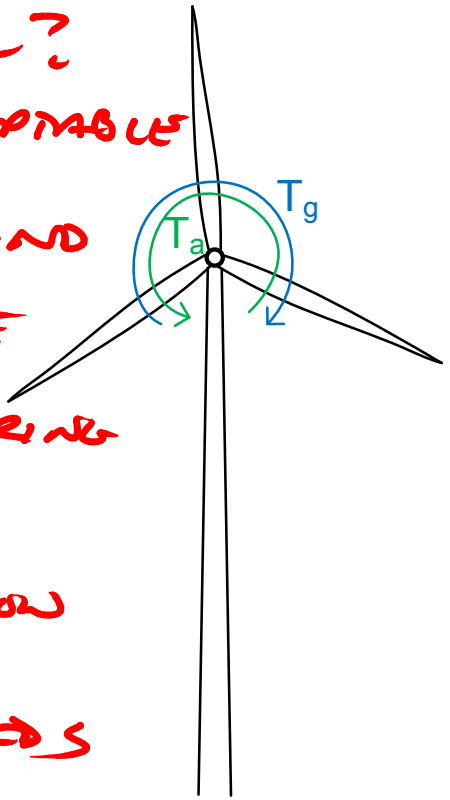
Wind Turbine Control

A. Introduction

WHY DO WE NEED CONTROL?

- KEEP ROTATIONAL SPEED WITHIN ACCEPTABLE RANGE
- KEEP TURBINE POINTED TOWARD WIND
- KEEP POWER WITHIN CERTAIN RANGE
- ENSURE ACCEPTABLE OPERATION DURING START-UP & SHUT DOWN
- OPTIMIZE POWER AT SPEEDS BELOW DESIGN RATING
- LIMIT POWER & LOADS AT SPEEDS ABOVE DESIGN RATINGS



CONSIDER EQUATION GOVERNING THE ACCELERATION OF W.T. ROTOR

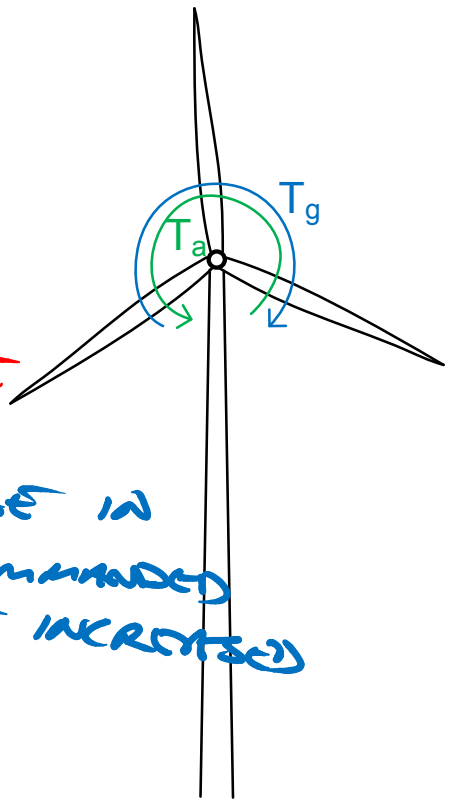
$$I\frac{d\omega}{dt} = T_a - T_g$$

FOR CONSTANT SPEED

$$T_a = T_g$$

Wind Turbine Control

A. Introduction $I\frac{dN}{dt} = T_a - T_g$



AS AERODYNAMIC LOAD INCREASES

→ NEED GENERATOR TORQUE TO INCREASE AS WELL

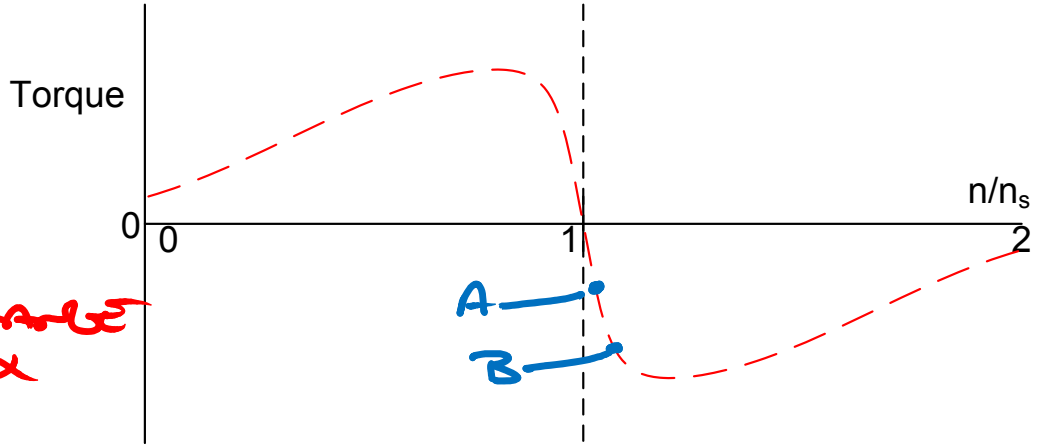
A→B REPRESENTS THE CHANGE IN GENERATOR OPERATION COMMANDED BY CONTROL SYSTEM DUE INCREASED WIND SPEED

AT SOME POINT, THE GENERATOR CANNOT PROVIDE MORE TORQUE

SO WE HAVE TO LIMIT AERODYNAMIC TORQUE

→ STALL BLADES

→ CHANGE θ_p → CHANGE α



Wind Turbine Control

A. Introduction

   1. Means of Control

AERODYNAMIC TORQUE

- PITCH BLADES
- STALL / NO STALL
- BEND TWIST COUPLING
- CONE / PITCH COUPLING
- TIP BRAKES

GENERATOR

- VARIABLE TORQUE
- VARIABLE SPEED

Wind Turbine Control

A. Introduction

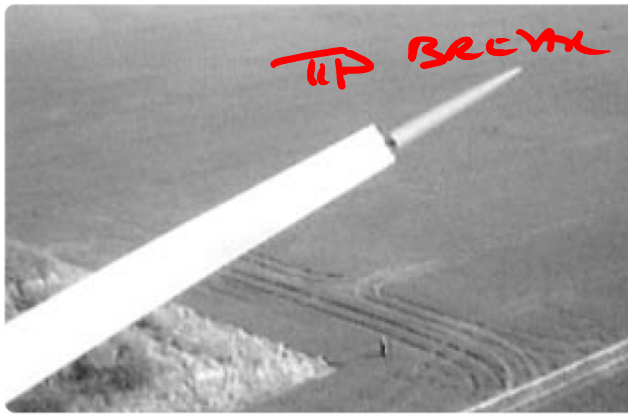
   1. Means of Control

YAW

PASSIVE (DOWNWIND)

VANES (UPWIND)

YAW MOTORS



GENERATOR

Wind Turbine Control

A. Introduction

   2. Control Inputs (Sensors)

ENVIRONMENTAL

WIND SPEED

WIND DIRECTION

MACHINE KINEMATICS

POSITION YAW, PITCH, BLADE AZIMUTH

VELOCITIES ROTOR, GENERATOR, GEARBOX SPEEDS

ACCELERATION TOWER TOP ACCELERATION

MACHINE DYNAMICS

SHAFT TORQUE

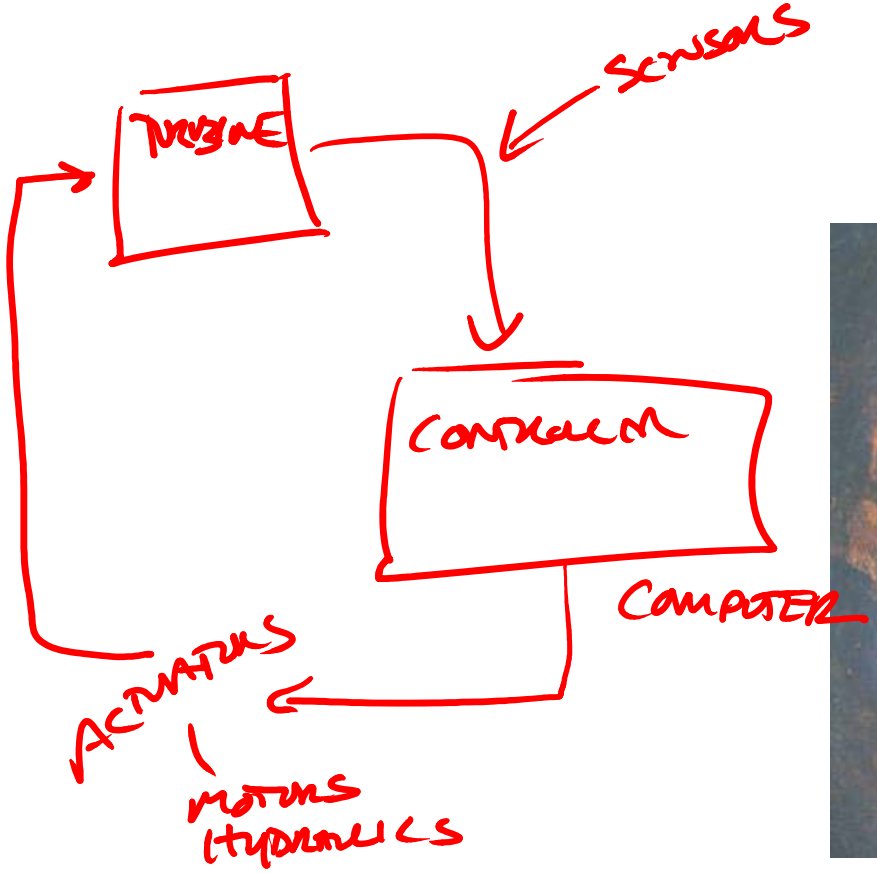
BLADE ROOT BENDING MOMENTS

TOWER FORE/AFT BENDING MOMENT

Wind Turbine Control

A. Introduction

   3. Interactions between Controller and Electro-Mechanical Systems



BLADE HUB