RESEARCH ARTICLE OPEN ACCESS

Assessment of Integrated Control of Micro grid to Regulate Frequency during Multiple Scenarios of Vehicle-to-Grid (V2G) Technology

Jyoti Chhipa [1], Dr. M. K. Bhaskar[2], Manish Parihar[3]
1 ME Scholar, Electrical Department, MBM Engineering College, Jodhpur, INDIA
2 Professor, Electrical Department, MBM Engineering College, Jodhpur, INDIA
3Ph.D Scholar, Electrical Department, MBM Engineering College, Jodhpur, INDIA

Abstract:

A study of micro-grid and constituent components such as solar PV plants, wind plants, diesel generator, Vehicle-to-Grid (V2G) technology and various types of control approaches used for the micro-grid has presented in this research paper. A MG is designed which has the components such as WPP, DG, SPVP, loads (both residential and industrial) and V2G technology. A bidirectional power flow control method has been designed for the Vehicle to Grid (V2G) technology to control the grid parameters during the dynamic states.

Keywords —**Photovoltaic Systems, DC-DC Converters, for Fuzzy Logic based Controller, MPPT**

I. INTRODUCTION

Microgrid (MG) is one of the most effective solutions to integrate renewable generation into power system. However, microgrids also have some limitations, such as increasing renewable energy accommodation, promoting multi-energy complementarity, and improving energy efficiency. Further, incorporation of electric vehicles (EVs) into residential/industrial microgrids (MGs) presents some limitations such as fluctuations in voltage, frequency, and lack of power supply.

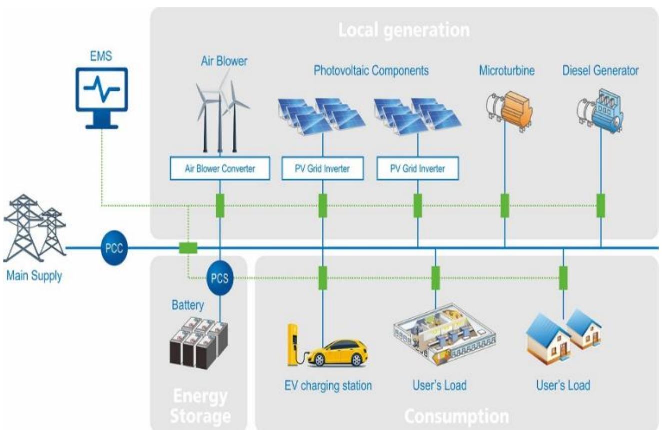

Fig 1 Micro-grid Configuration

A micro-grid (MG) is a localized energy system that operates independently or in conjunction with the main electrical grid. It consists of distributed energy resources (DERs), including renewable energy sources, energy storage systems, and controllable loads. A typical block scheme of MG is elaborated in Fig. 1.

Vehicle-to-Grid (V2G) technology refers to the process of utilizing electric vehicles (EVs) as a means of energy storage and supply, integrating them into the power grid infrastructure. V2G enables bidirectional power flow, allowing EVs to not only consume electricity from the grid but also to deliver excess electricity back to the grid when needed. This concept transforms EVs from simple energy consumers to active participants in the electrical system.

The block scheme of the proposed Micro-grid (MG) used for the study is shown in Fig. 2. It consists of generators two buses namely MG-Bus-1 and MG-Bus-2. MG Bus-1n and MG Bus-2 are connected to each other through a transformer T-MG. MG Bus-1 is operated at 25kV voltage and MG Bus-2 is operated at voltage of 600V.The generators such as solar PV plant (SPVP), a wind power plant (WPP) and a Diesel generator (DG) are connected to MG Bus-1. The load and V2G Technology are connected to MG Bus-2. Microgrid is operated at 60Hz frequency.

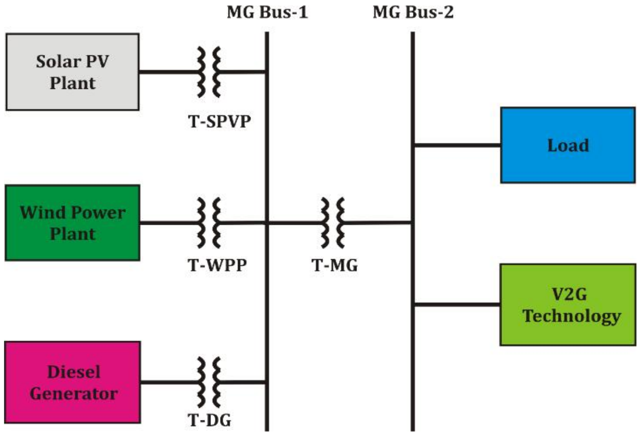

Fig. 2 Block diagram of proposed Micro-grid

II. Design and Implementation of MG and V2G Technology Control

Microgrid is designed in MATLAB using Simulink blocks as per block diagram detailed in Fig. 2. Overview of the connections of all components of MG in MATLAB environment are shown in Fig. 3. The WPP, SPVP, Loads, transformers, and DG are realized using the Simulink models.

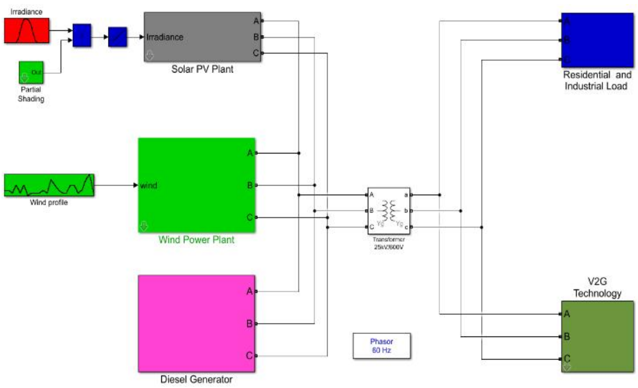

Fig 3 Overview of the connections of all components of MG

Vehicle to grid (V2G) system is proposed to regulate the frequency of Microgrid when events occur on a full day of 24 hour interval. V2G controls the charge of batteries connected to it and uses available power to regulate the when an event occurs during the day. Following five car-user profiles are implemented in this study:-

a) Profile-1: Peoples are going to office with possibility to charge their car batteries at work.
b) Profile-2: Peoples are going to office with possibility to charge their car batteries at work but with a longer ride.
c) Profile-3: Peoples are going to office with no possibility to charge their car batteries at work.
d) Profile-4: Peoples are staying at home.
e) Profile-5: Peoples working in night shift.

The above five different profiles has been simulated and can be modified. The user can set the number of vehicles following each type of profile. The user can also decide the rated capacity, the rated power and the efficiency of the power converter.

The cars of V2G are rated at 40kW and 85kWh with system efficiency of 90%. Since there are 100 cars in all the profiles, hence total rated capacity of the V2G technology is 4MW. Different scenarios are considered for the study with details given in Table I.

TABLE I
Scenarios for Case Study

S. No.	Profile	Number of Cars
		Scenario
1	Profile-1	35
2	Profile-2	25
3	Profile-3	10
4	Profile-4	20
5	Profile-5	10

III. Simulation Results and Discussion

The proposed Microgrid is simulated for the Scenario illustrated in Table I considering 35, 25, 10, 20, and 10 cars in the profile-1, profile-2, profile-3, profile-4 and profile-5 respectively.

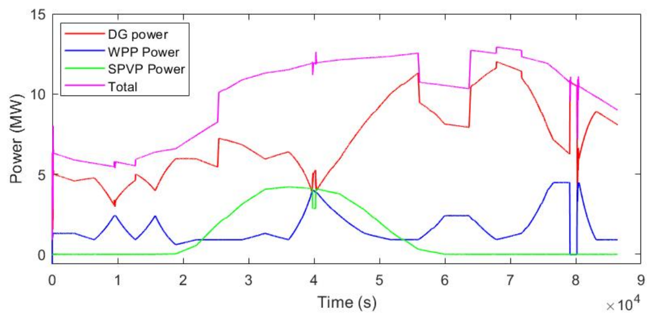

Fig. 4 Power supplied by generators during Scenario

Power supplied by the DG, WPP, SPVP, and total power injected into the MG is recorded and shown in Fig. 4. This is observed that total power is the summation of power supplied by the DG, WPP and SPVP

The pattern of residential load variations and industrial load variations is illustrated in Fig. 5.

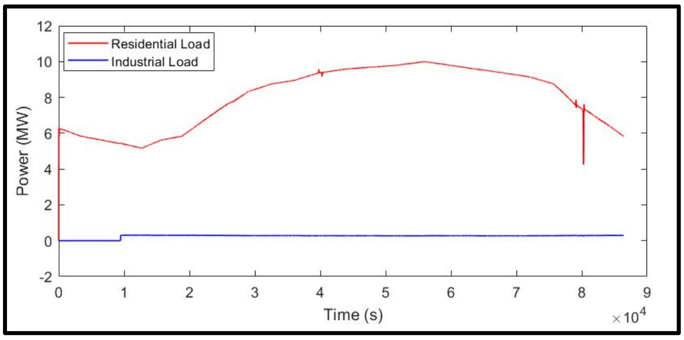

Fig. 5 Industrial and residential load for Scenario

This is observed that industrial load is turned on approximately near 3AM and then continues to take load from the MG. Residential load has maximum value of 10MW and it varies over the entire period of 24 hours. Small magnitude sudden changes are also seen on the load pattern curve.

Frequency of the MG during the Scenario is illustrated in Fig. 6.

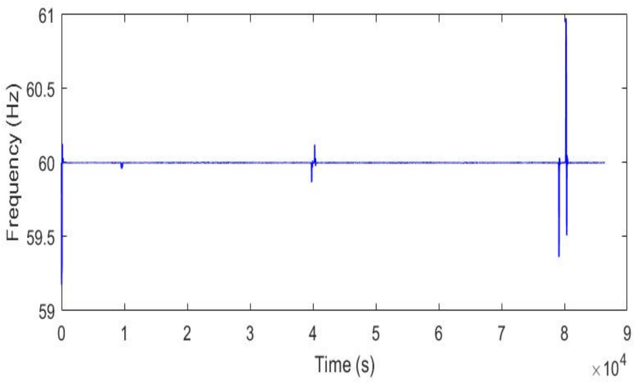

Fig. 6 Frequency for during scenario

This is observed that frequency normally remains at the nominal frequency of 60Hz. However, small magnitude changes have been observed when either the generation suddenly changes or the charging power taken by the V2G Technology changes.

However, the frequency immediately regains the nominal value following a sudden change in the frequency.

The charging and regulation power taken by the V2G Technology from MG during Scenario is shown in Fig. 7. This is observed that charging power taken by the cars of V2G technology changes depending on the profile of cars. Further, regulation power is only taken or supplied depending on the nature of disturbance in the MG.

Hence, it is established that V2G technology is effective to regulate the any sudden or dynamic change in the MG.

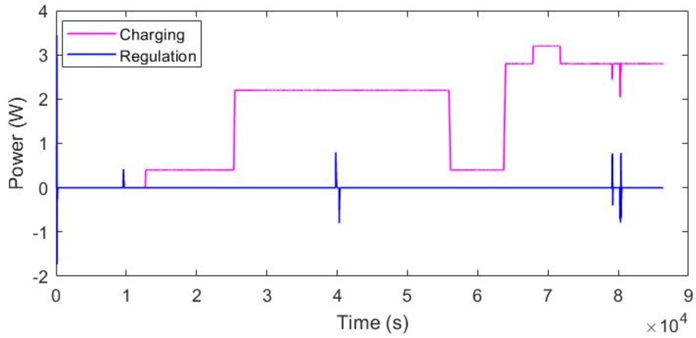

Fig. 7 Charging and Regulation Power of V2G Technology during Scenario

The charging and regulation reactive power taken by the V2G Technology from MG during Scenario is shown in Fig. 8.

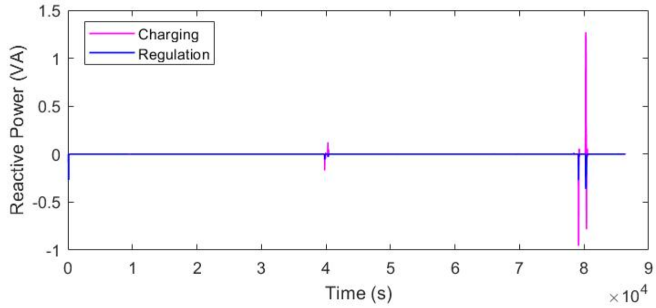

Fig. 8 Reactive power for charging and regulation of V2G Technology during Scenario

This is observed that charging reactive power and regulations reactive power taken or supplied by the cars of V2G technology changes when sudden changes are observed in the pattern of load or generation.

During normal operating conditions, the reactive power exchange is zero. Hence, it is established that V2G technology is effective to regulate any sudden or dynamic change in the MG in terms of reactive power.

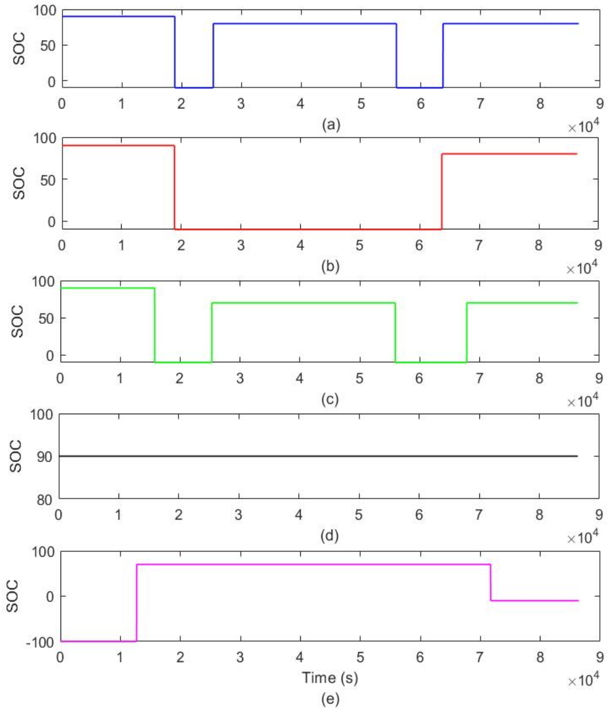

Fig. 9 State of charge during Scenario (a) Profle-1 (b) Profle-2 (c) Profle-3 (d) Profle-4 (e) Profle-5

The state of charge during Scenario for the cars included in Profle-1, Profle-2, Profle-3, Profle-4 and Profle-5 are shown in Fig. 9. This is observed that SOC of cars for Profle-1, Profle-2, Profle-3, and Profle-5 depending on the status of cars. However, SOC for cars included in Profile-4 is constant and equal to 90%. Negative values of SOC indicates that car is on road and not plugged in. Positive values of SOC indicates that cars are plugged in.

CONCLUSIONS

From the result discussion, it is concluded that proposed MG is effective to maintain the load-generation balance. Variations of generation of one generator have been mitigated by the other generators and load variations have been effectively absorbed by the proposed MG with V2G Technology. Proposed control of V2G technology effectively maintained the MG frequency to rated value of 60% with deviation less than 1%. Proposed control of V2G Technology is effective to provide bidirectional power flow depending on the cars in a profile. Profiles of V2G technology have been realized effectively and tested for operating scenario of the profiles.

REFERENCES

1. *Zhengji Meng, Xuekai Hu, Lei Wang, Shaobo Yang, Liang Meng, Hao Zhou, Ziwei Cheng, Tongfei Cui, "Research on internal external collaborative optimization strategy for multi microgrids interconnection system," Energy Reports, Volume 9, Supplement 7, 2023, Pages 1616-1626, https://doi.org/10.1016/j.egyr.2023.04.212.*
2. *Hussein Abubakr, Abderezak Lashab, Juan C. Vasquez, Tarek Hassan Mohamed, Josep M. Guerrero, "Novel V2G regulation scheme using Dual-PSS for PV islanded microgrid" Applied Energy 340 (2023) 121012, https://doi.org/10.1016/j.apenergy.2023.121012*
3. *Nsilulu T. Mbungu, Ali A. Ismail, Mohammad AlShabi, Ramesh C. Bansal, A. Elnady, Abdul Kadir Hamid, "Control and estimation techniques applied to smart microgrids: A review," Renewable and Sustainable Energy Reviews, Volume 179, 2023, 113251, https://doi.org/10.1016/j.rser.2023.113251.*
4. *Babangida Modu, Md Pauzi Abdullah, Mufutau Adewolu Sanusi, Mukhtar Fatihu Hamza, "DC-based microgrid: Topologies, control schemes, and implementations," Alexandria Engineering Journal, Volume 70, 2023, Pages 61-92, https://doi.org/10.1016/j.aej.2023.02.021.*
5. *Qingyu Su, Haoyu Fan, Jian Li, "Distributed adaptive secondary control of AC microgrid under false data injection attack," Electric Power Systems Research, Volume 223, 2023, 109521, https://doi.org/10.1016/j.epsr.2023.109521.*
6. *Manish Parihar, M.K. Bhaskar "Review of Power System Blackout" International Journal of Research and Innovation in Applied Science -IJRIAS vol.3 issue 6 June 2018, pp.08-13 URL: https://www.rsisinternational.org/journals/ijrias/DigitalLibrary/Vol.3&Issue6/08-13.pdf.*
7. *Fei Li, Chang Liu, Jianhua Zhang, Guangsen Guo, Yongdi Chen, Xiaocheng Wei, Resilience optimal control strategy of microgrid based on electric spring, Energy Reports, Volume 9, Supplement 2, 2023, Pages 236-245, https://doi.org/10.1016/j.egyr.2023.02.074.*
8. *Mahdi Sadegh Zarei, Hajar Atrianfar, "A hierarchical framework for distributed resilient control of islanded AC microgrids under false data injection attacks," ISA Transactions, 2023, https://doi.org/10.1016/j.isatra.2023.03.044.*
9. *Zhilin Lyu, Jiaqi Yi, Jian Song, Bin Liu, "Coordinated optimal control and dispatching operation of grid-connected AC/DC hybrid microgrid group," Electric*

Power Systems Research, Volume 221, 2023, 109430, https://doi.org/10.1016/j.epsr.2023.109430.

10. *F. Iraji, V. Azarm, E. Farjah and T. Ghanbari, "A suitable power sharing control of parallel-connected inverters in microgrids," 2017 5th International Conference on Control, Instrumentation, and Automation (ICCIA), Shiraz, Iran, 2017, pp. 313-318, doi: 10.1109/ICCIAutom.2017.8258699.*

11. *F. Alshammari and A. El-Refaie, "Time-Varying Optimization-Based Consensus Control For Microgrid's Secondary Control," 2021 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT), Washington, DC, USA, 2021, pp. 1-5, doi: 10.1109/ISGT49243.2021.9372276.*

12. *"IEEE Draft Standard for DC Microgrids for Rural and Remote Electricity Access Applications," in IEEE P2030.10/D07, April 2020 , vol., no., pp.1-46, 27 July 2020.*

13. *M. U. Mutarraf et al., "A Communication-Less Multimode Control Approach for Adaptive Power Sharing in Ship-Based Seaport Microgrid," in IEEE Transactions on Transportation Electrification, vol. 7, no. 4, pp. 3070-3082, Dec. 2021, doi: 10.1109/TTE.2021.3087722.*

14. *Manish Parihar, M.K. Bhaskar, Dharmendra Jain, Digvijay Sarvate, Deepak Bohra."Voltage Stability Analysis of Power System using Power World Simulator", Volume 5, Issue XI, International Journal for Research in Applied Science and Engineering Technology (IJRASET) Page No: 2508-2515, ISSN : 2321-9653, http://doi.org/10.22214/ijraset.2018.1137*

15. *C. Li, F. de Bosio, S. K. Chaudhary, M. Graells, J. C. Vasquez and J. M. Guerrero, "Operation cost minimization of droop-controlled DC microgrids based on real-time pricing and optimal power flow," IECON 2015 - 41st Annual Conference of the IEEE Industrial Electronics Society, Yokohama, Japan, 2015, pp. 003905-003909, doi: 10.1109/IECON.2015.7392709.*

16. *J. Mírez, "A modeling and simulation of optimized interconnection between DC microgrids with novel strategies of voltage, power and control," 2017 IEEE Second International Conference on DC Microgrids (ICDCM), Nuremburg, Germany, 2017, pp. 536-541, doi: 10.1109/ICDCM.2017.8001098.*

17. *F. Zhang et al., "Advantages and challenges of DC microgrid for commercial building a case study from Xiamen university DC microgrid," 2015 IEEE First International Conference on DC Microgrids (ICDCM), Atlanta, GA, USA, 2015, pp. 355-358, doi: 10.1109/ICDCM.2015.7152068.*

18. *E. Rodriguez-Diaz, E. J. Palacios-Garcia, A. Anvari-Moghaddam, J. C. Vasquez and J. M. Guerrero, "Real-time Energy Management System for a hybrid AC/DC residential microgrid," 2017 IEEE Second International Conference on DC Microgrids (ICDCM), Nuremburg, Germany, 2017, pp. 256-261, doi: 10.1109/ICDCM.2017.8001053.*

19. *K. M. Son, K. Lee, D. -C. Lee, E. -C. Nho, T. -W. Chun and H. -G. Kim, "Grid interfacing storage system for implementing microgrid," 2009 Transmission & Distribution Conference & Exposition: Asia and Pacific, Seoul, Korea (South), 2009, pp. 1-4, doi: 10.1109/TD-ASIA.2009.5356838.*

20. *Y. Guan, B. Wei, J. M. Guerrero, J. C. Vasquez and Y. Gui, "An overview of the operation architectures and energy management system for multiple microgrid clusters," in iEnergy, vol. 1, no. 3, pp. 306-314, September 2022, doi: 10.23919/IEN.2022.0035.*

21. *Kaur A, Kaushal J, Basak P. a review on microgrid central controller. Renew Sustain Energy Rev 2016;55:338–45.*

22. *Deng N, Zhang XP, Wang P, Gu X, Wu M. A converter-based general interface for AC microgrid integrating to the grid. 2013 4th IEEE/PES Innov Smart Grid Technol Eur ISGT Eur 2013. 2013. p. 1–5.*

23. *Planas E, Gil-De-Muro A, Andreu J, Kortabarria I, Martínez De Alegría I. General aspects, hierarchical controls and droop methods in microgrids: a review. Renew Sustain Energy Rev 2013;17:147–59.*

24. *N. Chen, H. Wang, H. Li and D. Xu, "Generic Derivation of Optimal Architecture for A Resilient Microgrid with Graph Theory," 2019 IEEE 10th International Symposium on Power Electronics for Distributed Generation Systems (PEDG), Xi'an, China, 2019, pp. 359-364, doi: 10.1109/PEDG.2019.8807521.*