DHAKA UNIVERSITY OF ENGINEERING & TECHNOLOGY, GAZIPUR

OFFICE OF THE DIRECTOR (RESEARCH & EXTENSION)

Application for Approval of **Thesis Proposal**

M. Sc. Engg.

Date: 11-07-2021

1.	**Name of the student (Block Letters):**	**MUHAMMAD MUSLEH UDDIN**	**Status:**	**Full-Time**
2.	**Student No.:**	**16202004-F**	**Enrolled Session:**	**2016-2017**
3.	**Present Address:**	**Shyamoli residential area, chotopol, Chattogram**		
4.	**Name of the Department:**	**Electrical and Electronic Engineering**	**Program:**	**M. Sc. Engg.**
5.	**Name of the Supervisor:**	**Dr. Md. Monirul Kabir**	**Designation:**	**Professor**
6.	**Name of the Co-Supervisor (if any)**	**Not Applicable (N/A)**	**Designation:**	**N/A**
7.	**Date of First Enrolment:**	**27 March, 2018**		
8.	**Tentative Title (Block Letters):**	**AN IMPROVED METHOD TO MITIGATE FREQUENCY DISTURBANCES IN THE POWER SYSTEM DURING CYBER-ATTACK**		

9. Background and present state of the problem:

The growing electrical loads on interconnected grid systems make the system larger day-by-day. Therefore, operational deregulation causes dramatic changes in the current electrical systems. As a result, the power system becomes vulnerable and less reliable. On the other hand, providing the quality of power supply has become a critical issue due to the growth of electrical loads. Considering all these aspects,in order to make the system stable, especially frequency should be kept constant to its pre-assigned value. The whole system may collapse due to any frequency disturbance. In the interconnected power system, the cyber threat to the power plant is considered a powerful disruption that can severely unstable the system [1]. To mitigate this disturbance, advanced control measures should be taken, including the communication interface. For this, a suitable steady state condition is required to ensure a smooth power supply.

Nowadays, modern power system industry uses the supreme technological innovation that enables more adaptable and efficient access to the system structure. In addition, the reliability and security of information communication technology (ICT) and digital computer techniques are crucial for the operation of power systems, which increases the risk of cyber-attacks. The advanced control loop, sensor and communication networks are the cyber component of the power plant. To ensure system stability, impacts of cyber-attack on power system should be analyzed properly [2]-[5]. Confidential data is transferred using the communication network, which is one of the cyber-vulnerable components of the power system. An attacker can get it while sending data from the sensing department to the control department at the power station. The attacker can gain control over the automatic controller of a power plant after accessing confidential information. Ultimately, any change to the controller actions may create malicious data accessing in the controller, which disrupts the stability of the system. The authors have discussed about load frequency control (LFC), automatic generation control (AGC), automatic generation control-proportional, integral and derivative (AGC-PID), control switching unit (CSU) presented in [1], [2], where the nominal frequency is tried to be fixed although the change of load is made during cyber-attacks. It is known that failure of the power system may occur due to the maximum frequency deviation [6]. Therefore, to keep the desired frequency in the power system, an optimal and robust controller is needed. Although the existing controllers, such as, LFC, AGC, AGC-PID and CSU tried to solve the frequency disturbances during cyber-attacks, they failed to achieve significant improvement in such cases. However, to overcome such limitation, an effective and robust controller, i.e., Linear Quadratic Regulator (LQR) controller has been presented in this proposal for providing stable frequency in power system during cyber-attack.

10. Objectives with Specific Aims and Possible Outcomes:

Objectives:

Whenever a system disruption is occurred, such as, generation or, load imbalance or, any cyber-attack fault occurs in the power system, the system can lose its stability or, causes poorly damped oscillations. In this regard, to improve system efficiency, the research objectives are as follows:

(a) To develop an improved method integrating LQR controller to reduce frequency disturbancesin the power system during cyber-attack.
(b) To compare the performances of the developed method with the conventional methods using the controllers, such as, Load frequency control (LFC), Automatic generation control (AGC), Automatic generation control-Proportional, integral and derivative (AGC-PID), and Control switching unit (CSU).

Possible Outcomes:

It is expected from the proposed method:
(a) The proposed method integrating LQR controller is able to improve frequency deviation and settling time in reducing the frequency disturbances during cyber-attack in the power system.
(b) A faster and reliable stability improvement of the power system can be achieved by this proposed controller.

11. Outline of Methodology:

The entire working processto mitigate the frequency disturbances in the power system using the proposed method integrating LQR controller is shown in Fig. 1:

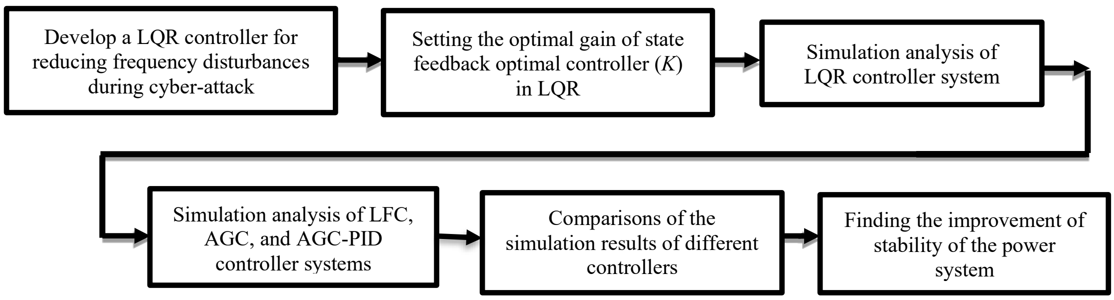

Fig. 1: Block diagram of the entire working process for mitigating the frequency disturbances in the power system using the proposed method using LQR controller.

Step 1: Initially, develop alinear quadratic regulator (LQR) controller for mitigating frequency disruptionsof the power system during cyber-attack.

Step 2: The feedback optimal controller gain *K* must be adjusted with the proper set value for a suitable transientresponse of the system. In this work, the proposed LQR controller is presented in Fig. 2, adapted from [7].The parameters of LQR utilized in this paper are the weighting matrices of Q and R.Prior to determining the parameter of LQR, a set of transfer functions of this model is designed from characteristics equations derived from Routh-Hurwitz array of newly established numerical problem presented in [7].

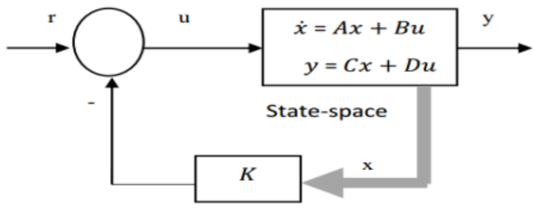

Fig. 2: The proposed method using LQR controller for a power system.

Step 3: To evaluate the proposed LQR controller performance, in this step, a series of experiment is conducted using MATLAB Simulink tool.

Step 4: In this step, another three controllers, such as, load frequency control (LFC), automatic generation control (AGC), automatic generation control-proportional, integral and derivative (AGC-PID), have been used that are implemented in the similar power system models individually. The transfer functions of these models are designed from characteristics equations derived from Routh-Hurwitz array of newly established numerical problem presented in [7],while the Proportional-Integral-Derivative (PID) controller gains for AGC-PID are determined using the tuning process.A set of simulation analysis in terms of frequency deviation and settling time were done for these controllers using MATLAB Simulator.

Step 5: The rigorous comparisons between the results of LQR, LFC, AGC and AGC-PID as well as CSU [2] are performed in this step in terms of dynamic response parameters.

Step 6: In this step, the improvement of the results for our proposed LQR controlleris investigated from the above comparisons.

12. References:

[1] M. Hassan, N. K. Roy and M. Sahabuddin, "Mitigation of Frequency Disturbance in Power Systems during Cyber-Attack",*2nd International Conference on Electrical, Computer & Telecommunication Engineering (ICECTE*), pp. 1 - 4, Rajshahi, 2016.

[2] M. A. Rahman, M. S. Rana and H. R. Pota, "Mitigation of Frequency and Voltage Disruptions in Smart Grid during Cyber-Attack," *Journal Control Automatic Electric System*, vol. 31, pp. 412-421, Jan. 2020.

[3] M. Mohan, N. Meskin and H. Mehrjerdi, "A Comprehensive Review of the Cyber-Attacks and Cyber-Security on Load Frequency Control of Power Systems," *Energies*, vol. 13, no. 15, pp. 1 -33, 2020.

[4] R. Deng, G. Xiao, R. Lu, H. Liang and A. V. Vasilakos, "False Data Injection on State Estimation in Power Systems Attacks, Impacts, and Defense: A Survey," in *IEEE Transactions on Industrial Informatics*, vol. 13, no. 2, pp. 411-423, April 2017.

[5] A. Farraj, E. Hammad and D. Kundur, "On using distributed control schemes to mitigate switching attacks in smart grids," *IEEE 28th Canadian Conference on Electrical and Computer Engineering (CCECE)*, pp. 1578-158, Halifax, Canada, 2015.

[6] M. A. Mahmud, "An alternative LQR-based excitation controller design for power systems to enhance small-signal stability", *International Journal of Electrical Power & Energy Systems*, vol. 63, pp. 1-7, 2014.

[7] H. Saadat, "Power System Analysis", *McGraw-Hill*, 3rdedition, 2011.

13. List of Courses having Course No., Course Name, Credit, Grade, Grade Point and G.P.A:

Course No.	Course Name	Credit	Grade	Grade Point	GPA
EEE-6309	Advanced High Voltage Engineering	3.00	A regular	3.50	**3.42**
EEE-6505	Intelligent Control System	3.00	A plus	4.00	
EEE-6603	Power Semiconductor Circuits	3.00	A regular	3.50	
EEE-6203	Neural Network Theory and Applications	3.00	A Plus	4.00	
EEE-6301	Optimization of Power System Operation	3.00	B plus	3.00	
EEE-6902	Data Communication & Computer Networks	3.00	B Regular	2.50	

Signature of the Tabulator / Course Coordinator: ....

14. Cost Estimate:

(a) Cost of Material (Break-up needed) Tk.....................

(b) Conveyance/ Data Collection (With Break-up) Tk …………

(c) Typing, Drafting, Binding & Paper etc. Tk 5,000.00

15. Justification of having Co-Supervisor: N/A

16. Doctoral Committee/ AC(PG) reference:

Meeting no.:………………Resolution No.:……………………Date:……………….

17. Appointment of Supervisor & Co-Supervisor Approved by the CASR

Meeting No.: 42th Resolution No.: 3(Kha) Date: 26.02.2019

18. Appointment of Doctoral Committee Approved by the CASR

Meeting No. (Only for Ph. D):...............Resolution No..Date..........................

19. Result of the comprehensive examination for Ph. D (Photocopy of the result should be enclosed)

Date:...Satisfactory/Unsatisfactory.

20. Number of Postgraduate Student(s) Working with the Supervisor at Present:

<table>
<tr><td rowspan="9">...
Signature of the Student

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Signature of the Supervisor

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Signature of the Co-Supervisor (if any)

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Signature of the Head of the Department</td><td colspan="2">Name and signatures of the members of the Doctoral Committee (if applicable)</td></tr>
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