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Efficient voltage control strategis for fuel cell energy system in power grids using statcom

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ABSTRACT

This paper presents a method to identify power system impedance in real-time using signals obtained from grid connected power electronic converters. The proposed impedance estimation has potential applications in Fuel cell/distributed energy systems, STATCOM, and solid state substations. The design of STATCOM parameters are considered an optimization problem according to the time domain-based objective function solved by a fuzzy controller that has a strong ability to find the most optimistic results associated with small disturbances imposed by power converters and determine the net impedance back to the source. A data capture period of 5 ms is applied to an accurate impedance estimation which provides the possibility of ultra fast fault detection The paper describes how the proposed method would enhance the distributed generation operation during faults

Keywords: Dispersed Generation, Wind Farm Modeling, Fuel Cell Modeling, STATCOM

INTRODUCTION

Recently the problem of global warming is the concern of different countries to reduce the emission of harmful gases due to electricity generation by burning fossil fuels. Therefore, extensive research and investment are already done for efficient utilization of clean renewable energy as suitable alternative energy. Among the renewable resources wind, solar and fuel cells are growing in importance and gain the interest of energy researches. As green renewable energy resources, wind and fuel cells have gained substitution potential for conventional fossil fuels . In this regard, the cost of electricity generated by wind energy has been continuously decreasing during the last decade. These cost reductions are due to new manufacturing technologies, large capacity, more efficient and more reliable wind turbines [1-4]. On the other hand, the wind speed variation is dependent on environmental conditions. Therefore, in order to ensure renewable energy diversity and effective utilization more than one renewable energy source are combined to form a coordinated and hybrid integrated energy system [5]. Integrated distributed generation is a valid alternative solution for distributed generation.

NEED OF RENEWABLE ENERGY SYSTEM

With high population growth and economic development in the world, there is a very high demand for energy. Traditional fossil sources such

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as oil, coal are costly and have a serious pollution to the environment. To have sustainable growth and social progress, it is necessary to meet the energy need by utilizing the renewable energy resources like wind, biomass, energy, co-generation, etc. In sustainable energy system, energy conservation and the use of renewable source are the key paradigm. The need to integrate the renewable energy like Fuel cell energy into power system is to make it possible to minimize the environmental impact on conventional plant. There has been an extensive growth and quick development in the exploitation of Fuel cell energy in recent years. The individual units can be of large capacity up to 2 MW, feeding into distribution network, particularly with customers connected in close proximity. Today, more than 28,000 Fuel cell generating turbines are successfully operating all over the world.

In the fixed-speed Fuel cell turbine operation, all the fluctuation in the Fuel cell speed are transmitted as fluctuations in the mechanical torque, electrical power on the grid and leads to large voltage fluctuations. During the normal operation, Fuel cell turbine produces a continuous variable output power. These power variations are mainly caused by the effect of turbulence, Fuel cell shear, and tower-shadow and of control system in the power system. Thus, the network needs to manage for such fluctuations. The power quality issues can be viewed with respect to the Fuel cell generation, transmission and distribution network, such as voltage sag, swells, flickers, harmonics etc. However the Fuel cell generator introduces disturbances into the distribution network.

One of the simple methods of running a Fuel cell generating system is to use the induction generator connected directly to the grid system. The induction generator has inherent advantages of cost effectiveness and robustness. However induction generators require reactive power for magnetization.

When the generated active power of an induction generator is varied due to wind, absorbed reactive power and terminal voltage of an induction generator can be significantly affected. A proper control scheme in Fuel cell energy generation system is required under normal operating condition to allow the proper control over the active power production. In the event of increasing grid disturbance, a battery energy storage system for Fuel cell energy generating system is generally required to compensate the fluctuation generated by Fuel cell turbine. A STATCOM-based control technology has been proposed for improving the power quality which can technically manages the power level associates with the commercial Fuel cell turbines.

SCOPE OF THE PROJECT

The scope of the project is to have sustainable growth and social progress, it is necessary to meet the energy need by utilizing the renewable energy resources like wind, biomass, energy, co-generation, etc In sustainable energy system, energy conservation and the use of renewable source are the key paradigm. The need to integrate the renewable energy like Fuel cell energy into power system is to make it possible to minimize the environmental impact on conventional plant. The integration of wind-energy energy into existing power system presents a technical challenges and that requires consideration of voltage regulation, stability, power quality problems. For that this project should be given the solution

STEPS OF IMPLEMENTATION

In the present work shunt active filter & battery energy storage system are considered to achieve the objectives of the compensation of harmonic current generated by a Non-Linear load & maintained stand alone supply for the critical load.

THE OBJECTIVES OF THE PROJECT ARE

To simulate the Micro Wind-Energy power generation unit with battery energy storage to provide uninterrupted power supply to critical load by using MATLAB.

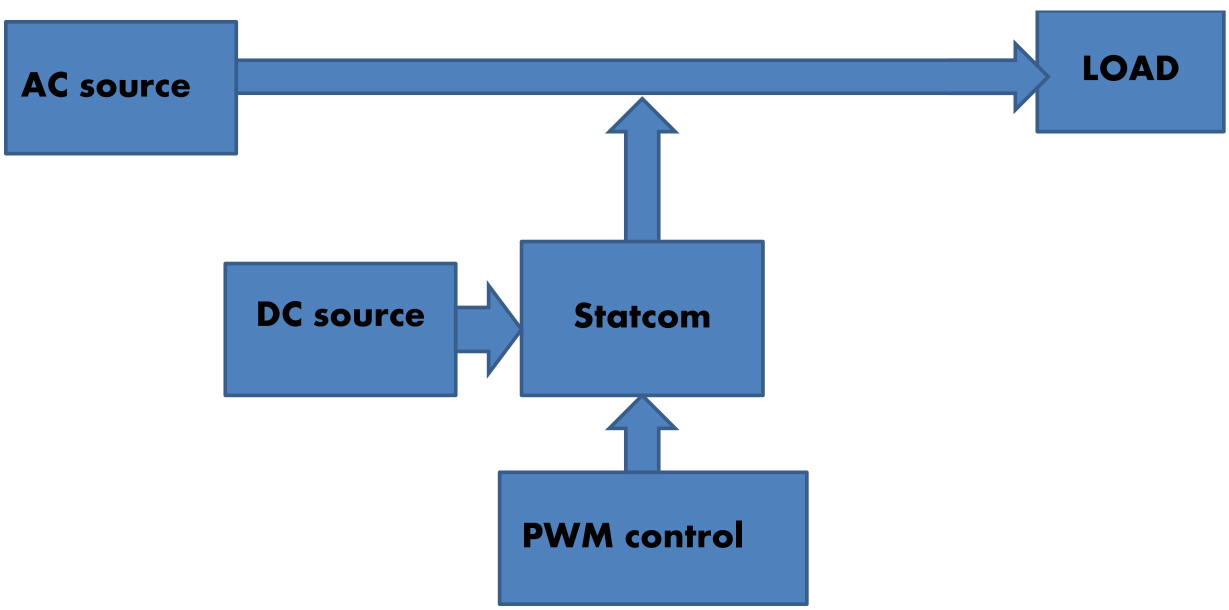
To maintain Unity power factor and power quality at the point of common coupling bus as per IEC-61400-21.

Unity power factor and power quality at the point of common coupling bus.Real and reactive power support from Fuel cell generator and batteries to the load. Stand-alone operation in case of grid failure.

EXISTINGSYSTEM

In this project we used harmonics reduction by using harmonics compensation techniques by using PI controller .it so not adaptive control so error solution will not be accurate. And response time for compensating harmonics is high. When a voltage and/or current waveform is distorted, it causes abnormal operating conditions in a power system such as:

- Voltage Harmonics can cause additional heating in induction and synchronous motors and generators.
- Voltage Harmonics with high peak values can weaken insulation in cables, windings, and capacitors.
- Voltage Harmonics can cause malfunction of different electronic components and circuits that utilize the voltage waveform for synchronization or timing.
- Current Harmonics in motor windings can create Electromagnetic Interference (EMI).
- Current Harmonics flowing through cables can cause higher heating over and above the heating that is created from the fundamental component.
- Current Harmonics flowing through a transformer can cause higher heating over and above the heating that is created by the fundamental component.
- Current Harmonics flowing through circuit breakers and switch-gear can increase their heating losses.
- RESONANT CURRENTS which are created by current harmonics and the different filtering topologies of the power system can cause capacitor failures and/or fuse failures in the capacitor or other electrical equipment.
- False tripping of circuit breakers ad protective relays.



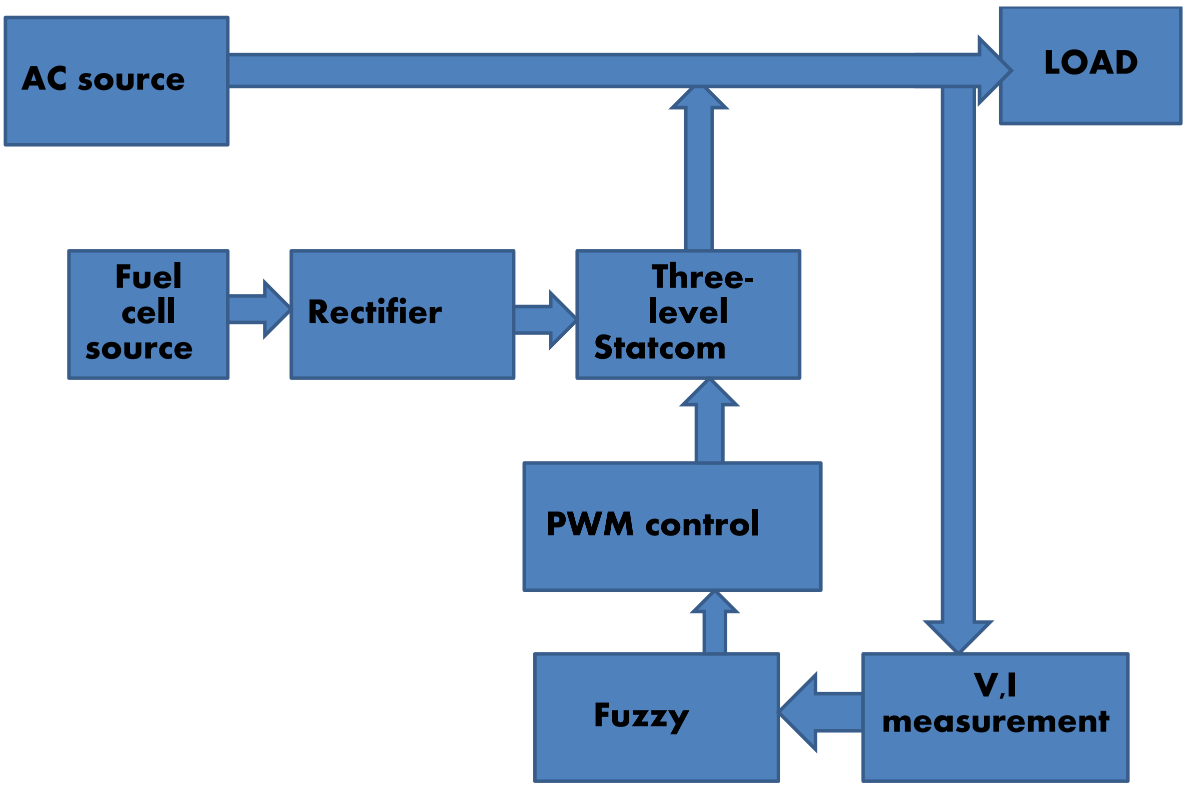
Disadvantages

- For this system cant eliminates 3rd and 9th harmonics in active power filters
- Delay compensation is not considered

PROPOSED METHOD

Delay compensator has include advancing angle of the current regulator output voltage as well as discrete current regulator design. Fuzzy controller has influencing in this system for compensate the Harmonics. This paper presents a method to identify power system impedance in real-time using signals obtained from grid connected power electronic converters. The proposed impedance estimation has potential applications in Fuel cell/distributed energy systems, STATCOM, and solid state substations.

The design of STATCOM parameters are considered an optimization problem according to the time domain-based objective function solved by a fuzzy controller that has a strong ability to find the most optimistic results associated with small disturbances imposed by power converters and determine the net impedance back to the source. A data capture period of 5 ms is applied to an accurate impedance estimation which provides the possibility of ultra fast fault detection The paper describes how the proposed method would enhance the distributed generation operation during faults.



Advantages of proposed system

- 3rd and 9th harmonics can be eliminated in proposed system.
- Possible to compensate the harmonics up to NYquist level.
- THD level is less then 3% in this method.

WORKING AND RELIABILIT

Power quality and reliability cost the industry large amounts due to mainly sags and short-term interruptions. Distorted and unwanted voltage wave forms, too. And the main concern for the consumers of electricity was the reliability of supply. Here we define the reliability as the continuity of supply. As shown in figure: 3.1, the problem of distribution lines is divided into two major categories. First group is power quality, second is power reliability. First group consists of harmonic distortions, impulses and swells. Second group consists of voltage sags and outages. Voltage sags is much more serious and can cause a large amount of damage. If exceeds a few cycle, motors, robots, servo drives and machine tools cannot maintain control of process.

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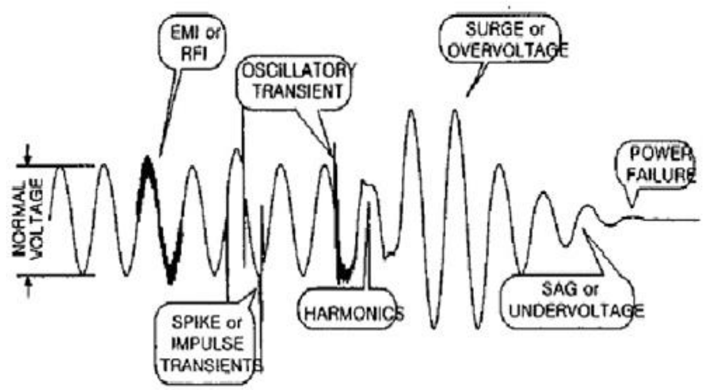


POWER QUALITY AND RELIABILITY

Both the reliability and quality of supply are equally important. For example, a consumer that is connected to the same bus that supplies a large motor load may have to face a severe dip in his supply voltage every time the motor load is switched on. In some extreme cases even we have to bear the black outs which is not acceptable to the consumers.

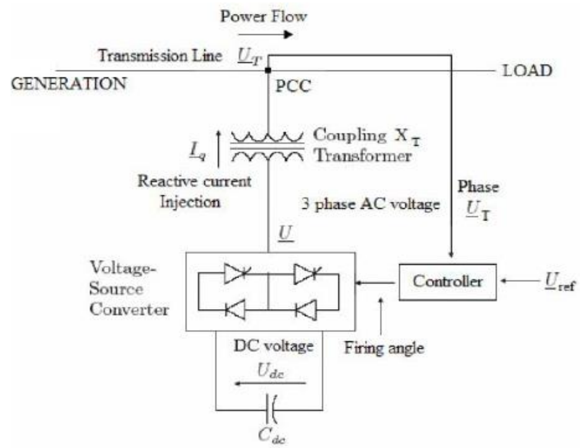
There are also sensitive loads such as hospitals (life support, operation theatre, and patient database system), processing plants, air traffic control, financial institutions and numerous other data processing and service providers that require clean and uninterrupted power. In processing plants, a batch of product can be ruined by voltage dip of very short duration. Such customers are very wary of such dips since each dip can cost them a substantial amount of money.

OPERATION

A STATCOM is build with Thyristors with turn-off capability like GTO or today IGCT or with more and more IGBTs. The static line between the current limitations has a certain steepness determining the control characteristic for the voltage. The structural and operating characteristics shown in the Figure: 3.3.The STATCOM is connected to the power system at a PCC (point of common coupling), through a step-up coupling transformer, where the voltage-quality problem is a concern. The PCC is also known as the terminal for which the terminal voltage is UT. All required voltages and currents are measured and are fed into the controller to be compared with the commands.

The controller then performs feedback control and outputs a set of switching signals (firing angle) to drive the main semiconductors witches of the power converter accordingly to either increase the voltage or to decrease it accordingly.

A STATCOM is a controlled reactive-power source. It provides voltage support by generating or absorbing reactive power at the point of common coupling without the need of large external reactors or capacitor banks. Using the controller, the VSC and the coupling transformer, the STATCOM operation is illustrated in Figure: 3.3.



STATCOM operation in a power system

The charged capacitor C_{dc} provides a DC voltage, U_{dc} to the converter, which produces a set of controllable three-phase output voltages, U in synchronism with the AC system. The synchronism of the three-phase output voltage with the transmission line voltage has to be performed by an external controller. The amount of desired voltage across STATCOM, which is the voltage reference, U_{ref}, is set manually to the controller. The voltage control is thereby to match UT with U_{ref} which has been elaborated. This matching of voltages is done by Varying the amplitude of the output voltage U, which is done by the firing angle set by the controller. The controller thus sets U_T equivalent to the U_{ref}.

The reactive power exchange between the converter and the AC system can also be controlled. This reactive power exchange is the reactive current injected by the STATCOM, which is the current from the capacitor produced by absorbing real power from the AC system.

Where, Iq is the reactive current injected by the STATCOM

- U_T is the STATCOM terminal voltage
- U_{eq} is the equivalent Thevinen's voltage seen by the STATCOM

If the amplitude of the output voltage U is increased above that of the AC system voltage, U_T, a leading current is produced, i.e. the STATCOM is seen as a conductor by the AC system and reactive power is generated. Decreasing the amplitude of the output voltage below that of the AC system, a lagging current results and the STATCOM is seen as an inductor. In this case reactive power is absorbed. If the amplitudes are equal no power exchange takes place.

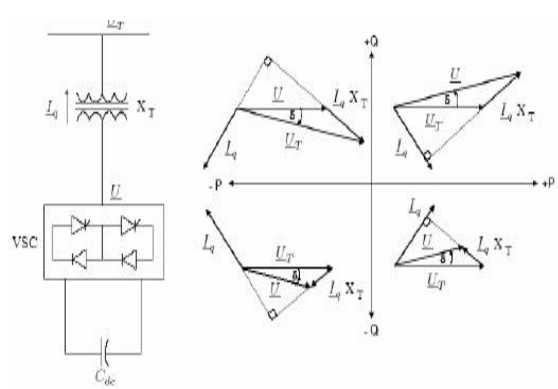


Fig. 3.4 Phasor diagrams for STATCOM applications.

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A practical converter is not lossless. In the case of the DC capacitor, the energy stored in this capacitor would be consumed by the internal losses of the converter. By making the output voltages of the converter lag the AC system voltages by a small angle, δ, the converter absorbs a small amount of active power from the AC system to balance the losses in the converter. The diagram in Figure: 3.4 illustrates the phasor diagrams of the voltage at the terminal, the converter output current and voltage in all four quadrants of the PQ plane.

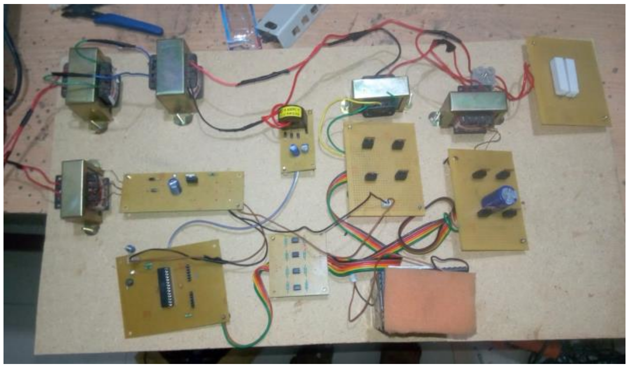

Figure 3.5: Hardware for Efficient Voltage Control Strategis for FUEL CELL Energy System in Power Grids using STATCOM

RESULTS AND DISCUSSIONS

Performance analysis of grid power

A critical load is considered as a nonlinear load for the simulation of the system. The performance of the system is observed for the power quality improvement of critical load. The inverter is switched "on" at 0.2 s. The source current I_s, inverter injected current I_{inv}, and load current I_L are measured with and without controller operation. It is observed that the system is operating in power quality mode up to 0.6 s. The dynamic performance of the system is monitored by operating the circuit breaker at 0.6 s. Under such condition the system performs as a stand-alone mode. The voltage sensor senses the condition and transfers the micro switches to generate the reference current in stand-alone reference generator.

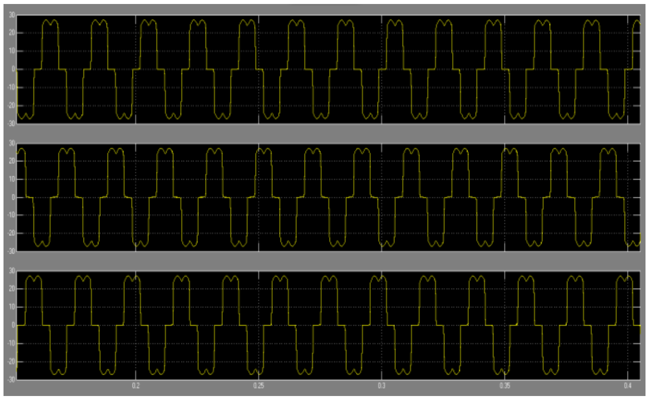

Fig 6.1. Simulated waveforms for compensation of harmonic current drawn by six pulse Rectifier. (a) DC Bus voltage

During this mode the inverter will support the critical load in the absence of source voltage. Due to the unavailability of source, the inverter will supply the full load current in this duration. Fig 6.1 Shows the DC bus voltage and R phase load, converter and grid current before and after harmonic compensation

CONCLUSION AND FUTURE ENHANCEMENTS

Conclusion

The proposed micro-Fuel cell energy conversion scheme with battery energy storage, with an interface of inverter in current controlled mode for exchange of real and reactive power support to the critical load. The hysteresis current controller is used to generate the switching signal for inverter in such a way that it will cancel the harmonic current in the system. The exchange of Fuel cell and energy power is regulated across the dc bus having energy storage and is made available under the steady state condition. This also allows the real power flow during the instantaneous demand of the load. The scheme maintains UPF and also harmonic free source current at PCC in the distributed network. The suggested control system is suited for rapid injection or absorption of reactive/real power flow in the power system. The battery energy storage provides rapid response and enhances the performance under the fluctuation of wind-energy output and improves the voltage stability of the system.

This scheme is providing a choice to select the most economical real power for the load amongst the available wind-battery-conventional resources and the system operates in power quality mode as well as in a stand-alone mode. Thus the proposed scheme in the grid connected system fulfils the power quality requirements and maintains the grid voltage free from distortion and harmonics.

Future Enhancements

The proposed a STATCOM control scheme for grid connected hybrid Fuel cell and energy power energy system to improve power quality is using for conventional control of PID controller, which is compensate critical load and reactive power demand.

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