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Technical note

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Response time in humidity measurement

In an ideal world, all measurement instruments would be 100% accurate. In the real world, however, there are many different factors that can affect their accuracy. One of these is the response time of the instrument. The response time can be defined as how quickly a sensor is able to react to changes in the measured variable and this can have a significant effect on measurement performance.

Defining response time

The response time is usually defined using two different attributes: T_{63} and T_{90}. These values indicate how long the measurement takes to reach 63% or 90% of the final value when there is an instant change in the variable being measured. There is a reason why 63% is chosen for defining the response time: T_{63} is equal to the time constant, usually denoted by the Greek letter τ (tau) in the first order linear time-invariant system, which is the mathematical model for physical systems that behave exponentially under a sudden change (Fig. 1). This means the system will reach 63% of the final value within one time constant, 95% of the final value within two time constants, and 98% of the final value within three time constants.

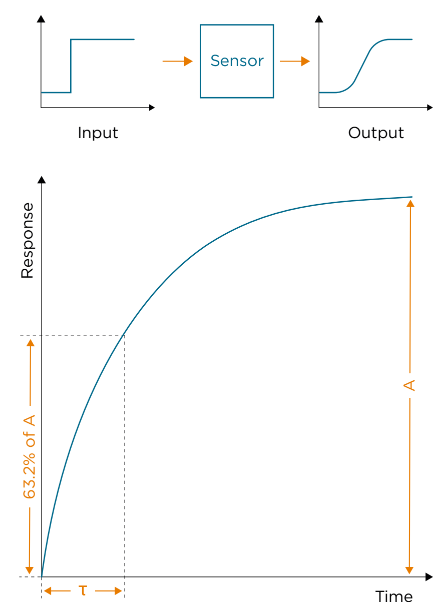

Figure 1. The first order linear time-invariant system

A humidity sensor will seek equilibrium with its surroundings in terms of relative humidity, which is by definition subject to temperature. For this reason, the response time of a relative humidity sensor is only relevant in situations where the temperature remains constant. When the temperature changes, the sensor's relative humidity measurement will not be correct unless the probe's temperature has stabilized. For this reason, the total response time of the instrument is defined by both the response time of the humidity sensor and the response time for the temperature change.

Accurate control in changing environments

The response time becomes significant when accurate control is needed. When a system is controlled by a feedback signal given by an instrument, the controller will not be able to react to changes that are faster than the response time of this instrument. For this reason, rapid and transient changes may not be reacted to, or the measurement instrument will not accurately control the system in response to the changes. In the worst case, with aggressively tuned controllers, the lag caused by the measurement instrument may cause unnecessary fluctuation or an increase in the stabilization time. As a rule of thumb, the response time of an instrument is sufficient when it is roughly half that of the shortest time constant in the system being controlled. Figure 2 illustrates the effect of temperature response time on relative humidity measurement accuracy in an environment with a ±1 °C fluctuation in temperature.

EFFECT OF TEMPERATURE MEASUREMENT RESPONSE TIME
ON RELATIVE HUMIDITY MEASUREMENT

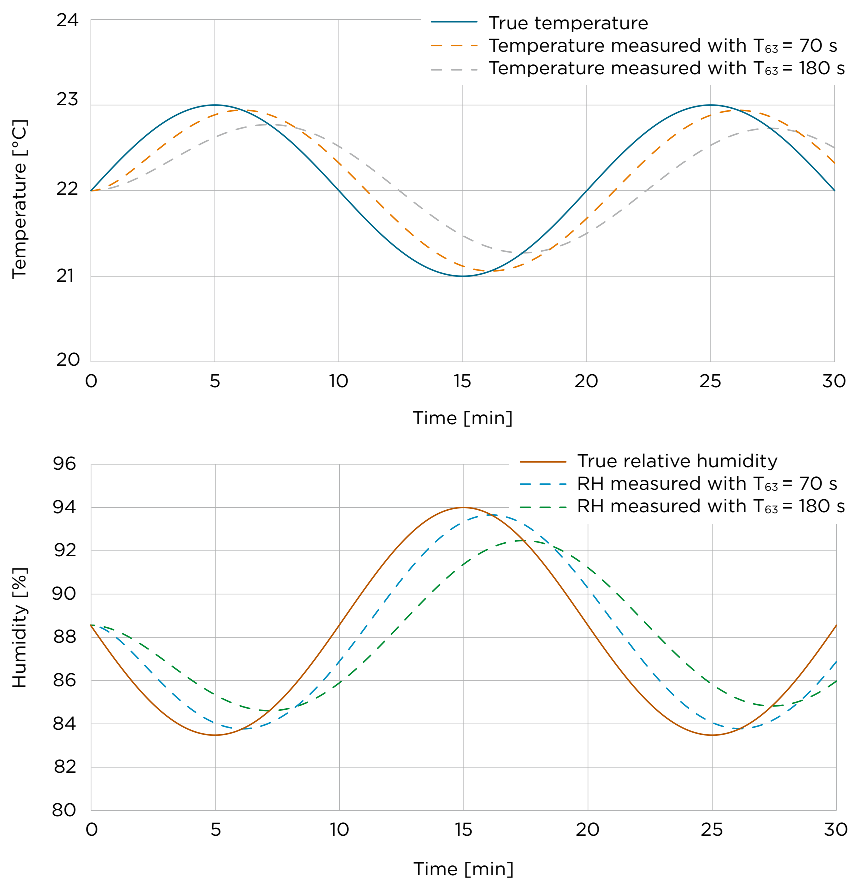

Figure 2. In the upper graph, the dashed lines represent the temperature readings of two instruments with different T_{63} response times in a slowly changing temperature. In the lower graph, the impact of the temperature measurement error on the relative humidity measurement is shown. The slow stabilization with respect to temperature causes an additional 3 ... 4 %RH error in the relative humidity measurement.

When choosing an instrument it is worth asking the following questions:

- *Is my application dynamic?*
- *Does the application involve changes in temperature?*
- *How rapidly can changes appear?*
- *How much temporal accuracy (control over short-term fluctuations) do I need?*
- *How long can stabilization times be, e.g. when calibrating?*
- *What is the shortest time constant in my system?*

When you know the answers to these questions you will be able to understand the response time requirement for your system.

Humidity and Temperature Probe HMP9 Measurement Performance

Relative Humidity

Sensor: HUMICAP I
Measurement range: 0 ... 100 %RH
Accuracy at +23°C (+73.4°F): ±0.8 %RH (0 ... 90 %RH)
T_{63} response time: 15 s

Temperature

Measurement range: -40 ... +120°C (-40 ... +248°F)
Accuracy at +23°C (+73.4°F): ±0.1°C (±0.18°F)
T_{63} response time: 70 s

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