1. Introduction

Traditional : region 1 : generator inoperative

rotor speed increase ↓ region 2 : maximizing the generated power

region 3 : maintain the rated generator power & rated rotor speed

switch region 2 → 3 based on rotor speed and blade pitch.

but delay of measure speed and pitch caused by low-pass filter cause leakage of power production

Maximize power under safety limit

A different approach : Perturbation and Observation method

but has problem

In this paper, ENMPC approach

Require predicition of the exogenous input

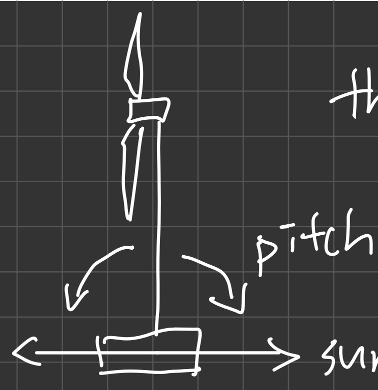
External factors or variables that effect system being controlled but not directly controlled by controller

i.e. wind and wave induced force

and ROM

model need simple to be solved, faster than real time

For ENMPC, need include platform motions (surge, pitch)



they are important because they effect relative wind speed

Recall equation (9), (10) in Review Model paper

Force $F_A = \alpha V_{rel}^2$ (thrust)

torque $W_A = \alpha V_{rel}^3$ (power depends torque)

Require reliable estimation of platform motion (hydrodynamic Model)

2. ROM

$J_{rot} \dot{\Omega} = T_{wind} - T_{gen}$ (Recall eq (41) and 2.5)

inertia, rotor acceleration

$\dot{\omega}_r = \frac{1}{\hat{J}_r}(T_A - \hat{T}_E)$

same thing here!

Recall : $I \cdot \alpha = T$ torque

inertia, acceleration

V_{noc} is estimated by platform ROM

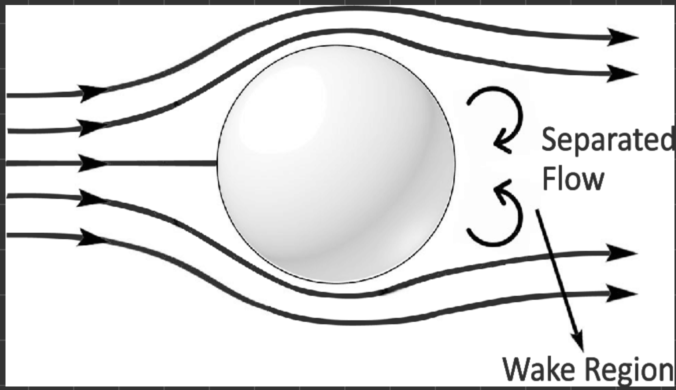
eq (23) $T_E = \frac{P_A}{\omega_r}$, P_A

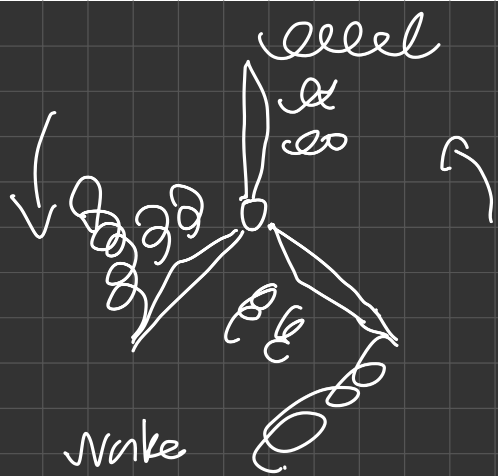
Eq (2) ??

Analyses with uniform wind profile, constant rotor speed

Require low-frequency blade pitch and generator torque

Include low-frequency wake inflow memory effect





2.1

we need to consider generator temperature to aviod damage

A simple model: $\dot{\theta} = -k(\theta - \theta_0) + c P_{gen}$

heat cap^{-1} ; heat coef ; external temp

3. Platform ROM

$P_{aero} \Leftrightarrow V_{rel}^3$

Need impose constraints on platform

Platform are forced by i) mooring lines

ii) hydrodynamic, static

iii) rotor thrust

diffraction ; radiction / viscous

External inputs: wind velocity, diffraction load

(have a wave radar for predict diffraction)

State space formulation

$$x_p' = A x_p + B u$$

$$y = C x_p$$

pitch, surge $\subseteq X_p$

5. Defn control opt prob

$$J(t) = \int_{T_0}^{T_0+T_w} P_{ecr}\, dt$$

energy over time power

Recall power is energy per unit time

hypo: $P_{electronic} > P_{generator}$

Impose a constraints on rotor thrust and platform motion

How to determine time window?

(Ω, θ, X_p) are measurable, λ observed

rotor speed, temp, mean induced velocity

The initial condition of new time window are from end of the past window

7 Numerical results

Verify ROM has a good approximation

Results shows a good approximation

How can you say the approximations are good?

7.2 Any statistical analysis?

time window: every 5 s.

No aerodynamic power limit, limit aerodynamic load (rotor thrust)

Constraint blade pitch speed rotor speed to avoid wind turbine

3 wind scenario : 15 m/s, 12 m/s, 9 m/s

15 m/s : ENMPC maintained a more stable temp and platform pitch than reference

12 m/s (rated wind speed) 4.31% increment of power production use ENMPC

Summary:

- Power production increased
- Improved model accuracy
- Use a 2-DOF (pitch, surge)

ENMPC developed for offshore wind turbine that consider platform motion.

Maximaze power production by allowing the generator work beyond rated power when ensure safety.

Consider a thermal model

Requires a prediction of the exogenous input

Systematically evaluates the blade pitch and generator torque by predicted exogenous input without delay.

Introduce constrain allows well-damped platform motion (no osilation)

which lower the control effort (decrease computation time)