PROFET™+2 12V Arduino Shield

BTS7002-1EPP, BTS7004-1EPP, BTS7006-1EPP, BTS7008-1EPP

About this document

Scope and purpose

This document provides a quick introduction to the PROFET™+2 12V Arduino Shield. The Shield can be used to control and protect outputs of a 12 V supply, turn ON/OFF loads (e.g. bulbs, heating resistors, motor drives), measure the load current and detect no-load condition. The PROFET™+2 12V family targets high current automotive applications (e.g. ECU power feeds, auxiliary power outlets, heaters).

Intended audience

Customers requiring a user manual to the PROFET™+2 12V Arduino Shield.

Table of contents

1 Introduction

1.1 Overview

The PROFET™+2 Arduino Shield with BTS700x-1EPP adds advanced driving and diagnostic of generic loads to the Arduino projects. The shield can be controlled with general logic IO-Ports of a microcontroller. Either an Arduino Uno R3, the Arduino Due, the XMC™1100 Boot Kit or the more powerful XMC™4700 Relax Kit and XMC™4800 Relax Kit from Infineon can be used as the master.

The board is available in different variations of the Smart High-Side Power Switch, depending on which of Infineon's products the user wants to employ. Each one 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). All of them are single channel devices with a very small ON-state resistance (e.g. the BTS7002-1EPP with one 2.6 mΩ channel). The board can be bought with the following components:

- BTS7002-1EPP (Nominal load current: 21 A)
- BTS7004-1EPP (Nominal load current: 15 A)
- BTS7006-1EPP (Nominal load current: 12.5 A)
- BTS7008-1EPP (Nominal load current: 11 A)

The PROFET™+2 Arduino Shield can easily be connected to any Arduino compatible board like the XMC™1100 Boot Kit via headers.

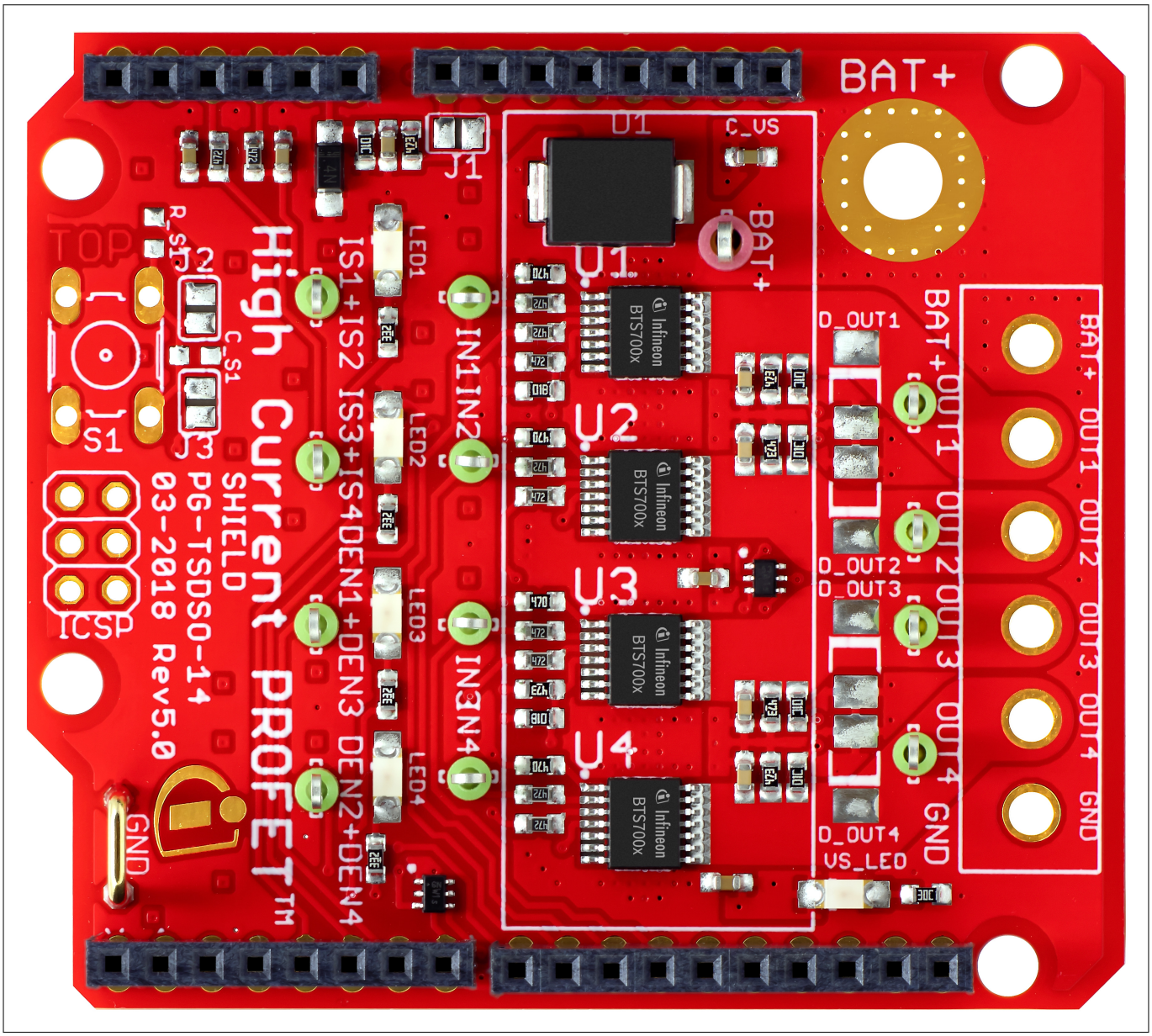

Figure 1 PROFET™+2 Arduino Shield

1.2 Key features

The PROFET™+2 Arduino Shield has the following features:

- Either an Arduino Uno R3, or an Arduino Due, or an XMC™ 1100 Boot Kit, or another similar board, connected to the shield, can control the four power channels via the general IO pins
- Drives resistive, capacitive and inductive loads with PWM or in DC (e.g. car bulbs, valves, motor 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: 4.1 V - 28 V; nominal range: 3.1 V - 35 V
  - Nominal current between 11 A per channel (BTS7008-1EPP) and 21 A (BTS7002-1EPP) per channel restricted due to the limited power dissipation of the PCB and the used PROFET™

  - PWM (Pulse Width Modulation) via input pins up to 400 Hz: higher frequencies are possible depending on load input voltage and duty cycle
  - A GND measuring bracket serves as an interface to attach GND terminals of measuring equipment (Oscilloscope-probe). And also for other signals there are test points (TP) to connect oscilloscope probes
- Diagnosis of the load/current feedback
  - Accurate feedback from the status of the load to the ADC of the microcontroller (current measurement and fault detection)
  - Open load detection in output state OFF for all four PROFET™ switches
  - Battery voltage monitoring via µC analogue pin and voltage divider
- Protection of load and driver circuit
  - Protection against overcurrent on the load side via diagnosis feedback
  - Absolute and dynamic temperature limitation with controlled reactivation
  - Overcurrent protection on the driver side with intelligent latch
  - Fault detection via IS pin
  - Protection against high transient voltages (ESD, ISO pulses)
  - Low conducted emission
  - Undervoltage protection
- Software
  - Demo-code available on GitHub (***https://github.com/Infineon***) -> PROFET™+2 12V

1.3 Block diagram

The ***Figure 2*** below depicts the block diagram of the PROFET™+2 Arduino Shield. The DEN pin of the devices U1+U3 and U2+U4 have been connected and this is illustrated within the block diagram by the green lines. The IS pin is routed once to GND via the RISx and once to µC via the RSENSEx. The IS pin of U1+U2 and the U3+U4 was connected and this is shown by the orange lines. Therefore it is only possible to use U1+U3 or U2+U4 at the same time to get a correct feedback at the IS pin. For more detailed explanations, see the schematic at the end of the user manual in the appendix.

1 Introduction

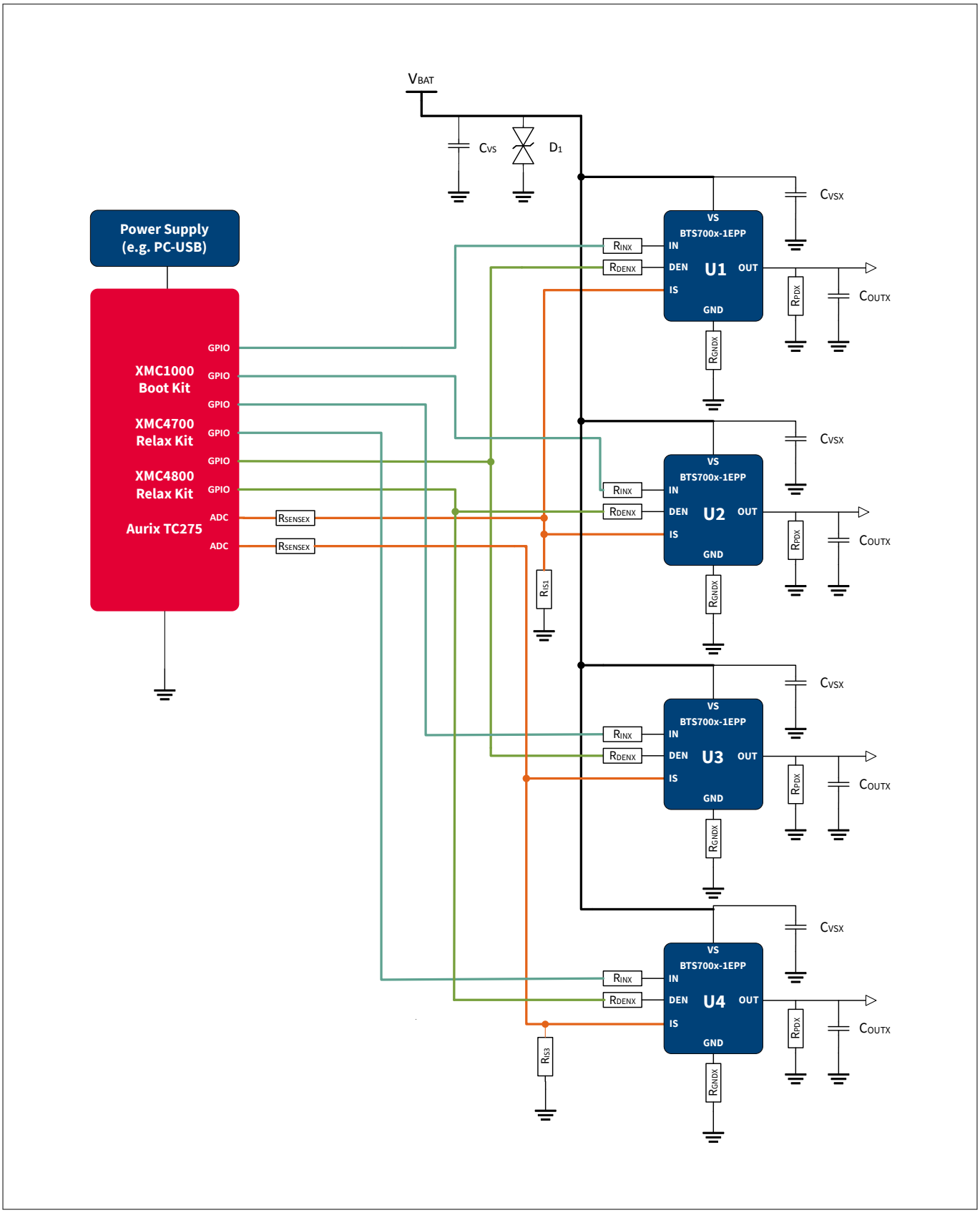

Figure 2 Block diagram

2 Board description

For a safe and sufficient functionality, discrete components are necessary: please refer to the datasheet to check which components are needed. The next ***Figure 3***, ***Figure 4*** and ***Figure 5*** show the schematics plus the corresponding layout of the PROFET™+2 Arduino Shield and the bill of materials (BOM). In the Appendix of the user manual are attached the schematics and the PCB layout.

2.1 Schematics

In the following ***Figure 3*** the schematics of the PROFET™+2 Arduino Shield are shown. The schematics are based on the application circuit in the BTS700x-1EPP datasheets.

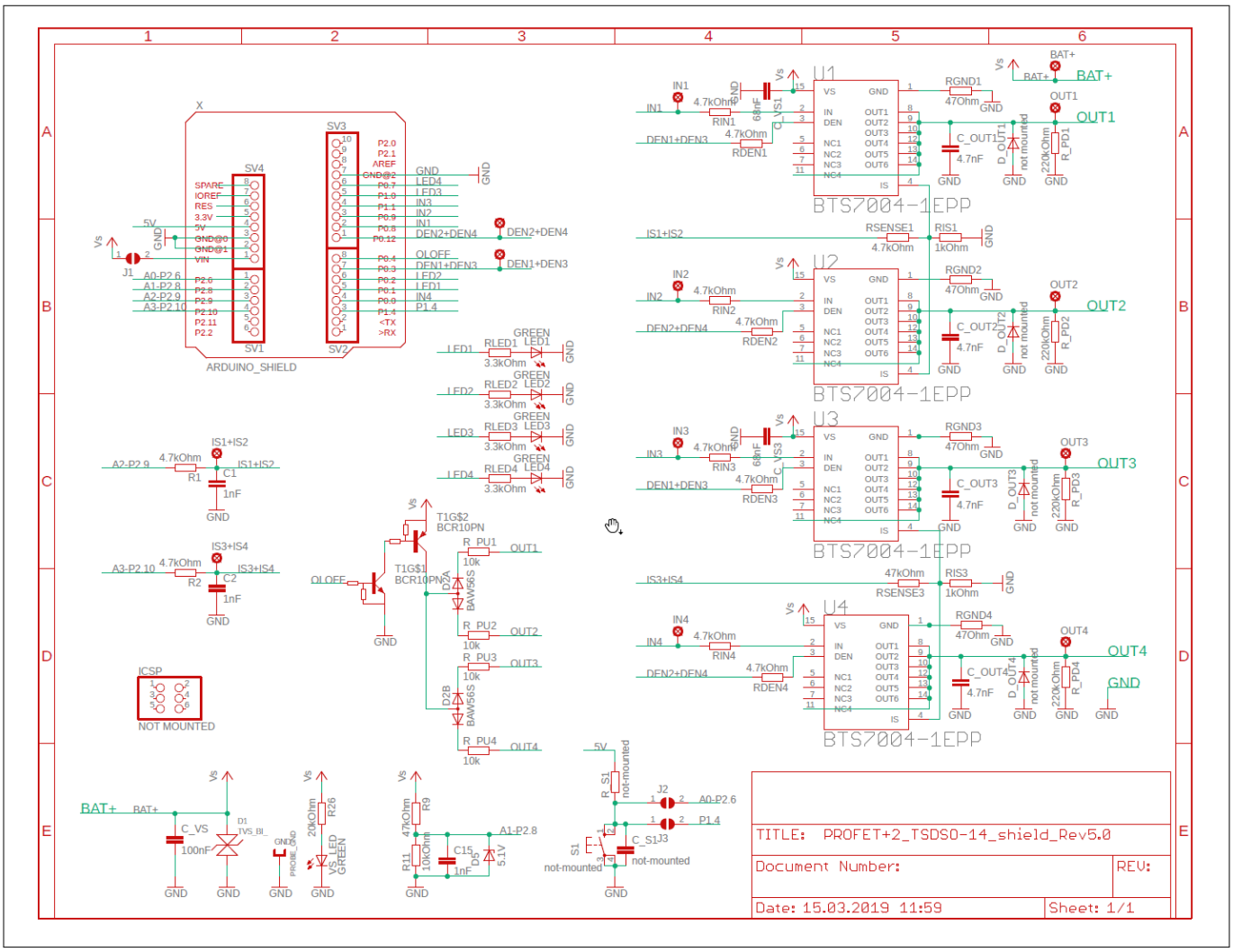

Figure 3 Schematics PROFET™+2 Arduino Shield

2.2 PCB layout

The next***Figure 4*** and ***Figure 5*** show the PCB layout of the PROFET™+2 Arduino Shield devided into top and bottom layers.

2 Board description

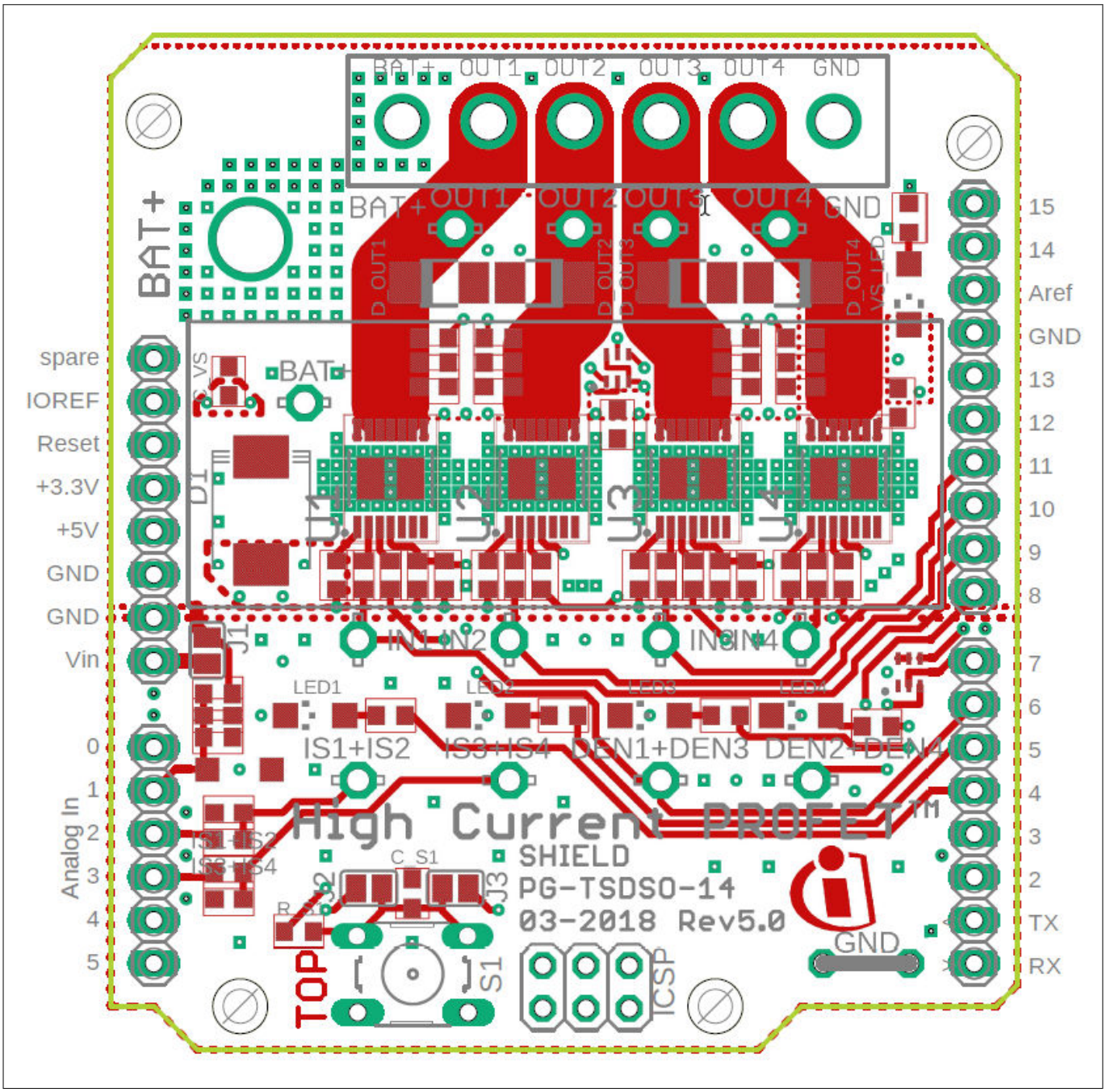

Figure 4 **PROFET™+2 Arduino Shield - Top layer**

2 Board description

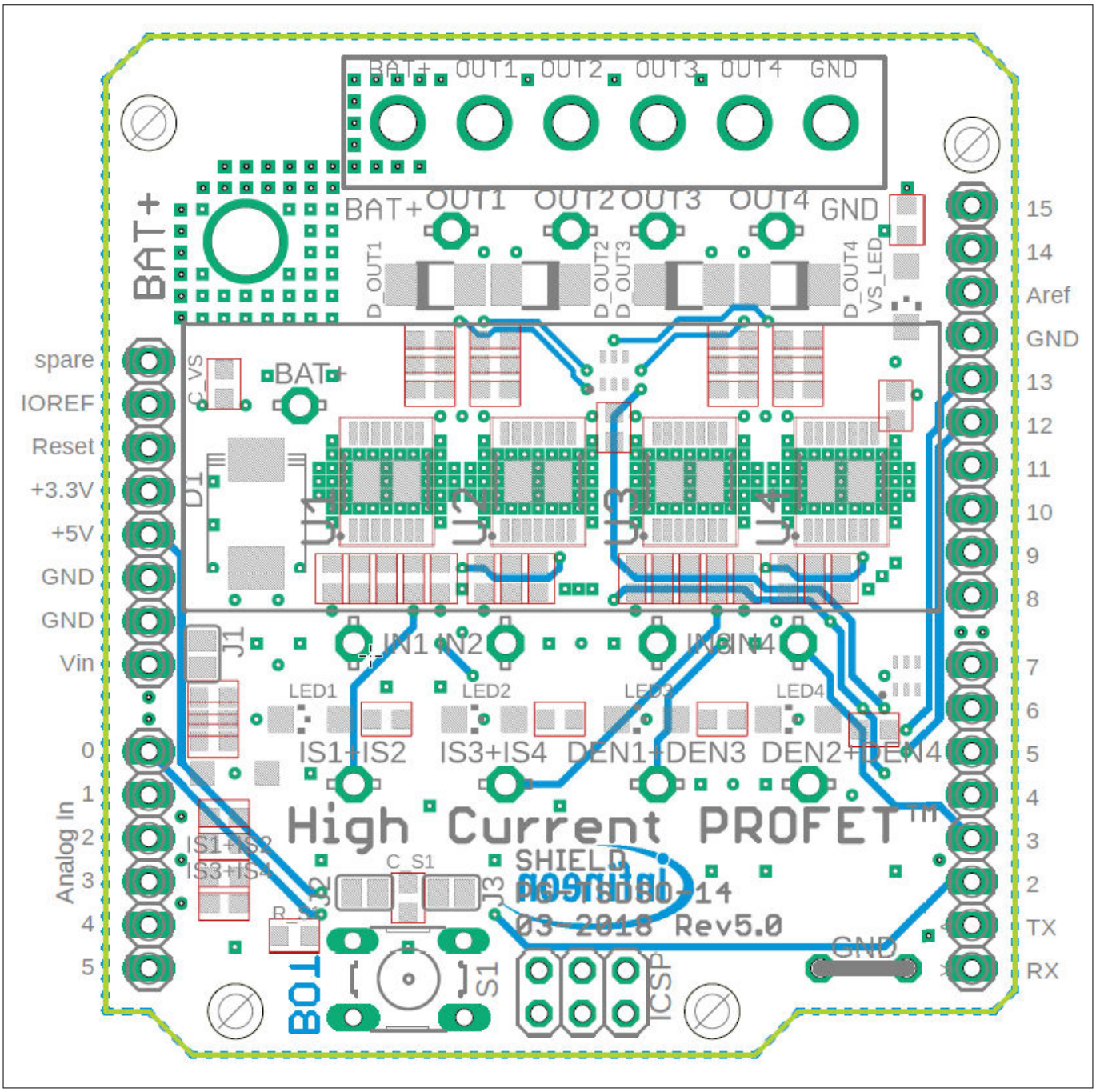

Figure 5 PROFET™+2 Arduino Shield - Bottom layer

2.3 Pin assignment

To use the PROFET™+2 Arduino 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 PROFET™ +2 Arduino 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. The ***Figure 6*** below shows the pin-out and the connectors of the PROFET™+2 Arduino Shield.

2 Board description

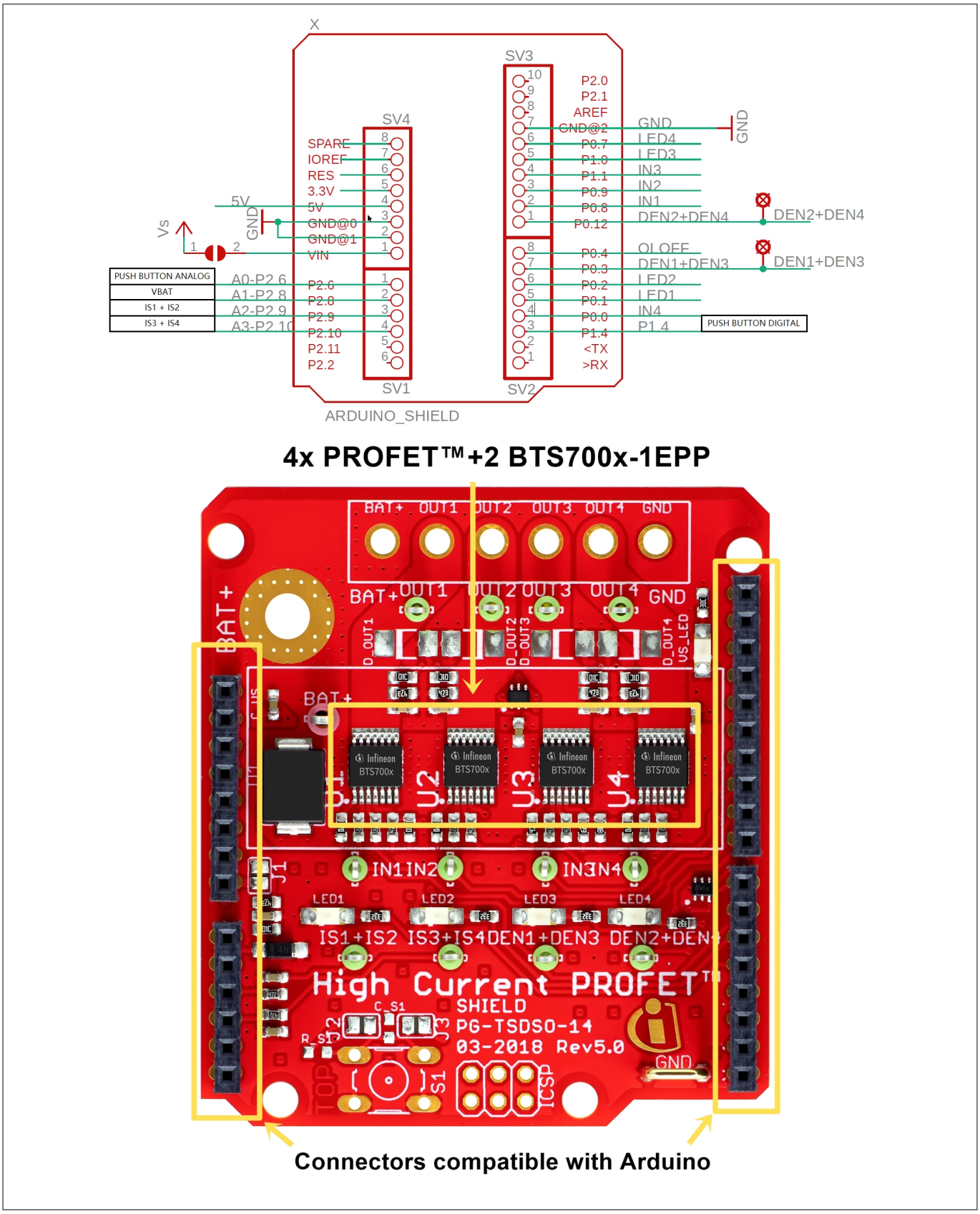

Figure 6 Pin-out and connectors

2.4 Pin definitions and functions

Table 1 Pin definitions and functions

PIN	Symbol	I/O	Function
D2	P1.4	I	Push button digital (optional)
D3	IN4	O	Input PROFET™+2 device U4
D4	LED1	O	Indicator LED1
D5	LED2	O	Indicator LED2
D6	DEN1+DEN3	O	Diagnosis enable PROFET™+2 Device U1+U3
D7	OLOFF	O	Option for Open Load in OFF Detection
D8	DEN2+DEN4	O	Diagnosis enable PROFET™+2 Device U2+U4
D9	IN1	O	Input PROFET™+2 device U1
D10	IN2	O	Input PROFET™+2 device U2
D11	IN3	O	Input PROFET™+2 device U3
D12	LED3	O	Indicator LED3
D13	LED4	O	Indicator LED4
GND@2	GND	-	Ground
GND@1	GND	-	Ground
GND@0	GND	-	Ground
VIN	VIN	-	Supply voltage
A0	A0 - P2.6	I	Push button analog (optional)
A1	A1 - P2.8	I	V_{bat}
A2	A2 - P2.9	I	Current sense of PROFET™+2 device U1+U2
A3	A3 - P2.10	I	Current sense of PROFET™+2 device U3+U4

2.5 Additional information

The following chapters give the user in-depth information about the board's special features.

2.5.1 Open Load in OFF Detection (OLOFF)

For some loads, it may be necessary to check their availability without powering them up. For example, it may be necessary to check if bulbs or LEDS (or the cable they are connected to) are intact or broken, without creating a flash light by switching them on.

In the example circuitry in ***Figure 7*** below, a small current (few milliamperes) is injected into the output, powerful enough to pull up the output if there is no load connected, but not powerful enough to activate the load in a distrubing manner. If the output voltage of a PROFET™+2 12V becomes too high, drain-source voltage will be lower than $V_{DS(OLOFF)}$, and the PROFET™ will provide an open load signal $I_{IS(OLOFF)}$, if DEN = "high" while IN = "low".

To avoid continuous power losses in OFF state in open load condition, and to be able to distinguish open load from short-to-battery in OFF state, the pull-up circuitry must be deactivated.

2 Board description

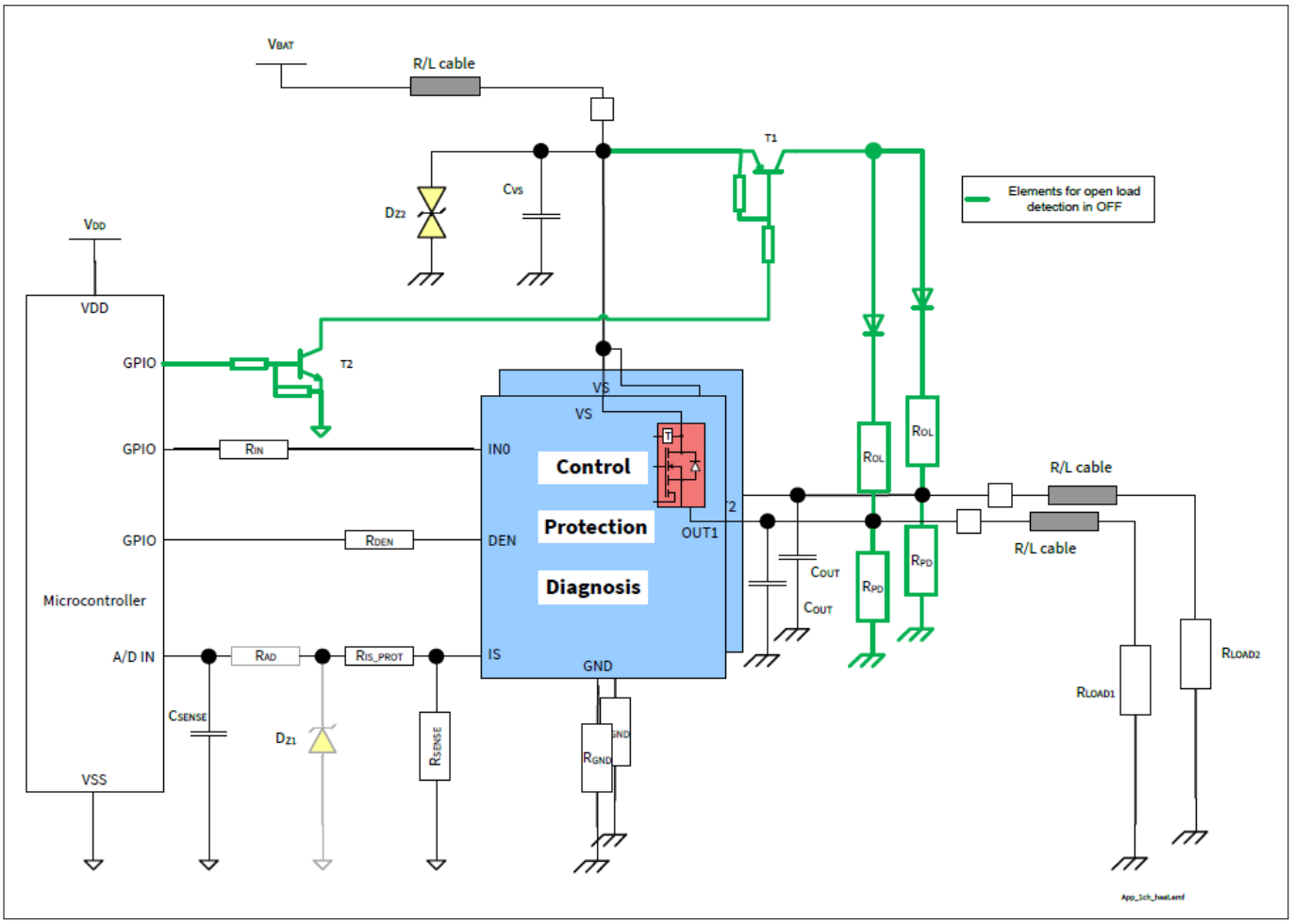

Figure 7 Application diagram with open load detection circuitry

Open load in OFF software flow principle:

- IN = low; DEN = high;
- activate pull-up(OLOFF = high);
- read IS(A2 - P2.9/A3 - P2.10) ;
- If IS = IIS(OLOFF)
- deactivate pull-up(OLOFF = low);
- read IS (A2 - P2.9/A3 - P2.10);
- If IS = $I_{IS(OLOFF)}$
- short-to-battery detected;
- else open load detected;
- else
- if IS = $I_{IS(fault)}$
- short-to-ground or overtemperature detected;
- else
- normal load condition detected;
- deactivate pull-up (OLOFF = low);
- end;

The limits of the pull-up current reflect the maximum allowed load current, which does not activate the load. That depends strongly on the load, and has to be adapted accordingly. As leakage currents battery-to-output (for example, output leakage current IL(OFF)) and output-to-GND may occur in a system, resistors for pull-up and pull-down may be needed.

For more information see our product datasheet of the PROFET™+2 BTS700x-1EPP and carefully read the Application Notes "PROFET™+ 12V 'What the designer should know'" and "PROFET™+ current sense 'What the designer should know'".

2.5.2 Diagnosis and Sense (DEN and IS)

The Diagnosis Enable (DENx) and the current sense (ISx) are conntected in a way, that you can only use 2 different BTS700x-1EPP at a time (U1+U3 or U2+U4).

For example, in order to use the U1 and the U3 devices, the user has to put the diagnosis enable signal DEN1 + DEN3 high and ensure that DEN2 + DEN4 are at a low level. The user has also to check that the value at the current sense pins is correct.

The current sense outputs of the devices U1 and U2 are connected by sharing one ADC input of the microcontroller (analog input A2). The same applies to the devices U3 and U4 which are connected to the analog input A3.

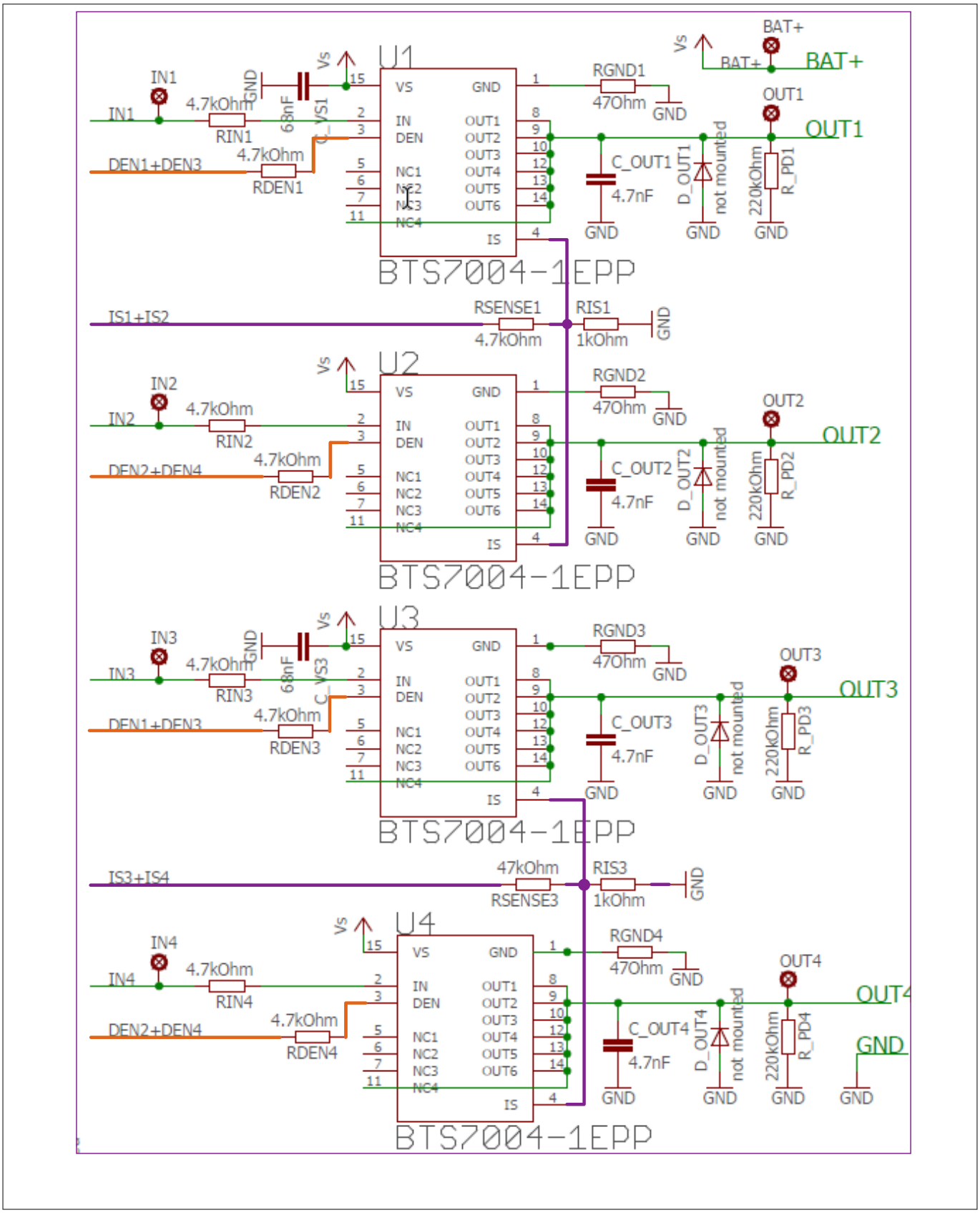

Figure 8 Diagnosis and Sense (DENx and ISx)

2.5.3 Battery voltage monitoring

The battery voltage can be measured with the board (voltage divider/analogue pin). The PROFET™+2 BTS700x-1EPP Arduino Shield provides the possibility to measure and monitor the V_{bat} voltage (Power Supply Voltage V_s: max. = 28 V).

The voltage divider for V_{bat} monitoring ensures that the analog input pin of the microcontroller (e.g. XMC1100™) doesn't get more than 5 V. Furthermore the zener diode D5 is protecting the V_{bat} input pin (A2) of the microcontroller against overvoltage. The ADC (analog/digital converter) inputs can get damaged by signals exceeding the input range specified in the electrical parameters. The inputs need to be protected all the time (during powered up as well as powered down state) to avoid damaging the ADC. The TVS diode D1 is limiting the power supply voltage for the PROFET™+2 devices and protect our PROFET™s from voltage transients.

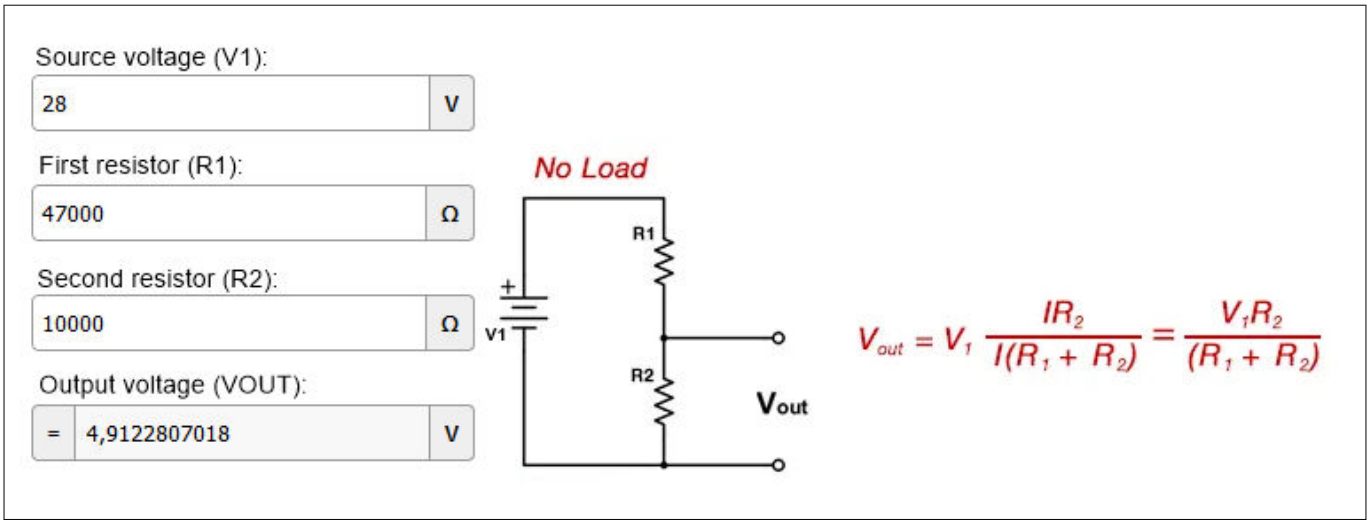

Figure 9 Voltage divider for V_{bat} monitoring

2.5.4 Supply options

If jumper J1 is connected, the microcontroller board is powered by BAT+. Otherwise, the user has always to connect the USB port to the microcontroller to supply the device. In case the user is employing the option of the connected jumper J1, then it has to be ensured that the installed LDO (voltage regulator) on the used microcontroller board (e.g. Arduino Uno, Aurix shield buddy, XMC™1100 boot kit, XMC™4700 Relax Kit ...) is able to withstand a maximum of 28 V.

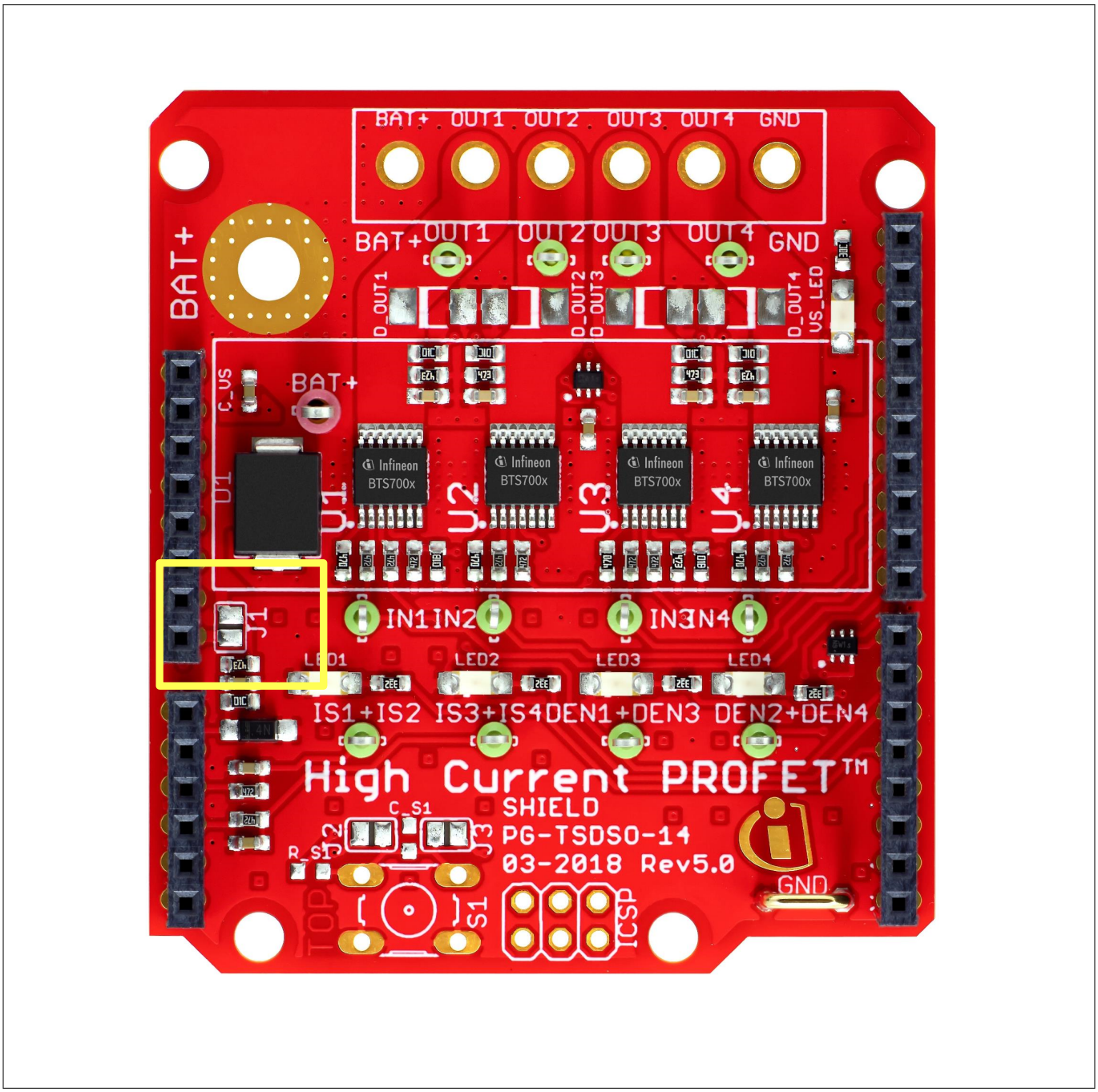

Figure 10 PROFET™+2 Arduino Shield with position of jumper J1

2.5.5 Push button (S1)

The option to solder a SMD push button at the placeholder S1 is also available. Additionally, a resistor(R_{S1}= 82 kOhm) and a capacitor (C_{S1} = 100 nF) are required to debounce the switch. Moreover, depending on the jumper J2/J3 setting, the push button is available either on the digital input D2 (P1.4) or on the analog input A0 (P2.6).

2 Board description

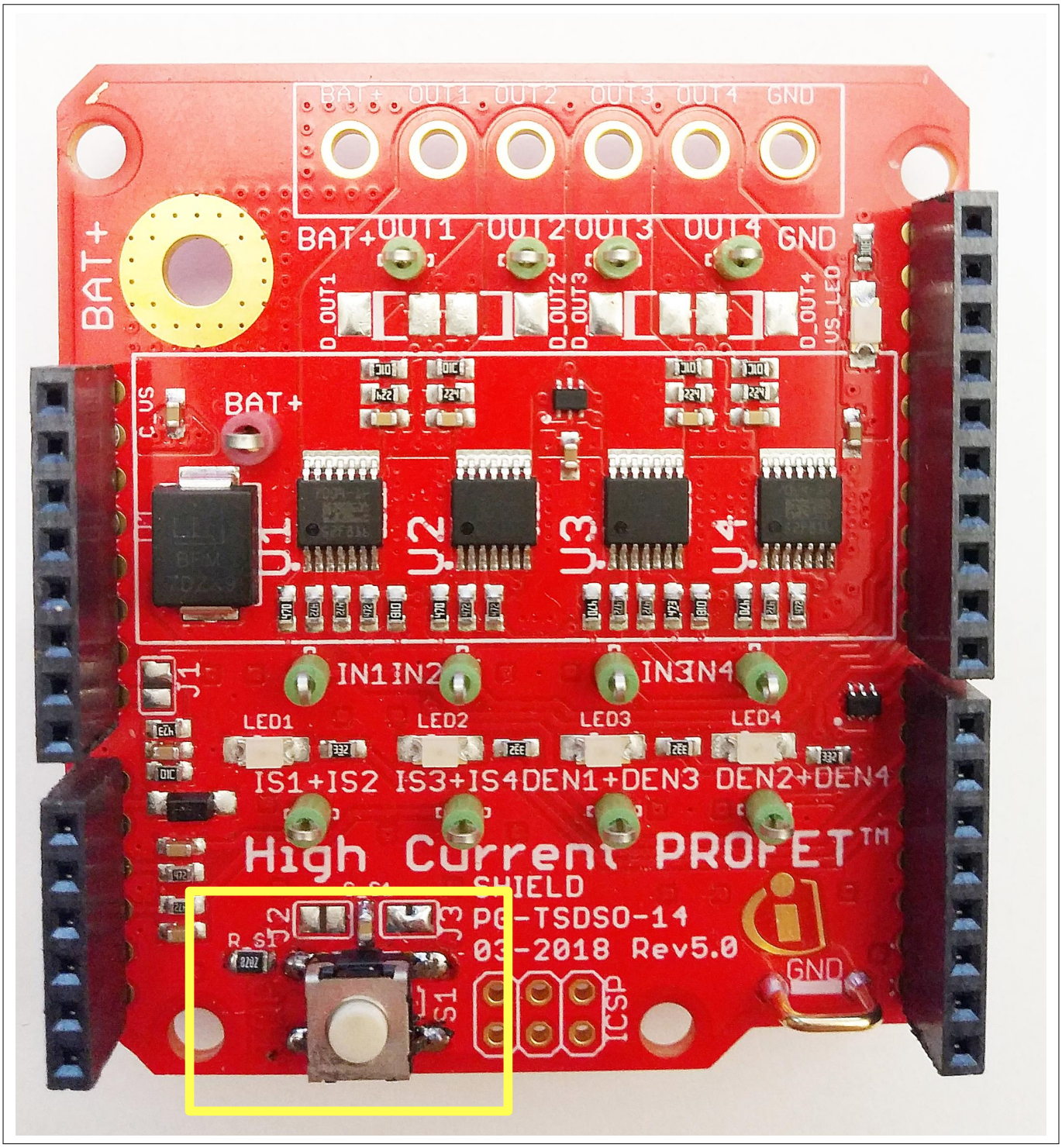

Figure 11 Push button positioning board

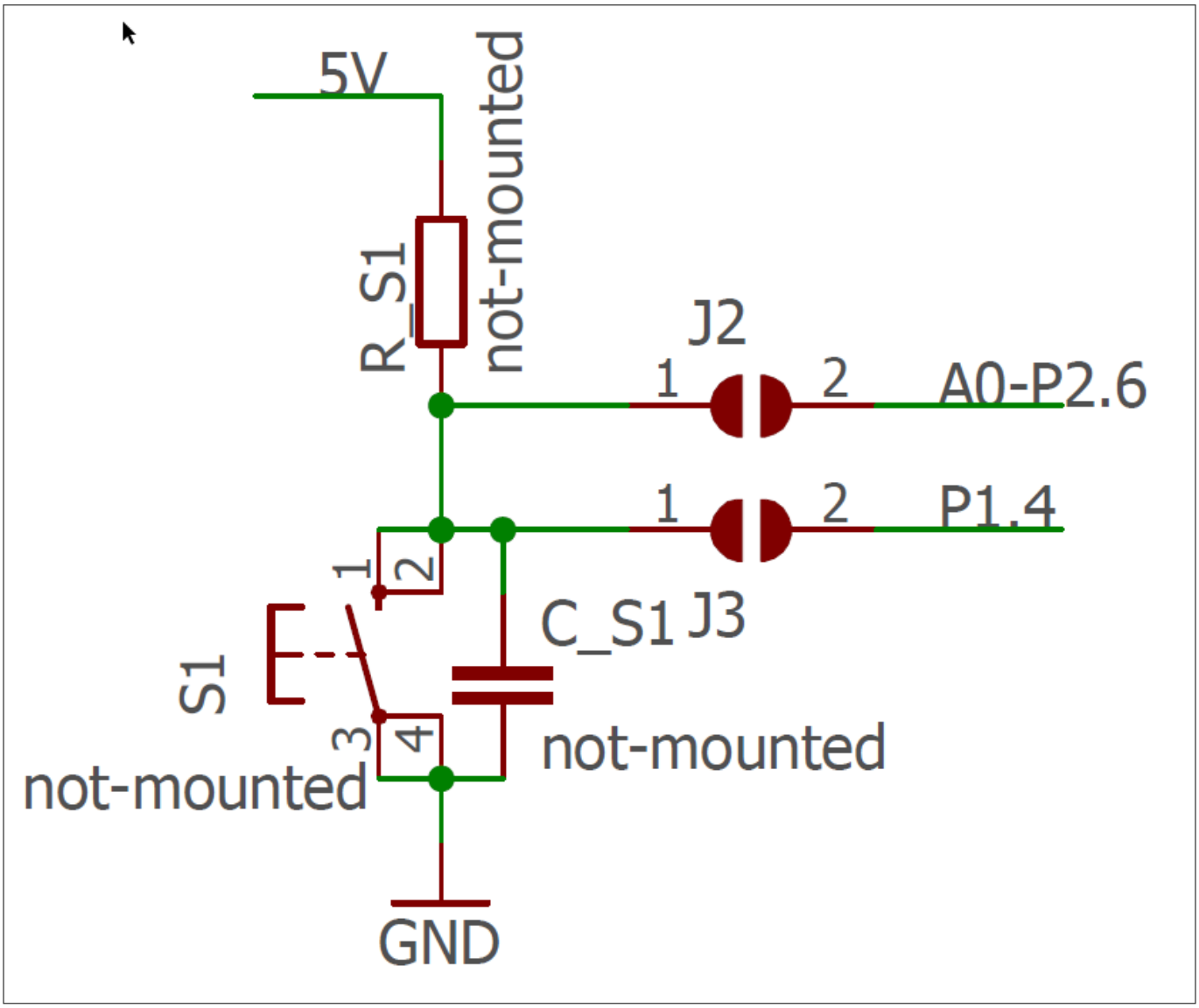

Figure 12 Push button positioning schematic

2.5.6 Free wheeling diode

If the use of inductive loads is required, then it is possible to mount a free wheeling diode at the channel outputs of the BTS700x-1EPP devices. The free wheeling diode eliminates flyback, which is the sudden voltage spike seen across an inductive load when its supply current is suddenly reduced or interrupted.

The diode has to be the of the size SMA (= DO_214AC), and should be placed at the position D_OUT1-4.

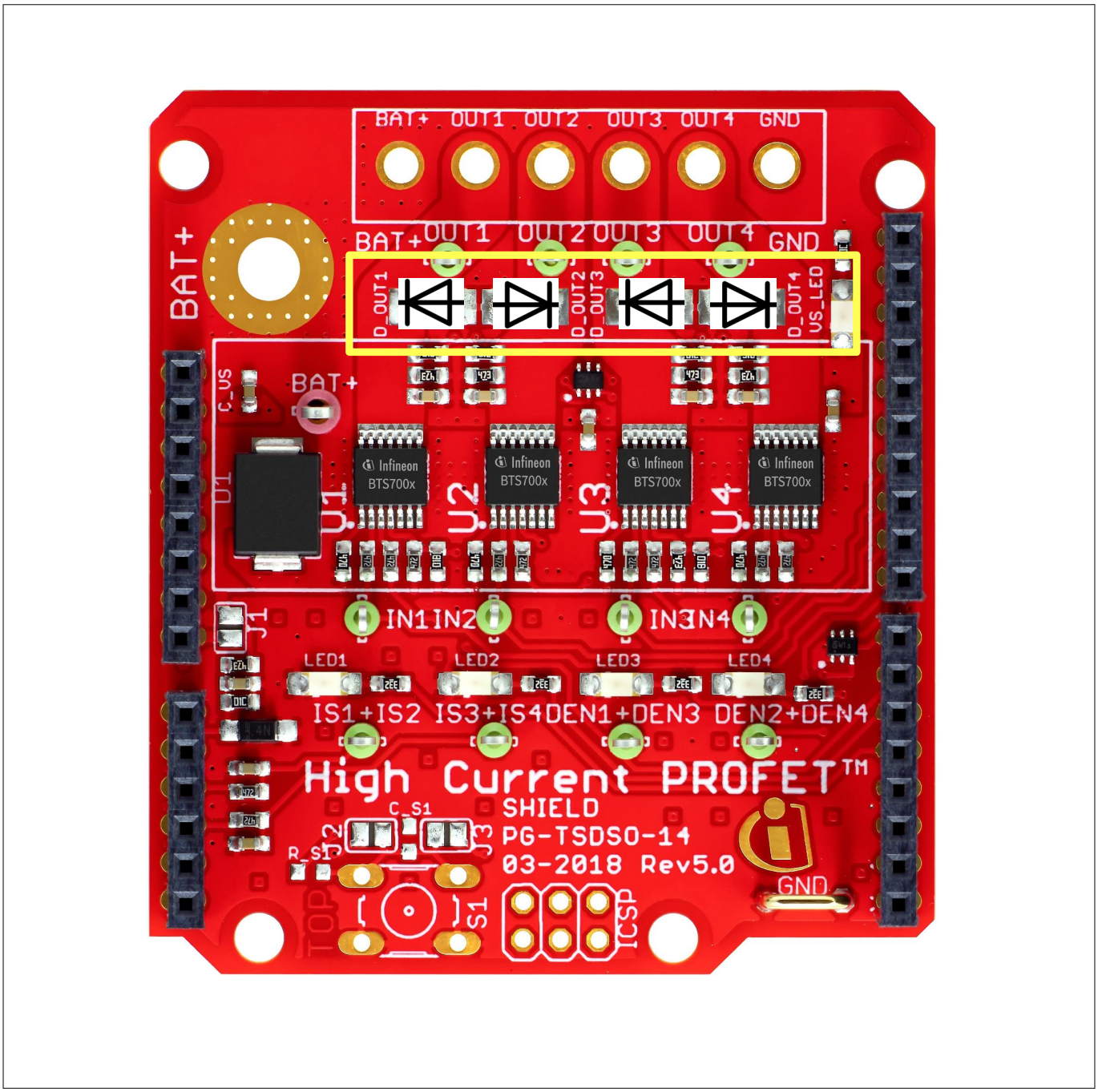

Figure 13 Positioning of free wheeling diodes

2.6 Bill of materials (BOM)

PROFET™+2 Arduino Shield - bill of materials (BOM)

Part	Value	Device	Package
BAT+	LSP13	LSP13	LSP13
C1	1 nF	C-EUC0603	C0603
C2	1 nF	C-EUC0603	C0603
C15	1 nF	C-EUC0603	C0603

2 Board description

Part	Value	Device	Package
C_OUT1	4.7 nF	C-EUC0603	C0603
C_OUT2	4.7 nF	C-EUC0603	C0603
C_OUT3	4.7 nF	C-EUC0603	C0603
C_OUT4	4.7 nF	C-EUC0603	C0603
C_S1	not mounted	C-EUC0603	C0603
C_VS	100 nF	C-EUC0603	C0603
C_VS1	68 nF	C-EUC0603	C0603
C_VS3	68 nF	C-EUC0603	C0603
D1	33 V	SMCJ33CA	SMC_JBEND
D2	BAW56S	BAW56S	INF-SOT363_V_1PRIMARY
D5	5.1 V	Z-DIODESOD123	SOD123
DEN1+DEN	3 LSP13	LSP13	LSP13
DEN2+DEN	4 LSP13	LSP13	LSP13
D_OUT1	not mounted	DIODE-DO-214AC	DO-214AC
D_OUT2	not mounted	DIODE-DO-214AC	DO-214AC
D_OUT3	not mounted	DIODE-DO-214AC	DO-214AC
D_OUT4	not mounted	DIODE-DO-214AC	DO-214AC
GND	PROBE_GND	MESSBUEGEL508	MESSBUEGEL508
ICSP	not mounted	PINHD-2X3	2X03
IN1	LSP13	LSP13	LSP13
IN2	LSP13	LSP13	LSP13
IN3	LSP13	LSP13	LSP13
IN4	LSP13	LSP13	LSP13
IS1+IS2	LSP13	LSP13	LSP13
IS3+IS4	LSP13	LSP13	LSP13
J1	open	solder_bridge	none
J2	open	solder_bridge	none
J3	open	solder_bridge	none
LED1	GREEN	LEDCHIPLED_1206	CHIPLED_1206
LED2	GREEN	LEDCHIPLED_1206	CHIPLED_1206
LED3	GREEN	LEDCHIPLED_1206	CHIPLED_1206
LED4	GREEN	LEDCHIPLED_1206	CHIPLED_1206
OUT1	LSP13	LSP13	LSP13
OUT2	LSP13	LSP13	LSP13
OUT3	LSP13	LSP13	LSP13

2 Board description

Part	Value	Device	Package
OUT4	LSP13	LSP13	LSP13
R1	4.7 kOhm	R-EU_R0603	R0603
R2	4.7 kOhm	R-EU_R0603	R0603
R9	47 kOhm	R-EU_R0603	R0603
R11	10 kOhm	R-EU_R0603	R0603
R26	20 kOhm	R-EU_R0603	R0603
RDEN1	4.7 kOhm	R-EU_R0603	R0603
RDEN2	4.7 kOhm	R-EU_R0603	R0603
RDEN3	4.7 kOhm	R-EU_R0603	R0603
RDEN4	4.7 kOhm	R-EU_R0603	R0603
RGND1	47 Ohm	R-EU_R0603	R0603
RGND2	47 Ohm	R-EU_R0603	R0603
RGND3	47 Ohm	R-EU_R0603	R0603
RGND4	47 Ohm	R-EU_R0603	R0603
RIN1	4.7 kOhm	R-EU_R0603	R0603
RIN2	4.7 kOhm	R-EU_R0603	R0603
RIN3	4.7 kOhm	R-EU_R0603	R0603
RIN4	4.7 kOhm	R-EU_R0603	R0603
RIS1	1 kOhm	R-EU_R0603	R0603
RIS3	1 kOhm	R-EU_R0603	R0603
RLED1	3.3 kOhm	R-EU_R0603	R0603
RLED2	3.3 kOhm	R-EU_R0603	R0603
RLED3	3.3 kOhm	R-EU_R0603	R0603
RLED4	3.3 kOhm	R-EU_R0603	R0603
RSENSE1	4.7 kOhm	R-EU_R0603	R0603
RSENSE3	47 kOhm	R-EU_R0603	R0603
R_PD1	220 kOhm	R-EU_R0603	R0603
R_PD2	220 kOhm	R-EU_R0603	R0603
R_PD3	220 kOhm	R-EU_R0603	R0603
R_PD4	220 kOhm	R-EU_R0603	R0603
R_PU1	10 kOhm	R-EU_R0603	R0603
R_PU2	10 kOhm	R-EU_R0603	R0603
R_PU3	10 kOhm	R-EU_R0603	R0603
R_PU4	10 kOhm	R-EU_R0603	R0603
R_S1	not-mounted	R-EU_R0603	R0603

2 Board description

Part	Value	Device	Package
S1	not-mounted	1002	B3S-1002 (OMRON)
SV1	1 row 6 pins	PINHD-1X6	1X06
SV2	1 row 8 pins	PINHD-1X8	1X08
SV3	1 row 10 pins	PINHD-1X10	1X10
SV4	1 row 8 pins	PINHD-1X8	1X08
T1	BCR10PN	BCR10PN	INF-SOT363_V_1PRIMARY
U1	BTS7004-1EPP	BTS7004-1EPP	SOP65P600X105-15N-1-V
U2	BTS7004-1EPP	BTS7004-1EPP	SOP65P600X105-15N-1-V
U3	BTS7004-1EPP	BTS7004-1EPP	SOP65P600X105-15N-1-V
U4	BTS7004-1EPP	BTS7004-1EPP	SOP65P600X105-15N-1-V
VS_LED	GREEN	LEDCHIPLED_1206	CHIPLED_1206

3 Appendix

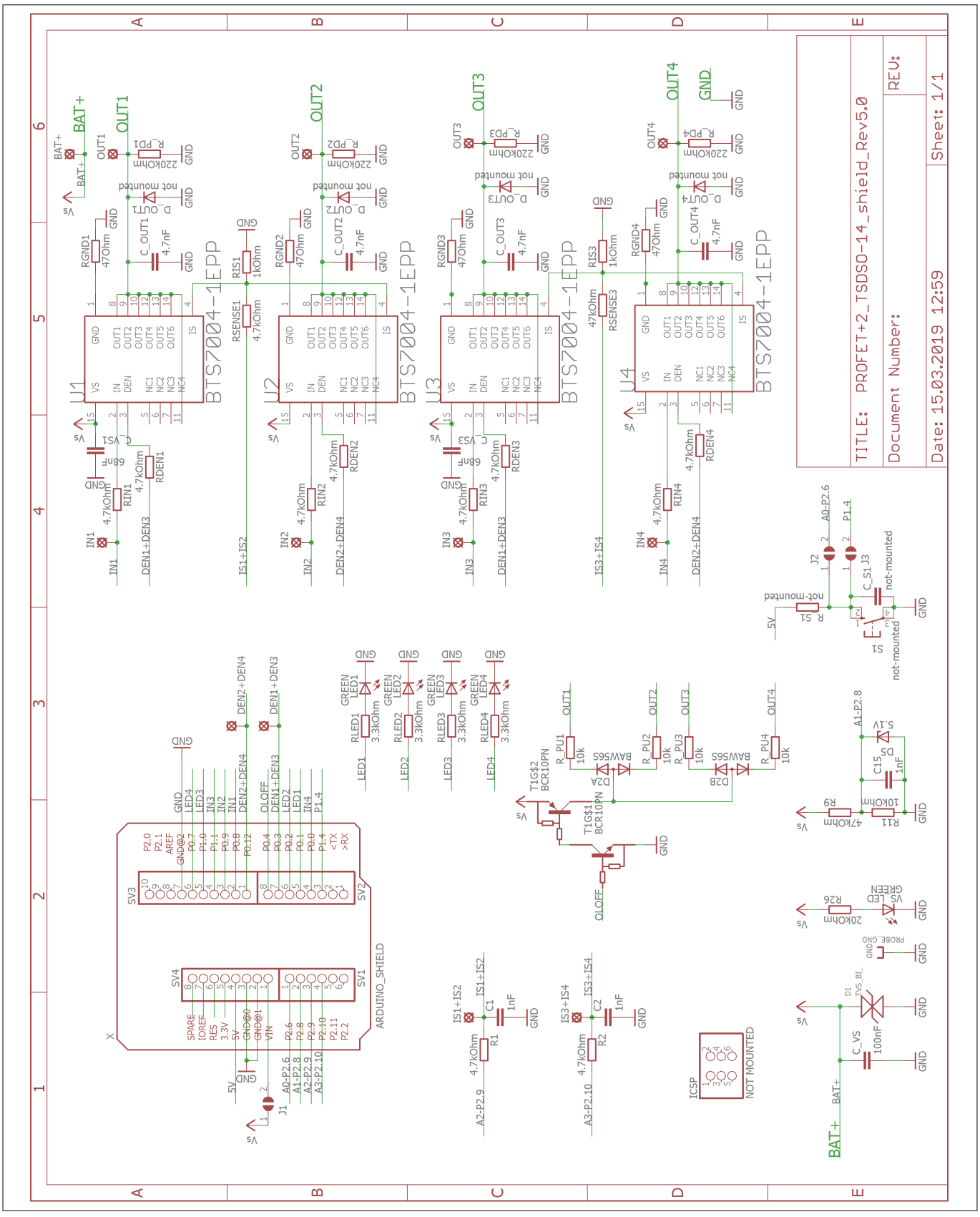

Figure 14 Appendix

Revision history

Document version	Date of release	Description of changes
1.00	2019-10-23	• User manual available

Trademarks

All referenced product or service names and trademarks are the property of their respective owners.

Edition 2019-10-23

Published by

Infineon Technologies AG

81726 Munich, Germany

Do you have a question about any aspect of this document?

Email: erratum@infineon.com

Document reference
IFX-hwz1563955817205

IMPORTANT NOTICE

The information contained in this application note is given as a hint for the implementation of the product only and shall in no event be regarded as a description or warranty of a certain functionality, condition or quality of the product. Before implementation of the product, the recipient of this application note must verify any function and other technical information given herein in the real application. Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind (including without limitation warranties of non-infringement of intellectual property rights of any third party) with respect to any and all information given in this application note.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

WARNINGS

Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury

X-ON Electronics

Largest Supplier of Electrical and Electronic Components

Click to view similar products for Power Management IC Development Tools ***category:***

Click to view products by Infineon ***manufacturer:***

Other Similar products are found below :

EVB-EP5348UI MIC23451-AAAYFL EV MIC5281YMME EV 124352-HMC860LP3E DA9063-EVAL ADP122-3.3-EVALZ ADP130-0.8-EVALZ ADP130-1.8-EVALZ ADP1740-1.5-EVALZ ADP1870-0.3-EVALZ ADP1874-0.3-EVALZ ADP199CB-EVALZ ADP2102-1.25-EVALZ ADP2102-1.875EVALZ ADP2102-1.8-EVALZ ADP2102-2-EVALZ ADP2102-3-EVALZ ADP2102-4-EVALZ AS3606-DB BQ25010EVM BQ3055EVM ISLUSBI2CKIT1Z LM2734YEVAL LP38512TS-1.8EV EVAL-ADM1186-1MBZ EVAL-ADM1186-2MBZ ADP122UJZ-REDYKIT ADP166Z-REDYKIT ADP170-1.8-EVALZ ADP171-EVALZ ADP1853-EVALZ ADP1873-0.3-EVALZ ADP198CP-EVALZ ADP2102-1.0-EVALZ ADP2102-1-EVALZ ADP2107-1.8-EVALZ ADP5020CP-EVALZ CC-ACC-DBMX-51 ATPL230A-EK MIC23250-S4YMT EV MIC26603YJL EV MIC33050-SYHL EV TPS60100EVM-131 TPS65010EVM-230 TPS71933-28EVM-213 TPS72728YFFEVM-407 TPS79318YEQEVM UCC28810EVM-002 XILINXPWR-083 LMR22007YMINI-EVM