BESS Enabled Micro Wind Energy Generation System for Power Quality Improvement

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Abstract - Within the micro-grid system, it's particularly difficult to keep up the essential load with continuous power provide. The proposed wind energy conversion system with battery energy storage is used to exchange the controllable real and reactive power within the grid and to sustain the power quality norms at the point of common coupling. Static Compensator (STATCOM) is connected at a point of common coupling with a battery energy storage system (BESS) to mitigate the power quality issues. The generated micro wind power will be stored in the batteries at low power demand hours. In this theme, inverter control is executed with hysteresis current management mode to achieve the faster dynamic switchover for the support of important load. The combination of battery storage with micro-wind energy generation system ,which will synthesize the output waveform by injecting or absorbing reactive power and enable the real power flow required by the load. The system reduces the burden on the standard supply and utilizes (µWEGS) and battery storage power. The system provides fast response. The scheme will also be operated as a stand-alone system in case of grid failure like a uninterrupted power provide. The system is simulated in MATLAB/SIMULINK and results are presented.

Keywords:Micro wind,Statcom,Power Quality

I. Introduction

Renewable sources typically produce power and voltage varying with natural conditions and grid association of those sources is essential if they are ever to realize their potential to significantly alleviate the current day issues of atmospheric pollution and global warming. The micro wind power generation system with battery energy storage is becoming a lot of prominent with the increasing demand of power generation. It conjointly reduces the setting pollution. However the output power of micro- wind generator is fluctuating and will affect the operation in the distribution network. The utility system cannot accept new generation without strict condition of voltage regulation because of real power fluctuation and reactive power generation/absorption. In the fixed-speed wind turbine operation, all the fluctuation within the wind speed are transmitted as fluctuations within the mechanical torque, electrical power on the grid and leads to massive voltage fluctuations.

During the normal operation, wind turbine produces a nonstop variable output power. These power variations are mainly caused by the effect of turbulence, wind shear, and tower-shadow and of control system in the power system. Therefore, the network desires to manage for such fluctuations. The power quality issues will be viewed with respect to the wind generation, transmission and distribution network, like voltage sag, swells, flickers, harmonics etc. However the wind generator introduces disturbances in to the distribution network .One in every of the straightforward strategies of running a wind generating system is to use the induction generator connected directly to the grid system. The induction generator has inherent benefits of value effectiveness and strong- ness. However; induction generators need reactive power for magnetization. When the generated active power of an induction generator is varied because of wind, absorbed reactive power and terminal voltage of an induction generator can be significantly affected. A proper control scheme in wind energy generation system is needed underneath normal operating condition to allow the right control over the active power production. In the event of accelerating grid disturbance, a battery energy storage system for wind energy generating system is generally required to compensate the fluctuation generated by wind turbine. It used for sensitive load applications because it provides the ability for a short period of your time. The wind energy generation system is response for either charging/discharging the battery and conjointly acts as a constant voltage output for the important load in the distribution system

The proposed control system with battery storage has the following objectives,first one is Unity power issue and power quality at the purpose of common coupling bus,next one is real and reactive power support from wind generator and batteries to the load and third one is Stand-alone operation in case of grid failure.

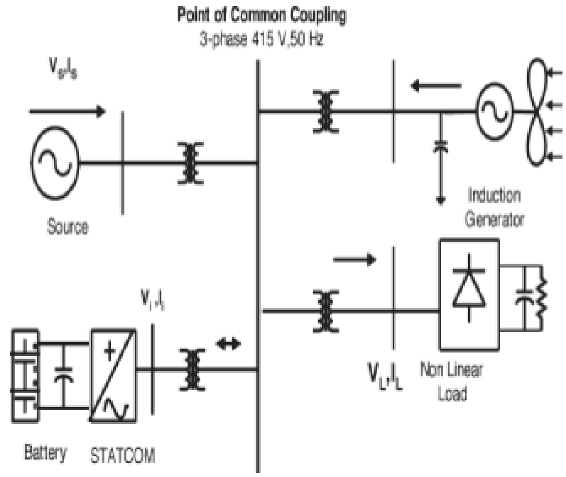

Figure. 1. Schematic diagram of micro-wind generator with battery storage sytem.

II. Extraction Of Wind Power With Batteries

The proposed wind energy extraction and battery energy storage with distributed network is configured on its operating principle and is predicated on the control strategy for switching the inverter for essential load application as shown in Fig. 1.

1.Micro-wind energy generating system

The micro-wind generating system (µWEGS) is connected with turbine, induction generator, interfacing transformer, and ac-dc converter to urge dc bus voltage. The power flow is represented with dc bus current for constant dc bus voltage in inverter operation. The static characteristic of wind turbine will be described with the relationship within the wind as in

$$P_{Wind} = \frac{1}{2}\rho\pi R^2 V_{wind}^3 \quad (1)$$

where ρ is air density, the rotor radius is R in meters, and Vwind is the wind speed in m/s. It is not possible to extract all kinetic energy of wind and is called CP power coefficient(only 59% is extracted). This power coefficient can be expressed as a function of tip speed ratio λ and pitch angle θ. The mechanical power can be written as (2)

$$P_{mech} = c_p P_{wind} \quad (2)$$

$$P_{mech} = \frac{1}{2}\rho\pi R^2 v_{wind}^3 \quad (3)$$

By using the turbine rotational speed, ωTurbine mechanical torque is shown in

$$T_{mech} = \frac{P_{mech}}{\omega_{Turbine}}$$

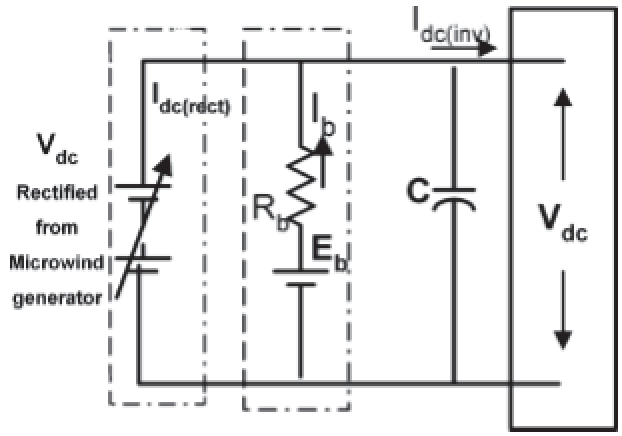

Fig. 2. Equivalent Circuit of DC link for battery storage and micro-wind generator.

2.Dc link for battery storage and micro-wind generator

The battery storage and µWEGS are connected across the dc link as shown in Fig. 3. The dc link consists of capacitor that decouples the µwind generating system and ac source (grid) system.The battery storage will get charged with the assistance of µwind generator. The use of capacitor in dc link is additional effcient, less expensive and is modeled as follows:

$$C\frac{dv}{dt} = I_{dc(rect)} - I_{dc(inv)} - I_b \qquad (4)$$

where C is dc link capacitance, V_{dc} is rectifier voltage, $I_{dc(rect)}$ is rectified dc-side current, $I_{dc(inv)}$ is inverter dc-side current, and Ib is the current through the battery. The battery storage is connected to dc link and is represented by a voltage source E_b connected in series with an internal resistance R_b. The internal voltage varies with the charged status of the battery. The terminal voltage Vdc is given in

$$V_{dc} = E_b - I_b * R_b \qquad (5)$$

II.CONTROL SCHEME OF THE SYSTEM

The management scheme with battery storage and micro-wind generating system utilizes the dc link to extract the energy from the wind. The micro-wind generator is connected through a intensify transformer and to the rectifier bridge thus as to get the dc bus voltage. The battery is employed for maintaining the dc bus voltage constant; so the inverter is implemented successfully in the distributed system [12]–[13]. The three-leg six-pulse inverter is interfaced in distributed network and twin combination of battery storage with micro-wind generator for essential load application, as shown in Fig. 2. The management scheme approach is based on injecting the present into the grid using "hysteresis current controller." Using such techniques the controller keeps the management system variables between the boundaries of hysteresis space and gives correct switching signals for inverter operation.

1. Grid Synchronization

In the three-section balance system, the RMS voltage supply amplitude is calculated at the sampling frequency from the supply phase voltage $(V_{sa}\ V_{sb}, V_{sc})$

$$V_{sm} = \sqrt{\left\{\frac{2}{3}(V_{sa}^2 + V_{sb}^2 + V_{sc}^2)\right\}} \qquad (6)$$

The unit vectors are obtained from ac source-phase voltage and the RMS value of unit vector u_{sa}, u_{sb}, u_{sc} as shown in

$$u_{sa} = \frac{V_{sa}}{V_{sm}},\ u_{sb} = \frac{V_{sb}}{V_{sm}},\ u_{sc} = \frac{V_{sc}}{V_{sm}} \qquad (7)$$

The in-section generated reference currents are derived using the in-section unit voltage template as in

$$i_{sa}^{*} = i.u_{sa},\ i_{sb}^{*} = i.u_{sb}\ ,\ i_{sc}^{*} = i.u_{sc} \quad (8)$$

where i is proportional to the magnitude of filtered source voltage for respective phases. It is the output taken from PI controller. This ensures that the supply current is controlled to be sinusoidal. The unit vector implements the necessary function in the grid for the synchronization.

2. Hysteresis Based Current Controller

Hysteresis based mostly current controller is implemented in the current management theme. The reference current is generated as in (10) and the particular current is detected by current sensors that are subtracted for getting current errors for a hysteresis based mostly controller. The ON/OFF switching signals for IGBT of inverter are derived from hysteresis controller. When the particular (measured) current is on top of the reference current, it is necessary to commutate the corresponding switch to induce negative inverter output voltage. This output voltage decreases the output current and reaches the reference current. The inverter injects the current into the grid in such a way that the source currents are harmonic free are in-phase with respect to source voltage. The present control mode of inverter injects the current into the grid in such a way that the source currents are harmonic free and their phase-angles are in-part with respect to supply voltage.

3. Statcom Performance when the load varies

The wind energy generating system is connected with grid having the nonlinear load. The performance of the system is measured by switching the STATCOM. The STATCOM responds to the step modification command for increase in extra load. When STATCOM controller is made ON, without amendment in any different load condition parameters, it starts to mitigate reactive demand also harmonic current.

III. SIMULATION RESULTS

1. System Performance:

The Simulink model library includes the model of Typical Supply, Asynchronous Generator, STATCOM,Voltage source Inverter, Grid Voltage, Battery, Line Inductance and others that has been made for simulation.

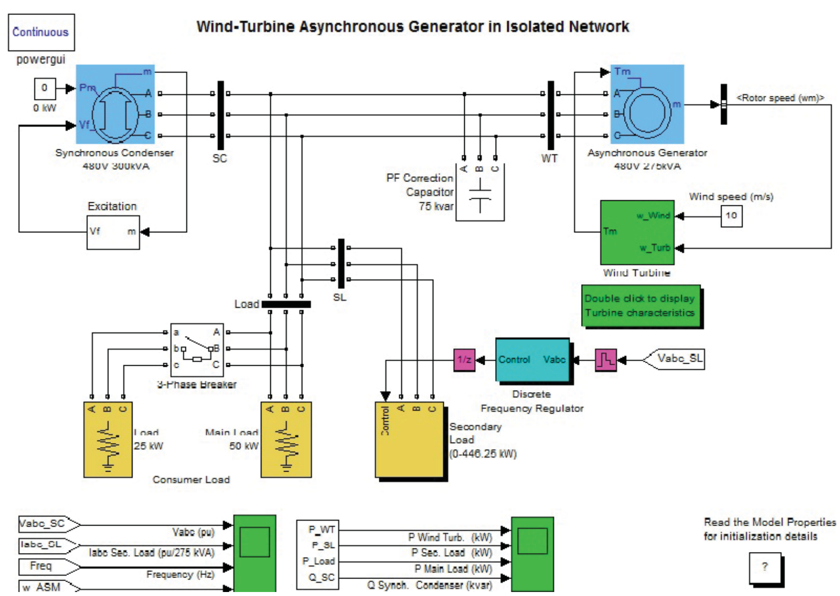

Fig.3 Wind turbine generator

The effectiveness of the proposed method is demonstrated through simulation results of grid voltage and current shown in Figure 6. This is due to the reference derived from the grid voltage.

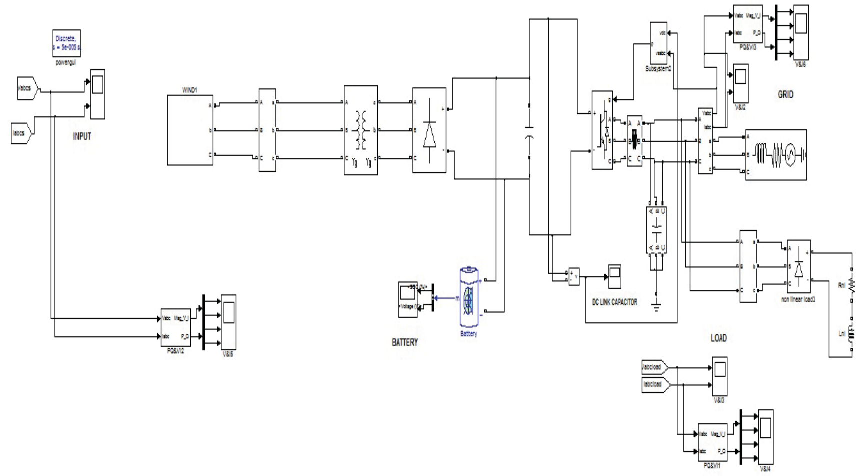

Fig.4 Micro WEGS under normal condition

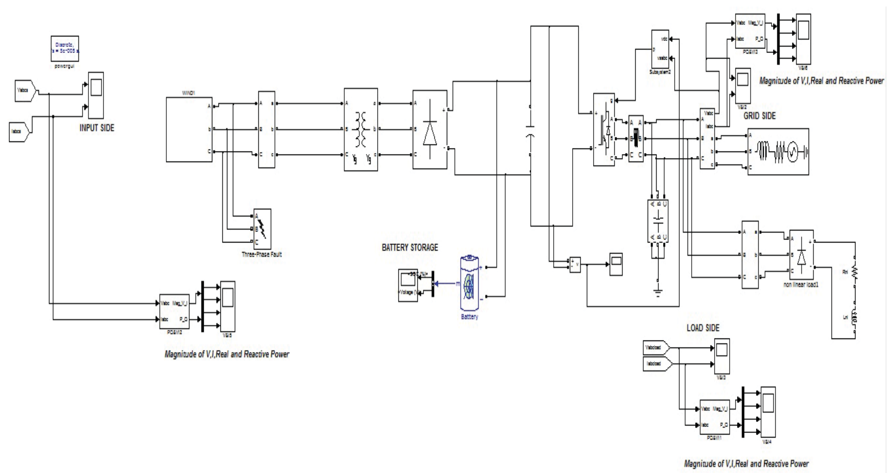

Fig.5 Micro WEGS under fault condition

The voltage and current waveform of the wind turbine generator operation is analyzed. The inverter output voltage under STATCOM operation with load variation is shown in Figure 6

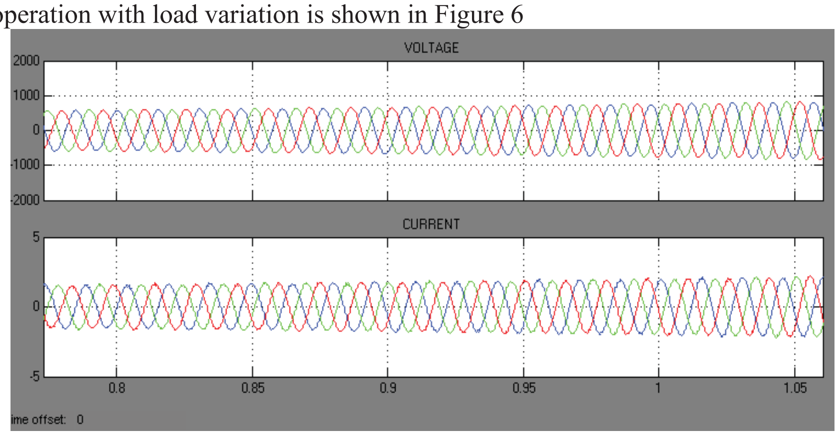

Fig.6 Inverter Voltage & Inverter Current with load variation

The magnitude of input voltage,current,Real power and reactive power are shown below. The supply current on the grid is affected because of the effect of non-linear load and wind generator, this purity of wave kind is lost on both sides in the system.

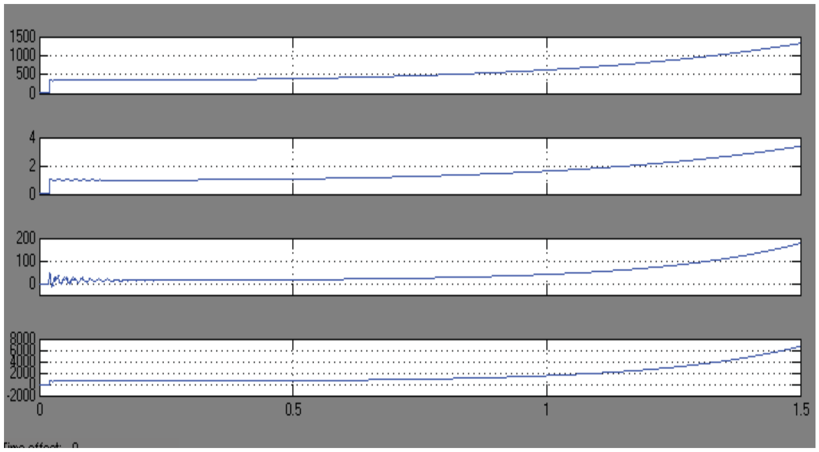

Figure 7 Magnitude of V, I, Real & Reactive Power at input side.

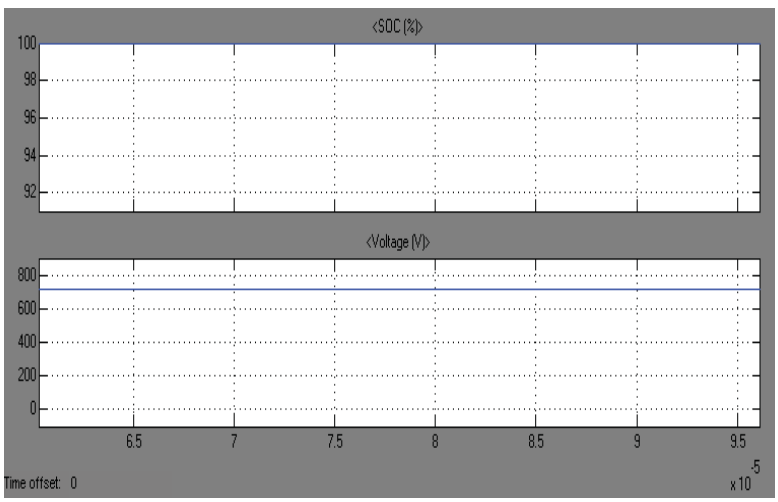

Fig.8 Battery SOC & Voltage

Load voltage regulation is defined by the drop in voltage when going from a no load to full load condition on a power supply. In additional practical terms, it is usually measured when going from a typical steady state load to a maximum load condition, realized underneath traditional operating conditions. Load voltage regulation is employed to evaluate the performance of an isolation transformer and distribution system below significant step load changes. Load voltage regulation is crucial before 0.21s and after the 0.21s voltage regulation" is that the stand-by mode of operation is shown in Figure 10.

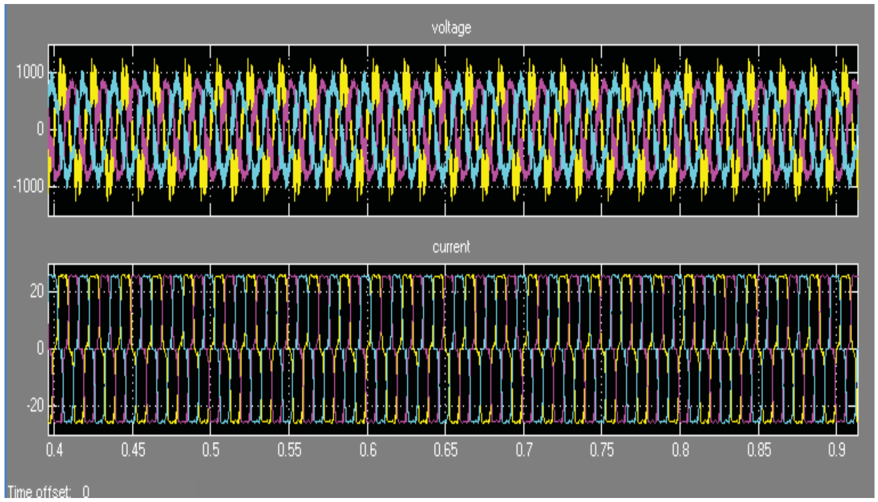

Fig.9 Voltage & Current at load side

The power quality improvement is observed at the point of common coupling, when the controller is in ON condition. The Fourier analysis of this waveform is expressed.The above scheme for critical load application has not only power quality improvement however it additionally supports the essential load with the energy storage through the batteries.

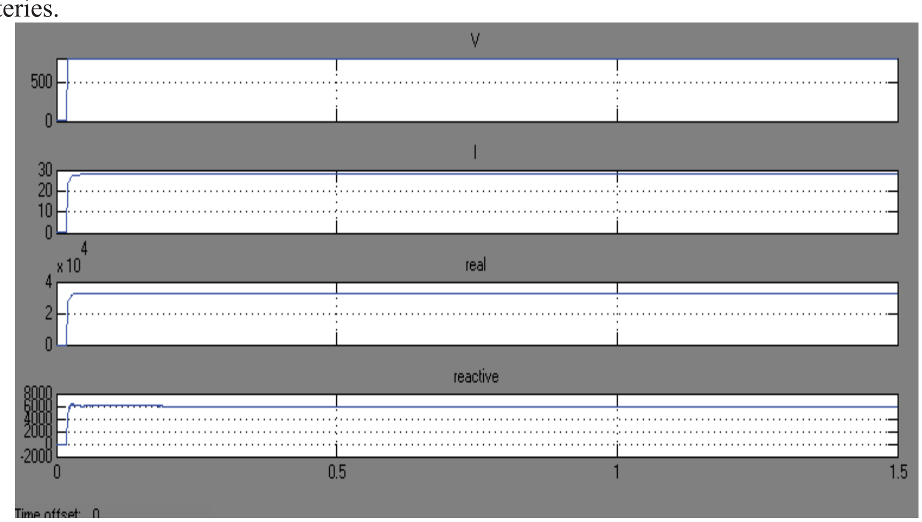

Fig.10 Magnitude of V, I, P, Q at load side

IV. CONCLUSION

The paper proposed micro-wind energy conversion theme with battery energy storage, with an interface of inverter in hysteresis current controlled mode for exchange of real and reactive power support to the vital load. The hysteresis current controller is employed to come up with the switching signal for inverter in such a approach that it will cancel the harmonic current within the system. The theme maintains unity power issue and also harmonic free source current at the point of common coupling within the distributed network. The exchange of wind power is regulated across the dc bus having energy storage and is created accessible underneath the steady state condition. This also permits the real power flow during the instantaneous demand of the load. The recommended control system is suited to rapid injection or absorption of reactive/real power flow in the power system. The battery energy storage provides speedy response and enhances the performance under the fluctuation of wind turbine output and improves the voltage stability of the system. This scheme is providing a alternative to pick the most economical real power for the load amongst the available wind-battery-conventional resources and also the system operates in power quality mode as well as during a stand-alone mode.

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