ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

Design and Implementation of STATCOM for Reactive Power Compensation and Voltage Fluctuation Mitigation in Microgrid

K.Prasath[1], M.Murugan, M.E.[2],

M.E. Power Systems Engineering, Department of Electrical and Electronics Engineering, Mother Terasa College of Engineering and Technology, Mettusalai, Illuppur, Pudukkottai (dt), Tamil Nadu, India.

Assistant Professor, Department of Electrical and Electronics Engineering, Mother Terasa College of Engineering and Technology, Mettusalai, Illuppur, Pudukkottai (dt), Tamil Nadu, India.

ABSTRACT: The main objective of this system is to reduce the voltage stress and unbalancing occurred due to windings into the power transformer. The intention of this system is to improve the transformer winding strategies using Winding Tap Injection (WTP) for medium voltage reactive power compensation. Power transmission through the transformer creates certain issues such as voltage stress, voltage unbalancing, harmonics distortions and so on. These all happened because of improper windings present into the transformer unit. In this proposed approach, Cascaded Multilevel Converter (CMC) based DSTATCOM is connected to the special designed winding taps on the primary windings of the transformer instead of the conventional Point of Common Coupling (PCC). For all the entire nature of work proves that the Voltage Stress is highly reduced because of winding problems. The proposed solution for compensation of reactive power and minimize voltage fluctuations is a static synchronous compensator (STATCOM) on AC bus of the microgrid. It includes a 2-level voltage source inverter(VSI) with a capacitor bank in DC link. It is embedded with grid synchronizing control system and DC link capacitor voltage regulating control system. The STATCOM is simulated with the existing architecture of COEP-microgrid and results of the same are discussed. This system also describes implementation of the designed STATCOM and its response in various microgrid scenarios.

KEYWORDS: Automatic Power Control, STATCOM, Microgrid, Grid-Tie Inverter, Voltage Control.

I. INTRODUCTION

COEP microgrid has a AC-bus and DC-bus, interconnected together with a tie line DC -AC converter. AC-bus is connected to wind power plants, pico-hydro plant, local AC-loads and to the electricity grid with an islanding scheme. Power quality on AC bus has to be maintained in both the modes of operation of microgrid (islanded and non-islanded). Sudden islanding of utility grid creates significant voltage disturbances on AC bus. The AC bus has grid tie inverters , AC-DC-AC converters, conventional synchronous generators as the sources supplying dynamic real power loads as well as reactive power loads. Supply of reactive power reduces the maximum amount of real power that can be supplied by the sources thereby resulting into poor utilization of their capacity. This provokes need of dynamic reactive power source on AC bus. STATCOM and SVC both are Flexible AC Transmission System (FACTS) devices that can be used for addressing the described problem. STATCOM has a better response time and better transient stability compared to SVC. This makes STATCOM an ideal choice for COEP microgrid. Fast acting STATCOM is a promising

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

technology being extensively used as the state-of-the-art dynamic shunt compensator for harmonic and reactive compensation in transmission and distribution system.

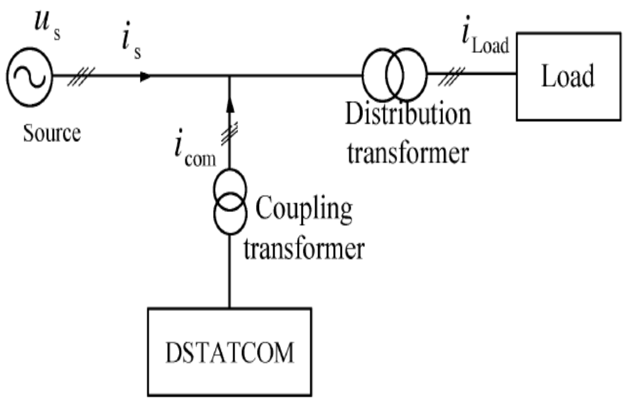

Fig.1. DST A TCOM connected through coupling step-down transformer

For transmission type static synchronous compensator, the converters are always designed for operation at Medium Voltage (MV) level and connected to Extra High Voltage (EHV) or High Voltage (HV) bus via a semicustom coupling transformer. For distribution STATCOM (DSTATCOM) systems, they are connected to the MV distribution or load bus either directly or via a set-up, semicustom coupling transformer limited by the high voltage stress for switching devices. In order to achieve further reduction of the voltage stress across the semiconductor devices, cascaded multilevel converters have been studied to realize a small and lightweight ST A TCOM. Since the cascade converter realizes high blocking voltage and low-harmonic output voltage, it needs no step-down transformers for medium voltage applications. However, the large number of cells in series makes the control system complicated and the whole system expensive for custom to afford.

Therefore, the solution of DST ATCOM connected to the system through a coupling transformer is more popular. However, the additional coupling transformer increases the power losses. To find a compromise solution, an integration of Voltage Source Converter (VSC) with the existing distribution transformer is presented in earlier systems. However, a extended delta wiring is adopted to connect the inverter and the major object is to achieve harmonic elimination, which is not suitable for the connection of cascaded multilevel converter. In addition, ST ATCOMs integrated with zig-zag transformer or star/hexagon transformer to realize reduced rating VSC are proposed in earlier systems. The transformer is mainly used to handle zero-sequence current component and deal with three phase unbalance in low voltage distribution network, which is not suitable for high capacity reacti ve power compensation applications. In earlier systems, a fundamental magnetic flux compensation method is proposed, and VSC is connected to the secondary windings of the transformer to achieve active power filter. The method is essentially low voltage compensation. Further, STATCOM integrated with Distribution Transformer (DT-STATCOM) was first proposed in earlier systems.

A. Existing System - Research Summary

In past systems, many types of transformer winding models are designed; all are having certain issues in certain level of applicability. These types of winding based transformer designs are suitable for centralized reactive power compensation in medium voltage (MV) or high voltage (HV) systems. However, the coupling transformers are nearly forty percent of the total weight and its losses can be nearly half of the total losses, which make it less favorable

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

than transformer-less structure. So this kind of systems is only suitable for decentralized compensation. The existing system contains several disadvantages; some of them are listed below: (a) Practical complexities are more in the implementation level, (b) Cost wise so high in experimental units, (c) Performance is comparatively low and takes more and more time for processing, and (d) Usage and need of Static Compensation is so high.

B. Proposed System Summary

In the proposed system, Cascaded Multilevel Converter (CMC) based DSTATCOM is designed with winding taps on the primary windings of the transformer instead of using the conventional Point of Common Coupling. The power transformer is used as the coupling transformer at the same time and the rated voltage of DSTATCOM is reduced, which is helpful to reduce the cascaded count and obtain a lower dc-link voltage.

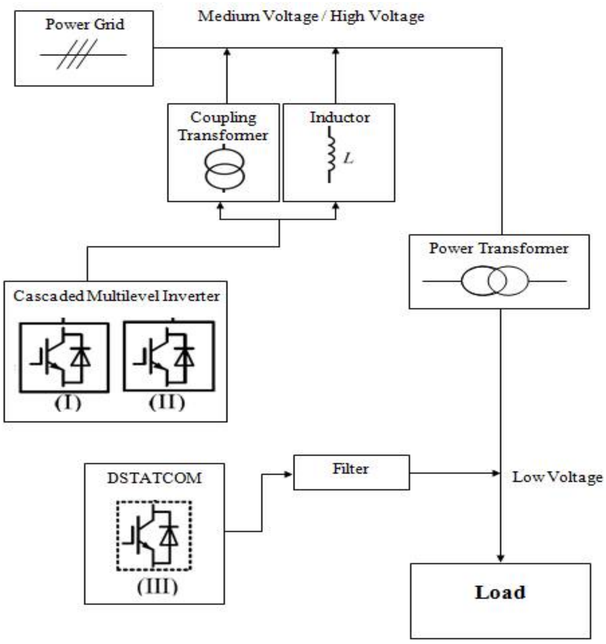

Fig.2 Block Diagram

The capacity utilization of the transformer is also improved. By using the operations of PI Controller, the robustness are enhanced and the design and tuning process are simplified. The proposed system contains several advantages; some of them are listed below: (a) Practical complexities are highly reduced in the implementation level, (b) Low Cost requirement in experimental units, (c) Performance is high and takes less time for processing and (d) Usage and need of Static Compensation is highly reduced.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

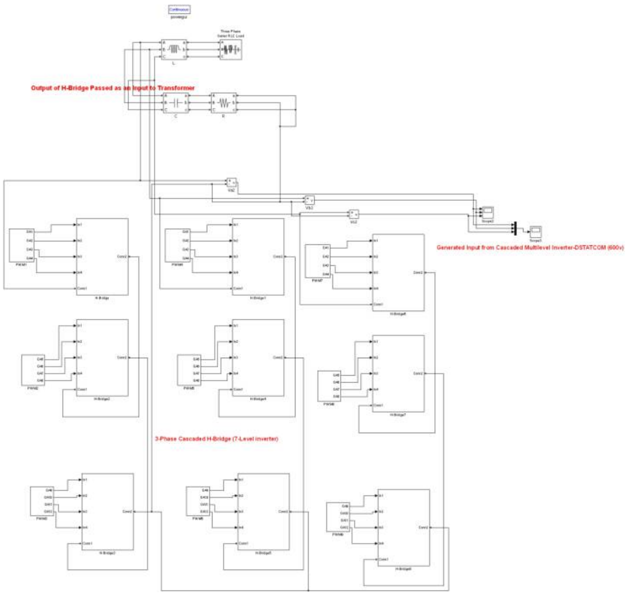

Fig.3 Circuit Diagram

II. LITERATURE SURVEY

In the year of 2010, the author "Balaguer I.J." proposed a paper titled "Control for Grid-Connected and Intentional Islanding Operations of Distributed Power Generation" in that he described such as: Intentional islanding describes the condition in which a microgrid or a portion of the power grid, which consists of a load and a distributed generation (DG) system, is isolated from the remainder of the utility system. In this situation, it is important for the microgrid to continue to provide adequate power to the load.

Under normal operation, each DG inverter system in the microgrid usually works in constant current control mode in order to provide a preset power to the main grid. When the microgrid is cut off from the main grid, each DG inverter system must detect this islanding situation and must switch to a voltage control mode. In this mode, the microgrid will provide a constant voltage to the local load. This paper describes a control strategy that is used to implement grid-connected and intentional-islanding operations of distributed power generation. This paper proposes an intelligent load-shedding algorithm for intentional islanding and an algorithm of synchronization for grid reconnection.

In the year of 2012, the author "Majumder R." proposed a paper titled "Reactive Power Compensation in Single-Phase Operation of Microgrid" in that he described such as: a coordinated control of distributed generators (DG) and distribution static compensator (DSTATCOM) in a microgrid is proposed in this paper. With high penetration of distributed sources and single-phase operation of the system, voltage unbalance can often go beyond the acceptable limit. With the feeders geographically spread out, it is not always possible to achieve reactive compensation at optimum location with the three-phase devices.

In this paper, a simple control strategy for DSTATCOM with communication in loop is proposed. The proposed reactive compensation technique is based on the voltage sag and the power flow in the line. The power flow and the voltage at different locations of the feeders are communicated to the DSTATCOM to modulate the reactive compensation. The single-phase DSTATCOM compensates for the reactive power deficiency in the phase while the DGs supply "maximum available active power."

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

During reactive power limit of the DG, the "maximum available active power" is fixed to a value lower than maximum active power to increase reactive power injection capability of the DGs. A primary control loop based on local measurement in the DSTATCOM always ensures a part of reactive compensation in case of communication failure. It is shown that the proposed method can always ensure to achieve acceptable voltage regulation. The data traffic analysis of the communication scheme and closed-loop simulation of power network and communication network are presented to validate the proposed method. In the year of 2009, the authors "Mehrdad Ahmadi Kamarposhti, Mostafa Alinezhad" proposed a paper titled "Comparison of SVC and STATCOM in static voltage stability margin enhancement" in that they described such as: One of the major causes of voltage instability is the reactive power limit of the system.

Improving the system's reactive power handling capacity via Flexible AC transmission System (FACTS) devices is a remedy for prevention of voltage instability and hence voltage collapse. In this paper, the effects of SVC and STATCOM in Static Voltage Stability Margin Enhancement will be studied. AC and DC representations of SVC and STATCOM are used in the continuation power flow process in static voltage stability study. The IEEE-14 bus system is simulated to test the increasing loadability. It is found that these controllers significantly increase the loadability margin of power systems.

III. EXPERIMENTAL RESULTS

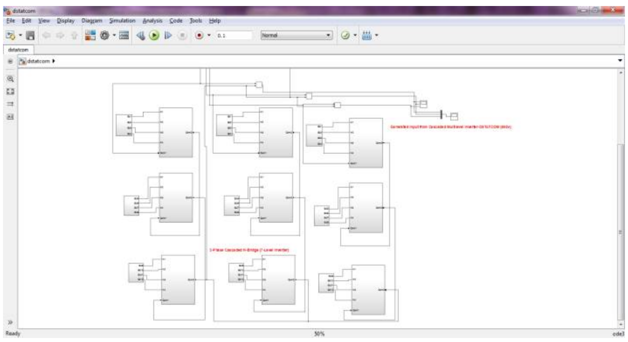

Fig.4 Phase Cascaded H-Bridge

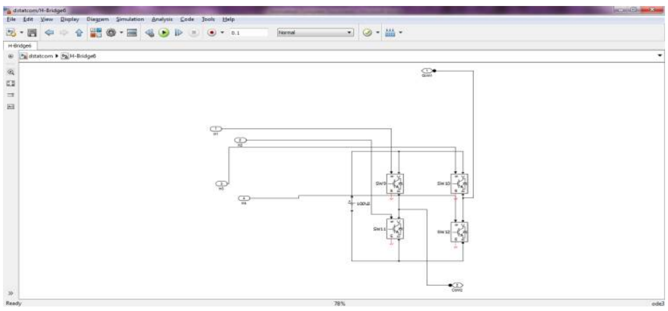

Fig.5 IGBT Configuration over H-Bridge Circuit

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

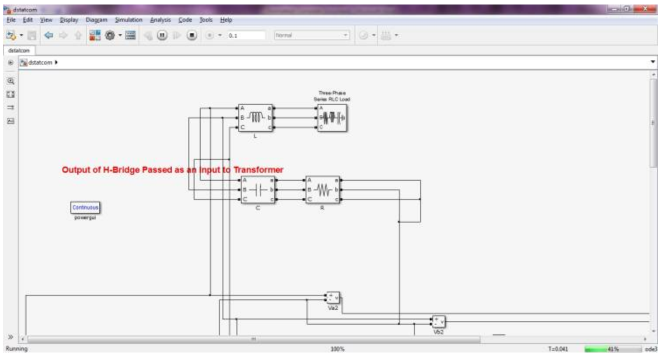

Fig. 6 RLC Circuit Design

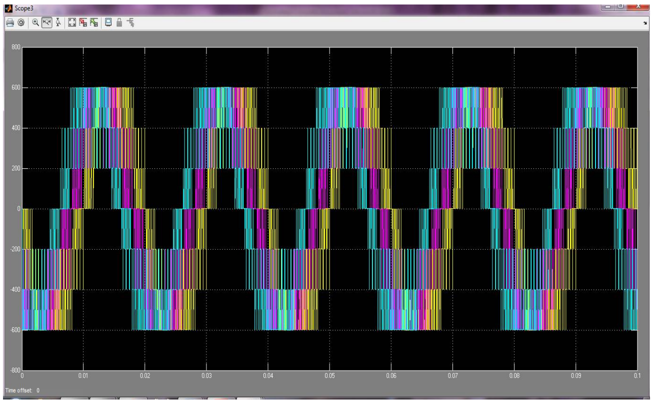

Fig.7 3-Phase High Voltage AC

IV. CONCLUSION AND FUTURE SCOPE

This system also describes the application of STATCOM in a microgrid with islanding scheme. STATCOM is designed for the reactive power compensation of microgrid and AC bus voltage regulation. STATCOM is simulated along with the microgrid in MATLAB to observe and improve transient response of the controls to dynamic loading and islanding scenarios. Designed control strategy responds to AC bus voltage fluctuations and configures STATCOM to throw dynamic reactive power accordingly. During sudden excessive reactive power demand, inspite of presence of control strategy, capacitor DC link voltage shows significant voltage droop before settling to the reference value. This dictates need for a better control strategy. In this system, a Cascaded Multilevel Converter (CMC) based DSTATCOM is designed with winding taps on the primary windings of the transformer. The viability and effectiveness of the proposed WTI-DSTATCOM system have been verified by both simulation and laboratory prototype experiment results, in which it can achieve a good reactive power compensation performance and fast dynamic response. The capacity utilization of the transformer is improved. Therefore, it is a cost-effective solution for medium voltage reactive power compensation. The proposed system guarantees the low harmonics distortion and voltage stress level is highly eliminated.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 5, May 2018

REFERENCES

[1] Balaguer I.J. ; Dept. of Electrical Eng. , Michigan State Univ. , East Lansing, MI, USA ; “Control for Grid-Connected and Intentional Islanding Operations of Distributed Power Generation” IEEE Transactions on Industrial Electronics, vol. 58, No. 1 , Dec. 2010.
[2] Majumder R. ; ABB Corp. Res., Vasteras, Sweden, “Reactive Power Compensation in Single-Phase Operation of Microgrid” IEEE Transactions on Industrial Electronics, vol. 60, No. 4 ,Nov. 2012.
[3] Mehrdad Ahmadi Kamarposhti, Mostafa Alinezhad, “ Comparison of SVC and STATCOM in static voltage stability margin enhancement ”, World Academy of Science, Engineering and Technology Vol:3 2009-02-20
[4] Hingorani, N. ; Gyugyi, L. ; Understanding FACTS:Concepts and Technology of Flexible AC Transmission Systems , Chapter 5 :Static Shunt Compensators: SVC and STATCOM , Page(s): 135 - 207 , Copyright Year: 2000
[5] Jamal Alnasseir “Theoretical and Experimental Investigations on Snubber Circuits for High Voltage Valves of FACTS Equipment for Over Voltage Protection” Master Thesis Project Erlangen 2007.
[6] Pranesh Rao and M. L. Crow, “STATCOM Control for Power System Voltage Control Applications” IEEE Transactions on Power Delivery, vol. 15, NO. 4, October 2000.
[7] Madhusudan,Sir C.R. Reddy College ,Ramamohan Rao, “Modeling and simulation of a distribution STATCOM (D-STATCOM) for power quality problems-voltage sag and swell based on Sinusoidal Pulse Width Modulation (SPWM)” IEEE Transactions, March 2012.
[8] Li D, Chen Q, Jia Z, et al. "A Novel Active Power Filter With Fundamental Magnetic Flux Compensation," IEEE Transactions on Power Delivery, vo1.l9 no.2, pp.799-805 , 2004.
[9] Li D, Chen Q, Jia Z, et al. "A High-Power Active Filtering System With Fundamental Magnetic Flux Compensation," IEEE Transactions on Power Delivery, vol.21 no.2, pp.823-830, 2006.
[10] Wang, C , et aI. , " A Novel Compensation Technology of Static Synchronous Compensator Integrated With Distribution Transformer, " IEEE Transactions on Power Delivery, vol. 28, no.2, pp. 1032-1039, 2013.
[II] M. J. Heathcote, J&P Tran~former Book, 12th ed. Oxford, U.K.: Reed Educational and Professional Publishing Ltd., 1998.
[12] L.J. Cui, E.T. Du, Theory and Calculations of Transformer, Beijing: China Machine Press, pp. 96, 1983. (in Chinese)
[13] C. Kumar and M. K. Mishra. “An improved hybrid DSTATCOM topology to compensate reactive and nonlinear loads,” IEEE Transactions on Industrial Electronics, vol. 61, no.12, pp. 6517-6527, Dec. 2014.
[14] S.Hu, Y. Li, B. Xie, M. F. Chen, et al.. “A Y-D multifunction balance transformer-based power quality control system for single-phase power supply system,” IEEE Transactions on Industry Applications, vol. 52, no.2, pp. 1270-1279, Mar.-Apr. 2016.
[15] S,J. Hu, , Z. W. Zhang, Y.H. Chen, et al.. “A new integrated hybrid power quality control system for electrical railway,” IEEE Transactions on Industrial Electronics, vol. 62, no.10, pp. 6222-6232, Oct. 2015.