Motor Control Shield
With BTN8982TA for Arduino

Motor Control Shield

For Arduino

User Manual

V0.9 2015-03

Automotive Power

Table of Contents

About this document

Scope and purpose

This document describes how to use the Motor Control Shield with BTN8982TA for Arduino.

Intended audience

Engineers, hobbyists and students who want to add a powerful Motor Control to Arduino projects.

Related information

Table 1 Supplementary links and document references

Reference	Description
BTN8982TA Reference Manuals	Product page which contains reference information for the half-bridge BTN8982TA
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

1 Motor Control Shield introduction

1.1 Motor Control Shield overview

The Motor Control Shield adds powerful motor control to the Arduino projects. The shield can be controlled with the general logic IO-Ports of a microcontroller. Either an Arduino Uno R3 or the XMC1100 Boot Kit from Infineon can be used as the master.

On board of the Motor Control Shield are two BTN8982TA NovalithIC™. Each is featuring one P-channel high side MOSFET and one N-channel low side MOSFET with an integrated driver IC in one package. Due to the P-channel high side switch a charge pump is not needed.

The BTN8982TA half-bridge is easy to control by applying logic level signals to the IN and INH pin. When applying a PWM to the IN pin the current provided to the motor can be controlled with the duty cycle of the PWM. With an external resistor connected between the SR pin and GND the slew rate of the power switches can be adjusted.

The Motor Control Shield can be easily connected to any Arduino board or the XMC1100 Boot Kit via headers.

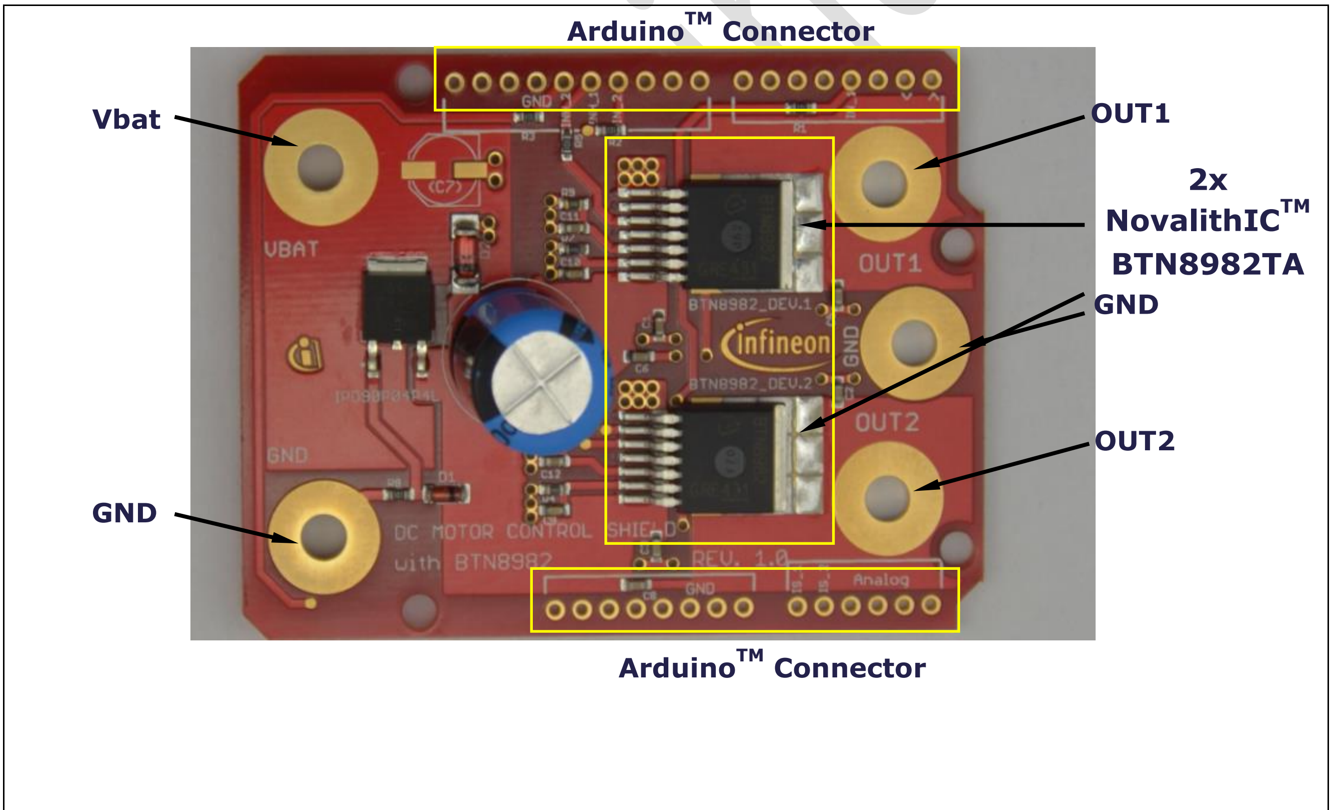


Figure 1 Motor Control Shield photo

1.2 Key features

The Motor Control Shield has the following features:

- An Arduino Uno R3, XMC1100 Boot Kit, or similar board connected to the shield can control the two half-bridges via the general IO pins.

- Brushed DC Motor Control up to 250 W continuous load
  - 8-18 V nominal input voltage (max. 6 – 40 V)
  - Average motor current 30 A restricted due to the limited power dissipation of the PCB (BTN8982TA current limitation @ 55 A min.)
- Drives either one brushed bi-directional DC motor or two uni-directional DC motors.
- Capable of high frequency PWM, e.g. 30 kHz
- Adjustable slew rates for optimized EMI by changing external resistor
- Driver circuit with logic level inputs
- Status flag diagnosis with current sense capability
- Protection e.g. against overtemperature and overcurrent
- Reverse polarity protection with IPD90P04P4L
- Further comments:
  - To keep the costs as low as possible the pin headers and connectors are not attached to the shield. The user can solder them by himself. The pin headers are not expensive, but the through whole soldering is a not insignificant cost factor.
  - The size of the DC-link capacity (C4 in the schematics and C10 in the application circuit.) with 1000µF is for most applications oversized. It is a worst case scenario if a 500W motor is connected to the shield. The capacity can be replaced by smaller capacities when using less powerful motors. Equation 10 in the BTN8960 /62 /80 /82 High Current PN Half Bridge NovalithIC™ (Rev. 0.3, 2014-09-11) Application Note should be used to calculate the value of the DC-link capacity.

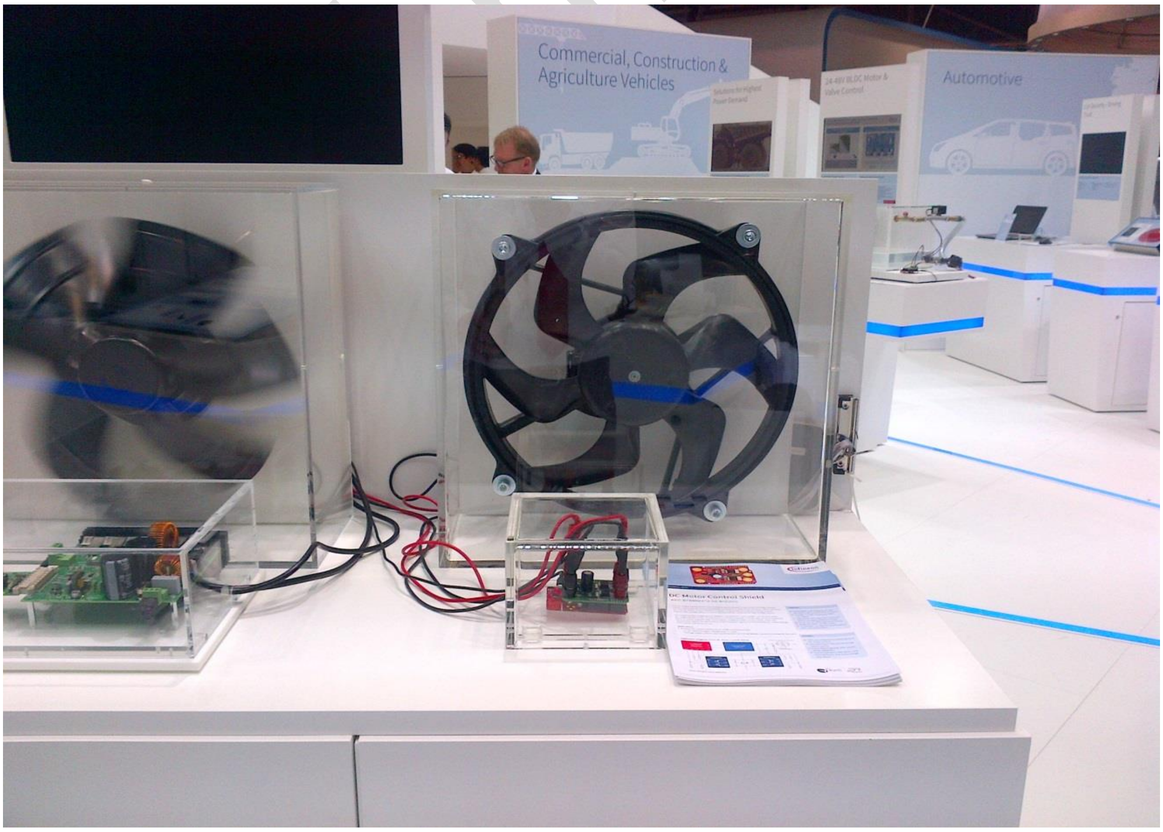


Figure 2 Motor Control Shield driving an engine cooling fan

1.3 Block diagram of a bi-directional Motor Control

As a starting point for the Motor Control Shield, the application block diagram shown in Figure 3 was used. For simplicity reasons the conductivity L_1 was removed in the Shield schematics. In the application block diagram the INH pins of both half-bridges are connected to one IO-port of the microcontroller. To be more flexible in the usage of the Motor Control Shield each INH of the two half-bridges is connected to a separate IO pin.

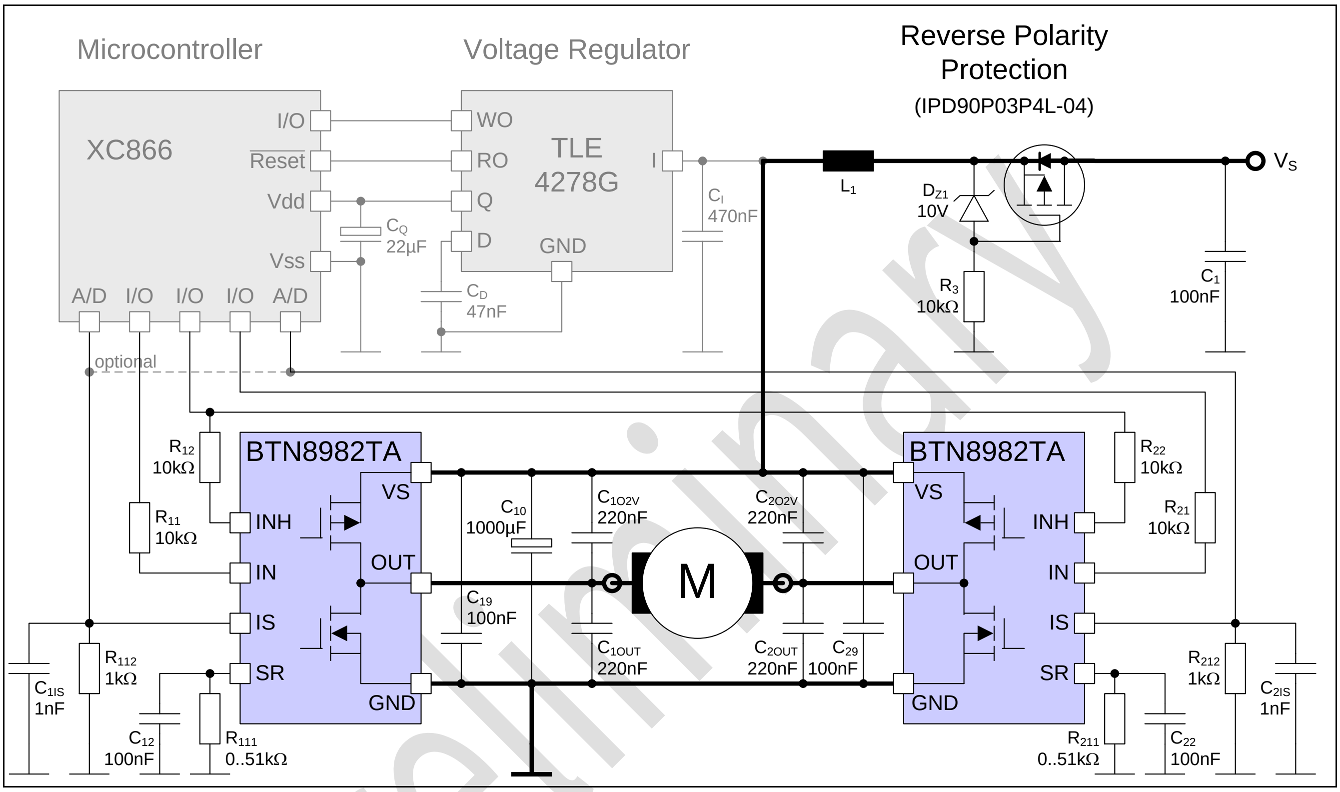


Figure 3 **Application circuit for a bi-directional motor control with BTN8982TA**

2 Motor Control Shield board description

For a safe and sufficient motor control design, discrete components are needed. Some of them must be dedicated to the motor application and some to the NovalithIC™.

Figure 4, Figure 5 and Figure 6 show the schematics plus the corresponding layout of the Motor Control Shield.

Due to the possibility of using the Shield with loads which can draw a current of up to 55 A the connectors Vbat, GND, OUT1 and OUT2 are designed as solid 4mm through whole connectors. This provides the possibility to connect plugs which are capable of such high currents. Nevertheless the thermal performance of the Shield itself limits the possible current which should be applied to the Motor Control Shield to 30 A. To reach the best performance in terms of parasitic inductance and EMC a GND plane, with maximal size was designed.

2.1 Schematics

In Figure 4 the schematics of the Motor Control Shield is shown. The schematics are based on the application circuit in the BTN8982TA Data Sheet.

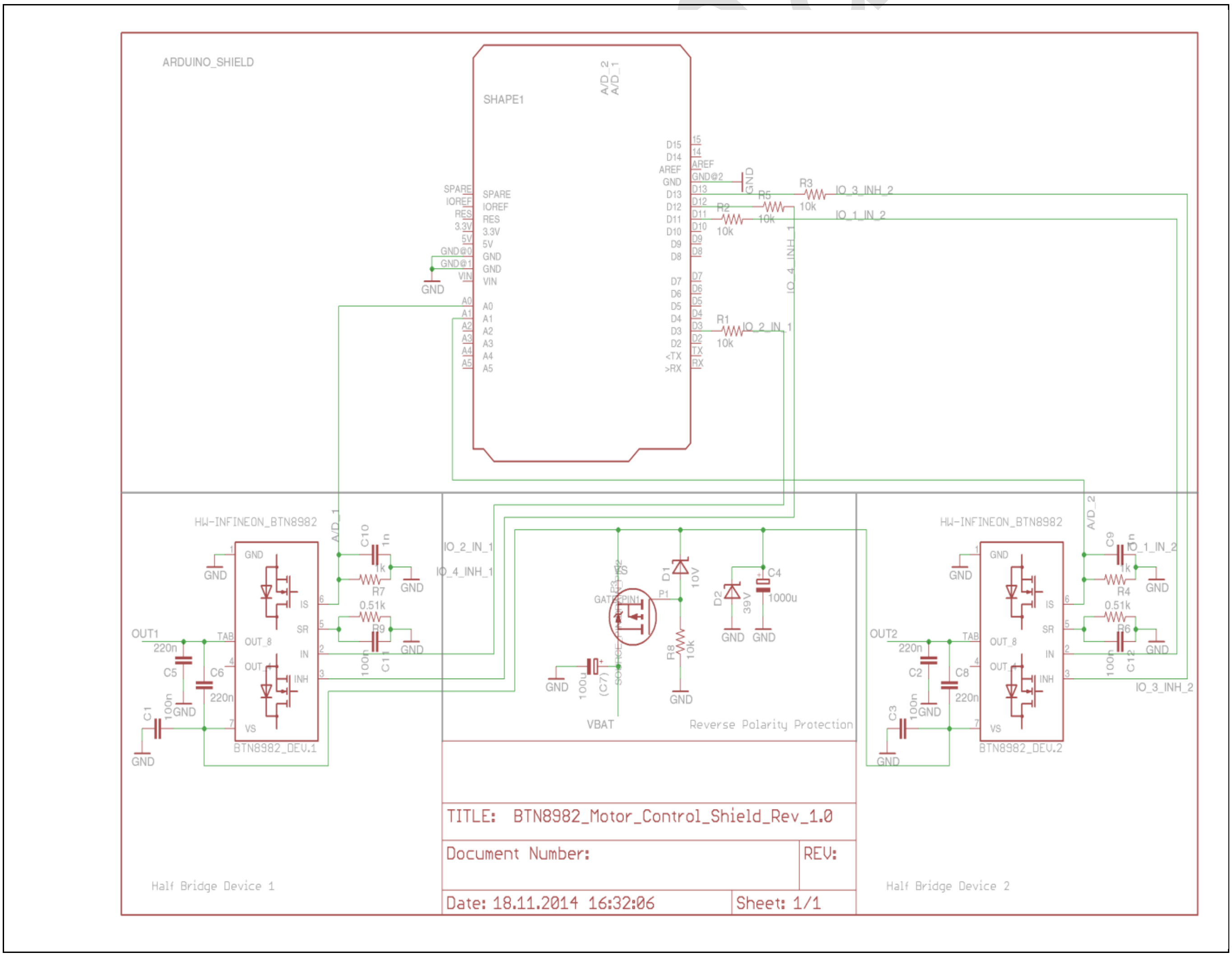


Figure 4 Schematics Motor Control Shield for Arduino with BTN8982TA

2.2 Layout

Figure 5 and Figure 6 show the layout of the Motor Control Shield. The layout follows the design rules in the BTN8960 /62 /80 /82 High Current PN Half Bridge NovalithIC™ Application Note (also see Chapter 2.3).

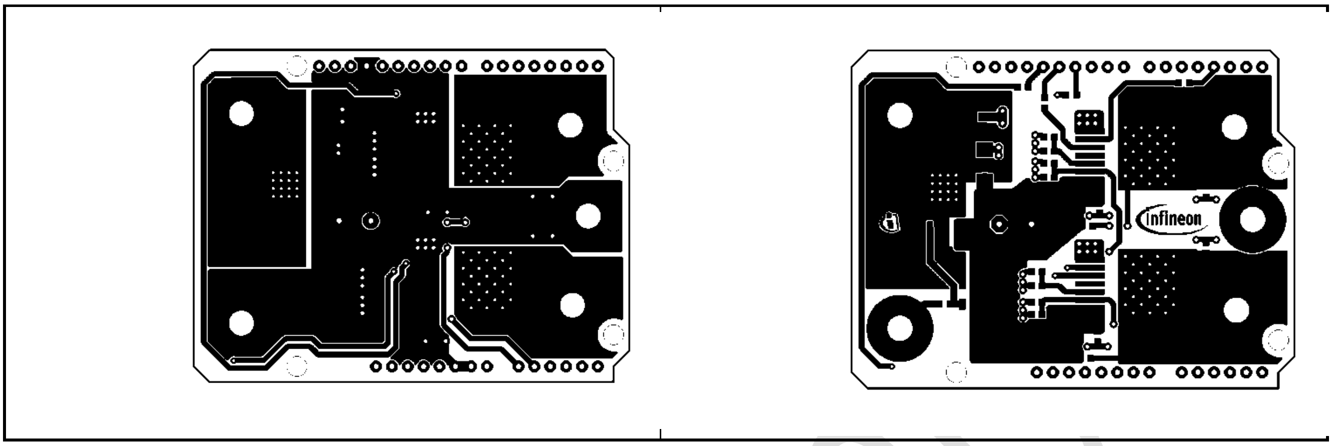


Figure 5 Motor Control Shield – Bottom and top layers

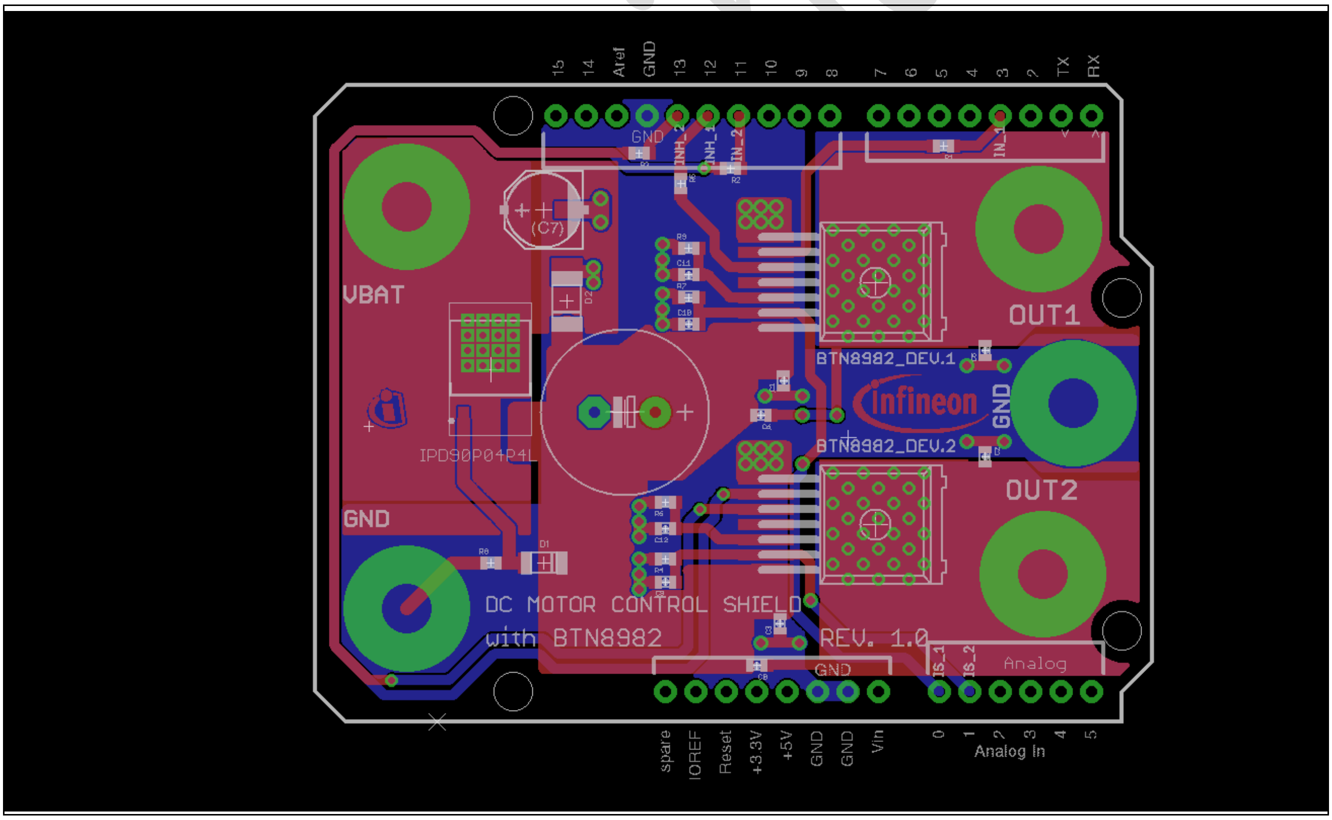


Figure 6 Motor Control Shield for Arduino with BTN8982TA – Layout

	C	D	E	F	G	H	I	J	M
1									
2	Device	Package	Description	Descript	Qty	Place_ YES/NO	Provided _by_cust omer _YES/NO	Distributor	Remarks_customer
3									
4	CAP0603-CAP	0603-CAP	Capacitor		4	yes			Standard device
5	CAP0603-CAP	0603-CAP	Capacitor		4	yes			Standard device
6	RCL_CPOL-EUE5-13	RCL_E5-13	POLARIZED CAPACI	TOR,	1	yes		Farnell Order Code: 2069026 or 1834156	Capaciator Radial
7	CPOL-EUD	PANASONIC_D	POLARIZED CAPACI	TOR,	1	no			
8	CAP0603-CAP	0603-CAP	Capacitor		2	yes			Standard device
9	DIODE ZENER	SMD-PACKAGES_SOD80	Diode		1	yes		Farnell Order Code: 1081361RL	NXP - BZV55-C10 - DIODE ZENER,10V,500MW
10	DIODE ZENER	SMD-PACKAGES_MELF-D	Diode		1	yes		Farnell Order Code: 1617744	VISHAY SEMICONDUCTOR - ZMY33-GS08 - DIODE ZENER,1W,33V
11	HW_INFINEON_IPD90P04P4L-04	TO-252-3-313-L	MOSFET		1	yes	yes		
12	HW-INFINEON_BTN8982TA	TO263-7-1	IC		1	yes	yes		
13	HW-INFINEON_BTN8982TA	TO263-7-1	IC		1	yes	yes		
14	RESISTOR0603-RES	0603-RES	Resistor		5	yes			Standard device
15	RESISTOR0603-RES	0603-RES	Resistor		2	yes			Standard device
16	RESISTOR0603-RES	0603-RES	Resistor		1	yes		Farnell Order Code: 1469826	VISHAY DRALORIC - CRCW0603510RFKEA - RESISTOR, 0603, 510R , 1%
17	RESISTOR0603-RES	0603-RES	Resistor		1	yes		Farnell Order Code: 1469826	VISHAY DRALORIC - CRCW0603510RFKEA - RESISTOR, 0603, 510R , 1%

Figure 7 Motor Control Shield for Arduino with BTN8982TA – Bill of Material (BOM)

2.3 Important design and layout rules:

The basis for the following design and layout recommendations is the parasitic inductance of electrical wires and design guidelines as described in Chapter three and four of the Application Note BTN8960 /62 /80 /82 High Current PN Half Bridge NovalithIC™ (Rev. 0.3, 2014-09-11).

- C4, so called DC-link capacitor: This electrolytic capacitor is required to keep the voltage ripple at the Vs-pin of the NovalithIC™ low during switching operation (the applied measurement procedure for the supply voltage is described in Chapter 3.1 of the Application Note). It is strongly recommended that the voltage ripple at the NovalithIC™ Vs-pin to the GND-pin is kept below 1 V peak to peak. The value of C4 must be aligned accordingly. See therefore Equation (10) in the Application Note. Most electrolytic capacitors are less effective at cold temperatures. It must be assured that C4 is also effective under the worst case conditions of the application. The layout is very important too. As shown in Figure 6, the capacitor C4 must be positioned with very short wiring close to the NovalithIC™. This must be done to keep the parasitic inductors of the PCB-wires as small as possible.

- C1/C3: This ceramic capacitors support C4 to keep the supply voltage ripple low and cover the fast transients between the Vs-pin and the GND-pin. The value of these ceramic capacitors must be chosen so that fast Vs-ripples at the NovalithIC™ do not exceed 1V peak to peak. The layout wiring for C1/C3 must be shorter than for C4 to the NovalithIC™ to keep the parasitic PCB-wire inductance as small as possible. In addition the parasitic inductance could be kept low by placing at least two vias for the connection to the GND-layer.
- C6/C8: These ceramic capacitors are important for EMI in order to avoid entering RF into the NovalithIC™ as much as possible. Good results have been achieved with a value of 220 nF. In terms of layout, it is important to place these capacitors between "OUT" and "Vs" without significant additional wiring from C6/C8 to the Vs- and OUT-line.
- C5/C2: These ceramic capacitor help to improve the EMC immunity and the ESD performance of the application. Good results have been achieved with a value of 220 nF. To keep the EMC and ESD out of the board, the capacitor is most effective when positioned directly next to the board connector. In addition, the parasitic inductance could be kept low by placing at least two vias for the connection to the GND-layer.

Other components:

- IC0, D1 and R8: Reverse polarity protection. See Chapter 4.4 of the Applikation Note.
- R9/R6: Slew rate resistors according to data sheet.
- C11/C12: Stabilization for slew rate resistors (R9/R6).
- R7/R4: Resistors to generate a current sensing voltage from the IS current.
- C10/C9: Ceramic capacitors for EMC immunity improvement. GND connection with at least two GND-vias. A good value is 1nF. In case the current should be measured during the PWM-phase this capacitor must be adapted to the ON-time inside the PWM-phase.
- R1, R2, R3 and R5: Device protection in case of microcontroller pins shorted to Vs.

2.4 Pin assignment

To use the Motor Control Shield the necessary control signals can be applied directly at the Arduino™ connectors. There is no need to use an Arduino or XMC 1100 Boot Kit to get the Motor Control Shield into an application. The control pins are logic level inputs which can be driven by any other microcontroller or with logic level signals. Besides the supply voltage Vbat has to be provided to the Vbat connector. Figure 8 shows the pinout/connectors of the Motor Control Shield.

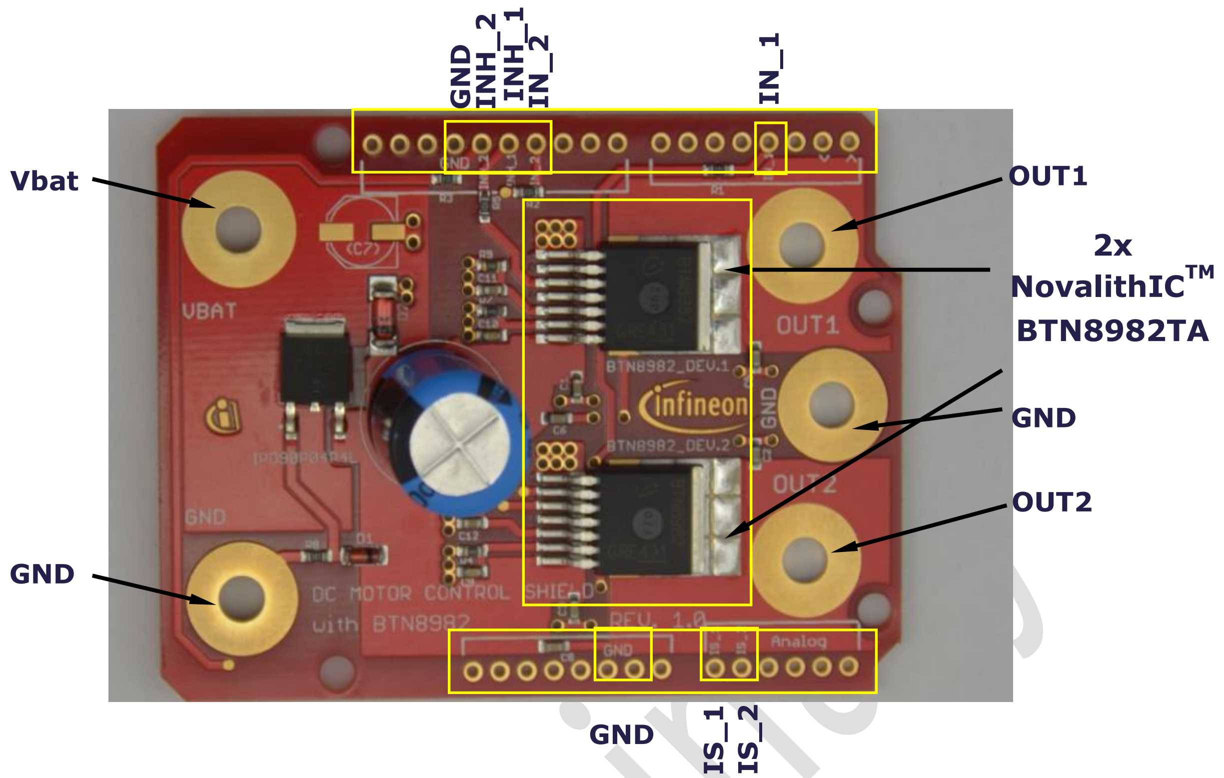


Figure 8 **Motor Control Shield connectors**

2.5 Pin definitions and functions

Pin	Symbol	I/O	Function
GND	**GND**	**-**	**Ground**
D3	IN_1	I	Input bridge 1 Defines whether high- or low side switch is activated
D11	IN_2	I	Input bridge 2 Defines whether high- or low side switch is activated
D12	INH_1	I	Inhibit bridge 1 When set to low device goes in sleep mode
D13	INH_2	I	Inhibit bridge 2 When set to low device goes in sleep mode
OUT_1	**OUT_1**	**O**	**Power output of the bridge 1**
OUT_2	**OUT_2**	**O**	**Power output of the bridge 2**
A0	IS_1	O	Current Sense and Diagnostics of half-bridge 1
A1	IS_2	O	Current Sense and Diagnostics of half-bridge 2
Vbat	**Vbat**	**-**	**Supply (Vs after the reverse polarity protection)**

3 BTN8982TA overview

The BTN8982TA used in the Motor Control Shield is an integrated high current half-bridge for motor drive applications. It is part of the NovalithIC™ family containing one p-channel high side MOSFET and one n-channel low side MOSFET with an integrated driver IC in one package. Due to the p-channel high side switch the need for a charge pump is eliminated thus minimizing EMI. Interfacing to a microcontroller is made easy by the integrated driver IC which features logic level inputs, diagnosis with current sense, slew rate adjustment, dead time generation and protection against overtemperature, undervoltage, overcurrent and short circuit.

The BTN8982TA provides a cost optimized solution for protected high current PWM motor drives with very low board space consumption.

3.1 Key features of the BTN8982TA NovalithIC™

- Path resistance of max. 20.4 mΩ @ 150 °C (typ. 10.0 mΩ @ 25 °C)
- High side: max. 10.5 mΩ @ 150 °C (typ. 5.3 mΩ @ 25 °C)
- Low side: max. 9.9 mΩ @ 150 °C (typ. 4.7 mΩ @ 25 °C)
- Enhanced switching speed for reduced switching losses
- Capable for high PWM frequency combined with active freewheeling
- Low quiescent current of typ. 7 µA @ 25 °C
- Switched mode current limitation for reduced power dissipation in overcurrent
- Current limitation level of 55 A min.
- Status flag diagnosis with current sense capability
- Overtemperature shut down with latch behavior
- Undervoltage shut down
- Driver circuit with logic level inputs
- Adjustable slew rates for optimized EMI
- Operation up to 40 V
- Green Product (RoHS compliant)
- AEC Qualified in PG-TO263-7-1 package

Figure 9 PG-TO263-7-1

3.2 Block diagram

The BTN8982TA is part of the NovalithIC™ family containing three separate chips in one package: One p-channel high side MOSFET and one n-channel low side MOSFET together with a driver IC, forming an integrated high current half-bridge. All three chips are mounted on one common lead frame, using the chip on chip and chip by chip technology. The power switches utilize vertical MOS technologies to ensure optimum on state resistance.

Due to the p-channel high side switch the need for a charge pump is eliminated thus minimizing EMI. Interfacing to a microcontroller is made easy by the integrated driver IC which features logic level inputs, diagnosis with current sense, slew rate adjustment, dead time generation and protection against overtemperature, undervoltage, overcurrent and short circuit. The BTN8982TA can be combined with other BTN8982TA to form H-bridge and 3-phase drive configurations.

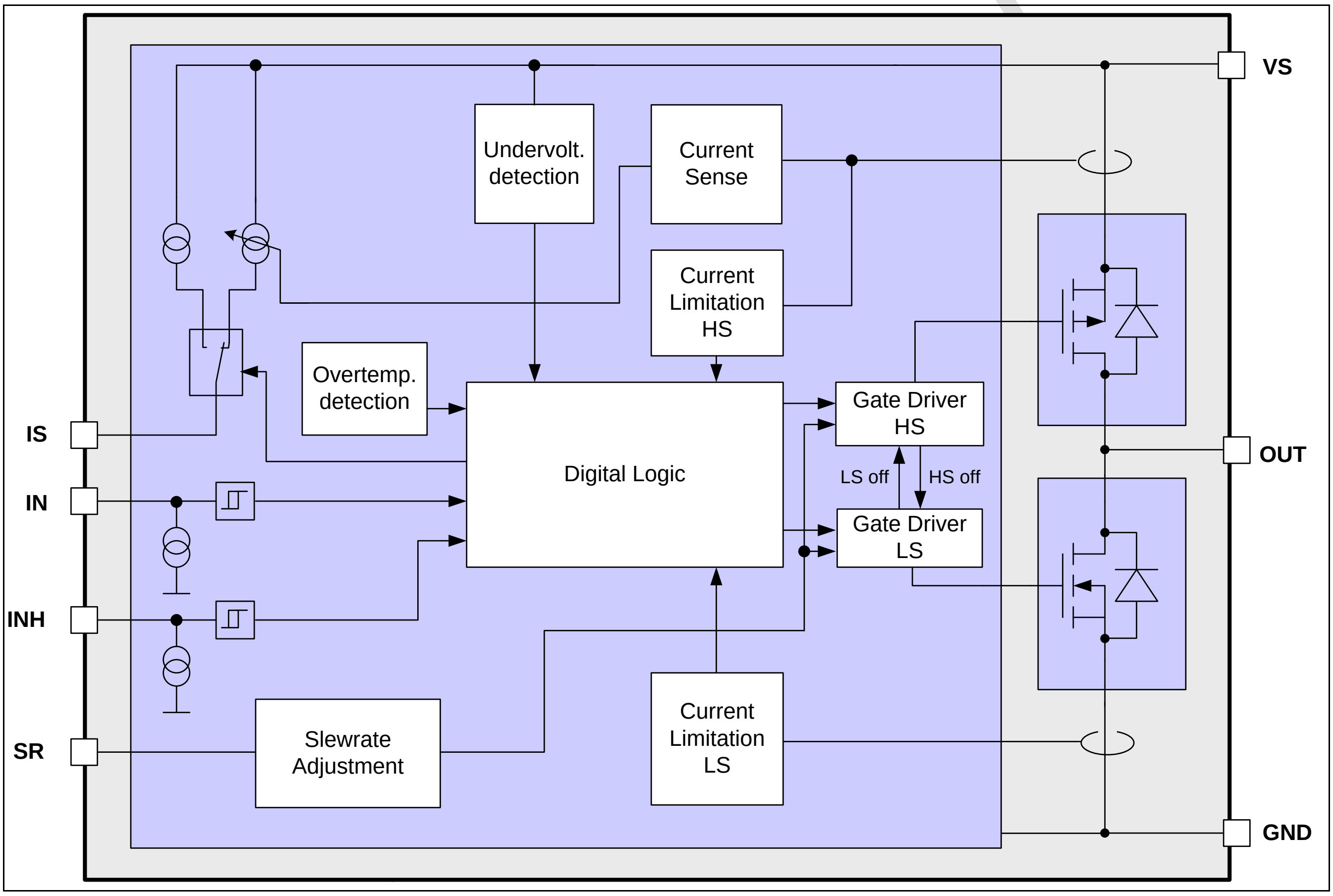


Figure 10 Block diagram BTN8982TA

3.3 Pin assignment

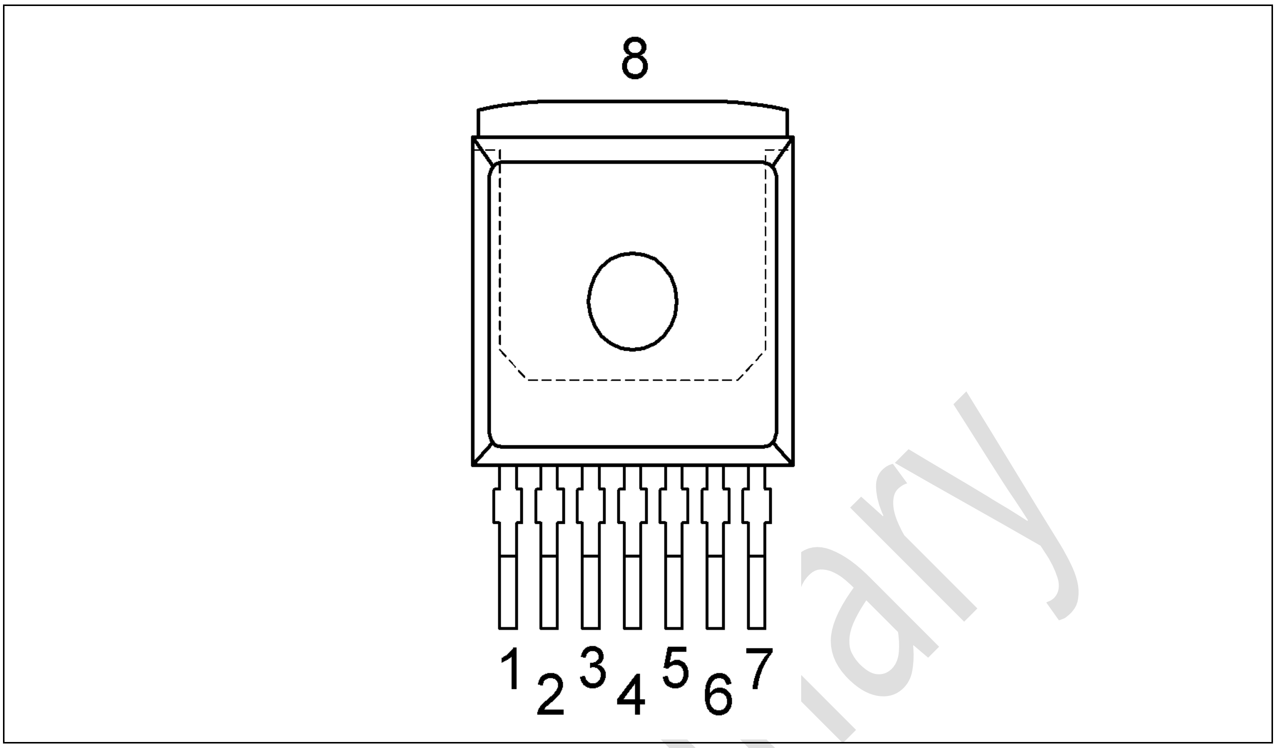


Figure 11 Pin assignment BTN8982TA (top view)

3.4 Pin definitions and functions BTN8982TA

Table 2

Pin	Symbol	I/O	Function
1	**GND**	**-**	**Ground**
2	IN	I	Input Defines whether high- or low side switch is activated
3	INH	I	Inhibit When set to low device goes in sleep mode
4, 8	**OUT**	**O**	**Power output of the bridge**
5	SR	I	Slew Rate The slew rate of the power switches can be adjusted by connecting a resistor between SR and GND
6	IS	O	Current Sense and Diagnostics
7	**Vs**	**-**	**Supply (Vbat at the Shield connector)**

4 Getting Started

4.1 Target applications

The application targeted by the BTN89xx devices is brushed DC Motor Control. Besides Motor Control any other inductive, resistive and capacitive load within the electrical characteristics of the NovalithIC™ can be driven by the BTN89xx. In the Motor Control Shield two BTN8982TA are used. Each is capable of driving up to 50 A. The limited thermal performance of the Shield PCB limits the recommended maximum current to 30 A.

4.2 Typical target application

With the Motor Control Shield either two mid power uni-directional DC-brushed motors or one bi-directional brushed motor (with the two half-bridges used in H-bridge configuration) can be driven. The half-bridges are controlled via the IN (Input) and INH (Inhibit) pins. The slew rate of the high frequency PWM can be adjusted by connecting an external resistor between the SR pin and GND. The BTM8982TA also provides a sense current at the IS pin. The Power Shield provides a fast and easy access to brushed DC motor solutions of up to 300 W.

4.2.1 Getting started: Shield

- Choose a mid-power, brushed DC motor.
- Choose a DC adapter. The nominal input of the Power Shield is 8 – 18 V DC. Maximum Voltage is 40 V
- Select pin headers and connectors of your choice and solder to the Power Shield. Due to cost reduction, the pin headers and connectors are not attached.
- Connect the Power Shield to Arduino Uno R3 or XMC 1100 Boot Kit.
- Connect power supply (5 V) to the Arduino Uno R3 or XMC 1100 Boot Kit (Micro USB). For the XMC Boot Kit a standard mobile phone charger can be used.
- Program the controller board with the motor control software (see 4.2.2).
- Connect the motor to OUT1 and OUT2 (H-bridge). For bi-directional applications connect the motor to OUT1 and OUT2 (H-bridge). For uni-directional use, the motor can be placed between an output OUT1/OUT2 and either GND or Vbat (half-bridge).
- Connect the DC adapter to the Power Shield (Vbat, GND).
- Turn on the power.

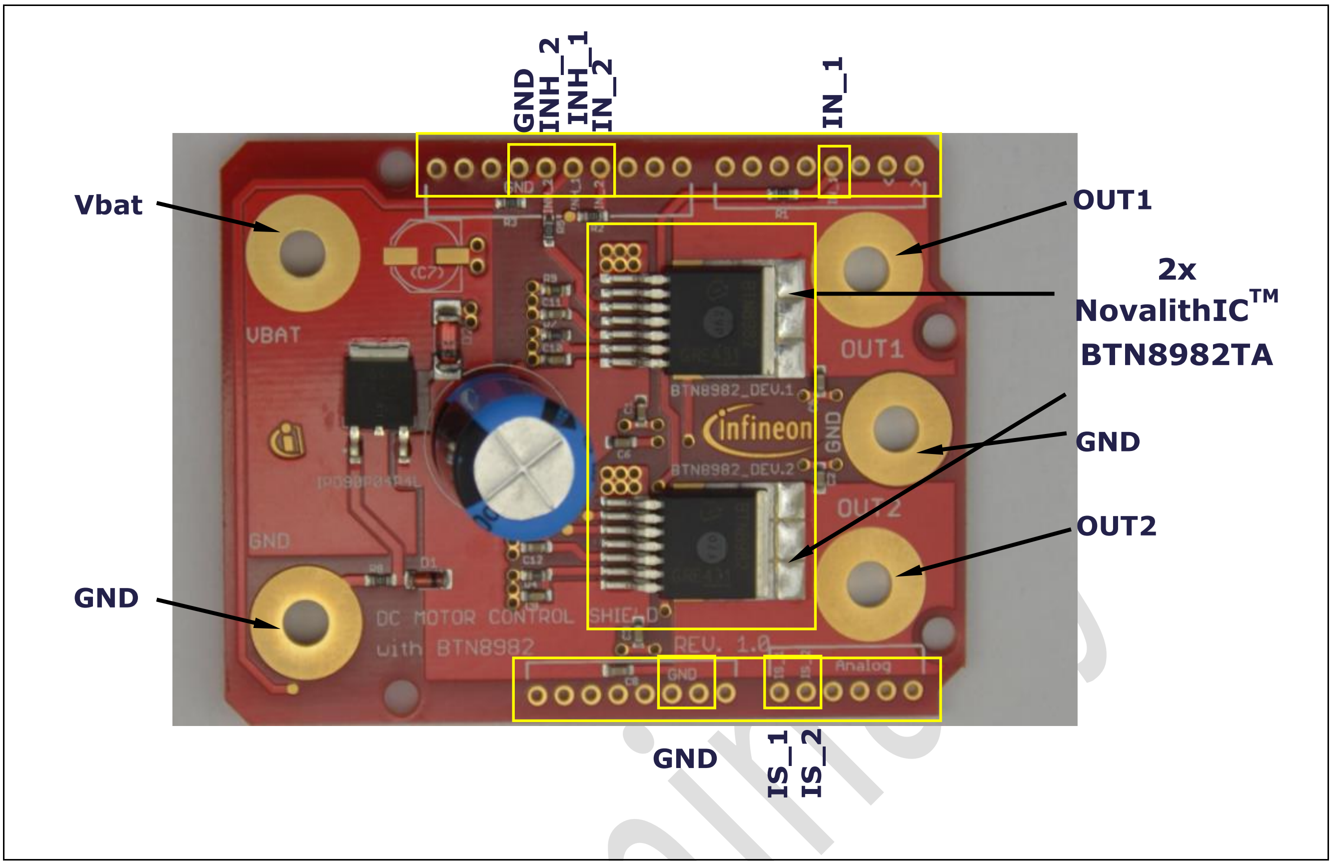


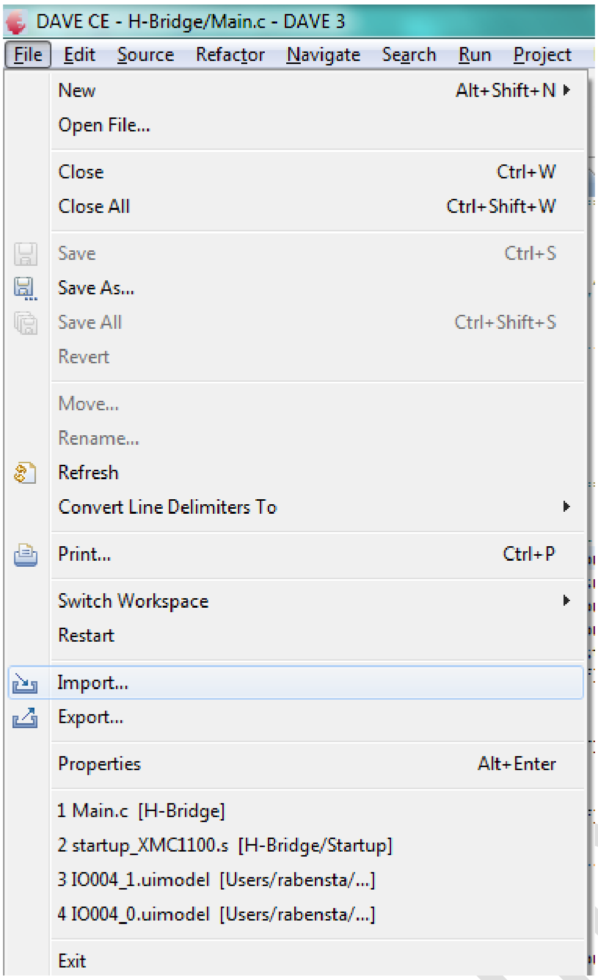
Figure 12 Motor Control Shield connectors

4.2.2 Getting started: Software

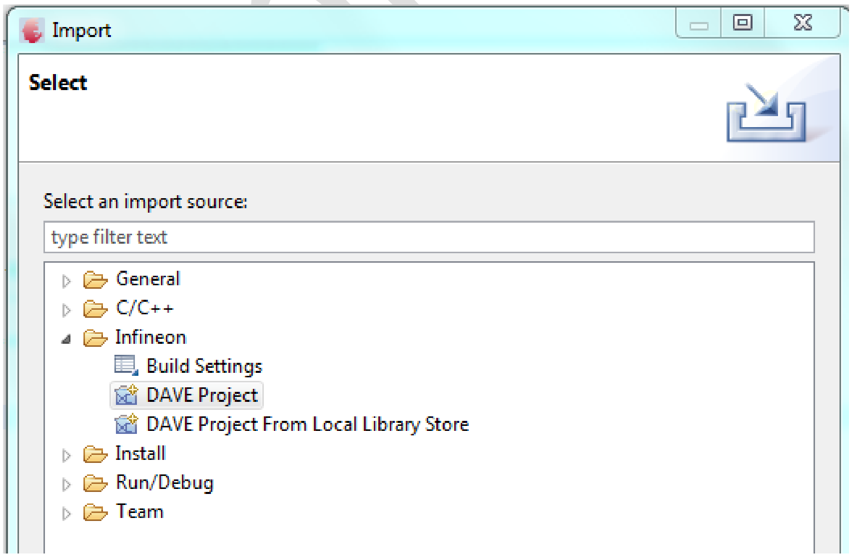
A simple example software for the XMC1100 Boot Kit is provided (H-bridge).

- Connect the XMC 1100 Boot Kit with a micro USB cable to the USB port of your PC.
- Download and install the DAVE™ - Free Development Platform for Code Generation from the Infineon website DAVE™.
- Start DAVE™ and import project file H-bridge:

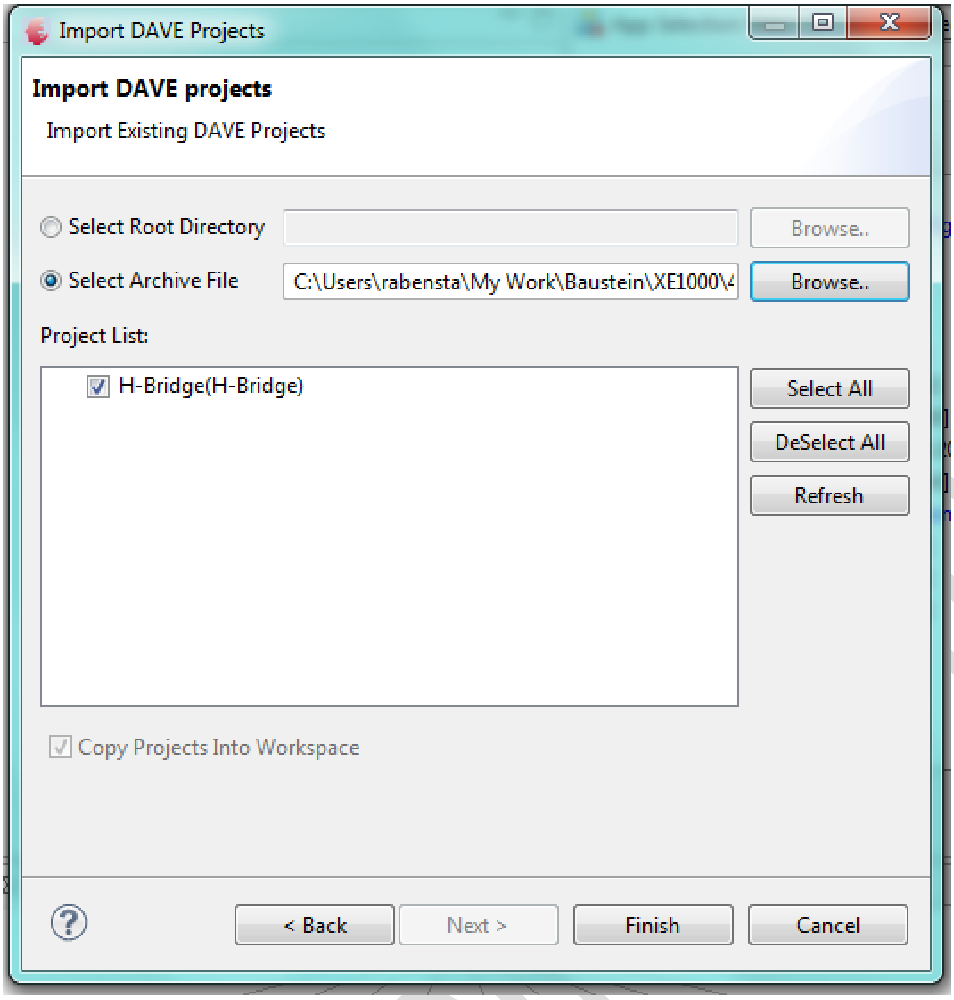
1: Select File → Import



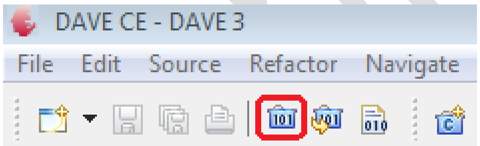
2: Choose Infineon DAVE project



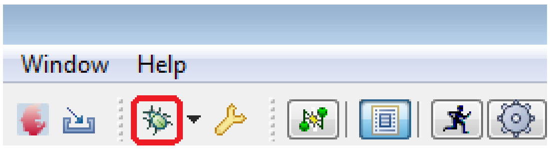
3: Select archive file → Browse for the file → Select the project → Click finish



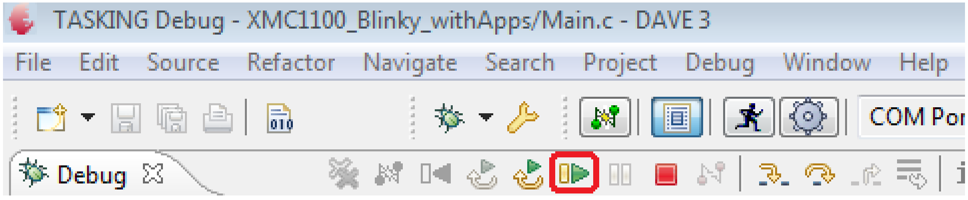
4: Build the project:



5: Start the debugger:



6: Run the software → the motor will spin



4.2.3 Software hints

For hints, tutorials, software examples, a quick introduction and further information around the DAVE™ – Free Development Platform for Code Generation, visit the DAVE™ web site.

- The DAVE™ App structure of the software example H-bridge for the Motor Control Shield is shown in Figure 13. The output voltage is controlled by the two PWMSP001 Apps. The ramp time is controlled by a third PWMSP001 App via interrupts. The inhibit signals are software controlled by the IO004 App.

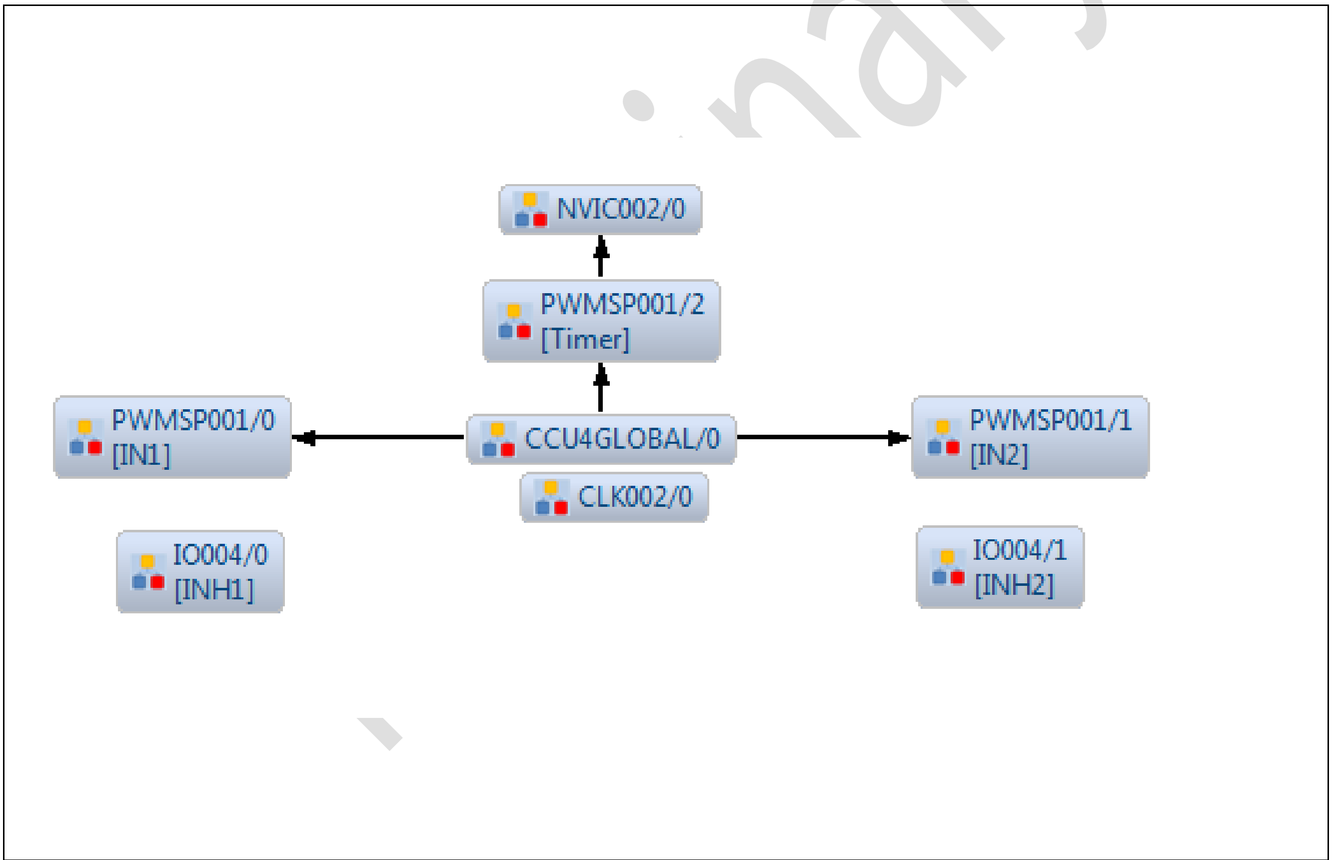
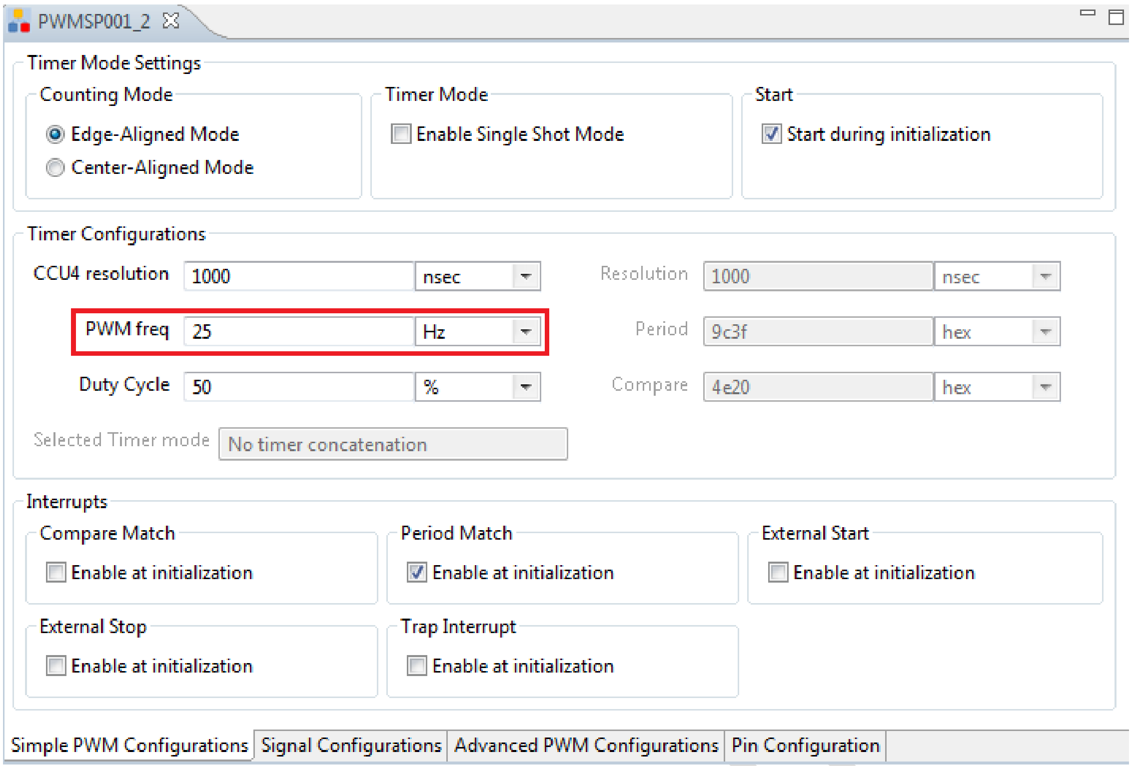


Figure 13 App structure of the example software H-bridge

To change the PWM frequency from 25 kHz to a different value the settings of both PWM App instances PWMSP001/0 and PWMSP001/0 have to be modified. There, the PWM frequency can be easily set to different values.



- Figure 14 shows the ramp generator and the parameters which can be set in main.c. The parameter "outputvoltage_max" and "outputvoltage_min" are controlled in the software by adapting the PWM duty cycle. With the duty cycle the motor speed and current consumption in controlled.

```
// Parameters
const int32_t supplyvoltage = 12;// supply voltage, used for scaling the duty cycle
const int32_t outputvoltage_max = 4;// maximum output voltage
const int32_t outputvoltage_min = -4;// minimum output voltage
const int32_t flat_time = 100;// ticks based on 25Hz. (100 ticks = 4 seconds)

/************************************************************
 *    Ramp Generator                                        *
 ************************************************************
 *                                                          *
 * max    -------------                                     *
 *       /  flat_time  \                                    *
 *      /               \                   /               *
 *     /                 \                 /                *
 * 0 -/-------------------\-------------------/----------   *
 *                         \                 /              *
 *                          \               /               *
 *                           \  flat_time  /                *
 * min                        -------------/                *
 *                                                          *
 ************************************************************/
```

Figure 14 **Ramp generator and its parameters**

1 Revision History

2 Major changes since the last revision

Page or Reference	Description of change
V0.9, 2015-03	

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