

SENSORS AND AUTOMATION

PRACTICAL NO : 3 : MEASUREMENT OF WATER LEVEL IN A TANK USING CAPACITIVE TYPE LEVEL PROBE.

The screenshot shows the 'Capacitance' section of the Sensor Analysis Laboratory. On the left, a diagram illustrates a tank of height h with a probe of outer radius r_2 and inner radius r_1 . The probe is connected to a 'CAPACITANCE' output. The 'Configure System' panel on the right includes the following settings:


- Height of Tank (cm): 500
- Outer Radius(r_2 cm): 2.5
- Inner Radius(r_1 cm): 0.1
- Span value: 445
- Services: Water

A green 'Configure System' button is located below the settings. Below the button, there are links for 'Block Diagram Capacitive Sensor' and 'Block Diagram Level Transmitter(Capacitive type)'. On the far right, there is a 'Formula' button.

This screenshot shows the same interface as the previous one, but with a formula pop-up window open. The pop-up window displays the following information:

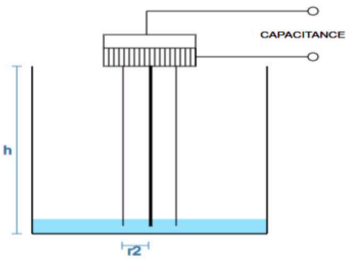
- URL: <https://portal.coepvlab.ac.in/vlab/resources/vlabs/elctricalLabs/SensorLab/Capacitance/form...>
- Formula:
$$C = 2 \pi \epsilon_0 (\epsilon_1 h_1 + \epsilon_2 h_2) / \ln (r_2 / r_1)$$
- Where,
 - C = Capacitance in μF
 - r_1 = radius of inner cylinder/pipe for 'pipe in pipe' type probe
 - r_2 = radius of outer cylinder/pipe for 'pipe in pipe' type probe
 - ϵ_0 = permittivity of the space = 8.85×10^{-12}
 - ϵ_1 = permittivity of air = 1
 - ϵ_2 = Dielectric constant of the process fluid/selected service
 - h_1 = Height (Level) of air column = span - liquid column height
 - h_2 = Height (Level) of liquid column
 - span = (Tank height * 0.9) - 5

The background interface shows the same diagram and configuration panel as the first screenshot.



Capacitance

Sensor Analysis Laboratory



Experiment

Selected values :

Height of Tank: 500 cm

Outer radius(r2): 2.5cm

Span Value: 445

Inner radius(r1): 0.1cm

Service: Water

45

Output Capacitance: 0.0691 μF


Reload
Submit
next

Capacitance Graph
Current Graph

[Block Diagram Capacitive Sensor](#)

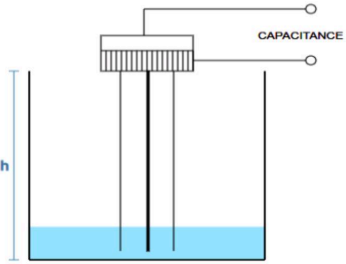
[Block Diagram Level Transmitter\(Capacitive type\)](#)

Formula



Capacitance

Sensor Analysis Laboratory



Experiment

Selected values :

Height of Tank: 500 cm

Outer radius(r2): 2.5cm

Span Value: 445

Inner radius(r1): 0.1cm

Service: Water

90

Output Capacitance: 0.13 μF

Reload
Submit
next

Capacitance Graph
Current Graph

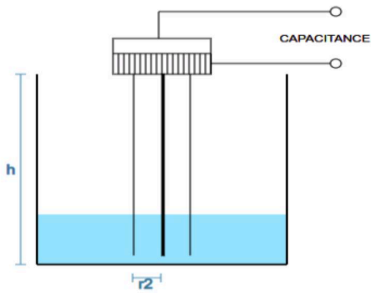
[Block Diagram Capacitive Sensor](#)

[Block Diagram Level Transmitter\(Capacitive type\)](#)

Formula



Capacitance



Experiment

Selected values :
Height of Tank: 500 cm
Outer radius(r_2): 2.5cm
Span Value: 445
Inner radius(r_1): 0.1cm
Service: Water

135

Output Capacitance: 0.19 μF

Reload

Submit

next

Capacitance Graph

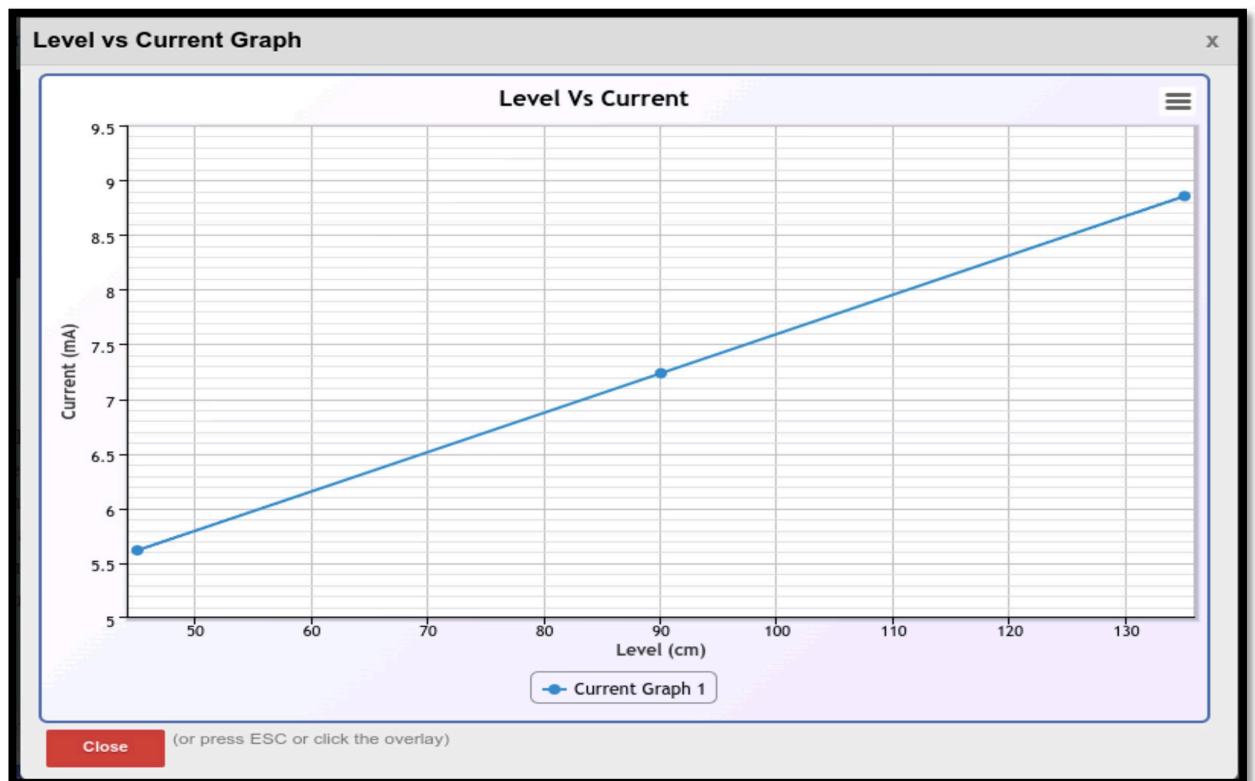
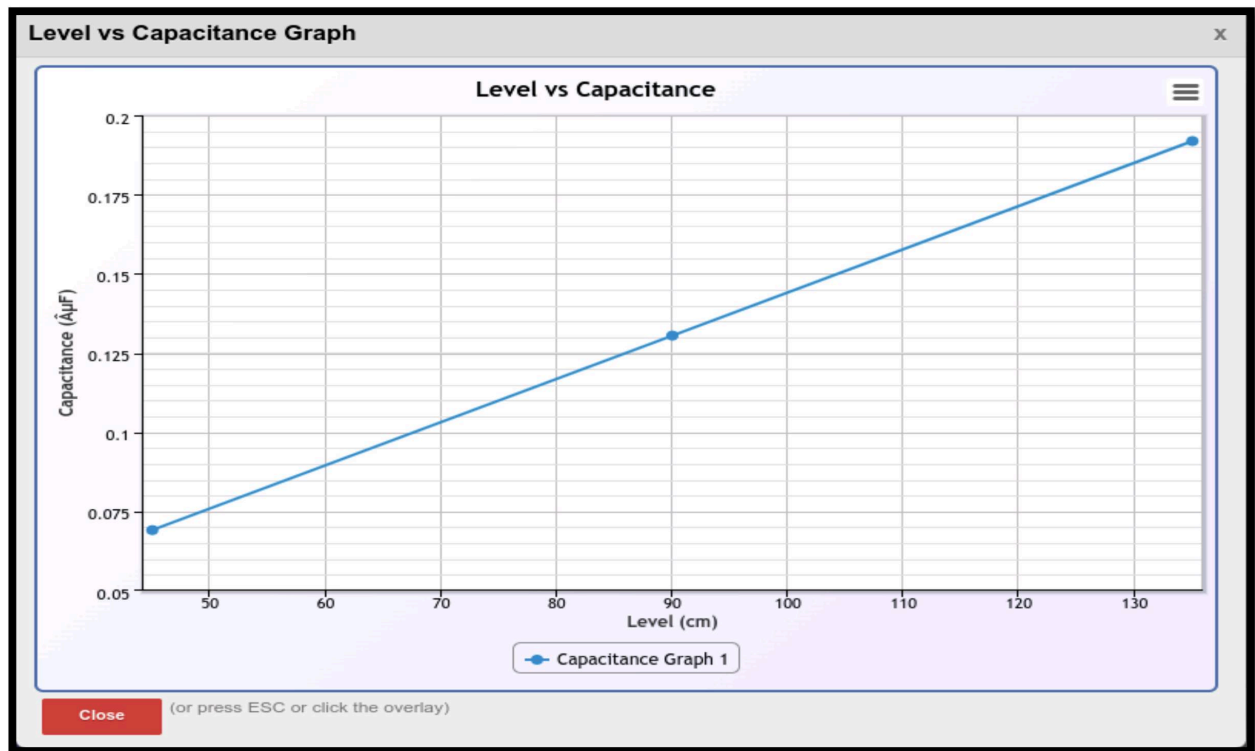
Current Graph

Block Diagram Capacitive Sensor

Block Diagram Level Transmitter(Capacitive type)

Formula

Graphs:



Sensors and Automation

Assignment No: 3

- Measurement of level in a Tank using Capacitive Type level Probe.

Formula:

$$C = 2\pi\epsilon_0(\epsilon_1 h_1 + \epsilon_2 h_2) / \ln(r_2 / r_1)$$

where,

C = Capacitance in μF

r_1 = radius of inner cylinder / pipe for 'pipe in pipe' type probe

r_2 = radius of outer cylinder / pipe for 'pipe in pipe' type probe.

ϵ_0 = permittivity of air space = 8.85×10^{-12}

ϵ_1 = permittivity of air = 1

ϵ_2 = Dielectric constant of the process fluid / selected service.

h_1 = Height (Level) of air column = Span-liquid column height

h_2 = Height (Level) of liquid column
span = (Tank height * 0.9) - 5

<u>Process Fluid / Service</u>	<u>Dielectric Constant (ϵ_2)</u>
Water	80
Hydrochloric	5
Coffee Beans	1.5
Grains of mustard seed	3.6
Skimmed milk powder	2.3

1) Reading 1: Water

$$r_1 = 0.1 \text{ cm}$$

$$r_2 = 2.5 \text{ cm}$$

$$\epsilon_0 = 8.85 \times 10^{-12}$$

$$\epsilon_1 = 1$$

$$\epsilon_2 = 80 \text{ (water)}$$

$$\text{Span} = (\text{Tank height} \times 0.9) - 5$$

$$= (500 \times 0.9) - 5$$

$$= 445$$

$$h_1 = \text{Span} - \text{liquid column height}$$

$$= 445 - 45$$

$$= 400$$

$$h_2 = 45$$

$$C = \frac{2\pi \times (8.85 \times 10^{-12}) \times (1 \times 400 + 80 \times 45)}{\ln(2.5/0.1)}$$

$$C = 6.91$$

$$\therefore C = 6.91 / 100 \quad (\text{cm to meter})$$

$$\therefore \underline{C = 0.0691 \mu\text{F}}$$

2. Reading NO: 2

$$\begin{aligned}\text{Span} &= (\text{Tank height} * 0.9) - 5 \\ &= (500 * 0.9) - 5 \\ &= 445\end{aligned}$$

$$\begin{aligned}h_1 &= \text{Span} - \text{liquid column height} \\ &= 445 - 90 \\ &= 355\end{aligned}$$

$$h_2 = 90$$

$$C = 2\pi \epsilon_0 (\epsilon_1 h_1 + \epsilon_2 h_2) / \ln(r_2 / r_1)$$

$$C = 2\pi \times (8.85 \times 10^{-12}) \times (1 \times 355 + 80 \times 90) / \ln(2.5 \div 0.1)$$

$$\therefore \underline{\underline{C = 0.13 \mu F.}}$$

3. Reading NO: 3

$$\begin{aligned}\text{Span} &= (\text{Tank height} * 0.9) - 5 \\ &= (500 * 0.9) - 5 \\ &= 445\end{aligned}$$

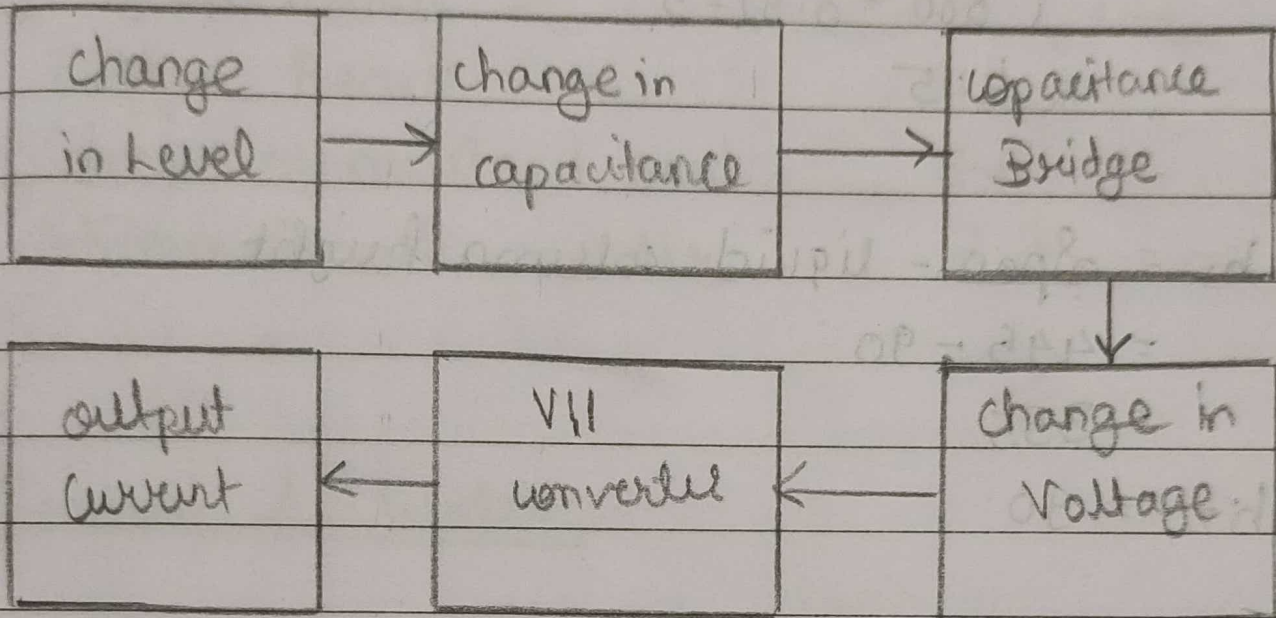
$$h_1 = 445 - 135 = 310$$

$$h_2 = 135$$

$$C = 2\pi \times 8.85 \times 10^{-12} (1 \times 310 + 135 \times 80) / \ln(2.5/0.1)$$

$$\underline{\underline{C = 0.19 \mu F.}}$$

• Block Diagram level to current converter



Block Diagram Sensor Working

$$C = 2\pi \cdot \epsilon_0 (\epsilon_1 \cdot h_1 + \epsilon_2 \cdot h_2) / \ln(r_2/r_1)$$

