

# BTC50010-1TAA & BTC30010-1TAA

Smart High-Side Power Connector  
2x Single Channel, 2x 1m $\Omega$

## Data Sheet

1.3, 2015-02-06

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## 1 Overview

### Applications

- Switching resistive, capacitive and inductive loads in conjunction with an effective peripheral free wheeling circuit
- Replaces electromechanical relay
- Most suitable for high current applications, such as Start-Stop, power distribution, main switch, heating systems
- PWM application with low frequencies



**PG-TO-263-7-8**

### Features

- Load or Supply Line switching up to 60 A DC
- Operating temperature up to 150°C
- Current controlled Input pin
- Low Stand-by current
- Two times one channel device, easily be combined for reverse blocking or to halve the  $R_{DS(ON)}$
- Electrostatic discharge protected (ESD)
- Optimized Electromagnetic Compatibility (EMC)
- Very low power consumption in ON state
- Compatible to cranking pulse requirement (test pulse 4 in ISO7637 and cold start pulse in LV124)
- Infineon® Reversave™: Reverse battery protection by self turn ON of the power MOSFET
- Inverse operation robustness capability
- Infineon® SMART CLAMPING
- Green Product (RoHS compliant, halogen free package)
- AEC Qualified
- Dustproof

### Description

The BTC50010-1TAA & BTC30010-1TAA are one High-Side Power Connector (BTC50010-1TAA) combined with a perfect fitting n-channel MOSFET (BTC30010-1TAA) to replace electromechanical relay. These easy to use twin devices can provide higher current-driven capability or additional reverse polarity protection feature. They offer switching without audible noise, weight reduction and increased switching cycle capability to comply with upcoming requirements on power distribution applications (e.g. battery disconnect switch). In addition, they

Type	Package	Marking
BTC50010-1TAA	PG-TO-263-7-8	C50010A
BTC30010-1TAA	PG-TO-263-7-8	C30010A

significantly reduce power/current consumption of the device while ON to increase energy efficiency. The device can withstand harshest cranking pulse such as test pulse 4 in ISO7637 and cold start pulse in LV124.

**Table 1 Product Summary**

Parameter	Symbol	Values
<b>BTC50010-1TAA</b>		
Weight (approx.)	$G1$	1.5 g
Nominal operating voltage	$V_{S(OP)}$	8 V ... 18 V
Extended operating voltage contain dynamic undervoltage capability	$V_{S(DYN)}$	3.2 V ... 28 V
Nominal load current	$I_{L(NOM)}$	30 A
Typical ON-state resistance at $T_j = 25\text{ °C}$ (CP pin open)	$R_{DS(ON)}$	0.9 mΩ
Typical input current in ON state	$I_{IN(ON)}$	2 mA
Typical stand-by current at $T_j = 25\text{ °C}$	$I_{S(OFF)}$	3 μA
<b>BTC30010-1TAA</b>		
Weight (approx.)	$G2$	1.5 g
Nominal load current	$I_{L(NOM)_C}$	30 A
Typical ON-state resistance at $T_j = 25\text{ °C}$	$R_{DS(ON)}$	0.9 mΩ
<b>BTC50010-1TAA &amp; BTC30010-1TAA</b>		
Operating voltage	$V_{S(OP)}$	8 V ... 18 V
Extended operating voltage contain dynamic undervoltage capability	$V_{S(DYN)}$	3.2 V ... 28 V
Nominal load current of parallel connected BTC50010-1TAA & BTC30010-1TAA	$I_{L(NOM)} + I_{L(NOM)_C}$	60 A

## 2 Block Diagram

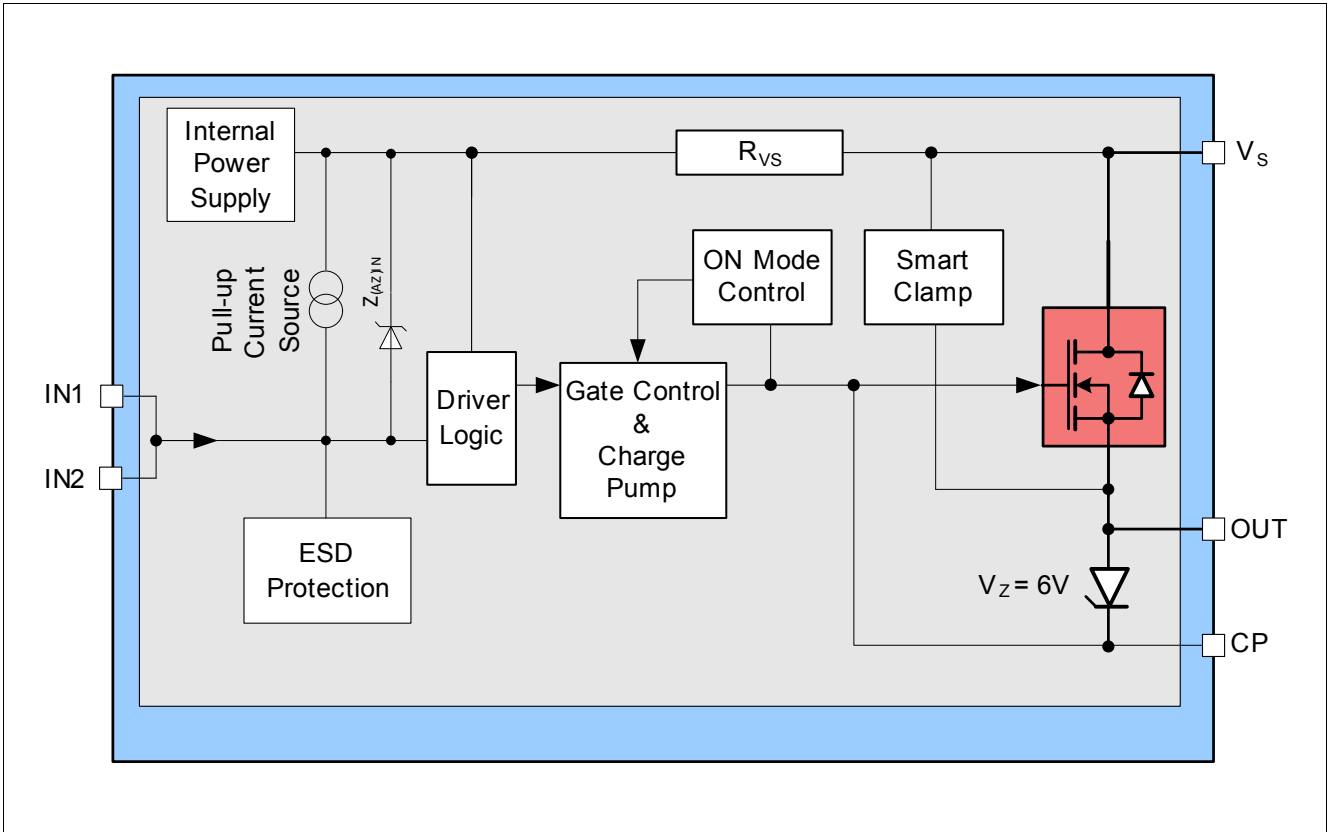


Figure 1 Block Diagram BTC50010-1TAA

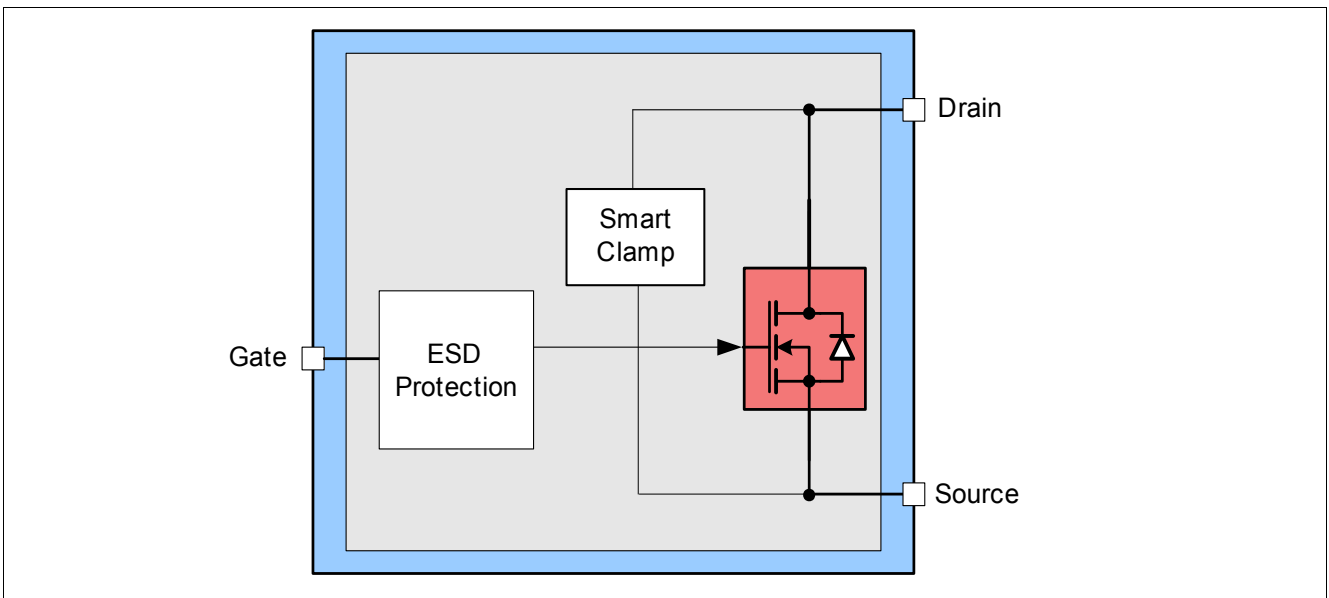


Figure 2 Block Diagram BTC30010-1TAA

### 3 Pin Configuration

#### 3.1 Pin Assignment

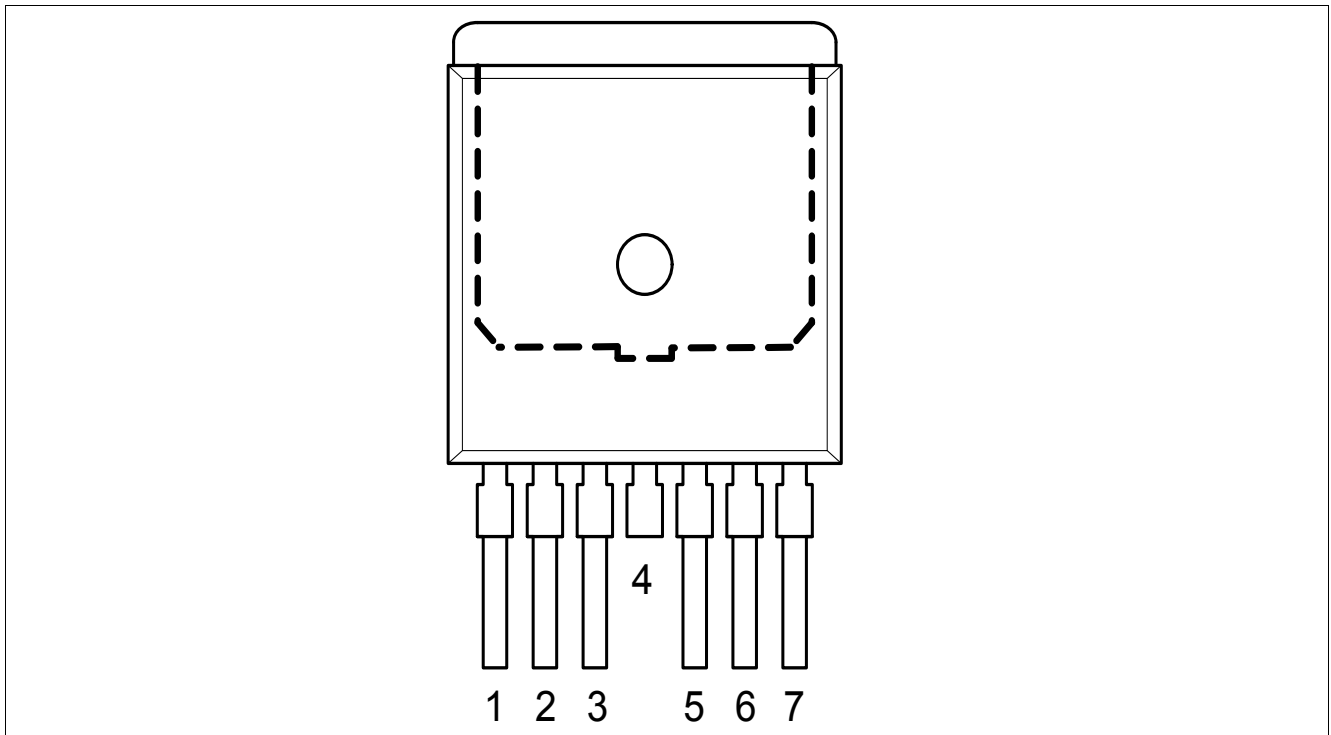


Figure 3 Pin Configuration for BTC50010-1TAA and BTC30010-1TAA

#### 3.2 Pin Definitions and Functions

Table 2 Pin definition and functions of BTC50010-1TAA

Pin	Symbol	Function
1	IN1	<b>IN</b> ; Pull down to module ground for channel activation <sup>1)</sup>
2	IN2	<b>IN2</b> ; Pull down to module ground for channel activation <sup>1)</sup>
3	CP	<b>Charge Pump Output</b> ; Output pin of internal charge pump voltage of <b>BTC50010-1TAA</b> for driving <b>BTC30010-1TAA</b>
4, Cooling Tab	VS	<b>Supply Voltage</b> ; Connected to battery voltage
5, 6, 7	OUT	<b>OUTPUT</b> ; High side power output <sup>2)</sup>

1) IN1 and IN2 are internally connected

2) All output pins are connected internally. All output pins have to be connected externally together on PCB. Not shorting all outputs pins will considerably increase the ON-resistance. PCB traces have to be designed to withstand the maximum current which can flow. PCB traces for output current are recommended to be designed symmetrically or having similar line resistance for any of the three output pins from this device.

**Table 3 Pin definitions and functions of BTC30010-1TAA**

Pin	Symbol	Function
1	Gate	<b>Gate;</b> is not allowed to be floating and has to be connected to CP pin of BTC50010-1TAA to be switched ON/OFF by BTC50010-1TAA.
2	NC	
3	NC	
4, Cooling Tab	Drain	<b>Drain;</b> Connected to battery voltage for "Parallel Circuit to halve the $R_{DS(ON)}$ " application in <a href="#">Figure 27</a> . Connected to load for "Blocking Current in Reverse Polarity" application in <a href="#">Figure 28</a> .
5, 6, 7	Source	<b>Source;</b> N-channel MOSFET Source <sup>1)</sup> . Connected to BTC50010-1TAA "OUT" pin for "Parallel Circuit to halve the $R_{DS(ON)}$ " application in <a href="#">Figure 27</a> . Connected to BTC50010-1TAA "OUT" pin for "Blocking Current in Reverse Polarity" application in <a href="#">Figure 28</a> .

- 1) All Source pins are connected internally. All Source pins have to be connected externally together on PCB. Not shorting all outputs pins will considerably increase the ON-resistance. PCB traces have to be designed to withstand the maximum current which can flow. PCB traces for output current are recommended to be designed symmetrically or having similar line resistance for any of the three output pins from this device.

### 3.3 Voltage and Current Definition

Figure 4 and Figure 5 shows all terms used in this data sheet, with associated convention for positive values.

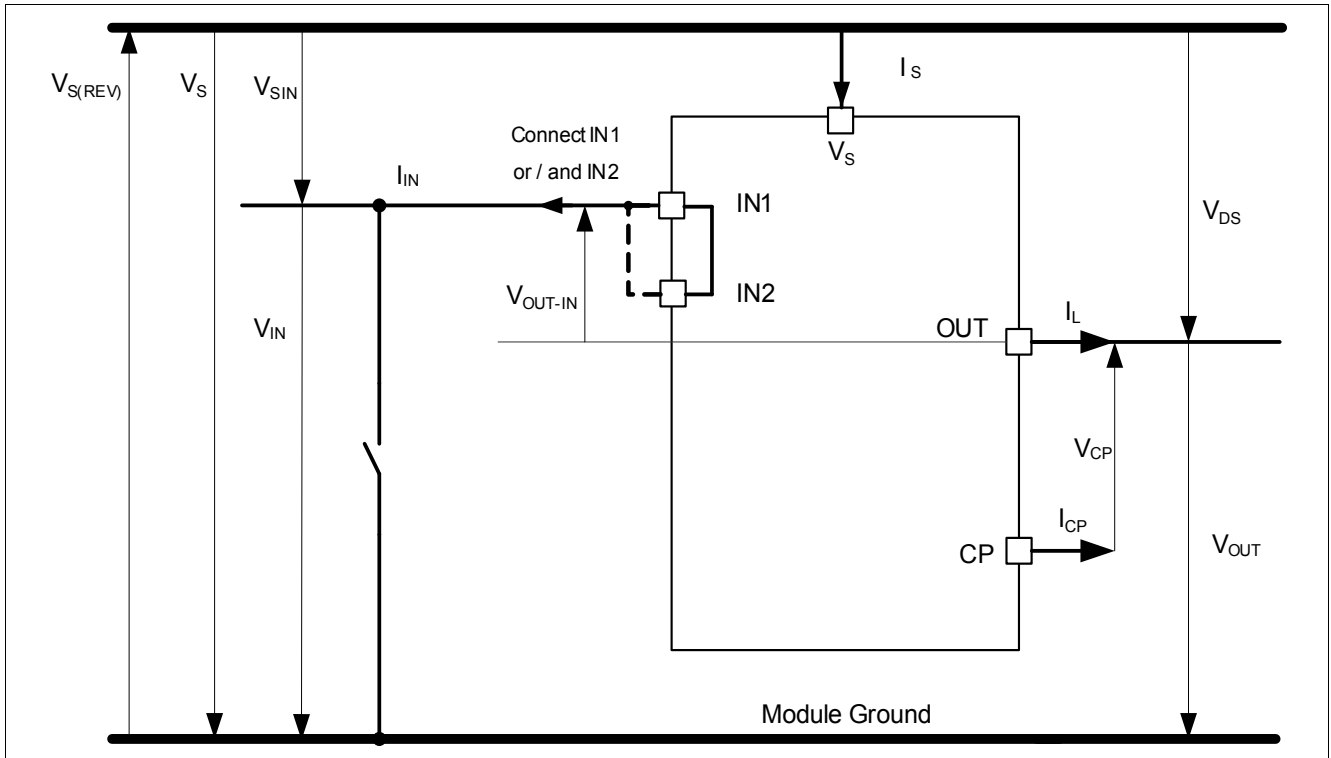


Figure 4 Voltage and Current Definition of BTC50010-1TAA

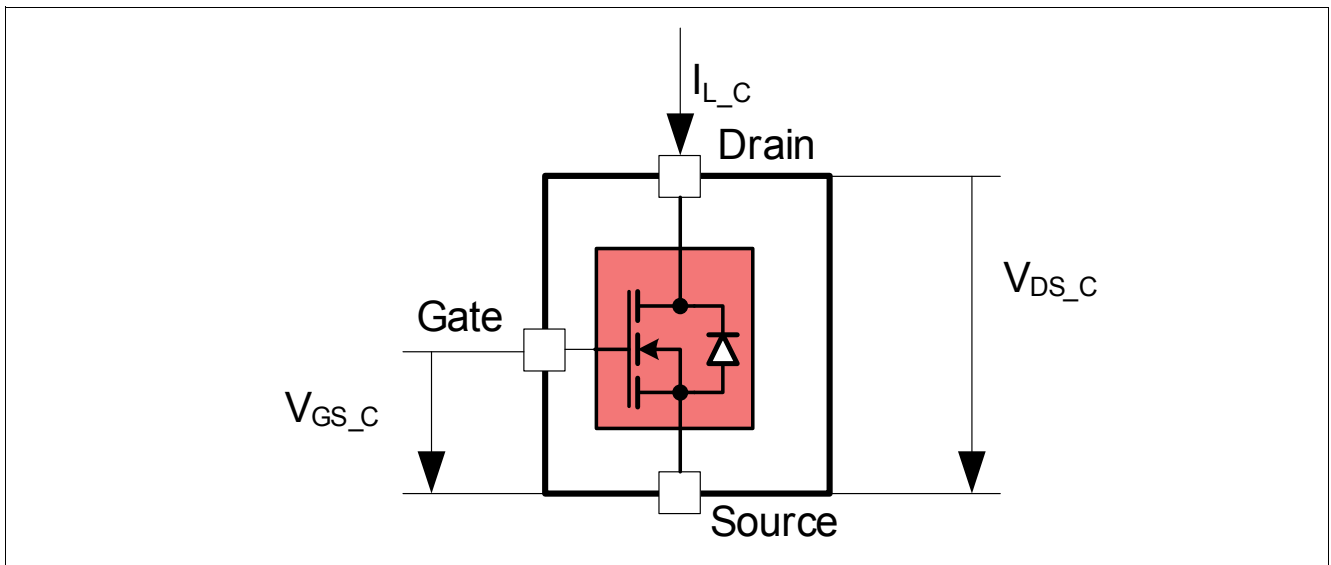


Figure 5 Voltage and Current Definition of BTC30010-1TAA



## 4 General Product Characteristics

### 4.1 Absolute Maximum Ratings

**Table 4 Absolute Maximum Ratings <sup>1)</sup>**

$T_j = -40\text{ °C}$  to  $+150\text{ °C}$ , all voltages and currents refer to definitions in **Figure 4** and **Figure 5** (unless otherwise specified). All parameters are specified for BTC50010-1TAA drives BTC30010-1TAA in parallel or anti serial (unless otherwise specified).

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
<b>Voltages</b>							
Supply Voltage	$V_S$	-0.3	–	28	V	–	P_4.1.1
Voltage from $V_S$ to IN pin	$V_{SIN}$	-0.3	–	60	V	–	P_4.1.2
Reverse polarity voltage	$V_{S(REV)}$	–	–	16	V	BTC50010-1TAA drive BTC30010-1TAA in parallel: $t < 2\text{ min}$ $T_A = 25\text{ °C}$ $R_L \geq 0.5\Omega$ $V_{IN} = 0\text{ V}$	P_4.1.3
				28		BTC50010-1TAA drive BTC30010-1TAA in anti serial: $T_A = 25\text{ °C}$ $V_{IN} = V_S$	
Supply voltage for load dump protection	$V_{S(LD)}$	–	–	45	V	<sup>2)</sup> $R_L = 1.0\ \Omega$ $R_{IN} = 100\ \Omega$	P_4.1.4
Voltage at CP pin	$V_{CP}$	-0.3	–	$V_{CP\_ON}$	V	$V_{CP} = V_{GS\_C}$	P_4.1.5
Voltage from OUT to IN pin $V_{OUTIN} = V_{OUT} - V_{IN}$	$V_{OUT-IN}$	-64	–	–	V	<sup>3)</sup>	P_4.1.6
Voltage from Gate to Source pin of BTC30010-1TAA	$V_{GS\_C}$	-0.3	–	$V_{CP\_ON}$	V	$V_{CP} = V_{GS\_C}$	P_4.1.7
<b>Currents</b>							
Current through CP pin	$I_{CP}$	-20	–	20	mA	for $t < 0.5\text{ ms}$ during switch ON/OFF	P_4.1.8
Device current vs. time capability at: $I_{6.0\_125^\circ\text{C}} = 0.85 \times 6.0 \times I_{RATE}$ for $I_{RATE} = 40\text{A}^4)$	$t @ I_{6.0}$	–	–	0.8	s	<sup>5)</sup> BTC50010-1TAA drive BTC30010-1TAA in parallel, current level: $I_{6.0\_125^\circ\text{C}} = 204\text{ A}$ , $T_A = 125\text{ °C}$ , <b>Figure 6</b>	P_4.1.9

**Table 4 Absolute Maximum Ratings (cont'd)<sup>1)</sup>**

$T_J = -40\text{ °C}$  to  $+150\text{ °C}$ , all voltages and currents refer to definitions in **Figure 4** and **Figure 5** (unless otherwise specified). All parameters are specified for BTC50010-1TAA drives BTC30010-1TAA in parallel or anti serial (unless otherwise specified).

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Continuous drain current BTC50010-1TAA	$I_D$	–	–	163	A	$T_C = 25\text{ °C}$ $V_{IN} = 0\text{ V}$ , $I_{CP} \leq 2\mu\text{A}$ Current is limited by bondwire	P_4.1.10
Continuous drain current of BTC30010-1TAA	$I_{D\_C}$	–	–	163	A	$T_C = 25\text{ °C}$ $V_{GS} \geq 6.2\text{ V}$ Current is limited by bondwire	P_4.1.11
<b>Power Stage</b>							
Average power dissipation	$P_{TOT}$	–	–	160	W	<sup>6)</sup> BTC50010-1TAA or BTC30010-1TAA For $T_{J(0)} \leq 105\text{ °C}$	P_4.1.14
<b>Temperatures</b>							
Junction Temperature	$T_J$	-40	–	150	°C	–	P_4.1.15
Dynamic Temperature increase while switching	$\Delta T_J$	–	–	60	K	–	P_4.1.16
Storage Temperature	$T_{STG}$	-55	–	150	°C	–	P_4.1.17
<b>ESD Susceptibility</b>							
ESD Susceptibility (all pins)	$V_{ESD}$	-2	–	2	kV	HBM <sup>7)</sup>	P_4.1.18
ESD Susceptibility BTC50010- 1TAA OUT pin vs. $V_S$	$V_{ESD\_out}$	-4	–	4	kV	HBM <sup>7)</sup>	P_4.1.19
ESD Susceptibility BTC30010- 1TAA Drain pin	$V_{ESD\_D}$	-4	–	4	kV	HBM <sup>7)</sup>	P_4.1.20
ESD Susceptibility BTC30010- 1TAA Source pin	$V_{ESD\_S}$	-4	–	4	kV	HBM <sup>7)</sup>	P_4.1.21

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

2)  $V_{S(LD)}$  is setup without DUT connected to the generator per ISO 7637-1.

3) Relevant to application case such as loss of load, loss of battery (also negative ISO pulse).

4)  $I_{Q\_b,125\text{ °C}} = a \times b \times I_{RATE}$ . "a" is the temperature re-rating factor from the fuse curve for 125°C refer to 25°C. "b" is the factor of load current to  $I_{RATE}$  at 25°C.

5) Use test PCB with 2 x 70  $\mu\text{m}$  Cu layers and size of 54 x 48 x 1.5 mm. Where applicable, thermal via array is placed under the device footprint on this PCB. BTC50010-1TAA & BTC30010-1TAA on PCB have  $R_{thJA(2P)} = 19.6\text{ K/W}$  (referring to 1W power dissipation for each device). PCB is vertical, keep constant environment temperature by indirect airflow of 6L/s.

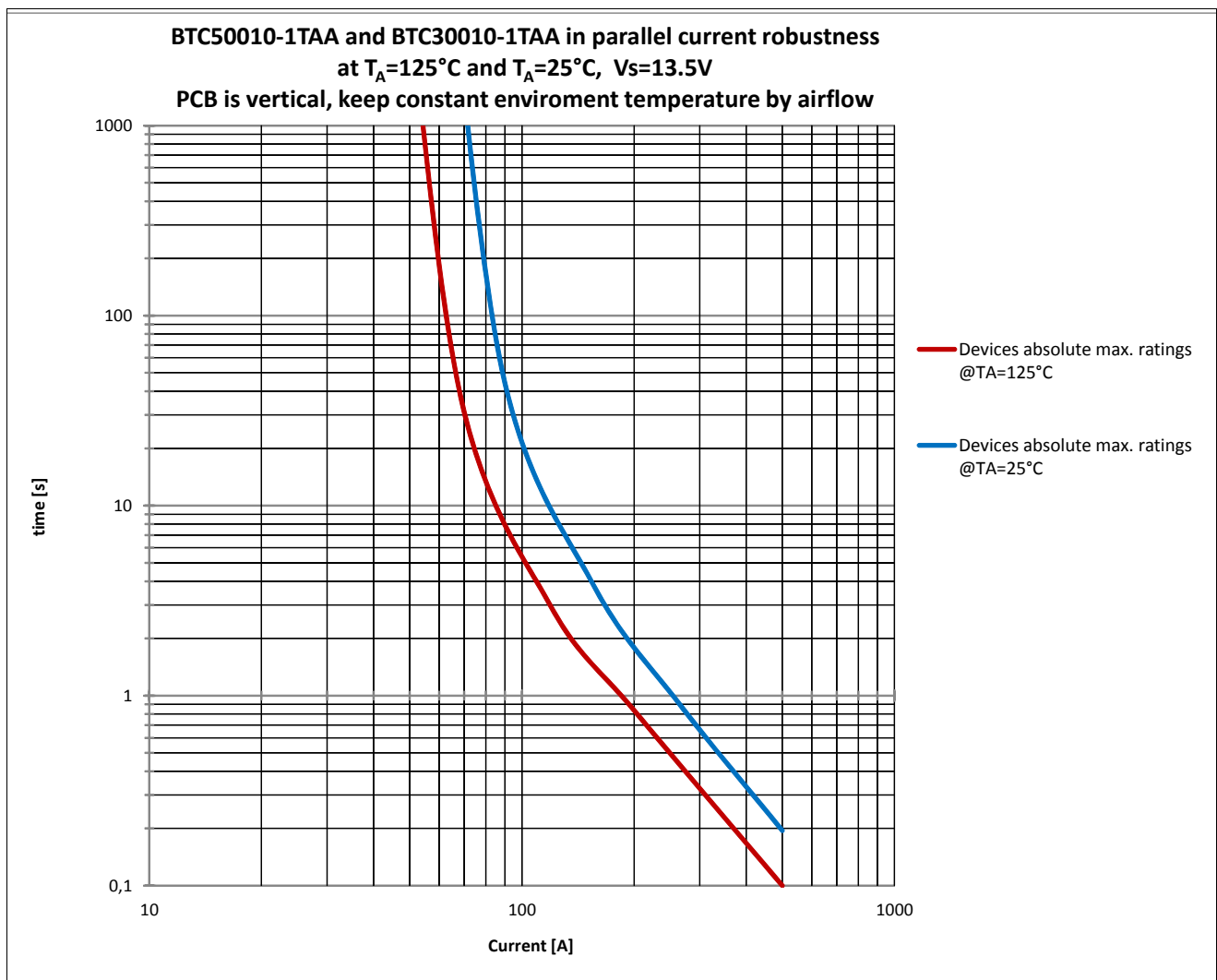
6)  $P_{TOT} = (T_{J(0)} - T_C) / R_{thJC}$ .  $P_{TOT\_max} = (105\text{ °C} - 25\text{ °C}) / 0.5\text{ K/W} = 160\text{ W}$ .

7) ESD susceptibility, HBM according to ANSI/ESDA/JEDEC JS-001-2010.

**BTC50010-1TAA & BTC30010-1TAA current robustness:**

Below diagram present the current robustness of BTC50010-1TAA & BTC30010-1TAA. Generally, module thermal characteristic is more depending on the module construction (e.g. PCB size, metal layer thickness and numbers, module connectors) than the thermal characteristic of BTC50010-1TAA & BTC30010-1TAA alone. When current pulse is longer than 0.3s, influence of module thermal characteristic is dominant. When current pulse is shorter than 0.3s, influence of thermal characteristic of BTC50010-1TAA & BTC30010-1TAA is getting significant.

Combining BTC50010-1TAA & BTC30010-1TAA together with a fuse in application, the total I/t curve of the module (incl. BTC50010-1TAA & BTC30010-1TAA) has to be above the fuse I/t curve. With specified test setup <sup>1)</sup> BTC50010-1TAA & BTC30010-1TAA can withstand minimum 10 fuse blows of a 40A ATO FUSE.



**Figure 6** BTC50010-1TAA & BTC30010-1TAA Current Robustness at  $T_A = 25^{\circ}\text{C}$  and  $T_A = 125^{\circ}\text{C}$ ;  $V_S = 13.5\text{V}$  <sup>1)</sup>

1) Use test PCB with 2 x 70  $\mu\text{m}$  Cu layers and size of 54 x 48 x 1.5 mm. Where applicable, thermal via array is placed under the device footprint on this PCB. BTC50010-1TAA & BTC30010-1TAA on PCB have  $R_{thJA}(2P) = 19.6 \text{ K/W}$  (referring to with 1 W power dissipation from each device). PCB is vertical, keep constant environment temperature by indirect airflow of 6l/s.

**Notes**

1. Stresses above the ones described in [Chapter 4.1](#) may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. 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**
**Table 5 Functional Range**

$T_J = 25\text{ °C}$ , all voltages and currents refer to definitions in and [Figure 5](#) (unless otherwise specified). All parameters are specified for BTC50010-1TAA drive BTC30010-1TAA in parallel or anti serial (unless otherwise specified).

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Nominal operating voltage	$V_{S\_OP}$	8	–	18	V	–	P_4.2.1
Extended static operating voltage	$V_{S\_OP\_EXT}$	5	–	28	V	<sup>1) 2)</sup> $I_L \leq I_{L(NOM)}$	P_4.2.2
Extended operating voltage contain dynamic undervoltage capability	$V_{S\_DYN}$	3.2	–	28	V	<sup>1)</sup> $V_S$ decreasing according to ISO7637 according to LV124	P_4.2.3
Static undervoltage level (start of loss of functionality)	$V_{S\_UV}$	–	–	4.5	V	$R_L = 270\ \Omega$ $V_S$ decreasing $V_{DS} \leq 0.5\text{ V}$ $I_{CP\_ON} = 0\ \mu\text{A}$ <a href="#">Figure 7</a>	P_4.2.4
Undervoltage restart level static	$V_{S\_UV\_Restart}$	–	–	5	V	$R_L = 270\ \Omega$ $V_S$ increasing $V_{DS} \leq 0.5\text{ V}$ $I_{CP\_ON} = 0\ \mu\text{A}$ <a href="#">Figure 7</a>	P_4.2.5
Charge pump current in ON state (maximum allowed leakage current at CP pin)	$I_{CP\_ON}$		0	2	$\mu\text{A}$	$V_{IN} = 0\text{ V}, t > t_{ON}$	P_4.2.6
Maximum allowed Current in OFF state IN pins High	$I_{IN\_OFF}$	–	–	30	$\mu\text{A}$	Pull-up current flow through internal current source	P_4.2.7

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

2) Within the range of  $V_{S\_OP\_EXT}$  and out of the range of  $V_{S\_OP}$ , device parameter deviation is possible.

*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.*

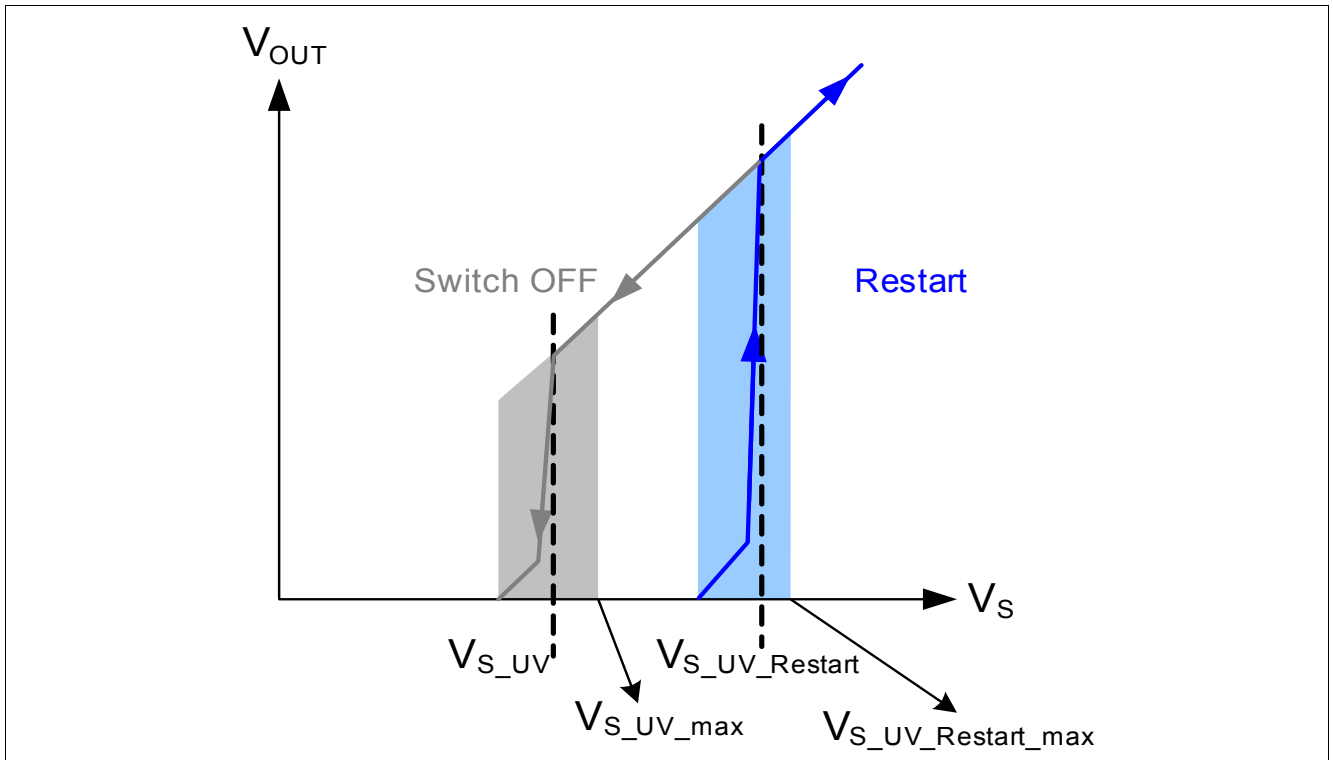


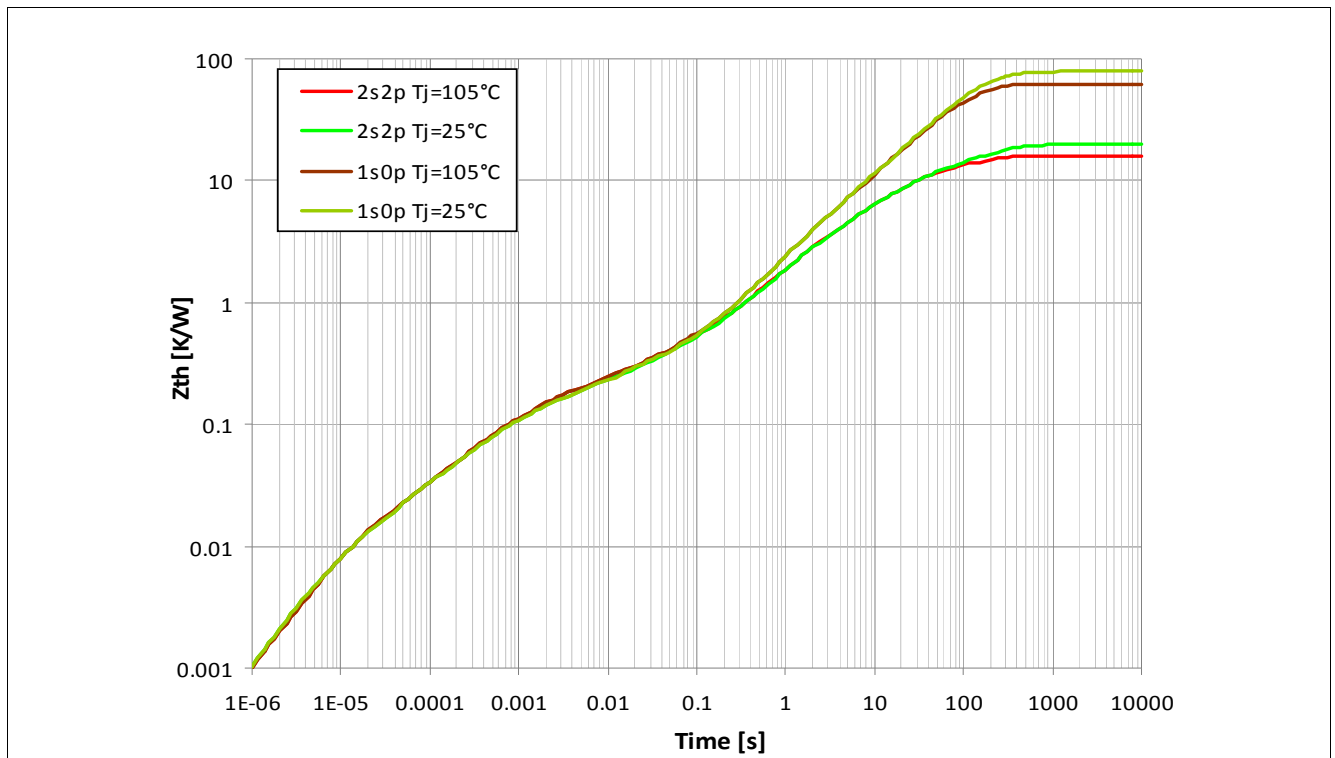
Figure 7 Undervoltage Behavior of BTC50010-1TAA Connected with BTC30010-1TAA on its CP Pin

### 4.3 Thermal Resistance

**Table 6 Thermal Resistance<sup>1)</sup> for BTC50010-1TAA or BTC30010-1TAA at  $T_j = 25\text{ °C}$**

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Junction to Case	$R_{thJC}$	–	–	0.5	K/W	2)	P_4.3.1
Junction to Ambient	$R_{thJA(2S2P)}$	–	20	–	K/W	2) 3)	P_4.3.2
Junction to Ambient	$R_{thJA(1S0p)}$	–	70	–	K/W	2) 4)	P_4.3.3

- 1) Not subject to production test, specified by design.
- 2) Device is dissipating 1W power.
- 3) Specified  $R_{thJA}$  value is according to Jedec JESD51-2,-5,-7 at natural convection on FR4 2s2p board; The product (chip + package) was simulated on a 76,4 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). Where applicable, a thermal via array under the exposed pad contacted the first inner copper layer.
- 4) Specified  $R_{thJA}$  value is according to Jedec JESD51-2,-5,-7 at natural convection on FR4 1s0p board; The product (chip + package) was simulated on a 76,4 x 114,3 x 1,5 mm board with 1 copper layer (1 x 70  $\mu\text{m}$  Cu).



**Figure 8 Typical Transient Thermal Impedance  $Z_{th(JA)} = f(t)$  for Different Cooling Areas**

**Figure 8** is showing the typical thermal impedance of BTC50010-1TAA or BTC30010-1TAA mounted on different PCB setup on FR4 1s0p (single layer) and 2s2p (quad layer) boards at  $T_j$  of 25°C and 105°C according to Jedec JESD51-2,-5,-7 at natural convection.

## 5 Functional Description

### 5.1 Power Stage

#### 5.1.1 Output ON-State Resistance

The ON-state resistance  $R_{DS(ON)}$  depends on the supply voltage as well as the junction temperature  $T_J$ . **Figure 18** shows the dependencies in terms of temperature and supply voltage, for the typical ON-state resistance. The behavior in reverse polarity is described in **Chapter 5.7**.

A LOW signal (see **Chapter 5.2**) at the input pin causes a current  $I_{IN}$  flowing internally from the  $V_S$  pin out of the IN pin to the module Ground, thus the power DMOS is switched ON with a dedicated slope, which is optimized in terms of EMC emission.

#### 5.1.2 Switching an Inductive Load

When switching OFF inductive loads with high side switches, the voltage  $V_{OUT}$  is driven below ground potential, due to the fact that the inductance intends to continue driving the current. To prevent the destruction of the device due to high voltages, the device implements an overvoltage protection, which clamps the voltage between  $V_S$  and  $V_{OUT}$  at  $V_{DS(CL)}$  (see **Figure 9**).

Nevertheless it is not recommended to operate the device repetitively under this condition. Therefore, when driving inductive loads, a free wheeling diode must be always placed.

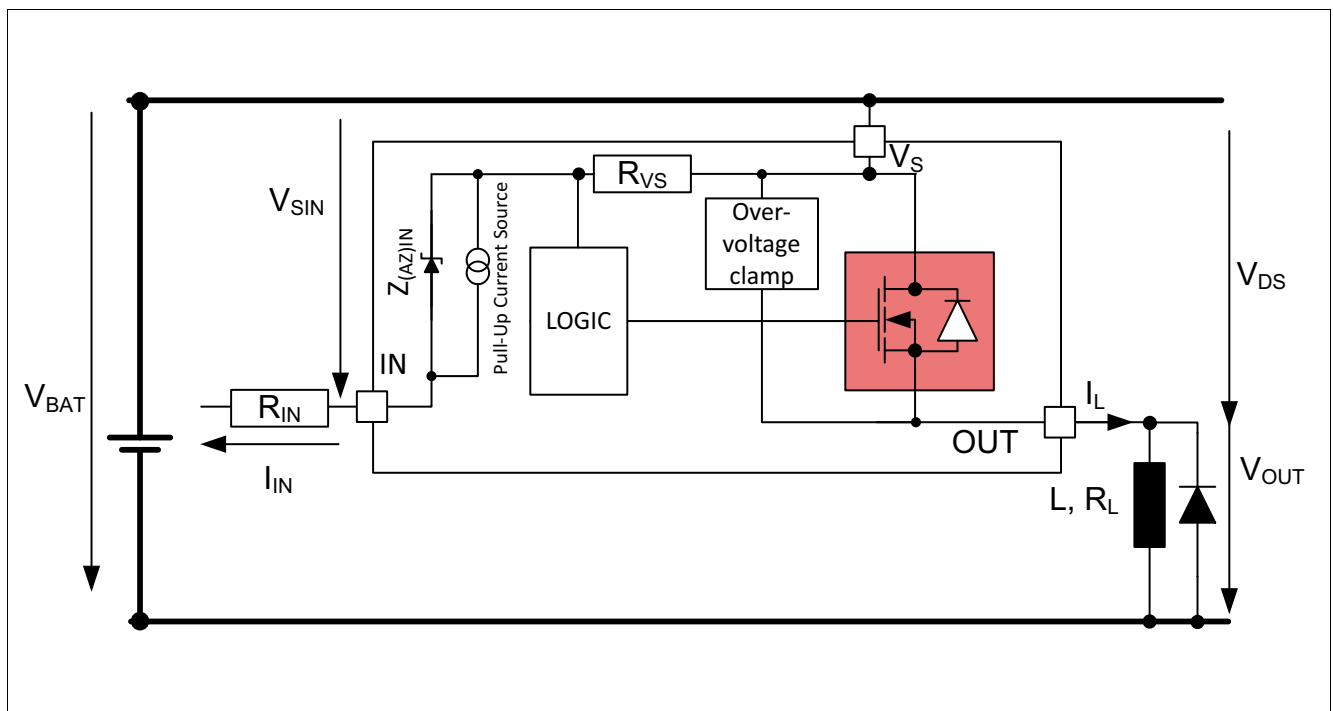
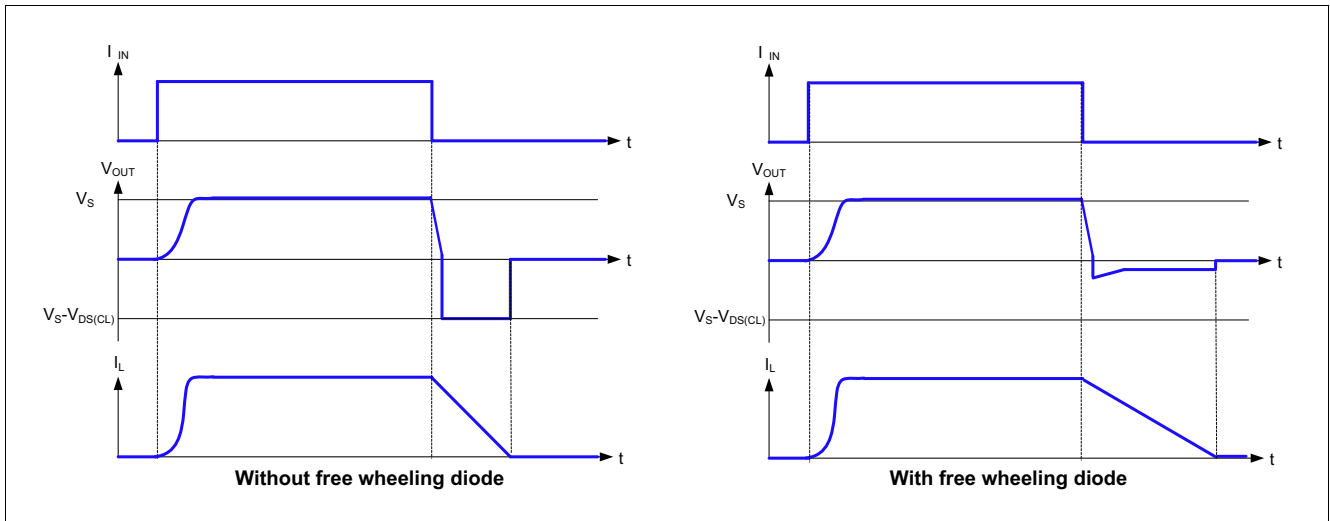


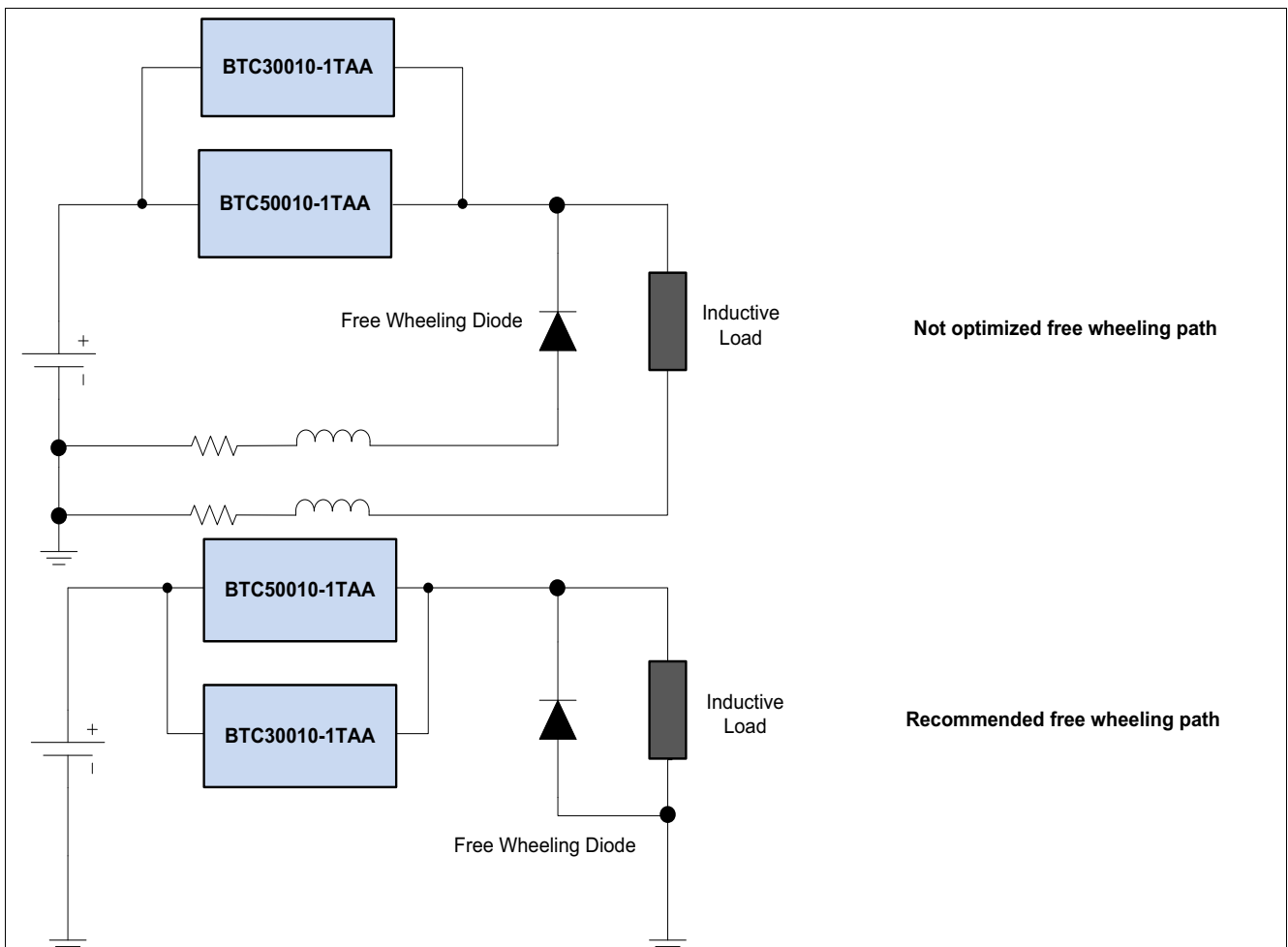
Figure 9 Overvoltage Clamp



**Figure 10 Switching an Inductance with or without free wheeling diode**

It is important to verify the effectiveness of the freewheeling solution (see [Figure 10](#)), which means the selection of the proper diode and of an appropriate free wheeling path. With regard to the choice of the free wheeling diode, low threshold and fast response are key parameter to achieve an effective result.

Moreover the diode should be placed in order to have the shortest wire connection with the load (see [Figure 11](#)).

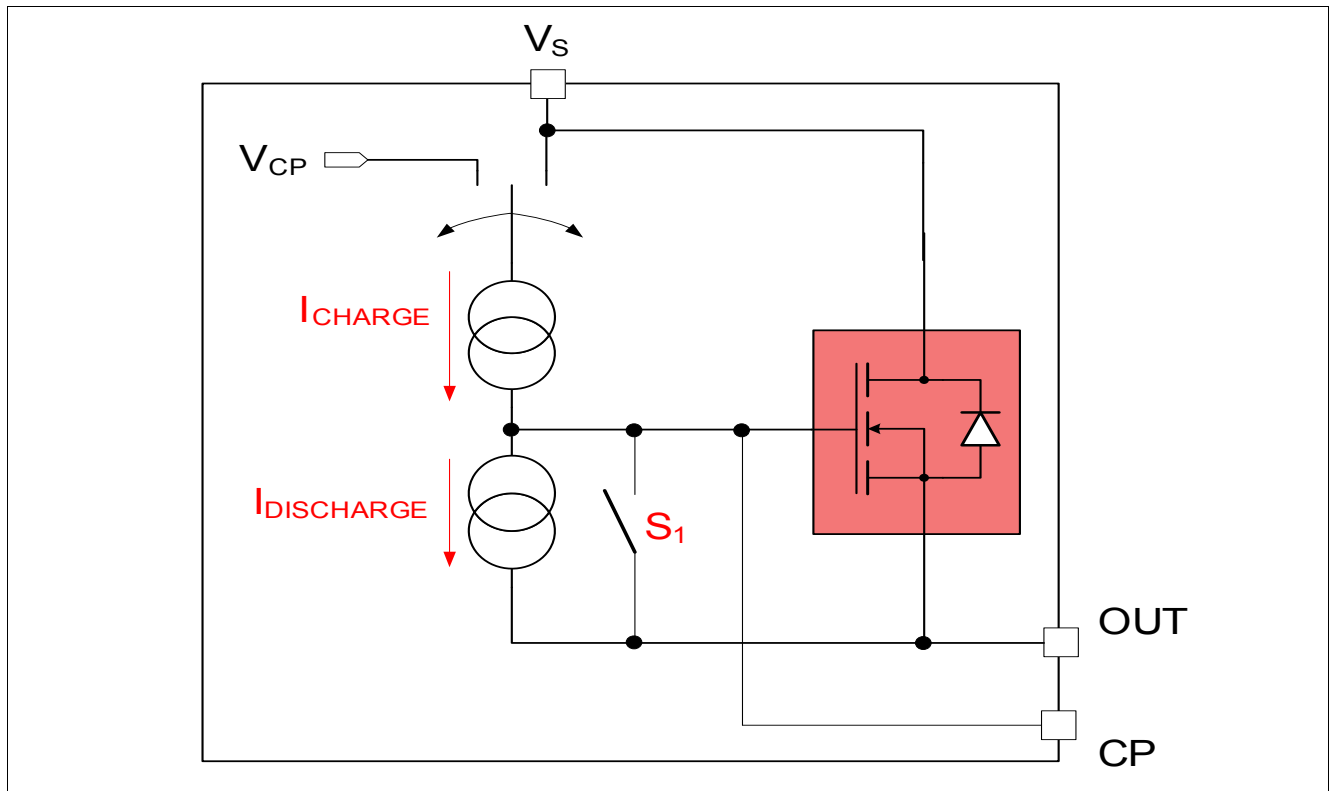


**Figure 11 Optimization of the free wheeling path**



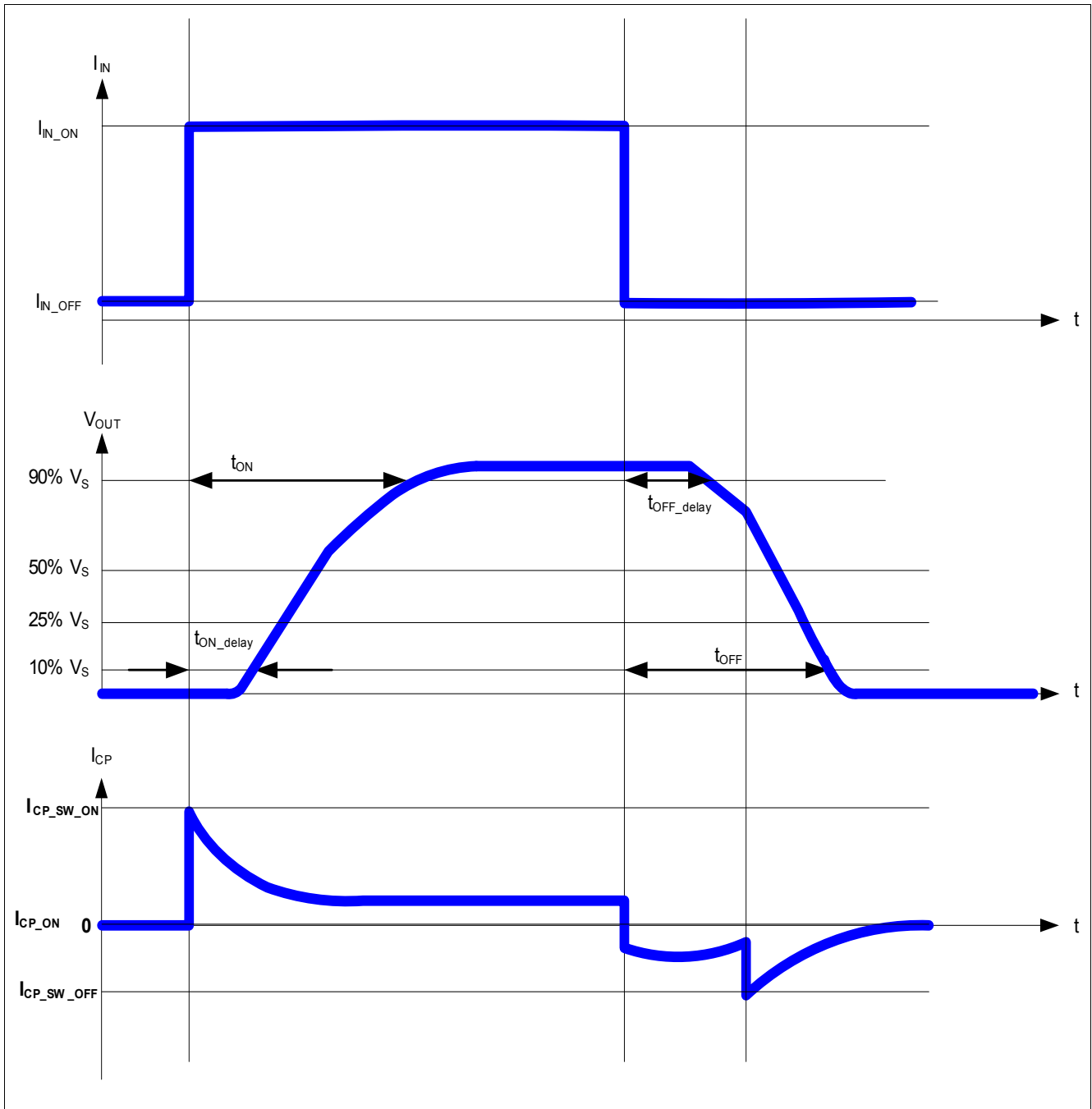
### 5.2 Gate Driver Functionality

BTC50010-1TAA has an embedded gate driver. It is used to drive the gate of an integrated power DMOS. The gate driver charges and discharges the gate of the DMOS with current  $I_{CHARGE}$  and  $I_{DISCHARGE}$ . Refer to **Figure 12**, the gate driver is accessible via the CP pin. BTC50010-1TAA is suitable for driving the BTC30010-1TAA in parallel to halve the connect resistance or in anti serial to block the reverse current. During Switch ON, BTC50010-1TAA charges the Gate capacitor of BTC30010-1TAA.



**Figure 12 Gate Driver Block Diagram of BTC50010-1TAA**

During switch OFF, when  $V_{out}$  decreases to around 2.5V below  $V_S$ , the internal switch  $S_1$  between gate and source will switch ON to reduce the high energy consuming switch OFF time. Additionally, when  $S_1$  is switched ON, the device is much more robust against electromagnetic disturbance which could come from  $V_S$  or output pin to ensure the device doesn't suffer from an unwanted switch ON.



**Figure 13** Timing Diagram of BTC50010-1TAA Connected with BTC30010-1TAA on its CP Pin

Note: **Figure 13** shows the general switching behavior. Under real condition, voltage or current sketch deviation is possible.

### 5.3 Undervoltage Protection

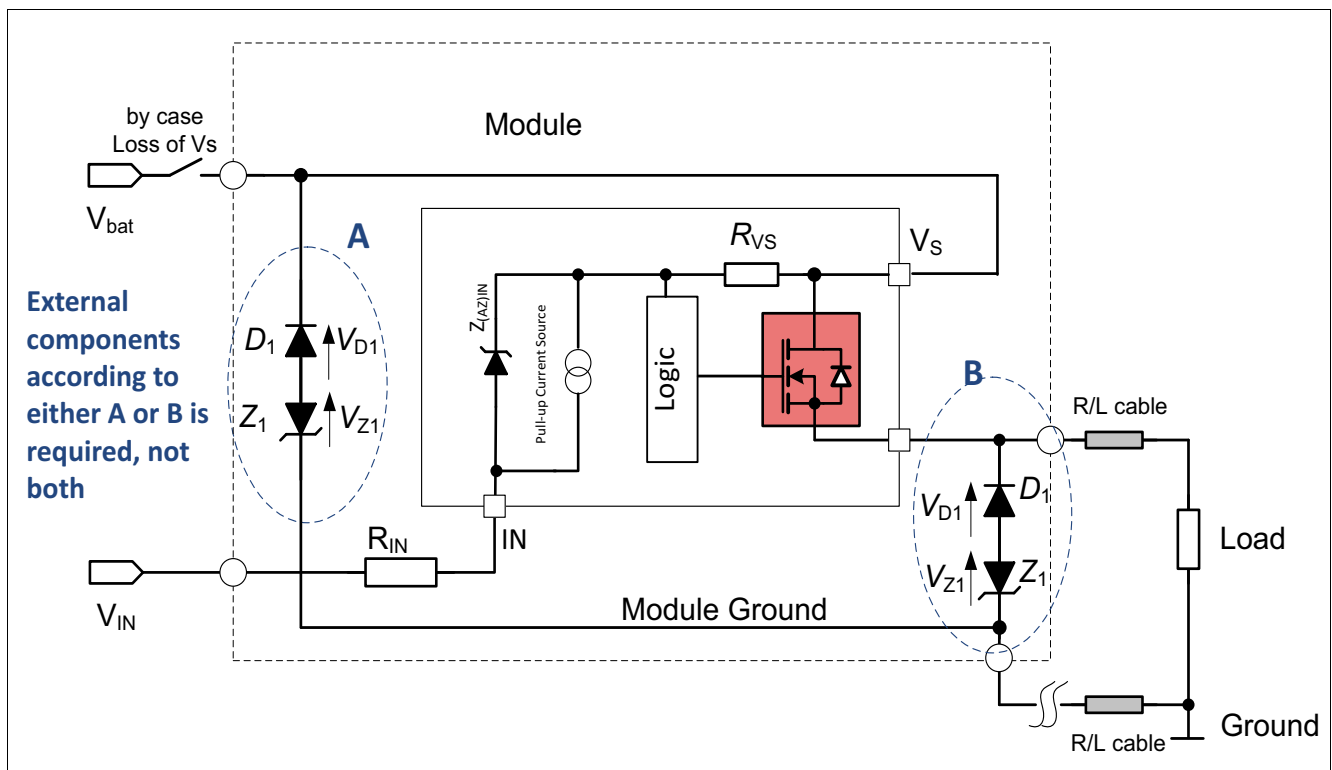
Below  $V_{S\_UV}$  maximum value, the under voltage condition is met. Upon further decrease of  $V_S$ , the device will begin to lose functionality, until finally it will turn OFF. During  $V_S$  increasing, as soon as the supply voltage is above the static level  $V_{S\_UV\_Restart}$ , device can be switched ON. **Figure 7** sketches the undervoltage mechanism.

### 5.4 Overvoltage Protection

The BTC50010-1TAA & BTC30010-1TAA provides Infineon® SMART CLAMPING functionality, which suppresses non nominal over voltages by actively clamping the overvoltage across the power stage and the load. This is achieved by controlling the clamp voltage  $V_{DS(CL)}$  depending on the junction temperature  $T_J$  and the load current  $I_L$ .

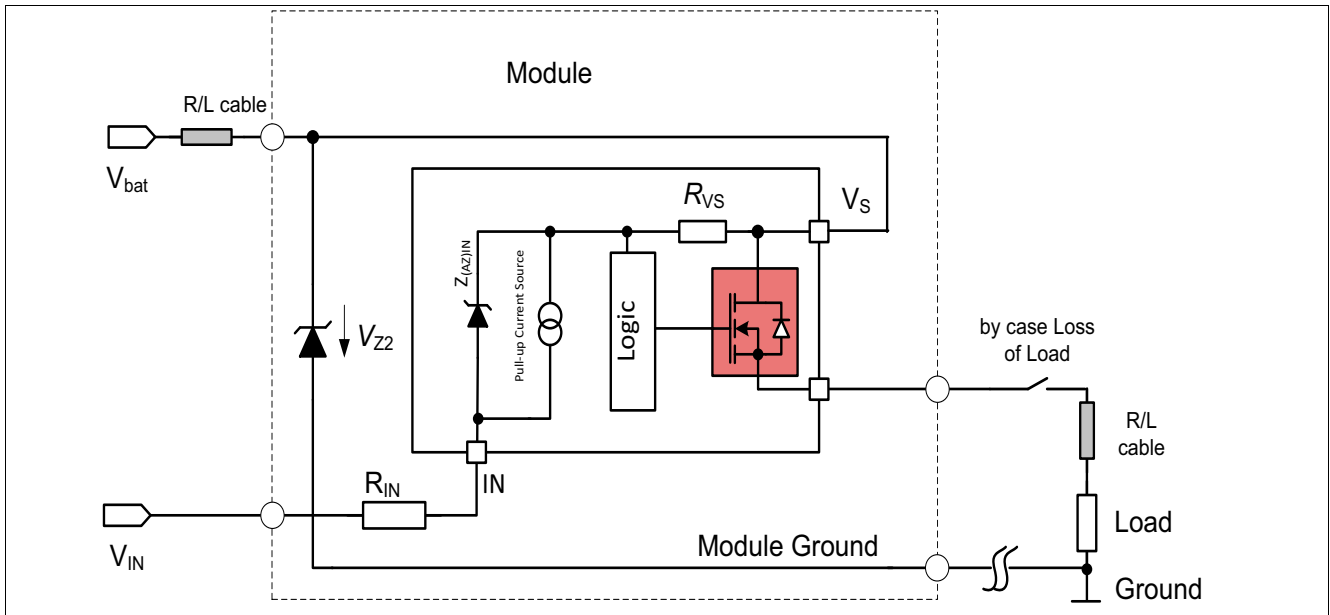
### 5.5 Protection during Loss of Load or Loss of $V_S$ Condition

In case of loss of  $V_S$  with charged line inductances, the maximum supply voltage has to be limited. It is recommended to use a diode and a Z-diode ( $V_{Z1} + V_{D1} < 16V$ , please refer to [Figure 14](#)).



**Figure 14 External Component for BTC50010-1TAA Loss of  $V_S$  Protection**

In case of loss of load with charged primary power line inductances, the maximum supply voltage also has to be limited. It is recommended to use a Z-diode ( $V_{Z2} < 28V$ ) or  $V_S$  clamping power switches between  $V_S$  and Module Ground (please refer to [Figure 15](#)).

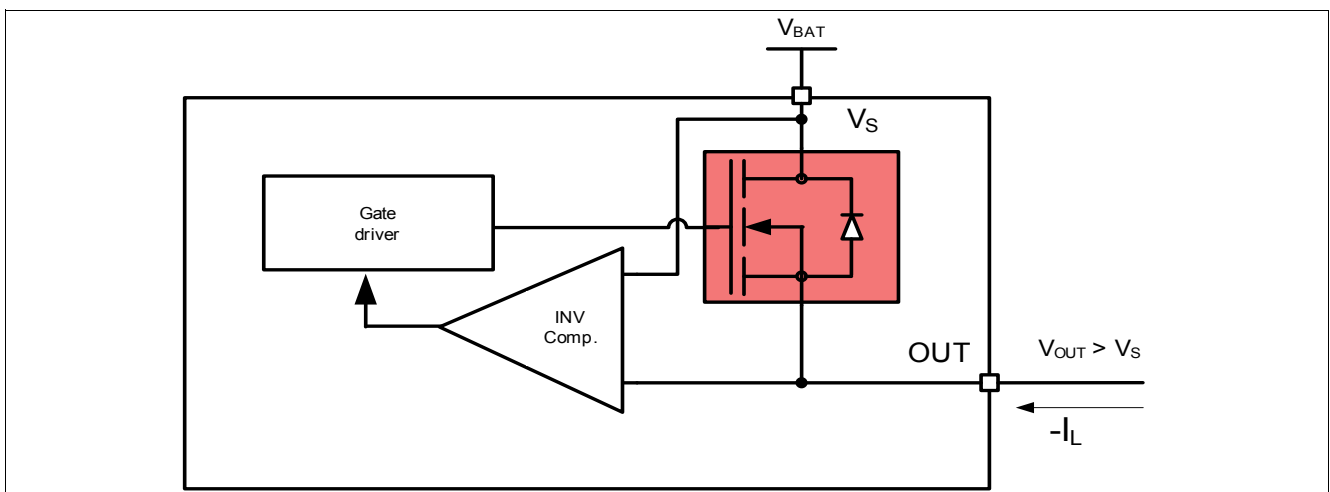


**Figure 15 External Component for BTC50010-1TAA Loss of Load Protection**

The 16V Z-diode refers to the maximum  $V_{S(REV)}$  voltage of the chip. The 28V Z-diode refers to the maximum supply voltage ( $V_S$ ) of the chip.

### 5.6 BTC50010-1TAA Inverse Current Capability

In case of inverse current, meaning a voltage  $V_{OUT}$  at the output higher than the supply voltage  $V_S$  (e.g. caused by a load operating as a generator), a current  $I_L$  will flow from output to  $V_S$  pin via the body diode of the power transistor (please refer to **Figure 16**). In case the IN pin is LOW<sup>1)</sup>, the power DMOS is already activated and keeps ON. In case, the input goes from “H” to “L”, the DMOS will be activated. Due to the limited speed of INV comparator, the output voltage slope needs to be limited. In case the IN pin is HIGH<sup>2)</sup>, power DMOS will not be switched ON automatically. Current will flow through the intrinsic body diode. This power dissipation could cause heating effect, which has to be considered.



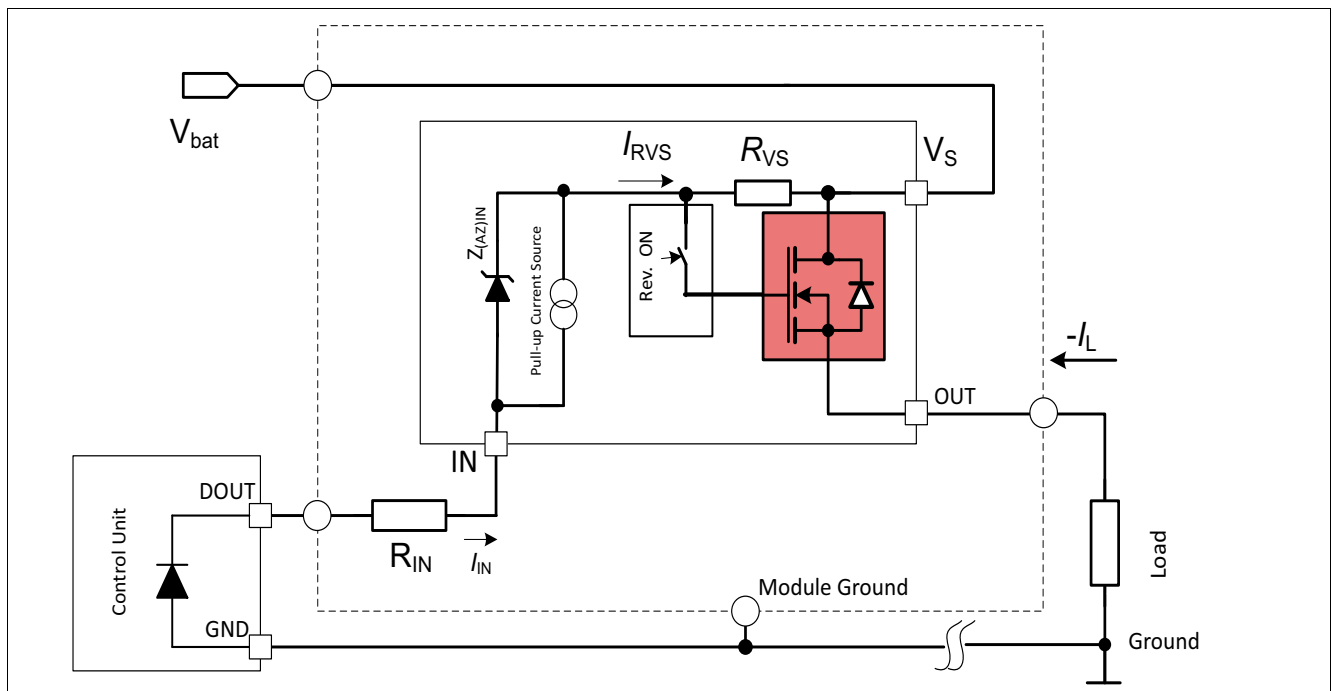
**Figure 16 BTC50010-1TAA Inverse Current Circuitry**

1) LOW means IN pin is pulled-down by external transistor or  $I_{IN} > 0$   
 2) HIGH (H) means  $I_{IN} = 0$

### 5.7 Reverse Polarity Protection

In case of reverse polarity for BTC50010-1TAA drive BTC30010-1TAA in parallel or BTC50010-1TAA alone, the intrinsic body diode of the power DMOS causes power dissipation. To limit the risk of over temperature, the device provides Infineon® Reversave™ function. The power in this intrinsic body diode is limited by turning the DMOS ON. The DMOS resistance is then equal to  $R_{DS(ON\_REV)}$  (please refer to **Figure 19** and **Figure 20**).

Additionally, the current into the logic has to be limited. The device includes a  $R_{VS}$  resistor which limits the current in the diodes. To avoid over current in the  $R_{VS}$  resistor, it is nevertheless recommended to use a  $R_{IN}$  resistor. Please refer to maximum current described in **Table 4**. **Figure 17** shows a typical application. The recommended typical values for  $R_{IN}$  is 100Ω.



**Figure 17 BTC50010-1TAA Reverse Polarity Protection with External Components**

*Note: The  $R_{VS}$  has a typical value of 80Ω at 25°C. Refer to **Figure 17**, the  $R_{VS}$  and  $R_{IN}$  build up a voltage divider to split up the supply voltage on BTC50010-1TAA, which protect the device during high voltage pulse (e.g. ISO pulse 3b).*

## 5.8 Electrical Characteristics

**Table 7 Electrical Characteristics: Power Stage**

$V_S = 13.5\text{ V}$ ,  $T_J = 25\text{ °C}$ , all voltages and currents refer to definitions in [Figure 4](#) and [Figure 5](#) (unless otherwise specified). All parameters are specified for BTC50010-1TAA drive BTC30010-1TAA in parallel or anti serial (unless otherwise specified).

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Voltage drop ( $V_{DS}$ and $V_{DS\_C}$ )	$V_{DROD}$	–	27	36	mV	$I_L = 30\text{ A}$ and $I_{L\_C} = 30\text{ A}$ BTC50010-1TAA drive BTC30010- 1TAA in parallel	P_5.8.1
ON-state resistance	$R_{DS(ON)}$	–	0.9	1.2	mΩ	BTC50010-1TAA or BTC30010-1TAA, <a href="#">Figure 18</a>	P_5.8.2
ON-state resistance hot	$R_{DS(ON)\_HOT}$	–	–	2.0	mΩ	BTC50010-1TAA or BTC30010-1TAA, $T_J = 150\text{ °C}$ <a href="#">Figure 18</a>	P_5.8.3
ON-state resistance in Infineon® Reversave™	$R_{DS(ON)\_REV}$	–	0.9	–	mΩ	BTC50010-1TAA or BTC30010-1TAA, $V_{IN} = 0\text{ V}$	P_5.8.4
ON-state resistance during inverse operation	$R_{DS(ON)\_INV}$	–	0.9	–	mΩ	BTC50010-1TAA or BTC30010-1TAA, $V_{IN} = 0\text{ V}$	P_5.8.5
BTC50010-1TAA & BTC30010-1TAA supply current stand-by IN pins floating	$I_{S\_OFF}$	–	3	13	μA	Leakage current flow through OUT pin	P_5.8.6
Drain to source smart clamp voltage ( $V_{DS(CL)} = V_S - V_{OUT}$ for BTC50010-1TAA; $V_{DS(CL)} =$ $V_D - V_S$ for BTC30010-1TAA)	$V_{DS(CL)}$	28	–	60	V	$I_{L\_C} = 50\text{ mA}$ $T_J = 25\text{ °C to }150\text{ °C}$	P_5.8.7

**Table 8 Electrical Characteristics: Input Stage**

$V_S = 13.5\text{ V}$ ,  $T_J = 25\text{ °C}$ , all voltages and currents refer to definitions in [Figure 4](#) and [Figure 5](#) (unless otherwise specified). All parameters are specified for BTC50010-1TAA drive BTC30010-1TAA in parallel or anti serial (unless otherwise specified).

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Input current in ON state IN pins Low	$I_{IN\_ON}$	–	2	3	mA	$V_S = 18\text{ V}$	P_5.8.8

**Table 9 Electrical Characteristics: Charge Pump**

$V_S = 13.5\text{ V}$ ,  $T_J = 25\text{ °C}$ , all voltages and currents refer to definitions in [Figure 4](#) and [Figure 5](#) (unless otherwise specified). All parameters are specified for BTC50010-1TAA (unless otherwise specified).

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Charge pump current during SWITCH ON	$I_{CP\_SW\_ON}$	0.7	2.2	–	mA	$V_{IN} = 0\text{ V}$ $V_{CP} = 0\text{ V}$	P_5.8.9
Charge pump current during SWITCH OFF	$I_{CP\_SW\_OFF}$	350	850	–	μA	$V_{IN} = V_S = 8\text{ V}$ $V_{CP} = V_{CP\_ON}$ $V_{OUT} = V_S$	P_5.8.10
Charge pump voltage	$V_{CP\_ON}$	5	–	7	V	$V_{IN} = 0\text{ V}$ <a href="#">Figure 30</a>	P_5.8.11

**Table 10 Electrical Characteristics: Timing**

$V_S = 13.5\text{ V}$ ,  $T_J = 25\text{ °C}$ , all voltages and currents refer to definitions in [Figure 4](#) and [Figure 5](#) (unless otherwise specified). All parameters are specified for BTC50010-1TAA alone (unless otherwise specified).

Parameter	Symbol	Values			Unit	Note / Test Condition	Number
		Min.	Typ.	Max.			
Turn ON time	$t_{ON}$	–	200	500	μs	See timing <a href="#">Figure 13</a> CP pin open	P_5.8.12
Turn OFF time	$t_{OFF}$	–	200	500	μs	See timing <a href="#">Figure 13</a> CP pin open	P_5.8.13
Turn ON delay time	$t_{ON\_delay}$	–	80	150	μs	See timing <a href="#">Figure 13</a> CP pin open	P_5.8.14
Turn OFF delay time	$t_{OFF\_delay}$	–	180	300	μs	See timing <a href="#">Figure 13</a> CP pin open	P_5.8.15

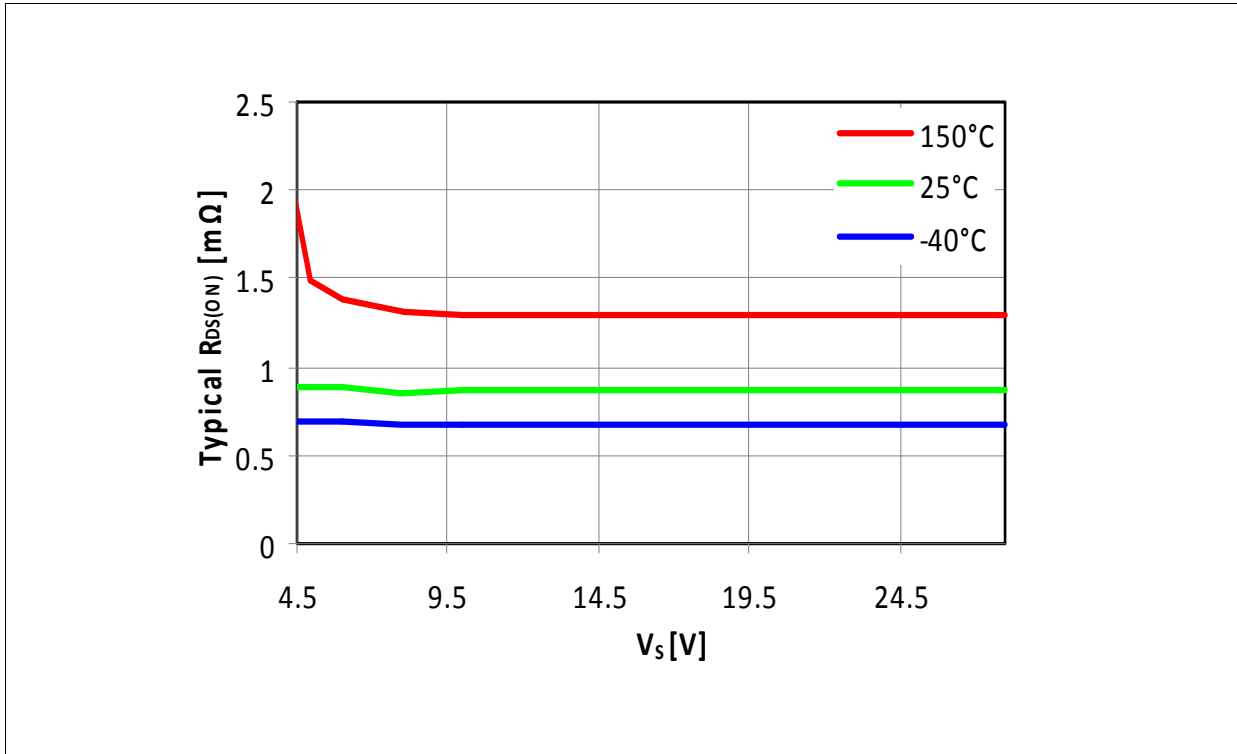


Figure 18  $R_{DS(ON)}$  vs.  $V_S$  of BTC50010-1TAA or BTC30010-1TAA

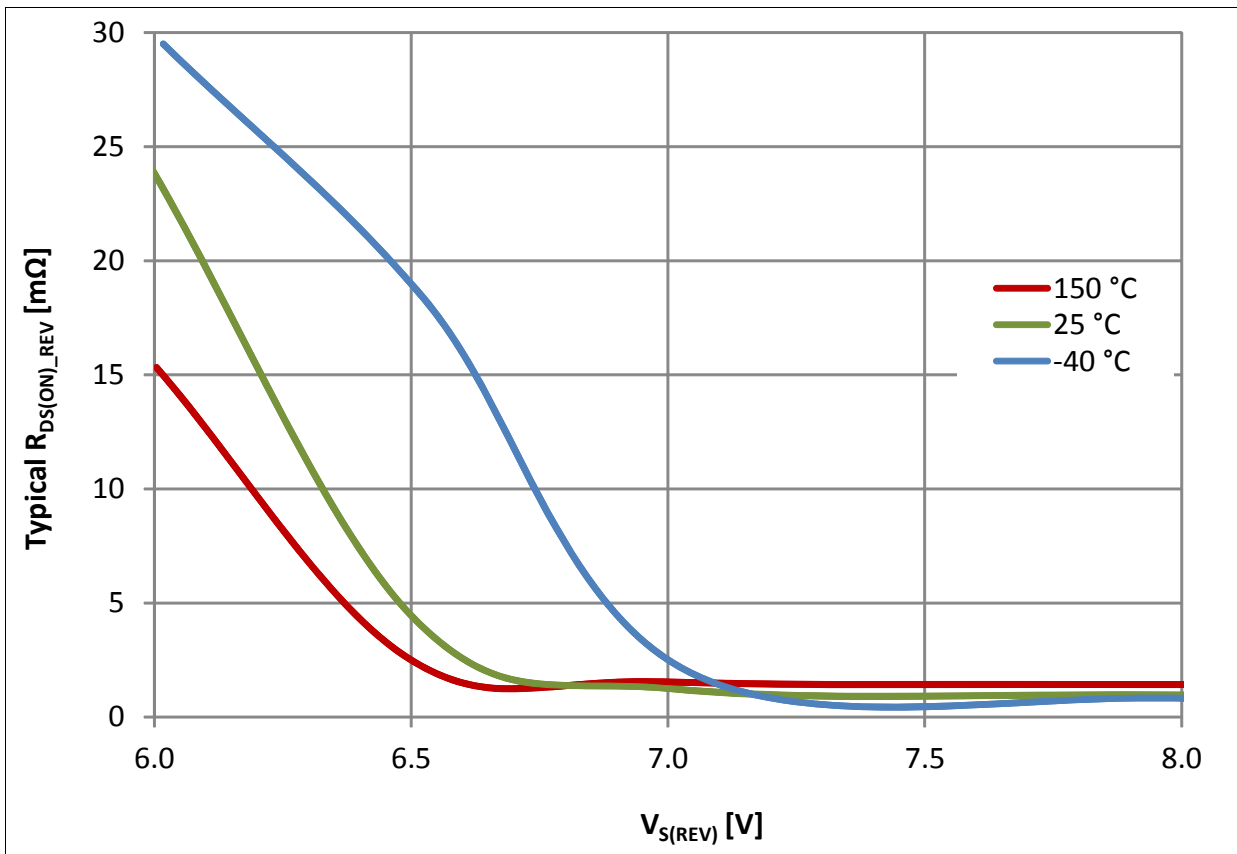


Figure 19 Typical  $R_{DS(ON)_REV}$  of BTC50010-1TAA or BTC30010-1TAA vs.  $V_{S(REV)}$  with  $V_{IN} = 0V$  in Reverse Mode for lower values of  $V_{S(REV)}$



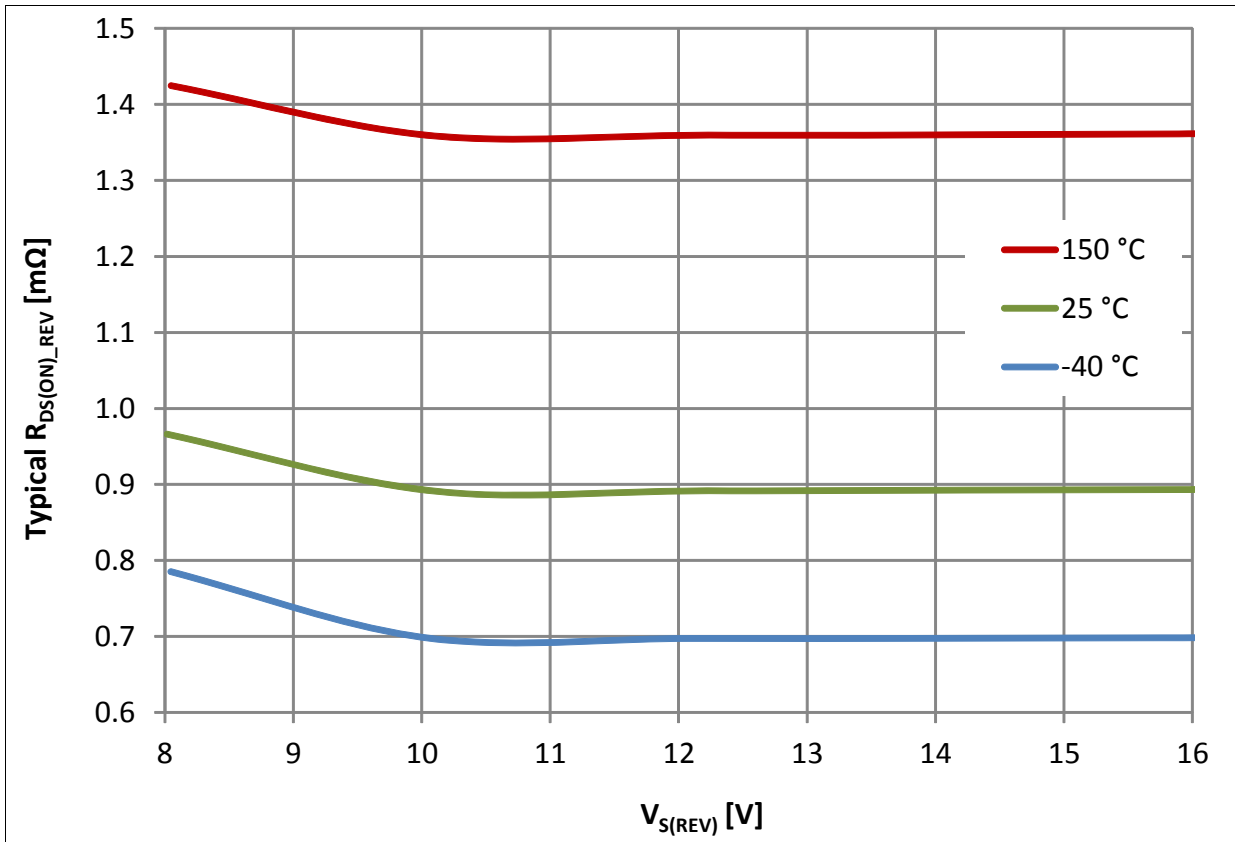


Figure 20 Typical  $R_{DS(ON)_REV}$  of BTC50010-1TAA or BTC30010-1TAA vs.  $V_{S(REV)}$  with  $V_{IN} = 0V$  in Reverse Mode for higher values of  $V_{S(REV)}$

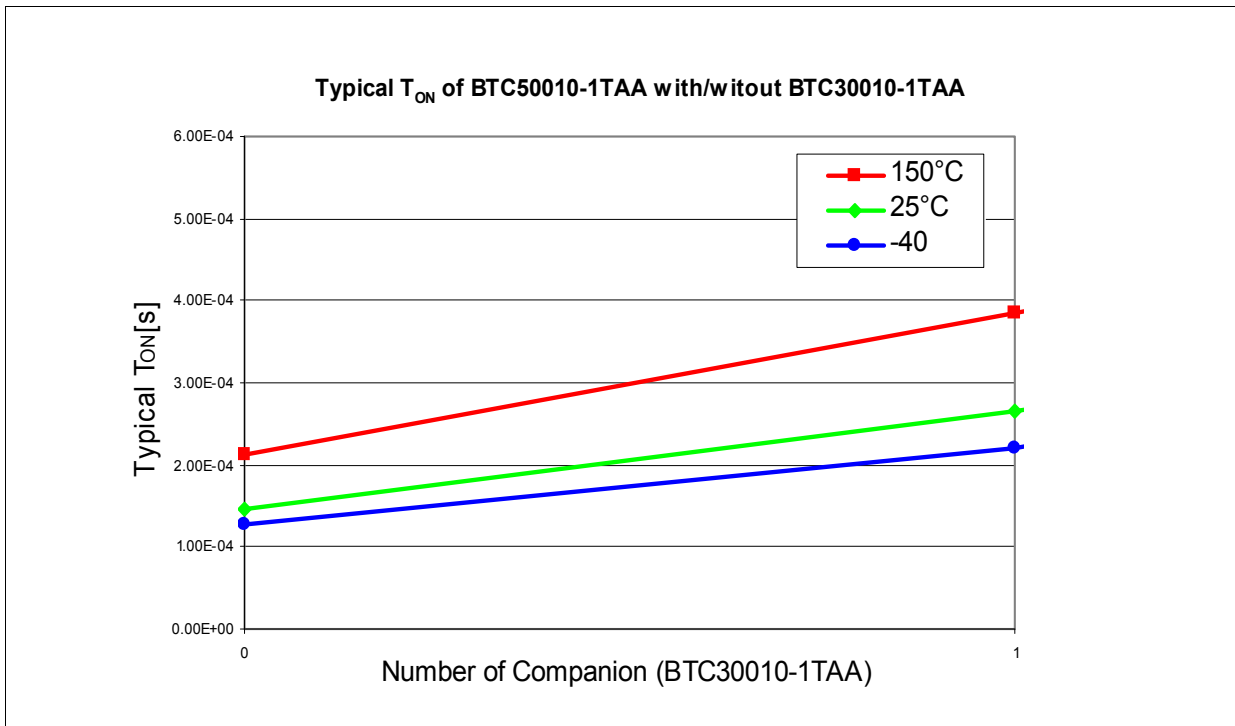


Figure 21  $T_{ON}$  of BTC50010-1TAA with/witout BTC30010-1TAA

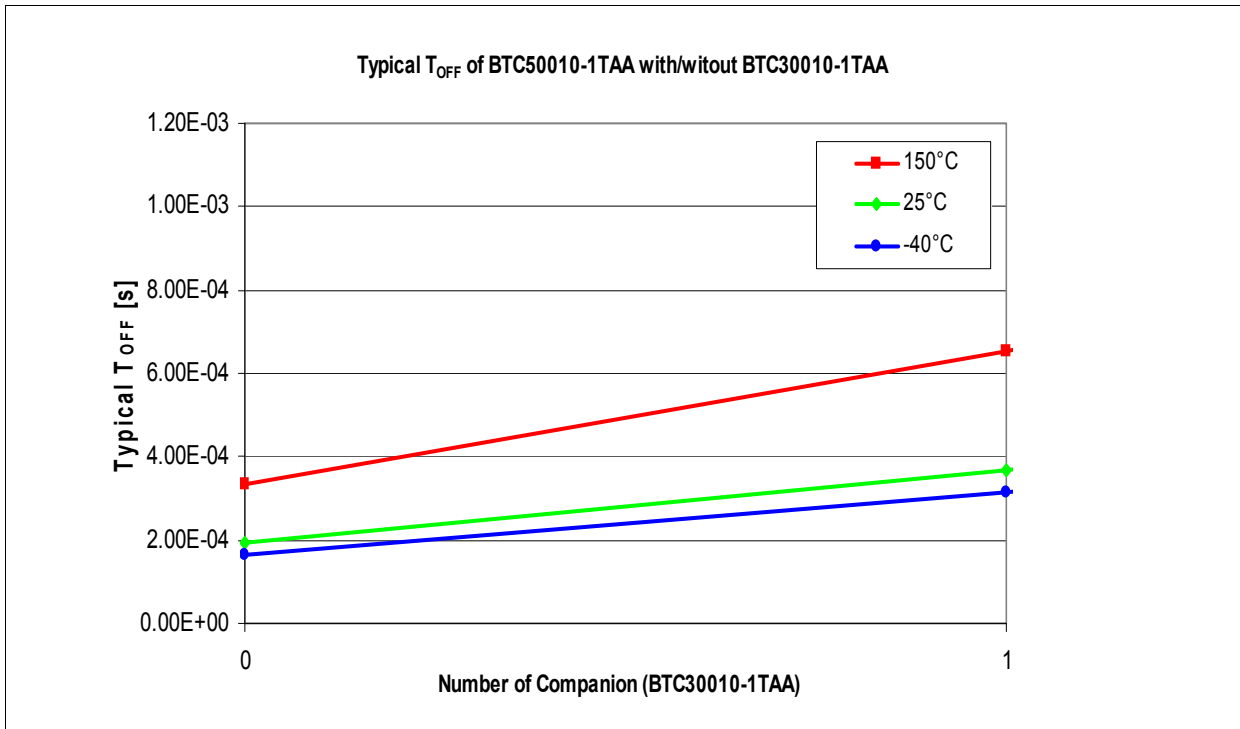


Figure 22  $T_{OFF}$  of BTC50010-1TAA with/without BTC30010-1TAA

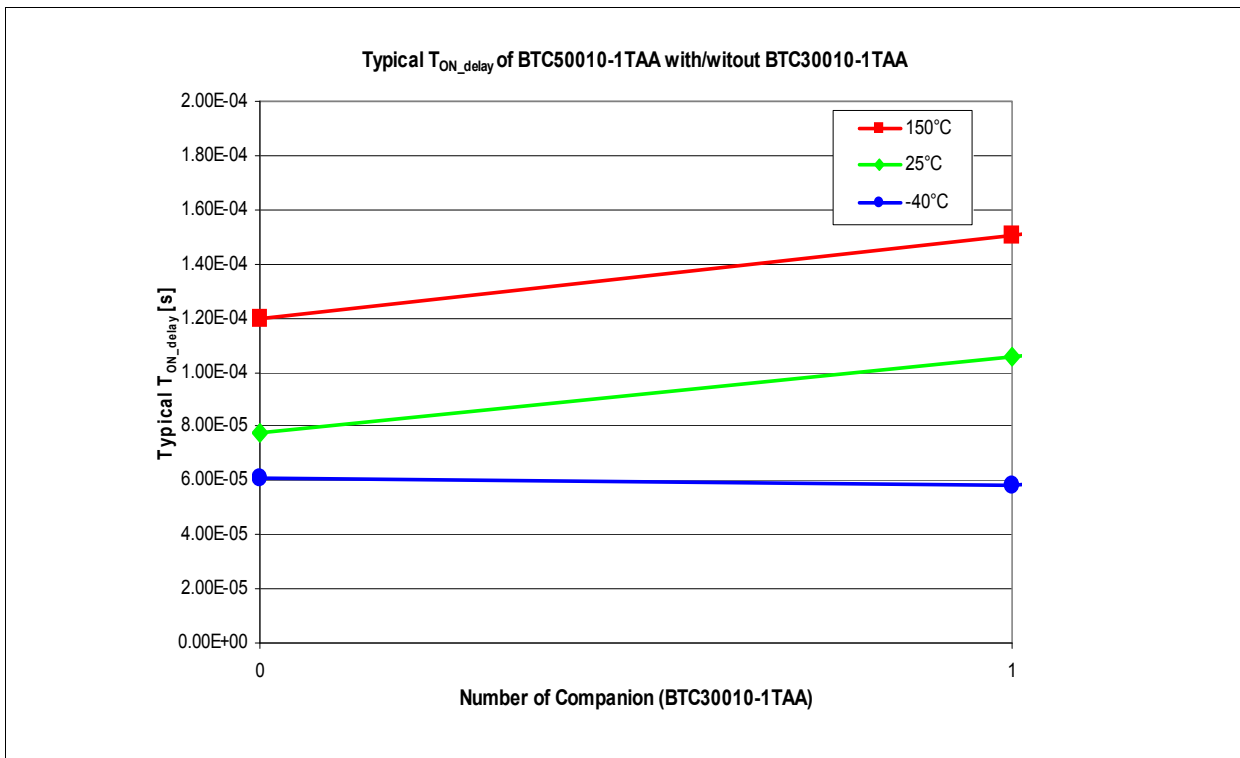


Figure 23  $T_{ON\_delay}$  of BTC50010-1TAA with/without BTC30010-1TAA

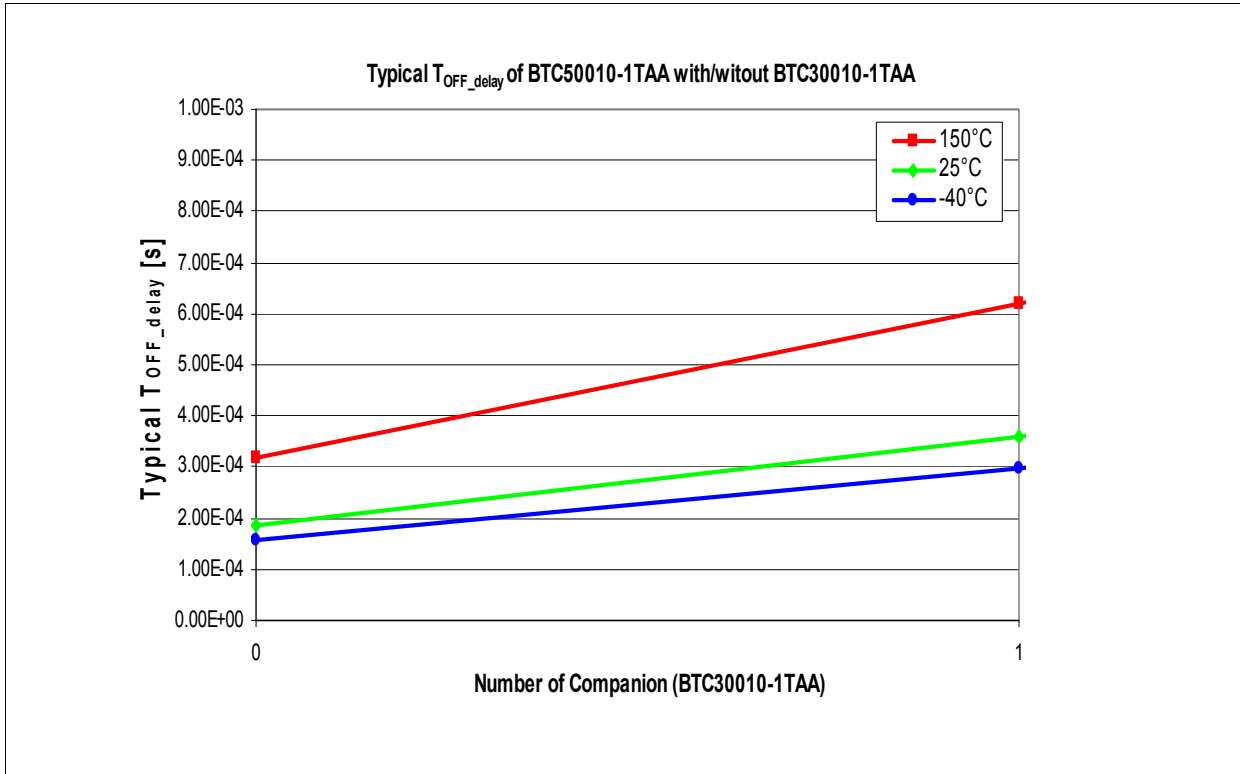


Figure 24  $T_{OFF\_delay}$  of BTC50010-1TAA with/without BTC30010-1TAA

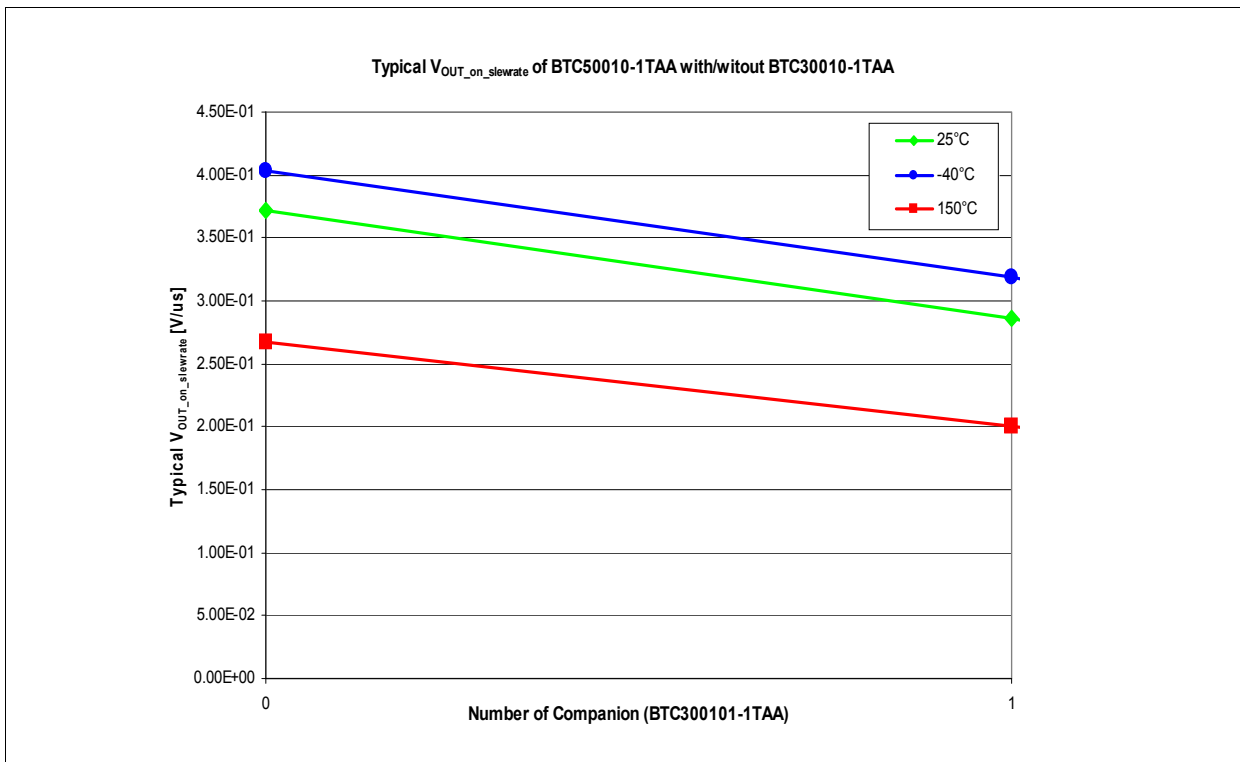


Figure 25  $V_{OUT\_ON\_slewrates}$  of BTC50010-1TAA with/without BTC30010-1TAA

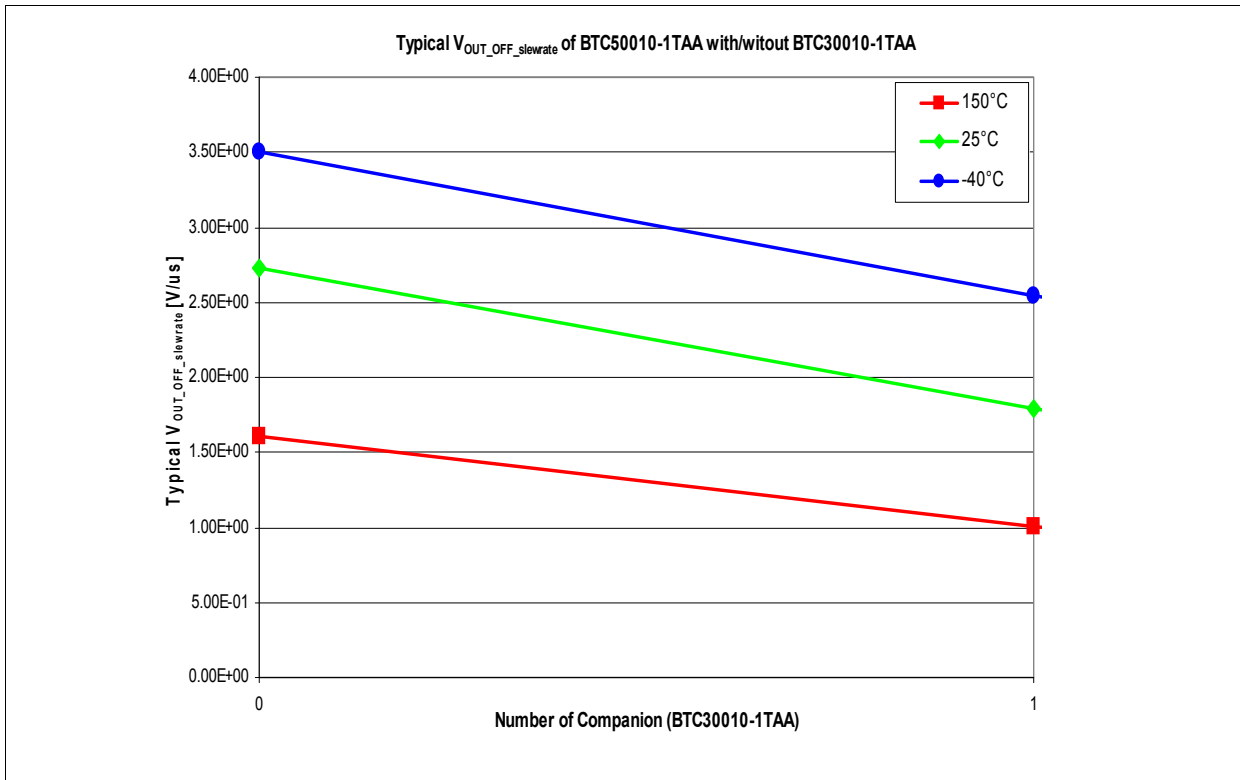


Figure 26  $V_{OUT\_OFF\_slewrates}$  of BTC50010-1TAA with/without BTC30010-1TAA

## 6 Application Information

This chapter describes especially how BTC50010-1TAA & BTC30010-1TAA can be combined and used together in application environment.

*Note: The following information is given as a hint for the implementation of the device only and shall not be regarded as a description or warranty of a certain functionality, condition or quality of the device.*

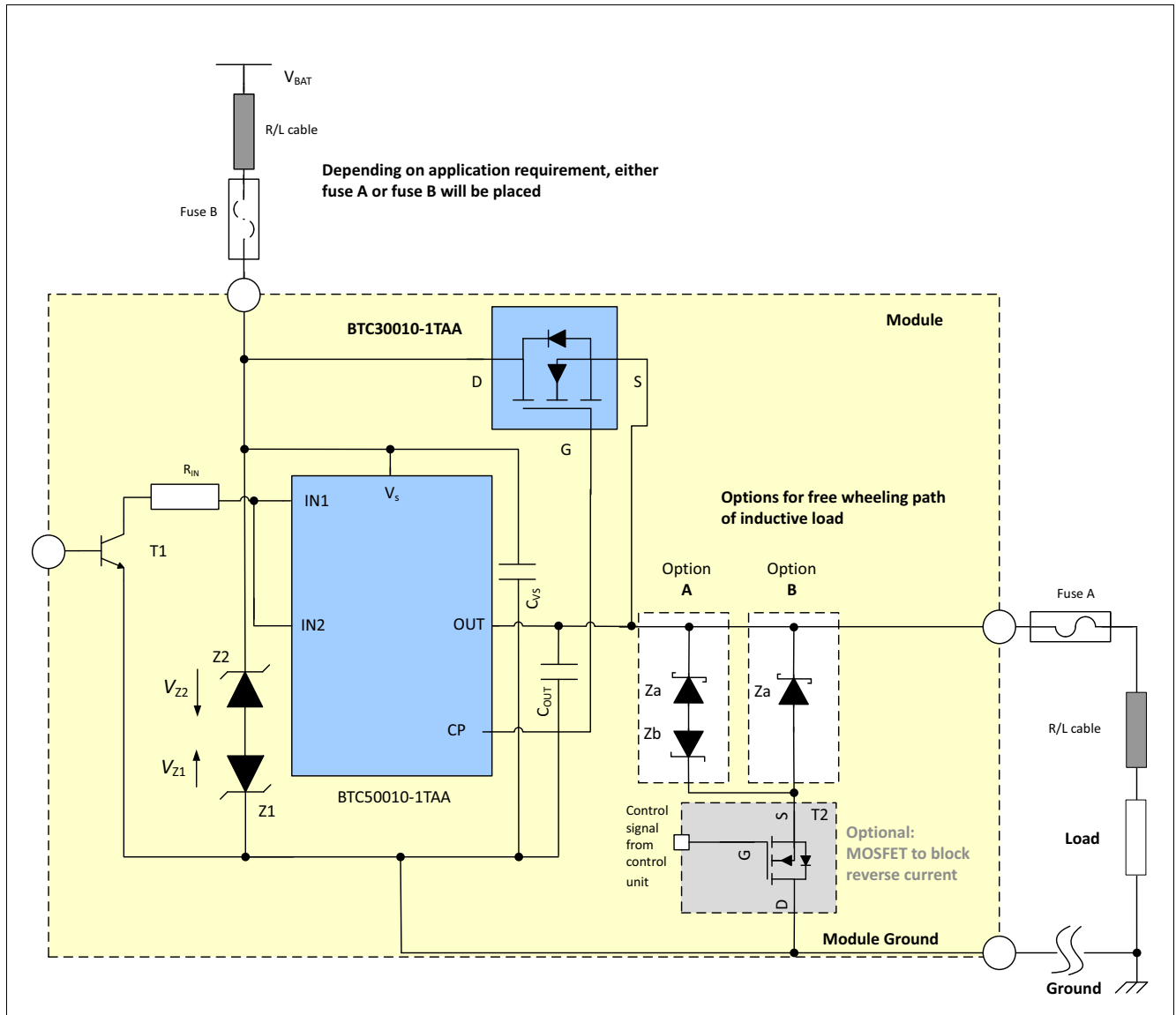


Figure 27 Application Diagram with BTC50010-1TAA & BTC30010-1TAA

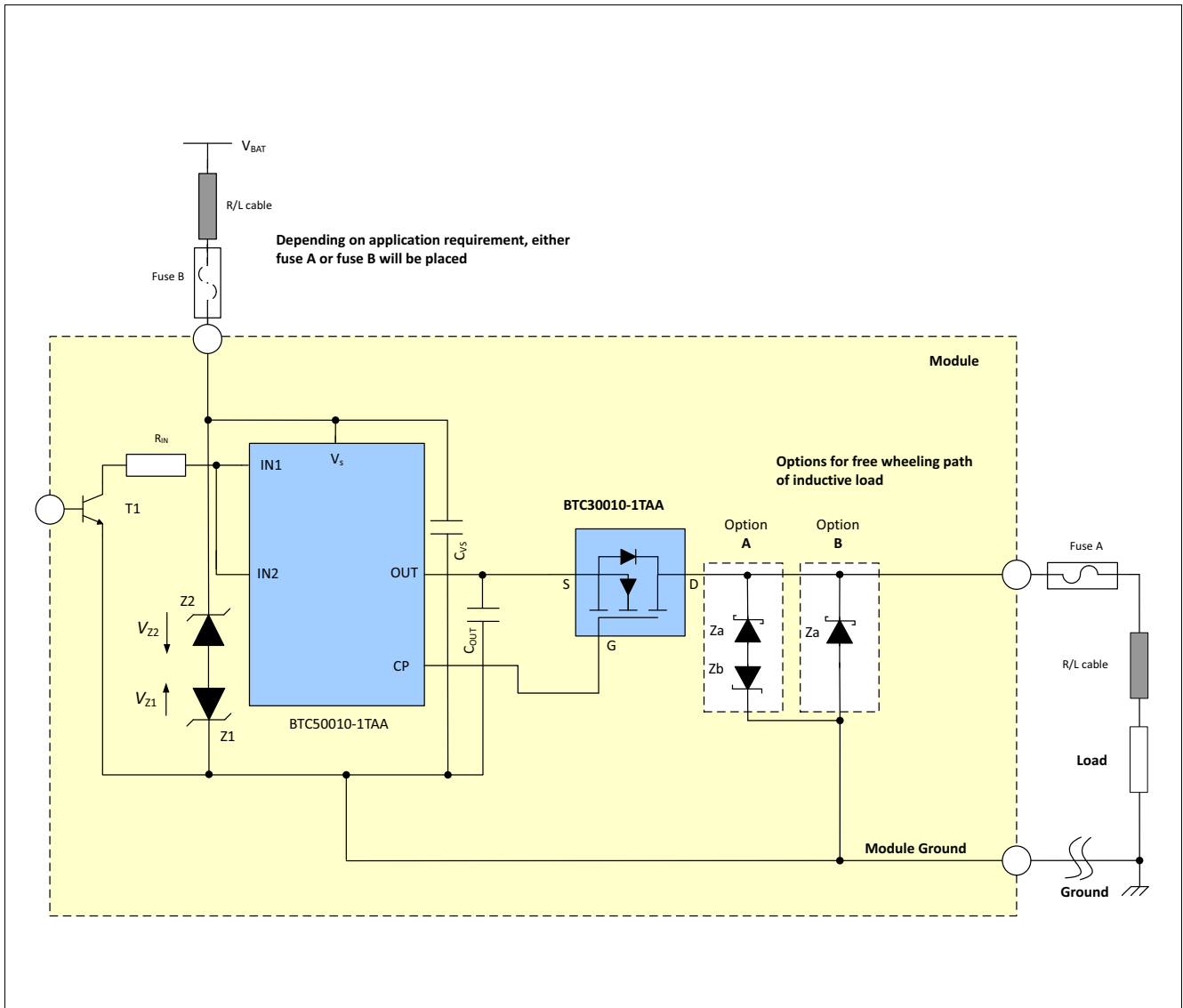


Figure 28 Application Diagram with BTC50010-1TAA and BTC30010-1TAA for Reverse Blocking.

Table 11 Bill of material

Reference	Value	Purpose
$T_1$	NPN or MOSFET transistor	NPN (e.g. BCR133) or MOSFET (e.g. BSS123) transistor suitable for 5V voltage range controlled by control unit for driving the BTC50010-1TAA
$R_{IN}$	100 $\Omega$	Protection of BTC50010-1TAA and the microcontroller or control unit during over voltage and reverse polarity, which could be created by huge negative pulse (like ISO pulse 1)
$Z_1$ and $Z_2$	Zener diodes	Protection of the BTC50010-1TAA & BTC30010-1TAA during loss of load (correspond to fuse blow on fuse A) or loss of battery (correspond to fuse blow on fuse B) or against huge negative pulse (like ISO pulse 1), please refer to <a href="#">Figure 14</a> and <a href="#">Figure 15</a> .

**Table 11 Bill of material (cont'd)**

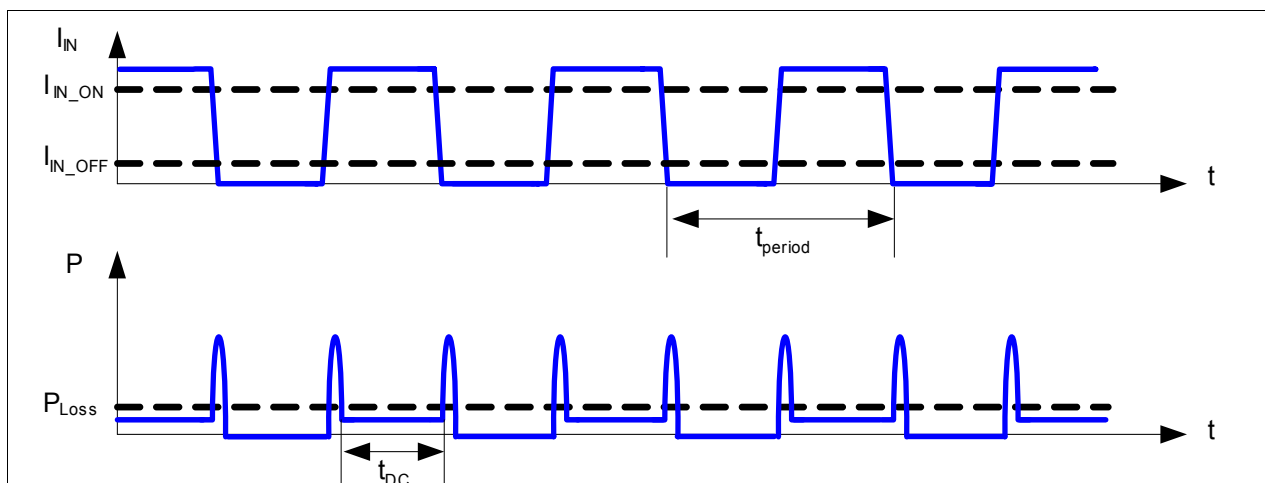
Reference	Value	Purpose
$Z_a$	Schottky diode	Protection of BTC50010-1TAA & BTC30010-1TAA when driving an inductive load, stand alone (option B) or together with $Z_b$ (option A).
and/or $Z_b$	Zener transient suppressor	Protection of BTC50010-1TAA & BTC30010-1TAA when driving an inductive load, to be used together with $Z_a$ in option A to accelerate the demagnetization process.
$T_2$	MOSFET transistor	Added optionally only for blocking the reverse current in free wheeling path, needed only for option A or B.
FUSE	e.g. 40A ATO FUSE <sup>1)</sup>	Protection of the BTC50010-1TAA & BTC30010-1TAA, wire harness and the load during short circuit. Depending on application requirement, either fuse A or fuse B will be placed.
$C_{VS}$	100 nF	Improve EMC behavior (in layout, please place it close to the pin)
$C_{OUT}$	10 nF	Improve EMC behavior (in layout, please place it close to the pins)

1) or 30A ATO see [Figure 28](#))

## 6.1 Information for Application Combining PWM Mode with Fuse

When the Connect FET (BTC50010-1TAA) is driving a Companion (BTC30010-1TAA) with its CP pin, the switch ON/OFF time will increase significantly compare to Connect FET (BTC50010-1TAA) alone (please refer to [Figure 21](#), [Figure 22](#) and BTC50010-1TAA data sheet), therefore the PWM frequency will decrease clearly compare to Connect FET (BTC50010-1TAA) alone. The maximum of average power dissipation  $^1)P_{loss}$  is not allowed to be exceeded. Above all, the condition of  $t_{DC} > t_{fuseblow\_max}$  must be fulfilled. The  $t_{fuseblow\_max}$  is the maximum fuse blow time at certain fuse blow current on the I/t curve of the selected fuse for certain application. During short circuit, the load current could rise up to multiple of the nominal current value until fuse blow. The  $t_{DC}$  is defined in [Figure 29](#).

$$P_{loss} = (\text{switching\_ON\_energy} + \text{switching\_OFF\_energy} + I_L^2 * R_{DS(ON)} * t_{DC}) / t_{period}$$


**Figure 29 Definition of Average Power Dissipation of BTC50010-1TAA & BTC30010-1TAA**

1) In real application with  $R_{thj,a}$  and  $T_{amb}$  the maximum allowed average power dissipation is defined:  $P_{loss} = (150^\circ\text{C} - T_{amb}) / R_{thj,a}$

### 6.2 Information for Driving Capability of Charge Pump Pin after Switch ON

Curves below show that the driving capability of BTC50010-1TAA's charge pump has a dependency on its gate voltage and battery voltage. It defines the relevant range of charge pump current for driving the gate capacity of BTC30010-1TAA.

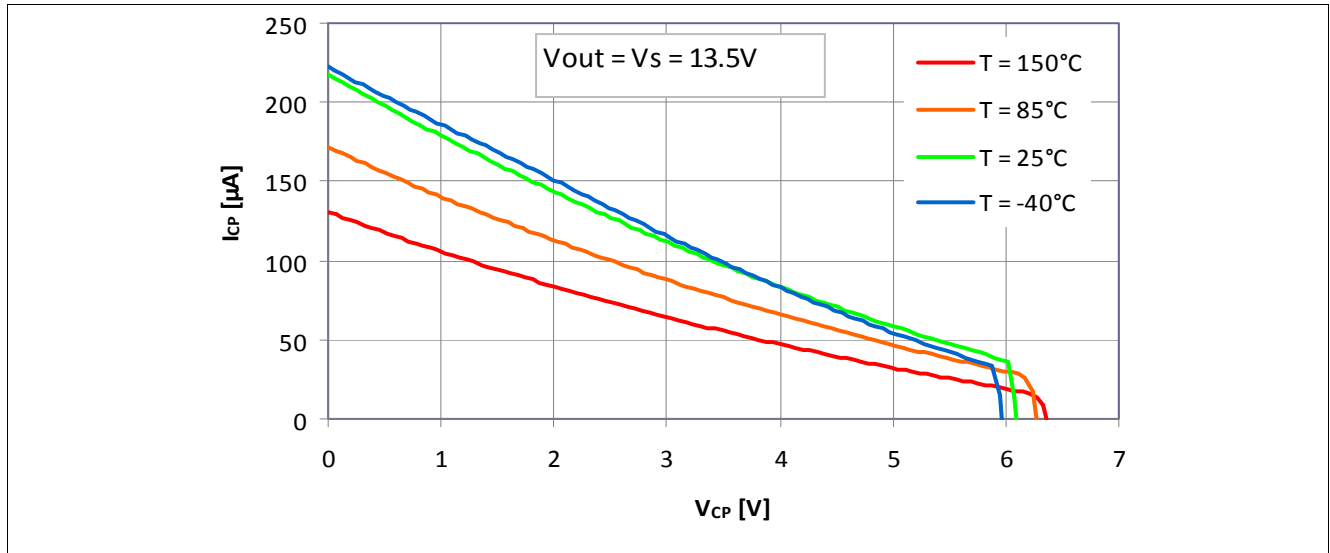


Figure 30 Typical Charge Pump Driving Capability of BTC50010-1TAA vs. its Gate-Source Voltage

### 6.3 Further Application Information

- Please contact us for information regarding the pin FMEA
- For further information you may contact <http://www.infineon.com/>



## 7 Package Outlines

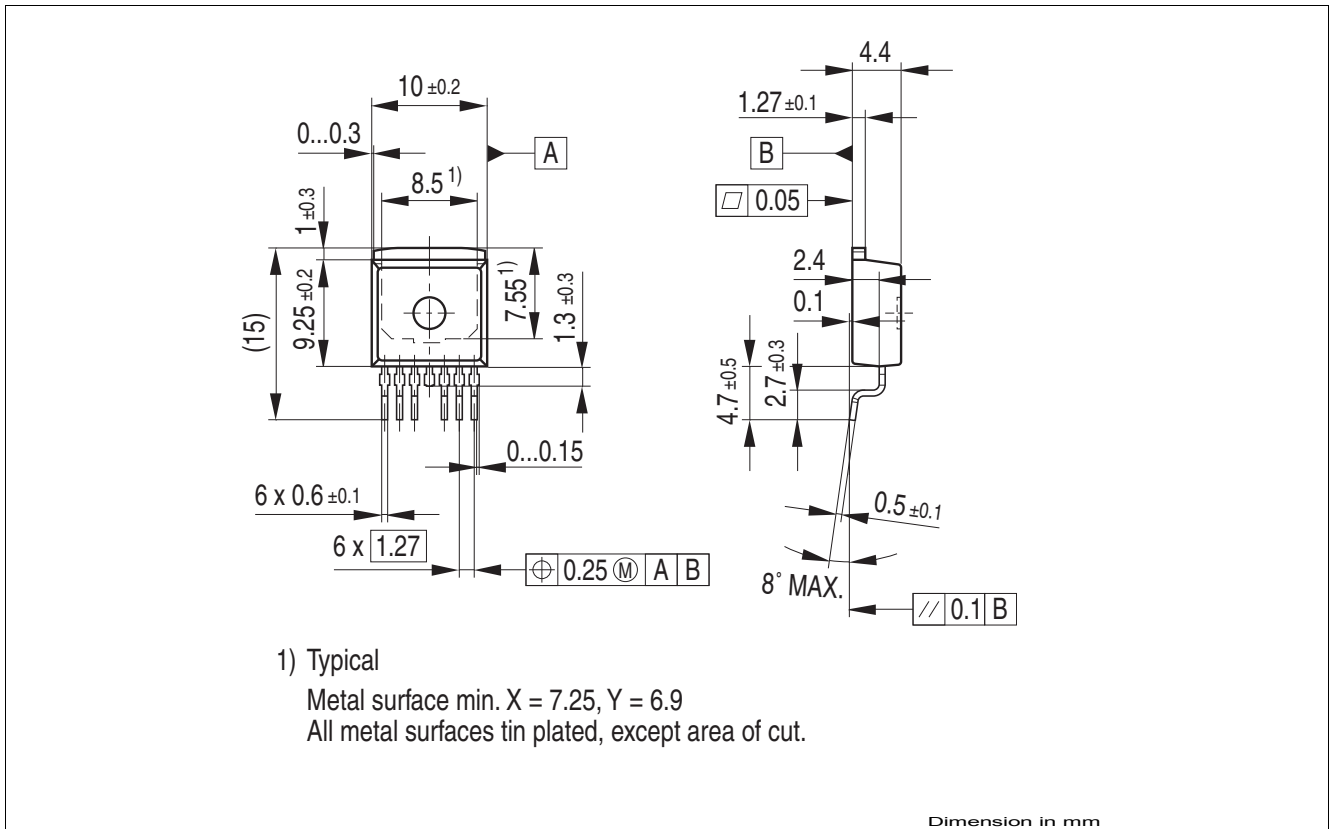


Figure 31 PG-TO-263-7-8 (RoHS compliant)

### 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).

BTC50010-1TAA & BTC30010-1TAA meet the MSL 1 (Moisture Sensitivity Level 1) according to IPC/JEDEC J-STD-020D and can withstand until 245°C peak reflow process.

## 8 Revision History

Revision	Date	Changes
1.0	2011-12-21	Data Sheet released
1.1	2012-06-15	Page 3, Application: in the first bullet point, "inductive" removed Page 4, Product Summary: in the 11th row, rename "Continuous drain current ID_C" to "Nominal load current IL(NOM)_C" Page 4, Product Summary: in the 16th row, rename "ID_C" to "IL(NOM)_C" Page 8, Figure 5 modified, rename "ID_C" to "IL_C" Page 10, parameter NIND (P_4.1.11) removed Page 10, parameter N0 (P_4.1.10) renamed as P_4.1.12 Page 10, parameter ID (P_4.1.10) and ID_C(P_4.1.11) added Page 10, parameter EAR (P_4.1.13) removed Page 11, Figure 6 modified, $E_{AR}$ curve removed Page 11, Figure 7 removed Page 15, Chapter 5.1.2 title modified, note added Page 20 ~ 21, Chapter 5.5 description modified Page 20 ~ 21, Figure 15 and Figure 16 modified Page 21, Figure 17 modified Page 22, Figure 18 modified Page 24, Table 11 first row, seventh column, rename "IDS" to "IL_C" Page 24, Table 11 seventh row, seventh column, rename "IDs" to "IL_C" Page 29, Figure 27 modified Page 30, Figure 28 modified Page 33, Figure 31 modified Page 33 ~ 34, Figure 32 and Table 12 added Page 34, Note "The following application information represents only as a recommendation for switching an inductive load. The function must be verified in the real application" added
1.2	2012-11-16	Page 9, Note "When driving resistive loads with remaining wire or parasitic inductances it must be ensured, that the device will not enter clamping mode during normal operating" added

Revision	Date	Changes
1.3	2015-01-26	<p>Comprehensive rework of rev. 1.2; several figures have been renumbered</p> <p><b>Chapter 1:</b> Overview</p> <p><b>Table 1</b> removed wording “over life time”, updated various symbols</p> <p><b>Applications:</b> first, third and fourth bullet: changed wording</p> <p><b>Features:</b> Change of wording</p> <p><b>Description:</b> Change of wording</p> <p><b>Chapter 3.2:</b> Updated Footnote 2</p> <p><b>Chapter 3.3:Figure 4</b> Change <math>V_{OUTIN}</math> to <math>V_{OUT-IN}</math></p> <p><b>Chapter 4:</b> Removed Note</p> <p><b>Chapter 4.1:</b> P_4.1.6: Change <math>V_{OUTIN}</math> to <math>V_{OUT-IN}</math></p> <p>P_4.1.12: removed from table</p> <p>P_4.1.13: removed from table</p> <p><b>Table 4:</b> Correction within footnote 5</p> <p><b>Page 11:</b> Footnote 1 modified</p> <p>Removed figure about Total Energy Capability for Switch Off Inductive Loads</p> <p>Reduced figures about Current Robustness</p> <p><b>Chapter 4.3 Page 14:</b> modified text</p> <p><b>Chapter 5.1.2:</b> Completely reworked subchapter</p> <p><b>Chapter 5.2:</b> Change of wording, removed remarks about energy capability.</p> <p><b>Chapter 5.5:</b> modified <b>Figure 14, Figure 15</b></p> <p><b>Chapter 5.6:</b> modified text about negative load current, new footnote (1) about definition of LOW and HIGH state</p> <p><b>Chapter 5.7:</b> modified <b>Figure 17</b></p> <p><b>Chapter 5.8</b></p> <p>P_5.8.11 add max. value</p> <p>P_5.8.12, P_5.8.13, P_5.8.14, P_5.8.15: add typical value</p> <p><b>Figure 19, Figure 20</b> new generated out of former figure</p> <p><b>Chapter 6:</b> Reworked text and note; removed figure 27,28 list of required external components</p> <p>New <b>Figure 27, Figure 28</b>, updated <b>Table 11</b></p> <p>Removed former chapter 6.3 (now within <b>Chapter 6</b>)</p> <p><b>Chapter 6.1:</b> and text modified</p>

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