Control Strategy For Ensuring Tower Clearance Allowance Whilst Maximizing Annual Energy Production

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Abstract

The current trend in the design of wind turbines is to increment the length of the blades in order to increase the annual power production, by means of a compromise between lightness and rigidity. One of the greatest problems related to this is a higher flexibility of the blade, which in combination with an increase in wind speed causes a greater deflection of the blades in the direction of the wind, with the consequent risk of collision between the blade tip and the tower. Several strategies have been developed in the state of the art that solve the problem (tilt angle modification, cone angle modification, thrust reduction with dynamic fine pitch), but all of them imply a reduction in the annual energy production. In an attempt to solve this energy loss, some strategies have been developed (as is the case of the strategy here explained, IPTCA) whereby the blade pitch angle is modified cyclically for each blade exclusively in a sector of rotation where the blade passes in front of the tower.

Objectives

The control strategy enables an increase in the distance between the tip of the blade which passes by the generator tower and the tower itself, to prevent possible collisions. To this end, the control method includes the application of a blade pitch angle control term which is calculated as a function of at least one signal indicative of wind speed and as a function of the azimuthal angle of each blade.

Given that the minimum distance occurs when the tip of the blade passes in front of the tower, an additional blade pitch angle term is added, whose value depends on the azimuthal position of the blade and whose maximum value is the result of an optimization over a set of representative simulations which take into account the delay of the pitch actuator, the azimuth sector in which the strategy will be applied as well as the additional pitch signal amplitude. The objective of the optimization is to reduce the associated loss of power production while avoiding collision between blade and tower.

Methods

The present strategy is based on calculating a blade pitch angle control term ($\Delta\beta$) for each blade as a function of the azimuthal position (θ) of each blade and of at least one signal indicative of wind speed (v), with the purpose of increasing the blade pitch angle (β). Subsequently, the blade pitch angle control term ($\Delta\beta$) for each blade is sent to each blade for the respective actuators to modify the pitch angle, as a function of said control term.

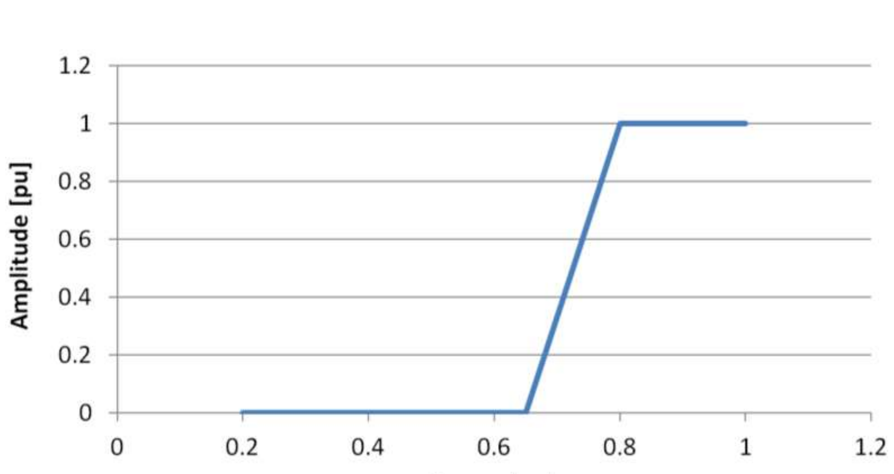
The function defining the value of the amplitude of the cyclic function as a function of the signal indicative of wind (v) is doubly dependent on the generated power and on the blade pitch angle, in such a way that, in the sub-nominal power regime, the function depends on the generated power and above the nominal wind speed (V_{Nom}), the function depends on the blade pitch angle.

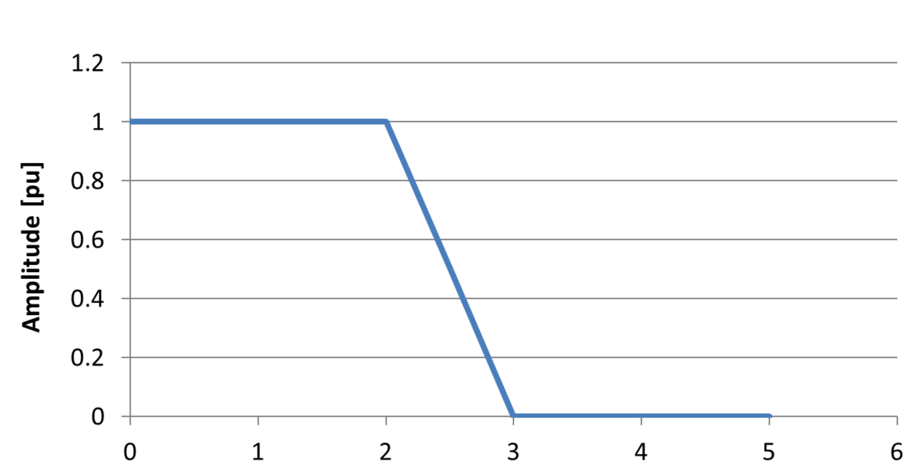
$$\Delta\beta = \Delta\beta\ (\theta,v) = A(v) * \sin(\theta-\pi/2) \quad \text{for } \theta_1 < \theta < \theta_2$$

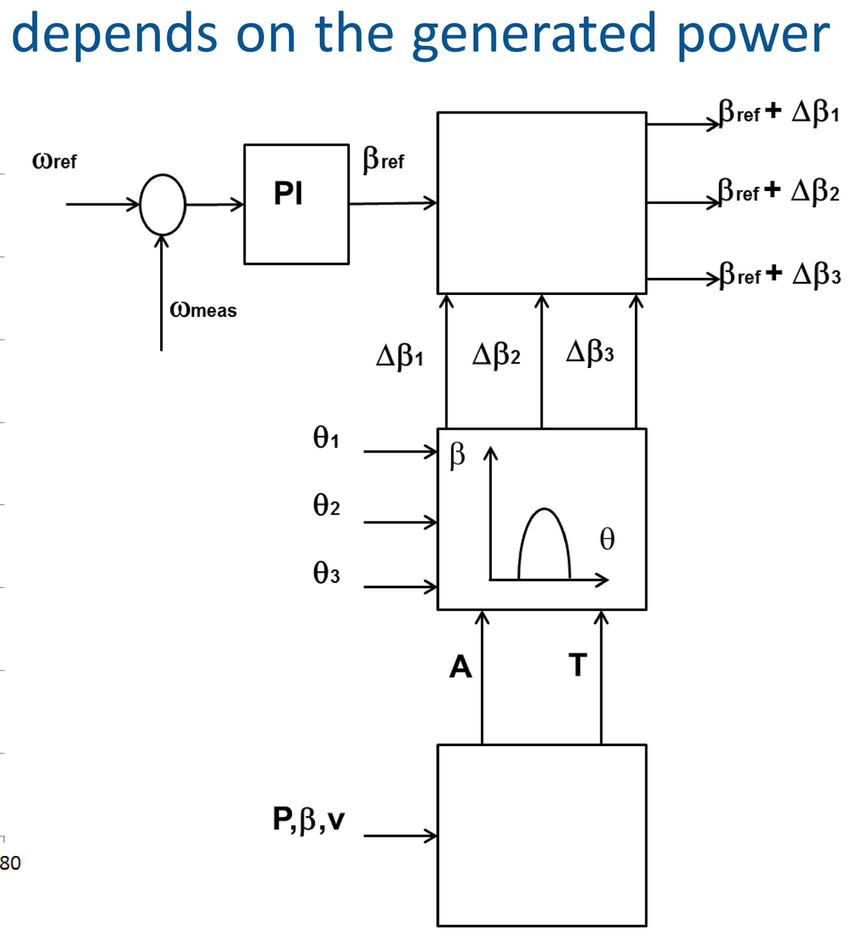
$$\Delta\beta = \Delta\beta\ (\theta,v) = 0 \quad \text{for } \theta_2 < \theta < \theta_1$$

$$A(P, \beta) = A(P) \quad \text{for } v < V_{Nom}$$

$$A(P, \beta) = A(\beta) \quad \text{for } v > V_{Nom}$$

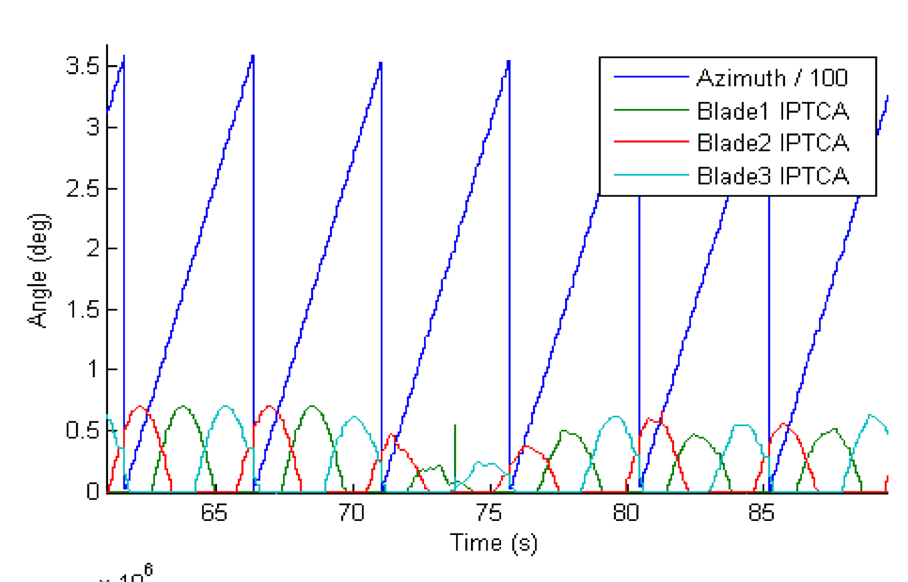


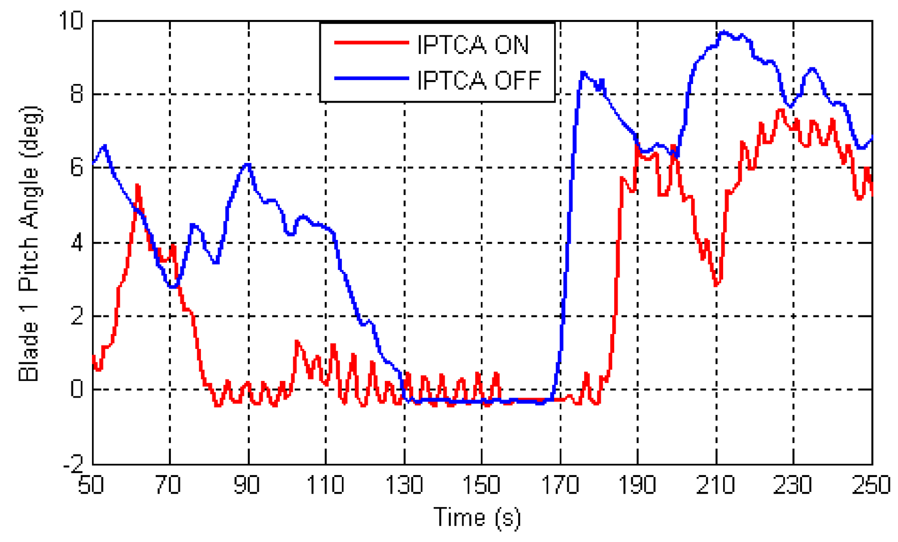


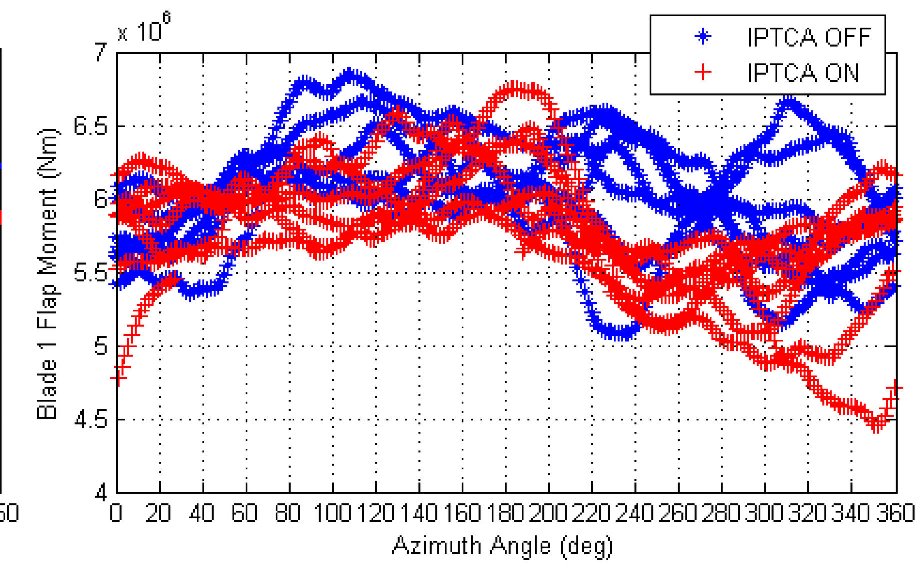


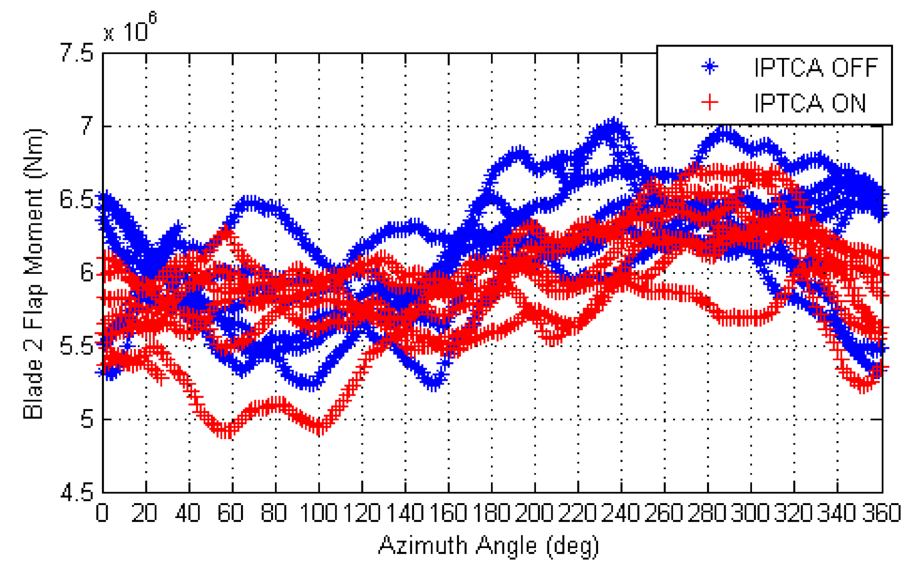
Conclusions

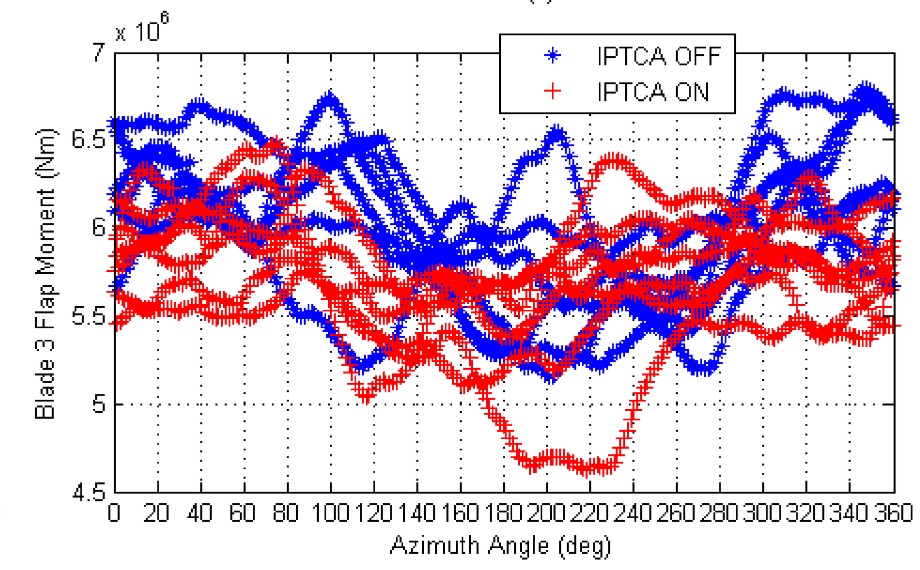
The effectiveness of this strategy has been demonstrated in simulation, as its application reduces the distance between the blade tip and the tower surface and minimizes the energy loss. The optimization procedure secures that a minimum distance is guaranteed whilst a minimum energy loss is targeted. This strategy has also been validated in field by means of a comparison of the blade root flap bending moments measures of data logs with similar wind conditions, one of them with the IPTCA activated and the other one with the IPTCA deactivated. As shown in the following figures, the blade flap bending moment of each blade is reduced azimuthally when the IPTCA applies. Its effect on the infield AEP is a pending issue.











References

1. US 2013045098 A

2. EP 2947313A1