EIPC
NEE-403
Unit-2
Level measurement

LEVEL MEASUREMENT

- Some of the most commonly used liquid-level measurement methods are:
  - FLOAT type
  - RF capacitance
  - Conductance (conductivity)
  - Hydrostatic head/tank gauging
  - Radar
  - Ultrasonic
- Before you can decide which one is right for your application, however, you need to understand how each works and the theory behind it.

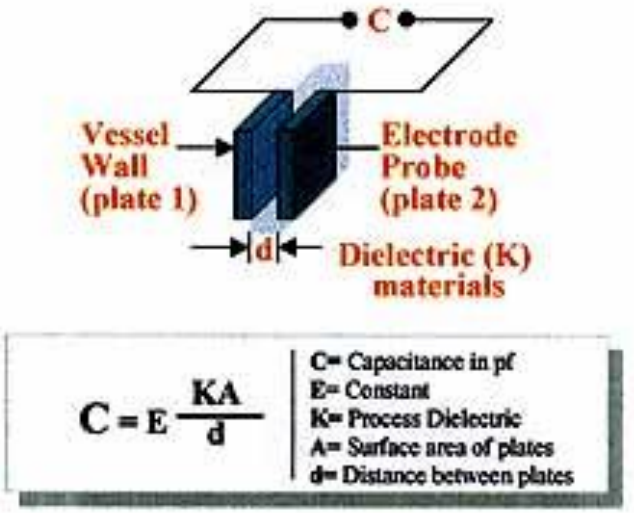
Float type Level transmitter

RF Capacitance

- RF (radio frequency) technology uses the electrical characteristics of a capacitor, in several different configurations, for level measurement.
- Commonly referred to as RF capacitance or simply RF, the method is suited for detecting the level of liquids, slurries, granulars, or interfaces contained in a vessel.
- Designs are available for measuring process level at a specific point, at multiple points, or continuously over the entire vessel height. Radio frequencies for all types range from 30 kHz to 1 MHz.

Capacitance Measurement Theory

- All RF level systems make use of enhancements of the same capacitance-measuring technique, and the same basic theory underlies them all.
- An electrical capacitance exists between two conductors separated by a distance, d. The first conductor can be the vessel wall (plate 1), and the second can be a measurement probe or electrode (plate 2). The two conductors have an effective area, A, normal to each other.
- Between the conductors is an insulating medium—the nonconducting material involved in the level measurement.



Capacitance Measurement Theory

- The amount of capacitance here is determined not only by the spacing and area of the conductors, but also by the electrical characteristic (relative dielectric constant, K) of the insulating material.
- The value of K affects the charge storage capacity of the system: The higher the K, the more charge it can build up.
- Dry air has a K of 1.0. Liquids and solids have considerably higher values, as shown in Table 1.

Capacitance Measurement Theory

- The capacitance for the basic capacitor arrangement shown in Figure 1 can be computed from the equation:

$$C = E (K A/d)$$

where:

C = capacitance in picofarads (pF)

E = a constant known as the absolute permittivity of free space

K = relative dielectric constant of the insulating material

A = effective area of the conductors

d = distance between the conductors

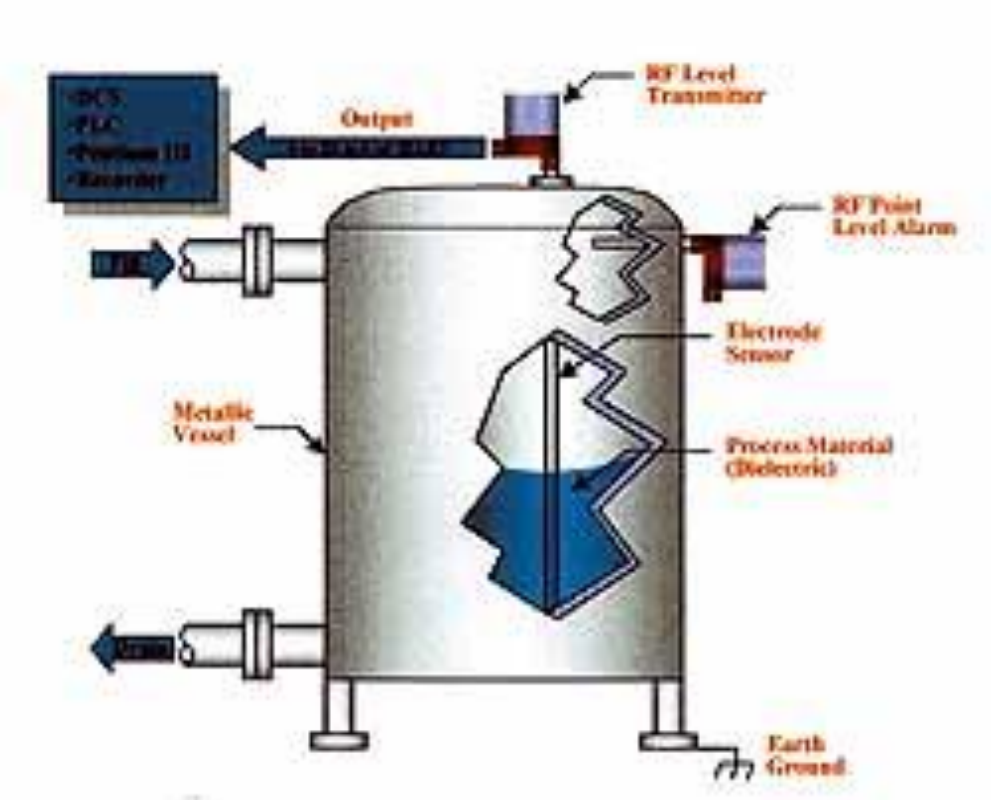
Capacitance Measurement Theory

- To apply this formula to a level-measuring system, you must assume that the process material is insulating, which, of course, is not always true.
- A bare, conductive, sensing electrode (probe) is inserted down into a tank to act as one conductor of the capacitor.
- The metal wall of the tank acts as the other.
- If the tank is nonmetallic, a conductive ground reference must be inserted into the tank to act as the other capacitor conductor.

Capacitance Measurement Theory

- With the tank empty, the insulating medium between the two conductors is air. With the tank full, the insulating material is the process liquid or solid.
- As the level rises in the tank to start covering the probe, some of the insulating effect from air changes into that from the process material, producing a change in capacitance between the sensing probe and ground.
- This capacitance is measured to provide a direct, linear measurement of tank level.

Capacitance Measurement Theory



- In the RF capacitance method of liquid level measurement, the electrode sensor connects directly to an RF transmitter outside the tank.

Capacitance Measurement Theory

- The electrode sensor, or probe, connects directly to an RF level transmitter, which is mounted outside the tank. In one design, with the probe mounted vertically, the system can be used for both continuous level measurement and simultaneous multipoint level control.

- Alternatively, for point level measurement, one or more probes can be installed horizontally through the side of the tank; Figure shows this type being used as a high-level alarm.

Capacitance Measurement Theory

TABLE 1

Dielectric Constants of Sample Substances

Substance	Value
Isopropyl alcohol	18.3
Kerosene	1.8
Kynar	8.0
Mineral oil	2.1
Pure water	80
Sand	4.0
Sugar	3.0
Teflon	2.0

Capacitance Measurement Theory

This view of a typical RF capacitance probe shows the electronic chassis enlarged to twice the size of its housing.

RF Impedance or RF Admittance.

- When another electrical characteristic, impedance, enters the picture, the result is further refinements in RF level measurement.
- Offering improved reliability and a wider range of uses, these variations of the basic RF system are called RF admittance or RF impedance. In RF or AC circuits, impedance, Z is
- $Z = R + 1/ j\ 2\ \pi\ f\ C$

  where: R = resistance in ohms

  f = measurement frequency (radio frequency for RF measurement)

  C = capacitance in picofarads

RF Impedance or RF Admittance.

- An RF impedance level-sensing instrument measures this total impedance rather than just the capacitance. Some level-measuring systems are referred to as RF admittance types. Admittance, A, is defined as a measure of how readily RF or AC current will flow in a circuit and is therefore the reciprocal of impedance (A = 1/Z). Thus, there is no basic difference between the RF impedance and RF admittance as a level-measurement technology.

In some cases, the process material tends to build up a coating on the level-sensing probe. In such cases, which are not uncommon in level applications, a significant measurement error can occur because the instrument measures extra capacitance and resistance from the coating buildup. As a result, the sensor reports a higher, and incorrect, level instead of the actual tank level.

RF Impedance or RF Admittance.

- Note that the equation for impedance includes resistance, R. The RF impedance method can be provided with specific circuitry capable of measuring the resistance and capacitance components from the coating and the capacitive component due to the actual process material level.
- The circuitry is designed to solve a mathematical relationship electronically, thereby producing a 4–20 mA current output that is proportional only to the actual level of the process material. It is virtually unaffected by any buildup of coating on the sensing probe, enabling an RF system to continue functioning reliably and accurately.

Conductance

- The conductance method of liquid level measurement is based on the electrical conductance of the measured material, which is usually a liquid that can conduct a current with a low-voltage source (normally <20 V). Hence the method is also referred to as a conductivity system. Conductance is a relatively low-cost, simple method to detect and control level in a vessel.
- One common way to set up an electrical circuit is to use a dual-tip probe that eliminates the need for grounding a metal tank. Such probes are generally used for point level detection, and the detected point can be the interface between a conductive and nonconductive liquid.

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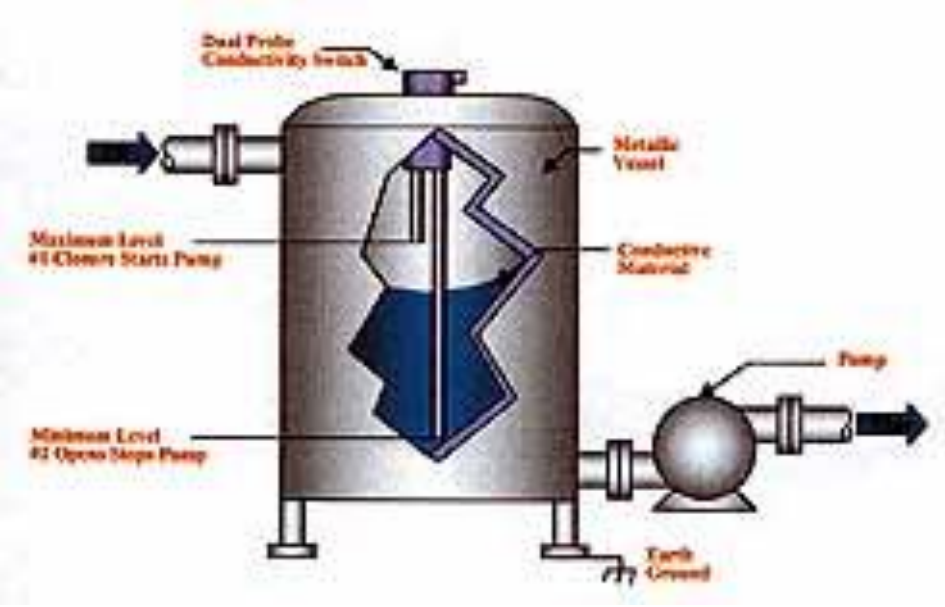
Conductance

Figure shows an arrangement with two dual-tip probes that detect maximum and minimum levels. When the level reaches the upper probe, a switch closes to start the discharge pump; when the level reaches the lower probe, the switch opens to stop the pump



- In the conductive type of level measurement, two dual-tip probes detect the maximum and minimum levels in a tank.

Thank You