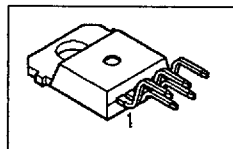


PROFET®

- 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 184...185

Package: TO218AB/5 (mounting flange is shorted to pin 3),
different package outlines (see page 192) on request

Ordering codes and packages see page 192

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 183)	I_L	self-limited	A	
Operating temperature range	T_I	-40 ...+150	°C	
Storage temperature range	T_{stg}	-55 ...+150		
Max. power dissipation	P_{tot}	170	W	
Maximum current through input pin (DC)	I_{IN}	±2.0	mA	
Maximum current through status pin (DC)	I_{ST}	±5.0		
see internal circuit diagram see chapter 2				
Thermal resistance	chip - case	R_{thJC}	0.75	K/W
	chip - ambient:	R_{thJA}	45	

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

Load Switching Capabilities and Characteristics

On-state resistance (pin 3 to 5) $I_L = 2\text{ A}$, $V_{IN} = \text{high}$	$T_j = 25\text{ }^{\circ}\text{C}$: $T_j = 150\text{ }^{\circ}\text{C}$:	R_{ON}	--	16 30	20 40	m Ω
Nominal load current (pin 3 to 5) ISO Proposal: $V_{bb} - V_{OUT} \leq 0.5\text{ V}$, $T_C = 85\text{ }^{\circ}\text{C}$		$I_{L(ISO)}$	17	--	--	A
Open load detection current	$T_j = 25..150\text{ }^{\circ}\text{C}$: $T_j = -40\text{ }^{\circ}\text{C}$:	$I_{L(OL)}$	2 2	-- --	1500 2000	mA
Turn-on time to 90% V_{OUT}		t_{on}	100	--	350	μs
Turn-off time to 10% V_{OUT}		t_{off}	10	--	80	
$R_L = 12\text{ }\Omega$						
Slew rate on 10 to 30% V_{OUT} , $R_L = 12\text{ }\Omega$		dV/dt_{on}	--	--	2	V/ μs
Slew rate off 70 to 40% V_{OUT} , $R_L = 12\text{ }\Omega$		$-dV/dt_{off}$	--	--	4	
Standby current (pin 3) $V_{IN} = 0$	$T_j = 150\text{ }^{\circ}\text{C}$:	$I_{bb(off)}$	--	12 18	25 60	μA
Operating current (Pin 1), $V_{IN} = \text{high}$		I_{GND}	--	2.2 ²⁾	--	mA
Short circuit shutdown delay after input pos. slope $T_j = -40..+150\text{ }^{\circ}\text{C}$: $V_{bb} - V_{OUT} = V_{ON} > V_{ON(SC)}$ (see page 183) min value valid only, if input "low" time exceeds 60 μs		$t_d(SC)$	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) $V_{IN(off)} = 0.4\text{ V}$		$I_{IN(off)}$	1	--	30	μA
On state input current (pin 2) $V_{IN(on)} = 3.5\text{ V}$		$I_{IN(on)}$	10	25	70	
Delay time for status with open load (see timing diagrams, page 191)		$t_d(ST\ OL1)$ $t_d(ST\ OL2)$	-- --	700 200	-- --	μs
Status valid after input slope (short circuit, open load) $T_j = -40 \dots +150\text{ }^{\circ}\text{C}$:		$t_d(ST)$	80	--	350	μs

²⁾ see diagram page 189, 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 181, (see chapter 3)

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
$T_j = -40 \dots +150^\circ\text{C}$:		5.4	--	6.9	
$T_j = -40 \dots +25^\circ\text{C}$, $I_{ST} = +1.6\text{mA}$:	$V_{ST(\text{low})}$	--	--	0.8	
$T_j = +150^\circ\text{C}$, $I_{ST} = +1.6\text{mA}$:		--	--	1.0	mA
	I_{ST}	--	--	1.6	

Operating and Clamp Voltages

Operating voltage	$T_j = 25^\circ\text{C}$: $T_j = -40 \dots +150^\circ\text{C}$:	$V_{bb(\text{on})}$	4.9 5.6	--	42 40	V
Undervoltage shutdown	$T_j = 25 \dots +150^\circ\text{C}$: $T_j = -40^\circ\text{C}$:	$V_{bb(\text{under})}$	2.4 3.0	--	4.9 5.4	
Undervoltage restart	$T_j = 25 \dots +150^\circ\text{C}$: $T_j = -40^\circ\text{C}$:	$V_{bb(\text{u rst})}$	-- --	--	4.9 5.6	
Overvoltage shutdown	$T_j = -40 \dots +150^\circ\text{C}$:	$V_{bb(\text{over})}$	42	--	52	
Overvoltage restart	$T_j = -40 \dots +150^\circ\text{C}$:	$V_{bb(\text{o rst})}$	40	--	--	
Overvoltage protection	$T_j = -40 \dots +150^\circ\text{C}$:	$V_{bb(\text{AZ})}$	50	56	--	
Load dump protection		$V_{bb(\text{LD})}$	--	--	93.5	
Output clamp (inductive load switch off)		$-V_{OUT(\text{CL})}$	--	10	--	
Short circuit shutdown detection voltage (pin 3 to 5)		$V_{ON(\text{SC})}$	--	8.6	10	

Protection Functions

Overload current limit (pin 3 to 5), see diagram page 187	$I_L(\text{lim})$					
Thermal overload trip temperature	T_{jt}	150	--	--		$^\circ\text{C}$
Inductive load switch-off energy dissipation ⁴⁾ , $T_{j\text{Start}} = 150^\circ\text{C}$, $V_{bb}=12\text{V}$ $V_{bb} = 12\text{V}$: $E_{\text{Load}} = \frac{1}{2} \cdot L \cdot I_L^2$ $V_{bb} = 24\text{V}$:	E_{ab} $E_{\text{Load}12}$ $E_{\text{Load}24}$	--	--	2.1 1.0 0.6		J
Reverse battery (pin 1 to 3) ⁵⁾	$-V_{bb}$	--	--	32		V

⁴⁾ while demagnetizing load inductance, dissipated energy in PROFET is $E_{ab} = \int (V_{bb} + |V_{OUT(\text{CL})}|) \cdot I_L(t) \, dt$,
approx. $E_{ab} = \frac{1}{2} \cdot L \cdot I_L^2 \cdot (1 + \frac{V_{bb}}{|V_{OUT(\text{CL})}|})$

⁵⁾ 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 15k Ω resistors be inserted in series with IN and ST.

Truth Table

	Input-level	Output level	Status	
			version D	version E/F
Normal operation	L	L	H	H
	H	H	H	H
Open load	L	⁶⁾	H	H
	H	H	L	L
Short circuit to GND	L	L	H	H
	H	L	L	L
Short circuit to V_{bb}	L	H	H	H
	H	H	H (L ⁷⁾)	H (L ⁷⁾)
Overtemperature	L	L	L	L
	H	L	L	L
Undervoltage	L	L	L ⁸⁾	H
	H	L	L ⁸⁾	H
Overvoltage	L	L	L	H
	H	L	L	H

L = "Low" Level

H = "High" Level

⁶⁾ Power Transistor off, high impedance⁷⁾ low resistance to V_{bb} may be detected by no-load-detection⁸⁾ no current sink capability during undervoltage shutdown

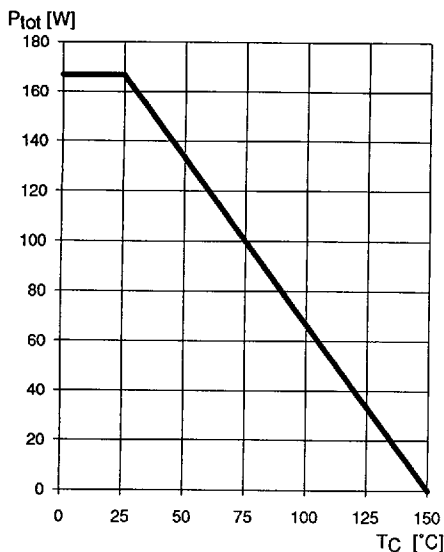
Options Overview

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

Type	BTS	542D	542E
Logic version		D	E
Overtemperature protection $T_j > 150\text{ }^{\circ}\text{C}$, latch function ⁹⁾ $T_j > 150\text{ }^{\circ}\text{C}$, with auto-restart on cooling		X	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) switches off when $V_{bb}-V_{OUT}>8.6\text{ V}$ typ. (when first turned on after approx. 150 μs) Achieved through overtemperature protection		X	X
Open load detection in OFF-state with sensing current 30 μA typ. in ON-state with sensing voltage drop across power transistor		X	X
Undervoltage shutdown with auto restart		X	X
Overvoltage shutdown with auto restart		X	X
Status feedback for overtemperature short circuit to GND short to V_{bb} open load undervoltage, overvoltage		X X X X	X X X X
Status output type CMOS Open drain		X	X
Output negative voltage transient limit (fast inductive load switch off) to -10 V typ		X	X
Load current limit high level (can handle loads with high inrush currents) low level (better protection of application)		X	X

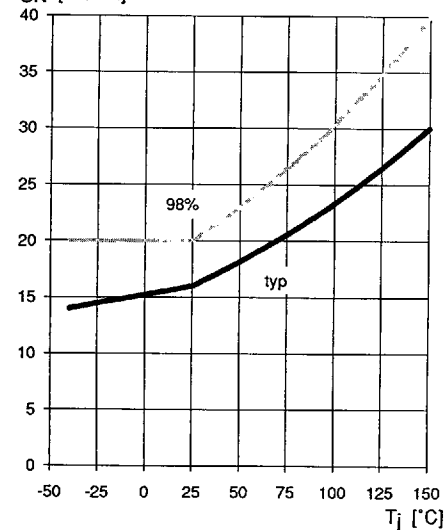
⁹⁾ Latch except when $V_{bb}-V_{OUT} < V_{ON(SC)}$ after shutdown. In most cases $V_{OUT}=0\text{ V}$ after shutdown ($V_{OUT} \neq 0\text{ V}$ only if forced externally). So the device remains latched unless $V_{bb} < V_{ON(SC)}$ (see page 183). No latch between turn on and $t_{d(SC)}$.

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

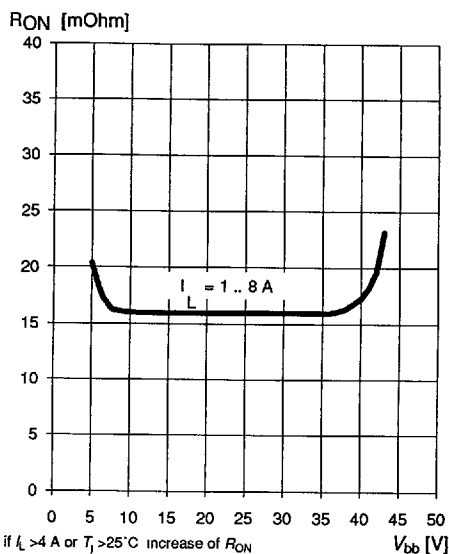


On-state resistance (V_{bb} -Pin to OUT-Pin)

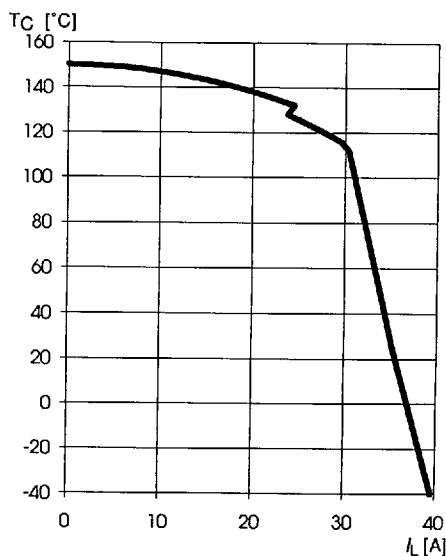
$R_{ON} = f(T_j)$; $V_{bb}=9..35V$; $I_L = 2 A$; $V_{IN} = \text{high}$
 R_{ON} [mOhm]



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

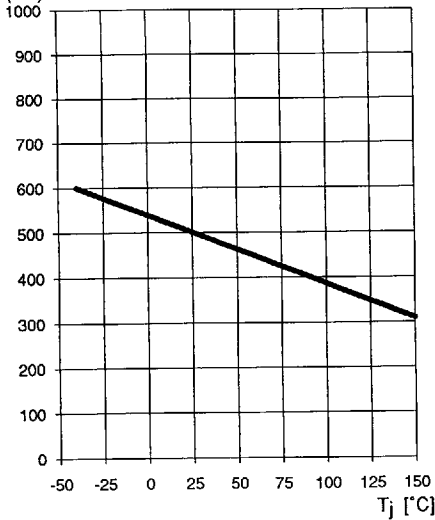


$T_C \text{ max} = f(I_L)$

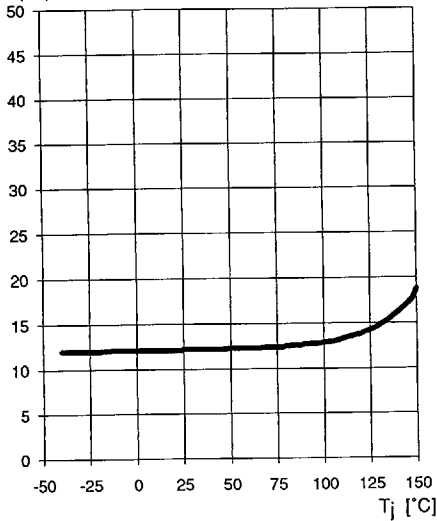


Typ. open load detect current

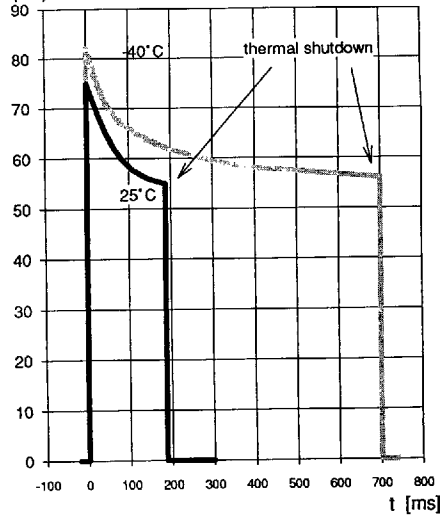
$I_{L(OL)} = f(T_j)$; $V_{bb}=9...35\text{ V}$; $V_{IN}=\text{high}$
 $I_{L(OL)}$ [mA]

**Typ. standby current**

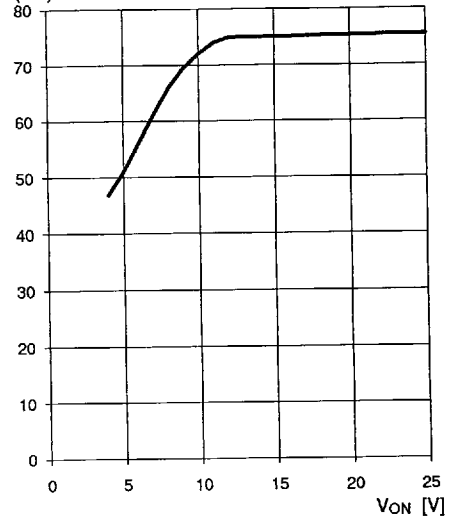
$I_{bb(off)} = f(T_j)$, $V_{bb}=9...35\text{ V}$, $V_{IN}=\text{low}$
 $I_{bb(off)}$ [μA]

**Typ. overload current**

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

**Typ. short circuit Current**

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



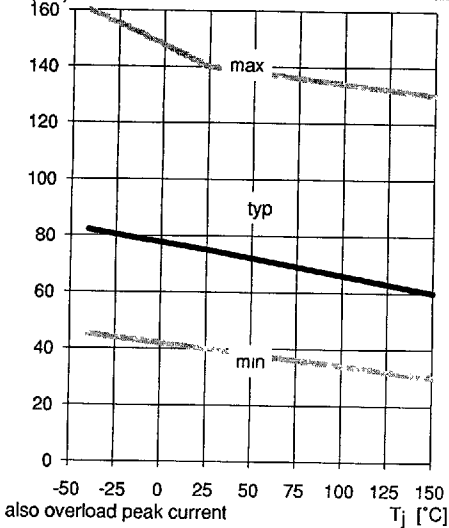
Short circuit current

max duration 350 μ s prior to shutdown

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

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

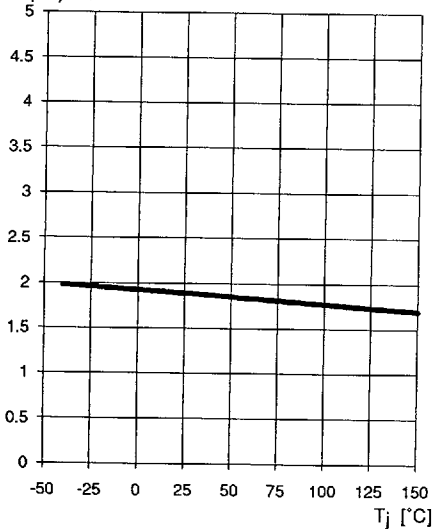
sc542de.xls



Typ. input turn on voltage threshold

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

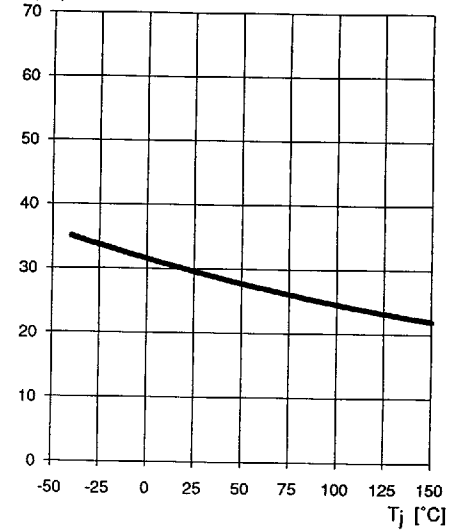
$V_{IN(T+)} [V]$



Typ. input current high

$I_{IN(on)} = f(T_j)$ $V_{IN} = 3.5...5.5V$

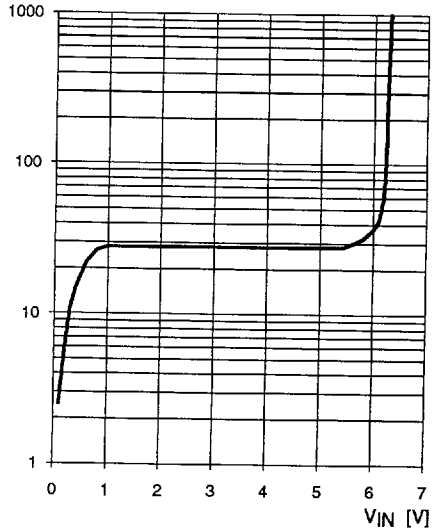
$I_{IN(on)} [\mu A]$



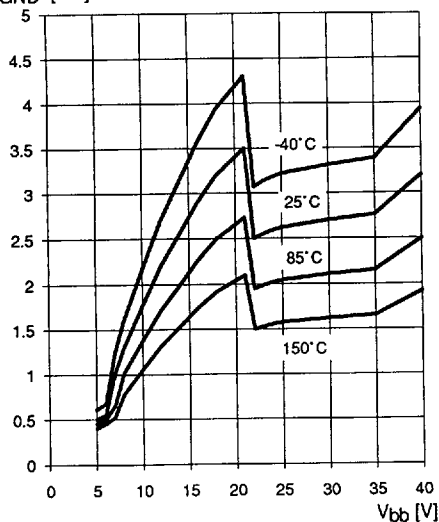
Typ. input current

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

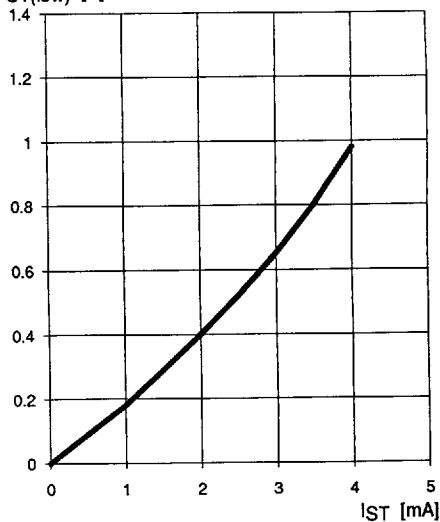
$I_{IN} [\mu A]$



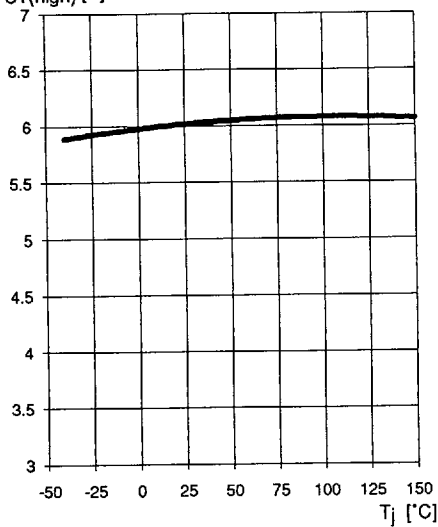
Typ. ground pin operating current

 $I_{GND} = f(V_{bb}, T_J); V_{IN} = \text{high}$ $I_{GND} [\text{mA}]$ 

Typ. status low voltage

 $V_{ST(\text{low})} = f(I_{ST}), V_{bb} = 9 \dots 35\text{V}, T_J = 25^\circ\text{C}$ $V_{ST(\text{low})} [\text{V}]$ 

Typ. status zener limit voltage

 $V_{ST(\text{high})} = f(T_J)$ $V_{ST(\text{high})} [\text{V}]$ 

Timing diagrams

Figure 1a: V_{bb} turn on:

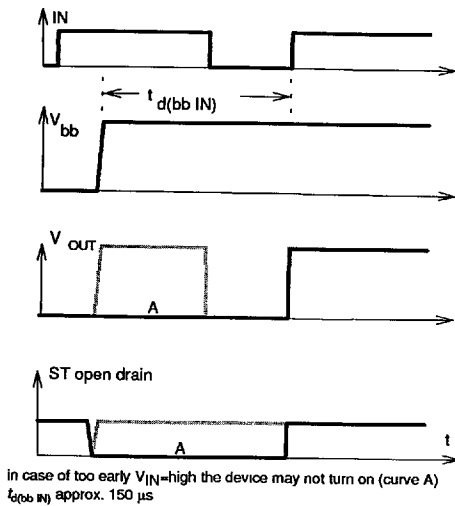


Figure 2a: Switching a lamp,

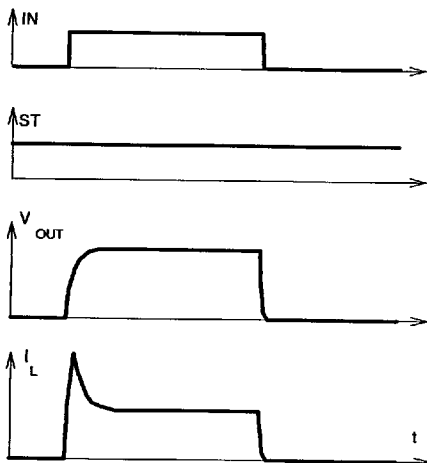
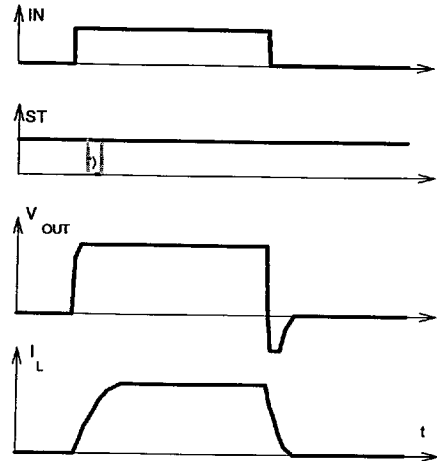


Figure 2b: Switching an inductive load,



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

Figure 3a: turn on into short circuit,

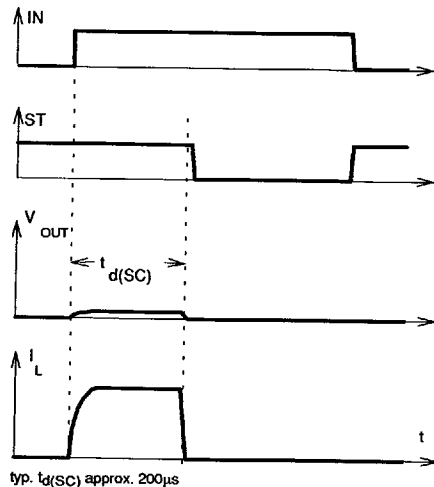


Figure 3b: short circuit while on:

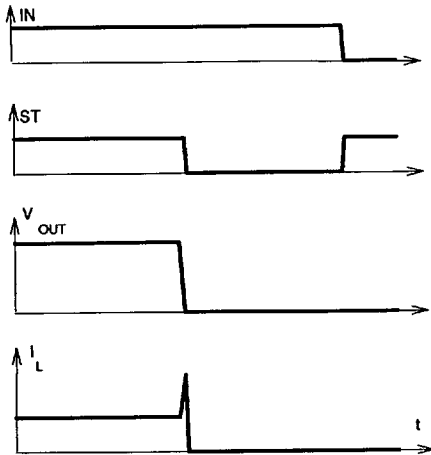
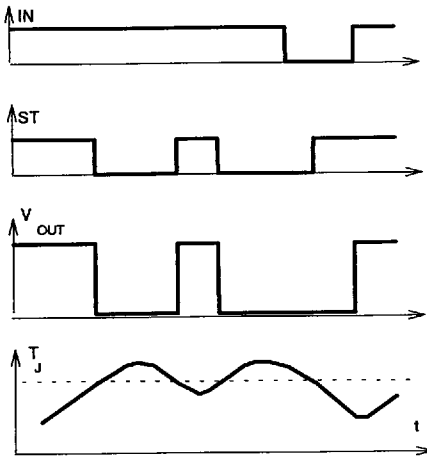
Figure 4a: overtemperature:
Reset if $T_J < T_{JR}$ 

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

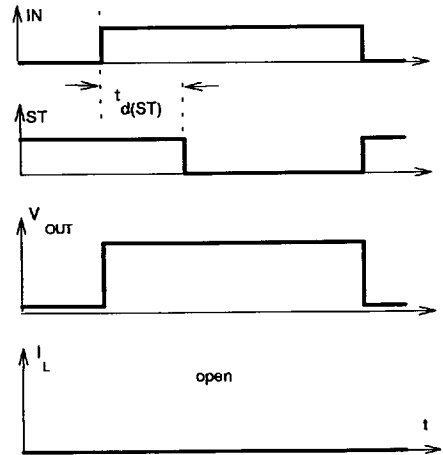
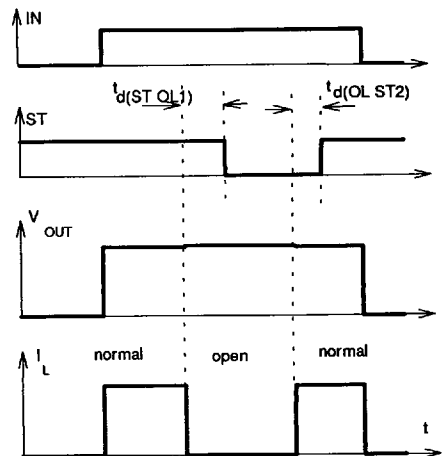


Figure 5b: open load: detection in ON-state, open load occurs in on-state



Package and ordering code**Standard**

BTS 542 E

C67078-S5400-A4

