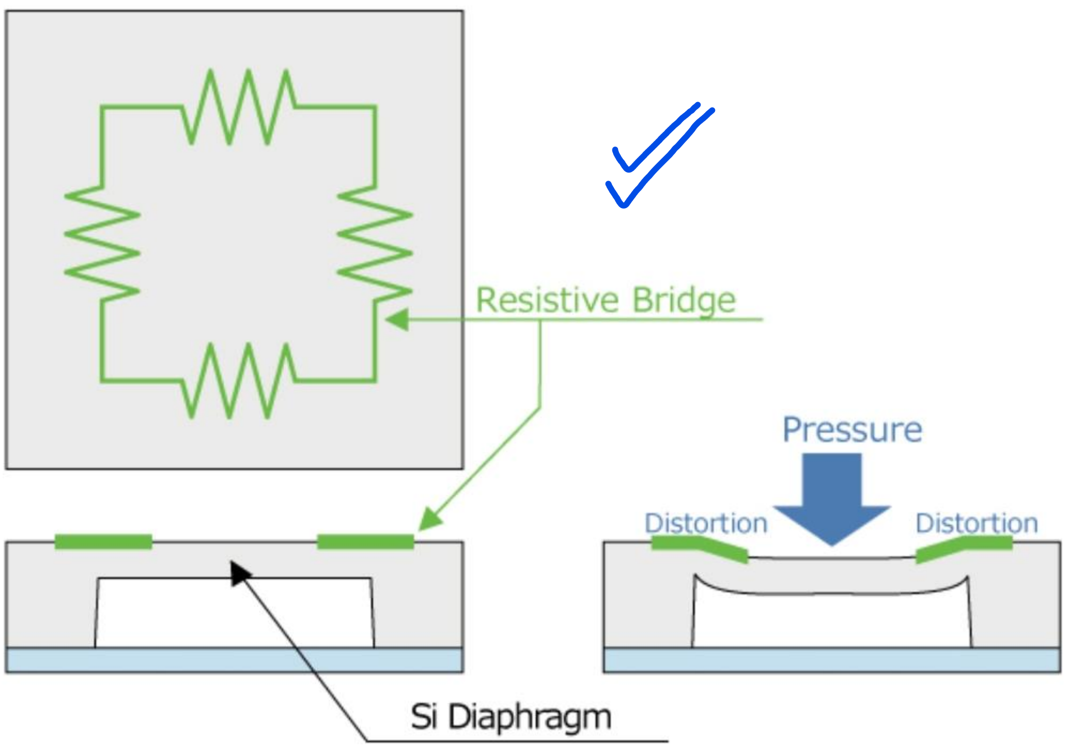
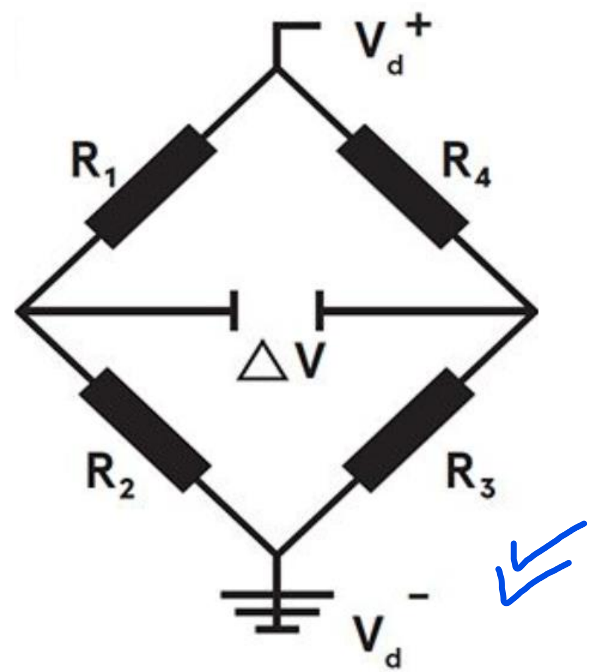
Sensors and Payloads

Barometric pressure sensor

Piezo-resistive pressure sensors utilize a single Si crystal plate as a diaphragm and diffuses impurities on its surface to form a resistive bridge circuit, making it possible to calculate pressure (atmospheric) by detecting the resistance change resulting from distortion of this resistive bridge when pressure is applied.
The phenomenon in which the resistivity (electrical conductivity) changes based on the pressure applied to this resistance is called the piezoelectric effect

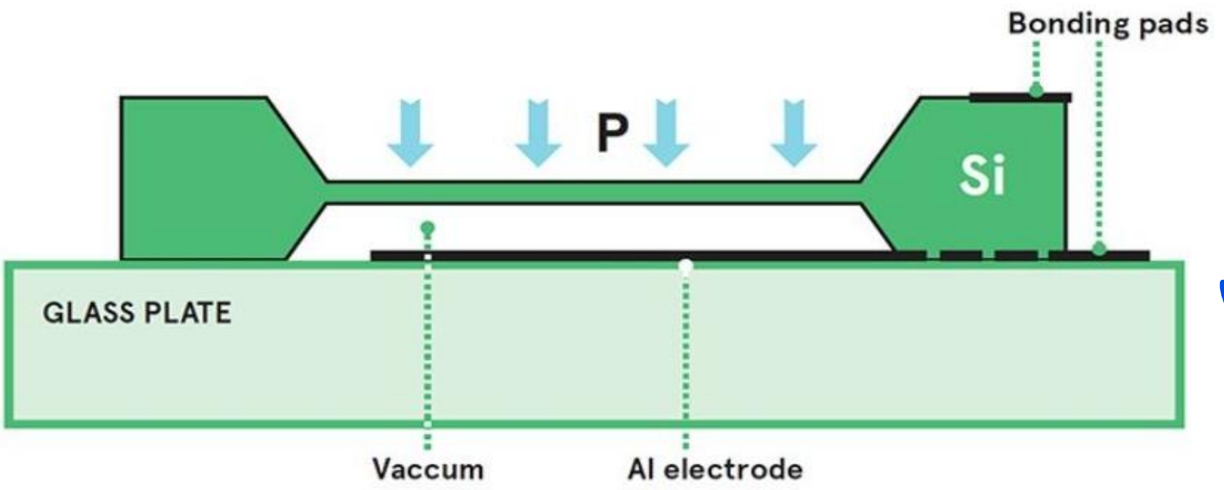




- Conductive sensing elements are fabricated directly on to the diaphragm. Changes in the resistance of these conductors provide a measure of the applied pressure. The change in resistance is proportional to the strain, which is the relative change in length of the conductor.
- The resistors are connected in a Wheatstone bridge network, which allows very accurate measurement of changes in resistance. The piezoresistive elements can be arranged so that they experience opposite strain (half are stretched and the other half are compressed) to maximise the output signal for a given pressure

MEMS capacitive pressure sensors

To create a capacitive sensor, conducting layers are deposited on the diaphragm and the bottom of a cavity to create a capacitor. The capacitance is typically a few picofarads.

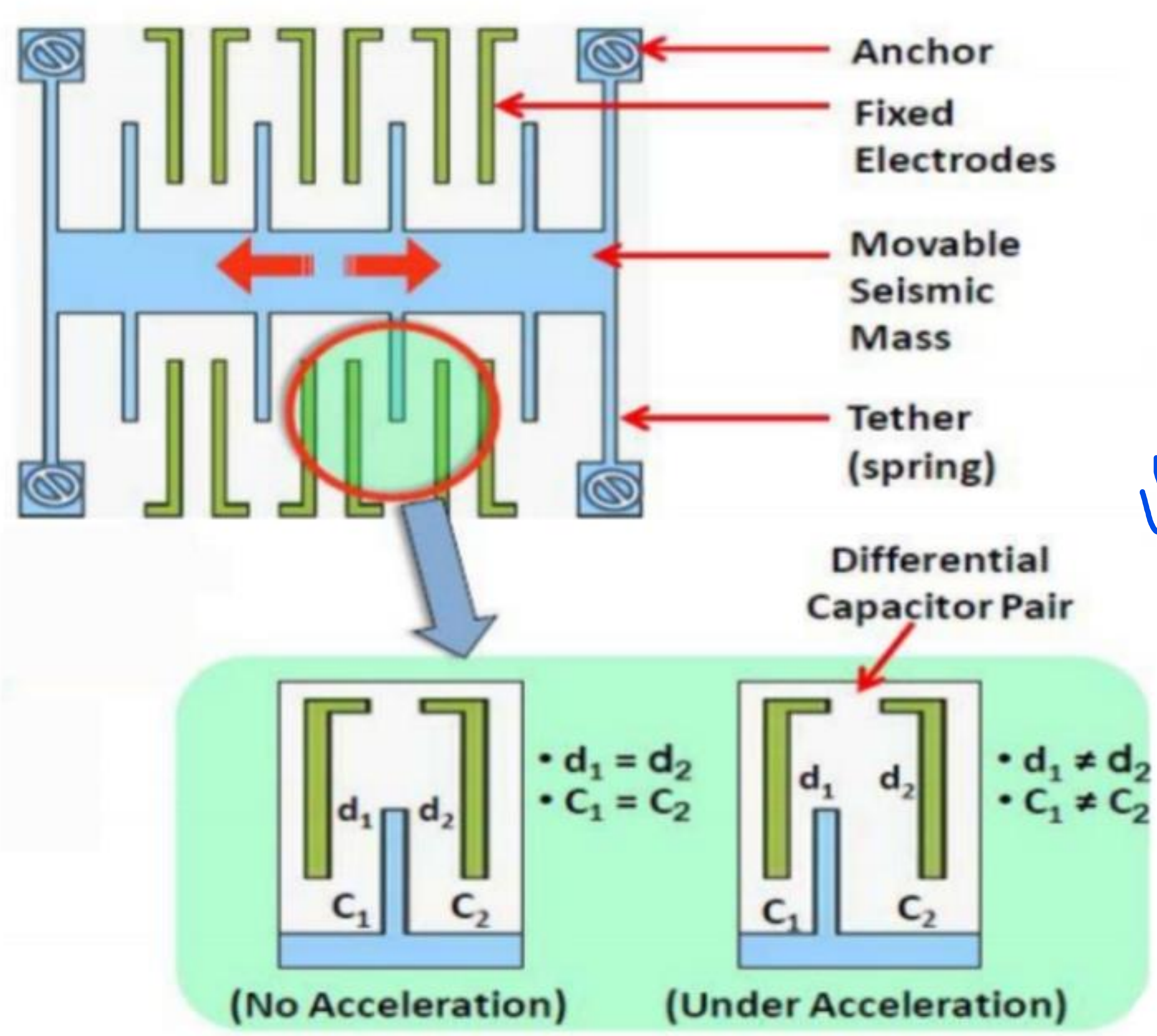


A cross section of a MEMs capacitive pressure sensor

Deformation of the diaphragm changes the spacing between the conductors and hence changes the capacitance (see right). The change can be measured by including the sensor in a tuned circuit, which changes its frequency with changing pressure.

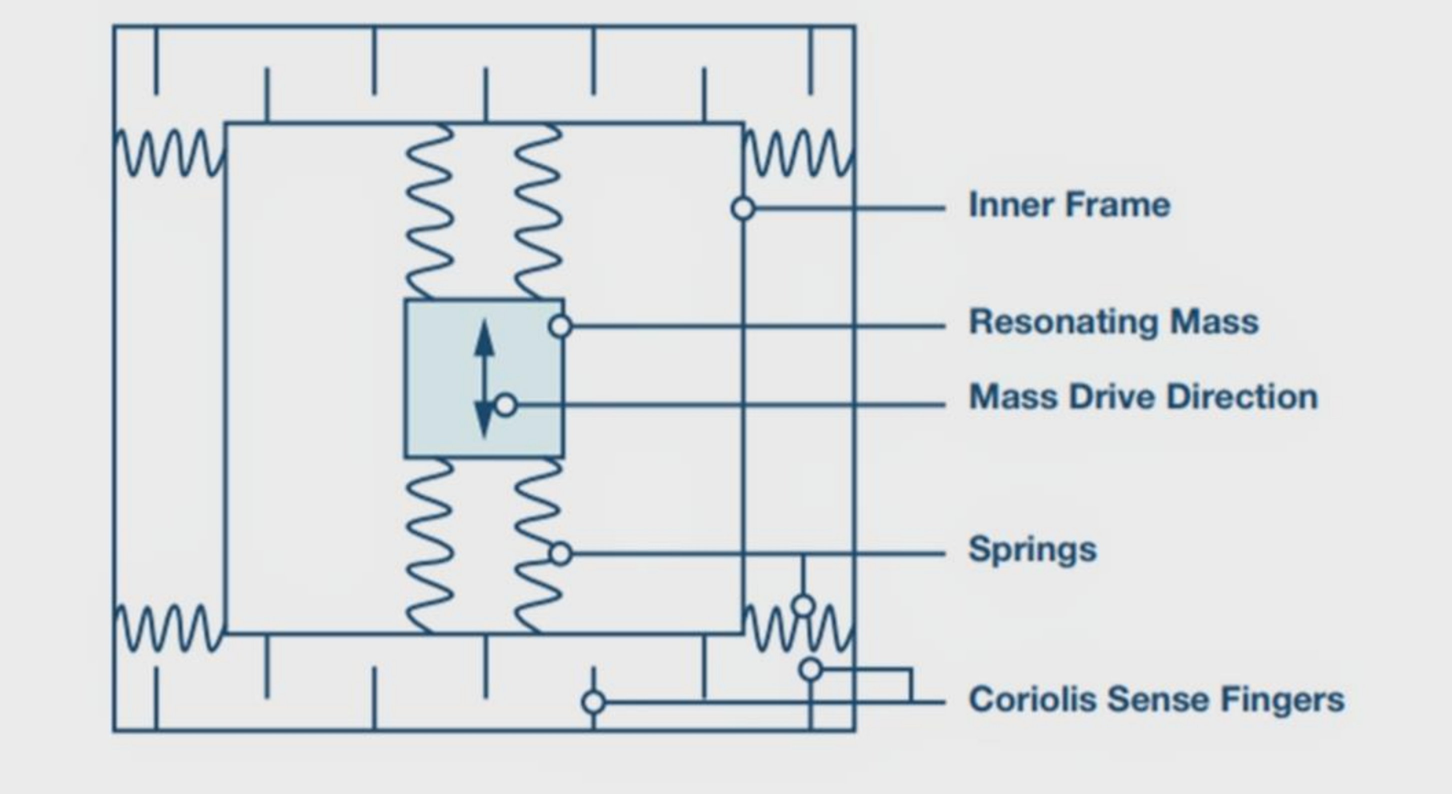
The sensor can be used with electronic components on the chip to create an oscillator, which generates the output signal. Because of the difficulty of fabricating large inductances on silicon, this will usually be based on an RC circuit.

MEMS accelerometer



- The accelerometer is composed by a circuit having seismic mass (made up of silicon) that changes its position according to the orientation and it is attached to the circuit of the device.
- an accelerometer is a circuit based on MEMS (Micro Electro Mechanical System), that measures the forces of acceleration that may be caused by gravity, by the movement or by tilting action.
- There are several pairs of fixed electrodes and a movable seismic mass. Under no acceleration the distances d1 and d2 are equal and as a result the two capacitors are equal, but a change in the acceleration will cause the movable seismic mass to shift closer to one of the fixed electrodes causing a change in the generated capacitance. This difference in capacitance is detected and amplified to produce a voltage that is proportional to the acceleration

Mems gyroscope

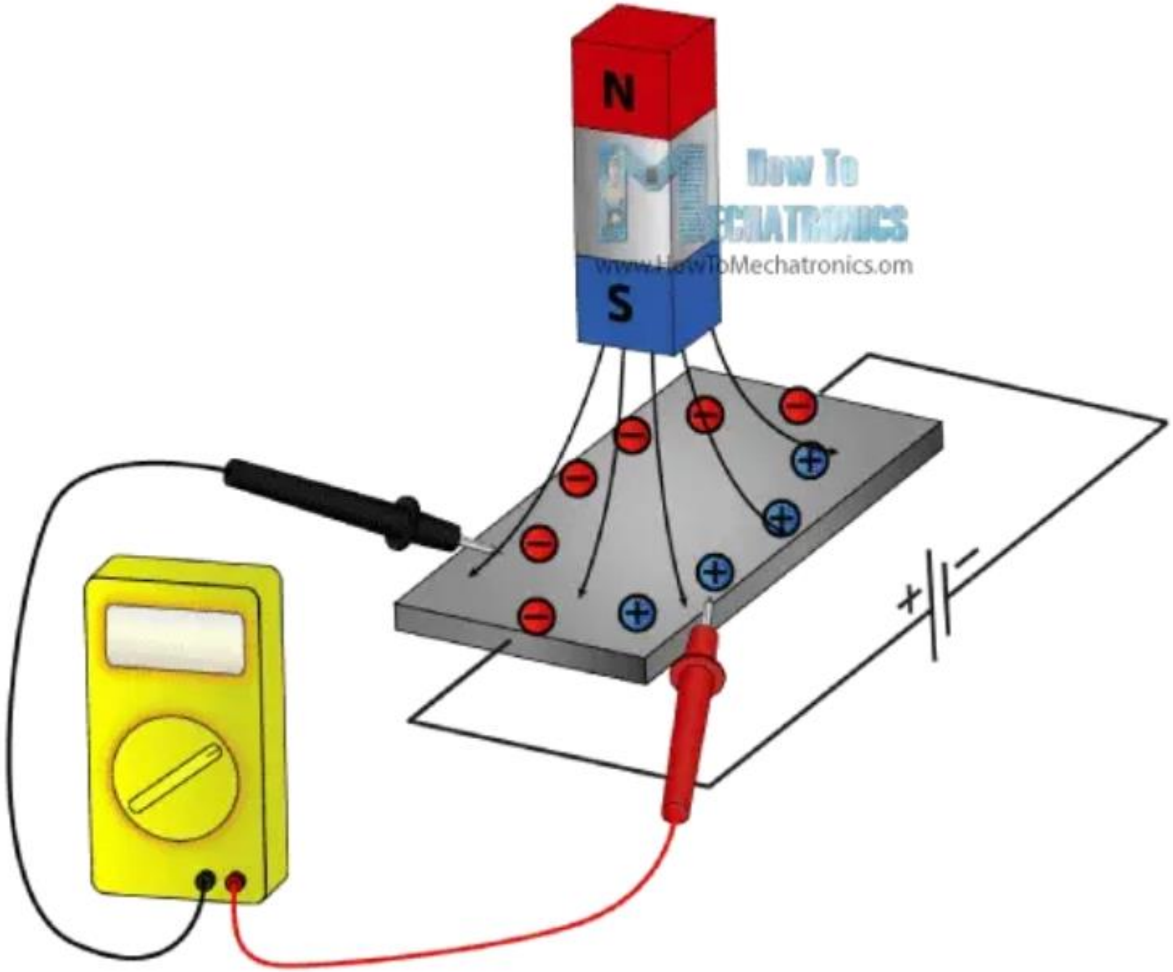


- MEMS (Micro-machined Electro-Mechanical Systems) devices that are base their operation on a vibrating structure that exploits the phenomenon of Coriolis force.
- The Coriolis force corresponds to the product of the mass of the object (whose longitude is to be maintained) times the acceleration that leads to the required slowing down or speeding up. The Coriolis force is proportional to both the angular velocity of the rotating object, as well as to the velocity of the object moving towards or away from the axis of rotation

- vibrating structure gyroscope contains a micro-machined mass which is connected to an outer housing by a pair of springs. This outer housing is then connected to the fixed circuit board using a second set of orthogonal springs.
- The test mass is continuously driven sinusoidally along the first set of springs. As any rotation of the system will induce Coriolis acceleration in the mass, it will subsequently push it in the direction of the second set of springs.
- As the mass is driven away from the axis of rotation, the mass will be pushed perpendicularly in one direction, and as it is driven back toward the axis of rotation, it will be pushed in the opposite direction, due to the Coriolis force acting on the mass
- The Coriolis force is sensed and detected by capacitive sense fingers that are integrated along the test mass housing and the rigid structure. As the test mass is pushed by the Coriolis force, a differential capacitance will develop and will be detected as the sensing fingers are brought closer together. When the mass is pushed in the opposite direction, different sets of sense fingers are brought closer together. Therefore, the sensor can detect both the magnitude as well as the direction of the angular velocity of the system

Mems magnetometer

- It measures the earth magnetic field by using Hall Effect.
- If we have a conductive plate like shown in the figure and we set a current to flow through it, the electrons would flow straight from one to the other side of the plate.
- Now if we bring some magnetic field near the plate we would disturb the straight flow and the electrons would deflect to one side of the plate and the positive charge to the other side of the plate. If we test with a voltmeter ,between these two sides we will get some voltage which depends on the magnetic field strength and its direction.
- Thus, a magnetometer assesses the way the current is distorted or angled due to the magnetic field, and the voltage at which this occurs is the Hall voltage, which is proportional to the magnetic field.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RADAR

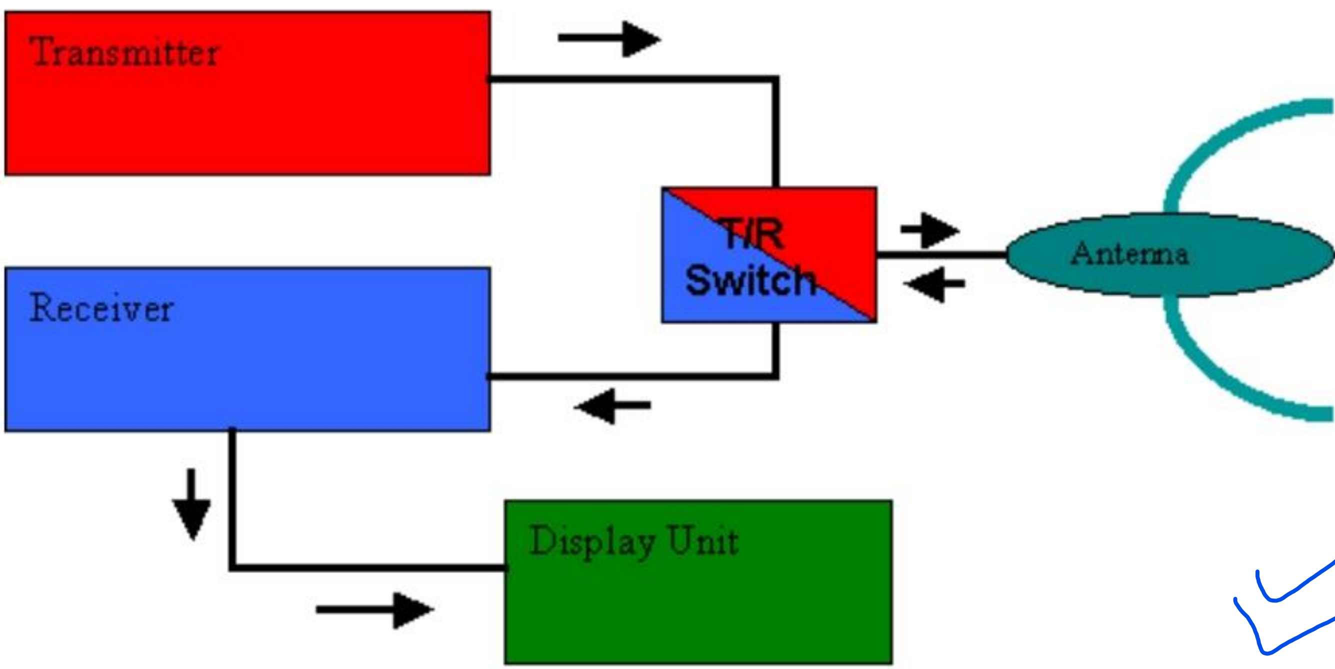
- RADAR stands for RAdio Detecting And Ranging and as indicated by the name, it is based on the use of radio waves. Radars send out electromagnetic waves similar to wireless computer networks and mobile phones.
- The signals are sent out as short pulses which may be reflected by objects in their path, in part reflecting back to the radar. When these pulses intercept object, part of the energy is scattered back to the radar.
- This concept is similar to hearing an echo. For example, when you shout into a well, the sound waves of your shout reflect off the water and back up to you. In that same way, the pulse reflects off object and sends a signal back to the radar. From this information the radar is able to tell where the object is and how much is its size.

- The speed of radio waves in free space, as we know is 3 x 108 ms-1 (186,000 miles per second).
- So if we measure the elapsed time between the transmission of the pulse and its reception back at the radar, we can use the formula:
- **Distance = Speed x Time**
- Most radars operate in the Ultra High Frequency (UHF) or Super High Frequency (SHF) bands. The Frequency of operation will depend on the function the radar is to perform,

Components Of The Radar

Radars in their basic form have four main components:

- A transmitter, which creates the energy pulse.
- A transmit/receive switch that tells the antenna when to transmit and when to receive the pulses.
- An antenna to send these pulses out into the atmosphere and receive the reflected pulse back.
- A receiver, which detects, amplifies and transforms the received signals into video format.



Application

- Surveillance (including weather)
- Early warning
- Navigation
- Ground mapping (from space or aircraft)
- Guidance control
- Target detection and tracking
- Terrain following/avoidance
- Collision avoidance and altitude measurement
- Air Traffic Control

Payloads

Payloads will be considered in two basic types:

- a) Non dispensable payload:sensors, cameras, etc. which remain with the aircraft, and
- b) Dispensable loads such as armament for the military and crop-spray fluid or firefighting materials for civilian use. There may also be a future requirement for UAV to deliver mail or materials into difficult terrain.

Non dispensable payload

Electro-optic Payload Systems

Daylight' Cameras :Optical, or 'visible light' cameras operate in the 0.4–0.7 µm wavelength range. The human eye sees light, generated from the sun, reflected at different frequencies (colours) from different objects, thus providing recognition of patterns.

Low-light-level Cameras: LLL cameras function in the same manner as standard optical cameras, but are fed an amplif i ed level of light, using fibre optics which accept light from a larger area and concentrate it onto the camera lens

Thermal Imagers:The infrared, or heat radiation, spectrum covers longer wavelengths – in the range of about 0.7 µm (near infrared) to 1000 µm (far infrared).The heat radiation is focused onto special receptors in the camera which convert it into a format which is displayed on a monitor in monochrome which is recognisable by the human eye. The objects emitting the greatest intensity of heat are usually presented as the darkest (black) in the greyscale, i.e. known as 'black-hot'

DELLRT

Radar Imaging Payloads:

The radar system used for ground target surveillance from UAV is known as synthetic aperture radar (SAR). The same antenna is used for emitting the outgoing signal and receiving the returned signal.It is mounted looking sideways (normal to) the direction of flight, and is scanned downwards from a depression angle of typically 60◦below the horizontal to the vertical. Radar wavelengths of typically 5–15 cm are used.

Laser Target Designation :

There is a military need to illuminate ground targets for attack by laser-guided missiles. Although this has been done by the manned aircraft which launches the missiles, it is better accomplished by one aircraft (manned or unmanned) laser-marking the target for others which release the weapons.

Dispensable Payloads

- In the civil field these may include agricultural crop-spraying with pesticides, fungicides or possibly fertilisers and anti-frost measures. Provided that the UAV has an adequate dispensable payload, water or other fire suppressant material may be carried and dropped.
- In all of these, care must be taken in the design to ensure that material cannot be inadvertently dropped and is released cleanly,without upsetting the balance of the aircraft, and without entering vulnerable parts of the aircraft.
- Thought has to be given as to the method of loading the material and its storage medium if the material is toxic.
- In the military environment, the dispensable loads will usually be armament: bombs, rockets or missiles. These will usually be under-wing-mounted on fixed-wing aircraft and side-mounted on rotary wing aircraft. To target weapon-aiming will be necessary and integrated with the electro-optic sensor(s).