Assignment 1: System description and analysis

Introduction

In this assignment you will study an air handling unit with a heater and a humidifier. Two variables will be controlled; air temperature, y_1, and humidity, y_2. That can be achieved by controlling the flow to the heater, u_1 and the flow to the humidifier, u_2. However, the two systems are depending on each other according to the enthalpy–entropy chart.

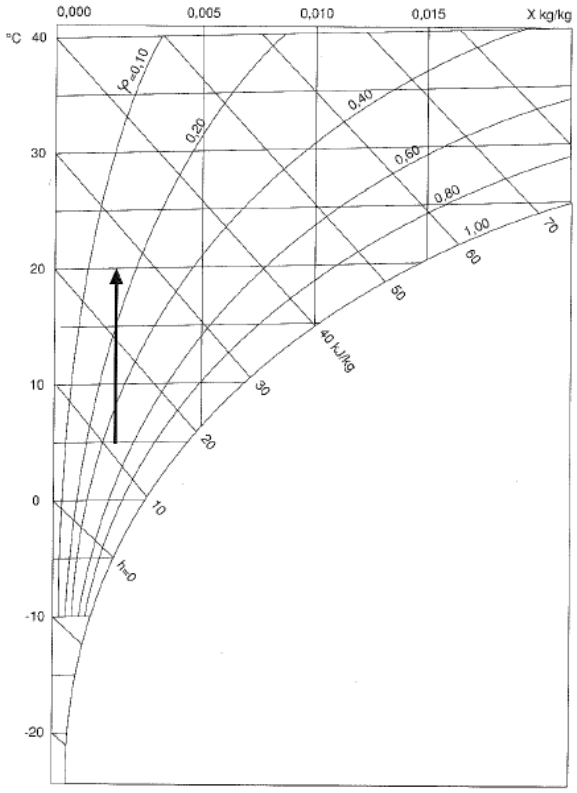


Figure 1: Heating

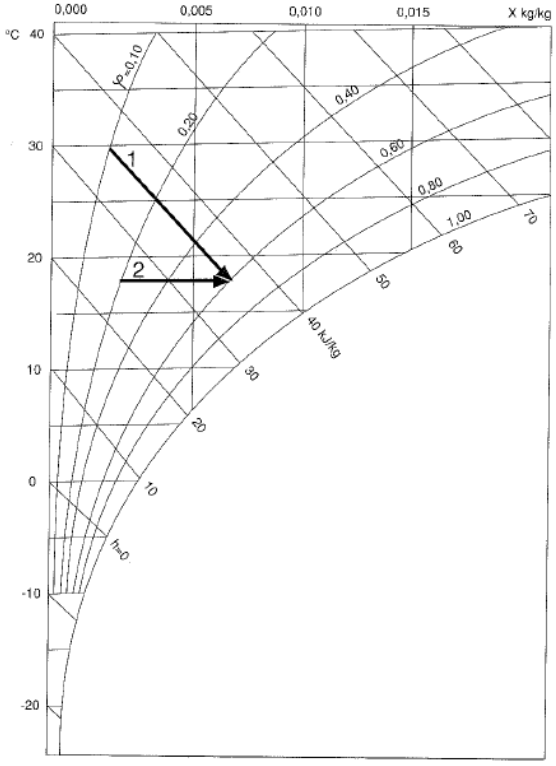
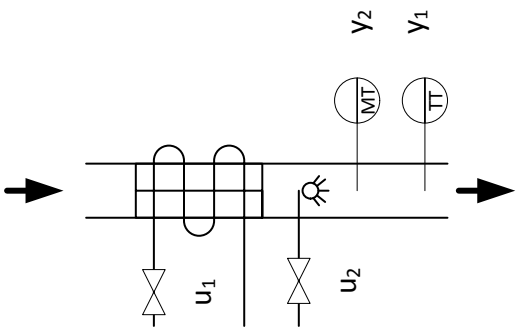


Figure 2: Humidifying with water (1) and steam (2).

The model

The air channel is described in Figure 3. Air is coming in from the left and passes the heater first and thereafter the humidifier.



Transfer function

Assume that both the heater and the humidifier can be described by a first order transfer function. The time constant for the heater is 50 s and the time constant for the humidifier is 10 s.

The control signals are normalized to be 0-1. That is the valve is fully open when u_i is 1 and fully closed when it is 0. As can be seen in the enthalpy–entropy chart the system is not linear. However, in this assignment we will assume linearity in a small region the system typically operates. Our assumption is that the incoming air temperature is 10 °C and 40 % RH. When u_1=1, the temperature increase is 15 °C. Corresponding information for the humidifier is that for a temperature of 20 °C and humidity of 10 % can increase the moisture content to 80% when the control signal, u_2, changes from minimum to maximum.

1. Find the transfer function $G(s)$ for the whole system.
2. Write the system in state space representation.

Analysis

3. Plot the singular values
4. Check observability and controllability

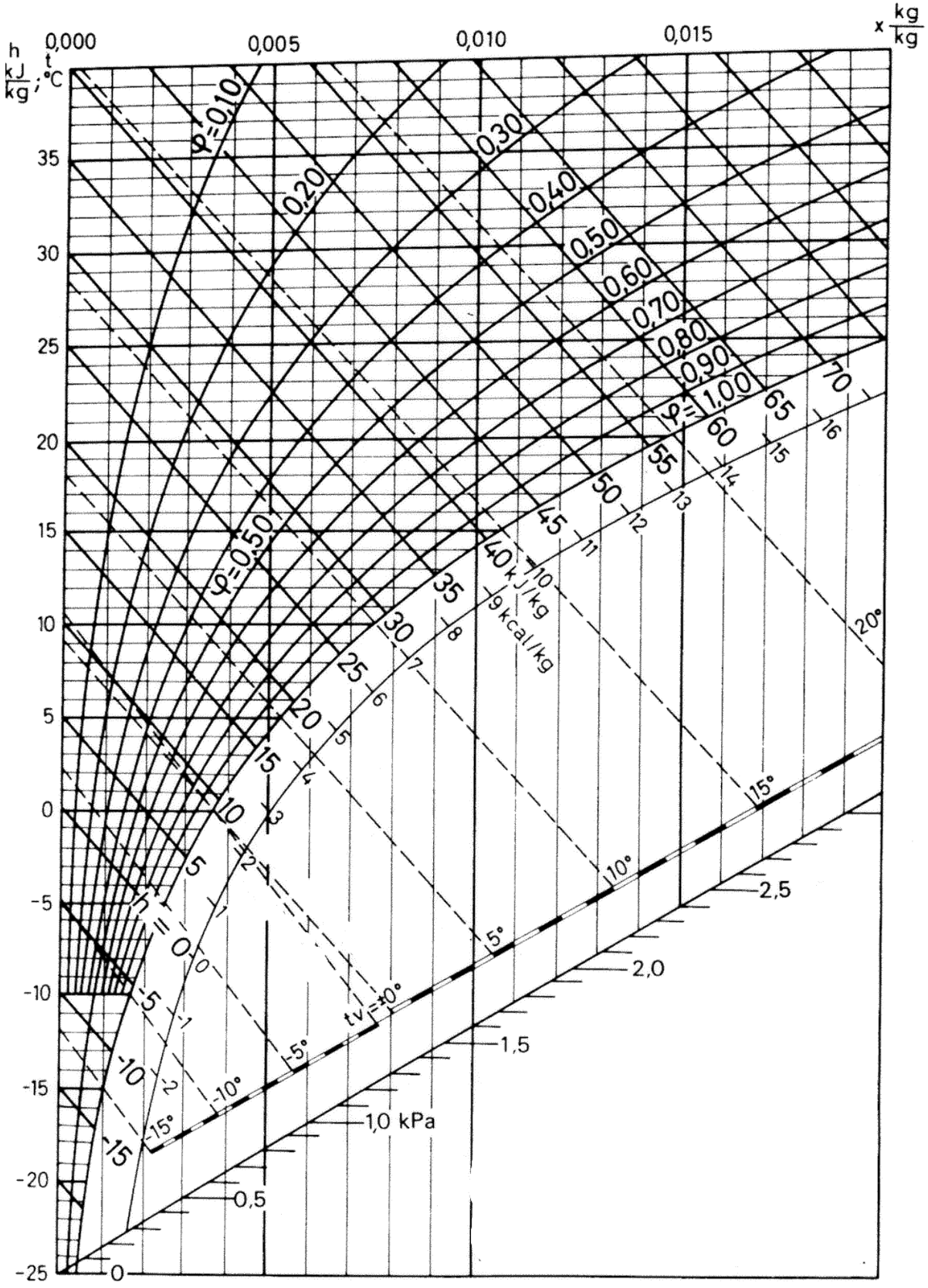
Transfer Function of the Closed Loop System

Add a controller where each variable (air temperature, y_1, and humidity, y_2) is controlled by a proportional controller with a gain, $k_{p,I}$, where i = 1 is temperature control and i = 2 humidity. Calculate the closed loop system (G_C), the sensitivity function (S), complementary sensitivity function (T), and input sensitivity function (S_u). Try different values of $k_{p,I}$; select 2-3 interesting values and:

5. Plot the singular values for G_C, S, T and S_u. Do not forget to comment your results in the report.

Report

Hand in a written report on how you solved the problem. It should contain a short
(i) background/introduction, (ii) method, (iii) results with plots and diagrams,
(iv) conclusion/discussion. Place your Matlab-script as an appendix. Put your name and the name of your file on the front page. Hand in the report by using Blackboard


h kJ/kg
t ;°C
x kg/kg
0,000
0,005
0,010
0,015
φ=0,10
0,20
0,30
0,40
0,50
0,60
0,70
0,80
0,90
φ= 1,00
φ=0,50
40 kJ/kg
9 kcal/kg
20°
15°
10°
5°
tv=±0°
-5°
-10°
-15°
2,5
2,0
1,5
1,0 kPa
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