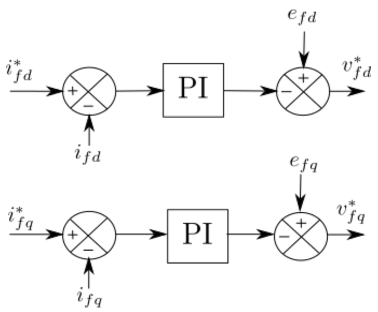

Fig. 12. Control currents flowing in the RL filter

Reference currents i_{fd}^* and i_{fq}^* are respectively given from the control block of the DC bus and control of reactive power at the GSC connection point to the grid (fig.11).

Neglecting losses in R_f resistance of RL filter and taking the orientation of the coordinate system (dq) connected to the rotary stator field ($v_{sd} = 0$), the equations for the powers generated by the GSC are given by [17]:

$$P_f = v_{sq} i_{fq} \quad (62)$$

$$Q_f = v_{sq} i_{fd} \quad (63)$$

From these equations, it is possible to impose the active and reactive power reference noted here P_f^* and Q_f^*, imposing the following reference currents:

$$i_{fd}^* = \frac{Q_f^*}{v_{sq}} \quad (64)$$

$$i_{fq}^* = \frac{P_f^*}{v_{sq}} \quad (65)$$

5.2.2 Control of the DC bus voltage

We can express of the powers involved on the DC bus by [17]:

$$P_{rec} = v_{dc} i_{rec} \quad (66)$$

$$P_c = v_{dc} i_c \quad (67)$$

$$P_{inv} = v_{dc} i_{inv} \quad (68)$$

These powers are linked by the relation [17]:

$$P_{rec} = P_c + P_{inv} \quad (69)$$

Neglecting all the Joule losses (losses in the capacitor, the converter and the RL filter), we can write:

$$P_f = P_{rec} = P_c + P_{inv} \quad (70)$$

By adjusting the power P_f , then it is possible to control the power P_c in the capacitor and therefore to regulate the DC bus voltage. To do this, the P_{inv} and P_c powers must be known to determine P_f^*. The reference power for the capacitor is connected to the reference current flowing through the capacitor:

$$P_c^* = v_{dc} i_c^* \quad (71)$$

Fig.13 shows that we can regulate the DC bus voltage using an external loop, based on a PI controller that generates the reference i_c^*.

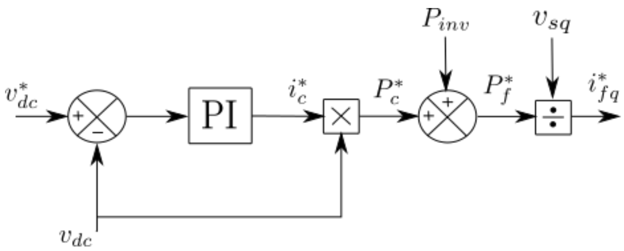

Fig. 13. Control loop of the DC bus voltage

Fig.14 shows the block diagram of the control of GSC. This block diagram includes the terms of decoupling and compensation to be able to independently control the (dq) axes currents circulating in the RL filter and the active and reactive power exchanged between the GSC and the grid.

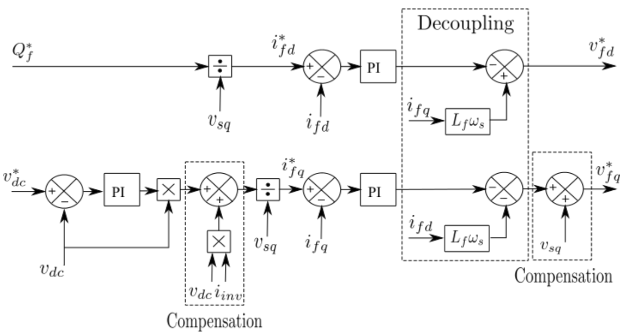

Fig. 14. Control of grid side converter

6 Simulation Results

The simulations of the whole system were performed with Matlab / Simulink, the DC bus reference voltage, denoted v_{dc}^* is set at 1200 V. The reactive power reference Q_f^* is set to 0 VAr, which guarantees a unitary power factor at the GSC connection to the grid. By cons, we will vary the stator reactive power Q_s by adjusting the reference value in the RSC control. We present in this section the results of the proposed control.

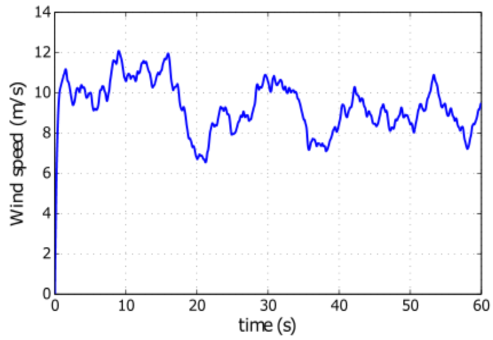

Fig. 15. Wind speed

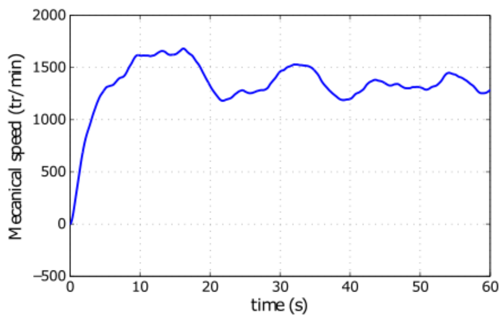

Fig. 16. Mechanical speed

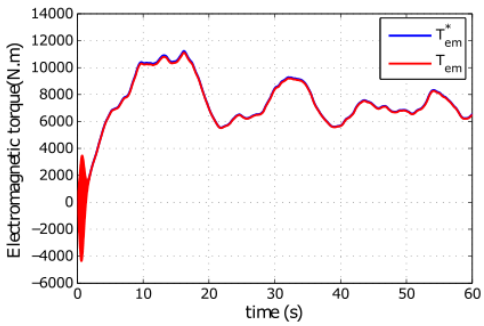

Fig. 17. Electromagnetic torque (reference and simulated)

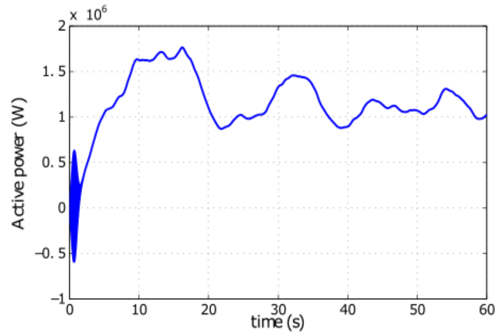

Fig. 18. Stator active power

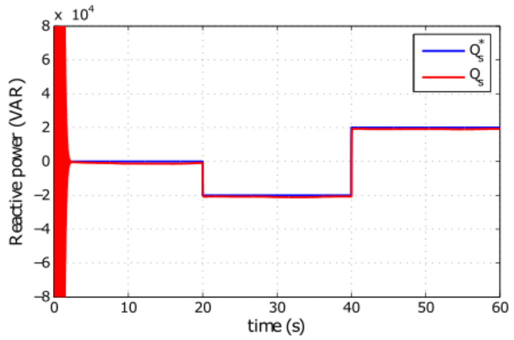

Fig. 19. Stator reactive power (reference and simulated)

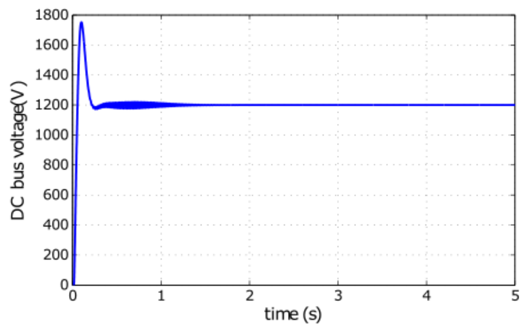

Fig. 20. DC bus voltage

Fig.15 illustrates the profile of the average wind speed used in simulation, while fig.16 shows the shaft rotational speed derived from the turbine. Fig.17 shows that the electromagnetic torque follows its reference, which allows for optimum power shown in fig.18, and we can see in fig.19 that the reactive power follows its reference exactly, this is due to control of direct and quadrature components of the rotor current. Finally, fig.20 shows that the DC bus voltage is perfectly regulated at 1200V.

7 Conclusion

This paper dealt with the modeling and control of a variable speed wind turbine system based on a DFIG. First, we explained why this wind system is the most widely used, partly because of savings from low sizing phase static converters implemented. Then we are interested in modeling the various constituents of the wind system. In fact, the aerodynamic and mechanical models of the turbine have been developed. Then, in order to establish the different commands of the two converters, we developed the model of DFIG. Finally, we implemented the vector control based on PI regulators. The results obtained demonstrate that the proposed control is effective and have many benefits.

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