SIEMENS PROFET® Target Data Sheet BTS 555 P

Smart Highside High Current Power Switch

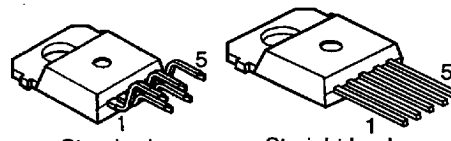
Features

- Overload protection
- Current limitation
- Short circuit protection
- Overtemperature protection
- Overvoltage protection (including load dump)
- Fast deenergizing of inductive loads
- Low ohmic inverse current operation
- Reverse battery protection
- Diagnostic feedback with load current sense
- Open load detection via current sense
- Loss of V_{bb} protection[1)]
- Electrostatic discharge (**ESD**) protection

Product Summary

Overvoltage protection	$V_{bb(AZ)}$	63	V
Operating voltage	$V_{bb(on)}$	4.5...34	V
On-state resistance	R_{ON}	3.6	mΩ
Load current (ISO)	$I_{L(ISO)}$	108	A
Short circuit current limitation	$I_{L(SCp)}$	450	A
Current sense ratio	$I_L : I_{IS}$	25 000	

TO-218AB/5



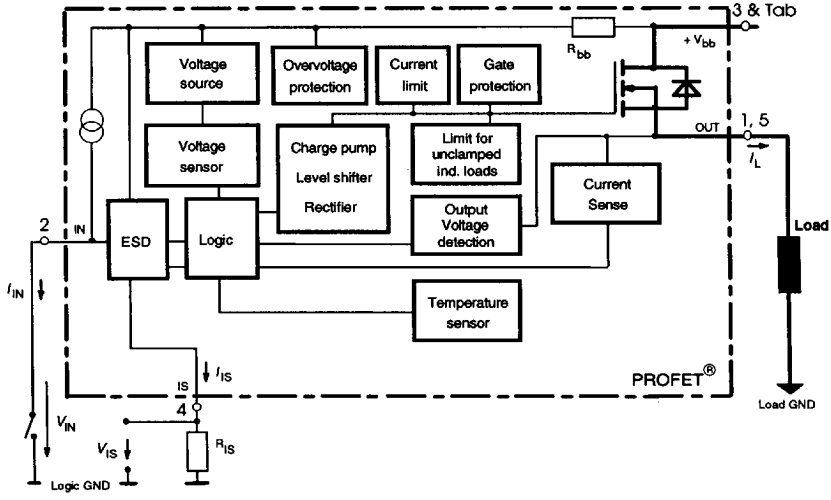
Standard Straight leads

Application

- Power switch with current sense diagnostic feedback for 12 V and 24 V DC grounded loads
- Most suitable for loads with high inrush current like lamps and motors; all types of resistive and inductive loads
- Replaces electromechanical relays, fuses and discrete circuits

General Description

N channel vertical power FET with charge pump, current controlled input and diagnostic feedback with load current sense, integrated in Smart SIPMOS® chip on chip technology. Fully protected by embedded protection functions.



1) Additional external diode required for energized inductive loads (see page 659).

Pin	Symbol		Function
1	OUT	O	Output to the load. The pins 1 and 5 must be shorted with each other especially in high current applications!*)
2	IN	I	Input, activates the power switch in case of short to ground
3	V_{bb}	+	Positive power supply voltage, the tab is shorted to this pin. In high current applications the tab should be used for V_{bb} connection.
4	IS	S	Diagnostic feedback providing a sense current proportional to the load current; zero current on failure (see Truth Table on page 658)
5	OUT	O	Output to the load. The pins 1 and 5 must be shorted with each other especially in high current applications!*)

*) Not shorting all outputs will considerably increase the on-state resistance, reduce the peak current capability and decrease the current sense accuracy

Maximum Ratings at $T_j = 25$ °C unless otherwise specified

Parameter	Symbol	Values	Unit
Supply voltage (overvoltage protection see page 655)	V_{bb}	52	V
Supply voltage for full short circuit protection $T_{j,start}$=-40 ...+150°C:	V_{bb}	34	V
Load current (short circuit current, see page 656)	I_L	self-limited	A
Load dump protection $V_{LoadDump} = U_A + V_S$, $U_A = 13.5$ V R_I[2)] = 2 Ω, R_L = 0.13 Ω, t_d = 200 ms, IN, IS = open or grounded	$V_{Load\ dump}$[3)]	80	V
Operating temperature range	T_j	-40 ...+150	°C
Storage temperature range	T_{stg}	-55 ...+150	
Power dissipation (DC), $T_C \leq 25$ °C	P_{tot}	310	W
Inductive load switch-off energy dissipation, single pulse V_{bb} = 12V, $T_{j,start}$ = 150°C, T_C = 150°C const. I_L = 20 A, Z_L = tbd mH, 0 Ω see diagrams on page 660	E_{AS}	tbd	J
Electrostatic discharge capability (ESD) (Human Body Model)	V_{ESD}	2.0	kV
Current through input pin (DC)	I_{IN}	+15, -250	mA
Current through current sense status pin (DC) see internal circuit diagrams on page 658 and 659	I_{IS}	+15, -250	
Thermal resistance chip - case:	R_{thJC}	≤ 0.40	K/W
junction - ambient (free air):	R_{thJA}	≤ 45	

2) R_I = internal resistance of the load dump test pulse generator.
3) $V_{Load\ dump}$ is setup without the DUT connected to the generator per ISO 7637-1 and DIN 40839.

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 pins 1,5) $V_{IN} = 0$, $I_L = 20\,A$ $T_j = 25\,°C$:	R_{ON}	--	3.1	3.6	mΩ
$T_j = 150\,°C$:			5.6	6.5	
Nominal load current (Tab to pins 1,5) ISO proposal: $V_{ON} = 0.5\,V$, $T_C = 85\,°C$	$I_{L(ISO)}$	98	108	--	A
Maximum load current in resistive range (Tab to pins 1,5) $V_{ON} = 2.5\,V$, $T_C = 25\,°C$:	$I_{L(Max)}$	400	--	--	A
$V_{ON} = 4.5\,V$, $T_C = 150\,°C$:		400	--	--	
see diagram on page 661					
Turn-on time[4] I_{IN} ⌜ to 90% V_{OUT}:	t_{on}	130	--	550	µs
Turn-off time I_{IN} ⌞ to 10% V_{OUT}:	t_{off}	60	--	240	
$R_L = 1.5\,\Omega$, $T_j = -40...+150\,°C$					
Slew rate on[4] (10 to 30% V_{OUT}) $R_L = 1.5\,\Omega$, (not tested, specified by design)	dV/dt_{on}	--	0.8	--	V/µs
Slew rate off[4] (70 to 40% V_{OUT}) $R_L = 1.5\,\Omega$, (not tested, specified by design)	$-dV/dt_{off}$	--	0.8	--	V/µs
Inverse Load Current Operation					
On-state resistance (Pins 1,5 to pin 3) $V_{IN} = 0$, $I_L = -20\,A$ $T_j = 25\,°C$:	$R_{ON(inv)}$	--	3.1	3.6	mΩ
see diagram on page 660 $T_j = 150\,°C$:			5.6	6.5	
Nominal inverse load current (Pins 1,5 to Tab) $V_{ON} = -0.5\,V$, $T_C = 85\,°C$	$I_{L(inv)}$	98	108	--	A
Operating Parameters[5]					
Operating voltage ($V_{IN} = 0$) $T_j = -40...+150\,°C$:	$V_{bb(on)}$	4.0	--	34	V
Undervoltage threshold[6] $T_j = -40...+150\,°C$:	$V_{bIN(u\,th)}$	--	--	4.0	V
Undervoltage start of charge pump see diagram page 663 $T_j = -40...+150\,°C$:	$V_{bIN(ucp)}$	--	5	6.5	V
Overvoltage protection[7] $T_j = -40\,°C$:	$V_{Z,IN}$	60	--	--	V
$I_{bb} = 40\,mA$ $T_j = 25...+150\,°C$:		63	67	--	
Standby current $T_j = -40...+25\,°C$:	$I_{bb(off)}$	--	12	25	µA
$I_{IN} = 0$ $T_j = 150\,°C$:		--	18	60	

4) See timing diagram on page 662.
5) $V_{bIN} = V_{bb} - V_{IN}$ see diagram on page 658.
6) When V_{bIN} increases up to $V_{bIN(ucp)} = 5\,V$ (typ.) the charge pump is not active and $V_{OUT} \approx V_{bb} - 3\,V$.
7) See also $V_{ON(CL)}$ in circuit diagram on page 659.

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Protection Functions					
Short circuit current limit (Tab to pins 1,5) V_{ON} = 12 V, time until limitation max. 300 µs					
T_c = -40°C:	$I_{L(SCp)}$	--	520	--	A
T_c = 25°C:		tbd	450	tbd	
T_c = +150°C:		tbd	320	tbd	
Short circuit shutdown delay after input current positive 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	--	300	µs
Output clamp (inductive load switch off) at $V_{OUT} = V_{bb} - V_{ON(CL)}$, I_L = 40 mA	$V_{ON(CL)}$	--	52	--	V
Short circuit shutdown detection voltage (pin 3 to pins 1,5):	$V_{ON(SC)}$	--	6	--	V
Thermal overload trip temperature	T_{jt}	150	--	--	°C
Thermal hysteresis	ΔT_{jt}	--	10	--	K
Reverse Battery					
Reverse battery voltage [8]	$-V_{bb}$	--	--	16	V
On-state resistance (Pins 1,5 to pin 3) V_{bb} = -12V, V_{IN} = 0, I_L = -20A, R_{IS} = 1 kΩ, T_j = 25°C:	$R_{ON(rev)}$	--	3.6	--	mΩ
Drain-source diode voltage ($V_{out} > V_{bb}$, I_{IN} = 0) I_L = -20A, T_j = +150°C	$-V_{ON}$	--	tbd	--	mV
Integrated resistor in V_{bb} line	R_{bb}	--	120	--	Ω
Diagnostic Characteristics					
Current sense ratio (static on-condition, V_{ON} < 1 V, V_{IS} = 0...5 V) $k_{ILIS} = I_L : I_{IS}$, $V_{bb(on)}$ = 6.5 ... 34 V [9], T_j = -40 ... +150°C 20 A < I_L < 180 A:	k_{ILIS}	20.9k	25k	31k	
10 A < I_L < 20 A:		19.3k	25k	35.3k	
I_{IN} = 0:		--	0	--	
see diagram on page 661 V_{ON} > 1 V:		--	X [10]	--	
Sense current saturation T_j = -40...+150°C:	$I_{IS,lim}$	6.5	--	--	mA
Current sense leakage current I_{IN} = 0, V_{IS} = 0 T_j = -40...+150°C:	$I_{IS(LL)}$	--	--	1	µA
V_{IN} = 0, V_{IS} = 0, $I_L \leq 0$ T_j = -40...+150°C:	$I_{IS(LH)}$	--	50	--	

8) The reverse load current through the intrinsic drain-source diode has to be limited by the connected load (as it is done with all polarity symmetric loads). Note that under off-conditions (I_{IN} = I_{IS} = 0) the power transistor is not activated. This results in raised power dissipation due to the higher voltage drop across the intrinsic drain-source diode. The temperature protection is not active during reverse current operation! Increasing reverse battery voltage capability is simply possible as described on page 659.

9) The voltage difference V_{bb} - V_{IS} must exceed 2V!

10) Sense current is no longer proportional to the load current due to sense current saturation, see $I_{IS,lim}$.

Parameter and Conditions at T_j = 25 °C, V_{bb} = 12 V unless otherwise specified	Symbol	Values			Unit
		min	typ	max	
Current sense settling time after positive input slope (90% of I_{IS} static) I_L = 0/20 A: (not tested, specified by design)	$t_{son(IS)}$	--	tbd	500	µs
Current sense settling time after negative input slope (10% of I_{IS} static) I_L = 20/0 A: (not tested, specified by design)	$t_{soff(IS)}$	--	tbd	500	µs
Current sense settling time after change of load current (60% to 90%) I_L = 15/25 A: (not tested, specified by design)	$t_{slc(IS)}$	--	tbd	500	µs
Input					
Required current capability of input switch[11] T_j = -40...+150°C:	$I_{IN(on)}$	3	--	--	mA
Input current for turn-off[12] T_j = -40...+150°C:	$I_{IN(off)}$	--	--	40	µA

11) Choose the resistance between IN and GND low enough so that the voltage V_{bIN} exceeds 10 V (typ., see R_{ON}-diagram on page 661).

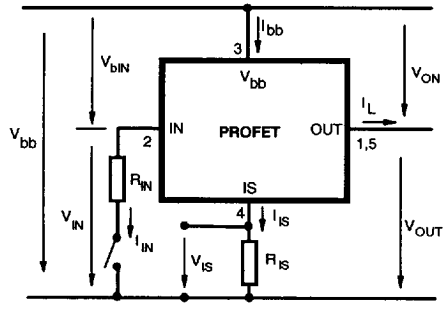
12) We recommend the resistance between IN and GND to be less than 330 Ω for turn-on and more than 850 kΩ for turn-off. Consider that when the device is switched off (I_{IN} = 0) the voltage between IN and GND reaches nearby V_{bb}.

Truth Table

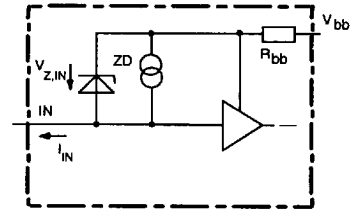
	Input current level	Output level	Current Sense I_{IS}
Normal operation	L H	L H	0 nominal
Current-limitation	L H	L H	0 <nominal[13]
Short circuit to GND	L H	L L	0 0
Over-temperature	L H	L L	0 0
Short circuit to V_{bb}	L H	H H	0 <nominal [14)]
Open load	L H	Z[15)] H	0 0
Negative output voltage clamp	L	L	0
Inverse load current	L H	H H	0 0

L = "Low" Level
H = "High" Level
Overtemperature reset by cooling: $T_j < T_{jt}$ (see diagram on page 663)
Short circuit to GND: Error signal latched until next turn on (see diagram on page 662)

Terms



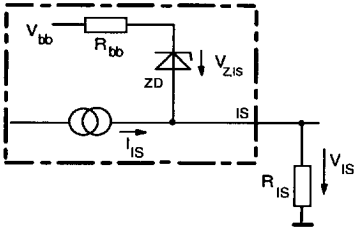
Input circuit (ESD protection)



When the device is switched off ($I_{IN} = 0$) the voltage between IN and GND reaches nearby V_{bb}.
$V_{Z,IN} = 67\,V$ (typ).

13) Sense current is no longer proportional to the load current due to sense current saturation, see $I_{IS,lim}$.
14) Low ohmic short to V_{bb} may reduce the output current I_L and can thus be detected via the sense current I_{IS}.
15) Power Transistor "OFF", potential defined by external impedance.

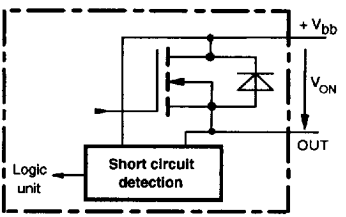
Current sense status output



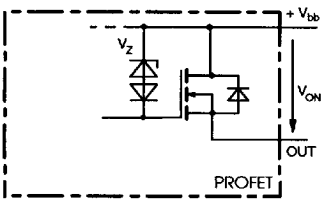
$V_{Z,IS}$ = 67 V (typ.), R_{IS} = 1 kΩ nominal.
Note: For large values of R_{IS} the voltage V_{IS} can reach nearby V_{bb}.

Short circuit detection

Fault Condition: V_{ON} > 6 V typ.; V_{IN} = 0

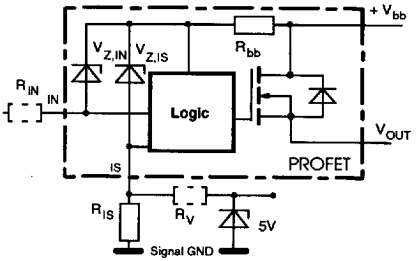


Inductive and overvoltage output clamp



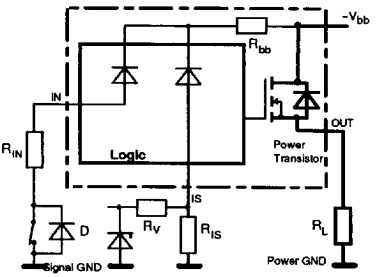
V_{ON} clamped to $V_{ON(Cl)}$ = 52 V typ.

Overvoltage protection of logic part



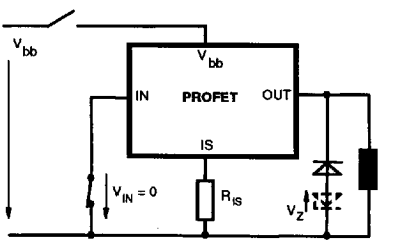
R_{bb} = 120 Ω typ., $V_{Z,IN}$ = $V_{Z,IS}$ = 67 V typ., R_{IS} = 1 kΩ nominal. Note that when overvoltage exceeds 72 V typ. a voltage above 5V can occur between IS and GND.

Reverse battery protection

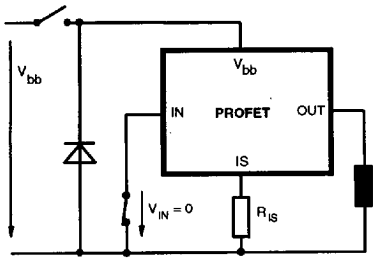


$R_V \geq 1$ kΩ, R_{IS} = 1 kΩ nominal. Add R_{IN} for reverse battery protection in applications with V_{bb} above 16 V[8]; recommended value: $R_{IN} = (|V_{bb}|/12V - 1) \times 120\,\Omega$.
To minimize power dissipation at reverse battery operation, the summarized current into the IN and IS pin should be about 120mA. The current can be provided by using a small signal diode D in parallel to the input switch, by using a MOSFET input switch or by proper adjusting the current through R_{IS} and R_V.

V_{bb} disconnect with energized inductive load

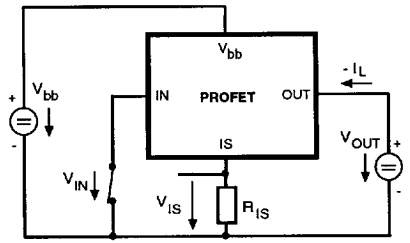


Provide a current path with load current capability by using a diode, a Z-diode or a varistor (V_Z < 52 V)!



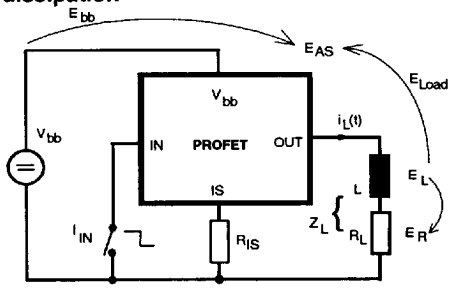
Note that there is no reverse battery protection when using a diode between V_{bb} and ground.

Inverse load current operation



The device is specified for inverse load current operation ($V_{OUT} > V_{bb} > 0V$).
In this case, the power transistor is "ON" with $V_{IN} = 0$ (specifications see page 655). With $I_{IN} = 0$ only the intrinsic drain source diode is conducting resulting in considerably increased power dissipation.
The current sense feature is not available during this kind of operation ($I_{IS} = 0$).
Note: *Temperature protection during inverse load current operation is not possible!*

Inductive load switch-off energy dissipation



Energy stored in load inductance:

$$E_L = {}^1/_2 \cdot L \cdot I_L^2$$

While demagnetizing load inductance, the energy dissipated in PROFET is

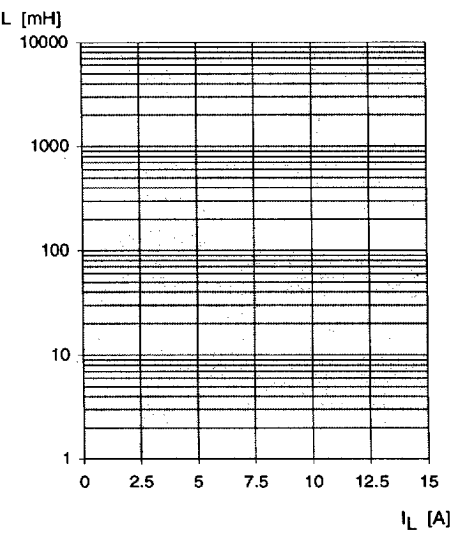
$$E_{AS} = E_{bb} + E_L - E_R = \int V_{ON(CL)} \cdot i_L(t)\, dt,$$

with an approximate solution for $R_L > 0\,\Omega$:

$$E_{AS} = \frac{I_L \cdot L}{2 \cdot R_L} (V_{bb} + |V_{OUT(CL)}|)\ ln\ (1 + \frac{I_L \cdot R_L}{|V_{OUT(CL)}|})$$

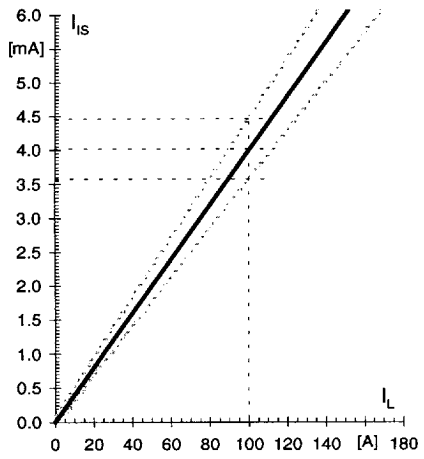
Maximum allowable load inductance for a single switch off

$L = f(I_L)$; $T_{j,start} = 150°C$, $V_{bb} = 12\,V$, $R_L = 0\,\Omega$

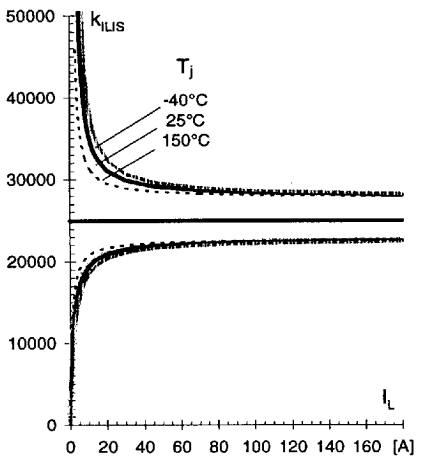


Characteristics

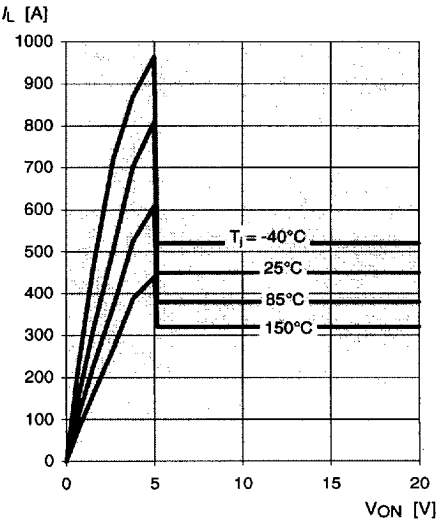
Current sense versus load current:



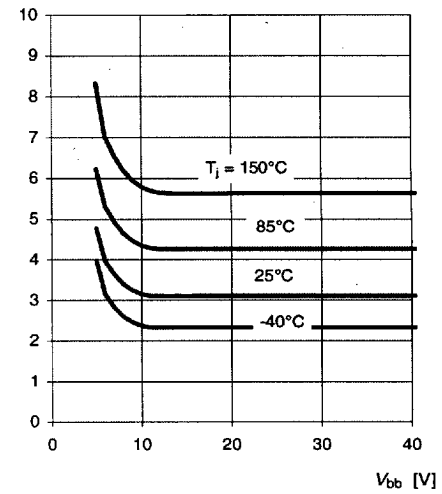
Current sense ratio:



Typ. current limitation characteristic
$I_L = f(V_{ON}, T_j)$

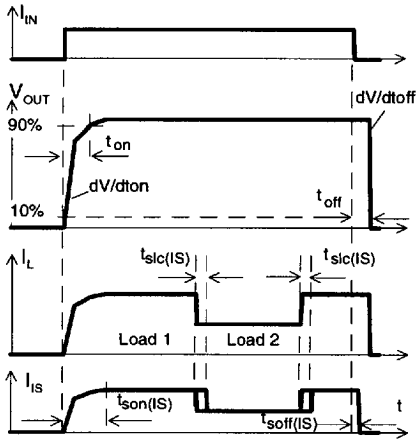


Typ. on-state resistance
$R_{ON} = f(V_{bb}, T_j)$; I_L = 20 A; V_{IN} = 0



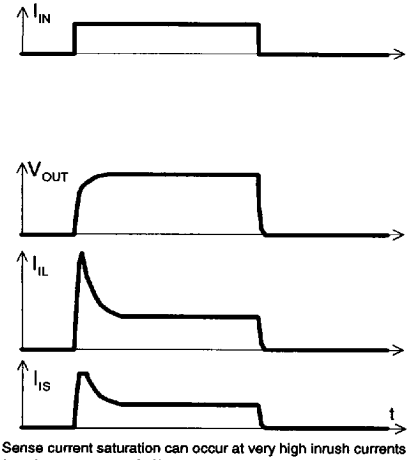
Timing diagrams

Figure 1a: Switching a resistive load, change of load current in on-condition:



The sense signal is not valid during a settling time after turn-on/off and after change of load current.

Figure 2a: Switching motors and lamps:



Sense current saturation can occur at very high inrush currents (see $I_{IS,lim}$ on page 656).

Figure 2b: Switching an inductive load:

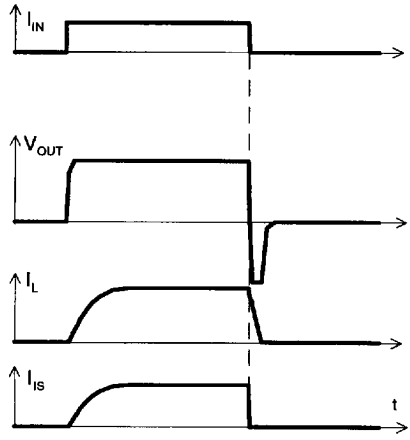
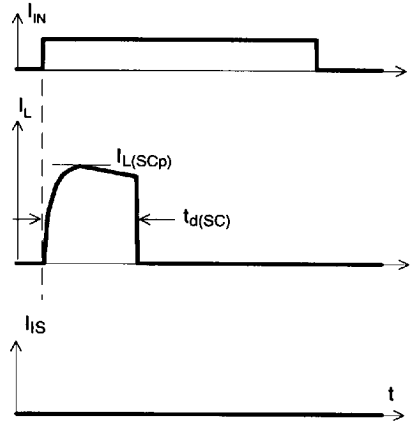


Figure 3a: Short circuit: shut down by short circuit detection, reset by $I_{IN} = 0$.



Error signal stays latched until next turn on

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

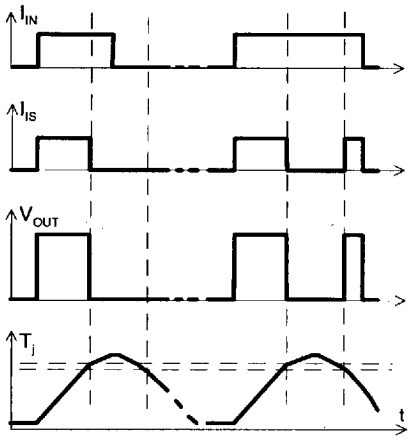
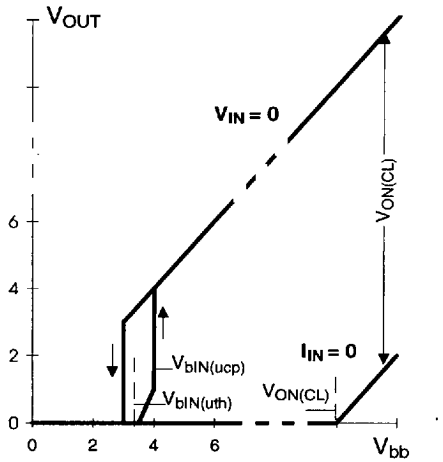


Figure 6a: Undervoltage restart of charge pump, overvoltage clamp

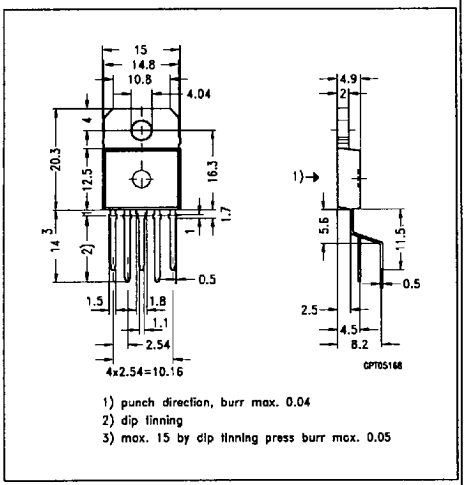


Package and Ordering Code

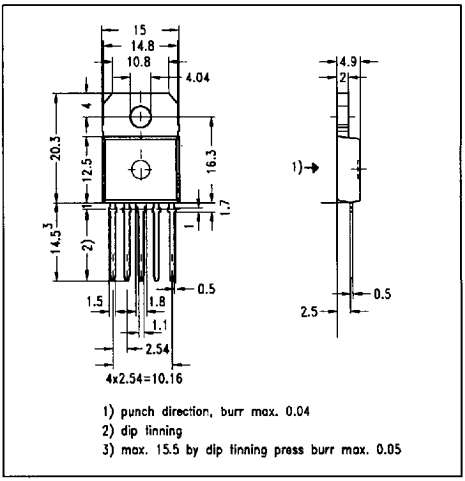
All dimensions in mm

Standard TO-218AB/5	Ordering code
BTS555P	Q67060-tbd-tbd

TO-218AB/5 Option E3146	Ordering code
BTS555P E3146	Q67060-tbd-tbd



1) punch direction, burr max. 0.04
2) dip tinning
3) max. 15 by dip tinning press burr max. 0.05



1) punch direction, burr max. 0.04
2) dip tinning
3) max. 15.5 by dip tinning press burr max. 0.05