Stability Improved in Micro Grid with Energy Storage Systems using Cascaded Converter

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***Abstract*-- In today's world, due to the growing demands of technology and rise in population, there has been a tremendous pressure on the electricity demands. The world needs to find alternative sources of energy. Hence renewable sources are being considered to meet the growing demands of energy. Renewable energy sources including photovoltaic cells and wind turbines require converters with high voltage gain in order to interface with power transmission and distribution networks. These conversions are conventionally made using bulky, complex, and costly transformers. Multiple modules of single-switch, single-inductor DC-DC converters can serve these high-gain applications while eliminating the transformer. This work generally classifies multiple modules of single-switch, single-inductor converters as high gain DC-DC converters transformers. The gain and efficiency of both series and cascade configurations are investigated analytically, and a method is introduced to determine the maximum achievable gain at a given efficiency. Simulations are used to verify the modeling approach and predict the performance at different power levels. Experimental prototypes for both low power and high power applications demonstrate the value of multiple module converters in high gain DC-DC converters for renewable energy applications.**

Keywords— Battery, dc-dc boost converter, mat lab, micro grid, multi-level inverter, photovoltaic, static switch.

I. INTRODUCTION

In the modernized electric system, the country wants to meet the challenges like huge energy needs including climate changes by integrating more energy from renewable sources and enhancing efficiency from non-renewable energy processes. Microgrid is a collection of DG units deployed in a community level to provide an independent and self-sufficient small scale power grid, together with connected and disconnected capability with the main grid depending on requirements [2].

The objective of the problem is to minimize the microgrid total operation cost which comprises the generation cost and cost of energy purchase but the integer scheduling decisions are determined in the master problem will be examined against the microgrid islanding feasibility in the sub-problem[3]. A hybrid microgrid system was composed of RES (Renewable Energy System) and CHP (Combined Heat and Power) systems together with a battery based storage system [1]. The microgrid is accompanied by a centralized energy management system (CEMS) in order to optimize the microgrid operation which is privileged by applying optimization techniques and management functions are applied by means of islanding operation capability. The proper operation of a microgrid which used the storage devices that increased the inertia and avoided the instability of the system and also revealed its importance [5],[6].The storage module was attached to the prime mover through a power electronic interface that a couples the micro sources to the microgrid[7].The energy management systems like determinist and droop control methods are used along with the storage units and many renewable sources[8]-[10],[14].To control the modes of microgrid, an intelligent load-shedding algorithm and synchronization algorithm for grid reconnection[10].The real and reactive power management strategies of electronically interfaced DG(Distributed Generation) units in the context of a multiple DG micro-gird system. A small signal dynamic model for multiple-DG systems including the power management strategies for its reliability and a coordinated strategy including many units has been revealed with load management system [11] & [12].

The evolutionary algorithm technique is used to solve the problem of optimization of exchange of electrical energy [13] and the droop control and power control strategies are used for the parallel operation of DG units [14]. A plug-in control scheme for progressive and selective charging/discharging of storage in hybrid microgrids for energy smoothing and ride through purposes [16].A double-layer coordinated control approach for microgrid energy management was proposed which consists of schedule layer and dispatch layer [17].The control techniques like genetic algorithm and particle swarm optimization techniques were used to solve for the optimal solutions [18], [19]. The power flow solver was combined with the dynamic programming recursive search technique in the previous work [2]. While the network domain of the system was solved by the power flow solver and for the time domain dynamic programming recursive search technique is used.

The main objectives of the proposed system include the following:

1. To reduce the intermittent nature of the supply from the renewable sources with the help of storage devices.
2. To enhance the quality of power being supplied from the distributed generation.
3. To stabilize the power flow in the microgrid to supply the local loads.

The paper organized as Section II, an insight of the proposed microgrid structure is given; in Section III modeling of the system will be analyzed. While Section IV gives information about the scheduling algorithm technique and thus the Section V deals with the discussion about the results obtained. Finally, the Section VI gives the conclusion and reference paper details.

II. MICROGRID

The local power generation network and storage devices in the microgrid allow the portion of grid and critical facilities to operate independent of the larger grid when necessary, and it eliminates blackouts. Redundant sources ensure that power supply continuously during power interruptions caused by weather changes or other reasons. Micro grid also back up the huge power and it supplies the electricity ancillary services when power demand and cost are high. Designed to proactively ensure reliability, improve economics and manage renewable sources as well.

In the proposed system, the block diagram consists of the renewable sources such as PV modules, wind farms and fuel cell stacks are used in order to reduce the power demand is shown in Figure.1. A DC bus is formed in order to reduce the power conversion losses and a single multilevel inverter is used in between the DC and AC buses for conversion. A storage battery is installed in the source side of the grid. When microgrid is integrated with intelligent control systems, it provide powerful capabilities that are increasingly valuable in today's energy system. Key features include automatic fault isolation, automatic islanding, and automatic service restoration. Microgrids are representative of what the future electrical grid can and should look like. Microgrids represent a current application for energy storage that is proving its worth every day.

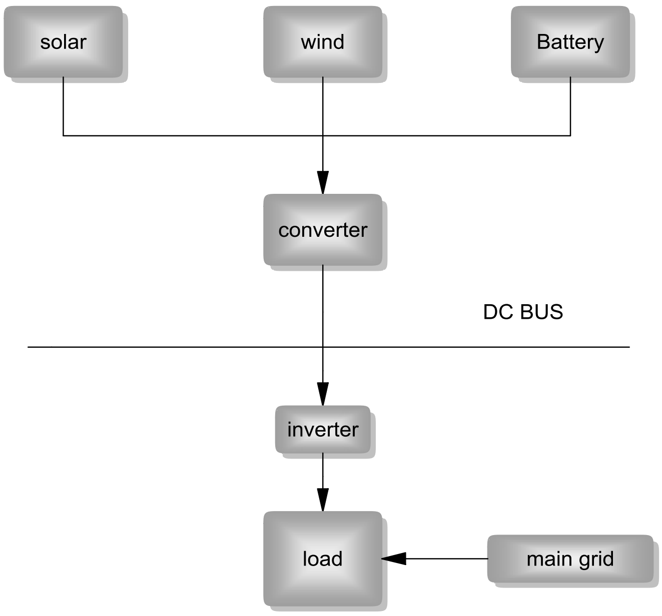

Fig. 1. Block diagram of proposed system

Energy derived from photovoltaic and wind sources inherently varies the amount of electrical energy produced varies with time, day of the week, season, and random factors such as the weather. Thus, renewable present special challenges to electric utilities. While hooking up many wind sources can reduce the variability, solar is reliably not available at night, and tidal power shifts with the moon so is never reliably available on peak demand.

The micro grids which are located near the loads improve the energy management of the system, which enables the on-site generation from small-scale generators that increases reliability and reduces losses due to transmission. In micro grid, the objectives of the energy management are varied depending on the modes of operation such as grid-connected mode or islanded mode.

III. SYSTEM MODELING

The developed microgrid structure can be used in domestic purposes which contains many renewable sources. Photovoltaic system and wind mill are considered to be a major sourcesof renewable energy for on-site generation. The developing system consists of photovoltaic system,wind mill,fuel cell and battery.

A. *Photovoltaic system*

The PV system is the major renewable energy source in this paper and the simulation diagram of the PV module is shown in Figure.2. The PV cell is an electronic device which produces electricity with the help of light which falls on it. The light is absorbed and the cell produces dc power. The device has two contacts between which the voltage is generated and through which the current can flow. It has no moving parts. Effectively they take light energy and convert it into electrical energy in an electrical circuit, and then the process is known as the photovoltaic effect. The efficiency of a PV cell is the measure of the proportion of the light hitting it that is actually converted into electricity. A solar module measuring 0.35 m × 0.45 m has an area of 0.135 m^2 and therefore when pointing in at the sun the light falling on it has the power of 0.135 × 1000 = 135 watts. If the module is 10% efficient, the power available from it is 10% of these i.2 13.5 watts.

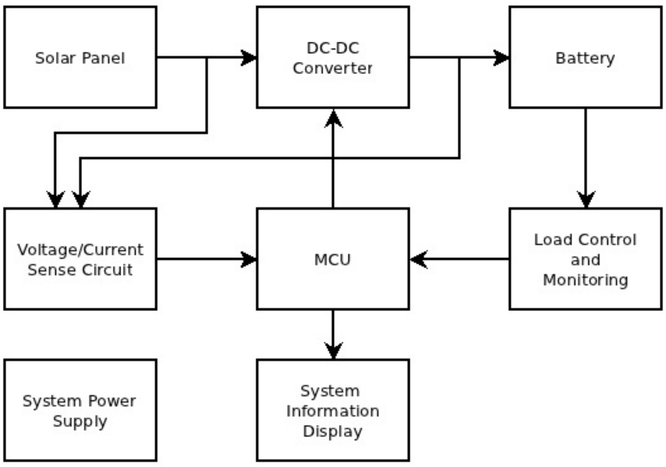

Fig. 2. Block diagram of PV module.

Irradiance is the measurement of the amount of sunlight falling on the module.96 number of PV cells is used in this paper.

B. MPPT

Maximum power point tracking is algorithm that included in charge controllers used for extracting maximum available power from PV module under particular conditions. The voltage level at which PV module can produce maximum power is called “maximum power point”. The maximum power point tracker is an electronic DC to DC converter that optimizes the match between the solar arrays (PV panel) and the battery bank or utility grid. The controller keeps testing that the PV system is operating at the PV maximum PowerPoint. In this paper incremental conductance technique is used to track power than P&O method. Incremental conductance mppt algorithm utilizes the incremental conductance (dI/dV) of the photovoltaic array to compute the sign of the change in power with respect to voltage (dP/dV). INC method provides rapid MPP tracking even in rapidly changing irradiation conditions with higher accuracy than the Perturb and Observe method. Ahmed *et.al* used P&O method in his paper. Due to the drawbacks like oscillating values, this paper uses INC method. The power-voltage curve's slope is null at the MPP, negative to the right of the MPP and positive to the left of the MPP. INC computes the maximum power point by comparison of the incremental conductance ($\Delta I/\Delta V$) to the instantaneous conductance (I/V). When the incremental conductance is zero, the output voltage is ascertained to be the MPP voltage and fixed at this voltage until the MPP encounters a change due to the change in irradiation conditions. Then the process above is repeated until a new maximum power point is reached.

C. Wind Mill

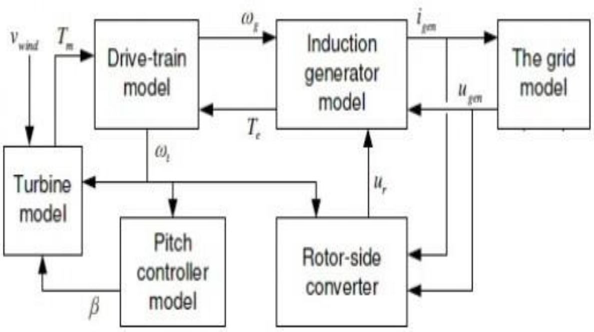

Fig. 3. Simulation diagram showing wind mill

The subsystem block of the wind mill is shown in Figure.3 and it consists of pitch angle controller, wind turbine model, Permanent Magnet Synchronous Generator and two mass drive train blocks.

D. Battery

The battery sub-system block consists of battery, circuit breaker, multiplexer and the scope which are shown in Figure.4. The battery in the sub-system gets various input signals and a control signal from renewable resources and also from the main grid. The type of battery used in the subsystem is Nickel-Metal-Hydride. The nominal voltages of the system represent the end of the linear zone of the discharge characteristics and rated capacity is the minimum effective capacity of the battery. The other parameters are selected based on the type of battery and nominal valves used in the subsystem.

III. CASCADED CONVERTER

The wind turbine output is rectified and fed to the cascade converter. The cascade configuration must boost the 1.35 kV rectifier output to 132 kV (98x). Each boost converter is designed to provide a gain of 9.9 at a duty cycle of 0.899. The switch and diode valve voltage stresses in a boost converter are equal to the stage output voltages. The average diode valve currents equal the stage output currents, and the average switch valve currents equal D times the stage input currents. The peak values of switch and diode valve currents are determined by the inductor current. Because each stage uses a single active valve that is connected to a fixed (ground) potential, the isolation level is determined during the switch off time. The gate drive of the top switch in a valve is driven from a voltage approximately equal to the valve’s withstand voltage. The isolation level of the first stage is 13.4 kV, and the isolation level of the second stage is 132 kV. The current and voltage ratings of the semiconductors.

V. RESULT AND DISCUSSION

The device voltage ratings were determined by doubling the calculated maximum withstand voltage to allow for a maximum overshoot of 2 per unit; the device current ratings are double the current stresses to provide a margin of safety. Devices were selected from based on the minimum number needed to withstand these derated valve voltage and current stresses. By using cascaded converter the output voltage will be increase in 25 times than actual voltage. The specifications of the catalog device (Vsemi and Isemi) were used to calculate the number of series and parallel devices in each valve. The number of devices per valve was then multiplied by the number of valves to reach the total device count. The device counts in the multiple module cascade and series converters are much smaller than that of the conventional HVDC and fullbridge converters. A smaller device count simplifies implementation by reducing external balancing network components, snubbers, and rate limiters that are required for series-connected devices. Smaller device counts mean fewer failure points and higher reliability. By using Cascaded converter in Hybrid System the peak voltage will be 2500 volts.

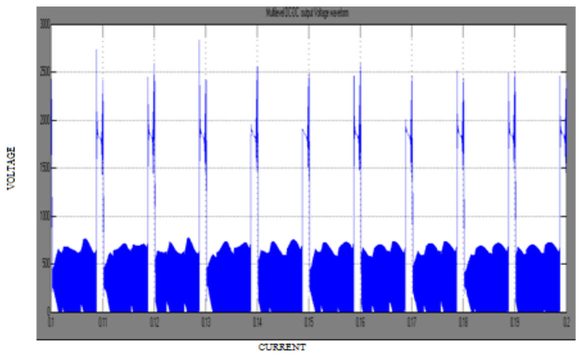

Fig.5. Converter Output Waveform

In solar system, the temperature be fixed at 25 and the electricity will be generated depending up on the wavelength which is 400-700nm. It consist of photo diode and photo transistor. In photo transistor it boost or amplify the low voltage to maximum efficiency. Solar system works up on by the radiance not due to the temperature of the panel. The I_{PV} and V_{PV} are the output from the panel, there is no increase in current and voltage up to saturation. Solar system generates 28 volts with increase in current.

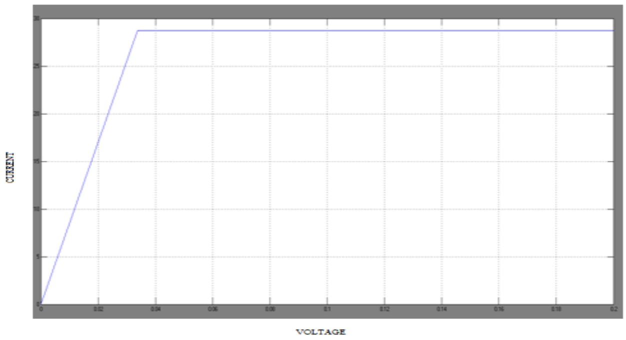

Fig. 6. Solar Output Waveform

The rotor speed reference of the generator is designed to extract the maximum power from the wind turbine at a certain wind speed:

$W_{r^*} = \lambda_{opt}(V_{w}/r_{m})$

where Vw is wind speed, rm is turbine radius, and λ is the tip speed ratio, λopt is the optimal λ of the maximum power coefficient. The current increases with the voltage up to 22 volts.

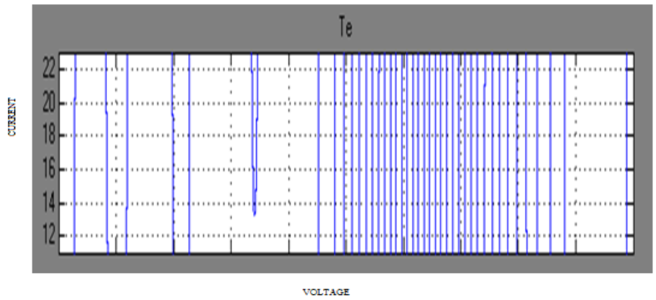

Fig.7. Output waveform for wind system

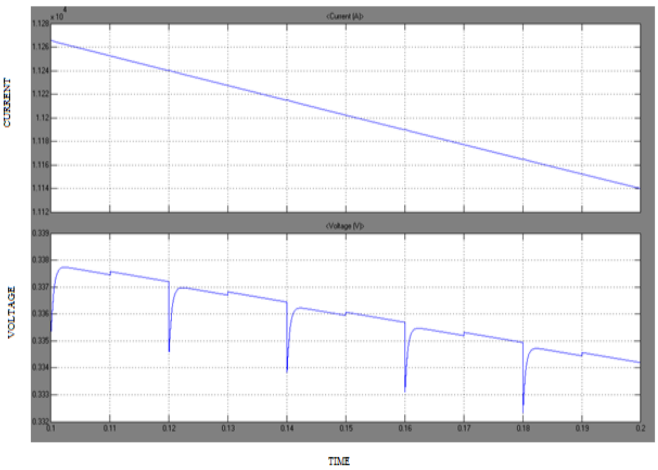

Fig.8. Output Waveform for Battery System

VI. CONCLUSION

In the proposed system, the conversion losses of the power electronic devices as well as the cost of devices are also reduced by the formation of DC bus instead of using many inverters. The formation of DC bus also helps in reduction of complexity of the system. The power quality problems in distribution systems are not new but customer awareness of these problems are increased recently. It is very difficult to maintain electric power quality at acceptable limits. In order to reduce the intermittent nature of the supply from the renewable sources, storage devices are used as a back-up in the system. The boost converters are connected in Cascaded form. By using Cascaded converter, there is no switching loss because the converter does not need any capacitors and diode for clamping. The boost converter connected in parallel and it boost the higher voltage from the panel and converts the variable voltage from the panel to a fixed voltage. One of the advantages of is that it still can obtain the regulated output voltage if one or more energy sources are diminished The control schemes were developed to extract maximum wind power and charge/discharge the battery with fast dynamics. It is beneficial for distributed energy generation and high power applications. The advantage of this power configuration and the corresponding control scheme is to improve the system survivability and power quality.

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