Understanding Brushless Camera Gimbals

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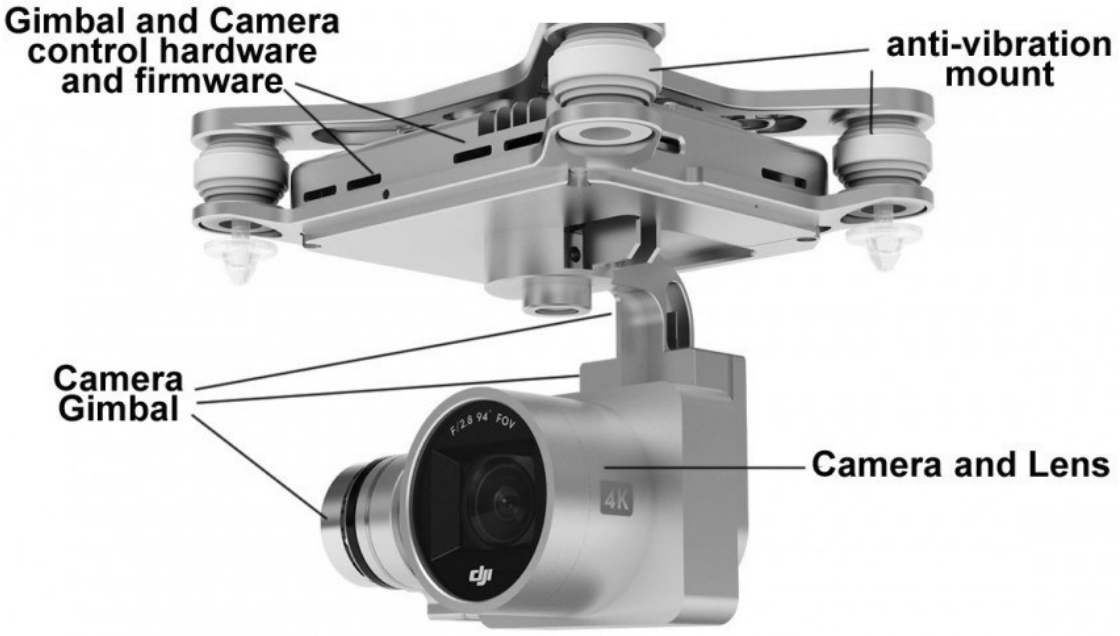
Introduction

At the heart of many modern camera drones is a magical device called a 3-axis Brushless Camera Gimbal. It contains many of the same technologies which are in the drone itself. Here is what they are and how they work – explained in the simplest terms possible.

The word *gimbal* can be used to describe any adjustable camera or compass holder designed to keep the device level. A more accurate description of the quadcopter gimbal would be a *3 – axis camera stabilization and anti-vibration device*. It uses brushless motors (powerful and quiet as well as long lasting) to adjust the position of the camera. 3-axis describes that the camera is adjusted in all directions – up/down, left/right and forward/backward (3 dimensions or, as we call it, the real world).

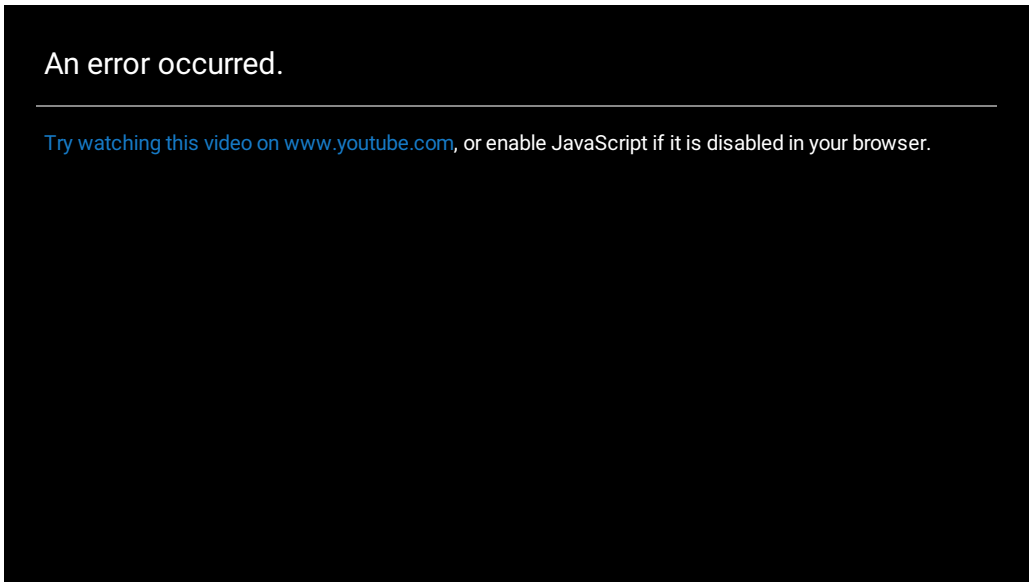
Drone gimbals are sold in two ways – as a separate unit upon which a camera (GoPro, for example) mounts or as a complete unit with an integrated camera (DJI, Blade, Yuneec). Shown below is the gimbal and camera assembly for a DJI Phantom 3 quadcopter.



Camera Gimbal

The larger mechanical parts of a gimbal are quite basic – the camera holder and 3 motors which work together to keep the assembly level and vibration free. However, what goes on behind the scenes to allow this is much more complex – so advanced, in fact, that the consumer camera gimbal was an impossibility until approx. 2012.

For those who want just the "Cliffs Notes" version or executive summary, the above as well as a one minute video we've made will suffice. For others, watch the video and read on below.



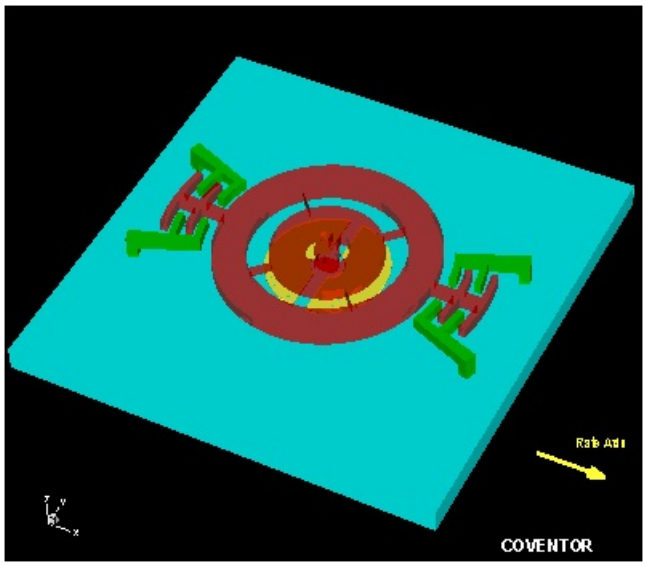
How Does it Work?

A modern drone gimbal uses many of the same technologies as your smart phone, video game controllers and your drone flight controller system. These new electro-mechanical devices are known by the acronym MEMS – which stands for *Micro-Electro-Mechanical Systems*. You will see them described by more specific names and functions such as IMU (Inertial Measurement Units), Accelerometers and Gyroscopes. In most all cases, the functions are somewhat similar – taking a mechanical force (like you swinging your hand with a Wii controller in it) and translating it to an electronic signal which can then be fed into a computer.

For the layman, think of the simplest MEMS as being a bubble level. We could create a level

and then, using various methods, have it send electrical impulses out when the level is NOT level…commands such as "slant a little more to the left…now right….OK, it's level now" and so on.

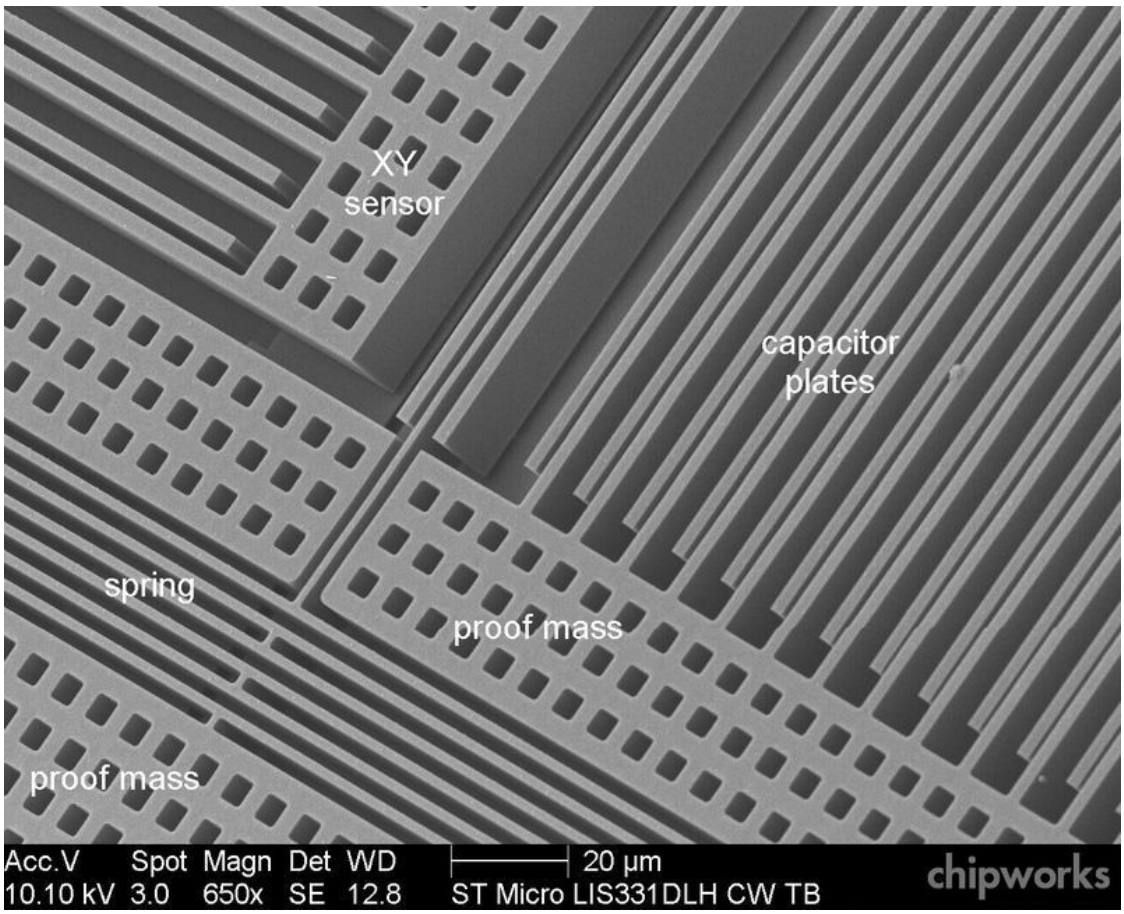
Most electronic components do not have any parts which move – they are purely electrical, with only electrons flowing through the maze inside the chips. MEMS are different – they actually ARE like a level, tuning fork or other mechanical device in that they have structures which move and respond to being pushed in one direction or another (g-forces, gravity, etc.).



Animation of a MEMS Gyroscope

The animation above shows a depiction of one such device. By measuring the electrical signals it can check the current state (level or not) of the gimbal.

Now – prepare yourself for what the REAL MEMS chips may look like magnified…



Interior of a MEMS chip, showing the many mechanical fingers

This is just one small part of a MEMS device – the fingers that you see are pushed in one direction or the other by g-forces (movement of your drone, the wind, etc.) and send electrical signals detailing the exact forces and direction of them back to a computer inside the gimbal controller.

Bringing it all together

To make the gimbal work requires a LOT of computing power – this is often encased in a circuit board called the controller. This board also contains the MEMS as well as *firmware* (built-in software) which the manufacturers has created.

This controller sends out – many times each second – commands to the 3 brushless motors that stabilize the camera. These commands not only keep the camera level, but can be tuned to remove most of the vibration caused by the propellers and flight motors on the drone itself.

The results are obvious when watching the video taken from these modern gimbals.

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