Comp3402 Wind Turbine Control (ctd)

C.B.Price November 2021

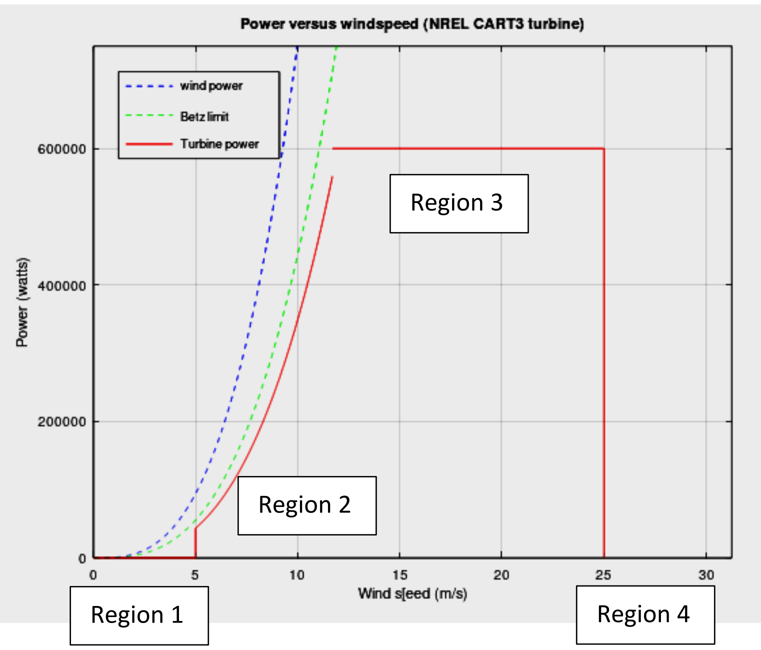
Purpose	(i) To learn about Wind Turbine control strategies for Regions 1-4 with a focus on Region 2 and Region 3. (ii) To conduct a series of **investigations** and subject the observations to analysis.
Files Required	Unreal4 resources and Octave scripts.
ILO Contribution	LO 4
Send to Me	nix
Homework	Read chapter 4

Investigations

---

1 Parameters for the NREL-CART3 600kW turbine

Below are the parameters for this wind turbine, defined in Unreal and also Octave. On the left is the power curve showing the four regions, the energy in the wind and the Betz limit. These curves are all proportional to wind-speed cubed, i.e. v^3.



$\boldsymbol{R}$	Rotor radius	20m
$\boldsymbol{\rho}$	Air density	1.2 kg/m^3
$\boldsymbol{J}$	Inertia	613,301
$\boldsymbol{\lambda_{opt}}$	Optimal tip speed ratio	6.537
$\boldsymbol{C_{pmax}}$	Maximum power coefficient	0.453
$\boldsymbol{v_{cutIn}}$	Cut-in wind speed	5 m/s
$\boldsymbol{v_{cutOut}}$	Cut-out wind speed	25m/s
$\boldsymbol{v_{cutRated}}$	Rated wind speed	11.7 m/s

Perhaps the most fundamental concept we need is λ the tip-speed ratio. This is the ratio of the speed of the tip of the blades as they move through the air, to the wind speed. Of course, the tip speed is in a plane normal to the wind speed:

$$\lambda = \frac{\omega R}{v}$$

Where *R* is the radius of the rotor and ω the angular velocity of the blade in radians per second. You can get this from the rotor rpm using the following relationship

$$1\, rpm \equiv (60)(2\pi) rad/sec$$

---

2 Investigating the Region-3 Controller

The expression for the pitch controller is

$$\Delta\beta = K_p(\omega_{rated} - \omega)\Delta t$$

which is the 'proportional' part of a standard PID controller. The error here is the difference between the rated and actual turbine rotational speeds (omegas)

The proportional coefficient K_p is set at default 2.0. Investigate the effect of changing K_p. Here's things to look out for

- Power rises significantly above 600 kW; the turbine will explode
- Power does not rise above 600 kW (even for short times)
- Any other new behaviour shown in the plots

3 Investigating the Blade Radius

Theory tells us that power is proportional to blade radius squared

$$P \propto R^2$$

so let's test this out

(a) Set the wind speed initial value to 10.0 (so you are in Region-2) and turn off stepping the wind, so you have a constant wind speed. Run some simulations for various Rs and note these down.

We are going to perform a nonlinear fit of the above model in Octave. The model function will be

$$P = KR^2$$

where the fitting will provide us with a value of K.

(b) Estimate K by substituting one pair of R-P values you measured and calculate K. Do this at the Octave command prompt. I got around 850. Now put this into the Octave script **Power_Radius_Fit** and see what you get.

(c) We can do something much more interesting, testing whether the power is actually 2 in the above expression. Make the following changes inside the Octave script

modelfun = @(p,x) (p(1)*x.^p(2))	Second search parameter p(2) is now the power. Here, x.^ means take x to the power of
startingVals = [your estimate,2.0]	

If you get anything really different from 2, then we may need to think. Often powers in theoretical expressions have simple ratios like 5/2, 3/2, etc. Is your power close to such a ratio?