Autonomous Control of Interlinking Converter with Energy Storage in Hybrid AC-DC Microgrid

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Abstract— Due to the decade of fossil fuels, renewable energy plays an important role to supply the power to meet our load requirements. The main drawback of renewable energy system is its installation cost is very high and renewable energy sources are mainly unpredictable. To eliminate the drawbacks in renewable energy, hybrid system plays a major role. Hybrid system is an interconnection of two or more sources. In this project solar energy and battery are used as a two different sources. Power from the solar energy is boosted by boost converter and boost converter act as a impedance matching network. When internal impedance of solar is matched with the boost converter impedance power will be transfer from source to load. Battery power is boosted by boost converter and output of solar and battery added together and given as a input to the inverter. To connect the 3 phase line to the microgrid it is necessary to find 3 phase network. Hence BLDC motor is used as load because it is used to verify the 3 phase network. The proposed design has an advantage i.e., battery bank and solar panel acts as a source, hence the uninterrupted power obtained to run the system

Key words: component; formatting; style; styling; insert (key words)

I. Introduction

The Smart residential units are often connected to a non-conventional energy sources to provide smart energy. Due to the complexity of the space allocation, these dedicated energy sources are highly localized and have low terminal power and voltage ratings. The power ranges typically, on the order of a hundred watts. Conventional designs involve two separate converters, a DC–DC converter such as boost converter (e.g., boost) and a voltage source inverter (VSI), connected either in cascade or in parallel manner, supplying DC and AC outputs at VdcOut and VacOut, respectively. Depending upon the requirements, topologies providing higher gains may be required to achieve step-up operation .This project investigates the use of single boost-stage architecture to supply hybrid loads.

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The Need for Renewable Energy

Renewable energy is one of the resources it comes from the natural resources such as wind energy, solar energy, water and geothermal heat energy. These resources are renewable and it maybe recycles and uses it for further use. Therefore it is used for all practical purposes, these resources can be considered to be inexhaustible, because the other important resources like conventional fossil fuels leads to damage or highly risky state composition. The global energy crunch has provided a renewed impetus to the growth and development of Clean and Renewable Energy sources. Apart from the rapidly decreasing reserves of fossil fuels in the world, another major factor working against fossil fuels is the pollution associated with their combustion.

II. Different Sources of Renewable Energy

A. Wind Power:

Wind turbines can be used to harness the energy available in airflows. Current day turbines range from around 600 kW to 5 MW of rated power. Since the power output is a function of the cube of the wind speed, it increases rapidly with an increase in available wind velocity. Recent advancements have led to aero foil wind turbines, which are more efficient due to a better aerodynamic structure.

B. Solar Power:

The tapping of solar energy owes its origins to the British astronomer John Herschel who famously used a solar thermal collector box to cook food during an expedition to Africa. Solar energy can be utilized in two major ways. Firstly, the captured heat can be used as solar thermal energy, with applications in space heating. Another alternative is the conversion of incident solar radiation to electrical energy, which is the most usable form of energy. This can be achieved with the help of solar photovoltaic cells or with concentrating solar power plants.

C. Small Hydropower:

Hydropower installations up to 10MW are considered as small hydropower and counted as renewable energy sources These involve converting the potential energy of water stored in dams into usable electrical energy through the use of water turbines. Run-of-the-river hydroelectricity aims to utilize the kinetic energy of water without the need of building reservoirs or dams.

D. Biomass:

Plants capture the energy of the sun through the process of photosynthesis. On combustion, these Plants release the trapped energy. This way, biomass works as a natural battery to store the suns Energy and yield it on requirement.

E. Geothermal:

Geothermal energy is the thermal energy which is generated and stored within the layers of the Earth. The gradient thus developed gives rise to a continuous conduction of heat from the Core to the surface of the earth. This gradient can be utilized to heat water to produce superheated steam and use it to run steam turbines to generate electricity. The main disadvantage of geothermal energy is that it is usually limited to regions near tectonic plate boundaries, though recent advancements have led to the propagation of this technology.

Among the various renewable energy resources, the energy through the solar photovoltaic effect can be considered the most necessary and prerequisite sustainable resource because of the Ubiquity, large quantity, and sustainability of solar energy. Renewable sources of energy acquire growing importance due to its enormous consumption and exhaustion of fossil fuel.

III. LITERATURE SURVEY

The main objective of the project is to analyze the hybrid interlink converter based microgrid for distribution system. The following papers helped in this work.

FredeBlaabjerg et al (2004) presented the Power Electronics as Efficient Interface in Dispersed Power Generation Systems. Proposed reviews the applications of power electronics in the integration of DG units, in particularly, wind power, fuel cells and PV generators. The global electrical energy consumption is rising and there is a steady increase of the demand on the power capacity, efficient production, distribution and utilization of energy. Power electronic, the technology of efficiently processing electric power, plays an essential part in the integration of the dispersed generation units for good efficiency and high performance of the power systems.

De Brabandere, et al (2007) presented a new control method for the parallel operation of inverter operating in an island grid or connected to an infinite bus is described. Frequency and voltage control including mitigated of voltage harmonics are achieved without the need the any common control circuitry or communication between inverters. Each inverters supplies a current that is the result of the voltage difference between a references AC Voltage source and grid voltage across virtual complex impedance.

Caisheng Wang et al (2008) presented the power management of a stand-alone wind/photovoltaic/fuel cell energy system.Proposes an ac-linked hybrid wind/ Photovoltaic (PV)/Fuel Cell (FC) alternative energy system for stand-alone applications. Wind and PV are the primary power sources of the system, and an FC electrolyze combination is used as a backup and a long-term storage system. An overall power management strategy is designed for the proposed system to manage power flow among the different energy sources and the storage unit in the system.

Nikkhajoei and lasseter, (2009) to a provide the plug in and play future and power quality requirements of CERTS. All micro sources regardless of their prime mover type must have a unified dynamic performance. the storage module attached to prime mover through a power electronic interfaces that couples the micro source to the micro grid . Dynamic performance of example of micro source when operating in the CERTS.Microgrid is evaluated based on digital time domain simulation in the EMTP. PV software environment.Effectiveness of the storage module, the electronic interface and then corresponding controls enhancing the micro source.

ManojDatta et al (2011) presented a frequency-control approach by photovoltaic generator in a PV–diesel hybrid power system. In this survey, a simple fuzzy-based frequency control method is proposed for the PV generator in a PV–diesel hybrid system without the smoothing of PV output power fluctuation.A photovoltaic (PV) system's output power fluctuates according to the weather conditions. Fluctuating PV power causes frequency deviations in the power utilities when the penetration is large. Usually, an energy storage system (ESS) is used to smooth the PV output power fluctuations and then the smoothed power is supplied to the utility. By means of the proposed method, output power control of a PV generator considering the conditions of power utilities and the maximizing of energy capture are achieved. Here, fuzzy control is used to generate the PV output power command.

IV. MULTI ANALYSIS OF CONVERTERS AND PROPOSED METHOD

Designing converters present a remarkable challenge for the power supply designer. There is no comparable power supply design task where specification, topology selection and the choice of output voltage regulation would have a more profound effect on the performance, cost and the complexity of the circuitry.

A. Buck Converter Step-Down Converter:

In fig 4.1 circuit the transistor turning ON will put voltage Vin on one end of the inductor. This voltage will tend to cause the inductor current to rise. When the transistor is OFF, the current will continue flowing through the inductor but now flowing through the diode. We initially assume that the current through the inductor does not reach zero, thus the voltage at Vx will now be only the voltage across the conducting diode during the full OFF time. The average voltage at Vx will depend on the average ON time of the transistor provided the inductor current is continuous.

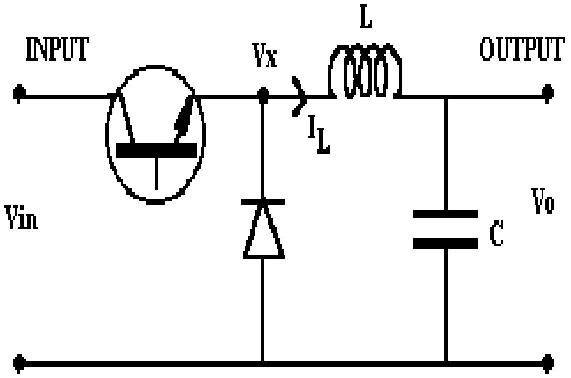

Fig. 4.1: Buck Converter Step-Down Converter

B. Boost Converter Step-Up Converter:

The schematic in Figure 4.2shows the basic boost converter. This circuit is used when a higher output voltage than input is required. While the transistor is ON Vx =Vin, and the OFF state the inductor current flows through the diode giving Vx =Vo.

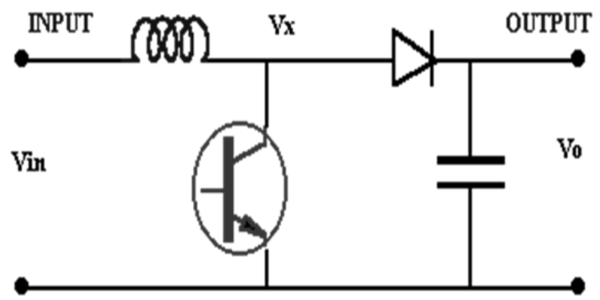

Fig. 4.2: Boost Converter Circuit

C. *Current Fed Full Bridge Converter:*

A full bridge DC-DC converter has four switching devices in two switching legs each of two devices connected in series between two supply voltage terminals, junction points of the legs being connected to a primary winding of a transformer, from a secondary winding of which an output voltage of the converter is derived by rectifying and filtering. The output voltage is regulated by phase shift control of the switching devices.

A characteristic of the conventional Full-Bridge converter is that it has a deadtime during its operation. Besides preventing switches A and B (or C and D) from conducting simultaneously, this deadtime is essential for conventional dual-end (half- and Full-Bridge, push-pull, etc.) converters to alter the average primary winding voltage on each half-cycle and, thus, obtain a regulated output voltage when the input voltage changes. During the deadtime, the input current becomes zero; this discontinuity causes a large input ripple current. Thus, large input filters must be used to satisfy the conducted EMC requirements. This dead time also needs a large output inductor to smooth the output voltage and limit the ripple current through it. The large output inductor slows the output response time.

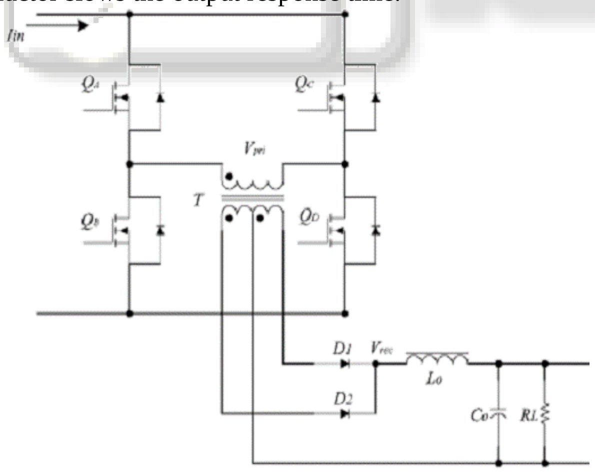

Fig. 4.3: Current Fed Full Bridge Inverter

Certain topologies have no deadtime, which results in energy being continuously transmitted from the input dc source to the output load in the whole switching period. Because of the lower input ripple current in a no deadtime dc–dc converter, the conducted EMI filter is relatively smaller. Lower output inductance value improves the output transient speed and reduces the output filter size, thus improving power density (power-to-volume ratio) of the dc–dc converter During deadtime, the primary voltage of the transformer is clamped near zero. This causes high primary current to circulate in the primary winding while not delivering energy to the output.

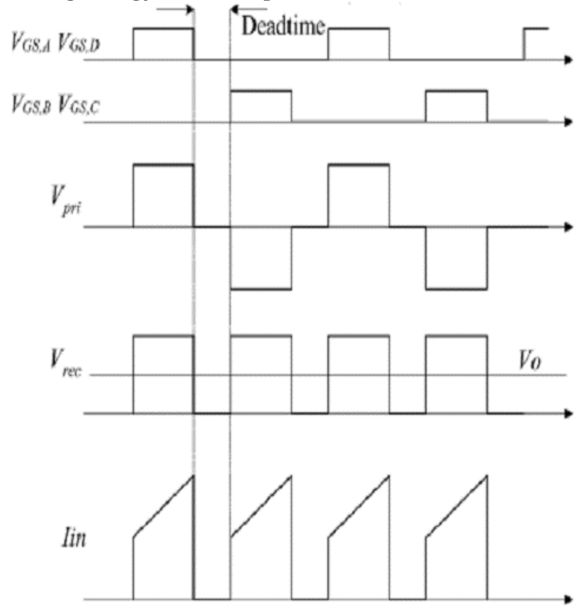

Fig. 4.4: Waveforms for current fed full bridge inverter

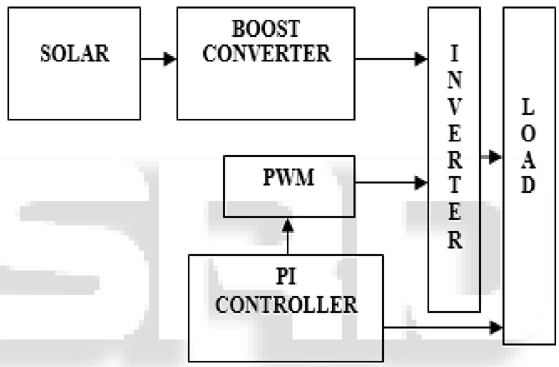

Fig. 4.5: Existing Block diagram

In existing system solar energy is used as a source and boost converter is used to boost the output voltage. Output of boost converter is fed as an input to the inverter and inverter output is fed to the load. In existing system to control the DC bus voltage of inverter PI controller method is used. The main drawback of existing system is only one source is used as an input and boost converter output is limited by duty cycle and we cannot improve the voltage beyond the particular limit. The main challenge regarding the dc-bus voltage controller for grid-connected single-phase inverters is the presence of the low-frequency ripple in the dc-bus capacitor voltage (this ripple is also present in three-phase unbalanced systems) .In a conventional dc-bus voltage control scheme, a very low bandwidth PI controller is usually used to regulate the dc-bus voltage .The PI controller should have a very low bandwidth in order to prevent the low-frequency ripple from propagating to the control loop through the dc-bus voltage feedback. Therefore, the conventional dc-bus voltage controller produces a very sluggish and poor transient response.

D. *Bdhc Topology:*

Boost converters comprise complementary switch pairs, one of which is the control switch (controls the duty cycle) and the other capable of being implemented using a diode. Hybrid converter topologies can be synthesized by replacing the controlled switch with an inverter bridge network, either a single-phase or three-phase one. The proposed circuit modification principle, applied to a boost converter. The resulting converter, called BDHC. The control switch Sa of a conventional boost converter has been replaced by the bidirectional single-phase bridge network switches (Q1–Q4) to obtain the BDHC topology. This proposed converter provides simultaneous ac output (vacout) in addition to the dc output (Vdcout) provided by the boost converter

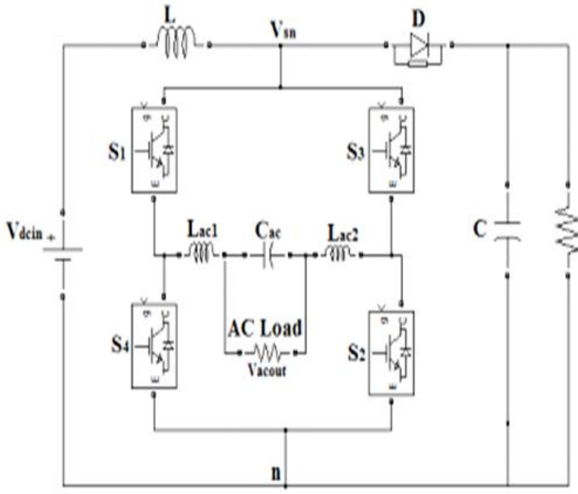

Fig. 4.6: Proposed BDHC

Boost converters comprise complementary switch pairs, one of which is the control switch (controls the duty cycle) and the other capable of being implemented using a diode. Hybrid converter topologies can be synthesized by replacing the controlled switch with an inverter bridge network, either a single-phase or three-phase one. The proposed circuit modification principle, applied to a boost converter. The resulting converter, called BDHC. The control switch Sa of a conventional boost converter has been replaced by the bidirectional single-phase bridge network switches (Q1–Q4) to obtain the BDHC topology. This proposed converter provides simultaneous ac output (vacout) in addition to the dc output (Vdcout) provided by the boost converter.

For the BDHC, the hybrid (dc as well as ac) outputs have to be controlled using the same set of four controlled switches Q1–Q4 . Thus, the challenges involved in the operation of BDHC are the following: 1) defining the duty cycle (Dst) for boost operation and the modulation index (Ma) for inverter operation; 2) determination of voltage stresses and currents through different circuit components and their design; and 3) control and channelization of total input power to both ac and dc loads

V. Results and discussion

A. *Input Side:*

The input voltage of 48 V dc for the steady-state open-loop behavior of the BDHC is shown in the Fig.5.1. It is for the switching controls of the PWM signals.

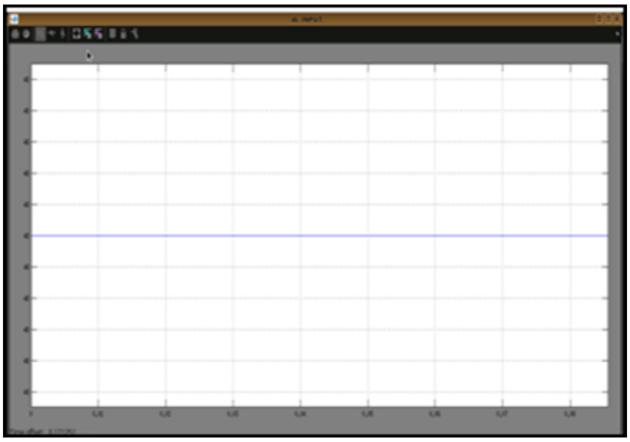

Fig. 5.1: Input voltages 48v for the steady state operation of BDHC

B. *Pwm Generation:*

It shows the gate control signals for the BDHC switches and the resulting switch node voltage (vsn) (referring to Figs. 3.8). The control schematic described in Section III has been used for the generation of the gate signals. The waveforms validate that, whenever the switches S1 and S4 or S2 and S3 are "on" at the same time, vsn= 0. This interval refers to shoot-through, and it controls the dc output. The ac output is modulated using the reference signal vm(t).

C. *AC And DC Output:*

Fig. 5.2 and Fig 5.3 given below shows the steady-state openloop behavior of the BDHC. For an input voltage of 48 V dc, the output dc voltages achieved are 75.4 V and 108 V dc for duty cycles of 0.4 and 0.6, respectively. The ac output is 30 V (rms) for modulation indices of 0.6 and 0.4, respectively. From these results, it is validated that, when the equality condition of relation (3) is maintained, for any value of duty (Dst), the magnitude of the ac output voltage is always 0.707 times the input voltage. Here, the dc and ac loads are 30 and 9 Ω, respectively. Hence, the prototype serves 390-W dc and 110-W ac loads approximately.

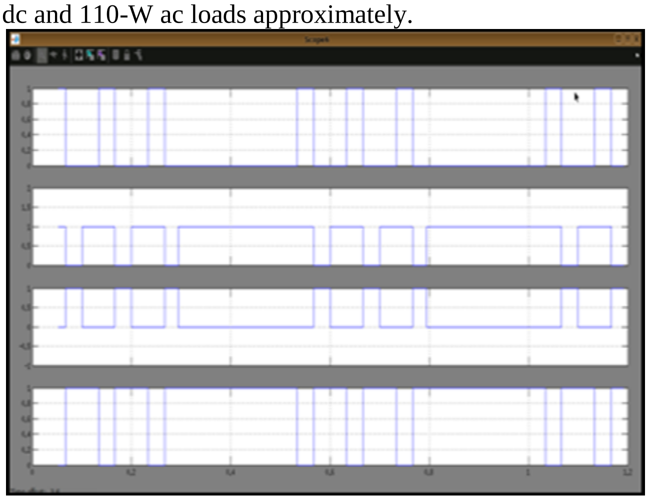

Fig. 5.2: Experimental validation of the proposed PWM control

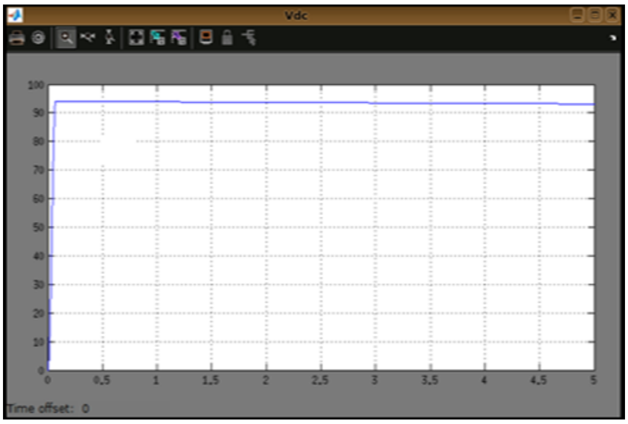

Fig. 5.3: DC output of the BDHC

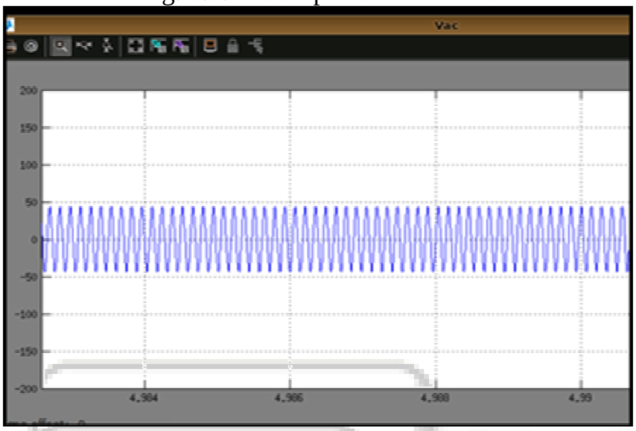

Fig. 5.4: AC output of the BDHC

VI. CONCLUSION

The proposed system was simulated by using MATLAB software. Compare to the existing system in proposed system the energy supplied to the grid was increased and by using adaptive droop control technique dc bus voltage was regulated so that efficiency of the power supplied was improved. An interlinking control scheme has been presented here for regulating power flows in a hybrid microgrid. The design is implemented in hardware by using PIC16F877A controller to generate the pulse to trigger the boost converter and three phase network. To increase the Pulse amplitude level we are using TLP250 Integrated circuits. The obtained three phase supply is given to the BLDC (Brushless DC) motor.

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