How to make your own gimbal?

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Contents

1 How to make your own gimbal?

Objective of this tutorial is to demonstrate how one can make his own gimbal. We will start from "What is Gimbal ?" and go through full gimbal making process and show a working Gimbal at the end.

2 Prerequisites

- 3D Design for 3D Printing of Gimbal.
- Basic idea about gimbal.

3 Hardware Requirement

- Two Vibration and Shock Absorbing Mounts
- Gimbal Motor Frame 1
- Gimbal Motor Frame 2
- Gimbal Motor Frame 3
- Camera Fixing Mount
- Three Brushless Gimbal Motors
- 3 Axis Brushless Gimbal Controller
- One MPU6050 Sensor
- Four Damping Shock Absorber Balls
- Some Hex Button Head Bolts
- Compatible Camera

4 Software Requirement

- 3D design software for 3D printing

5 Theory and Description

5.1 What is Gimbal?

A gimbal is a pivoted support that allows the rotation of an object about a single axis. A set of three gimbals, one mounted on the other with orthogonal pivot axes, may be used to allow an object mounted on the innermost

gimbal to remain independent of the rotation of its support.For example, on a ship, the gyroscopes, shipboard compasses, stoves, and even drink holders typically use gimbals to keep them upright with respect to the horizon despite the ship's pitching and rolling.

A gimbal is a platform that can pivot. It means that instead of being fixed to an unmoving base, an object on a gimbal can rotate along at least one axis. In the world of aeronautics, these axes are roll, pitch and yaw.

5.2 Roll, Pitch, Yaw Axis

It's easiest to understand roll, pitch and yaw by visualizing an object like an airplane as shown in Figure 1. Think of an imaginary line that runs through the front of the plane and out the back. A rotation along this line would result in a roll – the plane would start doing barrel rolls.

Now imagine another line running through both wings of the plane. A rotation along this line is a change in pitch. The plane either climbs or dives, depending on the direction of the pitch. A full circle would be a loop-the-loop.

Finally, imagine a vertical line that comes out of the top and bottom of the plane. This is the yaw axis. Rotating along this line results in a change in direction for the plane – either right or left.

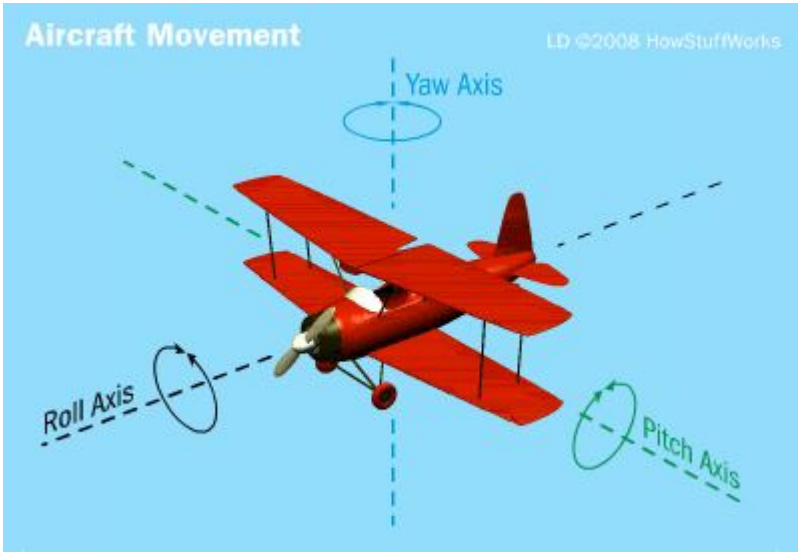


Figure 1: Showing Roll, Pitch, Yaw axis in Aircraft (Courtesy: science.howstuffworks.com)

5.3 Gimbal for quadcopter

As Drone cannot be perfectly stable either due to poor flying or adverse weather conditions. So here we need gimbal. A gimbal allows you to keep your video recording device stable and fixed. It will aim at the same direction, regardless of whether the craft holding it is pitching forward, left, right, etc.

So a gimbal is used to improve overall image quality, to reduce shakiness in video recordings, and to eliminate the dreaded jello effect common on so many videos. Jello-effect (also known as the wobble) appears when the camera is vibrating, in situations such as hand-held shots at telephoto settings, or when shooting from a moving vehicle. The rolling shutter causes the image to wobble unnaturally. One image of 3 axis camera gimbal is shown in Figure 2

Figure 2: Showing 3 axis gimbal with camera (Courtesy: www.bukalapak.com)

5.4 Balancing the Gimbal

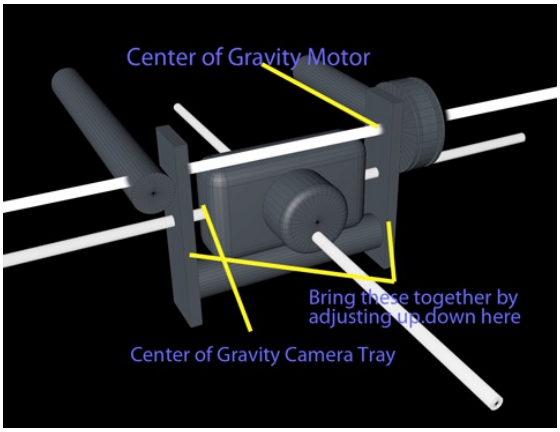
Its important to first balance your gimbal with your camera before you try to tune it as some parameters will change if you are using a different camera.

Its best to first choose what camera/lens you are going to use and try not change it as you will probably need to go through the whole balancing process again if the Centre of Gravity (COG) changes significantly (such as with zoom lens) In general a 14mm to 35mm lens is what you want to use with a gimbal as it gives a nice wide angle. Its also a good idea to put things like camera battery, memory card etc into to the camera before balancing.

Another tip is to attach a quick release mount as its makes life much easier when you need to remove the camera, or put it back on.

5.4.1 Balance the Pitch axis:

The first step is to balance the pitch axis. You will need to adjust the height of the camera and also the position (forward/backwards). When its perfectly balanced then when you move the camera to point down slightly, then it will stay there (with no power to motors/gimbal controller). Figure 3 shows balancing the Pitch axis.



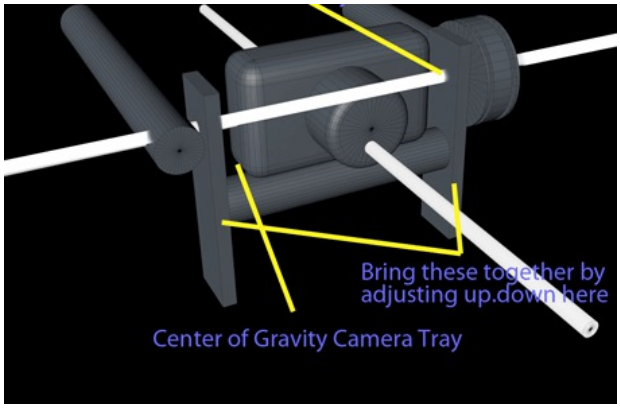


Figure 3: Balancing pitch axis of the gimbal (Courtesy: http://www.dronetrest.com)

5.4.2 Figure 3: Balancing the Roll axis:

Follow adjust your gimbal to make sure the COG of the camera is along the motor axis as shown in the image below. Again once its balanced when you change the angle it will stay there when the gimbal is turned off. Figure 4 shows balancing the Roll axis.

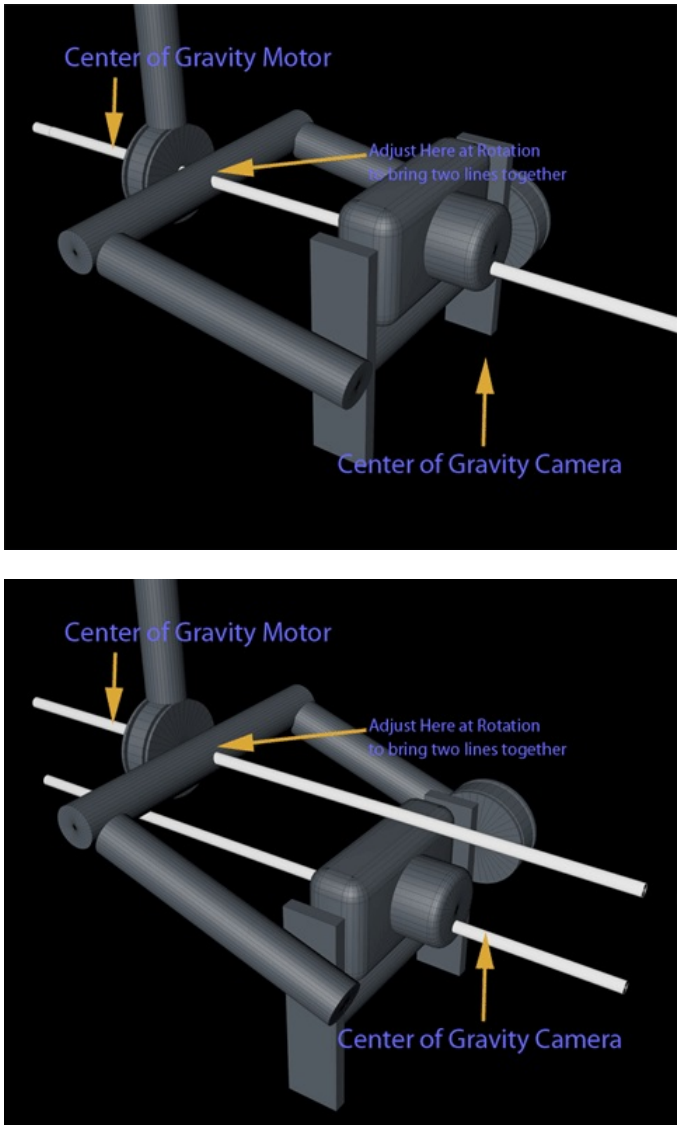


Figure 4: Balancing roll axis of the gimbal (Courtesy: http://www.dronetrest.com)

For more details, gifs and videos refer to
http://www.dronetrest.com/t/balancing-your-brushless-gimbal/55

6 Experiment

6.1 Making a Gimbal

Here I will use some 3D printed parts and some purchased parts for gimbal design. You can make your own 3D design using any 3D design software and then print 3D parts using 3D printing machine or you can use other's 3D designed parts for your gimbal. I got 3D designed parts from http://www.thingiverse.com/thing:1247236 for my 3 axis open brushless gimbal.You can also purchase all the parts. There are many stores are available. Some of them are:

- http://www.hobbyking.com/hobbyking/store/__960__501__Multi_Rotors_Drones_Parts-Camera_Gimbals.html
- http://axisgimbal.com/gimbal-parts etc.

6.1.1 Required 3D printed parts:

1. **Vibration and shock observing mounts:** We require two vibration and shock observing mounts shown in Figure 5 and Figure 6.

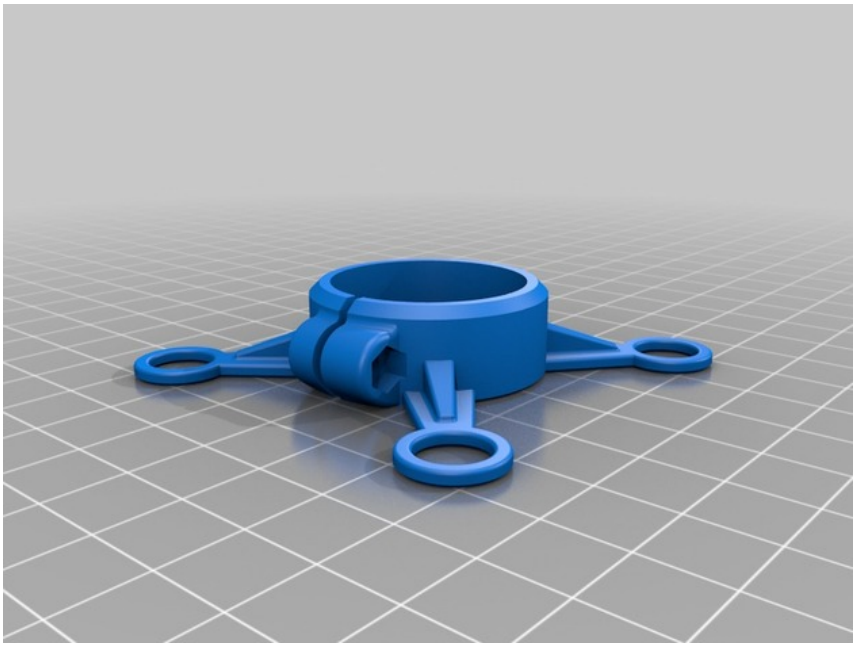


Figure 5: Lower vibration observing mount (Courtesy: www.thingiverse.com/thing:1247236)

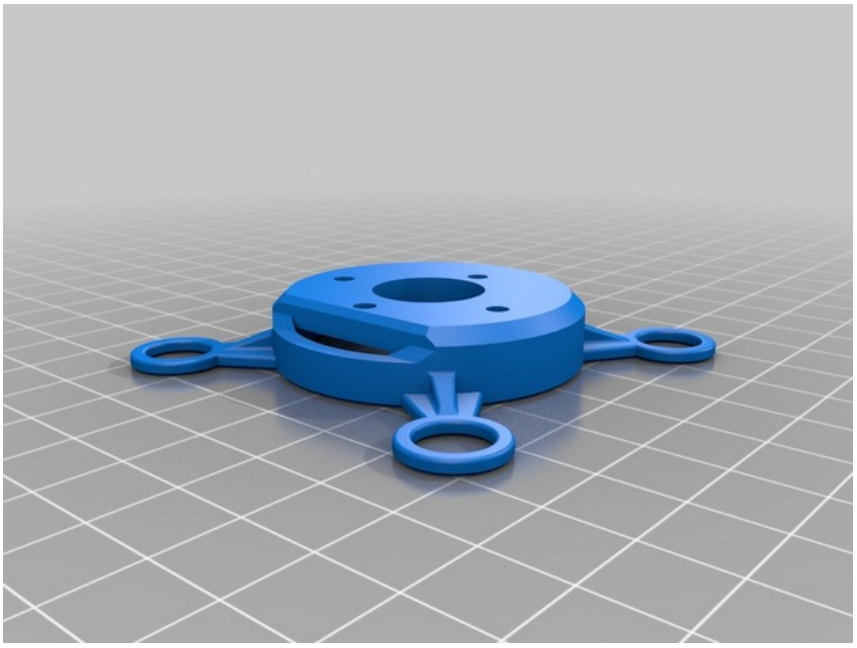


Figure 6: Upper vibration observing mount (Courtesy: www.thingiverse.com/thing:1247236)

2. **Gimbal Motor Frame 1:** To hold pitch axis motor shown in Figure 7.

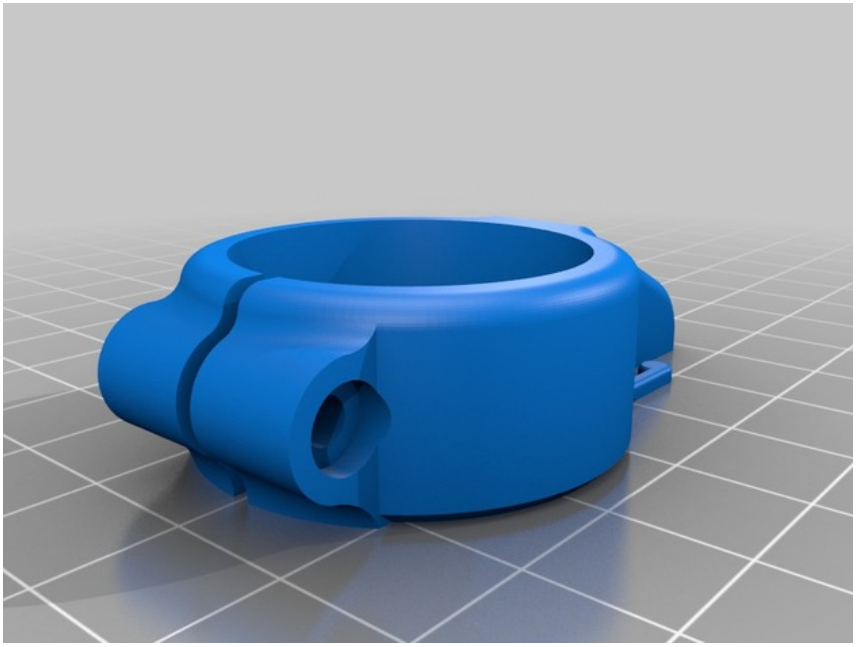


Figure 7: Gimbal Motor Frame 1 (Courtesy: www.thingiverse.com/thing:1247236)

3. **Gimbal Motor Frame 2:** To hold roll axis motor shown in Figure 8.

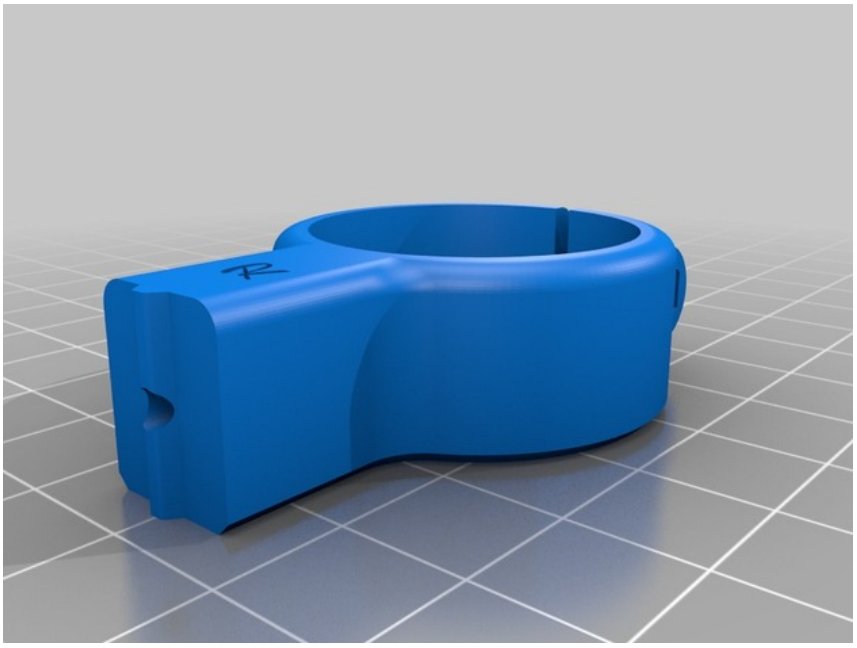


Figure 8: Gimbal Motor Frame 2 (Courtesy: www.thingiverse.com/thing:1247236)

4. **Gimbal Motor Frame 3:** To hold yaw axis motor shown in Figure 9.

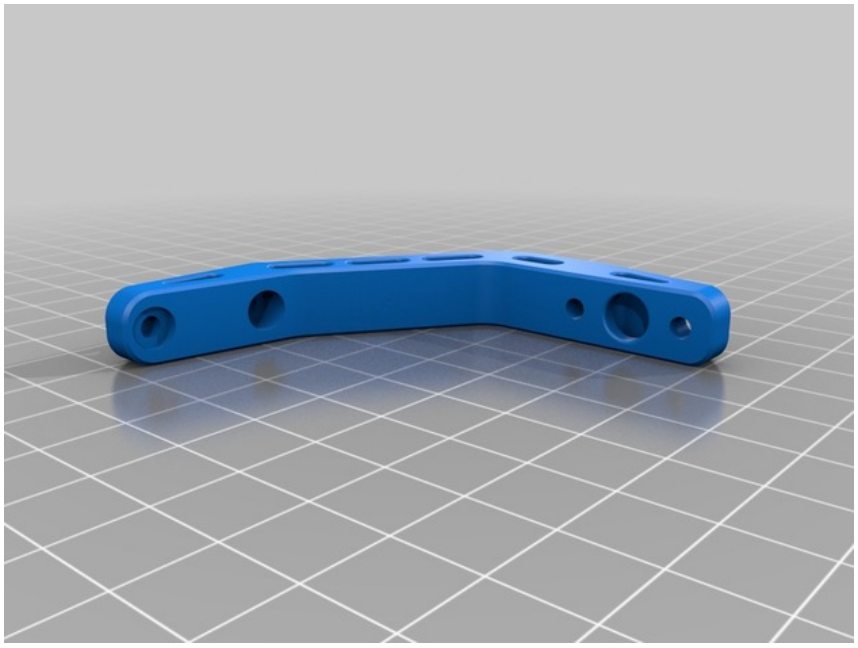


Figure 9: Gimbal Motor Frame 3 (Courtesy: www.thingiverse.com/thing:1247236)

5. **Camera Fixing Mount:** To hold camera shown in Figure 10.

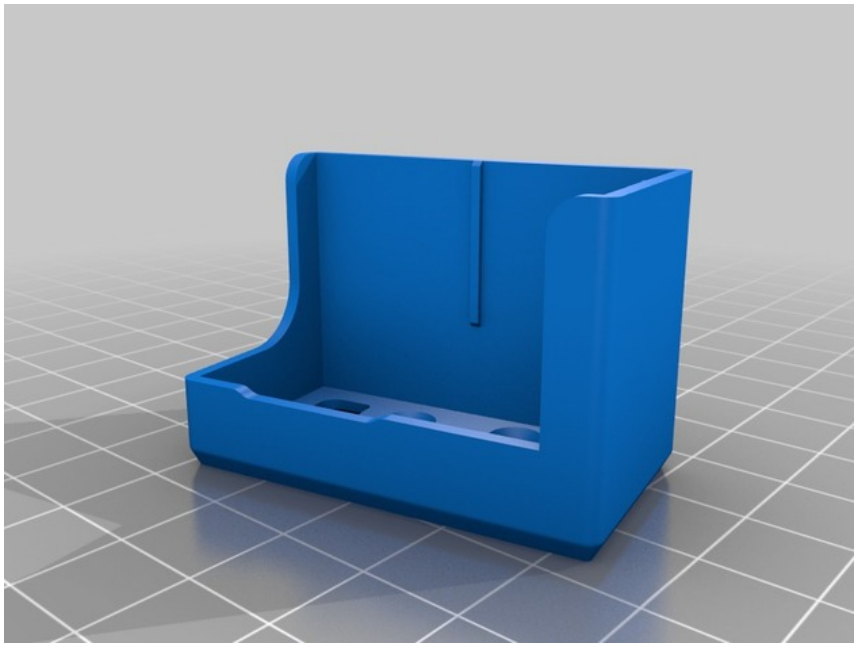


Figure 10: Camera Fixing Mount (Courtesy: www.thingiverse.com/thing:1247236)

6.1.2 Required purchased parts:

1. **Quanum 2208 Precision Brushless Gimbal Motor (GoPRO size 100-200g):** We require 3 Brushless Gimbal Motors to stabilize camera in all Pitch, Roll, and Yaw axises.

   These motors are pre-wound for optimal torque and smoothness. They come with a servo style connector and flexible cable, for plug and play compatibility with most Brushless Gimbal Controllers.

   The 2208 is the perfect size for a GoPRO class cameras (100-200g). It has a superb Fit and Finnish and is engineered to have a lean profile for easy integration into your set-up. The 2208 has preloaded bearings for slop free precision mount, and 14 poles (one of the highest for a motor this size) for ultra-smooth motion. The 2208 brushless gimbal motor is perfect for an upgrade to a kit setup, or the base for a DIY custom gimbal. The image of motor is shown in Figure 11.

   It can be found here,
   `http://www.hobbyking.com/hobbyking/store/__42247__Quanum_2208_Precision_Brushless_Gimbal_Motor_GoPRO_size_100_200g_.html`
   specifications:

   - Camera Range: 100-200 grams (GoPro size)
   - Poles: 14P12S
   - KV: 114
   - Idle current amps: .03A
   - Resistance: 23mh ohm
   - Weight: 39 grams
   - Voltage: 6-14volts (2-3 cell lipoly)
   - Lower back mounting: 16*19mm
   - Upper top mounting: 12mm hole to hole
   - Connection: 3 wire servo style connection 190mm long leads
   - Mounting Thread: M3

Figure 11: Quanum 2208 Precision Brushless Gimbal Motor (GoPRO size 100-200g) (Courtesy: hobbyking.com)

2. **Storm 32 3 Axis Brushless Gimbal Controller:** It is used to control motors.

   The Storm 32 3 Axis BGC is a high quality DIY brushless gimbal controller that offers unparalleled professional stabilisation properties at 32Bit level. The Storm 32 board also features an integrated HC06 Blue tooth unit which allows you to program the board wirelessly without any cable connections.

   The Storm 32 has a 32Bit microprocessor which operates at 72MHz and provides sufficient power to your DIY gimbal assembly. The 32Bit microprocessor and firmware combined provides an incredible range of programming functions.

   The on board output options provide a multitude of connectivity options including PWM, PPM, IR LEDs, joystick, button, 7 x auxiliary ports which can be used as inputs and/or outputs for PWM/Sum-PPM signals. The Storm 32 also supports the connection of a range of satellite receivers including Futaba S-Bus and Spektrum types. Figure 12 shows a image of controller. **Features:**

   - Processor: STM32F103RC at 72Mhz
   - Motor driver: DRV8313 with short circuit, overheat protection
   - On board gyro and acceleration sensor MPU6050
   - IR LED Interface
   - Futaba S-BUS Compatible / Spektrum satellite port
   - 7CH PWM/Sum-PPM input/output

   Specifications:

   - Power Supply: 12v (3S)
   - Drive Current: Max 1.5A
   - Dimensions: 50 x 50mm
   - Weight: 10g
   - Mount Holes: M3

   Package Includes:

   - 1 x Brushless controller
   - 1 x Controller case
   - 1 x MPU6050 sensor

- 1 x Sensor case
- 1 x Sensor connecting cable
- 1 x Pin set

It can be found here,
`http://www.hobbyking.com/hobbyking/store/__84191__Storm_32_3_Axis_Brushless_Gimbal_Controller.html`

Figure 12: Storm 32 3 Axis Brushless Gimbal Controller (Courtesy: hobbyking.com)

3. **DJI H3-3D Standard Version Part42 Damping Shock Absorber Ball:** We require 4 balls to stay gimbal shock free. Figure 13 shows one image of absorber balls. It can be found here,
`http://www.amazon.com/DJI-Standard-Version-Damping-Absorber/dp/B00RCAOPEI`

Figure 13: DJI H3-3D Standard Version Part42 Damping Shock Absorber Balls (Courtesy: amazon.com)

4. **Stainless Steal Bolts:** We require,

    - 3x M3 x 20mm HEX button head (for the motor clamps)
    - 1x M3 x 20mm HEX button head (for the frame 1-frame 2 connection)
    - 4x M3 x 8mm HEX button head (for the gimbal motor frame 3)
    - 4x M3 x 6mm HEX flat head (for the camera fixing mount)

Gimbal Making Process:
Now work is very simple. What you have to do is assembling of parts. First of all mount all three motors on all three gimbal motor frames and assemble them using screws and attach lower vibration observing mount to upper motor using bolts and screws. So your gimbal will look Figure 14.

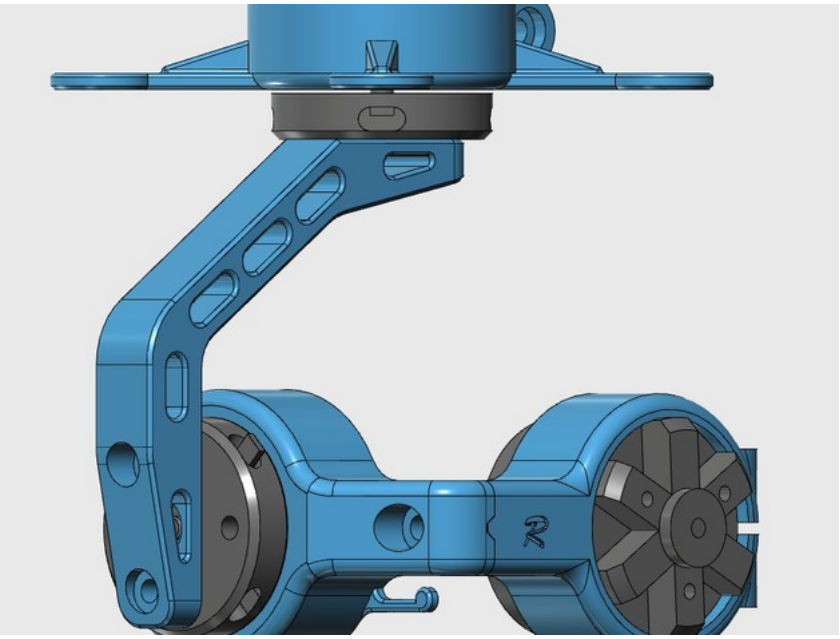


Figure 14: Phase 1 Gimbal (Courtesy: www.thingiverse.com/thing:1247236)

Now attach damping shock observer balls ans upper vibration observing mount to the gimbal. Then attach camera fixing mount to your gimbal using bolts. Your final gimbal will look like Figure 15:

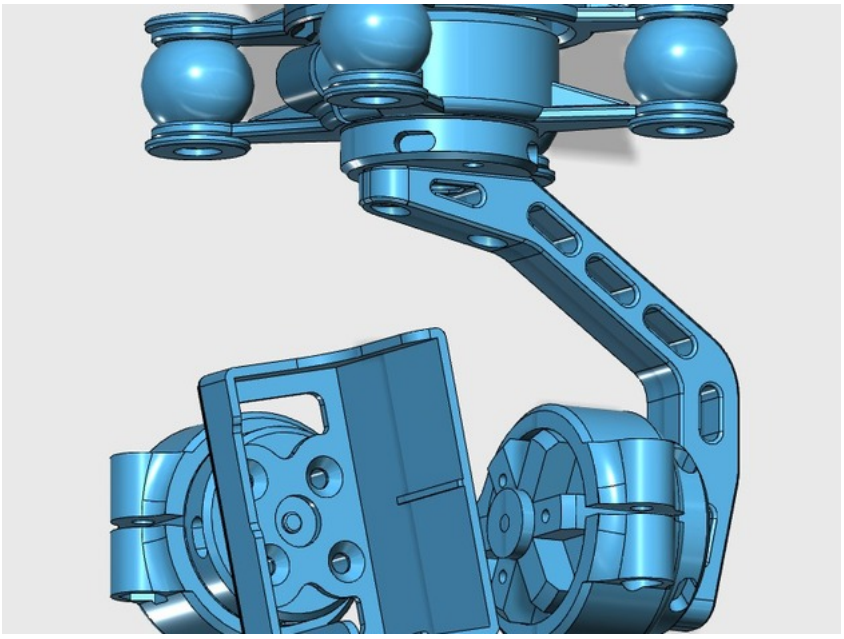


Figure 15: Final Gimbal (Courtesy: www.thingiverse.com/thing:1247236)

Now you will have to balance your gimbal according to what given in section theory and description.

7 Compatible Camera

- This gimbal is made for GoPro Hero3. So it is best for GoPro Hero3. But you can use any similar size GoPro camera because Camera Fixing Mount is fixed.
- You can also use DYS HDV-1 AERIAL VIDEO DRONE and ACTION CAMERA. That is a replacement for GoPro. It can be found at here
- You can also use any webcam that is compatible for your OS by making or 3D printing a box for camera that can be fixed on camera fixing mount.

8 Exercise

Some pictures of gimbal balncing the camera are as follows. Figure 16 shows Camera is balanced with respect to Pitch axis.

Figure 16: Camera balancing pitch axis (Courtesy: https://www.youtube.com/watch?v=80s-3GhD2zk)

Figure 17 shows Camera is balanced with respect to Roll axis.

Figure 17: Camera balancing roll axis (Courtesy: https://www.youtube.com/watch?v=80s-3GhD2zk)

Figure 18 shows Camera is balanced with respect to Yaw axis.

Figure 18: Camera balancing yaw axis (Courtesy: https://www.youtube.com/watch?v=80s-3GhD2zk)

9 References

- http://www.hobbyking.com/hobbyking/store/__964__960__Multi_Rotors_Drones_Parts-Gimbal_Accessories.html
- http://www.thingiverse.com/thing:1247236
- http://science.howstuffworks.com/gimbal.htm
- https://en.wikipedia.org/wiki/Gimbal
- http://quadcopterhq.com/what-is-a-gimbal/
- https://en.wikipedia.org/wiki/Rolling_shutter
- http://g03.a.alicdn.com/kf/HTB193EVHFXXXXXTXVXXq6xXFXXXb/FPV-font-b-2-b-font-f jpg
- http://www.dronetrest.com/t/balancing-your-brushless-gimbal/55
- http://axisgimbal.com/gimbal-parts/

- http://www.hobbyking.com/hobbyking/store/__960__501__Multi_Rotors_Drones_Parts-Camera_Gimbals.html
- http://www.hobbyking.com/hobbyking/store/__42247__Quanum_2208_Precision_Brushless_Gimbal_Motor_GoPRO_size_100_200g_.html
- http://www.hobbyking.com/hobbyking/store/__84191__Storm_32_3_Axis_Brushless_Gimbal_Controller.html
- http://robokits.co.in/quadrotors-hexarotors-drones/fpv-video-telemetry-osd/dys-hdv-1-aerial-video-drone-action-camera-gopro-replacement?gclid=CjwKEAjw4dm6BRCQhtzl6Z6N4i0SJADFPu1nRx_Fo9jfIlLykMuizjcP-umoKJ5WaOs01bwGvwcB&zenid=do0c7r2d5u3edfg460dpff1qi4
- https://www.youtube.com/watch?v=80s-3GhD2zk&feature=youtu.be