Universitat Politècnica de Catalunya

Renewable Energy Systems
AY 2021/2022

UNITE! Programme

Wind Turbine Generators

EXTENTION

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EXERCISE 1

In this first exercise is asked to insert a 0.1 Ω resistance between the asynchronous machine and the source, and then to analyse the effect of the resistance on the system.
In order to perform the assignment a Three-Phase Series RLC Branch is added on the Simulink model called "GEOENP2model70", in this block the branch type is set to "R" because we just need a resistance (and not an inductance and/or a condenser) and as resistance magnitude the value provided equal to 0.1 Ω is put.
In the figure below is shown the layout of the squirrel cage generator, the RLC branch and the grid:

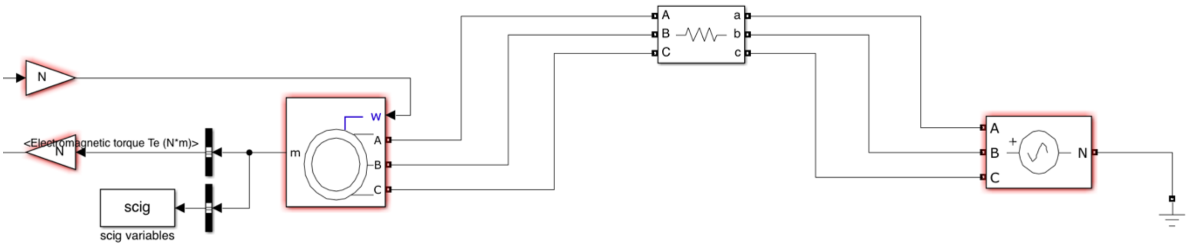

Figure 1 – Layout with the added resistance

The results are shown in the figures below:

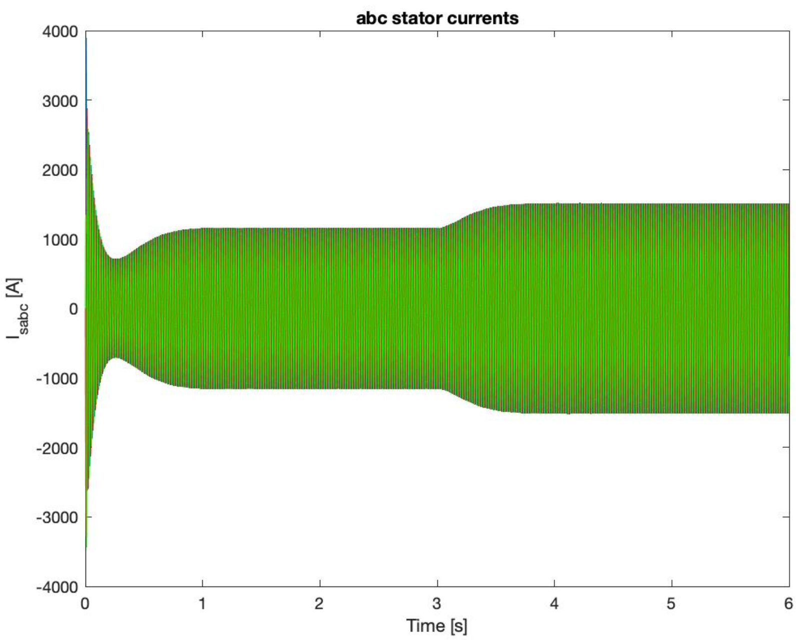

Figure 2 – abc stator currents

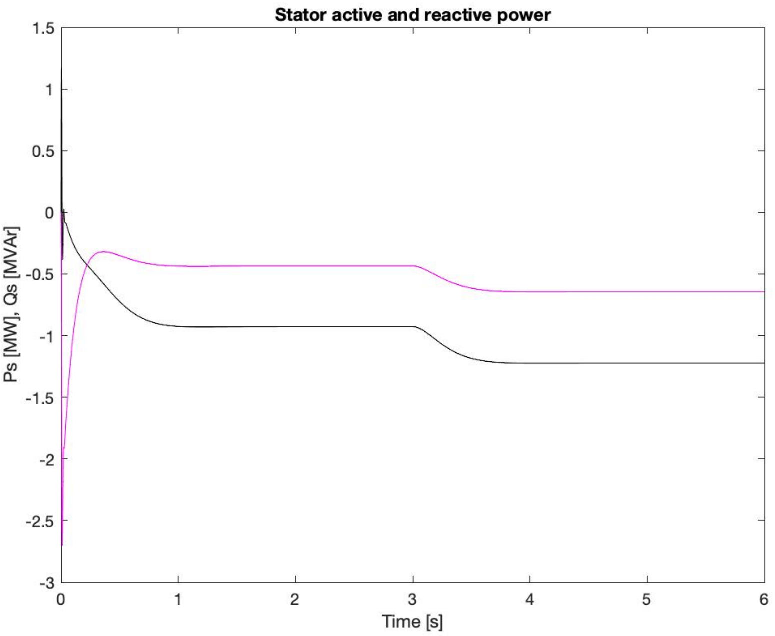

Figure 3 – Stator active and reactive power

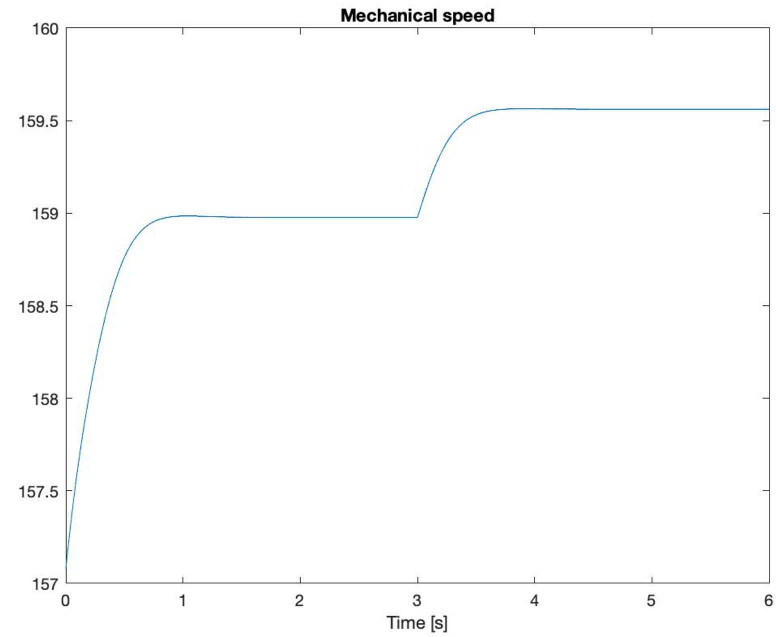

Figure 4 – Mechanical speed

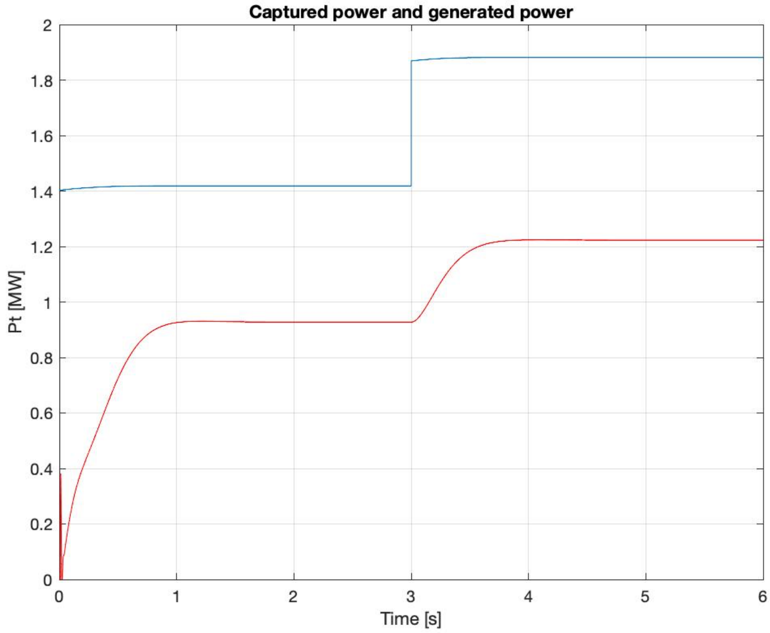

Figure 5 – Captured and generated power

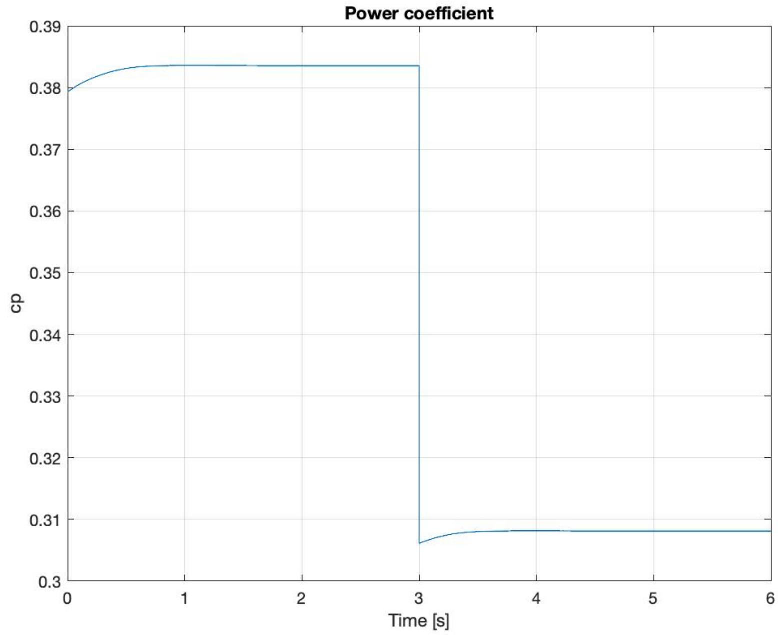

Figure 6 – Power coefficient

As a first comment we can say that the resistance added contributes to reduce the initial transient and also the ripple due to the step wind velocity variation, in fact overall it is clear that there are much less fluctuations with respect to the previous case without the resistance. This can be justified by the fact that in the first case the generator was directly connected to the grid and therefore it suffered from grid instabilities and fluctuations. In this second case the connection between the generator and the grid is not direct because the resistance decouples the two and therefore the grid fluctuations do not influence the SC generator.

As a second step, the value of the resistance R has been changed in order to further explore its effects on the systems. The resistance has been set firstly to 0.01 Ω and secondly to 1 Ω, the results are summarized in the figures below:

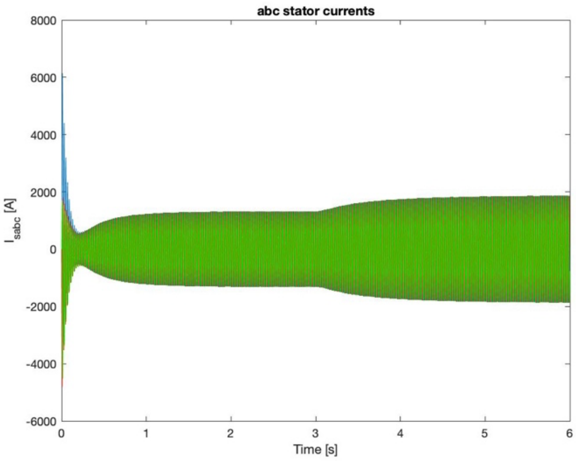

Figure 7 – abc currents for 0.01 Ω

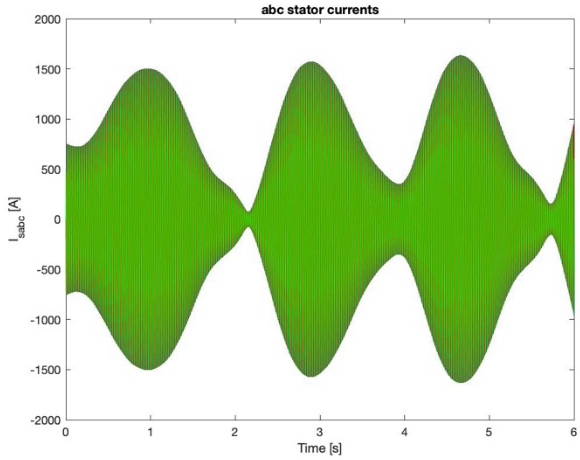

Figure 8 – abc currents for 1 Ω

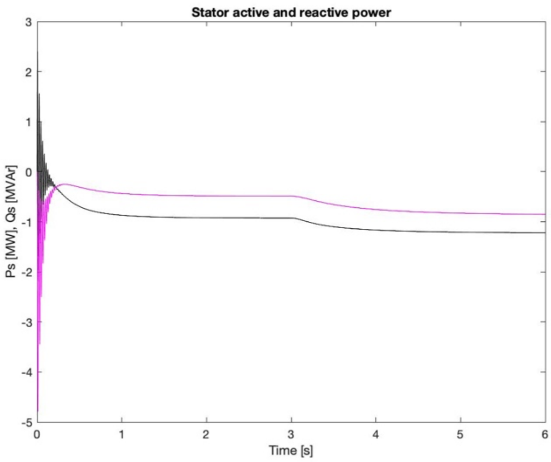

Figure 9 – Stator power for 0.01 Ω

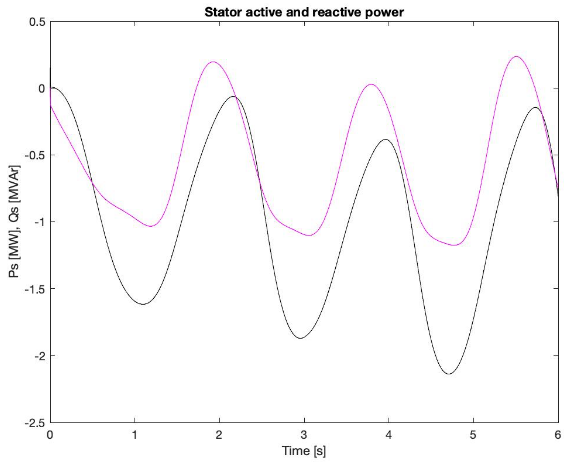

Figure 10 – Stator power for 1 Ω

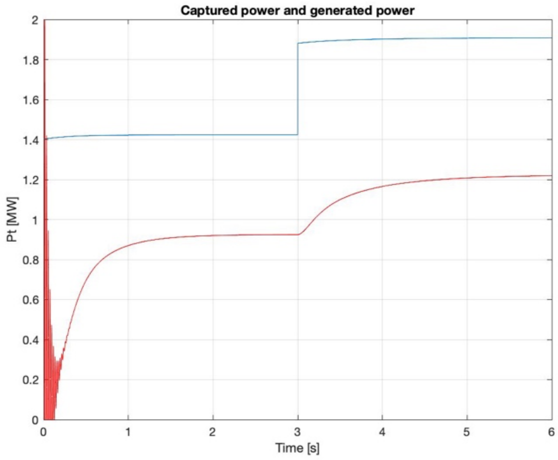

Figure 11 – Power for 0.01 Ω

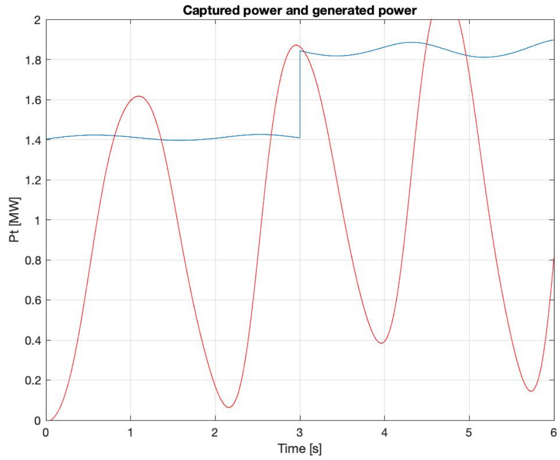

Figure 12 – Power for 1 Ω

Regarding the 0.01 Ω resistance we can say that this value is too small and does not influence the system in a positive way like the previous 0.1 Ω resistace, in fact in this case there are more ripples especially at the beginning of the simulation, this resistance is too small and the system acts like if it is not there.
For the 1 Ω resistance instead, it is clear that this high value does not have a positive effect on the system, in fact there are much more fluctuations.
The values of R = 0.5 Ω and R = 0.05 Ω have also been analyzed, the first one gives results slightly more stable than R = 1 Ω but all the plotted values are unstable, while the second one is not as affective as R = 0.1 Ω, therefore the optimal value for the resistance remains 0.1 Ω

EXERCISE 2

In this second exercise it is asked to connect to the grid two wind turbines instead of one, so the wind turbine model has been duplicated on the model called "GEOENP2odel" on SImulink. In order to avoid errors on MatLAB, the block containing the scig variables of the second turbine has been eliminated. After the two generators, two resistances R = 0.01 Ω have been connected, while after the connection point and before the grid, another resistance equal to 0.1 Ω has been added. The final layout is:

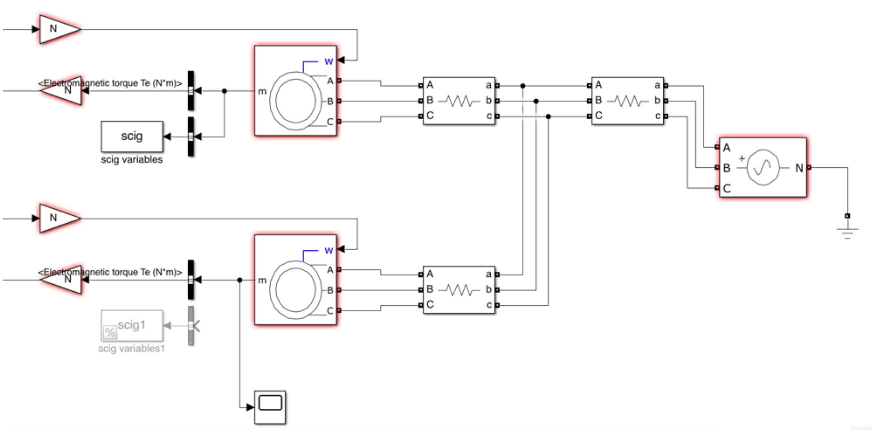

Figure 13 – Layout with two turbines

The results are shown in the following figures:

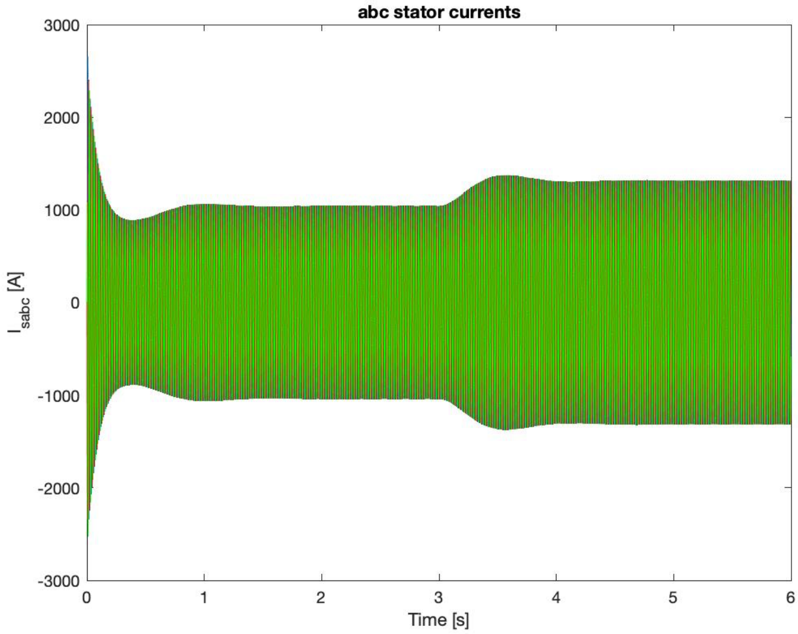

Figure 14 – abc stator currents

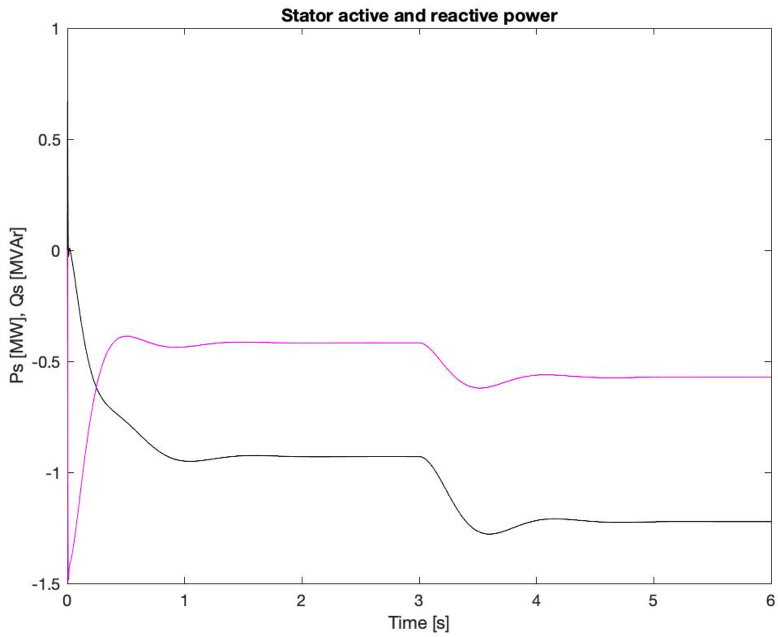

Figure 15 – Stator active and reactive power

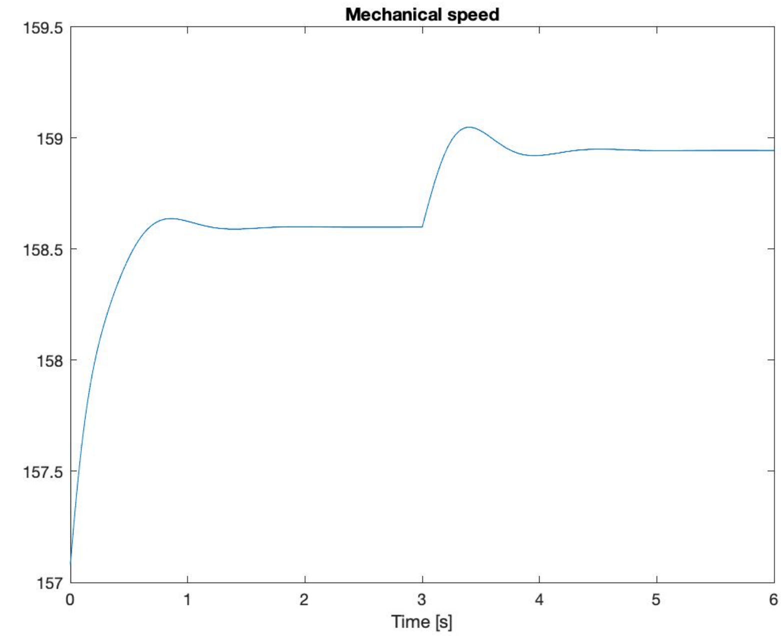

Figure 16 – Mechanical speed

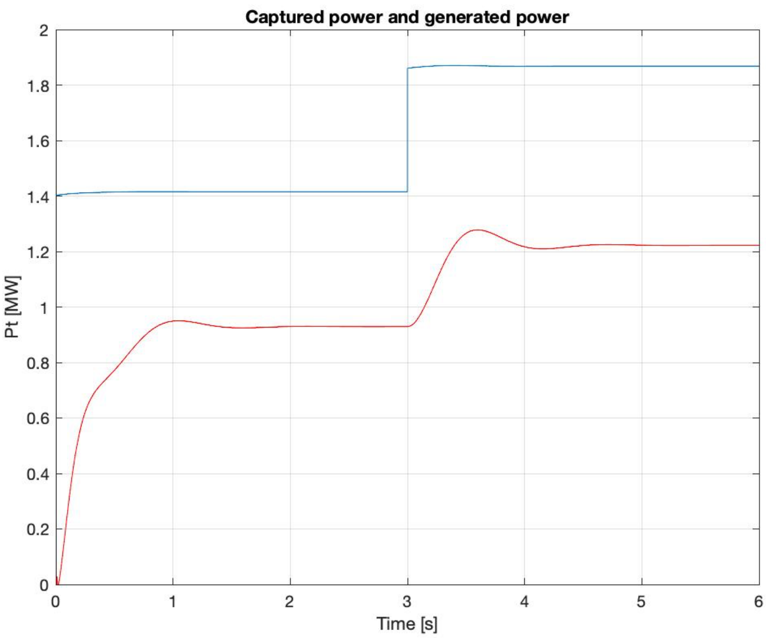

Figure 17 – Captured and generated power

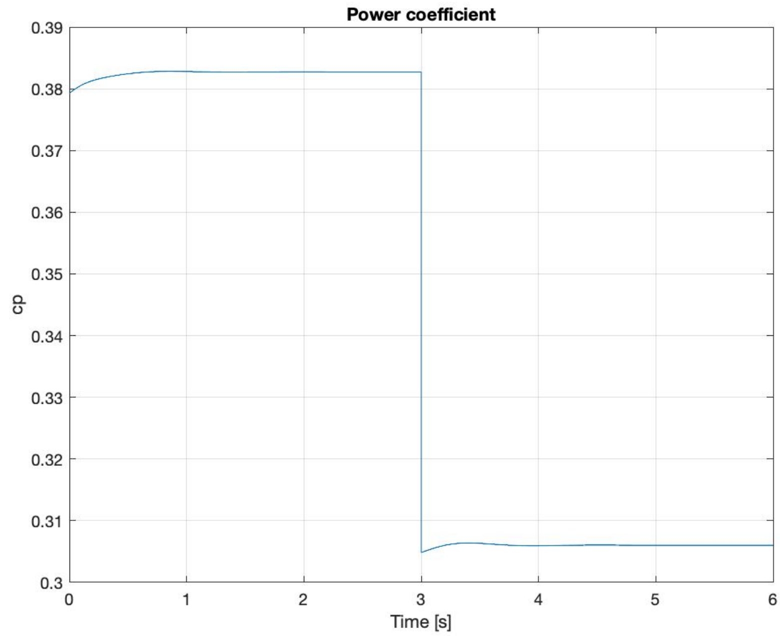

Figure 18 – Power coefficient

In this new configuration it is possible to observe that there are more ripples especially after the wind velocity step variation, in fact after this change in velocity there is a visible second transient (the first one is at the beginning) before the configuration stabilizes again.
This second second configuration is therefore more sensitive to the velocity variation that occurs at t = 3 s.

EXERCISE 3

In the third exercise it is asked to change the time at which the wind velocity variation occurs, in particular for the first wind turbine, the step variation now has to occur at t = 2 s, while for the second, at t = 4 s.
In order to perform this change, the two “step” blocks (one for each wind turbine) on the “GEOENP2model” on Simulink have been modified, in particular the step time has been set to the new one.

The results are summarized in the following figures:

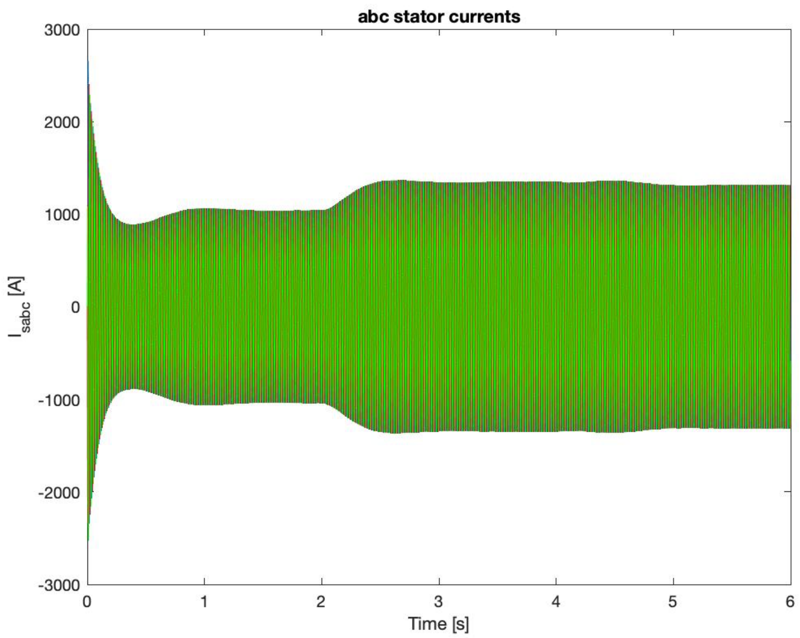

Figure 19 – abc stator currents

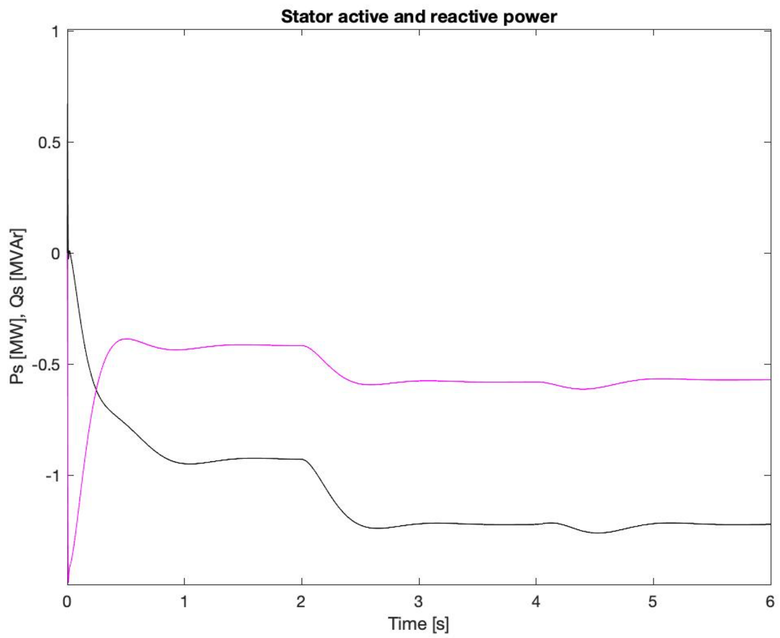

Figure 20 – Stator active and reactive power

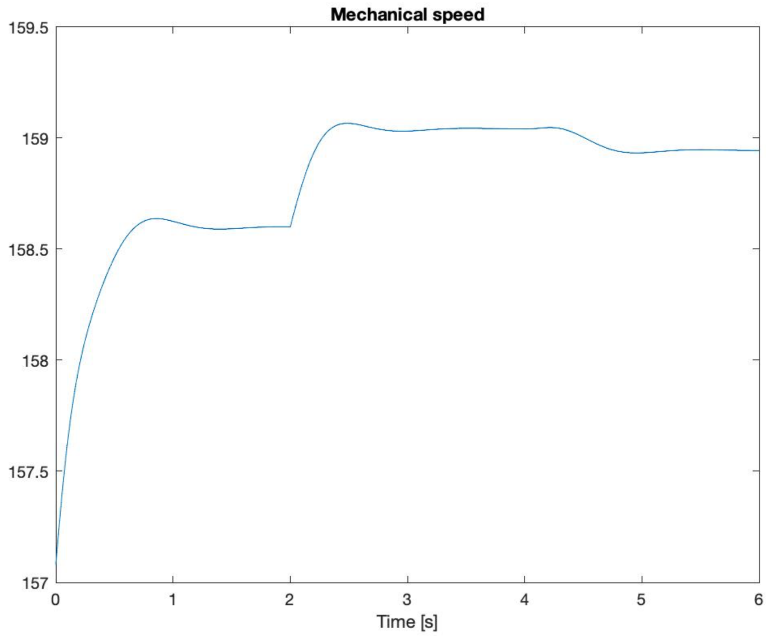

Figure 21 – Mechanical speed

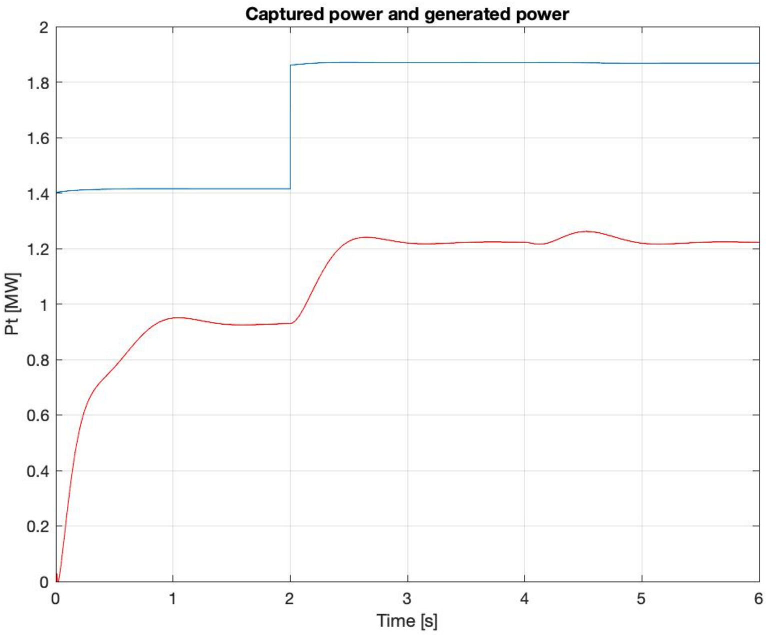

Figure 22 – Captured and generated power

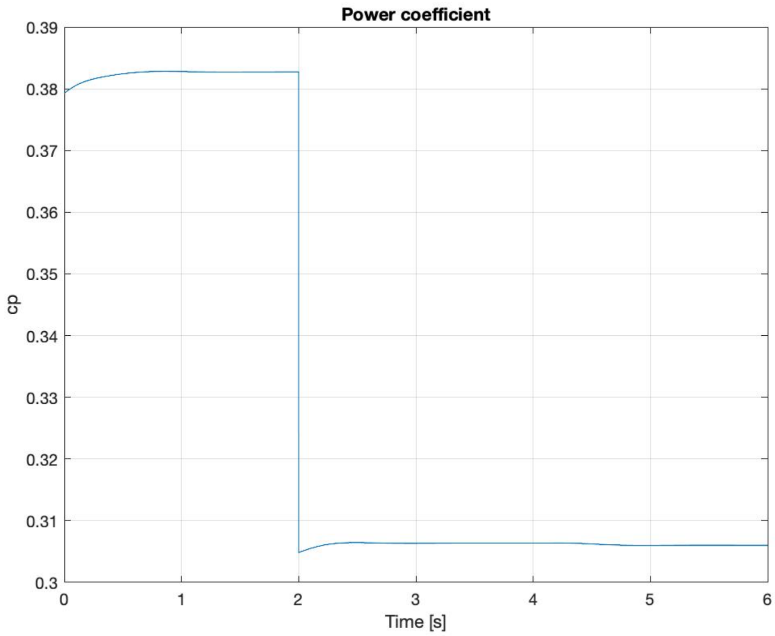

Figure 23 – Power coefficient

Since the data for the first turbine (with the step variation at t = 2 s) have been plotted, now the visible change in all the plotted parameters occurs at the new timestep, however the second turbine influences these parameters, in fact after t = 4 s it is possible to notice a ripple and a small transient in every graph above.
It is possible to state that the unsynchronized change in the wind speed makes the configuration more stable, in fact in the plots of the previous exercise there was just one transient (except for the initial one) at t = 3 s, but it generated more instabilities and a bigger ripple, while in this second configuration there are two smaller transients (also excluding the initial one).

In order to further explore the model, the values of the resistances have been switched: the resistance that connects the generator to the connection point is now equal to 0.1 Ω and the one that connects the connection point to the grid is 0.01 Ω. The comparison between the initial configuration and the one with the switched resistances is shown in the graphs below:

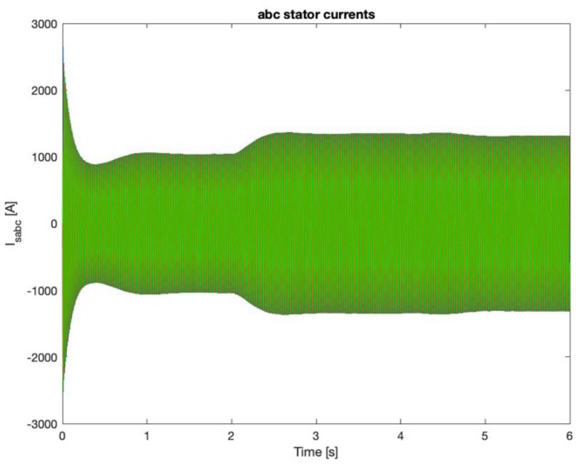

Figure 24 – Currents initial configuration

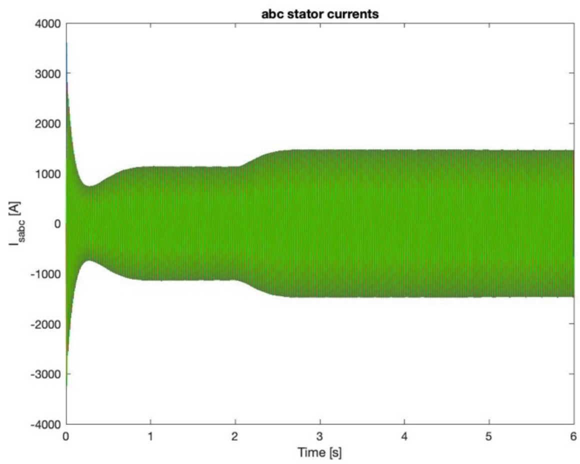

Figure 25 – Currents with switched resistances

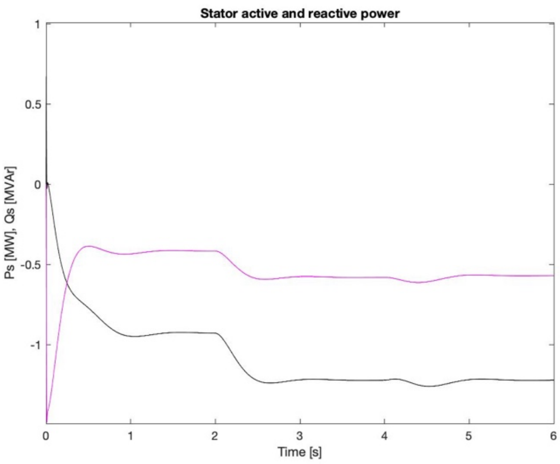

Figure 26 – Stator power initial configuration

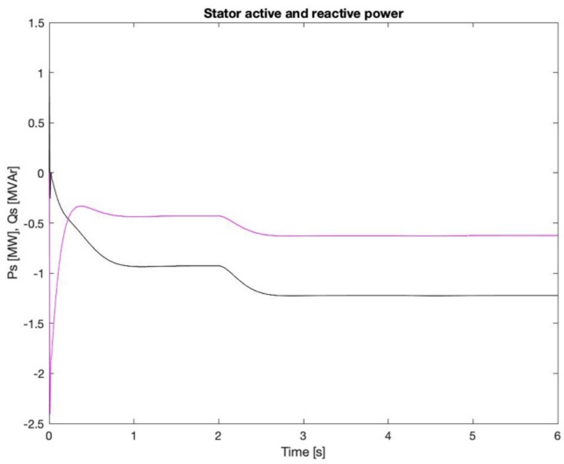

Figure 27 – Stator Power switched resistances

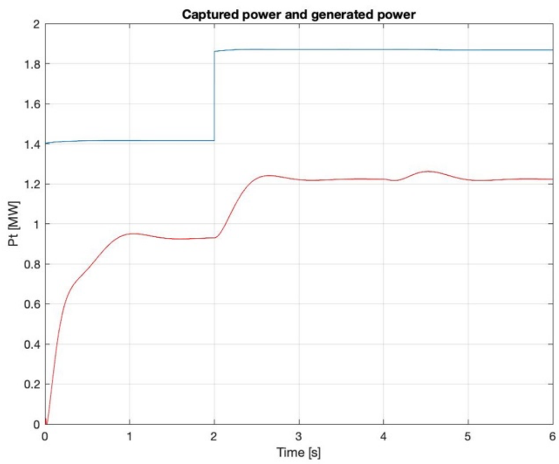

Figure 28 – Power initial configuration

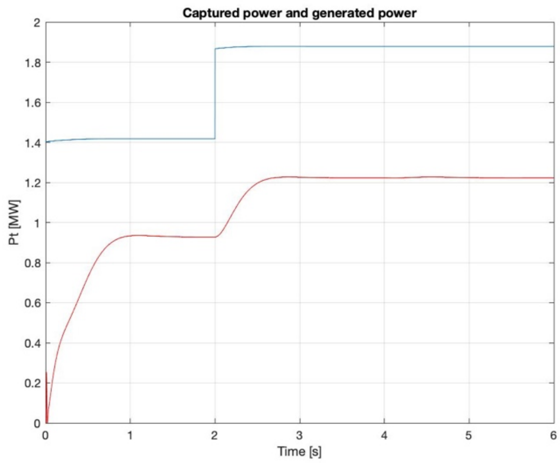

Figure 29 – Power with switched resistances

For the second configuration with the switched resistances, the ripple at t = 4 s due to the step velocity variation of the second turbine is much less visible, so in this case the second turbine does not influence the system like in the previous case.