# November

Hello Benefactors. Here's what I've been working on in November.

As you will know my release this month was a set of adaptors that allowed the Feel Stroker fleshlight alternative to be used with the OSR2 and SR6, and with the T-wist. This toy is probably better known as the one that comes with the Kiiroo Keon.

The main focus of my efforts, however, is to demonstrate a brushless gimbal motor drive for an OSR2-like device. This month I actually made some solid progress with this concept in two key areas. First, I have identified some new electronics hardware that should be close to plug-and-play for our application. Second, I made a breakthrough on the design of a 3D-printed gearbox that will allow us to get enough torque.

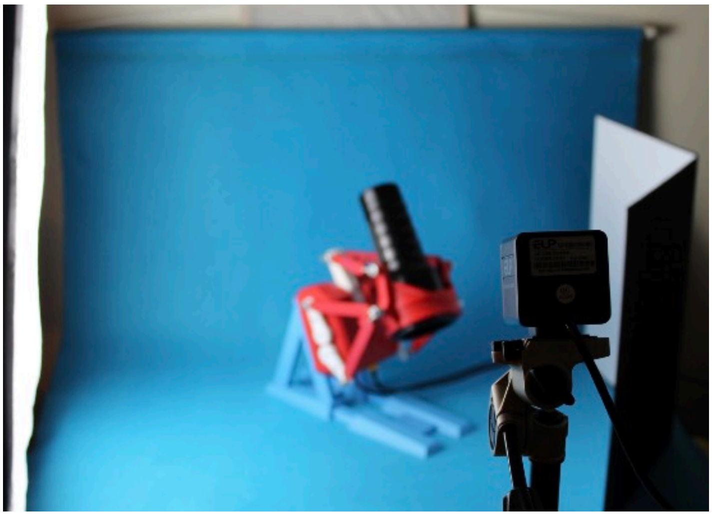
A pretty interesting month, all-in-all.

## Workflow

If I've learned one thing since I started my Patreon page it's that whenever you see a content creator who is very prolific, who always seems to be posting more new content, what you can be sure of is that they have optimised their workflow.

They have the tools and processes in place that allow them to streamline the creation of new content. That's why they can put out five or ten videos, say, in the time it takes you or I to make just one.

There's a lot of what I do that I can't really streamline, for example coming up with new designs. I've always kind of felt that the creative process seems to have people more so than people have a creative process.



*HD WEBCAM ON A TRIPOD IN FRONT OF MY PHOTOGRAPHIC SETUP*

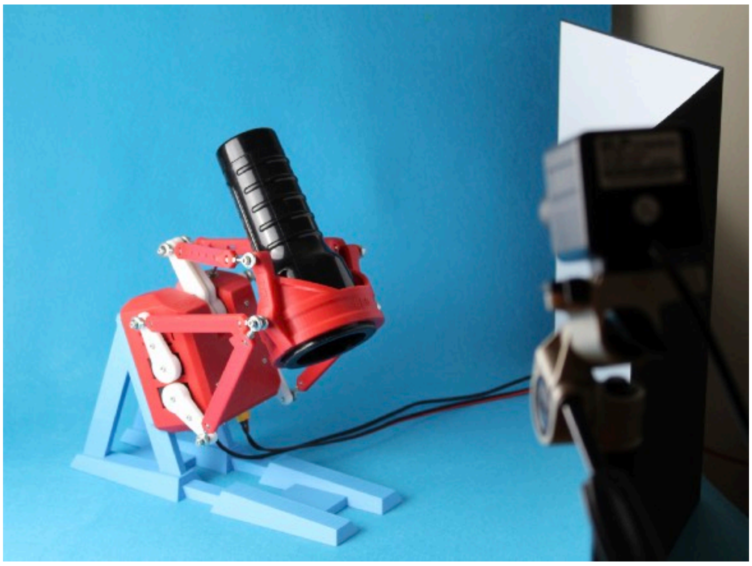
I have, however, set myself the goal of getting out four Patreon/SubscribeStar posts a month across my various tiers, and for that volume of content creation I have found that there are definitely some ways that I can streamline the process of getting the content finished and released.

The first one is perhaps the most obvious to someone reading my dispatches. I am finding it to be a very rewarding and useful habit to write down a summary of what I've worked on each month, but you will know that it doesn't start on these pages.

What I have created is a habit that any time I am working on something interesting I post an image of it and a short description to my Devstream on discord. The streamlining here is that I am both keeping you guys in the loop in real time, but I'm also giving myself a handy set of bullet points and images that make sitting down and writing a 3,000 word illustrated newsletter a lot easier than if I had to start from a blank sheet of paper.

Likewise these days I have a process in place if I want to take a photograph of one of my robots. In the old days I used to use my phone and I used to lay the parts out on my dining table, trying to find an angle where the light seemed okay and none of my living room was visible in the background. When I got my SLR camera and I tried to take some better photographs I spent the best part of a couple of days trying to get the right combination of a light, diffuser, reflector, etc.

These days I have a ready-to-go setup that I can put out in a matter of a few minutes and get consistently good quality images. This is the product of many lessons learned over many uses and the most recent addition, a cheap combined diffuser-light bought off amazon, really simplified the setup.



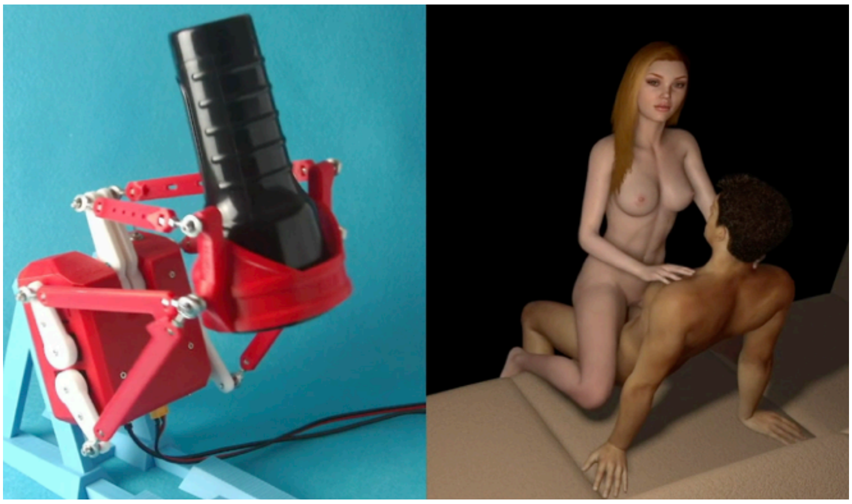
*THE SR6 BEING FILMED IN MY PHOTOGRAPHIC SETUP*

The biggest advances I have made have been to my digital workflow. I actually record quite a lot of video, and for my early videos this all used to be on my phone. I would literally clamp my phone to a lamp stand in front of my face and record the video on it, whilst recording the sound through a microphone attached to my computer, which I would merge the two later.

The day that I bought a couple of HD webcams all of that changed, and I've never looked back. Recording live from those and recording the sound at the same time using Open Broadcaster Software (OBS) saves me so much time. It used to take me several days each month to put together a video, whereas now it only takes me a few hours. Recording the video live during a livestream is also helpful, because I can engage with my community at the same time as recording, and doing it live means I can't be a complete perfectionist and keep re-recording.

This month's little advance was a natural extension of the other improvements. In the past when I have recorded my robots moving to scripted content such as VaM or video scripts I have recorded the two parts separately and then edited the video together later.

On this occasion I threw up my photographic setup, but then instead of using my SLR I placed one of my HD webcams on the tripod. Then I was able to use OBS to simultaneously record the SR6 and VaM on either side of the screen.



*THE VIDEO OUTPUT FROM THE COMBINED WEBCAM AND SCREEN RECORDING IN OBS*

Needless to say this saved me a lot of time when it came to putting the video together. It was pretty much ready to go as it was.

## Incorporating the Feel Stroker

I have recently been doing a bit of research into some of the commercial devices that are currently available to buy. The obvious place to start was to look at two devices: the Handy and the Kiiroo Keon. These devices are single axis strokers, so severely limited in their range of movement compared with my machines, but still interesting to look at for sure. I have now disassembled both of them, and I can certainly talk more about them if there's interest.

As part of this exercise I got my hands on a “Feel Stroker”. The Kiiroo Keon is basically a re-make of the Fleshlight Launch. In raw performance terms the device is actually inferior to the Launch, the Handy and definitely to OSR2 and SR6. It has a cheap, slow motor and really short stroke length. It does, however, have some really cool design features. One of these is that when Kiiroo parted ways with Fleshlight they had to make their own toy to go inside their device, and that gave them the opportunity to do a re-design of the classic flashlight case to optimise it for use in a stroker robot.

*COMMERCIAL SINGLE AXIS STROKER ROBOTS: THE HANDY (LEFT), THE KIIROO KEON (RIGHT)*

*STANDARD FLESHLIGHT (LEFT) FEEL STROKER (RIGHT)*

The Feel Stroker is actually a very smart piece of design. It’s designed to fit into a stroker machine, whereas the standard Fleshlight never was.

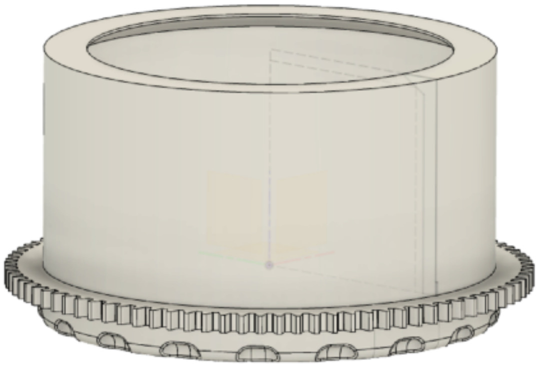
On the Fleshlight case the mounting features are on the side, which means that the receiver is around the outside of the toy and the toy is inserted into the machine from the top. On the feel stroker the mounting features are on the top of the toy, which means firstly that the receiver is no wider than the toy itself, and that the toy is inserted from the bottom of the machine. This is more compact, but it’s also a lot safer for the user in the event that the toy becomes detached during use.

A Fleshlight sleeve will fit into a Feel Stroker case. It's a bit tighter, but the diameters are more or less the same. The wide part of the Keon case is a bit shorter though.

The strangest little quirk of these two cases is that the Fleshlight case lid will screw onto the Feel Stroker case - though not the other way around. Incidentally this also means that the T-valve will fit onto the Feel Stroker case.

As it happened my evaluation of the Feel Stroker coincided with a number of requests by members of my community for support for other toys by the OSR2 and the SR6. As you know I am currently working on some longer-term projects, so creating an adaptor for the Feel Stroker seemed like a suitable candidate for a monthly hardware release.

*THE T-VALVE ON A FEEL STROKER.*



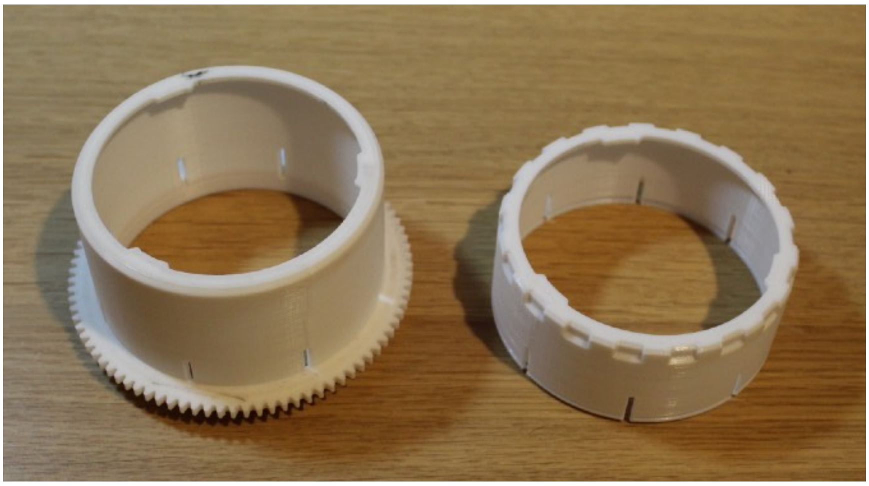
FIRST ATTEMPT AT MODELLING: IF YOU WANT TO UNDERSTAND A PROBLEM: MODEL FIRST, THINK SECOND!

My starting place was to create an alternate ring gear for the twist receiver. I quickly determined that I would need to come up with a different approach when it came to how to design a receiver to hold the feel stroker.

Usually I design my receivers to be printed from the bottom up, but in order to engage with the mounting features on the feel stroker it was obvious that I couldn't achieve the required overhang, and so I would have to print from the top-down.

To make things more challenging, I couldn't think of a way of printing the gear itself with a smooth upper and lower surface without starting the print of the gear itself from the print bed.

What I had to do is something that I generally try to avoid where possible, which was to divide the part into multiple sections, printed separately. I don't like this, because my general philosophy when I design is to minimise the part count. Something else that made this challenging is that I usually like to design parts that bolt together and I tend to avoid using glue, but the geometry that I had to work with didn't give me much space at all for the bolts I would need to hold the part together.

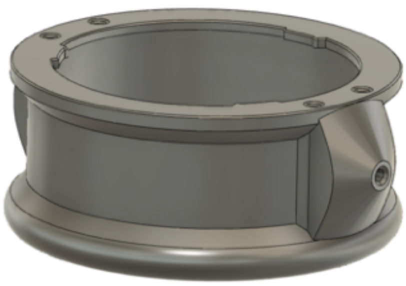


THE FEEL STROKER RING GEAR PROTOTYPE (LEFT) AND AN UPDATED DESIGN FOR THE UPPER PART (RIGHT). I WAS UNABLE TO SEPARATE THE ORIGINAL TWO PIECES ONCE THEY HAD SNAPPED TOGETHER!

In the end what I designed was two parts that clip together mechanically. I wasn't sure whether this would actually work, but when I put the first two pieces together it quickly became apparent that not only were they going to stay together during use, there was also no easy way that I could find of getting them apart at all! Naturally if you wanted you could glue these two parts together, though it's really not necessary.

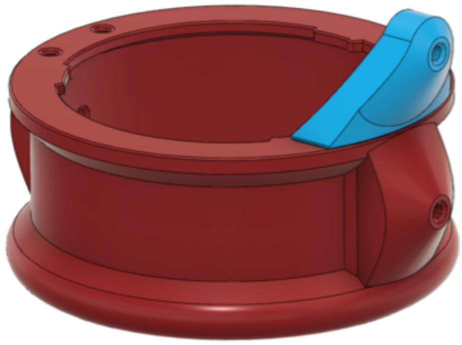
Next I moved on to look at designing a new basic receiver for the OSR2 and SR6 that would hold the feel stroker. This was actually more challenging than it might seem at first because, as with the ring gear design, the receiver had to be printed top-down. This meant that if I wanted to build in the attachment points for the pitcher arm or arms these would be below the level of the build plate.

Once I realised that the receiver design would have to be in multiple parts it made sense to me that I should design a receiver body that could be used with attachments for either an OSR2 or an SR6.

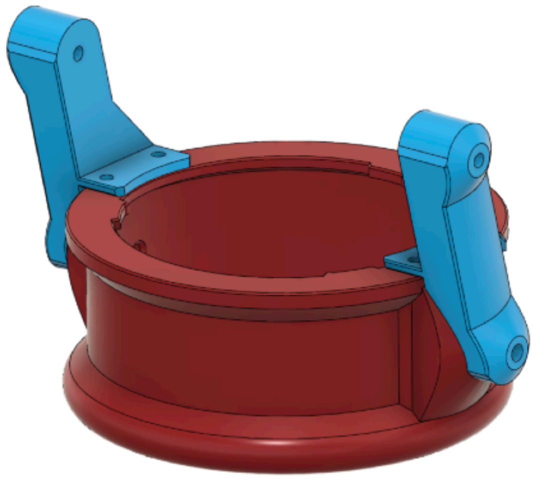


THE RECEIVER BODY DESIGNED FOR THE FEEL STROKER, PRINTED FROM THE TOP SURFACE DOWN IN THIS ORIENTATION

As I'm sure you can imagine, I love a detail design challenge like this. As always with the design of 3D printed parts the most important detail is the right choice of the build plate orientation. If you get this right it should be possible to design a part that prints well because it isn't too tall relative to its width and has minimal overhangs at small angles.



*OSR2 FEEL STROKER RECEIVER*

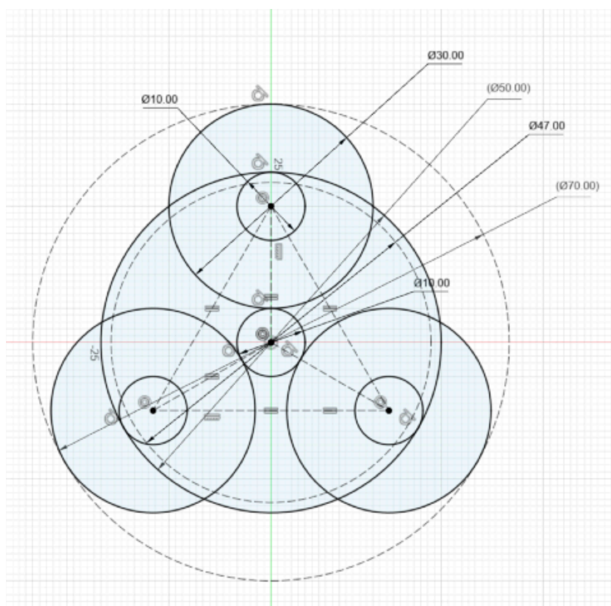


*SR6 FEEL STROKER RECEIVER*

The nice thing about the interface to the OSR2 and SR6 being in separate parts was being able to optimise the design and build orientation for each. The OSR2 attachment is a wide and tapered part and so can be printed from the bottom up. By contrast the attachment for the SR6 is quite tall and angled forwards and has to serve to widen the whole assembly because the SR6 receiver is slightly wider than the OSR2 one. This meant that the most sensible orientation for the attachments was to use their front faces as the print base surface. This contributed to the strength of the part and it also made it possible to print the tabs that sit on top of the receiver body.

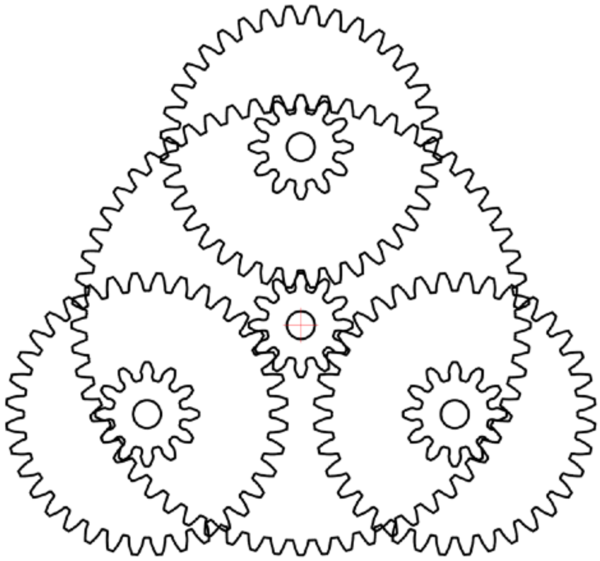
## Gearboxes

Brushless gimbal motors run at low speed and they produce a lot of torque for an electric motor. The ideal situation would be that they produce the equivalent torque to a servo and we could just install them in place of a servo. Unfortunately the torque that one of these motors produces is about a tenth of what we get from our 20kg.cm or more servos. What that means is that if we want to use these motors we will also need some kind of drive mechanism, for example a gearbox.




*MY INITIAL DRAWING OF MY MODIFIED PLANETARY GEARBOX CONCEPT*

This wouldn't be the same thing as a servo because the rotation speeds would still be relatively slow. For example if the motor got to around a typical maximum speed of 1000 rpm that would still only be 17 revolutions per second, which is well outside the human hearing range and nowhere near as fast as the rotation of the gears inside a servo. A 10:1 gearbox would give us the same torque as a servo and we'd still have a speed of over 600 degrees/second which is more than enough for a machine like, for example, the OSR2.

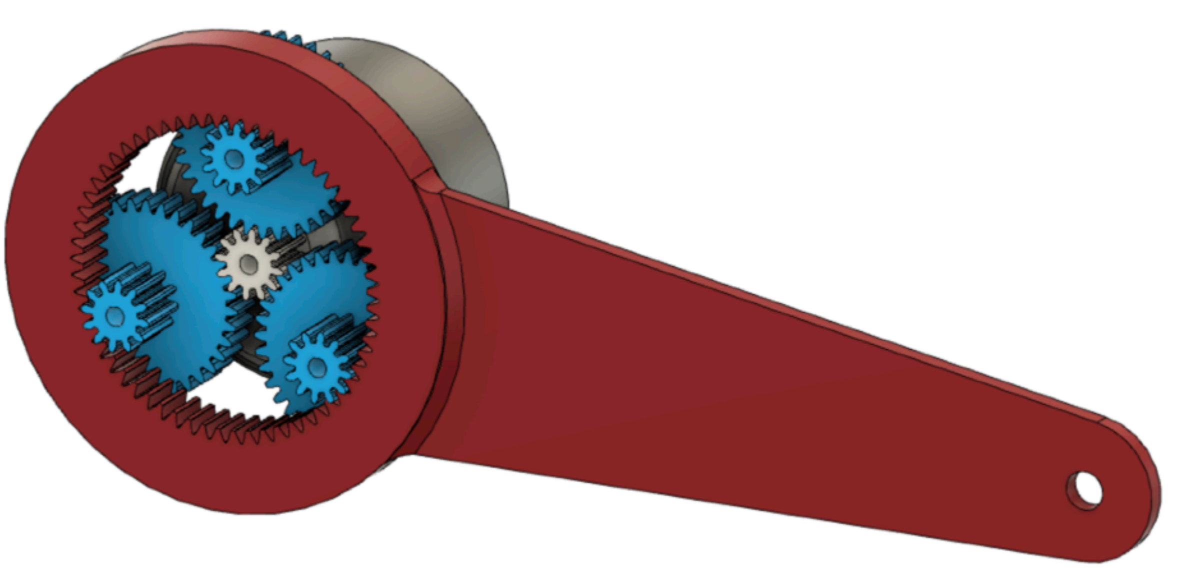


FIRST 2D DRAWING OF THE GEARBOX GEAR PROFILES

It's seemed to me for a while that some kind of planetary gearbox would be a good fit for this application. These are gearboxes where the "sun" gear at the centre turns a "ring" gear around the outside via several "planet" gears that sit in the gap between them. The problem with this was that for a simple 10:1 planetary gearbox the ring gear must be ten times the diameter of the sun gear, ie the ring gear would likely be about 10cm across, more than double the diameter of the motor.

In typical Tempest fashion I mulled this problem over for weeks and then an answer rudely presented itself to me right in the middle of the night. It was nagging at me so much I was completely unable to get back to sleep I had to go to my computer and start drawing it up in Fusion360.

I used a gear profile generator to create the 2D gear profiles and then I imported this into my Fusion360 model and fleshed the arrangement out into a 3D model of the gearbox. Then, exhausted after hours of tinkering with the design, I let myself lie down and have a nap.



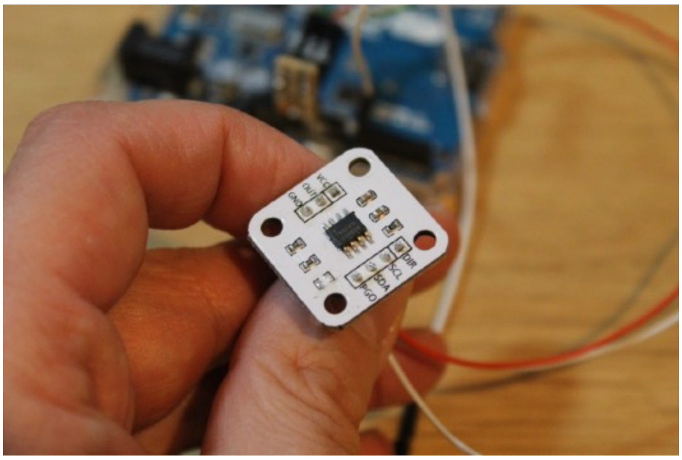
3D VIEW OF THE GEARBOX CONCEPT IN THE FORM OF AN ARM FOR AN OSR2-LIKE MACHINE

My idea, which I'm sure isn't original, was to add a separate, smaller, gear profile onto the planet gears. This would simultaneously reduce the outer diameter of the gearbox whilst increasing its ratio. In fact, I subsequently realised was that what I had designed wasn't a 9:1 gearbox as I'd originally thought, but a 15:1 gearbox. So not only did the concept work, but I had accidentally over engineered it.

I decided that for the purpose of testing rather than re-drawing the gearbox I will build this version and then change the ratio subsequently after I see how it performs.

# Electronic hardware

Something else that I have occupied myself with this month is my quest to find the right electronics to use on a brushless motor design. I have been using the AS5600 magnetic encoder, in combination with an Arduino-based board, namely the BGC 3.1.

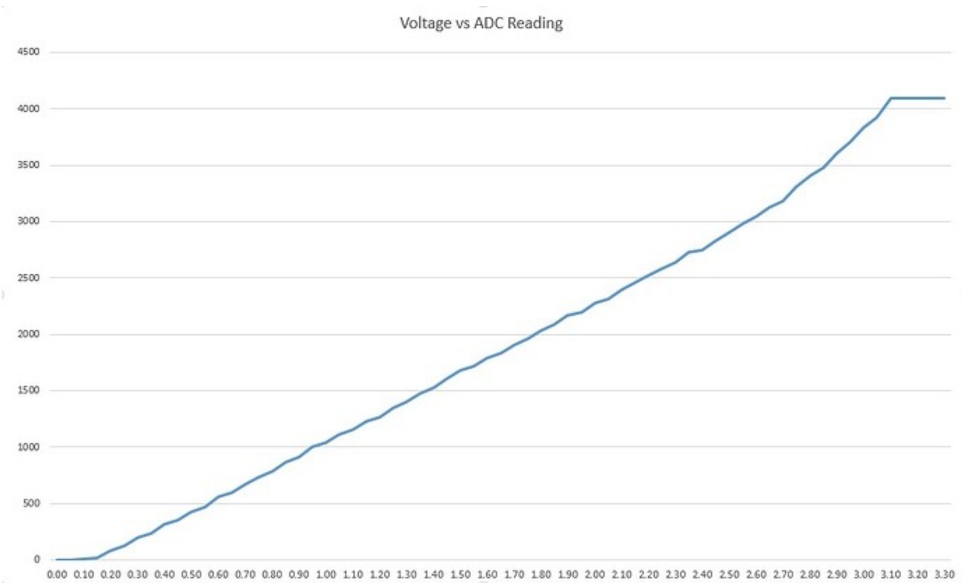


*AS5600 ENCODER BREAKOUT BOARD WITH THE RESISTOR REMOVED (BOTTOM LEFT)*

I started out using the I2C interface to the AS5600, which was able to report back a 12-bit resolution position for the magnet attached to the motor. The problem with I2C is that it takes time to send and receive this data, which meant that the Arduino was occupied for large proportions of the main loop communicating with the sensor. It also meant that the update rate was of the order of 100 times a second, which was not ideal.

The AS5600 offers an analog input, and for a while I wasn't able to figure out how to use it. Fortunately Telani was able to figure out that it can be activated by removing one of the resistors on the breakout board! This actually worked rather well, because this made it possible to connect up the encoder to one of the analog pins instead. This massively increased the rate at which the Arduino could read the encoder position.

The problem here is that I want to use the ESP32 for future designs. The ESP32 is vastly superior to the Arduino-based chips in nearly every way, but it seems to have a quirk that is a big problem for us in this context. That is that there is a non-linearity in its ADCs.



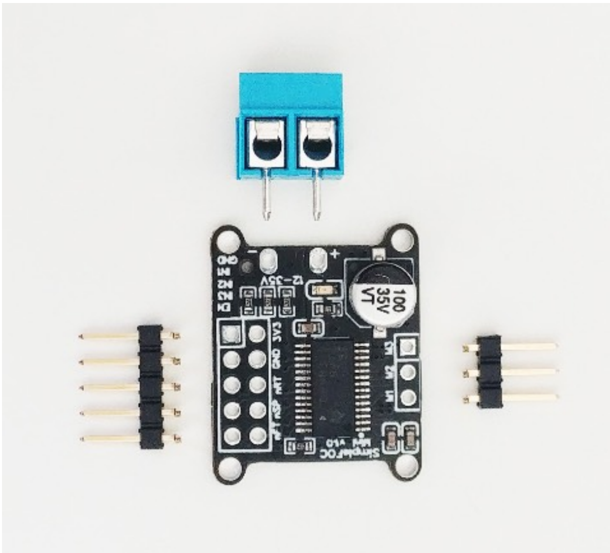

*VOLTAGE VS ADC READING ON AN ESP32*

The Analog-to-Digital Converter (ADC) is the sensor that reads off a pin voltage level, compares it against a reference (in this case 3.3v), and then generates a digital value (in this case 12-bit: ie 0-4095) that can be used by the software. On the ESP32 there is a dead zone at the bottom and top ends of the voltage range. This means that if our encoder reads off values below 0.15v or above 3.1v, which correspond to a range of angles, these values will not be seen properly by the ESP32.

This might not be a problem if we were confined to the middle of the graph, so for example for a camera gimbal where the range of angles the motor would see would be limited to a small range. Unfortunately however we will be requiring our motors to be making multiple revolutions for each stroke, which means we will need a sensor that functions effectively over the complete range of angles.

This has forced me to start looking for an alternative encoder and the one I am now looking at is the AS5048a. This is able to provide feedback via pulse width modulation, ie a timed on-off duty cycle that occurs 1,000 times a second. This seems to work well, and generally I've found it a lot more straightforward to work with than the AS5600.


*AS5048A MAGNETIC ENCODER*




*SIMPLEFOCMINI V1 MOTOR CONTROLLER*

I've made another recent discovery that's pretty exciting and that is that SimpleFOC have come out with a new breakout board, the SimpleFOC mini v1. The board uses the DRV8313 and is rated to 3A and 12-35 volts, so perfect for the motor that I'm using. I've got a couple of these boards on order so that I can give them a try and see how well they work.

I'm increasingly confident now though that these two boards, the AS5048a and the SimpleFOCmini, wired up to an ESP32 are a suitable control system for my upcoming designs.

## Finally...

I’d like to say a big thanks to you guys for the support you give me. I’m actually enjoying sharing this glimpse into my creative process with you, so I hope that it’s interesting to see and read. I would like to invite you guys to engage more on the discord server, especially if you see something I’ve posted and you have any questions or suggestions. I’m also definitely open to organising livestreams and hangouts on there too if there’s anything particular you’d like to see more of. Let me know.

Thanks again!
Tempest