

High Side Switch Shield

with BTS50010-1TAD for Arduino

About this document

Scope and purpose

This document describes how to use the High Side Switch Shield with BTS50010-1TAD for Arduino.

Intended audience

Engineers, hobbyists and students who want to add powerful High Side Switches to Arduino projects.

Related information

Table 1 Supplementary links and document references

Reference	Description
BTS50010-1TAD Data Sheet	Product page which contains reference information for the BTS50010-1TAD
Arduino Home Page	All information on Arduino
Arduino Uno Product Page	Arduino Uno R3 description
DAVE™ Development Platform	All details on DAVE™ IDE
XMC1100 Boot Kit	Product page which contains reference information for the XMC1100 Boot Kit
Shields for Arduino by Infineon	All details on Infineon's shields for Arduino
XMC Homepage	All information about the XMC™ microcontroller family

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1 High Side Switch Shield Introduction

This chapter will provide a brief introduction of the High Side Switch Shield.

1.1 High Side Switch Shield overview

The High Side Switch Shield adds powerful High Side Switches to Arduino projects. The shield can be controlled with the general logic IO-Ports of a microcontroller. For example either an Arduino Uno R3 or the XMC1100 Boot Kit from Infineon can be used as the master. But the High Side Switch Shield can be also used in stand alone mode without any microcontroller board. Since the input pin *IN* can be connected directly to *VS* (Battery voltage) the first stand alone tests with this High Side Switch Shield is very easy.

On board of the High Side Switch Shield is a self-protected BTS50010-1TAD mounted. The BTS50010-1TAD is an N-channel High Side MOSFET with an integrated driver IC in one package from Infineon Technologies. In addition to the driver, several security features have been integrated, like over-temperature-, short circuit- and over voltage protection. With the enhanced current sense pin *IS* it is possible to give a fault feedback after an overtemperature shut down, short to circuit or open load. For more information please see the datasheet of the BTS50010-1TAD.

The BTS50010-1TAD is easy to control by applying logic level signals to the *IN* pin. For example when applying a PWM to the *IN* pin, a motor can be controlled with the duty cycle of the PWM.

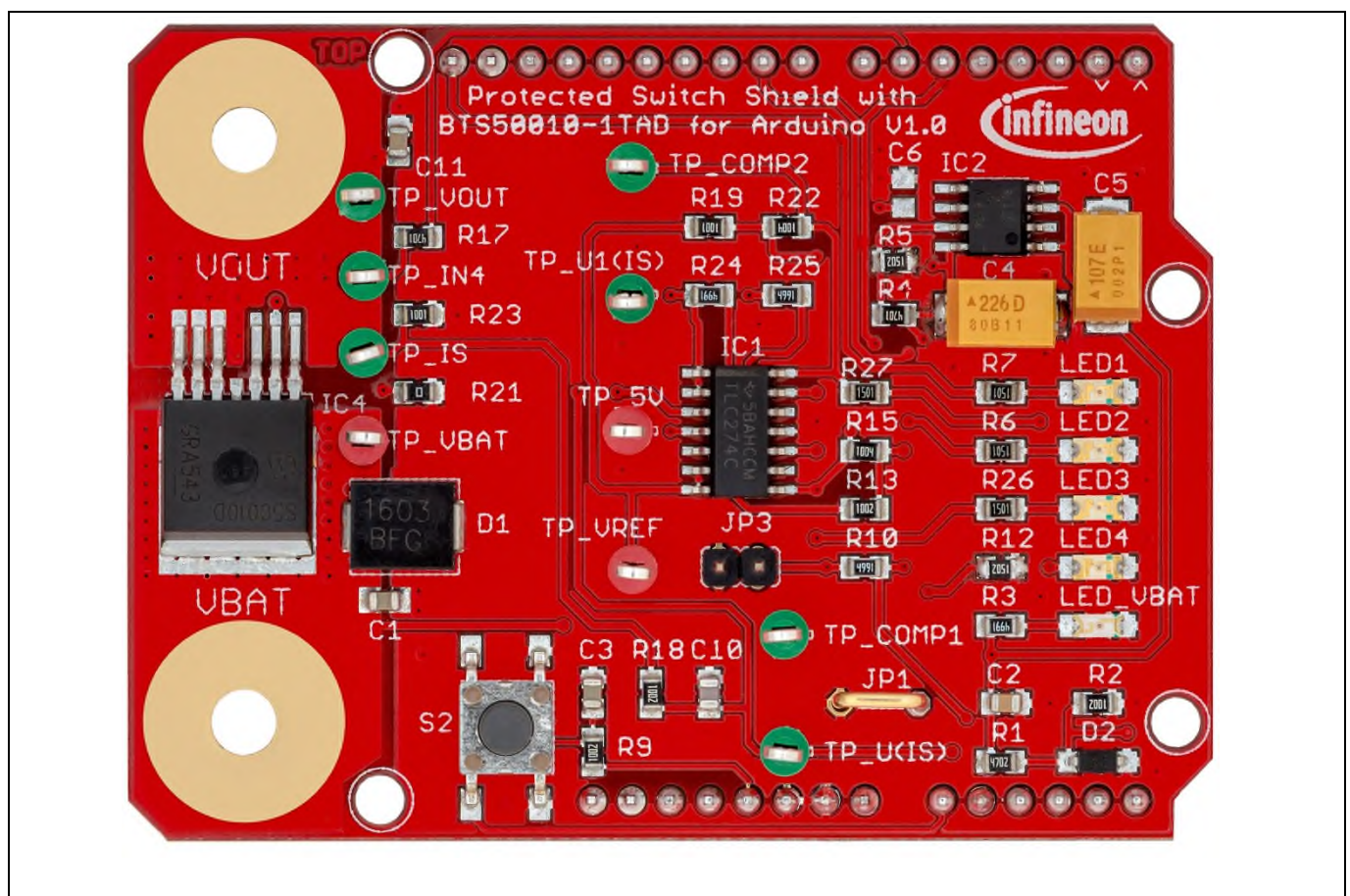


Figure 1 High Side Switch Shield photo

High Side Switch Shield Introduction

1.2 Key features

The High Side Switch Shield has the following features:

- An Arduino Uno R3, XMC1100 Boot Kit, or similar board connected to the shield can control the three High Side Switches via general IO pins.
- Able to switch all kind of loads like resistive, inductive and capacitive, limited by clamping energy
- High Side Switches BTS50010-1TAD
 - Input voltage : 3.3 to V_S
 - Operating voltage range $V_{S(OP)}$: 8 to 18V
 - Extended battery voltage $V_{S(DYN)}$: 3.2 to 28V
 - Maximum ON-state resistance ($T_J=150^{\circ}C$) $R_{DS(ON)}$: 2m Ω
 - Minimum nominal load current: 40 A
 - Minimum current limitation: 150 A
- Latched status signal after short circuit or over temperature detection
- Active clamp over voltage protection of the output (min. 28 V)
- Enhanced short circuit protection
- Capable of PWM for low frequencies
- Driver circuit with logic level inputs
- Diagnosis function
- Protection e.g. against overtemperature, overcurrent and overvoltage
- Communication with the environment via five LEDs and up to one push buttons
- Easy handling via push buttons, interrupt related handling is possible

1.3 Application diagram of the BTS50010-1TAD

In Figure 2 an application example of the BTS50010-1TAD is shown. This gives the clear information how to use the BTS50010-1TAD with a microcontroller. More details to the BTS50010-1TAD are given in chapter 3 or in the data sheet.

High Side Switch Shield Introduction

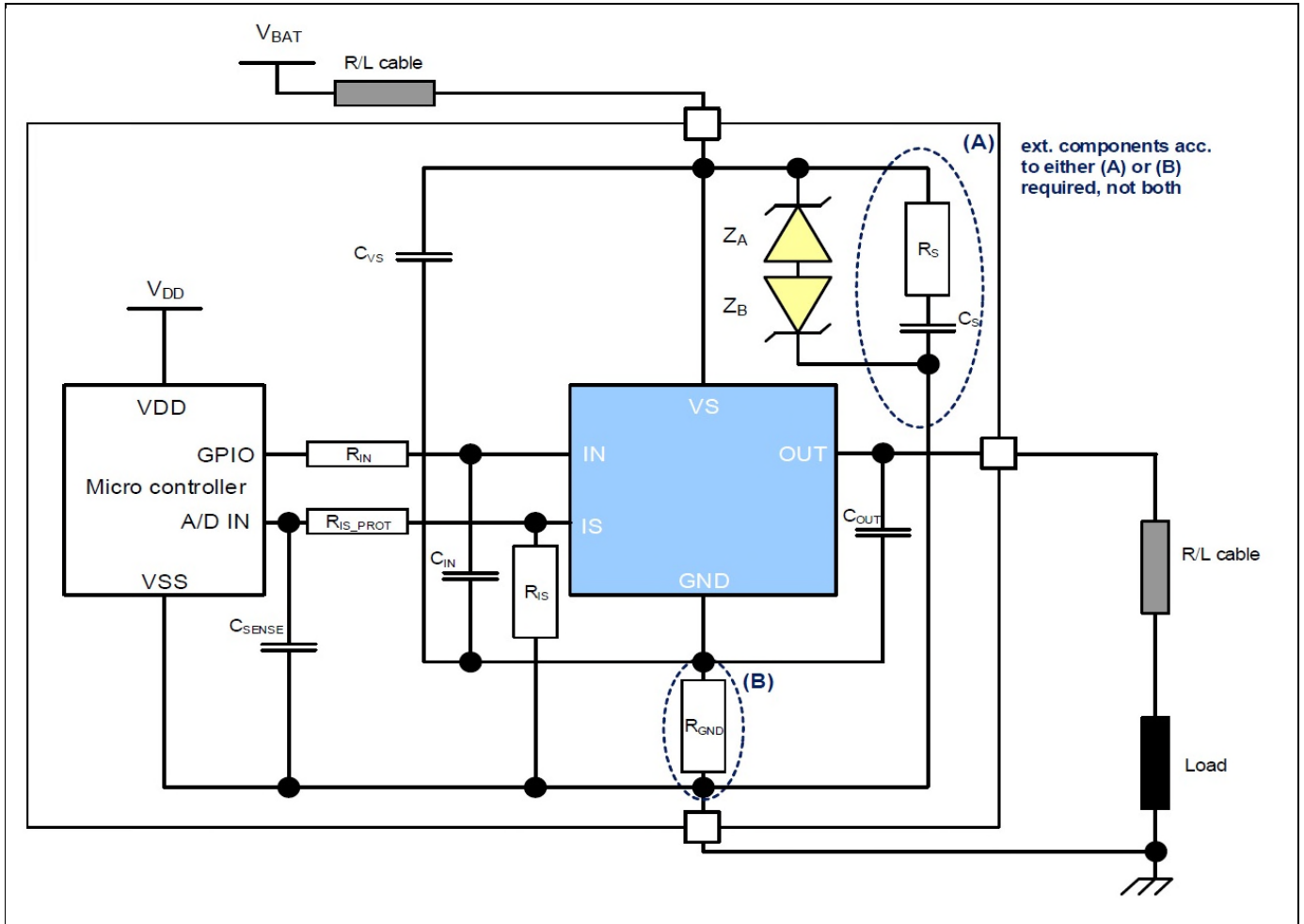


Figure 2 Application circuit for BTS50010-1TAD

2 High Side Switch Shield board description

For a safe and sufficient High Side Switch design, discrete components are needed. Some of them must be dedicated to the application and some to the BTS50010-1TAD.

Figure 3, Figure 4 and Figure 5 show the schematics plus the corresponding layout of the High Side Switch Shield.

2.1 Schematics

In Figure 3 show the schematics and their corresponding layout of the High Side Switch Shield. The schematics are based on the application circuit in the [BTS50010-1TAD Data Sheet](#).

High Side Switch Shield with BTS50010-1TAD for Arduino



High Side Switch Shield board description

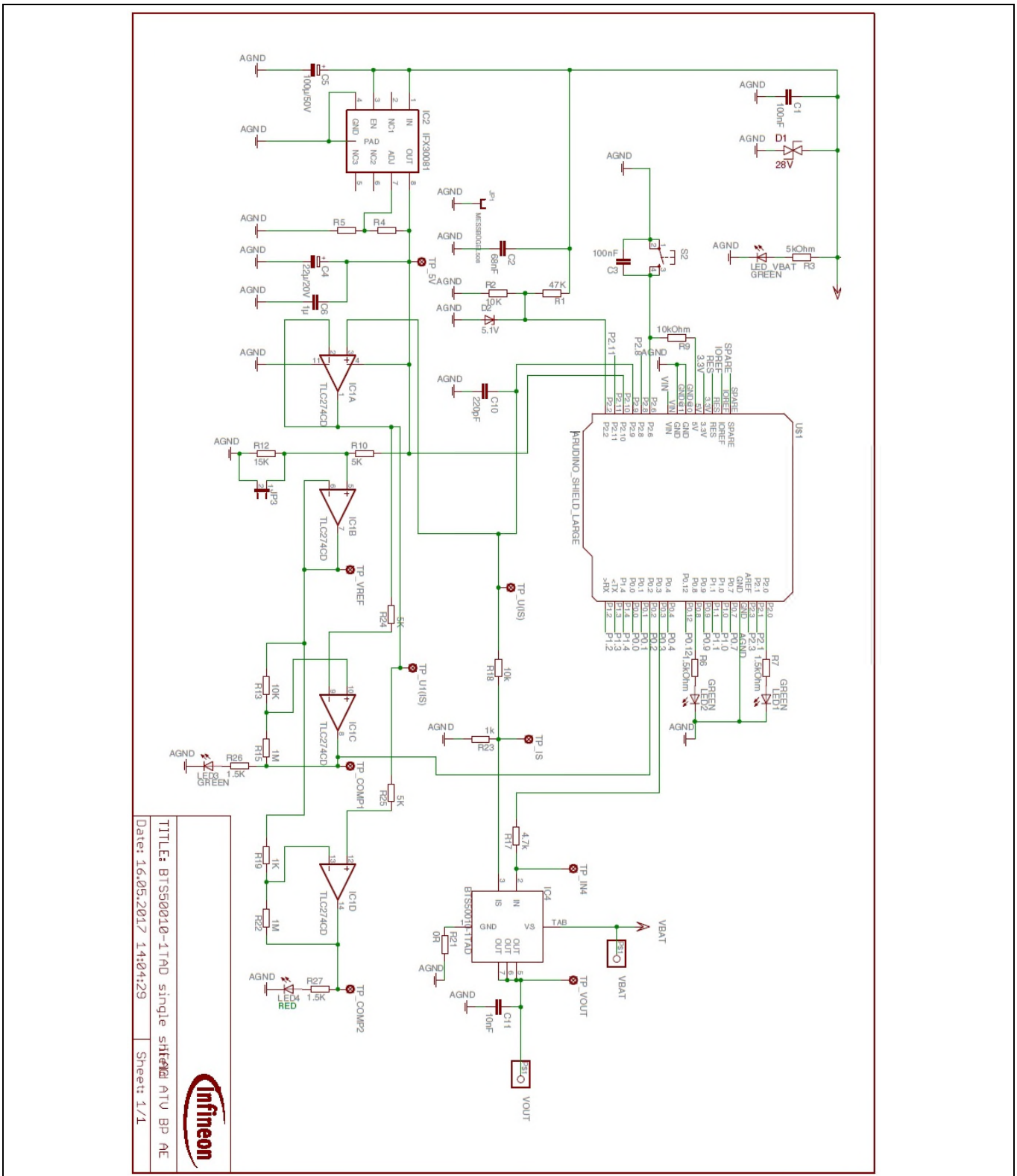


Figure 3 Schematics High Side Switch Shield for Arduino with BTS50010-1TAD

High Side Switch Shield board description

2.2 Layout

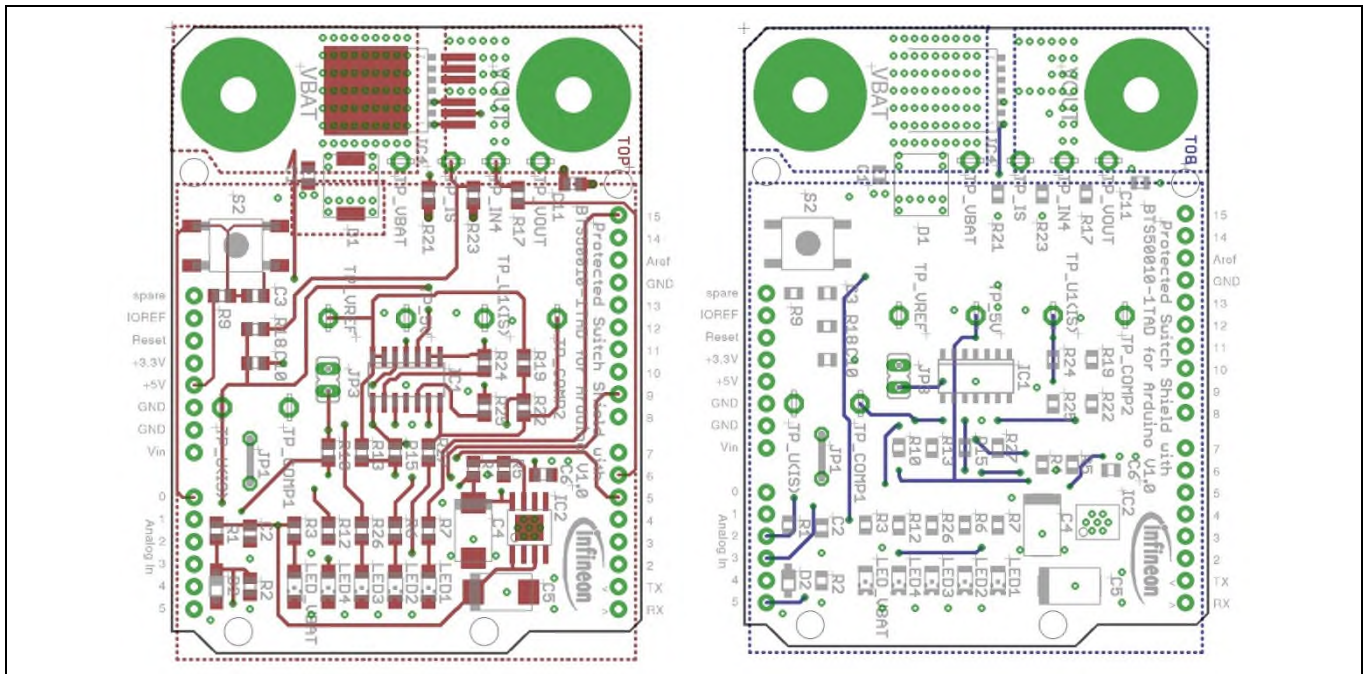


Figure 4 High Side Switch Shield – Bottom and top layers

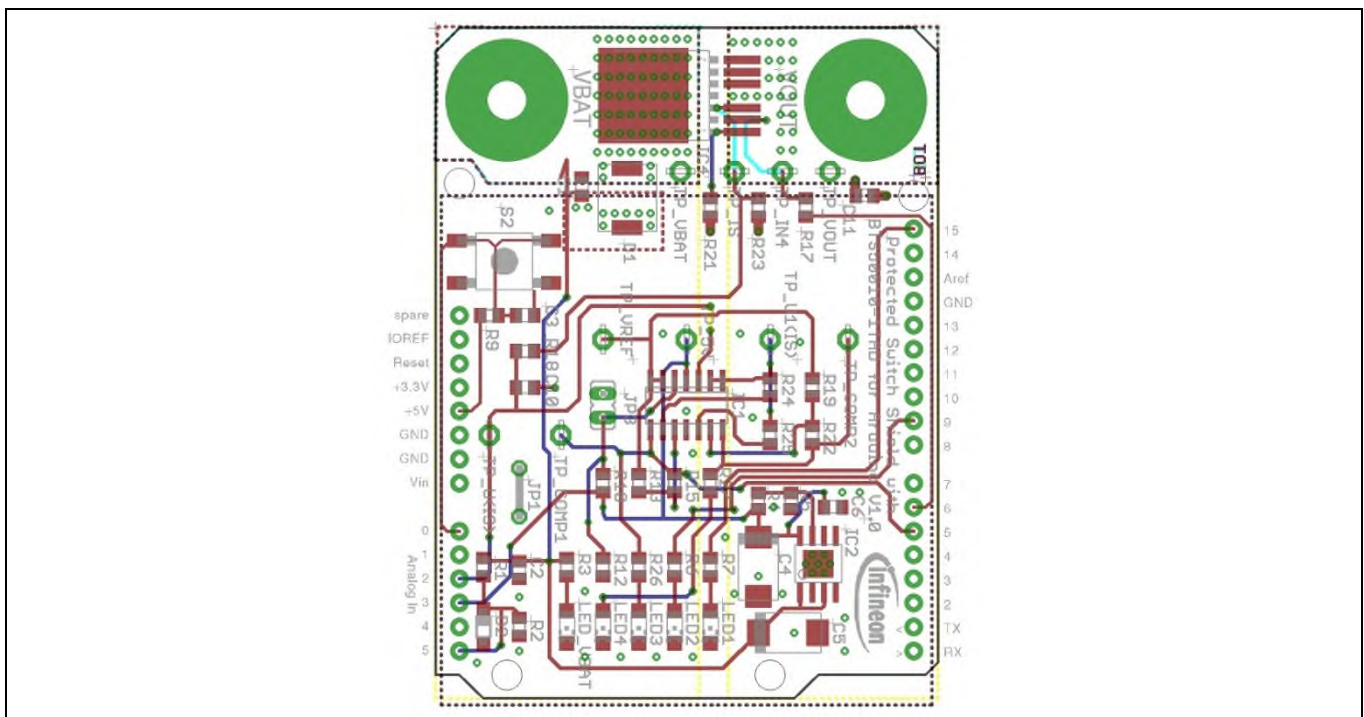


Figure 5 High Side Switch Shield – Complete layout

High Side Switch Shield board description

Table 2 Bill of Material

Part	Value	Device	Package	Description
C1, C3	100nF	C	C0805	CAPACITOR
C2	68nF	C	C0805	CAPACITOR
C4	22 μ / 20V	CPOL-EUSMCB	SMC_B	POLARIZED CAPACITOR
C5	100 μ / 50V	CPOL-EUSMCB	SMC_B	POLARIZED CAPACITOR
C10	220pF	C	C0805	CAPACITOR
C11	10nF	C	C0805	CAPACITOR
D1	28V	TVS-DIODE-DO-214B	DO-214AB	Diode
D2	5.1V	Z-DIODESOD123	SOD123	zener diode
IC1	TLC274CD	4AMP_P4+11D	SO14	OP AMP
IC2	TLS805B1SJ	TLS805B1SJ	SOIC8	VOLTAGE REGULATOR
IC4	BTS50010-1TAD	BTS50010-1TAD	PG-TO-263-7-10	High Side Switch
JP1	MESSBÜGEL508	MESSBÜGEL508	MESSBÜGEL508	mechanical Bridge
JP3		JP1E	JP1	JUMPER
LED2, LED3, LED5, LED_VCC	GREEN	LEDCHIPLED_1206	CHIPLED_1206	LED
LED6	RED	LEDCHIPLED_1206	CHIPLED_1206	LED
R1	47K	R	R0805	RESISTOR
R2	10K	R	R0805	RESISTOR
R3	5kOhm	R	R0805	Resistor
R6, R7, R26, R27	1.5kOhm	R	R0805	Resistor
R9, R13, R18	10kOhm	R	R0805	Resistor
R10, R24, R25	5K	R	R0805	Resistor
R4, R12	15K	R	R0805	Resistor
R15, R22	1M	R	R0805	Resistor
R5, R17	4.7k	R	R0805	Resistor
R19, R23	1K	R	R0805	Resistor
R21	0R	R	R0805	Resistor
S1		10-XX	B3F-10XX	OMRON SWITCH
SV1		MA06-1	MA06-1	PIN HEADER
SV2		MA08-1	MA08-1	PIN HEADER
SV3		MA10-1	MA10-1	PIN HEADER
SV4		MA08-1	MA08-1	PIN HEADER
TP_5V	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm
TP_COMP1	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm
TP_COMP2	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm
TP_IN4	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm
TP_IS	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm
TP_OUT4	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm
TP_U(IS)	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm
TP_U1(IS)	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm
TP_VCC	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm
TP_VREF	LSP13	LSP13	LSP13	SOLDER PAD drill 1.3 mm

2.3 Important design and layout rules

Following components are implemented in the shield.

- R9: This resistor is needed as pull-up resistor for the push-button S2. The resistor R9 is directly connected to the driving voltage for the processor (5V), push button is low active.
- IC2, R4, R5: The IC2 (TLS805B1SJ) is an automotive qualified voltage regulator. With the direct connected R4 and R5 an stable output voltage (5V for this board) is adjusted and will feed the comparator unit IC1. This 5V can be measured at testpoint TP_5V.
- IC1, LED3, LED4: IC1 (TLC274CD) includes four independent operational amplifiers and is used as comparator and buffer. This unit shell gives some optical feedback via LED3 and LED4 in stand alone mode. This means, no microcontroller will be used. IC1A buffers the sense voltage which will be provided by the sense current from the BTS50010-1TAD and R23. This voltage can be measured at TP_U1(IS). IC1B provides the reference voltage (TP_VREF) for the comparators IC1C and IC1D, which compares now V_S ($I_S \cdot R_{23}$) against VREF. In case of normal load, the green LED (LED3) will work, in case of fault conditions the red LED (LED4) will work. Via JP3 the reference voltage (VREF) can be adjusted, just connect a corresponding calculated resistor!
- R7, R6, R27, R26, R3: These resistors are used to provide the LEDs with the desired current.
- LED1: Indicates the connection of battery voltage
- S2: On-board push button, low active.
- R1, R2, R17: The resistors are used to protect the microcontroller. Input currents get reduced. R1 and R2 working as voltage divider. In case of the use of a controller it is possible to measure V_{BAT} till to the maximum value of 28V. The z-diode D2 will protect the input against high voltage spikes.
- IC4: IC4 (BTS50010-1TAD) is the protected High Side Switch.

2.4 Pin assignment

As mentioned before the High Side Switch Shield can be operated in two ways, in the stand alone mode (Shield only) or together with an Arduino controller board like the XMC1100 Boot Kit. All necessary control and sense signals can be applied directly at the Arduino™ connectors. The pin IN from BTS50010-1TAD uses a comparator with hysteresis. The switching ON / OFF takes place in a defined region, set by the threshold $V_{IN(L) Max}$ (0.8V) and $V_{IN(H) Min}$ (2.2V), therefore the pin IN can be driven by any other microcontroller or with logic level signals. Since the maximum input voltage at the pin IN can be V_{BAT} , a very flexible usage of the Shield is possible. Besides the supply voltage V_{BAT} has to be provided to the V_{BAT} connector. Figure 6 shows the pinout/connectors of the High Side Switch Shield.

The way how to connect the board to the load and / or battery voltage please read the chapter 4.1 and chapter 4.x in "Getting started" for the modes with controller board and without.

High Side Switch Shield board description

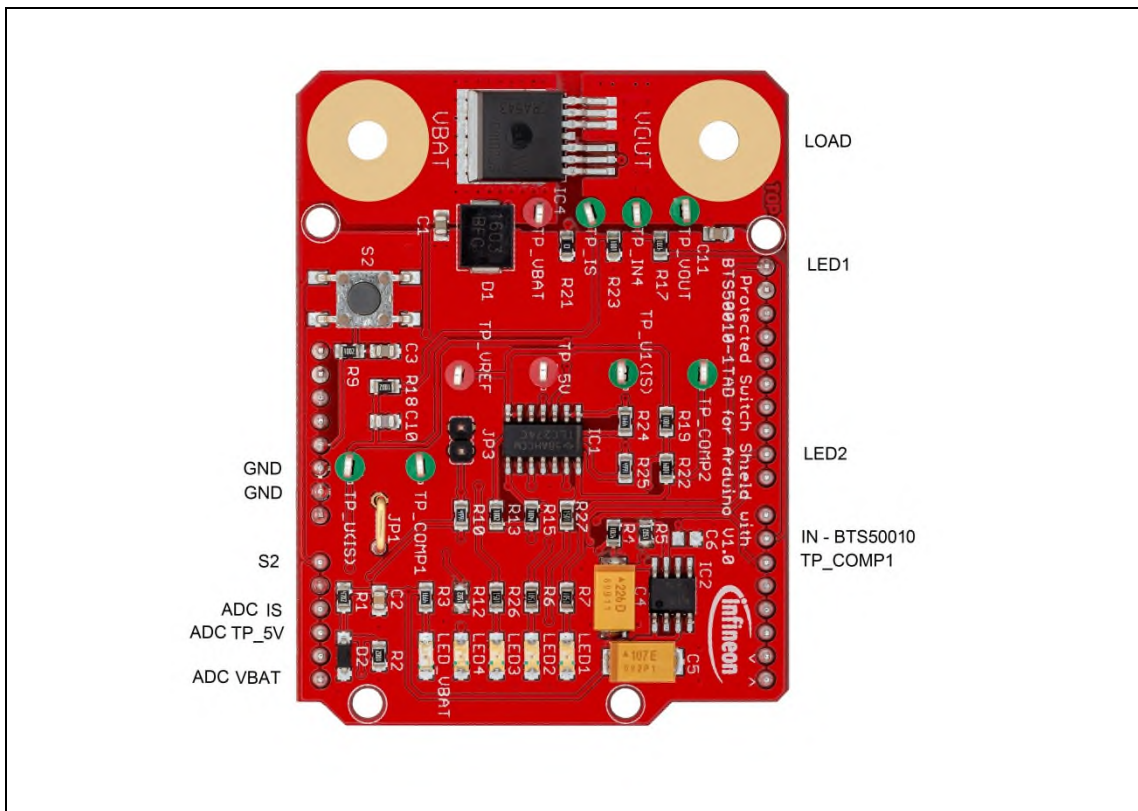


Figure 6 High Side Switch Shield connectors

2.5 Pin definitions and functions

The pin headers are connected as described in table 3.

Table 3 Pin definition

PIN	Symbol	Input / Output (processor)	Function
GND	GND		Ground
P2.6	S2	I	Handling of user input External Key can be connected, low active
P2.9	IS	I	ADC-input Measuring of IS
P2.10	TP_5V	I	ADC-input Measuring of availability of 5V
P2.2	VBAT	I	ADC-input Measuring of VBAT via voltage divider
P2.0	LED1	O	Visualization, freely definable per software
P0.8	LED2	O	Visualization, freely definable per software
P0.3	IN - BTS50010	O	Output of processor connected to input of BTS50010-1TAD to switch on / off
P0.2	TP_COMP1	I	Input to check state of comparator 1, can be measured at tespoint TP_COMP1

3 BTS50010-1TAD overview

The BTS50010-1TAD used in the High Side Switch Shield is a 1.0 m Ω high integrated single channel High Side switch which can be used in many applications. The power transistor itself is a built in N-channel power MOSFET. The whole device is monolithically integrated. This means that the power MOSFET, the driver and protection blocks are integrated in one package. Interfacing to a microcontroller is made easy by the integrated driver IC, which features logic level inputs, diagnosis and protection against overtemperature, undervoltage, overcurrent and short circuit.

The BTS50010-1TAD is automotive qualified and is optimized for 12V automotive and industrial applications.

3.1 Key features of the BTS50010-1TAD

- Single channel device
- Low Stand-by current
- Very low power DMOS leachage current in OFF state
- Drain-Source Resistance ($R_{DS(ON)}$) of max. 2 m Ω @ 150 °C (typ. 1.0 m Ω @ 25 °C)
- Capable of PWM for low frequencies
- 3.3V and V_s level compatible input
- Very low leakage current at OUT pin
- Minimum nominal load current of 40A
- Minimum current limitation level of 150 A min.
- Diagnosis function (Short circuit to battery, overtemperature detection)
- Latched behavior after overtemperature shut down or overtemperature detection
- Undervoltage shut down
- Enhanced short circuit protection
- Operation up to 28 V
- Green Product (RoHS compliant)
- AEC Qualified in PG-TO-263-7-10 package
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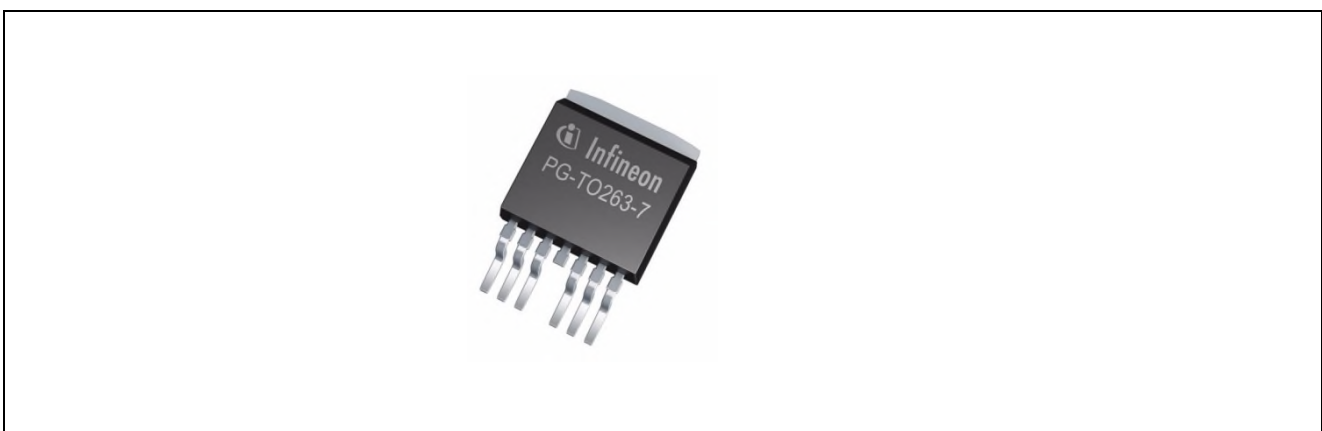


Figure 7 PG-TO263-7-10

BTS50010-1TAD overview

3.2 Block diagram

- The BTS50010-1TAD is able to switch resistive, inductive and capacitive loads. The limiting factors are the clamping energy (E_{AS}) and the maximum current and voltage capabilities
- The device offers dedicated ESD protection on the IN, VDD and IS pin, which refer to the Ground
- The BTS50010-1TAD provides Infineon® SMART CLAMPING functionality, which suppresses excessive transient overvoltage by actively clamping the overvoltage across the power stage and the load.

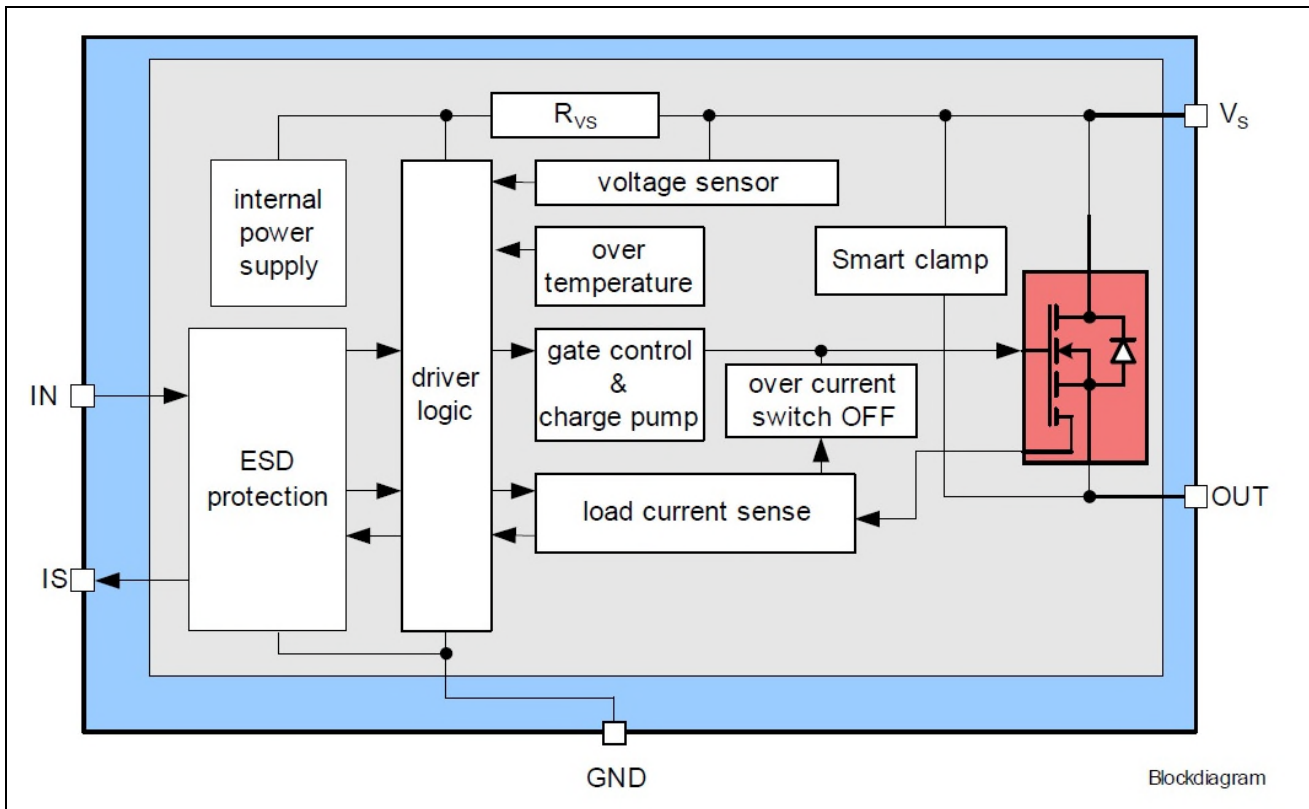


Figure 8 Block diagram BTS50010-1TAD

- In case of overload, high inrush current or short circuit to ground, the BTS50010-1TAD offers several protection mechanisms. Any protective switch OFF latches the output. To restart the device, it is necessary to set $IN = LOW$ for $t > t_{IN(RESETDELAY)}$, please see datasheet. This behavior is known as **latch behavior**.
- For temperature limitation the device has an built in absolute ($T_{J(TRIP)}$) temperature sensor. In case of over temperature the device will switch OFF to prevent destruction. The device restarts when the IN pin is set to low for $t > t_{IN(RESETDELAY)}$ and the temperature has decreased below $T_{J(TRIP)} - \Delta T_{J(TRIP)}$.
- The device provides an enhanced current signal called I_S at pin IS. As long as no “hard” failure mode occurs (short circuit to GND / overcurrent / overtemperature) and the condition $V_{IS} \leq V_{OUT} - 5V$ is fulfilled, a proportional signal in relation to the load current is provided. The accuracy of the sense current depends on temperature and load current. In case of failure, a fixed $I_{IS(FAULT)}$ is provided. In order to enable the fault current reporting, the condition $V_S - V_{OUT} > 2V$ must be fulfilled. In order to get the fault current in the specified range, the condition $V_S - V_{IS} \geq 5V$ must be fulfilled.

For more detailed information we refer to the data sheet of BTS50010-1TAD!

3.3 Pin assignment

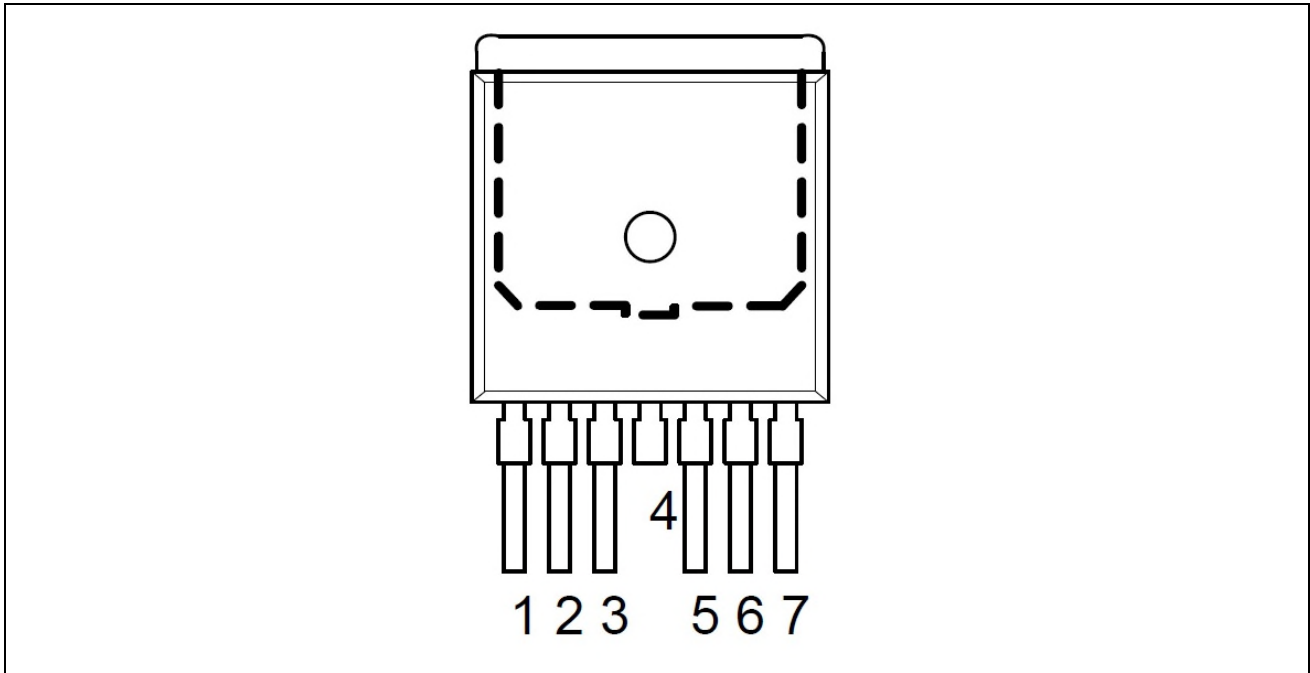


Figure 9 Pin assignment BTS50010-1TAD (top view)

3.4 Pin definitions and functions BTS50010-1TAD

Table 4

Pin	Symbol	I/O	Function
1	GND		Signal Ground
2	IN	I	Input, Digital signal to switch ON channel ("high" active)
3	IS	O	Sense, Analog / Digital signal for diagnosis, if not used: left open
4, Cooling tab	V_S		Supply Voltage, Battery voltage
5, 6, 7	OUT	O	Output, Protected high side power output channel

4 Getting started

4.1 Target applications

The applications targeted by the High Side Switch Shield are resistive, inductive and capacitive loads in DC or in PWM with very low frequencies. One BTS50010-1TAD is used on the shield and is capable of driving a nominal load current of 40 A (typ.) DC.

4.2 Typical target application

The most suitable applications for the BTS50010-1TAD are high current loads, such like heating systems, main switch for power distribution or for example start-stop power supply switch.

Common resistive loads can be heating elements, such as PTC auxiliary heater or glow plugs for example.

The shield can also be used to charge capacitors or drive loads that behave in a similar way such as bulbs. For these loads the device is able to handle the high inrush current.

4.2.1 Getting started: Shield + Arduino or XMC1100 Boot Kit

- Choose an appropriate load, for example a valve or glow plug
- Connect the High Side Switch Shield for example to the Arduino Uno R3 or the XMC 1100 Boot Kit
- To supply the Arduino/XMC1100 Boot Kit, connect the board with the proper USB cable. The logic of the shield is directly supplied by the Arduino/ XMC1100 Boot Kit
- Program the controller board with the High Side Switch software (see 4.2.2)
- Connect the GND of shield's with the ground of your power supply. Connect the output of the terminal (VOUT) with your load and the load to the GND of your power supply. Now connect the plus pole of the power supply to VBAT of the shield. Your power supply should not exceed 18V for nominal operation. Please see also figure 10 at next page.
- Turn on the power

Getting started

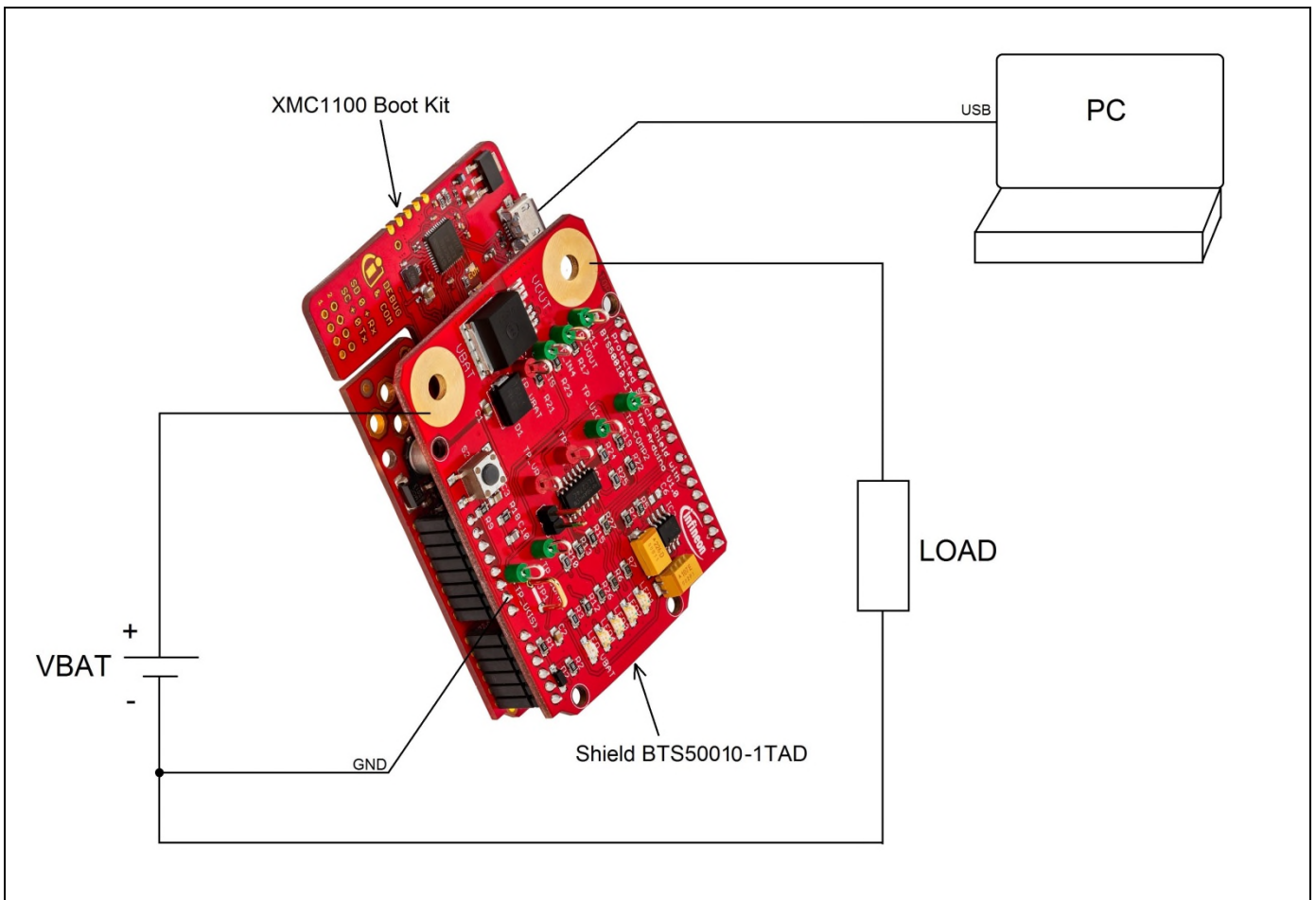


Figure 10 Example circuit of BTS50010-1TAD shield and XMC1100 Boot Kit

4.2.2 Getting started: Software for the XMC1100 Boot Kit

In order to use the High Side Switch Shield in combination with the XMC1100 Boot Kit following steps have to be taken first:

- Download the latest version of DAVE™ from www.infineon.com/dave
- Get the sample application software at www.infineon.com/shields-for-arduino
- Open DAVE™ and navigate via the toolbar to File > Import > Infineon > DAVE projects and pick the sample application as an archive file
- After the project was imported successfully, generate the code and build the projects with the corresponding buttons in the toolbar of DAVE™
- Connect the XMC1100 Boot Kit with your computer via USB
- To run the software click on the debug button and than on the run button

Getting started

4.2.3 Getting started: Software for Arduino Uno

To use the High Side Switch Shield with an Arduino Uno following steps need to be done first:

- Download the latest Arduino IDE from <https://www.arduino.cc/en/Main/Software>
- Get the sample application software at www.infineon.com/shields-for-arduino
- Open the sample application software
- Adjust the parameters for the PWM in the software code
- Connect your Arduino Uno with the computer via USB
- To run the software on the Arduino, upload the software with the corresponding button in the toolbar of the IDE

4.2.4 Software functionality with XMC 1100 Boot Kit

The installed example software provides an easy to use functionality just to show how to use the shield and the XMC1100.

The push-button S2 turns the corresponding BTS50010-1TAD on or off. For the switch function we use an interrupt from XMC1100.

4.3 Getting started: Shield BTS50010-1TAD in stand alone mode

The use of the shield BTS50010-1TAD in stand alone mode (without Arduino Uno R3 or the XMC 1100 Boot Kit) is shown in Figure 11.

- Choose an appropriate load, for example a valve or glow plug
- Connect the High Side Switch Shield to the load and an external switch corresponding to the example circuit given in Figure 11
- Turn on Power, power supply should not exceed 18V for nominal operation

Getting started

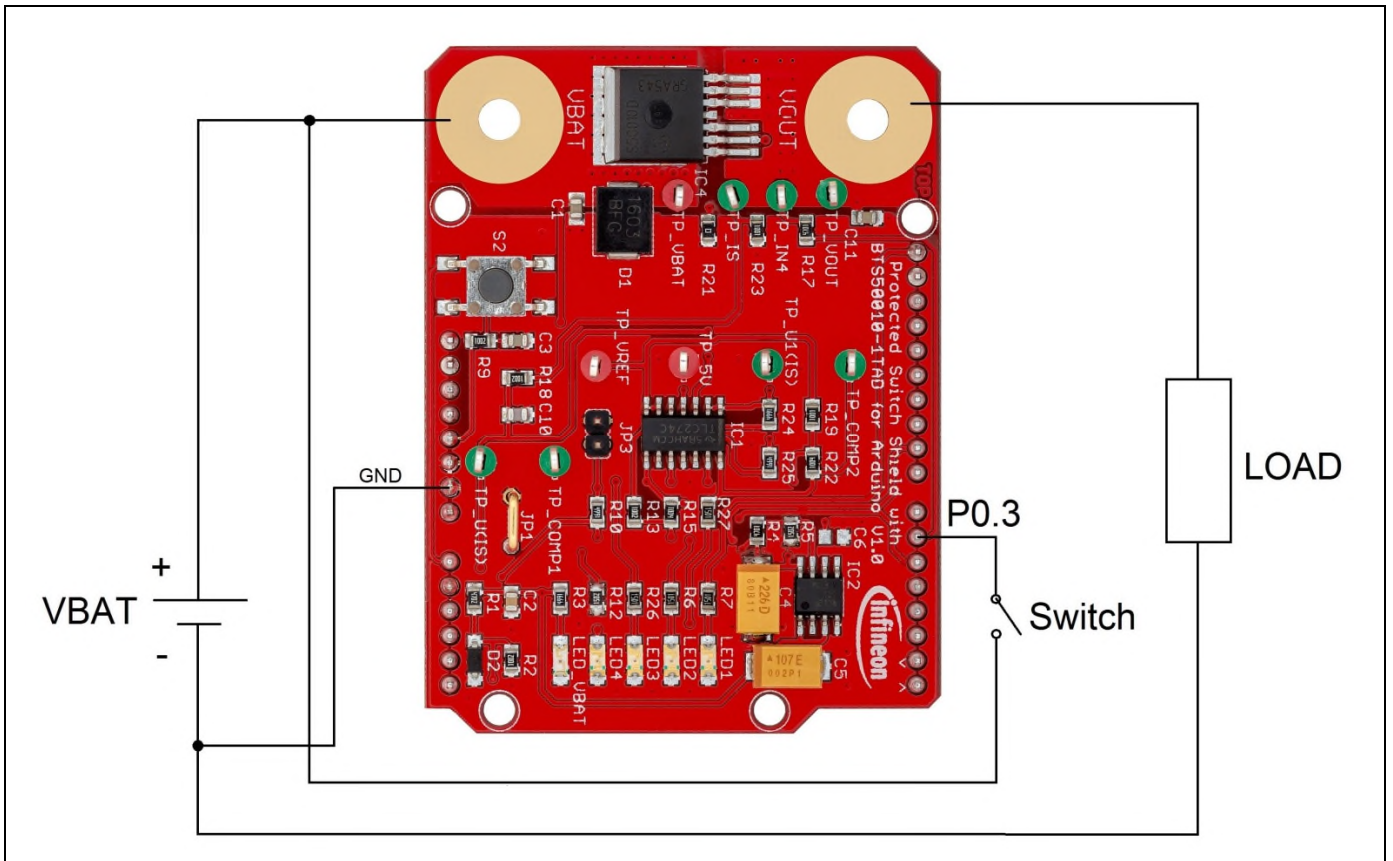


Figure 11 Example circuit of BTS50010-1TAD shield in stand alone mode

Getting started

Revision History

Major changes since the last revision

Revision	Description of change
V1.0 2017-05-01	Initial release