PointhiBoard Dokumentation

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Contents

1 Einleitung

Der Raspberry Pi ist ein einfacher Einplatinencomputer, welcher ideal für komplexe Steuerungs-/Regelungs- aufgaben im Bereich der Robotik, Hausautomatisierung, und vielen anderen Bereichen ist.
Er zeichnet sich durch einen niedrigen Stromverbrauch in Verbindung mit einer großen Anzahl von Schnittstellen, angefangen von USB und LAN über Bussysteme wie SPI und I2C bis zu einzelnen Digitalen Ausgängen, welche mithilfe von Linux angesprochen werden können.
Die Nutzung der Low-Level Schnittstellen die an einer Stiftleiste herausgeführt sind gestaltet sich aber nicht immer Trivial, auch ist die Spannungsversorgung in Robotern nicht für eine zusätzliche Last mit bis zu 1A ausgelegt. Aus diesem und anderen Gründen soll daher ein Erweiterungsboard für den Raspberry Pi entstehen welches grundlegende Aufgaben übernimmt, die für Systeme in Steuerungssystemen notwendig erscheinen.

1.1 Überblick der Funktionen

Die Grundlegenden Ausstattung, die die Erweiterungsplatine besitzen soll, bzw. bereits besitzt.

- Effizienter Spannungsregler der Spannungen zwischen 7V-25V auf saubere 5V regelt
- Pegelwandler für I2C, um sich mit normaler 5V-Hardware zu verbinden
- Schnittstelle für LCD-Touch-Display auf SPI-Basis, welche später auch für SPI→CAN Konverter benutzt werden kann.
- Echtzeituhr (RTC), weil der Raspberry Pi keine besitzt, diese aber für diverse Anwendungen benötigt werden
- Spannungsüberwachung und Überstromschutz, um auch mit LiPo-Versorgung sicher zu arbeiten (Tiefentladeschutz)
- Digitale Ein/Ausgänge und 8 Analoge Eingänge um ohne zusätzlicher Erweiterungsboard bereits einfache Steuerungen zu realisieren.
- RS232-TTL Schnittstelle
- RN-Standard Steckverbinder mit Verriegelung, für einfache Erweiterbarkeit und Betriebssicherheit.

2 Technische Spezifikationen

2.1 Mechanische Spezifikationen

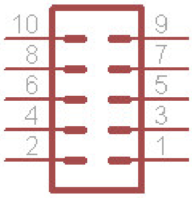
Characteristic	**Min**	**Typ.**	**Max**	**Units**
Breite	-	60	-	mm
Länge	-	110	-	mm

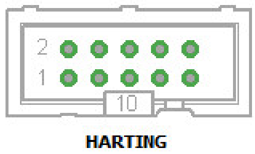
2.2 Elektrischer Spezifikationen

Characteristic	**Symbol**	**Test Conditions**	**Min**	**Typ.**	**Max**	**Units**
Versorgungsspannung	U_{IN}		8	12	20	V
Eingangsstrom	I_{IN}		-	-	8	A
Leerlaufstrom	I_{IN0}	$U_{IN} = 12V$	-	20	-	mA
Ausgangsspannung, 5V	U_{5V}		4.95	5	5.05	V
Ausgangsstrom, 5V	I_{5V}		-	-	2.5	A
Umgebungstemperatur			-10	20	50	$°C$

2.2.1 Steckverbinder

I2C

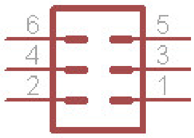


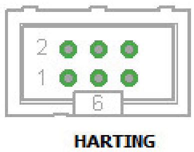


Der I2C-Stecker dient dazu Peripherie mit Spannung und einem Busdystem zu verbinden (I2c). Er ist gemäß den RN-Definitionen[1] belegt.

Pin 1	SCL (Taktleitung)
Pin 3	SDA (Datenleitung)
Pin 5,7	+5V
Pin 9	Batteriespannung
Pin 2,4,6,8	GND
Pin 10	INT

ICSP



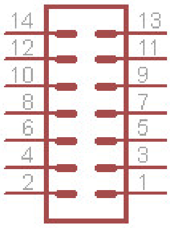


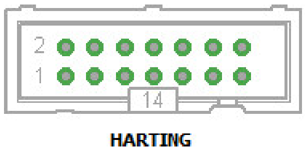
Der ICSP-Verbinder ist dazu vorhanden um den PIC mit einer Firmware beschreiben zu können. Er ist nicht als 5-Poligen Stiftleiste wie er oft realisiert wird ausgeführt, sondern als verpolungssicherer 6-Poliger Steckverbinder wie ich ihn in allen meinen anderen Schaltungen auch verwende.

Pin 1	PGD
Pin 2,4	VSS (GND)
Pin 3	PGC
Pin 5	VDD (+5V)
Pin 6	MCLRE/VPP

[1] http://www.rn-wissen.de/index.php/RN-Definitionen#I2C-Bus_Stecker

8-Bit Datenportstecker

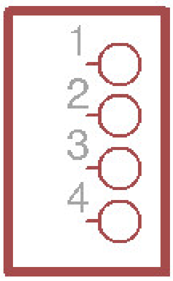


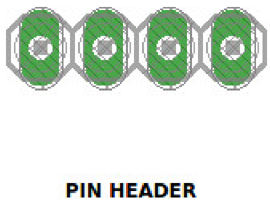


Es können hier 8 Signale übertragen werden, welche je nach Steckverbinder Analog oder Digital sein können.

Pin 1...8	PIN 0...7
Pin 9,11	+5V
Pin 10,12,14	GND
Pin 13	Batteriespannung

RS232-TTL





Der RS232-TTL-Stecker ist gemäß den RN-Definitionen[2] belegt.

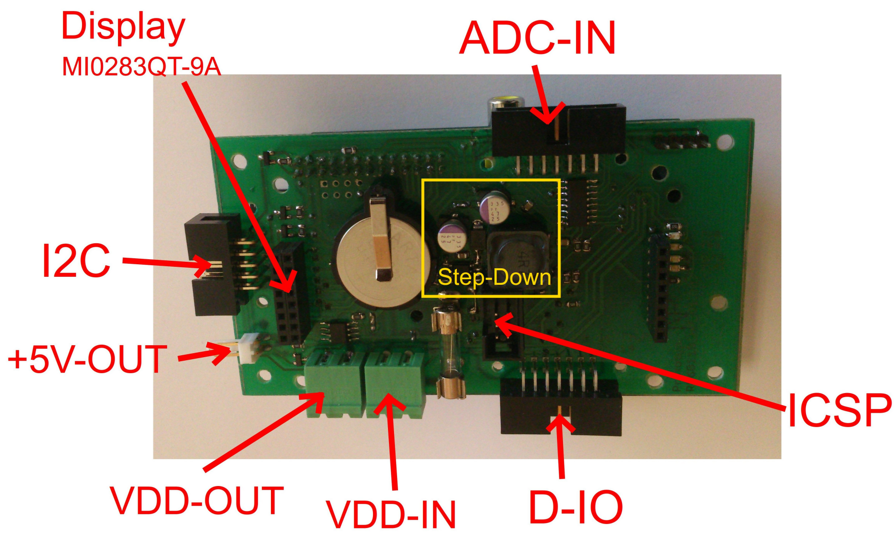
Pin 1	RX
Pin 2	TX
Pin 3	GND
Pin 4	+5V

[2] http://www.rn-wissen.de/index.php/RN-Definitionen#RS232_TTL_Stecker

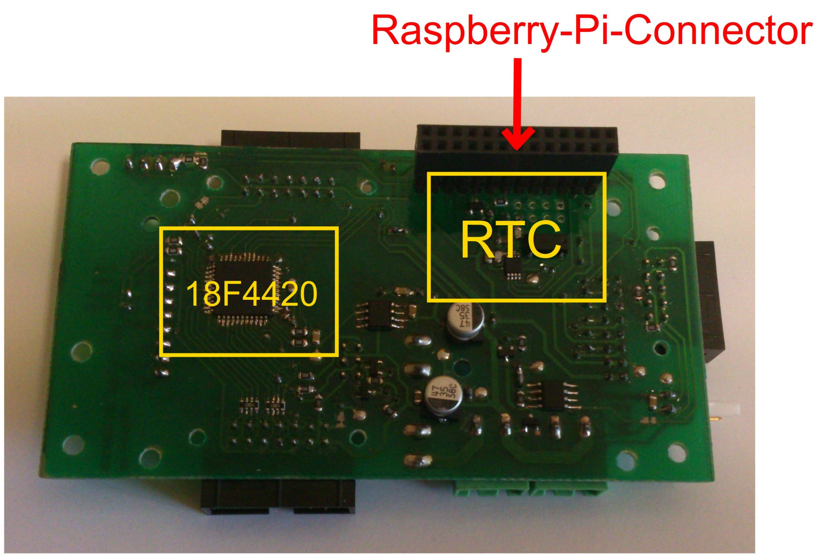
3 Platine

3.1 Übersicht

3.1.1 Top-Layer



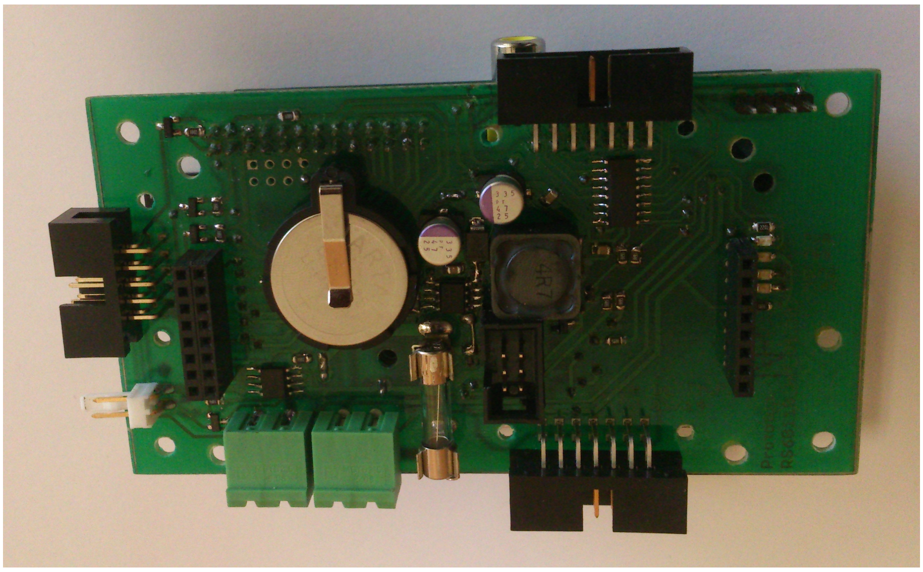
3.1.2 Bottom-Layer



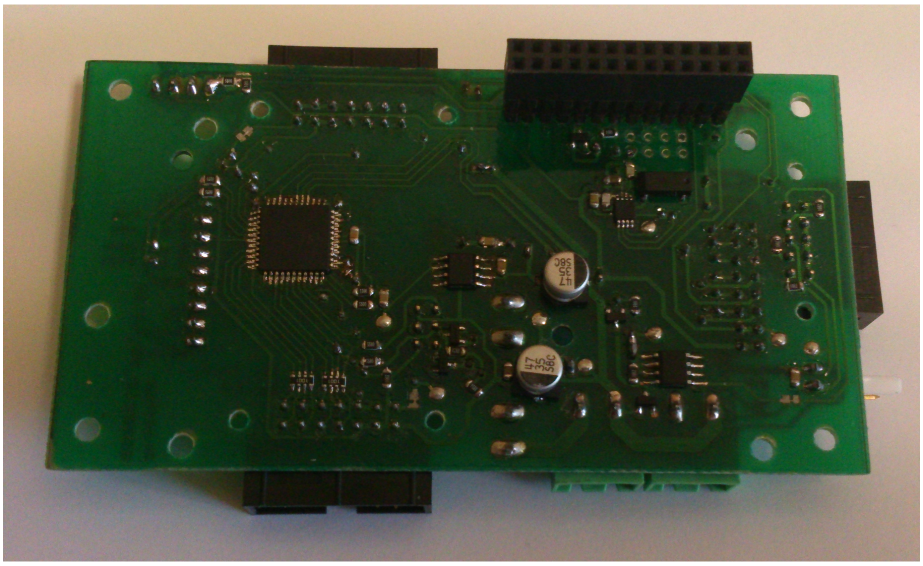
3.2 Bestückung

Es sollten zuerst alle SMD-Bauteile auf dem Bottom-Layer, danach die auf dem Top-Layer bestückt werden. Am Schluss werden noch alle Steckverbinder und die Batteriehalterung angelötet, wobei die große Buchsenleiste, die mit dem Raspberry Pi verbunden wird als letztes angelötet werden sollte.

3.2.1 Top-Layer



3.2.2 Bottom-Layer



4 Inbetriebnahme der Hardware

4.1 Flashen des Steuer-PIC

Es wird ein ICSP-Programmiergerät, welches einen PIC18F4420 flashen kann am Board angeschlossen (ICSP-Stecker). Der PIC sollte korrekt erkannt werden, und kann dann mit der Firmware beschrieben werden.

4.2 Testen des Step-Down-Wandler

1. Es wird am Eingang des Board ein Netzteil mit folgenden Einstellungen angeschlossen: $I_{max} \simeq 100mA, U_a = 5V$

2. Am Spannungs-Ausgang für den Raspbery Pi wird ein Multimeter angeschlossen, welches eine Spannung von ungefähr 5V anzeigen sollte.

3. Jetzt wird die Spannung des Netzteiles langsam auf etwa 10-12V gesteigert, die Spannung am Multimeter darf dabei eine Spannung von 5,1-5,2V nicht überschreiten! Falls die Spannung höher als etwa 5,2V steigen sollte funktioniert der Step-Down-Wandler nicht ordnungsgemäß. Der Step-Down-Wandler auf der Platine muss überprüft und wenn möglich repariert werden. Eine zu hohe Spannung am 5V-Spannungskreis könnte ansonsten zu einer Beschädigung diverser Bauteile auf dieser, und anderen angeschlossenen Platinen führen.

4.3 Fehlerbehebung

Problem	**Fehlerursache**
Keine der Status-LED leuchtet auf	Board nicht korrekt angeschlossen
	Sicherung durchgebrannt
	PIC nicht/falsch geflasht
+5V, PWR-Led leuchtet nicht	Tiefentladeschutz aktiv (kurz aufleuchtende STAT-LED)
	MOSFET schaltet nicht durch

4.4 Testen der Hardware

Der PIC wird mit der speziellen TEST-Firmware beschrieben[3]. Dann werden die beiden 14-Poligen Stiftleisten 1:1 miteinander verbunden. Sobald das Board mit Spannung versorgt wird startet die Testroutine. Solange die Testroutine aktiv ist blinken beide Status-LEDs schnell. Wenn diese dann erfolgreich war, Leuchtet "STAT" dauerhaft. Falls die Testroutine fehlschlägt fängt die LED "INFO" zu blinken an.

[3] siehe Flashen des Steuer-PIC

5 Inbetriebnahme der Software

Hier ist die Konfiguration einen Raspberry Pi der 2. Revision beschrieben. Wenn ein Raspberry Pi der 1. Revision verwendet wird muss i2c-1 durch i2c-0 ersetzt werden! Das verwendete Distribution ist das oft verwende Wheezy, bei Arch und anderen Linux Derivaten kann die Konfiguration abweichen!

5.1 Aktivieren von I2C und SPI

1. In der Datei **/etc/modprobe.d/raspi-blacklist.conf** werden die beiden Schnittstellen aktiviert, indem die beiden Zeilen wie folgt auskommentiert werden:

```
#blacklist spi-bcm2708
#blacklist i2c-bcm2708
```

2. In der Datei **/etc/modules** werden dann folgende Module hinzugefügt:

```
snd-bcm2835
i2c-bcm2708
i2c-dev
```

5.2 Aktivieren der I2C-Echtzeituhr

1. Hinzufügen der folgenden Zeile in der Datei **/etc/modules**:

```
i2c:mcp7941x
```

2. Es werden 2. Zeilen in der Datei **/etc/rc.local** hinzugefügt (vor dem Befehl “exit 0“):

```
echo mcp7941x 0x6f > /sys/class/i2c-dev/i2c-1/device/
    new_device
hwclock -s
```

3. Jetzt kann man die fake-hwclock deaktivieren

```
sudo update-rc.d fake-hwclock remove
```

4. Jetzt wird der Raspberry Pi neu gestartet, und dann die aktuelle zeit wie folgt in UTC gesetzt (natürlich das Datum durch das aktuelle ersetzten):

```
sudo date -s "9 JAN 2014 12:00:00"
```

5. Beim Herunterfahren wird dann ab sofort die Zeit in die Echtzeituhr geschrieben, und beim nächsten Starten daraus ausgelesen.

---

http://www.100randomtasks.com/raspberry-pi-rtc

5.2.1 Fehlerbehebung

Falls wie bei mir die folgende Fehlermeldung hwclock: "ioctl(RTC_RD_TIMEE) to /dev/rtc0 to read the time failed: Invalid argument" auftritt, werden einfach die folgenden Befehle in die Shell der Reihe nach eingegeben:

```
hwclock -w
hwclock -s
hwclock -r
```

5.3 Aktivieren des LCD-Touch-Displays (MI0283QT-9A)

1. Download "FBTFT drivers as loadable modules. See 'Step-by-step' for loading drivers." https://github.com/notro/fbtft/wiki#image-download

   ```
   sudo wget https://raw.github.com/Hexxeh/rpi-update/
       master/rpi-update -O /usr/bin/rpi-update && sudo
       chmod +x /usr/bin/rpi-update
   ```

2. Dann wird der Repository-Pfad geändert und ein update durchgeführt.

   ```
   sudo REPO_URI=https://github.com/notro/rpi-firmware rpi
       -update
   sudo shutdown -r now
   ```

3. In der Datei **/etc/modules** werden dann folgende Module hinzugefügt:

   ```
   fbtft_device
   ads7846_device
   ```

4. In der Datei **/etc/modprobe.d/pointhiboard.conf** werden dann folgende Optionen definiert:

   ```
   options ads7846_device cs=0 speed=2000000 model=7846
       x_min=250 x_max=3780 y_min=160 y_max=3930
       pressure_max=255 x_plate_ohms=60 gpio_pendown=25
       keep_vref_on=1 swap_xy=1
   options fbtft_device cs=1 speed=16000000 fps=25 name=
       mi0283qt-9a gpios=reset:23,led:24 rotate=90
   ```

5. In der Datei **/etc/X11/xinit/xinitrc** wird dann folgendes vor . /etc/X11/Xsession eingefügt:

   ```
   DISPLAY=:0 xinput --set-prop 'ADS7846 Touchscreen' '
       Evdev Axis Inversion' 1 1
   ```

6. Damit die Konsole beim booten auf dem Display dargestellt wird, muss folgendes am ende in **/boot/cmdline.txt** hinzugefügt werden:

   ```
   fbcon=map:10 fbcon=font:ProFont6x11
   ```

---

http://lallafa.de/blog/2013/07/watterotts-new-rpi-shieldbridge
http://busware.de/tiki-index.php?page=CCD_Installation
http://www.raspberrypirobot.com/1-8-tft-lcd-display-raspberry-pi-expansion-board/

6 Linux-Bibliotek

Um auf den Controller zuzugreifen kann man meine kleine Bibliotek nutzen, welche alle notwendigen Funktionen besitzt um mit dem Steuerpic zu kommunizieren.

6.1 Installation

1. Der Inhalt des Ordners **lib** wird auf die SD-Karte des RaspberryPi kopiert (mithilfe eines USB-Stick, scp, FTP,...).

2. Es wird in das Verzeichnis **libPointhiBoard** gewechselt, und danach wird die Bibliotek gebaut:

```
make clean CONF=Release
make build CONF=Release
```

3. Dann kopiert man die erstelle Bibliotek und deren Include-Datei in ein anderes Verzeichnis:

```
sudo cp dist/Release/GNU-Linux-x86/libPointhiBoard.so /
    usr/local/lib/libPointhiBoard.so
sudo cp src/PointhiBoard.h /usr/local/include/
    PointhiBoard.h
```

4. Falls **/usr/local/lib** beim kompilieren von Software nicht durchsucht wird muss dieser pfad noch in **/etc/ld.so.conf** hinzugefügt werden:

```
sudo sh -c "echo '/usr/local/lib' >> /etc/ld.so.conf"
sudo ldconfig
```

7 PIC-Firmware

7.1 I2C

7.1.1 Schreiben

Das erste übertragene Byte setzt den Schreib/Lese-Index fest. Dieser wird dann nach jedem weiteren Schreib/Lesebefehl jeweils um 1 inkrementiert, solange er nicht durch eine neue Schreibübertragung neu gesetzt wurde.

Index	**Aktion**	**Information**
0x01	Setze TRISB	1... Eingang, 0... Ausgang
0x0F	Setze PORTB	1... High, 0... Low

7.1.2 Lesen

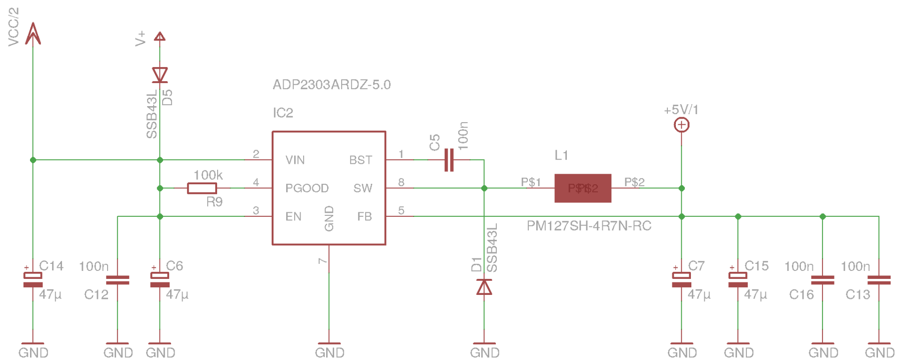
Je nach aktuellem Wert des Schreib/Lese-Index wird die jeweilige Variable ausgelesen, und danach der Schreib/Lese-Index um 1. Inkrementiert.

Index	**Aktion**	**Information**
0x01	Lese TRISB	1... Eingang, 0... Ausgang
0x0F	Lese PORTB	1... High, 0... Low
0x10	ADC - 0 VOLTAGE-HIGH-BYTE	
0x11	ADC - 0 VOLTAGE-LOW-BYTE	
0x12	ADC - 1 VOLTAGE-HIGH-BYTE	
0x13	ADC - 1 VOLTAGE-LOW-BYTE	
0x14	ADC - 2 VOLTAGE-HIGH-BYTE	
0x15	ADC - 2 VOLTAGE-LOW-BYTE	
0x16	ADC - 3 VOLTAGE-HIGH-BYTE	
0x17	ADC - 3 VOLTAGE-LOW-BYTE	
0x18	ADC - 4 VOLTAGE-HIGH-BYTE	
0x19	ADC - 4 VOLTAGE-LOW-BYTE	
0x1A	ADC - 5 VOLTAGE-HIGH-BYTE	
0x1B	ADC - 5 VOLTAGE-LOW-BYTE	
0x1C	ADC - 6 VOLTAGE-HIGH-BYTE	
0x1D	ADC - 6 VOLTAGE-LOW-BYTE	
0x1E	ADC - 7 VOLTAGE-HIGH-BYTE	
0x1F	ADC - 7 VOLTAGE-LOW-BYTE	
0x20	ADC - VCC VOLTAGE-HIGH-BYTE	
0x21	ADC - VCC VOLTAGE-LOW-BYTE	
0x22	ADC - +5V VOLTAGE-HIGH-BYTE	
0x23	ADC - +5V VOLTAGE-LOW-BYTE	

8 Anhänge

8.1 Schaltplanteile

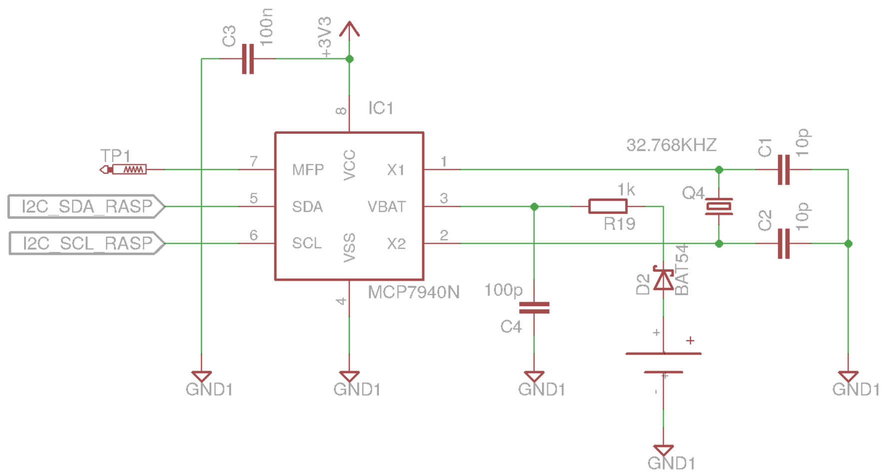
8.1.1 Step-Down-Wandler



Der Step-Down Wandler entspricht großteils der Beispielbeschaltung und Dimensionierung im Datenblatt. Abweichend zum Datenblatt wurden größere Kapazitäten am Eingang und Ausgang definiert, welche durch Paralellschaltung mehrerer Kondensatoren realisiert wurde um den ESR niedrig zu halten.

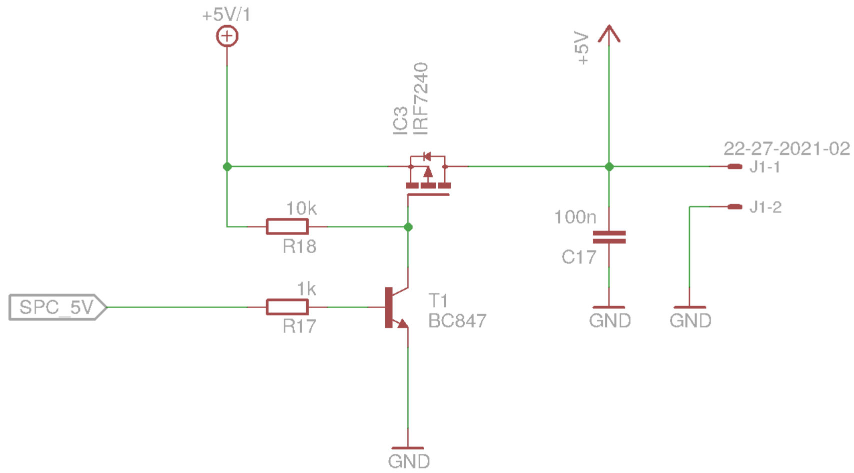
Die Spule ist Geschirmt um den Wirkungsgrad des Step-Down Wandlers niedrig zu halten, und besitzt einen Maximalstrom von etwa 8A um bei Strömen bis 3A sauber arbeiten zu können (Die Induktivität eines Schaltreglers sollte etwa 2-3 mal so viel aushalten wie eigentlich benötigt).

8.1.2 Echtzeituhr



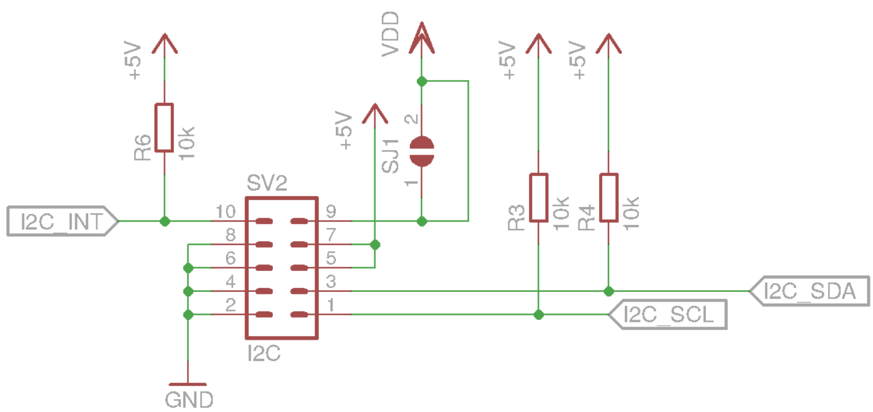
Es wird eine günstige Echtzeituhr genutzt, welche dank Lithium-Batterie auch ohne Versorgungsspannung ihre Zeit nicht verliert. Sie ist am 3,3V Bereich des I2C-Bus angeschlossen und entspricht in der Dimensionierung der Beispielbeschaltung.

8.1.3 FET-Treiber



Das ist eine grundlegende Schaltung um Spannungen ohne große Schaltverluste schalten zu können. Im Board wird diese Schaltung 2. Mal verwendet um im Tiefentladefall die Peripherie vollständig zu deaktivieren (inkl. RaspberryPi und allen an Steckverbinder angeschlossene Module)

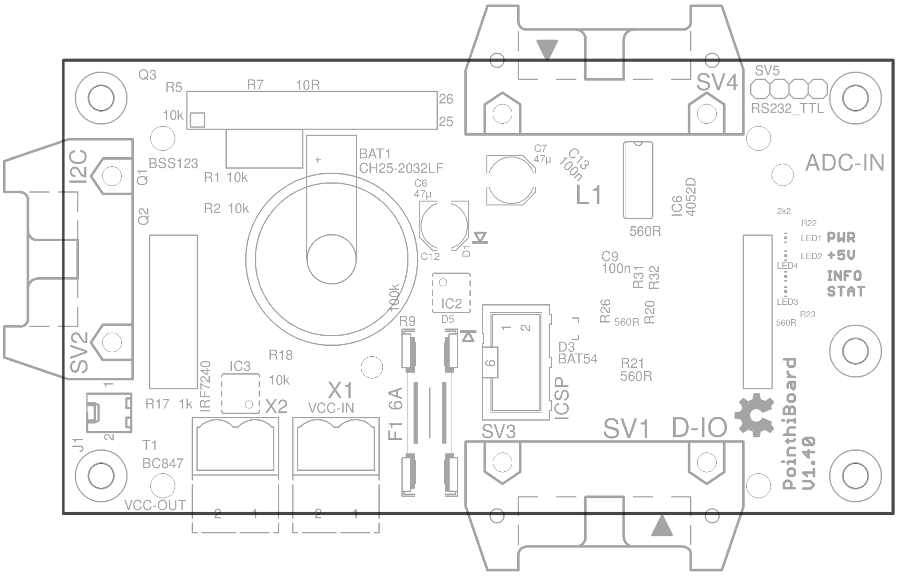
8.1.4 I2C-Steckverbinder + Pull-Up



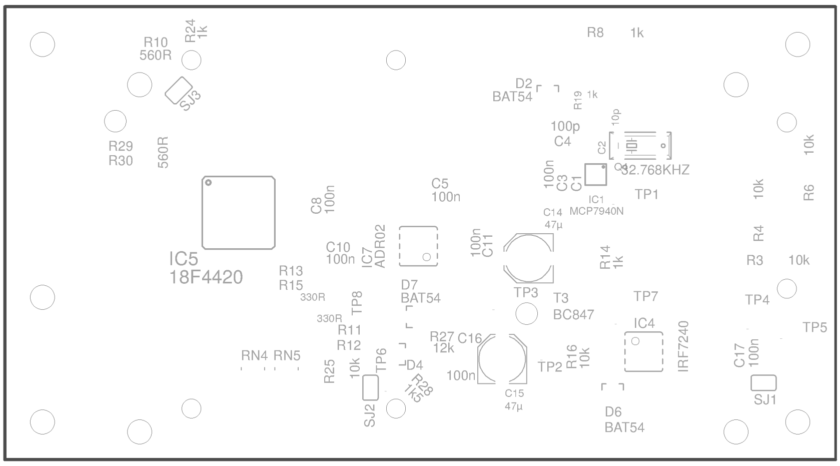
Der I2C-Steckverbinder ist die Hauptschnittstelle zum Anbinden zusätzlicher Peripherie. Sie ist nach RN-Standard belegt um eine kompalibität mit anderen Platinen zu gewährleisten.

8.2 Bestückungsplan

8.2.1 Top-Layer



8.2.2 Bottom-Layer



8.3 Stückliste

Part	Value	Package
BAT1	CH25-2032LF	CH25-2032LF
C1,C2	10p	C0805
C3,C4,C5,C8,C9,C10	100n	C0805
V11,C12,C13,C16,C17	100n	C0805
C6,C7,C14,C15	47	PANASONIC_D
D1	SSB43L	DO214AA
D2,D3,D4,D6,D7	BAT54	SOT23
D5	SSB43L	DO214AA
F1	6A	SHK20L
IC1	MCP7940N	MSOP8
IC2	ADP2303ARDZ-5.0	SOIC8
IC3,IC4	IRF7240	SOIC8
IC5	18F4420	TQFP44
IC6	4052D	SO16
IC7	ADR02	SOIC8
J1	22-27-2021-02	6410-02
L1	PM127SH-4R7N-RC	PM127SH
LCD1	MI0283QT-9A	MI0283QT-9A #TODO
LED1	RED	CHIP-LED0805
LED2	GREEN	CHIP-LED0805
LED3	BLUE	CHIP-LED0805
LED4	YELLOW	CHIP-LED0805
Q1,Q2,Q3	BSS123	SOT23
Q4	32.768KHZ	MM20SS
R7	10R	R0805
R11,R12,R13,R15	330R	R0805
R10,R20,R21,R23,R26	560R	R0805
R29,R30,R31,R32	560R	R0805
R8,R14,R17,R19,R24	1k	R0805
R28	1k5	R0805
R22	2k2	R0805
R1,R2,R3,R4,R5,R6	10k	R0805
R16,R18,R25	10k	R0805
R27	12k	R0805
R9	100k	R0805
RN4,RN5	EXB38V	resistor-dil
SJ1,SJ2,SJ3	SJ	jumper
SV2	I2C	3M_10L
SV1	D-IO	3M_14L
SV4	ADC-IN	3M_14L
SV3	ICSP	ML6
SV5	RS232_TTL	1X04
T1,T3	BC847	SOT23
X1	VCC-IN	MSTBV2
X2	VCC-OUT	MSTBV2

8.4 Bedienung des BusPirat

Der BusPirat[4] ist ein kompaktes Entwicklermodul zum Debuggen diverser Bussysteme. Er ist Open-Hardware, und kann in der Standardversion diverse Protokolle wie I2C, SPI, RS232, 1-Wire mitlesen und auch selber eigene Daten versenden.

Ich habe den BusPirat zum debuggen des I2C-Codes benutzt, und das hier stellt eine kurze Anleitung zur Inbetriebnahme dar.

8.4.1 Nötige Schritte zur Inbetriebnahme des I2C-Debugger

1. Einrichten des Terminals auf Ubuntu[5]
2. Konfiguration des BusPiraten über minicom

```
m
4
3
W
p
```

3. Herstellung der Elektrischen Verbindungen zum Board (SDA, SCL, GND)

8.4.2 Arbeiten mit dem I2C-Debugger

- Suche die mit dem Bus verbundenen I2C-Bausteine:

```
(1)
```

- I2C-Sniffer (bis 100kHz)

```
(2)
```

- Schreibe Daten zu einem I2C-Baustein:

```
[0xC0 0x01 0x00]
```

  Zuerst wird die Adresse geschrieben, danach kommen die zu übertragene Daten

- Lese Daten von einem I2C-Baustein:

```
[0xC1 r]
```

  Zuerst wird die Adresse geschrieben, danach kommt ein r:bitanzahl (funktioniert noch nicht ganz)

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http://dangerousprototypes.com/docs/I2C

[4] http://dangerousprototypes.com/bus-pirate-manual

[5] http://jumptuck.com/2010/01/20/using-the-bus-pirate-with-ubuntu

8.5 Lizenz

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