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Analysis of power quality issues with interline power flow controller for IEEE 14 bus system

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***Abstract* - This work involves the design of an IEEE 14 bus system with efficient FACTS device i.e., interline power flow controller (IPFC) using back-to-back connected three level inverter. The interline power flow controller with the PID controller aims to provide gating signals for the voltage source converters. An IEEE 14 bus system has been designed for the ensuring the operation of IPFC. The IEEE systems have been considered and affected by faults and determination of the optimal location of IPFC by conducting load flow analysis has been conducted. A Newton Raphson has been considered for conducting load flow analysis. This research work was conducted considering various faults like LLLG, LLG, LG faults for an IEEE 14 bus system. The performance comparison of an interline power flow controller and power system stabilizer for various faults has been analyzed considering an IEEE 14 bus system. All the components of the research work are designed using MATLAB simulink and the results are verified.**

***Index Terms* - interline power flow controller, IEEE 14 bus system, FACTS device.**

INTRODUCTION

Power system stability is a significant problem in the power system to guarantee that it operates continuously and reliably. As a result, it is necessary to safeguard the system from various faulty circumstances and to determine the stability of the power system in the event of any aberrant state, such as a short circuit or an open circuit. Load flow analysis is a method for determining the stability of a power system, and FACTS devices are protective devices that help to maintain that stability. The IEEE 14 bus system was used in this case study. For the analysis, an IEEE 14 bus system was used, as indicated in the diagram below. It is made up of synchronous and asynchronous machines, as well as RLC loads, and three types of buses are formed: PV bus, PQ bus, and slack bus. Some of the buses are classified as PV buses, meaning they generate electricity, while others are load buses. Interline power flow controller (IPFC), a FACTS controller, must be linked to the buses in order to manage power flow between them, and a power system stabiliser must also be attached to the buses in the IEEE 14 bus system. To determine the performance of two controllers in faulty circumstances, a comparison must be made. The best position of the FACTS device must first be identified in order to undertake the aforementioned analysis. The facts devices will provide voltage stability and power system stability. Long transmission lines, an interconnected grid, fluctuating system loads, and line faults in the system all contribute to instabilities in the power system. As a result of these instabilities, transmission line flows are decreased or even tripped. FACTS devices improve transmission system stability by increasing transfer capacity and lowering the danger of transmission line trips. Modern power businesses require high-quality energy delivered reliably with no power outages, as well as steady voltage and frequency. Voltage dips, frequency fluctuations, or a lack of supply can cause service disruptions with significant financial losses. The addition of TCSC to the distribution system without increasing the short circuit current level significantly improves customer dependability. The building of a new transmission line has a detrimental impact on the economy and the environment. FACTS devices used in existing transmission lines reduce the need for additional transmission lines, making the system more cost-effective. In Sweden, for example, eight 400 kV networks operate in parallel from north to south to transmit power. FACTS are installed in each transmission system. If FACTS is not used on the present system, studies suggest that four new 400kV transmission systems will be required. While new transmission lines take years to build, FACTS controllers may be installed in a power system in as little as 12 to 18 months. It has the ability to be upgraded in the future and just takes a modest amount of land. The electric utility industry's continual expansion and growth need constant adjustments to a previously predictable business. Electricity is becoming more and more valued as a commodity. As a result, transmission systems are being pushed to their temperature and stability limitations, with an emphasis on the quality of power provided. Financial and market pressures will require a more optimum and dependable functioning of the power system in terms of generation, transmission, and distribution in the developing utility environment. Power systems must operate in a dependable and secure manner, which necessitates the use of advanced technology.

IEEE 14 bus system:

Transmission and utility businesses use power flow studies, which are critical for transmission expansion planning (TEP), operation, and control. Real and reactive powers, as well as voltage magnitude and angle at each bus in the system, are the major outcomes of these research. The research does, however, give a lot more important information, such as line currents and line losses. Because of the scale and complexity of the systems, as well as the complexity of the mathematical techniques required to solve them, power flow studies on real power systems are done on computers. Because of the nonlinear connection between voltage and power, as well as the fact that receiving-end voltages, not production voltages, are generally unknown values that must be accounted for, an iterative mathematical approach is used. In power systems, power flow calculations are used for planning, operation, and control. The backbone of power flow analysis is power flow equations, often known as power flow. The power flow analysis entails calculating the network's power and voltages for a specific bus state. Load flow studies are performed to guarantee that electrical power is transferred from generators to loads via the grid. The Newton-Raphson approach is used in iterative strategies to solve the load flow issue. In the planning phases of new networks or the addition of new generators to an existing system, power flow analysis is critical. It aids in identifying the best ideal site as well as the proposed system's optimal capacity. It determines the voltages, active and reactive powers at all buses under normal and faulted operation situations, allowing all parameters to be set within the tolerance allowed. The magnitude of voltage, phase angle of voltage, active power, and reactive power of all the buses may be derived from the load flow analysis.

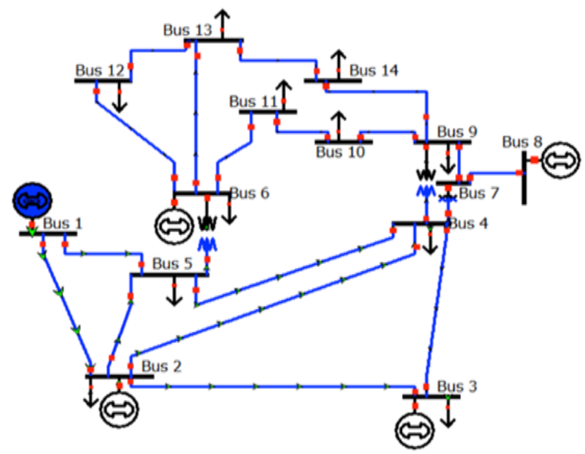


Fig 1: Schematic Diagram of IEEE 14 Bus System

NR method is used for solving nonlinear algebraic equations. It provides faster response and convergence compared to GS method. The following are the Power flow equations in realising NR method and can be given as

$P_i(real\ power) = |V_i| \sum_{j=1}^{m} (|V_j||Y_{ij}| \cos(\emptyset_{ij} + \delta_j - \delta_i))$ (1)

$Q_i(reactive\ power) = -|V_i| \sum_{j=1}^{m} (|V_j||Y_{ij}| \sin(\emptyset_{ij} + \delta_j - \delta_i))$ (2)

Where V_i is the voltage at i^{th} bus, V_j is the voltage at j^{th} bus, Y_{ij} is the admittance of i^{th} and j^{th} bus, $\emptyset_{ij}$ is the angle of admittance, δ_j is the phase angle of j^{th} bus, δ_i is the phase angle of i^{th} bus. J is the jacobian matrix used for solving the NR method which is given as

$$J = \begin{matrix} \frac{dp}{d\delta} & \frac{dp}{|V|} \\ \frac{dQ}{d\delta} & \frac{dp}{|V|} \end{matrix}$$

The bus admitance matrix Y_{ij} is given as

$$Y_{bus} = \begin{bmatrix} Y_{11} & \ldots.. & Y_{ij} \\ \ldots. & \ldots.. & \ldots. \\ Y_{ji} & \ldots & Y_{jj} \end{bmatrix}$$

Interline Power Flow Controller (IPFC):

The Interline Power Flow Controller (IPFC) is a FACTS controller that uses a Voltage Source Converter (VSC) to manage power in a multi-line system at a substation. The primary project's title is

Interline Power Flow Controller (IPFC), which is the subject of interest. The Interline Power Flow Controller (IPFC) project's goal is to determine the power transfer capabilities across two or more lines as well as the suggested voltage control function. A multi-line system's power flow can be controlled using an interline power flow controller (IPFC), Corrects power imbalance between overloaded and under loaded lines. As a result, the difference between stability and temperature level should be as small as possible.

The expression for the AC power through a transmission line can be given as

$$P = (V_S * V_R * \sin \delta) / X. \qquad (13)$$

The Interline Power Flow Controller (IPFC) is designed to offer a comprehensive power flow management scheme for a multi-line transmission system that uses an SSSC for series compensation on two or more lines. A multi-line IPFC is made up of a number of 'n' SSSCs, one for each line of the transmission system to be controlled, all connected by a common dc bus, as shown schematically in Fig 3.1. In addition to executing the independent and controlled reactive power compensation of each line, the IPFC system may transfer actual power between compensated lines.

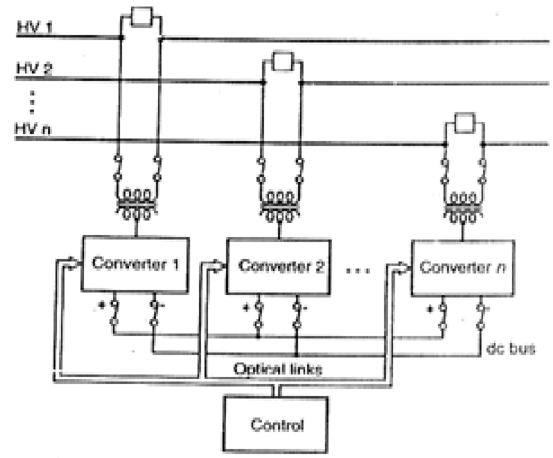


Fig 2: General schematic of IPFC

Simulation Of IEEE 14 Bus System

Finding the Optimal Location of FACTS Device-IPFC in IEEE 14 Bus System

An IEEE 14 bus system which is shown in below figure is considered as a test case and is simulated using MATLAB Simulink.

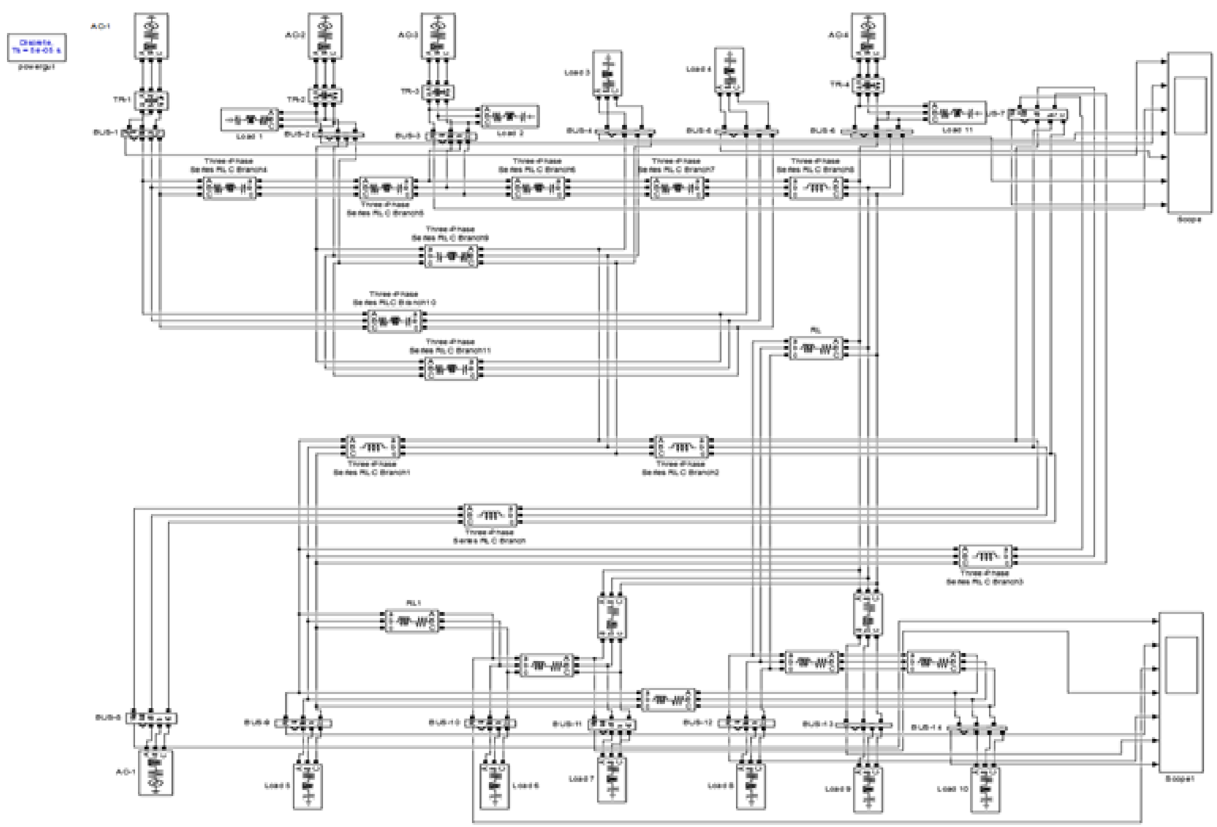


Fig 6: Simulink Diagram of IEEE 14 Bus System

Without fault

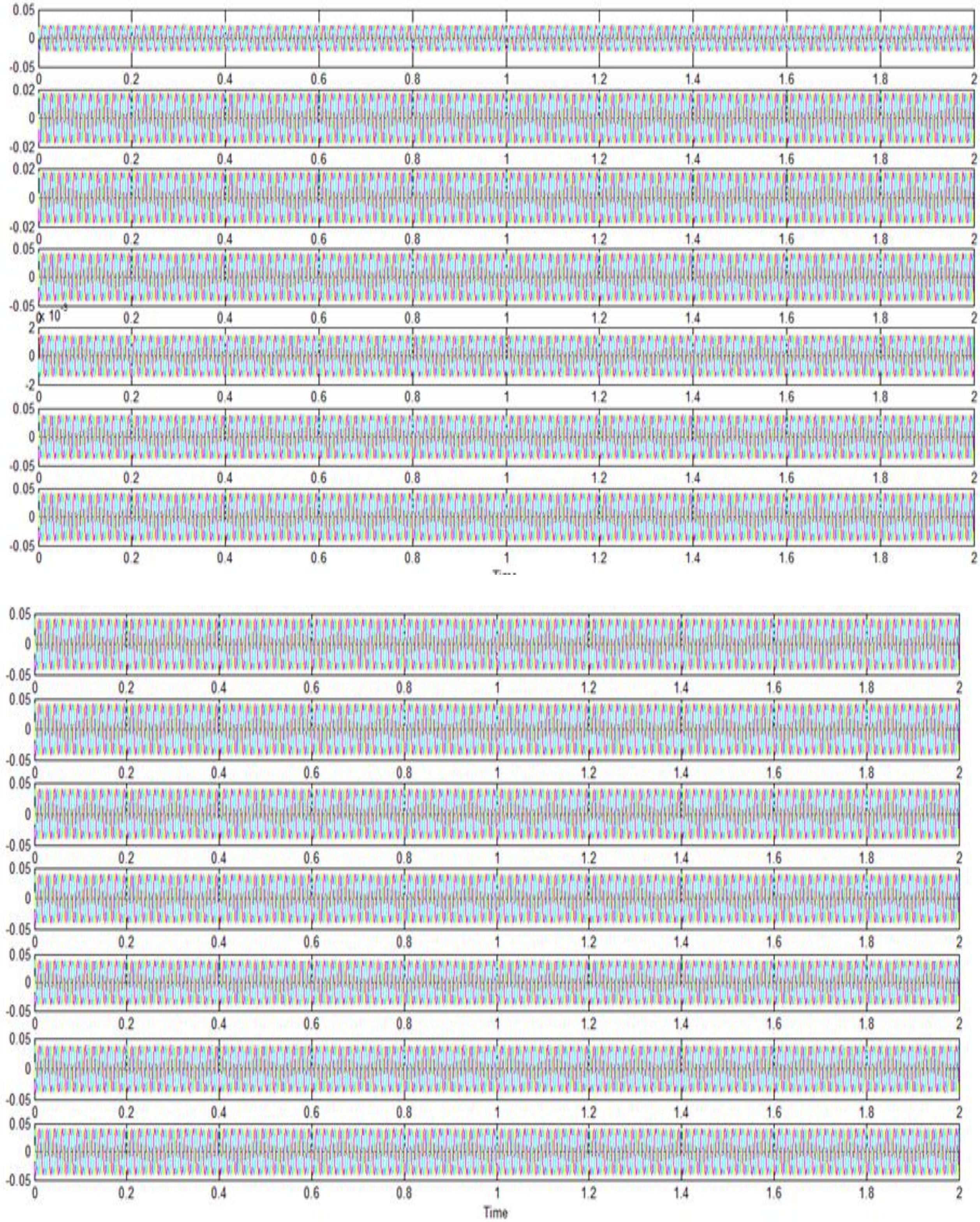


Fig 7: voltage waveform of 14 bus system without fault

Now the LLLG Fault was created at every bus from bus 1 to bus 14 and load flow analysis is performed which is shown below.

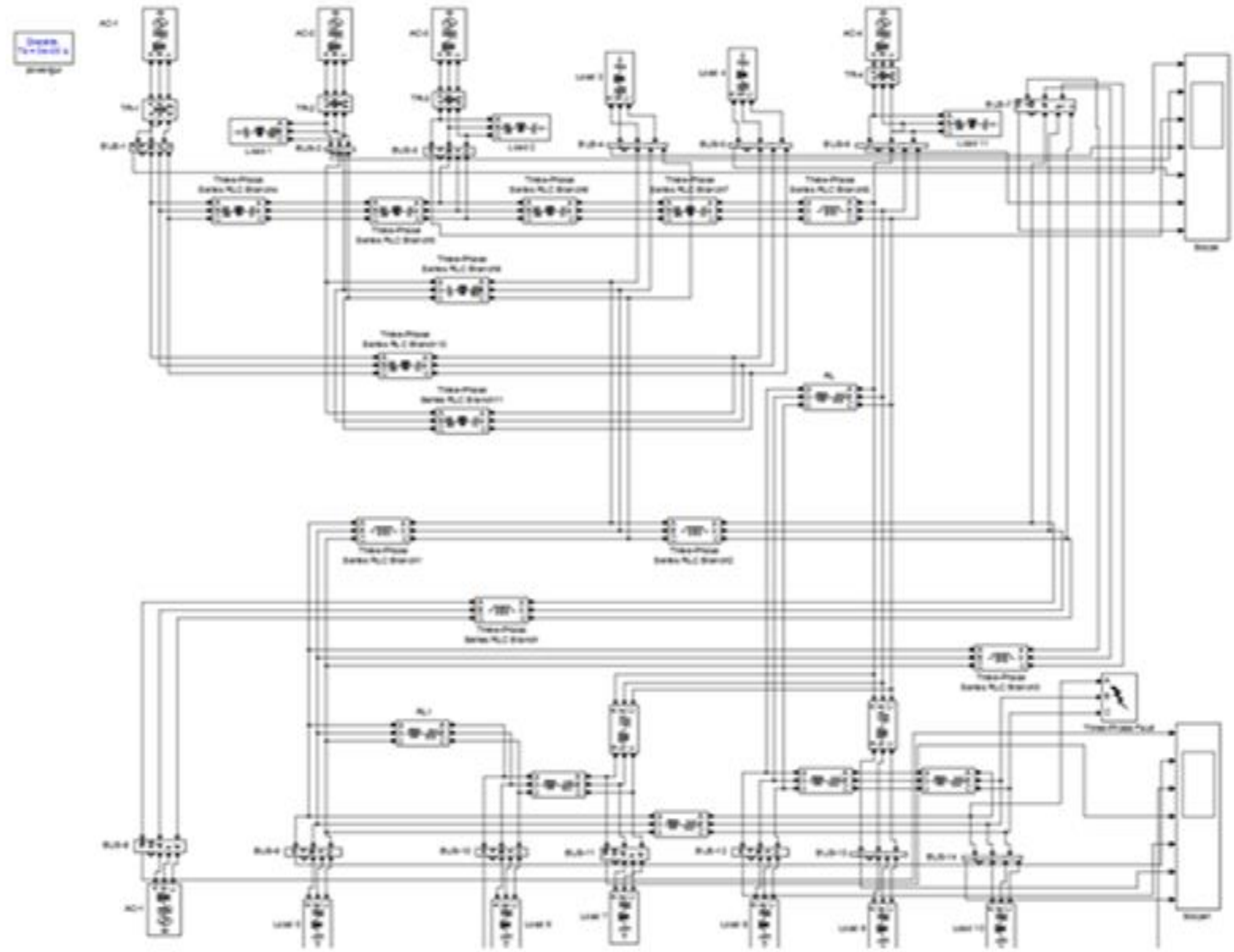
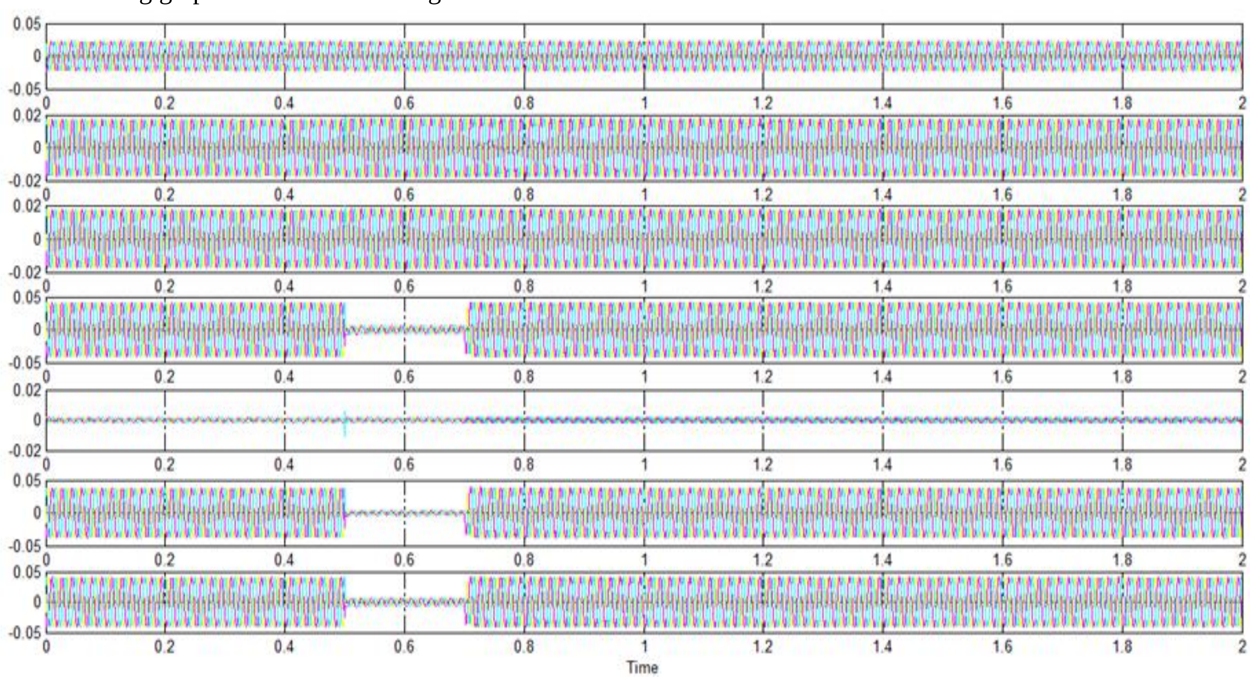


Fig 8: simulink diagram of IEEE 14 bus system with LLLG fault

The following graphs obtained are voltages at all the 14 buses with LLLG fault at bus 14.



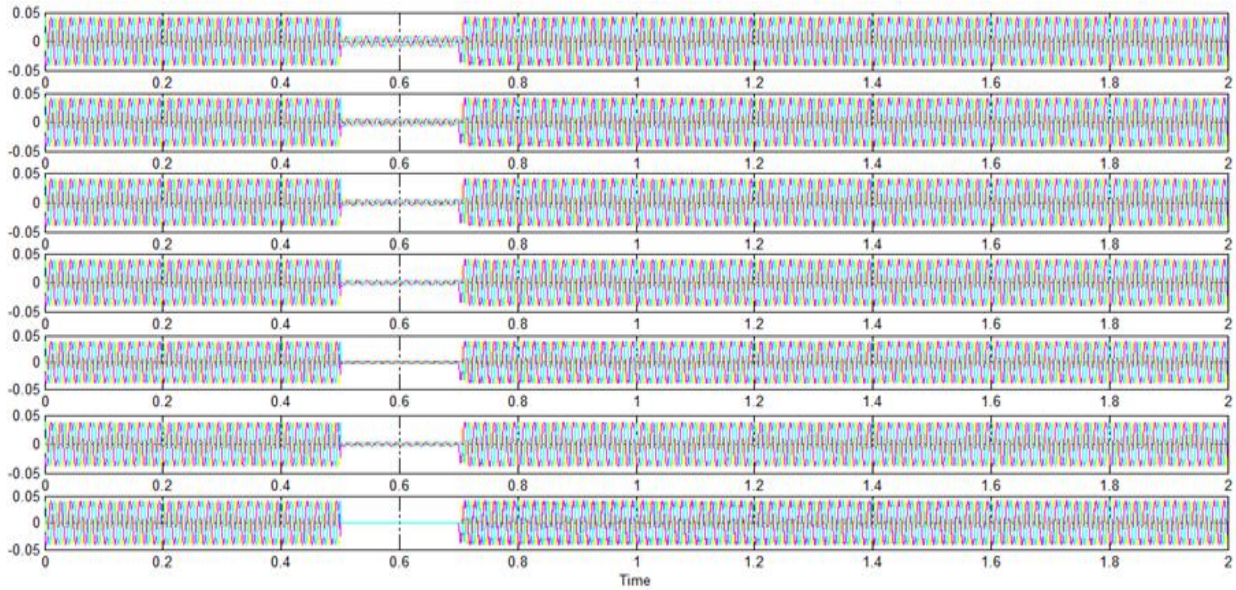


Fig 9: Voltage Waveforms of 14 buses LLLG fault at Bus 14

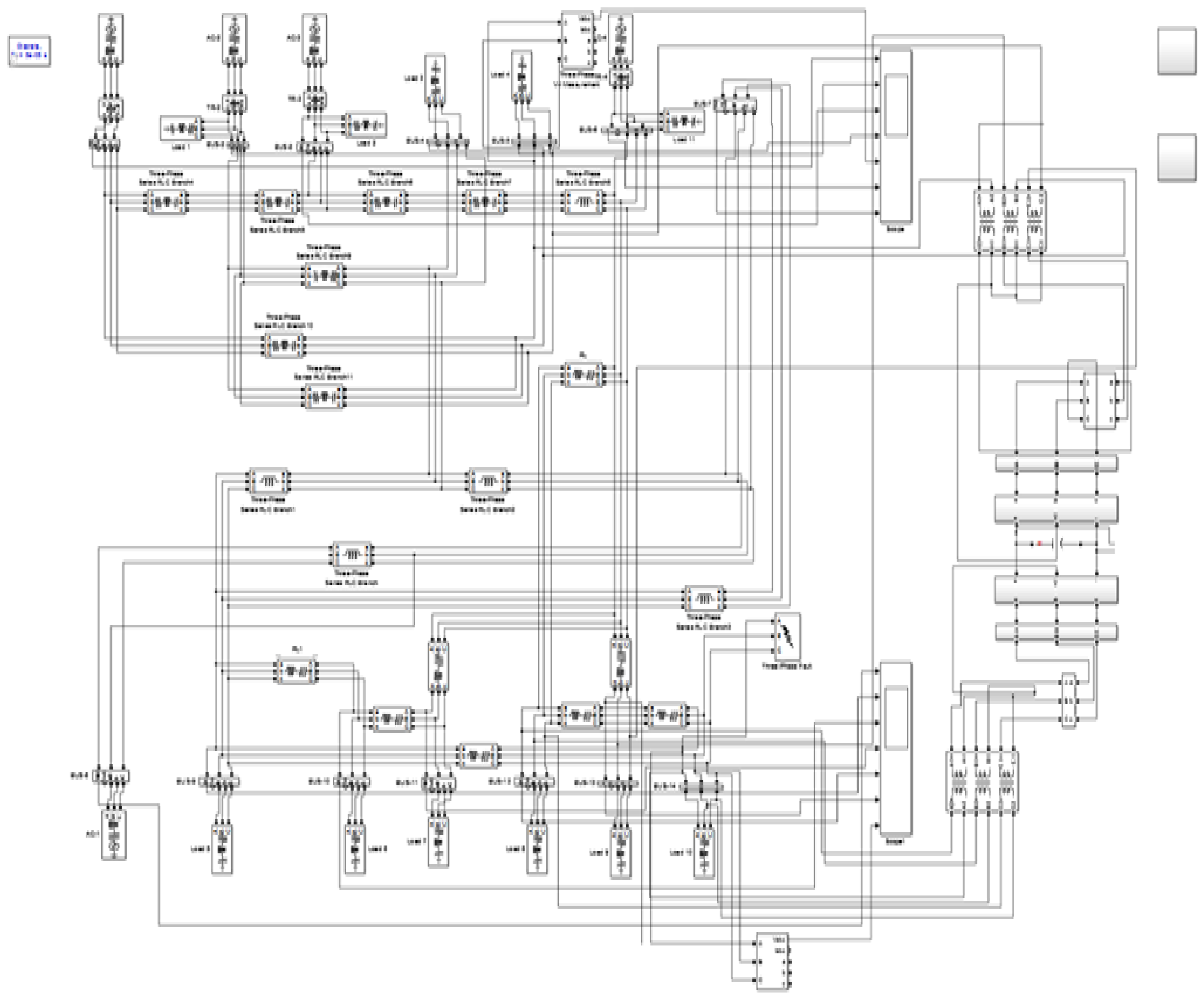
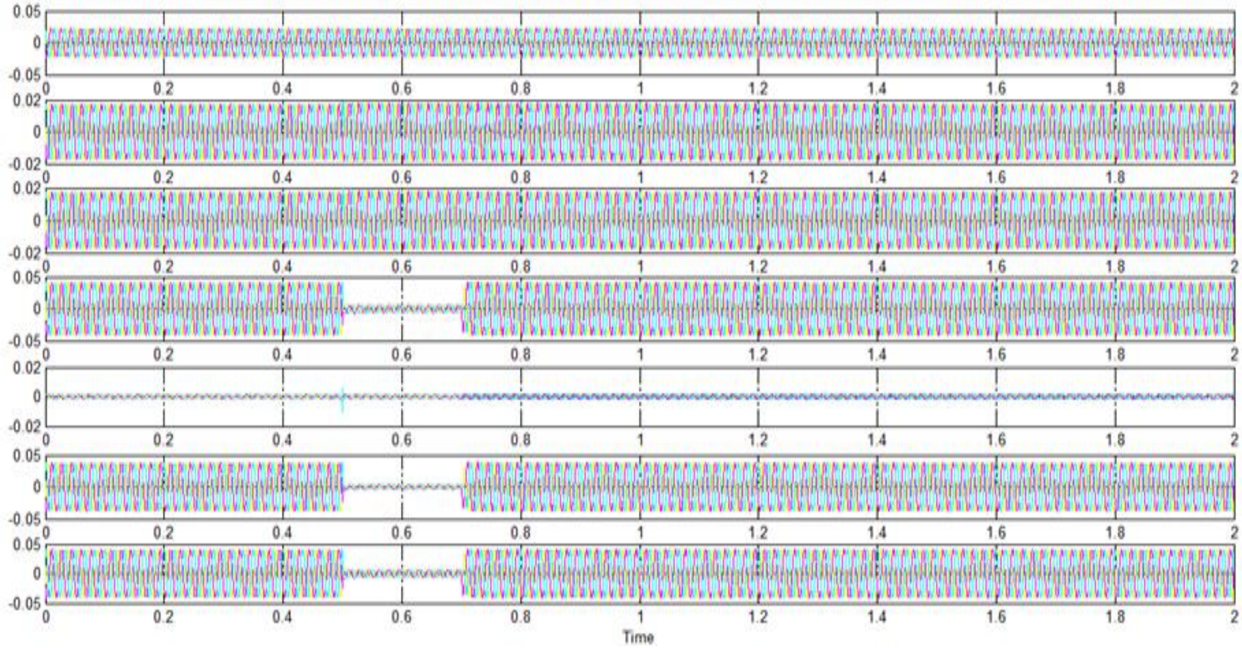


Fig 10: simulink diagram of IEEE 14 bus system with LLLG fault with IPFC

Now IPFC is connected at 5,7,12,14 and the following are the voltages at all the buses.



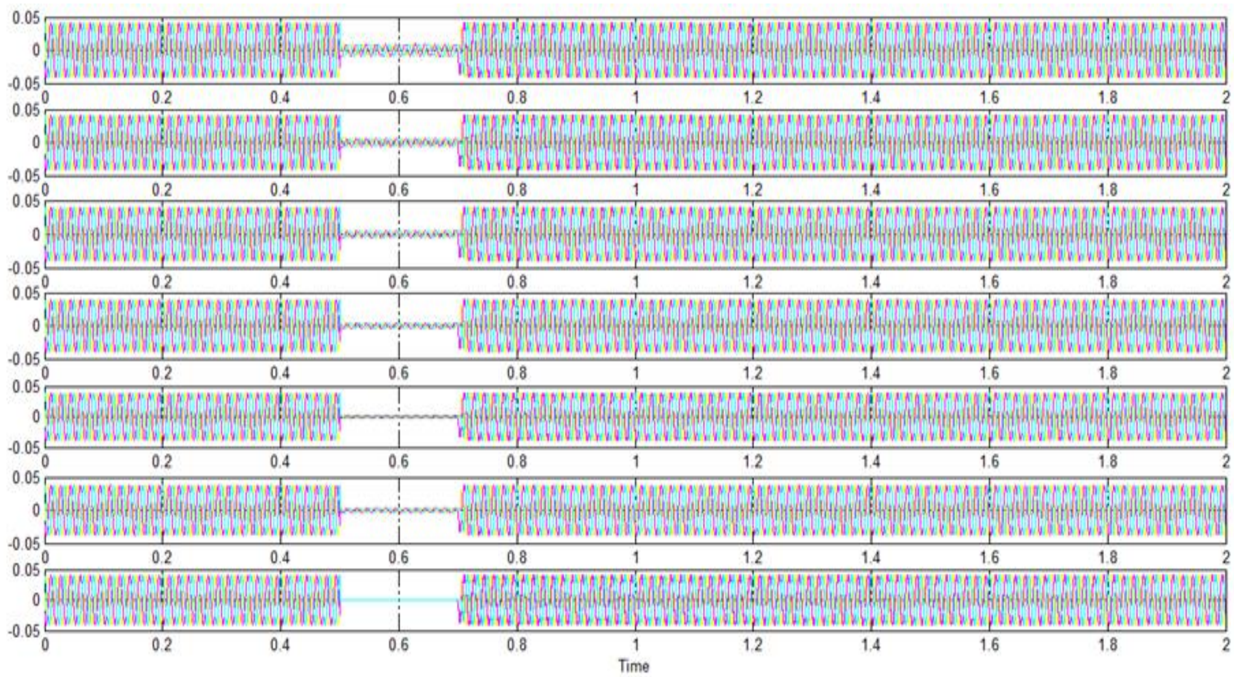


Fig 11: voltage waveform of 14 buses with IPFC

From the load flow data connecting IPFC at 5,7,12,14 provides better performance than 5,12,13,14. After connecting IPFC at these buses and if fault was created at any bus load flow analysis is maintained by the IPFC. So, the optimal location of IPFC is 5,7,12,14.

CONCLUSIONS

The design of an efficient FACTS device ie., interline power flow controller (IPFC) using back-to-back connected three level inverter has been designed in this work. The interline power flow controller has been designed with the PID controller to provide gating signals for the voltage source converters. An IEEE 14 bus system has been designed for the ensuring the operation of IPFC. The IEEE systems have been considered and affected by faults and determination of the optimal location of IPFC by conducting load flow analysis has been conducted. A Newton Raphson has been considered for conducting load flow analysis. This research work was conducted considering various faults like LLLG, LLG, LG faults for an IEEE 14 bus system. The performance comparison of an interline power flow controller and power system stabilizer for various faults has been analyzed considering an IEEE 14 bus system. All the components of the research work are designed using MATLAB simulink and the results are verified.

REFERENCE

[1] Ajami, A. and Kami, A.-R., "Modeling and Controlling of IPFC Based Current-Source Converter," Computer and Electrical Engineering, 2009. ICCEE '09. Second International Conference on, Vol.1, pp.353- 357, 28-30, Dec. 2009 doi:10.1109/ICCEE.2009.178

[2] Alomoush, M.I., "Coordinated tuning of IPFC and PSS to improve power system stability using BFO," Universities Power Engineering Conference (UPEC), 2010 45th International, pp.1-6, 2010.

[3] Aminifar, F., Fotuhi-Firuzabad, M., Nasiri, R. and Khodaei, A., "Effect of Interline Power Flow Controller (IPFC) on interconnected power systems adequacy," Power and Energy Conference, 2008. PECon2008. IEEE 2nd International, pp.1358-1363, 1-3 Dec. 2008 doi: 10.1109/PECON.2008.4762689.

[4] Athamneh, A.A. and Wei-Jen Lee "Benefits of FACTS devices for power exchange among Jordanian interconnection with other countries," Power Engineering Society General Meeting, 2006. IEEE, pp.7 doi: 10.1109/PES.2006.1709066

[5] Beekmann, A., Marques, J., Quitmann, E. and Wachtel, S., , "Wind energy converters with FACTS Capabilities for optimized integration of wind power into transmission and distribution systems," Integration of Wide-Scale Renewable Resources into the Power Delivery System, 2009 CIGRE/IEEE PES Joint Symposium, pp.1, 29-31 July 2009.

[6] Bharathi, R. and Rajan, C.C.A., "An Advanced FACTS Controller for Power Flow Management in Transmission System Using IPFC," Process Automation, Control and Computing (PACC), 2011 International Conference on, pp.1-6, 20-22 July 2011 doi:10.1109/PACC.2011.5978982.

[7] Bhowmick, S., Das, B. and Kumar, N., "An Advanced IPFC Model to Reuse Newton Power Flow Codes," Power Systems, IEEE Transactions on, Vol.24, No.2, pp.525-532, May 2009 doi:10.1109/TPWRS.2009.2016643.

[8] Chansareewittaya, S. and Jirapong, P., "Power transfer capability enhancement with optimal maximum number of facts controllers using evolutionary programming," IECON 2011 - 37th Annual Conference on IEEE Industrial Electronics Society, pp.4733-4738, 7-10 Nov. 2011 doi: 10.1109/IECON.2011.6119996.

[9] Chengaiah, Ch. and Satyanarayana, R.V.S., "Power flow assessment in transmission lines using Simulink Model with UPFC," Computing, Electronics and Electrical Technologies (ICCEET), 2012 International Conference on, pp.151-155, 21-22 March 2012 doi: 10.1109/ ICCEET.2012.6203778.

[10] Du, Z.B., Zhang, Y., Liu, L., Guan, X.H., Ni, Y.X. and Wu, F.F., "Structure-preserved power-frequency slow dynamics simulation of interconnected ac/dc power systems with AGC consideration," Generation, Transmission and Distribution, IET, Vol.1, No.6, pp.920- 927, Nov. 2007, doi: 10.1049/iet-gtd: 20070058.