

SEJ302 Control Systems Engineering

Project Design Brief

Your team is tasked with developing an industrial control solution for installation of a new wind turbine at Deakin University Waurn Ponds. In this project, you will need to develop a control solution which can then be automated. Your team will consist of 6 students with minimum of 1 mechanical, 1 mechatronic and 1 electrical student per group.

Each stream will have their own area of expertise and will therefore focus on the corresponding system and process control development.

* Mechanical (2 students) - Control of Pitching and Turbine speed system,
* Mechatronic (2 students) – Control of Nacelle orientation system,
* Electrical (2 students) – Control of Power generation system

Your team will be required to:

* Design the process flow diagrams for the system
* Determine the system dynamic model
* Undertake Laplace transformations of the system models and create transfer functions from them,
* Develop block diagrams and reduce them to their simplest forms.
* Develop and create the state flow diagrams and the Boolean equations
* Determine the system poles, zeros and analysis the stability.
* Plot the root locus and bode plots of the system and analyze the system stability.
* Determine the steady state error and devise a PID controller for the system
* Create ladder logic controller for the PLC using RSLogix 500 software,
* Create working Simulink model using Matlab.
* Present a working simulation and model of the system.
* Submission of final report.

The design requirements and specifications of the system are given below

Wind Turbine System Requirements

These are example requirements, and are intended solely to show how requirements documents can be linked to the model.

### Blade Requirements

|  |  |
| --- | --- |
| Type description | AL 40 |
| Blade length | 40 m |
| Material | Carbon/wood/glass/epoxy |
| Standard colour | RAL 7035 |
| Gloss | Class 2: (30-70%) to be measured acc. to DS/ISO2813 |
| Type of rotor air brake | Full blade |
| Blade profiles | FFA - W3, NACA 63.4 |
| Twist | 20° |
| Largest chord | 3.08 m |

### Brakes Requirements

|  |  |
| --- | --- |
| **Mechanical** |  |
| Type description | Active Brake |
| Brake disc | Steel, mounted on high speed shaft |
| Number of calipers | 2 piece |
| **Brake Hydraulics** |  |
| Voltage | 3 x 480 V |
| Working pressure range | 140-150 bar |
| Oil capacity | 11 l |

### Environment Requirements

|  |  |
| --- | --- |
| Temperature interval for operation | -30 to +30°C |
| Temperature interval for structure | -40 to +50°C |

### Geartrain Requirements

|  |  |
| --- | --- |
| Type description | 1. step planet, 2. step helical |
| Gear house material | Cast |
| Ratio | 1:84.3 |
| Mechanical power | 1800 kW |
| Bending strength acc. to ISO 6336 | SF > 1.6 |
| Surface durability acc. to ISO 6336 | SH > 1.25 |
| Scuffing safety acc. to DNV 41. | SS > 1.3 |
| Shaft seals | Labyrinth |
| Oil sump | App. 250 l |

### 

### Generator Requirements

|  |  |
| --- | --- |
| Type description | 1 speed generator, water cooled |
| Rated power | 1650 kW |
| Apparent power | 1808 kVA |
| Rated current IN | 1740 A |
| Max power at Class F PFma | 1815 kW |
| Max current at Class F IFmax | 1914 A |
| No load current I0 | 430 A |
| Reactive power consumption at rated power (tolerance. acc to IEC 60034-1) | 740 kvar |
| Reactive power consumption at no load (tolerance. acc to IEC 60034-1) | 447 kvar |
| Number of poles P | 6 |
| Synchronous rotation speed n0 | 1200 rpm |
| Rotation speed at rated power nN | 1214 rpm |
| Slip at rated power sN | 0.0117 |
| Voltage UN | 3 x 600 V |
| Frequency F | 60 Hz |
| Coupling | Δ |
| Enclosure | IP54 |
| Insulation class/ Temperature increase | F/B |

### Main Controller Requirements

|  |  |
| --- | --- |
| Annual average wind speed 8.5 m/s | 8.5 m/s |
| Wind shear 0.20 | 0.2 |
| Extreme wind speed | 42.5 m/s (10 min. average) |
| Survival wind speed 59.5 m/s (3 sec. average) | 59.5 m/s (3 sec. average) |
| Automatic stop limit 20 m/s (10 min. average) | 20 m/s (10 min. average) |
| Re-cut in 18 m/s (10 min. average) | 18 m/s (10 min. average) |
| Characteristic turbulence intensity | 16% (including wind farm turbulence) |
| Maximum in-flow angle | 8° |

### Nacelle Requirements

|  |  |
| --- | --- |
| Material EN-GJS-400-18U-LT | EN-GJS-400-18U-LT |
| Standard colour RAL 7035 | RAL 7035 |
| Corrosion class, outside Acc. to DS EN ISO 12944:C5 I | Acc. to DS EN ISO 12944:C5 I |
| **Rotor** |  |
| Number of blades 3 pieces | 3 pieces |
| Tip speed (synchronous) 61.8 m/s | 61.8 m/s |
| Rotor shaft tilt 5° | 5° |
| Eccentricity (tower center to hub center) | 3447 mm |
| Solidity (Total blade area/rotor area) | 0.05 |
| Rotor orientation | Upwind |

### Pitch Actuation Requirements

|  |  |
| --- | --- |
| Hydraulic pressure | 2e7 Pa |
| Accumulator Capacity | 0.1 L |
| Accumulator Preload Pressure | 1.5e7 Pa |
| Accumulator Maximum Pressure | 2.5e7 Pa |

### Pitch Controller Requirements

|  |  |
| --- | --- |
| Track angle within | 1 degree |
| Rise Time | 3 seconds |
| Settling Time | 5 seconds |

### Tower Requirements

|  |  |
| --- | --- |
| Type Description Conical, tubular | Conical, tubular |
| Material Welded steel plate | Welded steel plate |
| Corrosion class, outside Acc. to DS EN ISO 12944: C5 I | Acc. to DS EN ISO 12944: C5 I |
| Colour RAL 7035 | RAL 7035 |
| Access conditions | Internal, safety harness, ladder cage |

### Yaw Actuation Requirements

|  |  |
| --- | --- |
| Type description | Planetary gear motor |
| Gear ratio of yaw gear unit | app. 1:1687 |
| Voltage | 3 x 480 V |
| Rotational speed at full load | 1140 rpm |
| Number of yaw gears | 4 pieces |
| **Yaw Brake** | Hydraulic disc brake |
| Number of Yaw Friction Units | 6 pieces |
| Voltage | 3 x 480 V |
| Working pressure range | 140-150 bar |
| Oil capacity | App. 10 l. |

### 

### Yaw Controller Requirements

|  |  |
| --- | --- |
| Max Yaw Rate | 0.5 deg/sec |