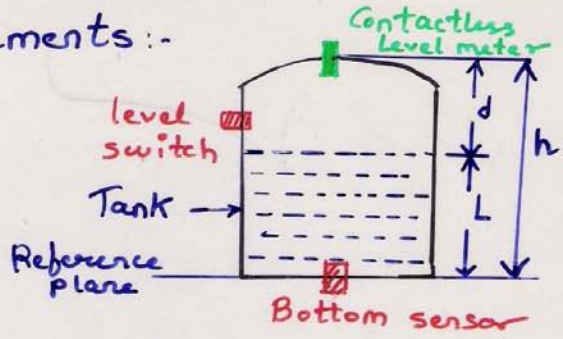
Level Measurements :-

- Level is defined as the filling height of a Liquid or bulk (solids) material in a tank or reservoir.



$$L = h - d$$

- L → Level
- h → tank height
- d → distance of sensor (Level meter) from level.

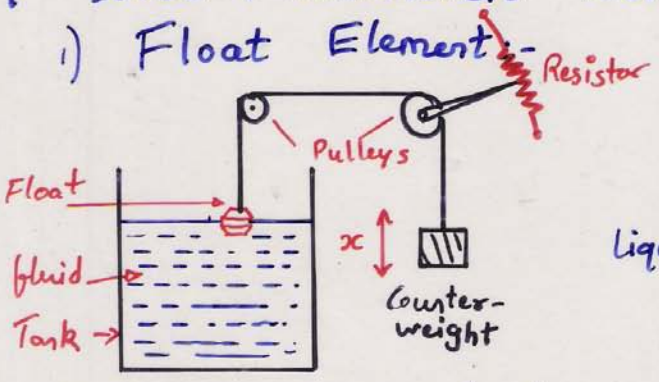
fig:- Principal operational modes of level measurm.

- Various modern methods exists to measure product level in process and storage tanks in the chemical, petro-chemical, water, and food industries, in mobile tanks on vehicles and ships, but also in natural reservoirs like seas, dams, lakes and ocean.

- Two Tasks for Level Measurement: -
  a) Continuous level monitoring. (Level Indication)
  b) level switches (eg to detect an alarm limit to prevent overfilling).

- Level Measurement Technique :-

1) Float Element :-



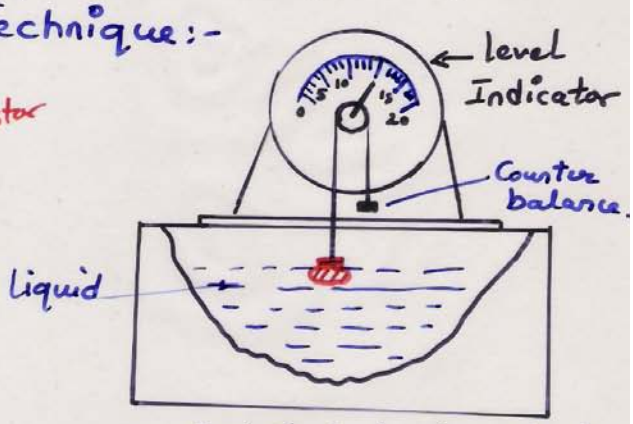


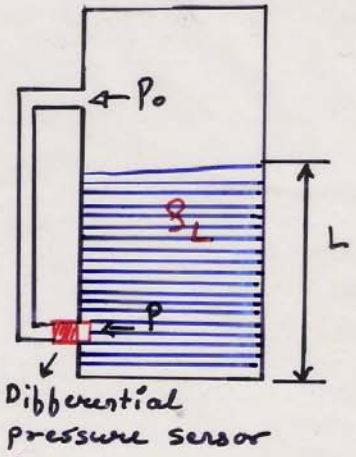
Fig:- Float-system for level measurement (Float-level meter)

Note:- Density of float < Density of fluid
Change in float Position ∝ change in liquid level

2) Level Estimation by Pressure Measurement: (Level-to Pressure Converters)

- A hydrostatic pressure P, caused by weight of product (Liquid or solids), is present at the bottom of a tank, in addition to atmospheric pressure P_o.

$$P = P_o + g\rho_L L \iff \boxed{L = \frac{P - P_o}{g\rho_L}}$$



- In process tanks with varying atmospheric pressure, a differential pressure measurement is achieved by measuring the difference between the pressure at the bottom and that at the top of tank above the liquid.

- Pressure due to a column of a liquid of constant density ρ is $P = \rho gh$, & this pressure is measured by an pressure transducer (manometer)

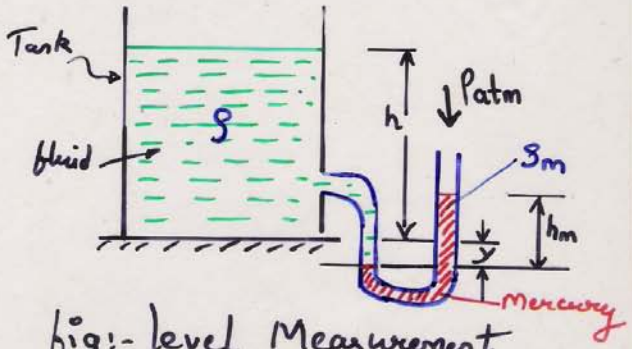


fig:- level Measurement by Manometer

- For manometer,

$$\rho gh = (\rho_m h_m - \rho y)g$$

- If mercury levels in the two legs of manometer are adjusted to be at same ht as bottom of container then $h_m = 2y$, $\therefore$ $\boxed{h = h_m\left(\frac{\rho_m}{\rho} - \frac{1}{2}\right)}$

$$\underline{\Delta h = K \Delta h_m}$$

- The mercury level can be measured by electrical transducer.

• Time-of-flight Measurements:-

• An indirect measurement of level is evaluating the time-of-flight of a wave propagating through the atmosphere above the liquid or solid.

Basic Principle:-

• Although different types of waves (ultrasonic, acoustic) are applied, the principle of all these methods is the same. That is.

A modulated signal is emitted as a wave toward the product (liquid or solids), reflected at its surface and received by a sensor, which in many cases is the same (eg Ultrasonic piezoelectric transducer).

• Emitter launches an ultrasonic wave towards the liquid.
• Its surface reflects the wave and sensor receives it.

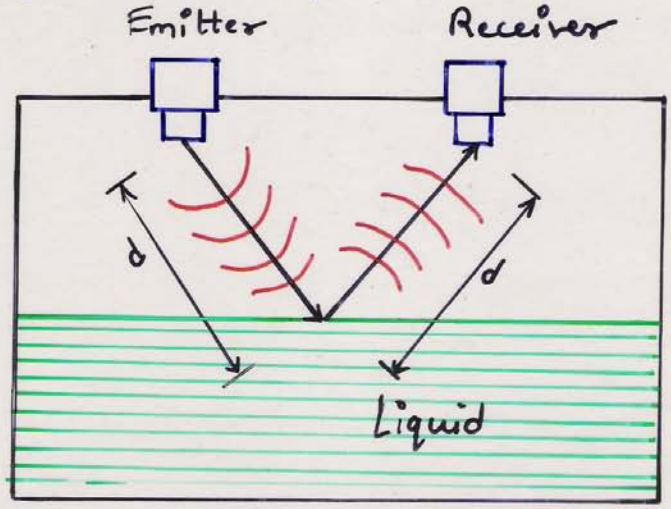
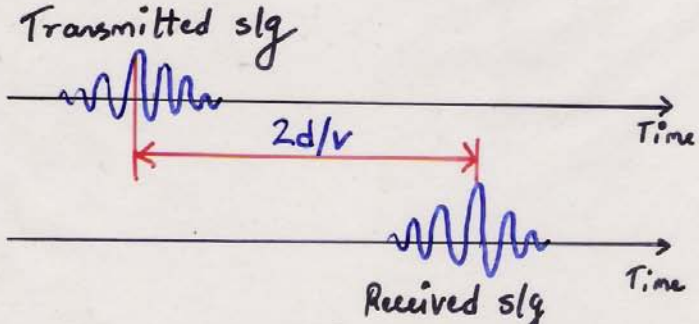


fig level Measurement by Ultrasonic Sensors.



fig(b) Due to propagation velocity of wave v, a time delay $\left(t = \frac{2d}{v}\right)$ is measured bet^n emission & receipt of signal.

Ultrasonic Sensors:-

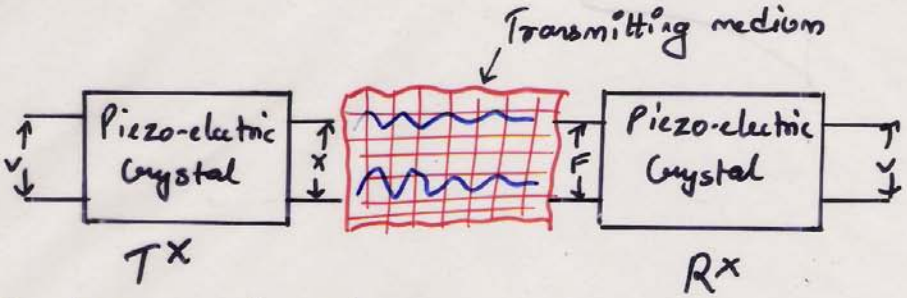


fig. Ultrasonic Measurement System.

- Ultrasonic Transmitter (T^x) uses inverse- P.E effect, ie if a voltage is applied across a crystal, it will undergo a corresponding deformations.
- The vibration of crystal is transmitted through the media from one end to the other.
- The R^x uses direct PE effect & converts force into corresponding voltage.

- What is Ultrasonic waves?

→ They are longitudinal acoustic waves with frequencies above 20KHz.

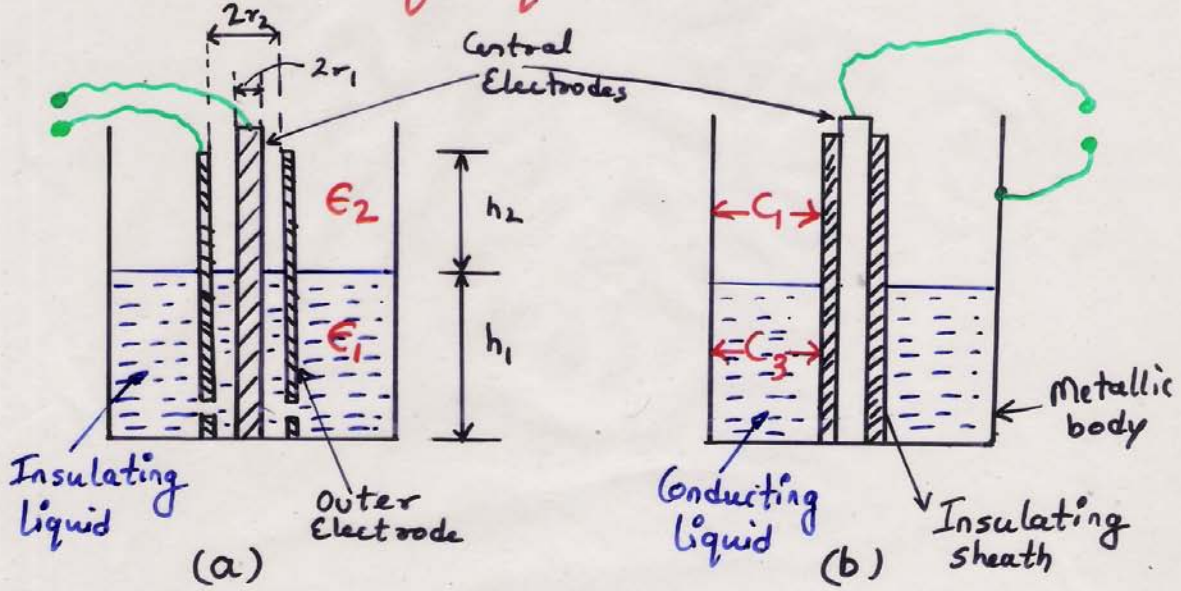
→ Ultrasonic waves needs a propagation medium, which for level measurements is the atmosphere above product being measured.

- Piezoelectric transducers are utilized as emitter and detector for Ultrasonic waves.
- Another procedure is to propogate the waves within the liquid by a sensor mounted at the bottom of the tank. The velocity of sound in the liquid must be known, along with dependences on temperature and type of liquid. This method is similar to an echo sounder on ships for measuring the water depth.

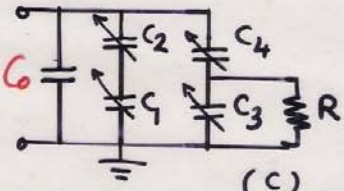
Capacitive Level Transducer:-

Principle:- $C = \frac{\epsilon_0 \epsilon_r A}{d}$ — C changes if 1) A changes 2) d changes 3) Dielectric changes.

- Change in C $\propto$ change in level of liquid.



ϵ_1 - dielectric const of fluid
h_1 - height of liquid



C_2, C_4 due to sheath
C_1, C_3 due to liquid
Net C_0 is related to level of liquid.

Fig: A Capacitive level transducer for use in
(a) Insulating and Conducting liquids
(b) Conducting liquids only. c) equivalent circuit.

- The capacitor with concentric cyclindrical electrodes can be used to measure the Level of liquids.

The Capacitances C due to two columns of liquids is (i.e. it's vapour)

$$C = 2\pi\epsilon_0 \left[\frac{\epsilon_1 h_1 + \epsilon_2 h_2}{\ln\left(\frac{r_2}{r_1}\right)} \right]$$

h_2 - space filled with vapour of liquid.
$\epsilon_2 \approx 1$.

[Characteristics of Capacitance — Level is linear]