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DC MOTOR COUPLED ALTERNATOR POWERED BY PHOTOVOLTAIC MODULE AND BATTERY

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Abstract: *Due to the high demand of power, the Renewable energy sector getting grow. This sector includes the solar, wind, bio-mass, and etc. In that, solar energy conversion system has many advantages over other non-conventional energy sources. The availability of sunlight will be in a throughout the year during the day time and it is pollution less. The main principle of the solar energy conversion technique is that converting sunlight intensity into electromotive force by using the photo-voltaic effect. The silicon material is used to convert the sunlight irradiance into electromotive force based on photovoltaic effect. The produced EMF will be in the form of DC. This DC will be regulated by using different DC-DC converter topologies. The regulated DC voltage is converted into AC in-order to supply for the AC loads with the inverter. This converting device may give single and three phase AC supply voltage based on the requirement. The ripples and harmonics will be present in the output AC voltage supply of the inverter.In this paper the DC-AC converting device will be replaced with the DC motor coupled alternator and ripples and harmonics of the output voltage will be compared. The batteries are used to provide the constant voltage for the DC motor from the PV module. The DC-DC converter used to regulate the charging voltage of the battery from the PV module.*

Key Words: *DC motor coupled alternator, PV module,Battery, Renewable energy, Solar energy conversion system.*

1. INTRODUCTION

Renewable energy is a socially and politically defined category of energy sources. Renewable energy is generally defined as energy that comes from resources which are continually replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat[1].

About 16% of global final energy consumption comes from renewable resources with 10% of all energy from traditional biomass, mainly used for heating, and 3.4% from hydroelectricity[13]. New renewable (small hydro, modern biomass, wind, solar, geothermal, and bio fuels) accounted for another 3% and are growing rapidly. The share of renewable in electricity generation is around 19%, with 16% of electricity coming from hydroelectricity and 3% from new renewable[2]. While many renewable energy projects are large-scale, renewable technologies are also suited to rural and remote areas, where energy is often crucial in human development.

Renewable energy sources, that derive their energy from the sun, either directly or indirectly, such as hydro and wind, are expected to be capable of supplying humanity energy for almost another 1 billion years, at which point the predicted increase in heat from the sun is expected to make the surface of the earth too hot for liquid water to exist[3].

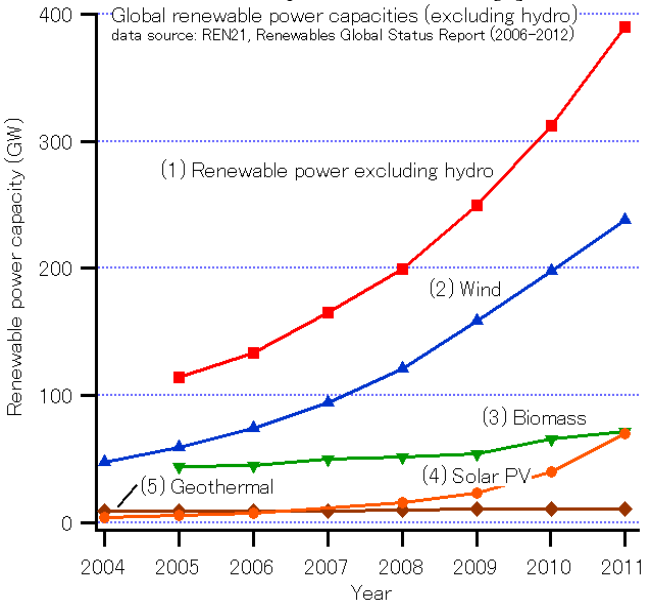

Chart -1: Global renewable power capacity excluding hydro.

2. SOLAR ENERGY CONVERSION- PRINCIPLE

Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such

as solar heating, solar photovoltaic, solar thermal electricity, solar architecture and artificial photosynthesis[7]. The direct conversion of solar energy into electric energy by means of photovoltaic effect which is defined as the "Generation of an electromotive force as a result of absorption of ionisation radiation"[4].When the photons from the sun are absorbed in semiconductor, they create free electrons with higher energies than the electrons which are providing the bonding in the base crystal. Once these electrons are created, there must be an electric field to induce these higher energy electrons to flow out of the semi conductor to do useful work[6]. The electric field in most solar cells is provided by a junction of materials which are having different electrical properties[14].Photon has to be absorbed in the active part of the material and result in electrons being excited a higher energy potential. Electron-hole charge carrier created by the absorption must be physically separated and moved to the edge of the cell[15]. Charge carriers must be removed from the cell and supplied to the loads.

3. PHOTOVOLTAIC MODULE

A solar cell, or photovoltaic cell (PV), is a device that converts light into electric current using the photovoltaic effect. A single converter cell is called a solar cell or a Photovoltaic cell and combination of such cells designed to increase the electric power output is called a solar module or solar array[10].

4. PROPOSED SYSTEM

Instead of three-phase inverter, DC motor coupled alternator is going to be used as a proposed system for this work. Comparing to the proposed system, the three-phase inverter required more number of PV modules to supply 500Vdc to 800Vdc as an input voltage[11]. The more number of batteries also required to give the back-up. This will cost more. So here the DC motor coupled alternator is proposed and the number of photovoltaic modules and batteries are reduced with DC-DC converter. The cost of the overall system will come down[12].

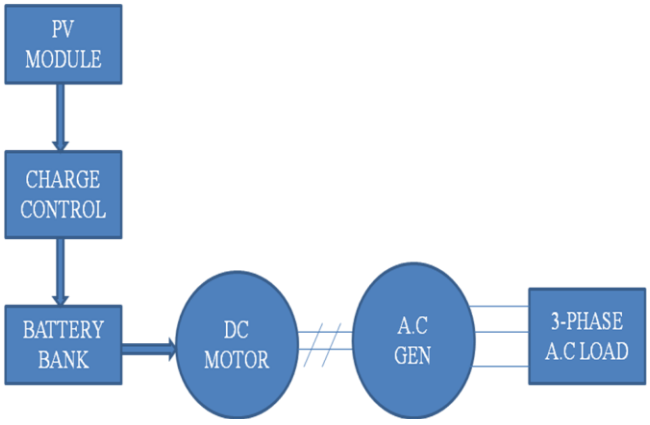

Fig -1: Block diagram for the proposed system

5. SYSTEM DESCRIPTION

PV array connected through the battery bank which is used to provide the constant voltage for DC shunt motor[8]. The buck-boost dc-dc converter works as a charge regulator or controller and its charging the batteries with a constant voltage. The DC shunt motor is supplied from the battery. The input voltage of the DC shunt motor may be 12V, 24V and 48V.The battery voltages will be boosted for the required input voltage range. The push-pull type dc-dc converter increasing the input voltage from battery voltage as required[9]. Separate dc supply is given to the armature and field. The self excited alternator is coupled with DC shunt motor. After starting the motor, the alternator produces the three phase ac supply and supplied to the loads. The loads may be of resistive, capacitive and inductive types.

6. EXPERIMENTAL RESULTS

Fig-2 shows the climate condition while taking the performance analysis of 72 cells family PV module. The temperature, humidity and wind direction has been indicated.

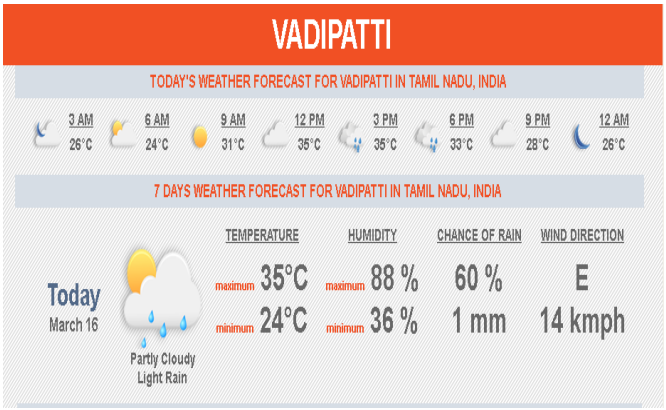

Fig -2: Climate Report.

Fig -3 shows the PV module performance analysis based on the different irradiations. The specifications of the PV module as follows,

PV module type – Polycrystalline
Power of the module – 240 Watts
Number of cells – 72 cells
Open circuit voltage (V_{OC}) – 22 V
Short circuit current (I_{SC}) – 14.2 A

Fig -3: PV Module Performance Analysis.

Fig -4 shows the parameters measurement setup for measuring open circuit voltage, short circuit voltage, short circuit current, maximum power voltage.

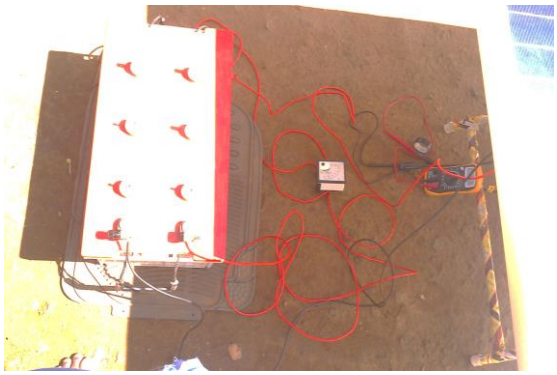

Fig -4: Parameters Measurement Setup.

Table -1 shows the output parameters of the 72 cells family PV module with different irradiations from the sunlight. The maximum power obtained from the PV module during the time of 10a.m to 1 p.m. the maximum power from this PV module is 158.60 Watts.

Table -1: Measured Readings.

Time (hrs)	Voltage (V_{OC},V)	Current (I_{SC} ,A)	Power (W_{mpp},W)
6:00	10.00	0.00	0.00
7:00	13.50	0.40	5.40
8:00	14.00	1.40	19.60
9:00	15.00	4.60	69.00
10:00	16.00	5.00	80.00
11:00	16.50	9.60	158.60
12:00	16.50	9.20	151.80
13:00	15.50	3.00	46.50
14:00	15.00	2.40	45.00
15:00	15.00	1.20	18.00
16:00	15.00	0.80	12.00
18:00	14.50	0.10	1.45

Fig -5 shows the name plate details of the DC motor coupled alternator. The DC motor is a shunt type constant speed motor. The shunt type 7.5 h.p DC motor is coupled with an alternator which has the capacity of 5KVA. The speed of DC shunt motor is 1500rpm, input voltage is 240Vdc. An alternator has the 0.8 power factor, three-phase 415Vac as an output.

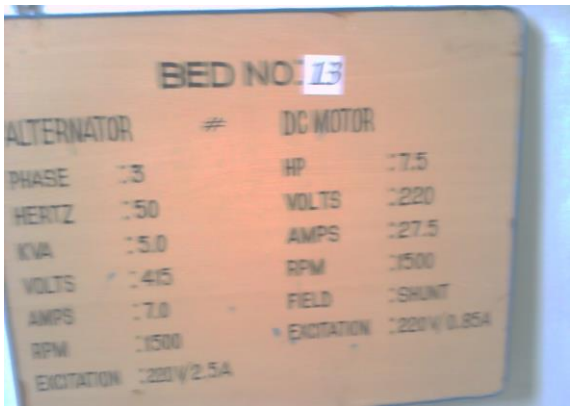

Fig -5: Name plate details.

Fig -6 shows the experimental setup for the DC shunt motor coupled alternator. The armature rheostat is used to reduce the starting current and field rheostat is used to excite the field coil of the motor. The armature and field coils are supplied with separate voltage with the magnitude of 220Vdc.

Fig -6: Experimental setup of the System.

Fig -7 shows the experimental results of alternator. The wave form was taken between the two phases. The isolation transformer is used to measure the line voltage of an

alternator. The isolation transformer will protect the digital signal oscilloscope while measuring the output voltage.

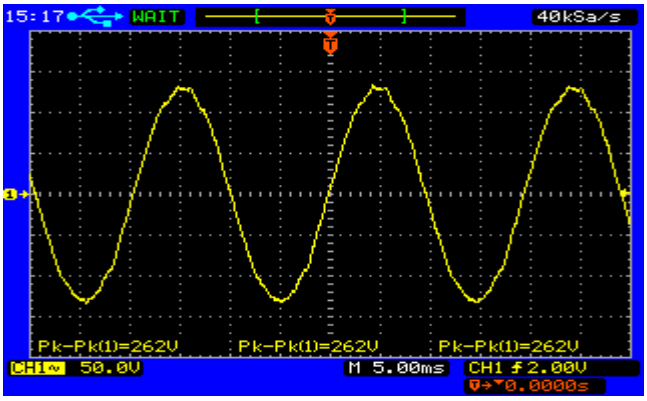

Fig -7: Output Waveform.

7. CONCLUSIONS

The proposed system works very well. It will give the cost effective performance instead of the three-phase inverter by using the PV modules and batteries in quantity. In three-phase inverter the switching sequence will produce the harmonics in output voltage waveform. This system can give the output voltage waveform with fewer harmonic.

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