

Power Quality Optimization in Microgrids Using Genetic Algorithm and Reinforcement Learning

J. Shalini Priya^{1*}, K. Rajesh², Sumathi Franklin³, K. Gunasekaran⁴

¹*Department of Electrical and Electronics Engineering, Sri Sairam Engineering College, Chennai, Tamil Nadu, India.*

²*Department of Mechanical Engineering, Andhra Engineering College, SPSR Nellore, Andhra Pradesh, India.*

³*PG & Research Department of Commerce, Thanthai Hans Roever College (Autonomous), Perambalur, Tamil Nadu, India.*

⁴*Department of Mechanical Engineering, Muthayammal Engineering College (Autonomous), Rasipuram, Namakkal, Tamil Nadu, India.*

**Corresponding author: shalini.eee@sairam.edu.in*

Abstract. In the micro grid (MG) system, the power quality enhancement is established using a new control algorithm in DSTATCOM device as presented in this paper. A micro grid is one of the best ways to solve the before mentioned problems. A MG is specified as a distributor cluster (DGs) and loads that provide heat and power in the region by a central controller. A new technique will mitigate issues like reactive power, harmonics, voltage sag, voltage swell. To resolve the above problems, calculation-based intelligence methods for intuitive energy quality reduction and transient solution problems have been found to be the most efficient. In the proposed system, the unbalanced voltage can be compensated through the voltage source inverter by using the control method of genetic algorithm-based reinforcement learning. The power quality issue which occurs in the micro grid is controlled and the results are verified using in MATLAB/Simulink.

Keywords: Micro grid, DSTATCOM, power quality improvement, controller, power quality issues

INTRODUCTION

The world's energy use is constantly growing with the growing demands of modern day, and hence the population is steadily expanding [1]. Moreover, considering that traditional energy systems are typically fossil fuel-based power stations, increased fuel consumption increases as well, which thus increases greenhouse gases and thereby contributes to greater environmental emissions [2]. A micro grid is one of the best ways to solve the before mentioned problems [3]. A MG is specified as a distributor cluster (DGs) and loads that provide heat and power in the region by a central controller [4]. The DGs are related to one other, with the main grid, by using a non-linear unit, such as a VSI or voltage source converter (VSC) [5]. The main function of power components is to provide a regulated connection between DGs and the central grid for the management of the power sharing ratio between the linked power supply sources, voltage, frequency and desired power sharing [6].

Ensure an acceptable power quality and stable service in all operations of the MG system [7]. The smart and robust control strategy is important in terms of conditions and MG operating modes. The specification of the controller parameters is also a crucial element in deciding the grid system output [8]. Ensure an acceptable power quality and stable service in all operations of the MG system. The smart and robust control strategy is important in terms of conditions and MG operating modes [9]. Some problems in distribution system such as power loss, size of filter and performance of compensation are addressed by the distribution static compensator (DSTATCOM) [10]. At the end of inverter, the LCL filter is utilized to eliminate the switching harmonics when a very small inductor value is used. In this DSTATCOM device the DC link voltage is reduced through the series connection of a capacitor with the inverter front end LCL filter [11]. The DC to AC conversion of power is required in DSTATCOM to compensate reactive power and harmonic distortions, and balancing power in distribution system of three phases [12]. When the main grid is interfaced with micro grid, the power quality maintenance is addressed as an essential aspect.

Received: 08.10.2022 Revised: 28.11.2022 Accepted: 12.12.2022
Licensed under a CC-BY 4.0 license | Copyright (c) by the authors

In the power distribution network, the power quality is degraded due to the nonlinear and unbalanced currents of power converters and the electrical loads [13]. By using inverters that are interacted with grid lines can be achieving the power injection and load compensation in micro grid system. For the power quality improvement, a single inverter system is used which has two operations [14]. The one is compensating active power from the PV system and used as an active power filter which is injecting the reactive power for the connected loads requirement [15].

PROPOSED SYSTEM

STATCOM is a shunt-linked system made up of VSI, small DC link and transformer. This STATCOM operating constraint can be described as: It is designed without the capacity to exchange active power with power system. In the proposed system, at the point of common coupling (PCC) the simultaneous voltage and current compensation which improves the PQ, offered other harmonic sensitive loads [16-18]. The proposed system is consists of distribution system, sensitive linear and nonlinear loads and static synchronous compensator (STATCOM). The basic model of STATCOM is shown in Figure 1.

$$P_{stat} = Re(\vec{V}_s \vec{I}_{sh}^*) = 0 \quad (1)$$

P_{stat} - Active power injection.

V_s - Voltage of STATCOM.

I_{sh} - Injected current.

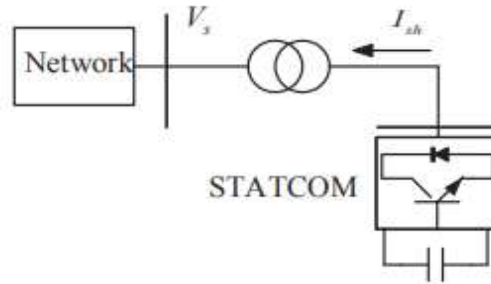


FIGURE 1. Basic Model of the STATCOM

For the dual voltage source inverter compensation, the switching gate signals are provided by the control method of ISCT that using the balanced PCC sinusoidal voltages to achieve the generation of reference current. The voltage in point of common coupling is distorted by the impedance of the feeder. To generate the reference current in distribution network the PCC voltage elements are having extraction in fundamental positive sequence.

ISCT is generally proposed for compensating the nonlinear and unbalanced loads through the active power filter. It has three conditions for load compensation as derived below,

The neutral current of the supply must be zero.

$$i_{as} + i_{bs} + i_{cs} = 0 \quad (2)$$

In between of the source current and positive fundamental sequence phase angle is,

$$\angle v_{ta1}^+ = \angle i_{as}^+ + \phi \quad (3)$$

The real load average power must be supplied by source,

$$v_{ta1}^+ i_{as}^+ + v_{tb1}^+ i_{bs}^+ + v_{tc1}^+ i_{cs}^+ = P_l \quad (4)$$

RESULTS & DISCUSSIONS

The simulation circuit diagram and results are given below. The Simulink model is simulated using MATLAB/ Simulink. In Figure 2 is proposed simulation circuit diagram is mentioned. In Figure 3 represents the input sag voltage. In Figure 4 mention below sag compensation of voltage.

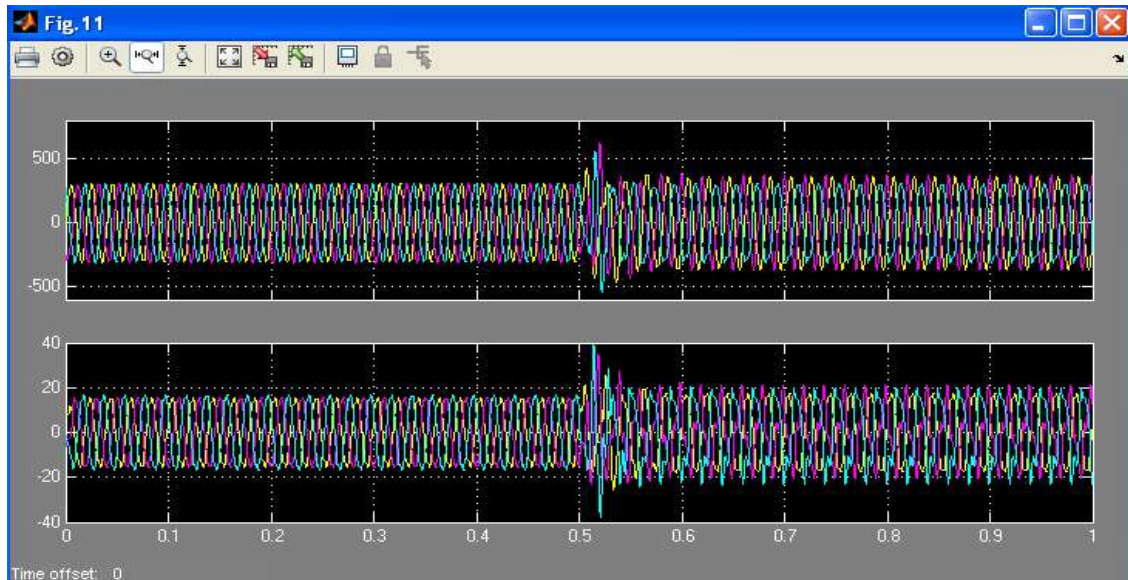


FIGURE 4. Compensated Voltage

In this proposed system, the dual inverters are used to compensate the problems in the power quality of the micro grid tied distribution power network.

CONCLUSION

The three-phase system based STATCOM topology has been analyzed using Matlab/Simulink software. The proposed system consists of distribution system, sensitive linear and nonlinear loads and static synchronous compensator (STATCOM). A MG is specified as a distributor cluster (DGs) and loads that provide heat and power in the region by a central controller. This proposed controller is used to provide the dynamic control of shunt and series multi converter operation of STATCOM for compensation of fault condition with APF filter. In addition, the proposed controller can be adapted to various system configurations and extended to any other FACTS device type. Also, the several devices consider as UPFC and proposed controllers in large power system configuration for achieving optimum power oscillation damping without affecting individual device performance. Here, simulation circuit diagram and results are obtained successfully. Sag compensation of voltage in the transmission system has accomplished. The Simulink model is simulated using MATLAB/Simulink.

REFERENCES

- [1]. C. P. Käsemann, I. Goldstein, C. Jacob, M. Rott and M. Schandrul, 2019, "Extension of the reactive power compensation for the pulsed power supply of ASDEX Upgrade," *Fusion Eng. and Design*, **146**, pp. 714-8.
- [2]. U. C. Chukwu and S. M. Mahajan, 2019, "The Prospects of V2G for Reactive Power Compensation in Electric Distribution Networks," *2019 IEEE Power & Energy Society General Meeting (PESGM)*, pp. 1-5.
- [3]. L. Sun, Z. Zhang, X. Gu, L. Yu and J. Li, 2019, "Analysis of Reactive Power Compensation Effect of a New Hybrid Excitation Brushless DC Generator," *IEEE Trans. on Industrial Electronics*, **67(5)**, pp.3562-3572.
- [4]. H. Cheng, T. Chen, C. Wang, Z. Zhao, Z. Li and Y. Guan, 2019, "Single-Phase Bridgeless Rectifier Based System with Enhanced Capability of Reactive Power Compensation," *IEEE Access*, **13(7)**, pp.181444-181457.

- [5]. J. M. Callegari, M. P. Silva, R. C. de Barros and E. M. Brito, A. F. Cupertino, H. A. Pereira, 2019, "Lifetime evaluation of three-phase multifunctional PV inverters with reactive power compensation," *Electric Power Systems Res.* **175**, pp. 1-71.
- [6]. R Ramaprabha, K Balaji, SB Raj and VD Logeshwaran, 2013, "Comparison of Interleaved Boost Converter Configurations for Solar Photovoltaic System Interface," *The J. of Eng. Res. [TJER]*, **10(2)**, pp. 87-98.
- [7]. D. L. Schultis, A. Ilo and C. Schirmer, 2019, "Overall performance evaluation of reactive power control strategies in low voltage grids with high prosumer share," *Electric Power Systems Res.*, **168**, pp.336-349.
- [8]. P. H. Kadam, 2019, "Review of Power Quality Problem Improvement by Integration of Solar PV Panel and DFIG Wind Farm System with UPQC", *International Research Journal of Engineering and Technology (IRJET)*, **06(09)**, pp.1903-1905.
- [9]. V. V. Reddy, D. A. Kumar and V. R. Kota, 2019, "A multilevel UPQC for voltage and current quality improvement in distribution system," *Int. J. of Power Electronics and Drive Systems*, **10(4)**, pp.1932-1943.
- [10]. G. Galma, and B. Pattanaik, 2019, "Current fed switched inverter using sliding mode controller (SMC) for grid application," *Int. J. of MC Square Sci. Res.*, **11(4)**, pp. 34-43.
- [11]. V. H. Babu and K. Balaji, 2020, "Survey on Modular Multilevel Inverter Based on Various Switching Modules for Harmonic Elimination," *Intelligent Computing in Eng., Springer, Singapore*, pp. 451-458.
- [12]. X. Zhou, W. Zhong, Y. Ma, K. Guo, J. Yin and C. Wei, 2021, "Control Strategy Research of D-STATCOM Using Active Disturbance Rejection Control Based on Total Disturbance Error Compensation," *IEEE Access*, **9**, pp. 50138-50150.
- [13]. S. Mishra, S. K. Dash, P. K. Ray and P. S. Puan, 2021, "Analysis and experimental evaluation of novel hybrid fuzzy-based sliding mode control strategy for performance enhancement of PV fed DSTATCOM," *Int. Trans. on Electrical Energy Systems*, **31(1)**, pp: 1-21
- [14]. A. Mahyavanshi, and M. A. Mulla, "Application of DSTATCOM for Voltage Sag and Reactive Power compensation Using MISC Control Strategy", *1st Int. Conf. on Emerging Trends in Eng. and Multidisciplinary Res.*, pp.95-100.
- [15]. Z. A. Fouad, "DSTATCOM Based on Artificial Intelligence for Voltage Profile Improvement," *J. of Soft Computing and Artificial Intelligence*, **2(1)**, pp. 41-55.
- [16]. S Murugan, TR Ganesh Babu and C. Srinivasan, 2017, "Underwater Object Recognition Using KNN Classifier," *Int. J. of MC Square Sci. Res.*, **9(3)**, pp. 48-52.
- [17]. R, Pandiaraj, and R. R. Hemamalini, 2020, "Enhancement of Power Quality Using Fuzzy Logic Controlled DSTATCOM," *Int. J. Adv. Sig. Img. Sci.*, **6(1)**, pp. 21–28.
- [18]. M. Paul, and D. Vineeth Kumar, 2022, "Model Based Predictive Control Strategy for Grid-Connected Wind Energy System," *Int. J. Adv. Sig. Img. Sci.*, **8(1)**, pp. 1–8.