ISSN (Print) : 0974-6846
Indian Journal of Science and Technology, *Vol 8(25), DOI: 10.17485/ijst/2015/v8i25/85920, October 2015* ISSN (Online) : 0974-5645

A Survey on Control and Communication of Smart Micro Grid

V. S. Bindhu* and D. M. Mary Synthia Regis Prabha

EEE, Noorul Islam University, Kanyakumari – 629120, Tamil Nadu, India

Abstract

TIn our day-to-day life we know that how much electricity is important and necessary. For the production of electricity, power generation should be in a sufficient manner. Power station is playing the vital role to generate power by using various sources of energy and it should produce more power when compared to the earlier stages i.e., now we all are in a modern era so that new technology is essential to produce more power and the power quality is also an important factor. In this situation the researches investigates and conclude to bring a new concept named micro grid. Micro grid requires storage devices that increase the inertia and avoid instability of the system. Micro grid is designed, built and controlled by "Customers" based on the internal requirement subject to the technical economic and regulatory opportunities and constraints faced. Micro grid means distributed generators on small scale rather than centralized generation and centralized control may be through renewable energy sources. The problem nearly micro grids were not particularly reliable because only one power plant supplies all of the energy. The solution for this problem is interconnecting some systems to improve reliability. To bring an alternate solution smart grid concept originates for the generation of power. Smart grid uses new intelligent techniques and automatic control through communication. For cost reduction, rise in efficiency and reliability, energy saving etc. smart grid is advantageous than micro grid.

Keywords: Autonomous Mode, Droop Controller, Maximum Power Point Tracker, Micro Grid, Plug and Play Approach, Power Line Communication, Renewable Energy Sources, Secure Communication, Smart Grid, Spatial Repititive Controller

1. Introduction

Now a days the use of fossil fuels causes serious damage to the environment such as air pollution and global warming. Therefore in order to protect the environment various energy sources and distributed generators are used. But the distributed generator produces unstable output and it seriously affect the power systems. So that it is decided to install more than one DGs to form a micro grid system. If the renewable energy sources are used in a proper way we can avoid the problems related with climate change and energy crisis etc also to find the remedy for global problems. Reliability and power quality are also one of the important factor in micro grid. Distributed generators are operated in parallel and it works with group of networks or as an isolated network. But controlling the group of networks is a tedious process and it follows two main configurations. First one is a centralized control i.e., the central agent is connected to the main grid and if any shut down or failure occurs in the main grid, it affects the whole system, and the second one is a decentralized control. It consists of a multiagent system i.e., if it is operated as a separate grid if any failure occurs in the main grid it does not affect the isolated grid. Separately controlled and excess power is given back to the power grid.

Later days the use of renewable energy sources increases the system complexity and to run the operation efficient monitoring and control methods are required. Therefore a new technology with smart grid system plays an important role. It refers that the combination of distributed generators into the grid using communication technology to increase the grid flexibility and reliability. Smart grids with smaller units are called as micro grids. Micro grid system produces fluctuations in the parameters

* *Author for correspondence*

such as frequency and voltage if the input is solar or wind. System stability is improved by using energy storage devices like flywheels, batteries and capacitors are used as back devices and it is used to store the excess power, if power generation is more than the demand of the power grid, then the stored excess power is released to the power grid. This is achieved by means of smart grid systems in form of real time control, good prediction etc[1-5].

2. Micro Grid System

An electrical system consists of multiple loads and distributed energy sources are operated parallel with the power grid to increase the efficiency and reliability is the micro grid system. It works as an autonomous system using renewable energy sources such as solar, wind etc. then diesel generator, fuel cells and battery energy storage systems and flywheel energy storage system to form a power network. In traditional method centralized generation is offered, cost is increasing, high power is generated also long distance transmission with more losses using coal-fired and fossil fuels for generating power. But in micro grid decentralized or distributed generation is offered and sufficient power is generated and transmitting with less losses using solar and wind power, also smart control. Comparing with centralized energy management system, distributed control eliminates communication link, thus system response speed and reliability is improved.

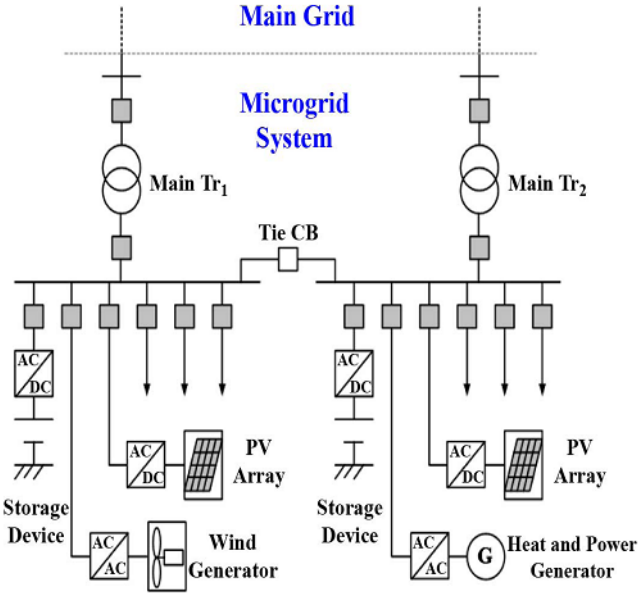


Figure 1. Structure of micro-grid system.

Micro grid improve grid efficiency, reliability and improves energy reliability. The problem nearly micro grids were not particularly reliable because only one power plant supplies all of the energy. The solution for this problem is interconnecting some systems to improve reliability. The arrow point represents the coupling point which is used to interconnect the micro grid with the main grid.

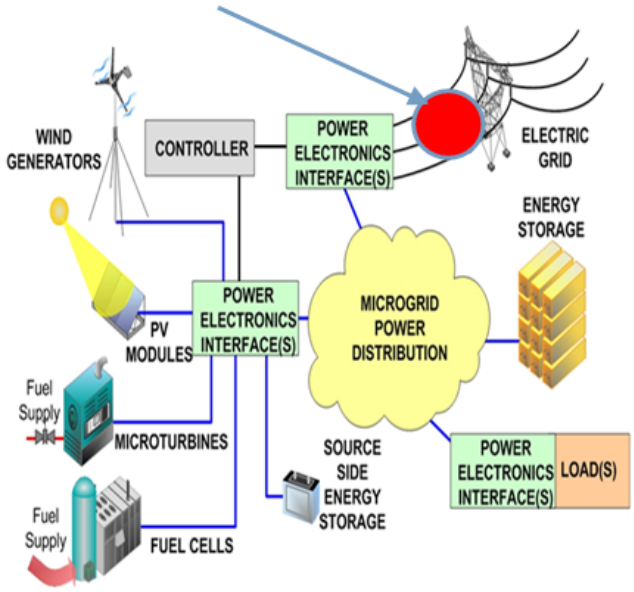


Figure 2. Example for a Micro grid system connected to the main grid.

3. Smart Grid System

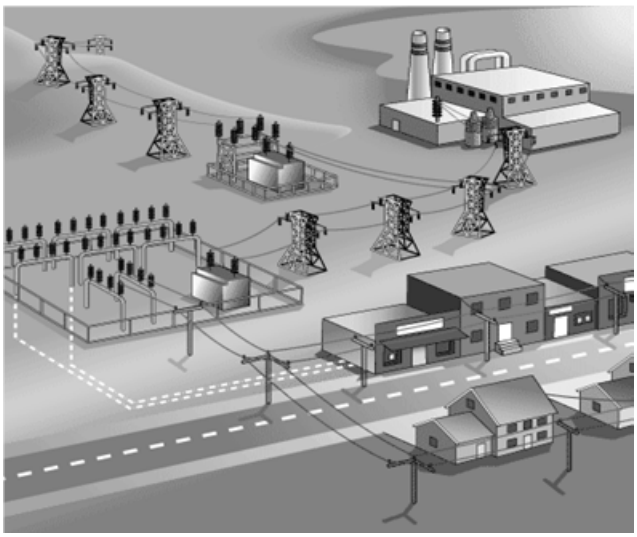


Figure 3. Smart Grid System.

In order to save energy in homes, to reduce cost and to increase reliability, efficiency etc. smart grid system is used and it uses an intelligent monitoring system it traces all the electricity flow of networks connected in the system and it uses smart meters to gather information. A smart grid system also uses super conductive transmission lines using this power loss is reduced and also interconnect several renewable energy sources such as solar and wind etc. When the power availability is less from the power grid we can turn on the smart grid system to run our selected home appliances. Power demand is more we should turn off the selected home appliances.

3.1 Smart Grid Power Line Communication

Communication is very much essential for smart grid systems. Smart meters are used for collecting information from various sources to increase the efficiency and at the same time electricity use want to shift from peak demand to those off peak demand. In order to achieve these goal two way communications between utility and consumer is necessary.

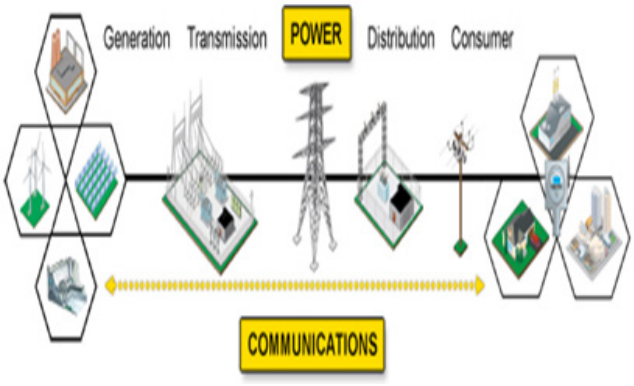


Figure 4. Communication topology.

3.2 Advantages, Disadvantages and Future Use of Smart Grid

Advantages such as it reduces the cost, increase the efficiency and reliability but it has disadvantages such as two way communication is necessary between consumer and provider and sensors so it is very costly, the power demand is not stable i.e., it increases or decreases the several components which are necessary for power generation. In future the smart grid system is available in all houses like internet, but because of financial reasons this might be risky for further improvement.

3.3 Related Work

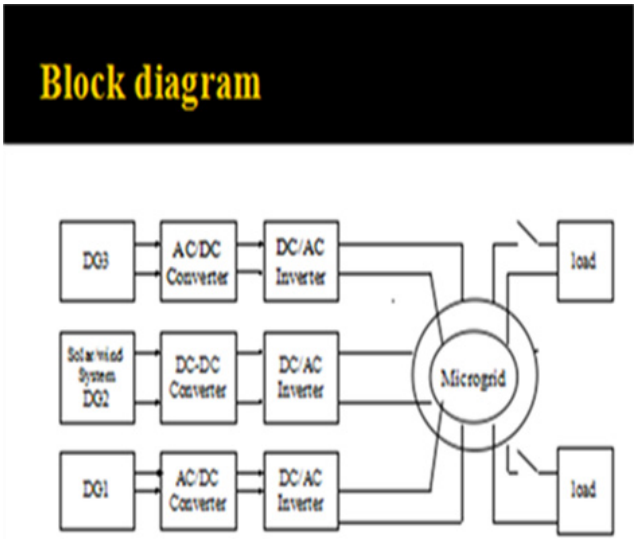
In[6-9] tells about the cyber secure communication. In order to reduce the low voltage problem at the time of transmitting power communication is very much important. Voltage collapse problem occurs due to addition of more power electronic devices, their complexity increases and many personnels are required so that cost increases. So in this paper they try to reduce the usage of many personnels and also to manage the problem of complexity. In order to reduce the voltage collapse an optimization algorithm is found out and it improves the voltage problem in the distribution grid. The optimization algorithm follows a chain of command from the generation side to the distribution side. To control the power flows, energy consumption must be measured, energy provision must be controlled and distributed grid must be monitored. Communication is very much important at the same time what type of communication used is also very important. In earlier days wired communication are used for power system monitoring, protection and diagnostics systems. But the usage of wind communication increases the cost because it requires the expensive communication cables and regularly we should maintain the cables and use for the purpose of communication. So this type of communication is rarely used and finds another solution by using wireless communication. Wireless communication is more advantageous than wired i.e., it provides low cost, flexibility and rapid deployment etc. also it provides some disadvantages i.e., always necessary to replace the batteries and regular maintenance is required.

In[10-12] Zigbee wireless technology is followed after the wireless network technology because of the advantages of reduction in cost, power, data rate, complexity and simplicity etc. but the zigbee channels overlap with the other channel and interference is produced. It is one of the disadvantages therefore an interference avoidance algorithm is implemented to indicate the interference and switch over to the safe mode for operation. Zigbee development kit is used for the purpose of implementing this algorithm. Lastly a leading technique of power line communication is preferred because power line infrastructure is already existing therefore installation cost is low, when compared to other communication system. In PLC network more number of devices are used, therefore noise is generated and the performance get affected. So in order to improve the performance it is very essential to remove the noises so the authors found

a clipping technique to remove the unwanted signal and uses an equalizer to compensate the effect of noises. So power line communication is very robust and can be used everywhere and it uses BB-PLC modems for connectivity. Plug and play approach is used for the effective control to improve power quality and efficiency. Usage of energy sources and power generation can be varied during day time and according to the variation in load the performance of micro grid varies and it automatically shift from grid connected to islanded mode. Without any communication there is an improvement in the network operation with minimum investment usage in sensing devices and control board are the advantages.

In[13-19] communication less system is a droop control method. In order to control the active and reactive power injected into the grid parallel connected inverters are used. These inverters supply the power to the ac bus and the resulting average is used to adjust the frequency and amplitude of the inverter. To achieve good power sharing the controller wants to be in need of adjustment with the frequency and amplitude of the inverter. This droop method is proposed that without intercommunication several parallel inverters are used to inject the power into the grid. In[20-25] autonomous operation taking place in which when overload condition occurs the inverters should ensure that changes. It is based on some control techniques i.e., if micro sources are located very near means the system become expensive and reliable for communication, but in micro grid the micro sources are located far away therefore it became less expensive and less attractive for communication. So this control technique is more efficient and a digital computer simulation approach is used and tested using the PSCAD/EMTDC software. In order to improve the system efficiency power electronic converter with photovoltaic systems are used. The maximum power is traced from the device and the algorithm used here will compare the actual power with past samples and then modify the change accordingly so that the power output is increased. This is the earliest method i.e., the authors found only analytical solution for this i.e., to find the closest maximum power an equation is formulated. This disadvantage is rectified in this paper, as this MPPT technique used here is to adjust the converter duty cycle directly and comparing the result so that an error is produced and it is used to control the converter output so that reliability is high, complexity is less and cost is also less. This algorithm is implemented by using LABVIEW running on a PC. To improve the performance of a controller a new control technique using spatial repetitive controller is implemented i.e., whenever there is a sudden increase or change in micro grid frequency this spatial type of controller is used to maintain stability of the system.

The above mentioned survey papers tells that to mitigate the low voltage problem a secure communication is necessary and to improve the low voltage problem an optimization algorithm is introduced which is in need of communication architecture. Firstly wired communication is preferred but due to the cable cost the researches find a new solution i.e., wireless sensor network which improves reliability and efficiency but due to the need of regular maintenance and replacement of battery they find an alternate solution i.e., Zigbee wireless sensor network reduces the cost but due to the interference problems with the Wi-Fi network, a new wireless network approach is proposed as Power Line Communication. In this approach the cost is less because the Power line already exists although it needs a BB-PLC modem is required. Therefore lastly or recently smart grid focused to develop an autonomous micro grid without any additional communication using plug and play approach.



4. Proposed System

My proposed topology is to design a control system consists of several DGs and loads to operate autonomously without any mutual communication system or without the information of any electrical elements present in the

micro grid. Also to develop a new control technique to cope up with the sudden increase or decrease in the load or micro grid frequency using plug and play approach, in order to maintain stability.

5. Conclusion

This paper explains the survey on control and communication of smart micro grid. To improve the power quality and reliability of the overall power distribution system a new concept named micro grid is established. In traditional method centralized generation is offered, cost is increasing, high power is generated also long distance transmission with more losses using coal fired and fossil fuels for generating power. But in micro grid decentralized or distributed generation is offered and sufficient power is generated and transmitting with less loss using solar and wind power also smart control. But problem with this micro grids were not particularly reliable because only one power plant supplies all of the energy. The solution for this is an alternate solution is a smart grid approach. Smart grid uses new intelligent techniques and automatic control through communication. For cost reduction, rise in efficiency and reliability, energy saving etc. smart grid is advantageous than micro grid. The survey papers discussed in the section explains the advantages and disadvantages of communication and my proposed topology is to design a control system consists of several DGs and loads to operate autonomously without any mutual communication system or without the information of any electrical elements present in the micro grid.

6. References

1. Singh B, Kasal GK, Chandra A, Kamal-Al-Haddad. Voltage and frequency controller for an autonomous micro hydro generating system. IEEE Transactions. 2008; 1–7.
2. Shimakage T, Sumita J, Uchiyama N, Kato T, Suzuoki Y. Supply and demand control of distributed generators in a micro grid. IEEE Transactions. 2008; 978-1-4244-2056-8/08/$25.00.
3. Jiang Z, Yu X. Active power-voltage control scheme for islanding operation of inverter-interfaced micro grids. IEEE Transactions. 2009; 1–6.
4. Soultanis NL, Hatziargyriou ND. Control issues if inverters in the formation of L.V. Micro grids. IEEE Transactions. 2007; 1–6.
5. Dagdougui H, Sacile R. Decentralized control of the power flows in a network of smart micro grids modeled as a team of cooperative agents. IEEE Transactions on Control Systems Technology. 2014 Mar; 22(2):510–8.
6. Rogers KM, Klump R, Khurana H, Aquino-Lugo AA, Overbye TJ. An authenticated control framework for distributed voltage support on the smart grid. IEEE Transactions on Smart Grid. 2010 Jun; 1(1):40–6.
7. Aquino-Lugo AA, Klump R, Overbye T. A control framework for the smart grid for voltage support using agent-based technologies. IEEE Transactions on Smart Grid. 2011 Mar; 2(1):173–9.
8. Sauter T, Lobashov M. End-to-End communication architecture for smart grids. IEEE Transactions on Industrial Electronics. 2011 Apr; 58(4):1218–27.
9. Gungor VC, Hancke GP. Oppurtunities and challenges of wireless sensor networks in smart grid. IEEE Transactions on Industrial Electronics. 2010 Oct; 57(10):3557–63.
10. Yi P, Iwayemi A, Zhou C. Developing zigbee deployment guideline under WiFi interference for smart grid applications. IEEE Transactions on Smart Grid. 2011 Mar; 2(1):110–9.
11. Kim Y, Bae JN, Kim JY. Performance of power line communication systems with noise reduction scheme for smart grid applications. IEEE Transactions on Consumer Electronics. 2011 Feb; 57(1):46–51.
12. Tenti P, Costabeber A, Trombetti D, Mattavelli P. Plug and play operation of distributed energy resources in micro grids. Proceedings of Conference Rec (INTELEC'10); 2010 Jun 6–10. p. 1–5.
13. Guerrero JM, Vasquez JC, Matas J, de Vicuna LG, Castilla M. Hierarchical control of droop- controlled AC and DC micro grids - A general approach toward standardization. IEEE Transactions on Industrial Electronics. 2011 Jan; 58(1):158–71.
14. Guerrero JM, Matas J, de Vicuna LG, Castilla M, Miret J. Decentralized control for parallel operation of distributed generation inverters using resistive output impedence. IEEE Transactions on Industrial Electronics. 2007 Apr; 54(2):994–1003.
15. Guerrero JM, Matas J, de Vicuna LG, Castilla M, Vasquez JC. Control strategy for flexible micro grid based on parallel line-interactive UPS systems. IEEE Transactions on Industrial Electronics. 2009 Mar; 56(3):726–35.
16. Guerrero JM, Matas J, de Vicuna LG, Castilla M, Miret J. Wireless-control strategy for parallel operation of distributed-generation inverters. IEEE Transactions on Industrial Electronics. 2006 Oct; 53(5):1461–9.
17. Vasquez JC, Guerrero JM, Luna A, Rodriguez P, Teodorescu R. Adaptive droop control applied to voltage -source inverters operating in grid-connected and islanded modes. IEEE Transactions on Industrial Electronics. 2009 Oct; 56(10):4088–95.
18. Vasquez JC, Mastromauro RA, Guerrero JM, Liserre M. Voltage support provided by a droop-controlled multifunctional inverter. IEEE Transactions on Industrial Electronics. 2009 Nov; 56(11):4510–8.
19. Guerrero JM, Matas J, de Vicuna LG, Castilla M, Miret J. Output impedence design of parallel-connected UPS inverters with wireless load-sharing control. IEEE Transac-

tions on Industrial Electronics. 2005 Aug; 52(4):1126–34.
20. Pogaku N, Prodanovic M, Green TC. Modelling, analysis and testing of autonomous operation of an inverter-based micro grid. IEEE Transactions on Power Electronics. 2007 Mar; 22(2):613–24.
21. Katiraei F, Iravani MR, Lehn PW. Micro-grid autonomous operation during and subsequent to islanding process. IEEE Transactions on Power Delivery. 2005 Jan; 20(1):248–56.
22. Rodriguez C, Amaratunga GAJ. Analytic solution to the photovoltaic maximum power point problem. IEEE Transactions on Circuits and Systems-1: Regular papers. 2007 Sep; 54(9):2054–9.
23. Koutroulis E, Kalaitzakis K. Design of a maximum power tracking system form wind-energy-conversion applications. IEEE Transactions on Industrial Electronics. 2006 Apr; 53(2):486–93.
24. Dasgupta S, Sahoo SK, Panda SK. Single-phase inverter control techniques for interfacing renewable energy sources with micro grid - Part 1: Parallel-connected inverter topology with active and reactive power flow control along with grid current shaping. IEEE Transactions on Power Electronics. 2011 Mar; 26(3):717–30.
25. Dasgupta S, Sahoo SK, Panda SK, Amaratunga GAJ. Single-phase inverter control techniques for interfacing renewable energy sources with micro grid - Part 2: Series connected inverter topology to mitigate voltage-related problems along with active power flow control. IEEE Transactions on Power Electronics. 2011 Mar; 26(3):732–45.
26. Rath SP. Energy conservation through energy management. IEEMA Magazine; 2008 Jan.
27. Khadeerullah S. Wireless transmission of electric power. Electrical India Magazine; 2008 Jan.
28. Available from: www.nima.com, www.howstuffworks.com, www.wikipedia.com, www.xcelenergy.com/smartgridcity, www.schneider.com, www.powersmiths.com and www.renewableenrgyworld.com