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A NOVEL DC MICRO GRID HYBRID SYSTEM WITH MPPT CONTROL FOR INDUSTRIAL APPLICATIONS

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Abstract- Electricity can be produced by conventional energy sources or by non-conventional energy sources. The conventional energy sources (Oil, Gas, and Coal) are finite and it generates pollution. As the environmental pollution generating systems, employing the existing resources in the best way. The alternative energy sources like wind, fuel cell, solar, tidal, etc. available abundant in nature. They have the advantages of sustainability, renewability and pollution reduction. the hybrid generation system has become significant because of the complementary characteristics among the new and renewable energy resources. Solar energy and wind energy are the two renewable energy sources most common in use. The use of renewable energy sources for remote telecommunication systems has become more popular recently due to technological advancements and lower costs. Because, the telecom base transceiver station (BTS) requires uninterrupted power supply to ensure reliable communication services. This project gives the discussion about efficient dual input converter for hybrid solar–wind energy systems to supply telecom in rural areas. So, the objective is to investigate and design a suitable fused converter topology for hybrid solar-wind systems. Diesel generator systems require regular maintenance and it is costly. It generates noise pollution. The first section is a short overview of the literature. In the second and third section, block diagram and system description of solar/ wind with fused converters; Modeling of each block is presented. Fourth section contains the simulation results and calculation of the same. Finally, the findings of the investigations are highlighted in the conclusion. Transportation and storage of diesel is also a major problem in remote areas. The improvement in efficiency with MPPT and without MPPT controller is calculated by simulating with MAT LAB/Simulink.

Keywords—Renewable, DC micro grid, energy management, DC link, energy storage system, power converters.

I. INTRODUCTION

The microgrid system is an electrical network which consists of the interconnected loads and distributed energy generation systems. The development of the hybrid renewable generation system has overcome all the disadvantages of the conventional generation systems. The architecture of the microgrid system consists of the interconnected loads and distributed energy generation systems, that consists of the standalone and grid connected loads applications. The microgrid system enhances the load reliability, reduce emissions and improve the power quality [1]. The implementation of the microgrid components composed of the modeling and integrating the energy sources parallel to the grid. The smart microgrid consists of some challenges are commonly called as the IT challenges for the energy distribution operators. The efficiency and viability of the energy management was improved by using the

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automated systems that depends on capturing the fine grained data composed of voltage and current consumed by the systems, accepted load demand commands. The process of microgrid system briefly discussed in [2]. The characteristics of the micro grid system are grouping of interconnected loads and distributed energy sources, can operate in islanded mode and grid connected mode if desired, acts as a single controllable entity as load systems. The brief classification of the micro grids are discussed in [3].

In today's work the overall efficiency of hybrid AC or DC microgrid system is assessed in the grid tied mode. In this wind turbine generator, photovoltaic system in addition to electric battery are used for the growth of micro grid from the customer point of view, microgrids deliver both thermal and electricity requirements and in addition improve local reliability, reduce emissions, improve power excellence by supportive voltage and also lowering voltage dips and potentially reduced charges of energy offer [4-5]. Distributed energy sources can potentially reduce the requirement for distribution as well as transmission services. There are various advantages offered by micro grids to help end consumers, utilities and community, such as enhanced power performance, reduced overall power consumption, lowered greenhouse gases and pollutant emissions, increased service quality and local reliability [6].

The EMS consists of the communication systems such as RS 485 and ZigBee communication network protocol. The generation systems, storage system, and DC bus regulator system are provided with the above mentioned communication system that communicates to the EMS system [7-8]. This EMS commands the generation system when to operate as per the load demand and State of Charge (SoC)of the battery. This EMS incorporates the Induction Machine control algorithm, that gives first priority to the load satisfaction, batterymanagement and selling the power to the EB system through the bidirectional AC-DC converter using the AC grid. The EMS incorporates the Induction Machine control are so called as the intelligent control. Such control management system essential for the nonlinear DC microgrid system for the purpose of optimization and distributed energy generation [9-10].

II. DC MICROGRID

Fig. 1 represents a generalized block schematic of DC microgrid. Permanent magnet synchronous generator (PMSG) is suitable to be used as a generating source in microgrid as it has several advantages over other WTG topologies. PMSG is fully controllable variable speed topology which uses full power converters (VSC) [2]. It has high power-to weight ratio and does not have reactive power requirement for magnetization, which makes it easier to control.

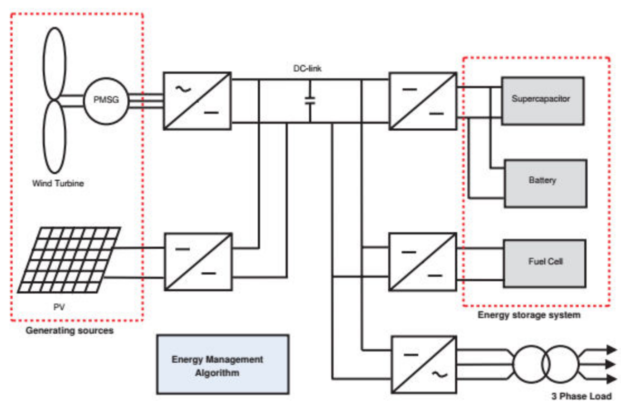

Fig.1.Block schematic of DC microgrid

Out of the different storages available, supercapacitor, fuel cell and battery have certain unique characteristics which complement each other, thus these could form a hybrid energy storage system. Supercapacitor has quick charge-discharge cycles and can be used to supply high amount of power for a short duration of time. Battery is generally used as standby and fuel cell can be used to provide huge amount of energy during high load

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demand. The following characteristics of DC microgrid have been proposed.

- The DC microgrid must be reliable. Power supply quality should be maintained to a suitable level.
- The DC microgrid must solely utilize renewable en energy resources.
- The DC microgrid must be stable. It should be able to sustain dynamic load conditions and variation in generating power due to intermittent nature of wind and solar energy.
- The system should have least maintenance requirement and minimum cost of installation.
- The DC microgrid should be able to adapt changes even after initial sizing and installation. These may be changes in storage or generation capacity, and changes in the load pattern.

III. NEED FOR ENERGY MANAGEMENT

Energy management algorithm and power converters together provide the necessary control to the system [3]. WTG and photovoltaic panel can be controlled to extract maximum power from the available natural sources. Energy storage system requires management for deciding which storage should be used in case of a hybrid energy storage system, and for deciding the charge-discharge cycles of chosen storage. The DC-link voltage must be maintained constant for balanced flow of energy among the multiple sources and loads, in a DC microgrid. Also, a variation of DC-link voltage would disrupt normal operation of the system and could cause the whole system to collapse [4]. Eq. 1 and Eq. 2 gives the generalized stability criteria for microgrid:

$$\frac{P_m - P_e}{\omega} = J\frac{d\omega}{dt} \quad (1)$$

$$P_{load}(t) \leq \ddot{P}_g(t) \pm \dddot{P}_s(t) \quad (2)$$

Where,
Pm = wind turbine mechanical power (W)
Pe = wind turbine electrical power (W)
J = inertia (kg.m2)
ω = WTG speed (rad/sec)
$P_{load}(t)$ = instantaneous load power (W)
Pg(t) = total instantaneous power of generating sources (W)
Ps(t) = total instantaneous power delivered by ESS (W)

Energy management algorithm (EMA) provides intelligence to the system and controls the functioning of each block of the system. Energy management algorithm has several significant roles:

- Reliability: providing uninterrupted supply to the load.
- Quality: maintaining quality of supply.
- Stability: maintaining DC-link voltage constant.
- Maximum utilization of generating sources using MPPT algorithm.
- Efficient management of storages.

Sizing of generating sources and storages is a prime concern while designing any isolated system, since the load demand should be met completely by generating sources and the ESS, without grid intervention [5]. Inspite of this, sizing is not the fundamental requirement of the microgrid presented here. The microgrid would be able to adapt changes in storage or generation capacity. Battery would play a primary role of supplying voltage to the system. This is also essential for wind turbine generator and photovoltaic panel. Thus, battery should rarely be discharged and would be used as standby. Battery management in this manner leads to increased lifetime of the battery, reduced maintenance, cost and size of the battery.

IV. INDUCTION MOTOR (IM)

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An induction motor is an example of asynchronous AC machine, which consists of a stator and a rotor. This motor is widely used because of its strong features and reasonable cost. A sinusoidal voltage is applied to the stator, in the induction motor, which results in an induced electromagnetic field. A current in the rotor is induced due to this field, which creates another field that tries to align with the stator field, causing the rotor to spin. A slip is created between these fields, when a load is applied to the motor. Compared to the synchronous speed, the rotor speed decreases, at higher slip values. The frequency of the stator voltage controls the synchronous speed. The frequency of the voltage is applied to the stator through power electronic devices, which allows the control of the speed of the motor. The research is using techniques, which implement a constant voltage to frequency ratio. Finally, the torque begins to fall when the motor reaches the synchronous speed. Thus, induction motor synchronous speed is defined by following equation,

$$n_s = \frac{120f}{P}$$

Where f is the frequency of AC supply, n, is the speed of rotor; p is the number of poles per phase of the motor. By varying the frequency of control circuit through AC supply, the rotor speed will change.

A. Control Strategy of Induction Motor

Power electronics interface such as three-phase SPWM inverter using constant closed loop Volts l Hertz control scheme is used to control the motor. According to the desired output speed, the amplitude and frequency of the reference (sinusoidal) signals will change. In order to maintain constant magnetic flux in the motor, the ratio of the voltage amplitude to voltage frequency will be kept constant. Hence a closed loop Proportional Integral (PI) controller is implemented to regulate the motor speed to the desired set point. The closed loop speed control is characterized by the measurement of the actual motor speed, which is compared to the reference speed while the error signal is generated. The magnitude and polarity of the error signal correspond to the difference between the actual and required speed. The PI controller generates the corrected motor stator frequency to compensate for the error, based on the speed error.

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V.MATLAB/SIMULATION RESULTS

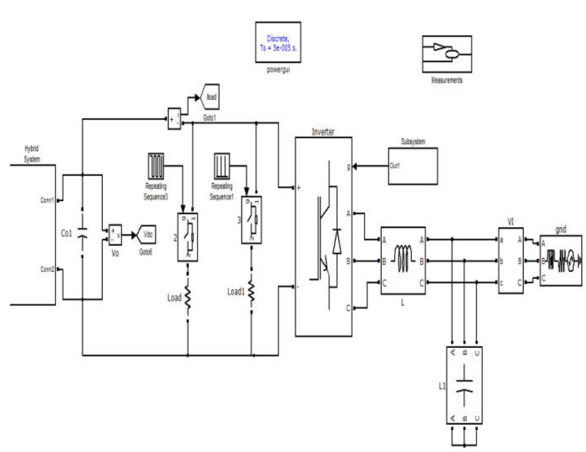

Fig 2 Simulation model for hybrid system connected to microgrid

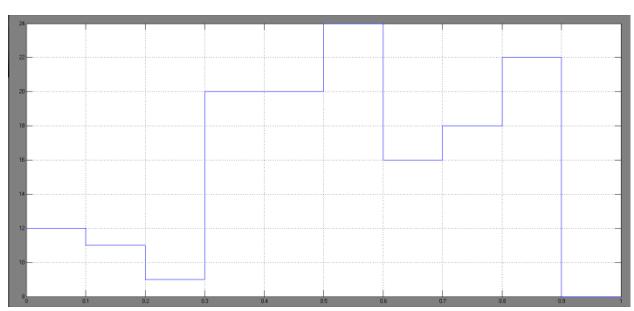

Fig 3Simulation wave form of Wind velocity

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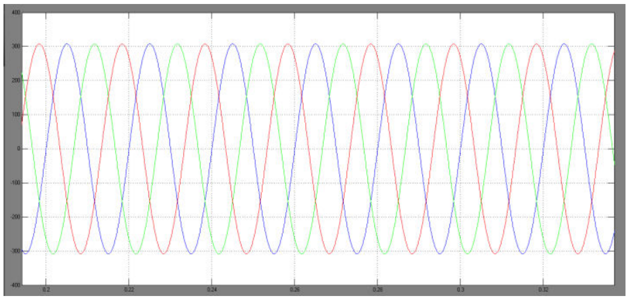
Fig 4 Simulation wave form of wind voltage

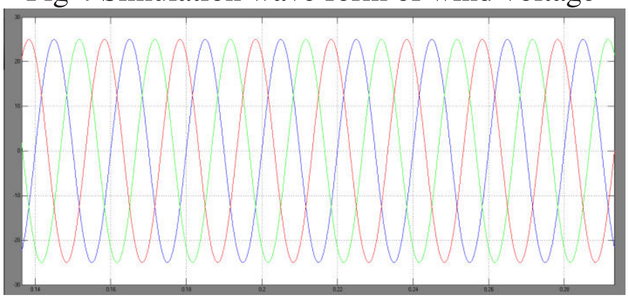
Fig 5 Simulation wave form of wind current

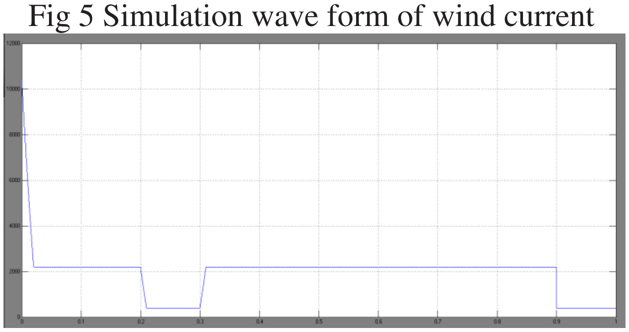
Fig 6 Simulation wave form of Wind speed

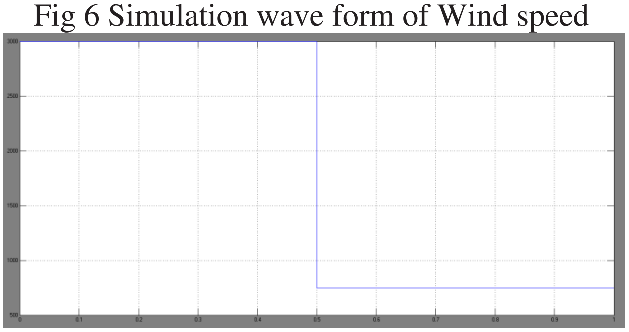
Fig 7 Simulation wave form of Power extracted from PV

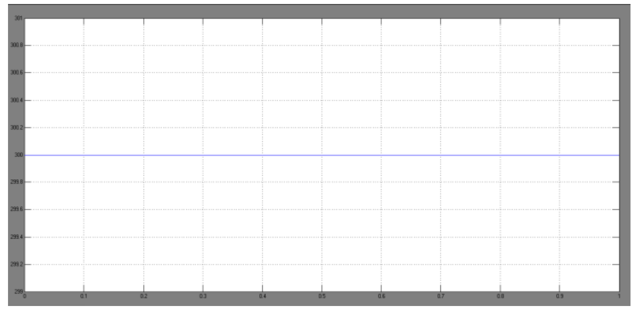
Fig 8 Simulation wave form of DC link voltage

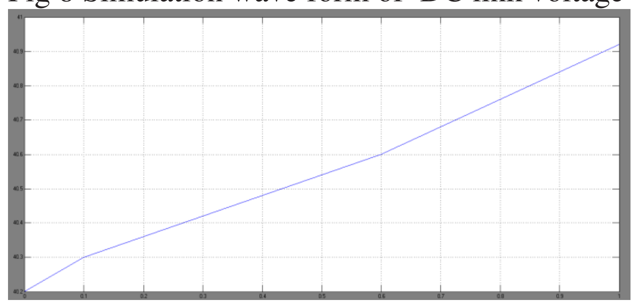
Fig 9 Simulation wave form of State of charge of Super capacitor

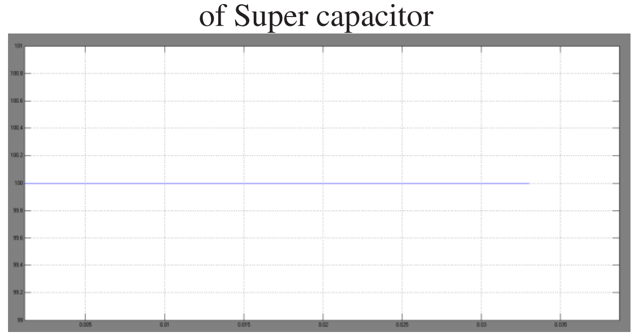
Fig 10 Simulation wave form of Battery voltage

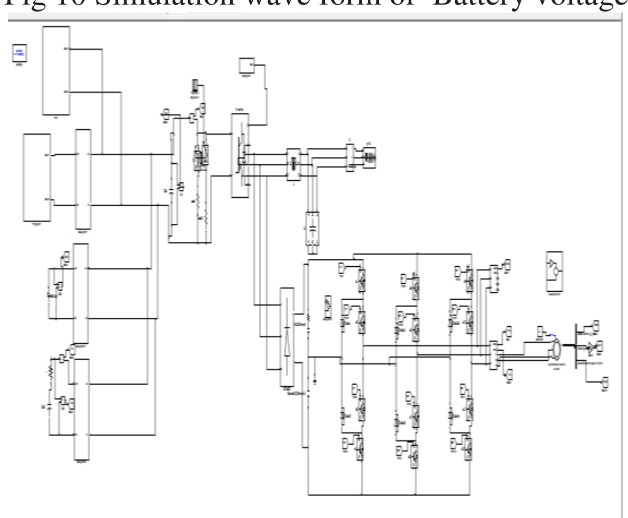
Fig 11 Simulation module for hybrid system connected to IM

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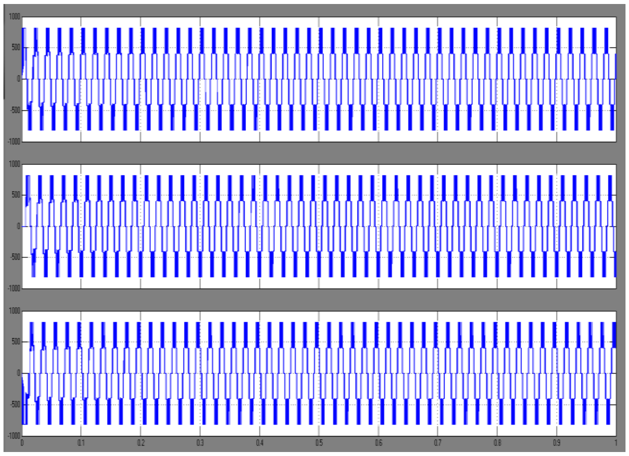

Fig12 Simulation wave form of line voltage

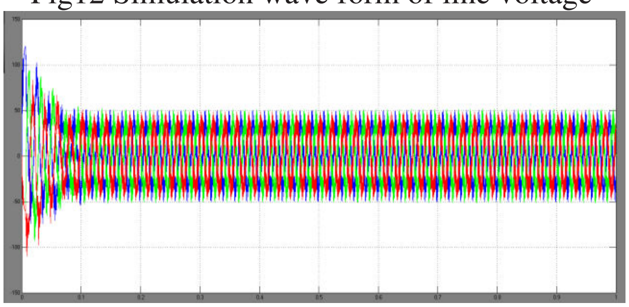

Fig 13 Simulation wave form of line currents

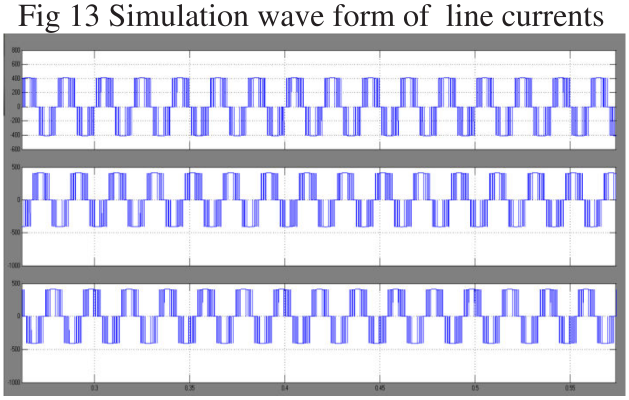

Fig 14 Simulation wave form of phase voltage

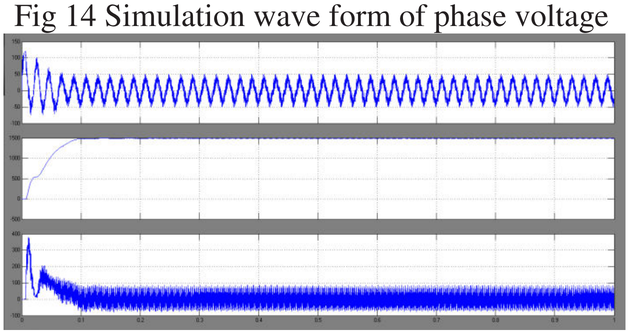

Fig 15 Simulation wave form of Induction motor of stator current, speed and torque

VI.CONCLUSION

This paper implements the Induction Machine control to achieve the optimization of an energy management system for the smart grid applications. The sources had been successfully integrates and the respective waveforms are obtained. The optimization control of the smart grid system was done through the implementation of Induction Machine, which comprises of the number of rules. Such type of intelligent management system increases the accuracy of this nonlinear system and it also achieves the optimization and distributed energy generation by its control algorithm. In future the Energy Management System will be implemented by using the artificial neural network and also integrated with some other energy sources.

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