Design and Implementation of PV-Hydro-battery based microgrid

Mariya Khan, Divya Agrawal
P.G. Student, Assistant Professor
Department of Electrical Engineering,
GHRIET, Pune, India

Abstract: The suggested work consists of independent small scale matrix with disseminated vitality asset sun oriented and hydro which is animated. Power request is overseen between the sun oriented exhibit and hydro vitality asset while load is leveled utilizing Battery Control. Battery Energy Storage framework (BESF) is utilized to oversee load changes which are controlled by Bidirectional Converter. The bidirectional converter helps in lessening the battery limit and expanding battery life. Most extreme power yield from Solar Photovoltaic (SPV) is accomplished by Incremental Conductance (INC) based calculation. Recreated output is shown to demonstrate the planning and control of PVbattery-hydro based independent miniaturized scale matrix.

Index Terms – Solar, hydro, Bidirectional Converter, regulation

I. INTRODUCTION

Electrical vitality need is expanding step by step everywhere throughout the pieces of world. The creation of Electrical vitality by ordinary strategies for example utilization of non-renewable energy sources has been prompting exhaustion of Fossil energizes, increment in contamination and corruption of condition Because of falling of petroleum derivatives and increment popular of intensity age, sustainable power sources are picking up significance. Solar Photovoltaic, Wind Energy, Hydro Power are popular generation sources of Electrical Energy. This vitality age sources are Eco-accommodating, non contaminating and savvy. [1] Nowadays cost of Solar Photovoltaic (SPV) is diminishing and it is picking up significance in all strata of individuals as it is ubiquitous. Most extreme nonstop vitality can be accomplished from SPV through Maximum Power Point Tracking (MPPT). MPPT strategies like Incremental conductance method, Perturb and Observe method (P&O), Fuzzy Logic Method and so forth can be actualized to get most extreme yield control from SPV. [2] This Solar power age can be incorporated to utility framework for tackling intensity of sunlight based and conveying the peak request between two sources. [3-4]. Different Control procedures have been executed for independent sun powered microgrid for supply load request just on Solar. [5]. However, because of its discontinuous nature it must be coordinated with other electrical vitality age source, for example, wind control, hydro power, and diesel generator sets and so on. Wind vitality is additionally picking up significance because of its simplicity of electrical vitality age and small/miniaturized scale hydro control plants are being utilized in country regions. All these sustainable power sources are not fit for providing vitality during the time because of their discontinuous nature and thus dispersed vitality age is required. Circulated vitality age, for example, sun oriented diesel, sun powered breeze, wind diesel, sun based warm biomass is being utilized. [6-7]

II. MODELLING OF SYSTEM:

a. Solar System

The PV Array consists of the PV module, whereas PV module consists of quantity of sun powered cell arranged in parallel or series. Fig.2 shows the equal circuit diagram of the sun powered cells. [9] The performance characteristics of a sun powered cell can be shown by measuring its current versus the voltage (IV curve).

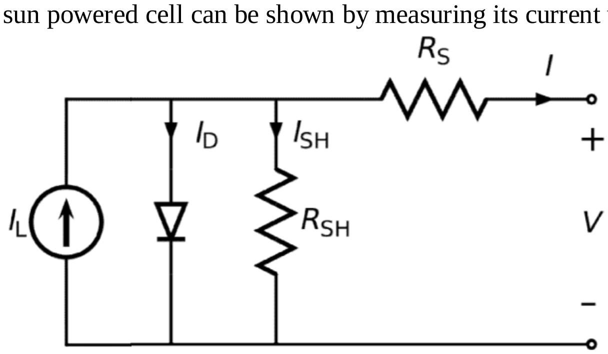

Figure 2: Equivalent Circuit Diagram of Solar Cell

b. Hydro Turbine System:

In the suggested model PMS generator is utilized for getting electrical vitality from the hydro control. The AC control is changed over to DC control by utilizing a rectifier and afterward is bolstered to DC-DC converter for getting controlled wanted DC control. The yield of hydro control plant is put away in battery.

c. Battery:

Considering the total power capacity of solar PV array and hydro, the battery energy storage framework (BESF) is selected. Battery is used to regulated voltage and frequency and load leveling in the system. To reduce high frequency noise caused by Voltage source converter ripple filter is used.

III. SYSTEM DESCRIPTION:

a. Solar System:

The solar system has different parts that are sun oriented inverter, PV exhibit and support converter, with a harmonic reduction using inductance- capacitance arrangement. The PV cluster is conveying 10 kilowatt at 1000W/m2 sun based light. The Direct current control being created by the PV cluster is utilized to charge the DC interface capacitor. The Photovoltaic exhibit can be scientifically displayed as

$$q \quad Vpv\ P_{pv} = V_{pv}I_{pv} = N_1 I_{ph}[\quad * \quad - 1]$$
$$kAT\ N_2$$

In the above equation, T is individual cluster temperature in Kelvin, A is ideality factor, which is 2.46, Iph is the flow of electrons in photovoltaic cell, P_{pv} is dc power output of PV exhibit, N_2 & N_1 are number of series and parallel cell arranged in PV module, q is charge on electron, P_{pv}, V_{pv}, and I_{pv} are the output power DC, Produced DC potential difference and flow of electrons respectively. The boost converter is utilized to coordinate the Solar Photovoltaic voltage level to the voltage dimension of wanted DC voltage. For working of our applications, the required voltage is high as compared to the output voltage yielded by the PV cell, which cannot be used to drive our applications. The arrangement of series and parallel mix of Solar Photovoltaic cell orchestrated in a PV module setup additionally don't give the required DC yield. Subsequently, the converter is compulsory to help the small yield voltage of PV cluster.

Figure 3 demonstrates the closed loop control of boost converter. The switching device used in boost converter can boost the output voltage by change in duty cycle

Conversion of Direct current potential difference to sinusoidal Alternating potential difference is done by converter which could be Voltage source converter which viewed from the load side appears as a Constant Voltage source. The sounds created by VSC are separated by LC channel.

b. Hydro System:

The hydro framework is made up of permanent magnet synchronous machine two converter in anti parallel arrangement (i.e. one as rectifier and other as inverter), and LC channel. A remotely driven hydro turbine coupled to synchronous generator is operated as a PMSG. The power created by the PMSG is given to the load to back to back converter through rectifier via common DC interface. Rectification operation is provided by generator side converter which converts variable voltage and variable frequency supply of Hydro turbine at PMSG terminals to DC voltage. This DC control accessible at the terminals of rectifier is changed over to AC control by utilizing PWM inverter and the yield of PWM inverter comprise of harmonics which can be filtered by using LC filter.

c. Battery Storage:

The battery stockpiling is overseen through Bidirectional DC-DC Converter (BDDC) which directs the Direct potential difference of Voltage source inverter. Bidirectional DC-DC converter gives task in two modes for example Buck mode and Boost mode. Amid buck mode, charging of battery happens and amid boost mode releasing of battery happens relying upon the condition of charge of battery. It likewise synchronizes the power age and burden leveling by putting away additional power in battery. In pinnacle request state, battery supplies the power shortage from sun based and hydro age.

IV. CONTROL STRATEGY:

a. Control of Inverter:

In the above demonstrated model of standalone microgrid, two generation sources that are solar and hydro are used for power generation whereas battery system is used as backup. The main challenge is to integrate the above system with the load. The load could be linear or non-linear. The generation sources are associated to the inverter via DC-DC converter and battery backup is associated to the inverter via Bidirectional DC-DC converter for both charging and discharging mode. All the connection is done to the inverter at Point of Common Contact. The inverter then converts direct current input to Alternating current output demanded by the load at voltage and frequency regulated to that of load. It is a critical segment of framework, and its control ought to be to such an extent that output should match the voltage requirement of load. The control of inverter is done through constant current control method as given in Fig 4. In this method initially the source current is compared to reference value. The 3 phase current are converted to αβ through Clarke Transformation which are further converted into dq variables. This current is compared to reference values for managing the output of PI Controller such that errors can be minimized. Phase locked loop is used to measure load voltage and its phase angle, it also gives data regarding frequency change. Depending upon the phase angle, the constant current controller generates firing pulses for the inverter to follow the load voltage. Inverse park's transformation is used to convert this signal into three phase signal and then into switching pulses for inverter by comparing Microgrid.

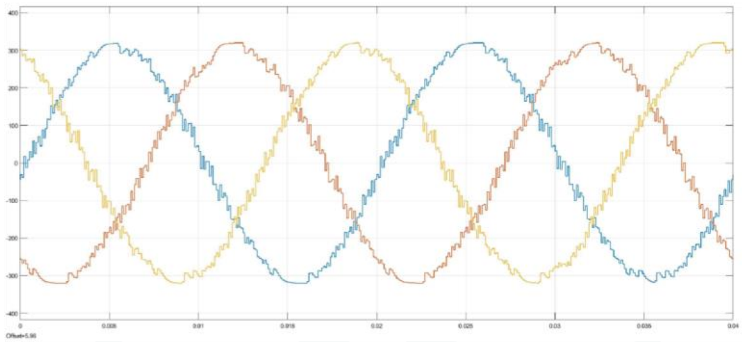

Figure 8: Voltage waveform at output load terminals

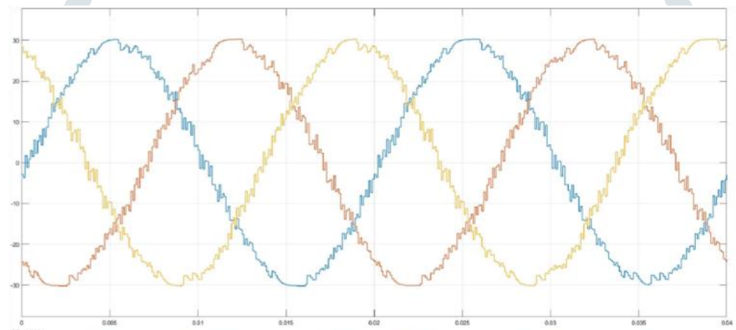

Figure 9: Current waveform at output load terminals

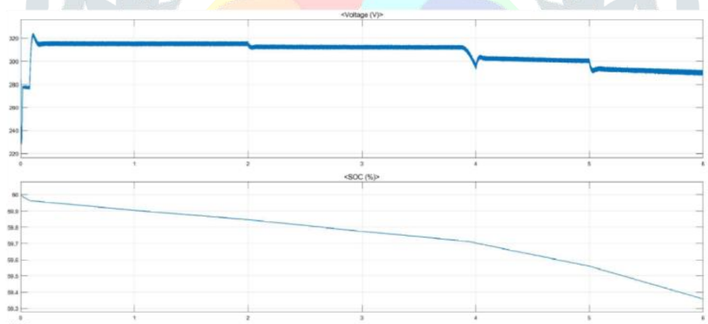

Figure 10: Voltage and state of charge of Battery

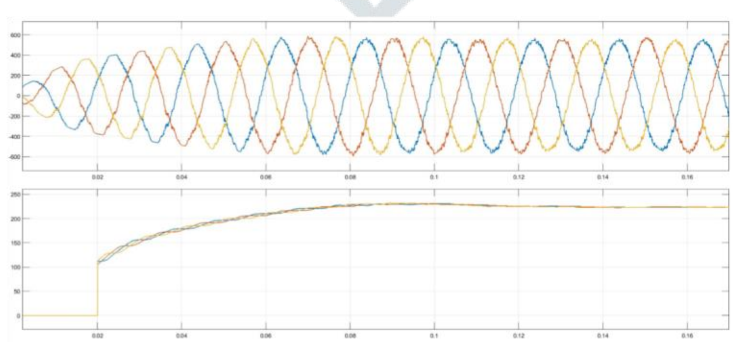

Figure 11: Control of Voltage Source Inverter

VI. CONCLUSION:

In the above proposed system, standalone micro grid consisting of Solar power, hydro power and battery energy storage device has been stimulated in MATLAB/SIMULINK and it is observed that this standalone micro grid can supply power to Linear and nonlinear load. The load is leveled through the battery and frequency and voltage is being regulated. The solar supplies 10 KW of power and hydro system is supplying about 4.5. kW of power.

VII. ACKNOWLEDGMENT:

The writers would like to acknowledge Mr. V.M. Panchade, Head, Electrical Engineering Department and all Professor members of GHRIET for their constant support and motivation.

REFERENCES

[1] S.R. Bull, "Renewable Energy Today and Tomorrow" Proceedings of IEEE, pp 1216-1226, August 2001.

[2] T Esram and PL Chapman, "Comparison of photovoltaic array maximum power point tracking techniques", IEEE transactions energy conversion, pp 439-449, June 2007.

[3] N Srisen and A sangswang, " Effects of PV grid connected system location on o distribution system" Proceedings of IEEE Asia Pacific Conference, pp 852-855, Dec 2006.

[4] R J Wai & W H Wang," Grid connected Photovoltaic generation system" IEEE transaction on circuits and systems, PP 953-964, 2008.

[5] J Philip, S. Mishra, C Jain, Al Haddad, K Kant, B Singh, " Control and implementation of a standalone solar photovoltaic hybrid system" IEEE transaction on industrial Application, 2016.

[6] H Matsuo & T Hirose, " Standalone Hybrid Solar Wind power generation system applying dump power control without dump load" IEEE transaction on Industrial Electronics, pp 988-997, 2012.

[7] G Agnihotri, S gupta & S.Meshram , " Design of hydro and solar hybrid system for remote areas" in International conference on Electrical and Electronics Engg, Volume 2, October 2011.

[8] G Agnihotri, S gupta & S.Meshram , " An efficient constant current controller for PV solar power generator integrated with the grid" IEEE 5th Power India Conference, December 2012. https://en.wikipedia.org/wiki/Theory_of_solar_cells.