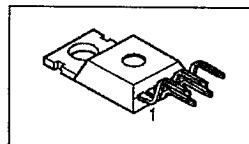


PROFET®

- High-side switch
- Short-circuit protection
- Overtemperature protection
- Overload protection
- Load dump protection
- Undervoltage and overvoltage shutdown with auto-restart and hysteresis
- Reverse battery protection
- Input and status protection
- Clamp of negative output voltage with inductive loads
- Protection against charged inductive load disconnect¹⁾
- Open load detection in ON-state
- Maximum current internally limited
- Status output for load fault
- R_{ON} constant versus V_{bb}
- Electrostatic Discharge (ESD) protection

Version differences see truth table and options overview, page 140...141

Package: TO220AB/5 (mounting flange is shorted to pin 3),
different package outlines (see page 148) on request



Ordering codes and packages see page 148

Pins				
1	2	3	4	5
GND	IN	V_{bb}	ST	OUT
-	I	+	S	O (Load,L)

Maximum Ratings

Parameter	Symbol	Values	Unit
Active overvoltage protection	$V_{bb(AZ)}$	> 50	V
Load current (Short-circuit current, see page 139)	I_L	self-limited	A
Operating temperature range	T_j	-40 ... +150	°C
Storage temperature range	T_{stg}	-55 ... +150	
Max. power dissipation	P_{tot}	125	W
Maximum current through input pin (DC)	I_{IN}	± 2.0	mA
Maximum current through status pin (DC) see internal circuit diagram see chapter 2	I_{ST}	± 5.0	
Thermal resistance chip - case	R_{thJC}	1	K/W
chip - ambient:	R_{thJA}	75	



¹⁾ with 150 Ω resistor in GND connection or freewheeling diode between V_{bb} and GND or freewheeling diode parallel to load. To protect against V_{bb} loss with an inductive load, it is recommended that a freewheeling diode be added between V_{bb} and GND.

Electrical Characteristics

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

Load Switching Capabilities and Characteristics

On-state resistance (pin 3 to 5) $I_L = 2\text{ A}$, $V_{IN}=\text{high}$	$T_j=25^\circ\text{C}$: $T_j=150^\circ\text{C}$:	R_{ON}	--	30 56	38 70	$\text{m}\Omega$
Nominal load current (pin 3 to 5) ISO Proposal: $V_{bb} - V_{OUT} \leq 0.5\text{ V}$, $T_C = 85^\circ\text{C}$		$I_{L(\text{ISO})}$	9	--	--	A
Open load detection current	$T_j=25..150^\circ\text{C}$: $T_j=-40^\circ\text{C}$:	$I_{L(\text{OL})}$	2 2	-- --	750 1000	mA
Turn-on time	to 90% V_{OUT}	t_{on}	50	--	300	μs
Turn-off time	to 10% V_{OUT}	t_{off}	10	--	60	μs
$R_L = 12\Omega$						
Slew rate on 10 to 30% V_{OUT} , $R_L = 12\Omega$		dV/dt_{on}	--	--	2	$\text{V}/\mu\text{s}$
Slew rate off 70 to 40% V_{OUT} , $R_L = 12\Omega$		$-dV/dt_{off}$	--	--	4	
Standby current (pin 3) $V_{IN}=0$	$T_j=150^\circ\text{C}$:	$I_{bb(\text{off})}$		12 18	25 60	μA
Operating current (Pin 1), $V_{IN}=\text{high}$		I_{GND}	--	2.22)	--	mA
Short circuit shutdown delay after input pos. slope $T_j = -40...+150^\circ\text{C}$: $V_{bb}, V_{OUT} = V_{ON} > V_{ON(SC)}$ (see page 139) min value valid only, if input "low" time exceeds 60 μs		$t_{d(\text{SC})}$	80	--	350	μs

Input and Status Feedback³⁾

Allowable input voltage range, (pin 2 to 1)	V_{IN}	-0.5	--	5.5	V	
Input turn-on threshold voltage	$V_{IN(T+)}$	1.5	--	2.4	V	
Input turn-off threshold voltage	$V_{IN(T-)}$	0.8	--	--	V	
Input threshold hysteresis	$\Delta V_{IN(T)}$	--	0.5	--	V	
Off state input current (pin 2)	$V_{IN(\text{off})} = 0.4\text{ V}$	$I_{IN(\text{off})}$	1	--	30	μA
On state input current (pin 2)	$V_{IN(\text{on})} = 3.5\text{ V}$	$I_{IN(\text{on})}$	10	25	70	
Delay time for status with open load (see timing diagrams, page 147)	$t_{d(ST\text{OL1})}$ $t_{d(ST\text{OL2})}$	-- --	700 200	--	--	μs
Status valid after input slope	$T_j = -40 \dots +150^\circ\text{C}$: (short circuit, open load)	$t_{d(ST)}$	80	--	350	μs

2) see diagram page 145, Add I_{ST} , if $I_{ST} > 0$ 3) if a ground resistor R_{GND} is used, add the voltage across this resistor. Internal Z-diode typ. 6.1 V, see maximum ratings page 137, (see chapter 3)

BTS 432 E

Parameter and Conditions at $T_j = 25^\circ\text{C}$, $V_{bb} = 12\text{V}$ unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Status output (open drain)					
zener limit voltage, $T_j = +25^\circ\text{C}$:	$V_{ST(\text{high})}$	5.5	6.1	6.6	V
$T_j = -40...+150^\circ\text{C}$:		5.4	--	6.9	
$T_j = -40...+25^\circ\text{C}$, $I_{ST} = +1.6\text{mA}$:	$V_{ST(\text{low})}$	--	--	0.8	
$T_j = +150^\circ\text{C}$, $I_{ST} = +1.6\text{ mA}$:	I_{ST}	--	--	1.0	mA
		--	--	1.6	

Operating and Clamp Voltages

Operating voltage	$T_j = 25^\circ\text{C}$: $T_j = -40...+150^\circ\text{C}$:	$V_{bb(\text{on})}$	4.9 5.8	--	42 40	V
Undervoltage shutdown	$T_j = 25...+150^\circ\text{C}$: $T_j = -40^\circ\text{C}$:	$V_{bb(\text{undor})}$	2.4 3.0	--	4.9 5.4	
Undervoltage restart	$T_j = 25...+150^\circ\text{C}$: $T_j = -40^\circ\text{C}$:	$V_{bb(\text{u rst})}$	-- --	--	4.9 5.8	
Oversupply shutdown	$T_j = -40...+150^\circ\text{C}$:	$V_{bb(\text{over})}$	42	--	52	
Oversupply restart	$T_j = -40...+150^\circ\text{C}$:	$V_{bb(\text{o rst})}$	40	--	--	
Oversupply protection	$T_j = -40...+150^\circ\text{C}$:	$V_{bb(\text{AZ})}$	50	56	--	
Load dump protection		$V_{bb(\text{LD})}$	--	--	93.5	
Output clamp (inductive load switch off)		$-V_{OUT(CL)}$	--	10	--	
Short circuit shutdown detection voltage (pin 3 to 5)		$V_{ON(SC)}$	--	8.6	10	

Protection Functions

Overload current limit (pin 3 to 5), after 50 ms, $V_{ON} = 8\text{ V}$, no heatsink ⁴⁾ , , see diagram page 143...144					
$T_j = -40...+150^\circ\text{C}$	$I_L(\text{lim})$	17.6	36	70	A
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Inductive load switch-off energy dissipation ⁵⁾ , $T_{j\text{ start}} = 150^\circ\text{C}$, $V_{bb} = 12\text{V}$ $E_{\text{Load}} = \frac{1}{2} * L * I_L^2$	E_{ab} E_{Load12} E_{Load24}	-- --	--	1.7 0.8 0.5	J
Reverse battery (pin 1 to 3) ⁶⁾	$-V_{bb}$	--	--	32	V

4) this occurs, if circuit resistance is so high, that no short circuit shutdown occurs ($V_{ON} < V_{ON(SC)}$)

5) while demagnetizing load inductance, dissipated energy in PROFET is $E_{ab} = \int(V_{bb} + |V_{OUT(CL)}|) * i_L(t) dt$,
approx. $E_{ab} = \frac{1}{2} * L * I_L^2 * (1 + \frac{V_{bb}}{|V_{OUT(CL)}|})$

6) Reverse load current (through intrinsic drain-source diode) is normally limited by the connected load. Reverse current I_{GND} of about 0.4 A at $V_{bb} = -32\text{ V}$ through the logic (see chapter 3) 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. In case of using GND-resistor it is recommended that 15kΩ resistors be inserted in series with IN and ST.

Truth Table

	Input-level	Output level	Status		
			version D	version E/F	version I1
Normal operation	L	L	H	H	H
	H	H	H	H	H
Open load	L	?)	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 ⁸⁾)	H (L ⁸⁾)	H
Overtemperature	L	L	L	L	L
	H	L	L	L	L
Under-voltage	L	L	L ⁹⁾	H	L ⁹⁾
	H	L	L ⁹⁾	H	L ⁹⁾
Overvoltage	L	L	L	H	L
	H	L	L	H	L

L = "Low" Level

H = "High" Level

- ?) Power Transistor off, high impedance
 8) low resistance to V_{bb} may be detected by no-load-detection
 9) no current sink capability during undervoltage shutdown

Options Overview

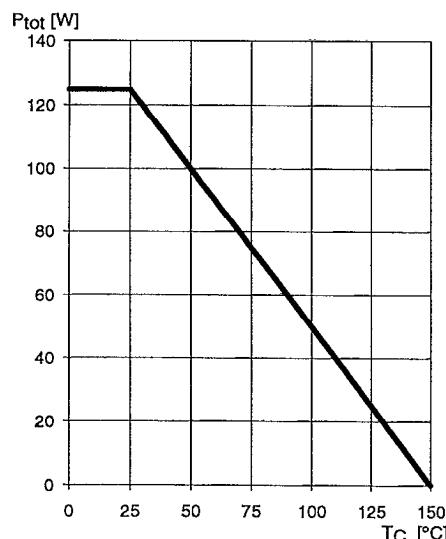
all versions: High-side switch, Input protection, ESD protection, load dump and reverse battery protection

Type	BTS	432D	432E	432F	432I1
Logic version		D	E	F	I
Overttemperature protection $T_J > 150^\circ\text{C}$, latch function ¹⁰⁾	X		X	X	
$T_J > 150^\circ\text{C}$, with auto-restart on cooling		X			
Short-circuit to GND protection switches off when $V_{bb} - V_{OUT} > 3.5 \text{ V typ.}$ (when first turned on after approx. 150 μs)	X	X	X	X	
switches off when $V_{bb} - V_{OUT} > 8.6 \text{ V typ.}$ (when first turned on after approx. 150 μs)					
Achieved through overtemperature protection					
Open load detection in OFF-state with sensing current 30 μA typ. in ON-state with sensing voltage drop across power transistor	X	X	X		X
Undervoltage shutdown with auto restart	X	X	X	X	
Oversupply shutdown with auto restart	X	X	X	X	
Status feedback for overttemperature	X	X	X		X
short circuit to GND	X	X	X		X
short to V_{bb}					X
open load	X	X	X		X
undervoltage, oversupply	X				X
Status output type CMOS	X		X		X
Open drain		X	X		
Output negative voltage transient limit (fast inductive load switch off)					
to -10 V typ	X	X	X		
to -16 V typ				X	
Load current limit high level (can handle loads with high inrush currents)	X	X		X	
low level (better protection of application)			X	X	

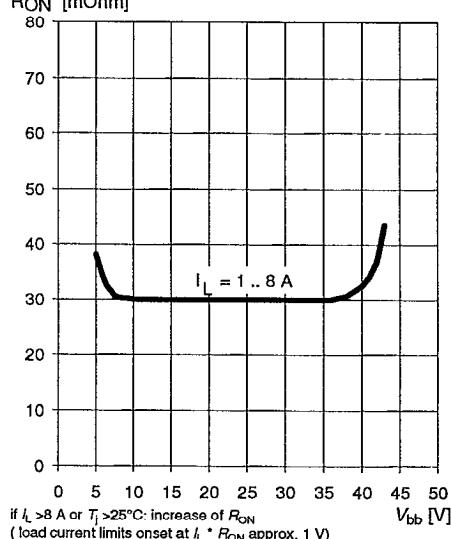


¹⁰⁾ Latch except when $V_{bb} - V_{OUT} < V_{ON(SC)}$ after shutdown. In most cases $V_{OUT} = 0 \text{ V}$ after shutdown ($V_{OUT} \neq 0 \text{ V}$ only if forced externally). So the device remains latched unless $V_{bb} < V_{ON(SC)}$ (see page 139). No latch between turn on and $t_{d(SC)}$.

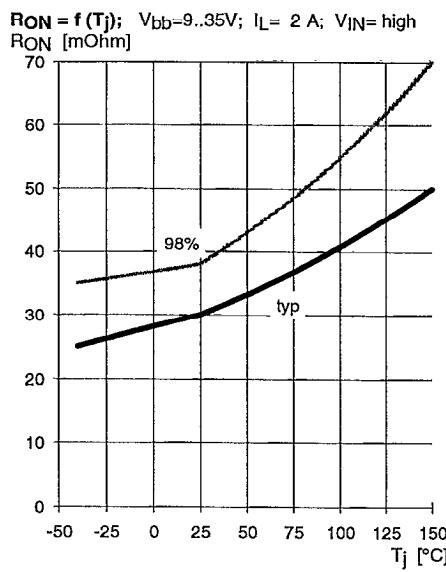
Maximum allowable power dissipation
 $P_{tot} = f(T_C)$



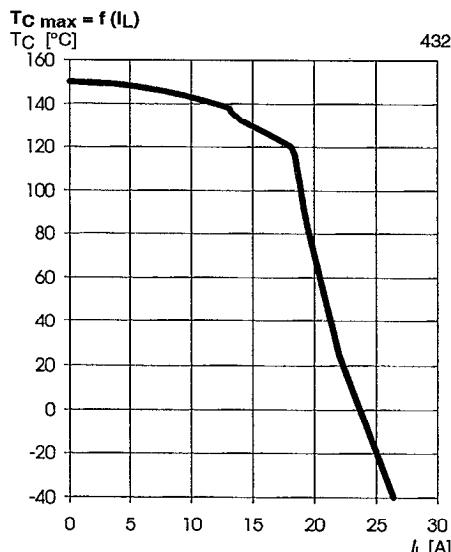
Typ. on-state resistance (V_{bb} -Pin to OUT-Pin)
 $R_{ON} = f(V_{bb}, I_L)$; V_{IN} = high, $T_j = 25^\circ\text{C}$



On-state resistance (V_{bb} -Pin to OUT-Pin)

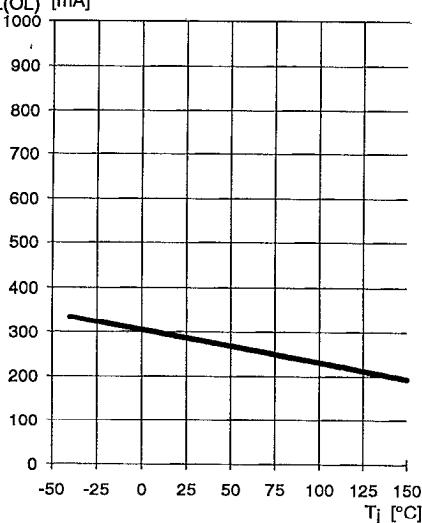


Max. case temperature vs DC load current

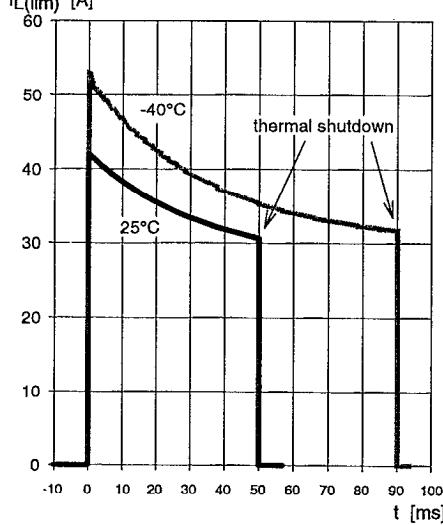


Typ. open load detect current

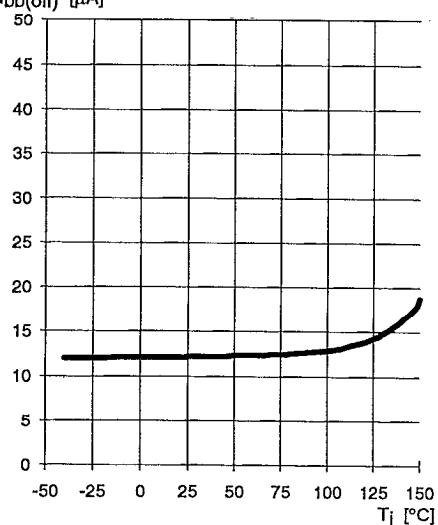
$I_{L(OL)} = f(T_j)$; $V_{bb} = 9..35 \text{ V}$; $V_{IN} = \text{high}$
 $I_{L(OL)} [\text{mA}]$

**Typ. overload current**

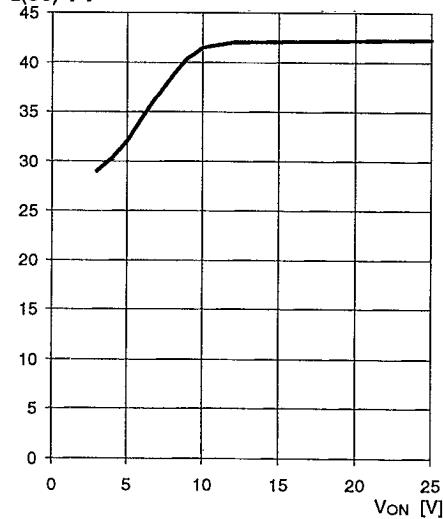
$I_{L(lim)} = f(t)$; $V_{bb} = 12 \text{ V}$, $V_{bb} - V_{OUT} = 8 \text{ V}$,
no heatsink, Parameter: T_j Start
 $I_{L(lim)} [\text{A}]$

**Typ. standby current**

$I_{bb(off)} = f(T_j)$, $V_{bb} = 9..35 \text{ V}$, $V_{IN} = \text{low}$
 $I_{bb(off)} [\mu\text{A}]$

**Typ. short circuit Current**

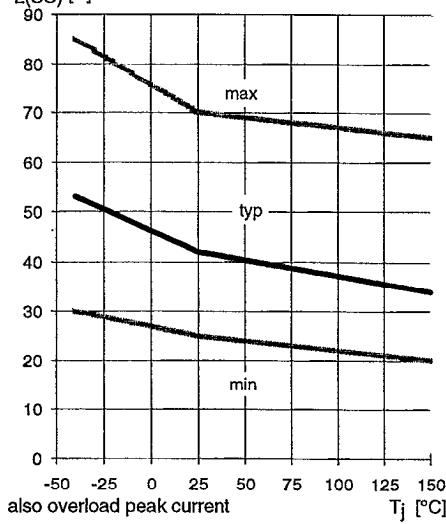
$I_{L(SC)} = f(V_{ON})$; $T_j = 25^{\circ}\text{C}$
 $I_{L(SC)} [\text{A}]$



Short circuit currentmax duration 350 μ s prior to shutdown

$$I_{L(SC)} = f(T_j), V_{bb} = 12 \dots 35V; V_{IN} = \text{High}$$

$$I_{L(SC)} [\text{A}]$$

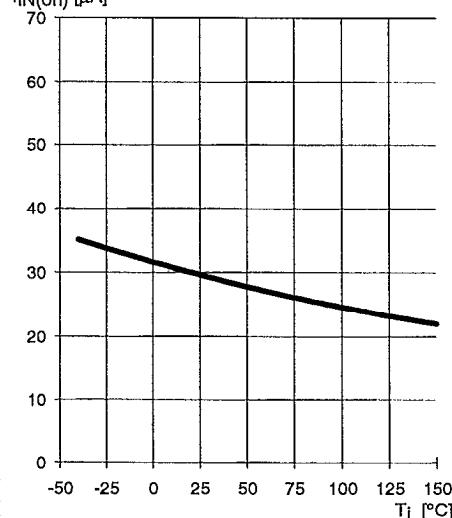


also overload peak current

Typ. input current high

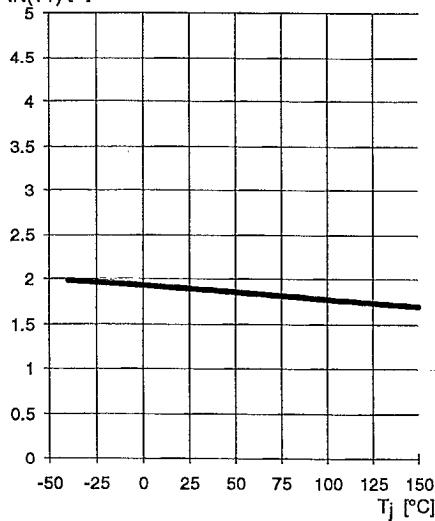
$$I_{IN(on)} = f(T_j) \quad V_{IN} = 3.5 \dots 5.5V$$

$$I_{IN(on)} [\mu\text{A}]$$

**Typ. input turn on voltage threshold**

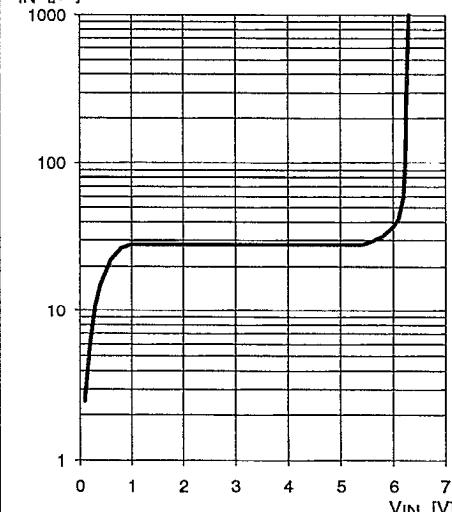
$$V_{IN(T+)} = f(T_j); \quad V_{bb} = 9 \dots 35V$$

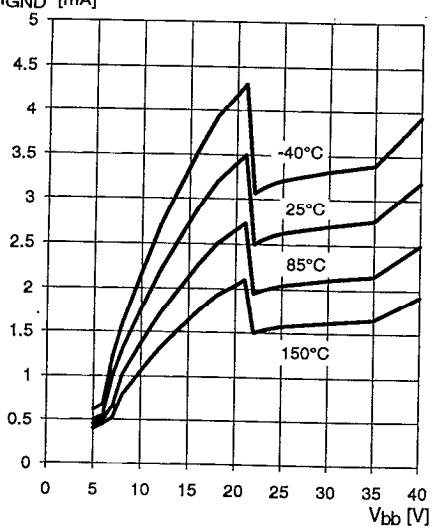
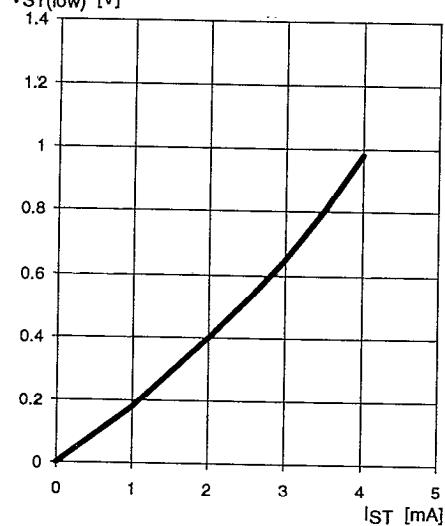
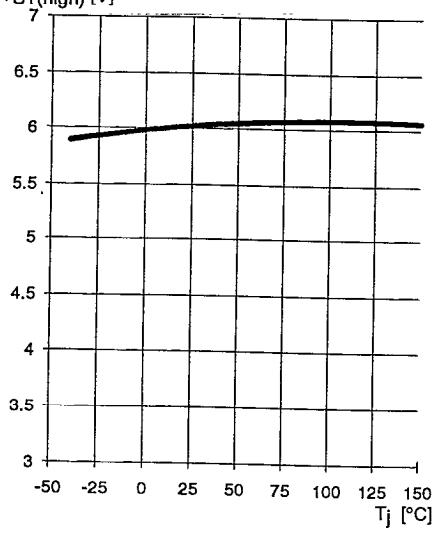
$$V_{IN(T+)} [\text{V}]$$

**Typ. input current**

$$I_{IN} = f(V_{IN}), \quad V_{bb} = 9 \dots 35V, \quad T_j = 25^\circ\text{C}$$

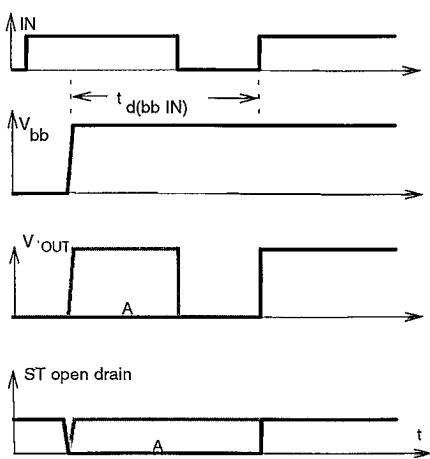
$$I_{IN} [\mu\text{A}]$$



Typ. ground pin operating current $I_{GND} = f(V_{bb}, T_j)$; $V_{IN} = \text{high}$ I_{GND} [mA]**Typ. status low voltage** $V_{ST(\text{low})} = f(I_{ST})$, $V_{bb} = 9 \dots 35V$, $T_j = 25^\circ\text{C}$ $V_{ST(\text{low})}$ [V]**Typ. status zener limit voltage** $V_{ST(\text{high})} = f(T_j)$ $V_{ST(\text{high})}$ [V]

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 μ s

Figure 2a: Switching a lamp,

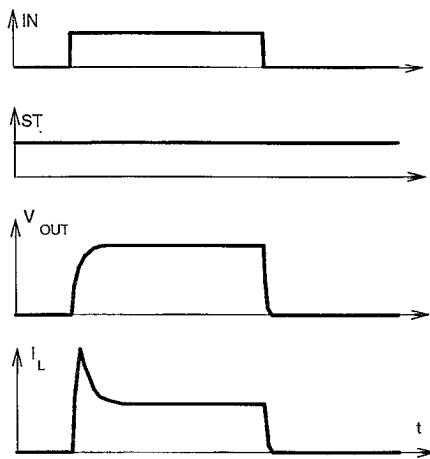
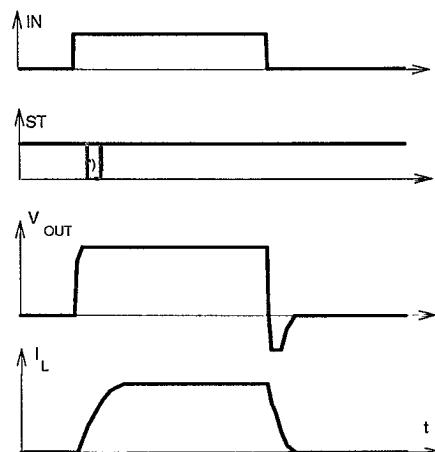


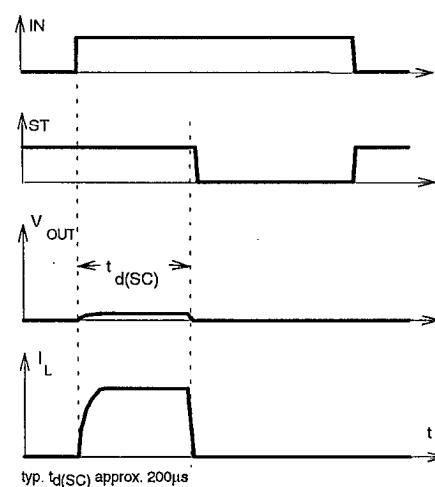
Figure 2b: Switching an inductive load,

(Better protection of application: versions BTS 432 F)



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

Figure 3a: turn on into short circuit,



typ. $t_d(SC)$ approx. 200 μ s

Figure 3b: short circuit while on:

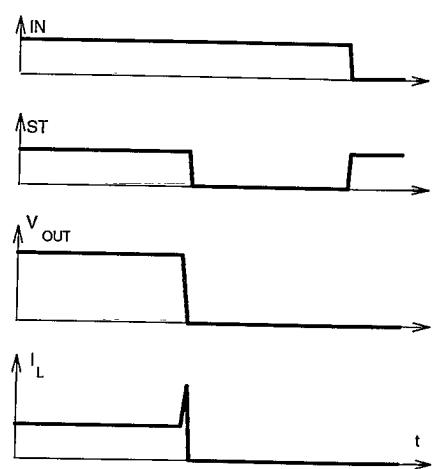


Figure 5a: open load: detection in ON-state, turn on to open load

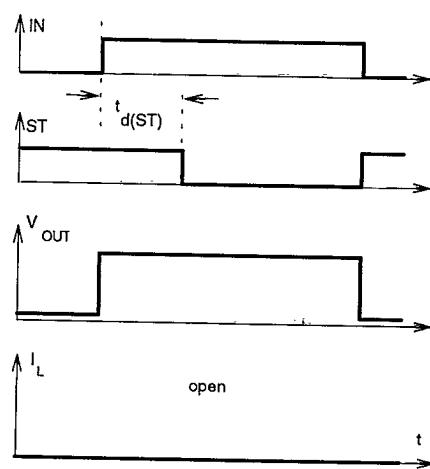


Figure 4a: overtemperature:
Reset if $T_j < T_{j\text{th}}$

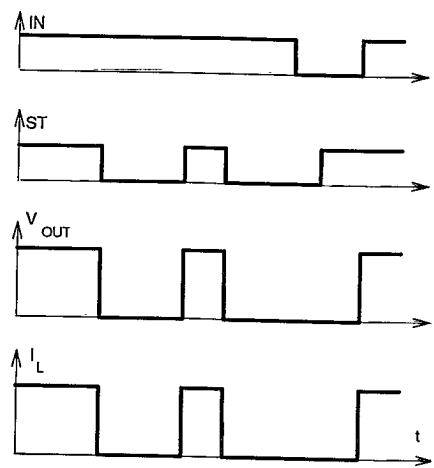
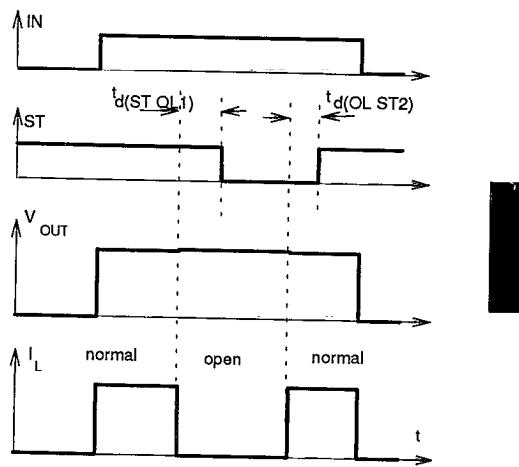


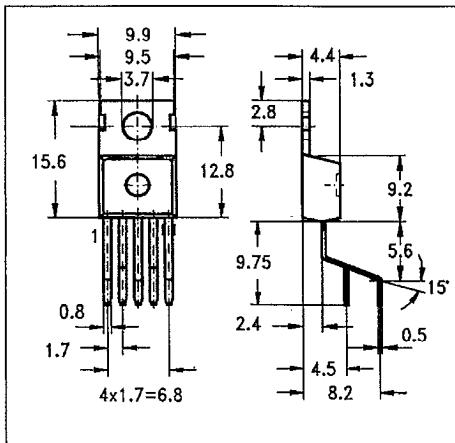
Figure 5b: open load: detection in ON-state, open load occurs in on-state



Package and ordering code

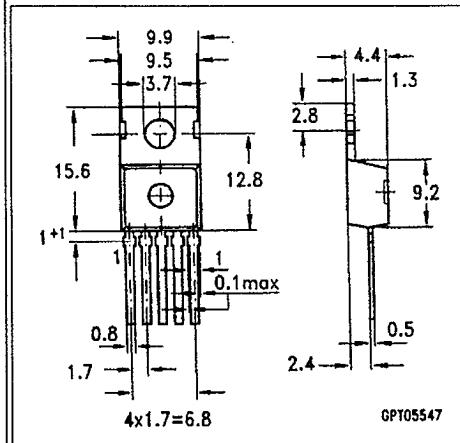
Standard

BTS 432 E C67078-S5303-A4



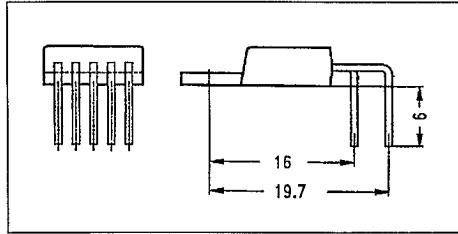
E3043

BTS 432 E C67078-S5303-A14



E3040

BTS 432 E C67078-S5303-A8



SMD

BTS 432 E E3062 Tube: C67078-S5303-A12

