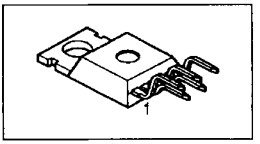
SIEMENS

Preliminary BTS 432 l1

PROFET®

- High-side switch
- Short-circuit protection
- Overtemperature protection
- Overload 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)]
- Protection against loss of ground[2)]
- Open load detection in OFF-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 163...165

Package: TO220AB/5 (mounting flange is shorted to pin 3), different package outlines (see page 168) on request

Ordering codes and packages see page 168

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 163)	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	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 agains V_{bb} loss with an inductive load, it is recommended that a freewheeling diode be added between V_{bb} and GND.

2) with additionl external shottky diode between V_{bb}- and GND-pin

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}	--	30 56	38 70	mΩ
Nominal load current (pin 3 to 5) ISO Proposal: V_{bb} - V_{OUT} ≤ 0.5 V, T_C = 85 °C	$I_{L(ISO)}$	9	--	--	A
Open load detection current	$I_{L(OL)}$	--	30	--	µA
Open load detection voltage	$V_{OUT(OL)}$	--	3	--	V
Turn-on time to 90% V_{OUT} Turn-off time to 10% V_{OUT} R_L = 12 Ω	t_{on} t_{off}	50 10	-- --	300 60	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, I_{ST}=0 T_j=150°C :	$I_{bb(off)}$	 --	 40	 80	µA
		--	48	120	
Operating current (Pin 1), V_{IN}=high	I_{GND}	--	2.2[3]	--	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 163) min value valid only, if input "low" time exceeds 60 µs	$t_{d(SC)}$	80	--	350	µs
Input and Status Feedback[4]					
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	$V_{IN(T-)}$	1.2	--	--	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 167)	$t_{d(ST\ OL3)}$		200		µs
Status valid after input slope T_j=-40 ... +150°C: (short circuit)	$t_{d(ST)}$	80	--	350	µs

[3] Add I_{ST}, if I_{ST} > 0

[4] 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 161, (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 (CMOS)					
T_j =-40...+150°C, I_{ST}= - 50 µA:	$V_{ST(high)}$ [6]	4.4	5.1	6.5	V
T_j =-40...+25°C, I_{ST} = +1.6 mA:	$V_{ST(low)}$	--	--	0.8	
T_j = +150°C, I_{ST} = +1.6 mA:		--	--	1.0	
Max. status current for current source (out):	$-I_{ST}$	--	--	0.25	mA
valid status output, current sink (in) [5]:	$+I_{ST}$	--	--	1.6	
T_j =-40...+150°C					
Operating and Clamp Voltages					
Operating voltage T_j =-40...+150°C:	$V_{bb(on)}$	5.6	--	40	V
Undervoltage shutdown T_j =25..+150°C:	$V_{bb(under)}$	2.0	--	4.8	
T_j =-40°C:		2.0	--	5.2	
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)	$-V_{OUT(CL)}$	--	16	--	
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 V, no heatsink[7],					
T_j=-40...+150°C version I:	$I_{L(lim)}$	8.8	25.5	57	A
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Inductive load switch-off energy dissipation[8],	E_{ab}	--	--	1.7	J
$T_{j\ Start}$ = 150 °C, V_{bb}=12V V_{bb} = 12 V:	E_{Load12}			0.4	
E_{Load} = ½ * L * I_L^2 V_{bb} = 24 V:	E_{Load24}			-0.9	
Reverse battery (pin 1 to 3) [9]	$-V_{bb}$	--	--	32	V

5) no current sink capability during undervoltage shutdown

6) $V_{St\ high} \approx V_{bb}$ during undervoltage shutdown

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

8) while demagnetizing load inductance, dissipated energy in PROFET is $E_{ab} = \int V_{bb(AZ)} * i_L(t)\ dt$.

9) 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. Input and Status currents have to be limited. is recommended that 15kΩ resistors be inserted in series with IN and ST.

Truth Table

	Input-level	Output level	Status version I1
Normal operation	L H	L H	H H
Open load	L H	[10] H	L H
Short circuit to GND	L H	L L	H L
Short circuit to V_{bb}	L H	H H	L H
Overtemperature	L H	L L	L L
Undervoltage	L H	L L	L[11] L[11]
Overvoltage	L H	L L	L L

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

[10] Power Transistor off, high impedance, versions BTS 432I1 internal pull up current source for open load detection.
[11] no current sink capability during undervoltage shutdown

Options Overview

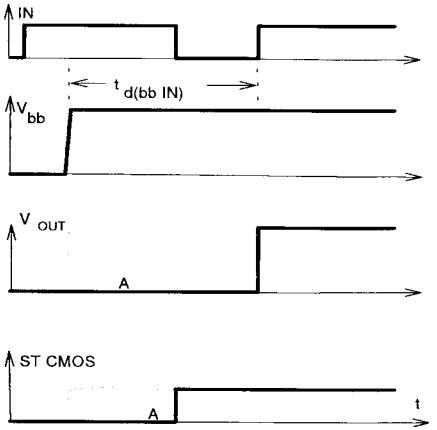
all versions: High-side switch, Input protection, ESD protection, load dump and reverse battery protection

Type BTS	432I1
Logic version	I
Overtemperature protection	
T_j >150 °C, latch function[12]	X
T_j >150 °C, with auto-restart on cooling	
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
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
Undervoltage shutdown with auto restart	X
Overvoltage shutdown with auto restart	X
Status feedback for	
overtemperature	X
short circuit to GND	X
short to V_{bb}	X
open load	X
undervoltage, overvoltage	X
Status output type	
CMOS	X
Open drain	
Output negative voltage transient limit (fast inductive load switch off)	X
Load current limit	
high level (can handle loads with high inrush currents)	
low level (better protection of application)	X

[12] 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 163). No latch between turn on and $t_{d(SC)}$.

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:

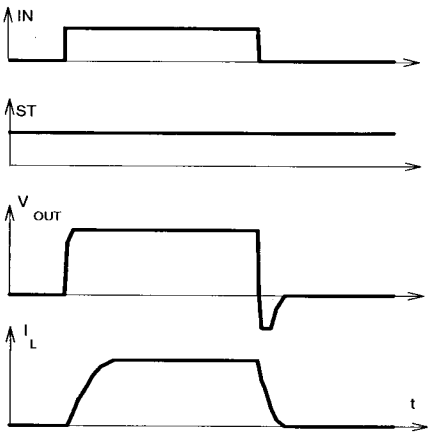
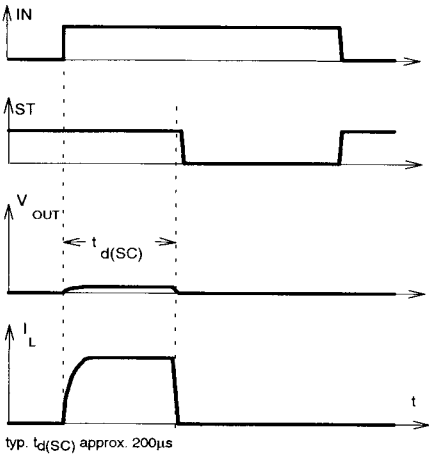


Figure 3a: turn on into short circuit,



typ. $t_{d(SC)}$ approx. 200µs

Figure 3b: short circuit while on:

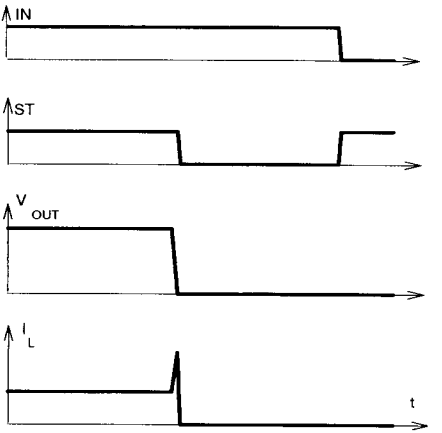
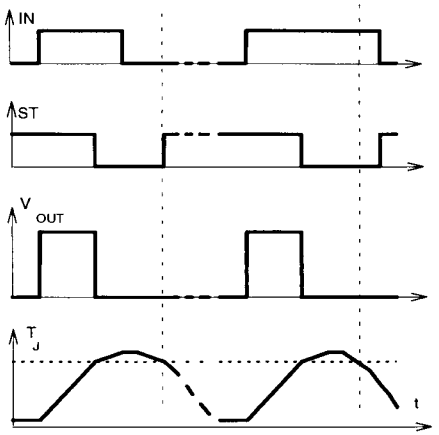


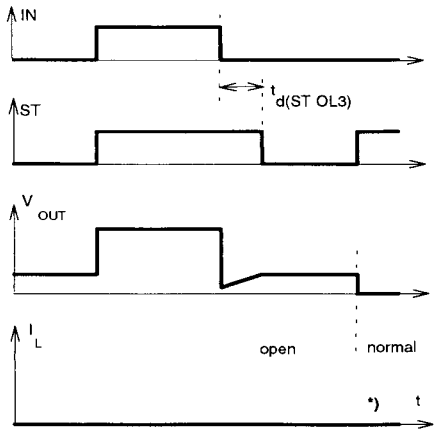
Figure 4a: overtemperature,

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



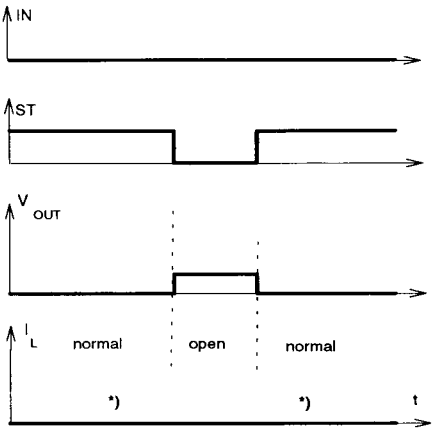
*) ST goes high , when V_{IN}=low **and** $T_j < T_{jt}$

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



$t_{d(ST,OL)}$ depends on external circuitry because of high impedance
*) I_L = 30 µA typ.

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

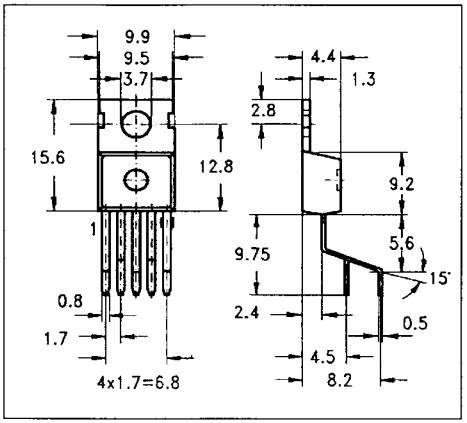


*) I_L = 30 µA typ

Package and ordering code

Standard

BTS 432 I1	C67078-S5308-A2



SMD

BTS 432I1 E3122A	T&R: C67078-S5308-A3