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STUDY AND SIMULATION OF AC/DC MICROGRID WITH HYBRID CONVERTER

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Abstract - *Now-a-days with inadequacy in electrical energy & continuously enlarging fuel cost, leads to investigation on the Non-Conventional energy sources. Recently, there are many problems regarding increasing energy demand and decreasing in fossil energies, due to this the utility grid is integrated with the renewable energy sources to fulfill the demand. The major technical contribution of this paper is to study and implementation of DC microgrid.*

The wind & solar system are connected to the load through Boost Derived Hybrid Converter. Hybrid converter topologies which can supply simultaneously AC as well as DC from a single DC source. The modeling and simulation of hybrid system is done using MATLAB2018a /SIMULINK. The performance of the hybrid system is evaluated under different speeds & different irradiation levels. Simulation results show that the proposed hybrid system has the potential to meet the demand of an isolated area such as Islands, electrified areas, etc. A 25W prototype is used to validate the operation of the hybrid system and by adding solar plates or wind mill it will increase the capacity of generation and able to supply the maximum demand.

Key Words: **Boost-Derived Hybrid Converter Irradiance, Hybrid energy system, Non-Conventional Energy Resources, DC grid, etc.**

1. INTRODUCTION:

In this paper, wind and solar plant is design to make a Micro-grid. For the local use in remote areas Micro-grid is a good solution. As the need of energy is increasing drastically day by day, Microgrid is good solution to meet the energy demand. Microgrid is a small scale grid which can operate separately or with other small power grid. Micro-grid is used to generate, distribute and control power in small section. Micro- Grids are design to provide continuous power and balance customer local demand.

In the year 2012, 44.8 GW of new wind energy conversion systems were installed worldwide. The trends have been towards increasingly larger turbine sizes, culminating in the installation of off-shore wind parks that are not located to far from load centres. The energy system proposed in the paper seeks to address both issues related to electricity and transportation sectors. One potential solution to this is hybrid, Micro-grids that can be either vertically integrated with high-rise building as frequently encountered in urban areas.

In this paper, Hybrid Converter is also designed. Hybrid Converter work as both Inverter & Chopper. Working of Hybrid Converter depends on the switching of MOSFET. Input of Hybrid Converter is DC and it gives AC & DC as output with the help of Inverter and Chopper and then it is supplied to the loads.

This paper presents both DC and AC loads supplied by different kinds of energy sources efficiently by power electronic converters.Fig.1 shows the schematic of the system in which single DC source supplies both AC and DC loads. The architecture involving the hybrid converter in which both the operations are performed by a single converter. Because of the inherent shoot through protection, the hybrid converter has higher power processing capability and improved reliability. The use of single boost stage architecture is discussed in this paper. Simulation results are provided to validate the performance. The decrease in converter size along with output voltage ripple and reduction in switch voltage stress can be analyzed from the results. Conventional boost circuit is having two switches, one is a controllable switch (controls the duty cycle) and other can be implemented using a diode. Replacing the controllable switch in the boost circuit either with a single phase or three phases VSI leads to the realization of hybrid converter. Microgrid consists of four parts:
1. Distribution system

2. Distributed generation sources (DG)

3. Energy storage (ES)

4. Controllers and loads

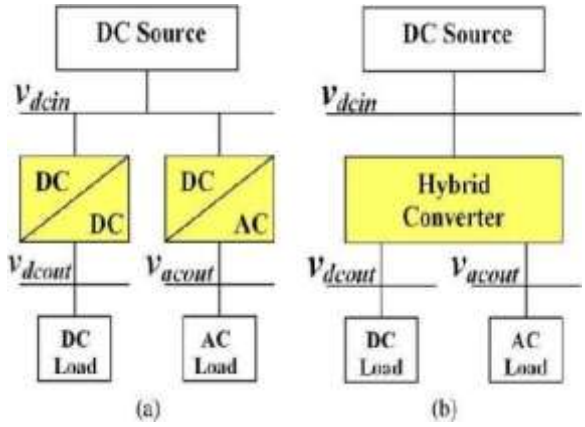

Fig 1-: Schematic Diagram of the system providing both ac and dc from single dc source.

These days, fossil fuel is recognized as a main reason of air pollution, especially in carbon emission. Energy source is changed from fossil fuel to eco-friendly source by means of renewable energy. Energy storage is used to improve the instability and unpredictability due to renewable source. Renewable resources are photovoltaic system, solar cell, wind turbine, battery and almost all that sort of things also can be operated in DC power. Therefore, DC distribution system or DC microgrid is being developed.

The objectives of this paper are to proposed DC microgrid to controls onsite generation and power demand to meet the objectives of providing power and injecting power into the utility grid if required. The microgrid controller becomes essential for balancing power and load management.

2. OVERVIEW OF DC MIGROGRID

A block diagram is as shown in fig.2. The DC bus connects Wind Energy Conversion System, PV cells, energy storage comprising battery system, grid interface. The wind plant is connected to the DC bus via AC-DC Converter (rectifiers) as wind plant generates alternating current. The solar panels are connected to the DC bus via a DC-DC converter (Boost Converter).

The multilevel energy storage helps to the intermittent and volatile renewable power outputs to manage and deterministic controlled power to main grid is obtained by optimization. This provides uninterrupted power supply to loads when needed is a core duty of microgrids.

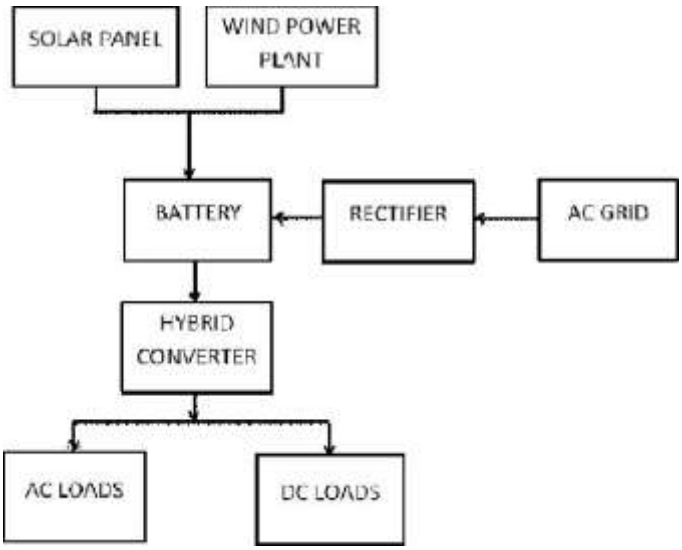

Fig-2: Block Diagram of Microgrid

With the increase in load demand due to technological developments and increase in population, decaying of fossil-fuel and environmental concerns such as air pollution, climate change is increasing rapidly. In current scenario, for professionals the photovoltaic technology presents an exciting and bright future. Nano-micro grids are being interfaced with different grid formed which contains power from different conventional or non-conventional energy sources. This interfacing is done by using different power electronic converters. With this in mind, to drive dc and ac loads simultaneously from a dc input in a single step, a new topology of Boost Derived Hybrid Converter (BDHC) is implemented.

3. OPERATION OF BOOST DERIVED HYBRID CONVERTER

A. Operation of BDHC in Simulation:

The operation of BDHC undergoes following interrogation: (i) Boost operation is controlled by DUTY CYCLE (ii) Inverter operation is done by MODULATION INDEX.

B. Operating Principle:

The schematic diagram of BDHC is as shown in figure 3. If current through starting inductor (L) is

maintained greater than zero, then the circuit will operate in mode of continuous conduction.

In this new BDHC technology, the controlling of AC output has been achieved by employing a modified scheme of Sinusoidal Pulse Width Modulation (SPWM).

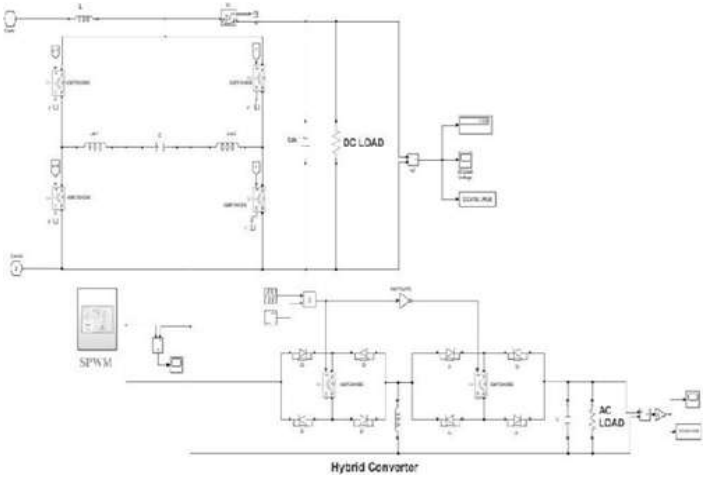

Fig-3: Hybrid Converter Circuit in Matlab

BDHC can be operated in three modes:

a. Shoot-through Interval (STI):

This interval is as shown in Figure 4. This interval has been achieved by Gating ON each switch of a particular leg (either S1-S4 or S2-S3). And the duty cycle of BDHC is decided on the basis of duration of shoot-through interval. The diode D is reverse bias during this period. The inverter output current circulates within the bridge network switches. Thus, BDHC allows additional switching states.

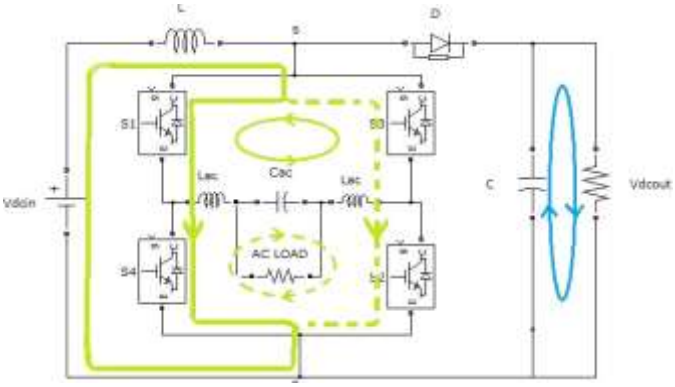

Fig-4: Circuit Diagram of Shoot through Interval

b. Power Transfer Interval (PTI):

This interval is as shown in Figure 5. During this interval the current is flowing through the opposite leg (S1-S2 or S3-S4) of BDHC via AC load in the converter circuit, the interval of power transfer in attained. During this, the diode D starts conducting and the DC output voltage is obtained.

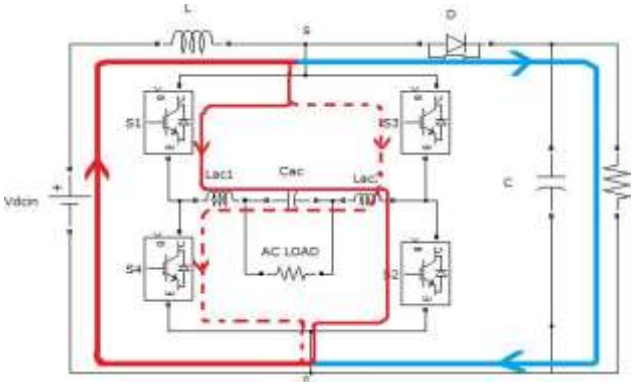

Fig-5: Circuit Diagram of Power Interval

c. Zero Interval (ZI):

This interval is as shown in Figure 6. This interval occurs when the inverter current circulates among the bridge network switches in not sourced. The diode D conducts during this interval. During STI only DC output is obtain only when the capacitor is initially charged. In PTI, both the outputs are obtained. And during ZI only DC as output is obtain.

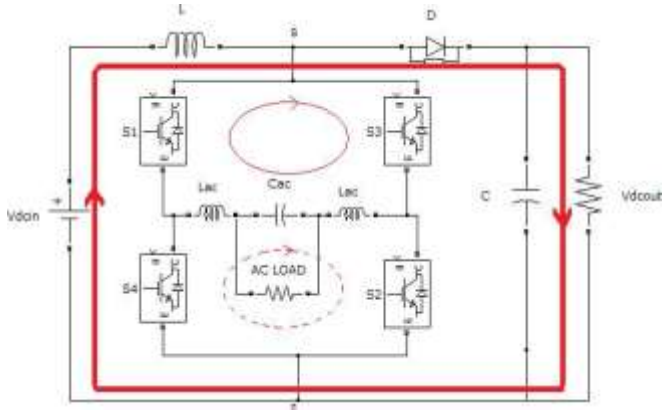

Fig-6: Circuit Diagram of Proposed Converter.

4. WORKING PROCEDURE OF MATLAB SIMULATION:

Microgrids are power distribution networks in which users & generators are in close proximity hence reduces transmission losses as well Cost.

1) Microgrid collects generated power from all the distributed generation resources (Renewable Resources) to form the DC bus system.
2) It connects one part of DC bus to battery for storage & other part of DC bus to hybrid converter.
3) This hybrid converter takes DC as input & gives AC as well as DC as output. It means that hybrid converter is a combination of Chopper & Inverter.

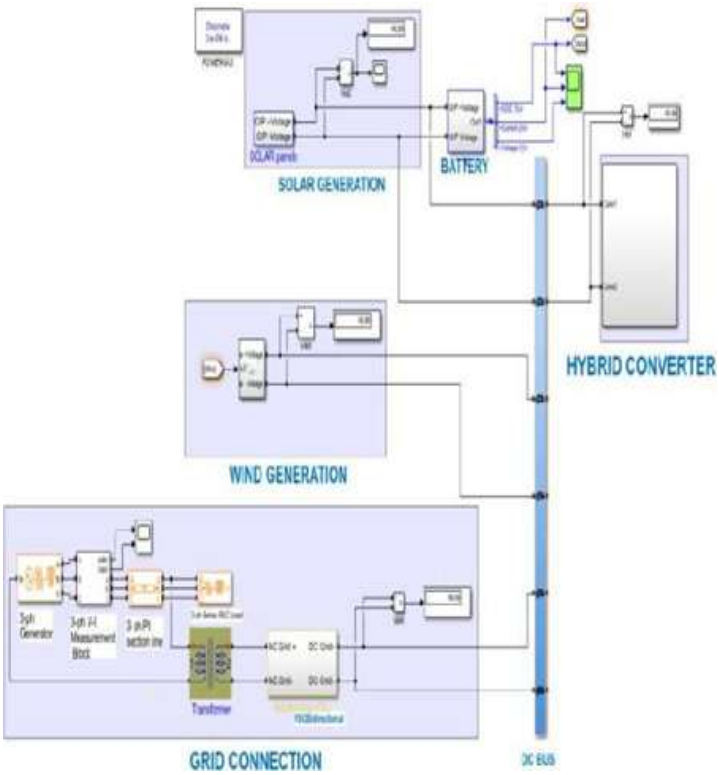

Fig-7: Simulation Circuit in Matlab

4) On the other hand, Battery stores power & if it gets charged above 80% then it supplies power to AC commercial grid through bidirectional switch & if it gets discharged to about 40% then it takes power from AC commercial grid through switch. The battery acts after 30sec when it gets charged or discharged to 40% or 80%.

6. HARDWARE OF THE PROJECT:

After the analysis of Microgrid is carried out in simulation, the modal has been implemented using the following components:

6.1 COMPONENTS USED:

A) SOLAR PANEL:

The solar panel is charged through the sun radiations and it generates the power. There are mainly three type of solar panels are available in market like, monocrystalline, polycrystalline and thin film. Monocrystalline panel is more efficient than other so here this type of solar panel used. Monocrystalline panels are generally constructed from high quality silicon cell.

B) CHARGE CONTROLLER:

Charge controller manages the power going into the battery from the solar panels. Charge controller is used to limit the rate at which electric current is added to or drawn from electric batteries. Due to the weather condition, the generation if fluctuate so to supply constant voltage to battery the charge controller is used. It is also used to prevent overcharging and may protect against overvoltage which can reduce battery performance or lifespan. It may also monitor battery temperature to prevent overheating. Some charge controller system also display data, transmit data to remote display.

C) BATTERY: Battery storage in power stations use for low leveling storing electrical energy at time of low demand for use during peak periods. It is charged from renewable energy sources like solar panel. Deep cycle batteries are design for the purpose of discharging to a lower capacity between 50%-80% than conventional battery. Deep cycle of our battery is C10.

Lithium-ion solar batteries are the ideal match for solar energy storage needs. We have a solar energy system with energy storage. Typical lead acid batteries used for solar energy storage have many problems including; they are almost never adequate to handle generated energy storage needs, do not efficiently and effectively store generated power, do not last long, they are very heavy and made of a toxic material.

D) HYBRID CONVERTER: The foregoing system has various types of loads i.e. DC and AC loads, which are capable of being interfaced with different conventional and non-conventional energy sources. This interfacing is achieved by means of different electronic converters. With this in mind, to drive DC and AC loads simultaneously from a single DC input in a single step, a new technology of boost derived hybrid converter can be implemented. Boost derived hybrid converter provides simultaneous DC and AC power as per the requirement to the loads from a "single switch controlled boost converter". It requires lesser number of switches to provide AC and DC outputs with an increased reliability.

Fig 8: A)

Fig 8: B)

Fig-8: A) & B) Hardware of the Project using various Loads

7. RESULTS

The solar power plant is modelled and simulated using MatlabR2018a/Simulink. The integration of solar panel & wind plant as a dc input sources has been implemented and verified in MATLAB R2018a/Simulink to drive DC as well as AC loads simultaneously. It gives about 230V AC and about 115V DC as outputs. The analysis of different types of load is done in MatlabR2018a/Simulink. And a prototype is also implemented depending upon the results of simulation.

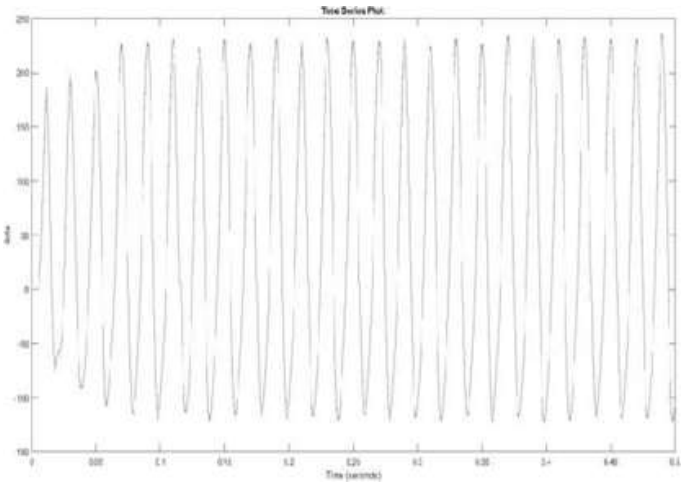

Fig 9: AC output of Hybrid Converter in Matlab

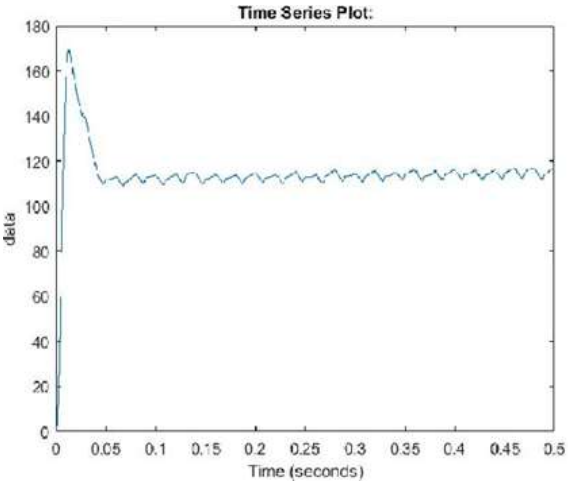

Fig-10: DC output of Hybrid Converter in Matlab

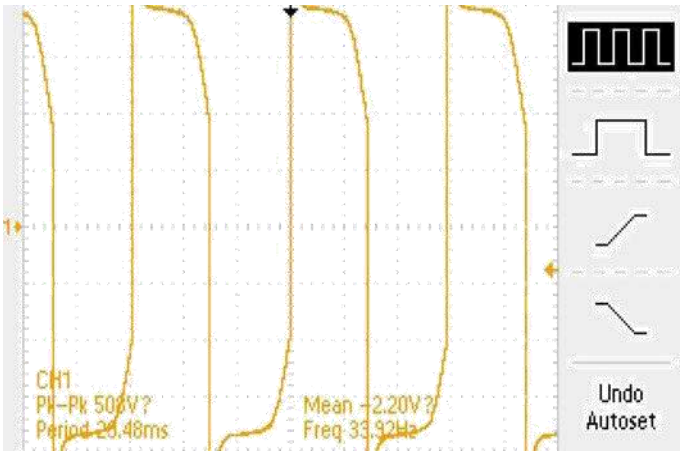

Fig-11: AC output of Hybrid Converter of Hardware

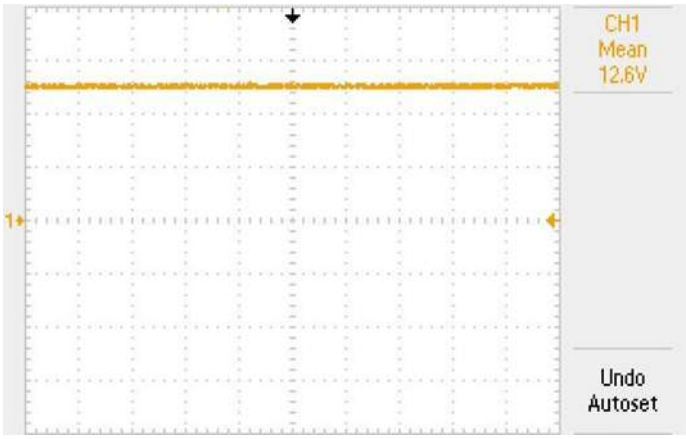

Fig 12: DC output of Hybrid Converter of Hardware

The integration of solar panel as a dc input source has been implemented and verified by hardware, and it drives DC as well as AC loads simultaneously. It gives about 220V AC and about 12.6 DC as outputs.

8. CONCLUSION

Micro-grid is an extension of main grid providing on-site generation capable of fulfilling its local load demand. A DC microgrid for non-conventional power integration has been proposed. Its functioning was demonstrated through simulation. Integration with commercial AC grid was controlled by means of power electronic devices. A storage battery is used to quantify the uncertainty affiliated with the forecast of aggregated wind and PV- based power generation was created. It plays a critical role in compensating renewable power fluctuations and providing the power needed when solar and winds stops. The optimization for power exchanges and dc voltage control using adaptive control are performed through power electronic converters that serve as interfaces to all resources. It is concluded that micro-grid is to be added to the main grid to increase the reliability, improve power quality, avoid the use of depleting fossil fuels, and reduce greenhouse emissions. The micro-grid is connected to islanded or isolated and grid connected modes. Depending upon the requirement these renewable energy sources are connected to the main grid or operate separately. As renewable energy sources are intermitted in nature, energy storage schemes are required to store the energy. It is desirable to develop reliable micro-grid

operation and effective energy storage algorithms which would enhance the performance of hybrid power systems.

9. REFERENCES

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