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Synchronous Distributed Generation System using RF Communication for Off-the Grid System

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Abstract: ***Distribution energy generation is nothing but to generating energy from different energy sources like renewable, non-renewable or mixture of both connected in grid fashion. The grid is taken in consideration as separate grid or stand-alone grid. For interconnecting energy sources, RF communication is used. RF communication module will communicate phase angle information about different energy sources with each interconnected energy source, and after statistical analysis of information transferred potential energy sources set in sync with each other specifically based on power information. This synchronization among potential similar energy sources plays crucial role in entire ideology. Furthermore we have demonstrated the research in area with prototype model build, and research finding are shared in paper with insightful statistically processed real time analysis.***

Keywords: Distribution generation, Renewable sources, wireless communication, off the grid

1. Introduction

In today's industrial scenario, energy is generated from a number of renewable and non-renewable sources which needs to be utilized optimally to save energy and reduce cost. For proper utilization/ storage of energy for real time on demand supply on a power generation grid, the energy generated from different sources are required to be combined properly. The power output from various sources should be in sync with reference to particular instances of amplitude and phase angle of each channel at the time of grid interconnection. If they are not in sync, the assets used in developed systems goes for a toss, particularly converters and other important parts are seriously damaged. To curb the ill effects of mismanaged power channel interconnection, communication between cross functional power channels plays crucial role. The parameters related to distribution renewable electricity generating technologies (DREGTs) shows a number of technical barriers such as variability, grid integration and also high capital cost. Renewable energy installed capacity in India shown in following table as:

Table 1: Types of Renewable Sources and its Use

Type	Capacity in MW
Wind	26866.66
Solar	6762.85
Small Hydal Project	4273.47
Biomass power and gasification	4831.33
Waste to power	115.08

There are three types of distributed generators induction, synchronous or inverters. All these generators are connected to the grid by different methods.

Generally, synchronous generators have the most complex protection requirements, since they must be synchronized in frequency and phase before being connected to the grid. Induction generators cannot generate electricity without a supply of reactive power from the grid or from capacitor banks, hence do not require synchronization. Grid-tie inverters do not require complex protection as these are connected using protection relays. However out of these inverter mostly standalone inverters used in off-grid systems which cannot export power to the grid. Attempting to connect an inverter that is not capable of grid interconnection will damage the inverter. Most popular centralized system can be distinguished from distributed generation system as-

Table 2: Difference between Centralized and Distributed Grid System

Centralized Grid Interconnection	Distributed Grid Interconnection
Electricity is produced at large 1MW to 1000MW and delivered to users via transmission lines and distribution system called centralized electricity system	The use of smaller power plant 1KW to the 100KW power plant located near the users known as distributed system.
Much mature technology	Appropriate for small community
Well-developed industry	Allowed for direct privet investment
Higher load diversity	Reduced transmission and distribution losses.
Low cost per KW	Greater system resilience

2. Related Work

Distributed refers to generating electricity with rated capacity of 100KW or less and can be characterized by-

1) Nano grid - serving 1 to 10 users
2) Micro grid – serving up to 100 users
3) Mini Grid -serving 100 to1000 users integrated

A. Smart grid

It refers to information and communication technology that can be integrated into electricity system having advantages as reliability, reduced technical losses, and lower operating cost. Smart inverters can allow distributed photovoltaic system to communicate with grid operator and adjust output in response to grid needs.

B. Solar-Wind hybrid energy generation system

This system generate electricity from only renewable sources for stand-alone grid. Also it uses battery and maximum charge selection unit for storage purpose from solar and wind turbine [1].

C. Hybrid Power Generation System Using Wind Energy and Solar Energy

It makes use of special device called charge controller which controls the source which will be activated and deactivated depending on day time (uses solar panel) and night time(uses wind turbine) [2].

D. Grid Connected PV/Wind (GCPW) Hybrid System with Improved Power Quality

It uses PLL for phase angle matching purpose which consist of phase detector, low pass filter, VCO and feedback drive [3].

E. Solar pv-wind hybrid power generation system

It uses microcontroller for comparing output of solar and wind. After comparison charges battery by switching the relay [4].

F. Impact of wireless communication Delay on Load Sharing among Distribution Generation Systems through Smart Micro grids

Optimal controller is proposed which can maintains delay in all transfer paths. And simulation results were verified that proposed time varying communication delay [5].

G. DC microgrid for wind and solar power integration

The system proposes operational optimization and power electronics based voltage droop control. All results are demonstrated using simulation [6].

3. Proposed System

For illustration, a model is prepared for researching more into practical liability of idea being discussed in paper so far. For simplicity of real time data analysis two channels are prepared, and research carried out with taking insightful points in consideration. One power channel is the output power from solar energy generator assembly and another channel is battery output which resembles stored power transmission in interconnected power grid.

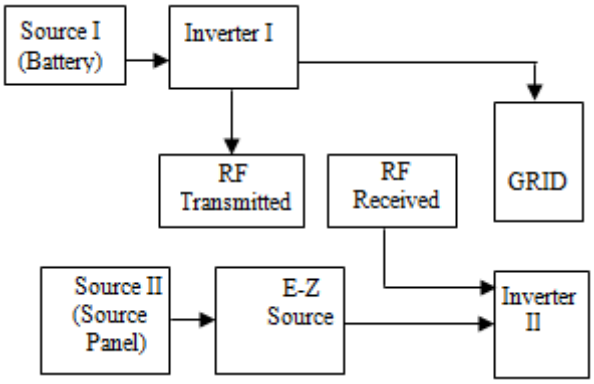

Figure 2: Block Diagram

In processing power arriving at confluence of two channels, inverters are used in each channel as there is need for converting DC power from channels to AC power. Inverters are just in time manipulative instruments and may be altered as per usage requirement. Now, along with two or multiple channels and respective inverters, RF module RF434MHz is used for the purpose of power information exchange. These building blocks are arranged shown below. The blocks used in system can be illustrated as below

A. Battery

It is lead acid rechargeable battery of 7.5mAh rating. It is used as one of the source for generating DC volt of 12V. It is composed of one or more electrochemical cells. This batteries cost is more than disposal batteries, but have much lower cost of recharging before they need replacing. Some rechargeable battery types are available in the same sizes and voltages, and can be used interchangeably with them. During charging, as the positive active material is oxidized, causing production electrons, and the cathode consuming electrons. The electrolyte act as the buffer and provides path for electron flow, as in lithium-ion and nickel-cadmium cells, or it may be an active participant in the electrochemical reaction, as in lead-acid cells.

Figure 3: Battery

B. Solar Panel

Solar panel generates electricity by absorbing sun rays in the form of impure DC volt. A photovoltaic (PV) module is a packaged, connect assembly of typically 6×10 solar cells. These packages generate electricity used for residential as well as commercial purposes. Each module is rated by its DC output power, and typically ranges from 100 to 365 watts.

Figure 4: Solar Panel

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. There are a few commercially available solar panels available that exceed 22% efficiency and reportedly also exceeding 24%. A single solar module can produce only a limited amount of power; most installations contain multiple modules. In this proposed two solar panels are used connected to EZ source for further filtering purpose. The

price of solar power has continued to fall so that becoming popular.

C. E-Z Source

As the solar panel output is not constant due to variation and hence panel output is not perfectly 12V required for proper inverter operation as source. To have filtration and constant output, after solar panel E-Z source module is developed. This will create a proper 12V and fed to Inverter II. The output of the Embedded EZ Source inverter is used to control the harmonics present in the load.

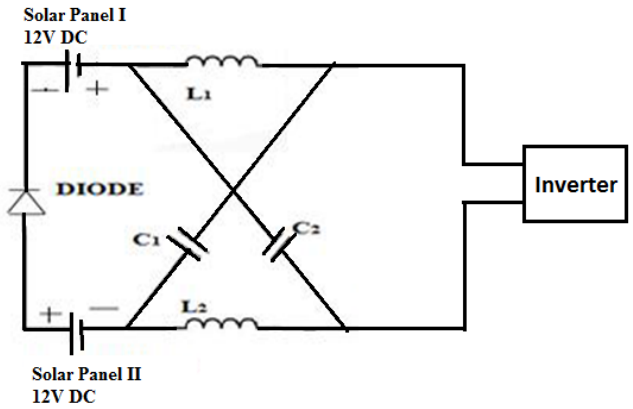

Figure 5: Schematic diagram of E-Z source

D. Inverter

Two inverters used in this project, Inverter I for solar and other Inverter II for battery source. This inverters are made with same configuration and tolerances of components used in it. Inverter I get energized with battery source and provides trigger for RF transmitter. After matching power information with Inverter I Inverter II get ON.

E. RF 433MHz module

This module is responsible for power information exchange. Unless phase angle of both inverter get match, load on the grid cannot sustain. For this purpose RF transmission at battery side Inverter I and RF receiver at solar side Inverter II. Once battery energized inverter I will on, start transmission of matching bits to Inverter II. On receiving power information Inverter II gets ON. And hence both inverter output is in sync with each other providing supply to grid. RF 433MHz module uses ASK modulation and requires 5Vsupply for operation. This modules have inbuilt encoder and decoder IC for bit by bit transmission purpose.

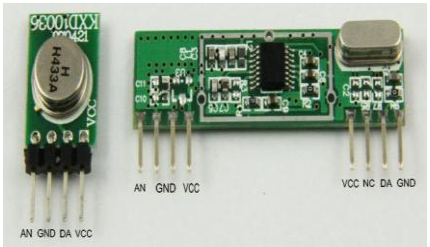

Figure 6: RF module

4. Performance Analysis

The physical prototype model developed is operationalized in step by step fashion in order to demonstrate and study the basic ideology discussed. The steps are as follows-

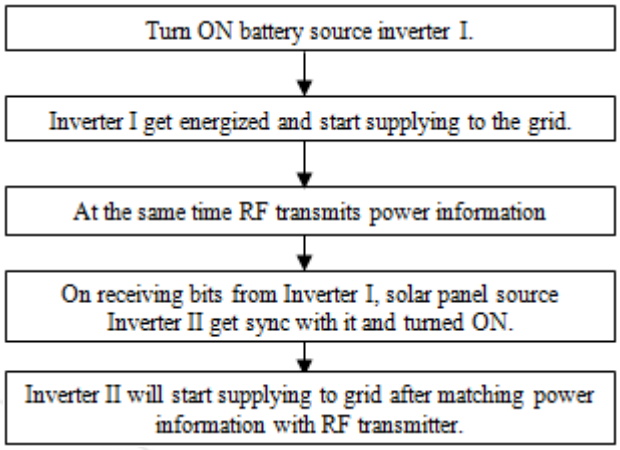

Figure 7: Flowchart showing working of proposed system

Both Inverter I and Inverter II uses same components as MOSFETs, transformer, and the PWM IC SG3525 etc. and made with same tolerance value.
Inverter I PCB shown in following figure.

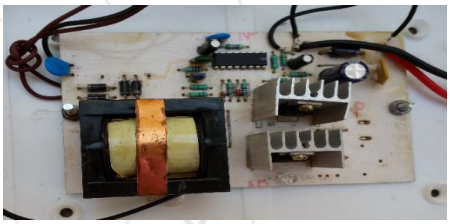

Figure 8: PCB of Inverter I

Inverter II built with E- Z source because, it is energized from solar panel which requires filtrations. Inverter II PCB shown as

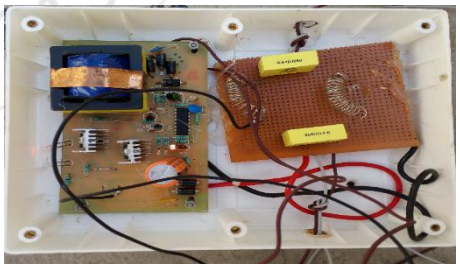

Figure 9: PCB of Inverter II with EZ source

In similar fashion as the interconnection is planned, some of the building blocks do change as we choose from different renewable or non-renewable energy sources. In current demonstrated model, a grid like structure is being built with nine connection points on the board. As both inverters turned ON after matching respective phase angles, the power bulb connected at one of the interconnection point as resembling power consuming instrument, glows with full intensity. At all connection points of interconnected power grid 230V (standard) power supply is available and generated power is appropriately demonstrated of being load balanced. The

required power will be generated as IC SG3525 is connected in feedback connection. IC will trigger MOSFETS to generate PWM AC voltage of 12V in nine levels. The 12V AC output from MOSFET given to transformer and hence 230V will obtained at grid. Grid board shown in figure.

Figure 10: Grid with nine testing points

5. Result

Output of system comprises of providing electricity on grid with matching phase angle and developing power depending on load requirements only. The phase angle of both inverters are matched, so that voltage on grid at any point is same i.e. 230V, otherwise both inverters get damaged.

Figure 11: Grid shows output

6. Conclusion and Future Scope

The developed system will make efficient use of renewable energy sources which also includes load balanced electricity generation. This system will work efficiently without noise problem along with assurance of no damage to inverter(s). The system subdues noise problems by making use of RF communication, and also delay problems in communication are removed by developing both inverters with same tolerance value components. This system best suited for generation as well as distribution of energy constantly by using number of renewable sources. Hence effective utilization of renewable energy maximizes throughput and daily requirement of electricity to everyone can be easily obtained.

Future scope will be definitely, scaling up of developed system, along with improvement in systems developed technically to tackle challenges that day to day life brings forth.

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