

The BSP 75/A provides features and protective functions which make it particularly suitable for automotive applications as well as for industrial use.

Figure 4 shows the chip layout of the BSP 75/A. The DMOS output stage comprises 2/3 of the area, the CMOS and bipolar circuits for protective functions around 1/3 of the area of this monolithic HITFET®.

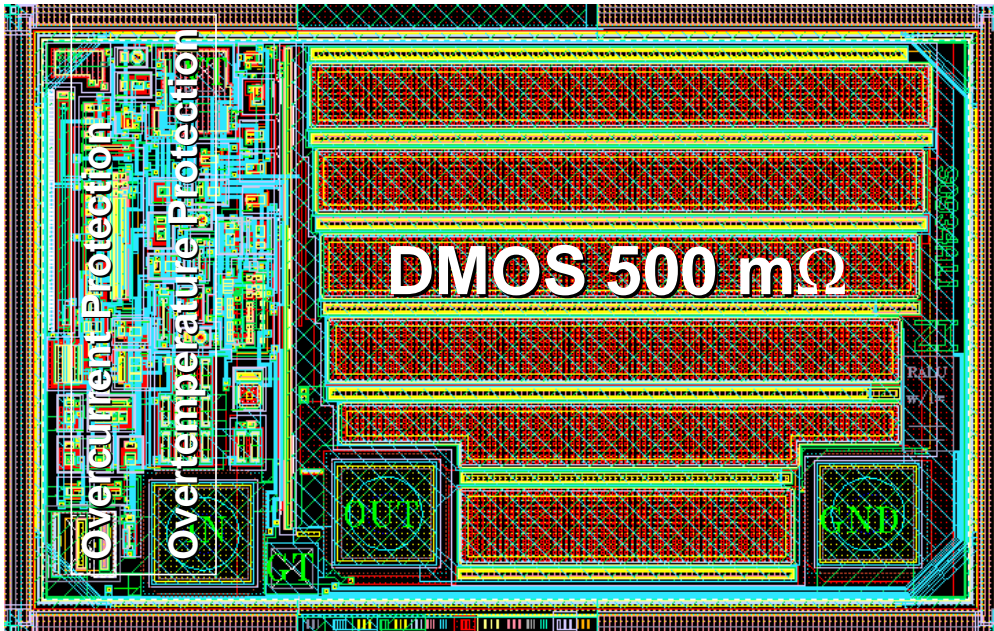


Figure 4 Chip Photography of BSP 75

2 Protection Functions

The protection functions of the BSP 75/A include protection against short circuit and overload, together with overvoltage protection by an active zener clamp. In addition it has very good ESD characteristics, load dump protection and a logic level input.

2.1 Overload, Short Circuit and Overtemperature Protection

As with the existing HITFET®, the overload protection - which includes short circuit and overtemperature protection - acts in stages. This means that if the internal current limit $I_{D(lim)}$ is exceeded, the output stage is not switched off immediately, but the current is limited to $I_{D(lim)}$ (1.4 A typ). The device thus operates in the analogue region, and the voltage between drain and source increases. This leads to a rise in the chip temperature. To prevent the maximum junction temperature being exceeded, a temperature sensor switches off the output stage. Thus the device protects itself.



For loads with capacitive behaviour, such as a lamp when being switched, the inrush current is limited to $I_{D(lim)}$, which increases operating lifetime. Figure 5 shows the switching of a 5 W lamp with a nominal current of around 0.7 A. The 'inrush current' here is limited to around twice the nominal current.

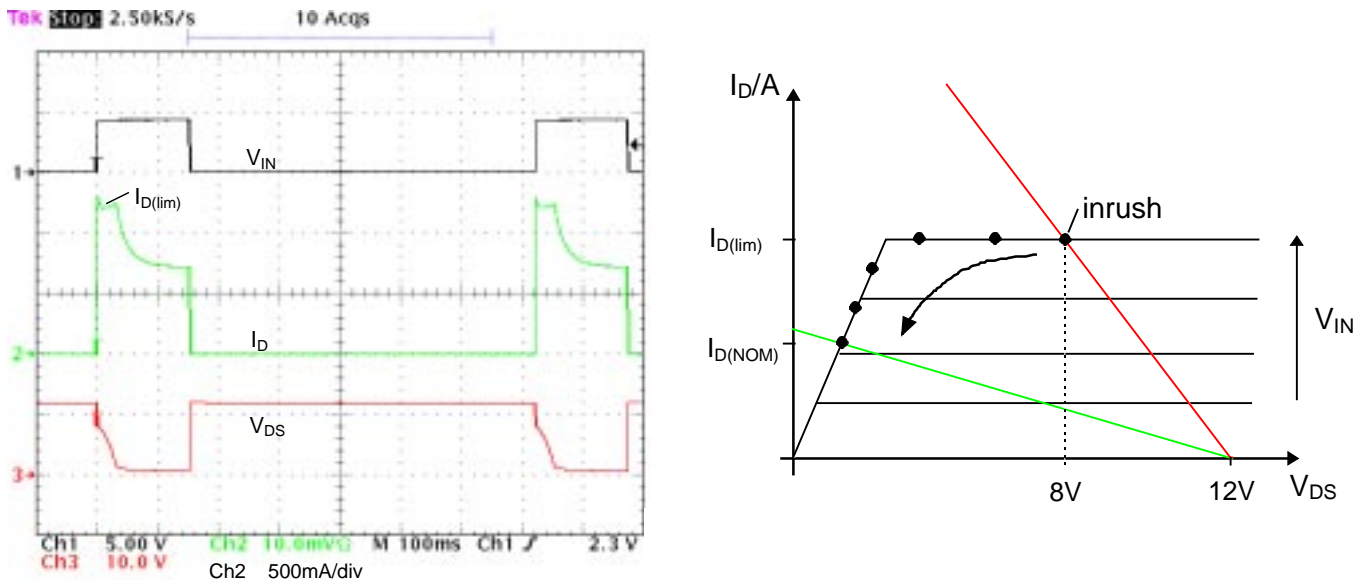


Figure 5 Switching of a 5W Bulb

The bottom trace on the oscillogram shows the drain-source voltage during switching. Next to the oscillogram, the output characteristics are shown with the corresponding operating points during the switching operation. Initially the current is limited to $I_{D(lim)}$ for a voltage of $V_{DS} \approx 8V$ (inrush). The operating point then moves along the curve in the direction shown by the arrow, until the nominal current at $V_{DS} = I_{D(NOM)} \times R_{ON}$ is reached.



2.2 Short Circuit Protection

If there is a permanent short circuit and the BSP 75/A is switched on, the current is only limited by the internal current limitation ($I_{D(lim)}$) of the device. This leads to an increasing chip temperature (depending on the cooling conditions). If the temperature of the chip rises to 165 °C (typ.), the device automatically switches itself off. In contrast to the single channel HITFET[®], the BSP 75/A is not a 'latch type' (stays off after thermal shutdown), but a 'restart on cooling type'. The temperature needs only to fall 10 K (typ.) in order for the device to switch back on again.

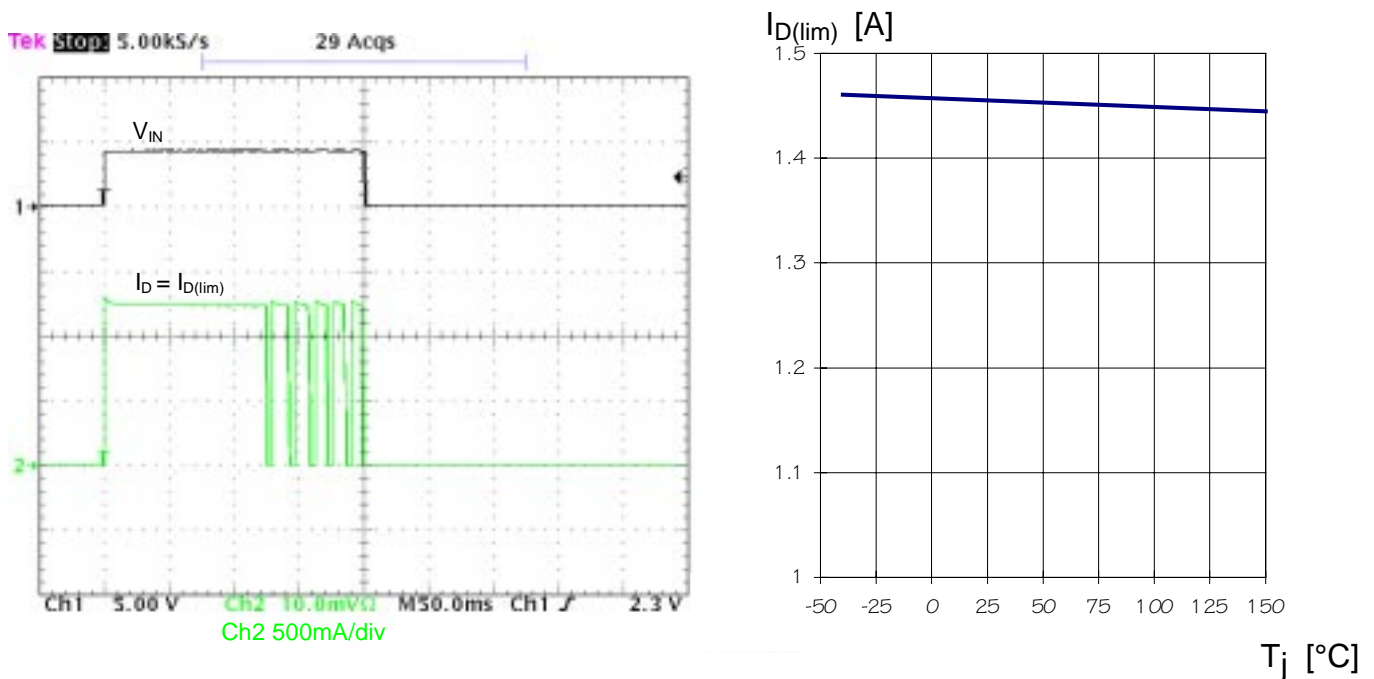


Figure 6 Switching on during Short Circuit Condition; Current Limit against Temperature

Figure 6 also shows that the current limit of $I_{D(lim)}$ is relatively independent of temperature. In this case, the excellent analogue capabilities of the SPT process take effect, which makes possible the exact temperature compensated current control. On the right hand side, the current limitation (1.4 A typ.) is shown against temperature. This diagram is taken directly from the data sheet.

If a short circuit occurs during normal operation, the current increases from the load current value (here 0.5 A) to $I_{D(lim)}$, and limited to this value until Temperature Shutdown becomes active. Figure 7 shows this operation with a 30 V battery applied. Due to high power dissipation and rapid increases in chip temperature, the temperature dependent behaviour is seen more clearly in this case. In accordance with the data sheet, the BSP 75/A is short circuit protected for a battery voltage up to 32 V.



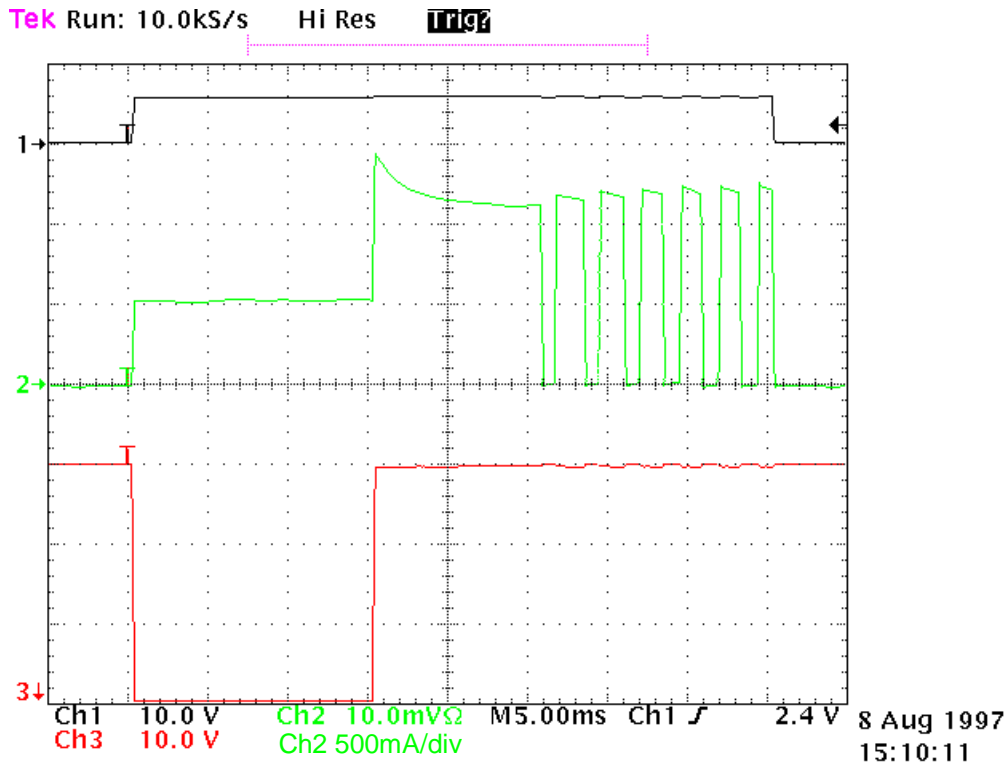


Figure 7 Short Circuit during Normal Operation

The required voltage supply for the correct operation of the previously described protection functions (current limitation, overtemperature protection) is taken from the input voltage V_{IN} . The threshold voltage for the protection functions is - by design - below the turn-on threshold of the DMOS. This guarantees the operation of the protection functions before the DMOS is switched on.

2.3 Switching of Inductive Loads: Overvoltage Protection

The BSP 75/A has an active zener-diode clamp between drain and gate, in order to protect the device against overvoltage when using inductive loads (e.g. inductors, relays, motors). When the device is switched off and the voltage across the inductive load rises above 63V, the zener diode will start to conduct and control the gate, so keeping the MOSFET on. Compared to Avalanche Breakdown, the switch-off energy in this case is considerably larger. Figure 8 displays the switching of a solenoid, clearly showing the point of switching (change of inductivity).



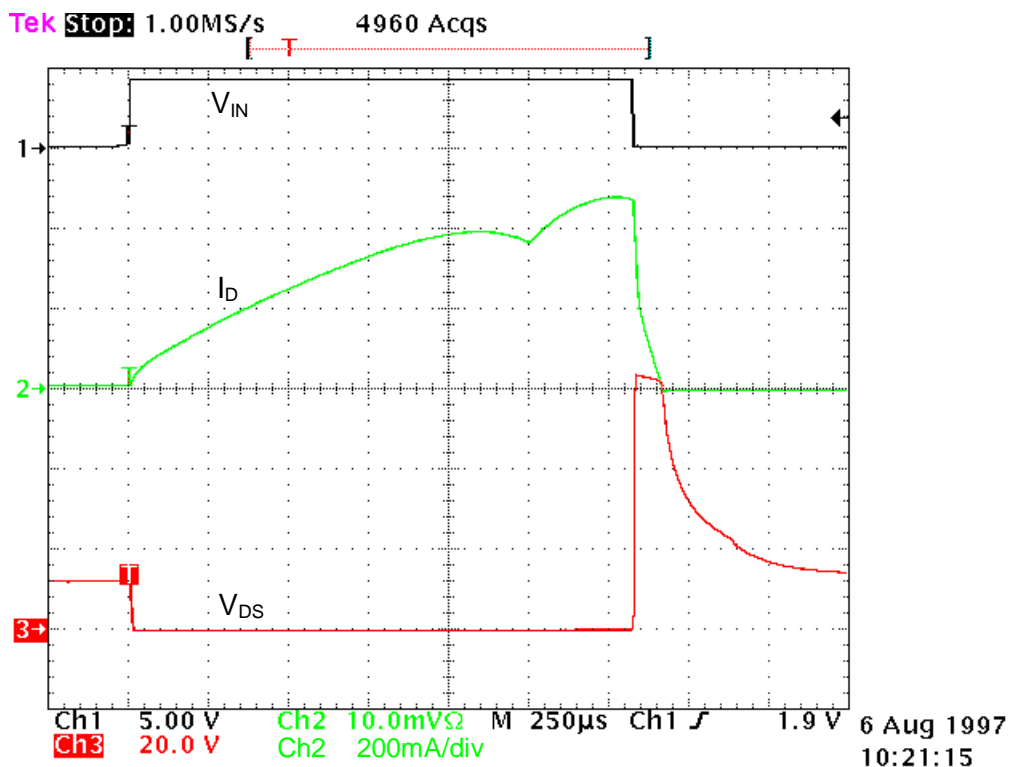


Figure 8 Switching of a Solenoid

A short switch-off time with a large di/dt exists with no chance of damage to the device, due to the active zener diode clamp (for $V_{DS(AZ)} > 60V$).

Application Example:

The switching-off of a relay is a typical example for demonstrating the inductive overvoltage behaviour. If the BSP 75, BSP 75A is used to drive a relay, no external free-wheeling diode is necessary, as V_{DS} is limited by the device itself.

This overvoltage protection function does not require a supply voltage.

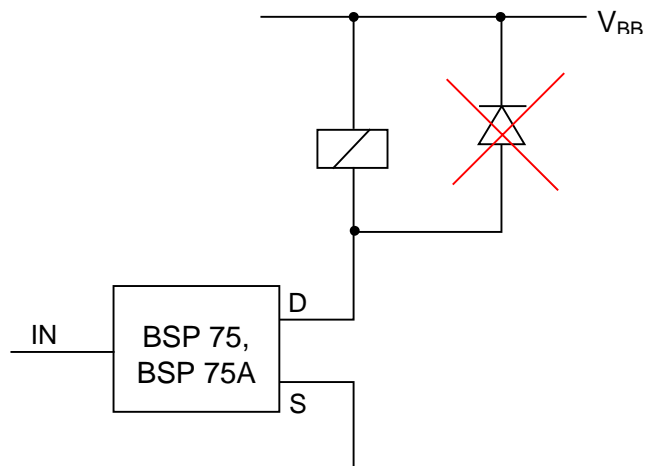


Figure 9 BSP 75/A used as Relay Driver



2.4 ESD Protection

The BSP 75, BSP 75A is protected against electrostatic discharge up to 4 kV for every pin combination. The chances of damage to the device during handling is therefore dramatically reduced. The drain and source pins can withstand an even greater ESD-voltage. This robustness against electrostatic discharge between the drain and source is of particular importance for additional installations (e.g. a loud speaker system for a car telephone) because the drain connection is exposed by means of the wiring harness during installation.

2.5 Load Dump Protection

For a typical load with a 50 Ω relay, the BSP 75/A is load dump protected up to 80V, independent of the switching state. The exact measuring conditions are mentioned in the data sheet under 'maximum ratings'.



3 Difference Between BSP 75 and BSP 75A

The BSP 75 has four connections. The three pins on the SOT 223 package are INPUT, DRAIN and SOURCE. There is also a metal connection directly between the leadframe and substrate of the chip, referred to as TAB. In order to prevent parasitic effects, the substrate must have the same potential as the source. For the BSP 75 the connection between the TAB and SOURCE must be performed externally.

The only difference with the BSP 75A is that pin 3 (Source) is connected to the leadframe of the chip. This implies that the necessary connections between the SOURCE and TAB has been performed internally and there is no need for an external connection.

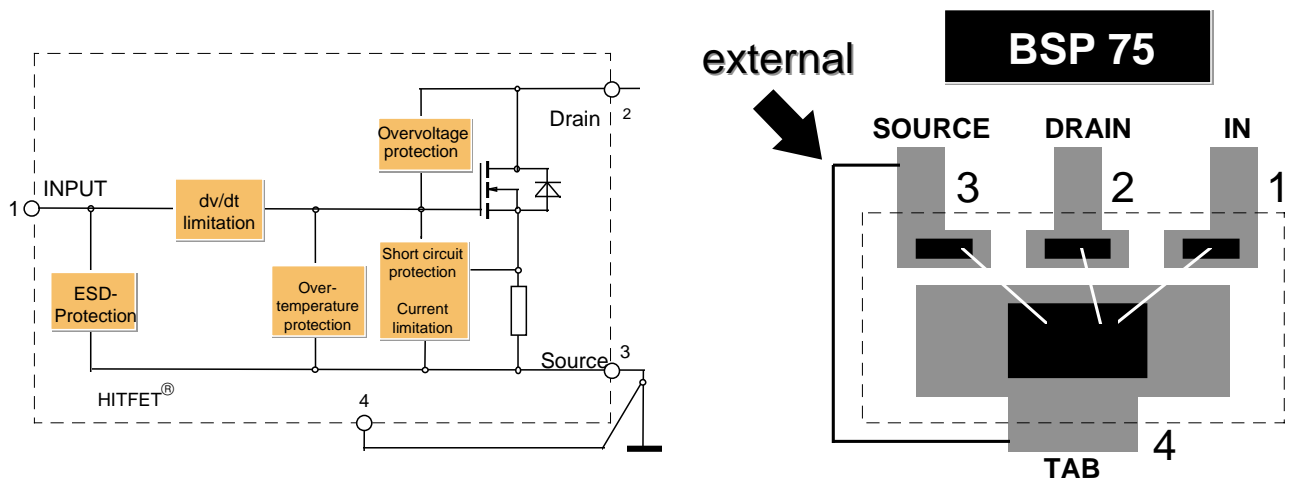


Figure 10 BSP 75 Block Diagram and Chip Bonding

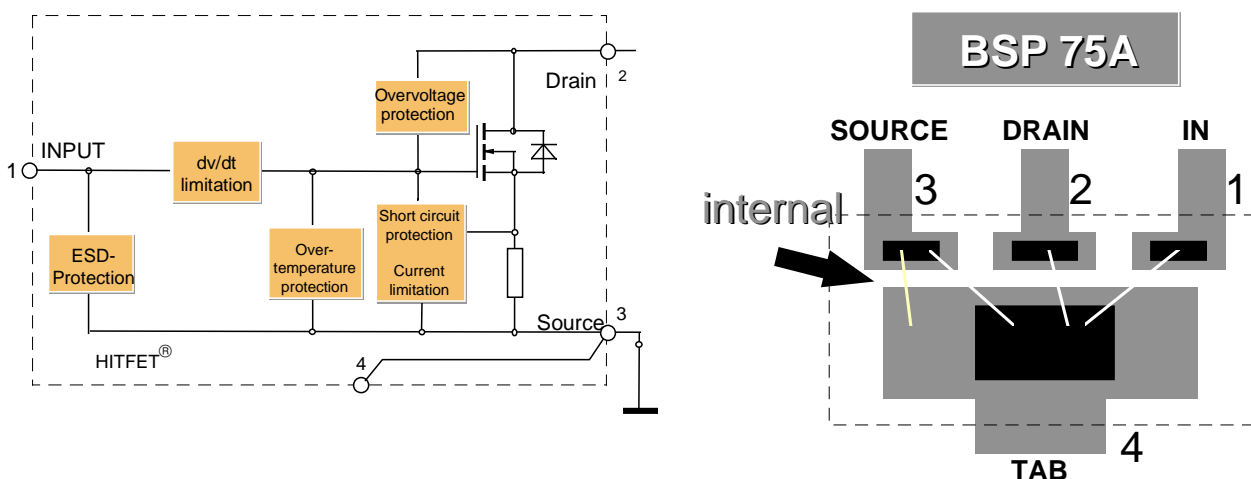


Figure 11 BSP 75A Block Diagram and Chip Bonding. Internal connection between source and substrate (pin 3 and leadframe) using a bonding wire.



3.1 The Difference in Practice

3.1.1 BSP 75

a) Operation with floating TAB

The data sheet states that a connection between TAB and pin 3 must be performed, to avoid negative parasitic effects due to a charging of the substrate. This cannot be guaranteed with an unconnected TAB-contact, although the BSP 75 will principally work with floating. floating.

⇒ **Data sheet, page 1:** TAB must be connected to pin 3

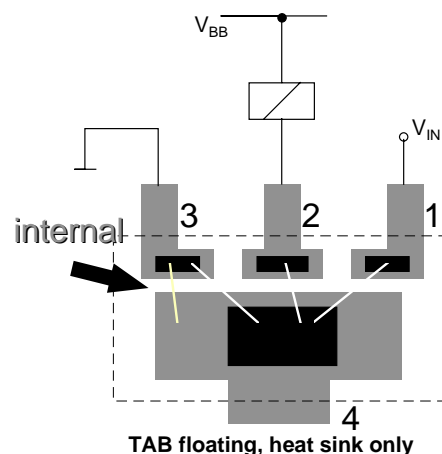
b) Pin 3 floating, only TAB is connected to ground.

This mode of operation is not possible because the DMOS source is not connected. This connection serves as a reference for the input voltage.

3.1.2 BSP 75A

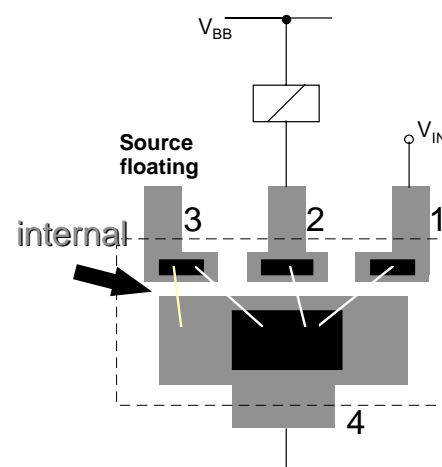
a) Operation with floating TAB

The BSP 75A is generally used without connecting up TAB. Therefore this TAB connection is used purely to disperse heat. With this mode of connection a one-to-one replacement for existing solutions is possible.



b) Pin 3 floating, only TAB is connected to ground.

This mode of operation is also possible for the BSP 75A, as the internal wire forces the source and substrate to the same potential. The additional bonding wire in the load circuit, which causes a small increase in the on-state resistance, can be neglected in this mode of operation.



4 Application Areas of BSP 75, BSP 75A

Due to the extensive range of protection features the BSP 75/A is suitable for a multitude of applications areas and for loads such as relays, signal lamps or inductive loads. Due to the following points, the BSP 75/A is particularly suited for the automotive world:

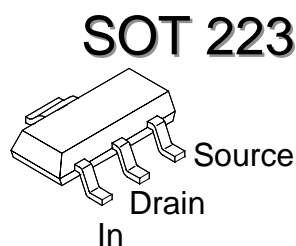
- fully functional up to $T_j = 150^\circ\text{C}$ in normal operation, as well as in the overload condition (current limited operation)
- no minimum supply voltage required for full operation of the protective functions
- ESD-protected up to 4 kV

In summary, the BSP 75/A combines Smart Power with a very small "footprint" (SOT 223 package).

5 Outlook

On the basis of the success with the BSP 75/A, we will be extending our range of Smart Power products. Further devices in the SOT 223 package will therefore follow, having ON-resistances of 200, 100 and 50 m Ω (BSP 76, 77, 78).

The implementation of our strategy 'silicon instead of heatsink' will be continued here, with the first 50 m Ω fully protected switch in the SOT 223 package. This new product family will then be rounded off with the BTS 118 (100 m Ω) and BTS 134 (50 m Ω) in the D-Pak package. This is the first deployment of this package for Smart Power Switches.



BSP 76
BSP 77
BSP 78



BTS 118
BTS 134

Remark:

At the BSP 75/A the Tab contact is connected to Source (either externally or internally) because the backside of the chip is Source due to the Smart Power Technology.

At BSP 76/77/78 the backside of the chip is the Drain contact (vertical technology), therefore Tab has Drain potential.

⇒ **BSP 75/A and BSP 76/77/78 are only pin compatible, when only the pins are connected and the Tab is floating.**

