Measurement of Relative Humidity

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Humidity Sensors

Definition:

✓**Relative humidity is defined as the ratio (stated as a percent) of the moisture content of air compared to the saturated moisture level at the same temperature and pressure.**

Major Requirements of humidity sensors:

- ✓ **Predictable behavior.**
- ✓ **Good long-term stability.**
- ✓**Should be ruggedly constructed for reliable operation under adverse conditions.**
- ✓**Should be simple to operate and maintain.**

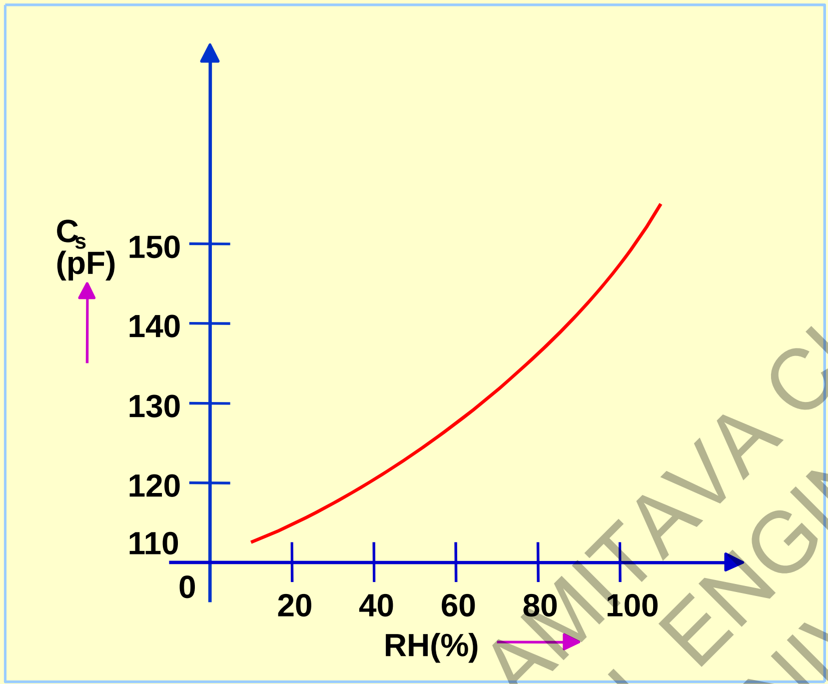
Humidity Sensors (contd…)

Why Electronic Humidity Sensors?

- ✓ **They can be incorporated directly into an electrical measuring circuit, avoiding many problems often associated with mechanical counterparts.**
- ✓ **Easier to operate and maintain than mechanical sensors.**
- ✓ **They are highly versatile and can be used to drive a variety of humidity display and humidity control appliances.**
- ✓ **They are easier to calibrate.**

Humidity sensors must meet two competitive objectives: to be both reliable and inexpensive.

Capacitive Humidity Sensor - A



The Characteristic of a Philips make Capacitive (*RH*) Sensor

App. Relationship between *RH* and C_s:

$$\frac{C_s}{C_s(12\%)} = 0.985 + 0.34\left(\frac{RH}{100}\right)^{1.4}$$

$C_s(12\%)$ is the capacitance of the sensor at $RH = 12\%$.

- ✓ **The arrangement is designed for measuring *RH* from 10% to 90%.**
- ✓ **The long-term characteristic remains unaffected by condensation of water on foil surface.**

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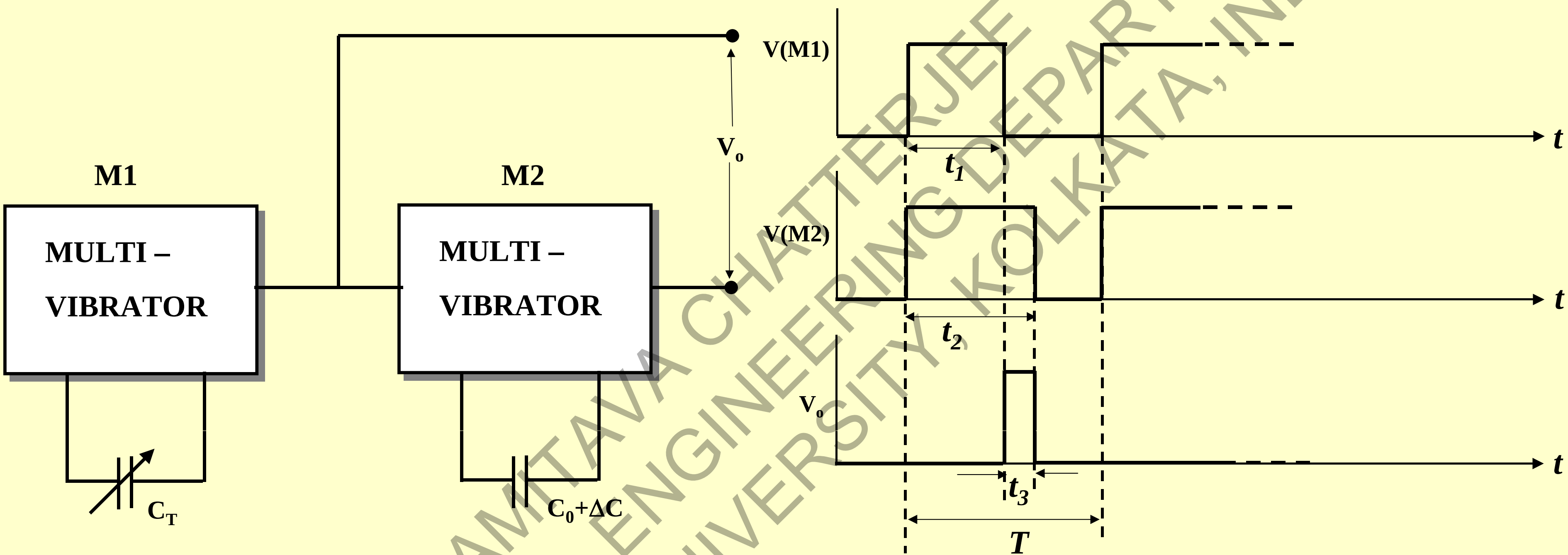
Capacitive Humidity Sensor - A (contd…)

Measuring Circuit

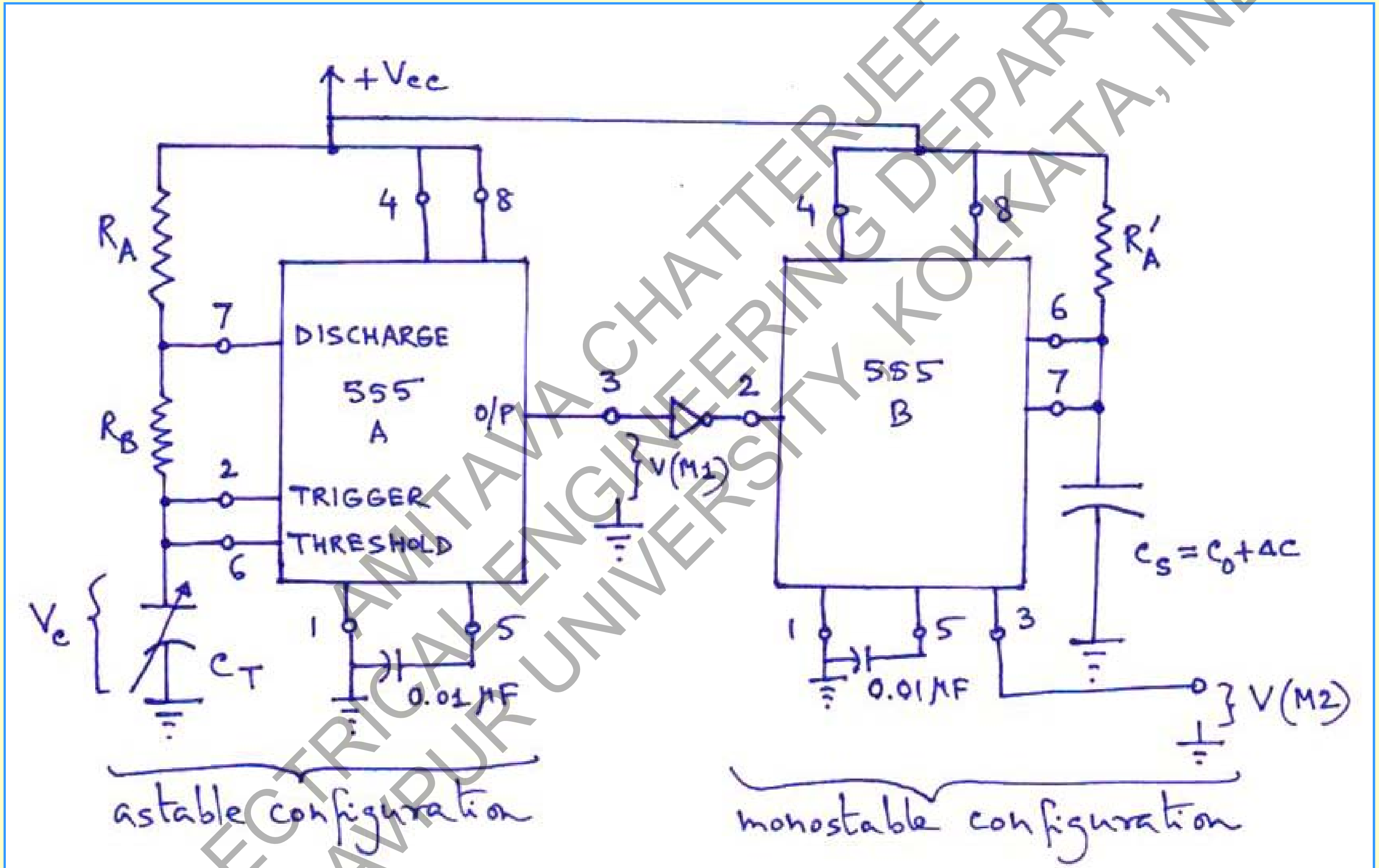


✓ **The capacitance is given by** $C_s = C_0 + \Delta C$ **, where** C_0 **= constant part of the capacitance and** ΔC **= the capacitance part that varies with the *RH* value.**

$$\overline{V_o} = \left(\frac{t_3}{T}\right)V_B = \left(\frac{t_3}{T}\right)V_{CC} \text{ or } \overline{V_o} \propto \Delta C$$

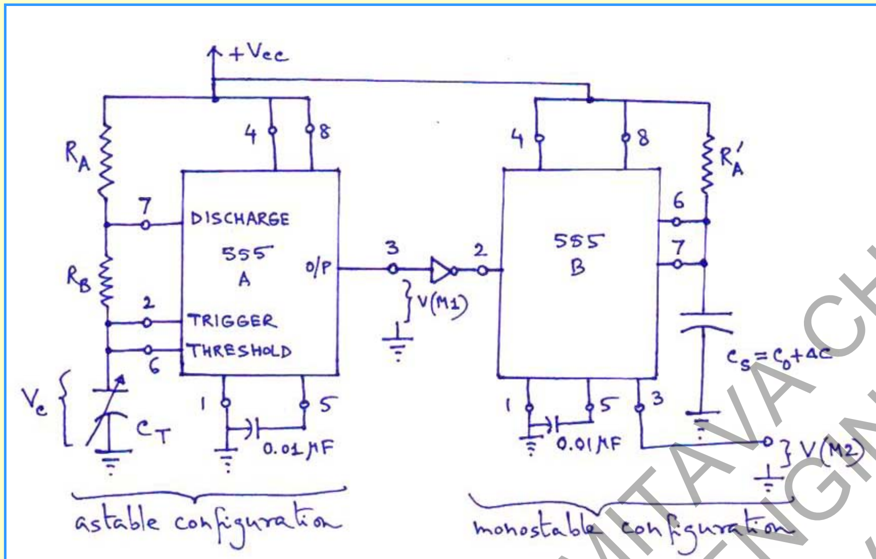
Capacitive Humidity Sensor – A (contd…)

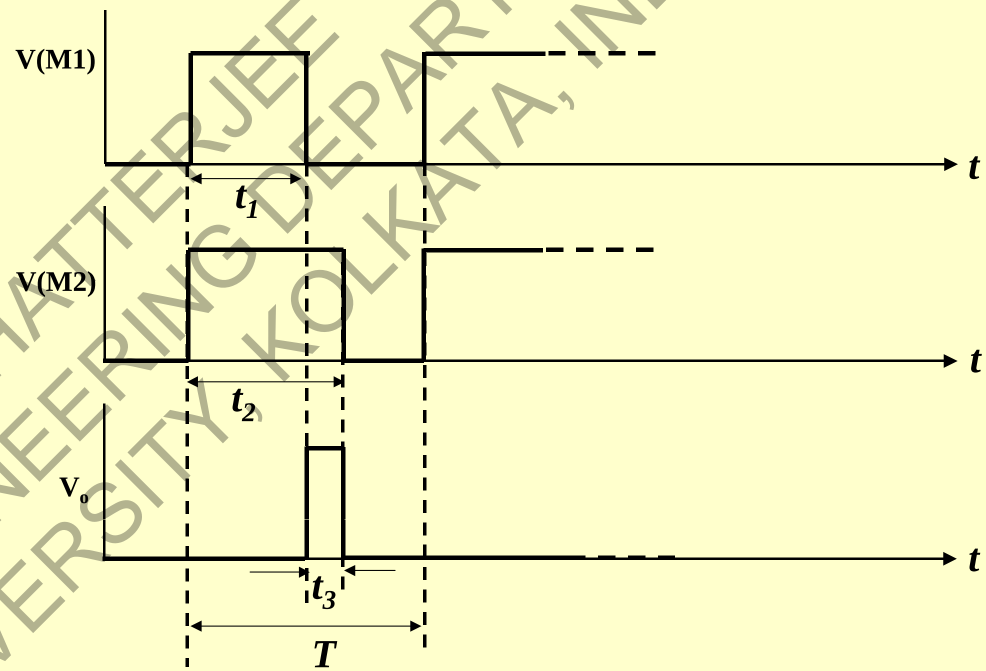
Measuring Circuit



Capacitive Humidity Sensor – A (contd…)

Measuring Circuit





For astable multivibrator ➡

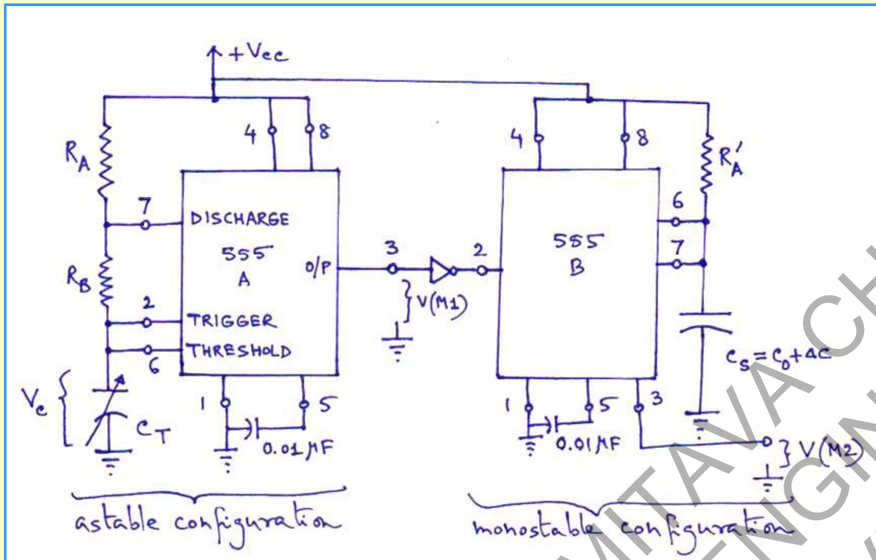
$$t_{high} = t_1 = 0.695(R_A + R_B)C_T = 0.695(R_A + R_B)C_0$$

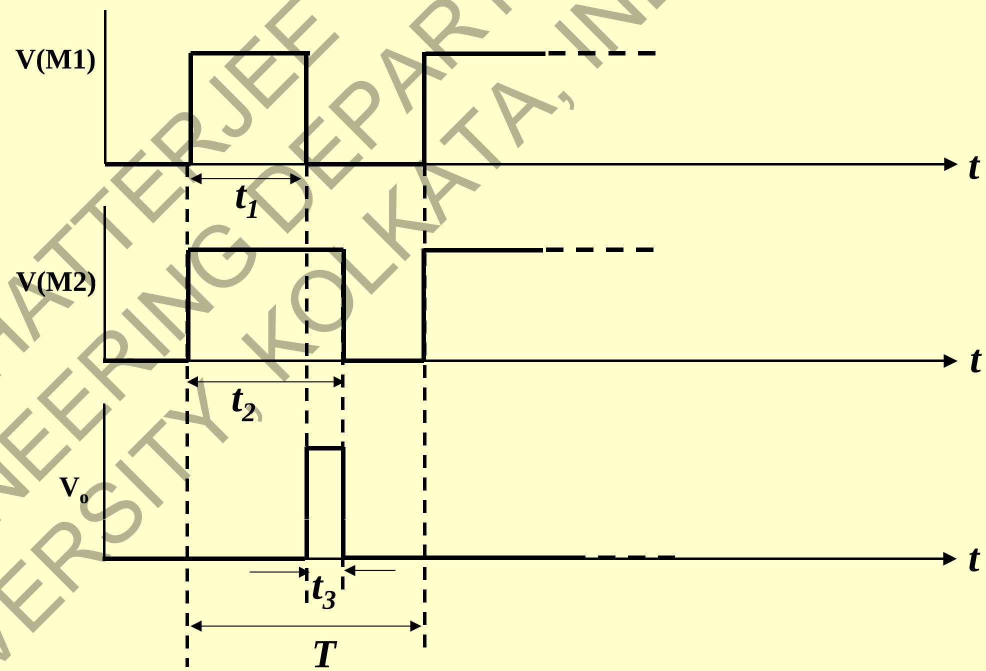
$$t_{low} = t_1' = 0.695 R_B C_T = 0.695 R_B C_0$$

$$T = t_1 + t_1' = 0.695(R_A + 2R_B)C_0$$

Capacitive Humidity Sensor – A (contd…)

Measuring Circuit





For monostable multivibrator ➡ $t_{high} = t_2 = 1.1R_A^{/}\left(C_0 + \Delta C\right)$

Make the design so that ➡ $0.695\left(R_A + R_B\right) = 1.1R_A^{/} = K$

Then ➡ $t_1 = KC_0$ and $t_2 = K\left(C_0 + \Delta C\right). \therefore t_3 = t_2 - t_1 = K\Delta C$

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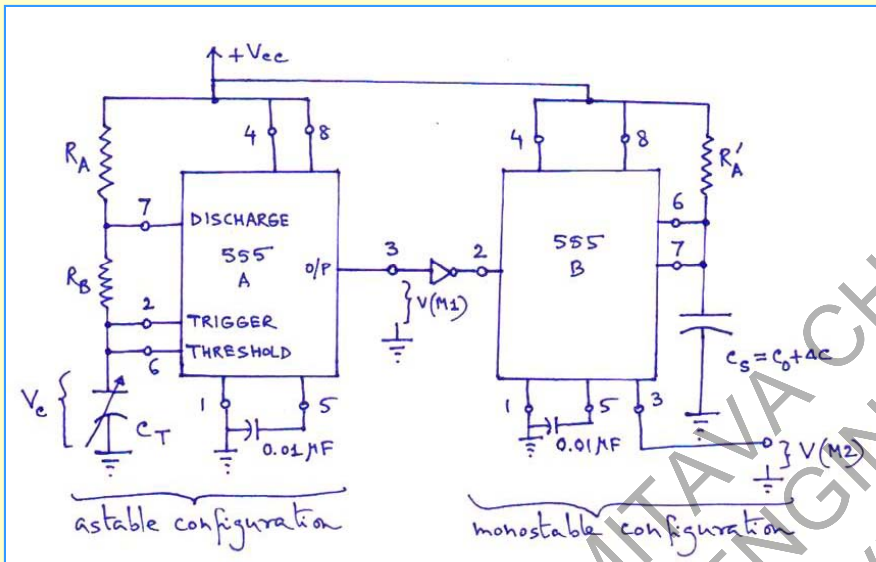
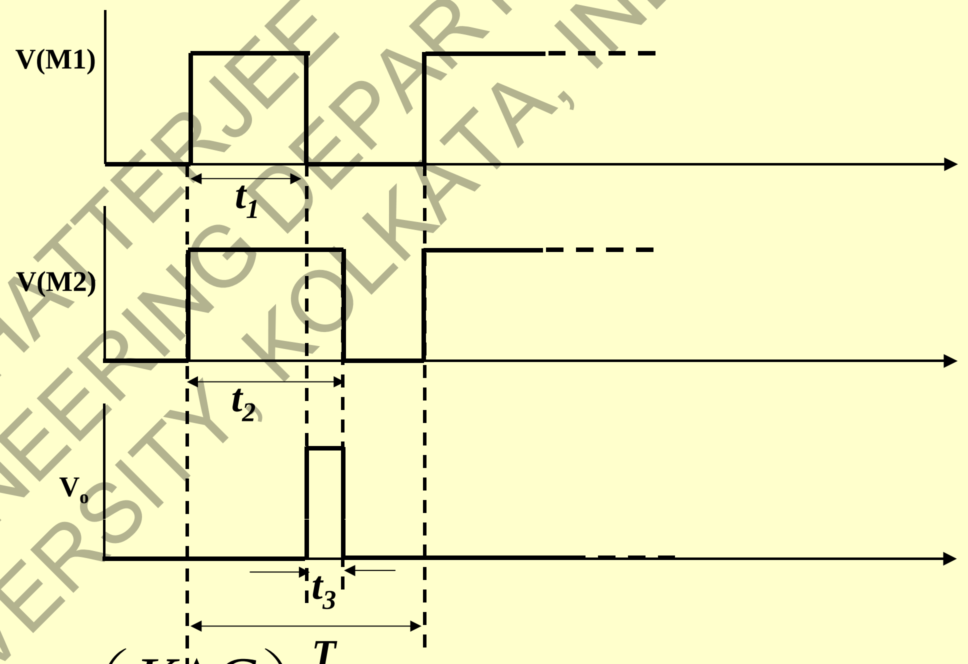
Capacitive Humidity Sensor – A (contd…)

Measuring Circuit





Assuming all pulses of equal magnitude V_B, mean output voltage:

$$\overline{V_o} = \left(\frac{t_3}{T}\right)V_B = \left(\frac{t_3}{T}\right)V_{CC} = \left(\frac{K\Delta C}{T}\right)V_{CC}$$

$$= \left(\frac{0.695(R_A + R_B)V_{CC}}{0.695(R_A + 2R_B)C_0}\right)\Delta C = \left(\frac{(R_A + R_B)V_{CC}}{(R_A + 2R_B)C_0}\right)\Delta C$$

$$\overline{V_o} \propto \Delta C$$

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Capacitive Humidity Sensor – A (contd…)

App. Relationship between *RH* and C_s:

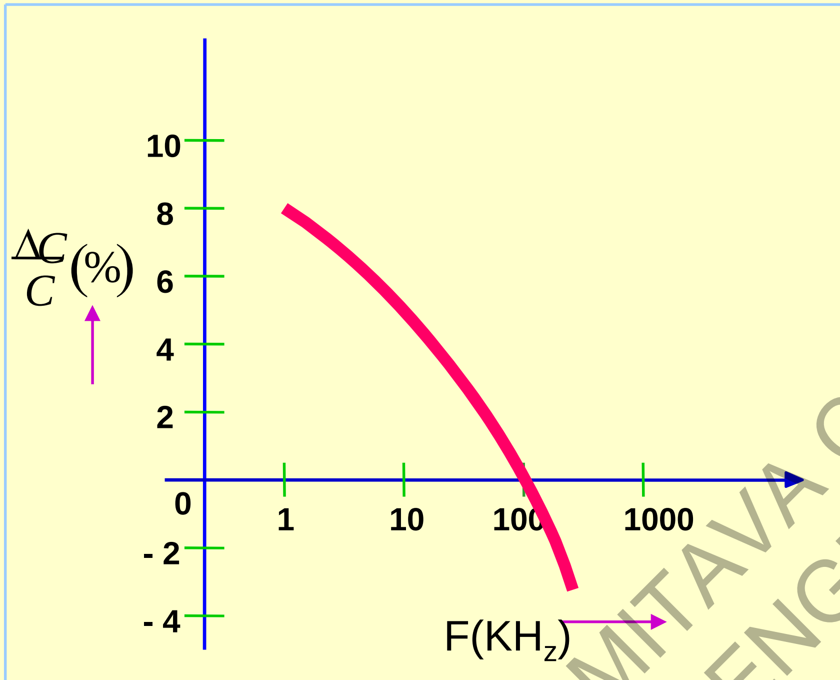
$$\frac{C_s}{C_s(12\%)} = 0.985 + 0.34\left(\frac{RH}{100}\right)^{1.4}$$

$C_s(12\%)$ is the capacitance of the sensor at *RH* = 12%.

- ✓ **The capacitance C_s not only depends on the primary measurand *RH*, but also on some other secondary variables e.g. operating frequency and ambient temperature.**

Capacitive Humidity Sensor – A (contd…)

Influence of Secondary Variables:



The influence of operating frequency on capacitance

f (KHz)	C_0 (pF) (RH = 0%)	ΔC (12%) (pF)	ΔC (100%) (pF)
1	116.1	3.6	45.5
10	112.7	3.5	44.2
100	109.0	3.3	42.7
1000	104.6	3.3	41.0

Capacitance of humidity sensor at four different frequencies (nominal values)

✓ **The temperature dependence of the sensor capacitance (over the operating frequency range) ≈ 0.1%/K .**

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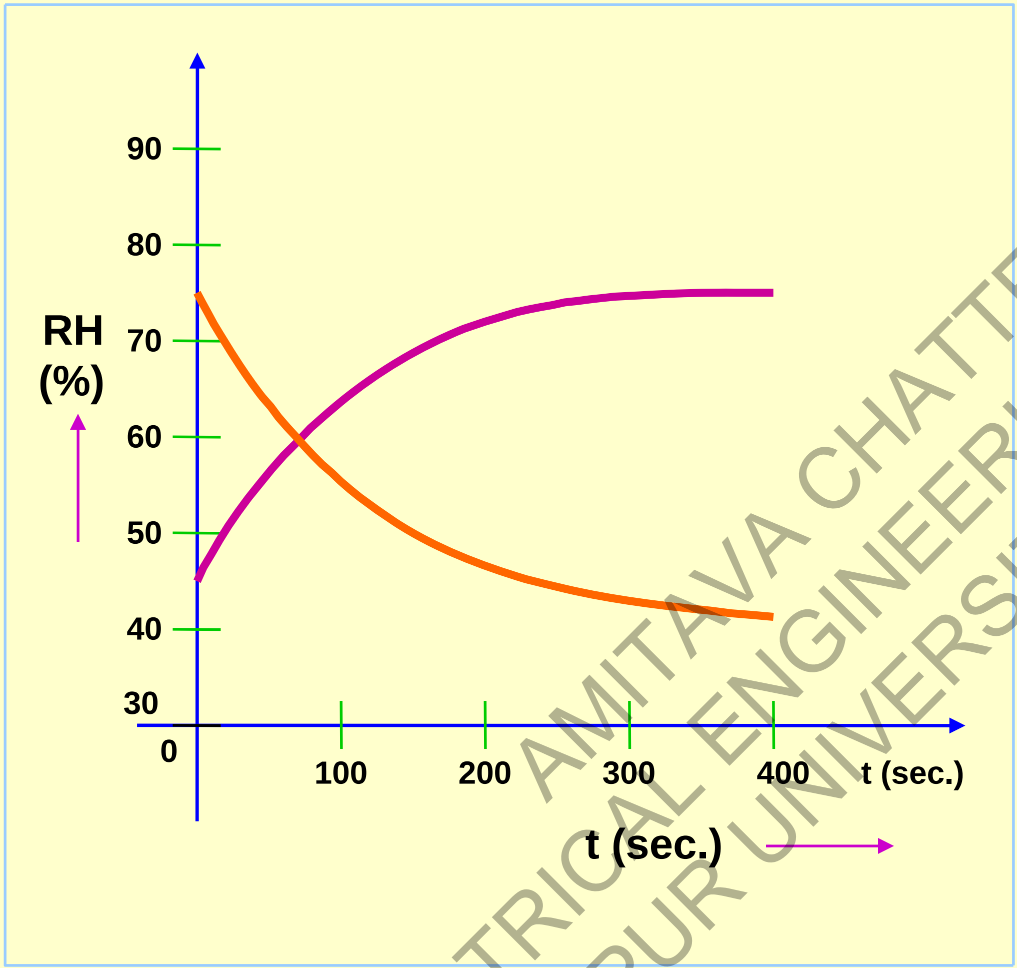
Capacitive Humidity Sensor – A (contd…)

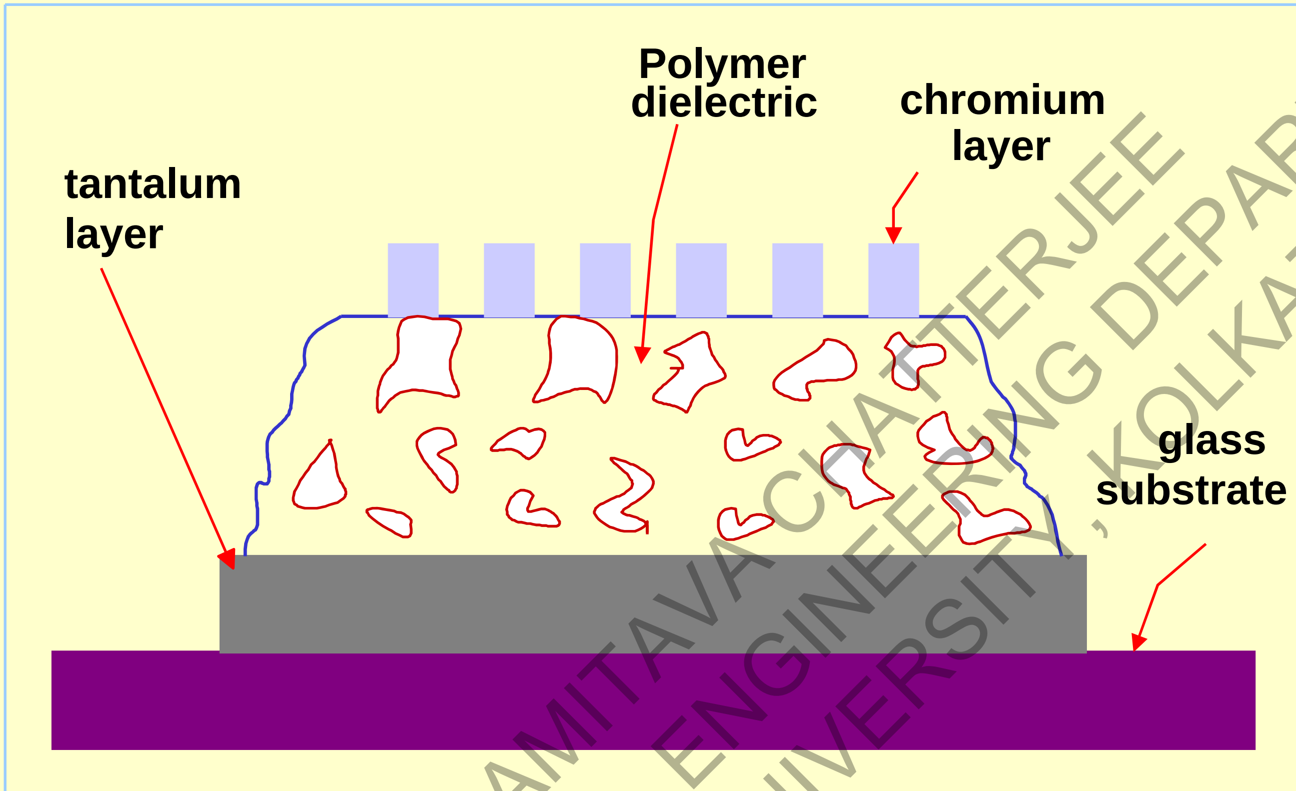


Time response of the sensor

The sensor has a slow response time

Conclusion: **The sensor will not be particularly suitable for those situations where the *RH* undergoes fast variations.**

Capacitive Humidity Sensor – B



The Capce. vs. *RH* relation:

$$C = 375 + 1.7RH \quad \text{pF}$$

✓**Here the dielectric is a polymer which has the ability to absorb water molecules.**

✓**A sensor of this type has its input range of 0% to 100% *RH*, with a capacitance of 375 pF at 0% *RH* and a linear sensitivity of 1.7 pF per % *RH*.**

Thank You