HYBRID POWER GENERATION SYSTEM BY USING DESIGN OF CUK CONVERTER

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Abstract—**This paper presents an control of a hybrid power generating system (HPGS) based on a wind turbine (WT) and a solar-photovoltaic (PV) array. A Permanent Magnet DC Motor (PMDCM) is coupled with a WT for electromechanical energy conversion. A battery energy storage system (BESS) is reinforced in the hybrid system to ensure power leveling under wind and solar. For obtaining the maximum power to regulate the output DC voltage from a solar PV array and wind turbine, a DC-DC Cuk converter is controlled using perturbation and observation algorithm in MPPT technique. PWM Controller is used to generate trigger pulse in power circuit switches. The circuit will be implemented using PIC Controller. The proposed HPGS and its control algorithms are modeled in MATLAB/Simulink and its performance is tested in real time under presence of AC Synchronous Induction motor.**

Keywords- Wind Turbine, PV Array, Battery Energy Storage, Hybrid Power Generating System, Dump Loads, Cuk converter, Motor.

I. INTRODUCTION

Electricity is most needed for our day to day life. There are two ways of electricity generation either by Non-renewable energy resources or by renewable energy resources. Electrical energy demand increases in word so to fulfill demand we have to generate electrical energy. Now a day's electrical energy is generated by the Non-renewable energy resources like coal, diesel, and nuclear etc.[1] The main drawback of these sources is that it produces waste like ash in coal power plant, nuclear waste in nuclear power plant and taking care of this wastage is very costly. And it also damages the nature. The nuclear waste is very harmful to human being also. The conventional energy resources are depleting day by day. Soon it will be completely vanishes from the earth so we have to find another way to generate electricity. The new source should be reliable, pollution free and economical.

The renewable energy resources should be good alternative energy resources for the conventional Non-renewable energy resources. There are many renewable energy resources like geothermal, tidal, wind, solar etc. the tidal energy has drawbacks like it can only implemented on sea shores. While geothermal energy needs very lager step to extract heat from earth. Solar and wind are easily available in all condition. The renewable energy resources like solar, wind can be good alternative source. Solar energy has drawback that it could not produce electrical energy in rainy and cloudy season so we need to overcome this drawback we can use two energy resources so that any one of source fails other source will keep generating the electricity. And in good weather condition we can use both sources combine.

II. HYBRID ENERGY SYSTEM

Energy system which is fabricated or designed to extract power by using two energy sources is called as the hybrid energy system. Hybrid energy system has good reliability, efficiency, less emission, and lower cost.[8,12]

The major disadvantages of using independent renewable energy resources are that unavailability of power for all time. In this proposed system solar and wind power is used for generating power. So that any one source of power fails other will take care of the generation. Both the energy sources have greater availability in all areas. It needs lower cost. There is no need to find special location to install this system.

A. Solar Energy

Solar energy is that energy which is gets by the radiation of the sun. Solar energy is present on the earth continuously and in abundant manner. Solar energy is freely available. It doesn't produce any gases that mean it is pollution free. It is affordable in cost. It has low maintenance cost. Only problem with solar system it cannot produce energy in bad weather condition. But it has greater efficiency than other energy sources. It only need initial investment. It has long life span and has lower emission.

B. Wind Energy

Wind energy is the energy which is extracted from wind. For extraction we use wind mill. Ii is renewable energy sources. The wind energy needs less cost for generation of electricity. Maintenance cost is also less for wind energy system. Wind energy is present almost 24 hours of the day. It has less emission. Initial cost is also less of the system. Generation of electricity from wind is depend upon the speed of wind flowing.

A main advantage of this system is:

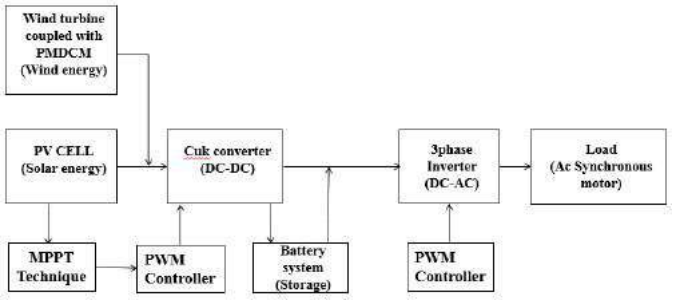
- We can use any one source and keep another source as a stand by unit. This will leads to continuity of generation. This will make system reliable.

- It has less emission.
- Maintenance cost is less.
- Life span of this system is more.
- Efficiency is more.

III.PROPOSED SYSTEM

In this paper, a wind-PV HPGS is proposed for remote areas. Wind turbines are usually used to generate the electrical power. The photovoltaic system consists of a solar or photovoltaic cells that made of semiconducting materials are used to generate power. To absorb power intermittency of wind speed and solar-irradiance fluctuations, a BESS is used. A three-leg self-commutated switch based VSC is employed to regulate AC bus voltage and frequency at load terminals and improving the power quality.[8] A DC-DC cuk converter is used to extract power from solar PV array terminals and wind turbine which is coupled with PMDCM.[11] The common inherent drawback of wind and photovoltaic systems are their intermittent natures that make them unreliable. However, by combining these two intermittent sources and by incorporating maximum power point tracking (MPPT) algorithms, the systems power transfer efficiency and reliability can be improved significantly.[9] When a source is unavailable or insufficient in meeting the load demands, the other energy source can compensate for the difference. Several hybrid wind/PV power systems with MPPT control have been proposed and discussed in works Most of the systems in literature use a separate DC/DC cuk converter connected in parallel in the rectifier stage to perform the MPPT control for each of the renewable energy power sources.

IV.DESIGN OF HYBRID POWER SYSTEM



Block diagram of Hybrid energy generation system

A. Wind Turbine

Wind turbine is that system which extracts energy from wind by rotation of the blades of the wind turbine. Basically wind turbine has two types one is vertical and another is horizontal. As the wind speed increases power generation is also increases. The power generated from wind is not continuous its fluctuating. For obtain the non-fluctuating power we have to store in battery and then provide it to the load. Here wind turbine is mechanically coupled with Permanent Magnet DC motor for the rotation of blades.

B.PV Cell

Solar PV panel is use to convert solar radiation to the electrical energy. The physical of PV cell is very similar to that of the classical diode with a PN junction formed by semiconductor material. When the junction absorbs light, the energy of absorbed photon is transferred to the electron-proton system of the material, creating charge carriers that are separated at the junction. The charge carriers in the junction region create a potential gradient, get accelerated under the electric field, and circulate as current through an external circuit. Solar array or panel is a group of a several modules electrically connected in series parallel combination to generate the required current and voltage.

C. MPPT technique

To improve the energy efficiency, it is important to operate PV system always at its maximum power point. Many maximum power point Tracking (MPPT) techniques are available and proposed various methods for obtaining maximum power point. The algorithm used here is Perturbation and Observation Method. The operating voltage is sampled and the algorithm changes the operating voltage in the required direction and samples dp/dv. If dp/dv is positive, then the algorithm increases the voltage value towards the MPP until $dPdV$is negative. This iteration is continued until the algorithm finally reaches the MPP. .[10,13]

D.PWM Controller

Switching devices used in inverters and converter uses PWM control signals for producing an AC and Dc output voltage respectively. This modulation technique can be used to encode information for transmission, its main use is to allow the control of the power supplied to electrical devices. The main advantage of PWM is that power loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on and power is being transferred to the load, there is almost no voltage drop across the switch.

E. Cuk converter

The cuk converter is supplied through the output terminals of a solar-PV array and wind turbine. The Cuk converter contains inductors in series with the converter input and output ports. The switch network alternately connects a capacitor to the input and output inductors [3,4]. The Cuk converter can either operate in continuous or discontinuous current mode. It boosts a low voltage of a PV array and wind turbine to charge a battery at 24 V using a maximum power point tracking control algorithm.

F.Battery Storage System

The battery at the DC bus ensures power balance during change in solar-PV array power and wind power generation with respect to consumer load demand [8]. During periods of high renewable power generation and less load demands, the BESS charges to accumulate surplus renewable energy. Similarly during less renewable power generation and high load demands, BESS discharges to compensate deficit load demands.

G.Three Phase Inverter

Inverters are used in power systems to convert Direct current (DC) power from batteries into Alternating

current(AC) Power.The topology of a three-phase inverter consists of 3 legs; each leg includes a switch in either the up or down position. [6] The resulting eight possible switching configurations give rise to 6 active voltage space vectors and 2 zero vectors. The animation shows a specific sequencing of the 8 states where the active vectors rotate in discrete 60º steps. The output from this inverter is to be fed to a 3-phase balanced load.

H.Load

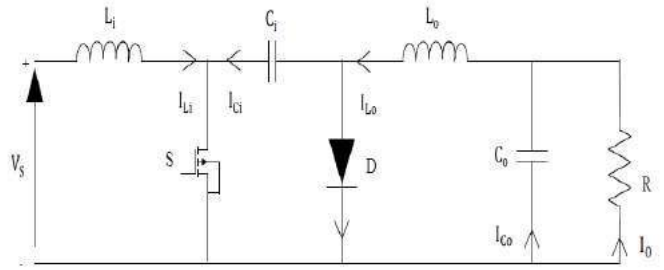
An induction motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. An induction motor can therefore be made without electrical connections to the rotor. The load used here is Half HP, and the ratings are 220 V with 1500 rpm. It is the resistive load with 10 watts power and 4.7 kV.

I.MOSFET Switch

The MOSFET or Metal Oxide Semiconductor Field Effect Transistors by the far most common field effect transistor in both digital and analog circuits. MOSFET is a voltage-controlled device. MOSFET has positive temperature co-efficient for resistance. This makes parallel operation of MOSFET easy. If a MOSFET shares increased current initially, it heats up faster its resistance rises and this increased resistance causes this current to shift to other devices in parallel.

V.MODELLING OF CUK CONVERTER

It is one of the best basic DC-DC converters because its output voltage is negative and the output voltage may be higher or lower than the input voltage. The Cuk converter contains inductors in series with the converter input and output ports. The switch network alternately connects a capacitor to the input and output inductors.



A.Modes Of Operation

During mode 1, when transistor switch is closed then current through inductor L_i rises. At the same time the voltage of capacitor C_i reverse biases diode D and turns it off. The capacitor C_i discharges its energy to the circuit formed by C_i, C_o, L_o and the load.[3]

During mode 2, when the input voltage is turned on and switch S is open then diode D is forward biased and capacitor C_i is charged through L_i, D and the input supply V_s. The energy which is stored in the inductor L_o is transferred to the load. The diode D and the switch S provide a synchronous switching action.[3]

B.Design Requirements

The average output voltage can be calculated in term of the switch duty cycle.

D = on time duration of switch/ total switching time period

Duty cycle = $\dfrac{Vo}{(Vs - Vo)}$

Output voltage $V_o = -V_s\left(\dfrac{D}{1-D}\right)$

(Where the negative sign indicates voltage inversion)

Design parameter and equations of cuk converter:

$$L_i = \frac{DV_{in}}{\Delta I_{Li} f_s}$$

$$L_o = \frac{V_o(1-D)}{\Delta I_{Lo} f_s}$$

$$C_i = \frac{D}{(Rf_s)(\frac{\Delta V_{ci}}{V_o})}$$

$$C_o = \frac{1-D}{8L_o F_s^{\,2}(\frac{\Delta V_{co}}{V_o})}$$

The inductor and capacitor value of the converter is calculated by considering 10% voltage ripple and current ripple.[4]

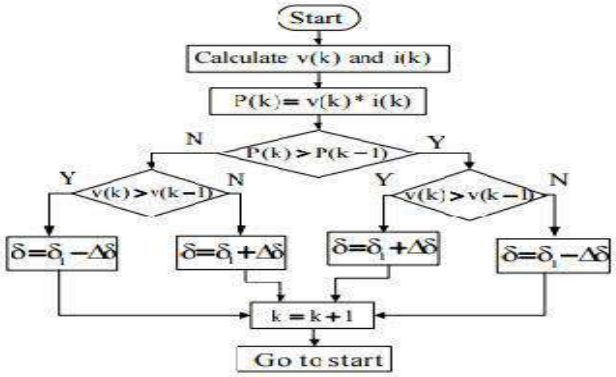
VI.MPPT TECHNIQUE

To improve the efficiency of the solar panel MPPT is used. According to maximum power point theorem, output power of any circuit can be maximize by adjusting source impedance equal to the load impedance, so the MPPT algorithm is equivalent to the problem of impedance matching. In present work, the Ćuk Converter is used as impedance matching device between input and output by changing the duty cycle of the converter circuit. A major advantage of Ćuk converter is that high or low voltage obtained from the available voltage according to the application. Output voltage of the converter is depend on the duty cycle, so MPPT is used to calculate the duty cycle for obtain the maximum output voltage because if output voltage increases than power also increases.

A.Perturbation and Observation Method

It is the simplest method of MPPT to implement. In this method only voltage is sensed, so it is easy to implement. In this method power output of system is checked by varying the supplied voltage. If on increasing the voltage, power is also increases then further 'δ' is increased otherwise start decreasing the 'δ'. Similarly, while decreasing voltage if power increases the duty cycle is decreased. These steps continue Simulation and Analysis of Perturb and Observe MPPT Algorithm for PV Array 221 till maximum power point is reached. The corresponding voltage at which MPP is reached is known as reference point (Vref).[11]

B.Flow Chart Of Perturbation and Observation Method



VII. VOLTAGE SOURCE INVERTER

When the power requirement is high, three phase inverters are used. When three single-phase inverters are connected in parallel, we can get the three-phase inverter. These inverters take their dc supply from a battery or from a rectifier. A large capacitor is connected at the input terminals tends to make the input dc voltage constant. This capacitor also suppresses the harmonics fed back to the source. Each switch conducts for 180°. Three switches remain on at any instant of time. There are six modes of operation in a cycle and the duration of each mode is 60°. The gating signals are shifted from each other by 60° to obtain three phase balanced voltages.[7]

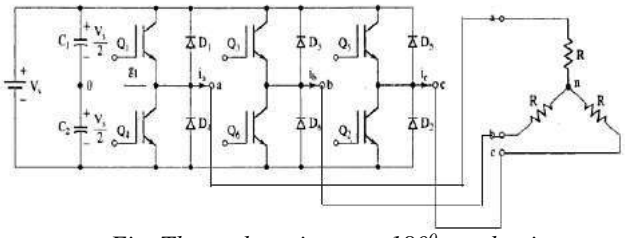


Fig. Three phase inverter 180^0 conduction

PULSE GENERATOR	DELAY IN DEGREE	DELAY IN MILLISECONDS
Pulse generator 1	0	0
Pulse generator 2	60	3.33ms
Pulse generator 3	120	6.66ms
Pulse generator 4	180	10ms
Pulse generator 5	240	13.33ms
Pulse generator 6	300	16.66ms

Fig. Conduction Period

VIII.HARDWARE IMPLEMENTATION

For the hardware implementation we use different components. They are listed below as

1. PIC Microcontroller 16F873A.
2. Voltage Regulators
   - 7812 voltage regulator
   - 7805 votage regulator
3. IC IR2110 for the amplification of the pulses given by PIC16F84A

A. *Voltage Regulator*

78L05 is the regulator is used for the regulation of the DC output from the filter. Fed as input for PIC Microcontroller.78L12 is the regulator is used for the regulation of the Dc output to fed as input for driver circuit.

B. PIC Micro Controller

In this project the hardware is implemented using the Pic-Microcontroller "Pic 16F873A". The advantages of the Pic-microcontroller is that the instruction set of this controller are fewer than the usual microcontroller. Unlike Conventional processors, which are generally complex, instruction set computer (CISC) type, Pic microcontroller is a RISC processor.

C. IR 2110

Some of the features of IR 2110 are:

- Floating channel designed for bootstrap operation
- Gate drive supply range from 10 to 20V
- Under voltage lockout for both channels 3.3V logic compatible
- Separate logic supply range from 3.3V power ground $\pm$ 5V power ground $\pm$ 5V offset

IX.MODELLING OF HYBRID SYSTEM

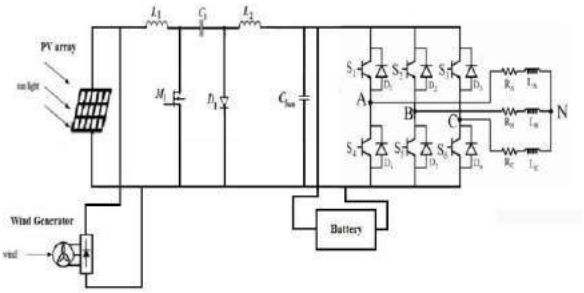
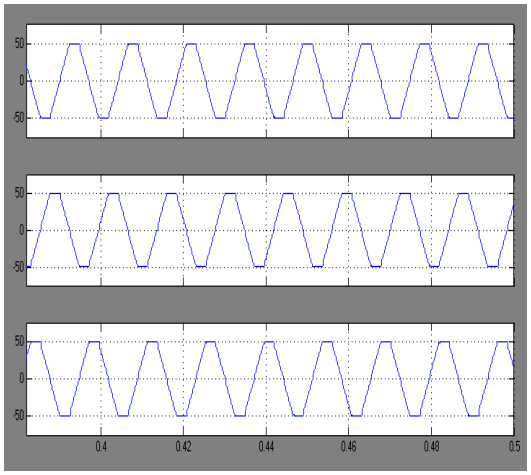


Fig.Circuit Diagram of Hybrid System using Cuk Converter

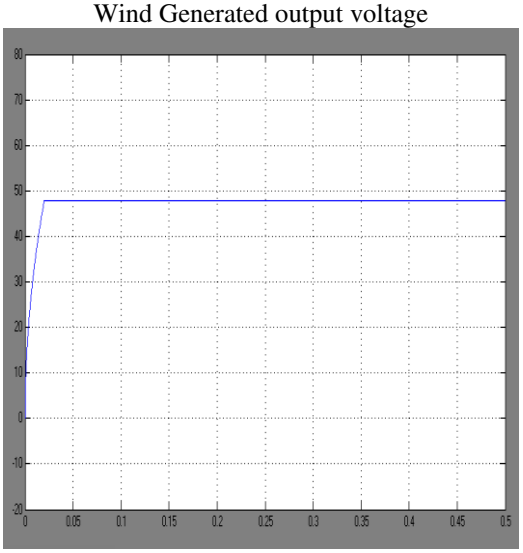
Generated Output Voltages are,

Constituents	Input Voltage	Output Voltage
PV Cell	-	48 V (DC)
Wind Turbine	-	48 V (AC)
Rectifier	48 V (AC)	48 V (DC)
Cuk Converter	48 V (DC)	120 V (DC)
Inverter	120 V(DC)	120 V (AC)

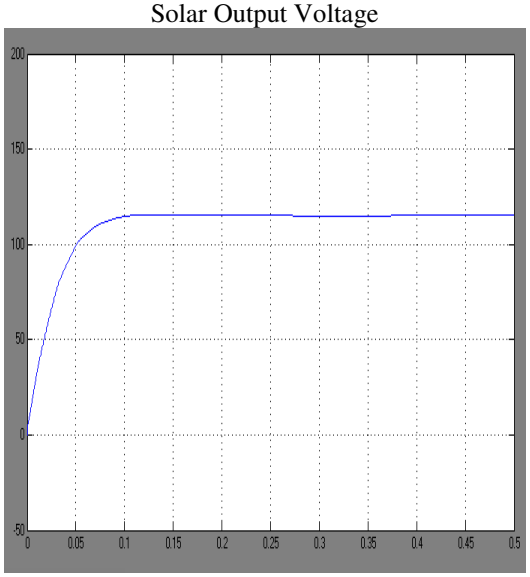
X.SIMULATION RESULTS



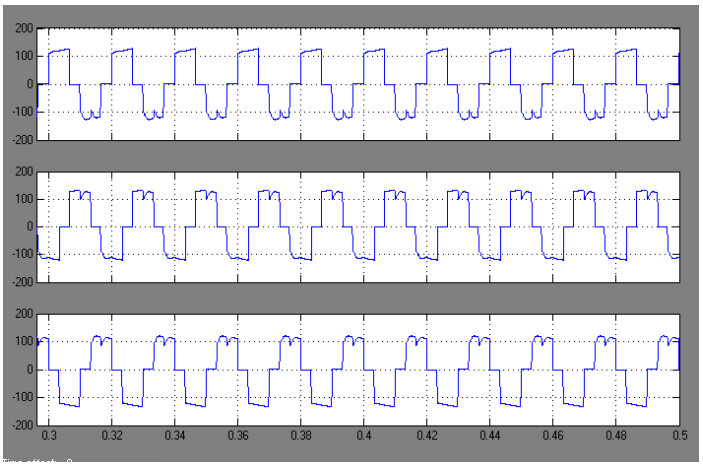
Wind Generated output voltage



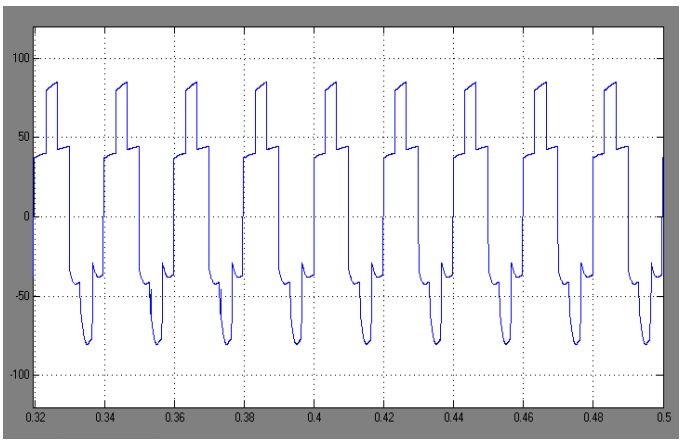
Solar Output Voltage



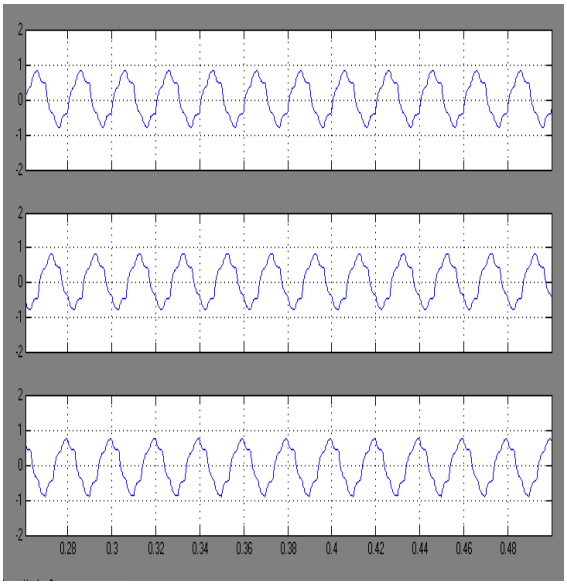
Cuk Converter Output Voltage



Inverter Output Voltage (Ph-Ph)



Inverter Output Voltage (Ph-N)



Inverter Output Current

XI.RESULTS

The generated voltage is fed to the induction motor for remote applications. The simulation of V-I characteristics of hybrid power system were obtained. This design is implemented as a hardware by PIC Microcontroller. In this paper the collection of solar panel with the help of reflectors and tracking. Further energy obtained using windmill with the addition of permanent magnet DC motor and altered design together acts to an increase in the efficiency. Cuk converter gives Buck operation for less than 50% duty cycle and gives boost operation for more than 50% duty cycle. It is found by system performance that the best performance of cuk converter is at 45% duty cycle for buck operation and 63% duty cycle for boost operation. At this duty cycle the output Voltage regulation is minimum, the ripple in output is very less than and output becomes stable compared to other outputs. The working model of the hybrid system was successfully implemented and demonstrated. It is shown to be highly attractive economically.

XII. CONCLUSION

Hybrid power generation system is good and effective solution for power generation than conventional energy resources. It has greater efficiency. It can provide to remote places where government is unable to reach. So that the power an be utilize where it generated so that it will reduce the transmission losses and cost. Cost reduction can be done by increasing the production of the equipment. The control and implementation in real time of HPGS employing wind and solar-PV energy has been presented. A three-phase VSC and a battery energy storage system at its DC bus are used for regulating voltage and frequency at load terminals. A Cuk converter has been used in between solar PV array and DC bus of VSC to achieve maximum power point tracking. The design of cuk converter produced high rating for reduced duty cycle. The proposed P&O MPPT technique for PV array has worked satisfactory under change in solar irradiation. The performance of HSPGS has been found satisfactory under change in generation and load perturbations. Design concepts are validated through simulation and results obtained shown using cuk converter will be highly stable with high efficiency.

XIII.FUTURE SCOPE

The scope of hybrid system mainly solar and wind in Jodhpur are very high and it is very reliable for both rural and urban areas. For future research should be done on design and install a hybrid system with other renewable sources like Biomass, Water etc. for remote location. Future Scope In this paper we study the various data about the wind, solar for generating the hybrid at small level that help to the decision makers to study the various factors in construct a Hybrid generation plant with a various minimum cost with highest generating capacity. For future scope different time period has been use for calculating the power and efficiency. Cuk converter can be used for universal input voltage and wide output power range. The Cuk converter uses capacitive energy transfer. In the Cuk converter overshoot and settling time varies much if there is small change in boost capacitor. The closed loop Cuk converter has an efficiency of 98.69%.

REFERENCES

[I] W. Jidong and Y. Fan, "Optimal capacity allocation of standalone wind/solar/battery hybrid power system based on improved particle swarm optimisation algorithm, " lET Renewable Power Generation, vol.7, pp. 443-448, Sept. 2013.

[2] X. Xiaoling, C. K. Tse, and R. Xinbo, "Bifurcation Analysis of Standalone Photovoltaic-Battery Hybrid Power System," IEEE Trans. Circuits and Systems, vol. 60, pp. 1354-1365, May 2013.

[3] Jeremy, K., S. Seyed and H. William, 2006. An improved reliability cuk based solar inverter with sliding mode control. IEEE T. Power Electron., 21(4): 1107-1115.

[4]. Neeraj Tiwari1, D. Bhagwan Das2," MPPT controller for Photo voltaic Systems Using Cuk dc/dc convertor" International Journal of Advanced Technology & Engineering Research (IJATER)

[5] K.Kavitha*, Dr. Ebenezer Jeyakumar, "A Synchronous Cuk Converter Based Photovoltaic Energy System Design and Simulation" International Journal of Scientific and Research Publications, Volume 2, Issue 10, October 2012

[6] H. Jiefeng, Z. Jianguo, D. G. Dorrell, and 1. M. Guerrero, "Virtual Flux Droop Method -A New Control Strategy of Inverters in Microgrids,"IEEE Trans. Power Electronics, vol. 29, pp. 4704-4711, Sept. 2014.

[7] B. Singh, A. Chandra, and K. AI-Haddad, Power quality problems and mitigation techniques, Chichester, West Sussex, United Kingdom: John
Wiley & Sons Inc. 2015

[8] M. Rezkallah, A. Hamadi, A. Chandra, and B. Singh, "Hybrid AC-DC standalone system based on PV array and wind turbine," In Proc. IEEEIES
Annual Conjerence, 2014, pp. 5533-5539.

[9] Hairul Nissah Zainudin, Saad Mekhilef, "Comparison Study of Maximum Power Point Tracker Techniques for PV Systems", Cairo
University, Egypt, December 19-21, 2010, Paper ID 278.

[10] Katherine A. Kim and Philip T. Krein, "Photovoltaic Converter Module Configurations for Maximum Power Point Operation", University of
Illinois Urbana-Champaign Urbana, IL 61801 USA.

[11] Fangrui Liu, Yong Kang, Yu Zhang, Shanxu Duan, "Comparison of P&O and hill climbing MPPT methods for grid-connected PV converter," 3rd IEEE Conference on Industrial Electronics and Applications, 2008 (ICIEA 2008), pp.804-807, 3-5 June 2008.

[12] Chih-Chiang Hua, Jong-Rong Lin, "Fully digital control of distributed photovoltaic power systems," Proceedings of IEEE International Symposium on Industrial Electronics (ISIE 2001), vol. 1, pp. 1-6, June 2001.

[13] Weidong Xiao, A modified adaptive hill climbing maximum power point tracking control method for photovoltaic power system, Master Thesis, The University of Brtish Columbia, July 2003.