# An Adaptive Control For Wind Turbine

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## 1. Brief introduction

In this paper, an adaptive control is proposed to maximize the energy conversion for a wind turbine driven by a PWM (Pulse Width Modulation) Inverter. This paper focuses on the optimization of the current loops of the machine. Two different strategies of wind turbine management have been tested in steady and transient state (with the variation of the load). The principle of the optimization consists of minimizing Joule losses in PWM and Generator. The second strategy (adaptive) is implemented with successful results.

**Key words:** Adaptive Control, Variable Speed, Wind Turbine, PWM Inverter, current loops.

## 2. Mathematical model of the system

*A. Wind Energy: energy conversion*

Wind turbine using Permanent Magnet Synchronous Generator is represented figure 1:

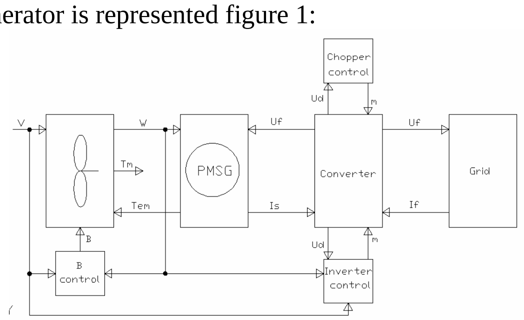


Fig. 1. Wind Turbine using PMSG

The structure most usually used consists in directly controlling the currents of phase by using 3 independent current loops [1, 2] , as shown figure 2.

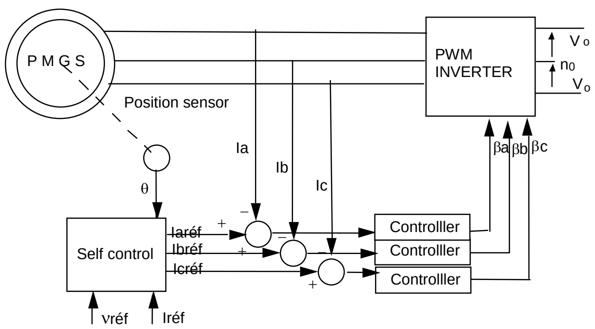


Fig. 2. Basic Voltage Source Converter structure

## 3. Design of an adaptive control

The efficiency of a wind turbine is dependent on the ratio of its blade tip speed, to the wind speed. Thus, as the speed of prevailing winds vary, so will the turbines efficiency. A method of extracting maximum energy from prevailing winds is therefore essential at all wind speeds. This can be achieved by controlling the turbines by means of an optimal control [3, 4].

For a Permanent Magnet Synchronous Generator the principle of the optimization consists of minimizing Joule losses in PWM and Generator. To do that, it is necessary to choose minimum phase current, considering fixed torque (figure 3).

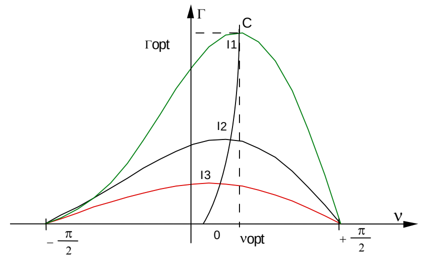

Fig. 3. Γ (ν) (with I1 > I2 > I3)

In the optimal control, the operating point is positioned on C curve (maximum torque and minimum current).

The optimal algorithm will act on ν angle such as:

$$\left(\frac{dI}{d\nu}\right)_{C\ constant} = 0$$

The principle of the optimal control is described figure 4.

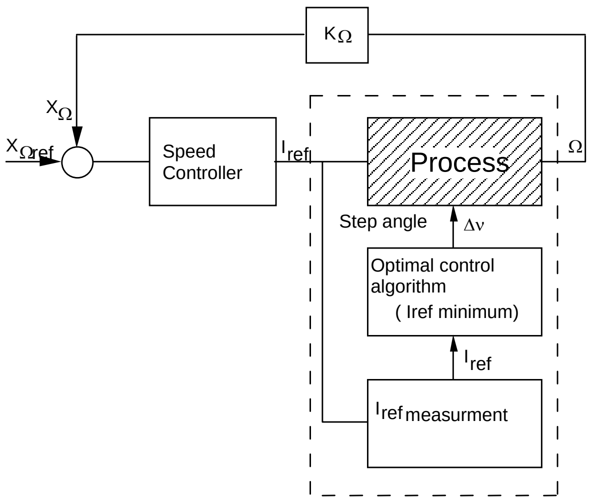


Fig. 4. Principle of the optimal control structure

## 4. Experimental results

To test the performances of the last structure, we applied to the generator a load varying in crenels. Experimental results are obtained figure 5:

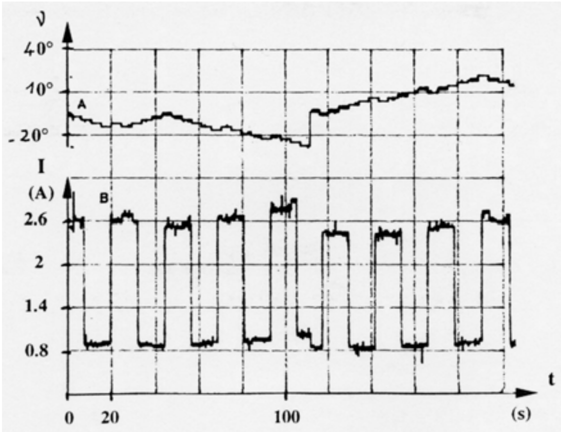


Fig. 5. I(t) and ν(t) (variable load)

The results obtained in this case, are really bad because the contribution of the various increments is no more prevalent in the current fluctuations and the algorithm diverges.

Notice: discontinuity in the ν angle on figure 11 corresponds to a reset of the ν angle by the control when its value exceeds 20° (security).

Thus, to take into account the variations of current I, one solution consist in elaborating Δν increment considering current/power of the generator.

### *A. New structure of the optimal control*

A new structure of optimal control considering load variations has been implemented (figure 6).

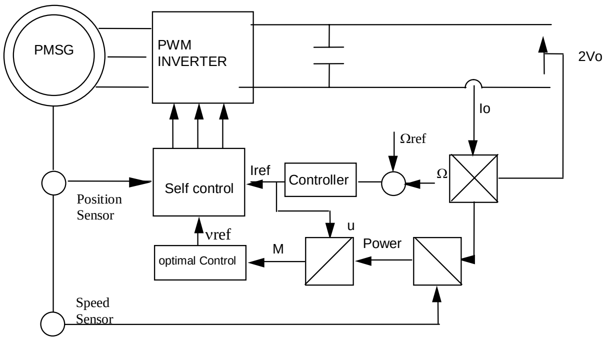


Fig. 6. New structure for the optimal control

The new algorithm is represented figure 6. If |M(k) - Mref| is not higher than ΔMo, that means that the Δν step did not cause sufficiently significant change to make a decision on the new sign of the increment, then the old sign is kept until the sum of the steps is significant.

Figure 7 shows the results of this test. ν Angle oscillates around a stable average value.

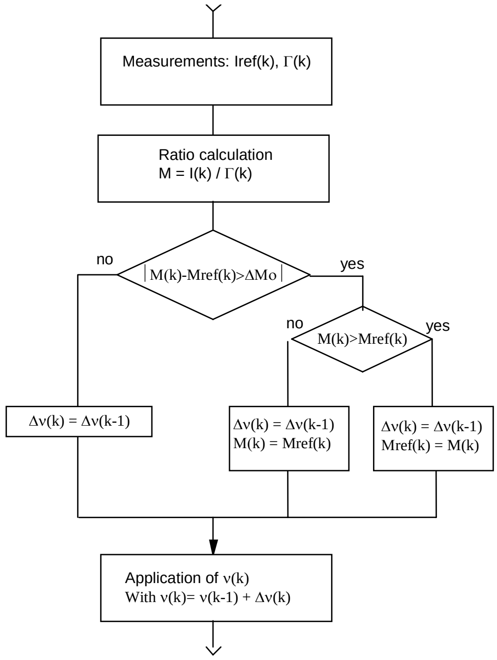


Fig. 6. *Optimal control algorithm*

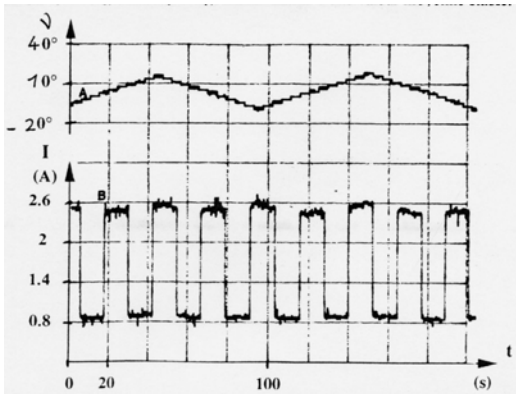


Fig. 7. ν and I (new MPPT algorithm)

## 5. Conclusion

An adapting optimal control is presented in this paper. A classical structure was implemented but results were not satisfactory, particularly in transient state (variation of the load), because of instability. This structure has been improved and advantages of the new control are verified when the load is varying.

## References

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