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RENEWABLE ENERGY MICROGRID GENERATION SYSTEM USED ONSIDE LOAD DEMAND FOR RURAL DEVELOPMENT

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Abstract. The impact of Electricity can understand in such a way that the development of the world is unthinkable without it. However, almost seventy years completed for our freedom, but so many rural areas have not Electrification in India. Such rural areas are very far from the development of basic requirements of the peoples, so how they can support the Nation's development. They required affordable and reliable electricity to start and achieve proper development. But some areas are situated in hilly areas or very far from power generating plants, difficult to develop the power transmission line. In such areas, renewable power plants can be developed on the demand site and fulfil the requirement of the peoples for Electrification and industrial and professional. Such kinds of the plant not only fulfil the load demands but also environmentally friendly. This article focuses on the design of a microgrid system using a solar array with a grid-connected system. MPPT controlling technology is used for capturing most of the sun irradiation. The power management system is also used for handling and distributing the generated solar power and grid power. The proposed microgrid system is designed using MATLAB/SIMULINK for connecting various types of loads. The Simulink model shows that the proposed microgrid system effectively, efficiently fulfils the load demand. It is a reliable system for fulfilling on-load demand in rural areas.

Keywords: Renewable energy, rural development, Electrification, microgrid system, Solar generation system.

1 Introduction

In electrical power systems, so many changes are applied, and day by day, some are applied for better and efficient operation. The discussion about the generation side, most of the power is generated from the thermal power plant—about 55 per cent of the power is generated from the thermal power plant in India [1]. The efficiency of such a plant is also very less, it is about 34-35 per cent and same time pollute the environment. So now the time has come to move on to the other energy sources available in nature used to produce electrical power. It is required to consider the renewable energy sources for producing electrical power that is easily available free of cost. It is already started, but the contribution of the renewable energy sector is very less around 7-10% [6]. In developing countries like India, most of the power is supplied to the urban areas only. Rural areas are getting Electricity only for a few hours. Some rural areas haven't had any electrical supply system until now as 70 years completed for our country's freedom [10]. As per one of the surveys till 2016, about 15.6 per cent of Indian people living in rural areas are not getting electrification [9]. Its means about two hundred four Indian peoples are living without Electricity. And if talk about renewable energy sources Electrification most of the state has very fewer plants. There are many reasons: Theft of Electricity, Poor policies for electrifications, Political leaders focused only on vote bank, Lack of resources and Villages situated in forest and hilly areas are not suitable for transmission lines [16]. The above factors affecting Electrification in the Indian state are shown in table 1 for rural areas where Electrification is not used until 2018-19.

Table 1. Percentage of households haven't Electrification

Name of States	Households Without Electricity Rural (%)
Bihar	94.4
Utter Pradesh	89
Assam	87.6
Orissa	82.6
Best Bengal	82.3
Rajasthan	77.6
Madhya Pradesh	65.5
Karnataka	58.3
Kerla	58.1
Tamil Nadu	55.5
Gujrat	43.6
Maharastra	41.6
Haryana	36.8
Himachal Pradesh	23

As shown in table 1, about 57% of total households in the country are not yet electrified [9]. Of these, 66% of the rural households do not have access to Electricity. Most of the electrified households face a severe problem of clean power during peak hours, i.e., from evening 6 PM to 9 PM. and also face severe voltage fluctuations during the peak hours[11]. Hence it is virtually equivalent to no electricity as, during this period, the villager performs his household activities. The situation calls for alternative options for supplying grid quality power, and renewable energy sources based power production is of worth consideration for such situations[3].

Table 1 data shows that few states are working in this area and trying to provide Electrification for the rural peoples to contribute to the building of the Nation. The government of India also formed The Rural Electrification Corporation Limited, which can

identify the rural areas where Electrification has not reached and try to connect such areas as soon as possible[2]. The electrical power system has a very waste Transmission network connecting all generating plants in parallel called a national grid. So many medium and long transmission lines are used to transmit the power from generating plant to load centres. When using such a long transmission line faced so many technical problems, investing a large amount of cost, and most of the power is dissipated in terms of line loss[7]. Means if using classical generation and transmission system, facing technical issue all time, paying more cost and pollute the environment. So, it's better to install a small generating unit of renewable energy system near to load centre. In this way, Electricity can provide in the rural areas where transmission lines plantation is not possible due to geographical issues. Such a system does not require a transmission line and has no transmission loss, so its efficiency is better than the classical methods[14]. So many articles suggested the different types of isolated and grid-connected microgrid systems used for Electrification. Article [1] presents the study of microgrid systems for transient and steady-state operation. They used two photovoltaic generation systems for the design of the microgrid.

The concept of a multi-bus microgrid system with distributed generation system proposed in the article [2,17] used a double controlled loop (Current & Voltage). To avoid the disturbances, generating units and loads are isolated with the help of a UPS system [3]. Authors [4] suggested that multiple DG systems interfaced electronically to manage the load centre's active and reactive power. Authors of [5,14,18] suggested AC-DC hybrid micro-grid systems connected with the grid and share the power automatically as per situations. It means if the load is less compared to another time, it transfers power to the grid, and if the load is high, it supplies to load. Maximum power point tracking techniques are proposed by [11,12] for renewable generation systems.

2. Proposed Micro Grid System

Nowadays, microgrid systems are used to fulfil the load demand on the side. The microgrid system is the collection of different generating systems like solar and wind connected with the load. Before designing and installing a generating plant, required to know the load demand, types of loads connected, the peak load demand and baseload demand, and plant expansion for future load demand fulfilment [8]. What is the duration of peak load demand and baseload demand in 24 hours? So, using the load duration chart identified all required information and then designed a microgrid system. The basic structure of the microgrid system is shown in figure1. This work used the PV array as the power plant further connected with a boost DC-DC converter to enhance the generated power level, as shown in figure 2. The Boost converter [13] is connected with 3 phase inverter system that helps convert DC power to AC power. Inverter system connected with battery system as well as power management system. A power management system connected with the grid plays a very important role here to identify the load and accordingly provide supply. When load demand is very low or not connected, the surplus generates power supply back to the grid. For the most appropriate use of a solar array, MPPT controlling system was used[12,15].

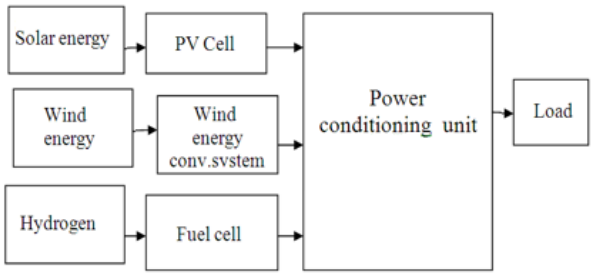

Fig.1. Structure of microgrid (Hybrid) System

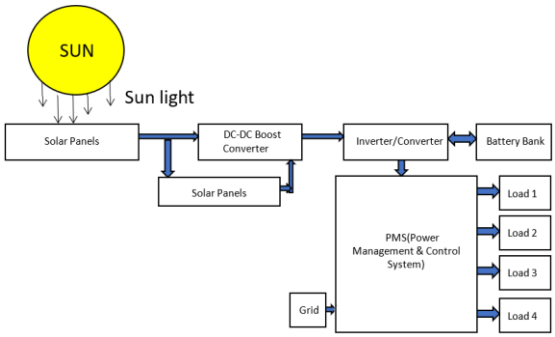

Fig.2. Solar connected microgrid system

Table 2 Connected load with their capacity

Load	Name of load	Capacity of load
1	Fan (single phase)	90W
2	AC	1000W
3	Water Pump (single phase)	800W
4	Heater	900W
5	Fridge	100W

This work used different types of loads used in the household, shown in table 2. The operation of the microgrid system in a different mode supplies different types of loads, and switching sequences are shown in table 3.

Table 3 Operation of micro-grid in different switching mode

S. No.	Mode of Operation	Solar Irradiation (W/M^2)	Switching of Load	Power Supply

1	Mode 1	1000	1,3	PV power=Power given to load + Battery Charging
2	Mode 2	700	1,3,5	PV power=Power given to load
3	Mode 3	300	1,2,3	PV power=0, Battery Power= Power Given load
4	Mode 4	1000	1,4	PV power=Power given to load

3. Simulation model using MATLAB

Design Simulink model of a microgrid on MATLAB is shown in figure 3.

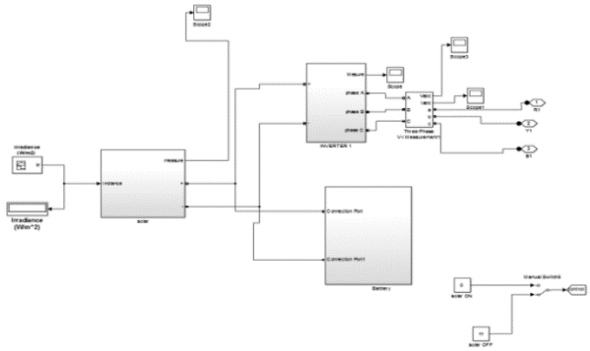

Fig.3. Simulink model of a microgrid system

The design of PV array with boost converter control Simulink model in MATLAB is shown in figure 4.

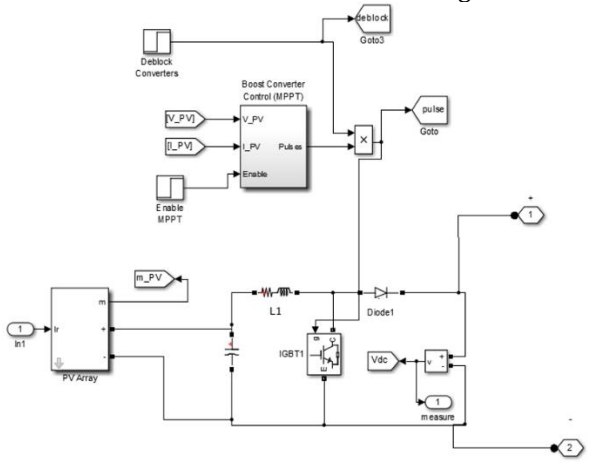

Fig.4. Simulink model of PV array

The simulation model of the Inverter and battery system is shown in figure 5 and figure 6, respectively.

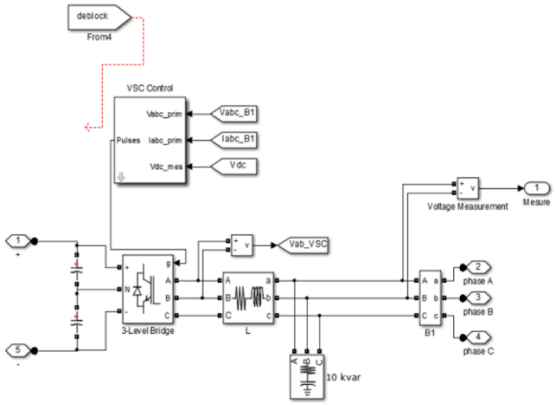

Fig.5. Simulink model of Inverter system

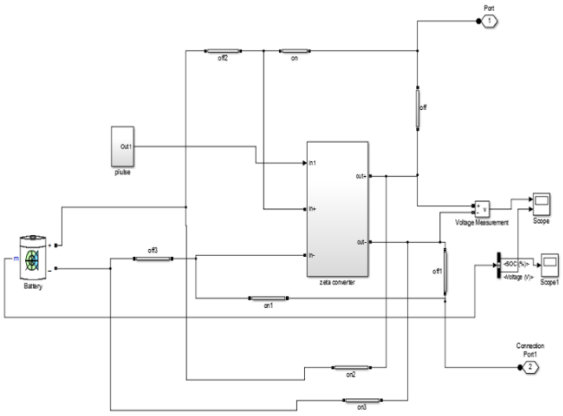

Fig.6. Simulink model of a battery system

4. Results and Analysis

The simulation model of a microgrid system using the solar system is run in MATLAB, and the output of the PV array is shown in figure 7. Initially, when the system started got over current for 0.02sec, but after 0.02 sec received an almost constant current which helped to operate the load smoothly.

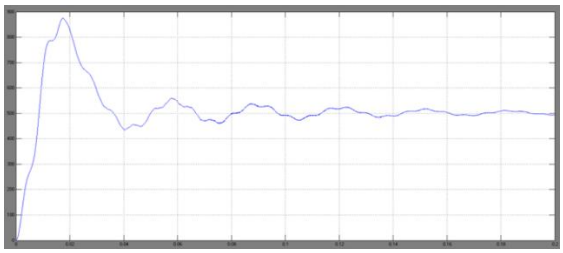

Fig.7. PV Array Diode Output

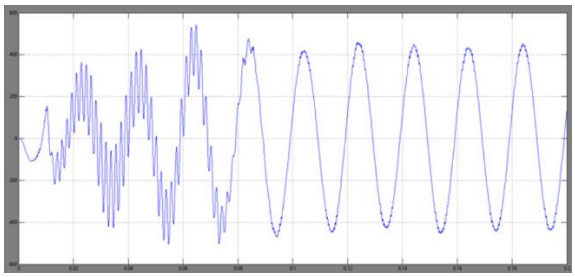

Fig.8. Inverter output voltage

The inverter output voltage is shown in figure 8, initially got some ripple, but after 0.2 sec, received pure sinusoidal output voltage. So, there is no ripple in

inverter output voltage which shows the improved power quality of the inverter system.

Similarly, the output voltage and current of the 3 phase inverter is shown in figure 9 and figure 10. It's also having some ripple at starting because of switching but very soon, almost at 0.2 sec for Voltage and current gives smooth values when handling various loads, so the proposed system is very effective and can operate the connected load efficiently.

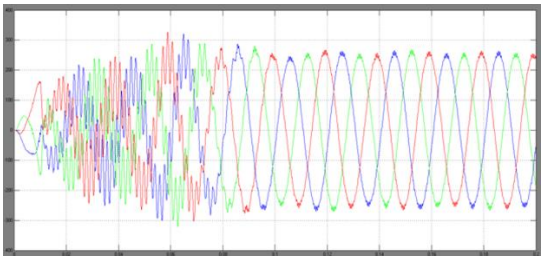

Fig.9. Inverter voltages in 3 Phase output system

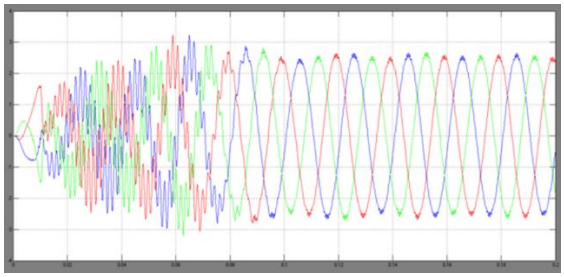

Fig.10. Inverter Current in 3 Phase system

5. Conclusions

A Microgrid system is the best possible solution for the Electrification of rural areas and areas far from urban areas, hospitals, educational systems, communication systems, and many more. Its cast of installation is also not much as the classical generating system required much money and space. Also running cost of a microgrid system is almost negligible and, most important thing environmentally friendly. So, in the modern system, microgrids play an important role to connect the rural people with the development of the Nation. This work considered different types of loads and fulfilled them without any problem. So, The system is reliable and easily handle problems if they arise. In this system, the only battery change required from time to time is the additional cost required.

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