I2C Controlled 5 V Power Supply

Assembly and Operation Guide

Revision	1
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Jaakko Koivuniemi OH7BF

Notice
Draft version.

Contents

NOTE: The main purpose of this kit is in self education and hobby use. Careful building and good skills in electronics are needed to build the power supply. The power supply should be tested before connecting it to any computer unit. Only low DC input voltages 7 - 25 V can be used. The battery or power supply feeding this unit has to be protected with fuses at its output terminals.

1 Features

The main features of the 5 V/3 A I2C controlled power supply are:

- LM2576 switching regulator with low 52 kHz switching frequency
- high efficiency 70 - 80 %
- wide input voltage range 7 - 25 V (limited by C2, D1 and U1)
- continuous output current up to 2 A (or 3 A limited by D1)
- PIC12F675 micro-controller for timed operation with open source code (PiPIC)
- typical input voltage reading error 0.1 - 0.3 V
- has been tested with Raspberry Pi[1] I2C bus at 10 kHz using **pipicpowerd** daemon
- On/Off button switch
- USB-A connector and screw terminal for output power
- modular 4P4C connector for 10 - 20 kHz I2C control
- level translation FETs on I2C bus
- less than 1 mA consumption in power off state

The components needed for assembly are shown in the bill of material table below.

[1] Raspberry Pi is a trademark of the Raspberry Pi Foundation.

Reference	Qty	Value	Description	Package	Check
C1	1	1μF/35V	Tantalum Capacitor	C1V5	
C2	1	100μF/35V	Electrolyte Capacitor	C1V8	
C3	1	2.2μF/25V	Tantalum Capacitor	C1V5	
C4	1	1000μF/25V	Electrolyte Capacitor	C2V13	
C5	1	100nF/63V	Plastic Capacitor	C2	
D1	1	1N5822	Schottky Diode (2 A output current)	DO201AD	
D2	1	Red LED	Light Emitting Diode	LED-3MM	
D3	1	Green LED	Light Emitting Diode	LED-3MM	
H1	1	Heat Sink	6 °C/W		
J1	1	HE10 6 pins	Header to PiPIC		
J2	1	4P4C	Modular Connector	Black	
JP1	1	Jumper 2 pins	Power Always On		
JP2	1	Jumper 2 pins	Power to PIC		
JP3	1	Jumper 3 pins	Continuous Voltage Measurement/Only when GP5 High		
JP4	1	Jumper 2 pins	Power to Level Translation FETs		
JP5	1	Jumper 2 pins	Connect I2C Ground Wire		
L1	1	100μH/3A	Power Inductor	Toroid25C12	
P1	1	Screw Terminal	Power Input	T2	
P3	1	Screw Terminal	5 V Power Output	T2	
P4	1	USB-A Connector	5 V Power Output	USB-A2	
Q1, Q2	2	2N3904	NPN Transistor	TO-92	
Q3, Q4	2	BS170	N-Channel FET	TO-92	
R1	1	10kΩ	1/2 W 5 %	R4	
R2	1	1.5MΩ	1/2 W 5 %	R4	
R3, R9, R10	3	100kΩ	1/2 W 5 %	R4	
R4	1	1.2kΩ	1/2 W 5 %	R4	
R5, R7	2	1kΩ	1/2 W 5 %	R4	
R6	1	3.9kΩ	1/2 W 5 %	R4	
R8	1	2.2kΩ	1/2 W 5 %	R4	
SW1	1	Push Button Switch	PCB Mount	SW-PUSH-2x2	
U1	1	LP2950-30	Voltage Regulator 3.0 V	TO-92	
U2	1	LM2576T-ADJ	Voltage Regulator	TO-220	
U3	1	PIC12F675	Micro Controller	8 pin DIP	
VR1	1	2 A or 3 A	MicroFuse or Polyswitch	F2	
	1	Tulip Socket	for PIC12F675	8 pin DIP	
	5	M3×10 screws and nuts			
	4	Jumper			
	4	mounting spacers			

2 Assembly

1. Check that all the components on the bill of materials table are available.
2. Good soldering skills are needed for reliable long term operation of the power supply. The solder mask should prevent bridging accidentally two pads together, but this could still happen unless care is taken.
3. Check the printed circuit board (PCB) for any defects.
4. Start by soldering all the resistors R1 - R10 on the printed circuit board. The silk screen has reference designator for each of them, see Fig. 1. Verify the resistance values with a multimeter before soldering.
5. Install and solder the 8 pin socket for U3 PIC12F675. Note the correct alignment on the silk screen.
6. Solder the small plastic capacitor C5 and tantalum capacitors C1 and C3 in place. Note the correct polarity for the tantalum capacitors. The long lead is plus and the short negative lead is soldered to the ground plane of the PCB. The plus sign on the silk screen is very small for the tantalum capacitors. Check it again for correct polarity.
7. Install the header J1 and jumpers JP1–JP5. Solder them while checking that they stay in vertical position.
8. Verify the orientation of the bipolar transistors Q1 and Q2 from silk screen before soldering them. Do the same with FETs Q3 and Q4.
9. Solder the input and output power connectors P1 and P3 in place. Solder the output fuse VR1 in place.
10. Solder the green and red LEDs D2 and D3 in place. Long lead is anode (plus) and short cathode (minus).
11. Note carefully the polarity of the power diode D1 from the band marking on the PCB before soldering.
12. Check the polarity of the electrolyte capacitors C2 and C4 before soldering. The long lead is plus and short minus.
13. Solder the SW1 push button and modular connector J2 to the printed circuit board.
14. Solder the main power inductor L1 in place.
15. Solder the USB-A connector to the PCB.
16. Fix the U2 LM2576 on the heat sink with a M3 screw and nut. Insert the five pins into the holes on the PCB and solder the pads. Check that no solder bridges are formed between the pads.
17. Use the four M3 screws with the plastic spacers on the all the corner mounting holes to elevate the board from the table.
18. Revision 1 PCB needs one jumper wire soldered between transistor Q2 emitter and ground.

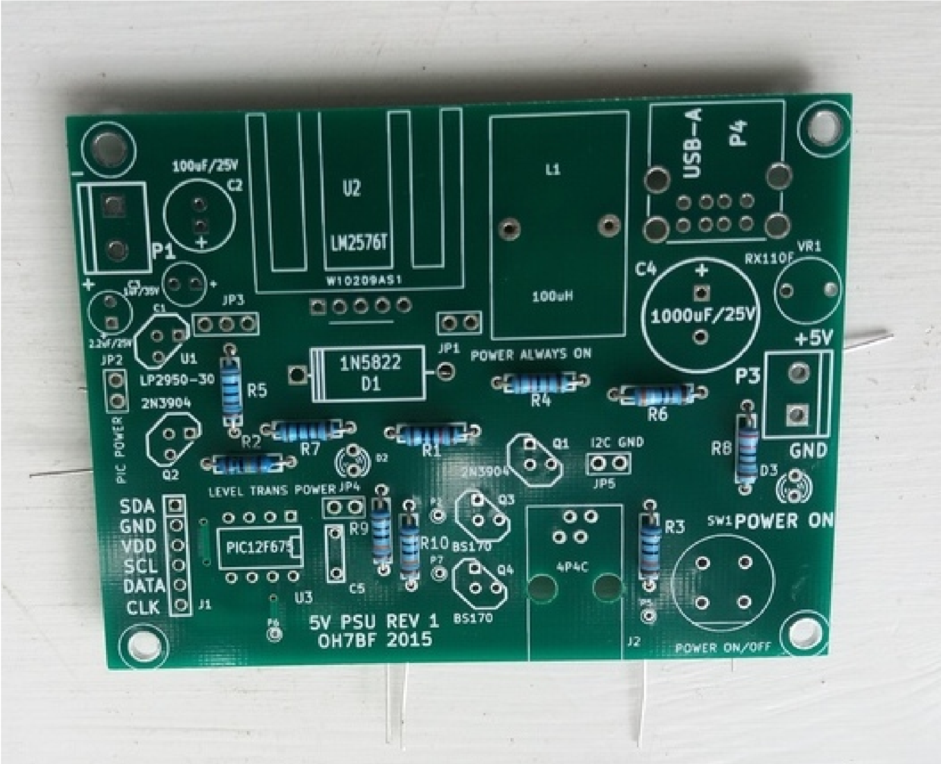


Figure 1: Soldering of resistors R1 - R10 on PCB. Cut and trim the leads on the other side.

19. The PIC12F675 micro-controller is inserted to the socket only after testing of correct voltages on the board.

3 Initial testing

1. Connect multimeter to the power input connector P1 and check that there is no short to the ground. Since the multimeter is charging the input capacitor C2 the resistance value can be low initially but will start to increase almost immediately.

2. Connect multimeter to the power output connector P3 and check for any short to the ground.

3. Check with multimeter that pin 1 on U3 socket is not shorted to ground.

4. Connect small 9 V battery to the input connector P1 while observing the correct polarity. Measure the voltage at the output of voltage regulator U1 at the JP2. The voltage should be very close to 3.0 V.

5. Connect the jumper JP1. The green LED should now lit and 5 V power is available. Check the output voltage with a multimeter. It should be 5.1 - 5.2 V. Remove the jumper JP1.

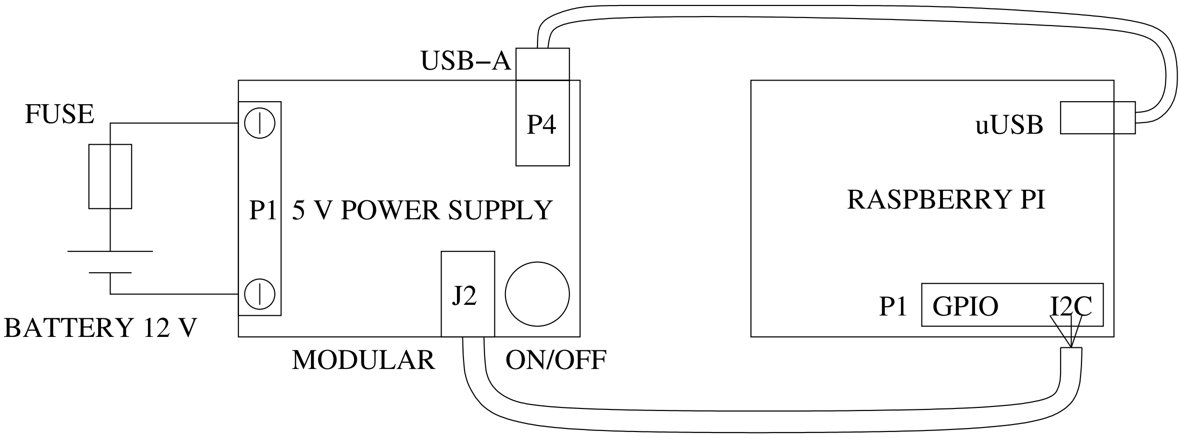


Figure 2: Battery power supply for Raspberry Pi. Note the fuse at the battery terminals. The power is brought to the micro-USB connector with the USB cable. The SDA and SCL lines are connected with 4P4C modular connector and telephone cable to the pins on the P1 header. Read the GPIO documentation carefully and double check the connections. The ground wire from GPIO is not needed in this case since the ground is already connected from the USB cable.

6. Remove the 9 V battery from input connector P1.
7. Insert U3 PIC12F675 to its socket. Connect jumpers JP2, JP4 and JP3 between pins 2 and 3.
8. Connect 9 V battery to input power connector P1. Press the red push button. The green LED should now be lit to indicate presence of 5 V power.
9. Remove 9 V battery from P1.
10. A 2.2 Ω 25 W power resistor can be connected to P3 to test the regulation with high output current. The resistor needs to be connected to a heat sink since it will become hot.
11. Test the pins on J2 modular connector with a multimeter for any shorts or solder bridges.

4 Using with Raspberry Pi

The power to the Raspberry Pi can be taken from the USB-A connector. The Raspberry Pi can control the power supply via the I2C bus after connecting the SDA and SCL signals to the GPIO. Double check these connections since the Raspberry Pi can be destroyed with wrong connections. Typical wiring for 12 V battery operation is shown in Fig. 2. After the cables are in place the power can be applied by pressing the red button on the power supply board.

Login to the Raspberry Pi as usual with your password. Then install the **i2ctools** and test the I2C connection to the power supply board.

```
pi@raspberrypi ~ $ sudo apt-get install i2c-tools
...
pi@raspberrypi ~ $ sudo i2cdetect -y 1
```

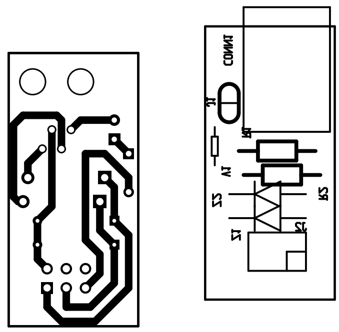


Figure 3: Small printed circuit board that can be used on Raspberry Pi P1 header to make 4P4C modular connector for I2C bus with 3.3 V, SDA, SCL and ground. The small 3.3 V zener diodes and 100 Ω resistors give extra protection to the GPIO. The mirror images can be used in toner transfer method of PCB production. The pins 1–6 from P1 header are connected, but the 5 V power lines are not used.

```
...
```

The PIC12F675 should acknowledge the address 0x26 if it is working correctly. Next clone the **PiPIC** repository, compile the **pipicpowerd** daemon and install it following the instruction in the 'install' file.

```
pi@raspberrypi ~ $ git clone https://github.com/oh7bf/PiPIC.git
pi@raspberrypi ~ $ cd PiPIC
pi@raspberrypi ~ $ less install
...
```

When the daemon **pipicpowerd** is running you should see the red LED lit on the power supply board every time battery voltage is measured. The daemon checks regularily if the red button has been pressed. This can initiate system shutdown and switching off the power to the Raspberry Pi. You may want to read the manual page of **pipicpowerd**.

5 Theory of operation

The 3.0 V regulator feeds power to the U3 PIC12F675 micro-controller. When the PIC detects change in logic state of digital input GP0 it turns on the switching regulator U2 LM2576 by setting digital output GP1 to high state. The internal 10-bit A/D-converter of the micro-controller is connected to GP4. When the JP3 jumper between pins 2 and 3 is in place the PIC can set GP5 high to lit the LED D2 and feed current to transistor Q2. The Q2 works as an amplifier for the small current from the battery and resistor R2. This DC voltage is then measured by the A/D-converter.
The I2C bus can be used to transfer commands to the PIC, which then does the necessary operations for the battery voltage measurement, reading the state of the On/Off button switch and switching off the main switching regulator U2 by setting GP1 to logic low.

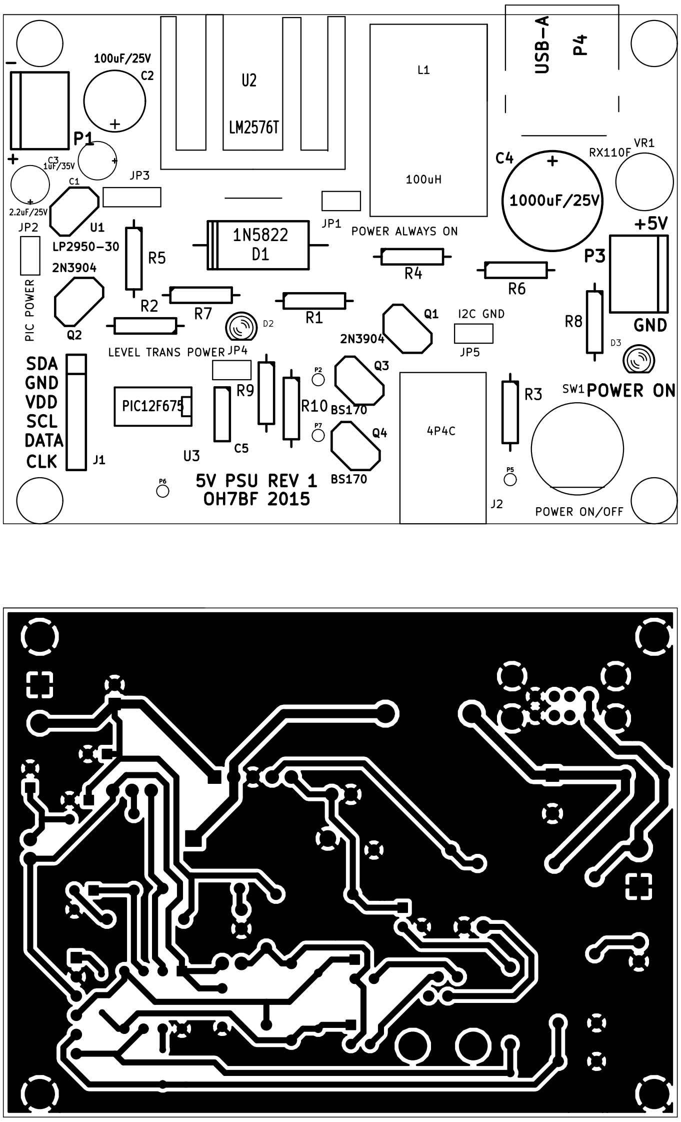


Figure 4: Power supply silk screen and printed circuit board.

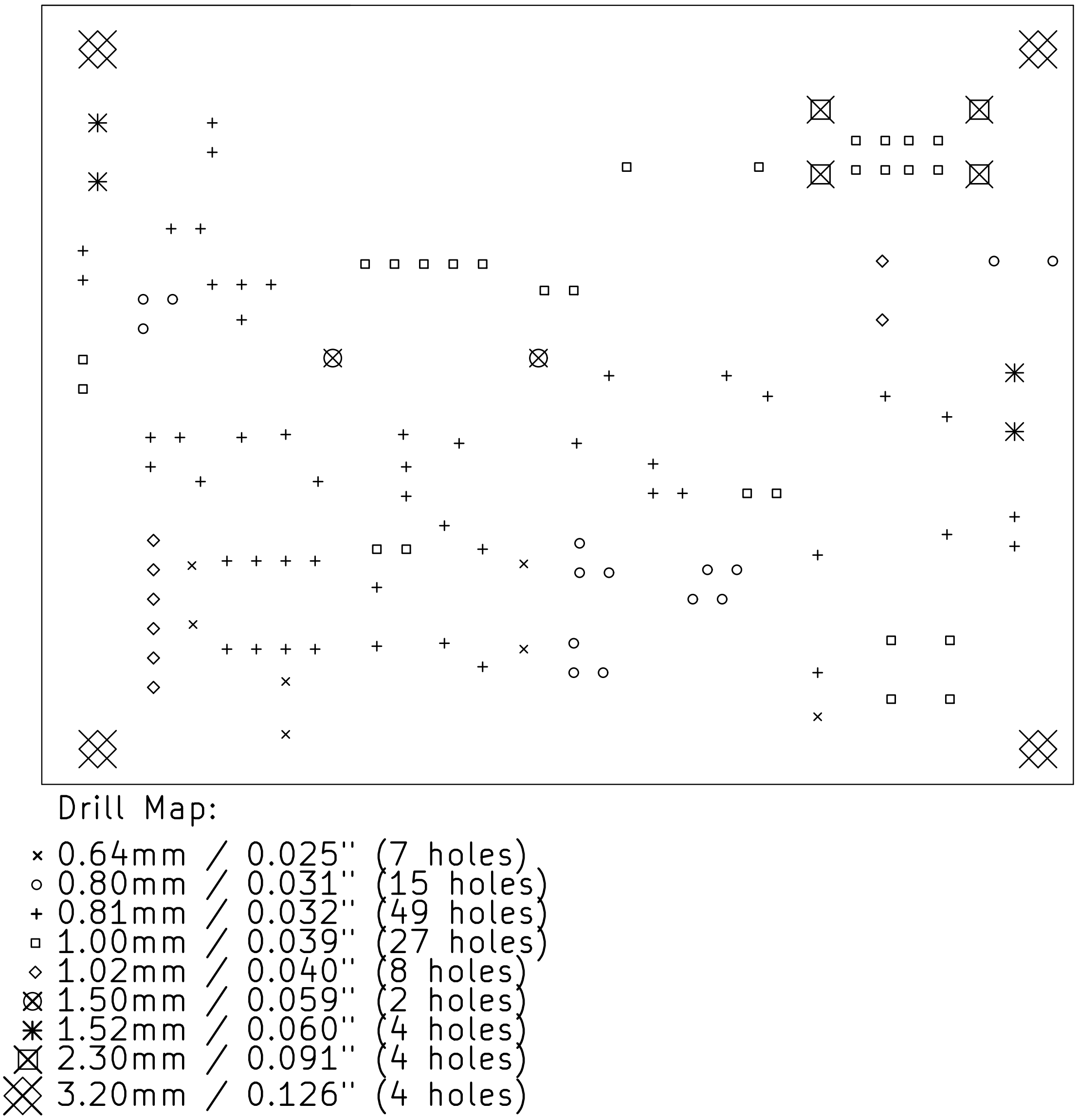
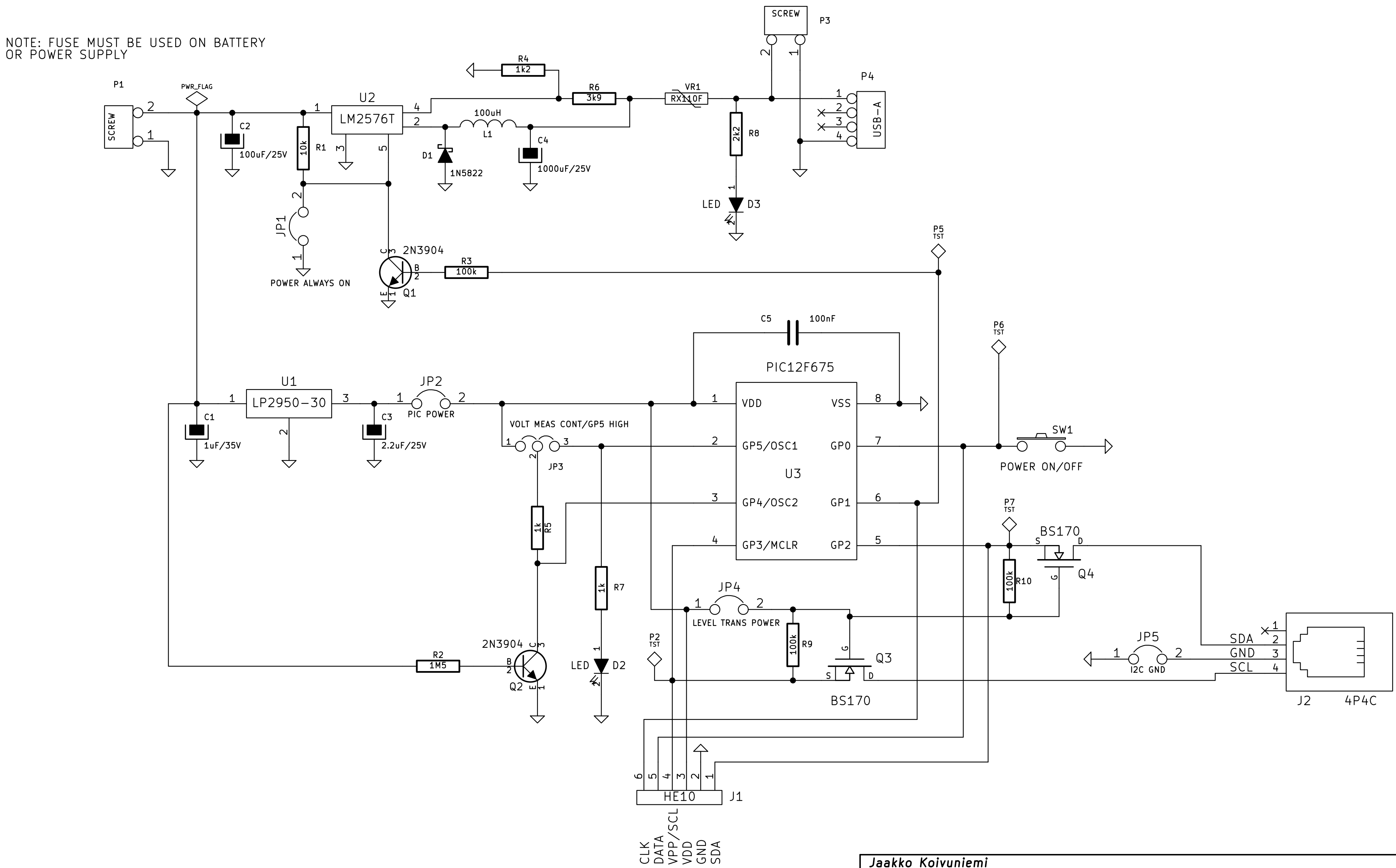


Figure 5: Drill map for the PCB.



Jaakko Koivuniemi		
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