# 24V Protected Switch Shield with BTT6030-2EKA and BTT6020-1EKA

## About this document

### Scope and purpose

This document describes how to use the 24V Protected Switch Shield with BTT6030-2EKA and BTT6020-1EKA.

### Intended audience

Engineers, hobbyists and students who want to switch 24 V loads in their Arduino projects.

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# 1 24V Protected Switch Shield introduction

## 1.1 24V Protected Switch Shield overview

The 24V Protected Switch Shield adds advanced driving and diagnostic of generic loads to the Arduino projects. The shield can be controlled with the general logic IO-Ports of a microcontroller. Either an Arduino Uno R3, the XMC1100 Boot Kit or the more powerful XMC4700 Relax Kit and XMC4800 Relax Kit from Infineon can be used as the master.

On board of the 24V Protected Switch Shield are two BTT6030-2EKA and one BTT6020-1EKA PROFET™+24V. Each of the BTT6030-2EKA features two 32 mΩ Smart high-side power switch-channels, whereas the BTT6020-1EKA features a single 20 mΩ channel. In total the shield provides five Smart High-Side Power Switch Channels. Each is built by a vertical N-channel power MOSFET with charge pump.

Due to the integrated charge pump the channels can be controlled by standard digital IOs (3.3 V and 5 V supported).

The 24V Protected Switch Shield can be easily connected to any Arduino compatible board like the XMC1100 Boot Kit via headers.

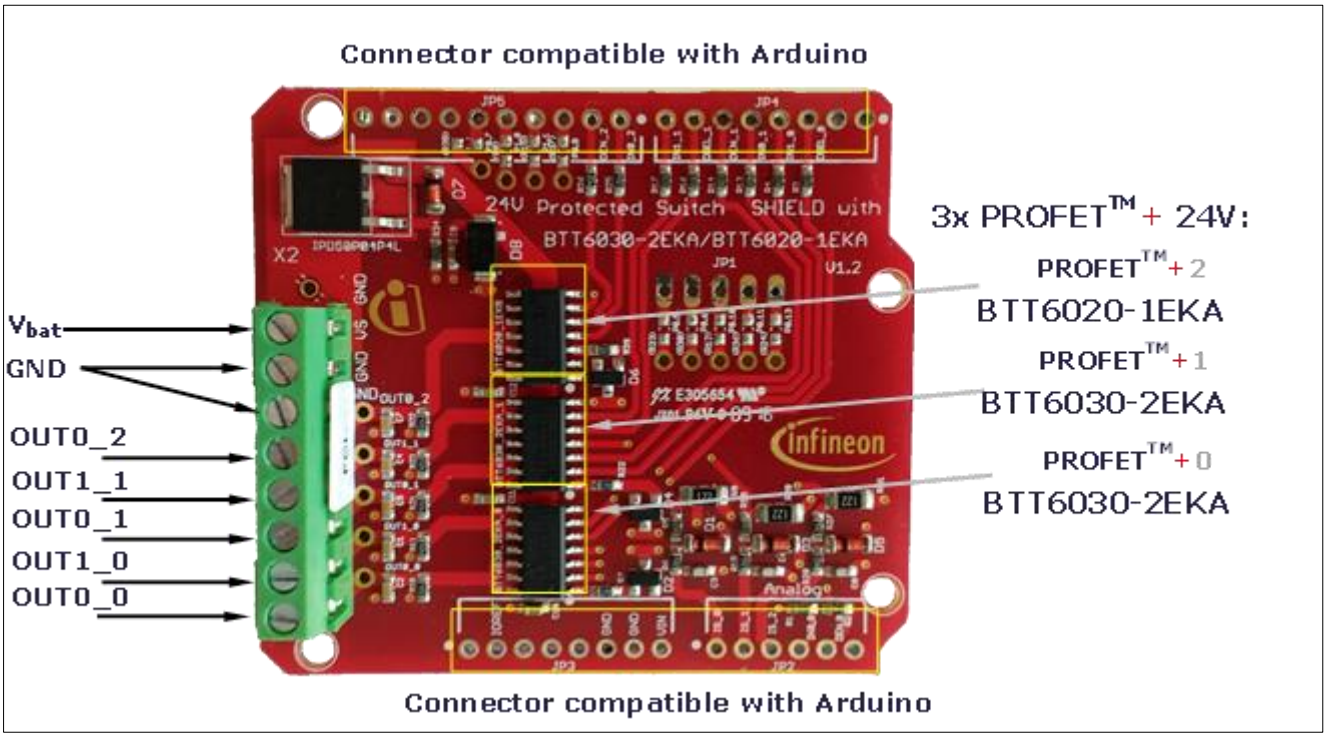



**Figure 1 24V Protected Switch Shield photo**

## 1.2 Key features

The 24V Protected Switch Shield has the following features:

- An Arduino Uno R3, XMC1100 Boot Kit, or similar board connected to the shield can control the five power channels via the general IO pins.
- Drives resistive, capacitive and inductive loads with PWM or in DC (eg. truck bulbs, car bulbs, valves, motors, relays, capacitors, LEDs…)

  - Infineon PROFET™ devices have an integrated charge pump, internal protection features and a current feedback to the ADC of the microcontroller
  - Supply voltage: Functional range: 5 V – 48 V; Nominal range: 8 V – 36 V
  - Nominal Current up to 5 A per channel restricted due to the limited power dissipation of the PCB (BTT6020-1EKA nominal Current: 7 A)
  - PWM (Pulse Width Modulation) via input pins up to 400 Hz
    higher frequencies possible depending on load, input voltage and duty cycle
- Diagnosis of the load / current feedback
  - Accurate feedback on the state of the load to the ADC of the microcontroller (current measurement & Fault detection).
  - Possibility to build feedback loops from the load side to the microcontroller
- Protection of load and driver circuit
  - Protection against overcurrent on the load side via diagnosis feedback
  - thermal protection of the driver
  - Overcurrent protection on the driver side (see datasheet)
  - Fault detection via IS pin
  - Protection against high transient voltages (ESD, ISO pulses)
  - Low conducted emissions
- Reverse current blocking with IPD50P04P4L-11

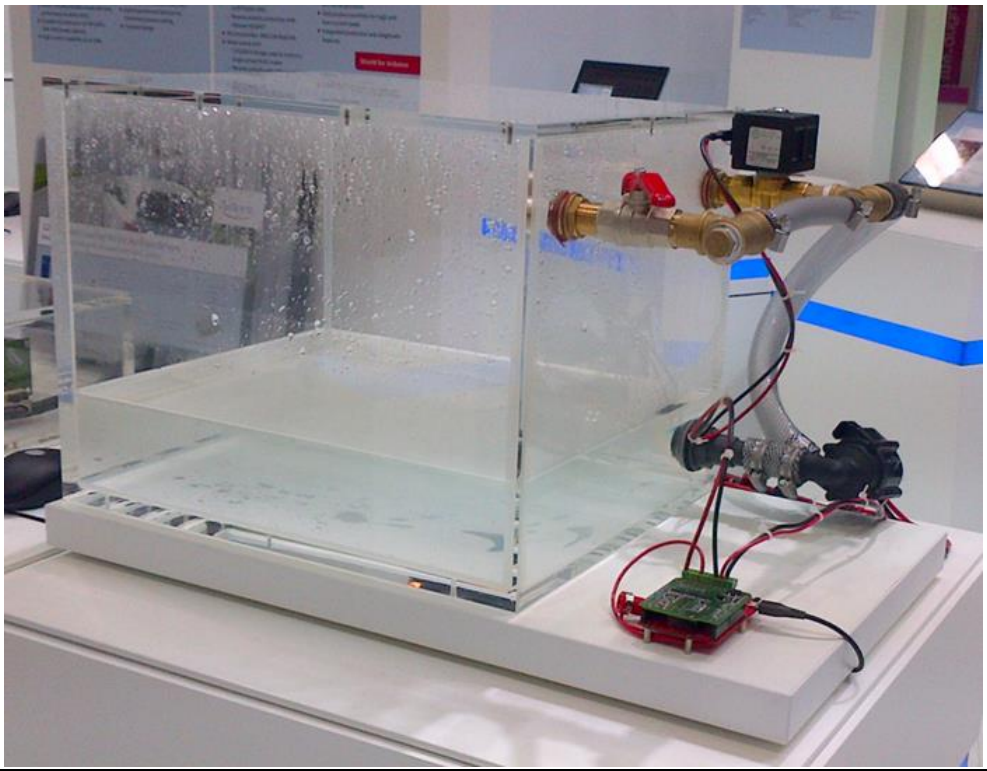


**Figure 2** **24V Protected Switch Shield driving a valve and water pump**

## 1.3 Block diagram of an automotive light control

Figure 3 depicts the Block diagram of the 24V Protected Switch shield. The IS pins of all 3 devices used for the current sensing could be connected to a single analog digital converter at the µC. But for simplification each IS pin is connected to an own analog digital converter. The microcontroller and its power supply are not part of the shield.

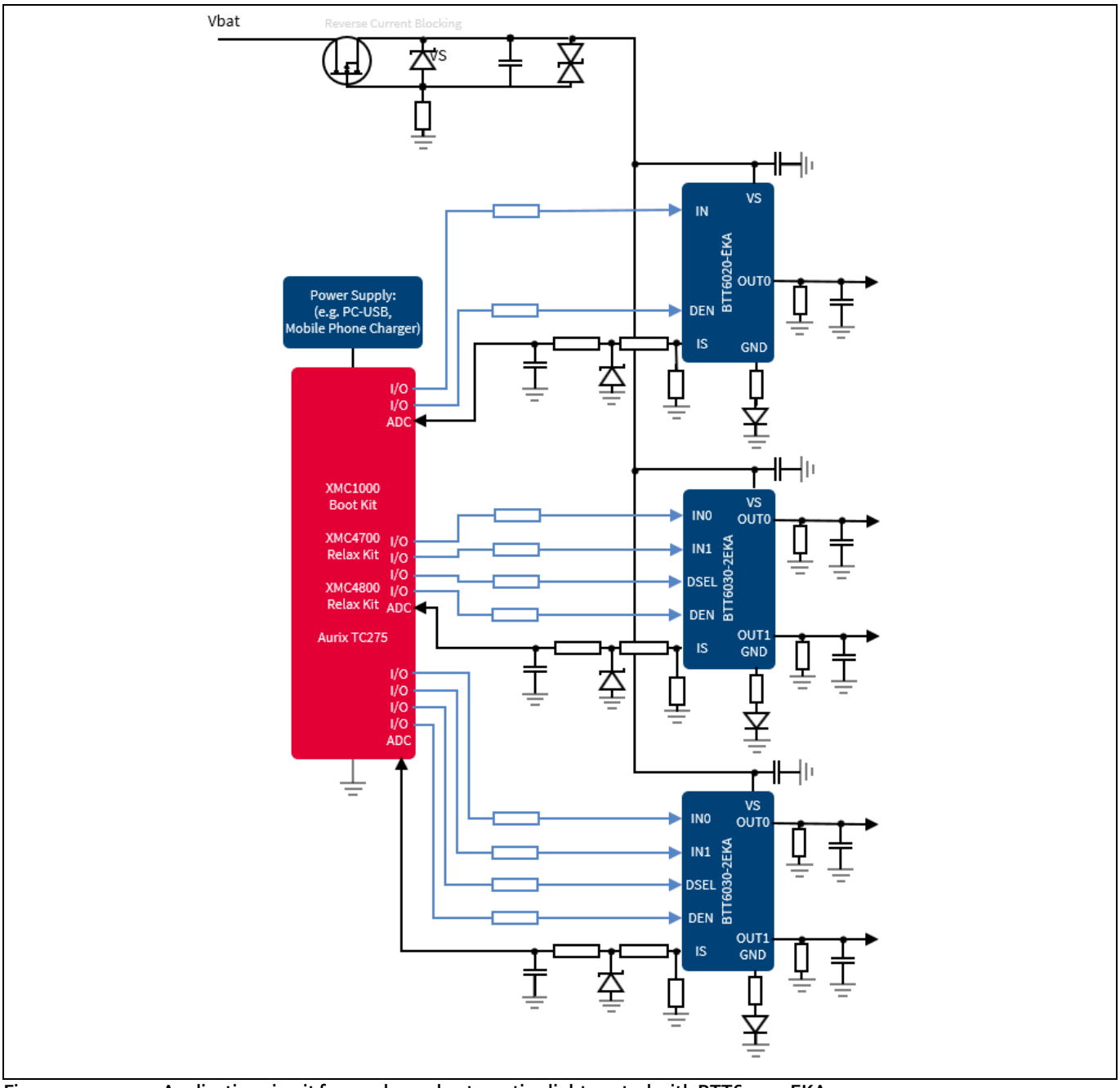



**Figure 3 Application circuit for a 5 channel automotive light control with BTT6030-2EKA**

# 2 24V Protected Switch Shield board description

For a safe and sufficient functionality, discrete components are necessary. Refer to the Datasheet to check which components are needed.

Figure 4, Figure 5 and Figure 6 show the schematics plus the corresponding layout of the 24V Protected Switch Shield. The Bill Of Material (BOM) can be found in Figure 7Figure 7.

## 2.1 Schematics

In Figure 4 the schematics of the 24V Protected Switch Shield is shown. The schematics are based on the application circuit in the BTT6030-2EKA Datasheet.

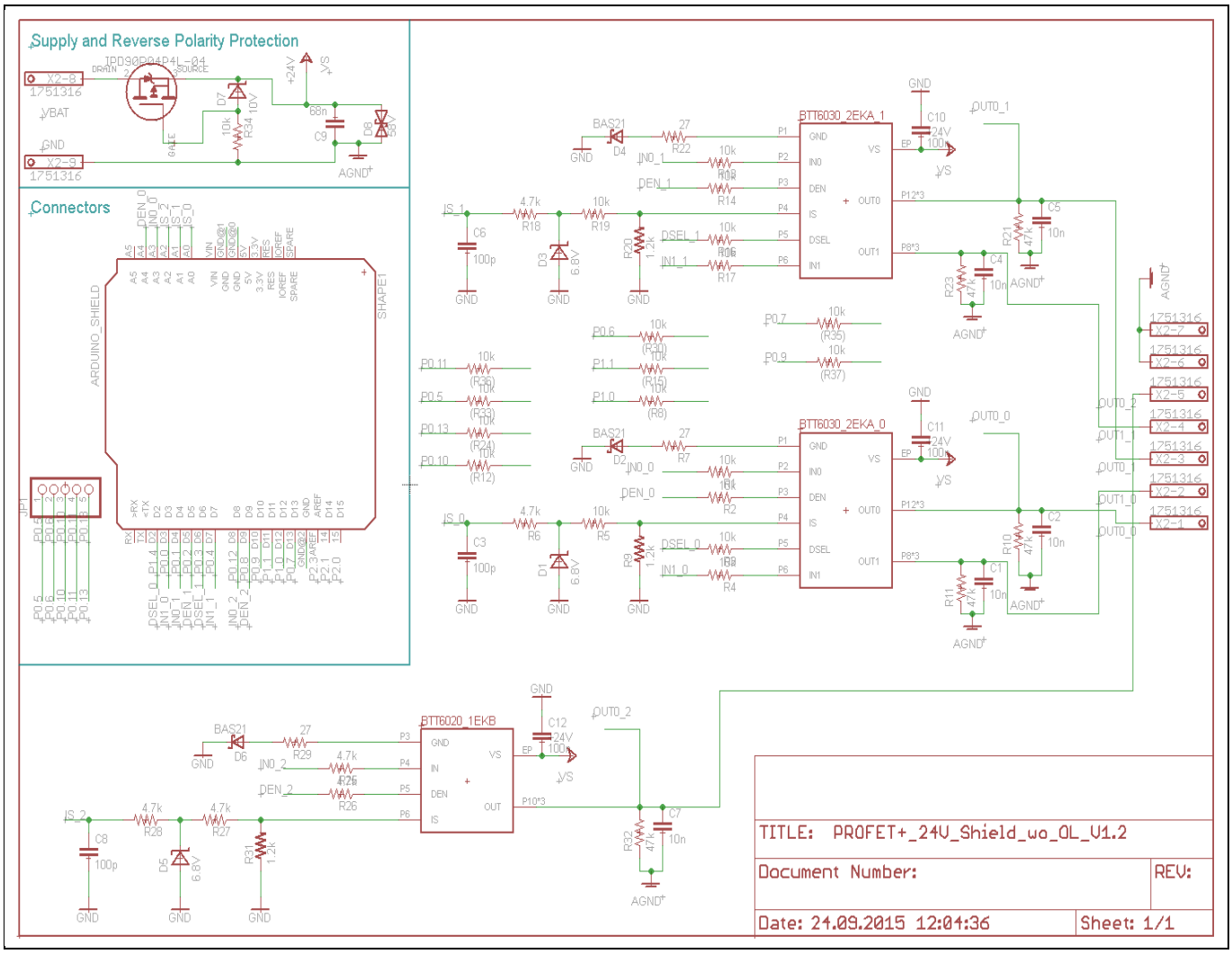



**Figure 4 Schematics 24V Protected Switch Shield with PROFETTM+ 24V for Arduino**

## 2.2 Layout

Figure 5 and Figure 6 show the layout of the 24V Protected Switch Shield.

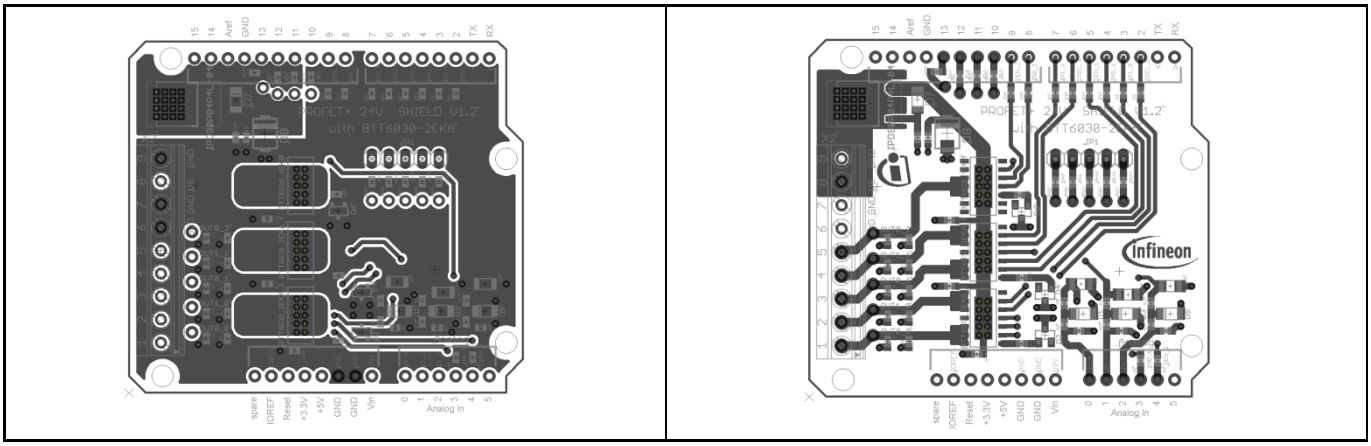


Figure 5 24V Protected Switch Shield – Bottom and top layers

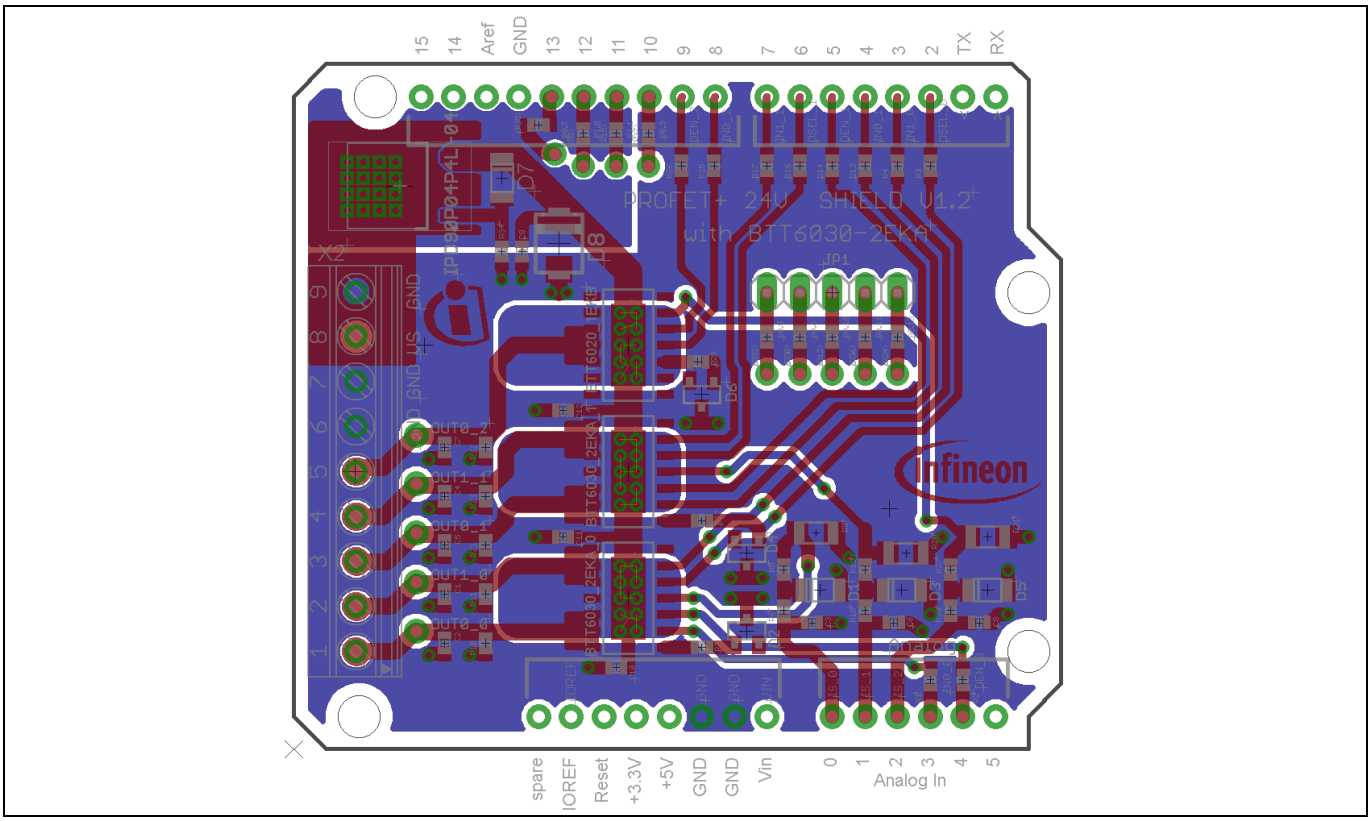



Figure 6 24V Protected Switch Shield with PROFETTM+ 24V for Arduino – Layout

| Part | Value | Device | Package | Description | Descrip | Qty | Place_YES/NO | Provided | Distributor | Ordernumber | Weblink |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | |
| EXAMPLE: C19, C4, C22, C21, C12, C16, C7, C6, C24, C1, C9, C27 | 1 µF | C-EUC0402 | C0402 | CAPACITOR, European symbol | | 12 | YES | YES | | | |
| C1, C2, C4, C5, C7 | 10n /50V | CAP0603-CAP | 0603-CAP | Capacitor | | 5 | yes | | | | |
| C3, C6, C8 | 100p /50V | CAP0603-CAP | 0603-CAP | Capacitor | | 3 | yes | | | | |
| C9 | 68n /50V | CAP0603-CAP | 0603-CAP | Capacitor | | 1 | yes | | Farnell Best. Nr.: 1414650RL | | |
| C10, C11, C12 | 100n /50V | CAP0603-CAP | 0603-CAP | Capacitor | | 3 | yes | | beta | | |
| D1, D3, D5 | 6.8V | SMD-PACKAGES_ZMM | SMD-PACKAGES_SOD80 | Zener Diode | | 3 | yes | | Farnell Best.Nr.: 1097205RL | | |
| D2, D4, D6 | BAS21 | BAS21 | SOT23 | Silicon Schottky Diode | | 3 | yes | | | | |
| D7 | 10V | SMD-PACKAGES_ZMM | SMD-PACKAGES_SOD80 | Zener Diode | | 1 | yes | | Farnell Best.Nr.: 1081361 | | |
| D8 | 58V | Supressor Diode | SMA | Supressor | | 1 | yes | | Farnell Best.Nr.: 1579006RL | | |
| IPD50P04P4L | HW_INFINEON_IPD50P04P4L-11 | HW_INFINEON_IPD50P04P4L-11 | TO-252-3-313-L | MOSFET | | 1 | yes | yes | | | |
| R1, R2, R3, R4, R5, R13, R14, R16, R17, R19, R34 | 10k | RESISTOR0603-RES | 0603-RES | Resistor | | 11 | yes | | | | |
| R6, R18, R25, R26, R27, R28 | 4.7k | RESISTOR0603-RES | 0603-RES | Resistor | | 6 | yes | | | | |
| R7, R22, R29 | 0.027k | RESISTOR0603-RES | 0603-RES | Resistor | | 3 | yes | | | | |
| R9, R20, R31 | 1.2k | RESISTOR 1206 | R1206 | Resistor | | 3 | yes | | | | |
| R10, R11 R21, R23, R32 | 47k | RESISTOR0603-RES | 0603-RES | Resistor | | 5 | yes | | | | |
| | | | | | | | | | | | |
| BTT6030_2EKA | INFINEON_BTS5030-2EKA | INFINEON_BTS5030-2EKA | IFX_PG_DSO_14_40_EP | 2Ch PROFET+24V | | 2 | yes | yes | | | |
| BTT6020_1EKA | INFINEON_BTS5020-1EKA | INFINEON_BTS5020-1EKA | IFX_PG_DSO_14_47_EP | 1Ch PROFET+24V | | 1 | yes | yes | | | |
| (R8), (R12), (R15), (R24), (R30), (R33) R(35), R(36), R(37) | 10k | RESISTOR0603-RES | 0603-RES | Resistor | | 9 | no | | | | |
| X2 | | | | MKDS 1/ 8-3,5 TERMINAL BLOCK PLUGGABLE, 8 POSITION | | 1 | yes | | Farnell Order Nr.: 1787882 | | |
| JP1 | | PINHD-1X5 | 1X05 | 5-pin 2.54mm male long header | | 1 | yes | | Farnell Order Nr.: 1593414 | | |
| Arduino Pins | | | | 6-pin 2.54mm male long header | | 1 | yes | | Farnell Order Nr.: 1593415 | | |
| Arduino Pins | | | | 8-pin 2.54mm male long header | | 2 | yes | | Farnell Order Nr.: 1593416 | | |
| Arduino Pins | | | | 10-pin 2.54mm male long header | | 1 | yes | | Farnell Order Nr.: 1593417 | | |

**Figure 7 24V Protected Switch Shield with PROFETTM+ 24V for Arduino – Bill of Material (BOM)**

## 2.3 Pin assignment

To use the 24V Protected Switch Shield the necessary control signals can be applied directly at the connectors. There is no need to use a microcontroller compatible with Arduino or XMC 1100 Boot Kit to get the 24V Protected Switch 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 $V_{bat}$ has to be provided to the $V_{bat}$ connector. Figure 8 shows the pinout/connectors of the 24V Protected Switch Shield.

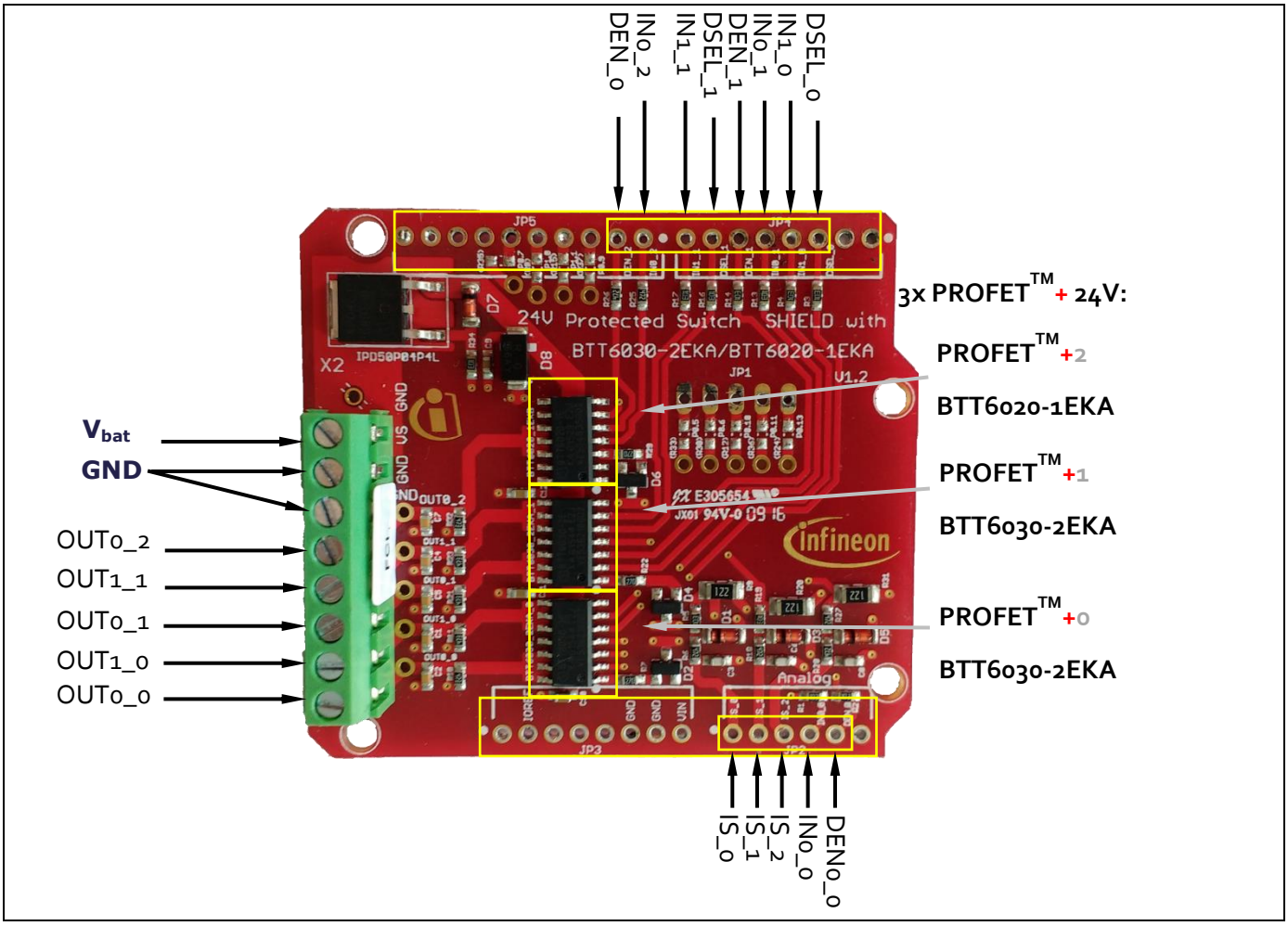



**Figure 8** 24V Protected Switch Shield connectors

## 2.4 Pin definitions and functions

Table 1

| Pin | Symbol | I/O | Function |
|---|---|---|---|
| GND | GND | - | Ground |
| D2 | DSEL_0 | I | Diagnostic select PROFET™+ 0<br>Selects if the diagnosis of channel 0 or 1 is muxed to the IS Pin (PROFET™+ 0) |
| D3 | IN1_0 | I | Input 1 PROFET™+ 0<br>Input to switch channel 1 on PROFET™+ 0 |
| D4 | IN0_1 | I | Input 0 PROFET™+ 1<br>Input to switch channel 0 on PROFET™+ 1 |

| | | | |
|---|---|---|---|
| D5 | DEN_1 | I | Diagnosis enable PROFET™+ 1<br>Turns diagnosis for PROFET™+ 1 on or off |
| D6 | DSEL_1 | I | Diagnostic select PROFET™+ 1<br>Selects if the diagnosis of channel 0 or 1 is muxed to the IS Pin (PROFET™+ 1) |
| D7 | IN1_1 | I | Input 1 PROFET™+ 1<br>Input to switch channel 1 on PROFET™+ 1 |
| D8 | IN0_2 | I | Input PROFET™+ 2<br>Input to switch channel on PROFET™+ 2 |
| D9 | DEN_2 | I | Diagnosis enable PROFET™+ 2<br>Turns diagnosis for PROFET™+ 2 on or off |
| A0 | IS_0 | O | Sense PROFET™+ 0<br>Current sense of PROFET™+ 0 |
| A1 | IS_1 | O | Sense PROFET™+ 1<br>Current sense of PROFET™+ 1 |
| A2 | IS_2 | O | Sense PROFET™+ 2<br>Current sense of PROFET™+ 2 |
| A3 | IN0_0 | I | Input 0 PROFET™+ 0<br>Input to switch channel 0 on PROFET™+ 0 |
| A4 | DEN_0 | I | Diagnosis enable PROFET™+ 0<br>Turns diagnosis for PROFET™+ 0 on or off |
| OUTy_x | OUTy_x | O | Power output of channel y on PROFET™+ x |
| $V_{bat}$ | $V_S$ | - | Supply |

# 3 BTT6030-2EKA overview

The BTT6030-2EKA is a 32 mΩ dual channel Smart High-Side Power Switch, embedded in a PG-DSO-14-40 EP, Exposed Pad package, providing protective functions and diagnosis. The power transistor is built by an N-channel vertical power MOSFET with charge pump. The device is integrated in Smart6 HV technology. It is specially designed to drive lamps up to 2 x P21 W 24 V or 1 x 70 W 24 V, as well as LEDs in the harsh automotive environment. For details please refer to the Datasheet.

## 3.1 Key features of the BTT6030-2EKA PROFET™ +24V

- Two channel device
- Very low stand-by current
- 3.3 V and 5 V compatible logic inputs
- Electrostatic discharge protection (ESD)
- Optimized electromagnetic compatibility
- Logic ground independent from load ground
- Very low power DMOS leakage current in OFF state
- Green product (RoHS compliant)
- AEC qualified

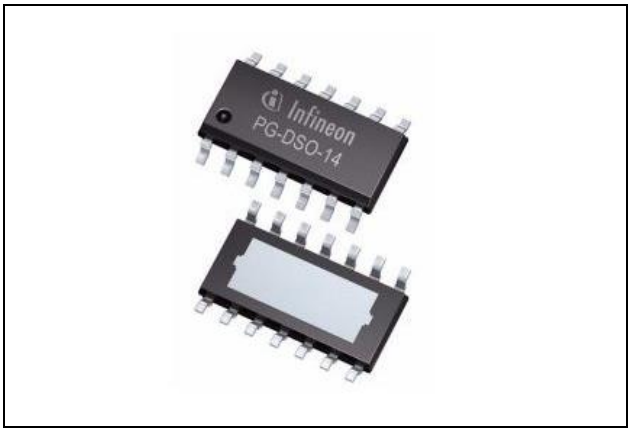



**Figure 9 PG-DSO-14-40EP**

## 3.2 Block diagram

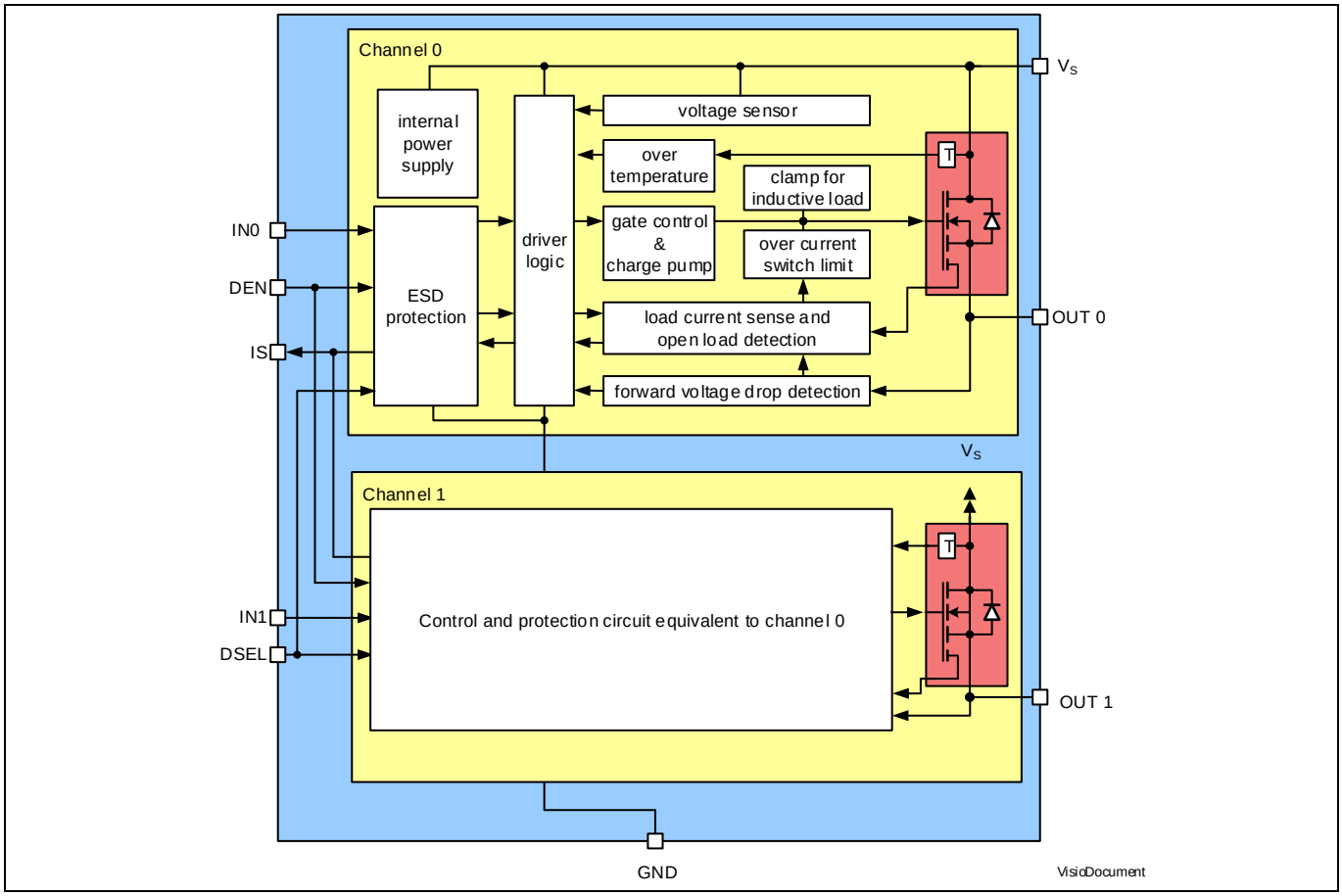



**Figure 10 Block diagram BTT6030-2EKA**

## 3.3 Pin assignment

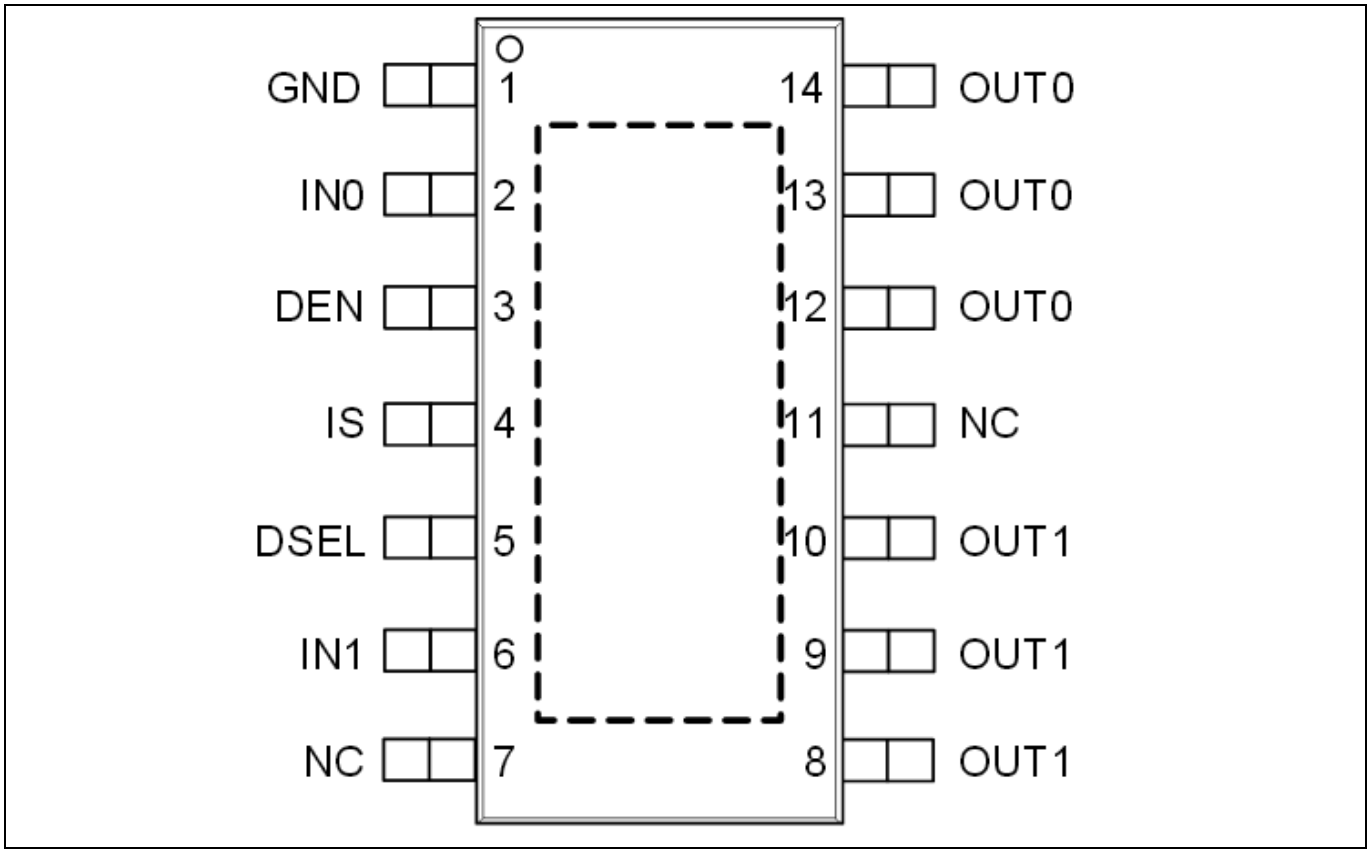



**Figure 11** **Pin assignment BTT6030-2EKA (top view)**

## 3.4 Pin definitions and functions BTT6030-2EKA

Table2

| Pin | Symbol | Function |
|---|---|---|
| **1** | GND | **Ground** |
| **2** | IN0 | **INput channel 0;** Input signal for channel 0 activation |
| **3** | DEN | **Diagnostic ENable;** Digital signal to enable/disable the diagnosis of the device |
| **4** | IS | **Sense;** Sense current of the selected channel |
| **5** | DSEL | **Diagnostic SELection;** Digital signal to select the channel to be diagnosed |
| **6** | IN1 | **INput channel 1;** Input signal for channel 1 activation |
| **7, 11** | NC | **Not Connected**; No internal connection to the chip |
| **8, 9, 10** | OUT1 | **OUTput 1;** Protected high side power output channel 1 |
| **12, 13, 14** | OUT0 | **OUTput 0;** Protected high side power output channel 0 |
| Cooling Tab | $V_S$ | **Voltage Supply;** Battery voltage |

# 4 BTT6020-1EKA overview

The BTT6020-1EKA is a 20 mΩ single channel Smart High-Side Power Switch, embedded in a PG-DSO-14-47 EP, Exposed Pad package, providing protective functions and diagnosis. The power transistor is built by an N-channel vertical power MOSFET with charge pump. The device is integrated in Smart6 technology. It is specially designed to drive lamps up to 5 x P21 W 24 V or 1 x 70 W 24 V, as well as LEDs in the harsh automotive environment. For details please refer to the Datasheet.

## 4.1 Keyfeatures of the BTT6030-2EKA PROFET™ +24V

- One channel device
- Very low stand-by current
- 3.3 V and 5 V compatible logic inputs
- Electrostatic discharge protection (ESD)
- Optimized electromagnetic compatibility
- Logic ground independent from load ground
- Very low power DMOS leakage current in OFF state
- Green product (RoHS compliant)
- AEC qualified

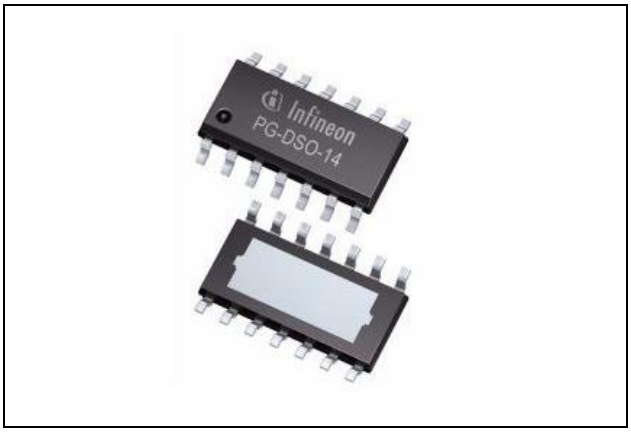



**Figure 12 PG-TO263-7-1**

## 4.2 Block diagram

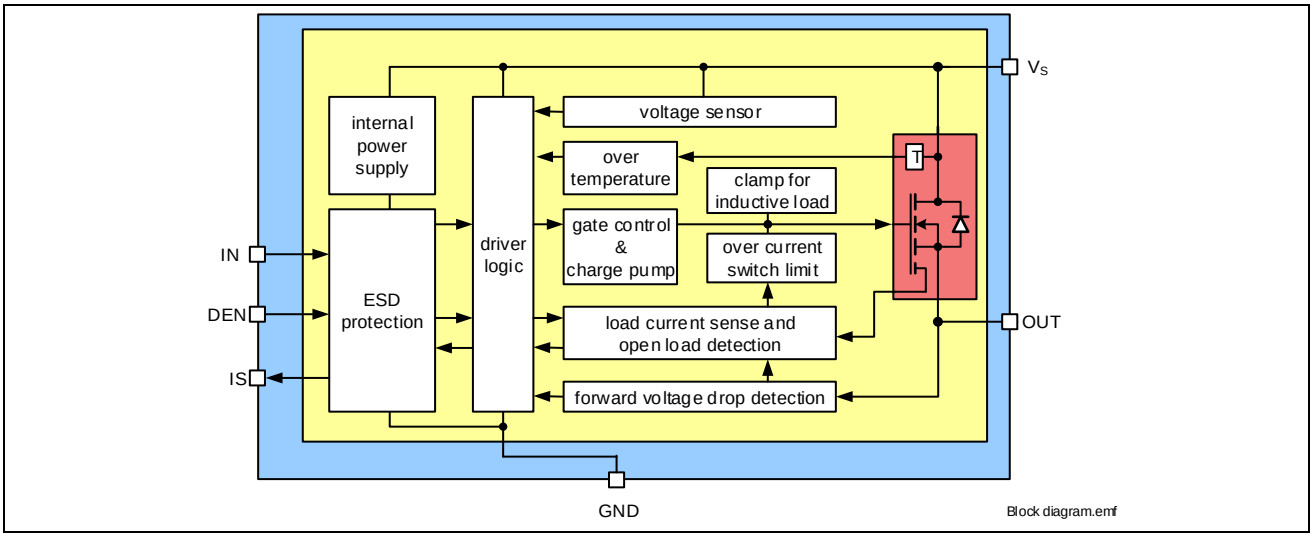



Figure 13 Block diagram BTT6020-1EKA

## 4.3 Pin assingsment

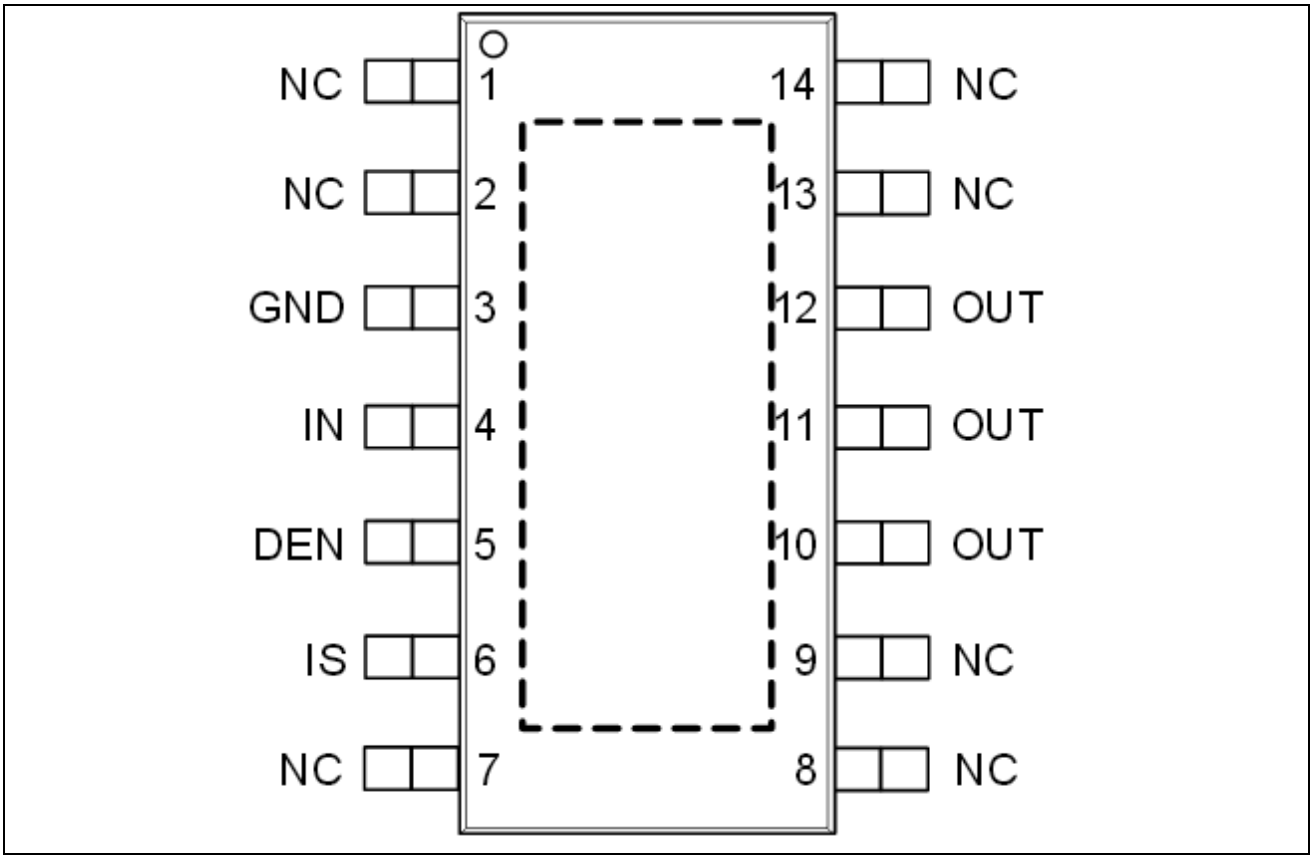



Figure 14 Pin assignment BTT6020-1EKA (top view)

## 4.4 Pin assingsment

Table 3

| Pin | Symbol | Function |
|---|---|---|
| **1, 2, 7, 8, 9, 13, 14** | NC | **Not Connected**; No internal connection to the chip |
| **3** | GND | **Ground** |
| **4** | IN | **INput channel;** Input signal for channel activation |
| **5** | DEN | **Diagnostic ENable;** Digital signal to enable/disable the diagnosis of the device |
| **6** | IS | **Sense;** Sense current of the selected channel |
| **10, 11, 12** | OUT | **OUTput;** Protected high side power output channel |
| Cooling Tab | $V_S$ | **Voltage Supply;** Battery voltage |

# 5 Getting Started

## 5.1 Target applications

The application targeted by the BT60xx devices is driving lamps in 24V Trucks and Transportation systems. Besides lamps any other inductive, resistive and capacitive load within the electrical characteristics of the PROFET™+24V can be driven by the BT60xx. In the 24V Protected Switch Shield two BTT6030-2EKA and one BTT6020-1EKA are used. Each channel of the BTT6030 is capable of driving up to 4 A (both channels active). The single channel of the BTT6020 is capable of driving up to 7 A. The limited thermal performance of the Shield PCB limits the recommended maximum current to 5 A.

## 5.2 Typical target applications

With the 24V Protected Switch Shield up to five 24 V loads can be driven. The switches are controlled via the INx (Input x) pins. The BTT60xx also provide a sense current at the IS pin. The Shield provides a fast and easy access to 24 V load switching up to 1 x 5 A + 4 x 4 A.

### 5.2.1 Getting started: Shield

- Choose loads compatible within the electrical characteristics in the Datasheets of the BTT60xx
  - E.g. 1 x 70 W 24 V lamp and 4 x 21 W 24 V lamps (Truck bulbs)
- Choose a DC adapter. The nominal input of the Shield is 8 – 36 V DC. Maximum Voltage is 48 V
- Connect the 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 lamp switching software (see 5.2.2).
- Connect the Out connectors of the shield
  - 70 W to OUT0_2
  - 21 W to Out0_1, Out 1_1, Out 0_0 and Out 1_1
- Connect the DC adapter to the Power Shield ($V_{bat}$, GND).

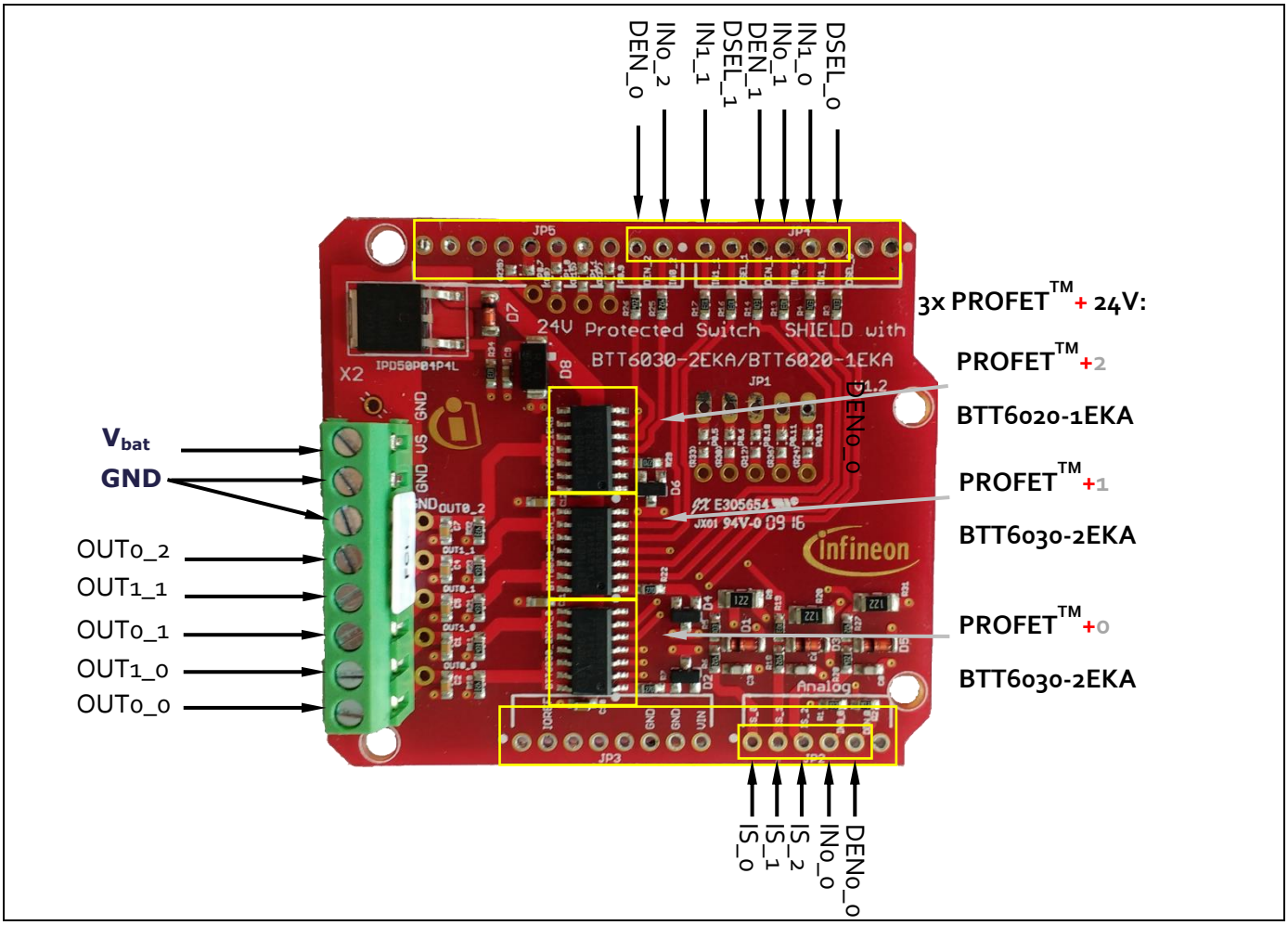


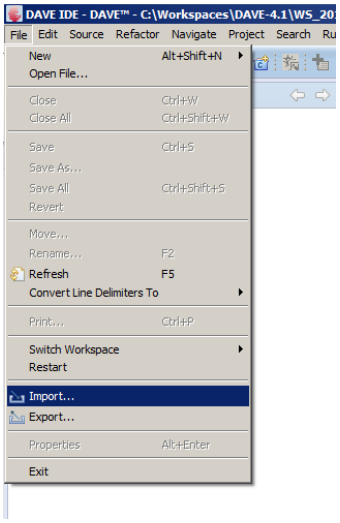

Figure 15 24V Protected Switch Shield connectors

## 5.2.2 Getting started: Software

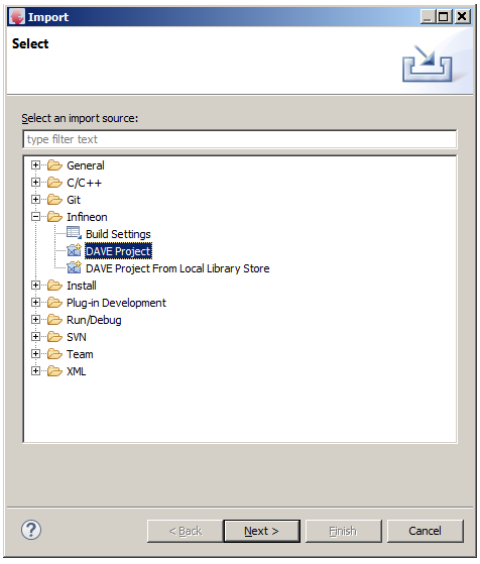
A simple example software for the XMC1100 Boot Kit is provided.

- Connect the XMC 1100 Boot Kit with a micro USB cable to the USB port of your PC.
- Download and install DAVE™ - Free Development Platform for Code Generation from the Infineon website DAVE™. Download the software example from the Infineon website: Infineon-24V_ProtectedSwitchShield_with_Profet+24V_for_Arduino_DAVE_Example_V10.zip-SW-v01_00-EN.zip
- Start DAVE™ and import project file "Infineon-24V_ProtectedSwitchShield_with_Profet+24V_for_Arduino_DAVE_Example_V10.zip-SW-v01_00-EN.zip":

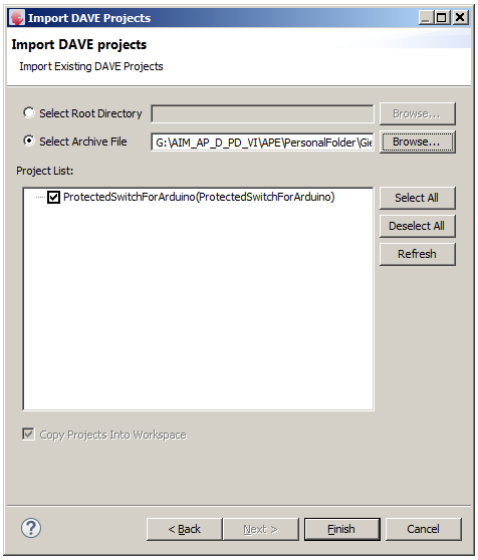
1: Select File → Import:



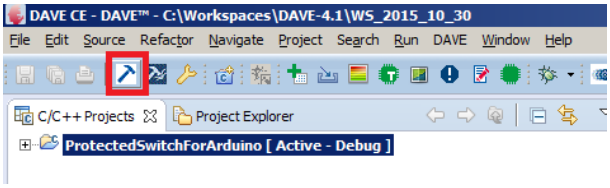

2: Choose Infineon→DAVE Project:



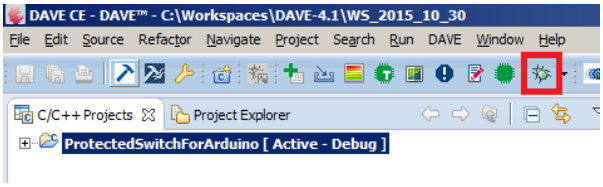

3: Select archive file→Browse for the downloaded file→select the project→click finish:



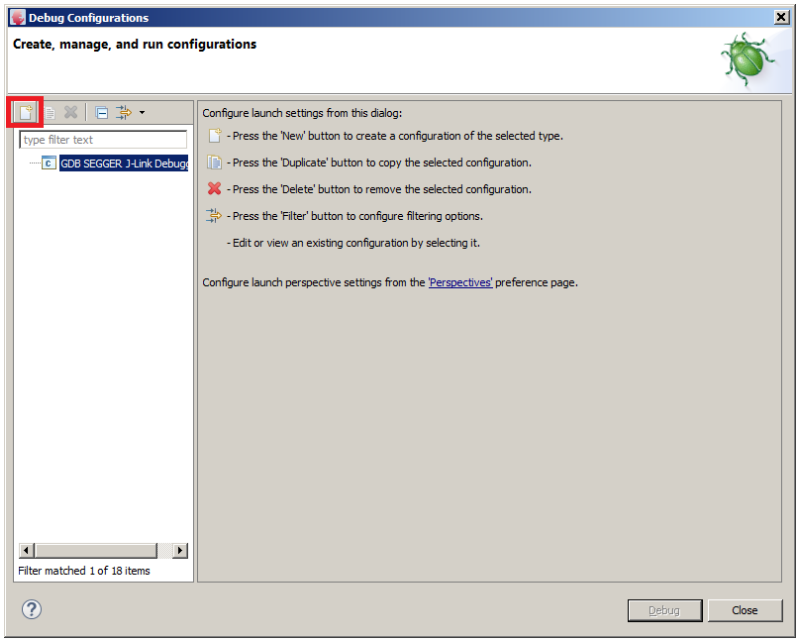

4: Build the code:



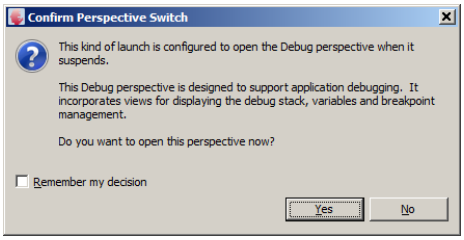

5: Start the Debugger



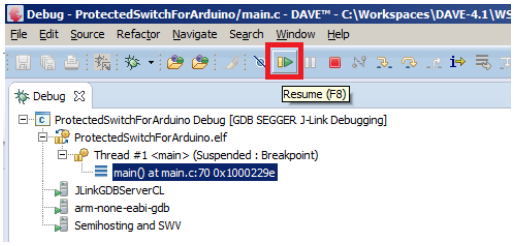

6: The first time you start the Software a new debug configuration needs to be created. Select the GDB SEGGER J-Link Debugger and click on new launch configuration. Keep all default values and click on Debug



7: Confirm the perspective switch




8: Run the code → the loads will be powered via PWM

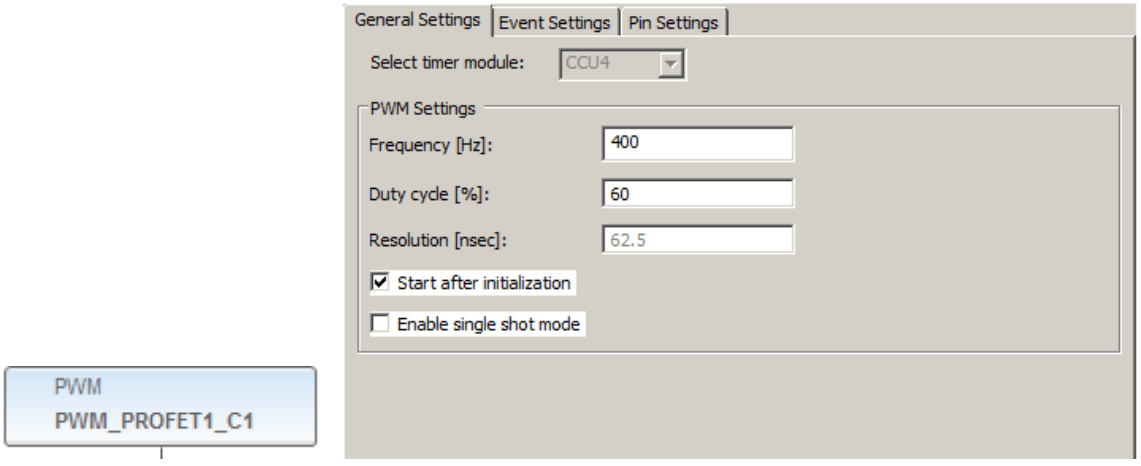



## 5.2.3 Software hints

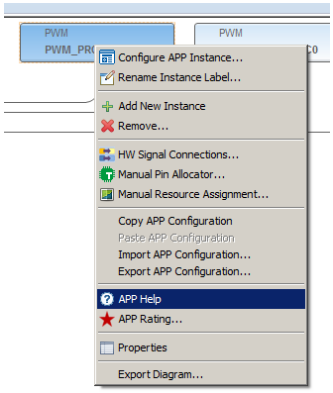
The Software will drive the 5 channels in different PWM configurations. Here is the mapping between Profet channel and PWM configuration:

| Channel | Dutycycle | Frequency |
|---|---|---|
| PROFET0 Channel 0 | 100% | --- |
| PROFET0 Channel 1 | 50% | 200Hz |
| PROFET1 Channel 0 | 75% | 320Hz |
| PROFET1 Channel 1 | 60% | 400Hz |
| PROFET2 | 80% | 120Hz |

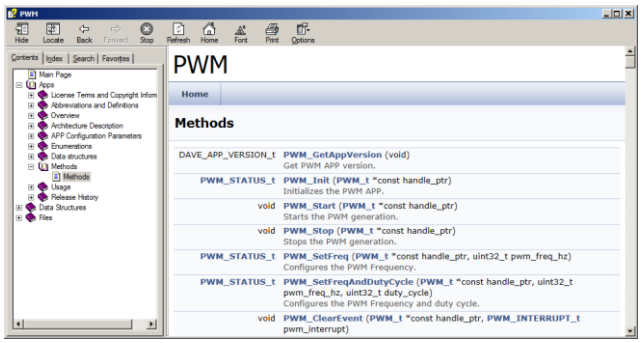
These values can be changed either via double click on the corresponding PWM APP:



Or during runtime using the API. To get information about the API right click on the APP and select APP Help:




The Help will open in a new Window. Selecting Apps → Methods shows a documentation of all available methods for this type of APP.




The Software does not only drive the loads in PWM. It also measures continuously the Sense signal and calculates out of it the load current during the high phase of the PWM period. The calculated currents are then stored in global variables enabling the user to process the values in his code e.g. for a protection strategy or to calculate the power consumption. For more details on how the load current is calculated check the documentation in the code. The provided software is an example and is not a reference software.

## Revision History

**Major changes since the last revision**

| Page or Reference | Description of change |
|---|---|
| V 1.0 | Created the document |
| | |
| | |

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