International Journal of Computer Engineering and Applications,
Volume- XIV, Issue - Special Issue, June 2020, www.ijcea.com ISSN 2321-3469
NCRTCEA- 2020

INDIRECT CURRENT CONTROL BASED HYBRID MICRO GRID

Esha Gannerla[1], Vishnuvardhan Vadla[2]

[1,2]Department of Electrical and Electronics Engineering

[1,2]St. Martin's Engineering College, Secunderabad, Telangana, India.

ABSTRACT:

This paper deals with the standalone hybrid microgrid (MG) and its control for rural energy system. Voltage source inverter (VSI) is the main organize unit of micro grid (MG) in which an indirect current control is applied. This VSI is used for power quality enhancement through harmonics inhibition of nonlinear loads; voltage regulation during contingencies such as load unbalance; and reactive power compensation at point of common coupling according to the system requirement. It is competent of supplying power balance under diverse changes among the generation, storage, and demand units. A reweighted zero attractor least mean square control algorithm is applied to generate pulse width modulation switching pulses for VSI and for proper functioning of VSI. A replica of micro grid (MG) is developed in MATLAB/Simulink background to simulate its performance in regular and in dynamic conditions at linear and nonlinear loads.

Keywords: Microgrid, Indirect current control, linear and non linear loads, Voltage source inverter

[1] INTRODUCTION

In developed regions of the world like USA and European countries, the energy is required to lead a comfortable lifestyle and for technological and industrial developments. The other aspect is also true that there are many countries in Africa and Asia, where some places are still deprived of electricity. People of such places have stagnant social development and minimal economic growth and they remain away from basic ancillary services like health, education, etc. In order to meet the increased demand of the world as well as to provide the basic ancillary services to far located places, the isolated microgrid (MG) [1]–[3] for rural electrification can be a noble option as compared to the normal grid. Such MGs can be ac and dc MGs having natural resources such as wind, solar, biomass, etc., and diesel generators (DGs) [4]–[7] to encourage the maximum use of renewable energy and economic utilization of fossil fuels.

The worldwide energy consumption is reported in [8] for all conventional (fossil fuels, large hydro, nuclear, etc.) and renew- able (wind, solar, small hydro, etc.) resources. It is reported that up to 2020 the consumption of fossil fuels is to be reduced up to 76% and renewables are expected to grow up to 16% with a total supply of 17 208 MToe.

This study shows that the renewables are taking over the fossil fuels slowly. The reasons to replace fossil-based energy with re- newables, are the depletion of these sources, which has increased the fuel price [9] and their effect on environmental deformities such as greenhouse gases, global warming, and rise in health is- sues viz., impaired hearing, impairing visibility, dizziness, etc. [10], [11]. The research and development in power electronics have made applications of renewable energy to grow fast and smooth [12], [13].

The electric power is provided to the remote places either by DG sets or available renewable resources such as wind, hydro, solar, etc. The DG sets impose cost on remote applications and lifestyle becomes expensive though the renewable resources are economic in generation but are very unreliable as their gen- erations are season dependent. Therefore, the combinations of renewable resources can be a promising technology to attain the reliability [14]–[16]. In [14], photovoltaic systems are in- vestigated with various control schemes. Such systems consist of dc–dc and dc–ac converters. Another combination of con- verters is called hybrid converters having switching between converters. A hybrid MG is reported in [15] with wind and diesel resources. In such MG droop control is utilized for the frequency regulation of an ac bus. In [16], a renewable MG for energy management is reported having configuration with two converters, one is ac–dc and other is a dc–dc converter for smooth power flow. While in the proposed work, a single volt- age source inverter (VSI) (dc–ac converter) as the control unit and one dc-dc converter is utilized for maximum power tracking (MPPT). In such system, the control complexity and cost of the system as well as maintenance are reduced. In standalone opera- tions, voltage and frequency regulation and power management are important aspects as reported in [17]. In [18], Rezkallah *et al.* have reported detailed studies on ac MG configurations and control. Such MGs can serve isolated and interior places having green or hybrid resources. To protect battery overcharg- ing dump loads are used. Perturb and Observe (P&O) and sliding mode controls are used for MPPT and pulsewidth modulation (PWM) pulse generation.

Moreover, wind is very unreliable resource due to its variable and unpredictable nature. To overcome this problem, a battery storage [19] together with hydro power, which is available in all seasons, is used. Commonly the squirrel cage induction genera- tor is used for hydro power generation due to its robustness and low maintenance but its efficiency is poor and frequency regula- tion is required. In this work, a synchronous reluctance generator (SyRG)-based hydro power generator delivers supply at rated frequency and voltage with the reactive power support using a capacitor bank. Such generators are without slip rings and rotor windings, therefore, the maintenance and the losses are reduced as a result, and its power efficiency is improved [20], [21]. The variable speed permanent magnet brushless dc generator (PM- BLDCG) is used for wind power generation. It provides higher average power than the alternator as it has trapezoidal electro- motive force and almost quasi-square shape currents. MPPT of wind power is achieved using a P&O technique [22].

This MG functions for power balancing during wind fluctu- ations and load demand variations. A reweighted zero attractor least mean square (RZALMS) [23], [24] control approach is implemented in the MG VSI, which is the main control unit of the system. RZALMS accelerates the convergence rate and has lower mean square error than the standard LMS [23]. With the help of analytical demonstration, RZALMS is better on the standard LMS in both transient and steady-state performance for sparse and nonsparse systems. It offers harmonics reduction of nonlinear loads, voltage regulation at load variations, reactive power compensation based on system requirement. It also man- ages balanced power flow among various units, i.e., wind–hydro generators, the battery storage, and loads.

[2] MG CONFIGURATION AND CONTROL STRATEGY

Fig. 1 depicts the renewable-based MG comprising of hydro and wind sources.

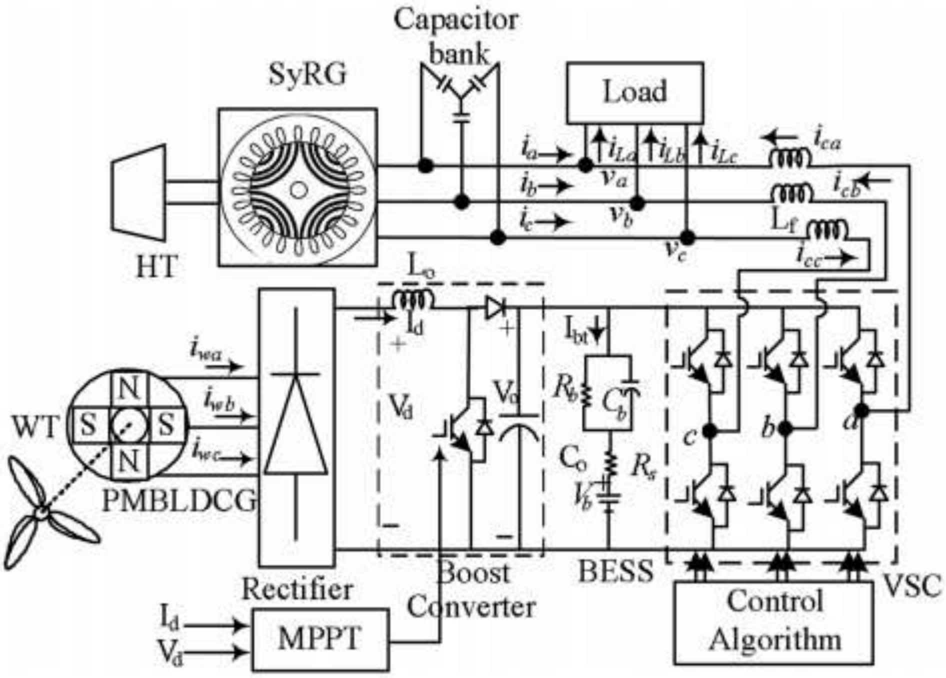

Figure: 1. Wind–hydro MG configuration

The hydro power is generated using SyRG, a constant power generator and this power is fed to the ac loads. The PMBLDCG is used to generate the electricity from wind power at variable speeds and a diode rectifier is used to convert it into dc power, which is fed to the boost converter for MPPT using the P&O control technique. This extracted power is delivered to the ac loads through a VSI and excess generated power is stored in the battery bank connected parallel to the VSI. This VSI is connected to the hydro power generator (SyRG) and loads at point of common coupling (PCC) through interfacing inductors (Lf). A capacitor bank is connected at SyRG terminals to support reactive power to MG for voltage buildup. The design data of the proposed MG are given in Appendix. To operate MG in satisfactory manner, it must provide good quality power as regulated sinusoidal voltage and frequency. This work presents MG performance with an RZALMS control approach to underpin a zero attractor for differentiating between zero taps and nonzero taps, as shown in Fig. 2.

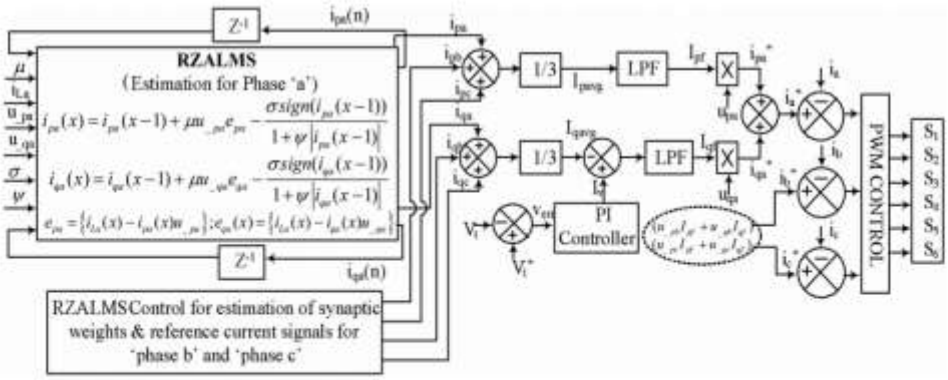

Figure: 2. MicroGrid control approach

[3] RESULTS AND DISCUSSION

Simulated results of MG are demonstrated in this section. Steady-state and dynamic responses of a renewable-based MG are shown and the behavior of intermediate signals of control approach at load unbalancing is depicted in detail. The wind MPPT using the P&O approach is also included. *A. MPPT of Wind Power* The MPPT of wind generation is achieved through applying a P&O approach. It is shown in Fig. 3 that at the wind speed variation, the PMBLDCG current of phase "*a"* is also reduced. Therefore, the output current of the dc–dc boost converter is also reduced. The output voltage (*Vo*) across the dc bus capacitor is fixed. The extracted power after MPPT is also reduced with wind speed changes.

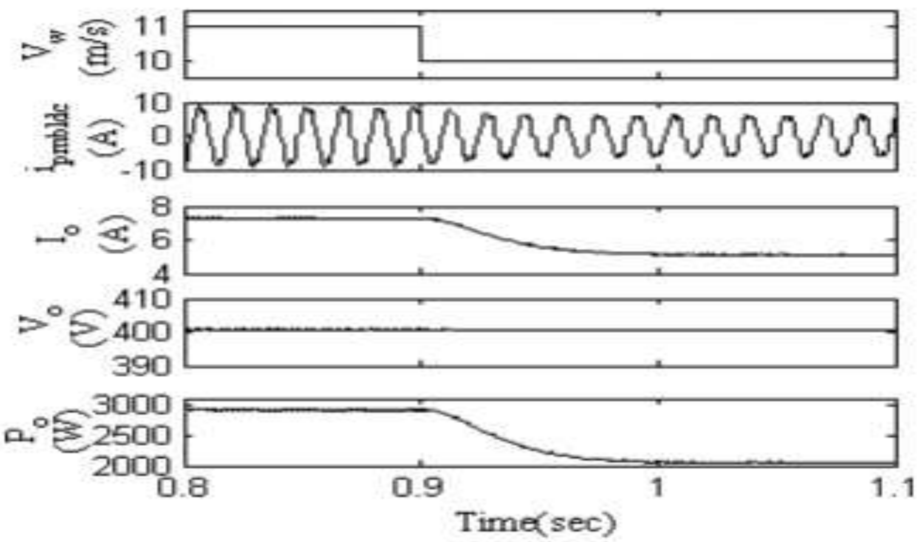

Figure: 3. P&O approach based MPPT

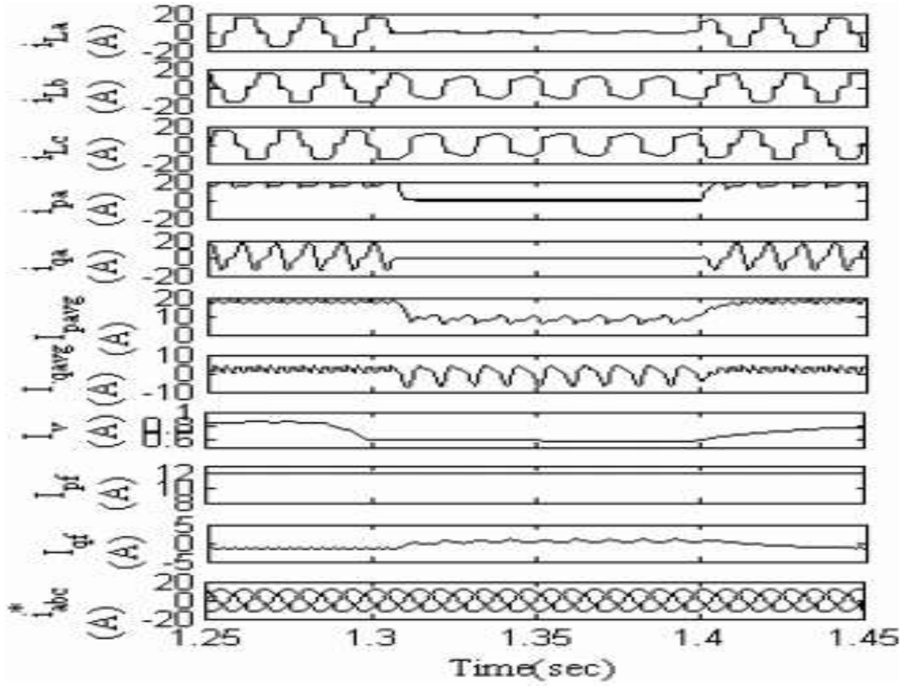

Figure: 4. Intermediate signals of RZALMS control algorithm at nonlinear load.

B. Response of RZALMS Control Approach at Linear and Nonlinear Loads

The performance of wind–hydro based MG depends on its control approach robustness. To demonstrate satisfactory response of the control approach, its various intermediate signals are depicted in Fig. 4 at nonlinear loads. The load unbalance is created at t = 1.3 s, and the load on that phase is recovered at t = 1.4 s. It is seen that at load unbalance, the load current of phase "*a*" (*iLa*) becomes zero and other two phase currents *iLb*, *iLc* also change their shape. Simultaneously active and reactive load power components (*ipa*, *iqa*) also become zero. The equivalent active and reactive load current components (*ip*avg,*iq*avg) are also reduced as the total load demand is reduced due to the absence of load on phase "*a*." The current component coming from a PI controller (*Iv*) and the reactive source power current components (*If q*) also change with the load variation. The active source power current component (*If p*) is constant as prime mover power is fixed and reference source currents are sinusoidal and balanced. The intermediate signals of the control approach are changing rapidly to achieve the steady state condition within couple of cycles

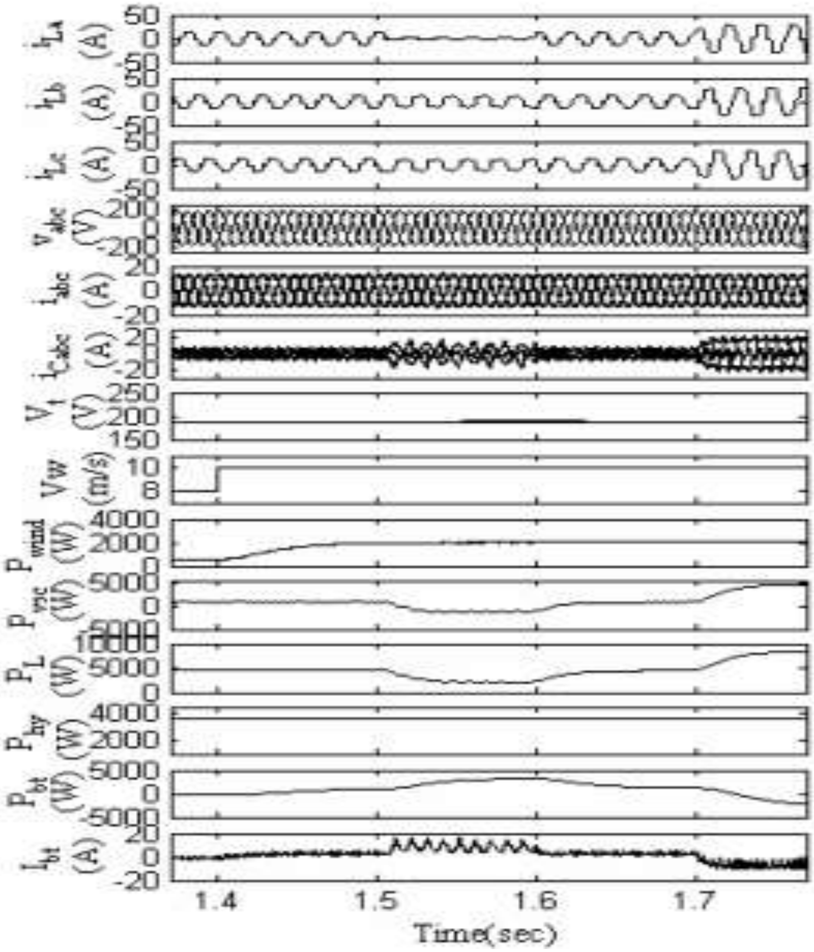

Figure: 5. Performance of MG under dynamic condition at nonlinear load

[4] CONCLUSION

A renewable wind–hydro based MG has been developed. The performance of MG has been demonstrated using RZALMS control approach to provide power quality solutions, i.e., harmonics suppression, reactive power compensation, load balancing, and voltage control. It has also managed the power balance in the MG during various states such as high wind power generation, load unbalancing, and peak load demand. Such MG provides energy independence in rural areas and contributes in reducing the fossil consumption and its bad impact on the environment. A single VSI has performed power quality improvement and power balancing. The PMBLDCG does not require speed sensor, position sensor, and wind speed sensor for MPPT control. Individual inverters and converters are not being used on various units viz., wind, hydro, battery bank, etc. Therefore, the overall system cost and maintenance is reduced.

REFERENCES

[1] Rashid, N. Hasan, K. T. Parvez, and M. N. I. Maruf, "Study and analysis of a small scale micro-grid using renewable energy resources," in *Proc. Int. Conf. Elect. Eng. Inf. Commun. Technol.*, Dhaka, Bangladesh, 2015, pp. 1–4.

[2] M. S. Mahmoud, M. Saif Ur Rahman, and F. M. A. L. Sunni, "Review of microgrid architectures – a system of systems perspective," *IET Renewable Power Gener.*, vol. 9, no. 8, pp. 1064–1078, 2015.

[3] S. V. Cotto and W.-J. Lee, "Microgrid modular design for tribal healthcare facilities: Kayenta health center PV system case study" *IEEE Trans. Ind. Appl.*, vol. 53, no. 6, pp. 5121–5129, Nov./Dec. 2017

[4] T. Ma, M. H. Cintuglu, and O. A. Mohammed, "Control of a hybrid AC/DC microgrid involving energy storage and pulsed loads," *IEEE Trans. Ind. Appl.*, vol. 53, no.1, pp. 567–575, Jan./Feb. 2017.

[5] K. Sun, X. Wang, Y. W. Li, F. Nejabatkhah, Y. Mei, and X. Lu, "Paral- lel operation of bidirectional interfacing converters in a hybrid AC/DC microgrid under unbalanced grid voltage conditions," *IEEE Trans. Power Electron.*, vol. 32, no. 3, pp. 1872–1884, Mar. 2017.

[6] F. Cingoz, A. Elrayyah, and Y. Sozer, "Optimized settings of droop pa- rameters using stochastic load modeling for effective DC microgrids op- eration," *IEEE Trans. Ind. Appl.*, vol. 53, no. 2, pp. 1358–1371, Mar./Apr. 2017.

[7] G. Pathak, B. Singh, and B. K. Panigrahi, "Three-phase four-wire wind- diesel based microgrid," in *Proc. IEEE 6th Int. Conf. Power Syst.*, 2016, pp. 1–6.

[8] World Energy Resources 2013 Survey, 2013. [Online]. Available: https://www.worldenergy.org/wp-ontent/2013/Complete_WER_2013 Survey.

[9] N. Bauer *et al.*, "Global fossil energy markets and climate change mitiga- tion: An analysis with REMIND," *Climatic Change*, vol. 136, pp. 69–82, 2013.

[10] G. Sahoo and Rajesh Kumar Tiwari, "Some New Methodologies for Secured Data Coding and Transmission", International Journal of Electronic Security and Digital Forensics, Inderscience Publisher. U.K. Vol. 3, No. 2, 2010, pp-120-137.

[11] G. Sahoo and R. K. Tiwari, "Designing an Embedded Algorithm for Data Hiding using Steganographic Technique by File Hybridization.", International Journal of Computer Science and Network Security, VOL. 8 No. 1, 2008, pp-228-233

[12] Gadadhar Sahoo and Rajesh Kumar Tiwari, "Some new Methodologies for Image Hiding using Steganographic Techniques", International Journal of Information Analysis and Processing, IJIAP Vol.1. No.1. Vol. 1, No. 1, 2008, pp.25–31.

[13] F. P. Perera, "Multiple threats to child health from fossil fuel combustion: Impacts of air pollution and climate change," *Environ. Health Perspectives*, vol. 136, pp. 69–82, 2016.

[14] B.Atilgan and A. Azapagic, "Life cycle environmental impacts of electric- ity from fossil fuels in Turkey," *J. Cleaner Prod.*, vol. 106, pp. 555–564, 2015.