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Design and Development of Hybrid Energy Control Scheme for Multi Purpose Usage in a Building

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Abstract: The use of renewable in remote villages has yielded mixed results over the last 20 years. Recently photo voltaic, small wind turbines and micro hydro systems have gained increasing recognition like reliability, cost-effective alternatives to grid extension and diesel gensets for village-electricity applications. At the same time hybrid systems based on combinations of PV/Wind/Batteries/Diesel gensets have proven reliable and economic for remote international telecommunication markets. With the growing emphasis on environmentally and economically sustainable development of international rural communities, the hybrid industry is responding with the development and demonstration of hybrid systems and architectures that will directly compete with conventional alternatives for village electrification. The main objective of this paper is to design and develop the hybrid energy control scheme for multipurpose usage in city buildings. The Master Microcontroller monitors the power flows and automatically makes judgments from preprogrammed data or from remote commands allowing efficient operation of the power sources. Additional controls are included in the package for AC-output and DC-input supervision/protection, as well as in PV and wind turbine generator. The system is housed in a prefabricated shelter. In the current date, India is a huge consumer of fossil fuel such as coal, crude oil, natural gas etc. The rapid usage of non-renewable energies such as for example fossil fuel, oil, natural gas, has generated problems of demand and supply. Due to which, the continuing future of Nonrenewable energies is now uncertain. The raising concerns towards global warming and quickly reducing conventional energy options have created the necessity of another energy sources. The need for hybrid system is continuing to grow because they are non-conventional energy sources in addition to that they are more energy efficient, reduce the global warming and pollution. In this paper the hybrid system was created and modeled employing Matlab/Simulink environment. The blend of Sun (PV) array system, Wind mill system, battery system and Diesel generator system are being used for power generation. Blocks like wind mill, PV model, Diesel generator, energy conversion program and load are applied and the outcomes and simulation are likewise presented and these outcomes can be utilized for the control scheme of multipurpose usage in a building.

Key words: Hybrid system · Renewable energy · Control scheme

INTRODUCTION

Renewable Energy Sources are those energy sources which are not destroyed when their energy is harnessed. Human use of renewable energy requires technologies that harness natural phenomena such as sunlight, wind, waves, water flow and biological processes such as anaerobic digestion, biological hydrogen production and geothermal heat. Among the above mentioned sources of energy there has been a lot of development in the technology for harnessing energy from the wind. Wind is the motion of air masses produced by the irregular heating of the earth's surface by sun [1]. These differences consequently create forces that push air masses around for balancing the global temperature. Wind energy is not a constant source of energy. It varies continuously and gives energy in sudden bursts. About 50% of the entire energy is given out in just 15% of the operating time. Wind strengths vary and thus cannot guarantee continuous power. It is best used in the context of a

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system that has significant reserve capacity such as hydro or reserve load and desalination plant to mitigate the economic effects of resource variability.

In 1839 a French physicist Edmund Becquerel proposed that few materials have the ability to produce electricity when exposed to sunlight. But Albert Einstein explained the photoelectric effect and the nature of light in 1905. Photoelectric effect state that when photons or sunlight strikes to a metal surface flow of electrons will take place. Later photoelectric effect became the basic principle for the technology of photovoltaic power generation. The first PV module was manufactured by Bell laboratories in 1954.

Hybrid systems offer a high level of energy strength throughout the combination of generation methods and frequently will incorporate storage area (battery and fuel cell) or diesel generator to guarantee maximum supply reliability and security. Wind generators and Solar panels are the famous of the alternative energy devices employed in hybrid power systems. Almost of all these advantages the hybrid system consisting of photo voltaic and wind as a primary sources poses a few of technical difficulties also scheduled to uncontrollable weather info like wind speed varying and the day and night, summer and winter months sun conditions. As a consequence of this the ability to strength the energy supply continuity should take care of by backup of alternate reliable energy sources as many of these as diesel generator, battery or fuel cell and so on. Thus we can guarantee the reliable supply for the consumers with this sort of hybrid power system. In this paper the hybrid program is designed and patterned using Matlab / Simulink environment. The combo of Photo voltaic (PV) array system, Wind flow turbine system and Diesel powered generator are intended for pertaining power generation. Blocks just like wind model, PV unit, the Diesel generator is used as for the energy demand which is available in the market, the battery also used as per the storage power from the renewable sources and loads are implemented and the outputs and simulation also presented [2].

Photvoltaic Arrangement: A photovoltaic energy system is mainly powered by solar energy. The configuration of PV system is manifested in Figure 1. It contains PV modules or arrays, which convert solar energy in the form of solar irradiation into electric energy. The dc-dc converter changes the level of the voltage to match it with the electrical appliances that are supplied by this system. This DC -DC converter may be either buck or boost or buck-boost contingent on the required and available voltage levels. The maximum power point tracing system coerces the maximum power from the PV modules. A bi-directional converter which is able to supply the current in both the directions is used to charge the battery when there is a power surplus and the energy stored by the battery is discharged into the load when there is a power deficit [3].

Doubly Fed Induction Generator: Wind turbines use a Doubly-Fed Induction Generator (DFIG) consisting of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter [4]. The stator winding is

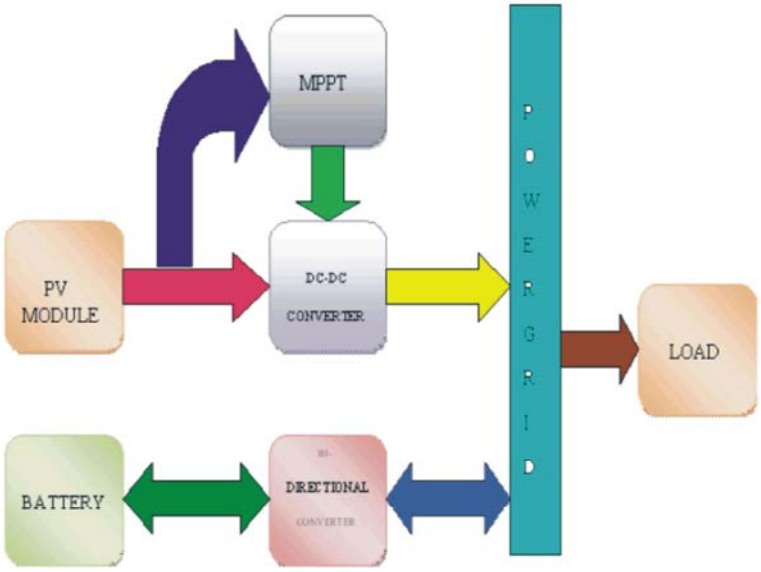

Fig. 1: Overall block diagram of PV energy system

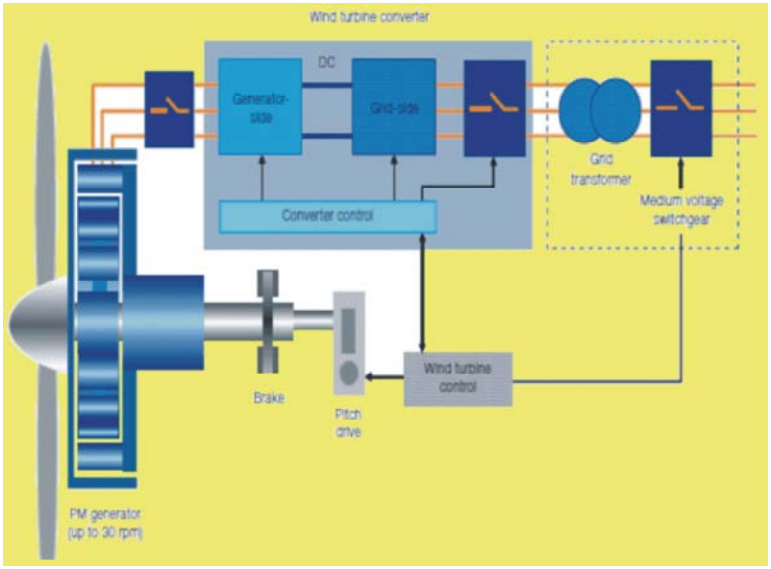

Fig. 2: Direct-drive generator with full-size converter

connected directly to the 50 Hz grid while the rotor is fed at variable frequency through the AC/DC/AC converter. The DFIG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing mechanical stresses on the turbine during gusts of wind. The optimum turbine speed producing maximum mechanical energy for a given wind speed is proportional to the wind speed. Another advantage of the DFIG technology is the ability for power electronic converters to generate or absorb reactive power, thus eliminating the need for installing capacitor banks as in the case of squirrel-cage induction generator [5]. In Figure 2 the working of wind turbine is demonstrated briefly.

The rated mechanical speed of a three-bladed 3MW wind turbine is approximately in the range of 15 rpm, which is a rather low value for electricity generation. The rotor speed is limited by the mechanical strength of the rotor blades and the maximum desirable blade tip speed (the rotor noise level is correlated to the blade tip speed to the sixth power approximately!). Double-bladed and single-bladed wind turbines can have considerably higher rotor speeds than three-bladed wind turbines [6]. They also have the advantage of reduced costs due to fewer rotor blades (the rotor blades account for approximately 20% of the total cost of a three-bladed wind turbine. However, scaling them to the multi-MW range increases the blade length and consequently the

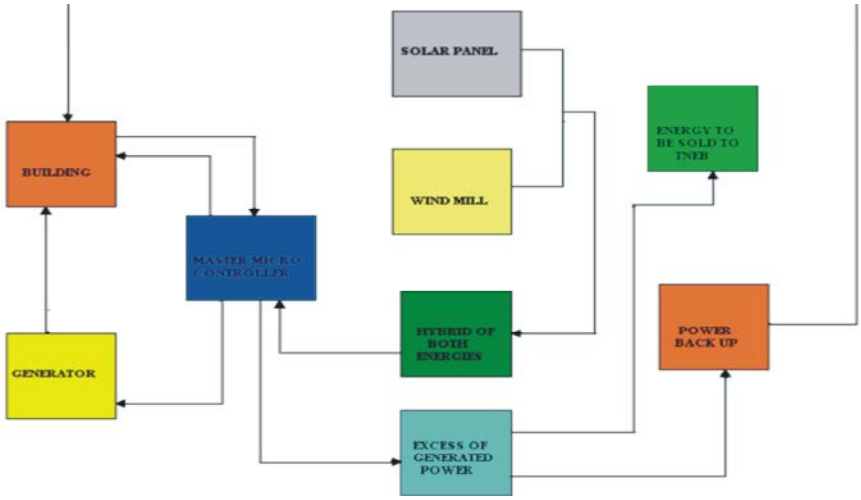

Fig. 3: Block diagram of hybrid system

mechanical stress on the rotor blades. In addition, two bladed wind turbines have a cyclic inertia moment against the yawing mechanism (which rotates the wind turbine nacelle in or out of the wind) and one-bladed wind turbines have in addition dynamic imbalances since the aerodynamic forces at the blade are not compensated by another blade [7].

We introduce hybrid energy control system for multipurpose usage in city buildings. The block diagram of the hybrid system is detailed and shown in the Figure 3. The system utilizes wind and solar panel based renewable energy generation. The total system is controlled by microcontroller based circuits [8] The Master Microcontroller monitors the power flows and automatically makes judgments from preprogrammed data or from remote commands allowing efficient operation of the power sources. Additional controls are included in the package for AC-output and DC-input supervision/protection as well as in PV and wind turbine generator control. The wind and solar energy is combined together to meet the maximum energy demand of the building. During summer months the energy from solar is excess and it can alone meet the energy demand though wind energy is not much available in these days, Where as in the second half of the year the wind energy is abundant compare to that of the solar energy during these days the wind mill is capable of providing energy to that of the demand to the building with the minor availability of solar energy. Sometimes the production of energy from solar and wind may be so efficient due to availability of both the energies by natural climatic conditions. During these days the excess energy can be stored in battery backup for future demand or the excess energy can be sold to the electric board of the state or country. Another practical difficulty is due to climatic disaster or due to abnormal weather conditions sometimes both wind and solar energies may not be available in this condition for emergency purposes the diesel generator with the capability of meeting the energy demand of the very important loads in the building is provided as the optional source for the energy demand of the building. Thus with the constant monitoring of the master microcontroller all these environmental conditions are met and satisfied automatically for the uninterruptable power supply for the building.

RESULTS AND RESULTS

Simulation Methods of the DFIG: Depending on the range of frequencies to be represented, three simulation methods are currently available in Simscape Power Systems™ Specialized Technology to model VSC based energy conversion systems connected on power grids.

The average model (discrete) such as the one presented in this paper in Figure 4. In this type of model the IGBT Voltage-sourced converters (VSC) are represented by equivalent voltage sources generating the AC voltage averaged over one cycle of the switching frequency. This model does not represent harmonics, but the dynamics resulting from control system and power system interaction is preserved. This model allows using much larger time steps (typically 50 microseconds), thus allowing simulations of several seconds.

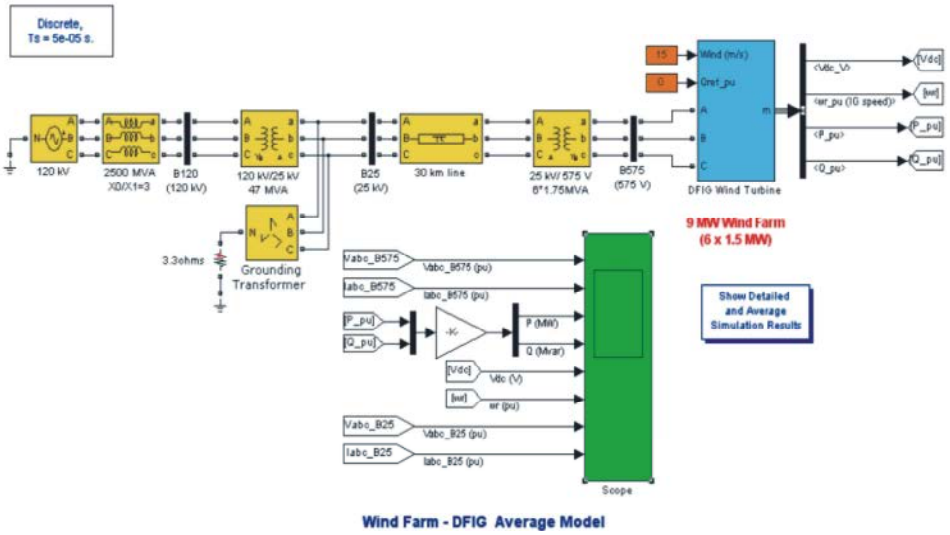

Fig. 4: Simulink Diagram of the Wind Farm -Dfig Average Model

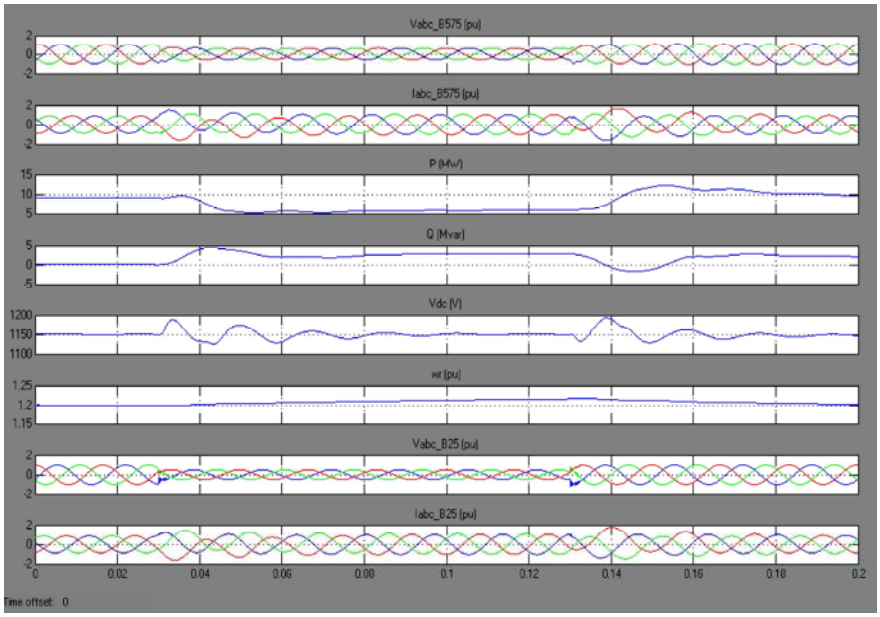

Fig. 5: Simulation Result of Wind Farm – D fig Average Model

Description: A 9 MW wind farm consisting of six 1.5 MW wind turbines connected to a 25 kV distribution system exports power to a 120 kV grid through a 30 km, 25 kV feeder. Wind turbines using a doubly-fed induction generator (DFIG) consist of a wound rotor induction generator and an AC/DC/AC IGBT-based PWM converter modeled by voltage sources. The stator winding is connected directly to the 60 Hz grid while the rotor is fed at variable frequency through the AC/DC/AC converter. The DFIG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing mechanical stresses on the turbine during gusts of wind [9].

In this model the wind speed is maintained constant at 15 m/s. The control system uses a torque controller in order to maintain the speed at 1.2 pu. The reactive power produced by the wind turbine is regulated at 0 Mvar.

Description of Solar Panel Model: A circuit based simulation model for a pv cell for estimating the IV characteristic curves of photovoltaic panel with respect to changes on environmental parameters (temperature and irradiance) and cell parameters (parasitic resistance and ideality factor). This simulink model represented in Figure 6 could be used to analyze in the development of MPPT (maximum power point tracking) algorithm, using a

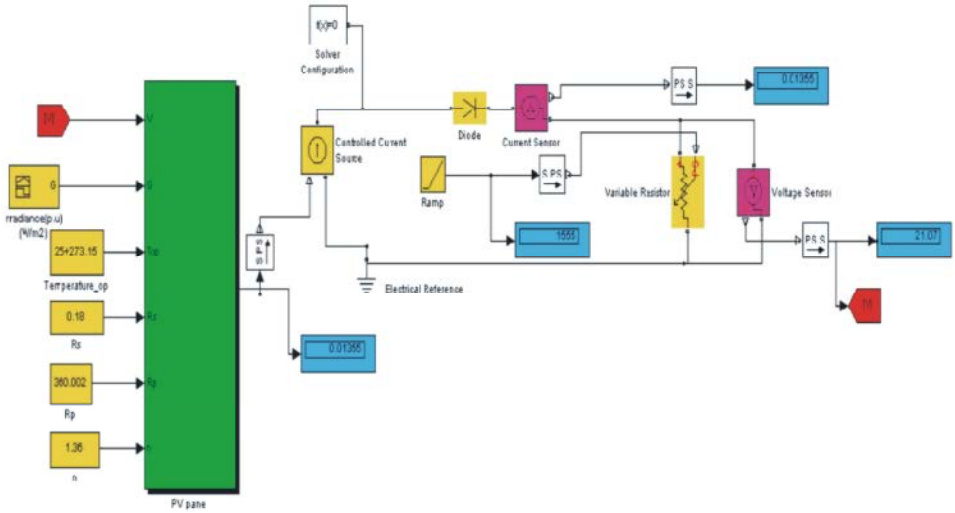

Fig. 6: Simulink diagram of the 60w 36 Cells Solar Msx60 Panel

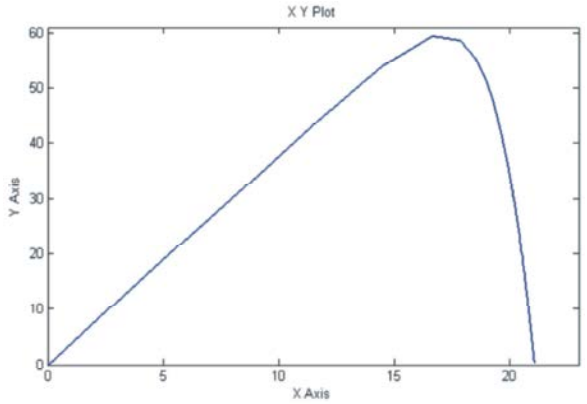

Fig. 7: P-V Graph Of The 60w 36 Cells Solar Msx60 Panel

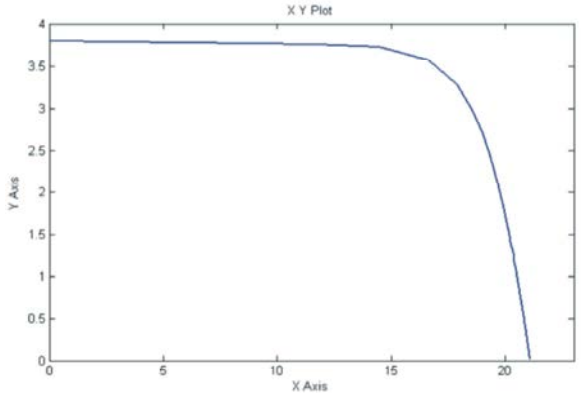

Fig. 8: I-V Graph Of The 60w 36 Cells Solar Msx60 Panel

Shockley diode equation an accurate simulink pv panel model is developed.60W solar MSX60 PV panel is chosen for evaluating the developed model. The P-V and I-V characteristics of 60W 36 cells MSX60 solar panel [10] is shown in the Figure 7 and Figure 8.

Description of Hardware: The block diagram of the hardware unit is detailed in Figure 9.the block diagram consists of components as follows a 12V 5W PV panel, a model wind mill, two 6V battery's and a 12V battery, three CFL lamps, a sepic converter, PIC micro controller, five driver circuits and five relay switches, the 10 LED'S placed to represent normal loads in the building the two CFL lamps represent the very important loads in the building. And finally a diesel generator for emergency purposes. The PV panel and the wind mill generate power by its nature in the absence of power generation the 6V batteries used as power generators for practical implementation.

The single-ended primary-inductor converter (SEPIC) is a type of converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input. The output of the SEPIC is controlled by the duty cycle of the control transistor [11]. The 12V battery is used for the storage purpose and CFL inverter converts the dc supply in to ac supply. The PIC micro controller is used as the master micro controller which controls the total hybrid system as explained earlier the function of the micro controller in chapter 4 [12]. The third CFL lamp represents the power that was sold to electric board of the state (or) country. The relay circuit controls automatically according to the commands of the master microcontroller. There are three conditions are coded in the master micro controller the conditions are coded for the uninterruptable power supply to the building. The conditions are as follows when both the renewable energy sources are in operation the energy is utilized for all the normal loads and the very important loads in the building and the excess power is stored in the battery and is sold to power grid. The second condition is when any one of the renewable source is under fault (or) cant able to generate power due to natural deficiency of the energy with the available power only the very important loads of the building is operated automatically and other normal loads are made to shut down automatically by the relays which are commanded by the master microcontroller. The third condition is when both

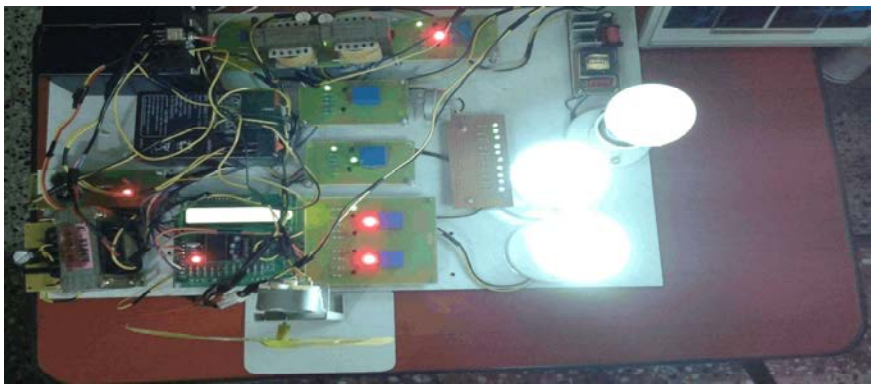

Fig. 9: Block Diagram of the Hardware model of the Hybrid System

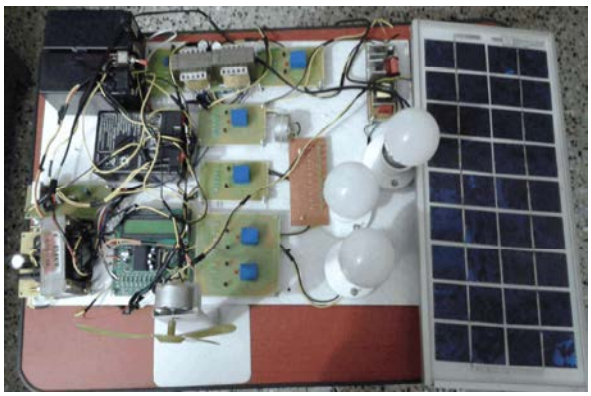

Fig. 10: Photo Images of Hardware Of Design And Development Of Hybrid Energy Control Scheme For The Multi-Purpose Usage In A Building

the renewable energies are failed to generate power the emergency diesel generator is automatically turned on by the master microcontroller for the operation of very important loads in the building. Thus we obtain an uninterrupted power supply for the building.

CONCLUSIONS

This Integration of renewable Energy source will be highly effective in all places, especially in commercial areas where need of electricity is more [13]. It causes no effect on nature i.e. pollution free, at the same time not proneness any kind of accident due to lightning. It is also useful to minimize power supply load i.e. cut short power charge. By using this system, we can save electricity charge because very less maintenance charge to this equipment is required. The designing of this equipment is done in such a way that it is very compact and acts as user friendly. When it is manufactured in a large scale, cost of this integrated natural resources power generation system is affordable. Moreover there is no power failure situation at any times. Therefore, it is the most reliable renewable power or electricity resources with less expenditure. Thus in this paper the hybrid program is designed and patterned using Matlab / Simulink environment. The combo of Photo Voltaic (PV) array system, Wind flow turbine system and Diesel powered generator are intended for pertaining power generation. Blocks just like wind model, PV unit is designed, the Diesel generator is used as for the energy demand which is available in the market, the battery also used as per the storage power from the renewable sources and loads are implemented and the outputs and simulation also presented. PV cell Module and array are simulated and effect of environmental conditions on their characteristics is studied Wind energy system has been studied and simulated.

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