AIM:

To study 2 sensor for linear length measurement available in the market.

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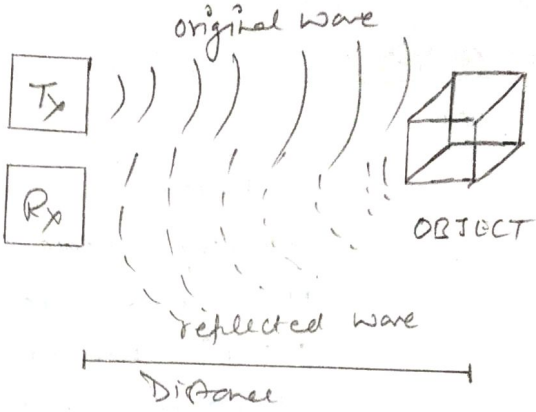
Non-Contact Type Sensor:

✦ Ultrasonic Sensor:

• Principle:

They work on the principle of time of flight. They emit sound waves at a frequency too high for human to hear. They then wait for the sound to be reflected back. Calculating distance based on the time required.



• Caliberation:

Caliberation is an important step to achieve a desired accuracy in an experiment following steps are involved as for us the caliberation of the ultrasonic sensor is involved.

Note: For caliberation and over measurement 2 will be using Arduino, the code for the caliberation and the test will be available on the link provided.

→ Objects used:

1. Arduino (Serial Monitor)
2. Ruler
3. Sensor (HC-SR04)
4. Object (for reflection)

⇒ Choose small intervals on the ruler, for the sensor to be used on these positions. Remember more the data points more the better caliberation.

⇒ Start the ultrasonic sensor closest to the vertical surface and then it on. Record the period of the pulse then record the ultrasonic sensor's distance along the ruler for next pulse.

⇒ Increment the ultrasonic sensors position by the fixed interval till you have enough data points.

NOTE: The calibration code can be viewed at url;
"github.com/avikasharoj/Length-measurement"

→ Calibration needs to be done on the horizontal plane, strictly check that the sensor and the object are in the same plane.

• Characteristics:

→ for HC:

Feature	HC-SR04
Working voltage	5V
Measurement range	2cm - 400cm
I/O pin needed	4
operating current	15mA
Ultrasonic freq.	40kHz
output	PWM

→ After measurement:

① Field of view: for any non-contact directional sensor the geometry of the external world is determined by its field of view.

FOV : (horizontal = 30°) & (vertical = 4°)

NOTE: To for the above characteristics and for accuracy and precision and range, the sensor is mounted fixed on the floor and several objects are placed in front of it.

② Range: 2cm to 400 cm

③ Accuracy: For accuracy measurement the reference of meter scale is taken that is already marked with standards.

Accuracy ≈ 0.025 cm/cm (Approx.)

④ Precision: for the raw data precision is around 0.2 to 0.8 cm but for filtered it can be 0.1 to 0.5 cm

⑤ Threshold: Threshold is 2cm, below that the Rx does not accurately receive the reflected signal. due to operation of the wavefront

⑥ Sensitivity: Sensitivity of the sensor is found up to 0.025 cm.

- Working Standards and Operation:

→ No additional high frequency sounds into the room.
→ No air currents into the measuring area.
→ No obstruction between the sensor and the object being detected, having size greater than the wavelength of the sound.
→ Object being detected should be larger than the wavelength of the sound being used.

- Operation of taking measurement

→ The setup is at the first been mounted and the objects been placed.
→ The measurements are done with an Arduino sketch, recorded from the PC serial display with CoolTerm and analyzed in Excel Spread sheet
→ To see when the influence of the measurement condition from the controlling program, the sketch included a series of 10 consecutive reading at different time intervals.
→ To clear the doubts on the consistency of the manufacturing condition, the readings were partially repeated with a second HC-SR04 from the same manufacturer.

NOTE: The test code has been uploaded at "github.com/avinashsaroj/Length-measurement"

- Comparison with the basic linear potentiometer.

Note: The point to be noted is that the potentiometer is a contact type design measuring device and we are in here dealing with a non contact type device, but for the sake of static characteristics, I will be comparing the both, but they are to be used in different circumstances

Characteristic	Potentiometer	HC-SR04 (Ultrasonic sensor)
Range	From 1 cm to 11 cm	2 cm to 400 cm
Accuracy	Depends on the user and the instrument being used.	0.035 cm/cm
Precision		0.1 cm to 0.5 cm
Threshold	10mm / 1 cm	2 cm
Sensitivity	to 0.1 mm / 0.01 cm	0.035 cm
Working Conditions.	• Clear surface • Slow and soft movement	• No obstruction in the path with size larger than the wavelength • The size of the object itself should be large than wavelength • No high freq. sound in the room.

END OF NON-CONTACT TYPE SENSOR

NAME- AVINASH KAROJ
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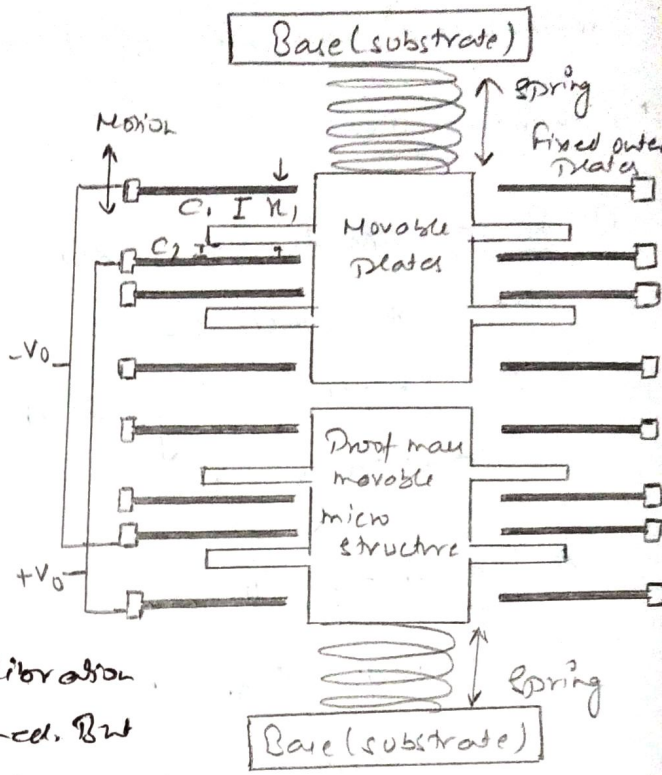
AIM:
To study 2 sensor for linear displacement measurement available in the market.

Contact type Sensor

MEMS accelerometer

- **Principle:**

The basic principle of operation behind the MEMS accelerometer is the displacement of a small proof mass etched into the silicon surface of the integrated circuit and suspended by small beams.



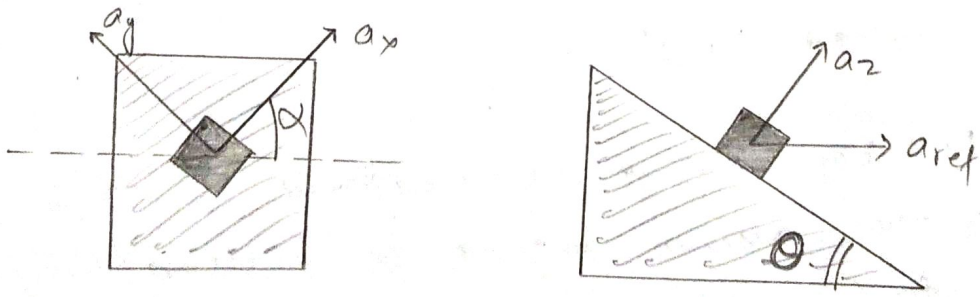
MEMS Accelerometer

- **Calibration:-**

There are many methods as for as calibration of the MEMS accelerometer is concerned. But I have chosen only 1 of them. This method involves the simultaneous excitation of the three axes of the accelerometer under test.

→ The accelerometer is mounted onto the surface of a clamp, inclined at an angle $\theta = 25°$ with respect to the horizontal plane on which the motion is realised.

→ The accelerometer has to be rotated on the clamp surface with angle $\alpha = 45°$ in order to simultaneously excite the three axes in the same way, with a single horizontal sinusoidal acceleration.



Inclined plane scheme

→ The o/p signal and the reference ones are analysed by the fast Fourier transform in correspondence to the oscillation frequency, with the purpose of evaluating their spectral amplitudes. The constant terms, gravity dependent, etc - will affect the results.

- Characteristics.

① Range: As far as MEMS accelerometer are concerned, I don't think it will be fair limiting their range to any limit, they can measure any degree of distance as long as the signal conditioning works.

② Accuracy: I am evaluating accuracy based on the measured data by a lab.

Error = 1.9%

③ Precision: The same distance was referred as 50m and the data was found to be spreaded around.

45.12 to 53.5m

④ Threshold: Threshold was found to be 0.15cm.

⑤ Sensitivity: As far as the sensitivity of the instrument is concerned, it can be mentioned in terms of acceleration and it is atleast $3m/s^2$.

NOTE: Although the range cannot be mentioned in the measurement of the distance but it can always be mentioned as far as the acceleration is concerned. For the MEMS accelerometer used above the range of acceleration is $\pm 16g$.

- Working Standards and Operations

→ It is to be used only for measuring the Periodic, Impulsive and random Signals

→ The response is to be collected using low noise specialized cables like the BNC shielded cables.

→ Noise is to be eliminated using the four pole Butterworth response band Pass filter.

→ The data is to be collected at a sampling freq. of 9kHz.

- Operation of Making Measurements

→ A PC based data acquisition for data collection and storage for further Signal Processing in MATLAB is used.

→ 4 accelerometers, 1 Conventional Piezo and 3 MEMS are attached to the shaker back to back

→ The MEMS accelerometer were Packaged in metal containers with some size and weight to make them more robust of use.

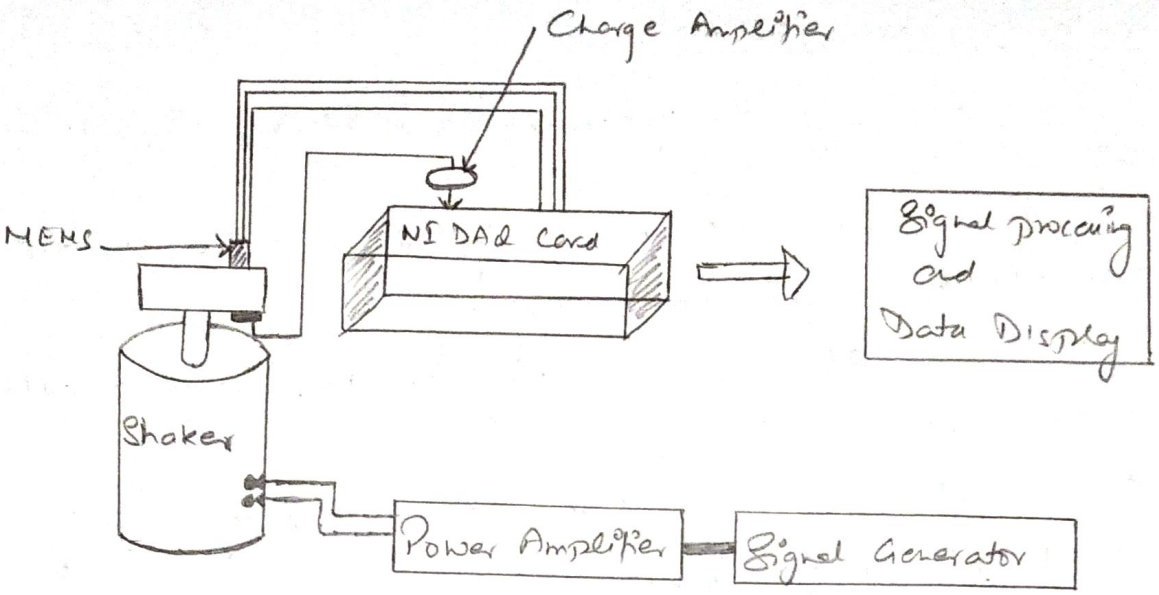
→ The accelerometers are bonded to the area of the measurement using rapid glue.

→ The MEMS mounting faces are circular, and same for all.

→ The MEMS accelerometer Power Supplies were stabilized to 5 volt using a Solid State Voltage regulator to avoid the Power Supply effects on the sensitivity,

→ Rated Specification for the accelerometers

Specification.	MEMS(C)
Sensitivity	450-550mV/g
Freq. range (Hz)	1500
Amplitude limit	±3
Linearity	±1%/1km
Shock limit (g)	100
Resolution (mg)	0.3



Test Setup

- Comparison with the basic linear potentiometer

NOTE: They are just compared for the sake of reference, but they have quite different application.

Characteristics	DOT	MEMS
Range	1 cm to 11 cm	±1g
Accuracy	depends on the user and the instrument	98-1%
Precision		45.12 to 53.5 cm (50 m mean)
Threshold	10mm / 1 cm	0.1 to 0.15 cm
Sensitivity	0.1mm / 0.01 cm	3mV/g

END of contact type sensor.