Moisture control with Philips' capacitive humidity sensor

Philips' capacitive humidity sensor has already proven itself over many years as one of the most effective and economical means of measuring and controlling humidity.

The sensor operates by sensing changes in capacitance of a thin-film polymer membrane as it absorbs moisture from its surroundings. Compared with many alternatives, it's simple to operate, highly reliable and fast. What's more, its long-term characteristics are unaffected by condensation of water on the membrane surface and other aggressive pollutants in the air.

Used in, for example, home hygrometers, weather stations, air-conditioners, climate controllers and tumble dryers, it's capable of providing long, trouble-free service with minimum maintenance.

Designed for a measuring range between 10% and 90% relative humidity the sensor's relatively linear characteristic allows it to be easily incorporated into simple, inexpensive measuring circuitry.

Features and benefits

- long-term reliability
- high sensitivity
- fast response
- high immunity against contaminants
- operates with simple measuring circuitry

Proven in a host of applications

Important application areas where Philips' sensor has already proven itself include:

- Heating, ventilating and air-conditioning systems
- Industrial-control installations
- Climate-control systems in, for example, industrial clean rooms, operating theatres, computer rooms and greenhouses
- Climatic chambers
- Drying processes
- Printing industry

Humidity control the Philips way

Accurate measurement and control of humidity is an important requirement of today's world. The humidity of the air, i.e. the amount of water vapour it contains, influences not only our comfort but also the effectiveness of many professional and industrial processes. Though several types of electronic humidity sensor exist, Philips' capacitive sensor has long proven to be one of the most reliable, durable and easiest to use.

The sensor is made up of a polymer film coated on both sides with a very thin air-permeable gold layer to form a capacitive element. The film is clamped between spring contacts inside a perforated plastic housing. Changes in relative humidity (RH) of the surrounding air cause a change in dielectric constant of the polymer film leading to a change of sensor capacitance. The relationship between sensor capacitance and relative humidity is a rather simple one which means that the sensor can easily be incorporated into an electrical measuring circuit.

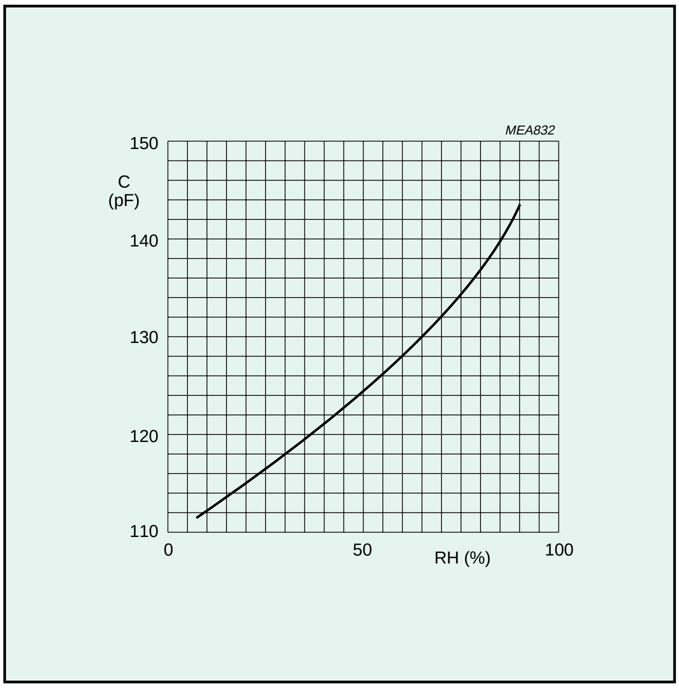

Fig.1 A simple relationship between capacitance and RH means the sensor can easily be incorporated into an electrical measuring circuit

Sensor specifications

Electrical	
Humidity range:	10 to 90%rh
Capacitance @ +25 °C, 43%rh, 100 kHz:	122 ± 15% pF
Dissipation factor @ +25 °C, 43%rh, 100 kHz:	≤ 0.035
Sensitivity between 12 and 75%rh:	0.4 ± 0.05 pF/%rh
Frequency range:	1 to 1000 kHz
Temperature dependence:	0.1%rh/K
Response time*:	
between 10 and 43%rh:	< 3 min
between 43 and 90%rh:	< 5 min
Hysteresis**:	≈ 3%
Maximum voltage:	15 Vp-p
Operating and storage temperature range:	–25 to + 85 °C
Mechanical	
Height:	20.0 mm
Width:	15.5 mm
Thickness:	5.0 mm
Lead distance:	5.08 mm

* to 90% of indicated %rh change at + 25 °C, in circulating air
** for excursion from 10%rh to 90%rh and back to 10%rh

Working with Philips' humidity sensor

Measuring circuitry

Measuring relative humidity using Philips' sensor involves the detection of relatively small capacitance changes. Depending on the level of precision required, several measuring circuits are possible. The circuit of Fig.2, using a metastable flip-flop IC offers simple measurement without linearization.

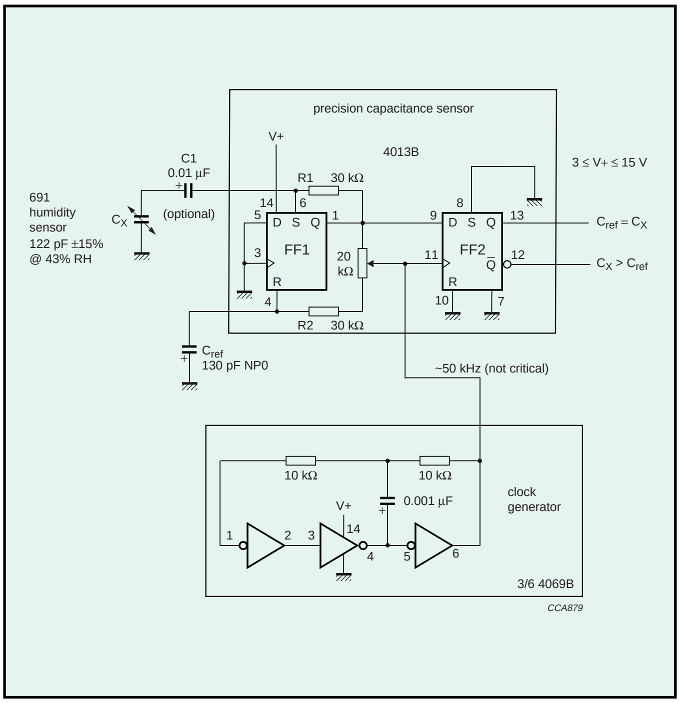

Fig.2 Measuring circuit without linearization based on metastable flip-flop. (Circuit courtesy of W. Stephen Woodward of University of North Carolina)

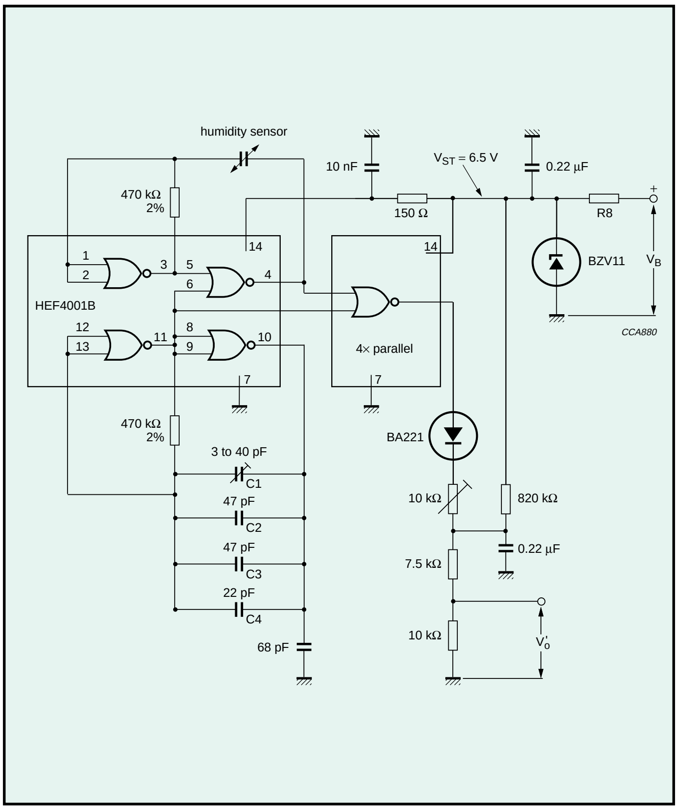

Fig.3 Measuring circuit with linearization. In the circuit, R_8 is chosen so that $R_8 \approx (V_B - V_{ST})/(2\ mA)\ \Omega$

For higher precision, the measuring circuit of Fig.3 incorporating a linearizing network can be used. This circuit is suitable for connecting to an external power supply.

Measuring-circuit calibration

The measuring circuit may be calibrated using a saturated salt solution in a small airtight container to create a *standard relative humidity environment* (ASTM Designation E 104). The saturated salt solution should be prepared from reagent grade chemicals and reagent water produced by distillation or by ion exchange.

Recommended salts (ASTM E 104)

	RH @ 25 °C
Lithium chloride $LiCl$	11.3%
Potassium acetate $KC_2H_3O_2$	22.5%
Magnesium chloride $MgCl_2$	32.8%
Potassium carbonate K_2CO_3	43.2%
Magnesium nitrate $Mg(NO_3)_2$	52.9%
Sodium chloride $NaCl$	75.3%
Potassium chloride KCl	84.3%
Potassium nitrate KNO_3	93.6%
Potassium sulphate K_2SO_4	97.3%

Potassium carbonate is usually chosen as a reference since its RH (43.2%) falls approximately in the middle of the measuring range of the sensor and because its temperature stability is high (from 43.1%rh at 0 °C to 43.2%rh at 30 °C).

Response time and hysteresis

The response time is defined as the time it takes for the sensor's reading to change by 90% of the total change following an immediate change of relative humidity. The response time obviously varies according to the relative humidity level, being shorter for low humidity levels than for higher levels.

The sensor's response also shows hysteresis due to the difference between the speed of moisture absorption and the speed of evaporation. The hysteresis value in the specification is given for steps of 10%rh allowing a stabilization time of 30 minutes between steps.

Maximum applied voltage

The sensor is a tough component with high dielectric strength able to withstand both DC and AC voltages up to 15 V. What's more, a low dissipation factor means it can accept high-amplitude measuring voltages without over heating. And in contrast to many competing technologies it meets the most stringent static-discharge specifications.

Operating frequency

The sensor's dissipation factor increases with humidity. It also falls with measuring frequency to a minimum value at around 1 kHz after which it increases again. When working at low levels of humidity (< 50%rh), it's therefore possible to use relatively low (< 1 kHz) measuring frequencies. But for the most reliable results over the total operating range of the sensor, measuring frequencies should be between 1 kHz and 1000 kHz.

Working in aggressive atmospheres

Although the sensor is virtually unaffected by most air pollutants including ammonia, the vapour of some solvents such as acetone will attack the foil and should be avoided when building the sensor into an assembly. Dusty environments should also be avoided since the hygroscopic properties of some dust particles can affect sensor reading if they're allowed to build up on the surface of the foil.

RELATIVE HUMIDITY

The humidity of the air is a measure of the amount of water vapour it contains. At any given temperature, water will continue to be absorbed by the air either until all available water has evaporated or the air has become *saturated*. Once the air is saturated, it contains its full capacity of water and no further evaporation will take place unless the temperature increases.

Defining relative humidity

Relative humidity (RH) is a convenient way of expressing the amount of water vapour contained in a volume of air. It's defined as the ratio (in percent) of the mass of water vapour in the air to the mass required to produce saturation at the same temperature. When the air is saturated, therefore, its RH is 100%.

The presence (or absence) of water vapour in air influences many physical, chemical and biological processes. Our comfort, for example, depends a lot on humidity since a very humid atmosphere (i.e. at or close to saturation) limits our bodies' ability to perspire and cool us. Usually, the most comfortable climatic conditions are between 45 and 65%rh and for us to remain comfortable, the humidity must decrease as the temperature rises. For example, at 30 °C, 70%rh is considered uncomfortable while 30%rh is quite tolerable.

By introducing humidity monitoring instrumentation, the energy management systems of office and industrial buildings could be better optimized and a lot of energy saved without loss of comfort by adapting the efficiency of energy management according to the season and the external climatic conditions.

Mechanical data and ordering

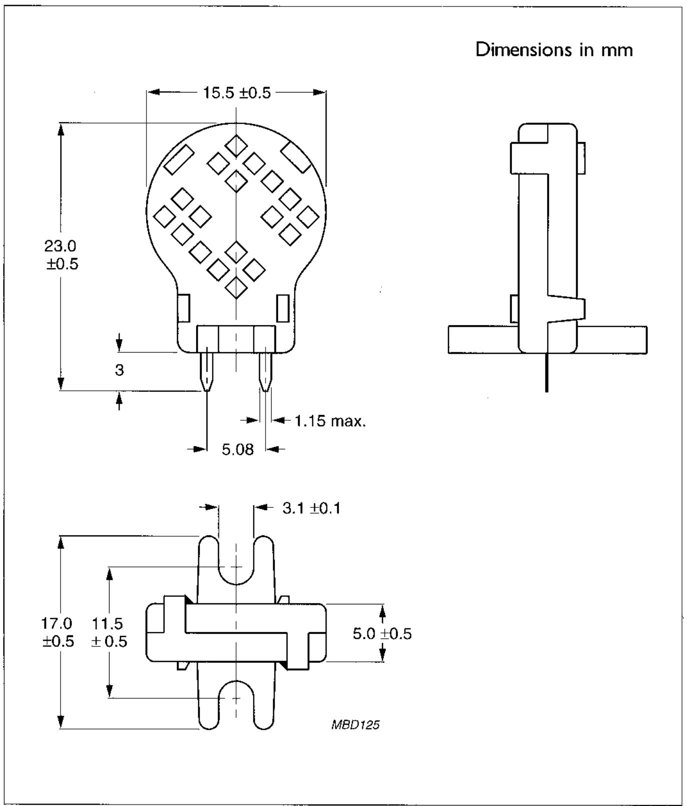

Fig.4 Component outline

Marking

PHILIPS H1.

Mounting

The device can be soldered directly on to a printed-circuit board or fastened with 3 mm bolts.

Soldering

Solderability: ≤240 °C; ≤4 s.
Resistance to heat: ≤240 °C; ≤4 s.

Robustness of terminations

Tensile strength: 10 N.

Ordering code

2322 691 90001.