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# HITFET - BTS3800SL

## Smart low side power switch

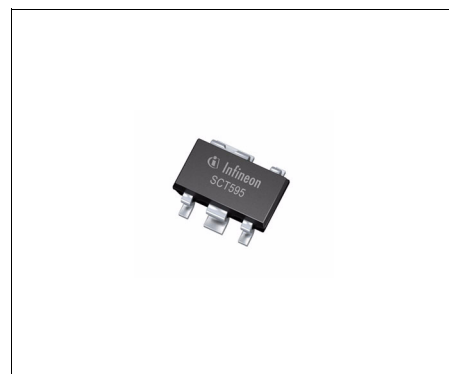
**BTS3800SL**



## 1 Overview

### Features

- Short circuit and over load protection
- Thermal shutdown with latch behavior
- ESD protection
- Over voltage protection
- Logic level input suitable for 5V and 3.3V
- Small footprint automotive power package
- Green Product (RoHS compliant)
- AEC Qualified



**PG-SCT595**

### Description

The BTS3800SL is a single channel Low Side power switch with embedded protective functions in PG-SCT595 package. The device is monolithically integrated with a N channel power MOSFET and additional protection functions.

The BTS3800SL is especially designed as a protected relay driver in automotive and industrial applications.

**Table 1 Product Summary**

|  |              |              |
|--|--------------|--------------|
| Drain voltage <sup>1)</sup>                              | $V_{DS}$     | 41 V         |
| Maximum Input Voltage                                    | $V_{IN}$     | 5.5 V        |
| Maximum On resistance at 150°C and 5V input voltage      | $R_{DS(ON)}$ | 1.6 $\Omega$ |
| Typical On-State resistance at 25°C and 5V input voltage | $R_{DS(ON)}$ | 0.8 $\Omega$ |
| Nominal load current                                     | $I_{D(nom)}$ | 350 mA       |
| Minimum Current threshold level                          | $I_{D(OVL)}$ | 0.75 A       |
| Single Clamping Energy                                   | $E_{AS}$     | 65 mJ        |

1) Active clamped

| Type      | Package   | Marking |
|-----------|-----------|---------|
| BTS3800SL | PG-SCT595 | 38      |

**Protective Functions**

- Electrostatic discharge protection (ESD)
- Active clamping over voltage protection
- Thermal shutdown with latching behavior
- Short circuit protection
- Current threshold switch off

**Applications**

- Designed for driving relays in automotive and industrial applications
- Protected power switch for small loads
- Protected line driver
- Protected supply switch
- Replacement of discrete circuits

**Detailed Description**

The device is able to switch all kind of resistive, inductive and capacitive loads, limited by  $E_{AS}$  and maximum current capabilities.

The BTS3800SL offers ESD protection on the IN Pin referring to the Source Pin (Ground).

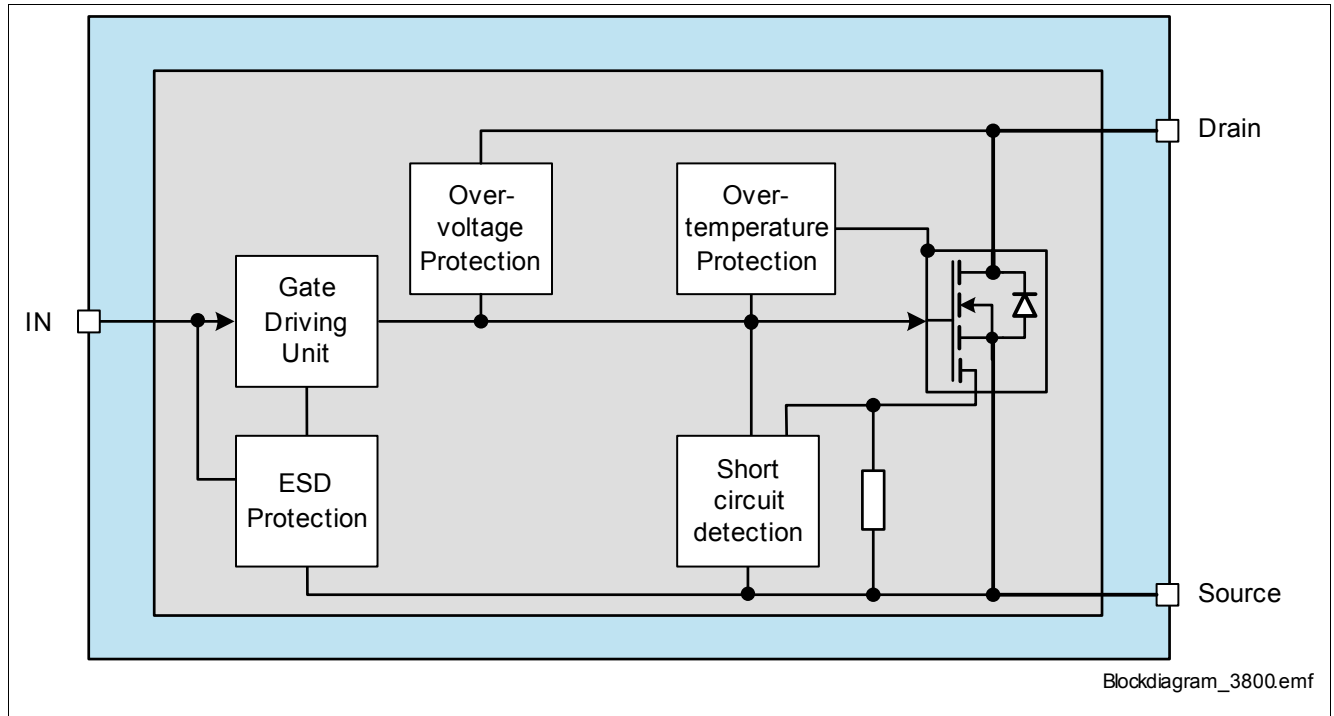
The overtemperature protection prevents the device from overheating due to overload and/or bad cooling conditions. The temperature information is given by a temperature sensor which is placed monolithically in the power stage.

The BTS3800SL has a thermal latch function. The device will turn off and stay off, even after the measured temperature has dropped below the thermal hysteresis. After cooling down the device can be switched on again by toggling the IN pin.

The over voltage protection is active during load dump or inductive turn off conditions.

In this conditions the power stage is limiting the Drain to Source voltage at  $V_{DS(AZ)}$  and dissipating energy.

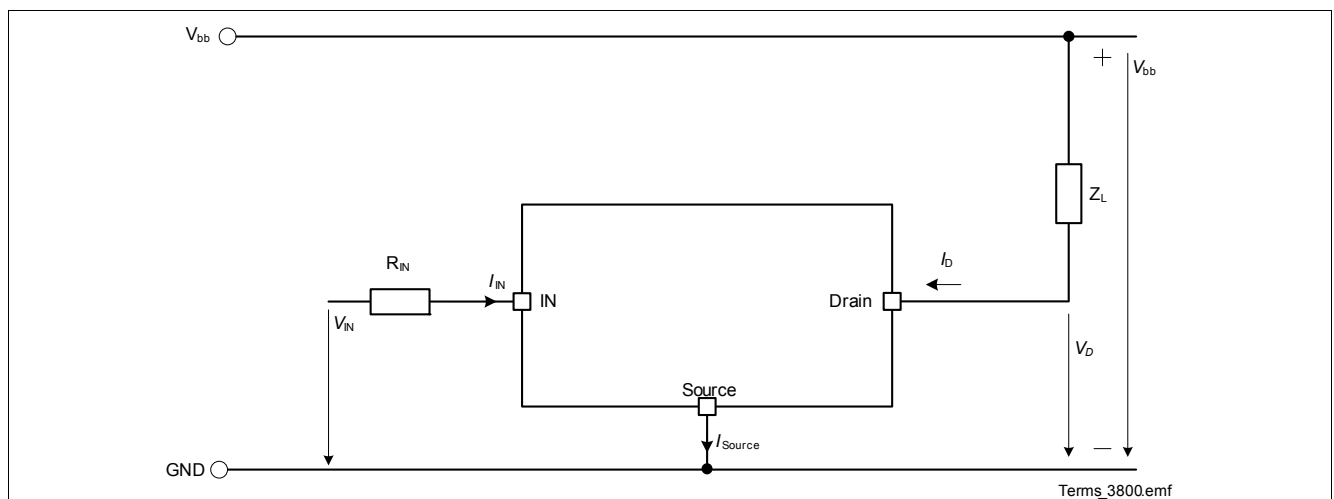
## 2 Block Diagram



**Figure 1** Block Diagram of BTS3800SL

### 2.1 Terms

**Figure 2** shows all external terms used in this data sheet.



**Figure 2** Naming of electrical parameters

### 3 Pin Configuration

#### 3.1 Pin Assignment BTS3800SL

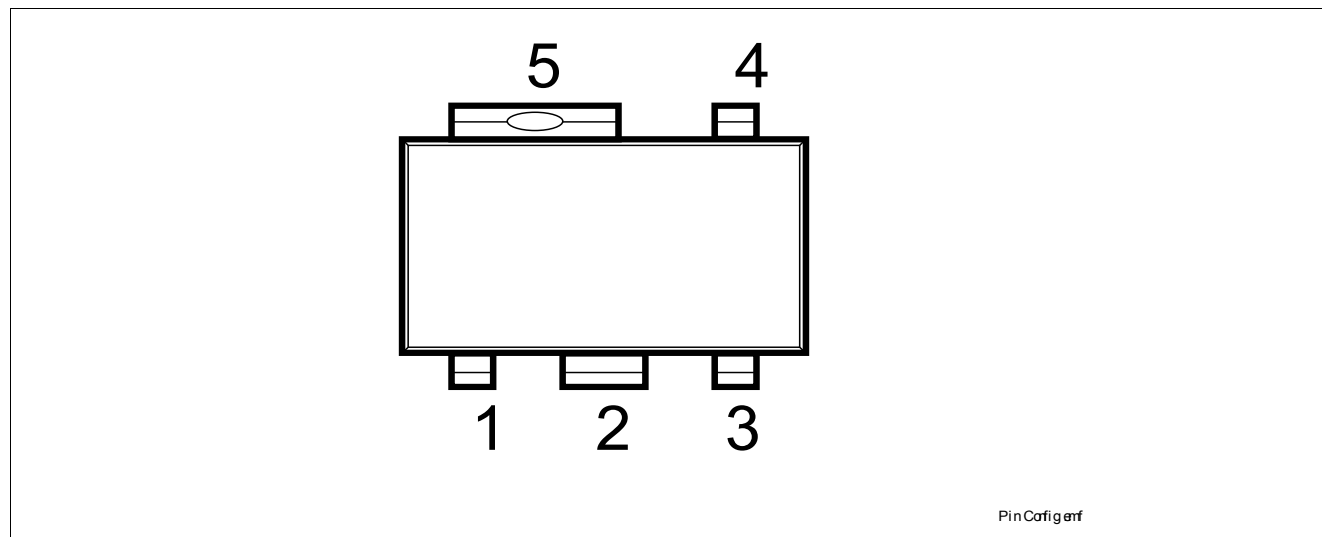


Figure 3 Pin Configuration PG-SCT595

#### 3.2 Pin Definitions and Functions

| Pin | Symbol | Function   |
|-----|--------|--|
| 1   | Drain  | <b>Drain pin</b> ; Load connection for power DMOS                |
| 2,5 | n.c.   | <b>not connected</b> ; Should be connected to ground for cooling |
| 3   | IN     | <b>Input pin</b> ; Digital input                                 |
| 4   | Source | <b>Source pin</b> ; Ground, Source of power DMOS                 |

## 4 General Product Characteristics

### 4.1 Absolute Maximum Ratings

#### Absolute Maximum Ratings<sup>1)</sup>

$T_J = -40\text{ °C}$  to  $+150\text{ °C}$ ; all voltages with respect to ground, positive current flowing into pin  
(unless otherwise specified)

| Pos.               | Parameter  | Symbol       | Limit Values |      | Unit               | Test Conditions  |
|--------------------|--|--------------|--------------|------|--------------------|--|
|                    |  |              | Min.         | Max. |                    |  |
| Voltages           |  |              |              |      |                    |  |
| 4.1.1              | Drain voltage  | $V_{DS}$     | –            | 41   | V                  | 2)   |
| 4.1.2              | Drain voltage for short circuit protection                       | $V_{DS(SC)}$ | –            | 36   | V                  |  |
| 4.1.3              | Input Voltage  | $V_{IN}$     | -0.3         | 5.5  | V                  | –  |
| 4.1.4              | Input Current  | $I_{IN}$     | self limited |      |                    | $-0.3\text{ V} < V_{IN} < 5.5\text{ V}$  |
|                    |  |              | -4           | 4    | mA                 | $5.5\text{ V} < V_{IN} < 8.0\text{ V}$   |
| 4.1.5              | Maximum Drain Current  | $I_D$        | –            | 0.75 | A                  | 3)   |
| Energies           |  |              |              |      |                    |  |
| 4.1.6              | Unclamped single pulse inductive energy                          | $E_{AS}$     | –            | 65   | mJ                 | $I_D = 350\text{mA};$<br>$T_{J(\text{start})} = 150\text{ }^{\circ}\text{C}$                           |
| 4.1.7              | Unclamped repetitive pulse inductive energy $1\times10^4$ cycles | $E_{AR}$     | –            | 14   | mJ                 | $I_D = 350\text{mA};$<br>$V_{bb} = 18\text{ V};$<br>$T_{J(\text{start})} = 85\text{ }^{\circ}\text{C}$ |
| 4.1.8              | Unclamped repetitive pulse inductive energy $1\times10^6$ cycles |              | –            | 12   | mJ                 | $I_D = 350\text{mA};$<br>$V_{bb} = 18\text{V};$<br>$T_{J(\text{start})} = 85^{\circ}\text{C}$          |
| Temperatures       |  |              |              |      |                    |  |
| 4.1.9              | Operating temperature  | $T_J$        | -40          | +150 | $^{\circ}\text{C}$ | –  |
| 4.1.10             | Storage temperature  | $T_{STG}$    | -55          | +150 | $^{\circ}\text{C}$ | –  |
| ESD Susceptibility |  |              |              |      |                    |  |
| 4.1.11             | ESD Resistivity<br><br>All pins<br>Drain vs. Source              | $V_{ESD}$    |              |      | kV                 | HBM <sup>4)</sup>  |
|                    |  |              | -4           | 4    |                    |  |
|                    |  |              | -8           | 8    |                    |  |

1) Not subject to production test, specified by design.

2) Active clamped.

3) Current protection threshold see **“Over Load Protection” on Page 13** for details.

4) ESD susceptibility, HBM according to EIA/JESD 22-A114.

*Note: Stresses above the ones listed here may cause permanent damage to the device.*

*Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

*Note: Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as “outside” normal operating range.*

*Protection functions are not designed for continuous repetitive operation.*

## 4.2 Functional Range

| Pos.  | Parameter                     | Symbol       | Limit Values |      | Unit | Conditions     |
|-------|-------------------------------|--------------|--------------|------|------|----------------|
|       |                               |              | Min.         | Max. |      |                |
| 4.2.1 | Input pin voltage (device ON) | $V_{IN}$     | 2.7          | 5.5  | V    | –              |
| 4.2.1 | Drain voltage                 | $V_D$        | –            | 41   | V    | active clamped |
| 4.2.2 | Input pin current consumption | $I_{IN(ON)}$ | –            | 0.5  | mA   |                |

*Note: Within the functional range the IC operates as described in the circuit description. The electrical characteristics are specified within the conditions given in the related electrical characteristics table.*

## 4.3 Thermal Resistance

*Note: This thermal data was generated in accordance with JEDEC JESD51 standards.*

*For more information, go to [www.jedec.org](http://www.jedec.org).*

| Pos.  | Parameter                  | Symbol       | Limit Values |      |      | Unit | Conditions |
|-------|----------------------------|--------------|--------------|------|------|------|------------|
|       |                            |              | Min.         | Typ. | Max. |      |            |
| 4.3.3 | Junction to Pin 5          | $R_{thJpin}$ | –            | –    | 27   | K/W  | 1) 2)      |
| 4.3.4 | Junction to Ambient (2s2p) | $R_{thJA}$   | –            | 110  | –    | K/W  | 1) 3)      |

1) Not subject to production test, specified by design

2) Specified  $R_{thJpin}$  value is simulated at natural convection on a cold plate setup (all pins are fixed to ambient temperature).  $T_a = 25^\circ\text{C}$ . Device is loaded with 0.5 W power.

3) Specified  $R_{thJA}$  value is according to Jedec JESD51-2,-7 at natural convection on FR4 2s2p board; The product (Chip+Package) was simulated on a 76.2 x 114.3 x 1.5 mm board with 2 inner copper layers (2 x 70  $\mu\text{m}$  Cu, 2 x 35  $\mu\text{m}$  Cu).  $T_a = 25^\circ\text{C}$ , Device is loaded with 0.5 W power.

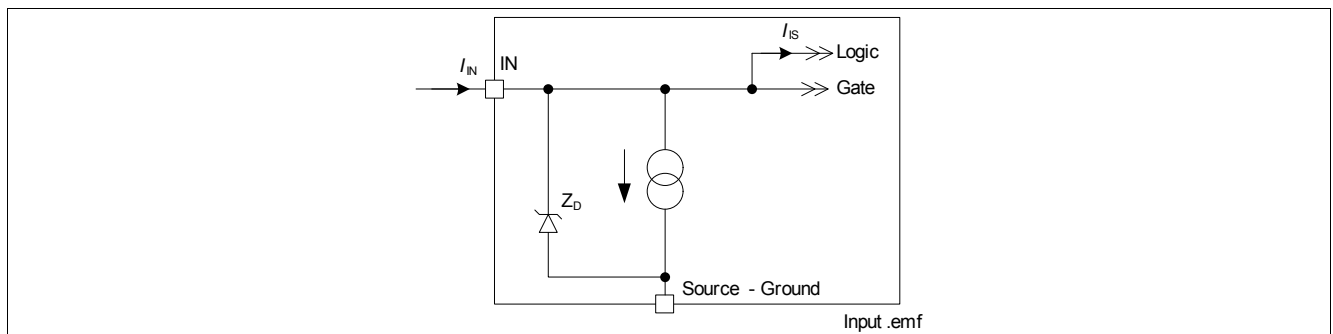
## 5 Input Stage

The following chapter describes the behavior and characteristic of the input pin.

### 5.1 Input Circuit

**Figure 4** shows the input circuit of the BTS3800SL. The Zener diode protects the input circuit against ESD pulses. The internal circuitry is powered via the input pin. During normal operation the input is connected to the gate of the power MOSFET. The current handling capability of the driving circuit does not influence the device behavior as long as the supply current  $I_{IN(nom)}$  is supplied.

During PWM operation the recharging of the gate increases the current consumption to the level  $I_{IN(PWM)}$ .



**Figure 4 Input Circuit**

The current sink to ground ensures that the channel switches off in case of an open input pin. The Zener diode protects the input circuit against ESD pulses.

### 5.2 Input Characteristics

*Note: Characteristics show the deviation of parameter at given input voltage and junction temperature.*

*Typical values show the typical parameters expected from manufacturing.*

*All voltages with respect to Source Pin unless otherwise stated.*

#### Electrical Characteristics: Input Stage

$T_j = -40\text{ }^{\circ}\text{C}$  to  $+150\text{ }^{\circ}\text{C}$ ,  $V_{bat} = 8.0\text{ V}$  to  $18\text{ V}$ ,

all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

| Pos.  | Parameter                     | Symbol        | Limit Values |      |      | Unit | Test Conditions   |
|-------|-------------------------------|---------------|--------------|------|------|------|---|
|       |                               |               | Min.         | Typ. | Max. |      |   |
| Input |                               |               |              |      |      |      |   |
| 5.2.1 | Supply current from Input Pin | $I_{IN(ON)}$  | —            | 0.25 | 0.5  | mA   | $V_{DS} = 0\text{ V};$<br>$V_{IN} = 5.5\text{ V}$               |
| 5.2.2 | Supply current during PWM     | $I_{IN(PWM)}$ | —            | 0.3  | 0.6  | mA   | <sup>1)</sup> $V_{IN} = 5.5\text{ V}$ with<br>20kHz PWM (50%DC) |
| 5.2.3 | Input ON threshold voltage    | $V_{IN(th)}$  | —            | 2.3  | 2.7  | V    | $V_{DS} = 13.5\text{ V};$<br>$I_D = 350\text{ mA}$              |

1) Not subject to production test

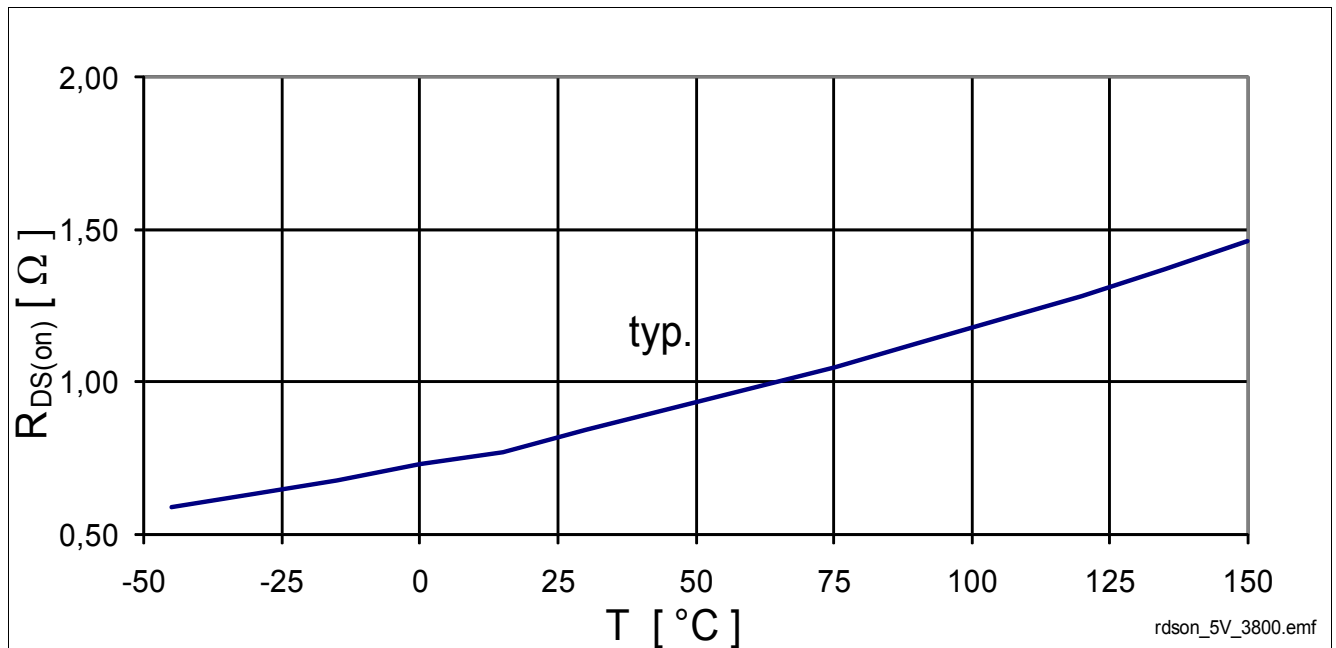


## 6 Power stage

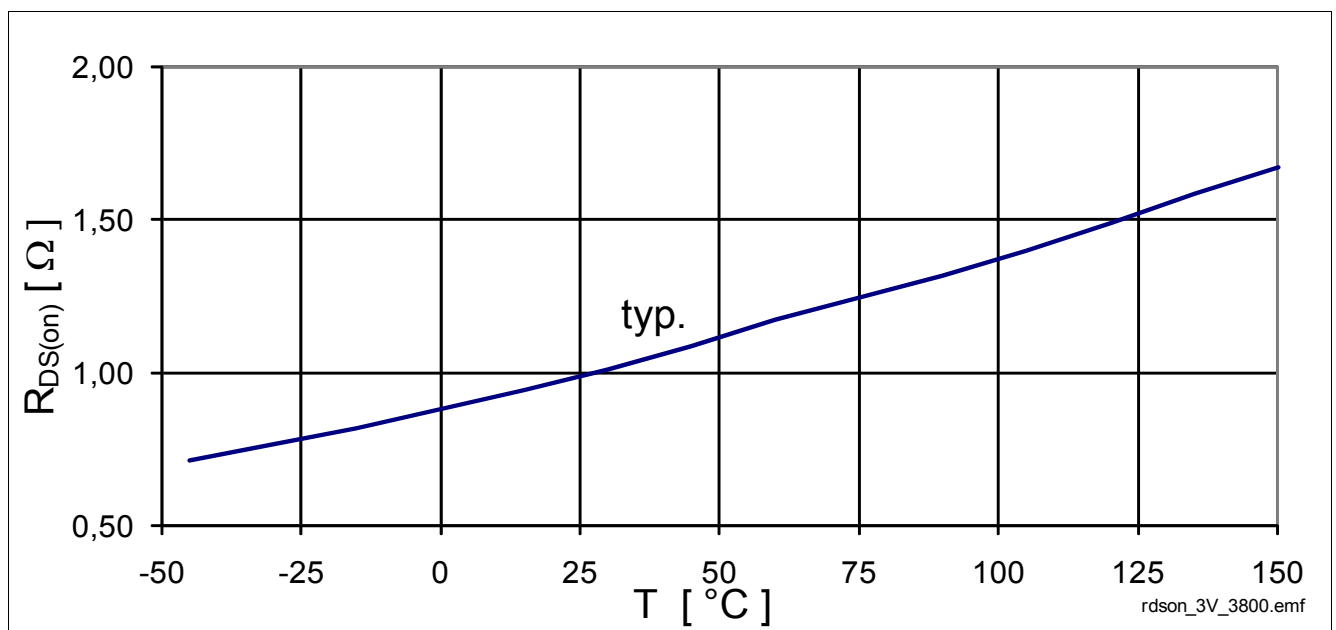
### 6.1 Output On-state Resistance

The on-state resistance depends on the junction temperature  $T_J$  and on the applied input voltage.

The following Figures show the dependencies for the typical on-state resistance  $R_{DS(on)}$ .



**Figure 5** BTS3800 Typical On-State Resistance,  $R_{DS(on)} = f(T_J)$ ,  $V_{IN} = 5.5V$

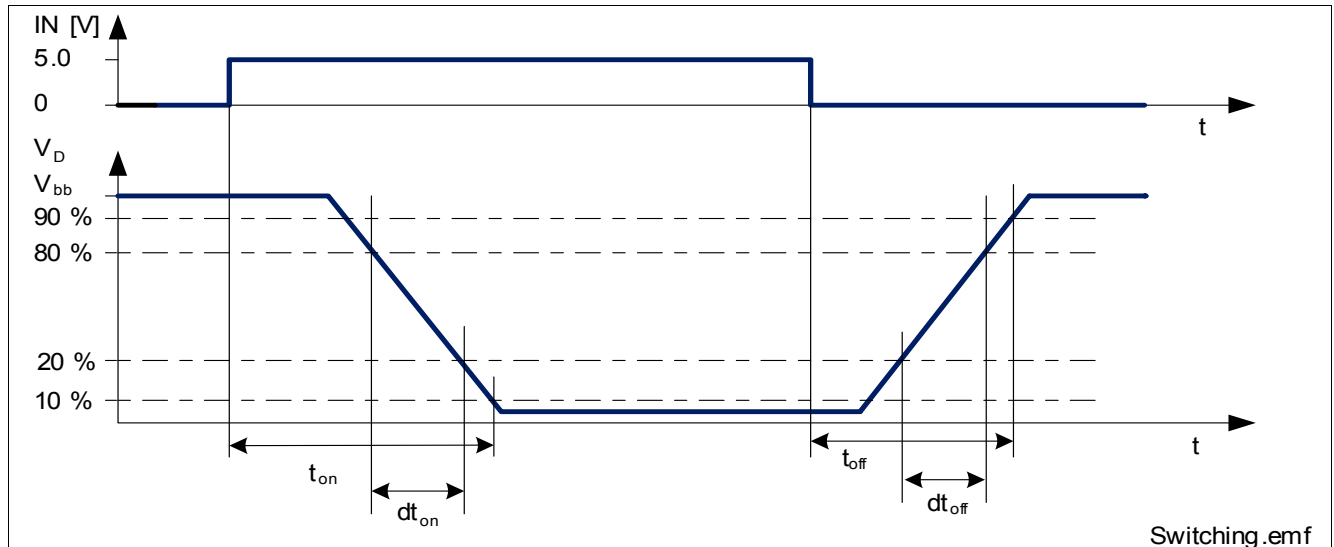


**Figure 6** BTS3800 Typical On-State Resistance,  $R_{DS(on)} = f(T_J)$ ,  $V_{IN} = 3V$

## 6.2 Output Timing

A voltage signal at the input pin above the threshold voltage causes the power MOSFET to switch on.

**Figure 7** shows the timing definition.



**Figure 7** Definition of Power Output Timing for Resistive Load

## 6.3 Power Characteristics

*Note: Characteristics show the deviation of parameter at given input voltage and junction temperature.*

*Typical values show the typical parameters expected from manufacturing.*

*All voltages with respect to Source Pin unless otherwise stated.*

### Electrical Characteristics: Power Stage

$T_j = -40\text{ °C to }+150\text{ °C}$ ,  $V_{bat} = 8.0\text{ V to }18\text{ V}$ ,

all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

| Pos.        | Parameter            | Symbol       | Limit Values |      |      | Unit     | Test Conditions  |
|-------------|----------------------|--------------|--------------|------|------|----------|--|
|             |                      |              | Min.         | Typ. | Max. |          |  |
| Power Stage |                      |              |              |      |      |          |  |
| 6.3.1       | On-State Resistance  | $R_{DS(on)}$ | –            | 0.8  | –    | $\Omega$ | <sup>1)</sup> $T_J = 25\text{ }^{\circ}\text{C}$ ;<br>$V_{IN} = 5.5\text{ V}$<br>$I_D = 350\text{ mA}$   |
|             |                      |              | –            | 1.4  | 1.6  | $\Omega$ | $T_J = 150\text{ }^{\circ}\text{C}$ ;<br>$V_{IN} = 5.5\text{ V}$<br>$I_D = 350\text{ mA}$  |
|             |                      |              | –            | 1.0  | –    | $\Omega$ | <sup>1)</sup> $T_J = 25\text{ }^{\circ}\text{C}$ ;<br>$V_{IN} = 3\text{ V}$<br>$I_D = 350\text{ mA}$   |
|             |                      |              | –            | 1.7  | 2.0  | $\Omega$ | <sup>1)</sup> $T_J = 150\text{ }^{\circ}\text{C}$ ;<br>$V_{IN} = 3\text{ V}$<br>$I_D = 350\text{ mA}$  |
| 6.3.2       | Nominal load current | $I_{D(nom)}$ | 350          | 520  | –    | mA       | <sup>2)</sup> $T_J < 150\text{ }^{\circ}\text{C}$ ;<br>$T_A = 105\text{ }^{\circ}\text{C}$ ;<br>$V_{IN} = 5\text{ V}$ ;<br>$V_{DS} = 0.5\text{ V}$ |

**Electrical Characteristics: Power Stage (cont'd)**
 $T_J = -40\text{ }^{\circ}\text{C}$  to  $+150\text{ }^{\circ}\text{C}$ ,  $V_{\text{bat}} = 8.0\text{ V}$  to  $18\text{ V}$ ,

all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

| Pos.  | Parameter                                | Symbol           | Limit Values |      |                 | Unit          | Test Conditions  |
|-------|--|------------------|--------------|------|-----------------|---------------|--|
|       |  |                  | Min.         | Typ. | Max.            |               |  |
| 6.3.3 | Zero input voltage drain leakage current | $I_{\text{DSS}}$ | –            | 2.5  | 6               | $\mu\text{A}$ | $V_{\text{D}} = 36\text{ V}; V_{\text{IN}} = 0\text{ V};$  |
|       |  |                  | –            | –    | 0.2<br>0.5<br>2 | $\mu\text{A}$ | $V_{\text{D}} = 13.5\text{ V}; V_{\text{IN}} = 0\text{ V};$<br>$T_J = 25\text{ }^{\circ}\text{C}^{1)}$<br>$T_J = 85\text{ }^{\circ}\text{C}^{1)}$<br>$T_J = 150\text{ }^{\circ}\text{C}$ |

**Switching**  $V_{\text{bb}} = 13.5\text{ V}$ ,  $R_{\text{L}} = 38\text{ }\Omega$ ,  $V_{\text{IN}} = 5.0\text{ V}$ 

|       |               |                                  |   |    |    |               |   |
|-------|---------------|----------------------------------|---|----|----|---------------|---|
| 6.3.4 | Turn-on time  | $t_{\text{on}}$                  | – | 3  | 5  | $\mu\text{s}$ | see <a href="#">Figure 7</a> for definition                                       |
| 6.3.5 | Turn-off time | $t_{\text{off}}$                 | – | 3  | 5  | $\mu\text{s}$ | see <a href="#">Figure 7</a> for definition                                       |
| 6.3.6 | Slew rate on  | $-dV_{\text{ds}}/dt_{\text{on}}$ | – | 6  | 12 |               | $dV_{\text{D}} = 80\text{ to }20\% V_{\text{bb}}$<br>see <a href="#">Figure 7</a> |
| 6.3.7 | Slew rate off | $dV_{\text{ds}}/dt_{\text{off}}$ | – | 12 | 22 |               | $dV_{\text{D}} = 20\text{ to }80\% V_{\text{bb}}$<br>see <a href="#">Figure 7</a> |

**Inverse Diode**

|       |                               |                 |   |      |      |   |  |
|-------|-------------------------------|-----------------|---|------|------|---|--|
| 6.3.8 | Inverse Diode forward voltage | $V_{\text{SD}}$ | – | -1.0 | -1.5 | V | $I_{\text{D}} = 350\text{ mA}$<br>$V_{\text{IN}} = 0\text{ V}$ |
|-------|-------------------------------|-----------------|---|------|------|---|--|

1) Not subject to production test, guaranteed by design.

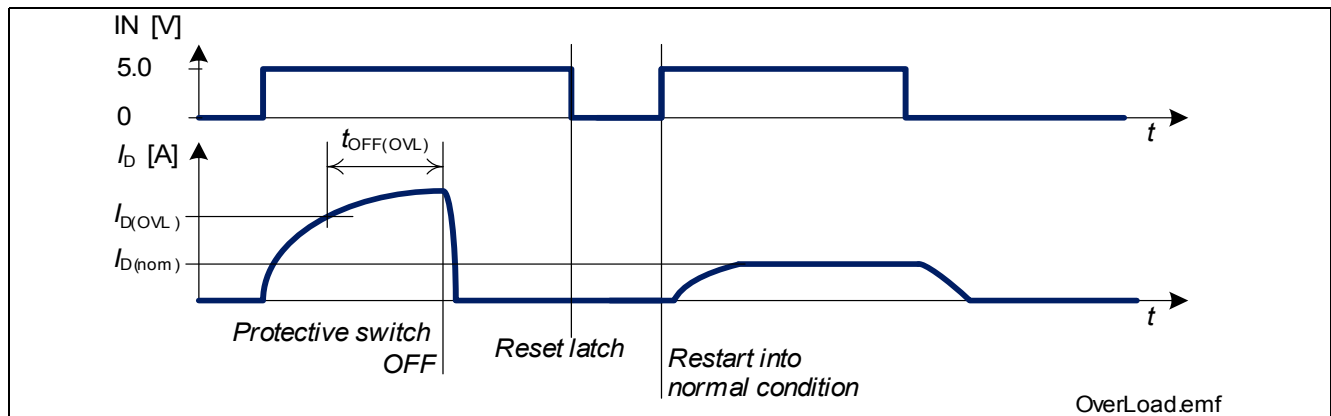
2) Not subject to production test, calculated by  $R_{\text{thJA}}$  and  $R_{\text{DS(on)}}$ .

## 7 Protection Functions

The device provides embedded protective functions. Integrated protection functions are designed to prevent IC destruction under fault conditions described in this datasheet. Fault conditions are considered as "outside" normal operating range. Protection functions are not designed for continuous repetitive operation.

### 7.1 Over Load Protection

The BTS3800SL is protected in case of over load or short circuit of the load. After time  $t_{\text{OFF(OVL)}}$ , the device switches off. It can be switched on by toggeling the IN pin. Please refer to [Figure 8](#) for details.



**Figure 8** Shut down at over load

### 7.2 Over Temperature Protection

A temperature sensor causes a overheated BTS3800SL to switch off to prevent destruction. It can be switched on again by toggeling the IN pin.

### 7.3 Reverse Polarity Protection

In case of reverse polarity, the intrinsic body diode of the power transistor causes power dissipation. The reverse current through the intrinsic body diode of the power transistor has to be limited by the connected load.

The over temperature and over load protection is not active during reverse polarity.

## 7.4 Protection Characteristics

*Note: Characteristics show the deviation of parameter at given supply voltage and junction temperature. Typical values show the typical parameters expected from manufacturing.*

### Electrical Characteristics: Protection

$T_j = -40\text{ °C to }+150\text{ °C}$ ,  $V_{\text{bat}} = 8.0\text{ V to }18\text{ V}$ ,

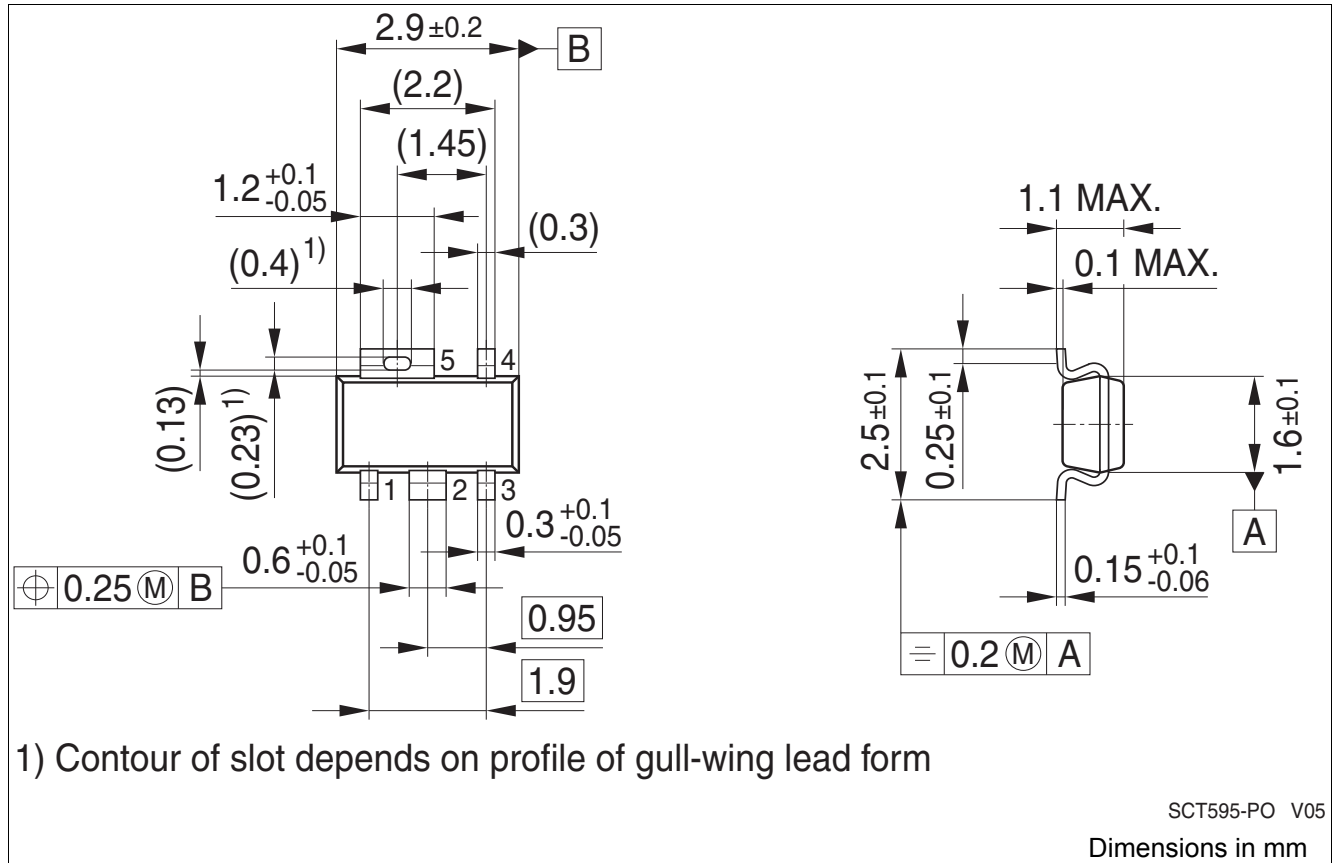
all voltages with respect to ground, positive current flowing into pin (unless otherwise specified)

| Pos.                        | Parameter                      | Symbol         | Limit Values |      |      | Unit | Conditions                                    |
|-----------------------------|--------------------------------|----------------|--------------|------|------|------|---|
|                             |                                |                | Min.         | Typ. | Max. |      |   |
| Over Load Protection        |                                |                |              |      |      |      |   |
| 7.4.1                       | Over load detection current    | $I_{D(OVL)}$   | 0.75         | –    | 1.5  | A    |   |
| 7.4.2                       | Over load shut-down delay time | $t_{OFF(OVL)}$ | 5            | –    | 15   | μs   | $V_{IN} = 5\text{ V}$                         |
| Over Temperature Protection |                                |                |              |      |      |      |   |
| 7.4.3                       | Thermal shut down temperature  | $T_{j(SC)}$    | 150          | 170  | 200  | °C   | 1)  |
| Over Voltage Protection     |                                |                |              |      |      |      |   |
| 7.4.4                       | Output clamping voltage        | $V_{DS(AZ)}$   | 41           | –    | 50   | V    | $I_D = 10\text{ mA}$<br>$V_{IN} = 0\text{ V}$ |

1) Not subject to production test, specified by design.



## 8 Package Outlines BTS3800SL



**Figure 9 PG-SCT595 (Plastic Green Semiconductor Transistor Package)**

### Green Product (RoHS compliant)

To meet the world-wide customer requirements for environmentally friendly products and to be compliant with government regulations the device is available as a green product. Green products are RoHS-Compliant (i.e. Pb-free finish on leads and suitable for Pb-free soldering according to IPC/JEDEC J-STD-020).

For further information on packages, please visit our website:  
<http://www.infineon.com/packages>.

## **9 Revision History**

| <b>Version</b> | <b>Date</b> | <b>Changes</b>              |
|----------------|-------------|-----------------------------|
| Rev. 1.1       | 2011-04-30  | initial released data sheet |



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