**Industrial Automation 2023/24**

**Part 1**

**Exercise 1 of 2**

Consider a greenhouse composed by three independent adjacent sectors, as reported by the plant below.

Module3

10m x 10m

Height 4m

Module 1

50m x 10m

Height 4m

Module2

10m x 10m

Height 4m

The walls, including the separation between the to modules, are made of glass, and their thermal transmittance[[1]](#footnote-1) is the one defined by a single glazing: 5.7 W/(m2⋅K).

1. Taking into account the “cooling cheese” exercise defined in class, define a model to evaluate the evolution of the temperature in the next 12 hours taking into account:
   1. The forecasted external temperature
   2. The forecasted sun radiation. This aspect has not been modelled in the “cooling cheese” problem. In this case, as simplifying hypothesis, we suppose that the sun radiation is just entering by the flat roof, also made by glass, at 95% (while the rest is reflected).
2. Verify the model copying forecasted values for 12 hours for temperature and sun radiation from a web site (for example <https://it.tutiempo.net/>, <https://it.tutiempo.net/genova.html?dati=allora>)
3. Suppose now to have one heat pump for each module. In the first module the heat pump has a maximum electric power of 25kW and 15kW in the second and third ones (please see in Internet or by some AI tool the COP to transform in thermal power). Suppose also to be able to perfectly measure the temperature in the three modules. Define control laws in discrete time (on samples of 60 s) for the three heat pumps based on:
   1. Relay
   2. PID

and evaluate them according to their ability to track the following temperatures (row 1 h of the day, row 2 desired T in °C in module 1, row 3 desired T in °C in module 2 and 3. In the rest of the day the temperature should stay around 15 °C.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 25 | 25 | 30 | 30 | 30 | 30 | 30 | 30 | 24 | 23 | 22 | 22 |
| 18 | 18 | 25 | 25 | 25 | 23 | 24 | 24 | 18 | 18 | 15 | 14 |

1. Evaluate the three methods taking into account separately, for each module:
   1. the quadratic deviation from the desired temperature over the whole day
   2. the overall power over the whole day for each heat pump and on the whole plant

1. https://en.wikipedia.org/wiki/Thermal\_transmittance [↑](#footnote-ref-1)