

**MIT Cheetah/ Research  
HobbyKing Robot Motor  
AKA SteadyWin V3**

**Hey SteadyWin:** If you are reading this, **please contact me**. I have many questions and you have failed to respond to many email and support requests. Your product is far from what is advertised. That is OK, but we need some answers to improve the product.



AliExpress Page

<https://www.aliexpress.com/32985671853.html>

Steady Win Company Page

<http://www.steadywin.cn/>

Video of someone using a different model

<https://www.youtube.com/watch?v=ecSQZINda6g>

My Videos

<https://www.youtube.com/watch?v=Fb6HQNZ4PzQ>

<https://twitter.com/buildlog/status/1219807520816017409>

<https://twitter.com/buildlog/status/1220372055776022528>

Ben Katz Blog

<https://build-its-inprogress.blogspot.com/search/label/HobbyKing%20Cheetah>

Ben Katz Github

[https://github.com/bgkatz/3phase\\_integrated](https://github.com/bgkatz/3phase_integrated)

Motor Drive documentation

[https://docs.google.com/document/d/1dzNVzblz6mqB3eZVEMyi2MtSngALHdgpTaDJIW\\_BpS4/edit](https://docs.google.com/document/d/1dzNVzblz6mqB3eZVEMyi2MtSngALHdgpTaDJIW_BpS4/edit)

Controller Schematic PDF

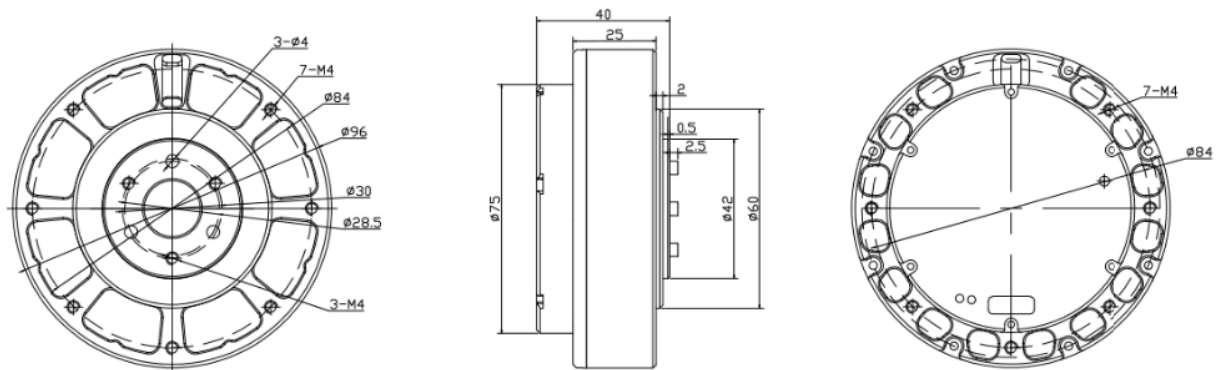
[https://drive.google.com/open?id=1LKZBExanS721uNWVH1Bye9HUD9dOXb\\_F](https://drive.google.com/open?id=1LKZBExanS721uNWVH1Bye9HUD9dOXb_F)

mBed (The Firmware)

[https://os.mbed.com/users/benkatz/code/Hobbyking\\_Cheetah\\_Compact/](https://os.mbed.com/users/benkatz/code/Hobbyking_Cheetah_Compact/)

Python Library

<https://github.com/bgkatz/USBtoCAN/tree/master/python%20library>



#### Notes:

The motor will turn on with a red LED. If you enable the motor it will turn green, but the rotor will not lock. If you send it to a position, it will go there and lock.

#### Parameters

Kp is desired position stiffness. If you set all commands to zero except for Kp, the motor will behave like a spring with stiffness Kp about the 0 angle.

Kd is velocity gain. Kd acts like a damper. If you set all the commands to zero except Kd and try to spin the motor by hand, you will feel some drag, proportional to Kd.

The feed-forward torque is a bias torque. If you set all the commands to zero except for the feed forward torque, the motor will just apply the torque you set.

All the commands get summed up in the motor drive, so the final torque is:

$$Kp_{position\_error} + Kd_{velocity\_error} + feedforward\_torque$$

Tip: If you want to go at a specific velocity, the Kd should be higher than the kp

#### [Command Packet Structure \(CAN Speed is 1Mbps\)](#)

The driver uses one packet to combine 5 commands. The commands are:

- 16 bit position command, scaled between P\_MIN and P\_MAX in CAN\_COM.cpp
- 12 bit velocity command, scaled V\_MIN and V\_MAX in CAN\_COM.cpp

- 12 bit Kp
- 12 bit Kd
- 12 bit Feed-Forward Current

```
// from ...  
https://os.mbed.com/users/benkatz/code/Hobbyking\_Cheetah\_Compact//file/6cc428f3431d/CAN/CAN\_com.h/  
  
#define P_MIN -12.5f // -4*pi  
#define P_MAX 12.5f // 4*pi  
#define V_MIN -45.0f  
#define V_MAX 45.0f  
#define KP_MIN 0.0f  
#define KP_MAX 500.0f  
#define KD_MIN 0.0f  
#define KD_MAX 5.0f  
#define T_MIN -18.0f  
#define T_MAX 18.0f
```

Sample C code for packing the bits

```
// enter values to pack here

unsigned int pos = 0x1234; // 16 bit
unsigned int vel = 0x0567; // 12 bit
unsigned int kp = 0x089A; // 12 bit
unsigned int kd = 0x0BCD; // 12 bit
unsigned int ff = 0x0EF1; // 12 bit

unsigned char can_msg[8];

can_msg[0] = pos >> 8;
can_msg[1] = pos & 0x00FF;
can_msg[2] = (vel >> 4) & 0xFF;
can_msg[3] = ((vel & 0x000F) << 4) + ((kp >> 8) & 0xFF);
can_msg[4] = kp & 0xFF;
can_msg[5] = kd >> 4;
can_msg[6] = ((kd & 0x000F) << 4) + (ff >> 8);
can_msg[7] = ff & 0xFF;

printf("Test %02x %02x %02x %02x %02x %02x %02x %02x", can_msg[0],
can_msg[1], can_msg[2], can_msg[3], can_msg[4], can_msg[5],
can_msg[6], can_msg[7]);
```

Simple C code to unpack response

```
int can_msg[6];
// example response ....
can_msg[0] = 1;
can_msg[1] = 0x12;
can_msg[2] = 0x34;
can_msg[3] = 0x56;
can_msg[4] = 0x78;
can_msg[5] = 0x9A;

unsigned int id = can_msg[0];
unsigned int pos = (can_msg[1] << 8) + can_msg[2];
unsigned int vel  = (can_msg[3] << 4) + ((can_msg[4] & 0xF0) >> 4);
unsigned int cur = ((can_msg[4] & 0x0F) << 8) + can_msg[5];

printf("\r\nid 0x%02X", id);
printf("\r\nPos 0x%03X", pos);
printf("\r\nVel 0x%03X", vel);
printf("\r\nCurrent 0x%03X", cur);
```

ESP32 CAN Library

<https://github.com/sandeepmistry/arduino-CAN>

My 3.3V CAN Adapter

<https://www.amazon.com/gp/product/B00KM6XMXO>

### Special Commands:

Enter Motor Mode

[0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFC]

Exit Motor Mode

[0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFD]

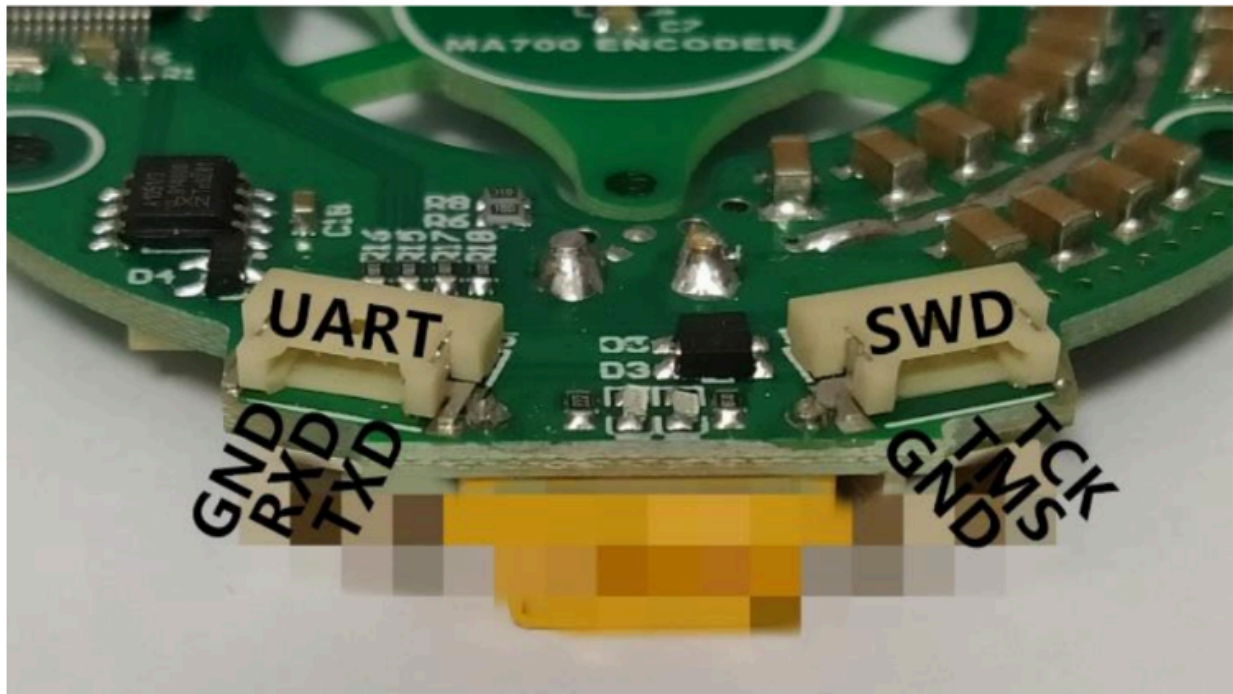
Zero Position Sensor - sets the mechanical position to zero.

[0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFE]







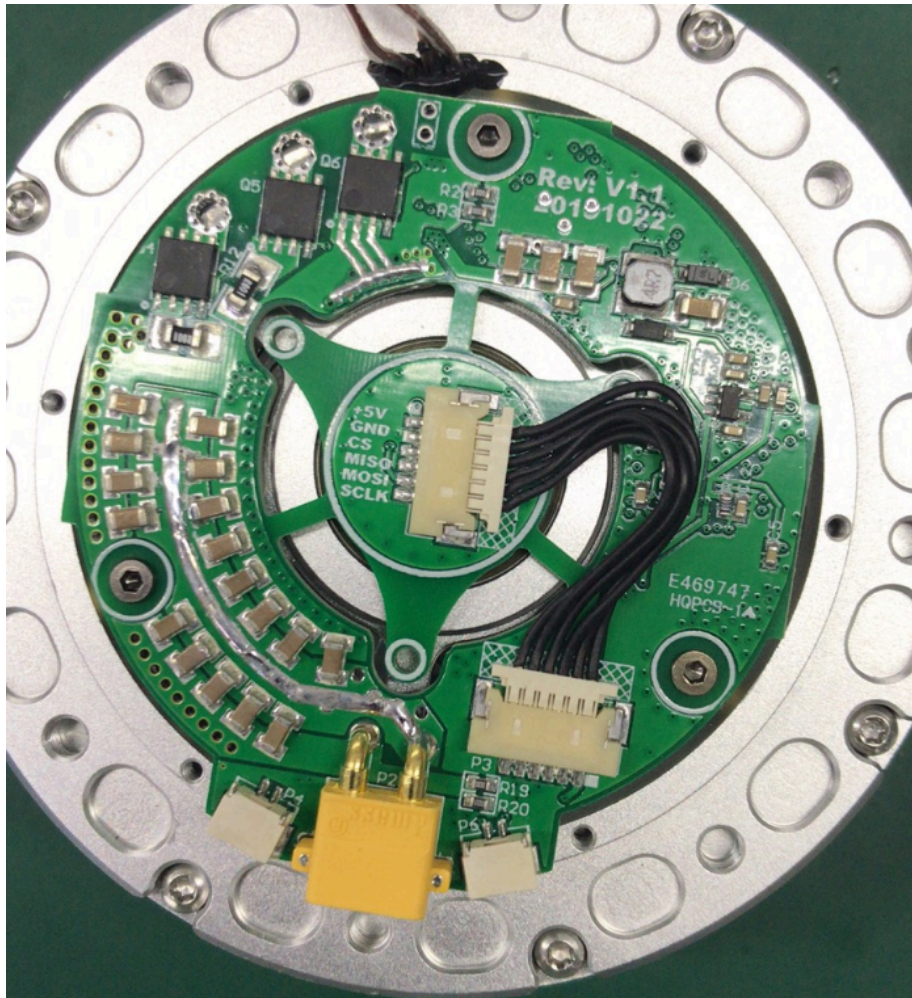


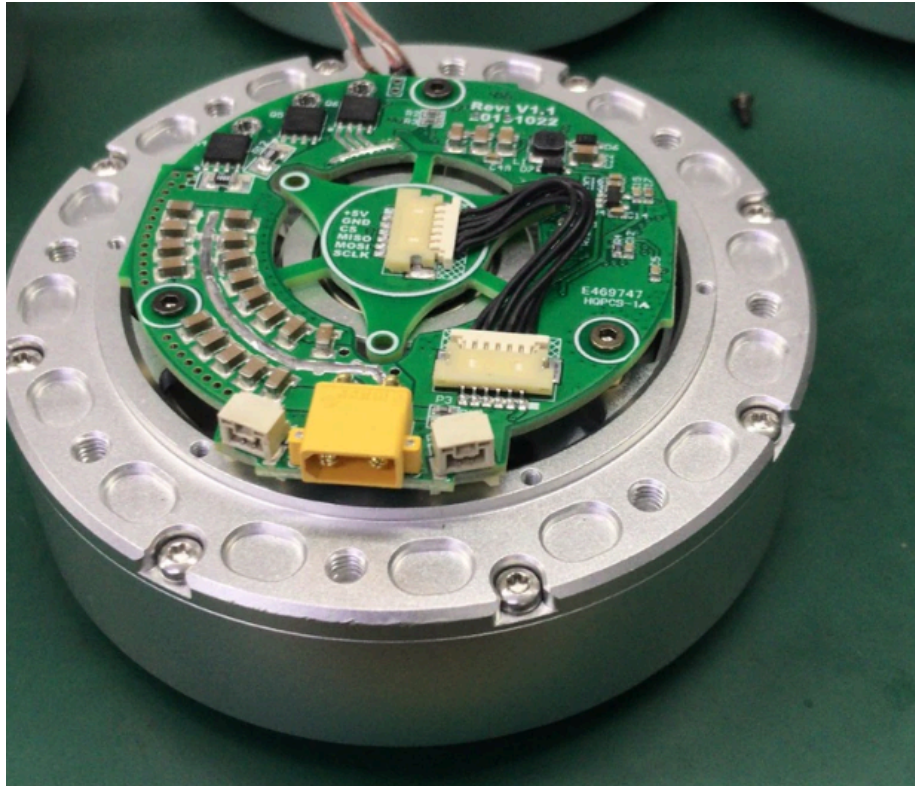
AliExpress source for the serial and prog cables.

<https://www.aliexpress.com/item/32902429074.html>

Serial port: 921600 baud, 8 bits, 1 stop bit, no parity bits

Picture of the controller. Note sure why the encoder is isolated and not connected on the PCB. It might be for thermal or mechanical isolation.





```
COM11 - Tera Term VT
File Edit Setup Control Window Help

HobbyKing Cheetah

Debug Info:
Firmware Version: 1.9
ADC1 Offset: 1941 ADC2 Offset: 1977
Position Sensor Electrical Offset: -0.3561
Output Zero Position: 101.0533
CAN ID: 1

Commands:
m - Motor Mode
c - Calibrate Encoder
s - Setup
e - Display Encoder
z - Set Zero Position
esc - Exit to Menu

FAULT
UDS_OCP
GDF
UULO
OTSD
UDS_HA
UDS_LA
UDS_HB
UDS_LB
UDS_HC
UDS_LC
```

```
COM11 - Tera Term VT
File Edit Setup Control Window Help

Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13313
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13312
Mechanical Angle: 17.157188 Electrical Angle: 0.205724 Raw: 13311
Mechanical Angle: 17.157959 Electrical Angle: 0.221831 Raw: 13314
Mechanical Angle: 17.158340 Electrical Angle: 0.229884 Raw: 13315
Mechanical Angle: 17.158722 Electrical Angle: 0.237938 Raw: 13316
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13313
Mechanical Angle: 17.158340 Electrical Angle: 0.229884 Raw: 13315
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13313
Mechanical Angle: 17.157959 Electrical Angle: 0.221831 Raw: 13314
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13313
Mechanical Angle: 17.156807 Electrical Angle: 0.197671 Raw: 13310
Mechanical Angle: 17.158722 Electrical Angle: 0.237938 Raw: 13316
Mechanical Angle: 17.157188 Electrical Angle: 0.205724 Raw: 13311
Mechanical Angle: 17.157188 Electrical Angle: 0.205724 Raw: 13311
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13312
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13313
Mechanical Angle: 17.156807 Electrical Angle: 0.197671 Raw: 13310
Mechanical Angle: 17.157959 Electrical Angle: 0.221831 Raw: 13314
Mechanical Angle: 17.156425 Electrical Angle: 0.189617 Raw: 13309
Mechanical Angle: 17.159492 Electrical Angle: 0.254045 Raw: 13318
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13313
Mechanical Angle: 17.156036 Electrical Angle: 0.181564 Raw: 13308
Mechanical Angle: 17.157188 Electrical Angle: 0.205724 Raw: 13311
Mechanical Angle: 17.158340 Electrical Angle: 0.229884 Raw: 13315
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13312
Mechanical Angle: 17.157959 Electrical Angle: 0.221831 Raw: 13314
Mechanical Angle: 17.157188 Electrical Angle: 0.205724 Raw: 13311
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13313
Mechanical Angle: 17.158722 Electrical Angle: 0.237938 Raw: 13316
Mechanical Angle: 17.158340 Electrical Angle: 0.229884 Raw: 13315
Mechanical Angle: 17.157959 Electrical Angle: 0.221831 Raw: 13314
Mechanical Angle: 17.157188 Electrical Angle: 0.205724 Raw: 13311
Mechanical Angle: 17.157570 Electrical Angle: 0.213778 Raw: 13313
Mechanical Angle: 17.159103 Electrical Angle: 0.245991 Raw: 13317
Mechanical Angle: 17.159103 Electrical Angle: 0.245991 Raw: 13317
Mechanical Angle: 17.157188 Electrical Angle: 0.205724 Raw: 13311
Mechanical Angle: 17.157570 Electrical
```

```
5/24/2019
COM11 - Tera Term VT
File Edit Setup Control Window Help

Commands:
m - Motor Mode
c - Calibrate Encoder
s - Setup
e - Display Encoder
z - Set Zero Position
esc - Exit to Menu

Commands:
m - Motor Mode
c - Calibrate Encoder
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esc - Exit to Menu

Configuration Options

prefix parameter          min    max    current value
b  Current Bandwidth (Hz)  100    2000   1000.0
i  CAN ID                  0      127    1
m  CAN Master ID           0      127    0
l  Current Limit (A)        0.0    40.0   40.0
f  FW Current Limit (A)     0.0    33.0   0.0
t  CAN Timeout (cycles)<0 = none> 0      100000  0

To change a value, type 'prefix' 'value' 'ENTER'
i.e. 'b1000' 'ENTER'
```

If only 5V is applied via the small 2 pin connector I get a continuous stream of faults on serial port....probably normal behavior.

```
COM5 - Tera Term VT
File Edit Setup Control Window Help
UGS_HC
UGS_LC

FAULT
UDS_OCP
GDF
UULO
OTSD
UDS_HA
UDS_LA
UDS_HB
UDS_LB
UDS_HC
UDS_LC
SA_OC
SB_OC
SC_OC
OTW
CPUU
UGS_HA
UGS_LA
UGS_HB
UGS_LB
UGS_HC
UGS_LC

FAULT
UDS_OCP
GDF
UULO
OTSD
UDS_HA
UDS_LA
UDS_HB
UDS_LB
UDS_HC
UDS_LC
SA_OC
SB_OC
SC_OC
OTW
CPUU
UGS_HA
UGS_LA
UGS_HB
UGS_LB
UGS_HC
UGS_LC
```



## C# Test Program

The screenshot shows a Windows application window titled "HobbyKing Cheetah Test". The interface is designed for controlling a motor system. On the left side, there are five input fields, each with a corresponding slider control to its right:

- Desired Position:** The input field contains the value "32000". The slider is positioned approximately three-quarters of the way across its range.
- Desired Velocity:** The input field contains the value "0". The slider is positioned at the center of its range.
- Kp (position):** The input field contains the value "200". The slider is positioned at the center of its range.
- Kd (velocity):** The input field contains the value "200". The slider is positioned at the center of its range.
- Feed forward I:** The input field contains the value "10". The slider is positioned at the center of its range.

Below these inputs is a "Send" button. On the right side of the window, there are four buttons arranged in two rows:

- Top row: "Open Port" and "Close Port".
- Bottom row: "Enable Motor" and "Disable Motor".

Below the "Send" button is a large, empty text area with a vertical scrollbar on the right side, intended for displaying log messages or status information.

## Programing Firmware

I am able to make basic changes to the firmware and upload them. [Here are some instructions](#)

### Example...

```
VI COM5 - Tera Term VT
File Edit Setup Control Window Help

Hobby King Cheetah

Debug Info:
Firmware Version: 1.9.1
ADC1 Offset: 1941    ADC2 Offset: 1976
Position Sensor Electrical Offset: -0.3390
Output Zero Position: -42.5070
CAN ID: 1

Commands:
m - Motor Mode
c - Calibrate Encoder
s - Setup
e - Display Encoder
z - Set Zero Position
o - To own it!
esc - Exit to Menu

FAULT
ODS_OCP
EDF
JULO
OTSD
ODS_HA
ODS_LA
ODS_HB
ODS_LB
ODS_HC
ODS_LC

Entering Motor Mode
```



## How this will be used with Grbl\_ESP32.

The Cheetah motor works a bit like a hobby servo. It has a limited range in rotation and that range is mapped across a 16 bit address. That mapping range is adjustable in firmware, but I will use the existing range for now.

That 16 bit range will be mapped as steps in Grbl in machine space. You can use the steps/mm setting to set a real world unit like degrees. So G0X360 might move one revolution. Mapping in machine space will still allow you to zero the axis, but it will respect the range of the machine (ie motor)

At startup, or whenever Grbl is in stepper\_idle mode the torque will be turned off. It will constantly read the Cheetah motor's position and update Grbl's axis location. This means you can manually move the motor and Grbl will track it.

When a Grbl move is made, stepper\_idle ends, the torque is turned on and the Cheetah motor begins tracking Grbl's motion. At first, a high update rate (100Hz) of CAN messages will be used. This means the motor does not need to do a rapid uncontrolled move to Grbl's current position. It also means that the speed, position and acceleration of Grbl is tracked by the motor. Later, step/direction signals could be hacking to the firmware.

I hacked Grbl\_ESP32 enough to demonstrate the motor. This is not final code, but functional. You can use it for reference. [See this file on a branch of the main code.](#)

## Step and Direction Control

[Step and direction is now working.](#)

## Links to Progress Videos (Tweets)

[Control](#)

[Feedback](#)

## Discussion



If you have read this far you deserve a link to the [Discord Server](#). Use the bldc\_servo\_motors channel. **Lots of good stuff appearing on the Slack Channel !!!**

## Donation



If you consider this doc helpful, please consider a [donation to support my open source projects via PayPal](#)

## Suggestions

I keep getting blank notices of suggestions. If you have a suggestion, do it on Slack.

## Extra Photos

Here is a photo of my test rig. The motor needs a lot of weight to keep it from jumping around. Even with the weight of this 400 watt power supply it can do some serious jumps.

- ESP32 near the power plug is acting as a USB to CAN adapter. It goes through the skinny blue CAN PCB near the motor.
- The red PCB is a 3.3V FTDI USB UART that goes through a breadboard with some resistors. They limit the current, if I screw anything up playing with those pins.
- The blue dongle in the middle is the programmer.
- Not shown is another ESP32 running Grbl\_ESP32 that generates step and direction signals. It plugs into the breadboard instead of the FTDI when in step/direction mode.

