HYBRID POWER PRODUCTION FOR MICRO GRIDS USING GRID SYNCHRONIZING INVERTERS

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Abstract- Economic, technology and environmental incentives are changing the face of electricity generation and transmission. By introducing the term grid connectivity of renewable energy to common man's life we can meet the energy demand to a large extent. There are several issues in grid integration.In this paper, we discuss the technical and economic feasibility of a low-cost distributed solar-thermal-electric power generation technology. Proposed system utilizes inverter topology to convert the direct current from the battery or the solar panel to alternating current in the same voltage and phase angle of the grid. This in turn require high power solid state switch, typically MOSFETs.

Index Terms – Introduction, Necessity, Issues and solutions, Proposed system and Simulation results

I. INTRODUCTION

Energy is the cornerstone of our modern society. It permits services and opportunities that range from the simple to the profound, from cooking meals to education. Without electricity we are denied healthcare, sanitation services, and the social, educational, economic, scientific, and agricultural progress that characterizes life.The economic development of a country is often closely linked to its consumption of energy. Although India ranks sixth in the world as far as total energy consumption is concerned, it still needs much more energy to keep pace with its development objectives. The currently electricity sector in India has an installed capacity of 211.766 GW as of January 2013. Captive power plants generate an additional 31.5 GW. Non Renewable Power Plants constitute 88.55% of the installed capacity and 11.45% of Renewable Capacity.India generated 855 BU (855 000 MU i.e. 855 TWh) electricity during 2011-12 fiscal.India's projected economic growth rate is slated at 7.4per cent during the period 1997-2012.

This would necessitate commensurate growth in the requirement of commercial energy, most of which is expected to be from fossil fuels and electricity. India's proven coal reserves may last for more than 200 years, but the limited known oil and natural gas reserves may last only 18 years to 26 years, which is acause of concern. The continued trend of increasing share of petroleum fuels in the consumption of commercial energy is bound to lead to more dependence on imports and energy insecurity. To meet the crisis, India Govt. has taken lot of initiatives to harvest Renewable Energy by various incentive/subsidy schemes. Initially we are thinking of off-Grid systems and now it is time to think of Grid tied systems. Renewable energy(RE) grid connection enables customers to use grid like a large battery, drawing energy when they need it and sending it out when they have an excess.

Economic, technology and environmental incentives are changing the face of electricity generation and transmission. Centralized generating facilities are giving way to smaller, more distributed generation partially due to the loss of traditional economies of scale. When power demand is foreseen to rapidly increase in near future, the need to upgrade the electrical system/ equipment becomes apparent. When operation must proceed while any change is in progress, the revision is very difficult. Now it's becoming common that consumers providing power back to the grid. Utilities have concerns about employee safety and system reliability regarding wide participation in power generation by interconnected non utilities. By utilizing renewable energy sources we can meet the electricity demand to an extent

Installing a solar electricity system is one way that householders can support renewable energy and reduce their greenhouse gas emissions. In urban areas, most householders prefer a grid-interactive system—solar

panels connected to the mains electricity grid via an inverter—so they can draw power from the grid during lean solar times and sell surplus power to the electricity retailer when the sun is shining. But householders who have grid connected solar systems warn that the process isn't as simple as it could be. Like all emerging technologies, it can take some time for regulators to understand the challenges involved in grid connecting and to provide the guidelines, codes and regulations to simplify the process.

II. NECESSITY

Among renewable energy sources we prefer solar energy . Solar power has plenty of advantages over other types of energy. It has variable applications, from the smallest home solar power systems to large, centralized power plants.Solar power is also very diverse. It's used to charge your cell phone or laptop, power cell phone towers, and provide electricity to your home and the entire electric grid. It can be used in a field, on a rooftop, as home siding and in outer space to power satellites and space stations - not to mention heat and cool home water supplies and living spaces.

Solar power's most obvious and hyped advantage is its cleanliness. While nonrenewable energy sources like coal, oil and gas are contributing to global climate change and poor air quality, solar power represents a clean, renewable solution to those problems. Solar power is also beneficial to both developed and developing countries, allowing access to clean electricity and clean water for poor and rural residents around the world.

In relation to other renewable resources, such as wind, geothermal, tidal energy and arguably, nuclear power, solar power is the most scalable for small-power generation. While geothermal power can be used to heat and cool the home, solar power can do that and more, providing hot water, HVAC and electricity. Wind power is a very beneficial energy source but is still difficult to use in an urban environment due to the size of wind turbines. Other renewable energy sources simply do not apply to home energy production.

In spite of several advantages provided by conventional power systems, the following technical, economic and environmental benefits have led to gradual development and integration of Distributed generation systems:

- Due to rapid load growth, the need for augmentation of conventional generation brings about a continuous depletion of fossil fuel reserve. Therefore, most of the countries are looking for non-conventional/renewable energy resources as an alternative.
- Reduction of environmental pollution and global warming acts as a key factor in preferring renewable resources over fossil fuels. As part of the Kyoto Protocol, the EU, the UK and many other countries are planning to cut down greenhouse gas (carbon and nitrogenous by-products) emissions in order to counter climate change and global warming. Therefore, they are working on new energy generation and utilization policies to support proper utilization of these energy sources. It is expected that exploitation of DERs would help to generate ecofriendly clean power with much lesser environmental impact.
- Distributed generation provides better scope for setting up co-generation, tri generation or CHP plants for utilizing the waste heat for industrial/domestic/commercial applications. This increases the overall energy efficiency of the plant and also reduces thermal pollution of the environment.
- Due to lower energy density and dependence on geographical conditions of a region, DERs are generally modular units of small capacity. These are geographically widespread and usually located close to loads. This is required for technical and economic viability of the plants. For example, CHP plants must be placed very close to their heat loads, as transporting waste heat over long distances is not economical.This makes it easier to find sites for them and helps to lower construction time and capital investment. Physical proximity of load and source also reduces the transmission and distribution (T&D) losses. Since power is generated at low voltage (LV), it is possible to connect a DER separately to the utility distribution network or they may be interconnected in the form of Micro grids. The Microgrid can again be connected to the utility as a separate semi-autonomous entity.(5) Stand-alone and grid-connected operations of DERs help in generation augmentation, thereby improving overall power quality and reliability. Moreover,a deregulated environment and open access to the distribution network alsoprovide greater opportunities for DG integration. In some countries, the fueldiversity offered by DG is considered valuable, while in some developingcountries, the shortage of power is so acute that any form of generation isencouraged to meet the load demand.

Application of individual distributed generators can cause as many problems as it may solve. A better way to realize the emerging potential of distributed generation is to take a system approach which views generation and associated loads as a subsystem or a "microgrid". During disturbances, the generation and corresponding loads can separate from the distribution system to isolate the microgrid's load from the disturbance without harming the transmission grid's integrity. This ability to island generation and loads together has a potential to provide a higher local reliability than that provided by the power system as a whole.

III. ISSUES AND SOLUTIONS

In order to best integrate PV and other renewable into the grid we need to approach the problem from several angles. We look to solve or eliminate the negative effects that can be brought on by adding a lot of intermittent generation without the appropriate hardware and/or controls. We also look to increase the amount of power delivered to the grid from solar generators by increasing the efficiency and reliability of the generation systems. We do this by employing advanced technologies that can help us to integrate locally high penetrations of PV while simultaneously maintaining, and even improving, the quality and reliability of the power delivered by our electrical grid.

(1) Primary issues, (2) Secondary issues

[1] Primary issues

Voltage, frequency, waveform and phase sequence of the generated voltage and grid voltage should be same ie, both should be synchronized.

[2] Secondary issues

A grid consists of 3 stages: generation, transmission and distribution. Transmission stage is made efficient using separate feeder.These are the major issues that come across while we go for grid connectivity of renewable sources.

Solutions:

(1)Voltage should attain the condition: Grid voltage- generated voltage=0.

Grid voltage and generated voltage shouldbe in same phase. If grid voltage is greater thanthe generated voltage , the grid current flows to the inverter system and the system will get damaged. Vice versa will also happen. So to avoid that both should be in same phase.(2)FrequencySame as in the case of voltage, a slight variation in frequency will not allow attaining the condition. As the no of cycles increases, this variation increases and results in same case as above.(3)Waveform of the both should be same otherwise what that take place in the case of voltage that same will occur, short circuit/system failure will occur. (4) Phase sequence both generated voltage and grid voltage should be in phase. If not what that happens in voltage will take place. (5)Secondary issue – Transmission of all these are causes several problems that would arise in the transmission of the generated voltage. Such as:

- When we use the same feeder for supplying power to the grid through distribution transformer and to the same grid, generated voltage is supplied through the step up transformer. The distribution transformer both windings get energized. As the both windings get energized flux will flow to the core and thus result in leakage of flux and wastage of power.
- The distribution transformers as well as any transformer have rating. By feeding the generating power back to the same grid distribution transformer core would come across a substantial amount of voltage and current which cannot be withstand by the transformer core.
- When the application of microgrid is found profitable by the society. There is a chance of expansion of generation by each consumers along with this rating of distribution transformer is also increased. In such case paralleling of transformer is made.
- When the grid supply is made off for any maintenance, the feedback voltage to the grid should also be zero. Otherwise this will lead to serious hazardous situations to the persons working on the transmission and distribution line.

So to provide synchronization of voltage, frequency, waveform and phase sequence. We only need to synchronize the generated voltage and grid voltage because by synchronizing the voltage other parameters will get synchronized too. As all parameters depend on voltage. In the case of transmission stage, feed backing the generated voltage to a separate feeder other than the incoming feeder. We can avoid all the problems that arise in transmission stage.

IV. PROPOESD SYSTEM

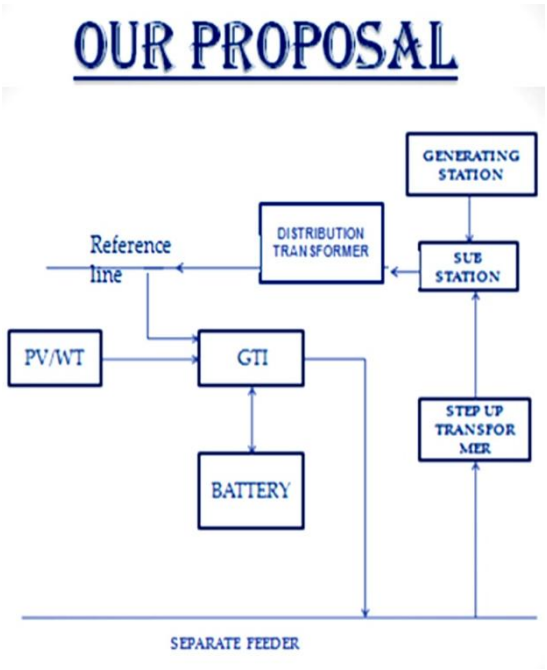

Figure 1: Methodology

Taking both inputs such as 230V, 50 Hz supply (reference line) and generated PV voltage into a grid tracking inverter .Which synchronizes both this inputs.

For a parallel storage battery is provided. The synchronized output 230V, 50Hz of grid tracking inverter is taken out through a separate grid to step up transformer .which step up to 11KV and given to the substation. Switching to different feeders is done by substation. By implementing this system we can commercialize the concept of grid integration of renewable energy.

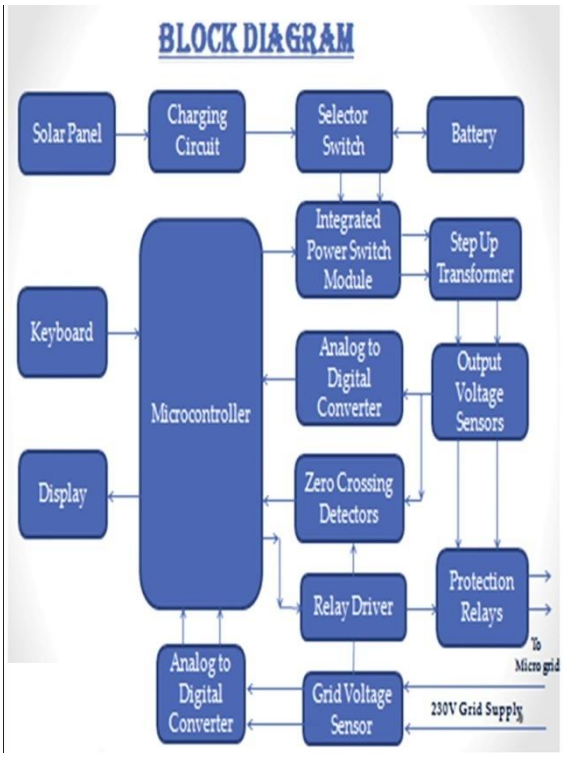

Figure 2: Block diagram

Block diagram explanation

Solar panels one of the power generating units in our system. This section contains an array of photo voltaic cells that absorbs the energy in the photons and converts it into electric potential. The voltage generated by the solar panels is bypassed to battery in order to store the energy.The charging circuit monitors the battery voltage and controls the charging action. It prevents over charging and leakage of the battery to the solar panel in absence of light.The selector switchdetermines the direct of current flow. The battery will be connected to the charging circuit as far as the sunlight is available and the battery voltage is less that the solar panel voltage. The output of the solar panel is directly connected to the inverting transformer once the battery is fully charged and the sunlight is available. In night and in absence of light the battery will be connected to the circuit. All these connections are made by this selector switch under control of microcontroller.Battery is the storage media of power. This battery can be either rechargeable batteries or super capacitors. There different types of rechargeable batteries like lead acid, nickel cadmium, nickel metal hydride, lithium thynolchloride etc. Our proposal utilizes inverter topology to convert the direct current from the battery or the solar panel to alternating current in the same voltage and phase angle of the grid. This in turn require high power solid state switch, typically MOSFETs or IGBTs. However cutting edge technologies in electrical and power electronic industries provide highly reliable high power integrated power switching modules. The low voltage inverted current is stepped up to the magnitude of the grid supply by the step up transformer. Power sensor have to measure both input power and output power from and to the grid. For this, we have to calculate input voltage, input current, input power factor, output voltage, output current and output power factor. All these actions are done by four blocks in the block diagram. They are

- Grid voltage sensor-to measure voltage.
- Analog to digital converter - to convert analog output from the sensor to hexadecimal from
- Output voltage sensor- to measure output voltage.
- Zero crossing detectors- to detect and measure the phase difference between voltage and current to calculate power factor and control switching.

Since we are playing with the high voltage high current grid supply, care must be taken to avoid catastrophes. The relay provide in between the gird supply and inverter output helps us to reduce the chance of accidents, losses since it is possible to isolate both in case of emergency by switching off this relay.However the microcontroller cannot drive this relay since it is an electromagnetic switch that requires high voltage and high current than the sourcing capacity of the microcontroller. Thus a relay driver is indispensable to integrate relay in this system.

For adequate control a human machine interface is provided. The key board unit helps the user to give commands and data to the system and the display unit helps us to read the commands from the system. An array of push to on switches can be utilized as key board while an alpha numeric LCD will be the best suit for display.

IV. SIMULATION MODEL

The proposed system is simulated in the PSIM version 9.0. The simulation circuit of proposed is shown below. by using grid synchronizing inverters renewable output voltage can be effectively connected to microgrid system by following steps.

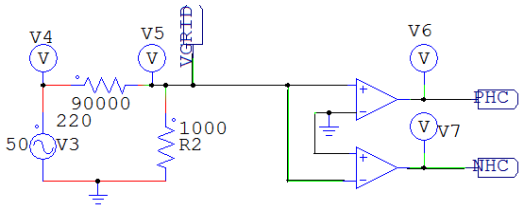

Fig.3

Power Supply Circuit

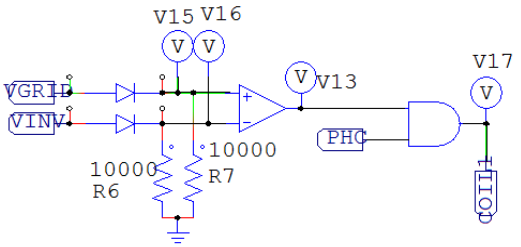

Fig.4 Positive Half Cycle Synchronization

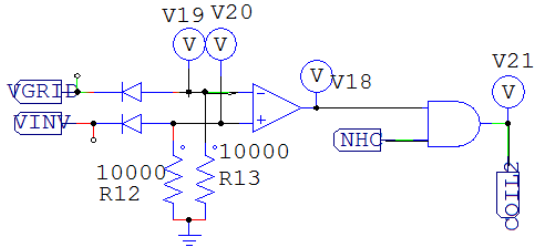

Fig.5 Negative Half Cycle Synchronization

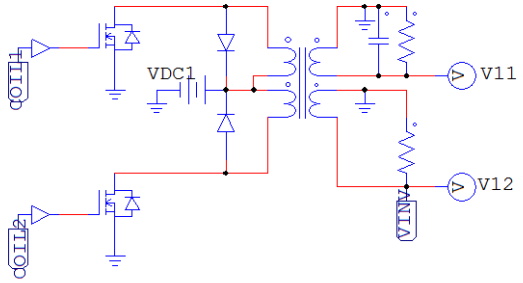

Fig.6 Grid Synchronization of Output Voltage

V1. SIMULATION RESULTS

From fig. 7 and fig. 8 it is clear that inverter voltage is synchronized with micro grid voltage in the terms of voltage, frequency and phase angle. That is by synchronizing micro grid voltage and inverter voltage we can effectively connect grid synchronizing inverter to the micro grid system.

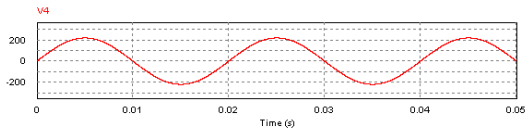

Fig.7 input voltage wave form

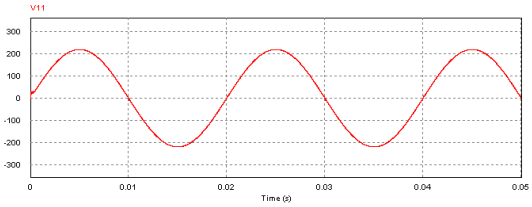

Fig.8 output voltage wave form

V. CONCLUSION

By implementing this low cost, highly efficient marketable product, We can commercialize the concept“ grid connectivity of renewable energy “all over India . Proposed system is the only solution up to date because of the following reasons:

- Solar energy is renewable and is available almost 8 hrs every day. It is free
- It is green energy, non-polluting and echo friendly
- No byproducts or waste
- Cheap and can be implemented by every electricity consumers
- Maximum energy production in peak load time

We can save our planet by saving fossil fuels and water during day time.The consumer can buy electricity as well as sell it.Consumers need to pay if and only if his consumption is greater than production. Otherwise the power distribution agencies will credit his account for his excess production. Thus focusing to renewable energy sources we can reduce the ongoing energy crisis to a large extent.

REFERENCE

[1] Shuai Jiang, Dong Cao, and Fang Zheng Peng, “Grid- Connected Boost-Half-Bridge Photovoltaic Microinverter System Using Repetitive Current Control and Maximum Power Point Tracking”, in IEEE transactions on power electronics, VOL. 27, NO. 11, November 2012.

[2] Robert H. Lasseter, Paolo Piagi University of Wisconsin-Madison Madison, Wisconsin, “Microgrid: A Conceptual Solution” ,in PESC’04 Aachen, Germany 20-25 June 2004

[3] H.M. Abdar, A. Chakraverty, D.H. Moore “Design and implementation of a specific grid tie inverter for an agent based micro grid” IEEE Trans. Industry Applications, vol. 51, no. 6 october 2010

[4] Peter Gorbe, Attila Magyar, Katalin M. Hangos “Line Conditioning with Grid Synchronized Inverter’s Power Injection of Renewable Sources in Nonlinear Distorted Mains” IEEE Trans. Industry Applications, VOL. 41, NO. 5, september/october 2005

[5] Robert H. Lasseter, “Microgrids and Distributed Generation” Journal of Energy Engineering, American Society of Civil Engineers, Sept. 2007.