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Data Sheet, Rev. 1.1, September 2011

HITFET - BTS3205N

Smart Low-Side Power Switch

Automotive Power

Never stop thinking

Smart Low-Side Power Switch
HITFET

BTS3205N

1 Overview

Features

- Logic Level input
- Short circuit and Overload protection
- Current limitation
- Input protection (ESD)
- Thermal protection with auto restart
- Compatible to standard Power MOSFET
- Analog driving possible
- Green Product (RoHS compliant)
- AEC Qualified

PG-SOT-223-4

Description

The BTS3205N is a one channel low-side power switch in PG-SOT-223-4 package providing embedded protective functions. The device is monolithic integrated and consist of an N-channel power MOSFET transistor and additional protection circuitry.

Table 1 Product Summary

Drain Voltage	V_D	42 V[1)]
Input Voltage	$V_{IN(max)}$	10 V
Typical On-State Resistance at T_j = 25°C and Vin = 10V	$R_{DS(ON,amb\ typ)}$	0.7 Ω
Maximum On-State Resistance at T_j = 150°C and Vin = 10V	$R_{DS(ON,hot\ max)}$	1.9 Ω
Nominal Load Current	$I_{Dnom(min)}$	350 mA
Drain Current	I_D	600 mA[2)]
Single Clamping Energy	E_{AS}	65 mJ

1) Active clamped
2) Internally limited

Type	Package	Marking
BTS3205N	PG-SOT-223-4	3205N

Protective Functions

- Electrostatic discharge protection (ESD)
- Active clamp over voltage protection
- Thermal shutdown with auto restart
- Short circuit protection

Fault Information

- Thermal shutdown
- Short to Battery and overload

Applications

- Designed for driving Relays in Automotive Applications
- All types of resistive, inductive and capacitive loads
- Suitable for loads with peak currents
- Replaces 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 BTS3205N offers ESD protection of the IN Pin in relation to the Source Pin.

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 in the power MOSFET. During thermal shutdown the device tries to sink an increased input current to feedback the fault condition.
The BTS3205N has a thermal-auto-restart function, the device will turn on again after the measured temperature has dropped down for the thermal hysteresis.

The over voltage protection is active during load-dump or inductive turn off conditions. The power MOSFET is limiting the Drain - Source voltage to the defined clamping voltage. This function is available regardless of the input pin state.

2 Block Diagram

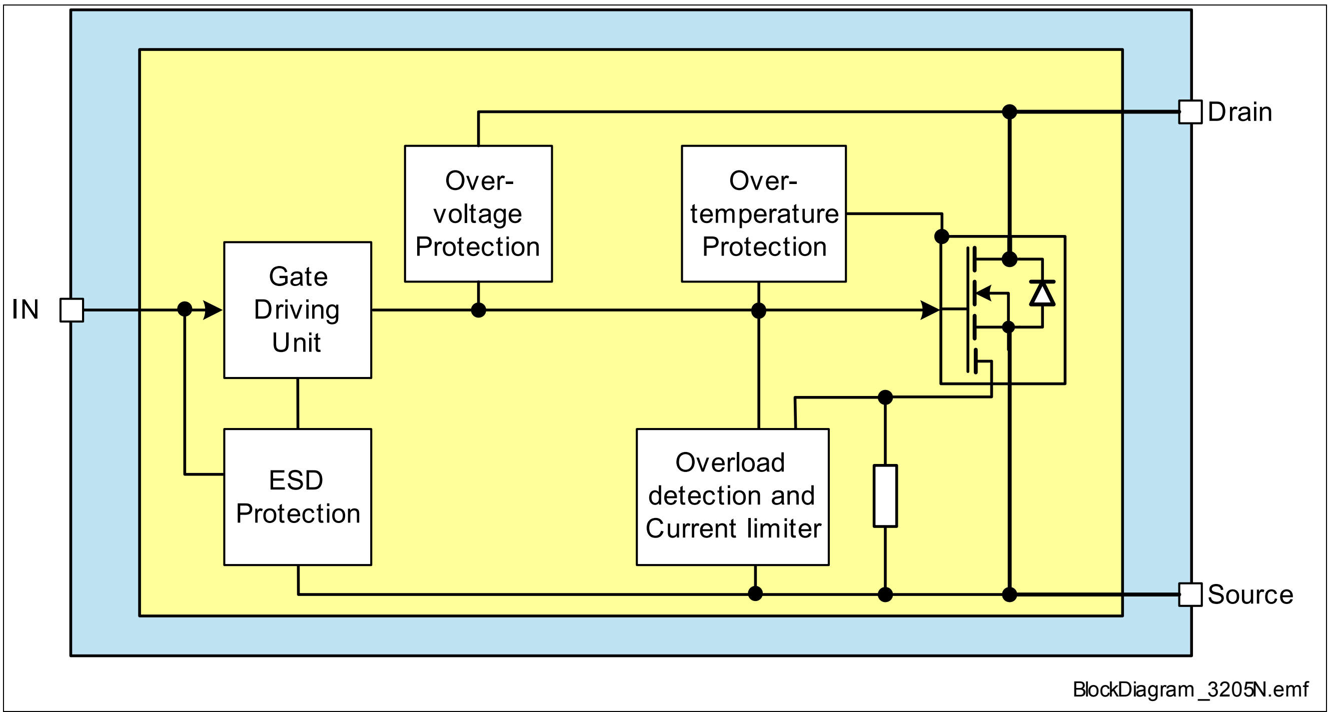

Figure 1 Block Diagram

2.1 Terms

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

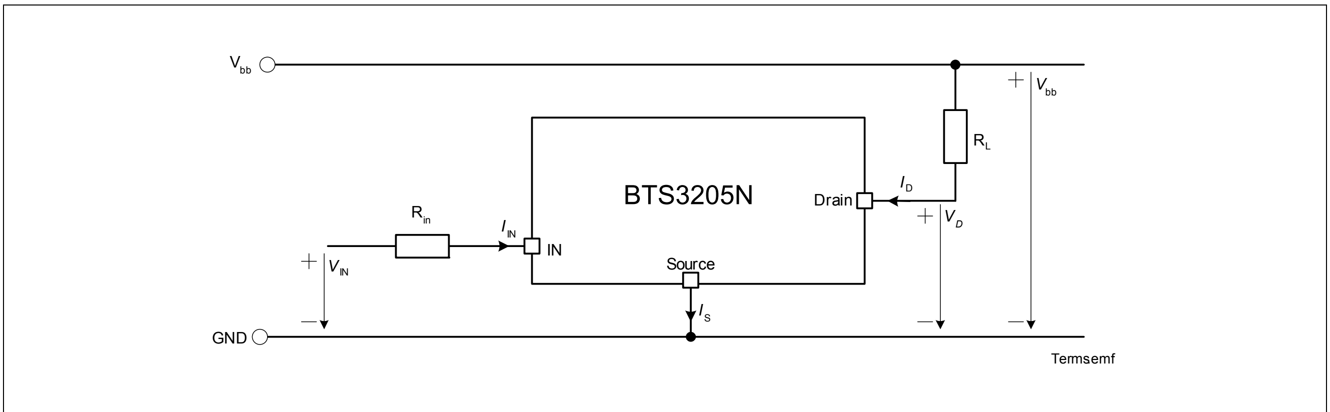

Figure 2 Terms

3 Pin Configuration

3.1 Pin Assignment BTS3205N

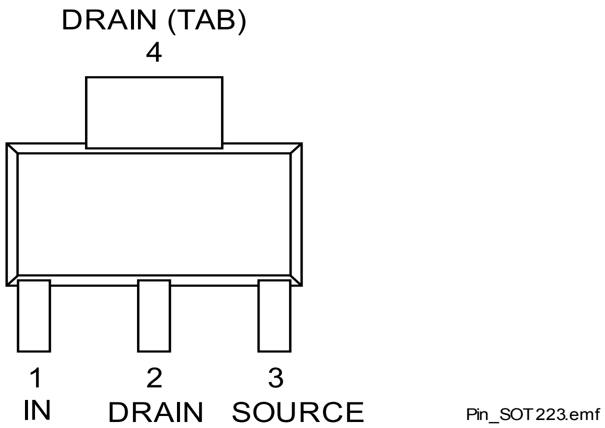

Figure 3 Pin Configuration PG-SOT-223-4

3.2 Pin Definitions and Functions

Pin	Symbol	Function
1	IN	Input / fault feedback
2, 4	Drain	Load connection
3	Source	Ground connection

4 General Product Characteristics

4.1 Absolute Maximum Ratings

Absolute Maximum Ratings [1)]

T_j = -40 ·C to +150 ·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_D	–	42	V	[2)] V_{IN} = 0 V, I_D = 10 mA
4.1.2	Input Voltage	V_{IN}	-0.2	10	V	–
4.1.3	Input Current	I_{IN}	self limited		mA	-0.2 V < V_{IN} < 10 V
4.1.4			-2	2	mA	V_{IN} < -0.2 V or V_{IN} > 10 V
4.1.5	Drain Current	I_D	–	600	mA	[3)] T_j = 25 °C
Energies						
4.1.6	Unclamped single pulse inductive energy single pulse	E_{AS}	0	65	mJ	I_D = 350 mA; V_{bb} = 28 V; $T_{J(start)}$ = 85 °C
4.1.7	Unclamped single pulse inductive energy single pulse		–	30	mJ	I_D = 250 mA; V_{bb} = 28 V; $T_{J(start)}$ = 150 °C
4.1.8	Unclamped repetitive pulse inductive energy 1×10^4 cycles	E_{AR}	0	18	mJ	I_D = 200 mA; V_{bb} = 13.5 V; $T_{J(start)}$ = 105 °C
4.1.9	Unclamped repetitive pulse inductive energy 1×10^6 cycles		–	13	mJ	I_D = 170 mA; V_{bb} = 13.5 V; $T_{J(start)}$ = 105 °C
4.1.10	Total Power Dissipation	P_{tot}	–	0.78	W	[4)] T_a = 85 °C
Temperatures						
4.1.11	Operating temperature	T_J	-40	+150	°C	–
4.1.12	Storage temperature	T_{stg}	-55	+150	°C	–
ESD Susceptibility						
4.1.13	Electrostatic discharge voltage [5)]	V_{ESD}	-2	2	kV	IN Pin R = 1.5 k; C = 100 pF; T_J = 25 °C

1) Not subject to production test, specified by design.
2) Active clamped.
3) Internally limited.
4) Device mounted on PCB according EIA/JEDEC standard JESD51-7 (4-layer FR4, 76.2 mm × 114.3 mm with buried planes). PCB is mounted vertical without blown air.
5) ESD susceptibility HBM according to EIA/JESD 22-A 114B, section 4.

4.2 Thermal Resistance

Pos.	Parameter	Symbol	Limit Values			Unit	Conditions
			Min.	Typ.	Max.		
4.2.1	Junction to Soldering Point	R_{thJC}	–	–	42	K/W	1) 2)
4.2.2	Junction to Ambient	R_{thJA}	–	63	–	K/W	1) 2)

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

2) Device mounted on PCB according EIA/JEDEC standard JESD51-7 (4-layer FR4, 76.2 mm × 114.3 mm with buried planes). PCB is mounted vertical without blown air with 0.78W power dissipation generated on the DMOS.

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.

4.2.1 Transient Thermal Impedance

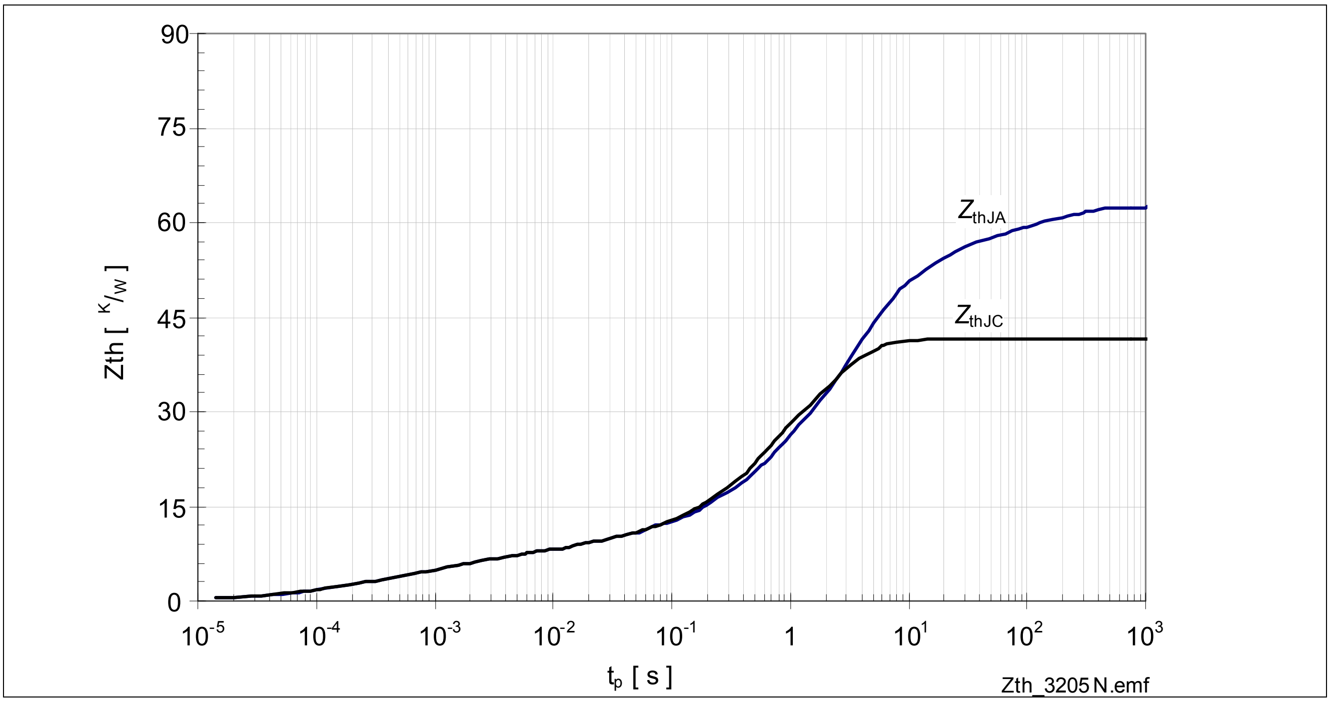

Figure 4 Typical Transient Thermal Impedance single pulse, Z_{thJA} and Z_{thJC}

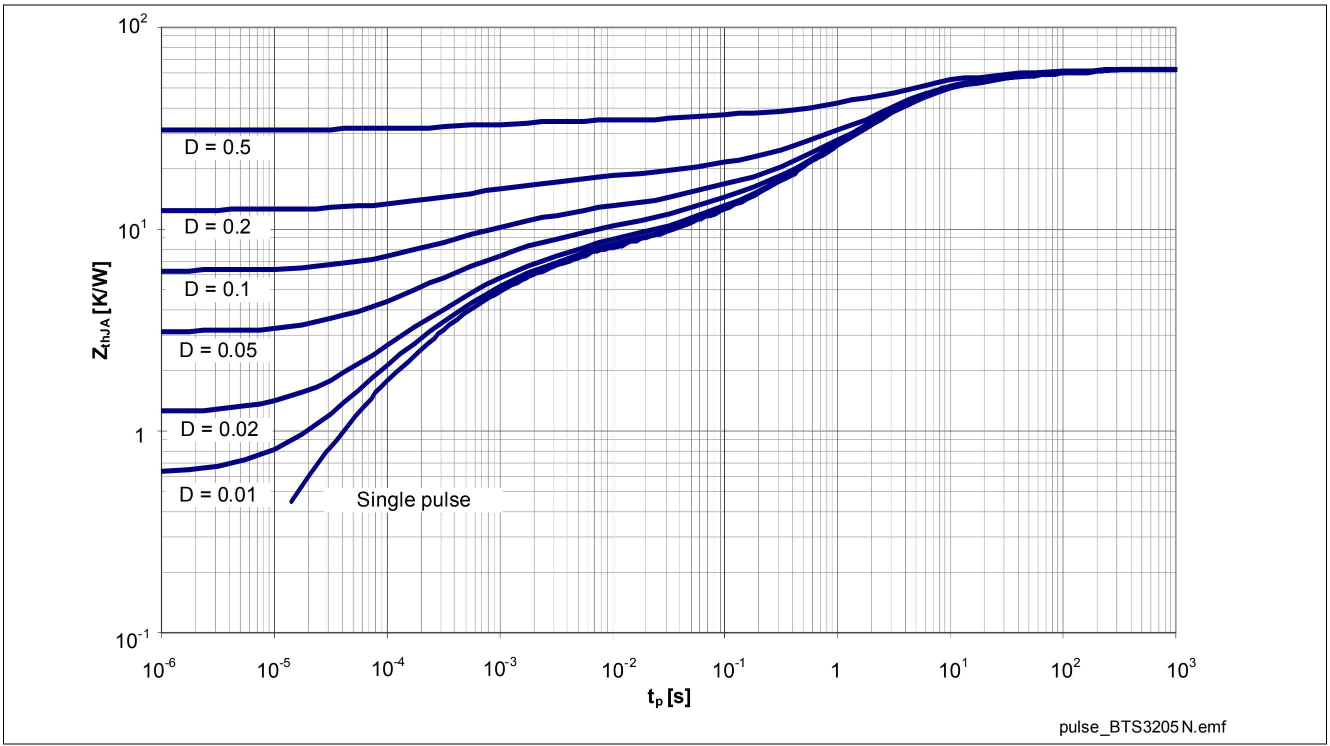

Figure 5 Typical Transient Thermal Impedance Z_{thJA} with different Duty cycles
$Z_{thJA} = f(t_p)$, D = tp/T, T_a = 25 °C
Device mounted on PCB according EIA/JEDEC standard JESD51-7 (4-layer FR4, 76.2 mm × 114.3 mm with buried planes). PCB is mounted vertical without blown air with 0.78W power dissipation generated for single pulse on the DMOS

5 Block Description and Characteristics

5.1 Input and Power Stage

5.1.1 Input Circuit

Figure 6 shows the input circuit of the BTS3205N. The zener Diode protects the input circuit against ESD pulses. The internal circuitry is supplied by the input PIN. During normal operation the Input is connected to the Gate of the power MOSFET. During fault condition the device tries to sink the current I_{INlim} in order to give the fault information back to the driving circuit.

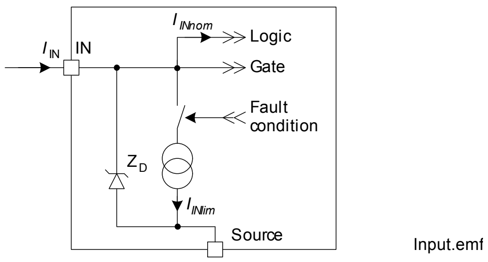

Figure 6 Input Circuit

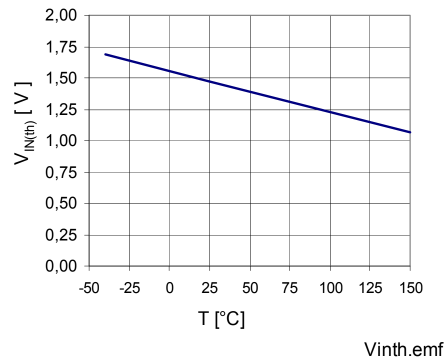

Figure 7 Typical Input Threshold Voltage V_{inth} = f(T_J); I_D = 50 µA, V_D = V_{IN}

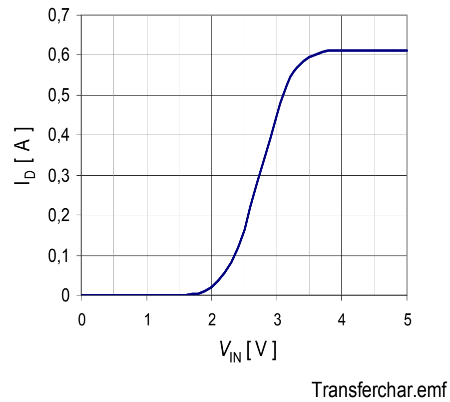

Figure 8 Typical Transfer Characteristic I_D = f(V_{IN}); V_D = 12 V, T_{Jstart} = 25 °C

5.1.2 Failure Feedback

During failure condition the BTS3205N tries to sink a increased input current I_{INlim}.

5.1.3 Output On-State Resistance

The on-state resistance depends on the junction temperature T_J. **Figure 9** shows this dependency for the typical on-state resistance $R_{DS(on)}$.

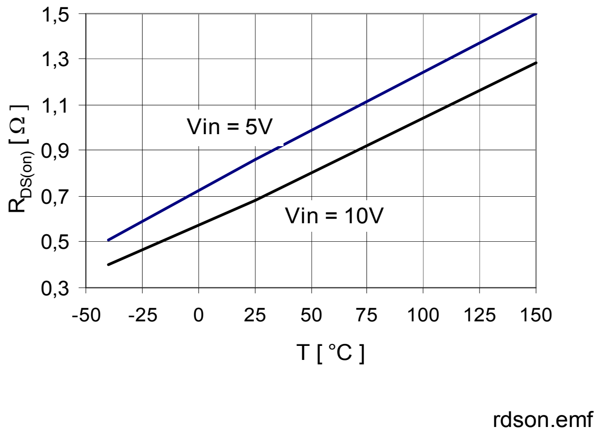

Figure 9 Typical On-State Resistance, $R_{DS(on)}$ = f(T_J)

5.1.4 Power Dissipation

The maximum allowed power dissipation in **Figure 10** is calculated by R_{thJC} and R_{thJA}.

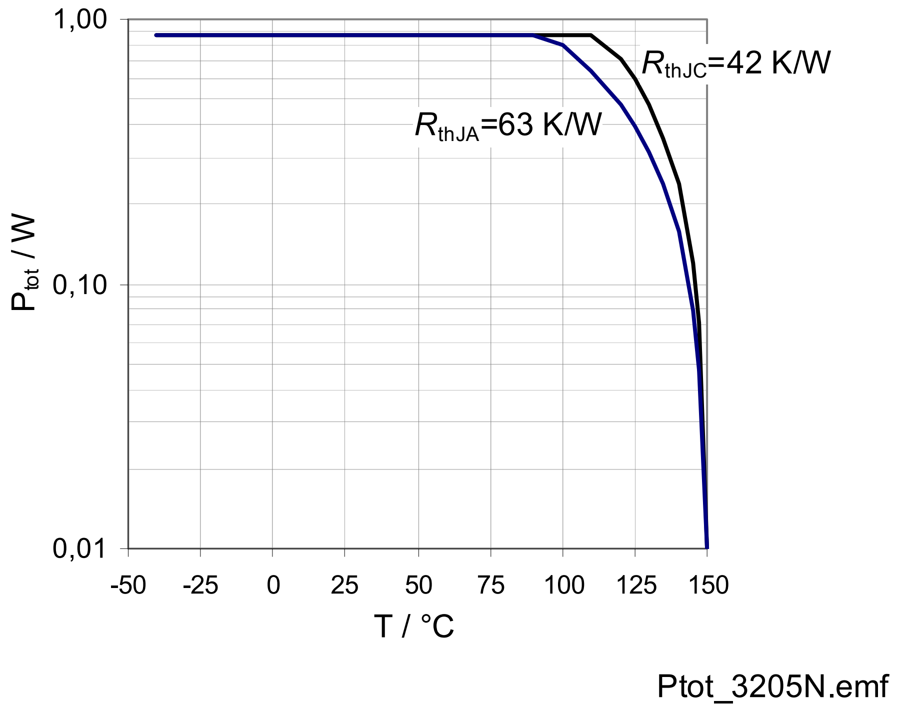

Figure 10 Maximal Allowable Power Dissipation

5.1.5 Output Timing

A voltage signal at the input pin above the threshold voltage causes the power MOSFET to switch on with a dedicated slope which is optimized for low EMC emission. **Figure 11** shows the timing definition.

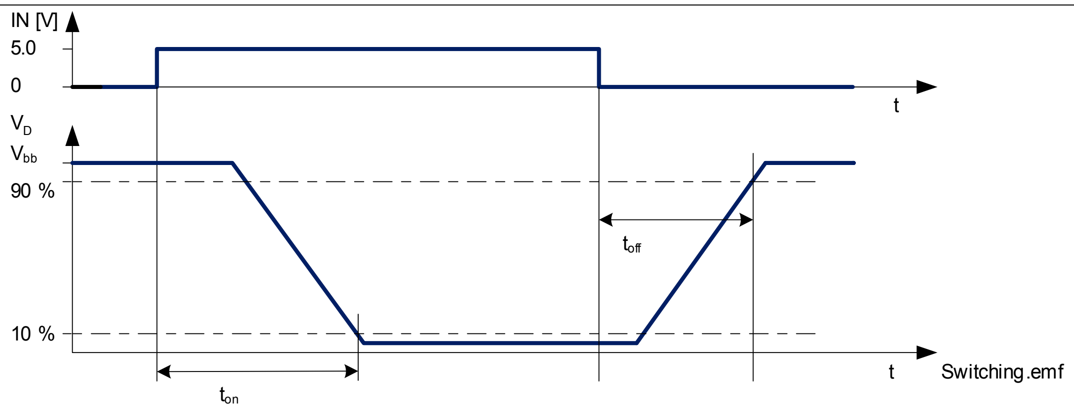

Figure 11 Definition of Power Output Timing for Resistive Load

5.1.6 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 and Power Stage

T_j = -40 ·C to +150 ·C , 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							
5.1.1	Nominal Input current	I_{INnom}	–	10	30	µA	V_D = 0 V; V_{IN} = 10 V
5.1.2	Input current protection mode	I_{INlim}	–	100	150	µA	V_{IN} = 10 V; T_J = 150 °C
5.1.3	Input threshold voltage	V_{INTH}	1.3	1.7	2.2	V	$V_D = V_{IN}$; I_D = 50 µA T_J = 25°C
5.1.4			0.8	–	–	V	$V_D = V_{IN}$; I_D = 50 µA, 150 °C
Power Stage							
5.1.5	On-State Resistance	$R_{DS(on)}$	–	0.9	–	Ω	[1] T_J = 25 °C; V_{IN} = 5 V; I_D = 200mA
5.1.6			–	1.8	2.4	Ω	T_J = 150 °C; V_{IN} = 5 V; I_D = 200mA
5.1.7			–	0.7	–	Ω	[1] T_J = 25 °C; V_{IN} = 10 V; I_D = 200mA
5.1.8			–	1.4	1.9	Ω	T_J = 150 °C; V_{IN} = 10 V; I_D = 200mA
5.1.9	Nominal load current	I_{Dnom}	350	520	–	mA	[1] T_J < 150 °C; T_A = 105 °C[2]; V_{IN} = 5 V
5.1.10	Zero input voltage drain current	I_{DSS}	–	–	5	µA	V_{DS} = 13.5 V; V_{IN} = 0 V; T_J = 150 °C
			–	2.5	6	µA	V_{DS} = 32 V; V_{IN} = 0 V; T_J = -40 °C to 85 °C
			–	4	7	µA	V_{DS} = 32 V; V_{IN} = 0 V; T_J = 150 °C

Electrical Characteristics: Input and Power Stage (cont'd)

T_j = -40 ·C to +150 ·C , 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.		
Switching V_{bb} = 12 V, R_L = 82 Ω							
5.1.11	Turn-on time	t_{on}	–	16	38	µs	V_{IN} = 10 V to 90% I_D
5.1.12	Turn-off time	t_{off}	–	15	45	µs	V_{IN} = 0 V to 10% I_D
5.1.13	Slew rate on	dV_{ds}/dt_{on}	–	2.5	9.3	V/µs	50% - 30% V_{bb}; R_L = 82 Ω; V_{IN} = 0 V to 10 V; V_{bb} = 12 V
5.1.14	Slew rate off	dV_{ds}/dt_{off}	–	6.0	18.2	V/µs	30% - 50% V_{bb}; R_L = 82 Ω; V_{IN} = 10 V to 0 V; V_{bb} = 12 V
Inverse Diode							
5.1.15	Inverse Diode forward voltage	V_D	–	-1.0	-1.5	V	I_D = -1 A; V_{IN} = 0 V

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

2) Device mounted on PCB according EIA/JEDEC standard JESD51-7 (4-layer FR4, 76.2 mm × 114.3 mm with buried planes). PCB is mounted vertical without blown air.

6 Protection Functions

The device provides embedded protection functions. 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.

6.1 Thermal Protection

The device is protected against over temperature due to overload and / or bad cooling conditions. To ensure this a temperature sensor located in the Power MOSFET is used.

The BTS3205N has a thermal auto-restart function. After the device has cooled down it will switch on again see **Figure 12**.

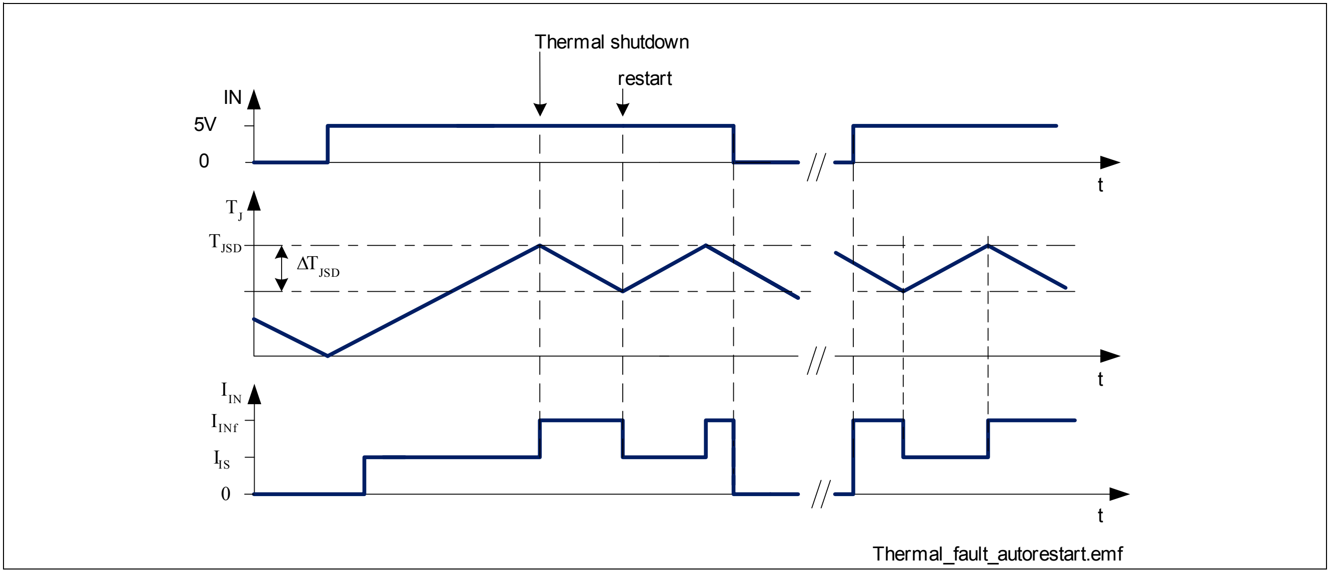

Figure 12 Error Signal via Input Current at Thermal Shutdown

6.2 Overvoltage Protection

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.

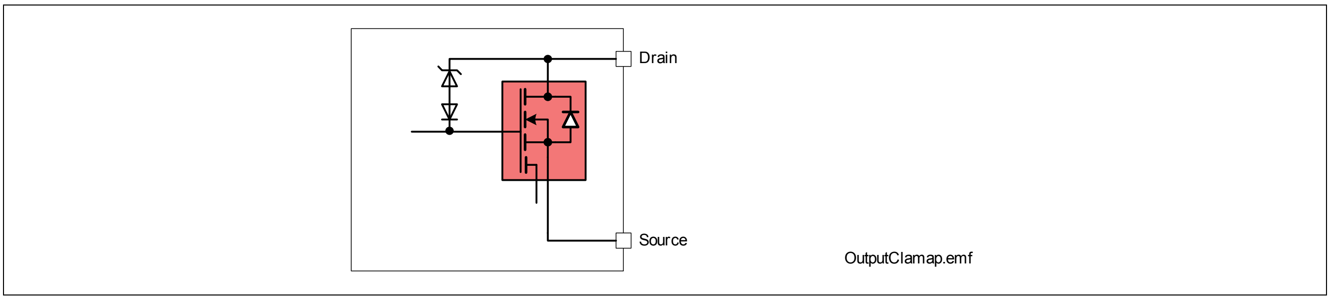

Figure 13 Output Clamp

The BTS3205N is equipped with a voltage clamp mechanism that keeps the Drain-Source voltage V_D at a certain level. See **Figure 13** and **Figure 14** for more details.

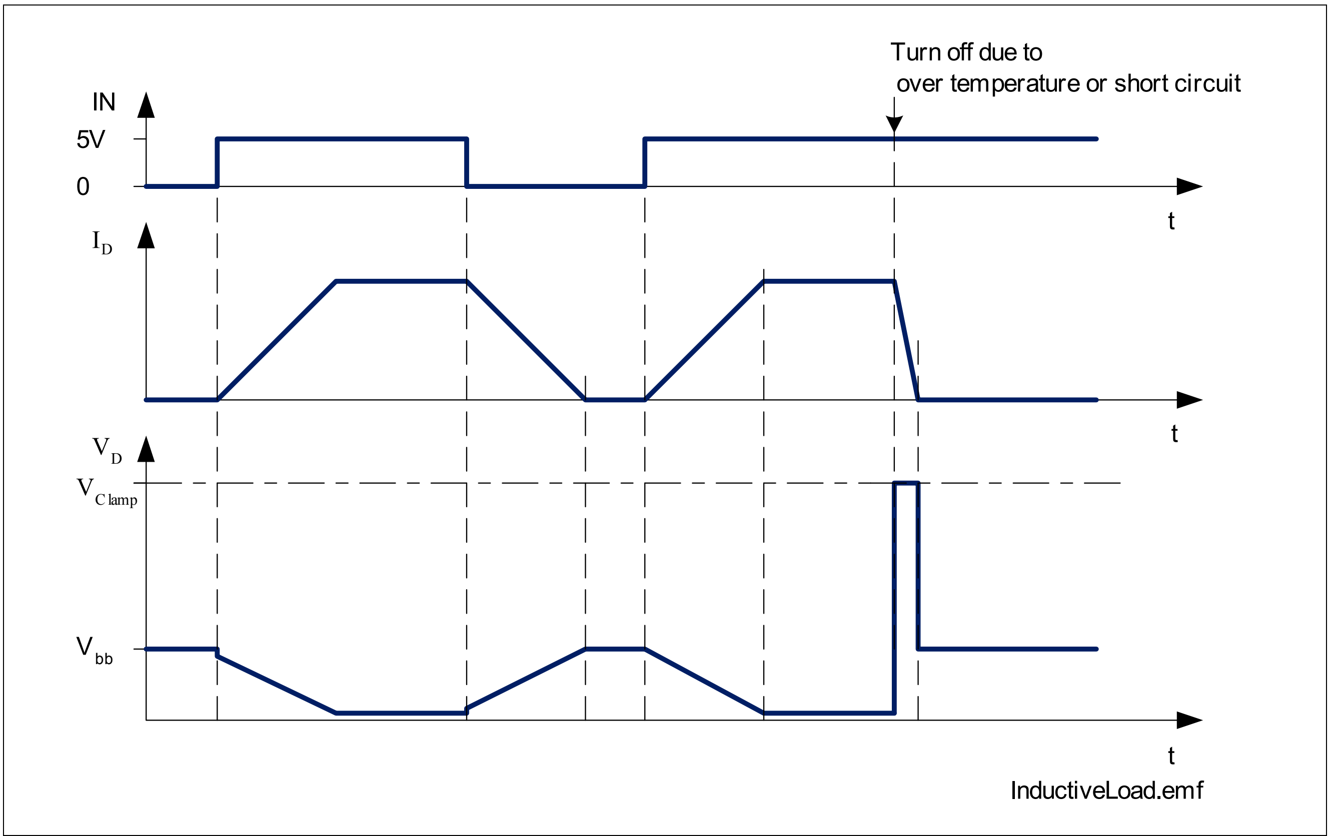

Figure 14 Switching an Inductance

While demagnetization of inductive loads, energy has to be dissipated in the BTS3205N. This energy can be calculated with following equation:

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

Following equation simplifies under assumption of $R_L = 0$

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

6.3 Short Circuit Protection

The condition short circuit is an overload condition of the device. If the current reaches the value of I_{lim} the device starts to limit the current. In the condition of current limitation the device heats up. If the thermal shutdown temperature is reached the device turns off. Figure 15 shows this behavior. During the current limitation the input current is above I_{INnom}. During the time period t_{dlim}, the current can be above I_{lim}.

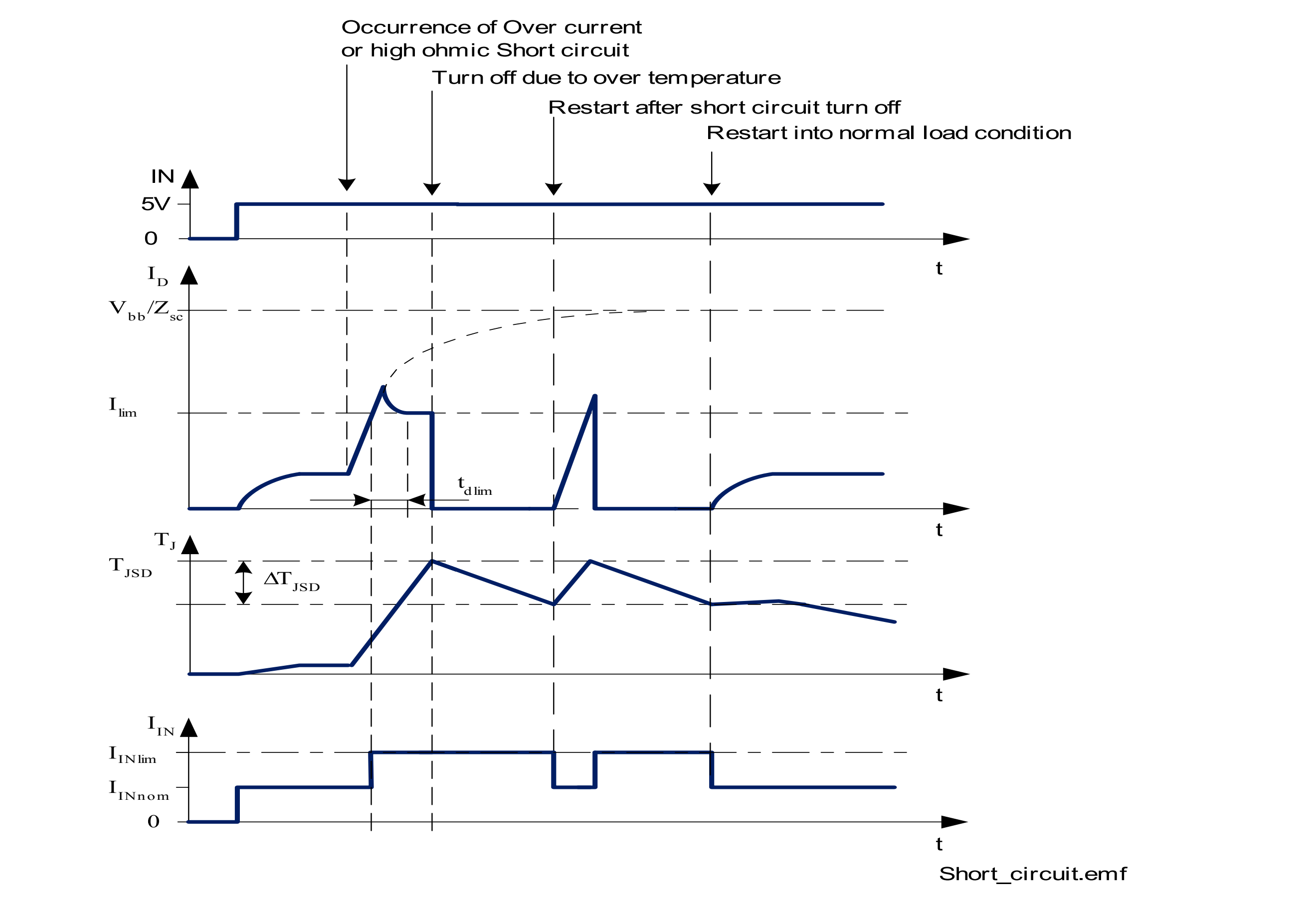

Figure 15 Short Circuit Behavior of BTS3205N

As the device is a low side switch it can be assumed that the Source to Ground path has a neglectable low impedance and resistance. Therefore all impedance and resistance in the load path during short circuit is merged into Zsc.

6.4 Characteristics

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

Electrical Characteristics: Protection Functions

T_j = -40 ·C to +150 ·C; 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.		
Thermal Protection							
6.4.1	Thermal shut down junction temperature	T_{JSD}	150	175[1)]	–	°C	–
6.4.2	Thermal hysteresis	ΔT_{JSD}	–	10	–	K	[1)]
Overvoltage Protection							
6.4.3	Drain clamp voltage	V_{Clamp}	42	–	55	V	V_{IN} = 0 V; I_D = 10 mA;
Current Limitation and Short Circuit Protection							
6.4.4	Current limitation	I_{lim}	0.6	0.9	1.2	A	V_{IN} = 10 V; V_{DS} = 12 V; $t_{measure} = 4 \times t_{dlim}$ T_J = 25 °C[1)]
			0.3	–	–		T_J = 150 °C
			–	–	1.4		T_J = -40 °C [1)]
6.4.5	Current limitation delay time	t_{dlim}	–	–	50	µs	[1)]

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

7 Package Outlines BTS3205N

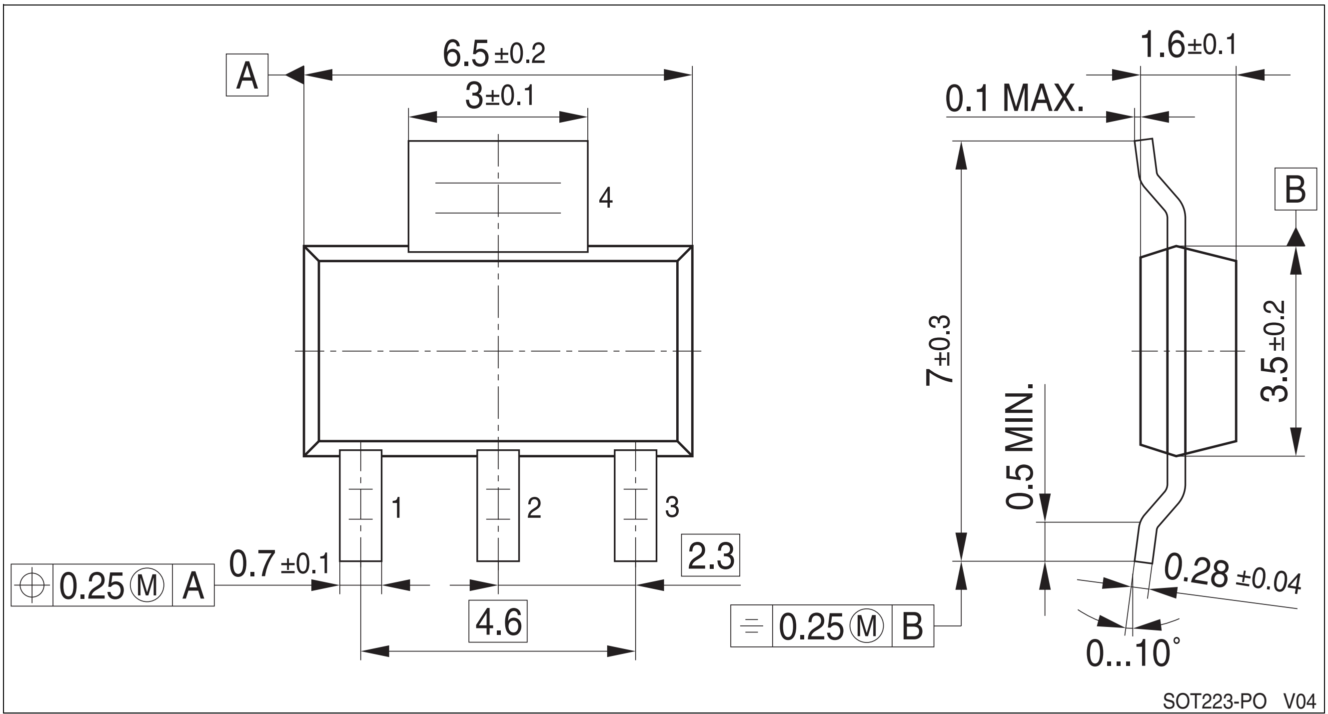

Figure 16 PG-SOT-223-4 (Small Outline Transistor)

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 alternative packages, please visit our website:
http://www.infineon.com/packages.

Dimensions in mm

8 Revision History

Version	Date	Changes
Rev. 1.1	2011-09-01	fixed a typo in EAR test conditions in chapter Max ratings updated Feature list and rephrased Detailed Description fixed a spelling error in 5.1.3 regarding “dependency”
Rev. 1.0	2008-09-25	released data sheet

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