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A Wide Area Monitoring System Using Neuro Control Technique for Load Restoration

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Abstract: System restoration following a blackout is one of the most important tasks for power system planning and operation. The restoration process returns the system back to a normal operating condition following an outage of the system. With the development of the wide area monitoring system (WAMS) using neuro control technique, voltage can be controlled and power system operators are capable of accessing to more accurate data in the restoration stage after a major outage. In this work, a restorable load estimation method is proposed by employing WAMS to monitor the system parameters in case the newly recovered system becomes unstable again. The concept of power conversion from renewable energy sources is included to compensate voltage sag during addition of new loads are analyzed and simulated using MATLAB. This improves the overall system reliability and avoids cascaded blackout during fault occurrence.

Keywords: Load restoration, Voltage Sag, restorable load, Wide Area Monitoring System (WAMS), Neuro control technique.

I. INTRODUCTION

The electrical power system is not a simple thing it's a complex man-made system so it has many problems where as on the other end, it should reliable and supply electrical energy continuously without any interruption [1]. There should be no blackout and outage. The black-outs and especially infrequent outages is a combination of series of interrelated events. These series of events are hard to account even with modern powerful systems and can no longer be contained to the small portion of the system. Sometimes these small events or disturbances can be amplified to a system wide effect. Therefore for this purpose many techniques have been developed to survive the power system during disturbances and to continue its operation [2]. Recent developed technique is wide area monitoring system using Neuro control technique. It is a technique which controls voltage during voltage sag while adding additional load to the system. Also it includes production of power from renewable energy sources such as wind energy to satisfy the load demand. WAMS became one of the most recent technologies that are quite popular for upgrading the traditional electric grid [2], [3]. This upgrade has become a necessity to modernize the electricity delivery system following the occurrence of major blackouts in power systems around the world. Although many algorithms were developed in the past for online monitoring of transmission systems and distribution systems including the estimation of operating frequency, the required level of details for real-time online assessment is yet to be achieved [4]. Based on the dynamic characteristics of power systems, the procedure of system restoration is generally divided into three stages: black start, reconfiguration of the network and restoration of load [2], [6]. WAMS consists of a number of Phasor measurement unit (PMU) and Phasor data concentrator (PDC) [7]. Data provided by the PMUs are very accurate and enable system analysts to determine the exact sequence of events which have led to the

blackouts, and help analyze the sequence of events which helps to find the exact causes and malfunctions that may have contributed to the catastrophic failure of the power system [8]. Moreover, discrete restorable loads are employed considering the limited number of circuit-breaker operations and the practical topology of distribution systems [1], [5],[10]-[14]. In this work, a restorable load estimation method is proposed employing WAMS data after the network frame has been reenergized, and it is also employed to monitor the system parameters in case the newly recovered system becomes unstable again.

II. BLOCK DIAGRAM

The Block diagram is shown in fig 1. Here the voltage source is connected to the load through line impedance and transformer. WAMS measures the voltage and current delivered to an essential load. In case of voltage sag or while adding additional load to the system, renewable energy sources such as wind energy can be used for load restoration. DFIG can be used to covert electrical energy from the wind which is converted to DC by using rectifier. Then the AC voltage can be passed to the Buck-boost converter which can increase or decrease the voltage depending on the demand. Two neurons control technique can be used to provide pulse for the buck boost converter. Then Pulse can be provided to an inverter by using PI Controller which converts the DC voltage to an AC voltage which can be supplied to satisfy the load demand

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through transformer. Hence the load can be restored and provides a continuous power supply.

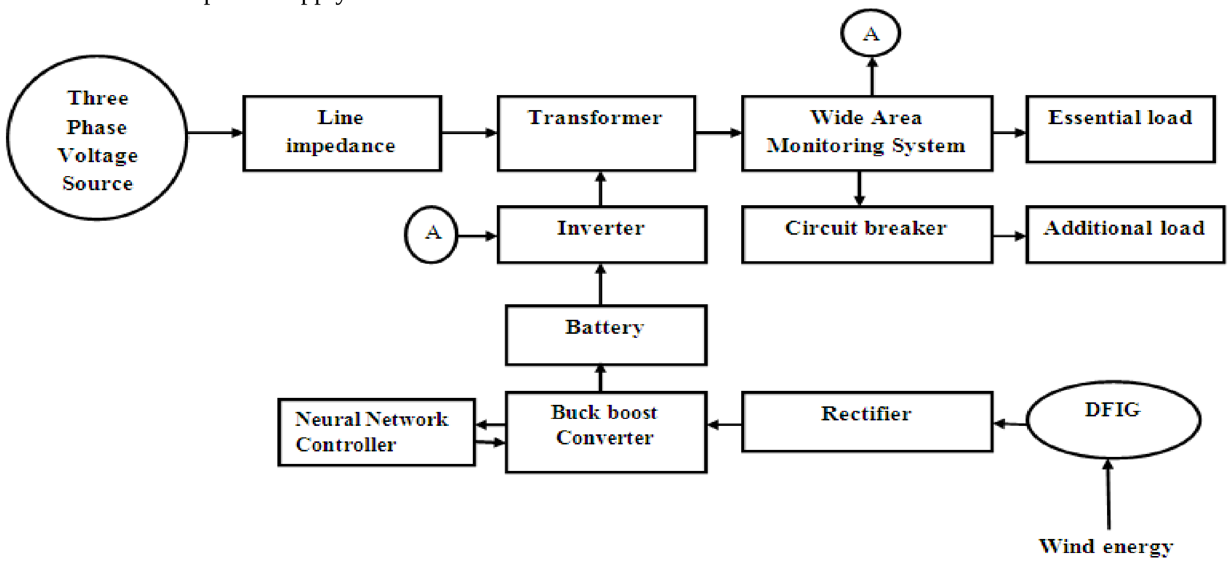

Fig.1. Block diagram of WAMS using neuro control technique

III. WIDE AREA MONITORING SYSTEM

WAMS are essentially based on the new data acquisition technology of Phasor measurement and allow monitoring transmission system conditions over large areas in view of detecting and further counteracting grid instabilities. Current, voltage and frequency measurements are taken by Phasor Measurement Units at selected locations in the power system and stored in the data concentrator every 100 milliseconds. The measured quantities include both magnitudes and phase angles, and are time synchronised via Global Positioning System (GPS) receivers with an accuracy of one microsecond. This early warning system contributes to increase system reliability by avoiding the spreading of large area disturbances, and optimizing the system performance. The capability to model and simulate electricity grid behavior over a range of time domains, frequency domains, and topological resolutions need to be developed. The applications comprise fast dynamic tools for angle transient and voltage stability and mid-term, long-term modeling to simulate all sorts of power plants and non-linear devices.

A. Wide Area Control

On-line dynamic analysis could be conducted based on the most recent system information as data, statuses and topology structures. The security of the system could anticipate failures of more than one critical component and simulations will be available to prevent actions or correct situations. The investment in communication is really the big issue for true feedback control. The measurements can come from several sources: SCADA, EMS applications, PMU and PDC. The secure region is constrained by the limits are relay settings, transient voltage dip/rise, voltage and frequency limit.

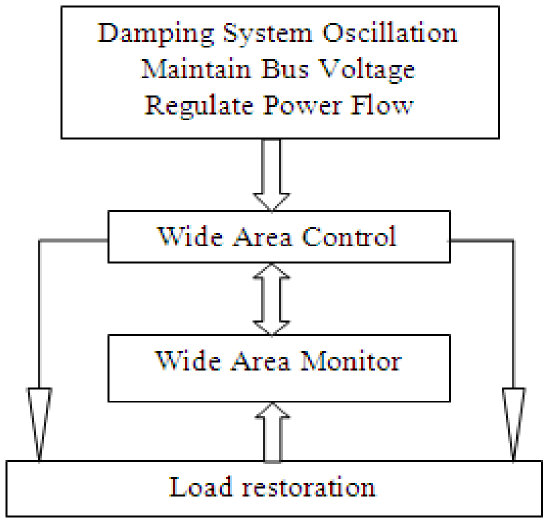

Fig. 2. Schematic diagram of Wide Area Control

The Wide Area Control (WAC) coordinates the actions of the distributed agents using SCADA (Supervisory Control and Data Acquisition), PMU or other available information. The WAC receives information/data of different areas in the power system and based on some predefined objective functions, sends appropriate control/feedback signals to the distributed agents in the power network. The increasing complexity and highly nonlinear nature of the power system today requires online wide area monitoring techniques for the effective control of power network with an adaptive WAC. The major motivation to have a wide area monitoring and control scheme is for the following benefits:

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a. Transmission capacity enhancement can be achieved by on-line monitoring of the system stability limits and capabilities.
b. Power system reinforcement based on feedback obtained during analysis of system dynamics.
c. Introduction of a coordinated approach for the execution of stabilizing actions in case of severe network disturbances.
d. Triggering of additional functions by a WAC.
e. Better understanding of the dynamic behavior of the system.

B. Wide Area Protection

When an abnormal condition/failure is not eliminated but spread, it can lead to catastrophic conditions. Work should be conducted to determine a security index and proximity to blackout in order to prevent or otherwise correct the system condition. So in all such cases there is a need of protection which consists of the following factors:
a. Classification of the disturbance
b. Location of the disturbance
c. Identification and prediction of disturbance

C. Neural Networks

The ultimate goal of the system restoration is to restore as much load as possible while in the shortest period of time after a blackout, and the restorable load can be estimated by employing WAMS using Neural network. This system Composed of two "neurons" that co-operate to perform the desired function. Neural networks are able to identify/model multiple-input, multiple-output time varying systems as generators and, with continually online training these models can track the dynamics of these systems thus yielding adaptive identification for changes in operating points and conditions. The proposed method is based on the design of a wide area monitor based on a neural network for a load restoration.

IV. **WIND ENERGY**

Wind possesses energy by virtue of its motion. A wind turbine is a device that converts kinetic energy from the wind into electrical power. A wind turbine used for charging batteries may be referred to as a wind charger. The wind turbines are manufactured in a wide range of vertical and horizontal axis types. The smallest turbines are used for applications such as battery charging. Arrays of large turbines, known as wind farms, are becoming an increasingly important source of renewable energy and are used by many countries as part of a strategy to reduce their reliance on fossil fuels. The wind turbine and the doubly-fed induction generator (WTDFIG) are used. The AC/DC/AC converter is divided into two components: the rotor-side converter (C_{rotor}) and the grid-side converter (C_{grid}). C_{rotor} and C_{grid} are voltage-sourced converters that use forced-commutated power electronic devices (IGBTs) to synthesize an AC voltage from a DC voltage source. A capacitor connected on the DC side acts as the DC voltage source. A coupling inductor L is used to connect C_{grid} to the grid. The three-phase rotor winding is connected to C_{rotor} by slip rings and brushes and the three-phase stator winding is directly connected to the grid. The power captured by the wind turbine is converted into electrical power by the induction generator and it is transmitted to the grid by the stator and the rotor windings. The control system generates the pitch angle command and the voltage command signals V_r and V_{gc} for C_{rotor} and C_{grid} respectively in order to control the power of the wind turbine, the DC bus voltage and the reactive power or the voltage at the grid terminals.

V. **SIMULATION RESULTS**

The performance of the proposed concept of simultaneous voltage sag compensation has been evaluated by Matlab/Simulink. To analyze the performance of WAMS using neuro control technique, source is assumed to be pure sinusoidal. Furthermore, for better visualization of results the load is considered as highly inductive.

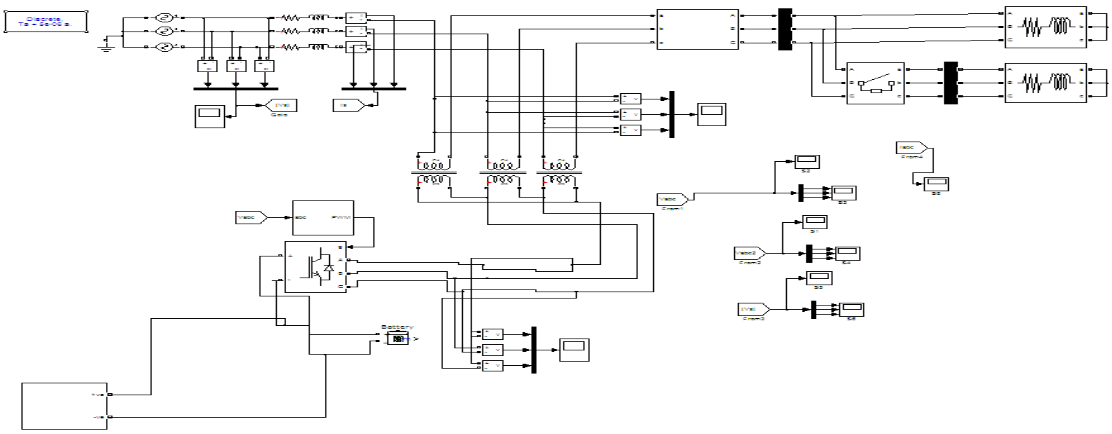

Fig. 3. Simulated Circuit Diagram for WAMS

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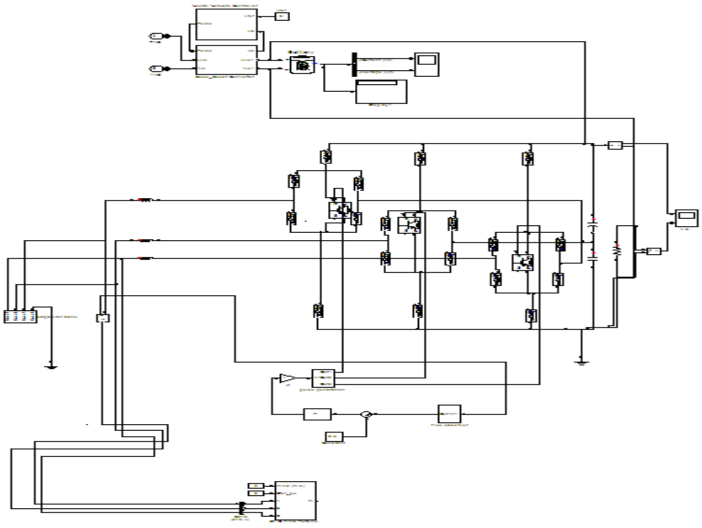

Fig. 4. Simulation diagram for wind energy storage

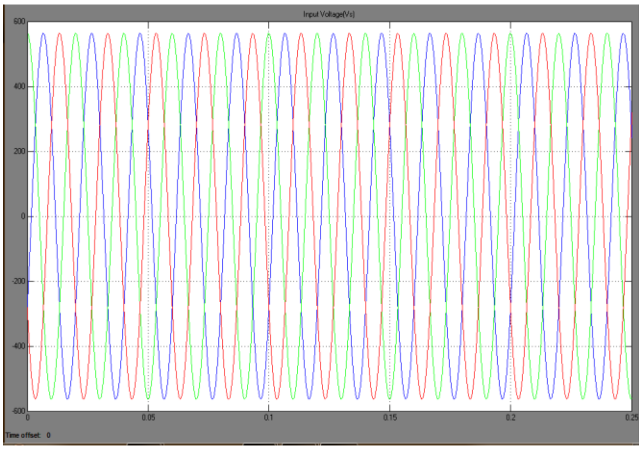

Fig. 5. Input Voltage Waveform

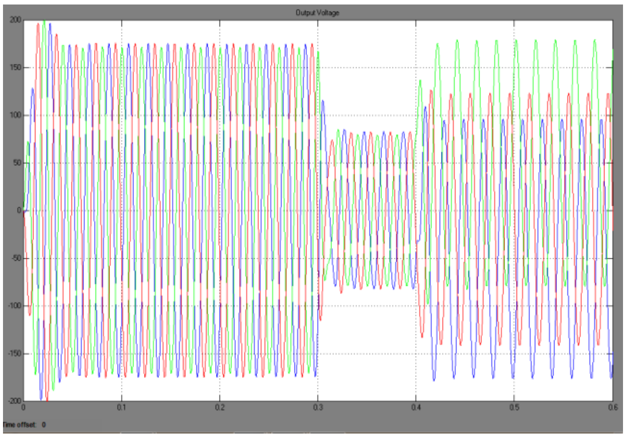

Fig. 7. Output Voltage after Load restoration

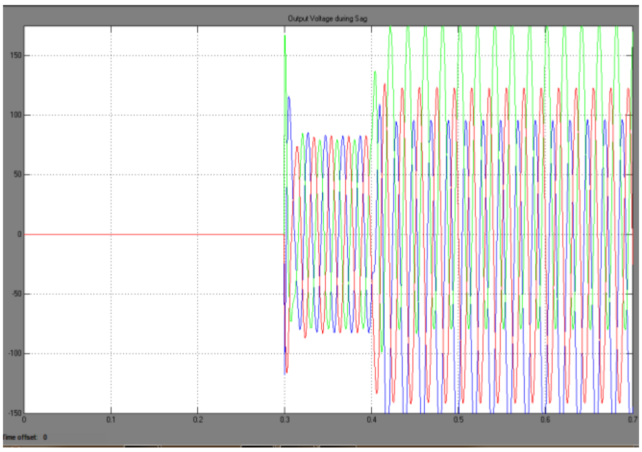

Fig. 6. Output Voltage during Voltage Sag

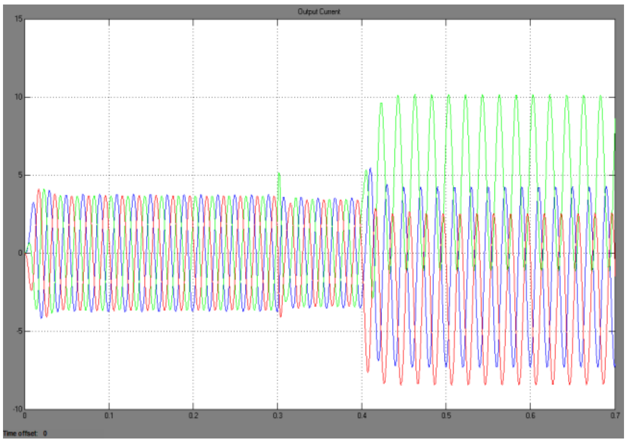

Fig. 8. Output Current

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VI. CONCLUSION

A new concept of controlling voltage sag through using wind power compensation by converter topology based on Neural Network Controller is introduced in WAMS and termed as Unified Power Quality Conditioner (UPQC). The proposed concept of UPQC approach is analyzed for voltage sag and swell conditions. The main purpose of a UPQC is to compensate for voltage imbalance, reactive power, negative-sequence current and harmonics. Based on the real-time system status collected by WAMS, it will be easier for dispatchers to establish the load restoration plan. The simulation results using the real time data for load restoration and demonstrate its effectiveness.

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BIOGRAPHIES

Dr.Govindaraj Thangavel born in Tiruppur, India , in 1964. He received the B.E. degree from Coimbatore Institute of Technology, M.E. degree from PSG College of Technology and Ph.D. from Jadavpur University, Kolkatta,India in 1987, 1993 and 2010 respectively. His Biography is included in Who's Who in Science and Engineering 2011-2012 (11th Edition). Scientific Award of Excellence 2011 from American Biographical Institute (ABI). Outstanding Scientist of the 21st century by International Biographical centre of Cambridge, England 2011.

Since July 2009 he has been Professor and Head of the Department of Electrical and Electronics Engineering, Muthayammal Engineering College affiliated to Anna University, Chennai, India. His Current research interests includes Permanent magnet machines, Axial flux Linear oscillating Motor, Advanced Embedded power electronics controllers,finite element analysis of special electrical machines,Power system Engineering and Intelligent controllers.He is a Fellow of Institution of Engineers India(FIE) and Chartered Engineer (India).Senior Member of International Association of Computer Science and Information. Technology (IACSIT). Member of International Association of Engineers(IAENG), Life Member of Indian Society for Technical Education(MISTE). Ph.D. Recognized Research Supervisor for Anna University and Satyabama University Chennai Editorial Board Member for journals like *International Journal of Computer and Electrical Engineering*,International Journal of Engineering and Technology,International Journal of Engineering and Advanced Technology (IJEAT).International Journal Peer Reviewer for Taylor &Francis International Journal "Electrical Power Components & System"United Kingdom,Journal of Electrical and Electronics Engineering Research,Journal of Engineering and Technology Research (JETR),International Journal of the Physical Sciences,Association for the Advancement of Modelling and Simulation Techniques in Enterprises,International Journal of Engineering & Computer Science (IJECS),Scientific Research and Essays,Journal of Engineering and Computer Innovation,E3 Journal of Energy Oil and Gas Research,World Academy of Science, Engineering and Technology,Journal of Electrical and Control Engineering (JECE),Applied Computational Electromagnetics Society etc.. He has published 132 research papers in International/National Conferences and Journals. Organized 40 National / International Conferences/Seminars/Workshops. Received Best paper award for ICEESPEEE 09 conference paper.Coordinator for AICTE Sponsored SDP on Soft Computing Techniques in Advanced Special Electrica Drives,2011.Coordinator for AICTE Sponsored National Seminar on Computational Intelligence Techniques in Green Energy, 2011.Chief Coordinator and Investigator for AICTE sponsored MODROBS - Modernization of Electrical Machines Laboratory. Coordinator for AICTE Sponsored International Seminar on "Power Quality Issues in Renewable Energy Sources and Hybrid Generating System", July 2013.

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