Exercise 1:
Calibration of an RH transmitter in non-static conditions

- Calibration setup:
  - Mass flow controller based flow mixing
  - Capacitive reference sensor
  - Open measurement tube
  - Enable fast linear ramps at room temperature
  - Computer control & recording
- Measurements
  - Ascending and descending ramps
  - Study:
    - Difference between static vs. non-static
    - Effect of time response: ramp speed, filter
- Trainer: Richard Högström

Exercise 2:
Errors in non-ideal non-static conditions

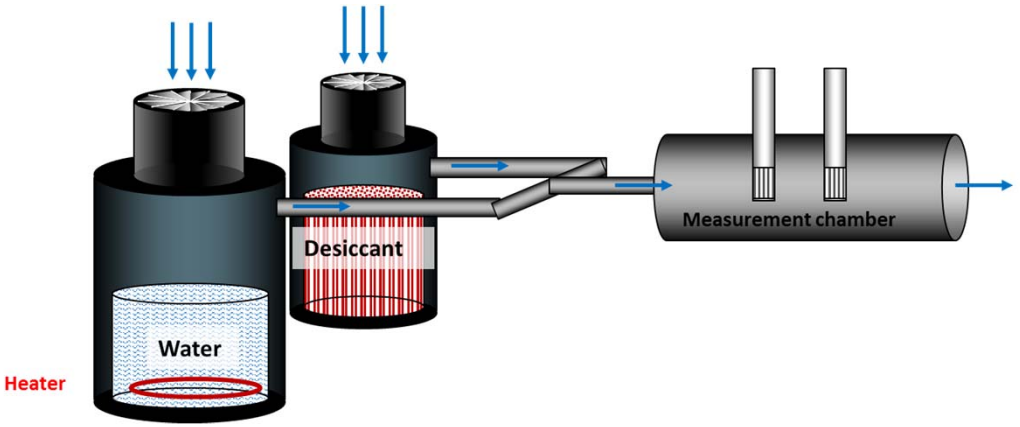
- Experimental measurement setup:
  - Fan based flow mixing
  - Capacitive sensors
  - Non-ideal humidity control
  - Computer control & recording
- Measurements
  - Non-linear ramps, unstable humidity
  - Study:
    - Differences in sensor response at non-static conditions
- Independent work

Exercise 2:

Errors in non-ideal non-static conditions

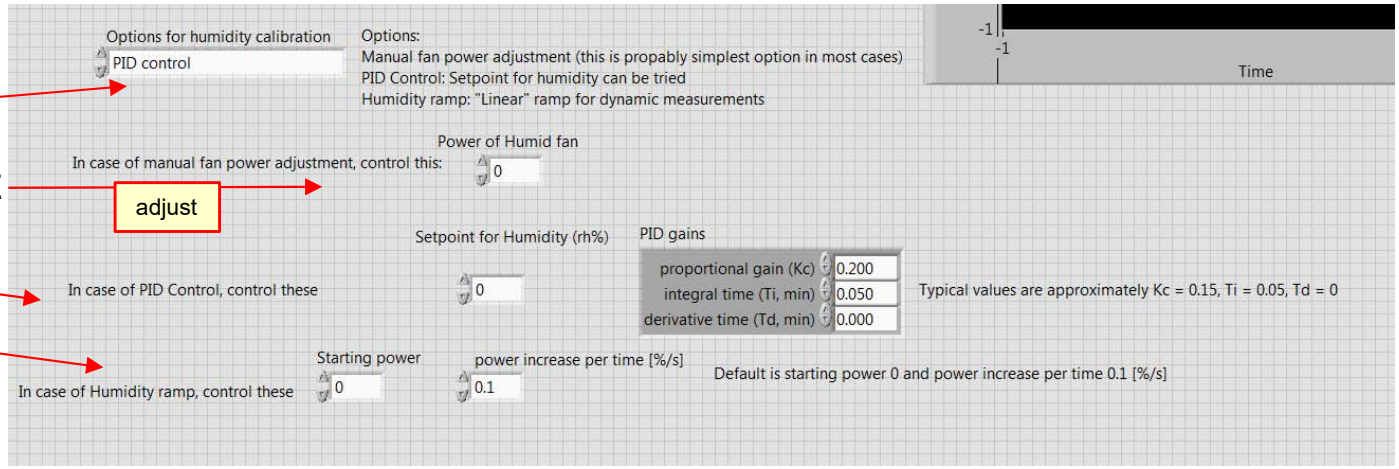
Early prototype field calibrator:

- Green main switch on front panel
- USB connection (front panel) to computer
- Separate power supply for the heater
  - Setting: 10 V



Control user interface:

- Operation modes:
  - Manual fan power adjustment
  - PID control
  - Humidity ramp



Exercise 2:

Errors in non-ideal non-static conditions

1. Start with ”dry” (which is actually not very dry but driest possible at the moment):
    1. Choose Manual fan power adjustment
    2. Set Power of Humid fan to 0

2. Generate step change by setting Set Power of Humid fan to 100
    1. After 5 min time of stabilation Set Power of Humid fan back to 0
    2. Let the system stabilise 5 min

    How was the step change?
    How responses of the sensors differed from each other?

3. Generate a ramp choosing Humidity ramp
    1. Set starting power = 1 and power increase per time = 0.1 [%/s]
    2. With these settings, the humidity ramp should take around 15 minutes

    The generated ramp is not fully linear:
    How this affects to the sensors and the difference between the sensor readings?

4. If you have time, you may try with PID control:
    1. Choose PID control
    2. Set control parameters: Setpoint for Humidity is 40%, Kc = 0.2, Ti=0.1 and Td = 0

    What you can see and how the sensors behave?

5. End the exercise by choosing Manual fan power adjustment and setting Power of Humid fan to 0

Exercise 3:
Time dependent factors in humidity measurements

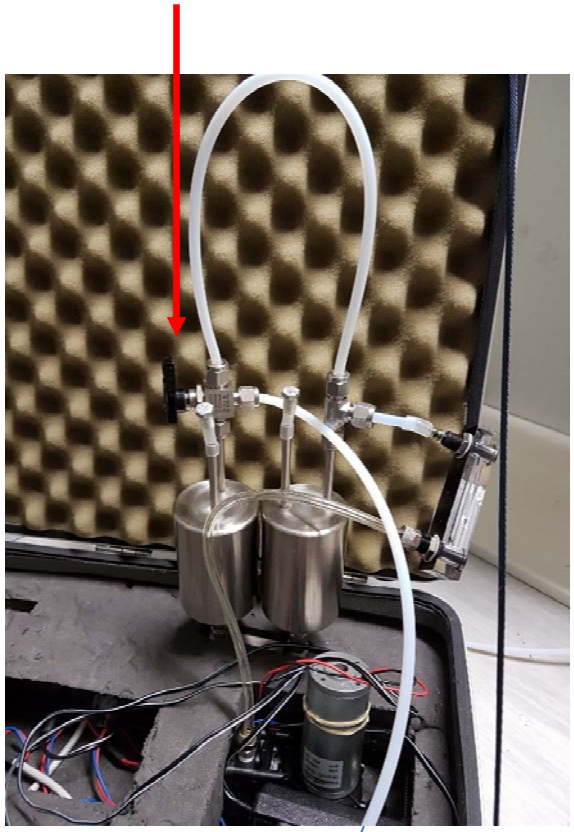
- Experimental measurement setup:
  - Flow switch to generate step changes
  - Tubing with different volumes
  - Old capacitive humidity sensors
- Measurements
  - Step changes at inlet
  - Visual monitoring of sensor readings
  - Study:
    - Effect of different tubings
    - Differences between sensors
- Independent work

Exercise 3:

Time dependent factors in humidity measurements

Dry/wet air source:

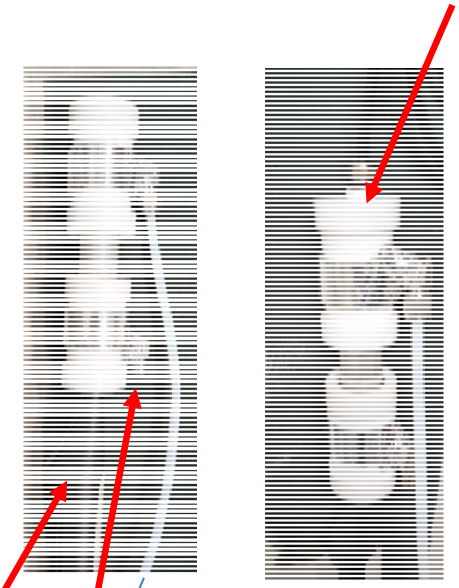
Switching valve:
(In this picture switched to wet)



to the chamber inlet

Measurement chamber:

Insert a DUC probe partly to the chamber through hole in the rubber flange.



Reference probe (connected to Testo 650)

to ambient

chamber inlet

Switch from dry to wet and back using the switching valve of the dry/wet air source system

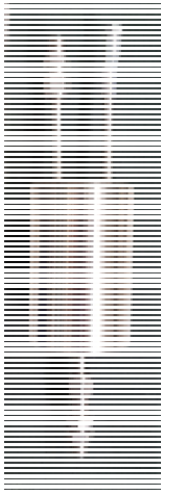
Connect a PTFE tube from the source to the chamber inlet. Tighten the swagelok connector by hand.

Humidity sensors to be studied:

- Vaisala HMP 233
- Rotronic HygroClip

For studying the effect of volume:

- Two PTFE tubes
- Extension chamber:



Exercise 3:

Time dependent factors in humidity measurements

1. Different sensors

1. Setup the system using single PTFE tube between the source and the chamber
2. With a HMP 233 sensor:
    1. Set switch valve to DRY and let the hygrometers stabilise
    2. Set switch valve to WET and observe changes in the displays of HMP233 and Testo 650
       How do they react to the change?
       Are there differences between the hygrometers?
    3. Compare your findings when switching the valve back to DRY
3. Repeat the task with a Rotronic sensor

2. Different volume

1. Extend the tube by connected the another PTFE tube between the first tube outlet and the chamber inlet
    1. Set switch valve to DRY and let the hygrometers stabilise
    2. Set switch valve to WET and observe changes in the displays
       How do they react to the change compared to the tests with a single tube?
    3. Compare your findings when switching the valve back to DRY
2. Extend the volume further by connecting the extension chamber between the two PTFE tubes
    1. Repeat the measurements and compare to the earlier tests
3. You may also repeat these tests with another hygrometer

Exercise 4:
Analysing results and estimating uncertainty

- Excel template to be completed
  - Incl. all needed input data
  - Incl. correlation
  - Incl. time dependent contributions
- To be done:
  - Identify uncertainty components
  - Estimate the uncertainty of the components
- The excel file ” Exercise4 v2 MasterTemplate.xlsx” is on the memory stick of your group
  - The file is protected; please save your file on the memory stick
- Independent work:
  - please follow instructions on the file
  - Input data are also available on paper copies