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Chapter 1

Introduction

The report presents theoretical analysis and experimental simulation data associated with the operation of a wind turbine with variable pitch. Pitch control is an important element of wind turbine design. Pitch control is analogous to the coarse control on a microscope. It is meant to facilitate a regular rotation rate for the blades. A well-tuned pitch control system allows for better and cheaper design of the generator control system.
The effect of both supply volt and load torque changes is on the open loop response of the pitch control system is simulated in this report using Matlab and Simulink. The effects of both these input are also discussed.
The open loop frequency response of the system is examined. The magnitude and phase characteristics of this response are plot on Bode, Nichols and Nyquist plots. How these plots and the open loop response allow inferring of closed loop characteristics is explained. The usefulness of these plot in design controllers for the system is also considered in Figure 1.1.
The effect of adding a proportional controller and a phase lead controller to the turbine system is demonstrated. Methods used to optimize these controllers for various steady state and transient parameters are explored. The responses at various stages of the controller design process are simulated and compared. Finally the limits of this model are acknowledge. Possible additions to increase the realism of this model are dealt with.

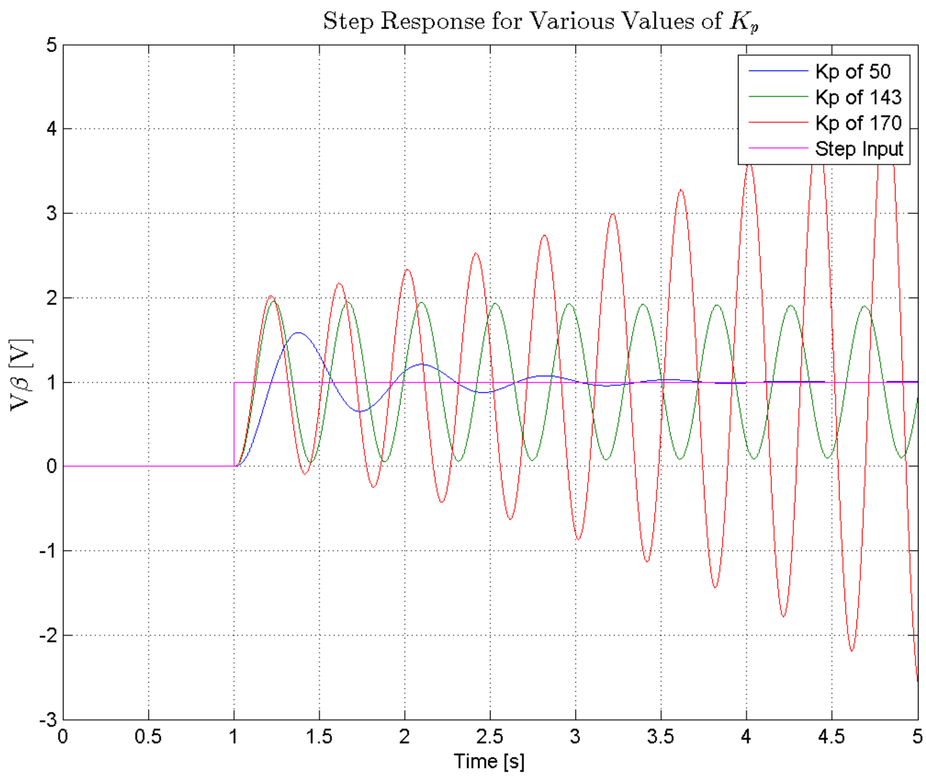

Figure 1.1: Step Response Vc

Chapter 2

Function by Theory

The transfer function of the system can be achieved by using block diagram manipulation and reduction. The canonical block can be used to obtain the transfer function between input voltage, V and current, I:

$$\frac{\frac{1}{s}\frac{1}{L}}{1+\frac{1}{s}\frac{1}{L}} = \frac{1}{sl+R}$$

The transfer function for across the gain of the motor X/I is:

$$\frac{X}{l} = Km$$

There are is an inertia, J1, and a damping, B1, due to the motor dynamics. There is also an inertia, J2, and damping, B2, due to the blade dynamics. These blade dynamics are reflected across a gearbox. They must be scale accordingly.

$$J = J_1 + \frac{J_2}{N_2}$$

$$B = B_1 + \frac{B_2}{N_2}$$

The canonical reduction is used as above, for V and I, for the transfer function between X and speed of motor :

$$\frac{\Omega}{X} = \frac{\frac{1}{J}\frac{1}{s}}{1+\frac{1}{J}\frac{1}{s}B}$$

Chapter 3

Loop Response

3.1 Open Loop Response to Changes in Motor Voltage

The system was subjected to a step change in the Motor Voltage from 0V to 1V at 5 second. There is a current spike of roughly 4.2A. This is known as the inrush current. The speed, reaches a steady state. By the time this steady state speed has been reached the current will have decayed to approximately zero. As there was no load torque applied to system there is no current drawn once motor gets to the set speed. As a result the response the blade pitch is second order. It appears therefore that the pitch response to a step in input voltage can be approximate as a ramp.

3.2 Open Loop Response to Changes in Disturbance Torque

The system was subjected to a step change in the Motor Voltage from 0V to 50V at 1 second. The increased load torque draws more current. As a result the machine must slow down to provide the required current due to the back emf. Again it appears therefore that the pitch response to a step in torque, as with the input voltage, can be approximate as a ramp. However, this time the slope will be negative.

3.2.1 Open Loop Response to Changes in Motor Voltage and Disturbance Torque

In this simulation both the motor voltage and torque were stepped at the same time by different amounts. The torque has a quicker effect the response as the speed goes slightly negative. However, the voltage dynamics quickly dominate and lift the speed positive again. The voltage step leads to an inrush current as before, which manifests itself as a spike in the plot. But this time the presence of a constant load means there is also a constant current drawn. This current is seen as the inrush current decays away.