A survey on Voltage Factor in Smart Grids

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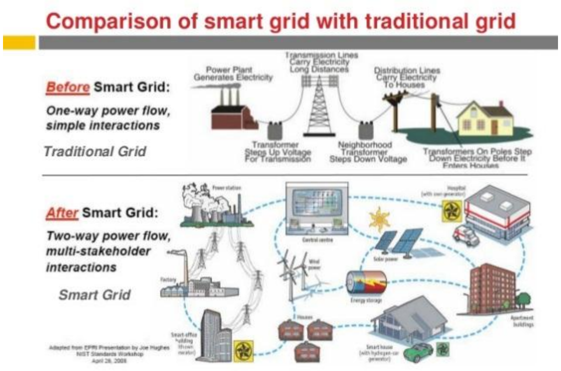
Abstract: The key characteristics of hybrid grid systems are operational performance in transmission, optimization of the hybrid, reliability of the system and efficiency of transmission. With the tremendous increase in amount of distributed generation in distributed networks new voltage control algorithms and schemes related to voltage control are necessary to co-operate. The linearized dependencies between the voltage magnitude and the active and reactive power consumption are the factors on which newly proposed voltage control algorithms are based on. Normally these linearized dependencies are obtained by algorithms, based on accurate grid topology information. These facts are typically missing, inaccurate, unavailable or incomplete due to the traditionally passive operation of low voltage distribution networks, therefore the proposed work introduces a methodology to extract these information based on historical smart meter data only. No grid topology information is required. The proposed scheme incorporates to the changing load conditions in the network. Practical laboratory data is utilized to validate the proposed method in reality. The voltage management strategy was implemented with the obtained voltage sensitivity factors for the laboratory grid.
Keywords: Smart grids, grid identification, load flow, sensitivity analysis, smart metering, voltage control.

1. Introduction:

The Smart grid includes several components that assist better deliver quality power to your home, managing voltage. Power factor measurement is carried out by the smart meters and technology on the distribution grid. The advanced electric meters are smart meters which provide us with more information regarding power delivered to homes. A transformer to step down voltage for the digital electronics is incorporative like other digital devices. Smart grid provides more reliable and efficient power supply that makes electronic devices to operate at their highest efficiencies which in-turn minimizes the cost to run them. Smart grid technology is used to optimize the voltage for every customer they serve by using actual information on voltage. This enables the more efficient and accurate power supply. The steady voltage and frequency is demanded by today's model and sensitive electronics. Higher than normal voltage causes equipment's to operate inefficiently and may cause damage. Similarly, low voltage causes equipment's to work erratically.

The future grid operation is challenged by a high penetration of distributed generators and electric vehicles in low voltage distribution network. For a better utilization of these distribution networks, in order to maintain, to improve, the power supply reliability and quality more intelligent methods must be incorporated. The most challenging tasks due to the nonlinear relationship between the grid voltage and network load is the development of voltage management techniques. In order to obtain voltage sensitivity factors a significant alternative scheme is making small modifications and measuring the result on the voltage factor. This method is inefficient there are several other voltage sensitivity calculation techniques in distribution grids require information about grid topology in order to get the voltage sensitivity co-efficient which increases computational efficiency. The voltages in each of the nodes of the grid system can be calculated with load flow algorithm if distribution grid parameters, load profiles and load models are available.



I. Literature Survey

1. Relevance of Voltage Control, Grid Re-configuration and Adaptive Protection in Smart Grids and Genetic Algorithm as an Optimization Tool in Achieving their Control Objectives:

The Author proposes a high level grid optimization technique using genetic algorithm in achieving voltage control and solving the voltage control problems. Grid optimization is particularly used to make the power grid "AS GOOD AS POSSIBLE" resulting in improving the utilization of current infrastructure and bring changes in investments for new generation, transmission, and distribution facilities. In addition it provides the reduction in overall cost of delivering power to end users improves the reliability of power grid, reduces resource usage and emissions of greenhouse gases and other pollutants. The proposed method uses three important objectives:

1. Voltage control
2. Grid re-configuration
3. Adoptive protection

Genetic algorithm technique is used to obtain the proper understanding among the current relays and distance relays.

2. SMART INTERCONNECTION OF A PV/WIND DG MICRO GRID WITH THE UTILITY DISTRIBUTION NETWORK:

A micro grid is a connection of small end to end electricity users which is connected to a huge centralized grid but is able to function independently which uses a local source of electricity supply. The author proposes a case study on micro grid system based on photo voltaic wind generation. Here a voltage control algorithm is proposed by using MAT LAB/SIMULINK toolbox. The algorithm achieves control over the active and reactive current components. Control operation, testing system and validation are incorporated using the above mentioned toolbox. Active and reactive current measurements are being analyzed and used in further calculations in dual power management. Here the control scheme results in operating photo voltaic system to supply maximum tracked power at different variation levels to the electric nodes which intern exhibits the load following capacity with the centralized grid.

3. DESIGN AND IMPLEMENTATION OF ACCURATE REACTIVE POWER COMPENSATOR FOR RENEWABLE GRID CONNECTED TRANSMISSION SYSTEM:

Due to several drawbacks and disadvantages in the usage of renewable resources like fossil fuels and nuclear energy has put a threat to introduce some other alternative energy resources in order to protect our environment. Hence scientists have come across the alternative method for production of power to maintain a balance in the supply among the source and load demand without utilizing fossil fuels and nuclear energy.

The hybrid grid system is the three layered system namely physical, control and application layer. The changes in the climate and seasonal changes are the outcomes of the renewable resources. Hence the system designed must be in a way that it should take out the maximum power from the energy resource which aims at minimizing the reactive power flow in the transmission line by correction in power factor which in turn reduces the cost for electrical energy.

The Reactive power is a measure for power expressed only in alternating current (AC) electric system. When the current and voltage are not in phase reactive power flows through AC circuit. Author proposes a model of hybrid grid integration of PV (photo voltaic) cells where the grid connected PV and wind turbine structure is proposed. For the above model an reactive power compensator is being developed in order to face the two major problems of load compensating and voltage control. The reactive power compensator model is developed using fourteen software packages which is incorporated through MATLAB software. The outcomes of the proposed model are verified under several related parameters.

4. Voltage sensitivity analysis of a laboratory distribution grid with incomplete data:

For improved power supply reliability and quality of the power transmission highly intelligent methods should be used. Rise in the voltage factor is commonly the important factor to reduce the increase of photovoltaic generation in low voltage network. Introducing high penetration of electric vehicles leads to voltage drop. Therefore there is a need to propose new voltage management schemes. Tremendous challenging task is the development of these voltage management schemes. Many linearized models are usually drawn through voltage sensitivity analysis.

It is not that easy to obtain the grid information in an accessible digital form. Low voltage grids are lesser known and these manually controlled components of electric grids. The grids are identified and the voltage sensitivity coefficients are obtained using different sensitivity models.

The algorithm is proposed in such a way that voltage sensitivity factors are obtained with low complexity. Both active and reactive power, voltage magnitudes of each of the nodes known as control nodes are verified by the smart meters. The algorithm is verified, tested and validated on a distributed grid simulated in MATLAB software toolkit.

5. VVC in the Smart Grid Era:

Volt-VAR control is represented as VVC in the smart grid environment. It is the basic requirement of the electric distribution systems. The main purpose of VVC is to maintain voltage at all nodes under certain loading functions. The main objective of Volt-VAR in smart grids are improving efficiency by reducing technical losses by voltage optimisation, promote a self-healing grid, and provides energy conservation, reduce electrical demand. VVC implies voltage regulating devices. Tremendous deployment of advanced VVC systems for improved efficiency and better components utilization. The author proposes an ideal scheme which identifies the characteristics of the existing system of the VVC system. There are several approaches to voltage regulating devices. The proposed method describes many alternatives for VVC objectives.

The essential role is played by the efficient VVC schemes in the electric utility smart grids. This method improves the overall efficiency by reducing electrical losses and helps to minimize demand for achieving better component usage.

TABLE I. COMPARATIVE SURVEY VOLTAGE FACTOR IN SMART GRIDS:

Number	Title	Publication year	Used algorithms	Advantages and disadvantages
1.	Relevance of Voltage Control, Grid Reconfiguration and Adaptive Protection in Smart Grids and Genetic Algorithm as an Optimization Tool in Achieving their Control Objectives.	2011	Genetic algorithm	Solves the voltage control problems
2.	2. SMART INTERCONNECTION OF A PV/WIND DG MICRO GRID WITH THE UTILITY DISTRIBUTION NETWORK:	2012	Control algorithm	Efficient solar power delivery
3.	DESIGN AND IMPLEMENTATION OF ACCURATE REACTIVE POWER COMPENSATOR FOR RENEWABLE GRID CONNECTED TRANSMISSION SYSTEM	2015	P&E algorithm	Disadvantage: The available power from the Photovoltaic System is highly dependent on solar radiation. Advantage: Increase in the efficiency of the transmission line.
4.	Voltage sensitivity analysis of a laboratory distribution grid with incomplete data	2015	Voltage management algorithm	Voltage correction during voltage drop.
5.	VVC in the Smart Grid Era:	2010	-	Minimal electrical losses, Minimal electrical demand, Reduced energy consumption.

Conclusion:

With incomplete or inaccurate data a linearized load flow model is identified by means of historical smart meter data for radial distribution grids. Information about grid topology is not required. The voltage sensitivities are got depending on historical data are accurate predictions of the real voltage sensitivities.

The approximated voltage sensitivities provide information about both the location and the phase of each node in the network. In voltage management strategies there are several voltage sensitivities. The algorithm has been validated in a practical laboratory surrounding. The algorithms correctly identify the phase to which each household was connected. The voltage sensitivities were used in a voltage control strategy. The required power of an electric vehicle can be consumed without harming the grid is evaluated by a central control unit. The control unit could quickly correct the voltage to a required level when the voltage is dropped below certain limits. For validating the modelling approach proposed in this work, and to provide alternative to the reactive power generated in the small scale distribution for an Electrical Machine Laboratory and Fluid and Thermal Laboratory an experimental setup is being organised. Before the fulfilment of the experimental setup, the thermal analysis of the same will be studied for understanding the response to our proposal under various thermal conditions. The design of the model once developed can be utilized for proper reactive power compensation technique which can manage the voltage in the network, thus decreasing the electrical tariff.

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