UESTC4003 - Control

MATLAB Based Design Exercise

Increasingly, renewable power has found itself being integrated into national power grids. Efficient use and power quality of this generated energy is of utmost importance with regards to maintaining stability of the grid. High capacity power storage devices are examples of devices that aid with this task. In this project, you will investigate the suitability and performance of one such storage technique (e.g. super-capacitor) using MATLAB.

Assume a power network consists with a wind generator and a battery bank. You are proposing to integrate a super capacitor to control the power generation output of the system, particularly to meet the transient load demands. The response time can be considered as one of the important factor when selecting the battery and super capacitor.

The objectives of the study are to:

- Understand the importance of storage devices in electrical power systems to control the stability of the grid.
- Familiarise with various energy storage techniques and their control limitations.
- Design and develop a model for a super-capacitor using MATLAB Simulink.
- Design and develop a model for an integrated system of wind turbine, battery bank and super-capacitor using MATLAB Simulink (consider real power input/output where relevant). Investigate the system performance for a given constant load, and when the load is subjected to disturbances.
    - The key part of the simulation work is to investigate and analyse of output waveforms for a constant load and for a load with a disturbance using the simulation model. For example, you can use the wind data in the attached "gridwatch_wind_data.csv" (included in column C (in kW) for a 24 hour period). You can define a constant load, for example, 450 kW for the first case and then estimate the relevant requirements (parameters) for the battery connected to the system. Use trial and error method to optimise the parameters. You can assume ideal conditions, and make any additional assumptions where necessary.
    - For the second case, introduce a random disturbance to your load. For example, assume the load suddenly increased to 750 kW at mid-day, just for a 5 minutes, and for the remainder of the day it continued at constant, 450 kW. Now estimate the relevant requirements (parameters) for the super capacitor connected to the system. Use trial and error method to optimise the parameters considering response time. You can assume ideal conditions and make assumptions where necessary.
- Simulation results should be included, for example you need to include relevant output waveforms of each (i.e. battery, super capacitor) and make sure the system is stable during both cases.

Your report should evidence the achievements of the key objectives highlighted above. You are expected to use 5-10 refereed sources of information, such as scientific journal articles and technical reports, to support your report (*You may wish to use "ScienceDirect" or "IEEE Xplore" to search for relevant papers online, or the University library*).

Your report should be a word (pdf) file that must be submitted to Moodle via the assessment link. Failure to submit this will result in a mark of zero.

Deadline of the report submission: **6th of December 2024** ***(Beijing time)***

Word limit: about 1200 words (plus reference list)

Total mark: 15% (assuming total mark of the course as 100%)

Late submissions will not be accepted.

Assessment matrix is shown below.

	Maximum total mark	Marks
Demonstrate understanding of the background: Has the student demonstrated an understanding of the importance of storage devices to control the stability of power grid?	20%	
Technical Understanding: Has the student demonstrated an understanding of the control problem including limitations?	30%	
Design and Analytical skills: Have the models (wind turbine, batter bank, super capacitor and the integrated system) been appropriately designed/presented/analysed?	30%	
Report: Is the report logically structured? Have the design results been appropriately interpreted and the conclusions well argued? Is the report clearly written and grammatically correct? Is the style appropriate for a technical report, including the use of references?	20%	
Total Marks	100%	

References:

1. L. Gelažanskas, A. Baranauskas, K.A.A. Gamage, M. Ažubalis, "Hybrid wind power balance control strategy using thermal power, hydro power and flow batteries", International Journal of Electrical Power & Energy Systems, Volume 74, January 2016, Pages 310-321.
2. MATLAB, "Supercapacitor Parameter Identification", accessed online on 02/10/2018 https://uk.mathworks.com/help/physmod/sps/examples/supercapacitor-parameter-identification.html
3. Zubieta, L. and R. Bonert. "Characterization of Double-Layer Capacitors for Power Electronics Applications." IEEE Transactions on Industry Applications, Vol. 36, No. 1, 2000, pp. 199-205.