Power Conditioning System Coupled with a Distributed Energy Resources Modelling and Control Design

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Abstract--- Today, Increase the demand for Renewable energy resources (RES) in distribution systems because total energy demand is supplied by the burning of fossil fuels and it is limited. In this paper presents a control strategy of three-phase grid interfacing inverter to effectively utilize the renewable energy Source with a grid. Controlling of the inverter in such a way that to utilize the following compensate load current, compensate load voltage, compensate load reactive power and load neutral Current. The Renewable Energy Source may be Solar or Wind depends on distribution system voltage level. All these works of the inverter are done either individually or combined to overcome the unbalanced effects of all types of linear, non-linear, balance or unbalance loads at the distribution level. This new control concept is demonstrated with extensive MATLAB/Simulink simulation to validated result.

I. INTRODUCTION

The solar and wind power has become more and more significant, attractive and less expensive, since the oil crises of the early 1970s. Even though there is a need to use renewable energy sources, the main problem with it is the dependency on environmental conditions like solar irradiance and wind speed. Micro-grids found popularity over the years due to the needs for distributed generation and with the integration of HRESs including photovoltaic (PV) and wind generators as well as the battery storage devices. The micro-grids have many benefits for both utility grids and customers, such as higher power quality, reduction in carbon emission, energy efficiency and reduced costs. Another capability of micro-grids is islanding which allows the micro-grid to be disconnected from the utility grid in case of upstream disturbances or voltage fluctuations.

The Energy has been discussed worldwide during last few decades. Replacing traditional fossil energy gradually is urgent nowadays. Wind power, as a kind of renewable energy, plays an important role in the sustainable generation and will be developed further in the future. Variable speed wind generators are now the most prevalent wind power generators and have been widely adopted in wind farms. The most prevalent control method utilized in variable speed wind generators is vector control. Although alternative control methods have been proposed, vector control is indispensable under certain situations such as ac-fault. Phase-Locked-Loop (PLL), estimating frequency and angle of terminal voltage, is indispensable in vector control. The situation that output frequency, which is determined by the PLL, is identical with the power grid frequency is regarded as grid-synchronization. However, it has been reported that PLL based vector control has synchronization problems under weak connection.

The Main difference between strong connection and the weak connection is the short-circuiting ratio (SCR) at the point of common connection (PCC) of a wind farm. High line impedance or low grid voltage leads to low SCR, i.e. weakness. Consequently, the terminal voltage of wind farm is more vulnerable to the weak connection. The terminal

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voltage of wind farm is the input of PLL, while the dynamic of PLL determines the injected currents of the wind farm, which will, in turn, affect the terminal voltage. The weakness aggravates the interaction between the wind farm and power grid, which significantly influences grid-synchronization. Hence, a lower grid voltage level and larger grid impedance will result in a less stable situation of grid-synchronization. The control of Energy Conversion System (ECS), based on a five-phase Permanent Magnet Synchronous Generator (PMSG), to ensure an optimum power exchange from the wind turbine, by taking account of the wind speed variations. The system includes a wind turbine, a five-phase Permanent Magnet Generator, two converters, an RL filter, and a DC-link capacitor. The machine side converter is controlled by using the Field Oriented Control, to drive the generator speed to its optimum value. However, the control algorithm of grid side is based on Voltage Oriented Control to inject a pure active power into the grid. The energy conversion system (ECS) has been concerned as one of the most fast growing energy sources. The wind turbine can function either at a fixed or variable speed. Most of the manufacturers are developing systems based on variable speed wind turbines, with pitch control, since it offers an ability to achieve maximum energy conversion efficiency, a higher production of wind energy, and reduction of mechanical stresses. As for the generator use, PMSG based wind turbine becomes more favored by the wind power industry, due to its advantages, such as gearless construction, dc-excitation system canceling, and full ability to control grid interface.

The decentralized control of radial distribution systems with controllable photovoltaic inverters and energy storage resources. For such systems, we investigate the problem of designing fully decentralized controllers that minimize the expected cost of balancing demand, while guaranteeing the satisfaction of individual resource and distribution system voltage constraints. Employing a linear approximation of the branch flow model, we formulate this problem as the design of a decentralized disturbance-feedback controller that minimizes the expected value of a convex quadratic cost function, subject to robust convex quadratic constraints on the system state and input. As such problems are, in general, computationally intractable, we derive a tractable inner approximation to this decentralized control problem, which enables the efficient computation of an affine control policy via the solution of a finite-dimensional conic program. As affine policies are, in general, suboptimal for the family of systems considered, we provide an efficient method to bound their suboptimality via the optimal solution of another finite-dimensional conic program. A case study of a 12 kV radial distribution system demonstrates that decentralized affine controllers can perform close to optimal.

II. PROPOSED APPROACH

This paper proposes a converter and a stochastic control strategy for Hybrid Renewable Energy System (HRES) for a stand-alone and grid-connected operation of power systems. The proposed hybrid system consists of a wind turbine, a PV, battery storage unit, inverter and a set of loads. The overall control strategy is based on stochastic pattern controller structure. The control concepts in an HRES and the application of the appropriate control schemes for system stabilization, efficient injection of high-quality power and proper load sharing are implemented. A stochastic pattern control for power stability of different Boost converter with high boost ratio from its regulation voltage structure is designed. The proposed stochastic pattern regulation system control is used to enhance the high gain capability with wide management range, low component stress, small output ripple and flexible extension. These features make the proposed controller be suitable for renewable energy applications. The proposed controller mode of operation, controller design, and efficiency, losses are analyzed using MATLAB sim power software and tested for variable wind and load conditions.

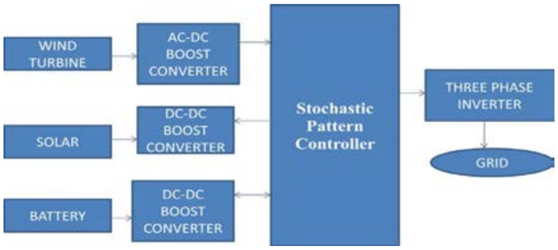

Fig. 1: Configuration of the Proposed System

Photovoltaic Energy

The word photovoltaic combines two terms – photo means light and voltaic means voltage.The Photovoltaic energy is obtained from sunlight in the form of solar energy. The sunlight is made to be focused on solar panels which have the ability to convert the solar energy into an electrical energy. The conversion of solar energy to an electrical energy is done by solar cells of the solar panel. A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A photovoltaic module is a packaged, connected assembly of solar cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output - an 8% efficient 230-watt module will have twice the area of a 16% efficient 230-watt module. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring.

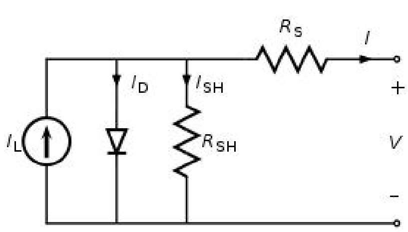

Fig. 2: Equivalent Circuit of Solar Cell

To understand the electronic behavior of a solar cell, it is useful to create a model which is electrically equivalent and is based on discrete electrical components whose behavior is well known. An ideal solar cell may be modeled by a current source in parallel with a diode; in practice no solar cell is ideal, so a shunt resistance and a series resistance component are added to the model. The resulting equivalent circuit of a solar cell is shown on the left. Also shown, on the right, is the schematic representation of a solar cell for use in the circuit diagram. Solar panels are the medium to convert solar power into the electrical power. Solar panels can convert the energy directly to heat the water with the induced energy. PV cells are made up of semiconductor structures as in the computer technologies. Sunbeam is absorbed with this material and electrons are emitted from the atoms that they are bounded. This release activates a current.

Boost Converter

A DC-to-DC converter is an electronic circuit or electro mechanical device that converts a source of direct current (DC) from one voltage level to another. It is a type of electric power converter. Power levels range from very low (small batteries) to very high (high-voltage power transmission).

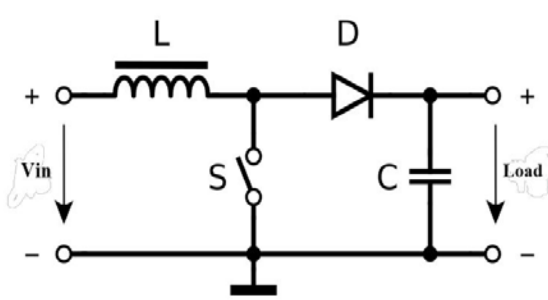

Fig. 3: A Simple Boost Converter Circuit

A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output(load). It is a class of switched-mode power supply (SMPS) obtaining at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter). Power for the boost converter can come from any suitable DC sources, such as batteries, solar panels, rectifiers and DC generators. A process that changes one DC voltage to a different DC voltage is called DC to DC conversion. A boost converter is a DC to DC converter with an output voltage greater than the source voltage. A boost converter is sometimes called a step-up converter since it "steps up" the source voltage.

Since power (P=VI) must be conserved, the output current is lower than the source current. The basic principle of a Boost converter consists of 2 distinct states of operation.

- Continuous Mode
- Discontinuous Mode

Here the input DC electricity from the solar panel is fed into this boost converter so that it boosts the input voltage to the desired high voltage current that is to be given as input voltage to the grid. Since this converter is a switching device it has the property to produce the noise and harmonics along with the boosted voltage. This, in turn, reduces the stability of the power system by causing some malfunction and power quality issues.

Wind Energy

Wind power is the use of air flow through wind turbines to mechanically power generators for electric power. Wind power, as an alternative to burning fossil fuels,is plentiful, newable, widely distributed,clean,produces no greenhouse gas emissions during operation, consumes no water, and uses the little land. The net effects on the environment are far less problematic than those of non-renewable power sources.

Wind farms consist of many individual wind turbines which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants. Offshore wind is steadier and stronger than on land, and offshore farms have the less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.

Stochastic Controller

This paper investigates control and optimization of distributed stochastic systems motivated by power system applications. In power system, power control is important at the user level in order to minimize energy requirements and to maintain communication Quality of Service (QoS) in the face of user mobility and fading channel variability. Clever power allocation provides an efficient means to overcome in the uplink the so-called near-far effect, in which nearby users with higher received powers at the base station may overwhelm signal transmission of far away users with lower received powers, and to compensate for the random fluctuations of received power due to combined shadowing and possibly fast fading (multipath interference) effects.

III. SIMULATION RESULT

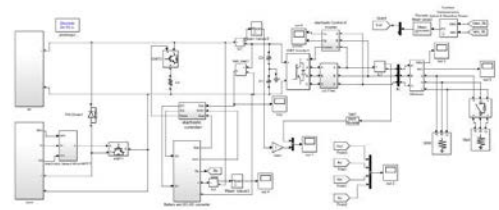

Fig. 4

IV. SIMULATION OUTPUT RESULTS

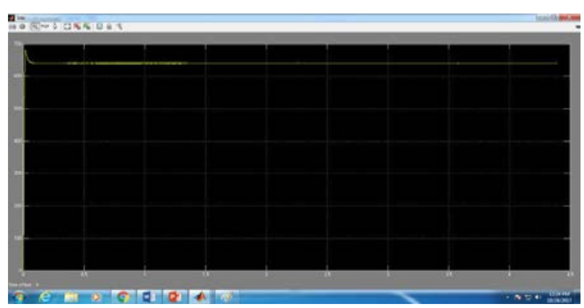

Fig. 5: Boost Converter Waveform

Fig 5 shows the improved the boost converter using stochastic control algorithm .it shows the improved output voltage of 680 v with respect to the simulation time range between(0-4.5 seconds).

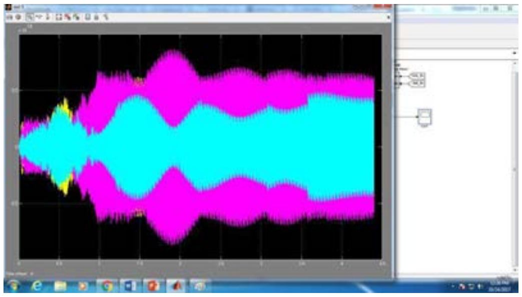

Fig. 6: Current Waveform

Fig 6 shows the improved output current using stochastic control algorithm .it shows the improved output current of 0.6x10-4 amps with respect to the simulation time range between (0-4.5 seconds).

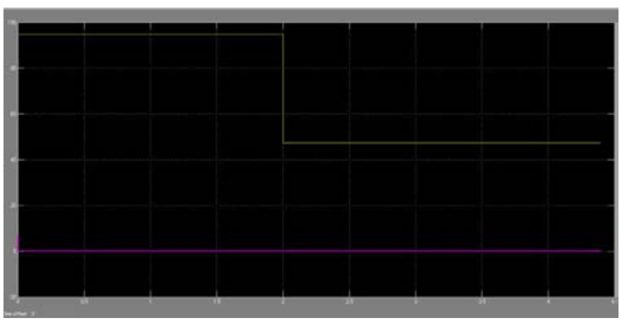

Fig. 7: PV Waveform

Fig 7 maximum power tracked from the PV panel has the voltage of 100v and if may vary at 2 seconds. At the begin level the photovoltaic voltage range is zero with respect to time.

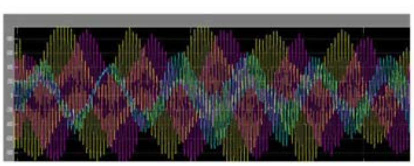

Fig. 8: Voltage Waveform

Fig 8 shows the improved output voltage of boost converter using stochastic control algorithm .it shows the improved output voltage of 800 v with respect to the simulation time range between (0-4.5 seconds).

V. CONCLUSION

The novel converter has the collective advantages of the Stochastic pattern technique from voltage regulation capability from novel boost converter, featuring in nature boost operation, the overall management range value, lower component stresses, small output ripple, flexible gain extension, and high efficiency. Compared with other high gain boosting technologies such as the tapped inductor, multi-inductor switch method or transformer-based method, the proposed topology has reduced the complexity which is suitable for hybrid mass production. The performance analysis and regulation of a hybrid renewable energy system.

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