HYBRID RENEWABLE ENERGY BASED MICRO GRID

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Abstract – *During the past decade the use of fossil fuels have amplified the effects on the global warming, natural disasters have cause havoc to entire electric grid disconnecting them from the critical loads such as hospitals, military bases, etc. Micro grid system is a concept that integrates the Distributed Energy Resources (DER) to form an independent electric infrastructure. In general micro grid contains DER in various conventional forms such as diesel generators in particular. Our design of micro grid incorporates renewable energy resources which delivers a cleaner energy generation. This presents the significance of the deployment of hybrid renewable energy based micro grid as a promising aspect in the future of power systems. With this intention the micro grid architecture is designed consisting of high penetration of distributed generators linked to the grid through controllable power electronic based devices, along with the inclusion of communication techniques, electrical energy storage systems. This paper carries out coordinated analysis of micro grid control strategies, algorithms, and methods of utilization of Renewable Energy Resources (RES). Finally, the hardware and simulation results under various operations carried out on distributed energy generated, state of charge of Distributed Energy Storage, and basic power management functions.*

***Key Words*: Micro grid, DER, Power management, Energy Storage, Renewable Energy, Control Strategy**

1. INTRODUCTION

The demand of energy due to the crisis of the energy resources i.e., Natural gas, coal, fuel, nuclear energy and etc., which drives the innovation for finding alternative energy resources. Coming to renewable energy, the role of solar energy is very important when compared to others and that is due to the available unlimited energy sources. Currently more renewable energy conversion systems are linked to low voltage or AC micro grids due to environmental issue affected by fossil fuel power plant. So AC micro grid is proposed for the connection of renewable power sources to AC systems, and thus fossil fuels requirements are reduced. Reverse conversions required in AC or DC grids may add losses to the system operation and makes the office appliances more complicated. The process of constructing a micro grid is to give high electric power to digital sustainable way. The connection of various AC and DC micro grid systems can facilitate in the advancement of smart grid. In this micro grid project power electronics plays a most important role in this construction. Recently microgrid improves the quality and performance by utilizing battery energy system.

1.1 MICRO GRID

A Microgrid is an independent energy system consisting of distributed energy sources (including demand management, storage, and generation) and loads capable of operating in parallel with, or independently from, the main power grid. Microgrids can perform dynamic control over energy sources, enabling autonomous and automatic self-healing operations. During normal or peak usage, or at times of the primary power grid failure, a microgrid can operate independently of the larger grid and isolate its generation nodes and power loads from disturbance without affecting the larger grid's integrity. Consequently microgrids are able to inter-operate with existing power systems, information systems, and network infrastructure, and are capable of feeding power back to the larger grid during times of grid failure or power outages. Microgrids likewise can integrate with renewable energy sources such as solar, wind power, small hydro, geothermal, waste-to-energy, and combined heat and power (CHP) systems.

1.2 RENEWABLE ENERGY RESOURCES

Renewable energy is becoming an increasingly important in today's world. Over the course of time the consistent developments in the renewable energy sector have proved to be successful. Considerably through research and development the costs of deploying the renewable energy system have come down significantly. This makes the design of systems with renewable energy possible.

2. RELATED WORK

Various papers have been published on the topic of micro grid they discuss about the concepts and control strategies of micro grid. This method is about integrating hybrid renewable energy sources into the micro grid as distributed energy resource and can be used in powering critical loads. It can provide improved efficiency and reliability for the future power system. The consumption of fossil fuel intensifies the environmental pollution. Hence our micro grid is designed to integrate hybrid renewable energy resources. The micro grid control strategy is designed and simulated by LabVIEW (Laboratory for Virtual Engineering Workbench). This is a micro grid concept where existing power transfer method is used. Future developments is carried out in the direction of advancement in micro grid power system.

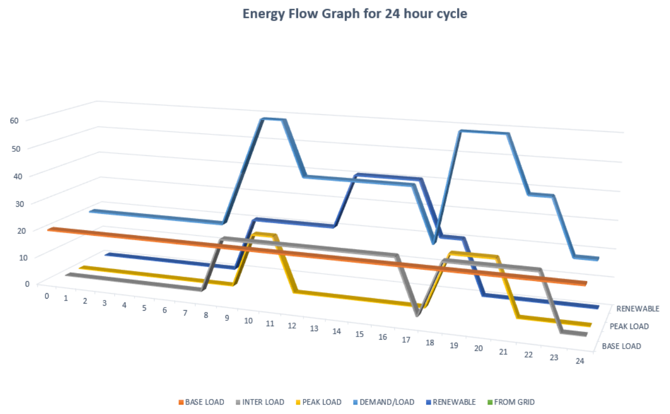

Chart -1: Load Flow Graph

Chart-1 gives us the details of the energy flow for a time period of 24 hours. The parameters taken for the representation in graph are Base load– which remains constant throughout the time cycle, Intermediate Load- which is used for short amounts of time period, Peak Load– Highest load consumption in the 24 hour timeline where most of the loads are used causing this event, Total demand– which gives us the summation of all the types of loads at particular time intervals. Along with the input energy from the grid and renewable sources.

3. BLOCK DIAGRAM

Fig-1 the block diagram of the proposed method. The Block Diagram comprises of three sections. Renewable Energy Section that contains all the hybrid renewable energy resources connected to the micro grid system. Renewable energy Section and Home Section, these data are processed by MyRIO accordingly and controllers are actuated. Charge controller, charge regulator are also known as battery regulator limits the rate at which electric current is added to the electric batteries. Inverter can also be used with transformers to convert the certain DC input voltage into a completely different AC output voltage may be higher or lower but the output power must always be less than the input power. The function of a fuse is to prevent the fire - that's the basic protection of a fuse offers - between power supply and appliance also there may be a few feet or meters of cable.

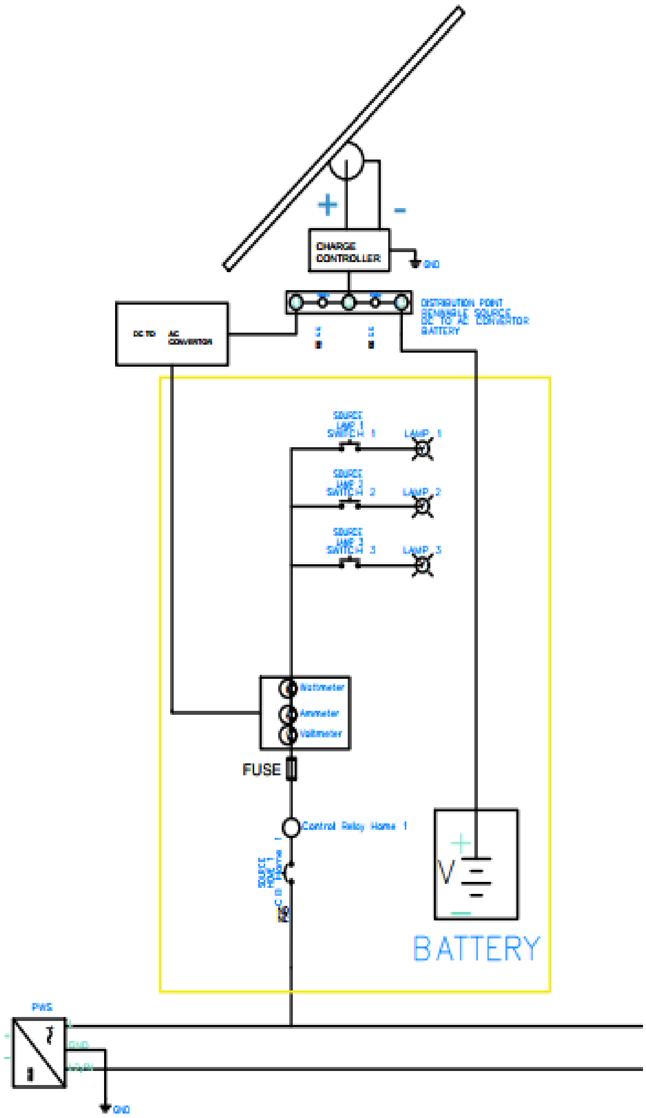

Fig -1: Block diagram of proposed Method (Section)

3.1 RENEWABLE ENERGY SECTION

The renewable energy section is realized with a Solar Photovoltaic panel and we have leveraged the existing resources a Fixed Energy Wind Turbine which already exist within our institution with intention to increase the penetration of distributed energy resources into our microgrid system. The Block diagram is considered modular and designed in such a way to include other energy resources into the system in the future which increases the capabilities of our system.

3.2 HOME SECTION

The Home Section consist of lamp loads that replicate the actual loads in a home for this prototype. Consequently this section acts as an energy receiver along with switches, fuse and Miniature Circuit Breaker (MCB) as additional safety measures.

4. SIMULATION

The simulation of the hybrid renewable energy micro grid is designed and established using LabVIEW software by National Instruments. The simulation results are obtained for a period of 24 hours and the loads are controlled manually by the user. The designed algorithm suits to the varied operation of the housing loads at various time intervals. The information about the status of electrical systems in the homes are displayed on the digital panel meters (virtual). The details such as Watts/hour, Voltage, Current consumed varies accordingly as per Real-Time. Simulation is carried out in various stages and operated simultaneously. The simulation consists of Real-Time Counter, Solar Section, Wind Section, House Section, and Control Panel Section.

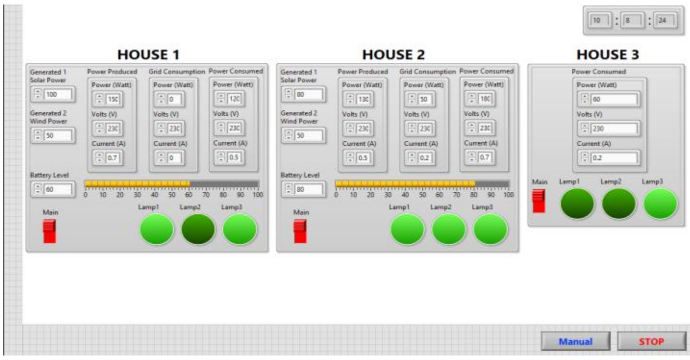

Fig -2: Simulation of Micro grid with all sections using LabVIEW

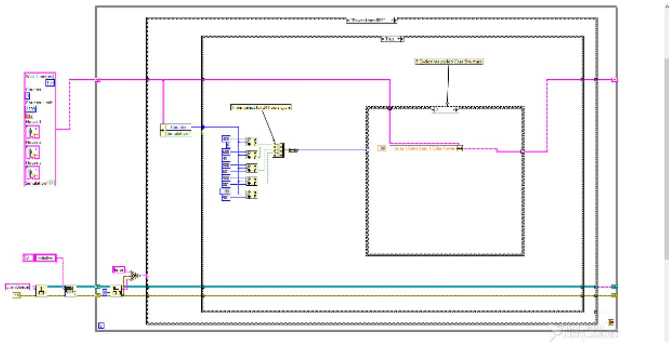

Fig -3: Block diagram of Renewable Energy Section

4.1 REAL TIME COUNTER

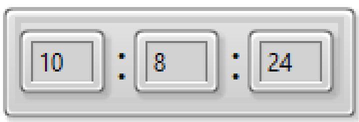

Fig -4: Real Time Counter Segment

Fig-4 the real time counter is designed with various segment to replicate the real time characteristics of a 24-hour time-cycle. This aides in the easy understanding of operation of solar renewable energy resources over a course of 24 hours in a span of few minutes. The solar renewable energy output is variable as it depends according to the irradiance of the Sun's rays.

4.2 HOUSE SECTION SIMULATION

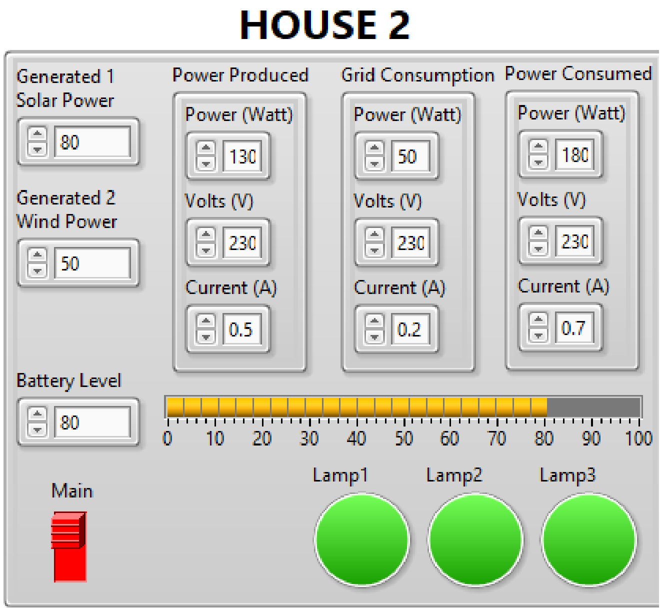

Fig -5: House Section in Simulation

The Fig-5 represents all the panel reading according to the simulation with reference to the timer counter. The Home Section consist of Digital Panel Meter (DPM) created virtually that displays the data of the power produced, grid consumption, Power Consumption, Battery Level in Percentage, Generated renewable power by different sources, and lamp loads which are used to simulation the normal operating conditions of three different load conditions. Such as base load, intermediate load and peak load.

Table -1: Output Characteristics of Simulation Result

Output parameters of Simulation			
Energy from the Renewables	**Voltage/ Current**	**Energy Consumption from Load**	**Watt s/hr**
Solar Photovoltaic Energy (Intermittent in Nature)	DC 12V/1A 10W	Minimum Consumption	20W
Fixed Wind Energy (Constant)	AC 240V/1A 20W	Medium Consumption	40W
Hydro-Electric Energy (Intermittent)	AC 230V/1A	Maximum/Peak Consumption	60W

5. HARDWARE IMPLEMENTATION

Hardware for micro grid is designed as a prototype for control and effective operation of the hybrid power system. Our prototype is an operational section of the micro grid providing a platform for the integration of the hybrid renewable energy resources within the electrical power system architecture. Moreover the control architecture delivers an efficient and reliable way of consuming the hybrid renewable energy resources which are typically inconsistent and intermittent in nature. Currently the methods of operation of the electrical power system have complications in integrating the renewable energy resource that are different in characteristics from the conventional power source. Thus our micro grid control architecture overcomes the difficulties of the electric power system by designing innovative solution to this problem and realizing a micro grid system that operates autonomously. By engineering the system which employs digital technology, we can improve the standards of the micro grid electric infrastructure as a crucial contribution to the grid in the foreseeable future.

5.1 HARDWARE COMPONENTS

The micro grid prototype is designed based on modularity which offers scope for further development which will upgrade the "efficiency, reliability" and paves way by the incorporation of various other futuristic technologies and platforms. Consequently this may shape the architecture of micro grid into a highly sophisticated system which may integrate diverse sub-systems and elements of the electric infrastructure.

5.2 SOLAR PHOTOVOLTAIC PANEL

Renewable energy source integrated into our prototype by using 10W Solar Photovoltaic panel. The solar PV cells converts sunlight directly into electricity, they are made up of semiconducting materials similar to those in computer chips. When sunlight is absorbed by these materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce electricity. This process of converting light (photons) to electricity (voltage) is called the photovoltaic (PV) effect.

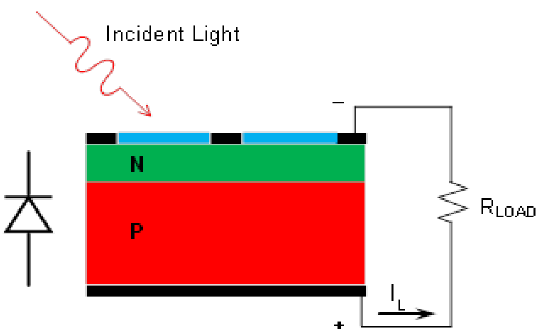

Fig -6: Solar Photovoltaic Cell Block diagram

Only sunlight of certain energies will work efficiently to create electricity, and much of it is reflected or absorbed by the material that make up the cell. Because of this, a typical commercial solar cell has an efficiency of 15%-about one-sixth of the sunlight striking the cell generates electricity. Low efficiencies mean that larger arrays are needed, and that means higher cost. Improving solar cell efficiencies while holding down the cost per cell is an important goal of the PV industry.

Fig -7: Solar Photovoltaic Module

5.3 DC-DC CONVERTER

The DC-DC Chopper section is used to convert the variable DC output voltage provided by the solar photovoltaic panel into fixed DC power suitable for using in various DC applications. Practical electronic converters use switching techniques. Switched-mode DC-to-DC converters convert one DC voltage level to another, which may be higher or lower, by storing the input energy temporarily and then releasing that energy to the output at a different voltage.

5.3 DC-AC INVERTER

The DC to AC Inverter section is designed as a diode based inverter circuit with relay, capacitors, and transformer. The inverter architecture converts the 20V DC supply from the Solar Renewable energy into single phase 230V AC supply which is at 50Hz frequency. DC to AC inverter provides 220

VAC when a 12VDC power source. It can be used to power very light loads like night lamps and cordless telephones, but can be modified into a powerful inverter by adding more MOSFET's. Remember that this is not a sine-wave inverter, not even a modified one. It's just a square-wave one so you can power only light bulbs, and small power tools that do not require a frequency with a sinusoidal wave form.

Input Voltage - A typical power inverter device or circuit requires a relatively stable DC power source capable of supplying enough current for the intended power demands of the system. The input voltage depends on the design and purpose of the inverter. 24, 36 and 48 V DC, which are common standards for home energy systems

Output Waveform - An inverter can produce a square wave, modified sine wave, pulsed sine wave, pulse width modulated wave (PWM) or sine wave depending on circuit design. There are two basic designs for producing household plug-in voltage from a lower-voltage DC source, the first of which uses a switching boost converter to produce a higher-voltage DC and then converts to AC. The second method converts DC to AC at battery level and uses a line-frequency transformer to create the output voltage.

Output Frequency - The AC output frequency of a power inverter device is usually the same as standard power line frequency, 50 or 60 hertz. If the output of the device or circuit is to be further conditioned (for example stepped up) then the frequency may be much higher for good transformer efficiency.

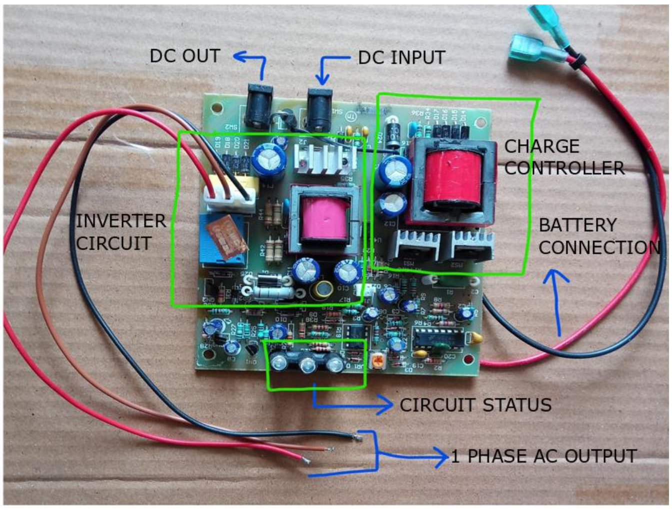

Fig -8: 3 in 1 Inverter, Converter & Charge Controller Module

5.4 CHARGE CONTROLLER

The Charge controller is integrated into the circuit. A charge controller, charge regulator or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk.

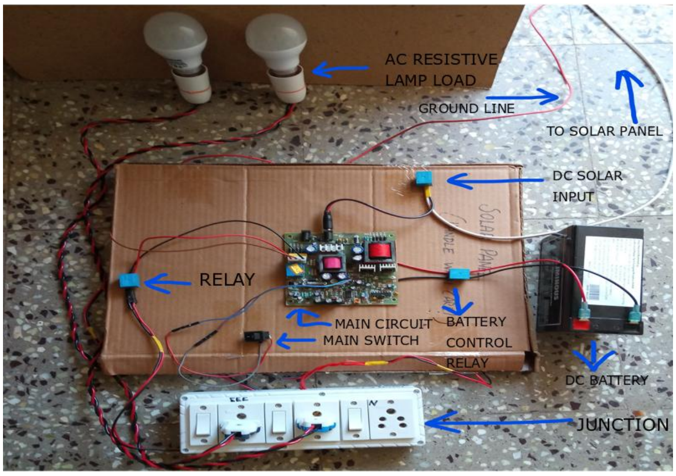

Fig -9: Complete Hardware

5.5 RELAY CONTROL SYSTEM

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal.

The relay is controlled by the use of MyRIO FGPA Board which is pre-programmed to operate effectively according to different conditions

The Coil voltage this voltage that the coil actuate the armature. This value should indicate also if the current is AC or DC.

The Coil current this value indicates the current that the coil will draw when it is powered with the indicated coil voltage. Very important characteristic to take into account when designing the driver of the relay. The current that goes through the driver must be enough to actuate the armature.

The Off-Voltage this characteristic shows the minimum voltage that the armature is pulled by the electromagnet. If the voltage goes below this value, the spring will overcome the magnetic force and relay will change state.

Table -2: Output Characteristics of Hardware

Result of Output characteristics (Hardware)			
1.	Solar Photovoltaic Input	Input: Solar Light Energy	Output: DC 12V,1A
2.	DC-DC Converter Output	Input: Variable DC DC 12V,1A	Output: Fixed DC DC 9V,!A
3.	DC-AC Inverter	Input: Variable DC 12V /1A DC	Output: Sinusoidal AC 230V/ 0.78A AC 50 Hertz
4.	DC Charge Controller	Input: Variable DC 12V/ 1A DC	Output: Fixed DC 12V/24V Charge controlled output

6. CONCLUSION

Thus the micro grid architecture is designed and autonomous control strategies are in place which makes the operations, and control in the micro grid. This micro grid is designed and simulated successfully in the LabVIEW. Thus the micro grid architecture is designed and autonomous control strategies are in place which makes the operations, and control in the micro grid. This micro grid is designed and simulated successfully in the LabVIEW. The micro grid architecture enhances the reliability of the renewable energy resources isntegration into the electric infrastructure thereby decreasing the reliance on the existing grid infrastructure and moving towards a greener energy.

7. SCOPE OF FUTURE DEVELOPMENT

The direction of future developments comprises of the enhancement of the operation of micro grid, devising various strategies of control and communication. Such as efficient utilization of Renewable Energy Resources (RES), Distributed Energy Storage (DES), Protection of the systems from cyber-physical attacks, and leveraging the power of Artificial Intelligence (AI), Machine Learning (ML) to design ground-breaking algorithms which can predict the weather, climate, RES output levels and demand. Such a development will prove to a great leap in the modernization of the existing electric infrastructure.

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