

# BTS3160D

10mOhm Smart Low Side Power Switch

Automotive Power



Never stop thinking

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## Smart Low Side Power Switch HITFET - BTS3160D

**BTS3160D**

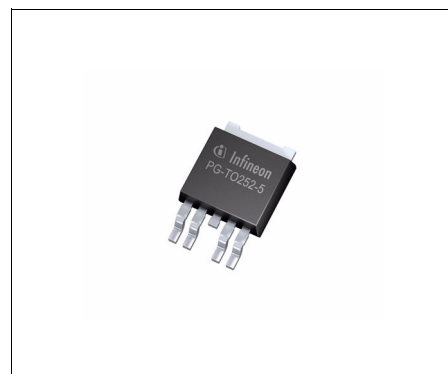


### 1 Overview

The BTS3160D is a one channel low-side power switch in PG-TO-252-5-13 package providing embedded protective functions.

The power transistor is realized by a N-channel vertical power MOSFET.

The device is controlled by a chip in Smart Power Technology.



**PG-TO-252-5-13**

#### Features

- Logic level input compatible to 3.3 V or 5V micro controllers
- Supply by  $V_{bb}$  line, down to 6 V
- Very low over all leakage current
- Providing digital fault information
- Electrostatic discharge protection (ESD)
- Green Product (RoHS compliant)
- AEC Qualified

**Table 1 Basic Electrical Data**

|                                                                |                  |              |
|----------------------------------------------------------------|------------------|--------------|
| Drain voltage                                                  | $V_D$            | 40 V         |
| Supply voltage                                                 | $V_S$            | 6.0 ... 45 V |
| On-State resistance at 25°C                                    | $R_{DS(ON,max)}$ | 10 mΩ        |
| Nominal load current                                           | $I_{Dnom}$       | 7.8 A        |
| Maximum inrush current                                         | $I_{DSC}$        | 70 A         |
| Leakage current MOSFET at $V_{bb} = 13.5$ V, $T_J = 85$ °C     | $I_{DSS}$        | 2 μA         |
| Supply current in off mode at $V_{bb} = 13.5$ V, $T_J = 85$ °C | $I_{SSS}$        | 4 μA         |
| Clamping Energy                                                | $E_{AS}$         | 0.3 J        |

| Type     | Package        |
|----------|----------------|
| BTS3160D | PG-TO-252-5-13 |

**Digital Diagnostic**

- Over temperature shutdown
- Over load shutdown
- Short circuit shutdown

**Protection Functions**

- Electrostatic discharge (ESD)
- Under voltage lock out
- Over temperature (shutdown with latch)
- Over voltage (active clamped)

**Application**

- Micro controller compatible low side power switch with digital feedback for 12V loads
- All types of resistive, inductive and capacitive loads
- Suitable for loads with high inrush current, such as lamps
- Also suitable for LEDs because of low leakage current
- Replaces electromechanical relays, fuses and discrete circuits

**Description**

The BTS3160D is a latching one channel low-side power switch in PG-TO-252-5-13 package providing embedded protective functions. The power transistor is build by a N-channel vertical power MOSFET. The device is controlled by a control chip in Smart Power Technology.

The device is able to switch all kind of resistive, inductive and capacitive loads. For lamp loads the lamp-inrush-current, eight- to ten-times the nominal current, has to be considered. The maximal inrush current has to be below the minimum short circuit shutdown current.

The ESD protection of the  $V_S$  and IN/Fault pin is in relation to GND.

The BTS3160D is supplied by the  $V_S$  Pin. This Pin can be connected to battery line. The supply voltage is monitored by the under voltage lock out circuit. The Gate driving unit allows to operate the device in the low ohmic range even with 3.3 V input signal. For PWM application the device offers smooth turn-on and off due to the embedded edge shaping function, in order to reduce EMC noise.

The over voltage protection is for protection during load-dump or inductive turn off conditions. The power MOSFET is limiting the drain-source voltage, if it gets too high. This function is available even without supply.

The over temperature protection is in order to save the device from overheating due to overload and bad cooling conditions. In order to reduce the device stress the edge shaping is disabled during thermal shutdown. After thermal shutdown the device stays off until the latch is reset by a IN-Low signal. For high dynamic overload conditions such as short circuit the device will turn off if a certain load current is reached. The short circuit shutdown is a latch function. The device will stay off until the latch is reset by IN-Low signal. In order to reduce the device stress the edge shaping is disabled during short circuit turn off.



## 2.1 Voltage and current naming definition

Following figure shows all the terms used in this datasheet, with associated convention for positive values.

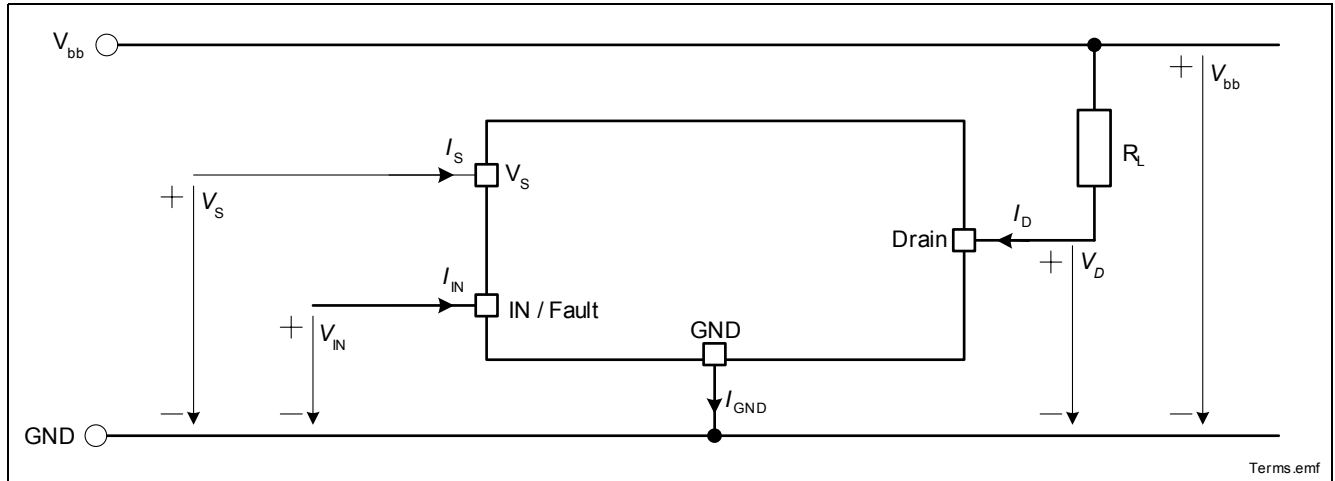


Figure 2 Terms

### 3 Pin Configuration

#### 3.1 Pin Assignment BTS3160D

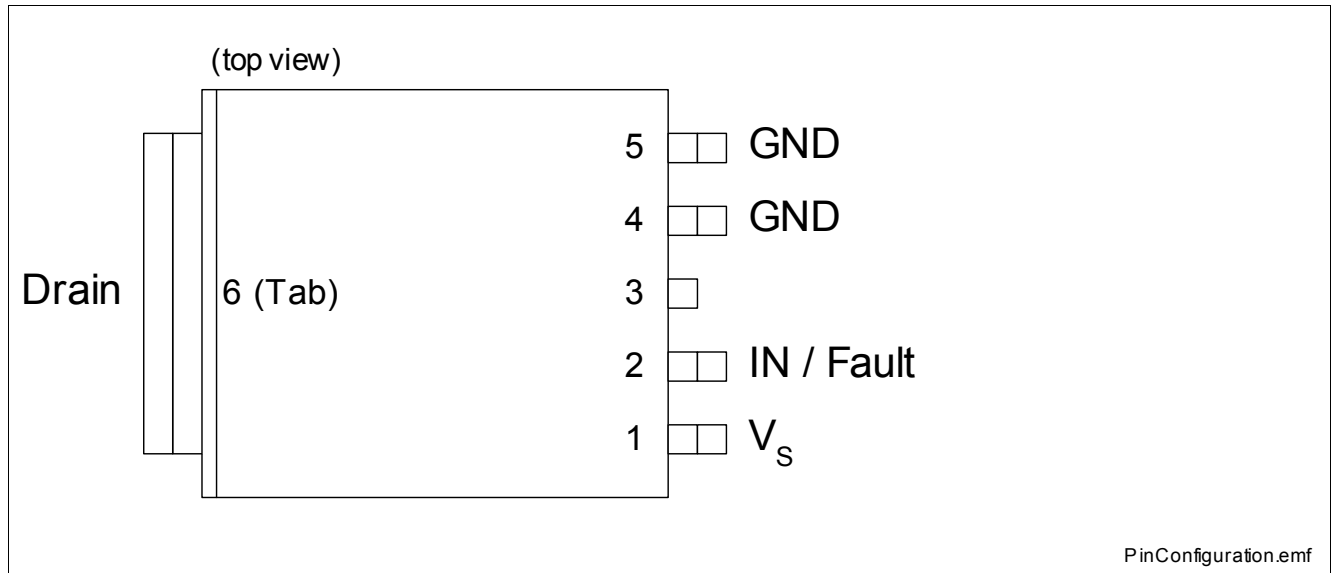


Figure 3 Pin Configuration PG-TO-252-5-13

#### 3.2 Pin Definitions and Functions

| Pin    | Symbol | Function                                                                              |
|--------|--------|---------------------------------------------------------------------------------------|
| 1      | $V_S$  | <b>Supply Voltage</b> ; Connected to Battery Voltage with Reverse polarity protection |
| 2      | IN     | <b>Control Input and Status Feedback</b> ; Digital input 3.3 V or 5 V logic.          |
| 3, Tab | Drain  | <b>Drain output</b> ; Protected low side power output channel                         |
| 4,5    | GND    | <b>Ground</b> ; Signal ground, Pin 4 and 5 must be externally shorted <sup>1)</sup>   |

1) Not shorting pin 4 and 5 will considerably increase the on-state resistance and reduce the peak current capability.

## 4 General Product Characteristics

### 4.1 Absolute Maximum Ratings

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

$T_j = -40\text{ °C to }+150\text{ °C}$ ;  $V_S = 6\text{ V to }30\text{ V}$ .

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

| Pos.               | Parameter                                                 | Symbol                | Limit Values |      | Unit               | Conditions                                                                                            |
|--------------------|-----------------------------------------------------------|-----------------------|--------------|------|--------------------|-------------------------------------------------------------------------------------------------------|
|                    |                                                           |                       | Min.         | Max. |                    |                                                                                                       |
| Voltages           |                                                           |                       |              |      |                    |                                                                                                       |
| 4.1.1              | Supply voltage                                            | $V_S$                 | -0.3         | 30   | V                  | —                                                                                                     |
| 4.1.2              | Supply voltage during active clamping                     | $V_{S(\text{pulse})}$ | -0.3         | 45   | V                  | 2)                                                                                                    |
| 4.1.3              | Drain voltage                                             | $V_D$                 | -0.3         | 40   | V                  | 3)                                                                                                    |
| 4.1.4              | Drain voltage for short circuit protection                | $V_{D(\text{SC})}$    | 0            | 30   | V                  | —                                                                                                     |
| 4.1.5              | Logic input voltage                                       | $V_{\text{IN}}$       | -0.3         | 5.3  | V                  | —                                                                                                     |
| Energies           |                                                           |                       |              |      |                    |                                                                                                       |
| 4.1.6              | Unclamped single pulse inductive energy                   | $E_{\text{AS}}$       | 0            | 0.3  | J                  | $I_D = 20\text{ A}$ ;<br>$V_{\text{bb}} = 30\text{ V}$<br>$T_{\text{J(Start)}} = 150^{\circ}\text{C}$ |
| 4.1.7              | Load dump protection<br>$V_{\text{LoadDump}} = V_A + V_S$ | $V_{\text{LD}}$       | 0            | 45   | V                  | $T_J = 25^{\circ}\text{C}$                                                                            |
| Temperatures       |                                                           |                       |              |      |                    |                                                                                                       |
| 4.1.8              | Junction Temperature                                      | $T_j$                 | -40          | 150  | $^{\circ}\text{C}$ | —                                                                                                     |
| 4.1.9              | Storage Temperature                                       | $T_{\text{stg}}$      | -55          | 150  | $^{\circ}\text{C}$ | —                                                                                                     |
| ESD Susceptibility |                                                           |                       |              |      |                    |                                                                                                       |
| 4.1.10             | ESD Resistivity<br>on all pins                            | $V_{\text{ESD}}$      | -4           | 4    | kV                 | HBM <sup>4)</sup>                                                                                     |

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

2) Not for DC operation, only for short pulse (i.e. load dump) for a total of 100 h in full device life.

3) Active clamped.

4) ESD susceptibility, HBM according to EIA/JESD 22-A114B

*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.         | Typ. | Max. |      |                                                                                 |
| 4.2.1 | Supply Voltage             | $V_S$        | 6            | 13.5 | 30   | V    | –                                                                               |
| 4.2.2 | Supply current in off mode | $I_{S(OFF)}$ | –            | 1.5  | –    | μA   | $V_{IN} = 0.0\text{ V};$<br>$V_S = 13.5\text{ V};$<br>$T_J = 25\text{ °C}$      |
|       |                            |              | –            | –    | 4    |      | $V_{IN} = 0.0\text{ V};$<br>$V_S = 13.5\text{ V};$<br>$T_J = 85\text{ °C}^{1)}$ |
|       |                            |              | –            | –    | 10   |      | $V_{IN} = 0.0\text{ V};$<br>$V_S = 13.5\text{ V};$<br>$T_J = 150\text{ °C}$     |
| 4.2.3 | Supply current in on       | $I_S$        | –            | 1.6  | 3    | mA   | $V_{IN} = 5.0\text{ V};$<br>$V_S = 30\text{ V}$                                 |

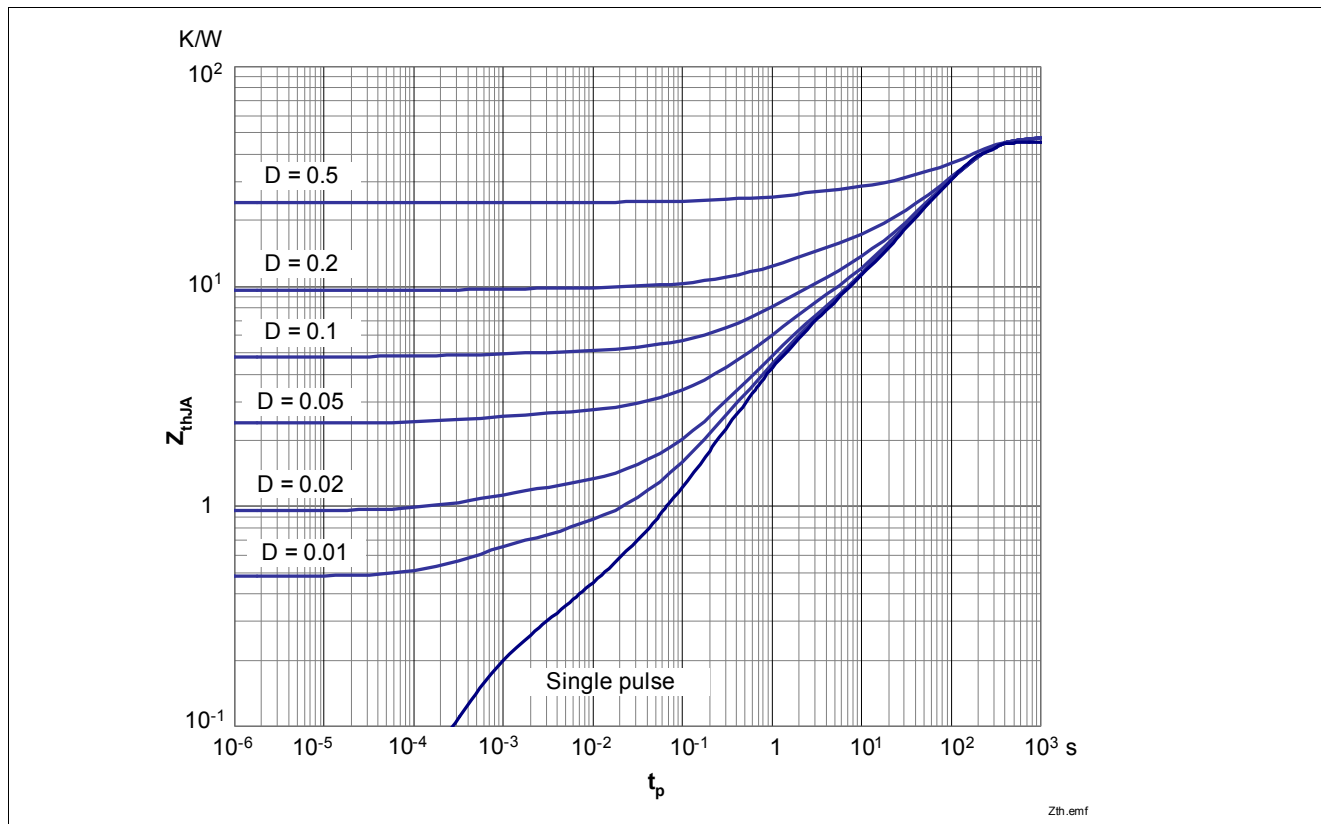
1) Not subject to production test, specified by design.

*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

| Pos.  | Parameter           | Symbol     | Limit Values |      |      | Unit | Conditions                                                                   |
|-------|---------------------|------------|--------------|------|------|------|------------------------------------------------------------------------------|
|       |                     |            | Min.         | Typ. | Max. |      |                                                                              |
| 4.3.1 | Junction to Case    | $R_{thJC}$ | –            | 0.9  | 1.1  | K/W  | <sup>1)</sup>                                                                |
| 4.3.2 | Junction to Ambient | $R_{thJA}$ | –            | 80   |      | K/W  | <sup>1)</sup> @min. footprint                                                |
|       |                     |            | –            | 45   |      | K/W  | <sup>1)</sup> @ 6 cm <sup>2</sup> cooling area, see <a href="#">Figure 4</a> |

1) Not subject to production test, specified by design



**Figure 4** Typical transient thermal impedance

$$Z_{thJA} = f(t_p), D = t_p/T, T_a = 25^\circ\text{C}$$

Device on  $50\text{ mm} \times 50\text{ mm} \times 1.5\text{ mm}$  epoxy PCB FR4 with  $6\text{ cm}^2$  (one layer,  $70\text{ }\mu\text{m}$  thick) copper area for drain connection. PCB mounted vertical without blown air.

## 5 Supply and Input Stage

### 5.1 Supply Circuit

The Supply pin  $V_S$  is protected against ESD pulses as shown in [Figure 5](#). Due to an internal voltage regulator the device can be supplied from battery line.

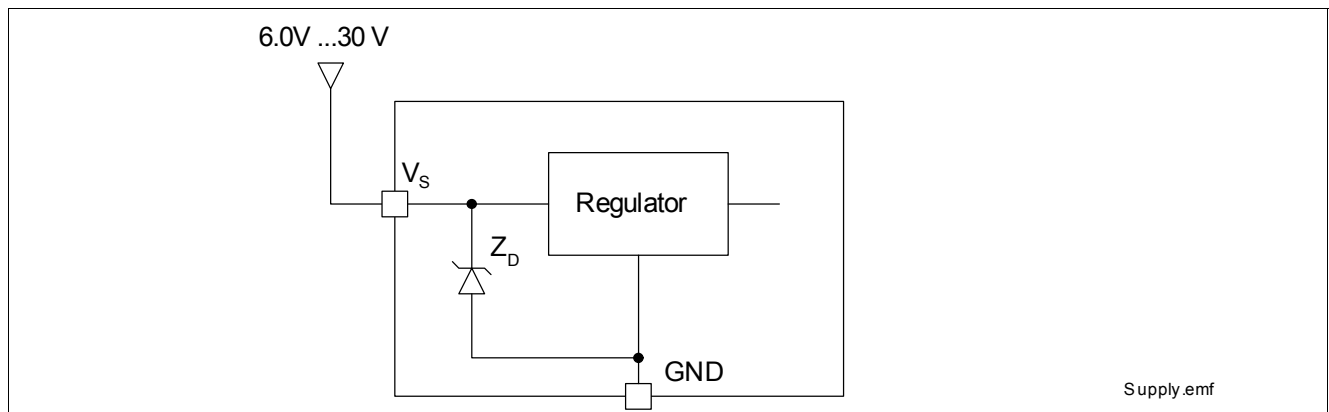


Figure 5 Supply Circuit

#### 5.1.1 Under Voltage Lock Out / Power On Reset

In order to ensure a stable device behavior under all allowed conditions the Supply voltage  $V_S$  is monitored by the under voltage lock out circuit. All device functions and protection are given for supply voltages above under voltage lockout  $V_{SUVON}$  but parameter deviations are possible below  $V_{S(min)}$ . There is no failure feedback for  $V_S < V_{SUVON}$ .

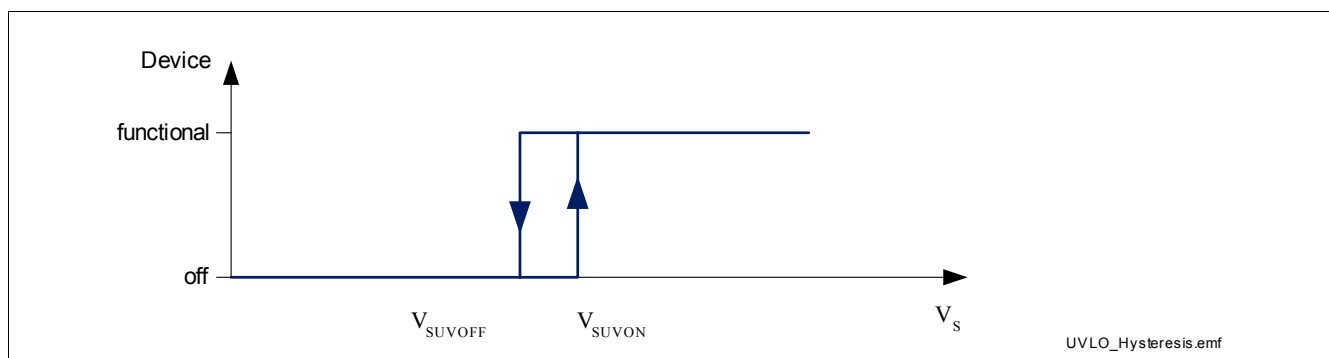
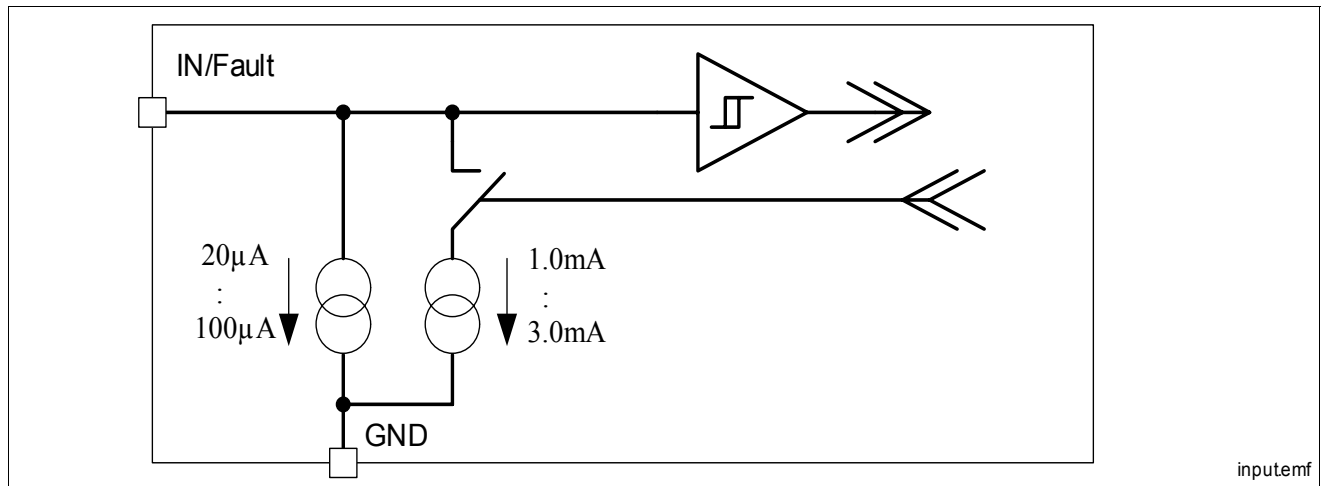


Figure 6 Under Voltage Lock Out

## 5.2 Input Circuit

**Figure 7** shows the input circuit of the BTS3160D. It's ensured that the device switches off in case of open input pin. A zener structure protects the input circuit against ESD pulses. As the BTS3160D has a supply pin, the operation of the power MOS can be maintained regardless of the voltage on the IN pin, therefore a digital status feedback down to logic low is realized. For readout of the fault information, please refer to **"Readout of Fault Information"** on **Page 12**



**Figure 7** Input Circuit

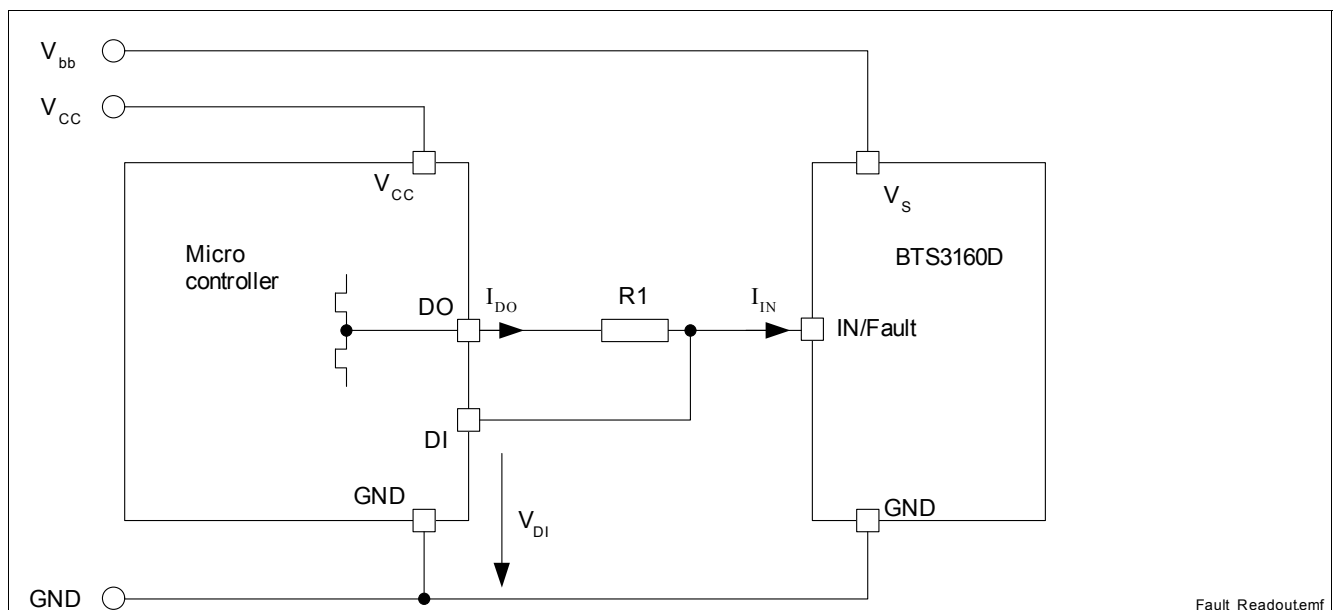
### 5.2.1 Readout of Fault Information

The BTS3160D provides digital status information via an increased current on the IN / Fault pin. The voltage on this pin is pulled down to logic low if a proper resistor is used. An example for the required circuitry is shown in **Figure 8**.

The increased current  $I_{IN(fault)}$  is an order of magnitude above the normal operation current  $I_{IN(nom)}$  therefore the voltage at the IN/Fault pin will decrease. The voltage at the pin is determined by the current and the serial resistor.

We recommend 3k3 for a 3.3V  $\mu C$  and 5k6 for a 5V  $\mu C$  to achieve a logic low signal.

For detailed calculation please refer to **"Dimensioning of serial Resistor at IN pin"** on **Page 26**



**Figure 8** Readout of Fault Information

### 5.3 Electrical Characteristics Supply and Input Stages

$V_S = 6\text{ V to }30\text{ V}$ ,  $T_j = -40\text{ °C to }+150\text{ °C}$

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

| Pos.                           | Parameter                | Symbol                  | Limit Values |      |      | Unit | Conditions                                                |
|--------------------------------|--------------------------|-------------------------|--------------|------|------|------|-----------------------------------------------------------|
|                                |                          |                         | Min.         | Typ. | Max. |      |                                                           |
| Under Voltage Lockout          |                          |                         |              |      |      |      |                                                           |
| 5.3.1                          | UV-switch-on voltage     | $V_{\text{SUVON}}$      | –            | –    | 5.5  | V    | $V_{\text{S}} = 5.5 \text{ V}$                            |
| 5.3.2                          | UV-switch-off voltage    | $V_{\text{SUVOFF}}$     | 4.0          | –    | –    | V    | $V_{\text{S}} = 4.0 \text{ V}$                            |
| 5.3.3                          | UV-switch-off hysteresis | $V_{\text{SUVHY}}$      | –            | 0.2  | –    | V    | $V_{\text{SUVON}} - V_{\text{SUVOFF}}$                    |
| Digital Input / Fault Feedback |                          |                         |              |      |      |      |                                                           |
| 5.3.4                          | Low level voltage        | $V_{\text{INL}}$        | –            | –    | 0.8  | V    | $V_{\text{S}} = 6 \text{ V}$ ;<br>no fault condition      |
| 5.3.5                          | High level voltage       | $V_{\text{INH}}$        | 2.0          | –    | –    | V    | $V_{\text{S}} = 6 \text{ V}$ ;<br>no fault condition      |
| 5.3.6                          | Input pull down current  | $I_{\text{IN}}$         | 20           | 50   | 100  | μA   | $V_{\text{IN}} = 5.3 \text{ V}$ ;<br>no fault condition   |
|                                |                          | $I_{\text{IN-Fault}}$   | 1            | 2    | 3    | mA   | $V_{\text{IN}} = 5.3 \text{ V}$ ;<br>all fault conditions |
| 5.3.7                          | Input Fault ON threshold | $I_{\text{Fault ONth}}$ |              |      | 600  | uA   | 1)                                                        |

1) not subject to production test

## 6 Power Stage

The power stage is built by a N-channel vertical power MOSFET (DMOS)

### 6.1 Output On-state Resistance

The on-state resistance depends on the supply voltage as well as on the junction temperature  $T_J$ . **Figure 9** shows the dependency over temperature for the typical on-state resistance  $R_{DS(on)}$ , while **Figure 10** shows the dependency over  $V_s$ .

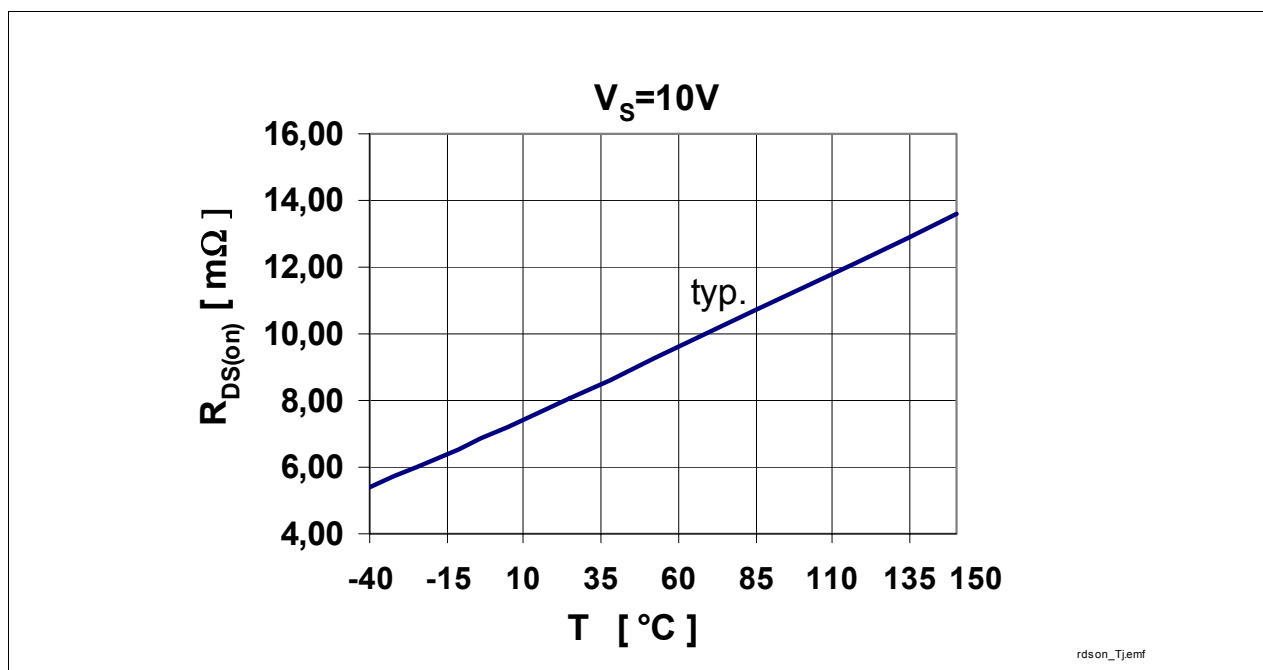


Figure 9 Typical On-State Resistance

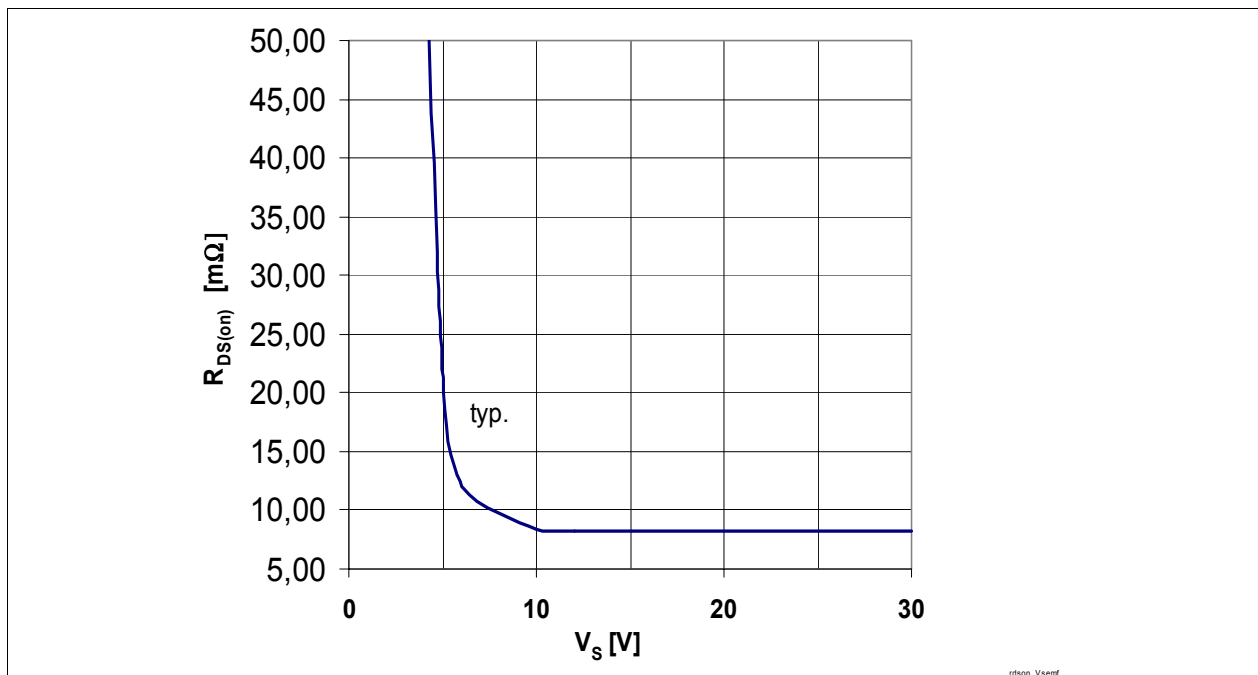


Figure 10 Typical On-State Resistance  $R_{DS(on)} = f(V_S)$

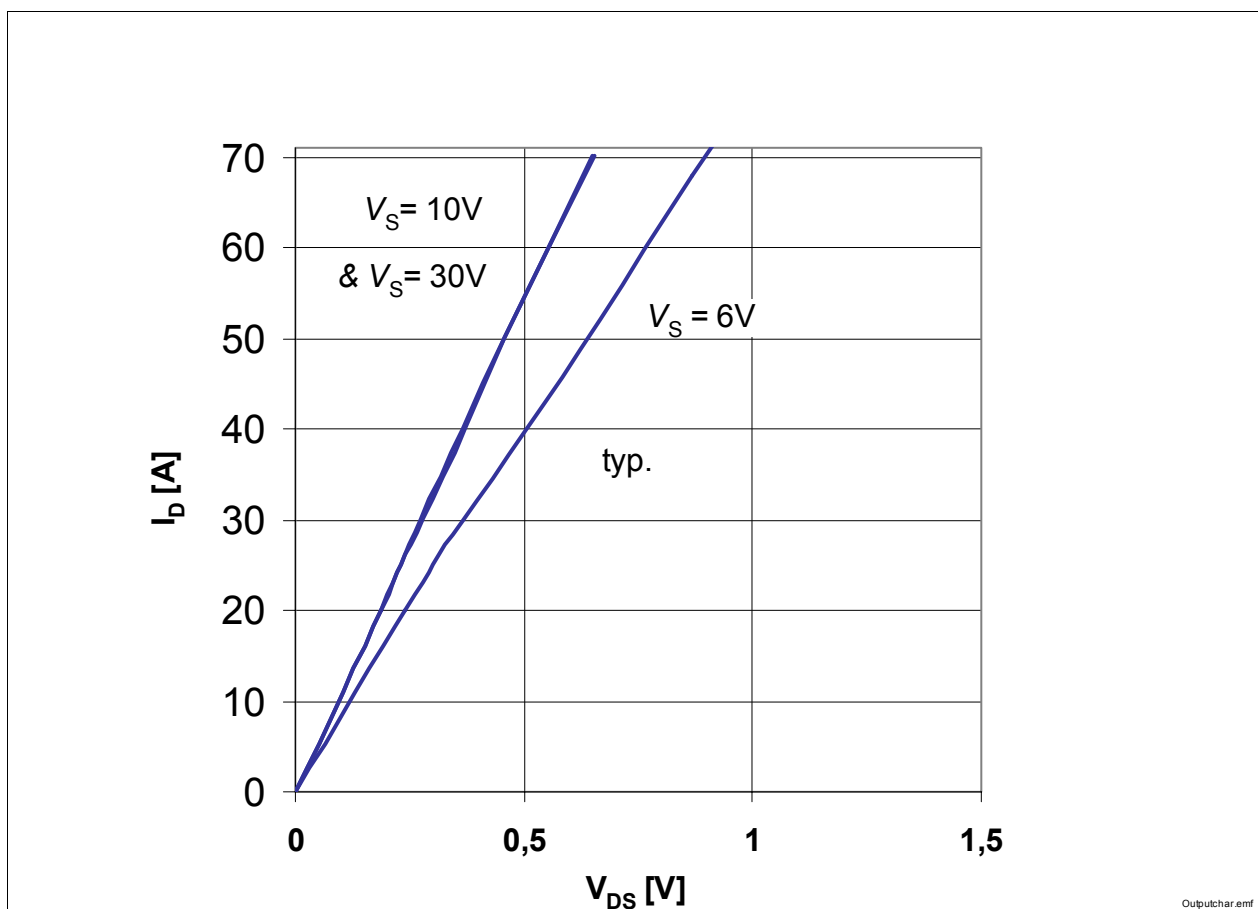


Figure 11 Typical Output Characteristics,  $T_{Jstart} = 25^\circ\text{C}$ , Parameter  $V_S$

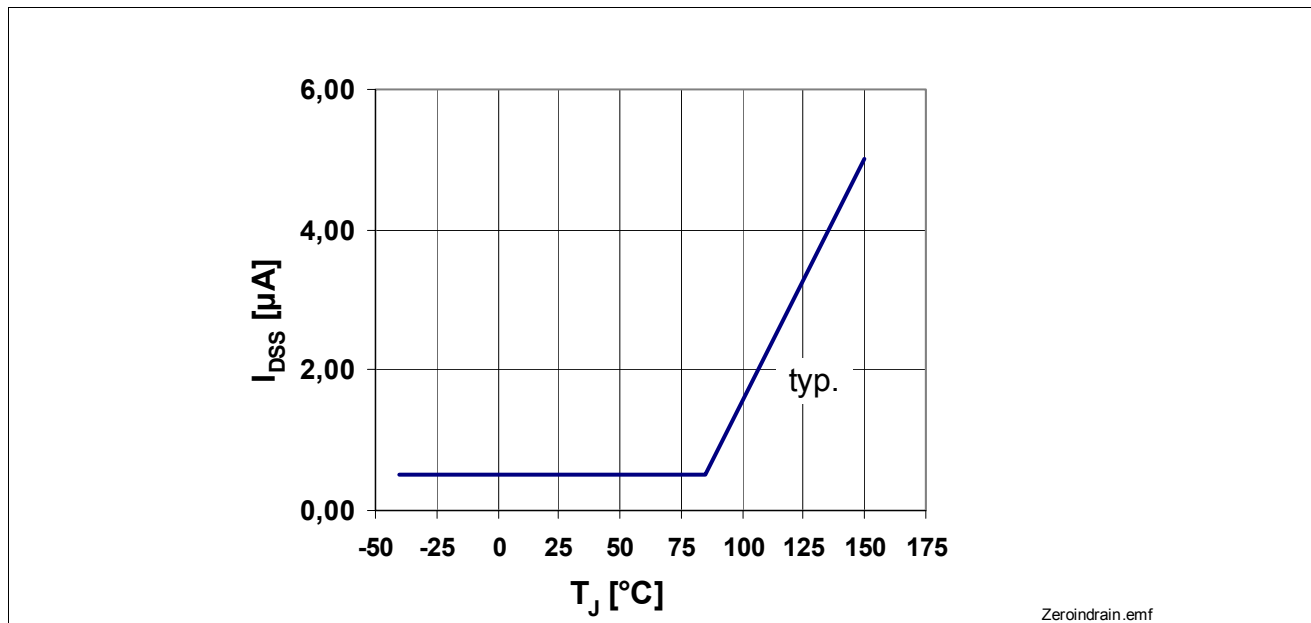
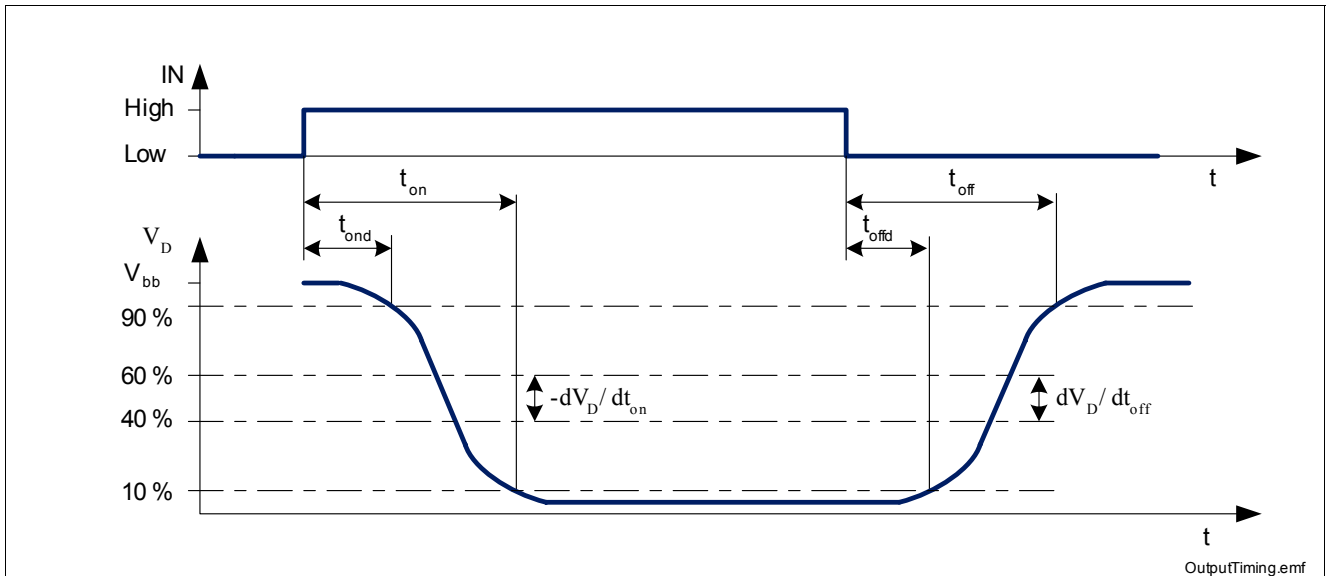


Figure 12 Typical Zero Input Voltage Drain Current,  $I_{DSS} = f(T_J)$



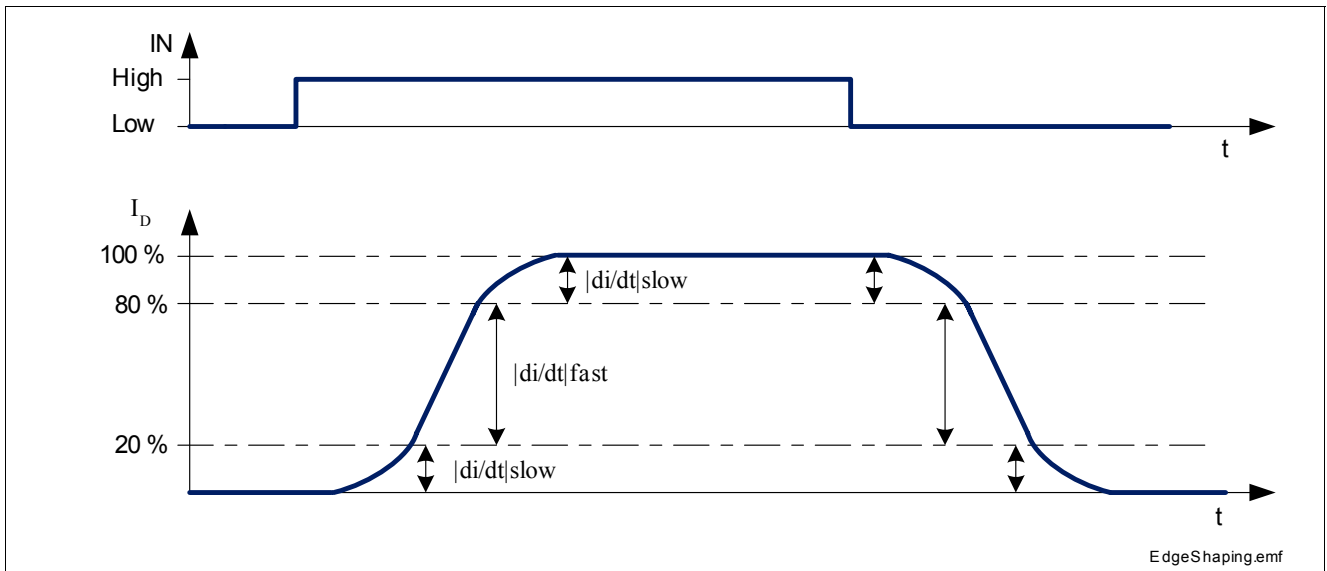
## 6.2 Output Timing and Slopes

A high signal on the input pin causes the power MOSFET to switch on with a dedicated slope which is optimized for low EMC emission. **Figure 13** shows the timing definition.



**Figure 13** Switching a resistive Load

In order to minimize the emission during switching the BTS3160D limits the slopes during turn on- and off to slow slew rate settings. The definition is shown in **Figure 14**. For best performance of the edge shaping the supply pin  $V_S$  should be connected to battery voltage. For supply voltages other than nominal battery the edge shaping can differ from the values in the electrical characteristics table below.



**Figure 14** Typical Slopes for resistive Loads

### 6.3 Inductive Output Clamp

When switching off inductive loads with low-side switches, the Drain Source voltage  $V_D$  rises above battery potential, because the inductance intends to continue driving the current.

The BTS3160D is equipped with a voltage clamp mechanism that keeps the Drain-Source voltage  $V_D$  at a certain level. See [Figure 15](#) for more details.

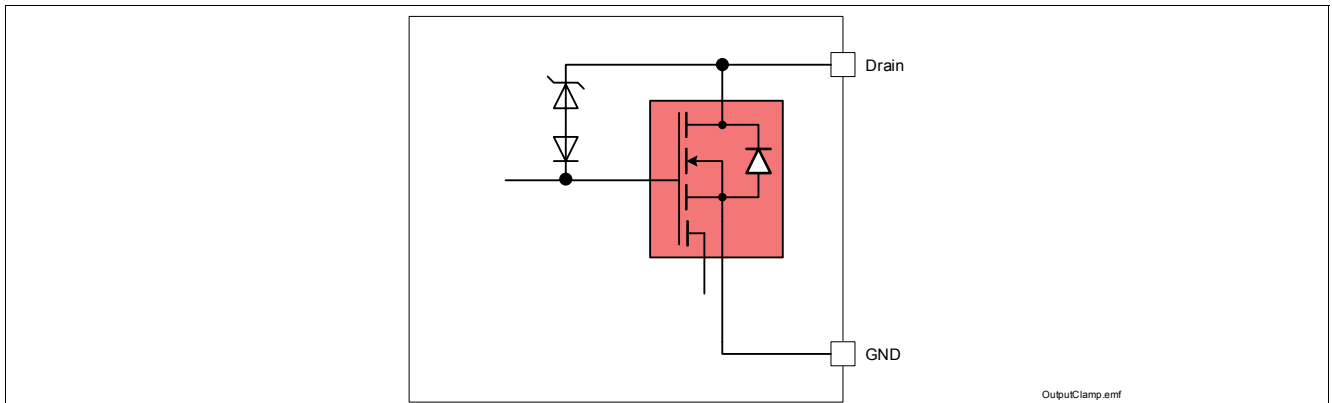


Figure 15 Output Clamp

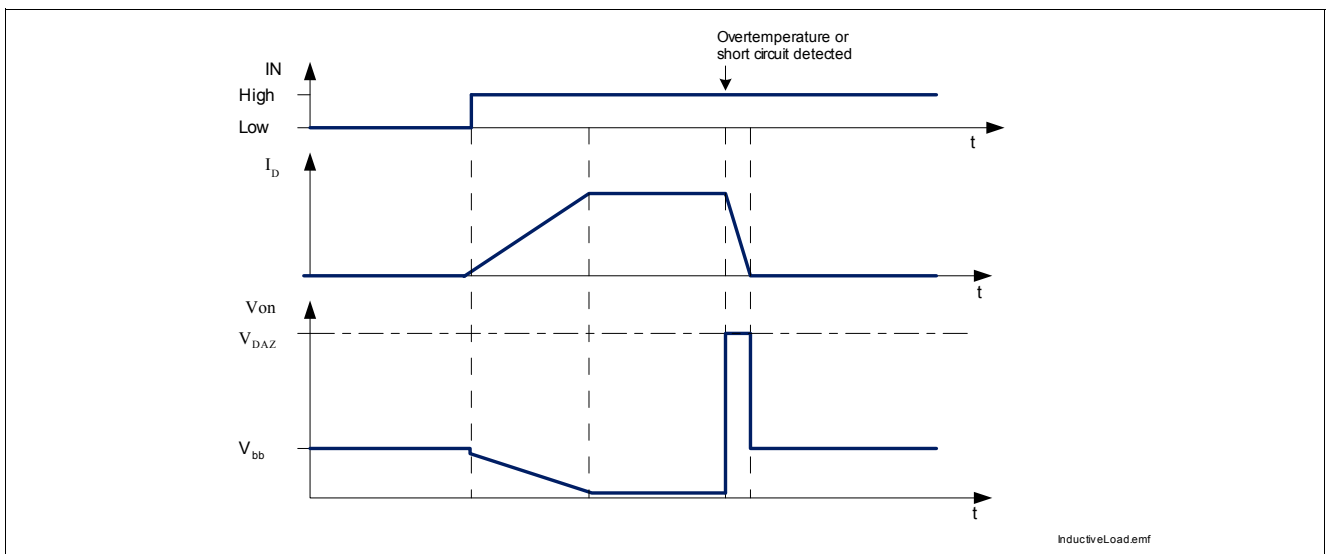


Figure 16 Switching an inductance

While demagnetization of inductive loads, energy has to be dissipated in the BTS3160D. This energy can be calculated with following equation:

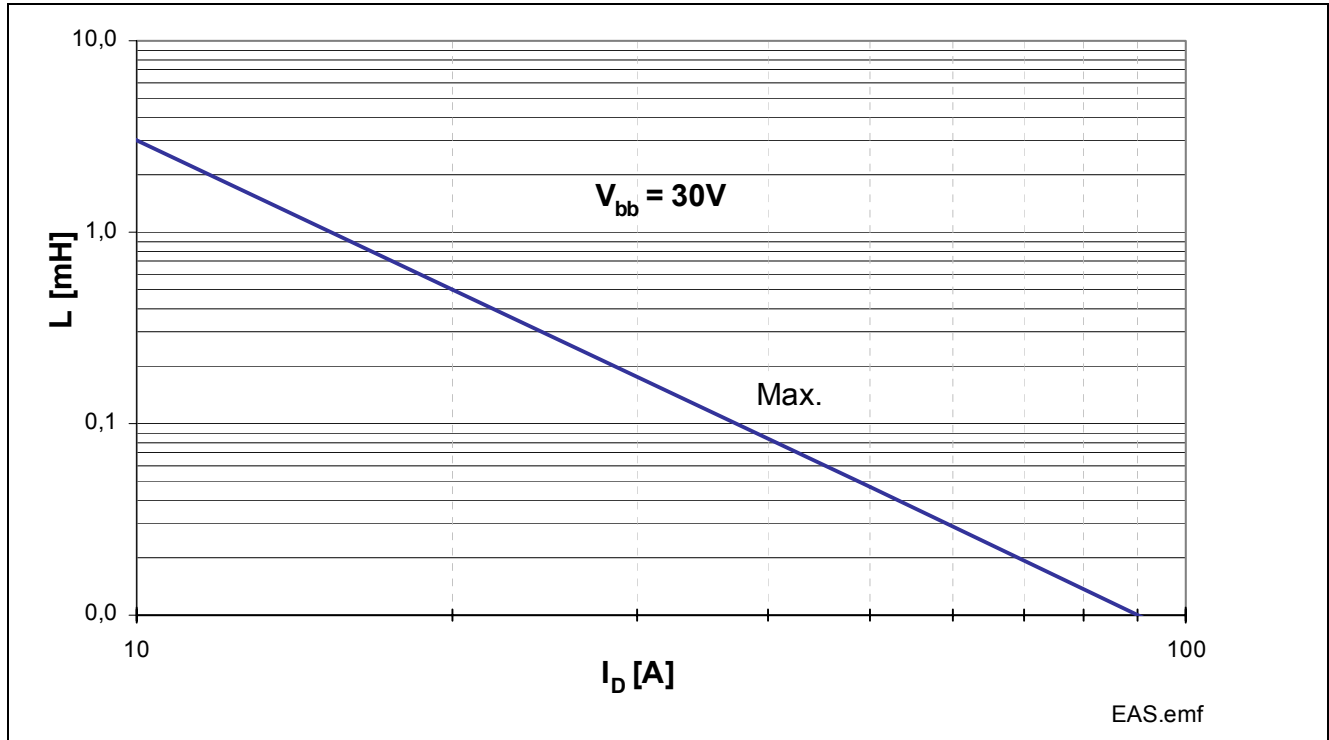
$$E = V_{DS(CL)} \cdot \left[ \frac{V_{bb} - V_{DS(CL)}}{R_L} \cdot \ln \left( 1 - \frac{R_L \cdot I_L}{V_{bb} - V_{DS(CL)}} \right) + I_L \right] \cdot \frac{L}{R_L}$$

Following equation simplifies under assumption of  $R_L = 0$

$$E = \frac{1}{2} L I_L^2 \cdot \left( 1 - \frac{V_{bb}}{V_{bb} - V_{DS(CL)}} \right)$$

**Figure 17** shows the inductance / current combination the BTS3160D can handle.

For maximum single avalanche energy please also refer to  $E_{AS}$  value in **"Energies"** on **Page 8**



**Figure 17** Maximum load inductance for single pulse  
 $L = f(I_D)$ ,  $T_{j,start} = 150\text{ °C}$

## 6.4 Electrical Characteristics Power Stage

$V_S = 6\text{ V to }30\text{ V}$ ,  $T_j = -40\text{ °C to }+150\text{ °C}$

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

| Pos.                    | Parameter                     | Symbol           | Limit Values |      |      | Unit | Conditions                                                                                                                                                   |
|-------------------------|-------------------------------|------------------|--------------|------|------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         |                               |                  | Min.         | Typ. | Max. |      |                                                                                                                                                              |
| Power Supply            |                               |                  |              |      |      |      |                                                                                                                                                              |
| 6.4.1                   | On-state resistance           | $R_{DS(on)}$     | –            | 8    | 10   | mΩ   | $I_D = 20\text{ A}$ ;<br>$V_{IN} = \text{high}$ ;<br>$V_S = 10\text{ V}$ ;<br>$T_J = 25\text{ °C}$                                                           |
|                         |                               |                  | –            | 14   | 18   | mΩ   | $I_D = 20\text{ A}$ ;<br>$V_{IN} = \text{high}$ ;<br>$V_S = 10\text{ V}$ ;<br>$T_J = 150\text{ °C}$                                                          |
| 6.4.2                   | Nominal load current          | $I_{Dnom}$       | 7.8          | 9.7  | –    | A    | <sup>1)</sup> $V_{on} = 0.5\text{ V}$ ;<br>$T_A = 85\text{ °C SMD}^{2)}$ ;<br>$V_{IN} = 5.0\text{ V}$ ;<br>$V_S \geq 10\text{ V}$ ;<br>$T_J < 150\text{ °C}$ |
| 6.4.3                   | ISO load current              | $I_{DISO}$       | 33           | 41   | –    | A    | <sup>1)</sup> $V_{on} = 0.5\text{ V}$ ;<br>$T_C = 85\text{ °C}$ ;<br>$V_{IN} = 5.0\text{ V}$ ;<br>$V_S \geq 10\text{ V}$ ;<br>$T_J < 150\text{ °C}$          |
| 6.4.4                   | Off state drain current       | $I_{DSS}$        | –            | 6    | 12   | μA   | $V_{bb} = 32\text{ V}$ ;<br>$V_{IN} = 0.0\text{ V}$                                                                                                          |
| 6.4.5                   |                               |                  | –            | 1    | 2    | μA   | <sup>1)</sup> $V_{bb} = 13.5\text{ V}$ ;<br>$V_{IN} = 0.0\text{ V}$ ;<br>$T_J = 85\text{ °C}$                                                                |
| Dynamic Characteristics |                               |                  |              |      |      |      |                                                                                                                                                              |
| 6.4.6                   | Turn-on delay                 | $t_{ond}$        | 20           | 75   | 110  | μs   | $R_L = 2.2\text{ Ω}$ ;<br>$V_{bb} = V_S = 13.5\text{ V}$                                                                                                     |
| 6.4.7                   | Turn-on time                  | $t_{on}$         | 80           | 150  | 250  | μs   | $R_L = 2.2\text{ Ω}$ ;<br>$V_{bb} = V_S = 13.5\text{ V}$                                                                                                     |
| 6.4.8                   | Turn-off delay                | $t_{offd}$       | 20           | 75   | 110  | μs   | $R_L = 2.2\text{ Ω}$ ;<br>$V_{bb} = V_S = 13.5\text{ V}$                                                                                                     |
| 6.4.9                   | Turn-off time                 | $t_{off}$        | 80           | 150  | 250  | μs   | $R_L = 2.2\text{ Ω}$ ;<br>$V_{bb} = V_S = 13.5\text{ V}$                                                                                                     |
| 6.4.10                  | Slew rate on                  | $-dV_D/dt_{on}$  | 0.1          | 0.3  | 0.7  | V/μs | $R_L = 2.2\text{ Ω}$ ;<br>$V_{bb} = V_S = 13.5\text{ V}$                                                                                                     |
| 6.4.11                  | Slew rate off                 | $dV_D/dt_{off}$  | 0.1          | 0.3  | 0.7  | V/μs | $R_L = 2.2\text{ Ω}$ ;<br>$V_{bb} = V_S = 13.5\text{ V}$                                                                                                     |
| 6.4.12                  | Slew rate during edge shaping | $ dl/dt _{slow}$ | –            | 0.04 | 0.07 | A/μs | <sup>1)</sup> $R_L = 2.2\text{ Ω}$<br>$V_{bb} = V_S = 13.5\text{ V}$ ;<br>ohmic load                                                                         |

$V_S = 6\text{ V to }30\text{ V}, T_j = -40\text{ °C to }+150\text{ °C}$ 

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

| Pos.   | Parameter                      | Symbol           | Limit Values |      |      | Unit       | Conditions                                                                         |
|--------|--------------------------------|------------------|--------------|------|------|------------|------------------------------------------------------------------------------------|
|        |                                |                  | Min.         | Typ. | Max. |            |                                                                                    |
| 6.4.13 | Slew rate between edge shaping | $ dl/dt _{fast}$ | —            | —    | 0.3  | A/ $\mu$ s | <sup>1)</sup> $R_L = 2.2\ \Omega$<br>$V_{bb} = V_S = 13.5\text{ V};$<br>ohmic load |
| 6.4.14 | Fault signal delay             | $t_{dfault}$     | —            | 4    | 10   | $\mu$ s    | <sup>1)</sup>                                                                      |

**Inverse Diode**

|        |                               |       |      |      |      |   |                                                                         |
|--------|-------------------------------|-------|------|------|------|---|-------------------------------------------------------------------------|
| 6.4.15 | Inverse Diode forward voltage | $V_D$ | -0.3 | -1.0 | -1.5 | V | $I_D = -12\text{ A};$<br>$V_S = 0\text{ V};$<br>$V_{IN} = 0.0\text{ V}$ |
|--------|-------------------------------|-------|------|------|------|---|-------------------------------------------------------------------------|

1) Not subject to production test.

2) Device on 50 mm  $\times$  50 mm  $\times$  1.5 mm epoxy PCB FR4 with 6 cm<sup>2</sup> (one layer, 70  $\mu$ m thick) copper area for drain connection. PCB mounted vertical without blown air.

## 7 Protection Functions

The device provides embedded protection functions against over temperature, over load and short circuit.

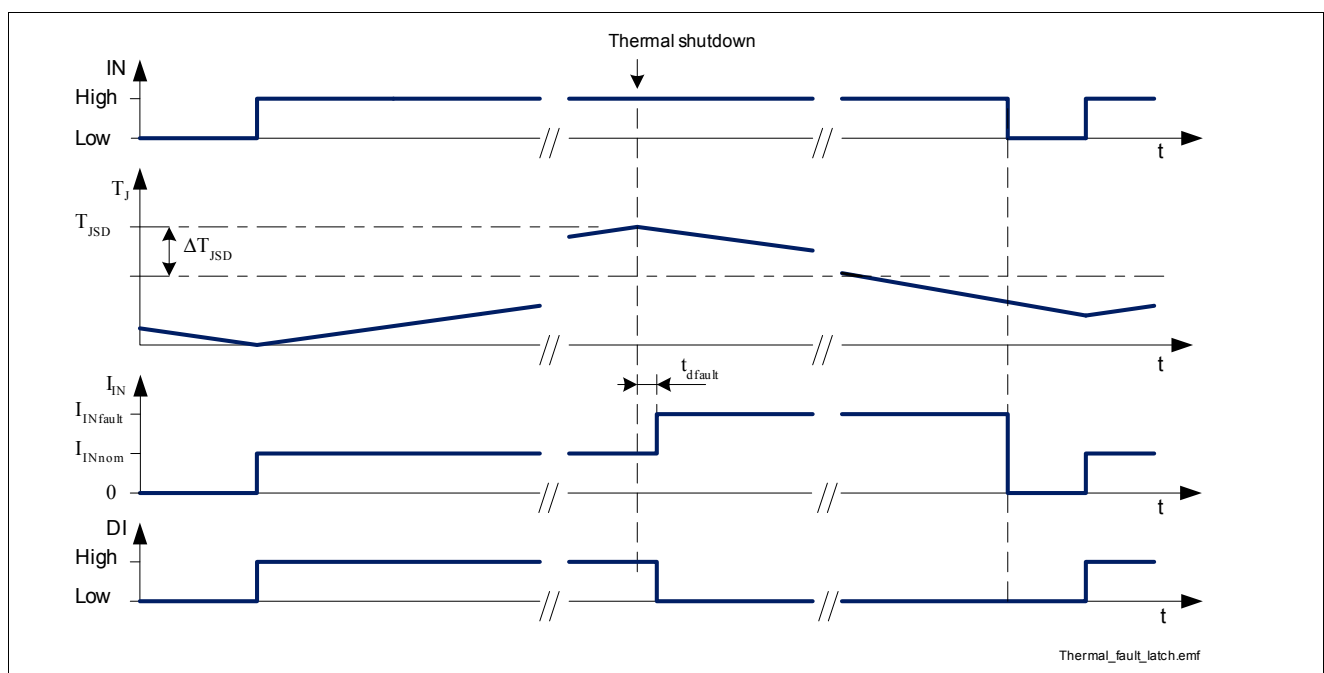
*Note: Integrated protection functions are designed to prevent IC destruction under fault conditions described in the data sheet. Fault conditions are considered as "outside" normal operation.*

### 7.1 Thermal Protection

The device is protected against over temperature resulting due to overload and / or bad cooling conditions.

The BTS3160D has a thermal latch function. The thermal latch is reset by IN-Low signal. See [Figure 18](#) for the latch behavior.

The diagram naming refers to [Figure 8](#)



**Figure 18** Status Feedback via Input Current at Over temperature

### 7.2 Over Voltage Protection

The BTS3160D is equipped with a voltage clamp mechanism that keeps the Drain-Source voltage  $V_D$  at a certain level. This stage is also used for inductive clamping.

See ["Inductive Output Clamp" on Page 18](#) for details.

### 7.3 Short Circuit Protection

The condition short circuit is an overload condition of the device. Dependent on the short circuit resistance the current increase is more or less steep. In condition of high ohmic short the device heats up and the turn off is due to over temperature. In condition low ohmic short the device turns off on a threshold current level before the over temperature condition is detected. In order to allow short current spikes, the turn off occurs with the delay time  $t_{dSC}$ . [Figure 19](#) shows the behavior mentioned above. In this example the short circuit always occurs after the device has switched on under normal load condition - Short circuit type 2. The definitions of voltages and currents are in respect to [Figure 8](#). The behavior of  $V_{DI}$  also depends on  $R_{IN}$ .

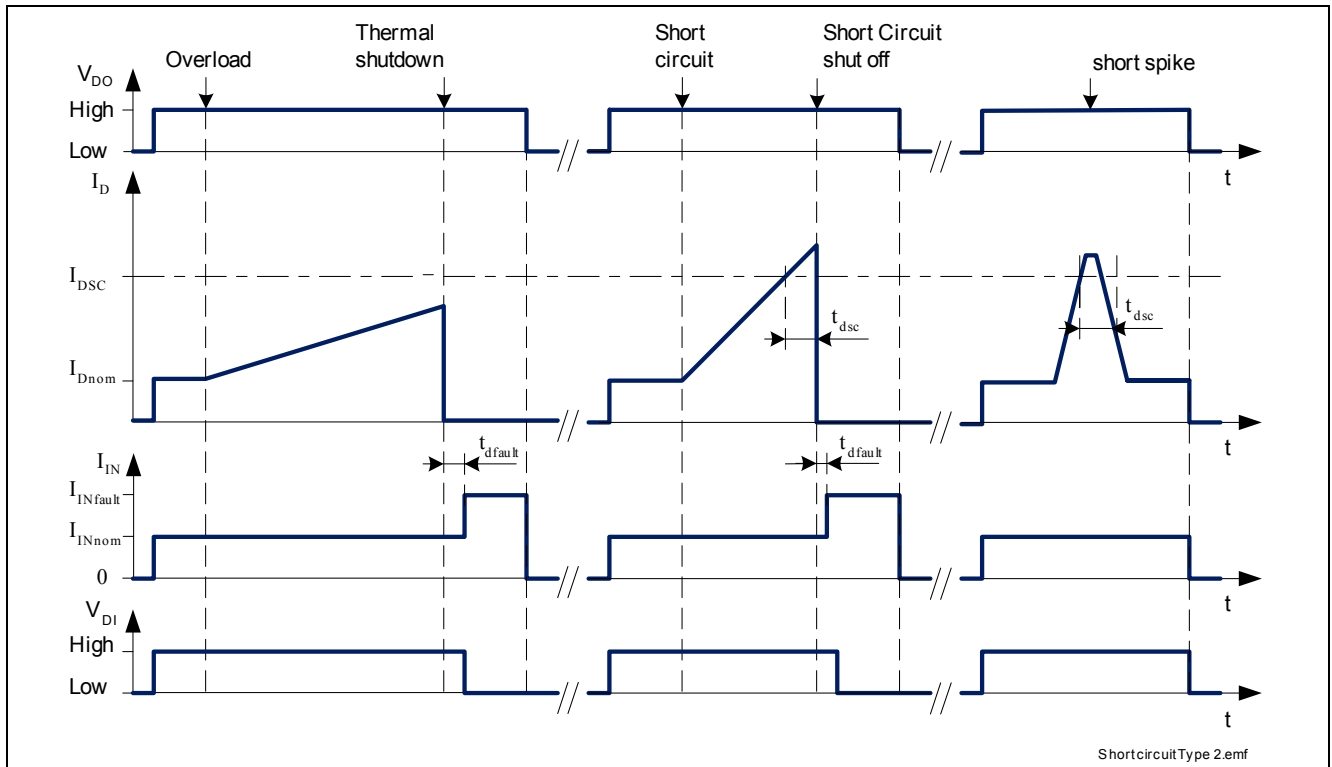


Figure 19 Short Circuit during On State, Typical Behavior for Ohmic Loads

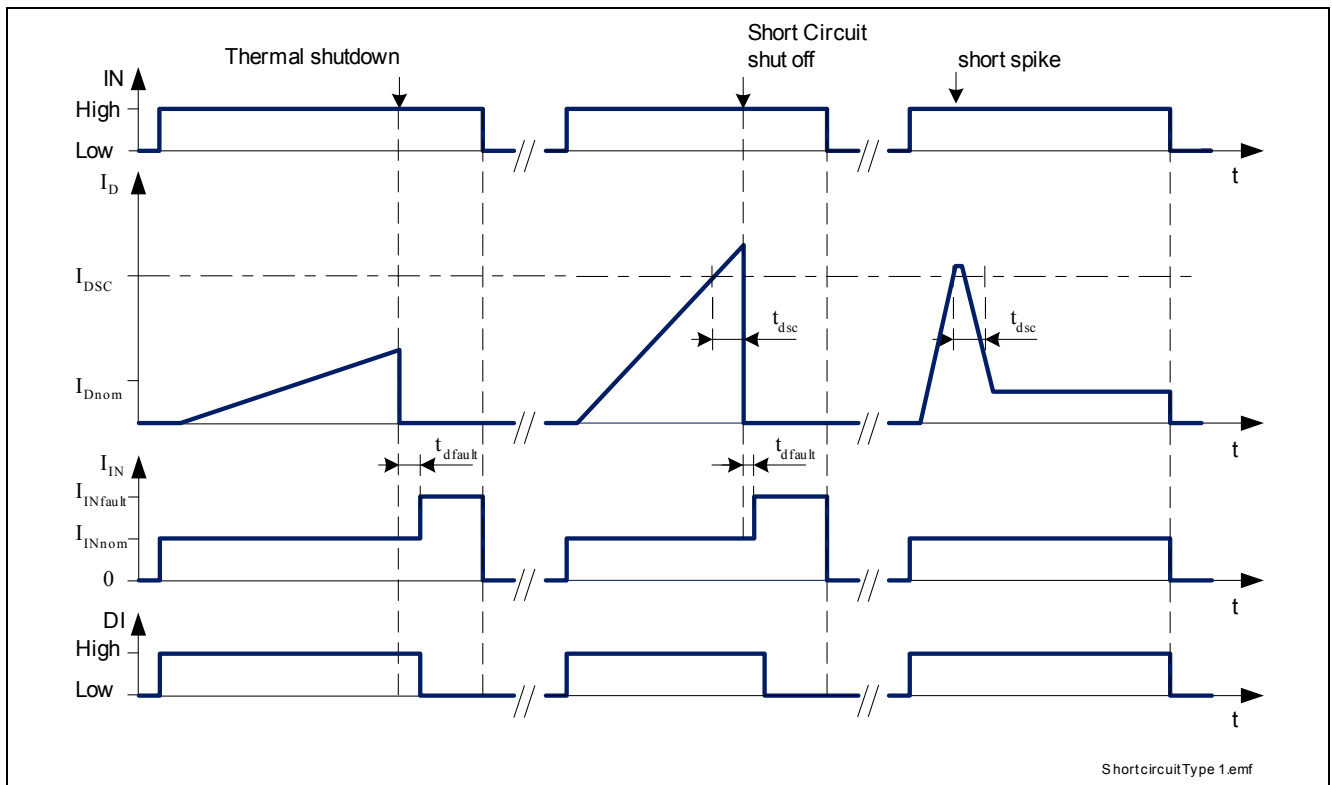
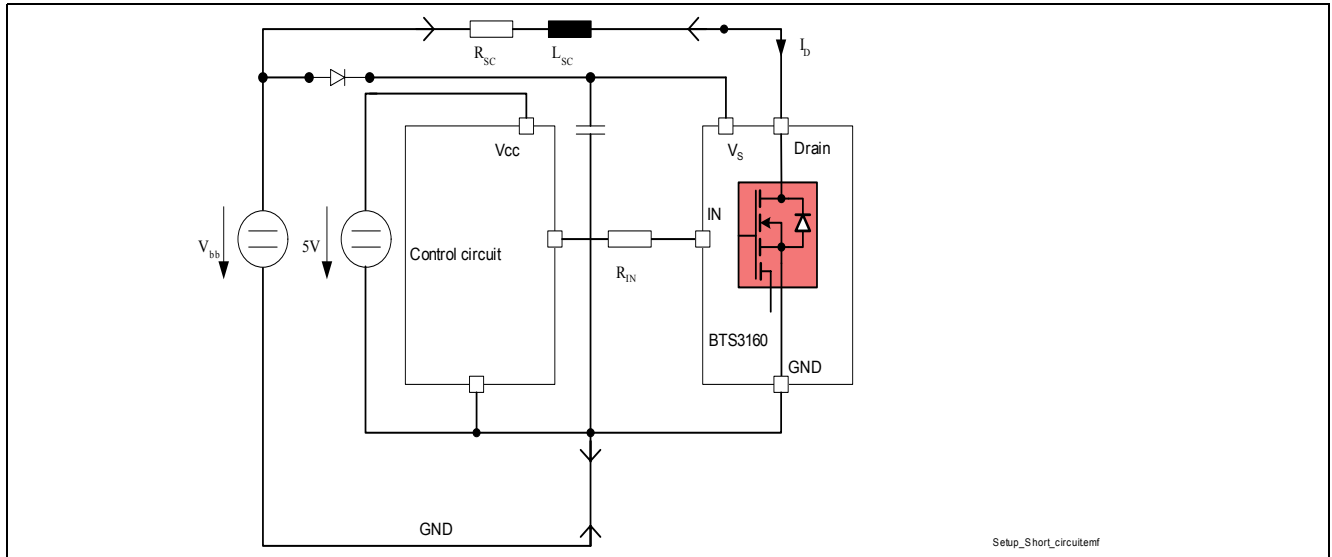


Figure 20 Turn On into Existing Short Circuit, Typical Behavior for Ohmic Loads

The case when the device switches on into an existing short circuit - Short circuit type 1- is shown in [Figure 20](#).

The test setup for short circuit characterization is shown in [Figure 21](#). The BTS3160D is a low side switch. Therefore it can be assumed that the micro controller and device GND connection have a low impedance. The  $V_s$  voltage needs to be stabilized to ensure the protection features. In application this is often already covered from the module standard circuits.



**Figure 21 Test Setup for Short Circuit Characterization Test**



## 7.4 Electrical Characteristics Protection

$V_S = 6\text{ V to }30\text{ V}$ ,  $T_j = -40\text{ °C to }+150\text{ °C}$

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

| Pos.                                                                          | Parameter                                                | Symbol                  | Limit Values |                   |      | Unit | Conditions                                                                                            |
|-------------------------------------------------------------------------------|----------------------------------------------------------|-------------------------|--------------|-------------------|------|------|-------------------------------------------------------------------------------------------------------|
|                                                                               |                                                          |                         | Min.         | Typ.              | Max. |      |                                                                                                       |
| Thermal Protection                                                            |                                                          |                         |              |                   |      |      |                                                                                                       |
| 7.4.1                                                                         | Thermal shut down junction temperature                   | $T_{\text{JSD}}$        | 150          | 175 <sup>1)</sup> | –    | °C   | $V_{\text{S}} = 6.0 \text{ V}$                                                                        |
| 7.4.2                                                                         | Thermal hysteresis                                       | $\Delta T_{\text{JSD}}$ | –            | 10                | –    | K    | <sup>1)</sup> $V_{\text{S}} = 6.0 \text{ V}$                                                          |
| Over Voltage Protection                                                       |                                                          |                         |              |                   |      |      |                                                                                                       |
| 7.4.3                                                                         | Drain source clamp voltage                               | $V_{\text{DAZ}}$        | 40           | 44                | –    | V    | $I_{\text{D}} = 10 \text{ mA};$<br>$V_{\text{S}} = 0.0 \text{ V};$<br>$V_{\text{IN}} = 0.0 \text{ V}$ |
|                                                                               |                                                          |                         | –            | 45                | 49   | V    | $I_{\text{D}} = 8 \text{ A};$<br>$V_{\text{S}} = 0.0 \text{ V};$<br>$V_{\text{IN}} = 0.0 \text{ V}$   |
| Short Circuit Protection, $6.0 \text{ V} \leq V_{\text{S}} \leq 30 \text{ V}$ |                                                          |                         |              |                   |      |      |                                                                                                       |
| 7.4.4                                                                         | Short circuit shutdown current for max. $t_{\text{dSC}}$ | $I_{\text{DSC}}$        | 70           | 100               | 130  | A    |                                                                                                       |
| 7.4.5                                                                         | Short circuit shutdown delay                             | $t_{\text{dSC}}$        | 1            | 4                 | 8    | μs   | <sup>1)</sup> $I_{\text{D}} > I_{\text{D(SC)}}$ ,<br>ohmic load                                       |

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



Conditions in formulas:

1.  $\mu C_{\text{Output current, min}} > \mu C_{\text{HIGH, max}} / R_{\text{IN}} > I_{\text{Fault\_ONth}}$   
with  $\mu C_{\text{Output current, min}}$  referring to the micro controller maximum output current capability.  
with  $\mu C_{\text{HIGH, max}}$  referring to the maximal high output voltage of the micro controller driving stage.  
This condition is valid during status feedback operation mode.
2.  $V_{\text{IN}} = \mu C_{\text{HIGH, min}} - (R_{\text{IN}} * I_{\text{IN, max}}) > V_{\text{INH, min}}$   
with  $\mu C_{\text{HIGH, min}}$  referring to the minimal high output voltage of the micro controller driving stage.  
This condition is valid during normal operation mode
3.  $\mu C_{\text{HIGH, max}} - (R_{\text{IN}} * I_{\text{IN-Fault, min}}) < \mu C(\text{DI})_{\text{L, max}}$   
with  $\mu C(\text{DI})_{\text{L, max}}$  referring to the maximum logic low voltage of the micro controller input stage  
The maximum current is either defined by the BTS3160D or the micro controller driving stage  
This condition is valid during status feedback operation mode
4.  $I_{\text{IN-Fault}} = \mu C_{\text{HIGH, min}} / R_{\text{IN}} > I_{\text{Fault\_ONth}}$   
with  $\mu C_{\text{HIGH, min}}$  referring to the minimum logic low voltage of the micro controller output stage  
The BTS3160D is resetting the fault latch, if the current on IN pin goes below  $I_{\text{Fault\_ONth}}$ .  
This condition is valid during status feedback operation mode

Out of this conditions the minimum and maximum resistor values can be calculated.

For a typical 5V micro controller with output current capability in the 3 mA range,  
a resistor range from 7.5 k $\Omega$  down to 4.5 k $\Omega$  can be used.

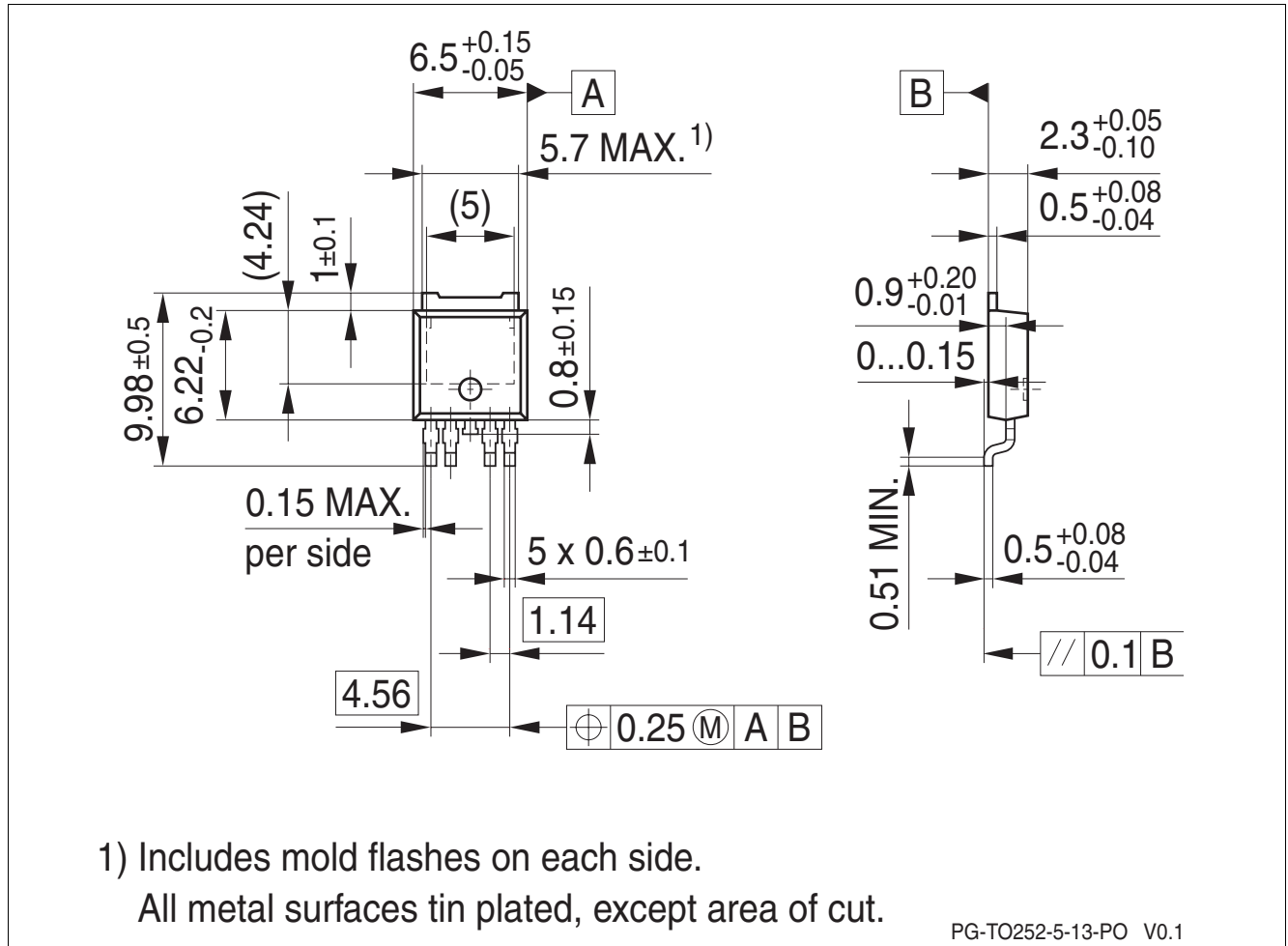
For a typical 3.3V micro controller a range from 4.6 k $\Omega$  to 2.5 k $\Omega$  is suitable.

We recommend 3k3 for a 3.3V  $\mu C$  and 5k6 for a 5V  $\mu C$  to achieve a logic low signal.

## 8.2 Further Application Information

- For further information you may contact <http://www.infineon.com/hitfet>

## 9 Package Outlines



**Figure 23** PG-TO-252-5-13 (Plastic Green Thin Outline 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).

## 10 Revision History

| Version  | Date       | Changes                                                                                                                                                                                                                                               |
|----------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Rev. 1.1 | 2008-02-28 | released automotive green and robust version<br>changed package naming to green package, updated package drawing<br>updated package drawing and description text on overview page<br>added RoHS logo to overview page and added green feature to list |
| Rev. 1.0 | 2007-08-14 | first released datasheet revision                                                                                                                                                                                                                     |
|          |            |                                                                                                                                                                                                                                                       |
|          |            |                                                                                                                                                                                                                                                       |

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