Hybrid Energy Storage System Micro Grids Integration for Power Quality Improvement using various Controller

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Abstract— Renewable energy technologies gives us much cleaner, abundant energy gathered from self-renewing resources such as the sun, wind etc. Increase in power demand leads to increase in powerfailure. Hence, renewable energy sources acts as constant load provider. A converter topology for hybrid wind/photovoltaic energy system is proposed. In reality, combining both solar and wind power sources provides us with much needed power generation. By using Renewable energies we have getting advantages of nil fuel cost and environmental impacts got reduced. In this paper, we will see a SEPIC converter topology is used for the hybrid power sources. Two inputs, one from wind energy and another from solar PV panel are given to the converter and maximum power is extracted by using fuzzy logic maximum power point tracking method. Depending on the availability of the energy sources this configuration allows two sources to supply the load separately or simultaneously. The output is given to inverter which converts dc to ac and then applied load. This hybrid energy is given to the three phase inverter. It will convert that DC voltage into AC voltage. This AC voltage is given to the load. The sinusoidal PWM technique is applied to the inverter to control the output voltage and the Fuzzy controller compensates reactive power in the grid. Simulation is carried out in MATLAB/ SIMULINK. Here in this paper, we will prove that fuzzy based controller is best for controlling the production and supplying of power in the bus by comparing with other controllers namely PI, Hysrterisis.

Keywords: SEPIC Controller, Inverter

I. Introduction

A. Solar Energy

The sun is a huge and vast source of energy for humanity, which provides competitive energy with high potential. Solar energy accounted around 16% of total power production by 2050 (compared to 1.8% in 2016)That's why we have been investing for several years in solar energy, an inexhaustible energy with low CO2 emissions which doesn't harm the environment or local residents, and sustainably meets the needs of individuals in electricity. The Group wishes to contribute to a more harmonious world, where progress meets the expectations of individuals, populations and the planet, a future that respects both individual and collective needs. Solar has got an important place in the energy production as one of the pillars of a sustainable energy transition.

B. Wind Power

Wind energy is a source of renewable energy. It does not contaminate, it is inexhaustible and reduces the use of fossil fuels, which are the origin of greenhouse gasses that cause global warming. In addition, wind energy is a "native" energy, because it is available practically everywhere on the plant, which contributes to reducing energy imports and to creating wealth and local employment.

Producing electricity through wind energy contributes to sustainable development and mass production of renewable resources.

The main advantage of the production of Wind energy is that it does not emit toxic substances into the air which can be very damaging to the environment and to other living creatures. Toxic substances can acidify land and water ecosystems, and corrode buildings. Air contaminants can trigger heart disease, cancer and respiratory diseases like asthma.

Since wind energy is clean, it does not contaminate water or any other resources ,an extremely important factor given the scarcity of water. Unlike fossil fuels and nuclear power plants, wind energy has one of the lowest water-consumption footprints, which makes it a key for conserving hydrological resources.

II. Existing Model

We all know that the buck boost converter is a DC to DC converter. The output voltage came from buck boost converter of the DC to DC converter is less than or greater than the input voltage. the value of magnitude of output voltage is found using Duty cycle . These converters popularly known to as step up or step down transformers and these names are coming from the analogous step up and step down transformer. The input voltages will be processed to step up/down to some level of more than/ less than the input voltage. According to the low conversion energy, the input power is equal to the output power. In this model we can see that the conversion and all other activities are controlled using PI , Hysterisis. But these controller lacks the accuracy and the reaction time is high

A. Disadvantages:

Reaction time is high, accuracy is less.

1) PI Controller

The inherent offset is completely eliminated using the control mode of PI Controller which has one-to-one correspondence of the proportional mode as well as the integral mode. These controllers are actively used where speed is not an issue. Since proportional controller cannot provide new nominal controller's output in case of new load condition, but in this new configuration necessity of fixed (offset) error has been replaced by integral term. Mathematically, this can be represented as,

$$P = K_p e_p(t) + K_p K_I \int_0^t e_p(\tau)\, d\tau + P_I(0)$$

Where,
P = PI controller's output
KP = Proportional Gain
KI= Integral Gain
ep (t)= Measured values of controlled variable

PI(0) = Integral term initial value

B. Disadvantages

1) Due to the addition of integral term speed of response of system becomes sluggish.
2) During start-up of a batch process, the integral action causes an overshoot.
3) PI controller lacks ability to predict the future errors, so it cannot eliminate steady state oscillations and leads to reduced settling time. Hence, overall stability system is comparatively low.

1) Hysterisis Controller

There are many different pulse width modulation techniques like space vector pulse width modulation, trapezoidal modulation, staircase modulation, delta modulation etc. which are been used for generating the triggering pulse for the system. Due to the increase demand in high frequency conversion and active power conversion the losses associated with these techniques are increasing hence the system becomes unstable. In order to increase the stability and to reduce the harmonics of the output waveform content the hysteresis current control method is implemented in this project. Hysteresis current control method is simple to implement and is also cost efficient

Hysteresis method is based on Schmitt triggering technique which switches precipitously between two states. the upper and lower states are pre-set, when the output of the system touches the upper limit the input to the circuit is turned off. Hence the output tends to decrease until it reaches the minimum threshold limit. When the output attains minimum threshold limit the input of the system is once again activated increasing the output once again. Hence the constant waveform is achieved at the output terminal of the system by operating between the pre-set limit the system behaves as per the scheme and makes the overall system highly stable.

2) Disadvantages

1) Error detection and correction is not accurate
2) More reaction time

3) PID Controller:

PID controller maintained in such a way that the output has zero error between process variable and desired output by closed loop operations.

4) P-Controller:

Proportional or P- controller gives output which is proportional to current error e (t). Proportional tool compares desired point with or feedback value. Output is got by Multiplying resulting error with proportional constant. Controller output will be zero if the error value is zero.

5) I-Controller:

I-controller is needed due to limitation of p-controller where there always exists an offset between the process variable and set point, where I controller provides necessary action to eliminate the steady state error. Integration of error continues until error value reaches to zero.

6) D-Controller:

The main limitation of I-controller is that it lacks the capability to predict the future behaviour of errors. So even if the set point is changed it will react normally only. So here comes D-controller which overcomes this limitation by predicting future behaviour of the error. The rate of change of error with respect to time, multiplied by derivative constant leads to the output. By increasing system response, we will get the output.

7) Disadvantages:

In PID all process can be used to an extent but over proportional action causes faltering or hesitation, over usage of integral action causes overshoot, more derivative action causes an oscillatory approach to setpoint.

III. PROPOSED MODEL

A. Fuzzy Logic Controller based:

In this project, we can see the energy of both wind and solar is tapped and is passed to grid using SEPIC Converter and fuzzy logic controllers are used. The SEPIC converter is highly capable of operating from an input voltage that is greater or less than the much regulated output voltage. Aside from being able to function as both a buck and boost, the SEPIC design also has minimal active components, a simple controller, and clamped switching waveforms which provide low noise operation. This model is being controlled using Fuzzy Logic controller and this controller having advanced versions of PI , Hysterisis controller will have more advantages .

Fuzzy logic system can be defined as a fuzzy system which utilizes a mathematical system to analyse analog input in terms of logical variables which use continuous values between 0 and 1 unlike the classic or digitalized logical which utilize digital values high (1) or low (0).Fuzzy control systems have been successfully applied to a wide variety of practical problems. It has been shown that these controllers may perform better than conventional model-based controllers, especially when applied to processes difficult to model with nonlinearities, and with uncertainties. The fuzzy control is nonlinear, adaptive to system easily, giving robust performance under parameter variation and load disturbance effect. A typical fuzzy control describes the relationship between the changes of the control

Du(k)= u(k)-u(k-1) on one hand , and the error e(k) and its change De(k)= e(k)-e(k-1) on the other hand. Such a control law can be formalized as:

$$Du(k)=F(e(k),De(k))$$

The actual output of the controller u(k) is obtained from the previous values of control u(k-1) that is updated by Du(k) :

$$u(k) = u(k-1) + Du(k)$$

This type of fuzzy controller is known as fuzzy PI according to the relation between variables e(k) and De(k) on one hand and Du(k) on the other hand. The difference is in the type of relationship. In the case of the PI controller this relationship is linear, while in fuzzy PI it is nonlinear in general. The PI controller (also fuzzy PI) is, however, known to give poor performance in transient response due to the internal integrating operation. The fast response of the drive is desired in servo motor applications, That's why the performance of fuzzy PI should be improved to give satisfactory rise time and minimum overshoot in step response. Here, the fuzzy controller system used is similar to that described by Lee, and it is a modified type of fuzzy P1 controller. it evaluates resetting rate (r) of control input applied to the system by error and rate of error change.

The control input is calculated by the following equation:

$$u(k+1)=(1-sqrt(r(k))*u(k)+Du(k)$$

The fuzzy rules for resetting rate are constructed to damp overshoot in response by resetting accumulated control input and to make response faster under large incremental control input. Rules for calculating incremental control input (du) and resetting rate (r).Respectively. Besides, the membership functions for error (e), rate of error change (de), and incremental control input (Du) and resetting rate (r).

B. Advantages:

- Computation is easy, widely available toolboxes and had dedicated integrated circuits.
- Convenient user interface, easier end user interpretation.
- FLC can incorporate a conventional design (PID, State feedback) and fine tune it to certain plant nonlinearities due to universal approximation capabilities.

IV. BLOCK DIAGRAM

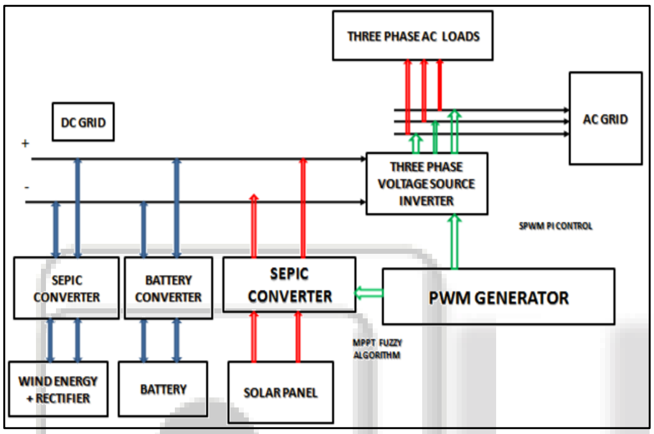

Fig. 1: Proposed Block Diagram

This block explains how the voltage generated from hybrid system is being finally given to the AC grid. The energy tapped from the solar panel and the wind turbine is fed to the SEPIC Converter (Single Ended Primary inductor converter).SEPIC which is DC to DC converter will convert the voltage to suitable efficient level. Then this voltage is fed to the DC grid. The battery along with the setup will continue to store energy till its limit is reached. The 3 phase voltage source inverter will convert the voltage from DC to AC, which is suitable for the working of Step up transformer. The Transformer the converts the voltage level to higher level and is then fed to the AC grid for the transmission. Here we will replace controllers with PI and Hysteresis and compare their properties in the power production in the final stages. Even though the working and the block diagram is same for all the controllers, the replacement of different controllers will lead to change in waveforms or amplitude of the waveforms. This changes will help us to better come into understanding about which controller is best.

V. SIMULATION DIAGRAM

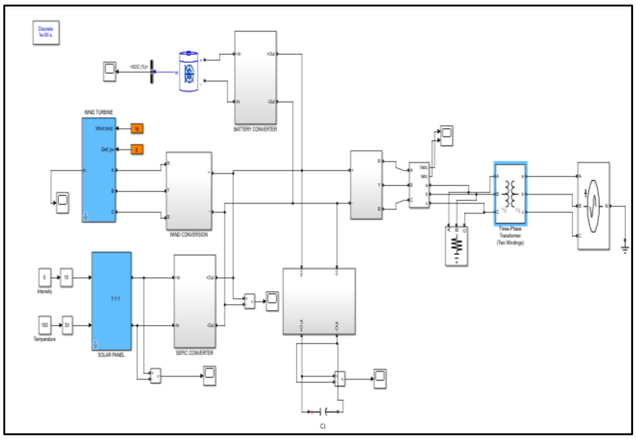

Fig. 2: Proposed Simulation Diagram-Fuzzy Logic

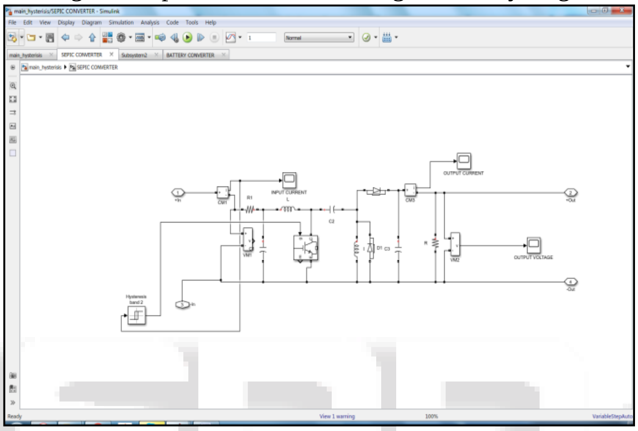

Fig. 3: Simulation model-Hysterisis controller

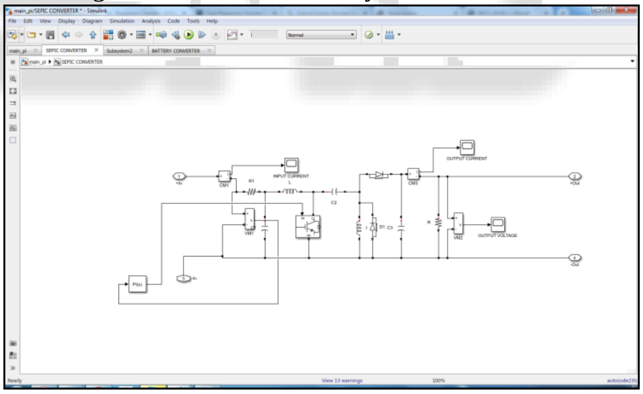

Fig. 4.Simulation model-PI controller

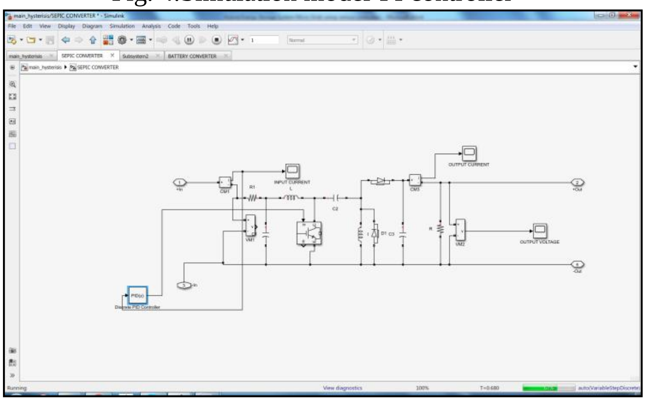

Fig. 5: Simulation model-PID controller

VI. RESULTS

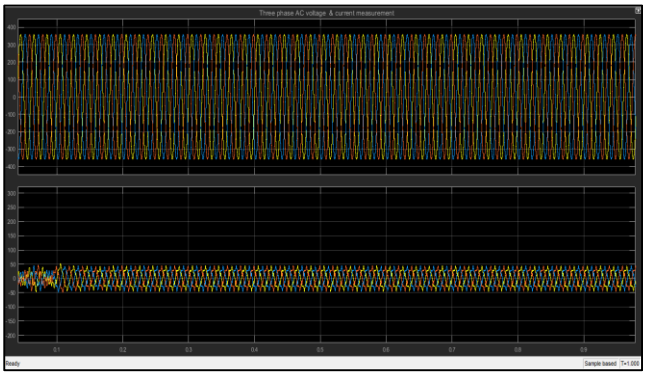

Fig. 6: AC Voltage and Current Measurement-Fuzzy Logic

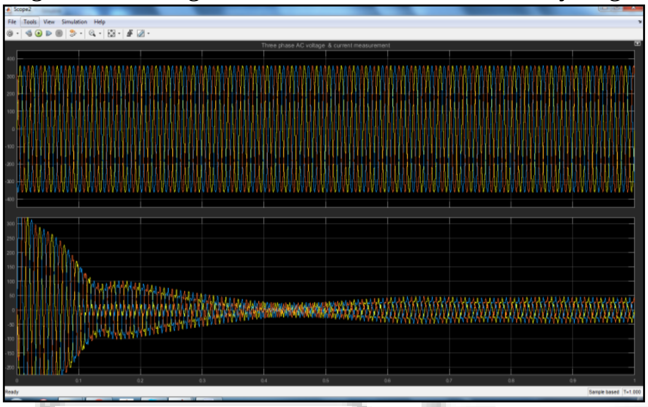

Fig. 7: AC Voltage and current measurement -PI

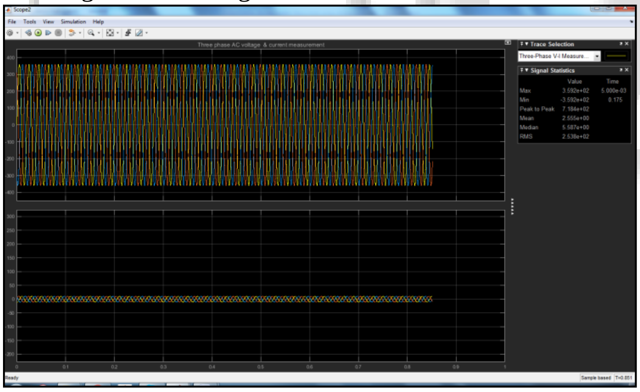

Fig. 8: AC Voltage and current measurement -Hysterisis

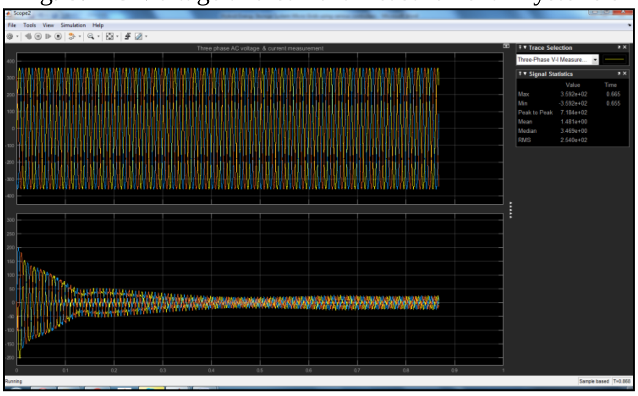

Fig. 9: AC Voltage and current measurement -PID

VII. CONCLUSION

By comparing the outputs of all the controllers Namely PI, Hysterisis, Fuzzy logic, PID controllers. we can see that the output of fuzzy logic controller is more stable and will meet the demand of the consumers. even though the power is produced using all controllers. By using Fuzzy logic controller, the accuracy is high and the objective is achieved with higher precision.

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