Analysis of Hybrid power generation system with Solar and Wind Turbine by varying PMSG and SCIG with same load values

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***Abstract*: As the demand of electrical power increases need of efficient energy sources also increases and sustainable power with low power losses also a concern to researchers. Renewable energy sources are the main source of future energy. In this field many researchers worked a lot for better results. Main problem to solve out is total harmonic distortions and maximum power tracking from solar and wind. In this proposed work focus is on different generators used for wind turbine and battery management system for backup.**

Analysis of Hybrid power generation system with Solar and Wind as source is proposed. In this system various analysis of voltage, current and power are observed. For controlling converters Fuzzy logic controller is used by changing generator with turbine as permanent magnet synchronous generator (PMSG) and Squirrel cage induction generator (SCIG) along with normal Photovoltaic (PV) system and PV emulators by taking load as same in all conditions.

This comparative analysis represents the variation in electrical parameters in different conditions. Fuzzy logic controller gives excellent results in close loop control system.

Introduction

Practical force sources like sun based, hydro, wind, and biomass can be used for electrical force age. Essentialness change of reasonable force sources with stream development in that would offer dependable and capable force office. Actually maintainable force source framework has ended up being essential alternative of normal electrical imperativeness age in light of addition in fuel costs, obliged stores and biological issues. The concern stayed by standard imperativeness sources like non availability of stimulates and natural change has been tended to in various countries and hoping to assemble the headway in the manageable force source framework. Imperativeness created by the manageable sources can energize neighborhood loads and the overflow force can be moved to the lattice with the use of power equipment converter.

The idea of electrical force move between manageable force sources and cross section depends upon the idea of voltage/stream. The voltage and current sustained by the converter should be synchronized to cross section with Harmonics level portrayed by IEEE and IEC standard. The compromise of maintainable source requires fitting force control that accepts huge occupation for framework profitability and required yield of the framework. The open force from these reasonable force sources can be improve and enlarge by colossal control of the framework. Some reasonable force source framework may require power following control to follow the best force point as though there ought to be an event of PV (Photovoltaic), wind power making units. The framework design requires the right control, proper converters, ideal cost pondering each natural factor.

Wind Power Generation

Presently a day's electrical force is a piece of everybody's life. As the interest of force expanding, the prerequisite to create power is additionally expanding. In this respects the future gauging of force age sources examination gives that there is absence of ordinary sources so power age should switch towards non-customary sources as Wind, Solar, Fuel Cell, Biogas, Geothermal and so on the most accessible sources among these are sunlight based and wind. Both of these force plants need a particular prerequisite of area where the plant need to arrangement.

Significant hindrance of these assets are their low proficiency age hardware. This is because of monetary reasons, that assuming effectiveness will be builds, complete force plant hardware will be costlier than the absolute age. This field, scientists are looking and investigating the approaches to look through those methods that can build proficiency and abatement all out cost of plant.

In this proposal, such fuel source (Wind) is considered for examination and investigation. All out power produced from wind in this world is 12 % (approx. 486.8 GW) where as in India its 9.1% (approx. 1,02,768 MW) of absolute force age [1].

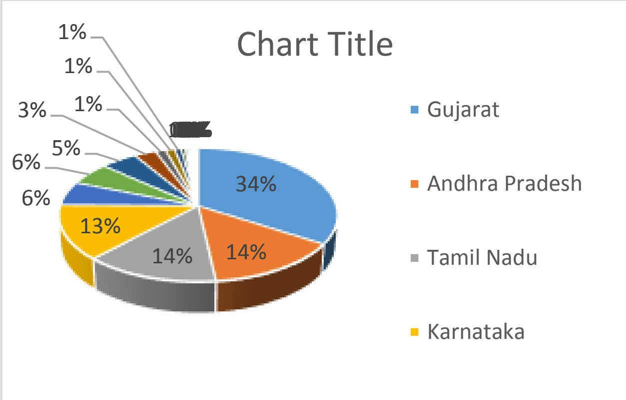

Fig. 1. Installed units of wind power in different states of India in MW up to 2019.

In Fig.1, the information showing the current circumstance of introduced units in India up to 2019. It shows that the greatest units are introduced in Gujarat (35071 MW) [2].

As demonstrated in Fig.2, the development of wind power in year 2001 to 2019 in India. The quantity of units of wind power is progressively expanding all over India because of its numerous advantages referenced in next point. The primary concern is its contamination less age and it is sustainable wellspring of energy. Information shows the expanding interests of introducing number of units of wind power all over India. To the extent information referenced in above calculates this shows that the interest of non-ordinary assets particularly wind is in necessity and not just India different nations additionally taking spotlight on it. This is expected to imploding of traditional sources and quick expansion in power interest. There is development of 10-15% in wind power plant establishment and future proposed to introduce development of 40% in forthcoming years, all through the world

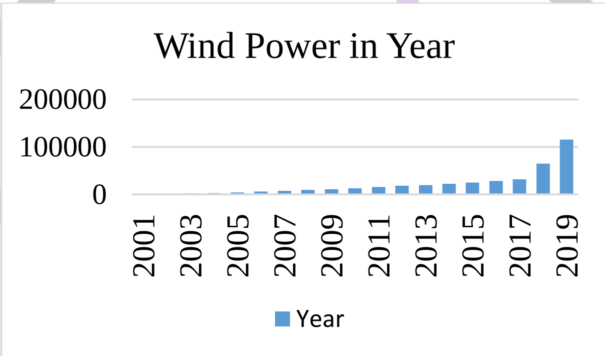

Fig. 2. Data of India cumulative installed wind capacity in 2001 to2019

To the extent information referenced in above calculates this shows that the interest of non-traditional assets particularly wind is in prerequisite and not just India different nations additionally taking spotlight on it. This is expected to falling of ordinary sources and quick expansion in power interest.

There is development of 10-15% in wind power plant establishment and future proposed to introduce development of 40% in impending years, all through the world. The explanation of interest in this source is that the area of its force plant is accessible effectively and the general expense of plant establishment and running expense is low when contrasted with traditional force plants. As anticipated breeze power age, will accomplish third or fourth force age source by 2025 [2].

Solar PV System

Photovoltaic (PV) cells include semiconducting materials that can change over an event radiation in the sun based reach into electric Current. PV cells are routinely involved silicon. They come in two groupings to be explicit translucent and slight film type. The got PV cell yield voltage is a component of the photocurrent, which is generally constrained by the heap current and moreover depends upon the sun illumination level that is seen during the activity.
Any self-ruling sun based cell control framework charges the battery from the daylight based cells in the daytime and supplies control from the battery to a heap during the evening. Customary framework played out this switchover system by checking the battery voltage reliably and direct yielding area signal there from by a control circuit.

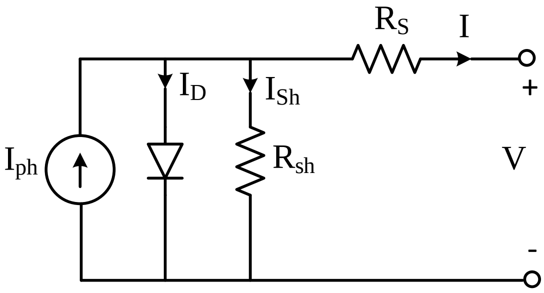

Fig. 3. Equivalent circuit of a PV model

Energy Storage procedures are delivered for giving ability to far off gadgets, for instance, sensor hubs in a framework which can't secure stable force. In the distant situation, the gadget should act naturally adequate and self-controlled with a fuel source. The energy procuring produces electrical energy from the including condition or from limitless sources, for instance, daylight based, wind, vibration, or warm energy, subsequently the gadget work for a more drawn out lifetime with the upgrades of the made energy. The most limit power point following (MPPT) technique can be used to procure the best force from an energy gathering gadget. It keeps up the working voltage of the gathering device to most limit power point so the procuring contraption makes energy with most noteworthy force. The yield control Po and the voltage of most limit power Vopt are resolved and got under from the model:

$$P_o = V_o \times [(V_{oc} - V_o) / R_s] \quad (1)$$

$$V_{opt} = (1/2)\, V_{oc} \quad (2)$$

Figure 4. shows PV cells, modules and arrays, solar cells are blocks for the construction of PV systems. It is composed of semiconductor, when semiconductor is light on the surface of the electron, then it is collected from the metal connected to this cell. To increase the power generated by the cell, the number of cells connected to the chain is very small. The power generated by the module is not sufficient for some applications, so the module has been added in series or parallel, which can or can fulfill the desire value [20].

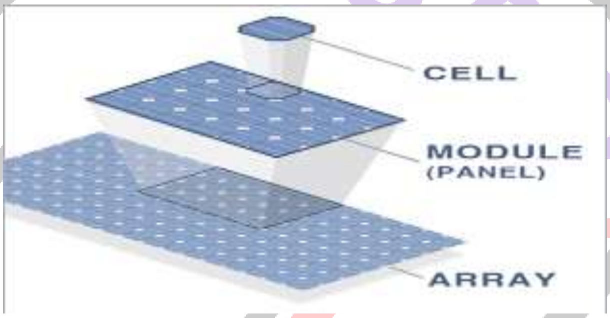

Fig.4. Photovoltaic Array

Mathematical Modeling of PV Array

PV cell and array models are shown in electrical equivalent circuits shown in Figure 5. It is represented by PV equation (3.1) [21].

$$I_{PV} = I_L - I_0 \left[\exp\left(\frac{V_m + I_m N_s R_s}{n N_s V_T}\right) - 1\right] - \left(\frac{V_m + I_m N_s R_s}{N_s R_{sh}}\right) \quad (3)$$

Where
I_L and I_O=photovoltaic output and saturation current of the array respectively
V_T= thermal voltage is
R_s = series Equivalent Resistance
R_{sh}=parallel equivalent resistance,
n diode = ideality factor
V_m and I_m =photovoltaic output voltages and current respectively.
To increase voltage rating of array Ns cell connected in series than thermal voltage V_T=KT/q. To increase output current of the PV array Np cell connected in parallel
Single diode model is a good combination of simplicity and accuracy. For power electronics practitioner single diode model is accurate and easy for doing analysis.

$$V_T = \frac{KT}{q} \quad (4)$$

$$I_D = I_o\left(e^{qVd/nKT} - 1\right) \quad (5)$$

$$I = I_{pv} - I_d - I_{sh} \quad (6)$$

$$I_{sh} = \left(V + {}^{IR_s}/_{R_{sh}}\right) \quad (7)$$

$$I_{ph} = I_L - I_o\left[\exp\left(\frac{V_{ph}+R_{sh}I_{sh}}{n}\right) - 1\right] \quad (8)$$

$$I_o = n_p I_{ph} - n_p I_{rs}\left[\exp\left(\frac{KV}{n_s}\right) - 1\right] \quad (9)$$

Solar Cell I-V Characteristic

I-V characteristics are representation of relation between voltage and current in Solar Cell in respect to irradiations and temperature conditions. This curve is used to analyses the parameter and behavior of particular cell and used as per requirement and response. This is also used to configure the system as per characteristics so the output will be gain maximum [27].

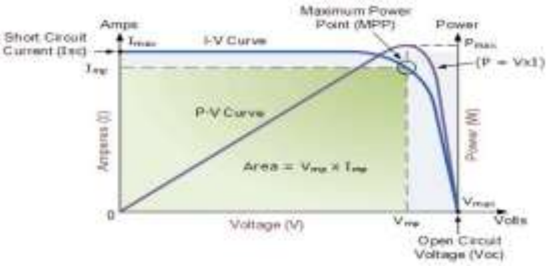

Fig.5. I-V characteristics curve of solar cell

The above graph shows the current-voltage characteristics of a typical silicon PV cell operating under normal conditions. The power from solar cell or any other source is the product of current and voltage gain. The curve is the resultant of power output from solar cell as it is cure between voltage and current.

DC-DC Converter

DC to DC converters are utilized for changing over one degree of info voltage to other degree of DC yield voltage. DC-DC converter comprises of inductor, capacitors and switches, DC-DC Converter interface with PV framework are basic for that we need a decent converter. These converters assume a job of charge controller, MPP trackers and PV interface with burden. [10].

Topologies-Boost Converter

There are many types of DC-DC converters. They are usually classified into two types: separate and non-isolated converters. A small high frequency-cyber electric isolation transformer is used to provide DC isolation between the input and output of the DC converter in the isolated topology; and the proportion of the transformer is achieved by the change log above or below the output voltage.

Non-isolated converters are classified into three types:

a) Step up (boost),

b) Step down (buck), and

c) Step up &Step down (buck-boost).

In proposed system Boost converter is used with PV module.

Boost converter

Yield voltage in this sort of converter is constantly more noteworthy than the info voltage. Along these lines, venture up converter can be connected to MPPT frameworks where the yield voltage ought to surpass the information voltage. For example, in a framework associated with the lattice, where the promoter converter holds a high yield voltage, regardless of whether the PV cluster voltage drops to lower esteems. Circuit topology of venture up converter as delineated in fig. 6.

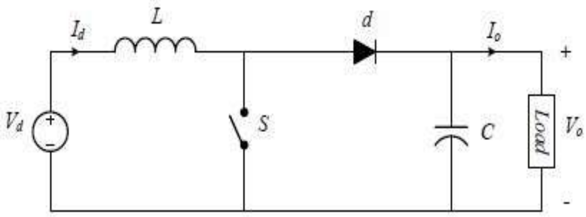

Fig.6. Equivalent Circuit of Boost Converter

$$D = 1 - \frac{V_d}{V_o} \quad (10)$$

$$L = \frac{V_d D}{2\Delta I_L f_s} \quad (11)$$

$$C = \frac{I_o D}{\Delta V_o f_s} \quad (12)$$

When the converter is running in the state of stable-state, then the duty ratio, D, can be expressed by the equation (12). While D shows the duty ratio, V_d and V_o respectively indicate the input and output voltage of the converter. From the above equation it can be seen that, the increase in the Duty Ratio D will increase the output voltage, the value of V_o.
Apart from this, the change in the charge ratio changes the output of the input and the converter current. In order to operate the converter in continuous conduction mode, the filter insulator and capacitor can be calculated by following equations.

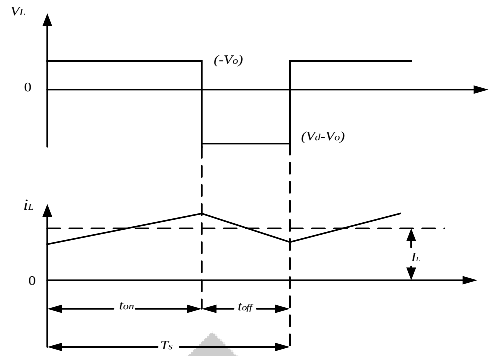

Fig.7. Triggering Pattern for Boost Converter Pulses

Maximum Power Point Tracking

The approach to build the productivity of a solar panel is to utilize a Maximum Power Point Tracker (MPPT), a power electronic technique that essentially expands the framework proficiency. By utilizing it, the system works at the Maximum Power Point (MPP) and produces its most extreme power output. Consequently, MPPT improves array efficiency thereby diminishing the general panel cost [3].

Over the past decade, a number of methods to track MPP has been developed. The considerable difference in these techniques accounts totally to their working characteristics such as required sensors, complexity, and cost range of effectiveness, convergence speed correct tracking when irradiation and/or temperature change, and hardware needed for the implementation or popularity among others.
Some of the most popular MPPT techniques are:

- Perturb and observe (hill climbing method)
- Incremental conductance method
- Fractional open circuit voltage
- Fractional short circuit current
- Fuzzy logic

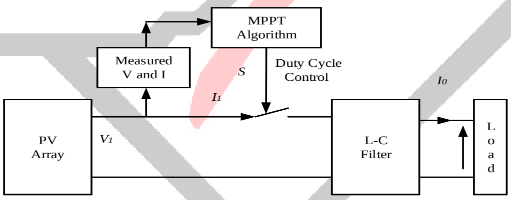

Fig.8. Block Diagram of MPPT algorithm

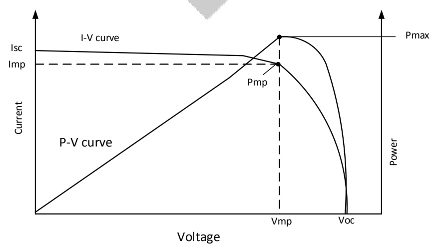

Fig.9. MPPT Power Voltage and Current curve

Perturb& observe algorithm and incremental conductance algorithm are the most familiar and commonly employed techniques among all. Techniques having different working principle such as fuzzy logic control, neural network, give a local maximum point and other, like the fractional open circuit voltage and short circuit current, produces an approximated Maximum Power Point, instead of an exact output. Under normal sunshine, P-V curve has only one maximum, otherwise, if partially shaded curve have multiple maxima. The Hill climbing principle is the working base for both incremental conductance and P&O methods, which guides the operating point in the direction of power increment. It's easy implementation and good performance credits under constant irradiance are the two major authenticated reasons for its popular use. The major drawback of the Hill Climbing Method is its oscillating tracking around the MPP, due to rapidly changing temperature, thereby resulting in the tedious and sometimes wrong directional tracking of the method.

The simulation modelling of proposed work in MATLAB and its responses using waveforms and comparison with synchronous generator and Induction Generator variations with keeping load profile similar. Fuzzy logic is used to control solar PV connected converter as DC/DC Buck converter.

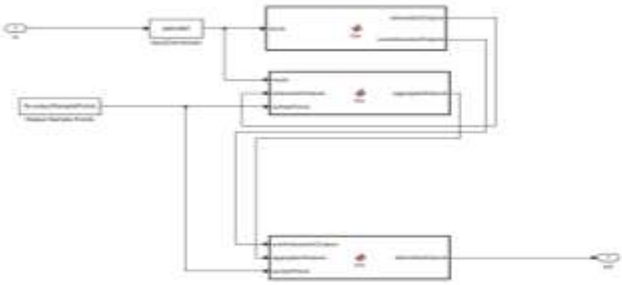

Fig. 10. Fuzzy Logic controller for proposed network

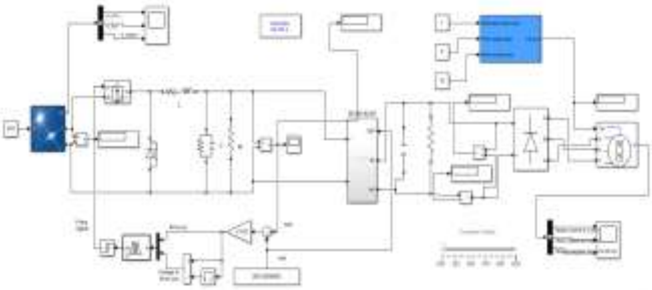

Fig. 11. Circuit diagram of proposed system with PV and wind using synchronous generator

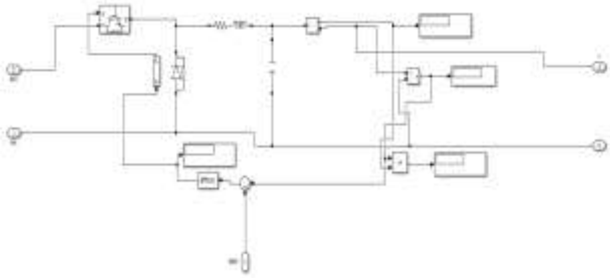

Fig. 12. Buck converter model in MATLAB used in proposed system

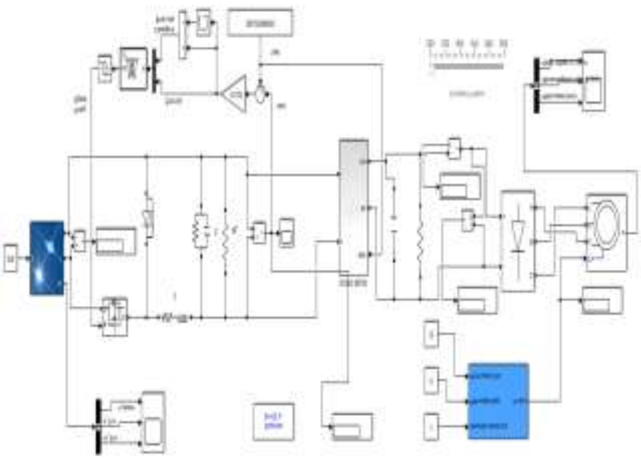

Fig. 13. Circuit diagram of proposed system with PV and wind using Induction generator

Results with PMSG:

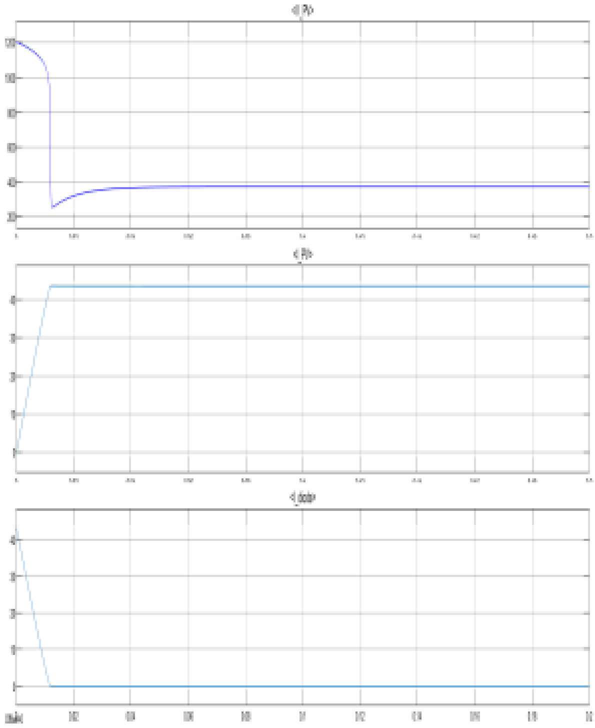

Fig. 14. Waveform for solar PV system with voltage, current and diode current

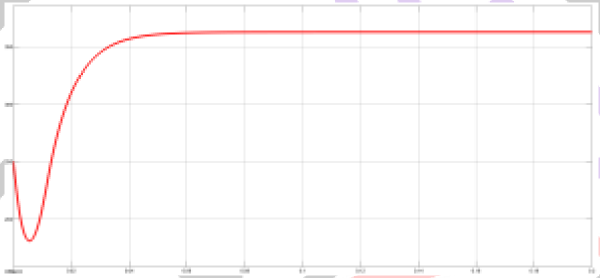

Fig. 15. Output Voltage at load

Table. 1. Comparison of parameters with Synchronous and Induction Generators

Parameter	Synchronous	Induction
PV voltage	371.4 V	371.4 V
Buck Voltage	362.7 V	362.7 V
Load Voltage	553.5 V	416.4 V
Load Current	0.3409 A	0.126 A

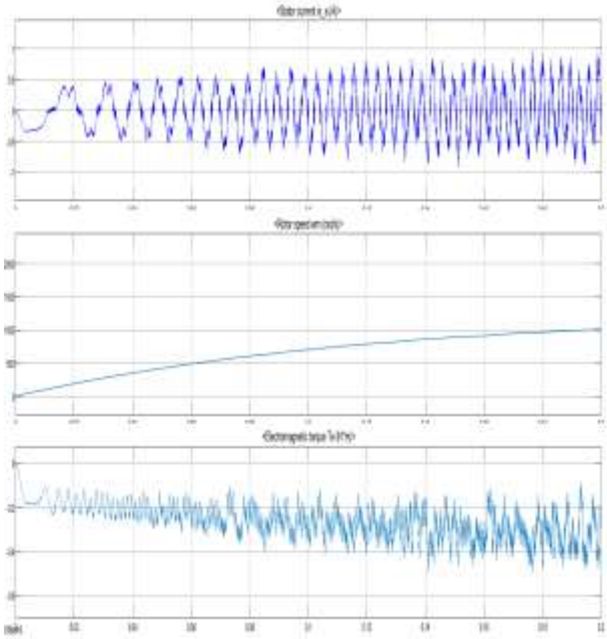

Fig. 16. Waveform for Synchronous generator parameters with proposed system.

Fig. 17. Comparative graph of parameters of proposed system

The responses shows that when synchronous generator is used with PV solar the variation is load voltage and current is observed as compared to Asynchronous generator. Results of SG is better than IG.

CONCLUSION AND FUTURE SCOPE

The system is designed with solar PV array and compared with two different wind turbine generators as Synchronous and Asynchronous generators along with converter control using fuzzy logic controller. This comparison is for analysis of generator response with proposed system and its constant load profile.

The analysis represents that while using synchronous generator, the system responses are better as compared with another Asynchronous generator. This is due to variation in wind profile and torque provided to it. Fuzzy logic controller controls the DC/DC voltage output from solar PV system.

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