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A Relay Based Controller Designing of Hybrid Power Systems

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ABSTRACT: The complementary nature of wind and solar determines the advantages and potentiality of hybrid power generation systems. The energy management system switches the mode of power supply and controls the load share according to the condition of wind power, solar radiation and load requirement. Through the suitable allotter of the generation ratio from wind power and photovoltaic cells, the distribution grid system, combined with battery bank can provide user with reliable electric power. This energy management system is applied in experimental equipment. The energy management system helps in overcoming the uncertainties of a renewable power source by paralleling of multiple power sources along with the main grid connection.

KEYWORDS: Energy management, Paralleling of multiple sources, MPPT.

I.INTRODUCTION

World energy consumption has been on the rise worldwide as developing nations begin to industrialize and as consumers in developed nations buy more energy consuming appliances to make life more comfortable. If the current trends continue, we may face an energy shortage in future. All the energy on earth is derived from the sun .However, it occurs in various forms that today, man has developed the technology to exploit and use for agricultural, industrial and personal advancement. Energy used to power our lives can be divided into two types: Renewable and Non-renewable. Renewable sources are those sources that are continuously replenished by the action of the sun on the earth. They include wind, hydro-power, solar, bio-fuels and geothermal. Non-renewable sources are usually fossil fuels whose supplies will one day run out. An exception is Nuclear power which, though a non-renewable, is not produced from a fossil fuel.

It's something of an uncomfortable fact that civilized society is almost completely reliant upon fossil fuels for nearly every aspect of its existence. While fossil fuels have been integral in the development of most industrial nations, there are a few realities of using them that society needs to come to terms with. There are many arguments in favour of society's need for renewable energy. It's a fact that the climate is changing and that fossil fuel emissions are contributing greatly to that change. By contrast, solar energy panels and wind turbines generate zero emissions in their generation of electricity. By recent Greenpeace estimates, the world could save around $180 billion a year by switching 70% of the planet's electricity production to renewable options. While this alone is an excellent economic argument in favour of renewable energy, the truth is that the sheer savings involved aren't the only economic factors that support the use of renewable energy as a positive way forward. Some local markets are already starting to gain access to renewable energy options in their local power grid that have them saving more money than with traditional fossil fuel sources. Historically, coal powered the Industrial revolution but when $5 barrel oil began to flow, coal declined in importance until the oil embargo which brought it back into importance.

However, due to environmental concerns, coal power plants have to adhere to stricter environmental standards. Despite this ,the earth still has over 400 years of coal supplies compared to 60 years of oil thus of the fossil fuels, coal remains the cheapest to produce electricity from. Natural gas is currently in abundant supply in North America and Russia which has led to a decline in gas prices which has helped boost electricity supply and lowered electricity tariffs.

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II. LTERATURE SURVEY

Yukihiro Ozaki et.al in his paper presents the power control of a stand-alone photovoltaic/ wind/ energy storage hybrid generation system with maximum power point tracker. In this paper, a hybrid generation system combining photovoltaic (PV), wind turbine (WT) and Electric Double Layer Capacitor (EDLC) is presented to supply stable power to residential power applications as stand-alone loads. The photovoltaic and wind systems are used as main energy sources while the EDLC is used as storage device. Three individual DC/DC converters are used to control the power to the load. Control with DC/DC converters is used for Maximum Power Point Tracker (MPPT) and hence maximum power extracting from the solar photovoltaic systems and wind turbine. Power fluctuation of renewable energy is compensated using Maximum Power Point Tracker. The system controls EDLC power to match demand and supply power. If PV and WT generate power is lower than demand power, the EDLC is controlled to discharge power to complete the difference of supply and demand power. If PV and WT generate power is higher than demand power, the EDLC is controlled to charge power.

Mohammad Nasim Imtiaz Khan et.al in their paper proposes the modeling and simulation of an efficient charge controller for photovoltaic system with maximum power point tracking. Design and simulation of an efficient, cost effective Charge Controller for Photovoltaic (PV) System is presented in the paper. To harness maximum power from the PV panel, the charge controller is equipped with Maximum Power Point Tracking (MPPT) feature. An efficient algorithm for MPPT is developed which requires less iteration to reach Maximum Power Point (MPP) than the traditional Perturb and Observe (P and O) method. Only an input voltage sensor is needed for the design and algorithm to track the MPP which makes the charge controller cost effective.

Zhenhua Jiang et.al in their work studies power management of hybrid photovoltaic-fuel cell power systems. To overcome the problem of intermittent power generation, PV power systems may be integrated with other power sources. Fuel cells are an attractive option because of high efficiency, modularity and fuel flexibility; however, one main week point is their slow dynamics. On the other hand, current technology batteries by themselves are usually insufficient to provide the long-term energy that the increasing loads require. Hybrid systems composed of fuel cells and batteries can be integrated with PV power systems to provide uninterrupted high-quality power. The goal of this study is to design an effective power management system for a PV/fuel cell/battery hybrid power system so that the combination can be used as a reliable power source.

III.SYSTEM MODEL AND BLOCK DIAGRAM

The structure of pure DC busbar system is shown in Fig 1. In pure DC bus bar system, PV system, WT system and grid power are connected to DC bus bar through electric devices which convert output power into DC form. This time DC load can be directly connected to DC bus bar while AC load needs electric devices. The working voltage of the designed system is fixed to 12 V DC. Thus the corresponding converters must be used to bring the generated voltage levels to this specified level.

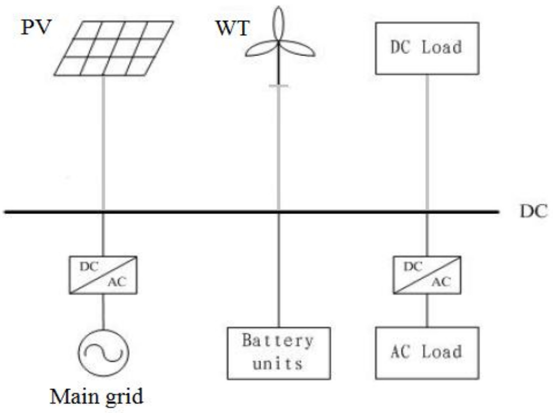

Fig 1: DC bus-bar model

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The block schematic representation of the project is shown in Fig 2. Wind-solar hybrid power generation systems include photovoltaic (PV) system, wind turbine (WT) and its associated battery unit. The Hybrid system is connected to grid to meet load demands in a reliable manner. The power sources are switched according to the availability of the power based on a definite algorithm. Converters are also provided for meeting the requirements of loads.

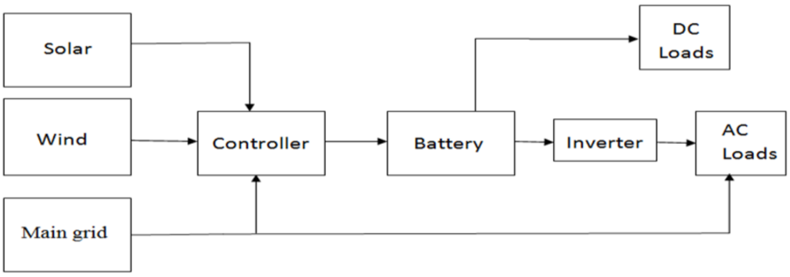

Fig 2: Block Diagram

IV.CONTROLLER CIRCUIT DESIGN

The disadvantage while dealing with the implementation of a hybrid system is the uncertainties of the resource availability. So a control mechanism should be provided for ensure reliability. Even if the output from a source is unavailable or is insufficient to meet the demand, other sources should complement it so that the user will get uninterrupted power. The Algorithm based on which the control mechanism is designed is given below in Table 1.

Table 1: Controller Design Algorithm

Solar	Wind	Grid	Preference
√	×	√	Solar
×	√	√	Wind
√	√	√	Solar and Wind
×	×	√	Grid

If the solar and grid power is available together the battery is charged from the solar power. Similarly if wind and grid power is available, the wind power is used to drive the load. When all three sources that is solar, wind and grid power is available output from both solar and wind are taken together to avoid the wastage. When none of the renewable sources are active, the grid power is utilized. In this scheme we can eliminate wastage and ensure minimum consumption of energy from the grid source.

The control circuit is designed using 12V relays as we fixed our bus bar voltage to be 12V. Diodes are connected across the relays to provide control. The control circuit designed is given below in Fig 3.

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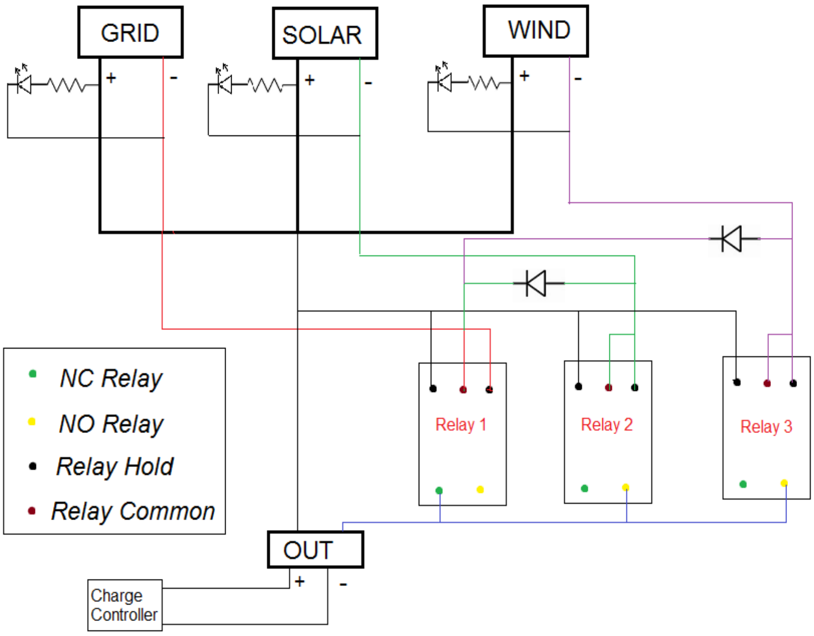

Fig 3: Controller circuit

The two diodes connected relay 1 and relay 2 and relay1 and relay 3 ensures that relay 1 is inoperative when either relay 2 or relay 3 or both is operating. That is the grid power is switched off when any of the renewable source is available. When both wind and solar is available, relay 3 and relay 2 are both operating and the battery is charged from both sources. Grid power is only active when no other option is available. Three LED's are connected each across solar, wind and grid power output. These are provided as the indicators to identify which incoming source is available at a definite period. An LED is also given to the output side indicating the flow of power from the control circuitry to the charge controller and there by charging the battery.

V.HARDWARE

Photovoltaic Cell

A solar cell, or photovoltaic cell (PV), is a device that converts light into electric current 1880s.The array of a photovoltaic power system, or PV system, produces direct current (DC) power which actuates with the sunlight's intensity. For practical use this usually requires conversion to certain desired voltages or alternating current (AC), through the use of inverters. Multiple solar cells are connected inside modules. Modules are wired together to form arrays, then tied to an inverter, which produces power at the desired voltage. For solar cells, a thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semi-conductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current that is, electricity. This electricity can then be used to power a load.

Wind turbine

Wind turbines are used to convert the wind power into electric power. Electric generator inside the turbine converts the mechanical power into the electric power. Wind turbine systems are available ranging from 50W to 2-3 MW. The energy production by wind turbines depends on the wind velocity acting on the turbine. Wind power is used to feed both energy production and consumption demand, and transmission lines in the rural areas. Wind turbines use wind energy to produce electricity. The wind turbines are machines that have a rotor with three propeller blades. These blades are specially arranged in a horizontal manner to propel wind for generating electricity. Wind turbines are placed in areas that have high speeds of wind, to spin the blades much quicker for the rotor to transmit the electricity produced to a generator.

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This model is implemented with a 4V output wind generating system. The 3 blade fan is coupled to the shaft of a 12V, 2000 rpm micro motor. When the fan is made to rotate an output according to the fan speed appears across the motor terminals. For larger output larger fan sizes must be used. Since our bus bar is of 12V dc, the maximum output of 4V is to stepped to 12V. An op-amp (LM 741) is used to get the required output level. Even if the input from Wind turbine exceeds 4V the output to controller is limited to 12V by the saturation of op-amp.

MPPT charge controller

MPPT or Maximum Power Point Tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called maximum power point (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature.

The major principle of MPPT is to extract the maximum available power from PV module by making them operate at the most efficient voltage (maximum power point). MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to a DC load, which is connected directly to the battery. The MPPT process will raise the current while lowering the voltage. This can be done through a process called DC to DC conversion. The reason this works is because we can exchange current and voltage and yet have the same amount of power (Watts) Notice the voltage is lowered as the current is raised yet it produces the same power. MPPT circuits use this process to lower the voltage close to the battery voltage while raising the current. As long as the voltage reaching the MPPT controller is higher than the battery voltage by about 5% or more, then the MPPT output current will be higher than the input.

VI. RESULT AND DISCUSSION

The grid connected solar-wind hybrid system model was successfully implemented. The control circuit was designed using 12V relays. Then consumption of power from main grid was limited to minimum thus depending more on the renewable sources of power. When there is availability of solar power or wind power, the corresponding relay was switched on and the battery was charged through the charge controller. When solar and wind power are both absent the battery is charged from the main grid. Also when both solar and wind is available, both relays corresponding to each one was turned on and the battery was charged from both sources thus avoiding the wastage. Thus reliability is ensured. The work can be developed for higher power levels to have practical applications in systems like smart grid. And using suitable methods of synchronizing it can be further developed to supply power back to main grid during excess production. On grid power systems with higher rating can be set up to provide power to isolated regions with plenty non-renewable resource availability. Fig 4 shows the picture of implemented hardware model.

In the hardware model a PV panel, wind turbine and grid connection is used to implement the hybrid power system. The PV panel used has an open circuit voltage of 18.61V and short circuit current of 0.65A. In the project a 4V output wind generating system is implemented. An op-amp (LM 741) is used to get the required output level from 4V generated power. From the 230 V ac main supply a 230/12 V transformer 230/12 V is used to step down to 12Vac. Then a rectifier IC is used to convert the 12 V ac to 12 V dc. A 25 V, 4500 micro Farad Capacitor is used as the filter circuit to obtain the ripple free dc of 12V magnitude. The output from all these sources is given to the designed controller circuit. The controller circuit has one output which is used to charge the battery through an MPPT charge controller. A 12 V led panel is used as the load to the system which is connected to battery through the charge controller terminal.

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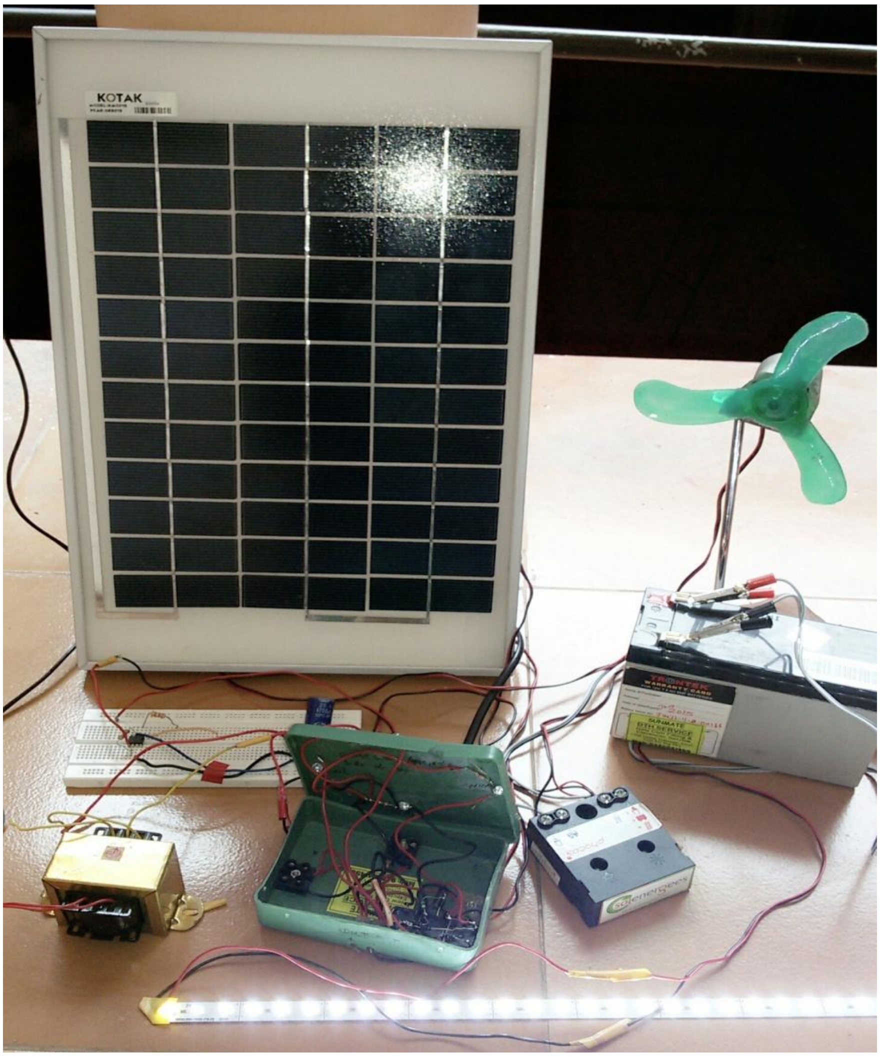

Fig 4: Hardware Setup

VII.CONCLUSION

An environmental friendly method to reduce the dependency on fossil fuels and other non-renewable resources is proposed here. The use of wind and solar power reduces the environmental impact to a great extent. In the present situation of diminishing of the fuels alternative energy sources must be developed for meeting the world's increasing demand of electricity. This can be only achieved by the wise use of our natural resources. The utilization of renewable energy resources is far more decentralized than that of non- renewable sources.. Underdeveloped areas can capitalize on local renewable resources to promote development that was previously restricted to areas with greater access to the large-scale infrastructure needed to support fossil fuel power plants. Other industries can benefit from the switch to renewable sources.

Overreliance on non-renewable resources over the past few centuries has revealed their inherent vulnerabilities. In the past few decades, mounting environmental problems, increasing worry over secure supply chains, and economic instability due to volatile energy prices have routinely plagued industrialized and developing nations as they strive to meet ever-growing energy demands. Although there are still technological hurdles to clear before renewable energy can

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be efficiently exploited, the economic and environmental benefits of renewable sources. suggest that this is a sound area of investment.

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