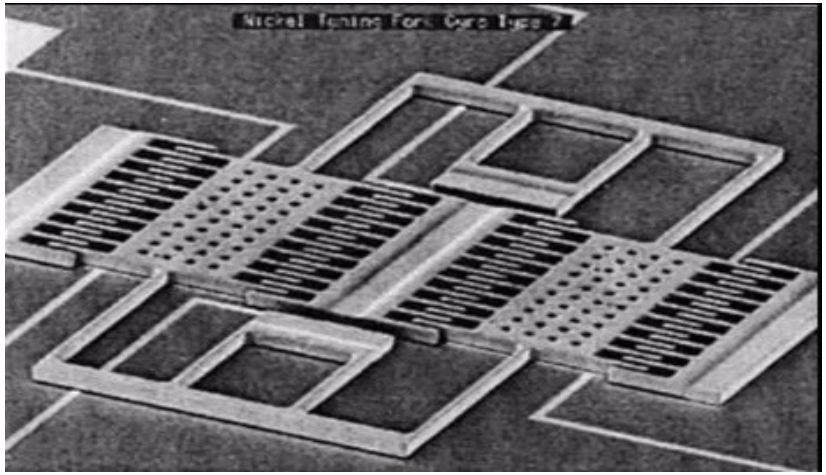
SHAKE, RATTLE & ROLL!

How Micro-Sensors In a Quadcopter Drone Control Its Flight

First, some definitions….

MEMS (Micro-Electro-Mechanical Systems): Very small machines, usually less than 100 micrometers (roughly the width of a human hair) in dimension. Although they are not integrated circuits, they are often made using the same photo-lithographic processes. Early MEMS were made using small amounts of metal (i.e. gold, aluminum, nickel, copper, etc.) deposited on silicon. Later technologies incorporate ceramics (i.e. clay) with metal alloys. The picture at the right shows a MEMS gyroscope which is approximately 100 microns (millionths of a meter) long.



CAPACITANCE: The ability to hold an "electron charge." The capacitance value is reached when electrons jump a gap between two plates and discharge occurs. As two metal plates slide by one another and/or as the distances between the plates changes, their capacitance changes.

ANGULAR MOMENTUM: A change in direction while moving.

ELECTRONS and ELECTRON HOLES: An electron is a sub-atomic particle which, when flowing causes electricity. An "electron hole" is the absence of an electron in a position where it could exist.

Coriolis Affect: A person standing on the surface of the earth as it rotates one revolution per day, will have a "frame of reference" that is also moving at the same rate and direction. An object falling or rising vertically relative to the center of the earth, will appear to the observer as moving diagonally because the observer's "frame of reference" is moving away from the object. This is often called a "fictitious force."

For an excellent YouTube presentation, see: https://www.youtube.com/watch?v=eqZgxR6eRjo

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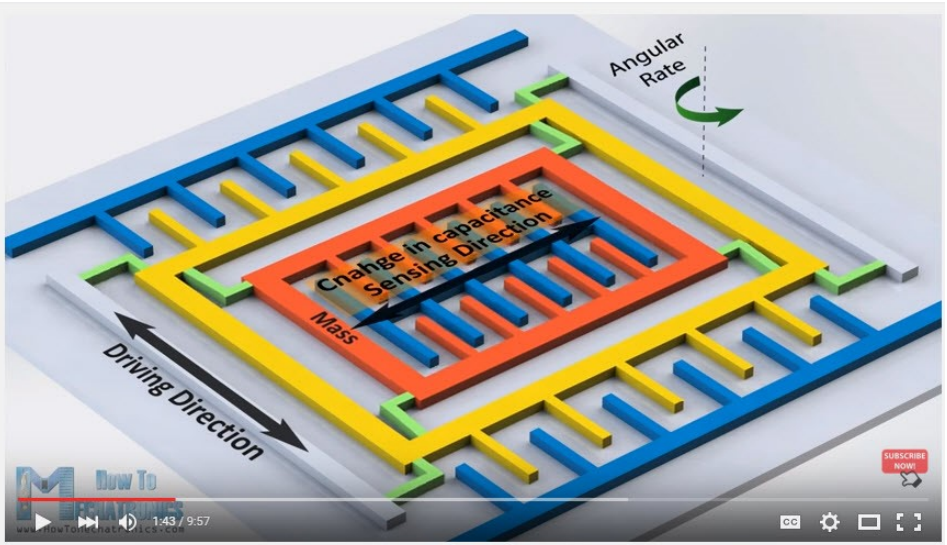
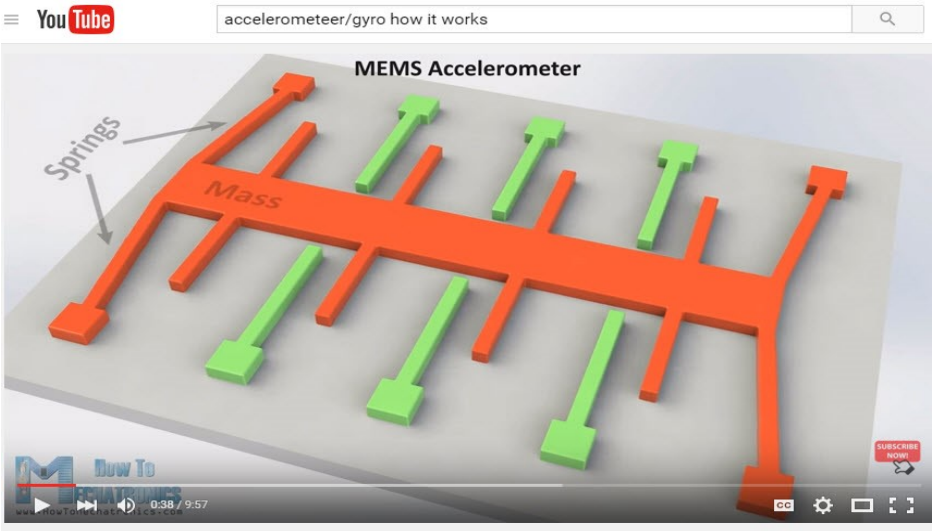
GYROSCOPE:

A MEMS gyroscope is used to measure a change in angular momentum; in other words, the degree of a turn while moving. As the drone containing the MEMS gyroscope alters direction, the direction and momentum of the gyroscope's component parts shift in the opposite direction. Similar to the way your body would shift in a car while it is turning. The shifts in the gyroscope's plates relative to one another causes the distances between them to change and their capacitance to change. The time-varied values in capacitance are correlated to changes in the angular momentum of the drone. The values of capacitance are recorded at various locations and times. The times and values are read and interpreted by a computer program to calculate changes in angular momentum.





ACCELEROMETER:

The MEMS Accelerometer shown in the illustration to the left measures the rate by which an object speeds up in a single direction. When the drone accelerates, the orange component moves forward or backward stretching the springs on each end. The movement of the orange component which is held by a spring, relative to the green fixed components alters the distance between them. As the distances between the orange and green plates change, their capacitance values change. The changing capacitance values are stored along with their corresponding times and are analyzed by a computer program to calculate acceleration.

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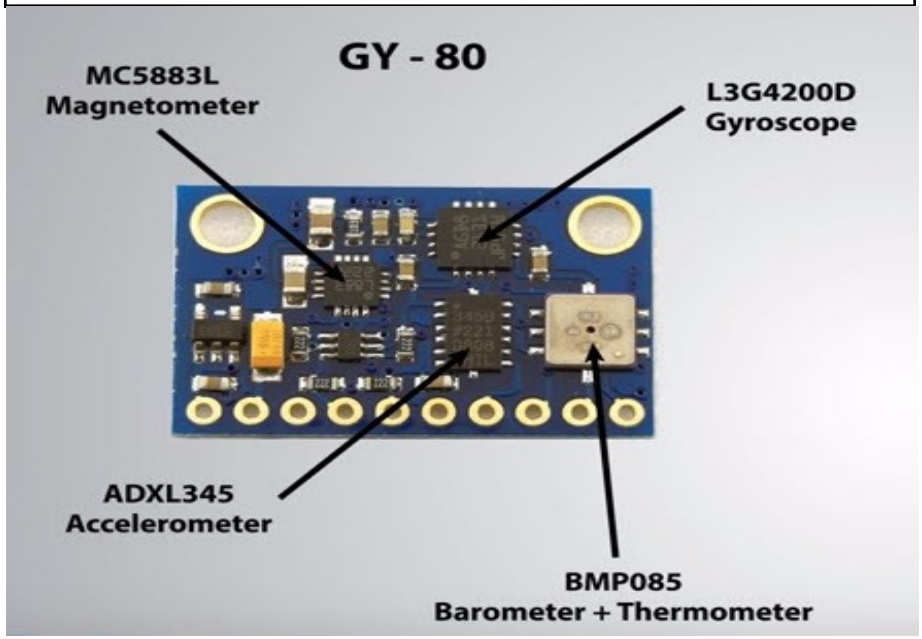
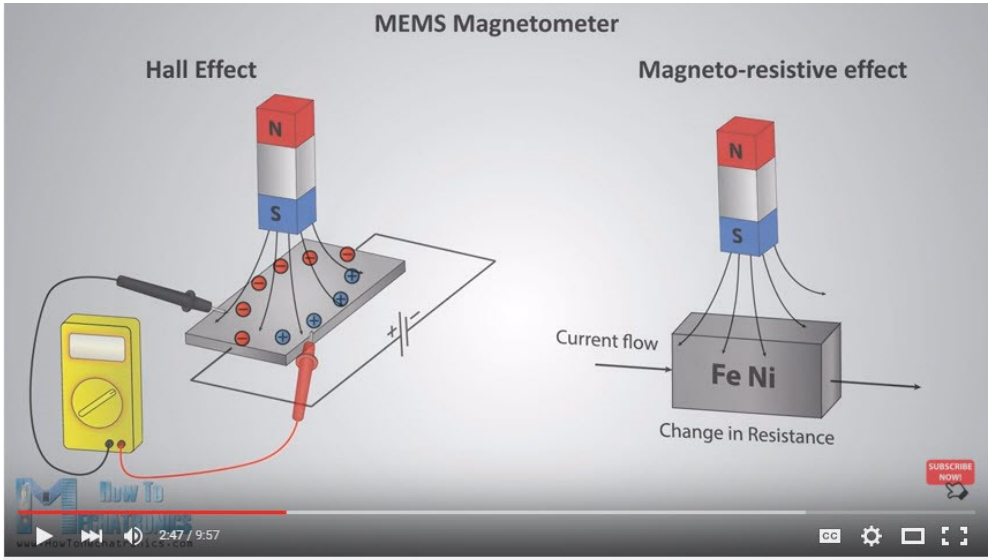
MAGNETOMETER:

As a drone moves around, there are subtle changes in the magnetic force on its magnetometer. These subtle changes cause more electrons to flow to one side of the metal plate leaving "electron holes" on the other side. The change in the arrangement of electrons and electron holes causes corresponding changes in the plate's conductivity. The conductivity values are measured and stored, and are analyzed by a computer program. The computer program reports to the computer on the drone its exact location and, compares it to the last value. The difference between the two values corresponds to the direction and rate of travel.





DRONE CONTROL BOARD:

All the micro-sensor components are usually mounted on one small board which is installed in the drone. We did not discuss the Barometer and Thermometer as they are usually installed onto more expensive drones. When installed, the Barometer is used to measure changes in altitude. It consists of a metal diaphragm over an enclosed area with a known pressure. When the outside barometric pressure exceeds the enclosed pressure, the diaphragm flexes inward. If the outside barometric pressure is less than the internal pressure, the diaphragm bulges outward. The changes in the "bulge" causes the diaphragm material to thin or thicken, thus changing its conductivity. Since the ground around the world can be at a wide range of altitudes, the Barometer is usually used in concert with an ultrasound measuring system . Such ultrasound systems can also be used for detecting and avoiding objects that may be in the drone's flight path.