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Integration of Microgrid using Renewables Energy Resources with Smart Inverter

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***Abstract* — This research paper is based on the integration of solar and wind renewable energy sources to generate electrical energy. The purpose of using solar and wind energy sources to make a reliable hybrid system. For solar energy, a solar panel is used to generate a DC voltage of 24 volts by incorporating a buck converter and MPPT unit. This technique is used for achieving max power by implementing perturb and observe (PO) algorithm and for wind energy, wind turbine is used with three phase rectifier for obtaining dc voltage. The DC output is converted into AC output by using 5-level cascaded H bridge multi-level inverter.**

***Index Terms*— hybrid system, MPPT technique, multilevel inverter, solar panel, wind turbine.**

I. INTRODUCTION

RENEWABLE energy resources are becoming more and more important these days. Different types of renewable energy resources are utilized around the world, the most of which are used is solar PV and wind power generation. Solar energy is a tremendous source of energy created by sun, and its usage is increasing more and more over the last decade. The wind energy uses wind turbines to generate electricity, it transforms kinetic energy into mechanical energy. The combination of renewable energy resources, both wind& solar are used for producing power called as wind solar hybrid system. This type of system is created to produce electricity by utilizing of solar panels and wind turbines. Wind and sunlight are natural sources of energy. They are tremendous and inexhaustible. The wind solar hybrid system can be used to produce electricity by which batteries can charged and by using a inverter we can run our AC appliances easily. Wind and solar energy both itself are a great combination and the system can produce electricity all year almost. The basic benefit of combining wind solar hybrid system is that it increases the system's reliability.

II. SYSTEM MODELING

Nowadays due to fossil fuels being a non-renewable source of energy which contributes to global warming when they are burnt they release very dangerous gases like carbon dioxide into the climate and the maintenance of fossil fuels can also be challenging due to the amount is used very quickly and it can be short in supply.

Now at this time renewable energy resources are playing a significant role in our daily lives as they are sustainable and robust. The need of solar energy is growing fast in our domestic lives because of its reliability and efficiency to encounter the upcoming demands of energy in the future.

A. Solar Array

Solar array is commonly used nowadays to generate electricity. A PV array module is used to generate dc voltage. With PV array a MPPT block is used to obtain maximum power and a buck converter to step down the voltage to a desired value. The dc voltage from buck converter is given as an input to multilevel inverter to convert it into ac voltage.

B. Maximum power point tracking (MPPT)

Maximum power point tracking is a method to produce highest power from PV panels. With the solar array MPPT method is used to convert the output to DC to AC and to work at a systematic voltage to produce power, also can be known as the maximum power point as the name indicates. In simple words it can be said that they change a DC high voltage output from solar PV to a specified lower value of voltage required for charging batteries.

C. Perturb and observe (PO) algorithm

The perturb and observe technique is used to get highest output from PV array. The output power obtained from PV array is added to the step size or delay ΔV and the power comparison is made between obtained new power the old power. If the obtained power is higher than previous power, $+\Delta V$ is added is added to the previous power. The process is continued until the obtained power is lower than previous power. If the new power is less than earlier power, then $-\Delta V$ is added to the power until the new power is greater than previously obtained power. The process will continue to go on until maximum power is obtained.

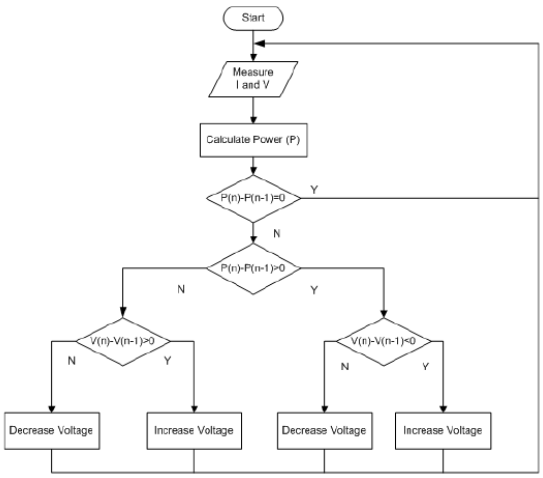

Fig 1: Basic algorithm of perturb and observe

D. *Buck Converter*

Buck Converter are also known as DC choppers which brings down the input DC voltage to a certain value of DC output voltage. Buck converter is used to step down the voltage generated by solar panel to 24 volts. The pulse of buck converter is obtained from MPPT unit to track max power.

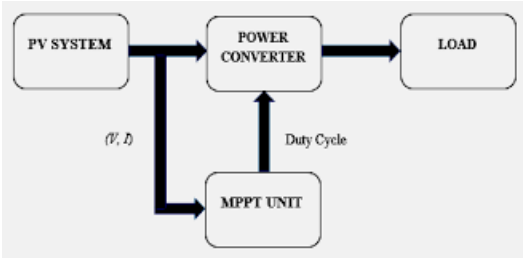

Fig 2: Block diagram of PV system with MPPT unit

E. *Wind Turbine*

Nowadays wind energy is used along with solar panel to improve the efficiency as well as reliability of system. For this purpose, the AC voltage of wind turbine is first converted into DC voltage and DC voltage from solar and wind is then given as input to the cascaded multilevel inverter. At the output of multilevel inverter, AC voltage is obtained.

F. *Multilevel inverter*

A multilevel inverter of 5 levels having cascaded H bridge configuration is used to convert the dc output of the microgrid into ac. In the MATLAB simulation, eight semiconductor switches (MOSFET) are used for acquiring a 5-level waveform at the output. The pulse width of each MOSFET is set according to their switching sequence.

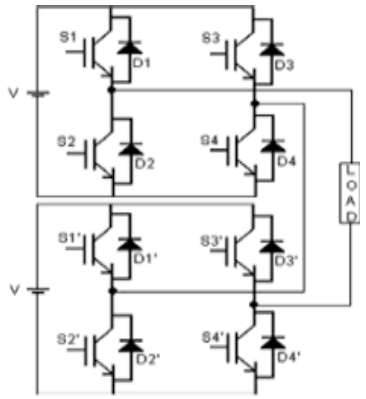

Fig 3: Circuit diagram of multilevel inverter

III. General Performance Parameters

The general performance parameters like solar panels, wind turbine, buck converter, rectifier and multilevel are included to achieve a DC output voltage which is further converted into AC output voltage by using the rectifier. For producing a DC voltage of 24 volts a solar panel is included along with a buck converter and MPPT charge control and wind turbine. An multilevel inverter is included to covert the DC output voltage into AC output voltage.

A. *Design parameters of solar array*

The module used for the simulation of pv array in this project is KYOCERA SOLAR KC200GT that generates the voltage up to 32 volts based on the number panels connected in series and parallel. The design parameters for solar pv array are shown in table 1.

Parameters	Specification
No of series connected panels	1
No of parallel connected panels	2
Power of individual panel	200 Watt
Open-circuit voltage/Panel	32.9 Volts
Short-circuit current/panel	8.21 A
Input radiation	1000 W/m^2
Temperature	25^{o}C

Table 1: Design parameter of PV array

B. *Design and calculation parameters of buck converter*

Buck converter is a type of converter that changes the output voltage from higher value to lower value. It consists of two solid state devices like diode and transistor, one energy storing element inductor and capacitor to reduce the ripples in output voltage and load.

Parameters	Value
Input voltage	32 V
Output voltage	24 V
Switching frequency	40 KHz
Duty cycle	75 %
Resistance	8 ohms
Inductance	25 uH
Capacitance	15.62 uF

Table 2: Design parameter of Buck converter

C. *Design parameters of wind turbine*

The wind turbine generates the AC voltage that is converted into DC voltage by using three phase rectifier. A capacitor is used in parallel configuration with the rectifier to reduces ripples in the voltage and generate a smooth waveform at the output. The output generated by wind turbine is set to 24 volts by adjusting pitch angle and wind speed. The design parameters for wind turbine are shown in table 3.

Parameters	Value
Base wind speed	120 m/s
Pitch angle	3 degrees
Wind speed	135 m/s

Table 3: Design parameter of Wind turbine

D. *Design parameters of multi-level inverter*

A multilevel inverter of 5 levels is used in the model that converts the DC output voltage from solar panel and wind turbine into AC voltage. A CBH inverters has reduced components in number in contrast to other inverter topologies. It consists of switches and capacitors. The combination of switches and capacitors is known as H bridge. Switching sequence of 5 level inverter is shown in table 4.

Switching sequence	Voltage levels							
	0	V	2V	V	0	-V	-2V	-V
S-1	ON	ON	ON	ON	ON	0FF	0FF	0FF
S-2	ON	0ff	0ff	0ff	ON	ON	ON	ON
S-3	0FF	0FF	0FF	0FF	0FF	ON	ON	ON
S-4	0FF	ON	ON	ON	0FF	0FF	0FF	0FF
S-5	ON	ON	ON	ON	ON	ON	0FF	ON
S-6	ON	ON	0FF	ON	ON	ON	ON	ON
S-7	0FF	0FF	0FF	0FF	0FF	0FF	ON	0FF
S-8	0FF	0FF	ON	0FF	0FF	0FF	0FF	0FF

Table 4: Switching sequence of 5 level inverter

Switching sequence	Delay	Pulse width	OR operation	Delay	Pulse width
S-1	delay=(0.02/8)*0	pw=(5/8)*100	No	NA	NA
S-2	delay=(0.02/8)*0	pw=(1/8)*100	Yes	delay=(0.02/8)*4	pw=(4/8)*100
S-3	delay=(0.02/8)*5	pw=(3/8)*100	No	NA	NA
S-4	delay=(0.02/8)*1	pw=(3/8)*100	No	NA	NA
S-5	delay=(0.02/8)*0	pw=(6/8)*100	Yes	delay=(0.02/8)*7	pw=(1/8)*100
S-6	delay=(0.02/8)*0	pw=(2/8)*100	Yes	delay=(0.02/8)*3	pw=(5/8)*100
S-7	delay=(0.02/8)*6	pw=(1/8)*100	No	NA	NA
S-8	delay=(0.02/8)*2	pw=(1/8)*100	No	NA	NA

Table 5 : Pulse width sequence of 5 level inverter

IV. CALCULATIONS

A. *Buck converter*

Input voltage = 32 V
Output voltage = 24V
Frequency f = 40 KHz
Resistance = 8 ohms
Duty cycle = V_{out}/V_{in}
Duty cycle = 24/32= 0.75
Inductance = (1-D)* R/ 2 *f
= (1-0.75)*8/2*40000
Inductance = 25 uH
Capacitance = $(1-D)/8L(\Delta V_o/V_o)$ *f^2
= $(1-0.75)/8*25*10^{-6}*(0.05)$ *$(40000)^2$
Capacitance = 15.62 uF

V. SIMULATION MODEL

The simulation of proposed model is performed on the MATLAB software. For solar, KYOCERA SOLAR KC200GT module is used that generates the voltage upto 32 volts based on the number panels connected in series and parallel. Permanent magnet synchronous machine is used with wind turbine. For multilevel inverter, 8 MOSFET switches are used.

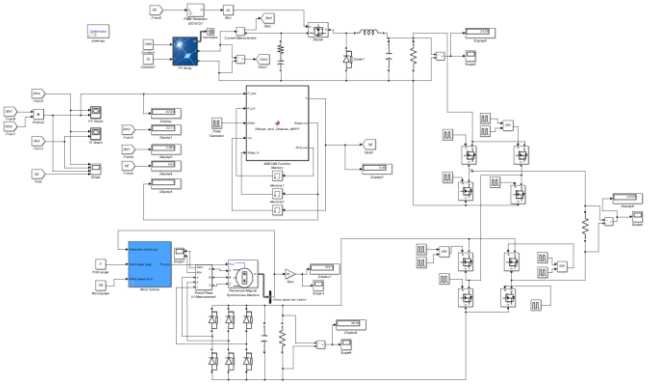

Fig (4) MATLAB simulation circuit

VI. RESULTS

A. *Solar*

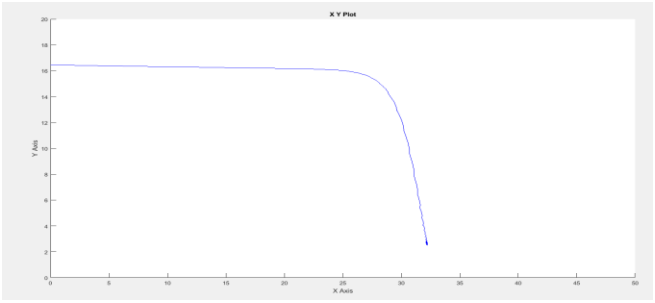

Fig (5) The graph between voltage and current

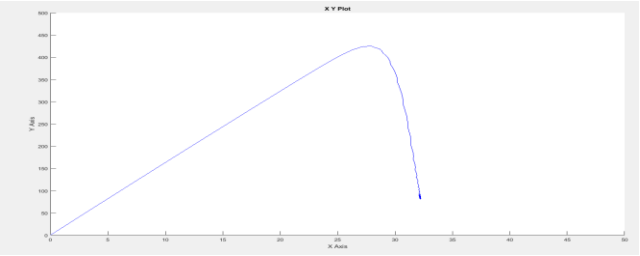

Fig (6) The graph between power and voltage

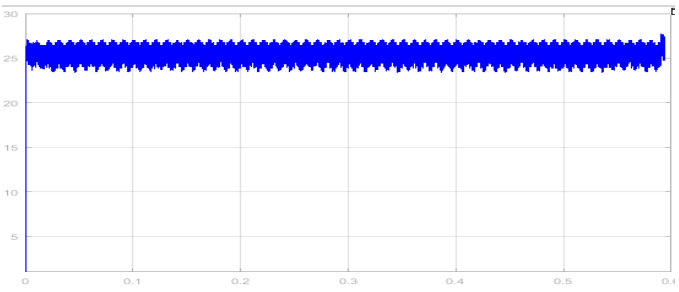

Fig (7) The graph voltage and time obtained from the solar bucked output voltage

B. *Wind Turbine*

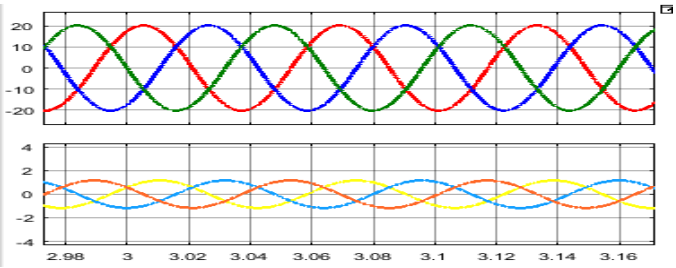

Fig (9) The graph of AC output voltage

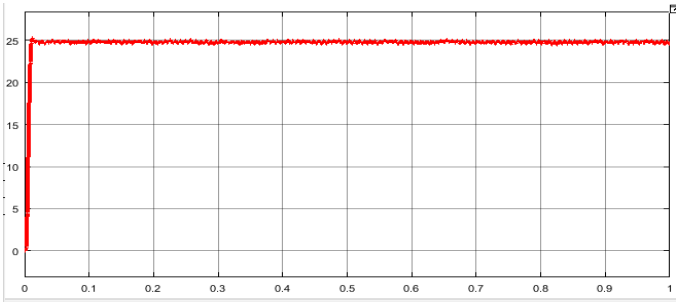

Fig (10) The graph of DC output voltage

C. *Multilevel Inverter*

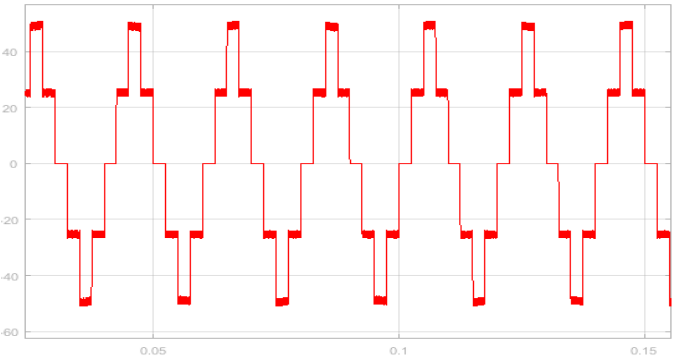

Fig (11) The output voltage of multilevel inverter

VII. Conclusion

Solar and wind energy jointly enhance the system's operating. If both of them are used combinedly, it would be easier to meet today's increasing demand of energy as they can be replacement of fossil fuels in future. Solar and wind energy are also used to observe the responses of RES with an AC grid. MPPT is used to get the max output of solar array and the voltage of solar and wind is changed from DC to AC with the help of multi-level inverter to produce a specified value of voltage to generate power. We can say that now renewable energy resources can be of great use instead of conventional energy resources.

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