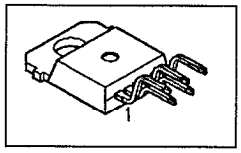
PROFET®

- 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 disconnect[1)]
- 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_j	-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 agains 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 °C, V_{bb} = 12V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Load Switching Capabilities and Characteristics					
On-state resistance (pin 3 to 5) I_L = 2 A, V_{IN}=high T_j=25 °C: T_j=150 °C:	R_{ON}	--	16 30	20 40	mΩ
Nominal load current (pin 3 to 5) ISO Proposal: V_{bb} - V_{OUT} ≤ 0.5 V, T_C = 85 °C	$I_{L(ISO)}$	17	--	--	A
Open load detection current T_j=25..150°C: T_j=-40 °C:	$I_{L(OL)}$	2 2	-- --	1500 2000	mA
Turn-on time to 90% V_{OUT} Turn-off time to 10% V_{OUT} R_L = 12 Ω	t_{on} t_{off}	100 10	-- --	350 80	µs
Slew rate on 10 to 30% V_{OUT}, R_L = 12 Ω	dV/dt_{on}	--	--	2	V/µs
Slew rate off 70 to 40% V_{OUT}, R_L = 12 Ω	$-dV/dt_{off}$	--	--	4	
Standby current (pin 3) V_{IN}=0 T_j=150°C:	$I_{bb(off)}$	 -- --	 12 18	 25 60	µA
Operating current (Pin 1), V_{IN}=high	I_{GND}	--	2.2[2]	--	mA
Short circuit shutdown delay after input pos. slope T_j =-40..+150°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 Feedback[3]					
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 V On state input current (pin 2) $V_{IN(on)}$ = 3.5 V	$I_{IN(off)}$ $I_{IN(on)}$	1 10	-- 25	30 70	µA
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 T_j=-40 ... +150°C: (short circuit, open load)	$t_{d(ST)}$	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 °C, V_{bb} = 12V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Status output (open drain)					
zener limit voltage, T_j =+25°C:	$V_{ST(high)}$	5.5	6.1	6.6	V
T_j =-40...+150°C:		5.4	--	6.9	
T_j =-40...+25°C, I_{ST} = +1.6mA:	$V_{ST(low)}$	--	--	0.8	
T_j = +150°C, I_{ST} = +1.6 mA:		--	--	1.0	
	I_{ST}	--	--	1.6	mA
Operating and Clamp Voltages					
Operating voltage T_j =25°C:	$V_{bb(on)}$	4.9	--	42	V
T_j =-40...+150°C:		5.6		40	
Undervoltage shutdown T_j =25..+150°C:	$V_{bb(under)}$	2.4	--	4.9	
T_j =-40°C:		3.0	--	5.4	
Undervoltage restart T_j =25...+150°C:	$V_{bb(u\ rst)}$	--	--	4.9	
T_j =-40°C:		--	--	5.6	
Overvoltage shutdown T_j =-40...+150°C:	$V_{bb(over)}$	42	--	52	
Overvoltage restart T_j =-40...+150°C:	$V_{bb(o\ rst)}$	40	--	--	
Overvoltage protection T_j =-40...+150°C:	$V_{bb(AZ)}$	50	56	--	
Load dump protection	$V_{bb(LD)}$	--	--	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) , see diagram page 187	$I_{L(lim)}$				
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Inductive load switch-off energy dissipation[4],	E_{ab}	--	--	2.1	J
$T_{j\,Start}$ = 150 °C, V_{bb}=12V V_{bb} = 12 V:	E_{Load12}			1.0	
$E_{Load} = {}^1/_2 * L * I_L^2$ V_{bb} = 24 V:	E_{Load24}			0.6	
Reverse battery (pin 1 to 3) [5]	$-V_{bb}$	--	--	32	V

[4] while demagnetizing load inductance, dissipated energy in PROFET is $E_{ab} = \int (V_{bb} + |V_{OUT(CL)}|) * i_L(t)\ dt$, approx. $E_{ab} = {}^1/_2 * L * I_L^2 * (1 + \frac{V_{bb}}{|V_{OUT(CL)}|})$

[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 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 useing 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
Normal operation	L H	L H	H H	H H
Open load	L H	[6] H	H L	H L
Short circuit to GND	L H	L L	H L	H L
Short circuit to V_{bb}	L H	H H	H H (L[7])	H H (L[7])
Overtem-perature	L H	L L	L L	L L
Under-voltage	L H	L L	L[8] L[8]	H H
Overvoltage	L H	L L	L L	H H

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

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

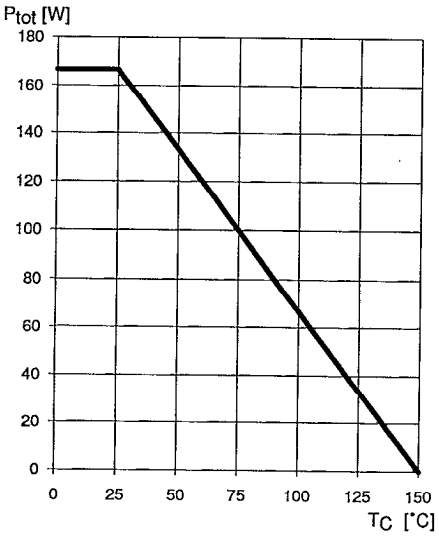
Options Overview

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 °C, latch function[9]	X	
T_j >150 °C, with auto-restart on cooling		X
Short-circuit to GND protection		
switches off when V_{bb}-V_{OUT}>3.5 V typ. (when first turned on after approx. 150 µs)		
switches off when V_{bb}-V_{OUT}>8.6 V typ. (when first turned on after approx. 150 µs)	X	X
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
Undervoltage shutdown with auto restart	X	X
Overvoltage shutdown with auto restart	X	X
Status feedback for		
overtemperature	X	X
short circuit to GND	X	X
short to V_{bb}		
open load	X	X
undervoltage, overvoltage	X	
Status output type		
CMOS	X	
Open drain		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)	X	X
low level (better protection of application)		

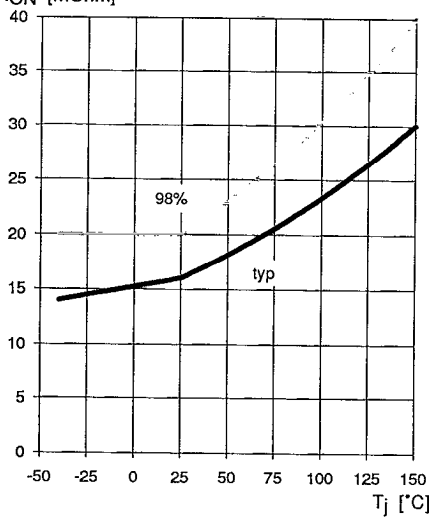
[9] Latch except when V_{bb} - V_{OUT} < $V_{ON(SC)}$ after shutdown. In most cases V_{OUT} =0 V after shutdown (V_{OUT} ≠ 0 V only if forced externaly). So the device remains latched unless V_{bb} < $V_{ON(SC)}$ (see page 183). No latch between turn on and $t_{d(SC)}$.

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

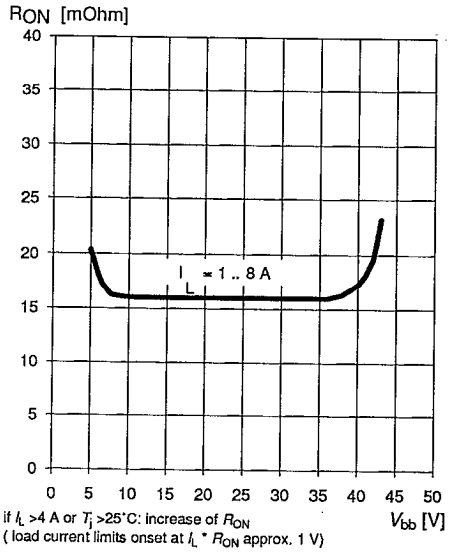


On-state resistance (V_{bb}-Pin to OUT-Pin)

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

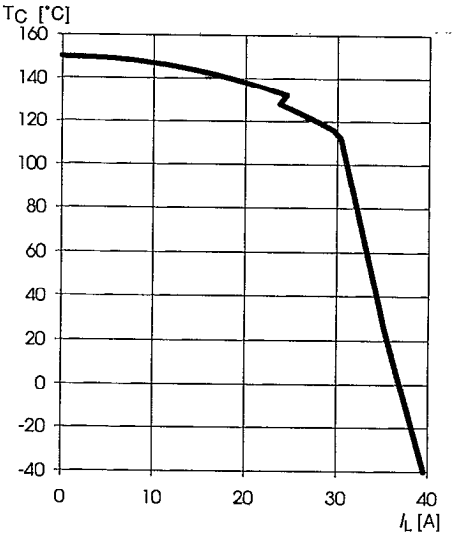


Typ. on-state resistance (V_{bb}-Pin to OUT-Pin)
$R_{ON} = f(V_{bb}, I_L)$; V_{IN}= high, T_j =25°C

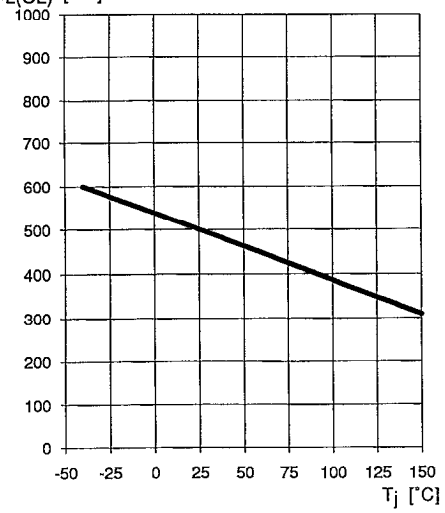


if I_L >4 A or T_j >25°C: increase of R_{ON}
(load current limits onset at I_L * R_{ON} approx. 1 V)

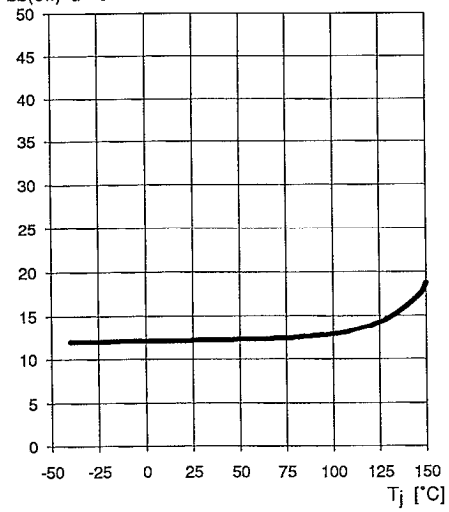
T_C max = f (I_L)



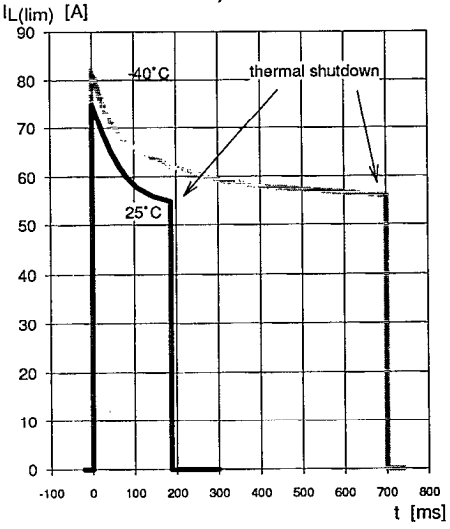
Typ. open load detect current
$I_{L(OL)} = f(T_j)$; V_{bb}=9..35 V; V_{IN}= high



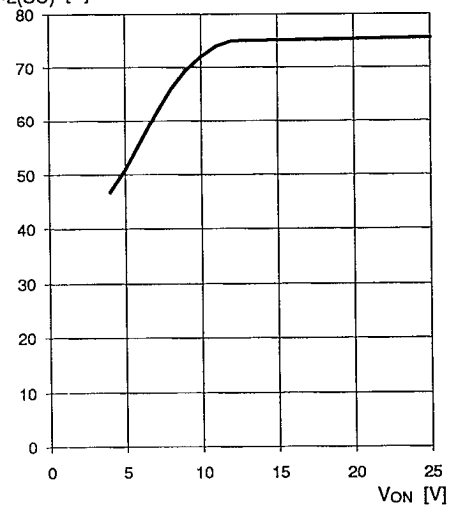
Typ. standby current
$I_{bb(off)} = f(T_j)$, V_{bb}=9...35 V, V_{IN}=low



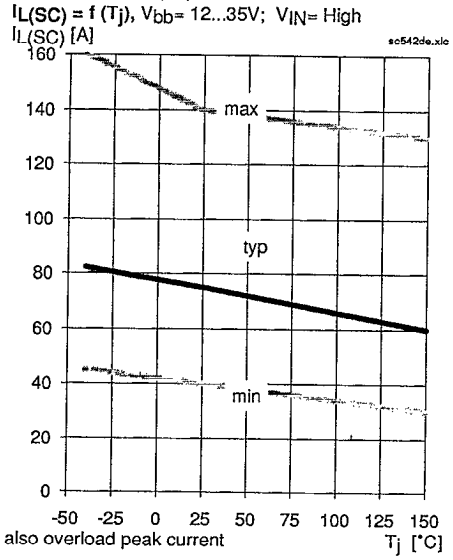
Typ. overload current
$I_{L(lim)} = f(t)$; V_{bb}= 12 V, V_{bb}-V_{OUT}=8 V, no heatsink, Parameter: $T_{j\,Start}$



Typ. short circuit Current
$I_{L(SC)} = f(V_{ON})$; T_j= 25°C

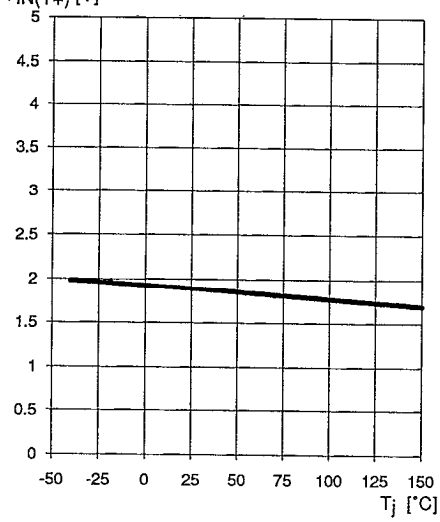


Short circuit current
max duration 350 µs prior to shutdown
$I_{L(SC)} = f(T_j)$, V_{bb}= 12...35V; V_{IN}= High

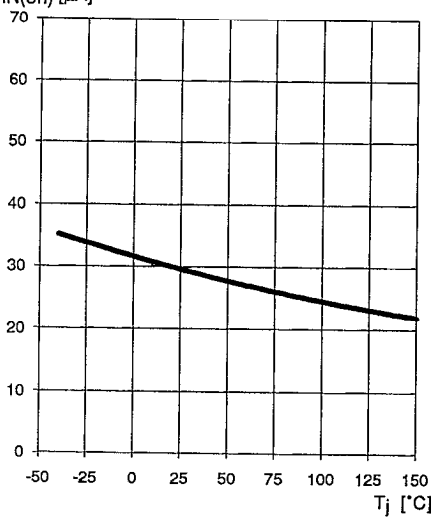


also overload peak current

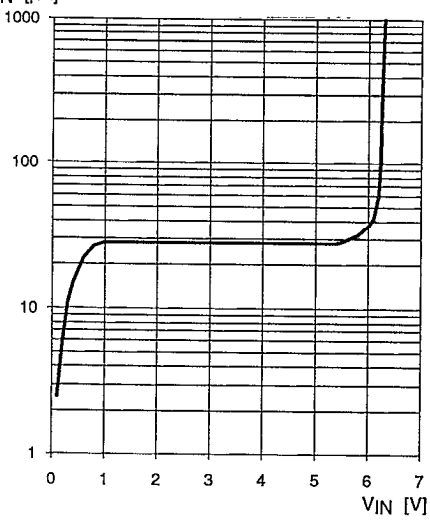
Typ. input turn on voltage threshold
$V_{IN(T+)} = f(T_j)$; V_{bb}=9...35 V



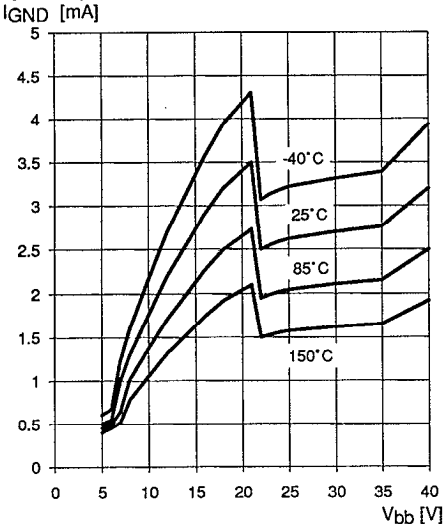
Typ. input current high
$I_{IN(on)} = f(T_j)$ V_{IN}= 3.5...5.5V



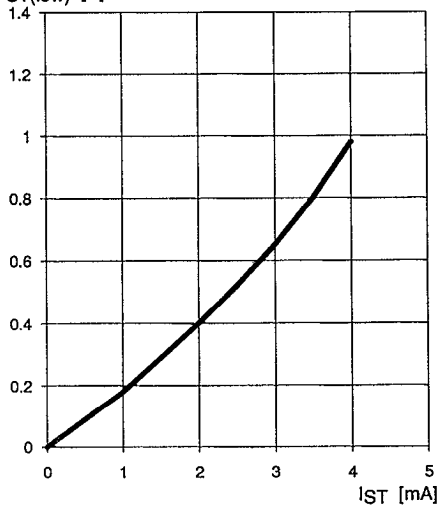
Typ. input current
$I_{IN} = f(V_{IN})$, V_{bb}= 9...35V, T_j=25°C



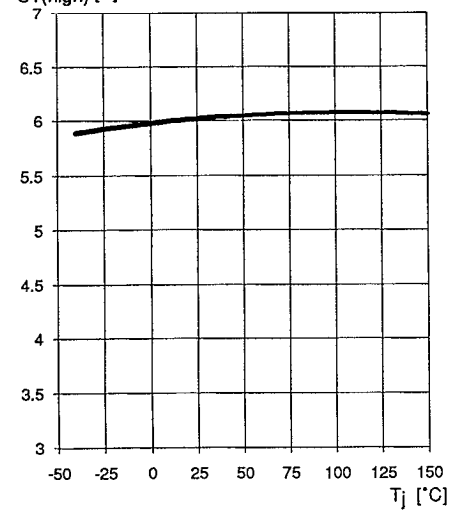
Typ. ground pin operating current
$I_{GND} = f(V_{bb}, T_J)$; V_{IN}= high



Typ. status low voltage
$V_{ST(low)} = f(I_{ST})$, V_{bb}= 9...35V, T_j=25°C

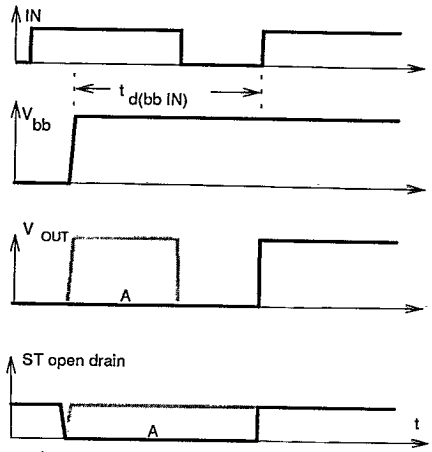


Typ. status zener limit voltage
$V_{ST(high)} = f(T_j)$



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,

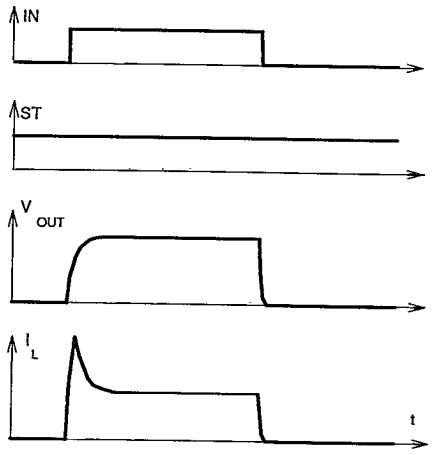
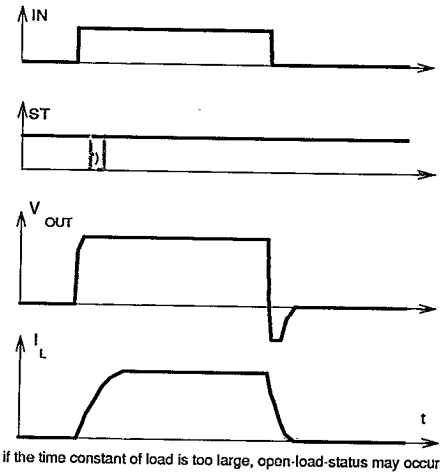
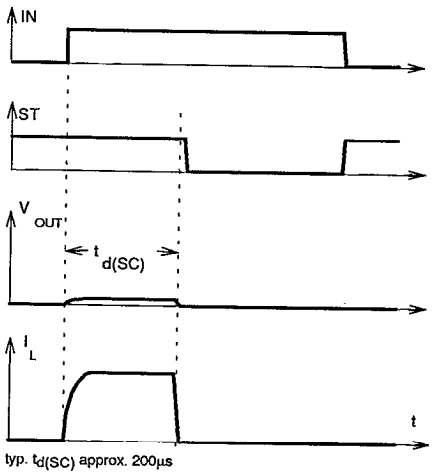


Figure 2b: Switching an inductive load,



*) 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. 200µs

Figure 3b: short circuit while on:

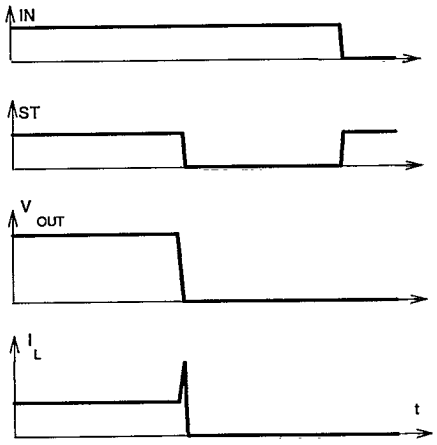


Figure 4a: overtemperature:
Reset if $T_j < T_{jt}$

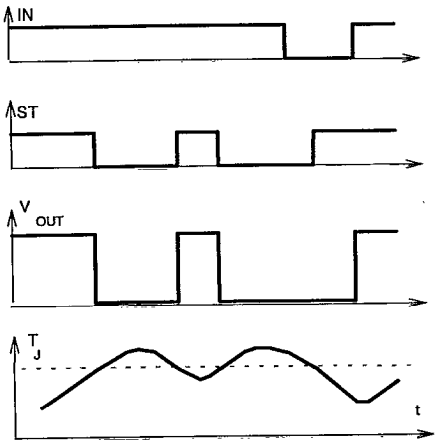


Figure 5a: open load: detection in ON-state, turn on to open load

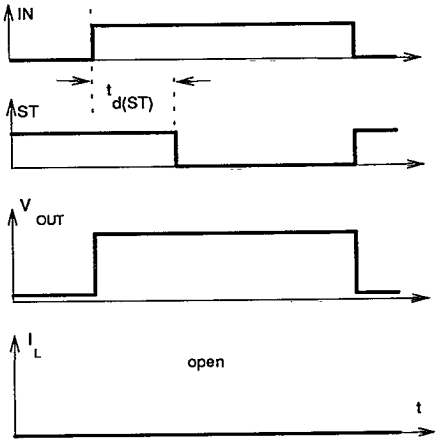
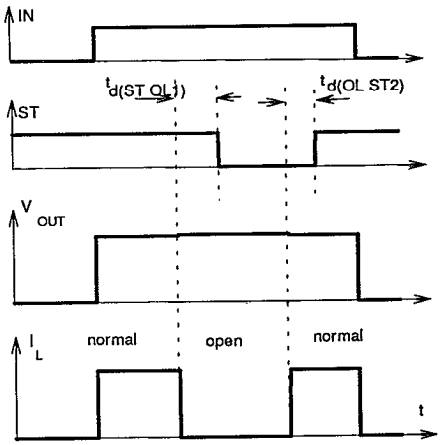


Figure 5b: open load: detection in ON-state, open load occurs in on-state



Package and ordering code

Standard

BTS 542 E	C67078-S5400-A4