ENERGY MANAGEMENT SYSTEM FOR MULTI INPUT LANDSMAN CONVERTER

Mr.S.Sivsamuthira Pandian
AP/EEE, PED, Francis Xavier Engineering College, Tirunelveli.
sivambame@gmail.com

Ms.R.Ganga Srini
PG Student, PED, Francis Xavier Engineering College, Tirunelveli.
sriniaj718@gmail.com

Abstract-Renewable energy sources have become a popular alternative electrical energy source where power generation in conventional ways is not practical. In the last few years the photovoltaic and wind power generation have been increased significantly. In this study, we proposed a hybrid energy system which combines both solar panel and wind turbine generator as an alternative for conventional source of electrical energy like thermal and hydro power generation. The voltage equalizer is used overcome the partial shading condition. A simple control technique which is also cost effective has been proposed to track the operating point at which maximum power can be coerced from the PV system and wind turbine generator system under continuously changing environmental conditions. The Landsman converter provides constant voltage to the voltage source inverter from hybrid energy. The bidirectional converter provides energy management to the entire system. The Maximum power point tracking methods Fuzzy logic algorithm is used extract maximum power from the hybrid system. The entire hybrid system is described given along with comprehensive simulation results that discover the feasibility of the system. A software simulation model is developed in Matlab/Simulink. The hardware is implemented using DSPIC30F2010 controller.

Key words: *MPPT, LANDSMAN converter, PV, PI controller, Fuzzy Logic.*

I. INTRODUCTION

Due to the critical condition of industrial fuels which include oil, gas and others, the development of renewable energy sources is continuously improving. This is the reason why renewable energy sources have become more important these days. Few other reasons include advantages like abundant availability in nature, eco-friendly and recyclable. Many renewable energy sources like solar, wind, hydel and tidal are there. Among these renewable sources solar and wind energy are the world's fastest growing energy resources. With no emission of pollutants, energy conversion is done through wind and PV cells.

Day by day, the demand for electricity is rapidly increasing. But the available base load plants are not able to supply electricity as per demand. So these energy sources can be used to bridge the gap between supply and demand during peak loads. This kind of small scale stand alone power generating systems can also be used in remote areas where conventional power generation is impractical.

Hybrid generation systems that use more than a single power source can greatly enhance the certainty of load demands all the time. Even higher generating capacities can be achieved by hybrid system. In stand alone system we can able to provide fluctuation free output to the load irrespective of weathers condition. To get the energy output of the PV system converted to storage energy, and constant power delivered by the wind turbine, an efficient energy storage mechanism is required, which can be realized by the battery bank.

II. OPERATION

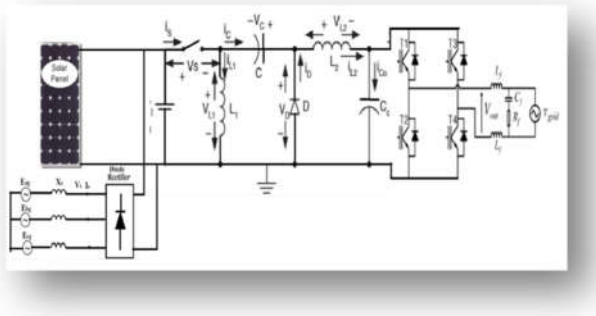

Figure 1: Circuit Diagram

The DC output voltage is obtained from the solar panel. The AC output voltage is obtained from the wind energy system. In the wind energy conversion system Permanent Magnet Synchronous Generator is used to produce the AC output voltage. Then the uncontrolled diode bridge rectifier is used to convert this AC output voltage into DC voltage. Both voltages are synchronized and fed into the LANDSMAN convertor. This LANDSMAN convertor converts variable DC voltage into fixed DC voltage. Here MPPT technique is used to obtain maximum power from the solar panel without any loss. In this MPPT technique, fuzzy logic algorithm is used to produce reference pulses which is compared with carrier signal in the pulse width modulator to produce the gate pulses. This gate pulses are given to the LANDSMAN converter. Then the fixed DC output voltage is given to the inverter to convert that DC voltage into AC output voltage. For that purpose single phase three level voltage source inverter is used here, in which PI controller technique is used to reduce the power quality problems. Then the AC output voltage is given to the grid.

The proposed system model is developed as follows here.

A) Permanent synchronous generator

The PMSG is described using equivalent circuit analysis.

VDC- Rectified DC output voltage

IDC – Rectified DC output current

Vs(rms) - Stator RMS voltage of the PMSG

Is(rms) - Stator RMS current of the PMSG

The rectified DC voltage is given as

$$VDC = 3\frac{\sqrt{6}}{\pi} Vs(rms) \quad \dots\dots\dots..(1)$$

$$IDC = \frac{\pi}{\sqrt{6}} Is(rms) \quad \dots\dots\dots.(2)$$

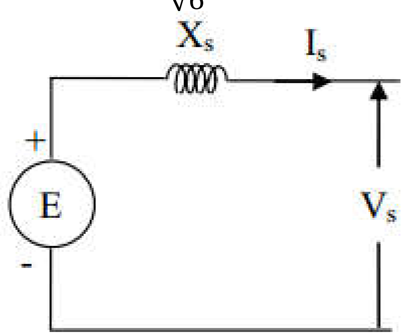

Figure 2: PMSG steady state equivalent circuit

This DC voltage (1) is given to the LUO converter.

B) Solar panel

From the PV panel the PV array current is given as,

$$Ipv = Isc - Id \qquad \ldots\ldots\ldots\ldots\ldots (3)$$

Where $= 10^{-9}\, Isc\left(exp\frac{20.7}{V0c}(Vpv + Rsc.Ipv)\right) \qquad \ldots\ldots\ldots\ldots (4)$

Isc – solar short circuit current

C) LUO converter output voltage

Now the LUO converter output voltage is,

$$Vluo = Vout = \left(\frac{2-\propto}{1-\propto}\right) VDC \quad \ldots\ldots\ldots\ldots.(5)$$

Where ∝- Duty cycle

The DC link current is

$$I0 = Iluo + Ipv \qquad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

D) Voltage source inverter

The direct axis and quadrature axis voltage of the inverter is ,

$$Vd = VDC\ gd \qquad \ldots\ldots\ldots\ldots\ldots..(7)$$

$$Vq = VDC\ gq \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

gd – Even harmonic presents in the output voltage

gq – Odd harmonic presents in the output current

$$gd = (\sum_{n=1,5,9} \cos(n-1)\,wt - \sum_{n=3,7,11} \cos(n+1)\,wt\ ) \ldots\ldots\ldots\ldots.(9)$$

$$gq = \left(\sum_{n=2,6,10} \sin(n-1)\,wt - \sum_{n=4,8,12} \sin(n+1)\,wt\right) \quad \ldots\ldots\ldots.(10)$$

Let as consider loss less power in the single phase inverter.

$$I0 = \frac{1}{2}(id\ gd + iq\ gq) \qquad \ldots\ldots\ldots\ldots.(11)$$

Where id ,iq – Direct and quadrature axis current.

$$I0 = Iluo + Ipv$$

$$= \frac{(1-\propto)}{\propto}\ IDc + Ipv$$

$$I0 = \frac{(1-\propto)\pi}{\sqrt{6}\propto} Is + Ipv \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

In this proposed system duty cycle and the converter reference currents are varied for extracts the maximum output current at any time instants.

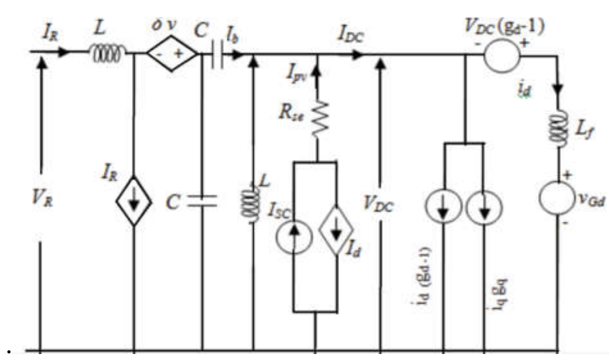

Figure 3: Direct axis equivalent circuit

III. OPERATIONG MODES

Case 1: (hybrid system wind and solar generations)

In this case both the wind and solar generating the power. In this mode wind system provides maximum voltage(Vdc) and the solar system provide the maximum current (Ipv). So that the LUO converter duty cycle varies related with the output voltage because both input source extracts the power.

Now the MPPT reference current is given as,

$$Iref(new) = Iref(old) + (\Delta(Ipv + Iluo)) \quad \ldots\ldots\ldots\ldots\ldots\ldots..(13)$$

$where\ (\Delta(Ipv + Iluo))$ - change in current

From this reference current the fuzzy logic controller adjust the duty cycle, so that LUO converter output voltage remains constants this voltage is fed to the inverter. Then for grid reference current it is given as,

$$Iref = \sqrt{2}(Vpv.Ipv + Vdc, Idc)/Vgrid \ .(14)$$

From this change in reference current the PI controller adjusts the pulses to the inverter so that PI controller achieves grid synchronization.

Case 2: (PMSG generating the power)

At night time the PV panel output is zero. At that time wind will supply power to the load through LUO converter.

Now the reference current is,

$$Iref(new) = Iref(old) + \Delta Iluo \quad \ldots\ldots\ldots\ldots\ldots\ldots..(15)$$

At this case converter extracts the maximum power from the PMSG.

Case 3: (PV generating power)

It the wind velocity is very less only solar provide voltage to the system.

Now the reference current is,

$$Iref(new) = Iref(old) + \Delta Ipv \quad \ldots\ldots\ldots\ldots\ldots\ldots.(16)$$

At that finally, the PV and PMSG system works together the fuzzy logic controller produces the PWM pulses to the LUO converter and the PI controller generates the reference current command from the grid. If only PV panel is works then the algorithm will not produce any duty cycle to the converter, but the PI controller extracts the maximum power from the PV system. In case PMSG works alone the algorithm produce the duty cycle.

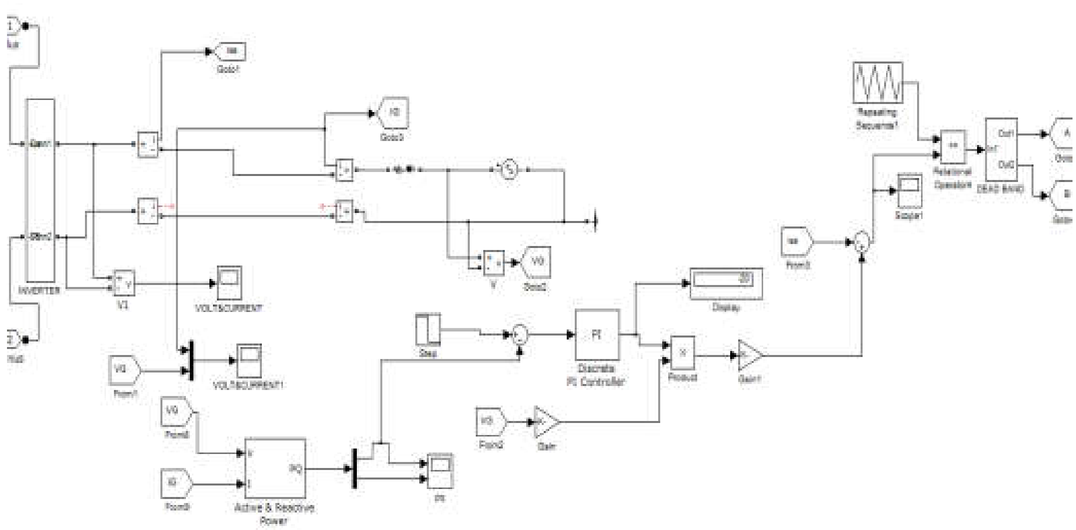

Figure 4: Matlab Simulink

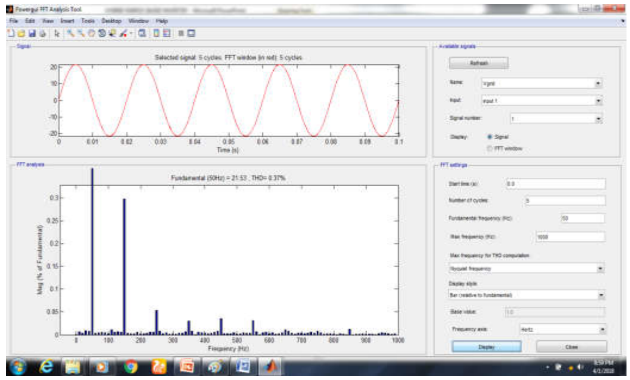

Figure 5: Inverter Voltage THD Waveform Using FFT Analysis

IV. CONCLUSION

A new reliable hybrid DG system based on PV and wind driven PMSG as sources, with only a boost converter followed by an inverter stage, has been successfully implemented. The mathematical model developed for the proposed DG scheme has been used to study the system performance in MATLAB. In addition, it has been established through simulation that the two controllers, digital MPPT fuzzy logic controller and PI controller which are designed specifically for the proposed system have exactly tracked the maximum powers from both the sources. Maintenance free operation, reliability and low cost are the features required for the DG employed in secondary distribution system. . The steady state waveforms captured at grid-side show that power generated by the DG system is fed to the grid at unity power factor. The voltage THD and the current THD of the generator meet the required power quality norms recommended by IEEE. The proposed scheme easily finds application for erection at domestic consumer sites in a smart grid scenario.

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