}	–	1200	1500	pF
Output capacitance V_{GS} = 0, V_{DS} = 25 V, f = 1 MHz	C_{oss}	–	320	580	
Reverse transfer capacitance V_{GS} = 0, V_{DS} = 25 V, f = 1 MHz	C_{rss}	–	160	260	
Turn-on time t_{on}, ($t_{on} = t_{d(on)} + t_r$) V_{CC} = 30 V, V_{GS} = 5 V, I_D = 3 A, R_{GS} = 50 Ω	$t_{d(on)}$	–	25	40	ns
	t_r	–	110	170	
Turn-off time t_{off}, ($t_{off} = t_{d(off)} + t_f$) V_{CC} = 30 V, V_{GS} = 5 V, I_D = 3 A, R_{GS} = 50 Ω	$t_{d(off)}$	–	210	270	
	t_f	–	100	130	

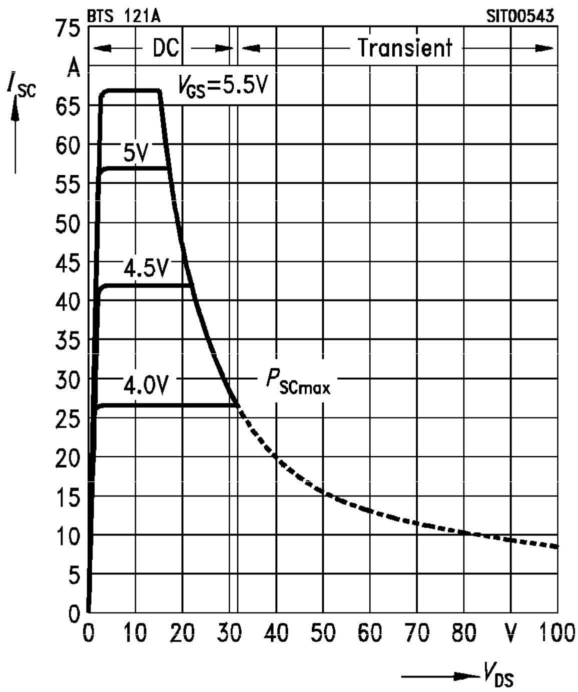
Electrical Characteristics (cont'd)
at T_j = 25 °C, unless otherwise specified.

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Reverse Diode					
Continuous source current	I_S	–	–	19	A
Pulsed source current	I_{SM}	–	–	76	
Diode forward on-voltage I_F = 38 A, V_{GS} = 0	V_{SD}	–	1.35	1.7	V
Reverse recovery time I_F = I_S, di_F/dt = 100 A/µs, V_R = 30 V	t_{rr}	–	150	–	ns
Reverse recovery charge I_F = I_S, di_F/dt = 100 A/µs, V_R = 30 V	Q_{rr}	–	0.58	–	µC
Temperature Sensor					
Forward voltage $I_{TS(on)}$ = 5 mA, T_j = – 55 ... + 150 °C Sensor override, $t_p \leq$ 100 µs T_j = – 55 ... + 160 °C	$V_{TS(on)}$	– –	1.3 –	1.4 10	V
Forward current T_j = – 55 ... + 150 °C Sensor override, $t_p \leq$ 100 µs T_j = – 55 ... + 160 °C	$I_{TS(on)}$	– –	– –	5.0 600	mA
Holding current, $V_{TS(off)}$ = 5 V, T_j = 25 °C T_j = 150 °C	I_H	0.05 0.05	0.1 0.2	0.5 0.3	
Switching temperature V_{TS} = 5 V	$T_{TS(on)}$	150	–	–	°C
Turn-off time V_{TS} = 5 V, $I_{TS(on)}$ = 2 mA	t_{off}	0.5	–	2.5	µs

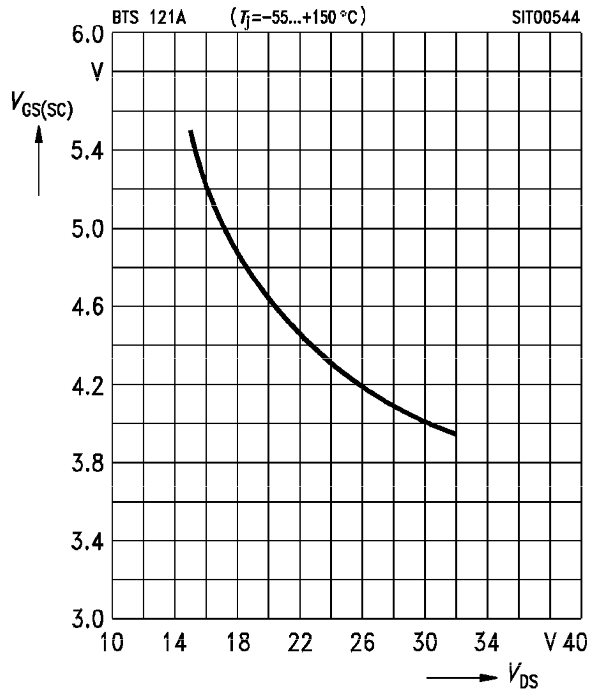
Examples for short-circuit protection
at T_j = – 55 ... + 150 °C, unless otherwise specified.

Parameter	Symbol	Examples			Unit
		1	2	–	
Drain-source voltage	V_{DS}	15	30	–	V
Gate-source voltage	V_{GS}	5.5	4.0	–	
Short-circuit current	I_{SC}	66.7	26.7	–	A
Short-circuit dissipation	P_{SC}	1000	800	–	W
Response time T_j = 25 °C, before short circuit	$t_{SC(off)}$	≤ 25	≤ 25	–	ms

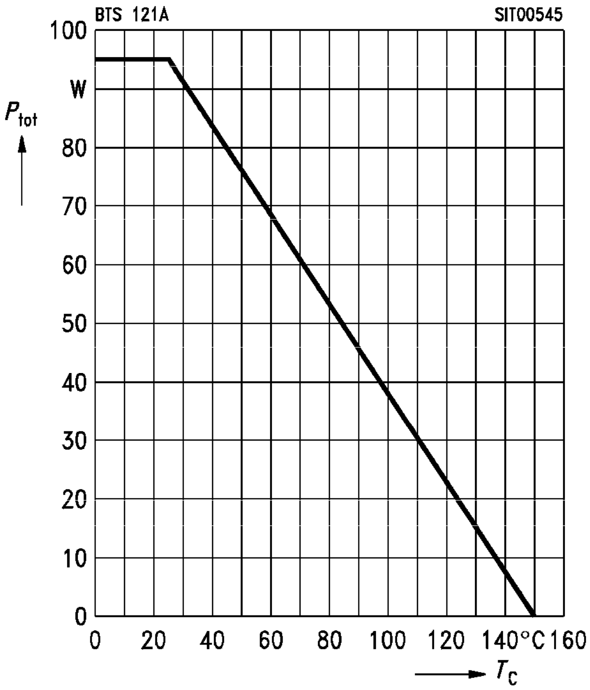
Short-circuit protection $I_{SC} = f(V_{DS})$
Parameter: V_{GS}
Diagram to determine I_{SC} for T_j = –55 ... + 150 °C



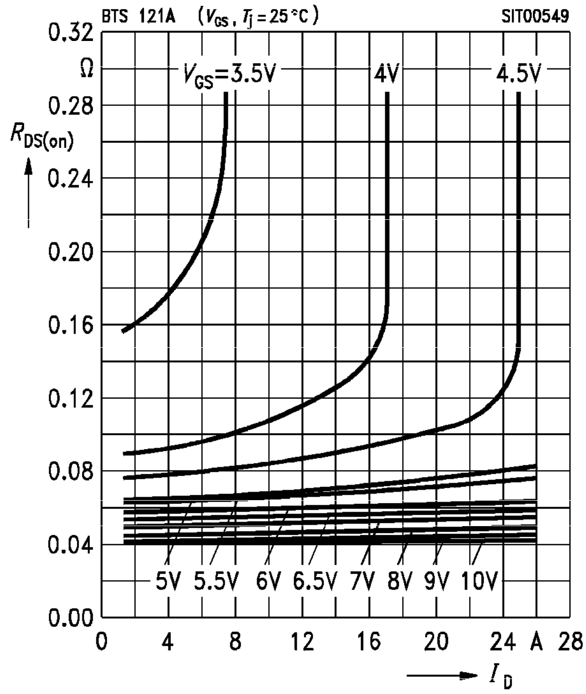
Max. gate voltage $V_{GS(SC)} = f(V_{DS})$
Parameter: T_j = – 55 ... + 150 °C



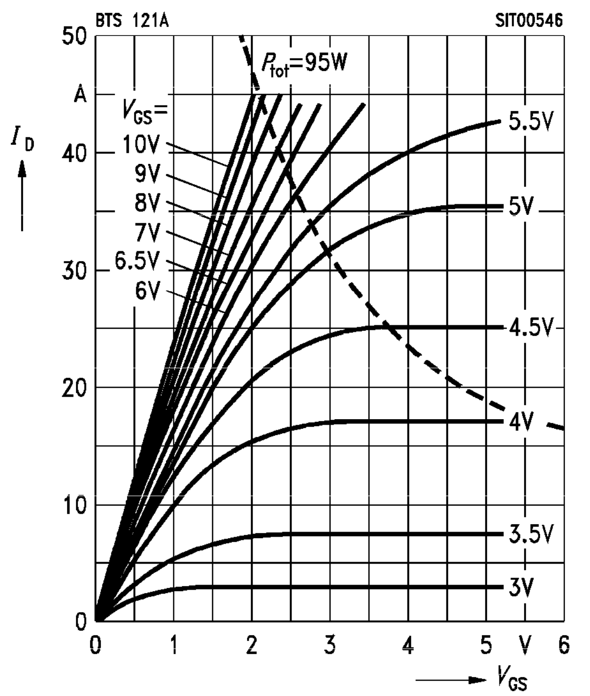
Max. power dissipation $P_{tot} = f(T_C)$



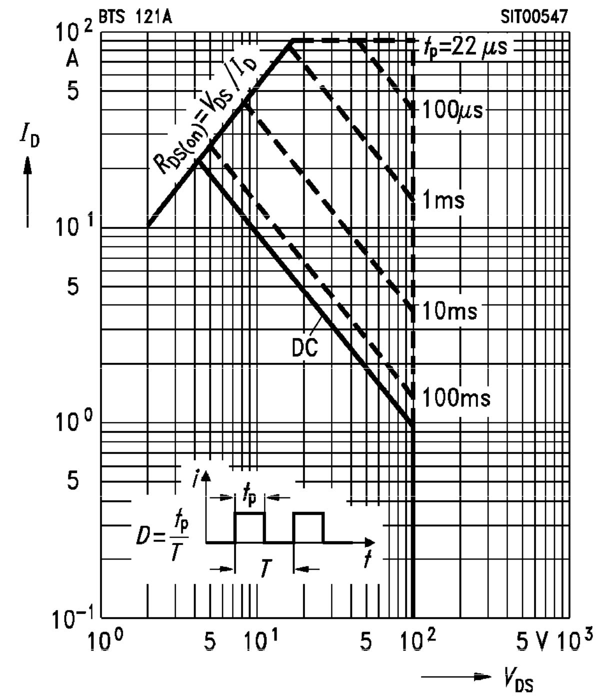
Typ. drain-source on-state resistance
$R_{DS(on)} = f(I_D)$
Parameter: V_{GS}



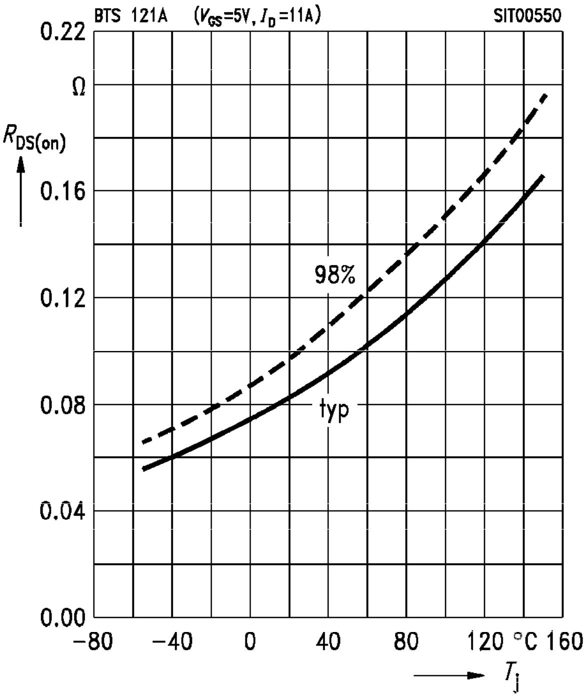
Typical output characteristics $I_D = f(V_{DS})$
Parameter: t_p = 80 µs



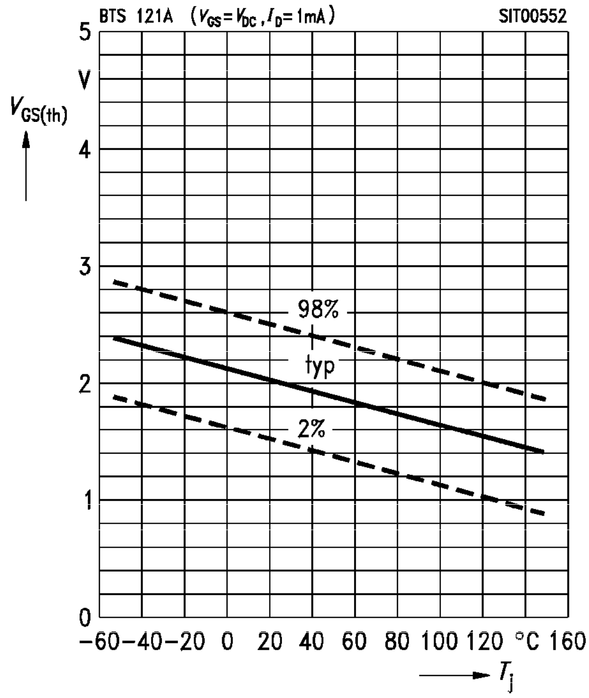
Safe operating area $I_D = f(V_{DS})$
Parameter: D = 0.01, T_C = 25 °C



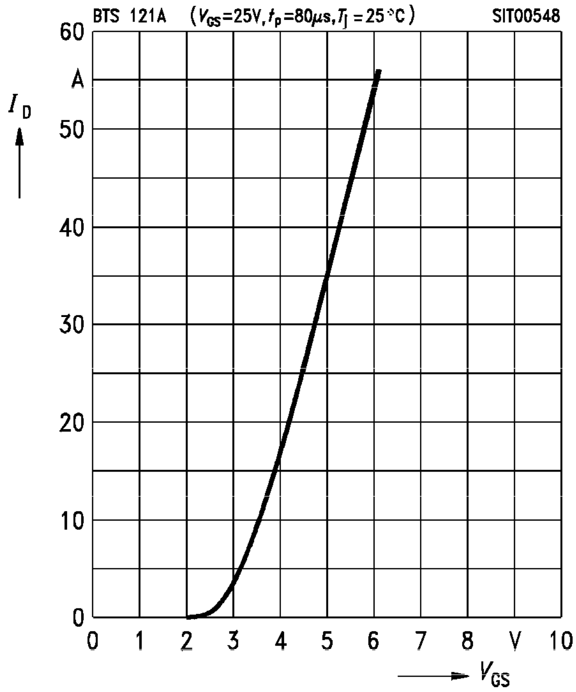
Drain-source on-state resistance
$R_{DS(on)} = f(T_j)$
Parameter: I_D = 4.5 A, V_{GS} = 9.5 V



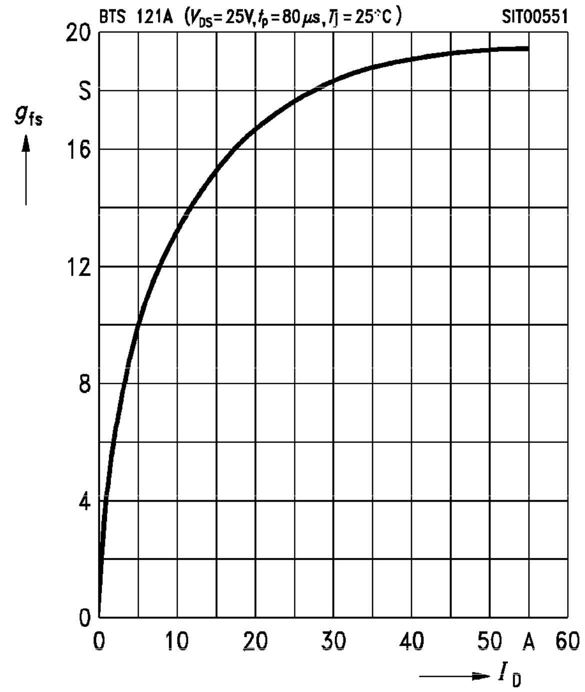
Gate threshold voltage $V_{GS(th)} = f(T_j)$
Parameter: V_{DS} = V_{GS}, I_D = 1 mA (spread)



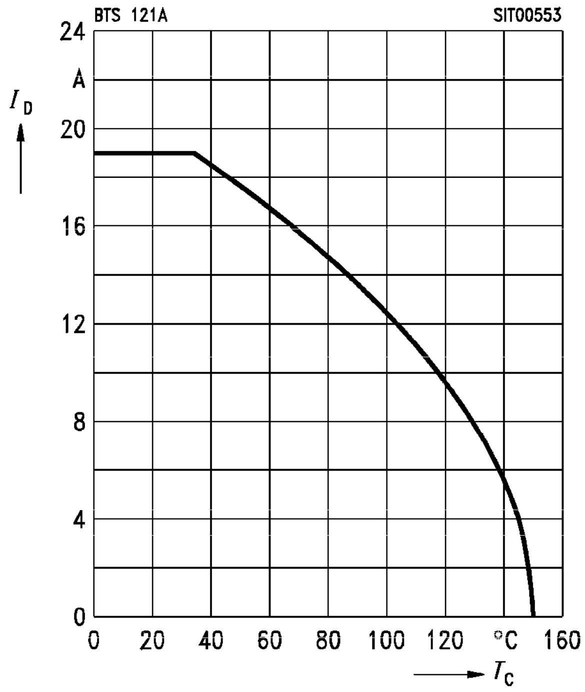
Typ. transfer characteristic
$I_D = f(V_{GS})$
Parameter: t_p = 80 µs, V_{DS} = 25 V



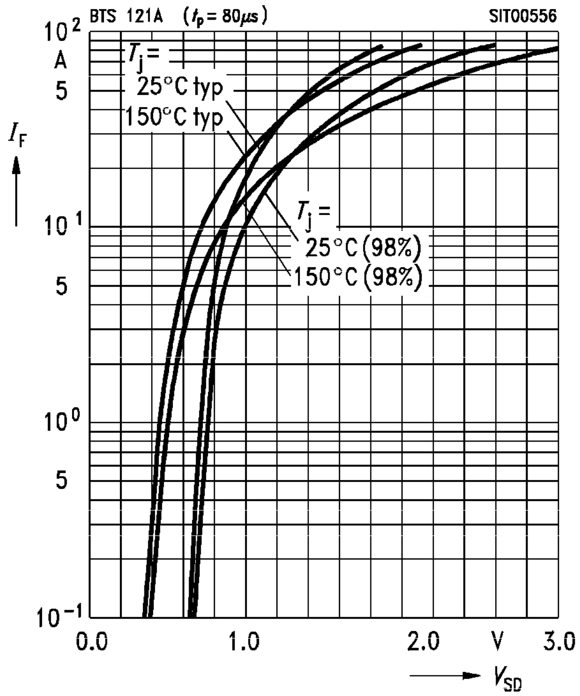
Typ. transconductance $g_{fs} = f(I_D)$
Parameter: t_p = 80 µs, V_{DS} = 25 V



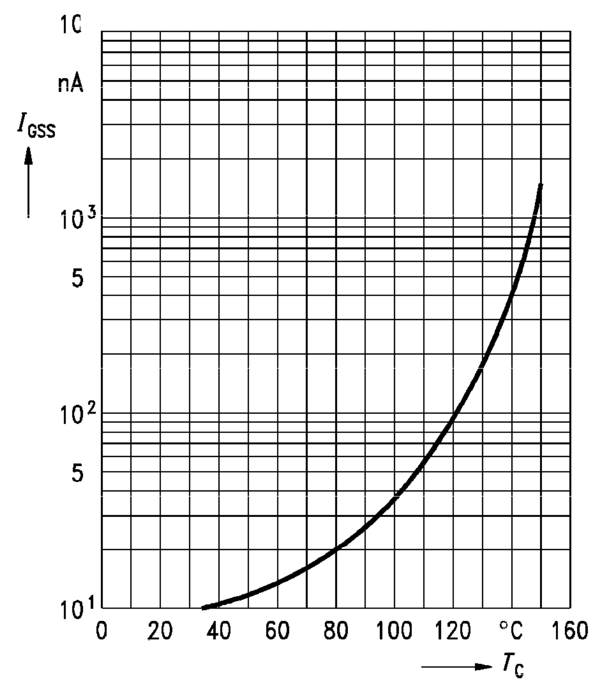
Continous drain current $I_D = f(T_C)$
Parameter: $V_{GS} \geq 10$ V



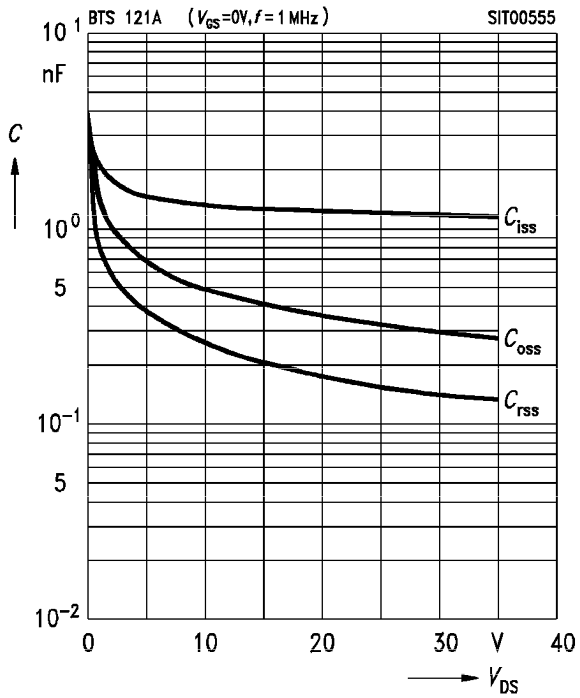
Forward characteristics of reverse diode
$I_F = f(V_{SD})$
Parameter: T_j, t_p = 80 µs (spread)



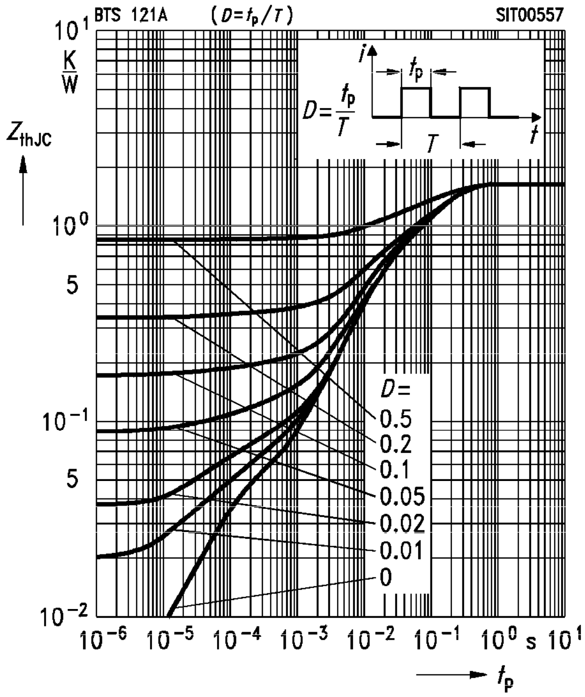
Typ. gate-source leakage current
$I_{GSS} = f(T_C)$
Parameter: V_{GS} = 20 V, V_{DS} = 0



Typ. capacitances $C = f(V_{DS})$
Parameter: $V_{GS} = 0, f = 1$ MHz

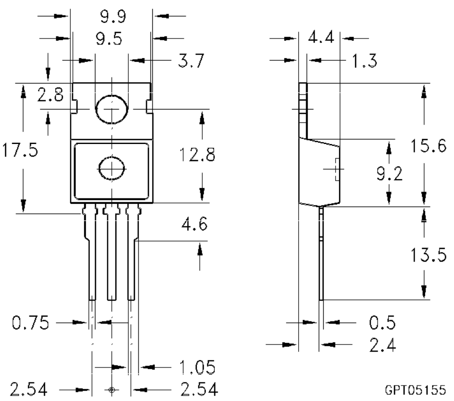


Transient thermal impedance $Z_{thJC} = f(t_p)$
Parameter: $D = t_p/T$



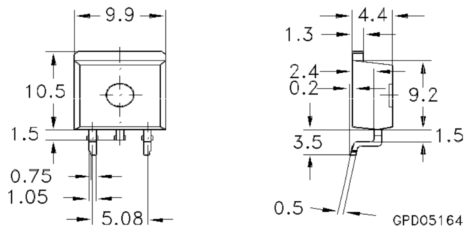
TO 220 AB Standard

Ordering Code C67078-S5010-A2



TO 220 AB SMD Version E 3045

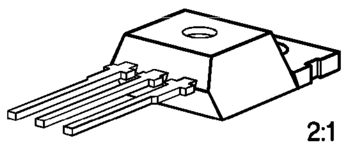
Ordering Code C67078-S5010-A5



SIEMENS

TEMPFET® **BTS 130**

- N channel
- Enhancement mode
- Temperature sensor with thyristor characteristic
- The drain pin is electrically shorted to the tab



Pin	1	2	3
	G	D	S

Refer to circuit design hints (see chapter Technical Information)

Type	V_{DS}	I_D	$R_{DS(on)}$	Package	Ordering Code
BTS 130	50 V	27 A	0.05 Ω	TO-220AB	C67078-A5001-A3

Maximum Ratings

Parameter	Symbol	Values	Unit
Drain-source voltage	V_{DS}	50	V
Drain-gate voltage, R_{GS} = 20 kΩ	V_{DGR}	50	
Gate-source peak voltage, aperiodic	V_{gs}	± 20	
Continuous drain current, T_C = 25 ˚C	I_D	27	A
ISO drain current T_C = 85 ˚C, V_{GS} = 10 V, V_{DS} = 0.5 V	$I_{D\text{-}ISO}$	7.5	
Pulsed drain current, T_C = 25 ˚C	$I_{D\ puls}$	108	
Short circuit current, T_j = – 55 ... + 150 ˚C	I_{SC}	80	
Short circuit dissipation, T_j = – 55 ... + 150 ˚C	P_{SCmax}	1200	W
Power dissipation	P_{tot}	75	
Operating and storage temperature range	T_j, T_{stg}	– 55 ... + 150	˚C
DIN humidity category, DIN 40 040	–	E	–
IEC climatic category, DIN IEC 68-1	–	55/150/56	
Thermal resistance Chip-case Chip-ambient	 $R_{th\ JC}$ $R_{th\ JA}$	 ≤ 1.67 ≤ 75	K/W

Electrical Characteristics
at T_j = 25 °C, unless otherwise specified.

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Static Characteristics					
Drain-source breakdown voltage V_{GS} = 0, I_D = 0.25 mA	$V_{(BR)DSS}$	50	–	–	V
Gate threshold voltage V_{GS} = V_{DS}, I_D = 1 mA	$V_{GS(th)}$	2.5	3.0	3.5	
Zero gate voltage drain current V_{GS} = 0 V, V_{DS} = 50 V	I_{DSS}				µA
T_j = 25 °C		–	1	10	
T_j = 125 °C		–	100	300	
Gate-source leakage current V_{GS} = 20 V, V_{DS} = 0	I_{GSS}				
T_j = 25 °C		–	10	100	nA
T_j = 150 °C		–	2	4	µA
Drain-source on-state resistance V_{GS} = 10 V, I_D =17 A	$R_{DS(on)}$	–	0.04	0.05	Ω
Dynamic Characteristics					
Forward transconductance $V_{DS} \geq 2 \times I_D \times R_{DS(on)max}$, I_D = 17 A	g_{fs}	8.0	13.0	18.0	S
Input capacitance V_{GS} = 0, V_{DS} = 25 V, f = 1 MHz	C_{iss}	700	940	1250	pF
Output capacitance V_{GS} = 0, V_{DS} = 25 V, f = 1 MHz	C_{oss}	–	500	750	
Reverse transfer capacitance V_{GS} = 0, V_{DS} = 25 V, f = 1 MHz	C_{rss}	–	180	270	
Turn-on time t_{on}, ($t_{on} = t_{d(on)} + t_r$) V_{CC} = 30 V, V_{GS} = 10 V, I_D = 3 A, R_{GS} = 50 Ω	$t_{d(on)}$	–	25	40	ns
	t_r	–	60	90	
Turn-off time t_{off}, ($t_{off} = t_{d(off)} + t_f$) V_{CC} = 30 V, V_{GS} = 10 V, I_D = 3 A, R_{GS} = 50 Ω	$t_{d(off)}$	–	100	130	
	t_f	–	75	95	

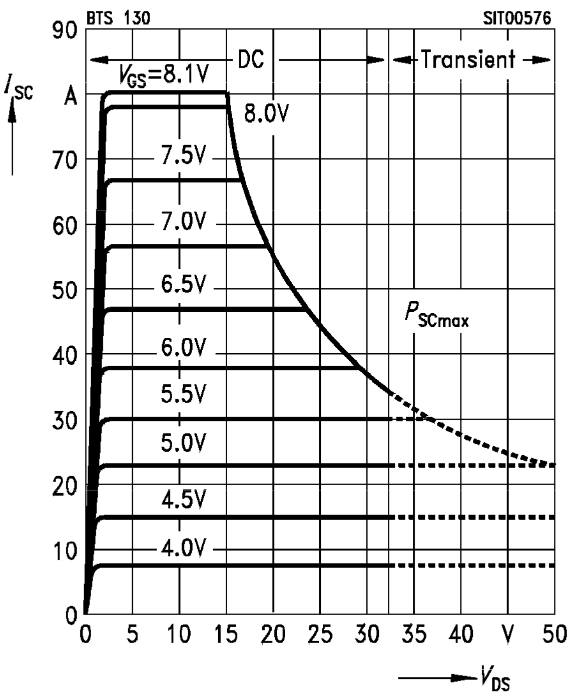
Electrical Characteristics (cont'd)
at T_j = 25 ˚C, unless otherwise specified.

Parameter	Symbol	Values			Unit
		min.	typ.	max.	
Reverse Diode					
Continous source current	I_S	–	–	27	A
Pulsed source current	I_{SM}	–	–	108	
Diode forward on-voltage I_F = 54 A, V_{GS} = 0	V_{SD}	–	1.5	2.0	V
Reverse recovery time I_F = I_S, di_F/dt = 100 A/µs, V_R = 30 V	t_{rr}	–	150	–	ns
Reverse recovery charge I_F = I_S, di_F/dt = 100 A/µs, V_R = 30 V	Q_{rr}	–	1.0	–	µC
Temperature Sensor					
Forward voltage $I_{TS(on)}$ = 10 mA, T_j = – 55 ... + 150 ˚C Sensor override, t_p ≤ 100 µs T_j = – 55 ... + 160 ˚C	$V_{TS(on)}$	– –	1.4 –	1.5 10	V
Forward current T_j = – 55 ... + 150 ˚C Sensor override, t_p ≤ 100 µs T_j = – 55 ... + 160 ˚C	$I_{TS(on)}$	– –	– –	10 600	mA
Holding current, $V_{TS(off)}$ = 5 V, T_j = 25 ˚C T_j = 150 ˚C	I_H	0.05 0.05	0.1 0.2	0.5 0.3	
Switching temperature V_{TS} = 5 V	$T_{TS(on)}$	150	–	–	˚C
Turn-off time V_{TS} = 5 V, $I_{TS(on)}$ = 2 mA	t_{off}	0.5	–	2.5	µs

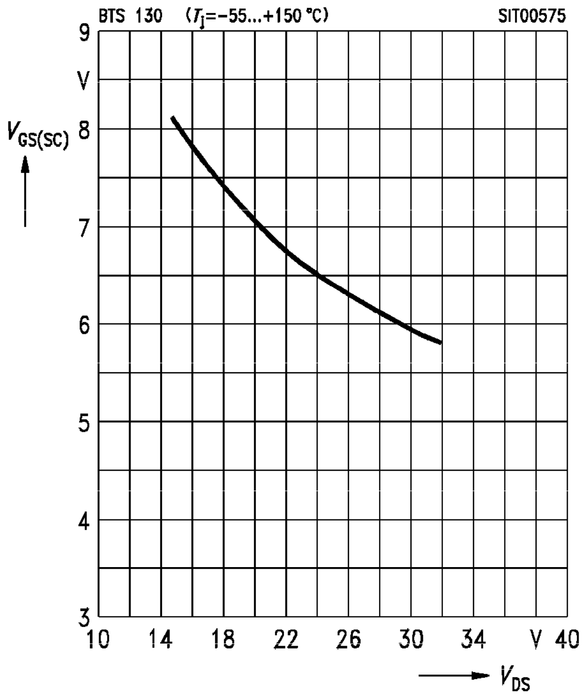
Examples for short-circuit protection
at T_j = – 55 ... + 150 °C, unless otherwise specified.

Parameter	Symbol	Examples			Unit
		1	2	–	
Drain-source voltage	V_{DS}	15	30	–	V
Gate-source voltage	V_{GS}	8.1	5.9	–	
Short-circuit current	I_{SC}	≤ 80	≤ 37	–	A
Short-circuit dissipation	P_{SC}	1200	1100	–	W
Response time T_j = 25 °C, before short circuit	$t_{SC(off)}$	25	25	–	ms

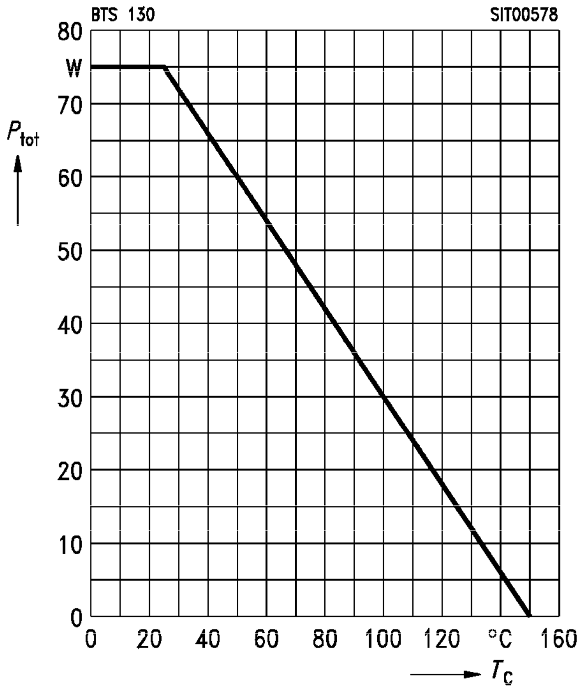
Short-circuit protection $I_{SC} = f(V_{DS})$
Parameter: V_{GS}
Diagram to determine I_{SC} for T_j = –55 ... + 150 °C



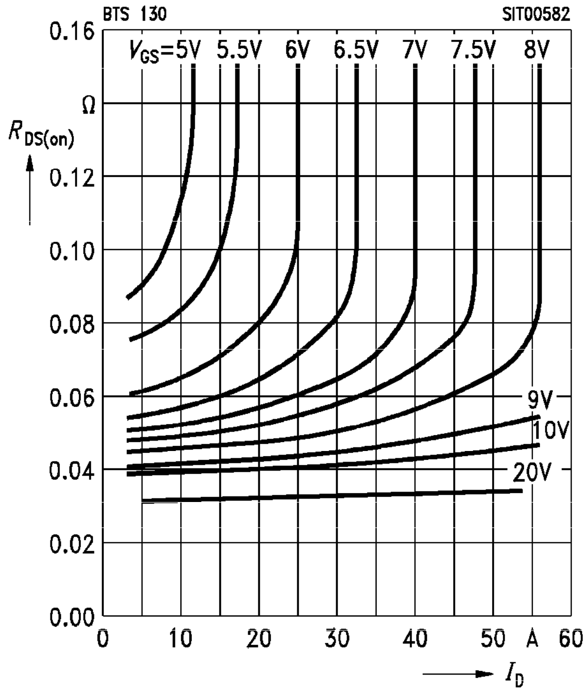
Max. gate voltage $V_{GS(SC)} = f(V_{DS})$
Parameter: T_j = – 55 ... + 150 °C



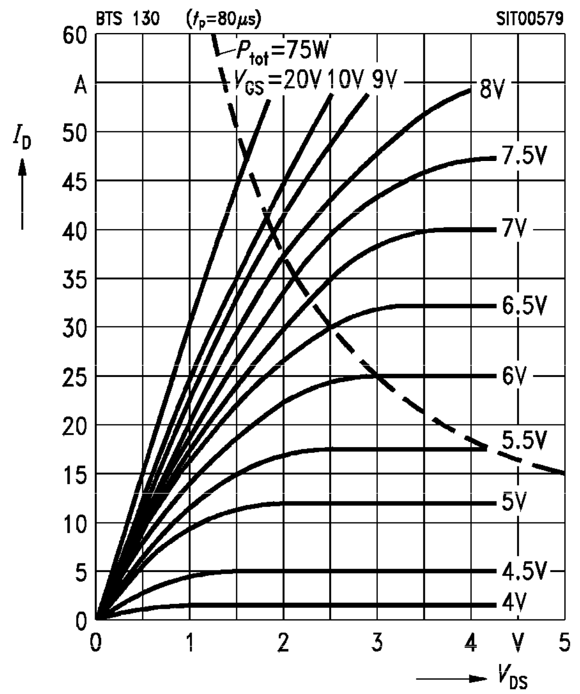
Max. power dissipation $P_{tot} = f(T_C)$



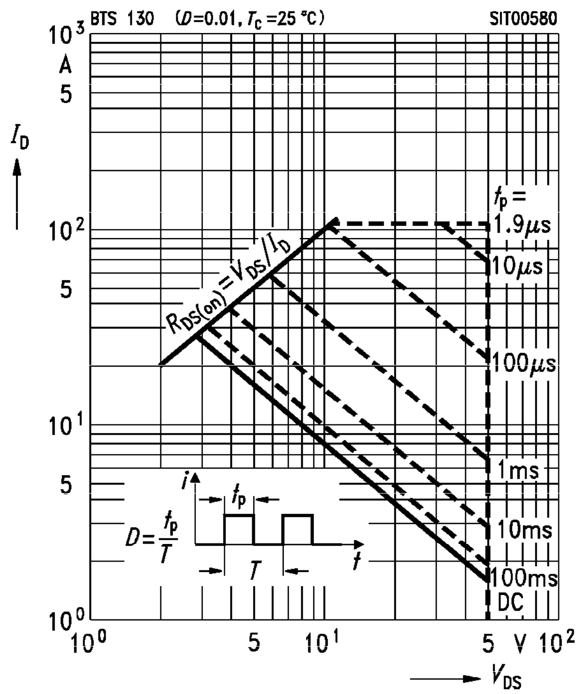
Typ. drain-source on-state resistance
$R_{DS(on)} = f(I_D)$
Parameter: V_{GS}



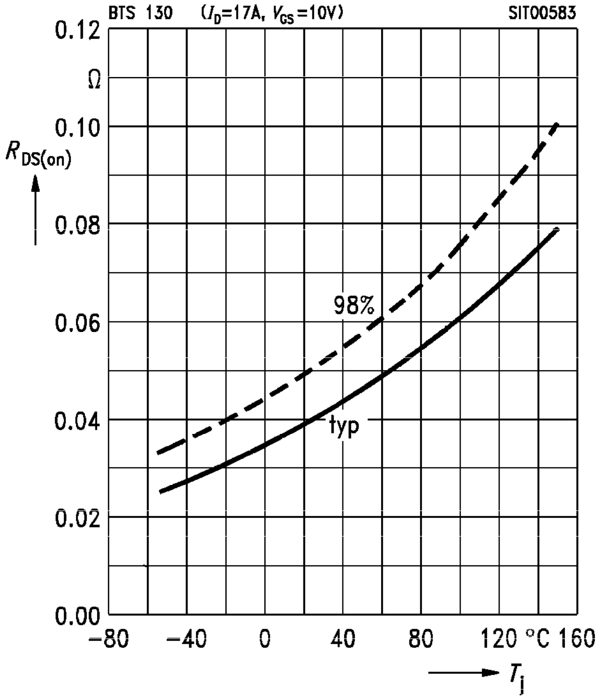
Typical output characteristics $I_D = f(V_{DS})$
Parameter: t_p = 80 µs



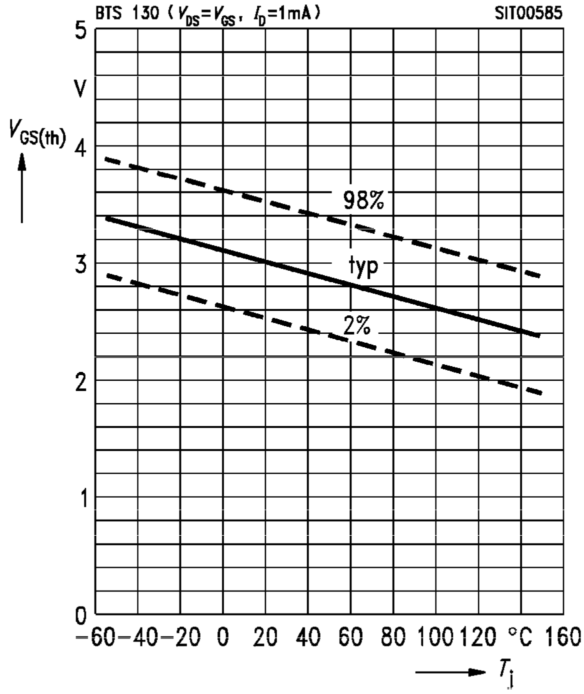
Safe operating area $I_D = f(V_{DS})$
Parameter: D = 0.01, T_C = 25 °C



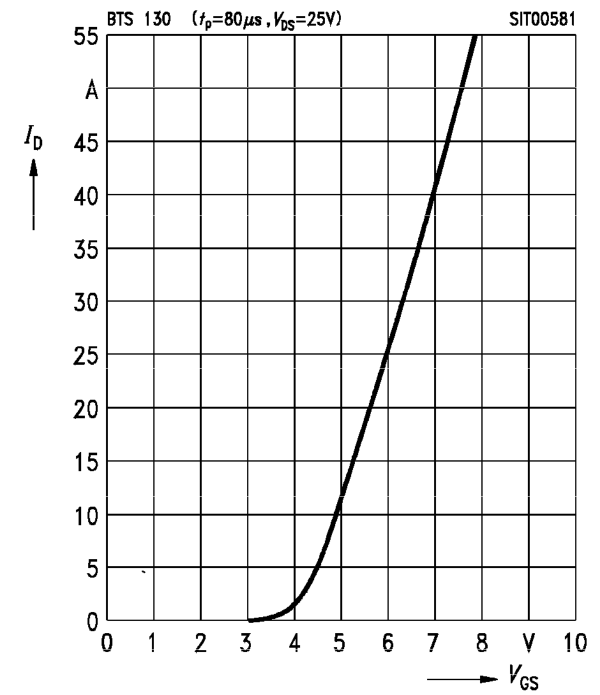
Drain-source on-state resistance
$R_{DS(on)} = f(T_j)$
Parameter: I_D = 17 A, V_{GS} = 10 V (spread)



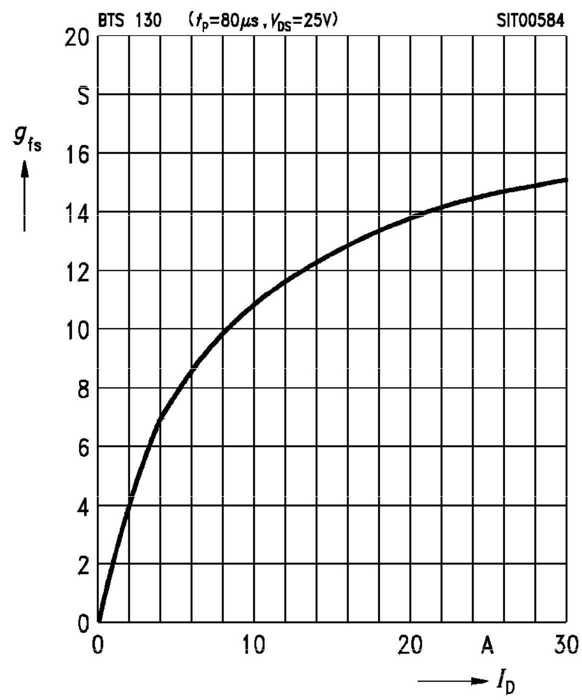
Gate threshold voltage $V_{GS(th)} = f(T_j)$
Parameter: V_{DS} = V_{GS}, I_D = 1 mA



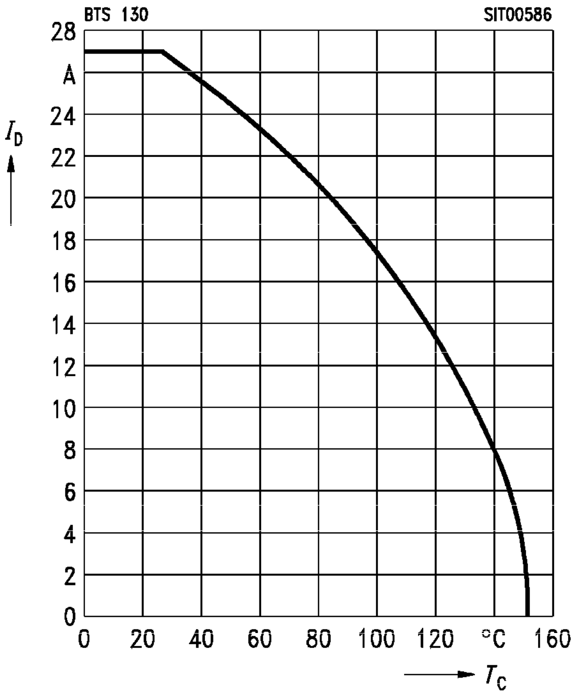
Typ. transfer characteristic
$I_D = f(V_{GS})$
Parameter: t_p = 80 µs, V_{DS} = 25 V



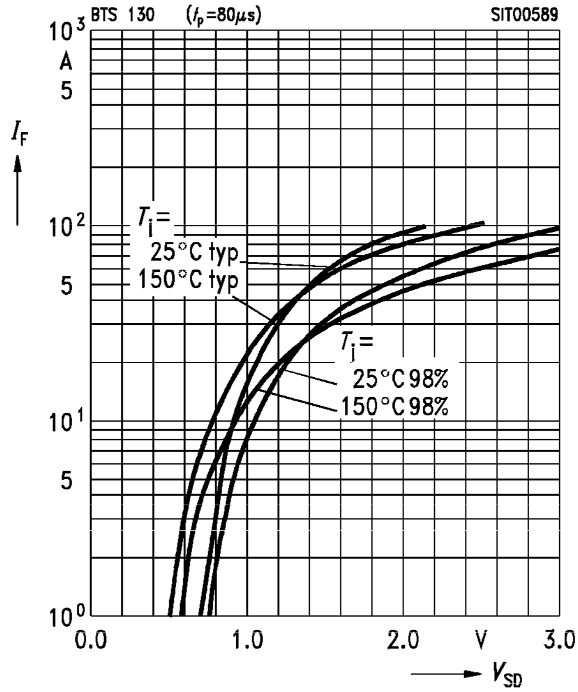
Typ. transconductance $g_{fs} = f(I_D)$
Parameter: t_p = 80 µs, V_{DS} = 25 V



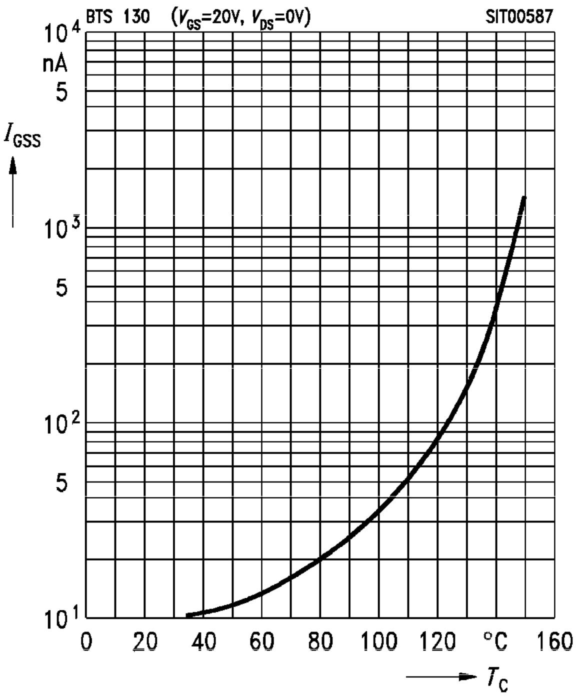
Continous drain current $I_D = f(T_C)$
Parameter: $V_{GS} \geq 10$ V



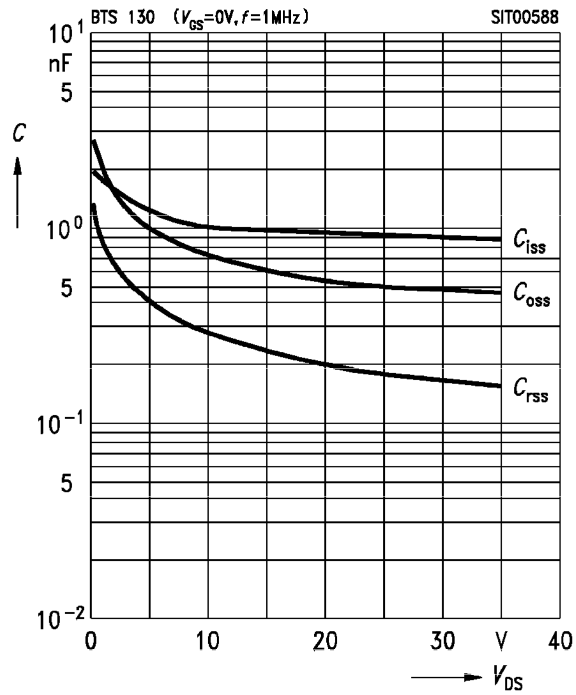
Forward characteristics of reverse diode
$I_F = f(V_{SD})$
Parameter: T_j, t_p = 80 µs (spread)



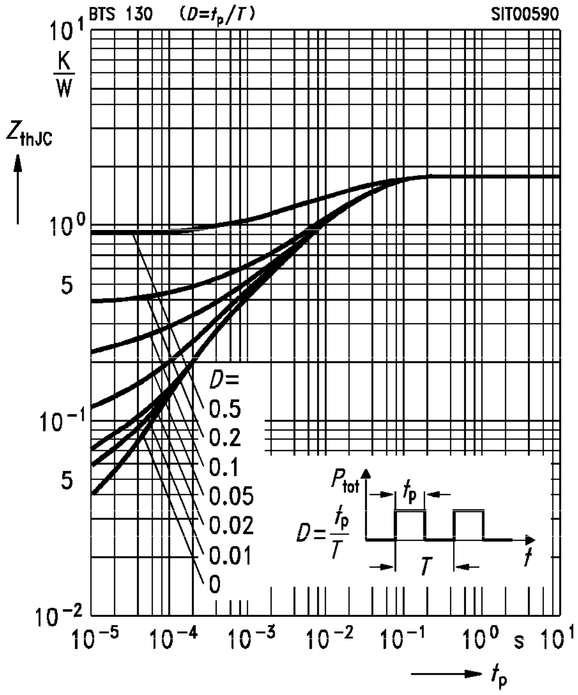
Typ. gate-source leakage current
$I_{GSS} = f(T_C)$
Parameter: V_{GS} = 20 V, V_{DS} = 0



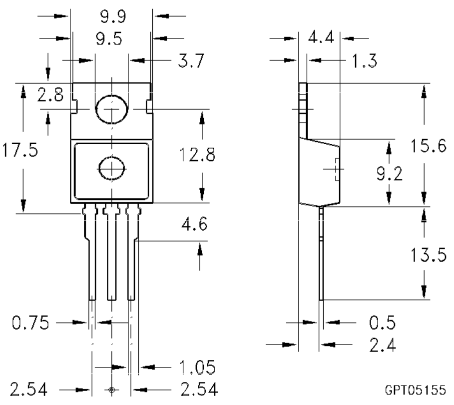
Typ. capacitances $C = f(V_{DS})$
Parameter: V_{GS} = 0, f = 1 MHz



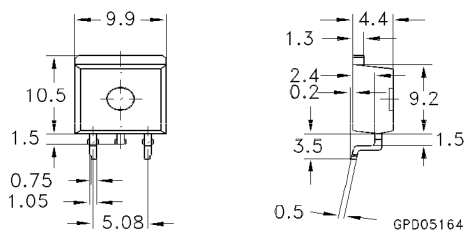
Transient thermal impedance $Z_{thJC} = f\,(t_p)$
Parameter: $D = t_p/T$



TO 220 AB	**Ordering Code**
Standard	C67078-A5001-A3



TO 220 AB	**Ordering Code**
SMD version E3045	C67078-A5001-A9



Smart Highside Power Switch

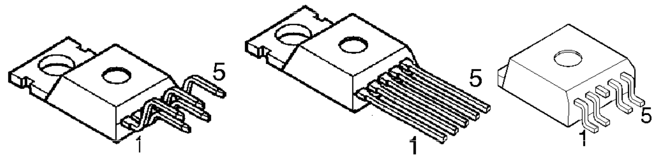
Features

- Overload protection
- Current limitation
- Short circuit protection
- Thermal shutdown
- Overvoltage protection (including load dump)
- Fast demagnetization of inductive loads
- Reverse battery protection[1)]
- Undervoltage and overvoltage shutdown with auto-restart and hysteresis
- Open drain diagnostic output
- Open load detection in ON-state
- CMOS compatible input
- Loss of ground and loss of V_{bb} protection
- **E**lectro**st**atic **d**ischarge (**ESD**) protection

Product Summary

Overvoltage protection	$V_{bb(AZ)}$	65	V
Operating voltage	$V_{bb(on)}$	4.7 ... 42	V
On-state resistance	R_{ON}	220	mΩ
Load current (ISO)	$I_{L(ISO)}$	1.8	A
Current limitation	$I_{L(SCr)}$	2.7	A

TO-220AB/5



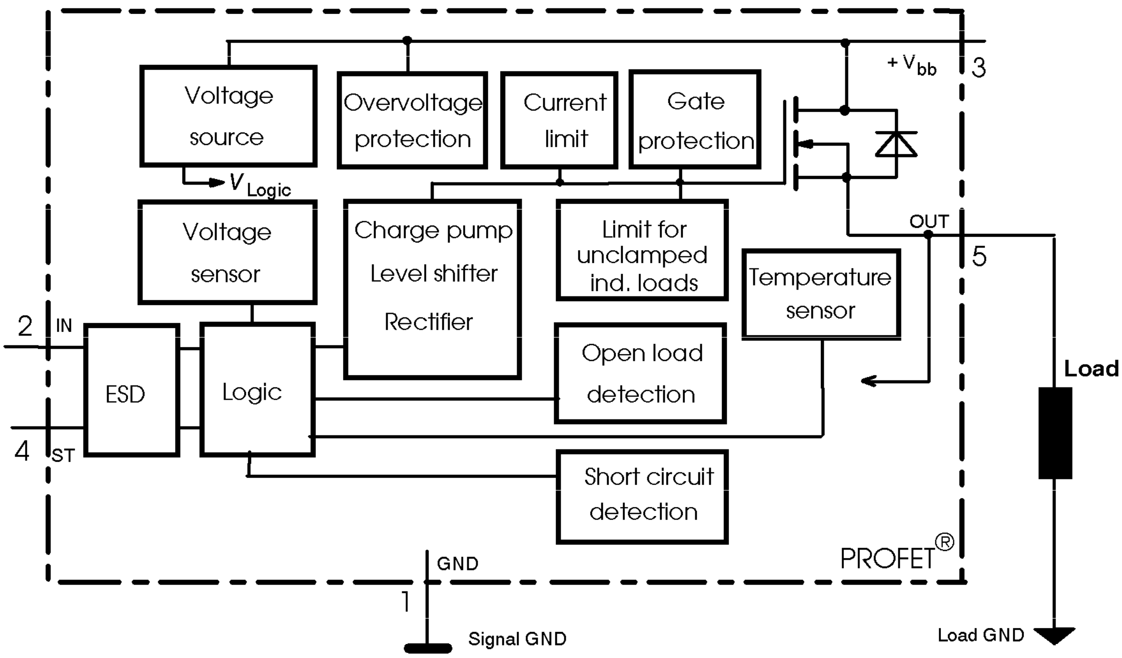
Standard Straight leads SMD

Application

- µC compatible power switch with diagnostic feedback for 12 V and 24 V DC grounded loads
- Most suitable for inductive loads
- Replaces electromechanical relays and discrete circuits

General Description

N channel vertical power FET with charge pump, ground referenced CMOS compatible input and diagnostic feedback, monolithically integrated in Smart SIPMOS® technology. Fully protected by embedded protection functions.



1) With external current limit (e.g. resistor R_{GND}=150 Ω) in GND connection, resistors in series with IN and ST connections, reverse load current limited by connected load.

Pin	Symbol		Function
1	GND	-	Logic ground
2	IN	I	Input, activates the power switch in case of logical high signal
3	Vbb	+	Positive power supply voltage, the tab is shorted to this pin
4	ST	S	Diagnostic feedback, low on failure
5	OUT (Load, L)	O	Output to the load

Maximum Ratings at T_j = 25 °C unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage (overvoltage protection see page 3)	V_{bb}	65	V
Load dump protection[2] $V_{LoadDump} = U_A + V_s$, U_A = 13.5 V R_I[3]= 2 Ω, R_L= 6.6 Ω, t_d= 400 ms, IN= low or high	$V_{Load\ dump}$[4]	100	V
Load current (Short circuit current, see page 4)	I_L	self-limited	A
Operating temperature range Storage temperature range	T_j T_{stg}	-40 ...+150 -55 ...+150	°C
Power dissipation (DC), $T_C \leq$ 25 °C	P_{tot}	50	W
Inductive load switch-off energy dissipation, single pulse T_j=150 °C:	E_{AS}	tbd	J
Electrostatic discharge capability (ESD) (Human Body Model)	V_{ESD}	1	kV
Input voltage (DC) Current through input pin (DC) Current through status pin (DC) see internal circuit diagrams page 6	V_{IN} I_{IN} I_{ST}	-0.5 ... +6 ±5.0 ±5.0	V mA

Thermal resistance chip - case: junction - ambient (free air): SMD version, device on PCB[5]:	R_{thJC} R_{thJA}	≤ 2.5 ≤ 75 ≤ tbd	K/W

2) Supply voltages higher than $V_{bb(AZ)}$ require an external current limit for the GND and status pins, e.g. with a 150 Ω resistor in the GND connection and a 15 kΩ resistor in series with the status pin. A resistor for the protection of the input is integrated.

3) R_I = internal resistance of the load dump test pulse generator

4) $V_{Load\ dump}$ is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839

5) Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm^2 (one layer, 70µm thick) copper area for V_{bb} connection. PCB is vertical without blown air.

Electrical Characteristics

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Load Switching Capabilities and Characteristics					
On-state resistance (pin 3 to 5) I_L = 1.6 A T_j=25 °C:	R_{ON}	--	190	220	mΩ
T_j=150 °C:			390	440	
Nominal load current (pin 3 to 5) ISO Proposal: V_{ON} = 0.5 V, T_C = 85 °C	$I_{L(ISO)}$	1.6	1.8	--	A
Output current (pin 5) while GND disconnected or GND pulled up, V_{bb}=30 V, V_{IN}= 0, see diagram page 7, T_j =-40...+150°C	$I_{L(GNDhigh)}$	--	--	10	mA
Turn-on time to 90% V_{OUT}:	t_{on}	12	--	125	µs
Turn-off time to 10% V_{OUT}: R_L = 12 Ω, T_j =-40...+150°C	t_{off}	5	--	85	
Slew rate on 10 to 30% V_{OUT}, R_L = 12 Ω, T_j =-40...+150°C	dV/dt_{on}	--	--	3	V/µs
Slew rate off 70 to 40% V_{OUT}, R_L = 12 Ω, T_j =-40...+150°C	$-dV/dt_{off}$	--	--	6	V/µs
Operating Parameters					
Operating voltage [6)] T_j =-40...+150°C:	$V_{bb(on)}$	4.7	--	42	V
Undervoltage shutdown T_j =25°C:	$V_{bb(under)}$	2.9	--	4.5	V
T_j =-40...+150°C:		2.7	--	4.7	
Undervoltage restart T_j =-40...+150°C:	$V_{bb(u\ rst)}$	--	--	4.9	V
Undervoltage restart of charge pump see diagram page 12	$V_{bb(ucp)}$	--	5.6	6.0	V
Undervoltage hysteresis $\Delta V_{bb(under)} = V_{bb(u\ rst)} - V_{bb(under)}$	$\Delta V_{bb(under)}$	--	0.1	--	V
Overvoltage shutdown T_j =-40...+150°C:	$V_{bb(over)}$	42	--	52	V
Overvoltage restart T_j =-40...+150°C:	$V_{bb(o\ rst)}$	40	--	--	V
Overvoltage hysteresis T_j =-40...+150°C:	$\Delta V_{bb(over)}$	--	0.1	--	V
Overvoltage protection[7)] T_j =-40...+150°C: I_{bb}=4 mA	$V_{bb(AZ)}$	65	70	--	V
Standby current (pin 3) V_{IN}=0 T_j=-40...+25°C:	$I_{bb(off)}$	--	10	15	µA
T_j= 150°C:		--	18	25	
Leakage output current (included in $I_{bb(off)}$) V_{IN}=0	$I_{L(off)}$	--	--	20	µA

6) At supply voltage increase up to V_{bb}= 5.6 V typ without charge pump, $V_{OUT} \approx V_{bb}$ - 2 V

7) Meassured without load. See also $V_{ON(CL)}$ in table of protection functions and circuit diagram page 7.

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Operating current (Pin 1)[8], V_{IN}=5 V, T_j =-40...+150°C	I_{GND}	--	1	2.1	mA

Protection Functions

Initial peak short circuit current limit (pin 3 to 5)[9], (max 450 µs if V_{ON} > $V_{ON(SC)}$)	$I_{L(SCp)}$				
T_j =-40°C:		4.0	--	11	A
T_j =25°C:		3.5	5.5	10	
T_j =+150°C:		2.0	3.5	7.5	
Overload shutdown current limit V_{ON}= 8 V, T_j = T_{jt} (see timing diagrams, page 10)	$I_{L(SCr)}$	--	2.7	--	A
Short circuit shutdown delay after input pos. slope V_{ON} > $V_{ON(SC)}$, T_j =-40..+150°C: min value valid only, if input "low" time exceeds 60 µs	$t_{d(SC)}$	--	--	450	µs
Output clamp (inductive load switch off) at V_{OUT} = V_{bb} - $V_{ON(CL)}$ I_L= 40 mA, T_j =-40..+150°C:	$V_{ON(CL)}$	61	68	73	V
I_L= 1 A, T_j =-40..+150°C:		--	--	75	
Short circuit shutdown detection voltage (pin 3 to 5)	$V_{ON(SC)}$	--	8.5	--	V
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Thermal hysteresis	ΔT_{jt}	--	10	--	K
Inductive load switch-off energy dissipation[10],	E_{AS}	--	--	tbd	J
$T_{j\,Start}$ = 150 °C, single pulse V_{bb} = 12 V:	E_{Load12}			tbd	
V_{bb} = 24 V:	E_{Load24}			tbd	
Reverse battery (pin 3 to 1) [11]	$-V_{bb}$	--	--	32	V

Diagnostic Characteristics

Open load detection current (on-condition) T_j=-40 ..150°C:	$I_{L\,(OL)}$	2	--	150	mA

8) Add I_{ST}, if I_{ST} > 0, add I_{IN}, if V_{IN}>5.5 V

9) Short circuit current limit for max. duration of $t_{d(SC)\,max}$=450 µs, prior to shutdown

10) While demagnetizing load inductance, dissipated energy in PROFET is $E_{AS}= \int V_{ON(CL)} * i_L(t)\,dt$, approx.

$$E_{AS}= {}^1/_2 * L * I_L^2 * \left(\frac{V_{ON(CL)}}{V_{ON(CL)} - V_{bb}}\right)$$, see diagram page 8

11) Requires 150 Ω resistor in GND connection. Reverse load current (through intrinsic drain-source diode) is normally limited by the connected load. Input and Status currents have to be limited (see max. ratings page 2 and circuit page 7).

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Input and Status Feedback[12]					
Input turn-on threshold voltage T_j =-40..+150°C:	$V_{IN(T+)}$	1.5	--	2.4	V
Input turn-off threshold voltage T_j =-40..+150°C:	$V_{IN(T-)}$	1.0	--	--	V
Input threshold hysteresis	$\Delta V_{IN(T)}$	--	0.5	--	V
Off state input current (pin 2), V_{IN} = 0.4 V	$I_{IN(off)}$	1	--	30	µA
On state input current (pin 2), V_{IN} = 5 V	$I_{IN(on)}$	10	25	70	µA
Status invalid after positive input slope (short circuit) T_j=-40 ... +150°C:	$t_{d(ST\ SC)}$	--	--	450	µs
Status invalid after positive input slope (open load) T_j=-40 ... +150°C:	$t_{d(ST)}$	300	--	1400	µs
Status output (open drain)					
Zener limit voltage T_j =-40...+150°C, I_{ST} = +50 uA:	$V_{ST(high)}$	5.0	6	--	V
ST low voltage T_j =-40...+150°C, I_{ST} = +1.6 mA:	$V_{ST(low)}$	--	--	0.4	

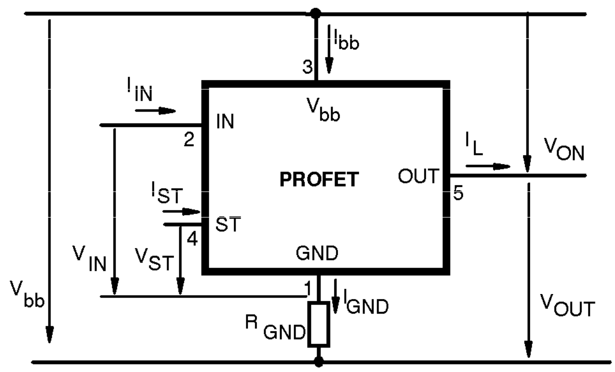
[12] If a ground resistor R_{GND} is used, add the voltage drop across this resistor.

Truth Table

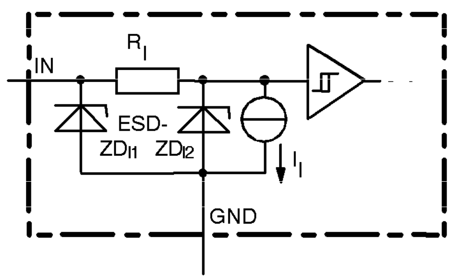
	Input-level	Output level	Status 412 B2	410 D2	**410** E2/**F2**	410 G2	410 H2
Normal operation	**L** **H**	**L** **H**	H H	H H	**H** **H**	H H	H H
Open load	**L** **H**	13) **H**	L H	H L	**H** **L**	H L	L H
Short circuit to GND	**L** **H**	**L** **L**	H L	H L	**H** **L**	H H	H L
Short circuit to V_{bb}	**L** **H**	**H** **H**	L H	H H (L[14])	**H** **H (L[14])**	H H (L[14])	L H
Overtemperature	**L** **H**	**L** **L**	L L	L L	**L** **L**	L L	L L
Undervoltage	**L** **H**	**L** **L**	L[15] L[15]	L[15] L[15]	**H** **H**	H H	H H
Overvoltage	**L** **H**	**L** **L**	L L	L L	**H** **H**	H H	H H

L = "Low" Level
H = "High" Level

Terms



Input circuit (ESD protection)



ZDI1 6 V typ., ESD zener diodes are not to be used as voltage clamp at DC conditions. Operation in this mode may result in a drift of the zener voltage (increase of up to 1 V).

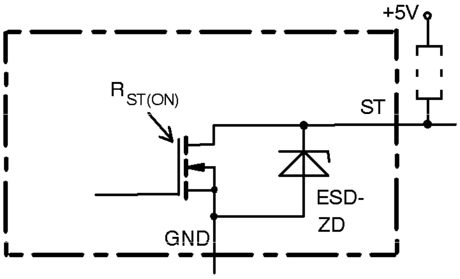
---

13) Power Transistor off, high impedance, versions BTS 410H, BTS 412B: internal pull up current source for open load detection.

14) Low resistance short V_{bb} to output may be detected by no-load-detection

15) No current sink capability during undervoltage shutdown

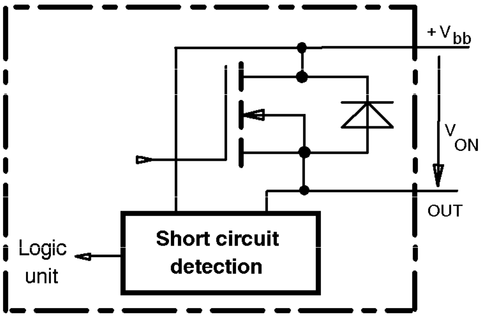
Status output



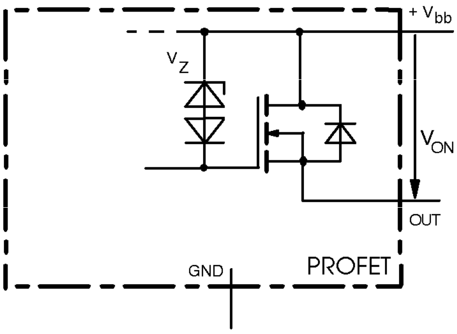
ESD-Zener diode: 6 V typ., max 5 mA;
$R_{ST(ON)}$ < 250 Ω at 1.6 mA, ESD zener diodes are not to be used as voltage clamp at DC conditions. Operation in this mode may result in a drift of the zener voltage (increase of up to 1 V).

Short circuit detection

Fault Condition: V_{ON} > 8.5 V typ.; IN high

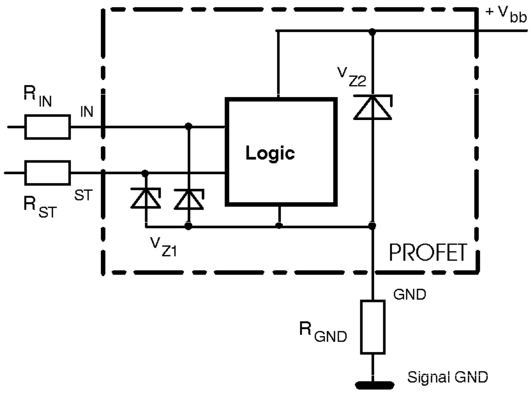


Inductive and overvoltage output clamp



V_{ON} clamped to 68 V typ.

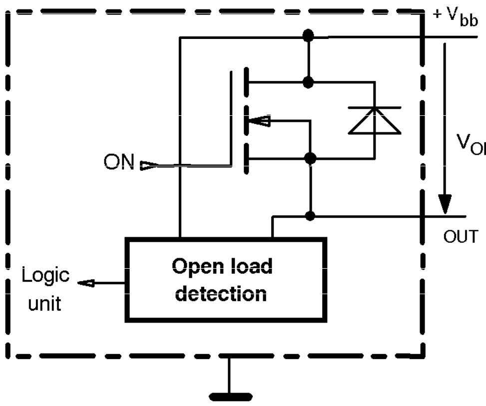
Overvolt. and reverse batt. protection



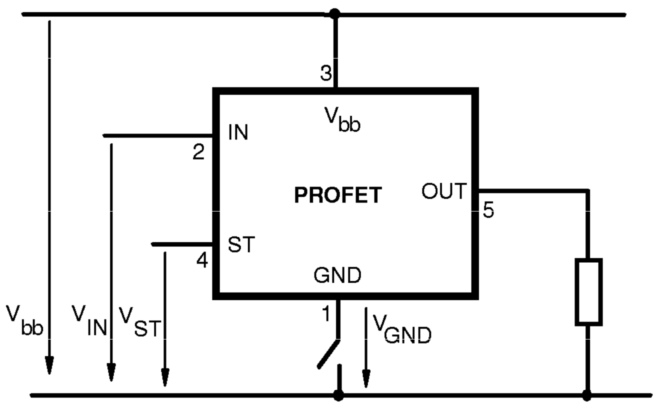
V_{Z1} = 6.2 V typ., V_{Z2} = 70 V typ., R_{GND}= 150 Ω, R_{IN}, R_{ST}= 15 kΩ

Open-load detection

ON-state diagnostic condition: V_{ON} < R_{ON} * $I_{L(OL)}$; IN high

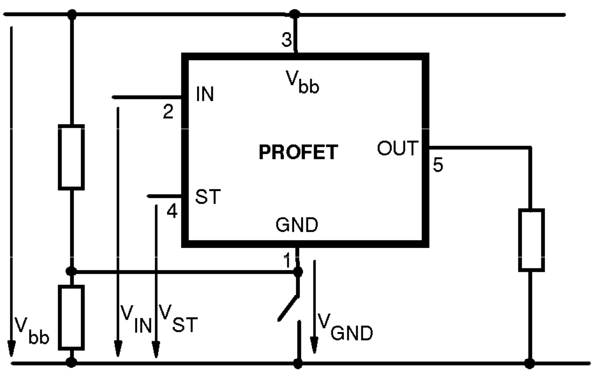


GND disconnect



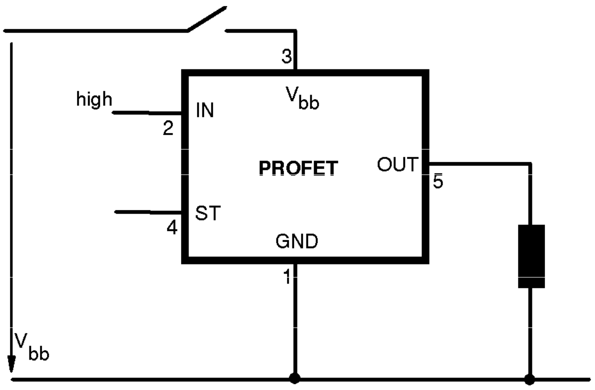
Any kind of load. In case of Input=high is $V_{OUT} \approx V_{IN} - V_{IN(T+)}$.
Due to V_{GND} >0, no V_{ST} = low signal available.

GND disconnect with GND pull up



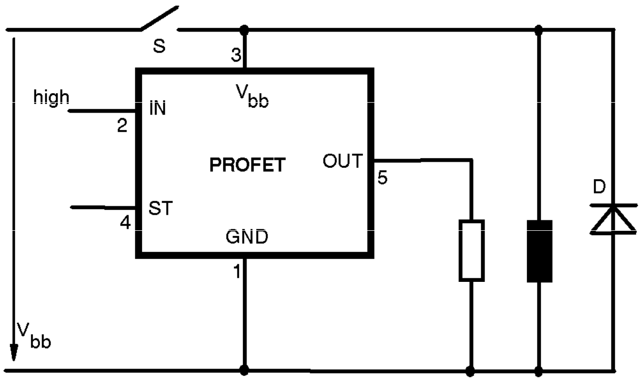
Any kind of load. If $V_{GND} > V_{IN} - V_{IN(T+)}$ device stays off
Due to $V_{GND} > 0$, no V_{ST} = low signal available.

V_{bb} disconnect with charged inductive load



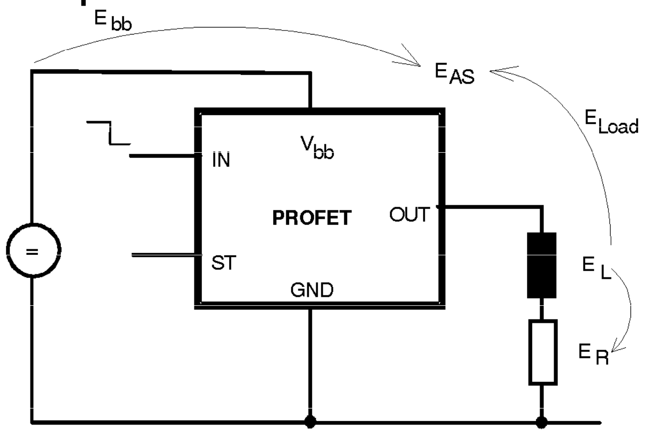
Normal load current can be handled by the PROFET itself.

V_{bb} disconnect with charged external inductive load



If other external inductive loads L are connected to the PROFET, additional elements like D are necessary.

Inductive Load switch-off energy dissipation



Energy dissipated in PROFET $E_{AS} = E_{bb} + E_L - E_R$.
$E_{Load} < E_L$, $E_L = {}^1/_2 * L * I_L^2$

Options Overview

all versions: High-side switch, Input protection, ESD protection, load dump and reverse battery protection with 150 Ω in GND connection, protection against loss of ground

Type BTS	412 B2	410D2	410E2	**410F2**	410G2	410H2
Logic version	B	D	E	**F**	G	H
Overtemperature protection with hysteresis						
T_j >150 °C, latch function[16][17]	X	X		**X**		X
T_j >150 °C, with auto-restart on cooling			X		X	
Short circuit to GND protection						
switches off when V_{ON}>3.5 V typ. and V_{bb}> 7 V typ[16] (when first turned on after approx. 150 µs)						X
switches off when V_{ON}>8.5 V typ.[16] (when first turned on after approx. 150 µs)	X	X	X	**X**		
Achieved through overtemperature protection					X	
Open load detection						
in OFF-state with sensing current 30 µA typ.	X					X
in ON-state with sensing voltage drop across power transistor		X	X	**X**	X	
Undervoltage shutdown with auto restart	X	X	X	**X**	X	X
Overvoltage shutdown with auto restart[18]	X	X	X	**X**	X	X
Status feedback for						
overtemperature	X	X	X	**X**	X	X
short circuit to GND	X	X	X	**X**	-	X
short to V_{bb}	X	-[19]	-[19]	**-[19]**	-[19]	X
open load	X	X	X	**X**	X	X
undervoltage	X	X	-	**-**	-	-
overvoltage	X	X	-	**-**	-	-
Status output type						
CMOS	X	X				
Open drain			X	**X**	X	X
Output negative voltage transient limit (fast inductive load switch off)						
to V_{bb} - $V_{ON(CL)}$	X	X	X	**X**	X	X
Load current limit						
high level (can handle loads with high inrush currents)	X	X	X			
low level (better protection of application)				**X**	X	X
Protection against loss of GND	X	X	X	**X**	X	X

[16] Latch except when V_{bb} - V_{OUT} < $V_{ON(SC)}$ after shutdown. In most cases V_{OUT} = 0 V after shutdown (V_{OUT} ≠ 0 V only if forced externally). So the device remains latched unless V_{bb} < $V_{ON(SC)}$ (see page 4). No latch between turn on and $t_{d(SC)}$.

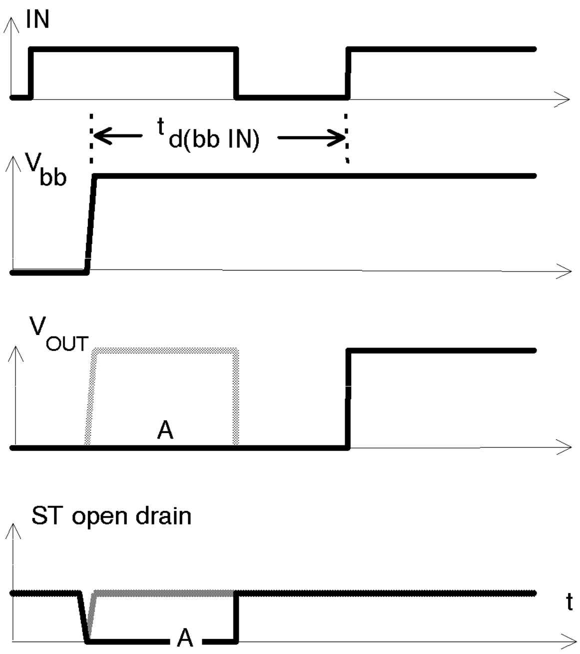
[17] With latch function. Reseted by a) Input low, b) Undervoltage

[18] No auto restart after overvoltage in case of short circuit

[19] Low resistance short V_{bb} to output may be detected by no-load-detection

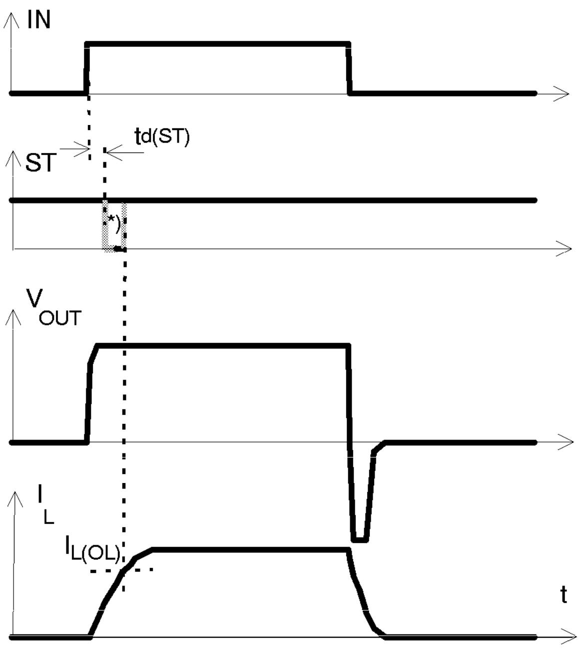
Timing diagrams

Figure 1a: V_{bb} turn on:



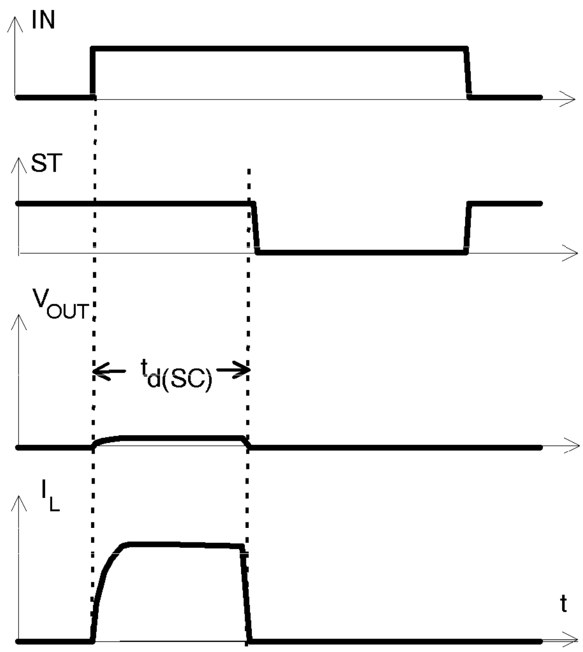
in case of too early V_{IN}=high the device may not turn on (curve A)
$t_{d(bb\ IN)}$ approx. 150 µs

Figure 2a: Switching an inductive load



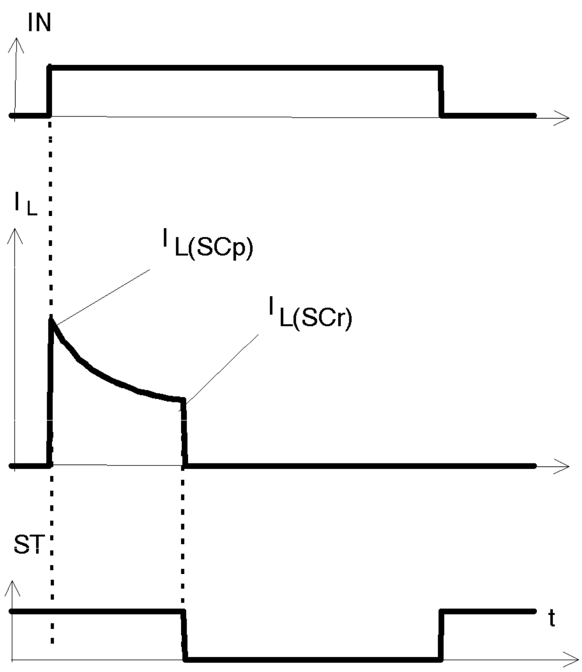
*) if the time constant of load is too large, open-load-status may occur

Figure 3a: Turn on into short circuit,



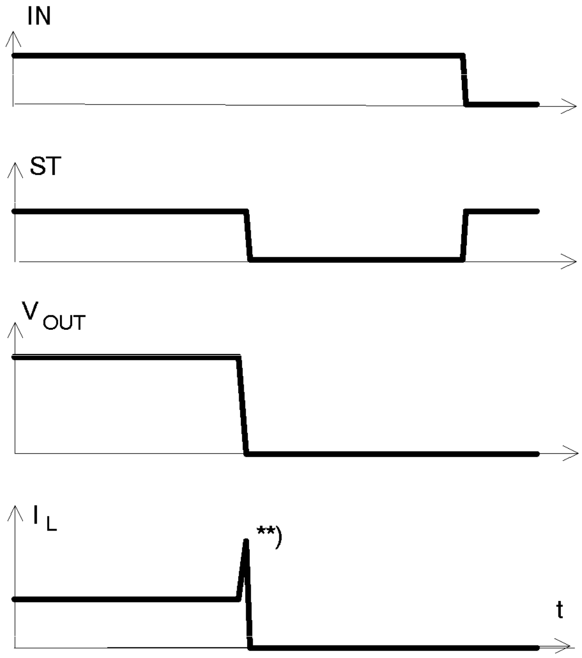
$t_{d(SC)}$ approx. 200µs if V_{bb} - V_{OUT} > 8.5 V typ.

Figure 3b: Turn on into overload,



Heating up may require several seconds,
V_{bb} - V_{OUT} < 8.5 V typ.

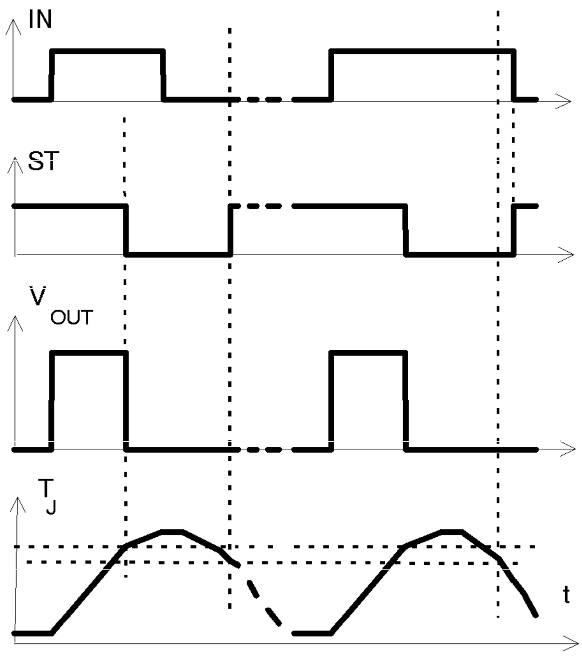
Figure 3c: Short circuit while on:



**) current peak approx. 20 µs

Figure 4a: Overtemperature,

Reset if (IN=low) and (T_j<T_{jt})



*) ST goes high , when V_{IN}=low **and** T_j<T_{jt}

Figure 5a: Open load: detection in ON-state, turn on/off to open load

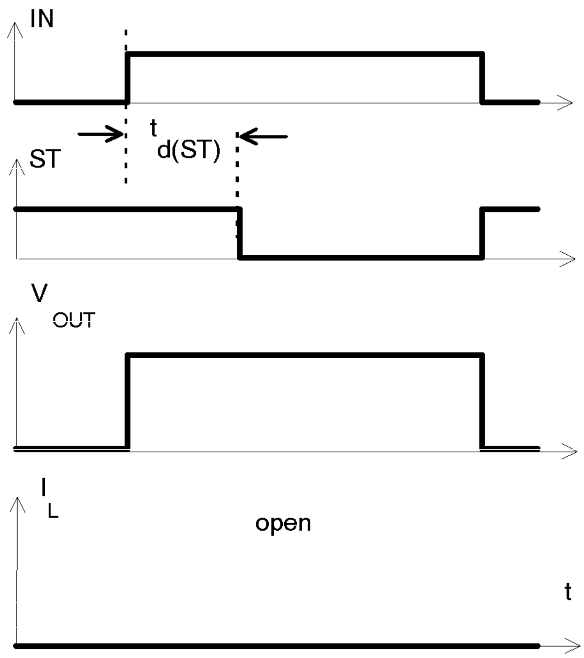
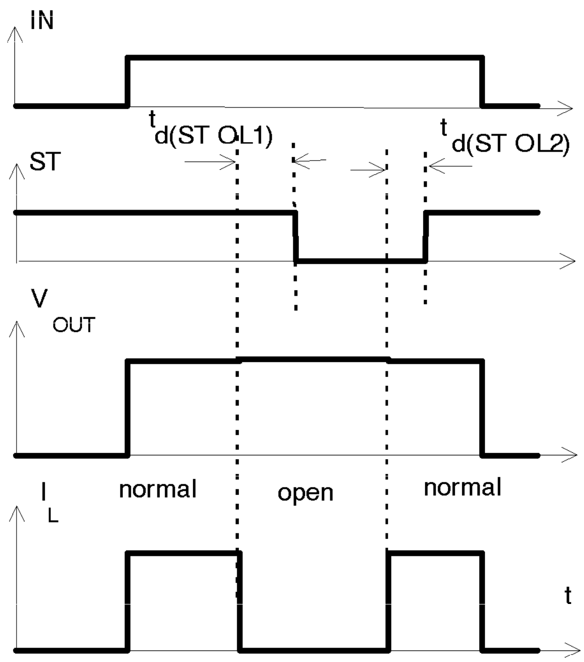


Figure 5b: Open load: detection in ON-state, open load occurs in on-state



$t_{d(ST\ OL1)}$ = tbd µs typ., $t_{d(ST\ OL2)}$ = tbd µs typ

Figure 6a: Undervoltage:

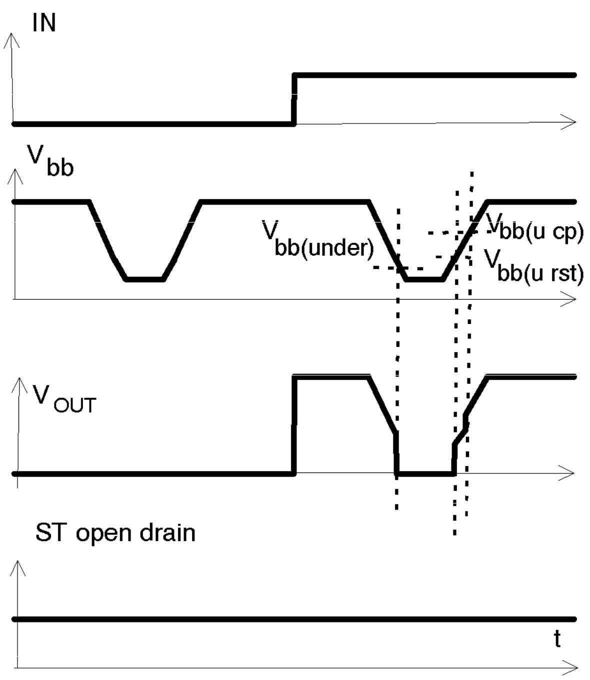
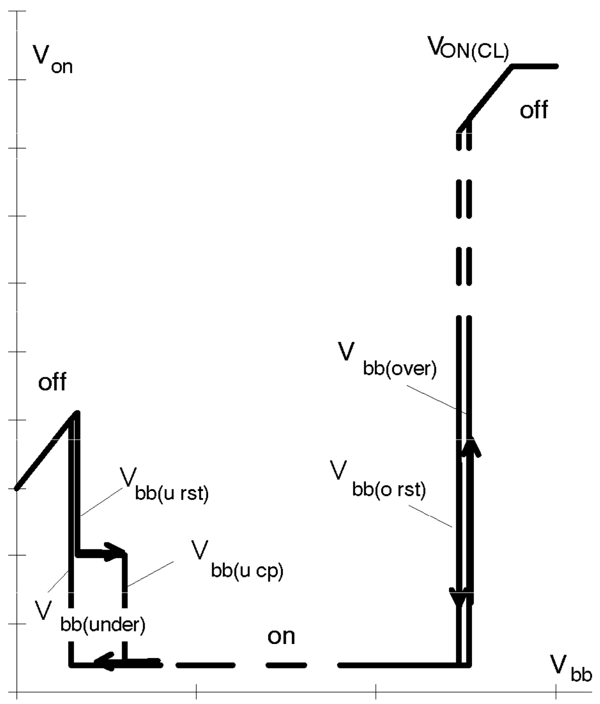


Figure 6b: Undervoltage restart of charge pump



charge pump starts at $V_{bb(ucp)}$ =5.6 V typ.

Figure 7a: Overvoltage:

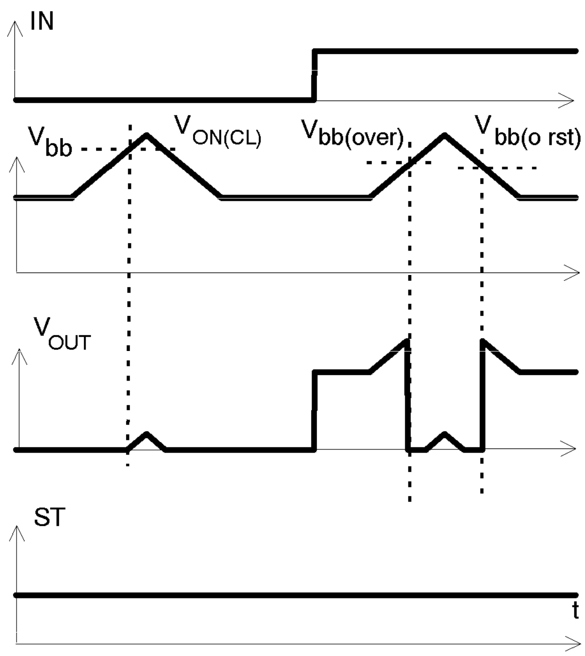
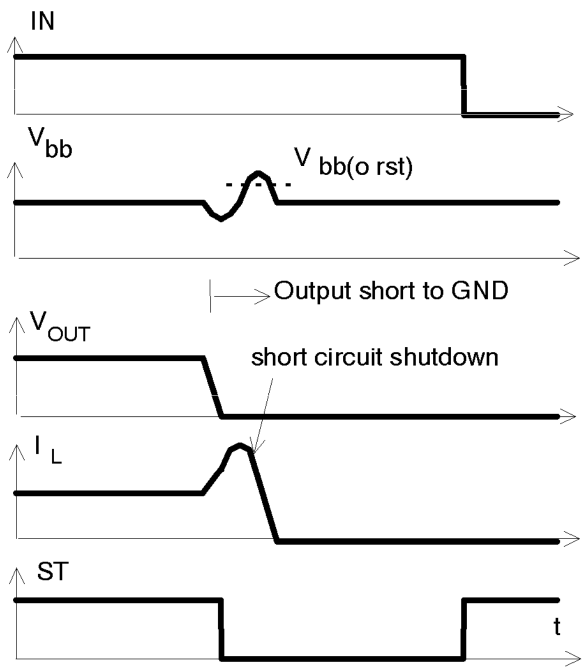


Figure 9a: Overvoltage at short circuit shutdown:



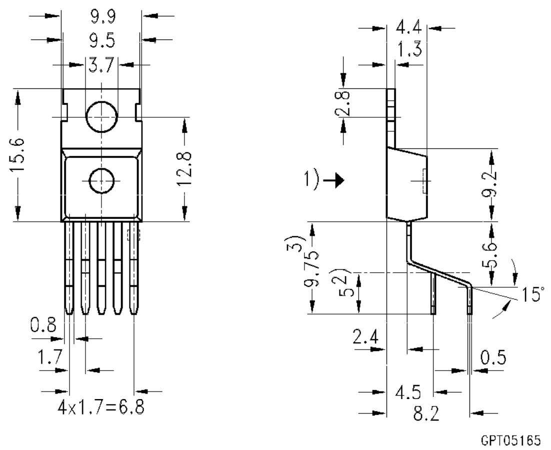
Overvoltage due to power line inductance. No overvoltage auto-restart of PROFET after short circuit shutdown.

Package and Ordering Code

All dimensions in mm

Standard TO-220AB/5 Ordering code

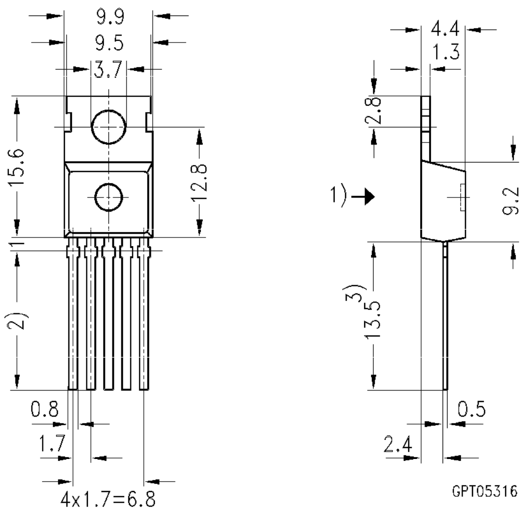
BTS 410 F2	Q67060-S6103-A2



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

TO-220AB/5, Option E3043 Ordering code

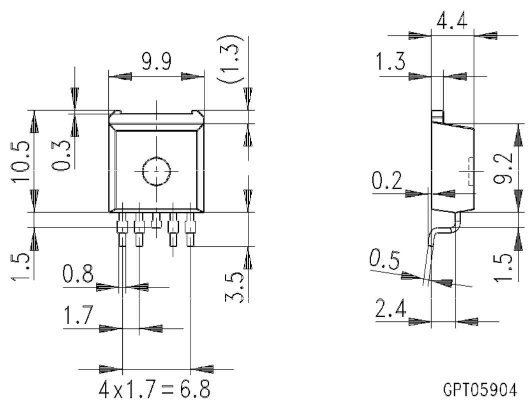
BTS 410 F2 E3043	Q67060-S6103-A3



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

SMD TO-220AB/5, Opt. E3062 Ordering code

BTS410F2 E3062A	T&R: Q67060-S6103-A4



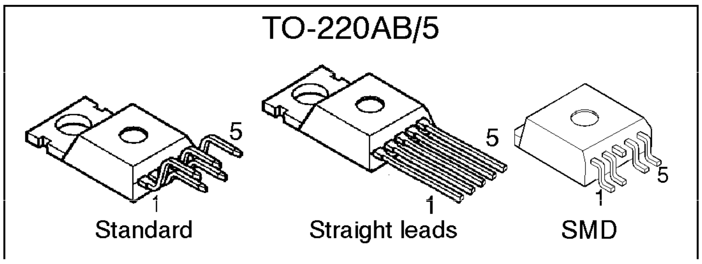
Smart Highside Power Switch

Features

- Overload protection
- Current limitation
- Short circuit protection
- Thermal shutdown
- Overvoltage protection (including load dump)
- Fast demagnetization of inductive loads
- Reverse battery protection[1)]
- Undervoltage and overvoltage shutdown with auto-restart and hysteresis
- CMOS diagnostic output
- Open load detection in OFF-state
- CMOS compatible input
- Loss of ground and loss of V_{bb} protection
- **E**lectrosta**t**ic **d**ischarge (**ESD**) protection

Product Summary

Overvoltage protection	$V_{bb(AZ)}$	65	V
Operating voltage	$V_{bb(on)}$	4.7 ... 42	V
On-state resistance	R_{ON}	220	mΩ
Load current (ISO)	$I_{L(ISO)}$	1.8	A
Current limitation	$I_{L(SCr)}$	5	A

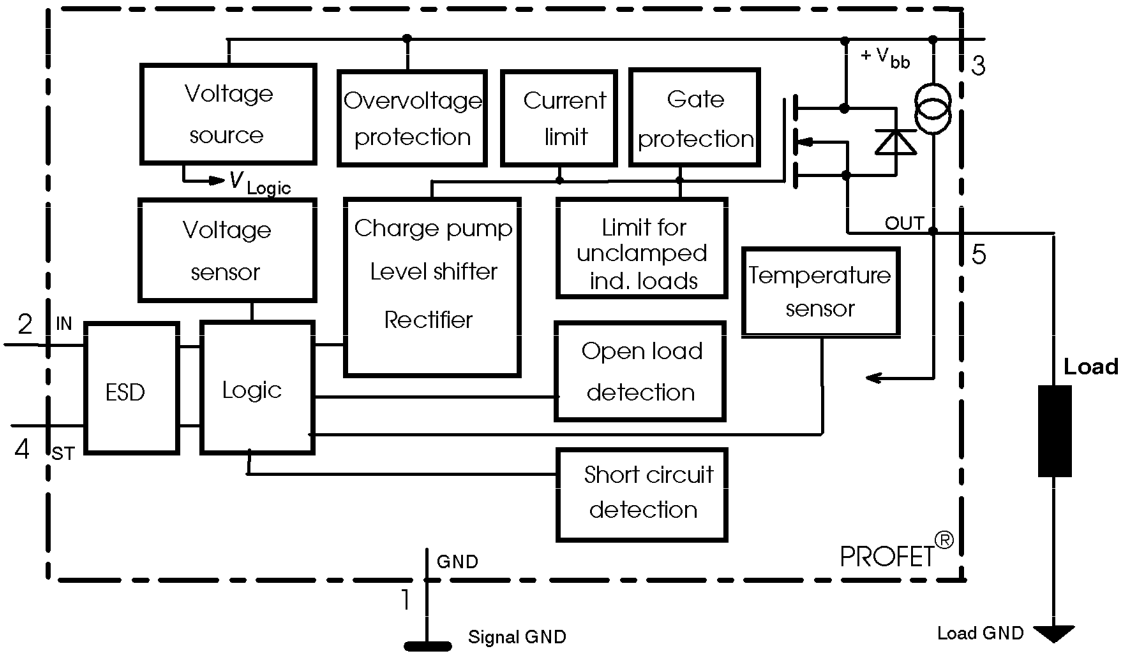


Application

- µC compatible power switch with diagnostic feedback for 12 V and 24 V DC grounded loads
- All types of resistive, inductive and capacitve loads
- Replaces electromechanical relays and discrete circuits

General Description

N channel vertical power FET with charge pump, ground referenced CMOS compatible input and diagnostic feedback, monolithically integrated in Smart SIPMOS® technology. Fully protected by embedded protection functions.



1) With external current limit (e.g. resistor R_{GND}=150 Ω) in GND connection, resistor in series with ST connection, reverse load current limited by connected load.

Pin	Symbol		Function
1	GND	-	Logic ground
2	IN	I	Input, activates the power switch in case of logical high signal
3	Vbb	+	Positive power supply voltage, the tab is shorted to this pin
4	ST	S	Diagnostic feedback, low on failure
5	OUT (Load, L)	O	Output to the load

Maximum Ratings at T_j = 25 °C unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage (overvoltage protection see page 3)	V_{bb}	65	V
Load dump protection[2] $V_{LoadDump} = U_A + V_s$, U_A = 13.5 V R_I[3]= 0.5 Ω, R_L= 6.6 Ω, t_d= 400 ms, IN= low or high	$V_{Load\ dump}$[4]	100	V
Load current (Short circuit current, see page 4)	I_L	self-limited	A
Operating temperature range Storage temperature range	T_j T_{stg}	-40 ...+150 -55 ...+150	°C
Power dissipation (DC), $T_C \leq$ 25 °C	P_{tot}	50	W
Inductive load switch-off energy dissipation, single pulse T_j=150 °C:	E_{AS}	tbd	J
Electrostatic discharge capability (ESD) (Human Body Model)	V_{ESD}	1	kV
Input voltage (DC) Current through input pin (DC) Current through status pin (DC) see internal circuit diagrams page 6	V_{IN} I_{IN} I_{ST}	-10 ... +16 ±5.0 ±5.0	V mA

Thermal resistance chip - case: junction - ambient (free air): SMD version, device on PCB[5]:	R_{thJC} R_{thJA}	≤ 2.5 ≤ 75 ≤ tbd	K/W

2) Supply voltages higher than $V_{bb(AZ)}$ require an external current limit for the GND and status pins, e.g. with a 150 Ω resistor in the GND connection and a 15 kΩ resistor in series with the status pin. A resistor for the protection of the input is integrated.

3) R_I = internal resistance of the load dump test pulse generator

4) $V_{Load\ dump}$ is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839

5) Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm^2 (one layer, 70µm thick) copper area for V_{bb} connection. PCB is vertical without blown air.

Electrical Characteristics

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Load Switching Capabilities and Characteristics					
On-state resistance (pin 3 to 5) I_L = 1.6 A T_j=25 °C: T_j=150 °C:	R_{ON}	-- 	190 390	220 440	mΩ
Nominal load current (pin 3 to 5) ISO Proposal: V_{ON} = 0.5 V, T_C = 85 °C	$I_{L(ISO)}$	1.6	1.8	--	A
Output current (pin 5) while GND disconnected or GND pulled up, V_{bb}=30 V, V_{IN}= 0, see diagram page 7	$I_{L(GNDhigh)}$	--	--	10	mA
Turn-on time to 90% V_{OUT}: Turn-off time to 10% V_{OUT}: R_L = 12 Ω	t_{on} t_{off}	15 5	-- --	60 50	µs
Slew rate on 10 to 30% V_{OUT}, R_L = 12 Ω	dV/dt_{on}	--	--	3	V/µs
Slew rate off 70 to 40% V_{OUT}, R_L = 12 Ω	$-dV/dt_{off}$	--	--	6	V/µs
Operating Parameters					
Operating voltage [6] T_j =-40...+150°C:	$V_{bb(on)}$	4.7	--	42	V
Undervoltage shutdown T_j =25°C: T_j =-40...+150°C:	$V_{bb(under)}$	2.9 2.7	-- --	4.5 4.7	V
Undervoltage restart T_j =-40...+150°C:	$V_{bb(u\ rst)}$	--	--	4.9	V
Undervoltage restart of charge pump see diagram page 12	$V_{bb(ucp)}$	--	5.6	6.0	V
Undervoltage hysteresis $\Delta V_{bb(under)} = V_{bb(u\ rst)} - V_{bb(under)}$	$\Delta V_{bb(under)}$	--	0.1	--	V
Overvoltage shutdown T_j =-40...+150°C:	$V_{bb(over)}$	42	--	52	V
Overvoltage restart T_j =-40...+150°C:	$V_{bb(o\ rst)}$	40	--	--	V
Overvoltage hysteresis T_j =-40...+150°C:	$\Delta V_{bb(over)}$	--	0.1	--	V
Overvoltage protection [7] T_j =-40...+150°C: I_{bb}=40 mA	$V_{bb(AZ)}$	65	70	--	V
Standby current (pin 3), V_{IN}=0, $I_{ST} \leq 0$ T_j=-40...+150°C:	$I_{bb(off)}$	 --	 40	 70	µA
Operating current (Pin 1) [8], V_{IN}=5 V	I_{GND}	--	1	--	mA

[6] At supply voltage increase up to V_{bb}= 5.6 V typ without charge pump, $V_{OUT} \approx V_{bb}$ - 2 V

[7] Meassured without load. See also $V_{ON(CL)}$ in table of protection functions and circuit diagram page 7.

[8] Add I_{ST}, if I_{ST} > 0, add I_{IN}, if V_{IN}>5.5 V

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values min	typ	max	Unit
Protection Functions					
Initial peak short circuit current limit (pin 3 to 5)[9], (max 450 µs if V_{ON} > $V_{ON(SC)}$) T_j =-40°C:	$I_{L(SCp)}$	9	--	23	A
T_j =25°C:		--	12	--	
T_j =+150°C:		4	--	15	
Overload shutdown current limit V_{ON}= 8 V, T_j = T_{jt} (see timing diagrams, page 10)	$I_{L(SCr)}$	--	5	--	A
Short circuit shutdown delay after input pos. slope V_{ON} > $V_{ON(SC)}$, T_j =-40..+150°C: min value valid only, if input "low" time exceeds 60 µs	$t_{d(SC)}$	--	--	450	µs
Output clamp (inductive load switch off) V_{OUT} = V_{bb} - $V_{ON(CL)}$ I_L= 40 mA, T_j =-40..+150°C:	$V_{ON(CL)}$	61	68	73	V
I_L= 1 A, T_j =-40..+150°C:		--	--	75	
Short circuit shutdown detection voltage (pin 3 to 5)	$V_{ON(SC)}$	--	8.5	--	V
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Thermal hysteresis	ΔT_{jt}	--	10	--	K
Inductive load switch-off energy dissipation[10],	E_{AS}	--	--	tbd	J
$T_{j\,Start}$ = 150 °C, single pulse V_{bb} = 12 V:	E_{Load12}			tbd	
V_{bb} = 24 V:	E_{Load24}			tbd	
Reverse battery (pin 3 to 1) [11]	$-V_{bb}$	--	--	32	V

Parameter and Conditions	Symbol	min	typ	max	Unit
Diagnostic Characteristics					
Open load detection current T_j=-40...+150°C: (included in standby current $I_{bb(off)}$)	$I_{L(off)}$	15	30	60	µA
Open load detection voltage T_j=-40..150°C:	$V_{OUT(OL)}$	2	3	4	V

9) Short circuit current limit for max. duration of $t_{d(SC)\,max}$=450 µs, prior to shutdown

10) While demagnetizing load inductance, dissipated energy in PROFET is $E_{AS}= \int V_{ON(CL)} * i_L(t)\,dt$, approx. $E_{AS}= {}^1/_2 * L * I_L^2 * \left(\frac{V_{ON(CL)}}{V_{ON(CL)} - V_{bb}}\right)$, see diagram page 8

11) Requires 150 Ω resistor in GND connection. Reverse load current (through intrinsic drain-source diode) is normally limited by the connected load. Input and Status currents have to be limited (see max. ratings page 2 and circuit page 7).

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	

Input and Status Feedback[12]

Parameter and Conditions	Symbol	min	typ	max	Unit
Input resistance see circuit page 6	R_I	--	9	--	kΩ
Input turn-on threshold voltage T_j =-40..+150°C:	$V_{IN(T+)}$	1.5	--	2.4	V
Input turn-off threshold voltage T_j =-40..+150°C:	$V_{IN(T-)}$	1.0	--	--	V
Input threshold hysteresis	$\Delta V_{IN(T)}$	--	0.5	--	V
Off state input current (pin 2), V_{IN} = 0.4 V	$I_{IN(off)}$	1	--	30	µA
On state input current (pin 2), V_{IN} = 3.5 V	$I_{IN(on)}$	10	25	70	µA
Delay time for status with open load after Input neg. slope (see diagram page 11)	$t_{d(ST\ OL3)}$	--	200	--	µs
Status invalid after positive input slope (short circuit) T_j=-40 ... +150°C:	$t_{d(ST\ SC)}$	--	--	450	µs
Status output (CMOS) T_j =-40...+150°C, I_{ST}= - 50 µA:	$V_{ST(high)}$[13]	4.4	5.1	6.5	V
T_j =-40...+150°C, I_{ST} = +1.6 mA:	$V_{ST(low)}$	--	--	0.4	
Max. status current for current source (out):	$-I_{ST}$	--	--	0.25	mA
valid status output, current sink (in) : T_j =-40...+150°C	$+I_{ST}$[14]	--	--	1.6	

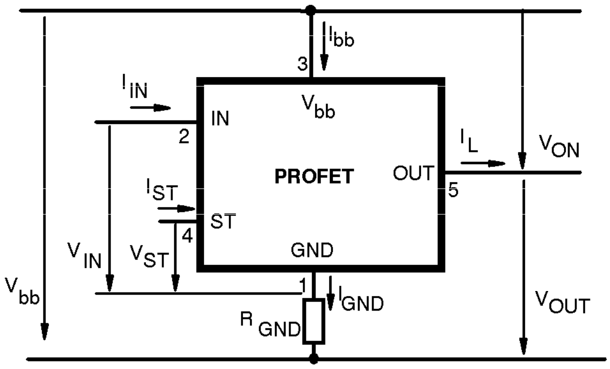
12) If a ground resistor R_{GND} is used, add the voltage drop across this resistor.
13) $V_{St\ high} \approx V_{bb}$ during undervoltage shutdown
14) No current sink capability during undervoltage shutdown

Truth Table

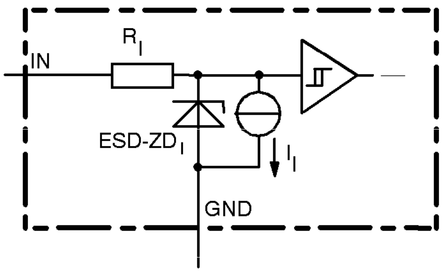
	Input-level	Output level	Status 412 B2	410 D2	410 E2/F2	410 G2	410 H2
Normal operation	L H	L H	H H	H H	H H	H H	H H
Open load	L H	[15] H	L H	H L	H L	H L	L H
Short circuit to GND	L H	L L	H L	H L	H L	H H	H L
Short circuit to V_{bb}	L H	H H	L H	H H (L[16])	H H (L[16])	H H (L[16])	L H
Overtem-perature	L H	L L	L L	L L	L L	L L	L L
Under-voltage	L H	L L	L[17] L[17]	L[17] L[17]	H H	H H	H H
Overvoltage	L H	L L	L L	L L	H H	H H	H H

L = "Low" Level
H = "High" Level

Terms

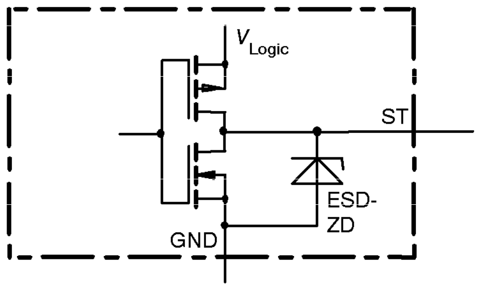


Input circuit (ESD protection)



ESD zener diodes are not to be used as voltage clamp at DC conditions. Operation in this mode may result in a drift of the zener voltage (increase of up to 1 V).

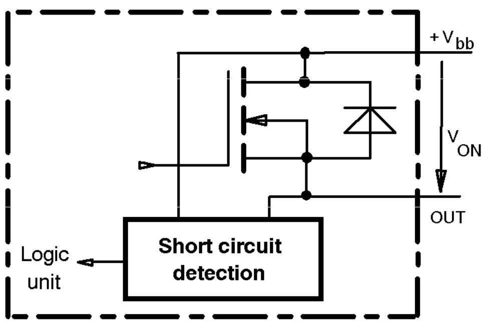
Status output



Zener diode: 6 V typ., max 5.0 mA, V_{Logic} 5 V typ, ESD zener diodes are not to be used as voltage clamp at DC conditions. Operation in this mode may result in a drift of the zener voltage (increase of up to 1 V).

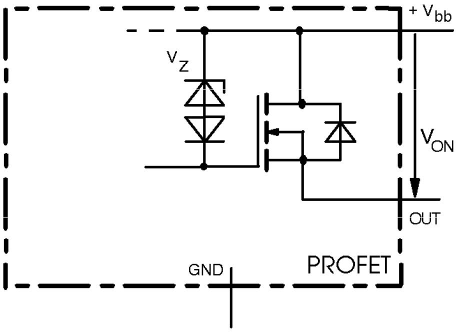
Short circuit detection

Fault Condition: V_{ON} > 8.5 V typ.; IN high



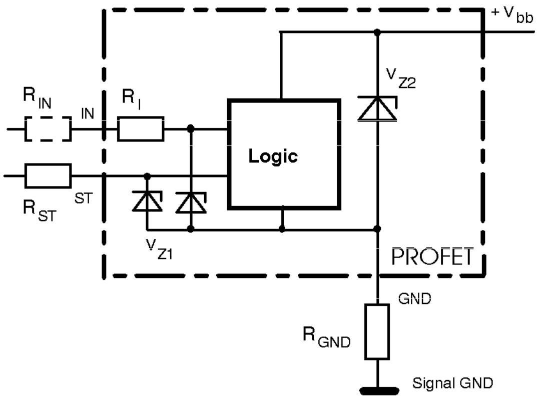
[15] Power Transistor off, high impedance, versions BTS 410H, BTS 412B: internal pull up current source for open load detection.
[16] Low resistance short V_{bb} to output may be detected by no-load-detection
[17] No current sink capability during undervoltage shutdown

Inductive and overvoltage output clamp



V_{ON} clamped to 68 V typ.

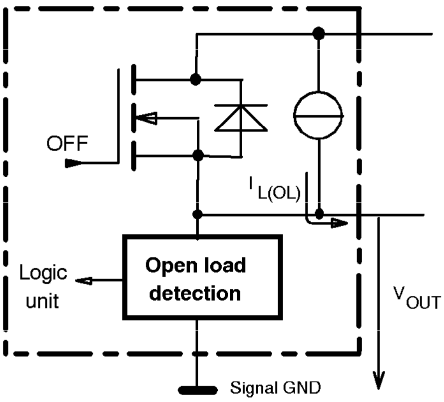
Overvolt. and reverse batt. protection



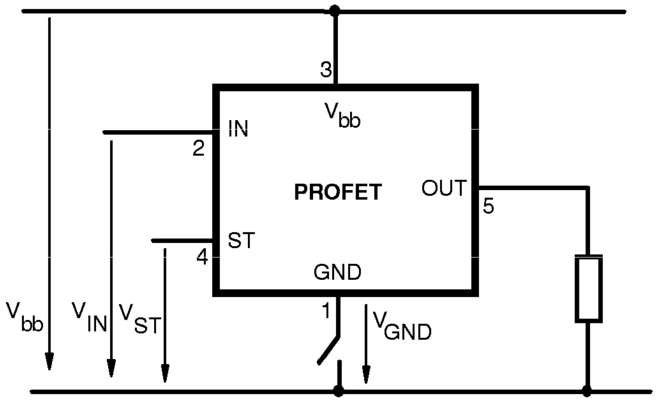
V_{Z1} = 6.2 V typ., V_{Z2} = 70 V typ., R_{GND} = 150 Ω, R_{ST}= 15 kΩ, R_I= 9 kΩ typ.

Open-load detection

OFF-state diagnostic condition: V_{OUT} > 3 V typ.; IN low

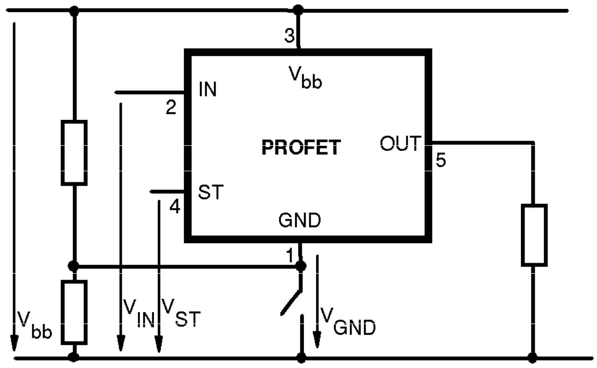


GND disconnect



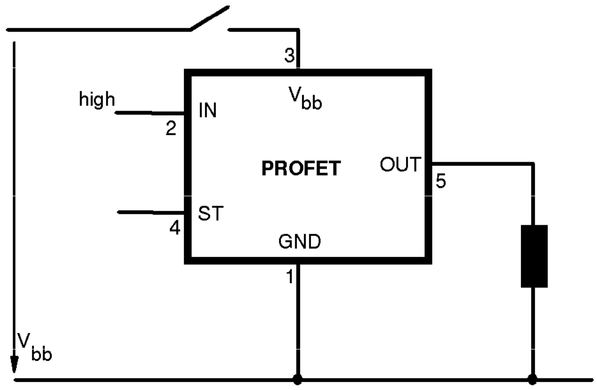
Any kind of load. In case of Input=high is $V_{OUT} \approx V_{IN} - V_{IN(T+)}$.
Due to V_{GND} >0, no V_{ST} = low signal available.

GND disconnect with GND pull up



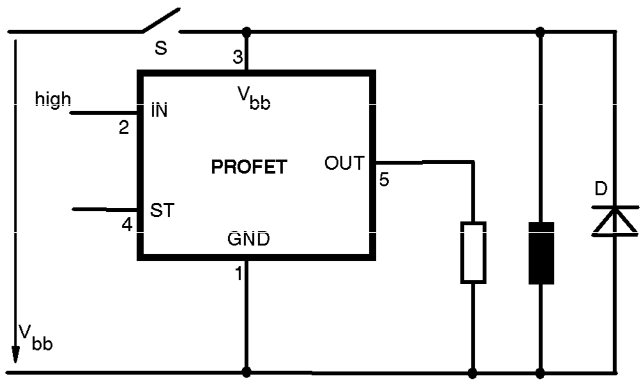
Any kind of load. If $V_{GND} > V_{IN} - V_{IN(T+)}$ device stays off
Due to V_{GND} >0, no V_{ST} = low signal available.

V_{bb} disconnect with charged inductive load



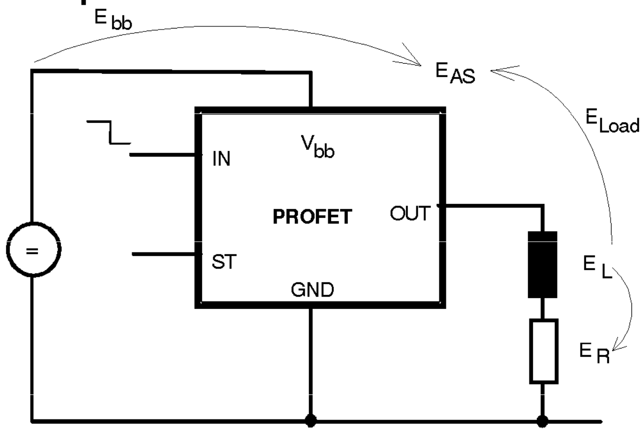
Normal load current can be handled by the PROFET itself.

V_{bb} disconnect with charged external inductive load



If other external inductive loads L are connected to the PROFET, additional elements like D are necessary.

Inductive Load switch-off energy dissipation



Energy dissipated in PROFET $E_{AS} = E_{bb} + E_L - E_R$.

$E_{Load} < E_L$, $E_L = {}^1/_2 * L * I_L^2$

Options Overview

all versions: High-side switch, Input protection, ESD protection, load dump and reverse battery protection with 150 Ω in GND connection, protection against loss of ground

Type BTS	**412 B2**	410D2	410E2	410F2	410G2	410H2
Logic version	**B**	D	E	F	G	H
Overtemperature protection with hysteresis						
T_j >150 °C, latch function[18][19]	**X**	X		X		X
T_j >150 °C, with auto-restart on cooling			X		X	
Short circuit to GND protection						
switches off when V_{ON}>3.5 V typ. and V_{bb}> 8 V typ[18] (when first turned on after approx. 210 µs)						X
switches off when V_{ON}>8.5 V typ.[18] (when first turned on after approx. 210 µs)	**X**	X	X	X		
Achieved through overtemperature protection					X	
Open load detection						
in OFF-state with sensing current 30 µA typ.	**X**					X
in ON-state with sensing voltage drop across power transistor		X	X	X	X	
Undervoltage shutdown with auto restart	**X**	X	X	X	X	X
Overvoltage shutdown with auto restart[20]	**X**	X	X	X	X	X
Status feedback for						
overtemperature	**X**	X	X	X	X	X
short circuit to GND	**X**	X	X	X	-	X
short to V_{bb}	**X**	-[21]	-[21]	-[21]	-[21]	X
open load	**X**	X	X	X	X	X
undervoltage	**X**	X	-	-	-	-
overvoltage	**X**	X	-	-	-	-
Status output type						
CMOS	**X**	X				
Open drain			X	X	X	X
Output negative voltage transient limit (fast inductive load switch off)						
to V_{bb} - $V_{ON(CL)}$	**X**	X	X	X	X	X
Load current limit						
high level (can handle loads with high inrush currents)	**X**	X	X			
low level (better protection of application)				X	X	X
Protection against loss of GND	**X**	X	X	X	X	X

18) Latch except when V_{bb} - V_{OUT} < $V_{ON(SC)}$ after shutdown. In most cases V_{OUT} = 0 V after shutdown (V_{OUT} ≠ 0 V only if forced externally). So the device remains latched unless V_{bb} < $V_{ON(SC)}$ (see page 4). No latch between turn on and $t_{d(SC)}$.

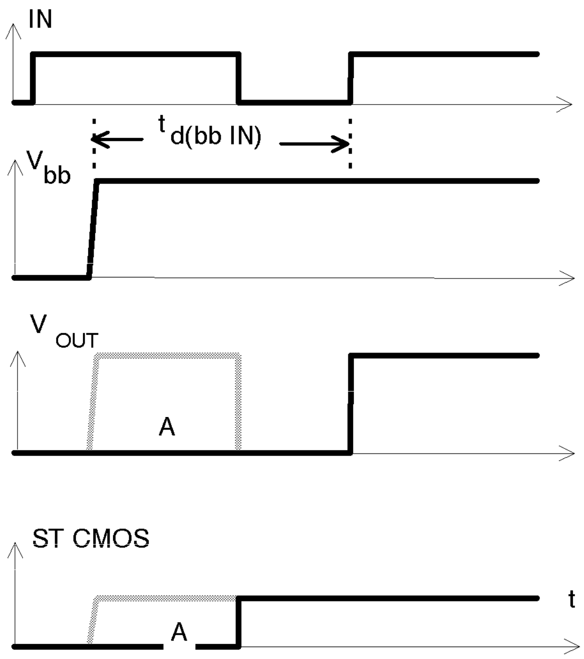
19) With latch function. Reseted by a) Input low, b) Undervoltage

20) No auto restart after overvoltage in case of short circuit

21) Low resistance short V_{bb} to output may be detected by no-load-detection

Timing diagrams

Figure 1a: V_{bb} turn on:



in case of too early V_{IN}=high the device may not turn on (curve A)
$t_{d(bb\ IN)}$ approx. 150 µs

Figure 2a: Switching a lamp,

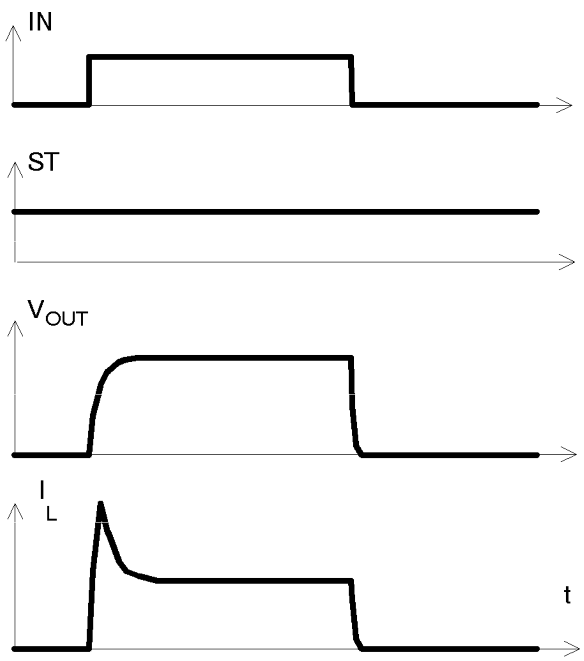


Figure 2b: Switching an inductive load

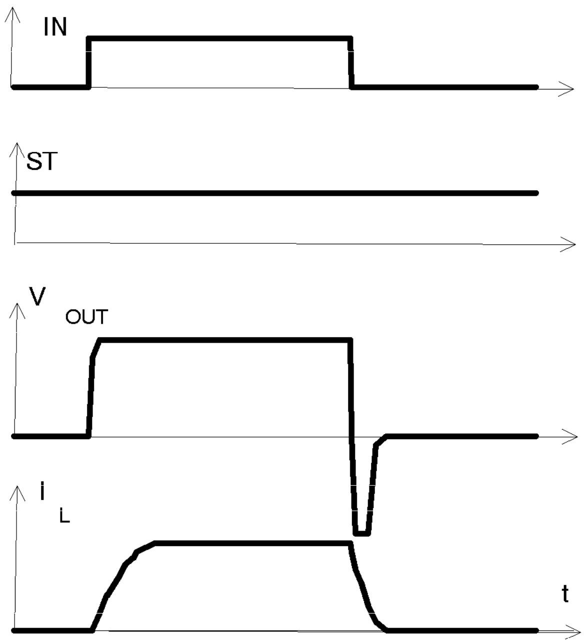
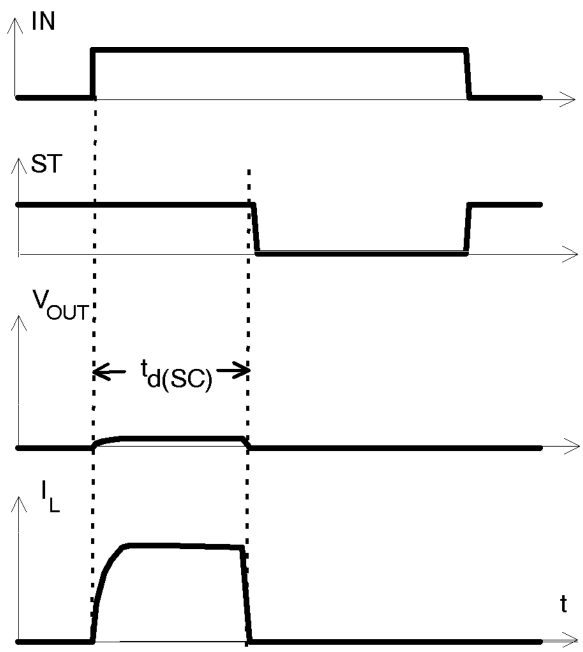
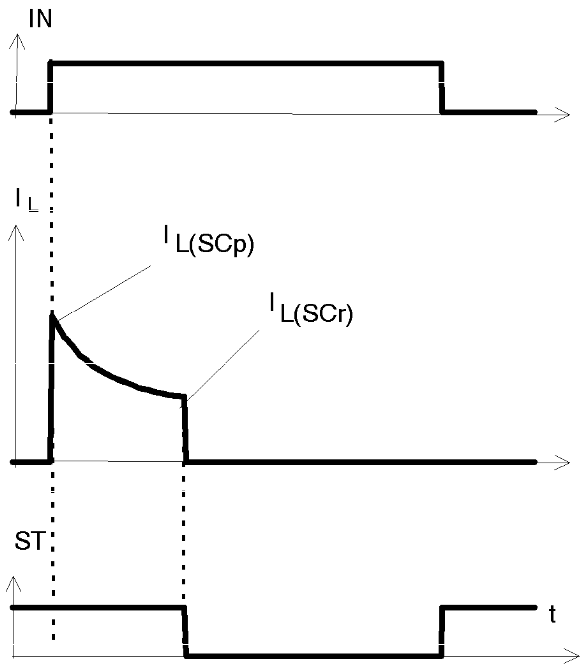


Figure 3a: Turn on into short circuit,



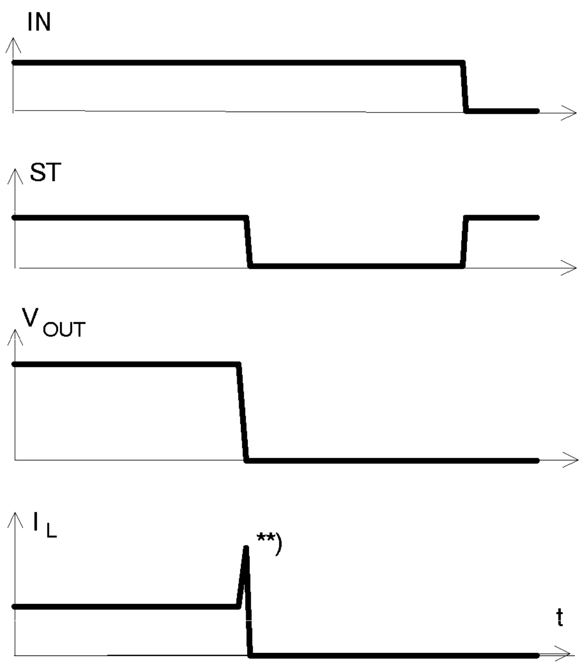
$t_{d(SC)}$ approx. 200µs if V_{bb} - V_{OUT} > 8.5 V typ.

Figure 3b: Turn on into overload,



Heating up may require several seconds,
V_{bb} - V_{OUT} < 8.5 V typ.

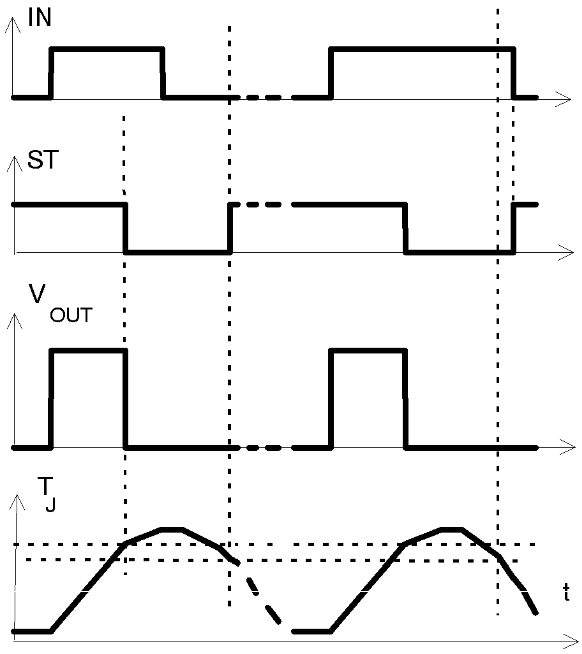
Figure 3c: Short circuit while on:



**) current peak approx. 20 µs

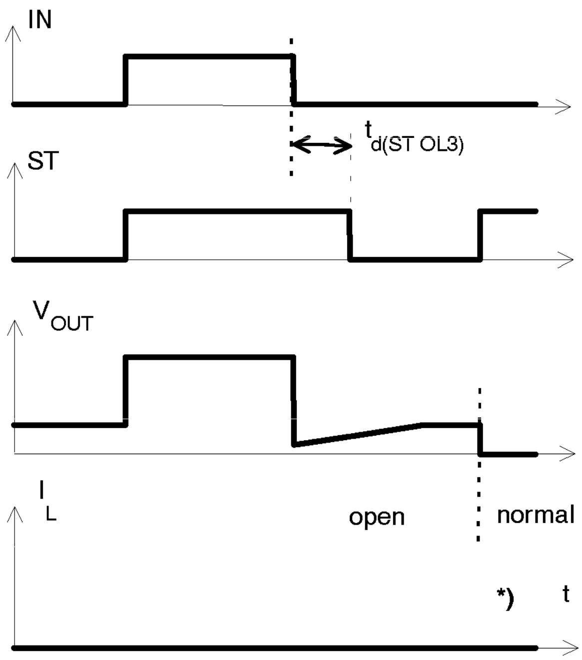
Figure 4a: Overtemperature,

Reset if (IN=low) and (T_j<T_{jt})



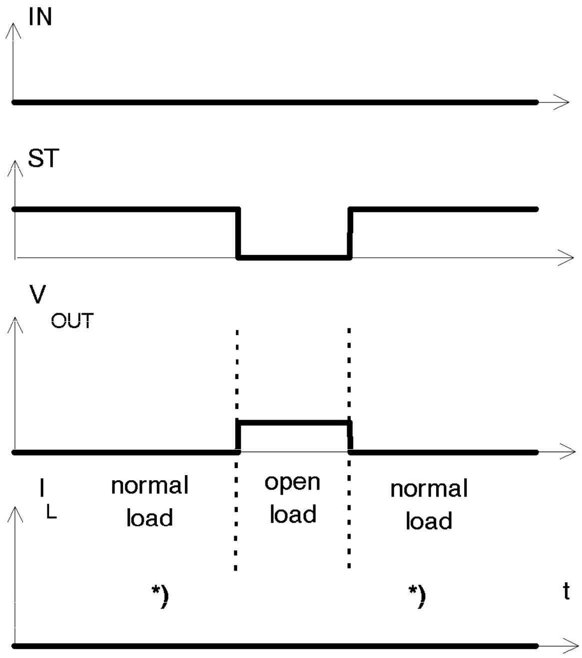
*) ST goes high , when V_{IN}=low **and** T_j<T_{jt}

Figure 5a: Open load: detection in OFF-state, turn on/off to open load



in case of external capacity $t_{d(ST,OL3)}$ may be higher due to high impedance *) I_L = 30 µA typ

Figure 5b: Open load: detection in OFF-state, open load occurs in off-state



*) I_L = 30 µA typ

Figure 6a: Undervoltage:

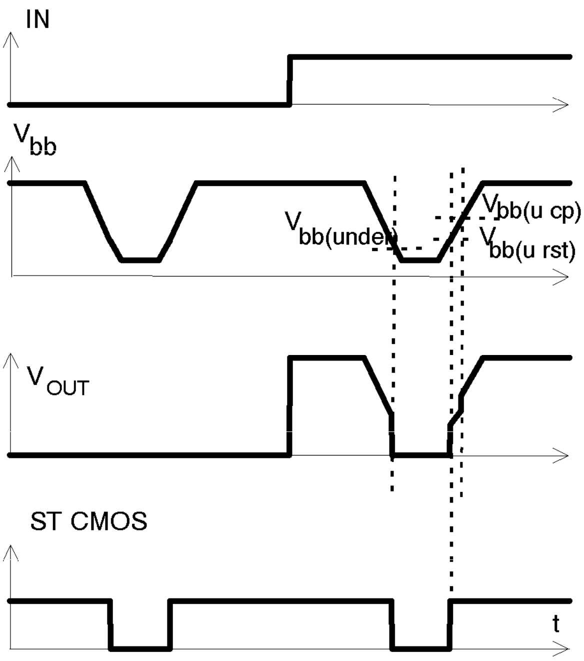
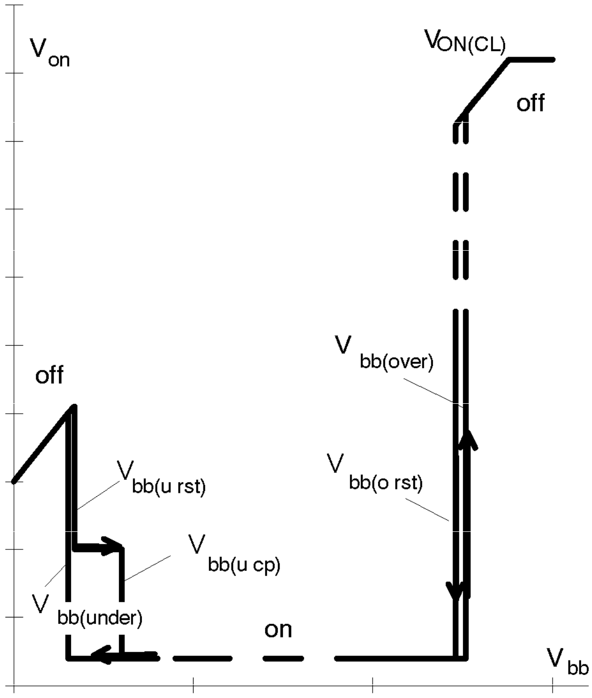
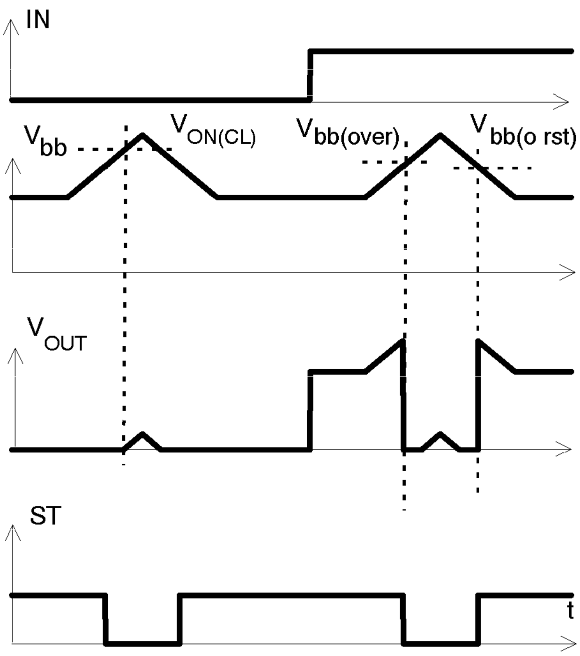


Figure 6b: Undervoltage restart of charge pump



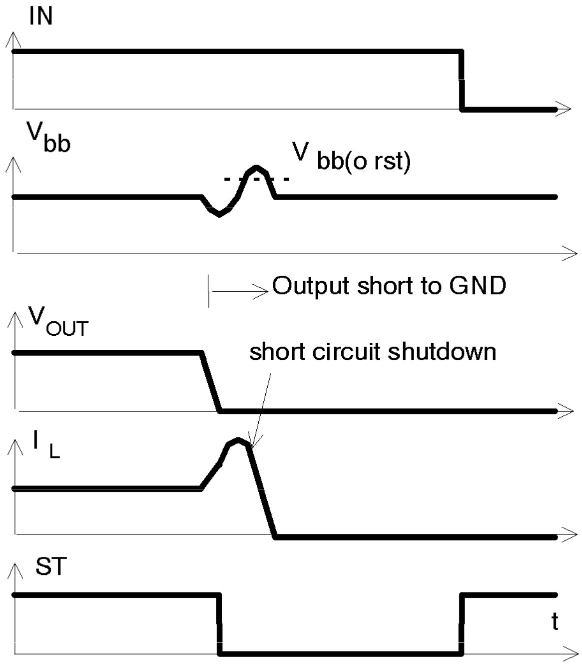
charge pump starts at $V_{bb(ucp)}$ =5.6 V typ.

Figure 7a: Overvoltage:



if V_{bb} > $V_{bb(AZ)}$ increase of V_{ST} due to GND resistor voltage.

Figure 9a: Overvoltage at short circuit shutdown:



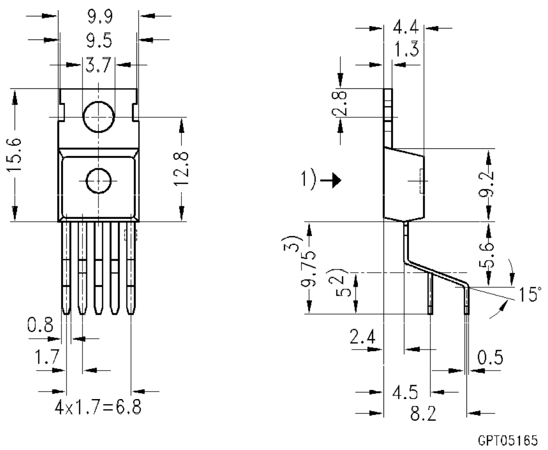
Overvoltage due to power line inductance. No overvoltage auto-restart of PROFET after short circuit shutdown.

Package and Ordering Code

All dimensions in mm

Standard TO-220AB/5 Ordering code

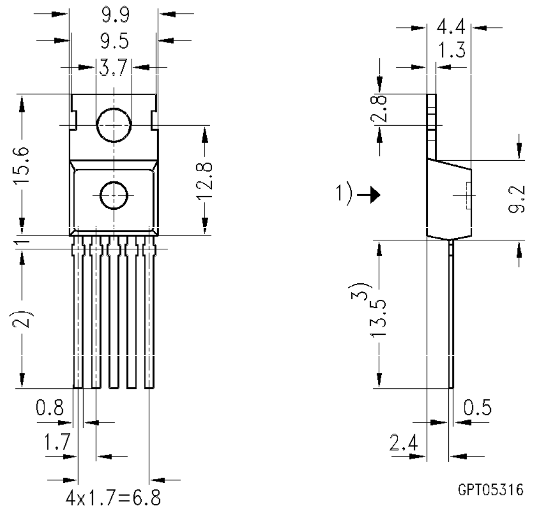
BTS 412B2	Q67060-S6109-A2



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

TO-220AB/5, Option E3043 Ordering code

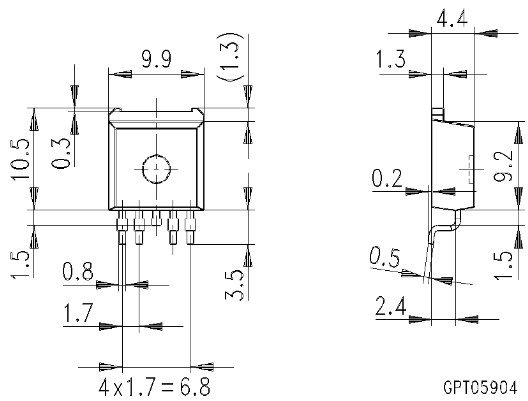
BTS 412B2 E3043	Q67060-S6109-A3



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

SMD TO-220AB/5, Opt. E3062 Ordering code

BTS 412B2 E3062A	T&R:	Q67060-S6109-A4



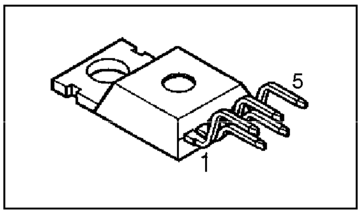
Smart Highside Power Switch

Features

- Load dump and reverse battery protection[1)]
- Clamp of negative voltage at output
- Short-circuit protection
- Current limitation
- Thermal shutdown
- Diagnostic feedback
- Open load detection in ON-state
- CMOS compatible input
- **E**lectrostatic **d**ischarge (**ESD**) protection
- Loss of ground and loss of V_{bb} protection[2)]
- Overvoltage protection
- Undervoltage and overvoltage shutdown with auto-restart and hysteresis

Product Summary

$V_{Load\ dump}$	80	V
V_{bb}-V_{OUT} Avalanche Clamp	58	V
V_{bb} (operation)	4.5 ... 42	V
V_{bb} (reverse)	-32	V
R_{ON}	38	mΩ
$I_{L(SCp)}$	44	A
$I_{L(SCr)}$	35	A
$I_{L(ISO)}$	11	A

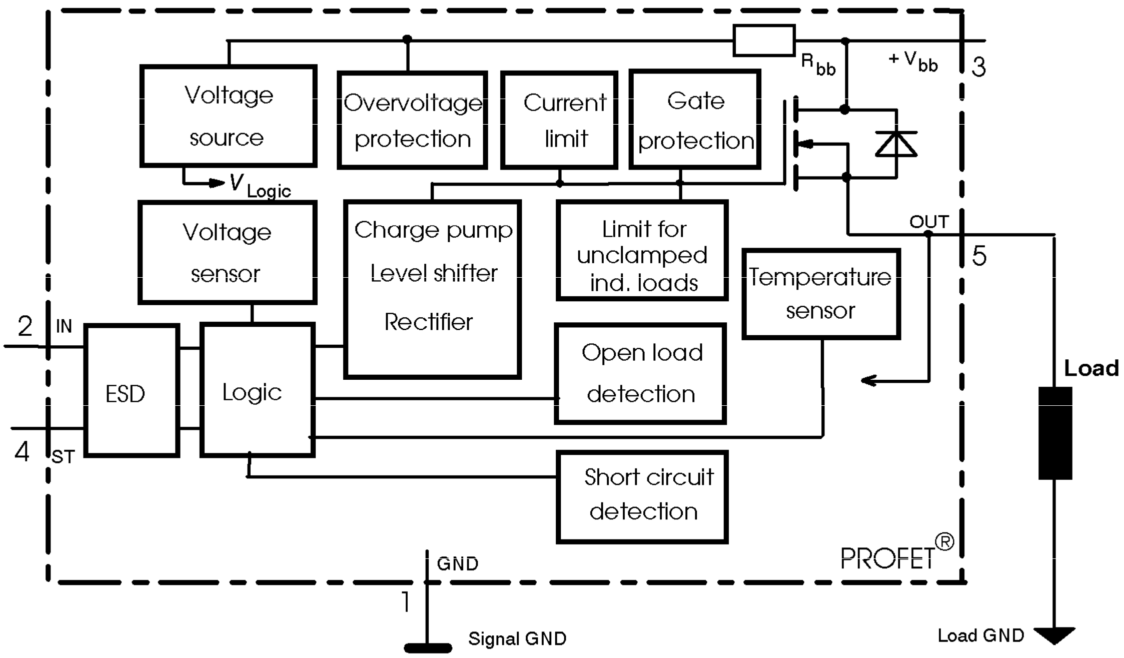


Application

- µC compatible power switch with diagnostic feedback for 12 V and 24 V DC grounded loads
- All types of resistive, inductive and capacitve loads
- Replaces electromechanical relays and discrete circuits

General Description

N channel vertical power FET with charge pump, ground referenced CMOS compatible input and diagnostic feedback, integrated in Smart SIPMOS® chip on chip technology. Fully protected by embedded protection functions.



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1) No external components required, reverse load current limited by connected load.
2) Additional external diode required for charged inductive loads

Pin	Symbol		Function
1	GND	-	Logic ground
2	IN	I	Input, activates the power switch in case of logical high signal
3	Vbb	+	Positive power supply voltage, the tab is shorted to this pin
4	ST	S	Diagnostic feedback, low on failure
5	OUT (Load, L)	O	Output to the load

Maximum Ratings at T_j = 25 °C unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage (overvoltage protection see page 3)	V_{bb}	63	V
Load dump protection $V_{LoadDump} = U_A + V_s$, U_A = 13.5 V R_I= 2 Ω, R_L= 1.1 Ω, t_d= 200 ms, IN= low or high	V_s[3)]	66.5	V
Load current (Short-circuit current, see page 4)	I_L	self-limited	A
Operating temperature range Storage temperature range	T_j T_{stg}	-40 ...+150 -55 ...+150	°C
Power dissipation (DC)	P_{tot}	125	W
Inductive load switch-off energy dissipation, single pulse T_j=150 °C:	E_{AS}	1.7	J
Electrostatic discharge capability (ESD) (Human Body Model)	V_{ESD}	2.0	kV
Input voltage (DC) Current through input pin (DC) Current through status pin (DC) see internal circuit diagrams page 6...	V_{IN} I_{IN} I_{ST}	-0.5 ... +6 ±5.0 ±5.0	V mA
Thermal resistance chip - case: junction - ambient (free air): SMD version, device on pcb[4)]:	R_{thJC} R_{thJA}	≤ 1 ≤ 75 ≤ tbd	K/W

3) V_S is setup without DUT connected to the generator per ISO 7637-1 and DIN 40839

4) Device on 50mm*50mm*1.5mm epoxy PCB FR4 with 6cm^2 (one layer, 70µm thick) copper area for V_{bb} connection. PCB is vertical without blown air.

Electrical Characteristics

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values min	Values typ	Values max	Unit
Load Switching Capabilities and Characteristics					
On-state resistance (pin 3 to 5) I_L = 2 A T_j=25 °C: T_j=150 °C:	R_{ON}	-- 	30 55	38 70	mΩ
Nominal load current (pin 3 to 5) ISO Proposal: V_{ON} = 0.5 V, T_C = 85 °C	$I_{L(ISO)}$	9	11	--	A
Output current (pin 5) while GND disconnected or GND pulled up, V_{IN}= 0, see diagram page 7, T_j =-40...+150°C	$I_{L(GNDhigh)}$	--	--	1	mA
Turn-on time to 90% V_{OUT}: Turn-off time to 10% V_{OUT}: R_L = 12 Ω, T_j =-40...+150°C	t_{on} t_{off}	50 10	160 --	300 80	µs
Slew rate on 10 to 30% V_{OUT}, R_L = 12 Ω, T_j =-40...+150°C	dV/dt_{on}	0.4	--	2.5	V/µs
Slew rate off 70 to 40% V_{OUT}, R_L = 12 Ω, T_j =-40...+150°C	$-dV/dt_{off}$	1	--	5	V/µs
Operating Parameters					
Operating voltage [5] T_j =-40...+150°C:	$V_{bb(on)}$	4.5	--	42	V
Undervoltage shutdown T_j =-40...+150°C:	$V_{bb(under)}$	2.4	--	4.5	V
Undervoltage restart T_j =-40...+150°C:	$V_{bb(u\ rst)}$	--	--	4.5	V
Undervoltage restart of charge pump see diagram page 12 T_j =-40...+150°C:	$V_{bb(ucp)}$	--	6.5	7.5	V
Undervoltage hysteresis $\Delta V_{bb(under)} = V_{bb(u\ rst)} - V_{bb(under)}$	$\Delta V_{bb(under)}$	--	0.2	--	V
Overvoltage shutdown T_j =-40...+150°C:	$V_{bb(over)}$	42	--	52	V
Overvoltage restart T_j =-40...+150°C:	$V_{bb(o\ rst)}$	42	--	--	V
Overvoltage hysteresis T_j =-40...+150°C:	$\Delta V_{bb(over)}$	--	0.2	--	V
Overvoltage protection[6] T_j =-40°C: I_{bb}=40 mA T_j =25...+150°C:	$V_{bb(AZ)}$	60 63	-- 67	--	V
Standby current (pin 3) T_j=-40...+25°C: V_{IN}=0 T_j=150°C:	$I_{bb(off)}$	-- --	12 18	25 60	µA
Leakage output current (included in $I_{bb(off)}$) V_{IN}=0	$I_{L(off)}$	--	6	--	µA
Operating current (Pin 1)[7], V_{IN}=5 V	I_{GND}	--	1.1	--	mA

[5] At supply voltage increase up to V_{bb}= 6.5 V typ without charge pump, $V_{OUT} \approx V_{bb}$ - 2 V

[6] see also $V_{ON(CL)}$ in table of protection functions and circuit diagram page 7. Meassured without load.

[7] Add I_{ST}, if I_{ST} > 0, add I_{IN}, if V_{IN}>5.5 V

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values min	typ	max	Unit
Protection Functions					
Initial peak short circuit current limit (pin 3 to 5)[8], (max 400 µs if $V_{ON} > V_{ON(SC)}$)	$I_{L(SCp)}$				
T_j =-40°C:		--	--	74	A
T_j =25°C:		--	44	--	
T_j =+150°C:		24	--	--	
Repetitive short circuit current limit $T_j = T_{jt}$ (see timing diagrams, page 10)	$I_{L(SCr)}$	22	35	--	A
Short circuit shutdown delay after input pos. slope $V_{ON} > V_{ON(SC)}$, T_j =-40..+150°C: min value valid only, if input "low" time exceeds 30 µs	$t_{d(SC)}$	80	--	400	µs
Output clamp (inductive load switch off) at $V_{OUT} = V_{bb} - V_{ON(CL)}$, I_L= 30 mA	$V_{ON(CL)}$	--	58	--	V
Short circuit shutdown detection voltage (pin 3 to 5)	$V_{ON(SC)}$	--	8.3	--	V
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Thermal hysteresis	ΔT_{jt}	--	10	--	K
Inductive load switch-off energy dissipation[9],	E_{AS}	--	--	1.7	J
$T_{j\,Start}$ = 150 °C, single pulse V_{bb} = 12 V:	E_{Load12}			1.3	
V_{bb} = 24 V:	E_{Load24}			1.0	
Reverse battery (pin 3 to 1) [10]	$-V_{bb}$	--	--	32	V
Integrated resistor in V_{bb} line	R_{bb}	--	120	--	Ω

Diagnostic Characteristics

Parameter and Conditions	Symbol	min	typ	max	Unit
Open load detection current T_j=-40 °C:	$I_{L\,(OL)}$	2	--	900	mA
(on-condition) T_j=25..150°C:		2	--	750	

8) Short circuit current limit for max. duration of 400 µs, prior to shutdown (see $t_{d(SC)}$ page 4)

9) While demagnetizing load inductance, dissipated energy in PROFET is $E_{AS} = \int V_{ON(CL)} * i_L(t)\,dt$, approx. $E_{AS} = {}^1/_2 * L * I_L^2 * \left(\frac{V_{ON(CL)}}{V_{ON(CL)} - V_{bb}}\right)$, see diagram page 8

10) Reverse load current (through intrinsic drain-source diode) is normally limited by the connected load. Reverse current I_{GND} of ≈ 0.3 A at V_{bb}= -32 V through the logic heats up the device. Time allowed under these condition is dependent on the size of the heatsink. Reverse I_{GND} can be reduced by an additional external GND-resistor (150 Ω). Input and Status currents have to be limited (see max. ratings page 2 and circuit page 7).

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Input and Status Feedback[11]					
Input turn-on threshold voltage T_j =-40..+150°C:	$V_{IN(T+)}$	1.5	--	2.4	V
Input turn-off threshold voltage T_j =-40..+150°C:	$V_{IN(T-)}$	1.0	--	--	V
Input threshold hysteresis	$\Delta V_{IN(T)}$	--	0.5	--	V
Off state input current (pin 2) V_{IN} = 0.4 V:	$I_{IN(off)}$	1	--	30	µA
On state input current (pin 2) V_{IN} = 3.5 V:	$I_{IN(on)}$	10	25	50	µA
Status invalid after positive input slope (short circuit) T_j=-40 ... +150°C:	$t_{d(ST SC)}$	80	200	400	µs
Status invalid after positive input slope (open load) T_j=-40 ... +150°C:	$t_{d(ST)}$	350	--	1600	µs
Status output (open drain)					
Zener limit voltage T_j =-40...+150°C, I_{ST} = +1.6 mA:	$V_{ST(high)}$	5.4	6.1	--	V
ST low voltage T_j =-40...+150°C, I_{ST} = +1.6 mA:	$V_{ST(low)}$	--	--	0.4	

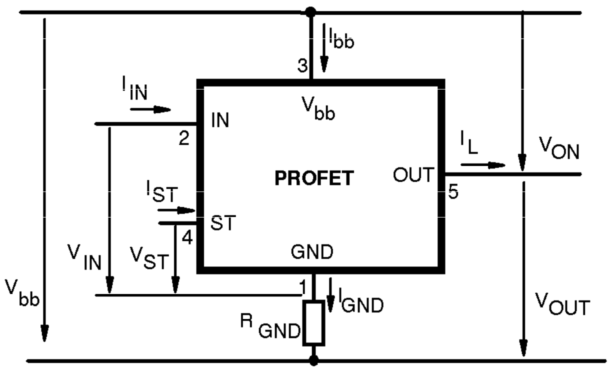
11) If a ground resistor R_{GND} is used, add the voltage drop across this resistor.

Truth Table

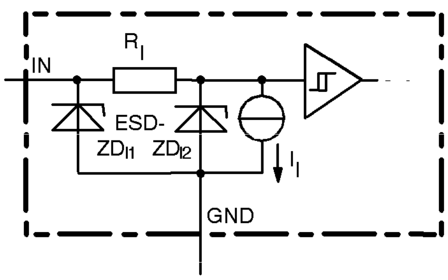
	Input-level	Output level	Status 432 D2	Status 432 E2/F2	Status 432 I2
Normal operation	L	L	H	H	H
	H	H	H	H	H
Open load	L	12)	H	H	L
	H	H	L	L	H
Short circuit to GND	L	L	H	H	H
	H	L	L	L	L
Short circuit to V_{bb}	L	H	H	H	L
	H	H	H (L[13])	H (L[13])	H
Overtem-perature	L	L	L	L	L
	H	L	L	L	L
Under-voltage	L	L	L[14]	H	L[14]
	H	L	L[14]	H	L[14]
Overvoltage	L	L	L	H	L
	H	L	L	H	L

L = "Low" Level
H = "High" Level

Terms

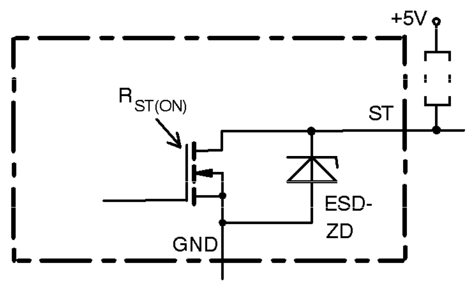


Input circuit (ESD protection)



ZD_{I1} 6.1 V typ., ESD zener diodes are not designed for continuous current

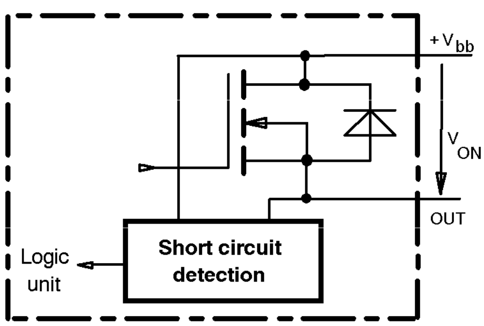
Status output



ESD-Zener diode: 6.1 V typ., max 5 mA;
$R_{ST(ON)}$ < 250 Ω at 1.6 mA, ESD zener diodes are not designed for continuous current

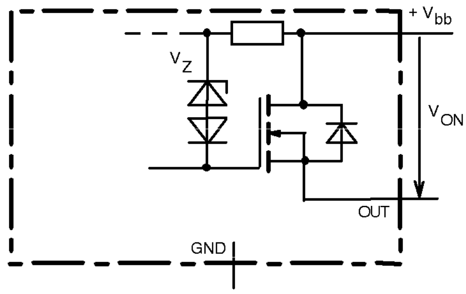
Short Circuit detection

Fault Condition: V_{ON} > 8.3 V typ.; IN high



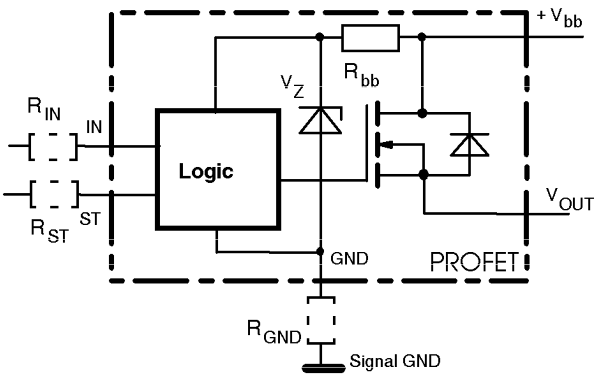
12) Power Transistor off, high impedance
13) Low resistance short V_{bb} to output may be detected by no-load-detection
14) No current sink capability during undervoltage shutdown

Inductive and overvoltage output clamp



V_{ON} clamped to 58 V typ.

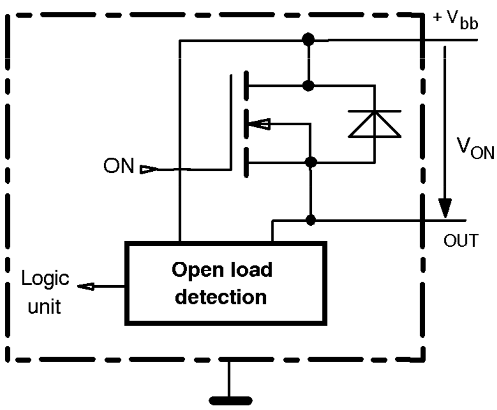
Overvolt. and reverse batt. protection



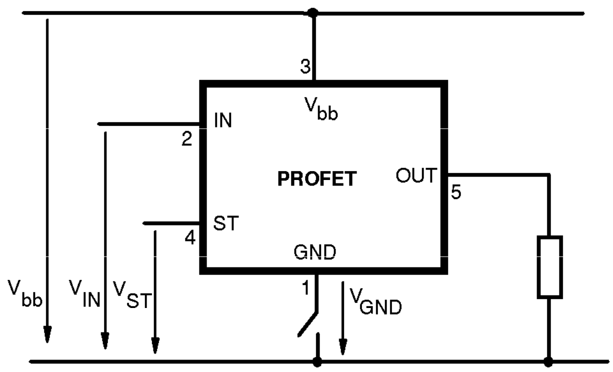
R_{bb} = 120 Ω typ., $V_Z + R_{bb}$*40 mA = 67 V typ., add R_{GND}, R_{IN}, R_{ST} for extended protection

Open-load detection

ON-state diagnostic condition: $V_{ON} < R_{ON} * I_{L(OL)}$; IN high

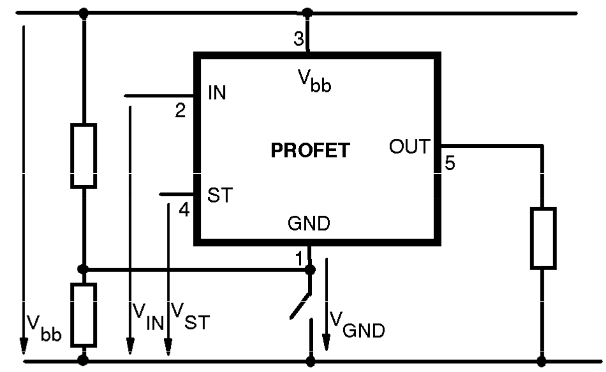


GND disconnect



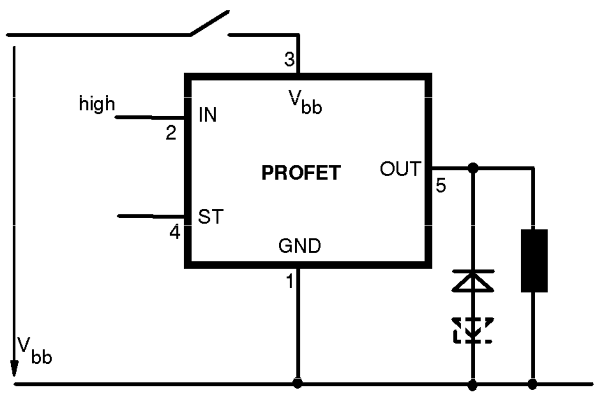
Any kind of load. In case of Input=high is $V_{OUT} \approx V_{IN} - V_{IN(T+)}$.
Due to V_{GND} >0, no V_{ST} = low signal available.

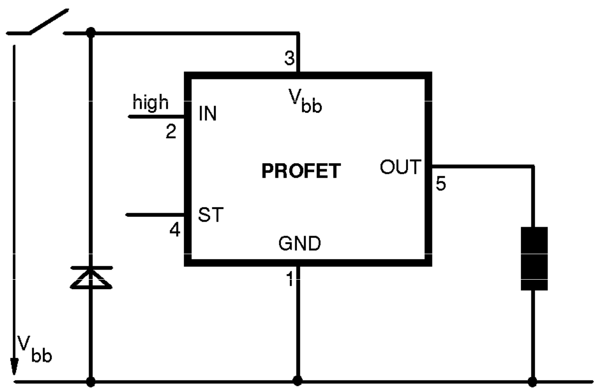
GND disconnect with GND pull up



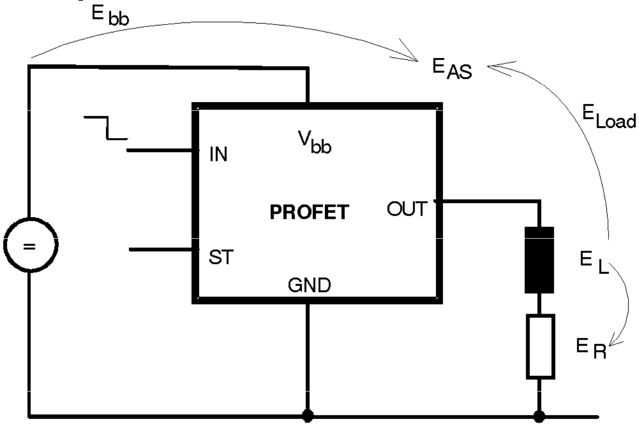
Any kind of load. If $V_{GND} > V_{IN} - V_{IN(T+)}$ device stays off
Due to V_{GND} >0, no V_{ST} = low signal available.

V_{bb} disconnect with charged inductive load





Inductive Load switch-off energy dissipation



Energy dissipated in PROFET $E_{AS} = E_{bb} + E_L - E_R$.

$E_{Load} < E_L$, $E_L = {}^1/_2 * L * I_L^2$

Options Overview

all versions: High-side switch, Input protection, ESD protection, load dump and reverse battery protection , protection against loss of ground

Type BTS	432D2	**432E2**	432F2	432I2
Logic version	D	**E**	F	I
Overtemperature protection				
T_j >150 °C, latch function[15)16)]	X		X	X
T_j >150 °C, with auto-restart on cooling		**X**		
Short-circuit to GND protection				
switches off when V_{ON}>8.3 V typ.[15)] (when first turned on after approx. 200 µs)	X	**X**	X	X
Open load detection				
in OFF-state with sensing current 30 µA typ.				X
in ON-state with sensing voltage drop across power transistor	X	**X**	X	
Undervoltage shutdown with auto restart	X	**X**	X	X
Overvoltage shutdown with auto restart	X	**X**	X	X
Status feedback for				
overtemperature	X	**X**	X	X
short circuit to GND	X	**X**	X	X
short to V_{bb}	-[17)]	**-[17)]**	-[17)]	X
open load	X	**X**	X	X
undervoltage	X	**-**	-	X
overvoltage	X	**-**	-	X
Status output type				
CMOS	X			X
Open drain		**X**	X	
Output negative voltage transient limit (fast inductive load switch off)				
to V_{bb} - $V_{ON(CL)}$	X	**X**	X	X
Load current limit				
high level (can handle loads with high inrush currents)	X	**X**		
medium level				X
low level (better protection of application)			X	

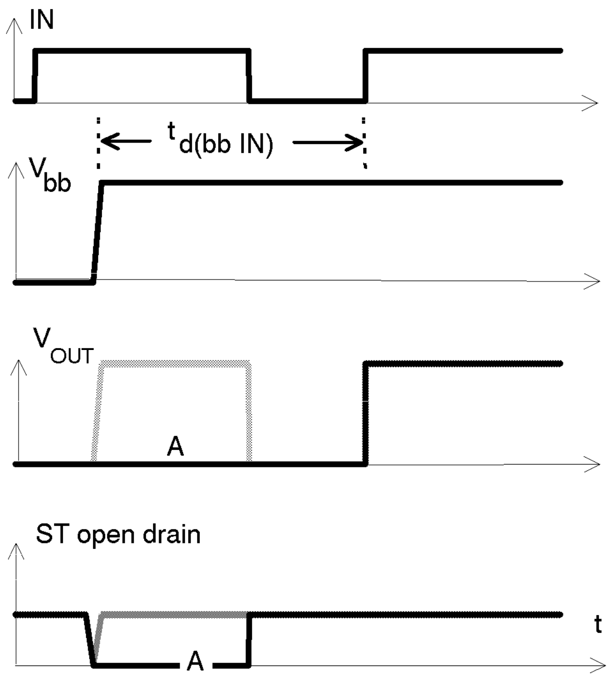
15) Latch except when V_{bb} - V_{OUT} < $V_{ON(SC)}$ after shutdown. In most cases V_{OUT} = 0 V after shutdown (V_{OUT} ≠ 0 V only if forced externally). So the device remains latched unless V_{bb} < $V_{ON(SC)}$ (see page 4). No latch between turn on and $t_{d(SC)}$.

16) With latch function. Reseted by a) Input low, b) Undervoltage, c) Overvoltage

17) Low resistance short V_{bb} to output may be detected by no-load-detection

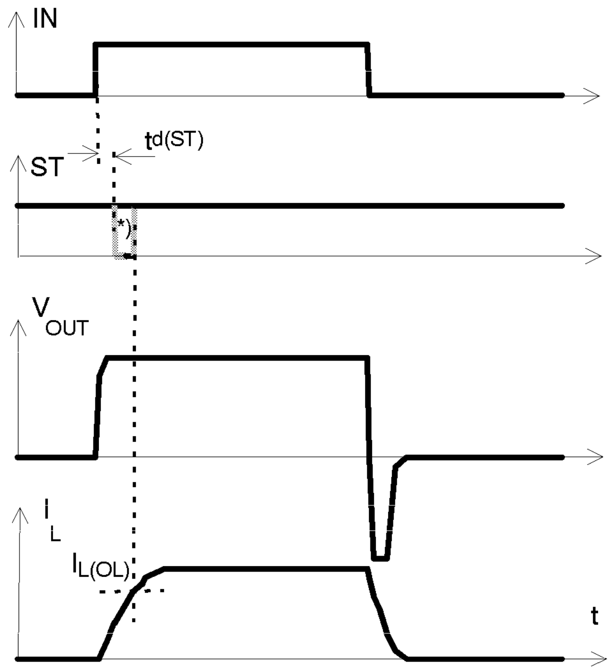
Timing diagrams

Figure 1a: V_{bb} turn on:



in case of too early V_{IN}=high the device may not turn on (curve A)
$t_{d(bb\ IN)}$ approx. 150 µs

Figure 2b: Switching an inductive load



*) if the time constant of load is too large, open-load-status may occur

Figure 2a: Switching a lamp,

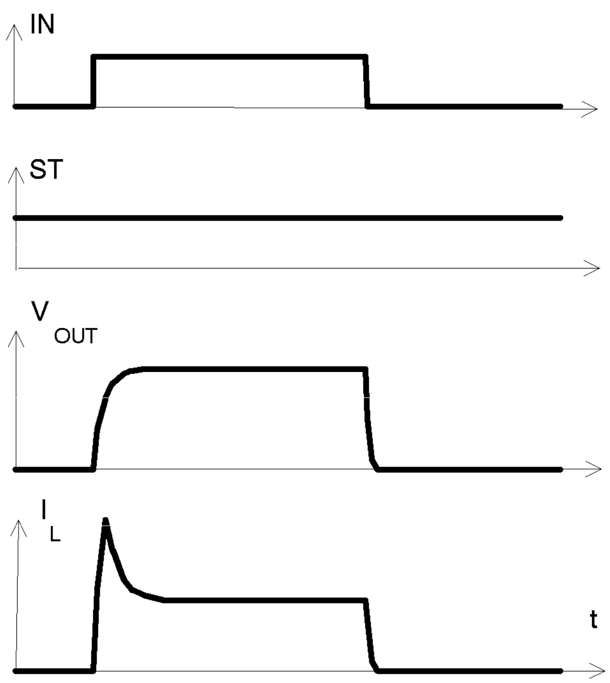
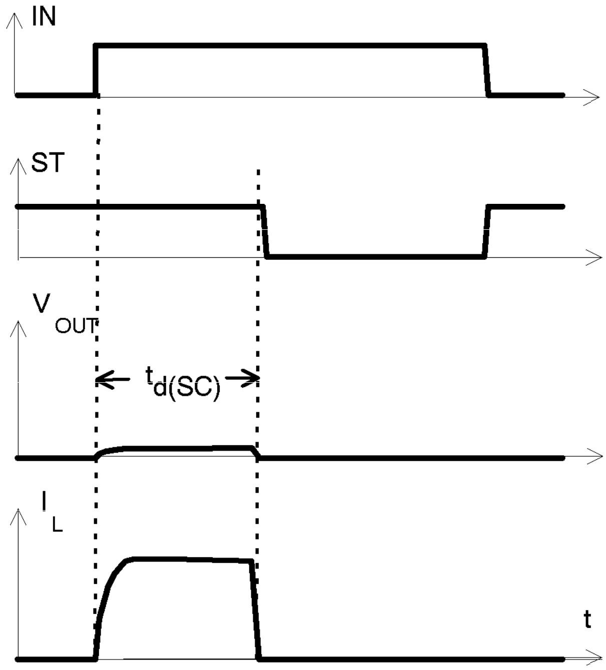
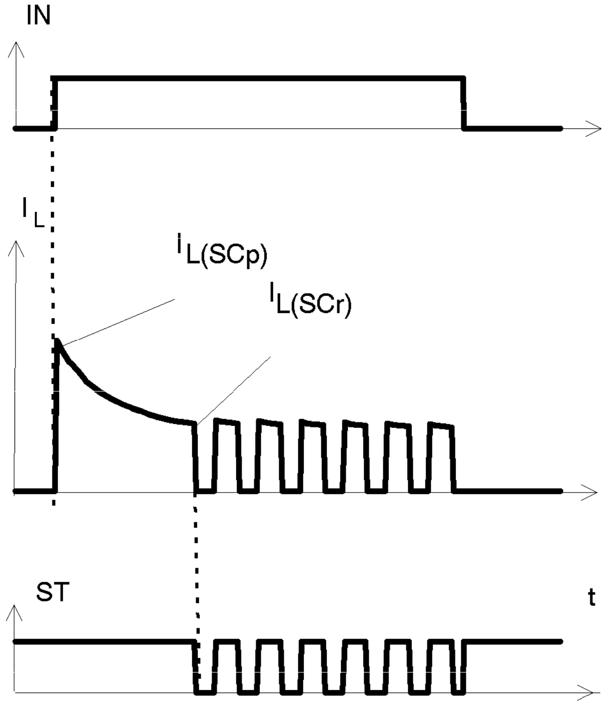


Figure 3a: Turn on into short circuit,



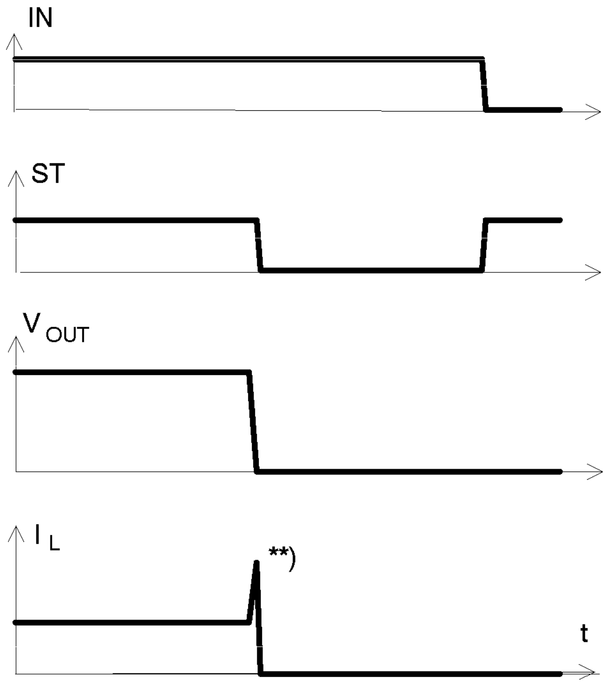
$t_{d(SC)}$ approx. 200µs if V_{bb} - V_{OUT} > 8.3 V typ.

Figure 3b: Turn on into overload,



Heating up may require several milliseconds , V_{bb} - V_{OUT} < 8.3 V typ.

Figure 3c: Short circuit while on:



**) current peak approx. 20 µs

Figure 4a: Overtemperature:
Reset if $T_j < T_{jt}$

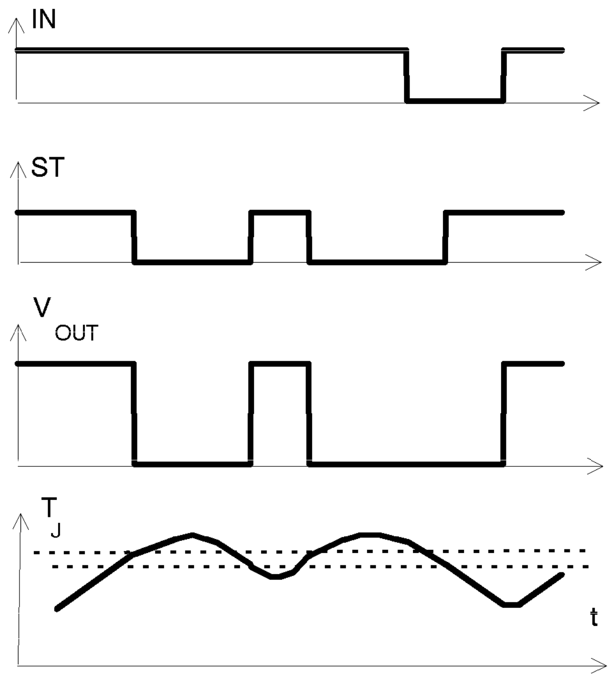


Figure 5a: Open load: detection in ON-state, turn on/off to open load

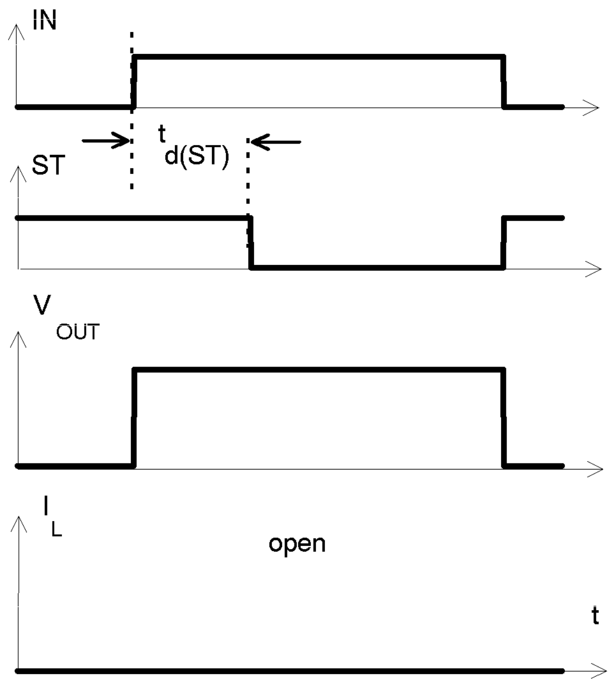
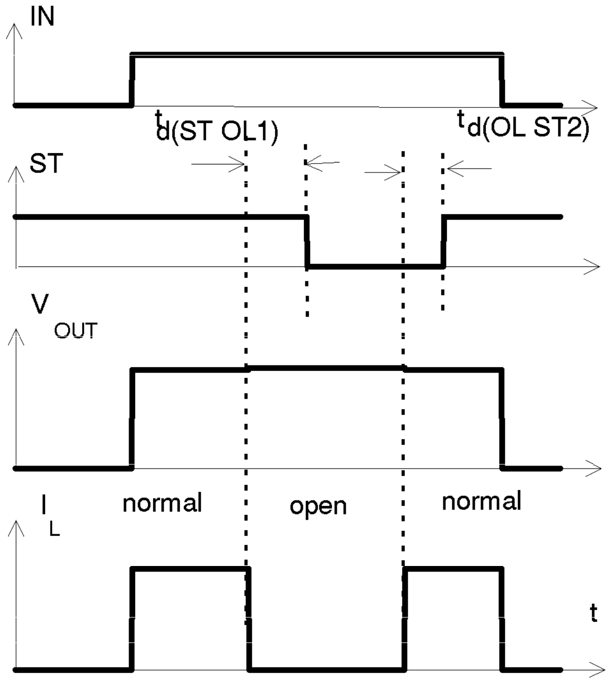
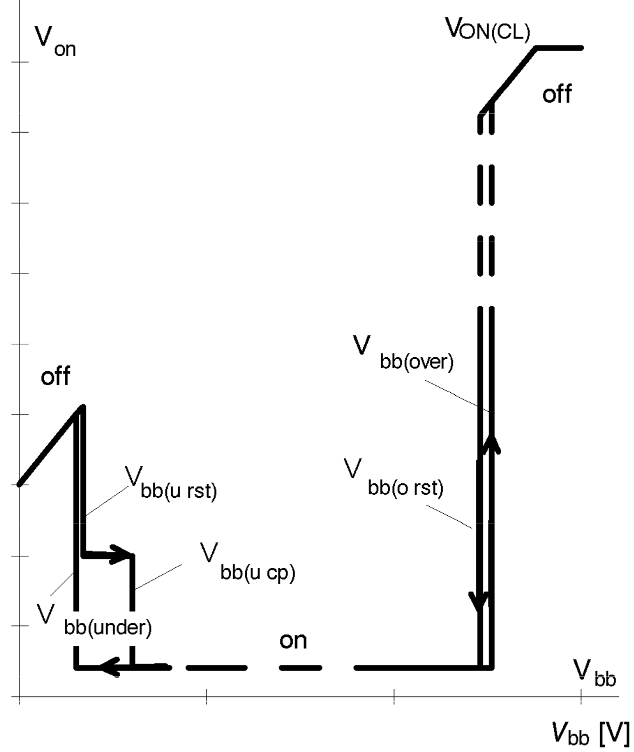


Figure 5b: Open load: detection in ON-state, open load occurs in on-state



$t_{d(ST\ OL1)}$ = tbd µs typ., $t_{d(ST\ OL2)}$ = tbd µs typ

Figure 6b: Undervoltage restart of charge pump
V_{ON} [V]



charge pump starts at $V_{bb(ucp)}$ =6.5 V typ.

Figure 6a: Undervoltage:

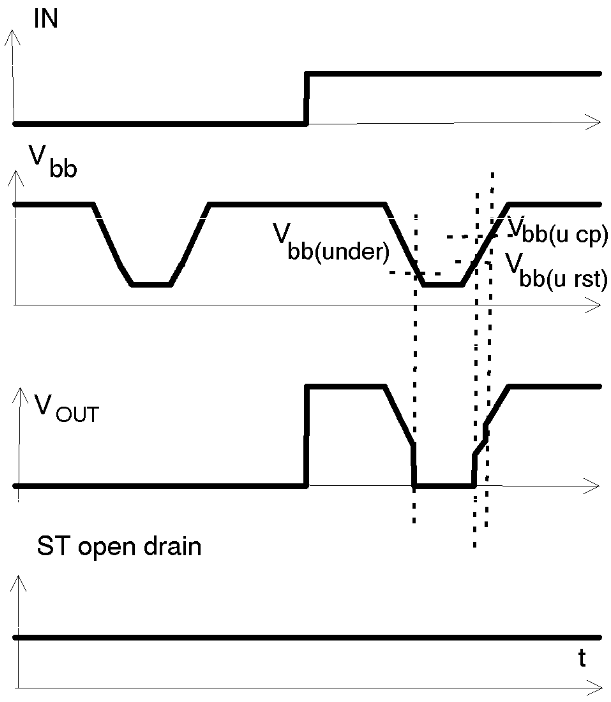
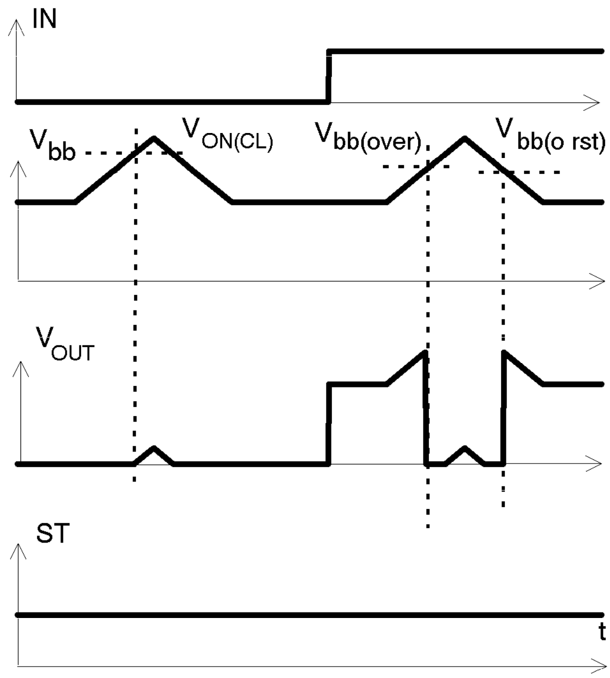


Figure 7a: Overvoltage:

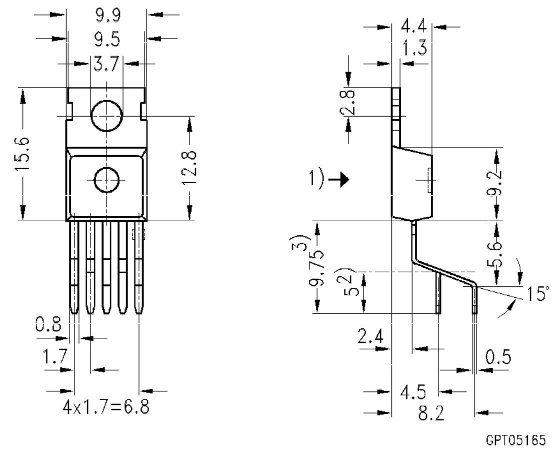


Package and Ordering Code

All dimensions in mm

Standard TO-220AB/5 Ordering code

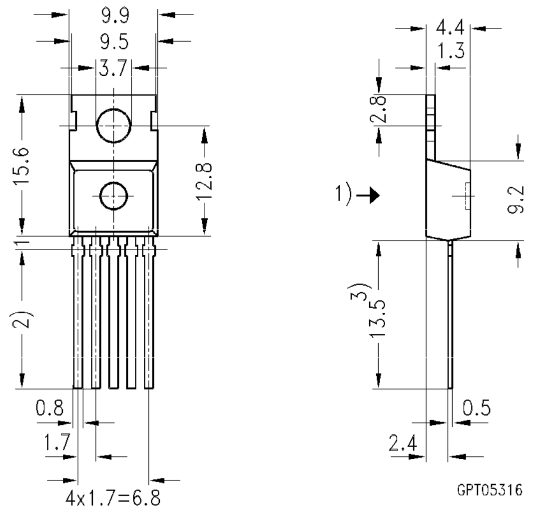
BTS 432 E2	Q67060-S6202-A2



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

TO-220AB/5, Option E3043 Ordering code

BTS 432 E2 E3043	Q67060-S6202-A4



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

SMD TO-220AB/5, Opt. E3062 Ordering code

BTS432E2 E3062A	T&R:	Q67060-S6202-A6