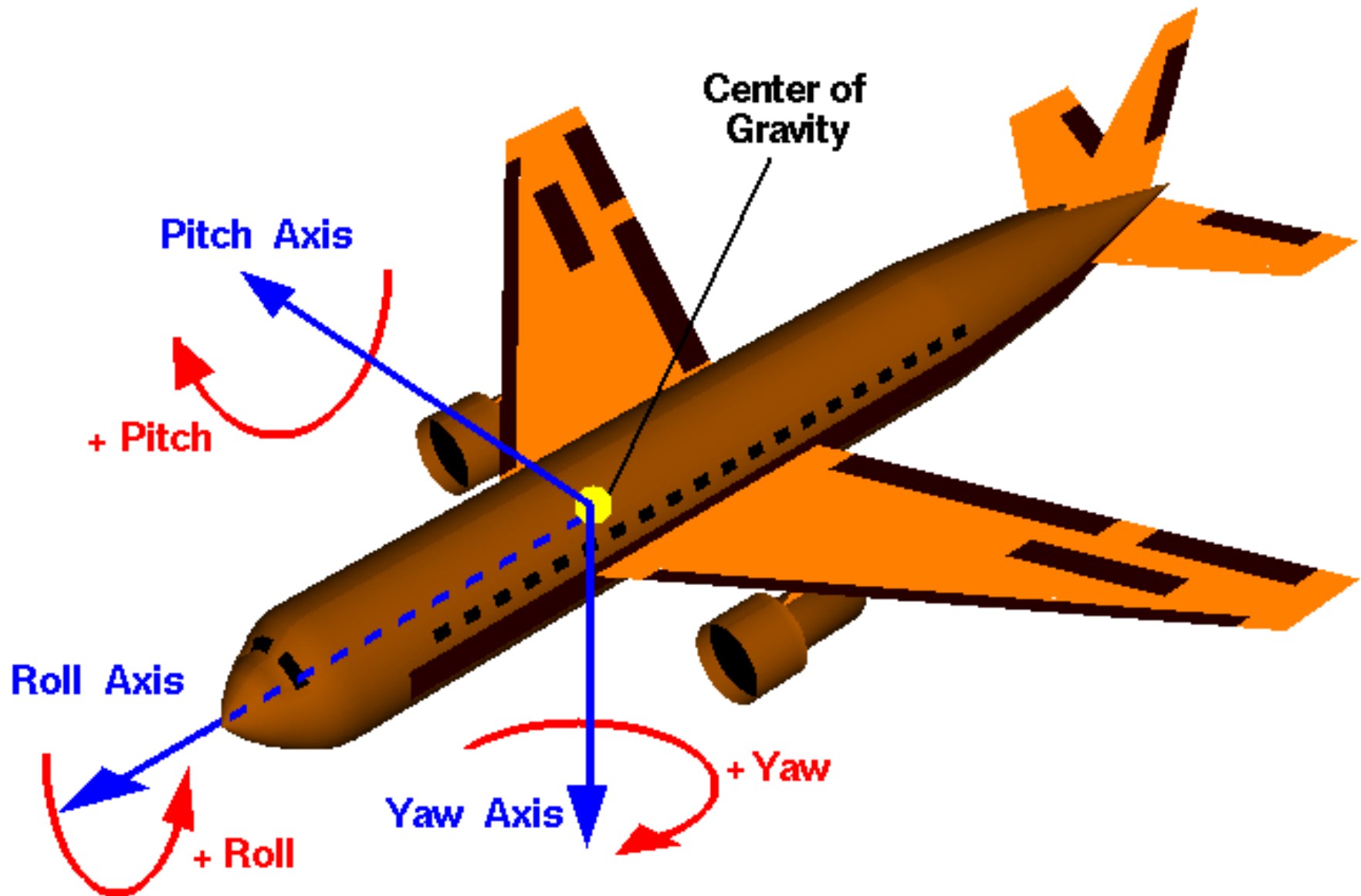


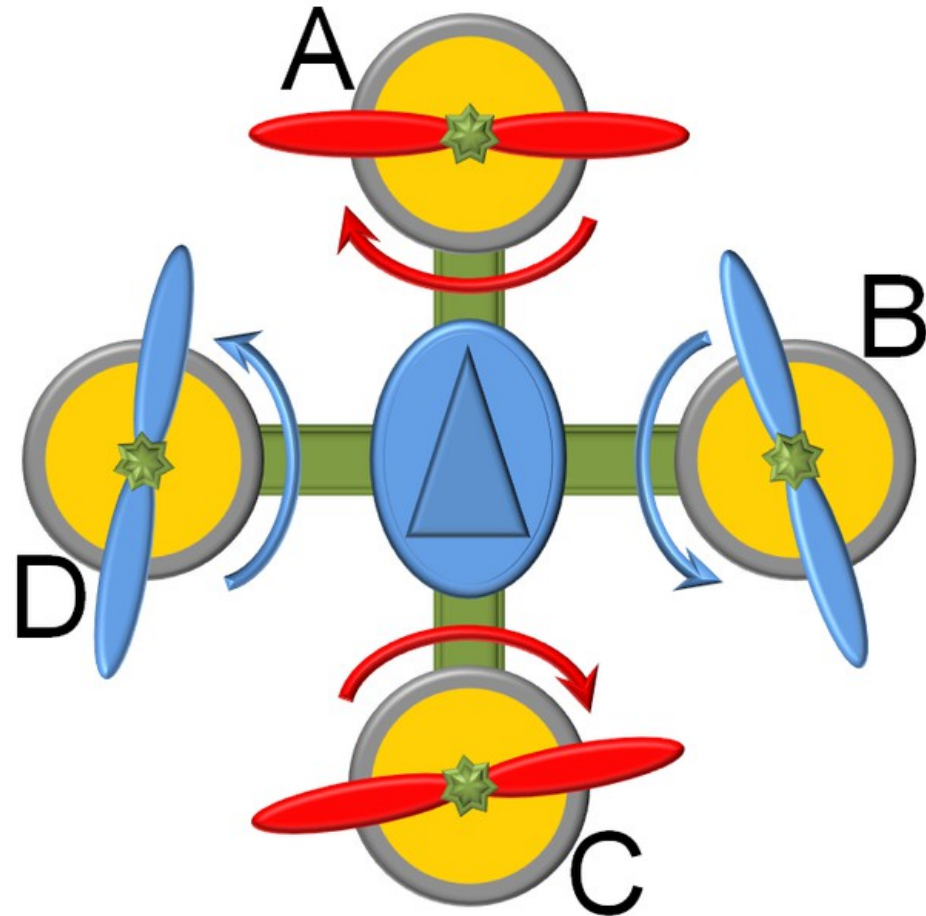
# Quadrocopter

Thomas Buck – TGQ2c – Claude-Dornier-Schule

# Luftfahrzeuge



# Theorie

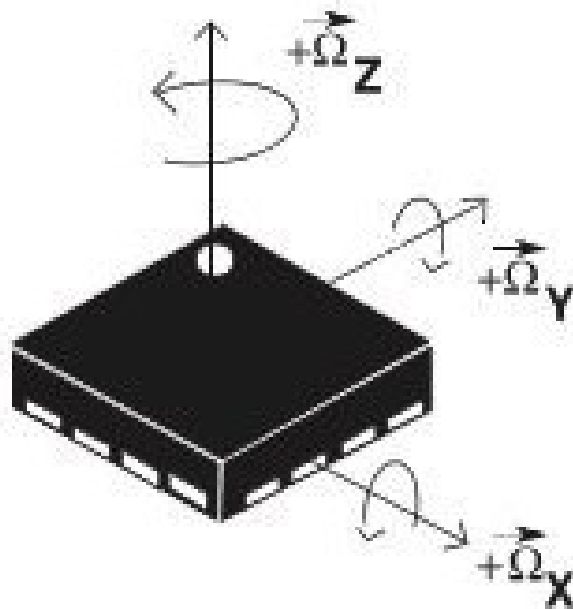


# Problematik

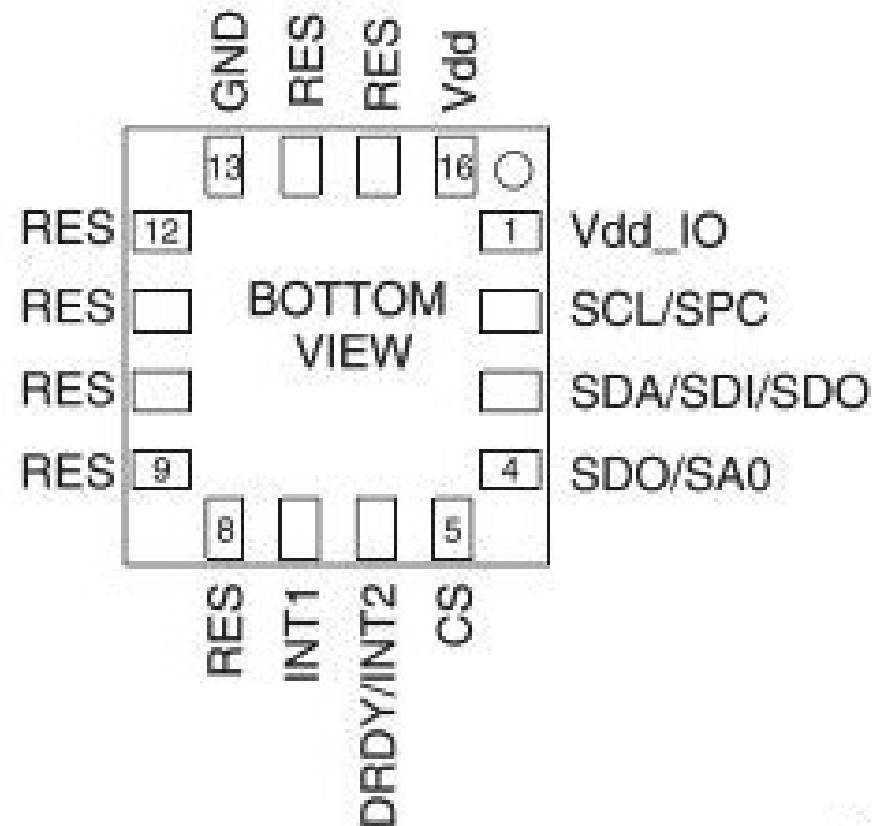
- Aktuelle Orientation messen
  - Sensoren, Filter
- Gezielte Änderung der Orientation über Motorgeschwindigkeit
  - Regler

# Gyroskop

→ Drehratensensor

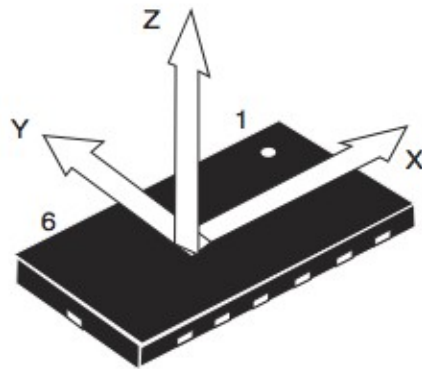


(TOP VIEW)  
DIRECTIONS OF THE  
DETECTABLE  
ANGULAR RATES



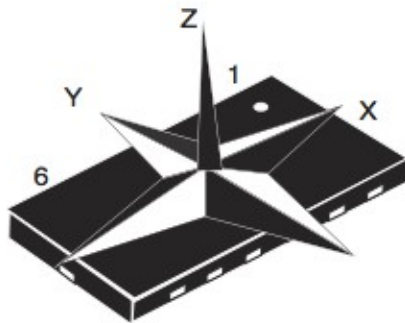
# Accelerometer

→ Beschleunigungssensor, Magnetsensor



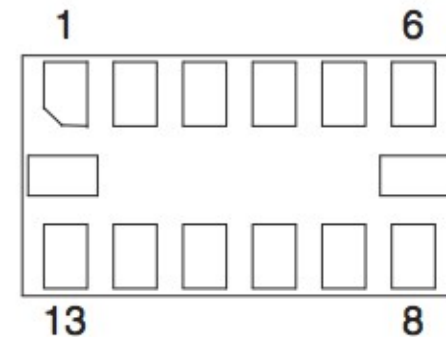
TOP VIEW

DIRECTION OF  
DETECTABLE  
ACCELERATIONS



TOP VIEW

DIRECTION OF  
DETECTABLE  
MAGNETIC FIELDS



BOTTOM VIEW

# Winkel?

- Vektor aus Accelerometer

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ -9,81 \end{pmatrix}$$

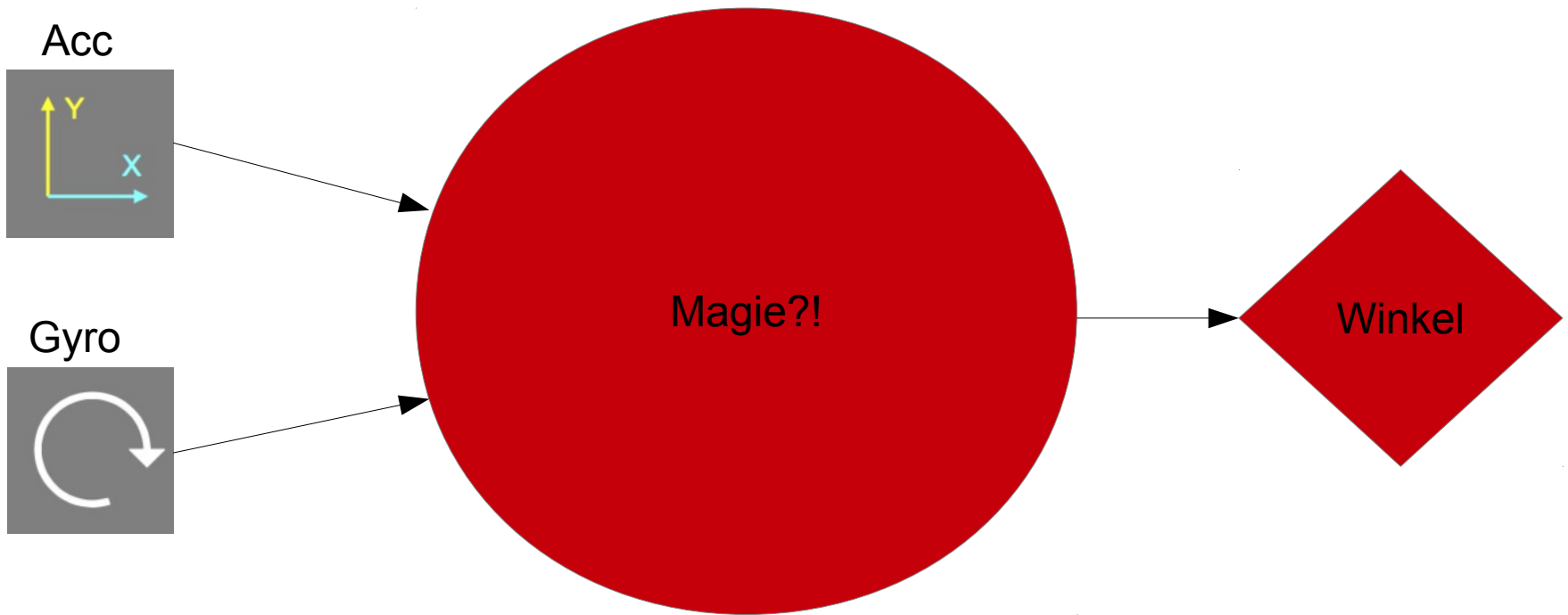
$$Pitch = \arctan\left(\frac{y}{\sqrt{x^2 + z^2}}\right)$$

$$Roll = \arctan\left(\frac{x}{\sqrt{y^2 + z^2}}\right)$$

- Drehrate nur integrieren

# Filter?!

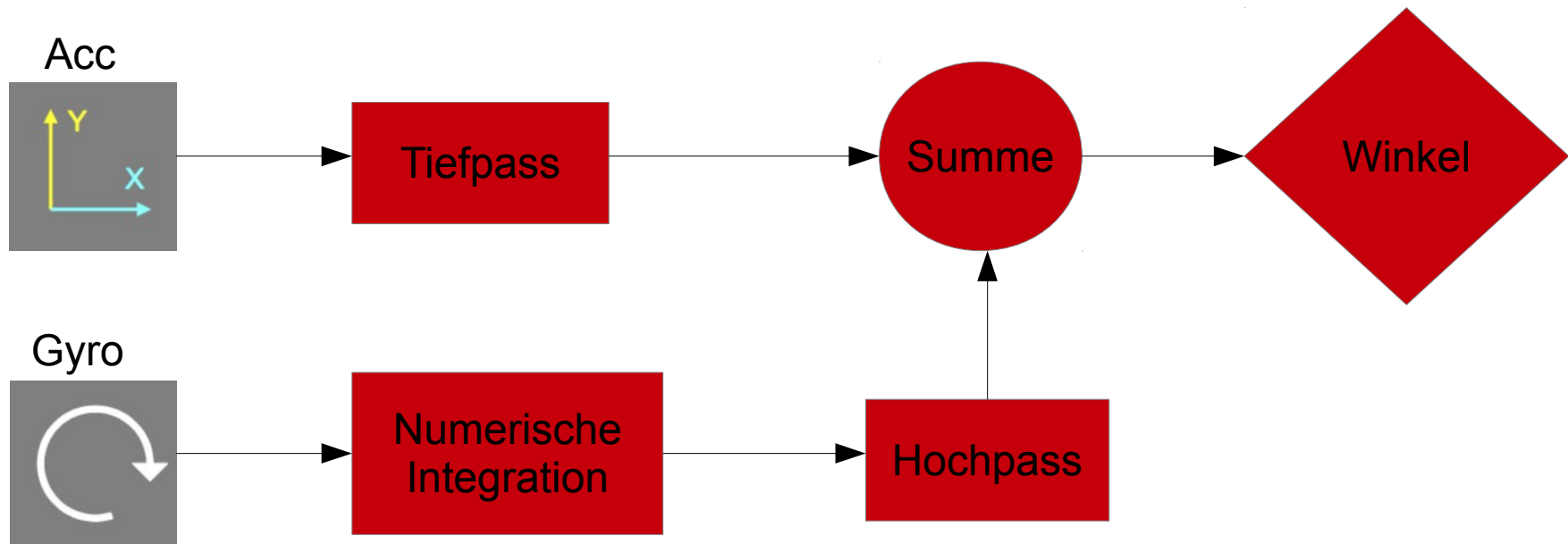
## Kalmanfilter





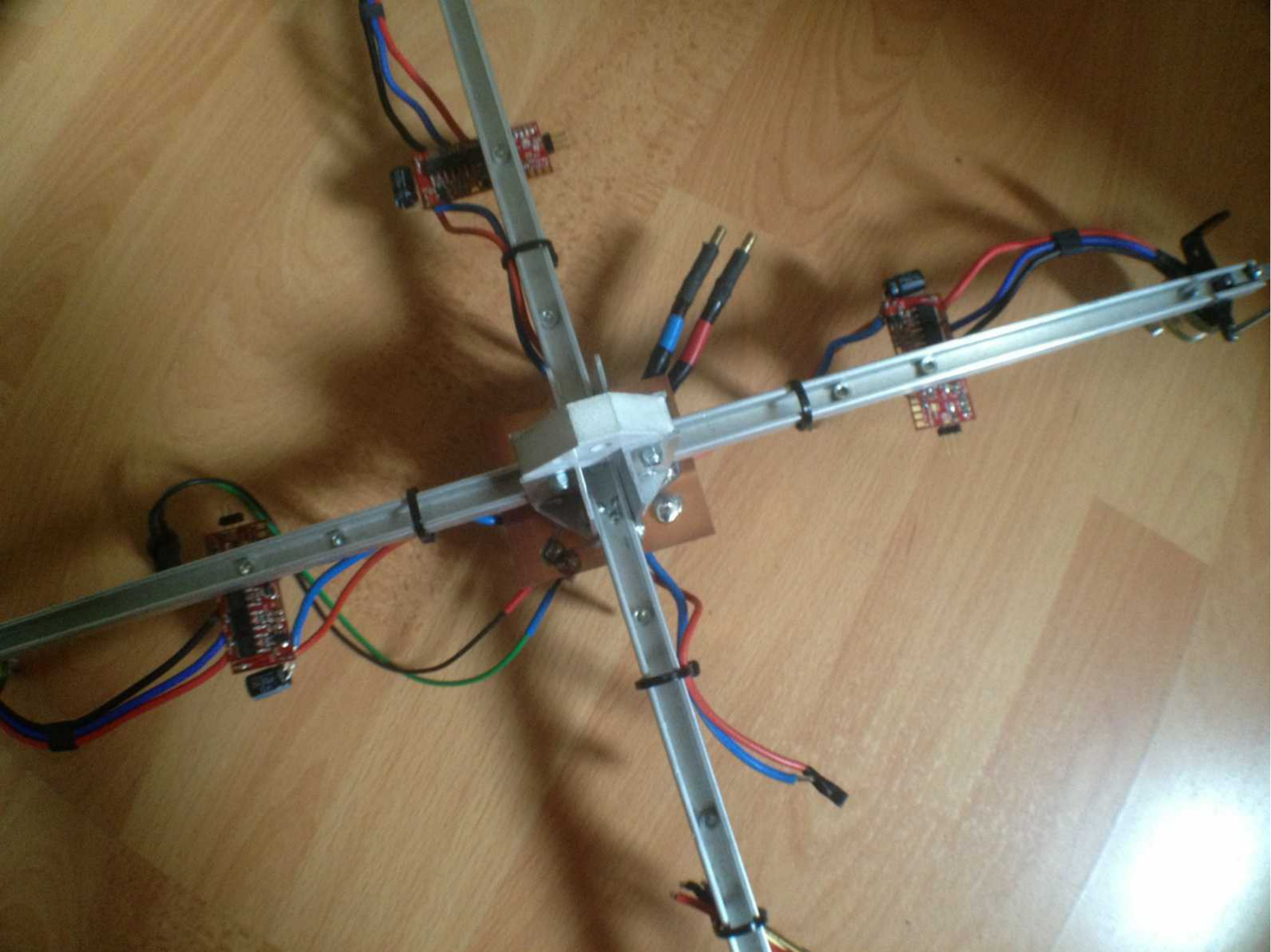
# Filter!

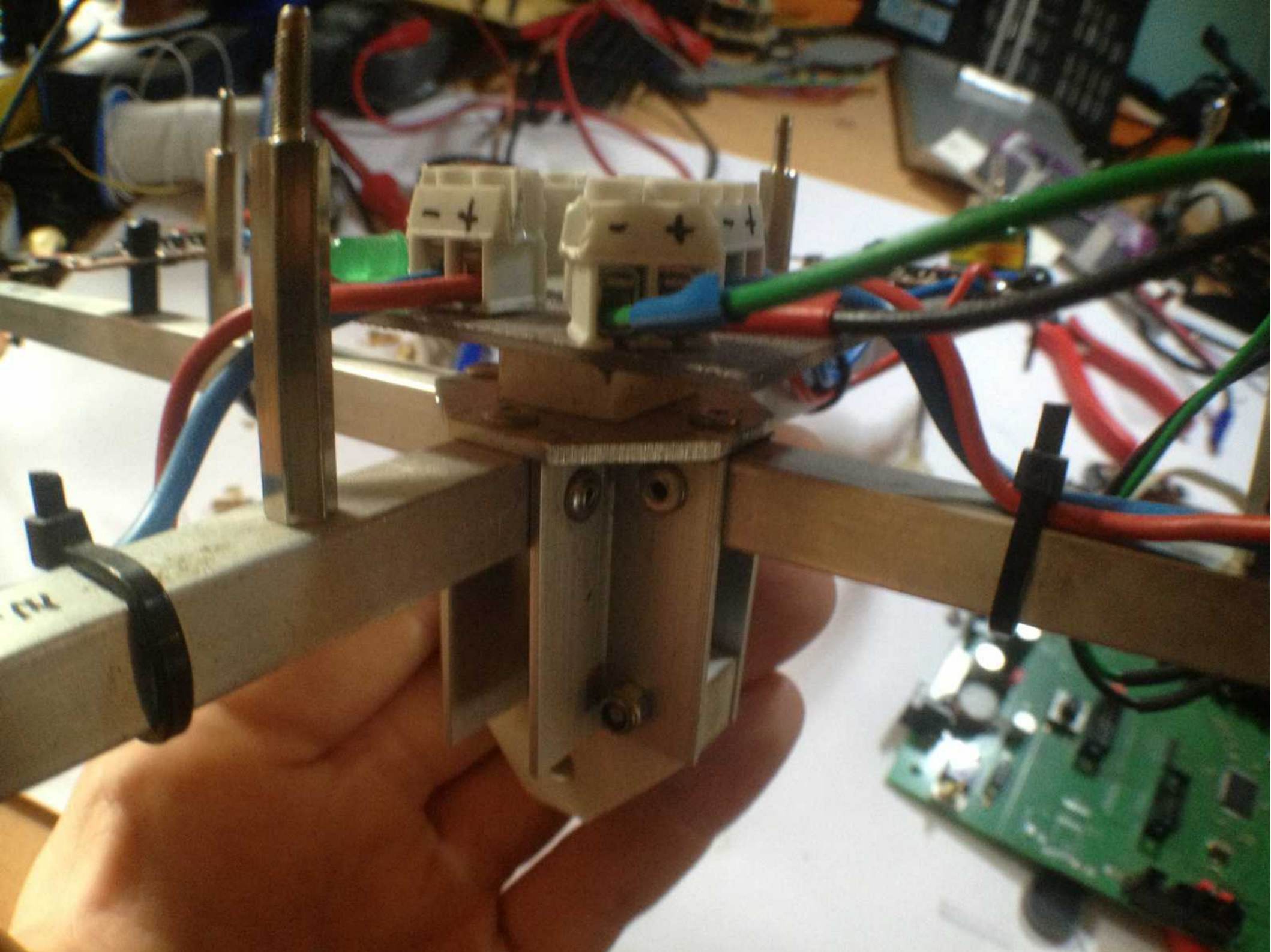
## Komplementärfilter



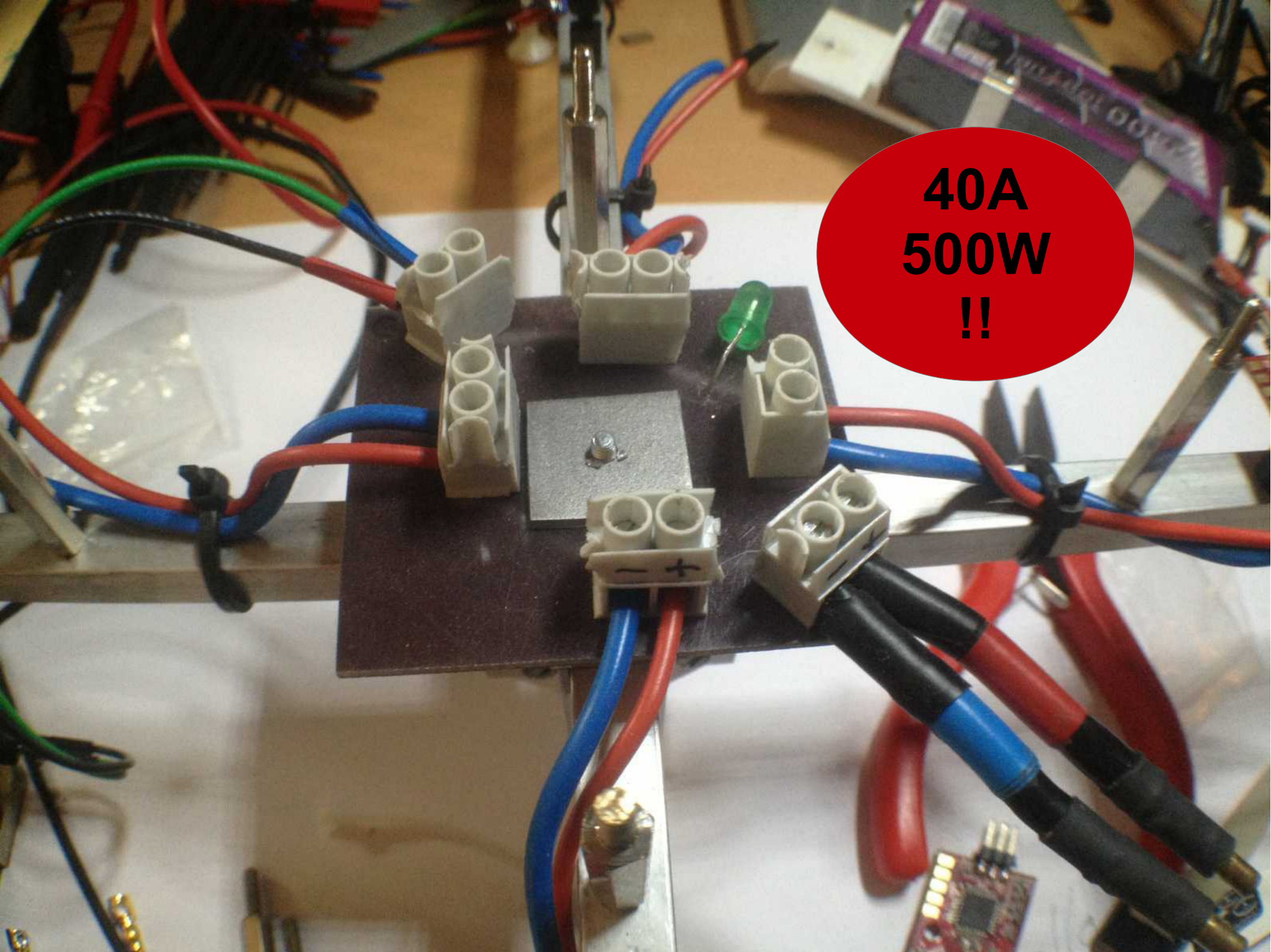
# Regler

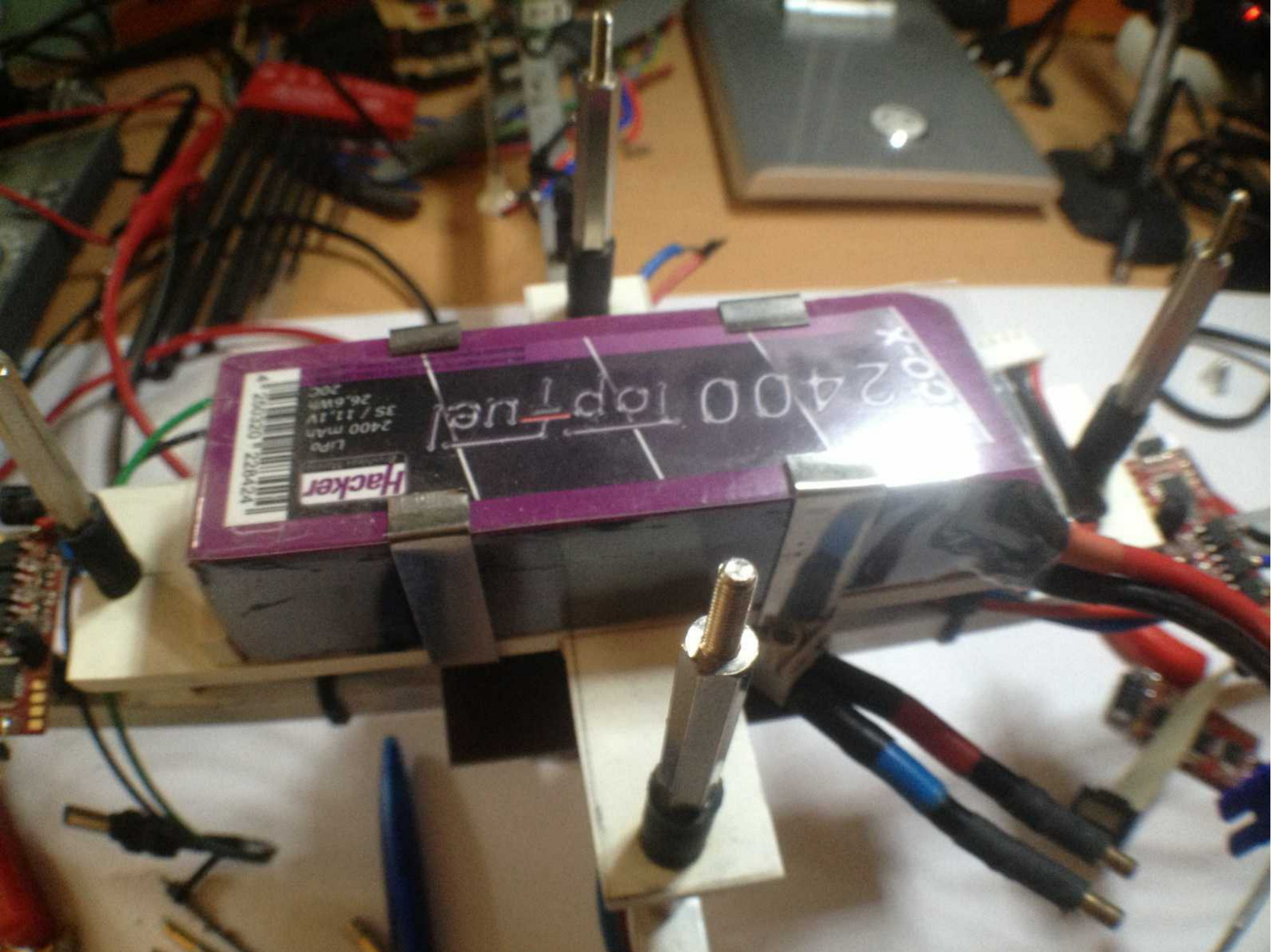
- Stetige lineare Regler
  - P-Glied (Proportionaler Regler)
  - I-Glied (Integrierender Regler)
  - D-Glied (Differenzierender Regler)
- Eingangssignal: Winkelfehler  $e = (\text{soll} - \text{ist})$
- **P:**  $u_p(t) = K_p \cdot e(t)$
- **I:**  $u_i(t) = K_i \cdot \int_0^t e(r) dr$
- **D:**  $u_d(t) = K_d \cdot \left(\frac{d}{dt}\right) \cdot e(t)$
- **PID:**  $u(t) = (K_p \cdot e(t)) + (K_i \cdot \int_0^t e(r) dr) + (K_d \cdot \left(\frac{d}{dt}\right) \cdot e(t))$





**40A  
500W  
!!**

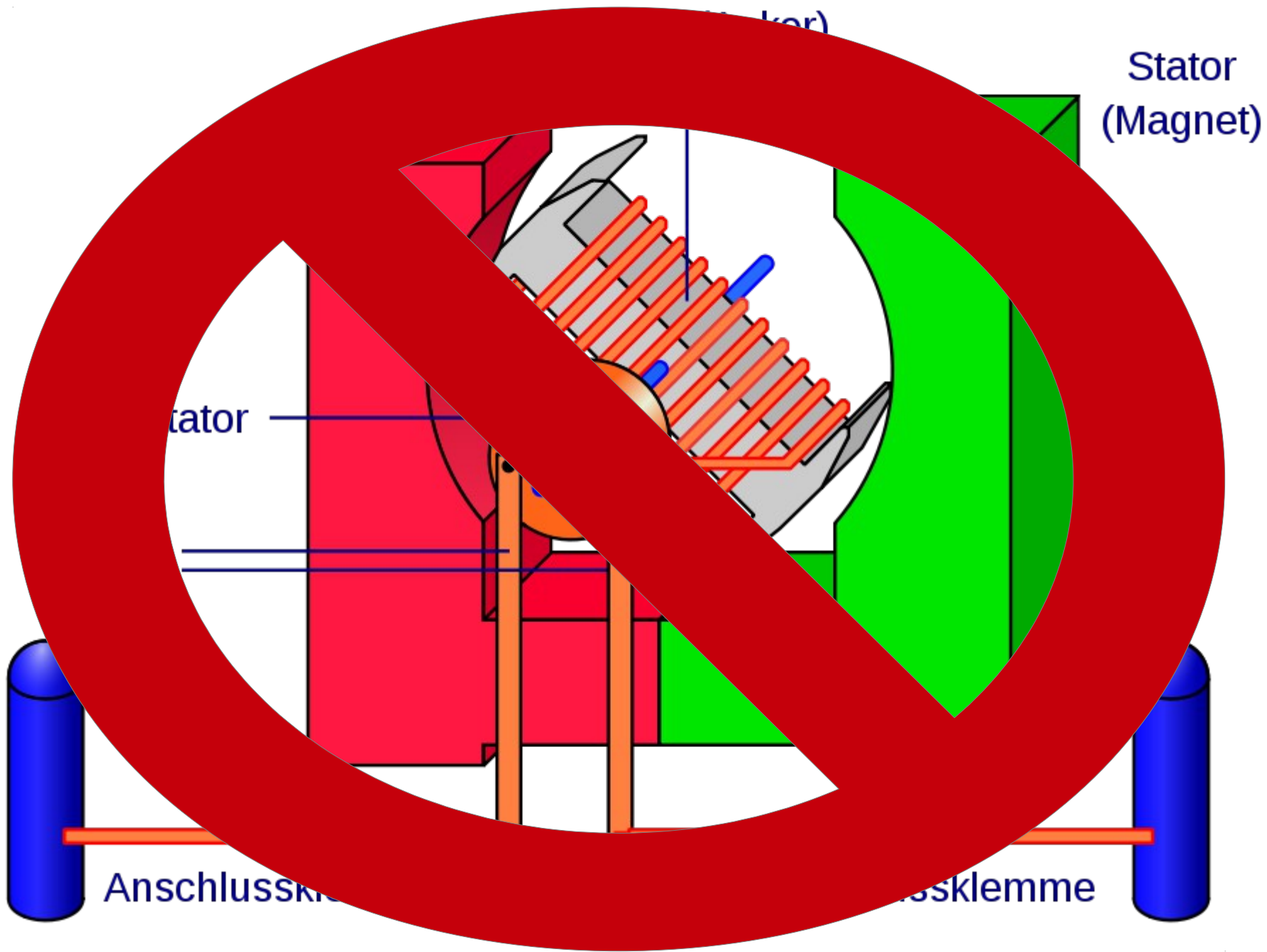




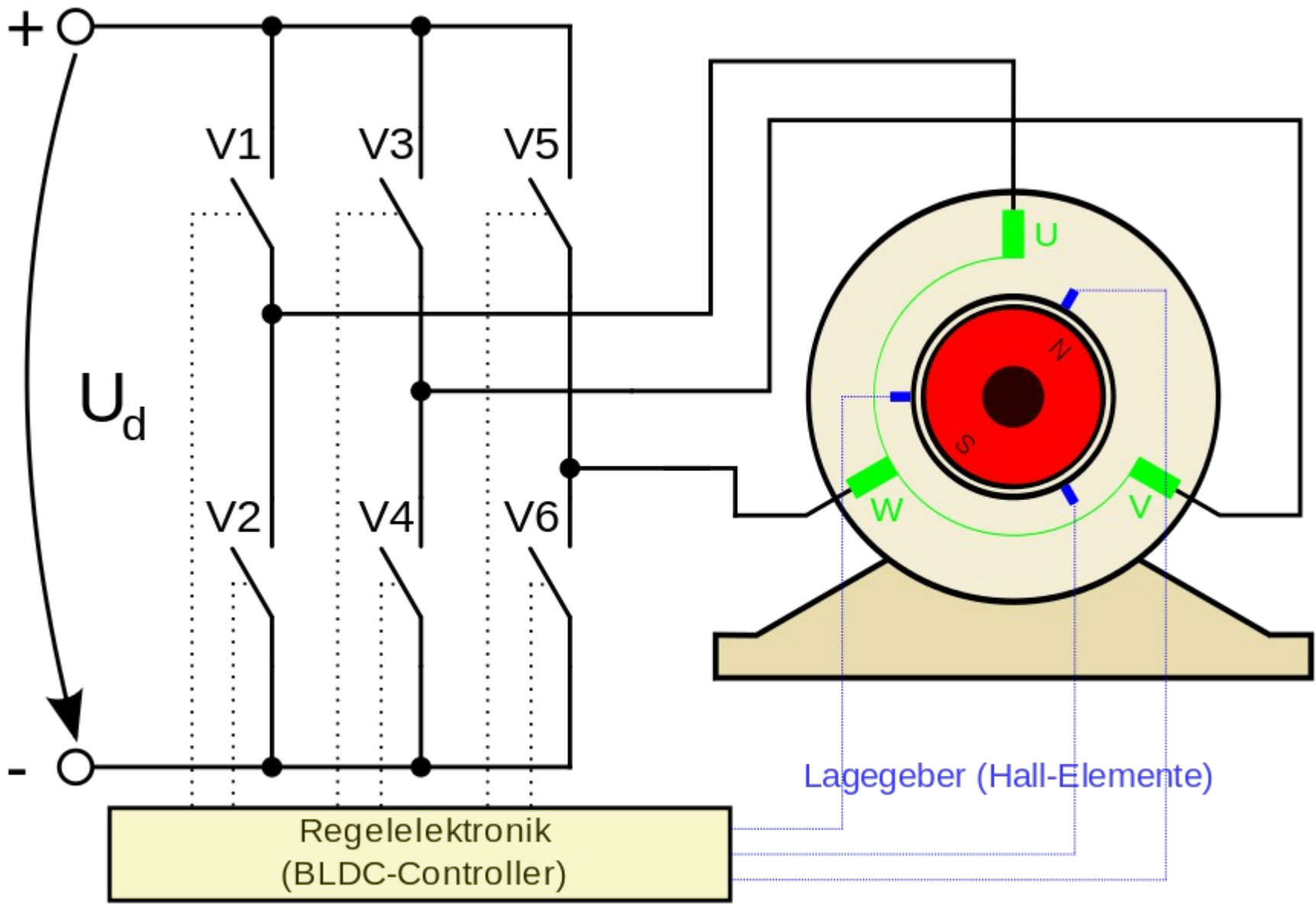
Hackler  
Lipo  
2400 mAh  
3S / 11.1V  
26.6Wh  
20C

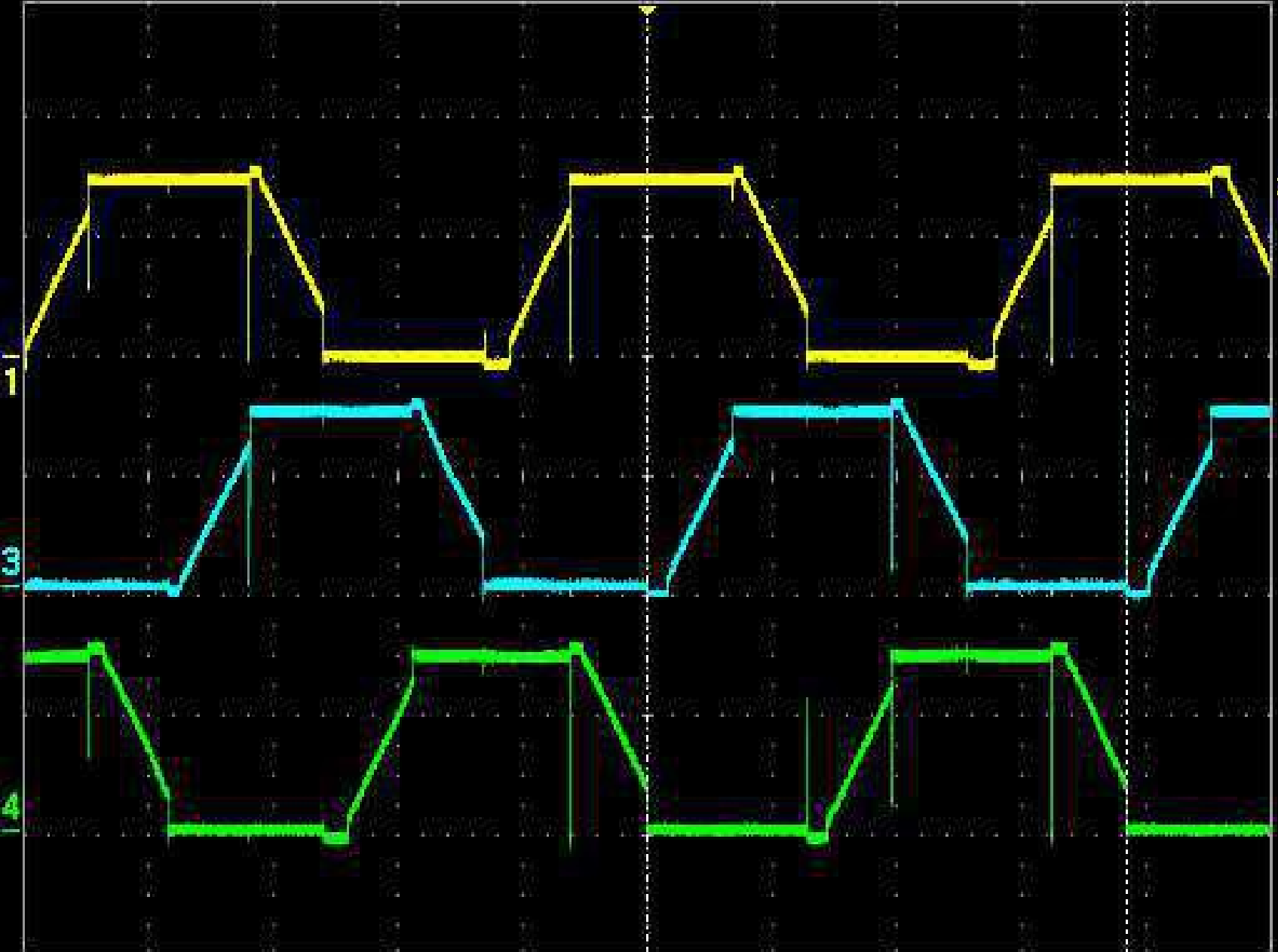
2400 TopFuel  
gox











$\Delta t = -768\mu s$      $1/\Delta t = 1.30kHz$     Edge    1    DC    14.8V

1: 10.0V	2: 1.00V	3: 10.0V	4: 10.0V
DC1MΩ	DC1MΩ	DC1MΩ	DC1MΩ
ofs 10.0V	Empty	ofs -9.20V	ofs -29.6V

CH3

Kopplung

DC1MΩ

Bandbreite



Tastkopf

Auto

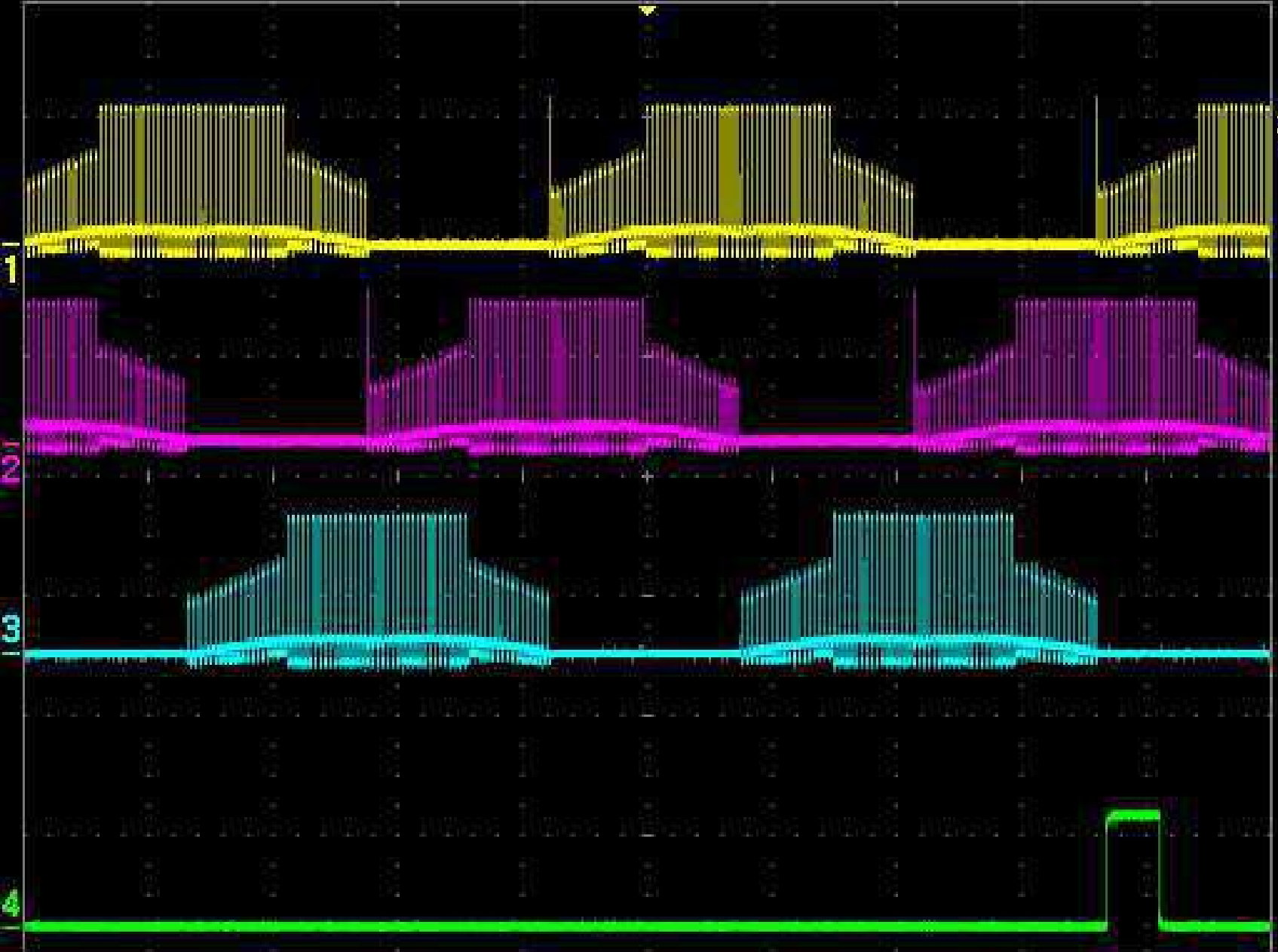
Invertiert

Aus

Ein

weiter

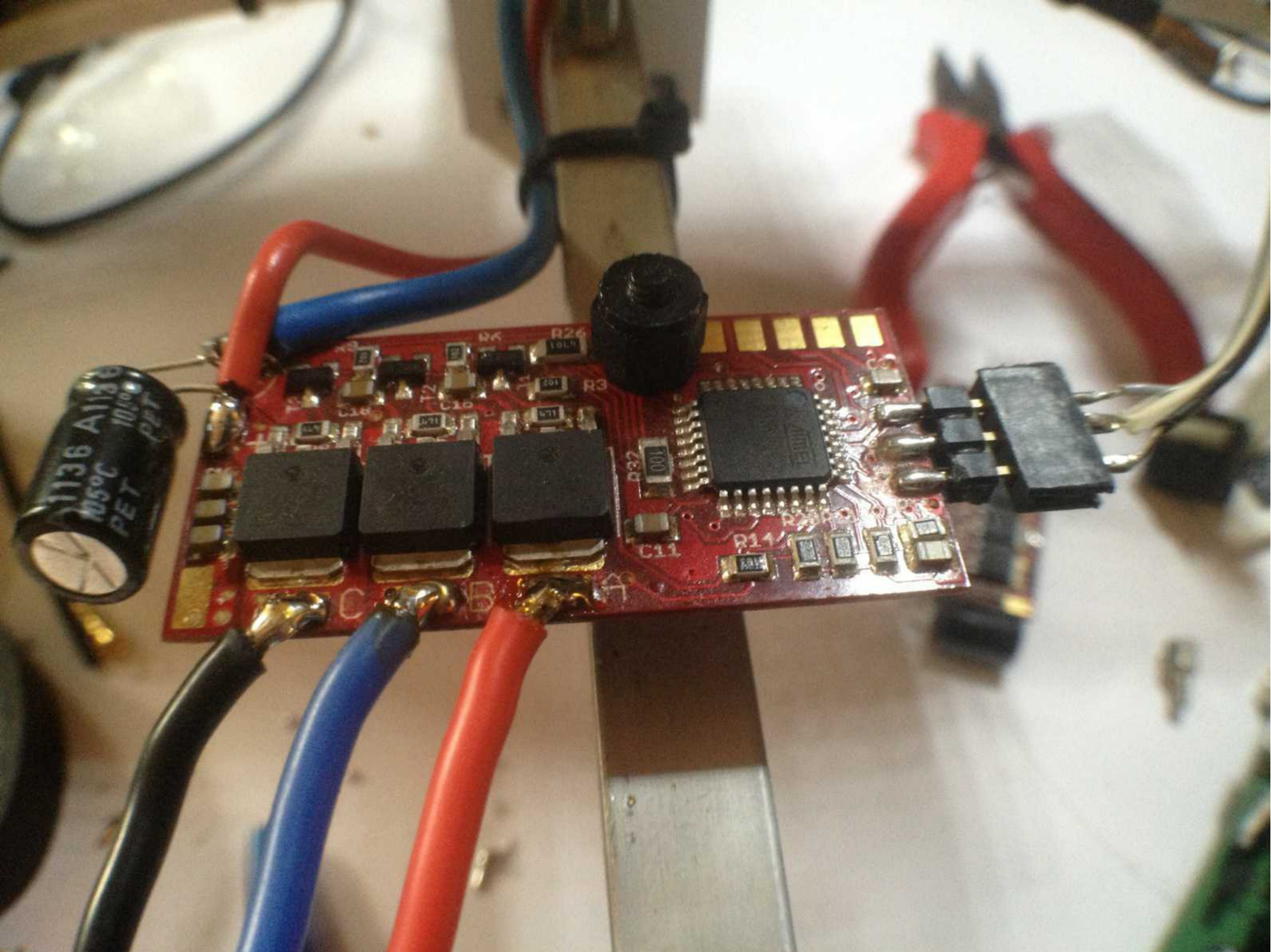
(1/2)

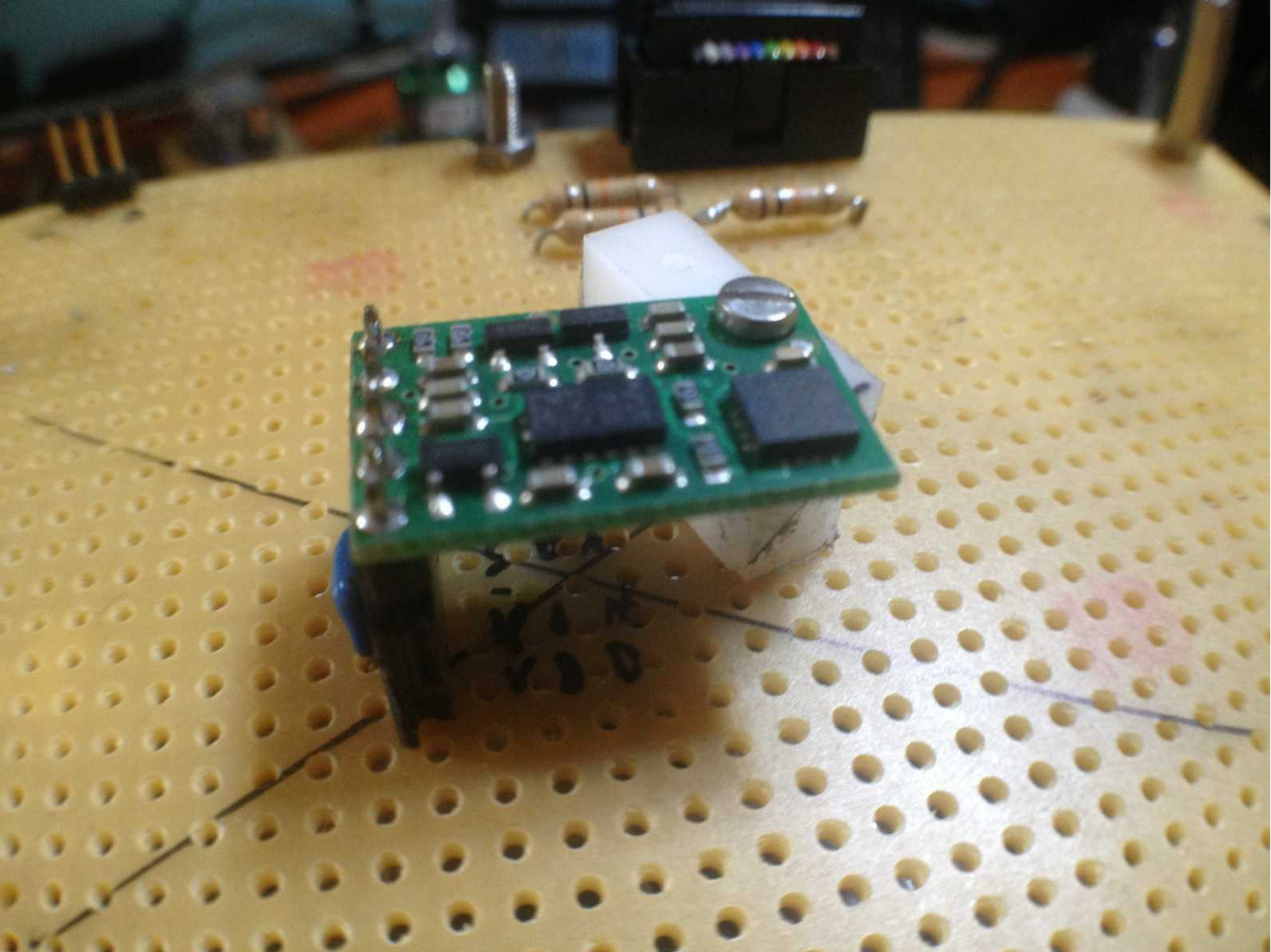


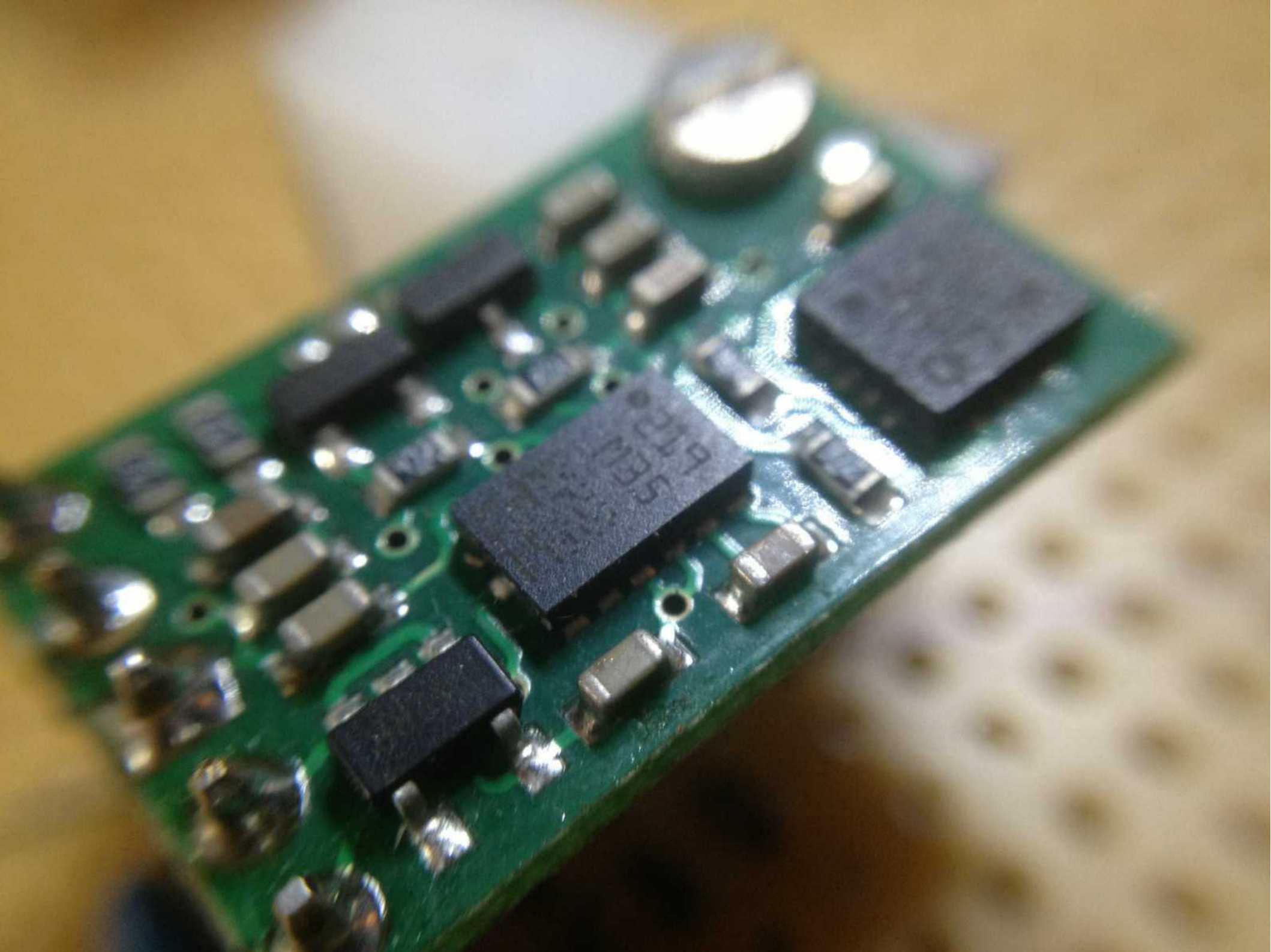
Edge 1 DC 10.6V

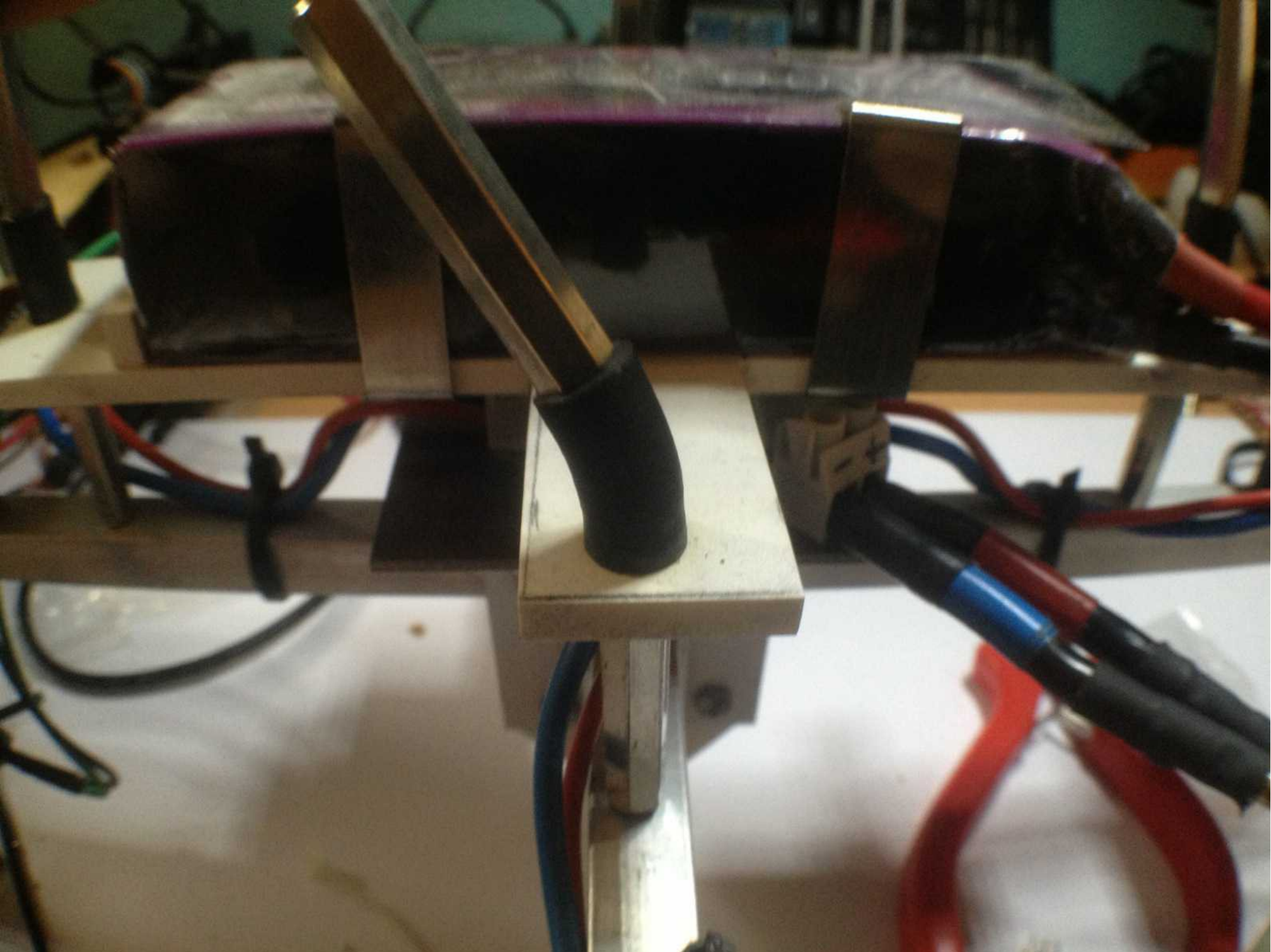
1: 10.0V	2: 10.0V	3: 10.0V	4: 5.00V
DC1MΩ	DC1MΩ	DC1MΩ	DC1MΩ
ofs 19.4V	ofs 2.80V	ofs -14.8V	ofs -18.9V





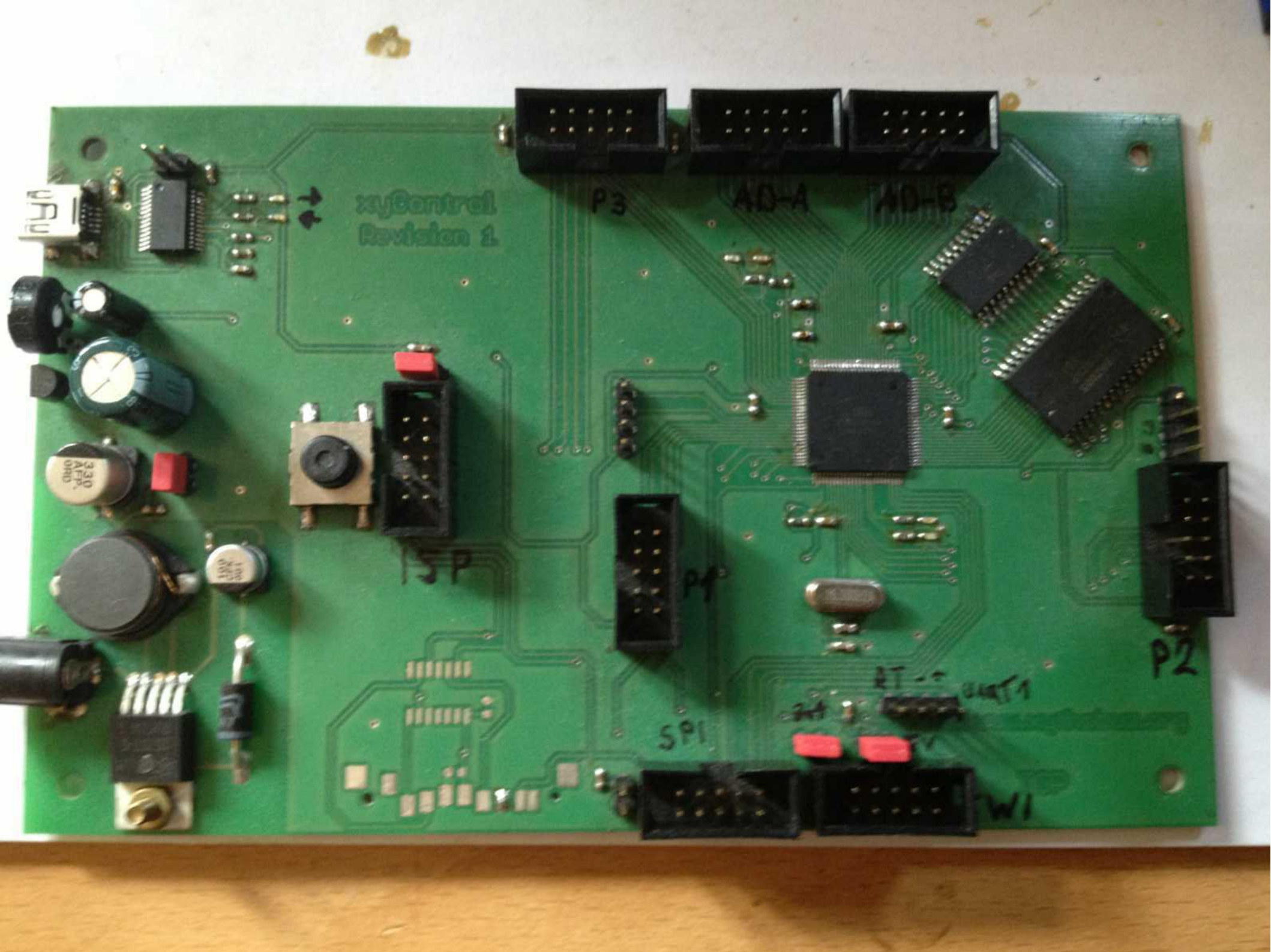












xyControl  
Revision 1

P3

AD-A

AD-B

ISP

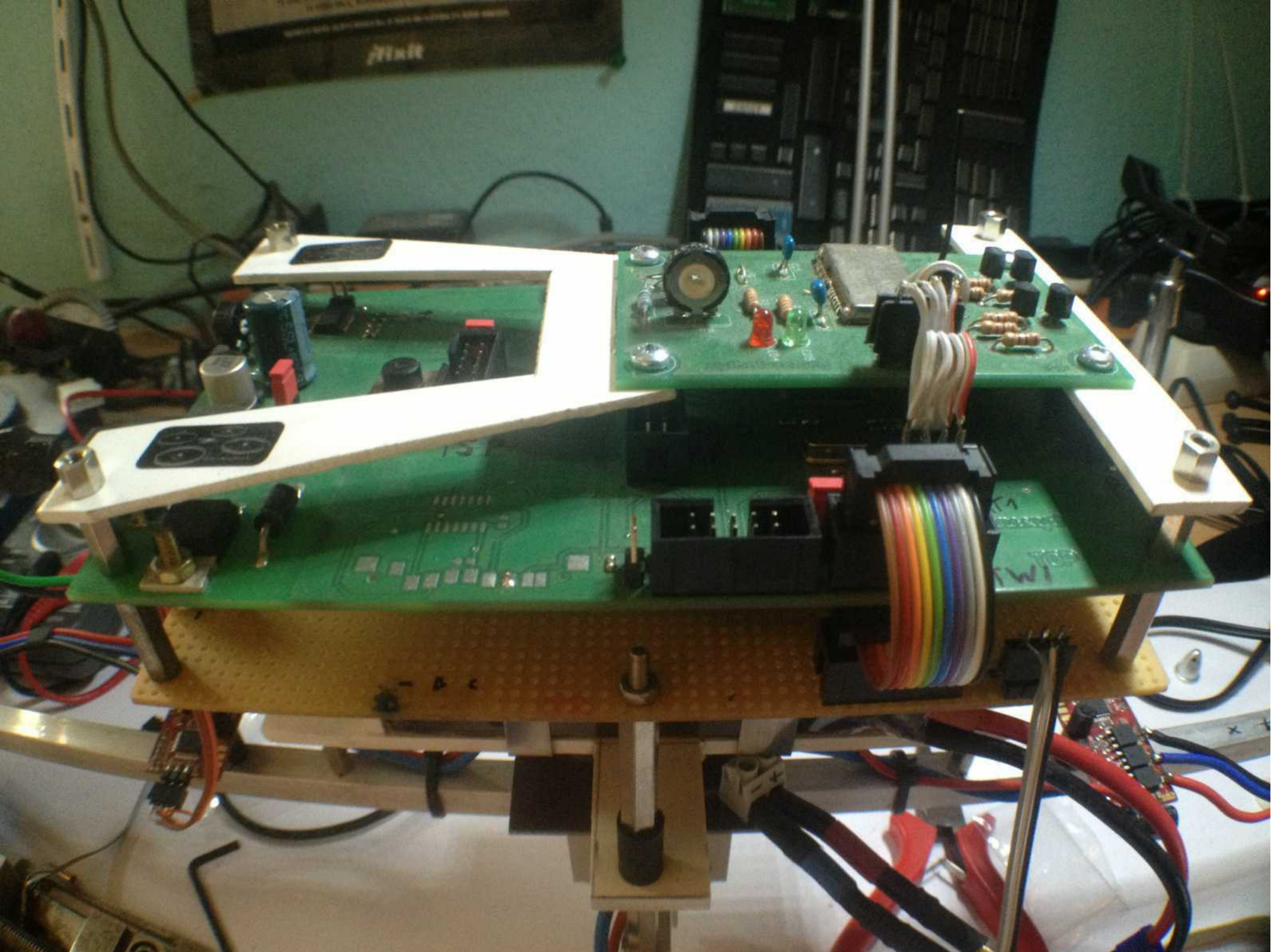
P4

SPI

P2

RT-5000

W1



# avrSerial

- Multi UART Support
- Einfach portierbar
- Freie Software
- Code: <https://github.com/xythobuz/avrSerial>
- Dokumentation: <http://xythobuz.de/avrserial>

# YASAB

- Yet another simple AVR Bootloader
- Basiert auf avrSerial
  - Multi UART Support
  - Einfach portierbar
- Unix Kommandozeilen Upload-Tool
- Android Upload-Tool
- Code: <https://github.com/xythobuz/yasab>

# Komplementärfilter

```
winkel = (winkel + (gyro * dt));           // Integrieren  
winkel *= (FACTOR_1 / (FACTOR_1 + dt));   // Hochpass  
winkel += (FACTOR_2 / (FACTOR_2 + dt)) * acc; // Tiefpass
```

# PID-Regler

```
error = winkelSoll - winkelIst;
```

```
sumError = sumError + (error * dt); // Integrieren  
dError = (error - lastError) / dt; // Differenzieren
```

```
output = (kp * error) + (ki * sumError) + (kd * dError);
```



xyCopter



Connected to xyRobot (00:12:6F:21:ED:BA)

Battery: 11.337891V

Pitch: 3.116182

Roll: -2.002680

Off!

On!

Off!

Left

Forward

Back

Right

Up

Down

Toggle

Battery

Angles

Reset



16:08





Connected to xyRobot (00:12:6F:21:ED:BA)  
Activated!

Roll: 16.531748 °  
Pitch: 13.158009 °  
Yaw: 0.000000 °  
Voltage: 10.781250 V  
Motors: 5 15 15 5



Left

Right

Forward

Back

Up

Down

Raw

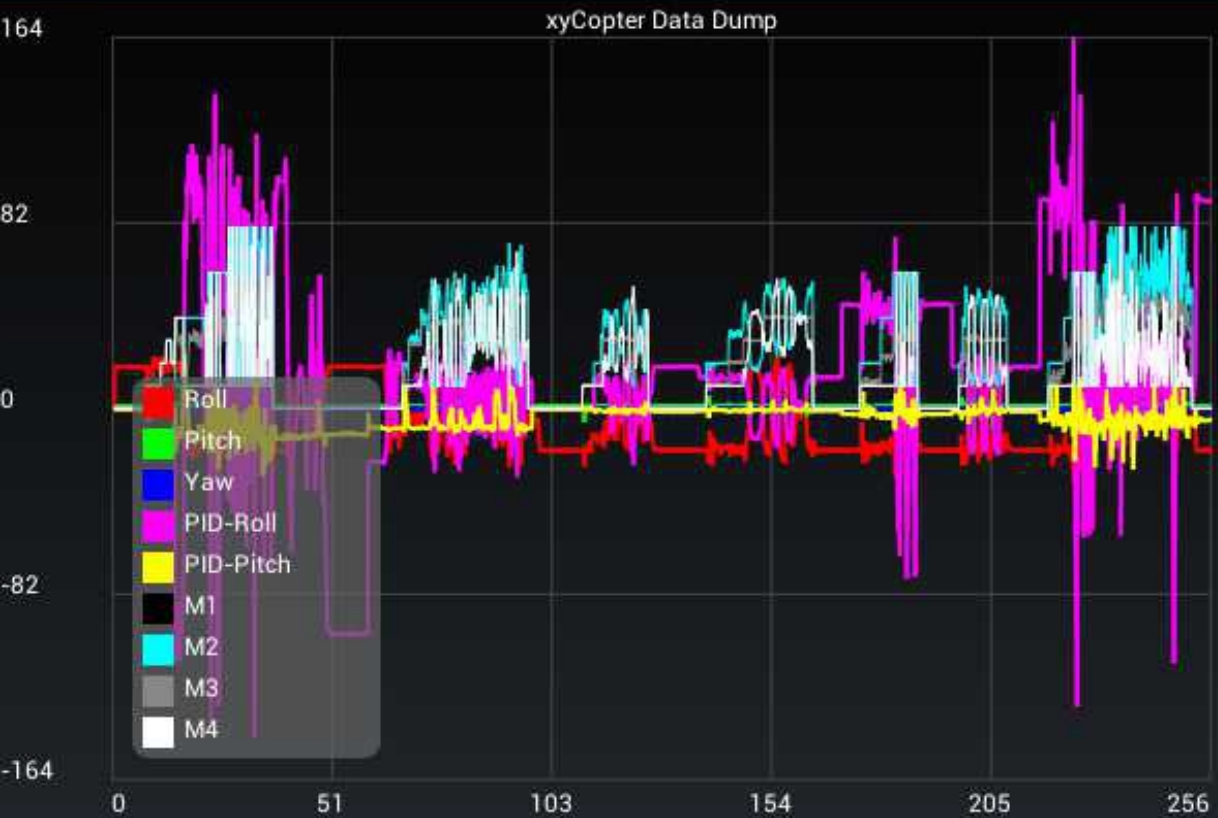
Toggle

Reset



12:53

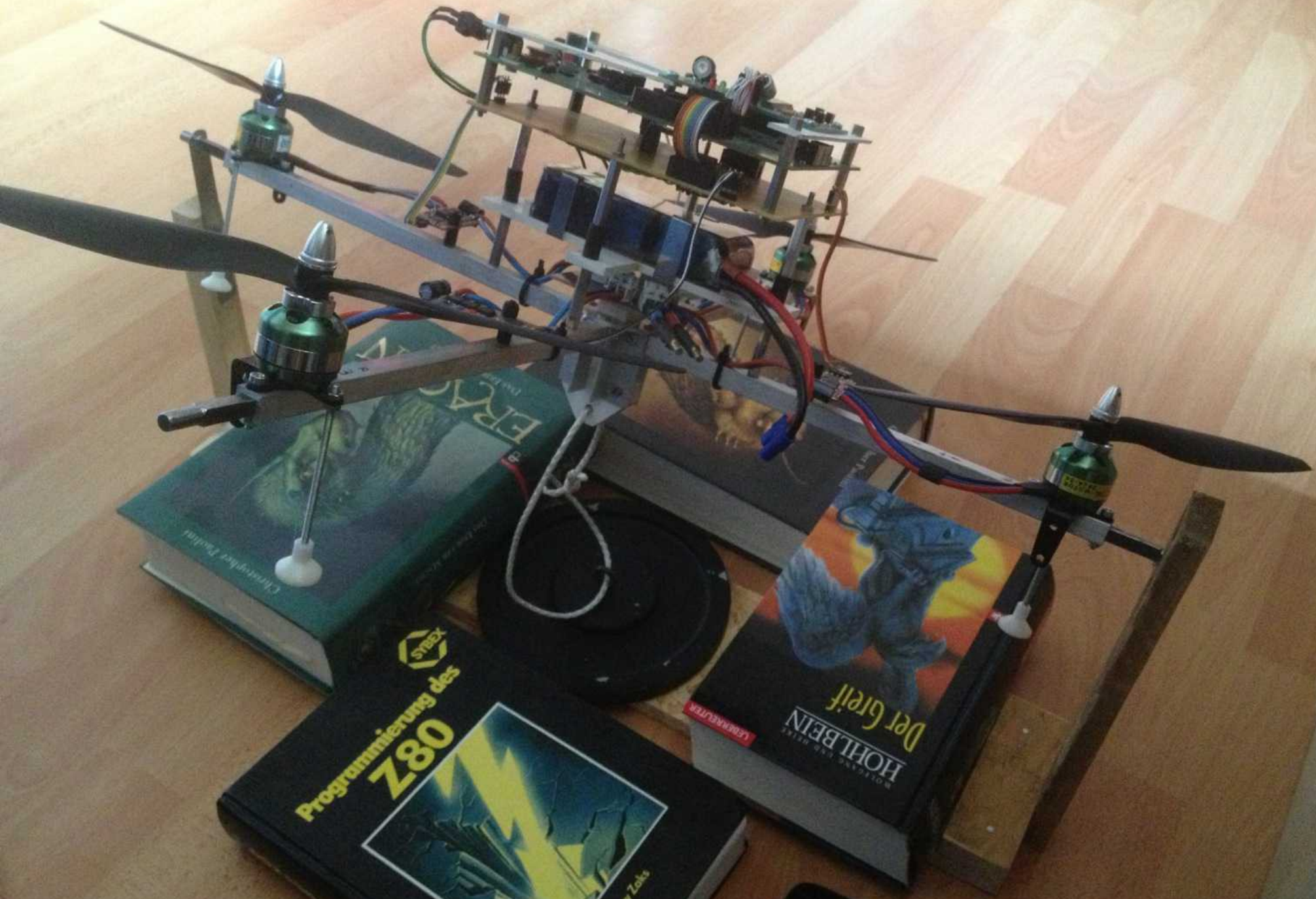




Roll: -18.28 °  
 Pitch: 1.06 °  
 Yaw: 0.00 °  
 Voltage: 12.26V (89%)  
 Motors: 0 0 0 0  
 PID: -5.28 91.39  
 Params: 5.000 0.000 0.000  
 Busy: 3 13 (430.0/1000 --> 570.0 free)  
 Throttle up to 30  
 Motor Off!  
 Motor On!  
 Throttle up to 20  
 Throttle up to 30  
 Throttle up to 40  
 Throttle down to 30  
 Motor Off!

Disconnected!

Left Right Forward Back Up Down  
 PID Motor Zero Reset



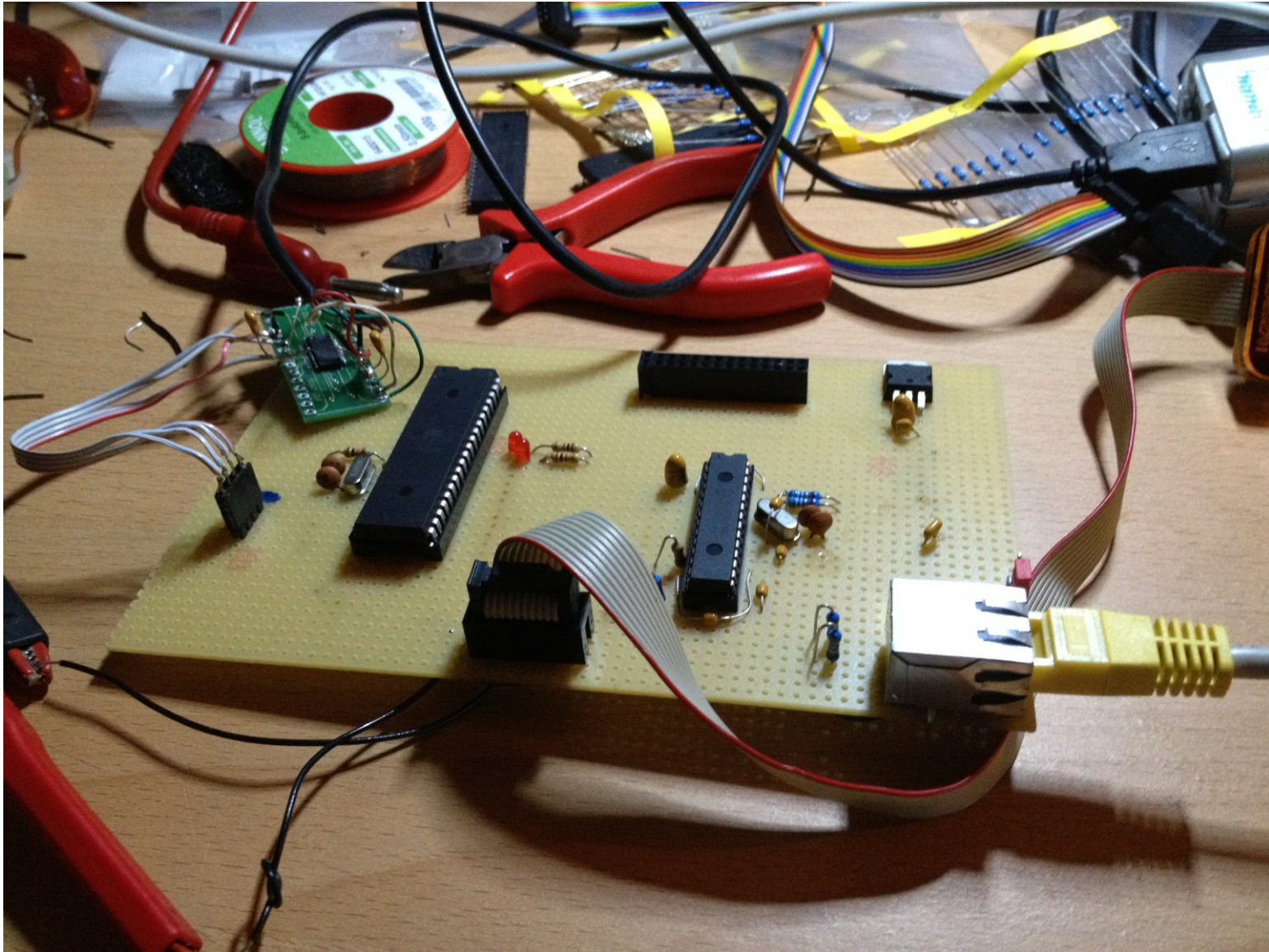
STREX  
Programmierung des  
**087**  
Robney Zoks

LEHRMATERIAL  
**Der Greif**  
HOHLBEIN  
MORGAN FOR HELL

ERVA  
Christoph Bucher



# Zukunft?



**Vielen Dank!**

Fragen?