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ENHANCEMENT OF VOLTAGE PROFILE IN DISTRIBUTION NETWORKS THROUGH PV-BASED HARMONICS SCHEME AND VSC-BASED STABILITY DSTATCOM

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ABSTRACT

The power system today are confused networks with hundreds of generating stations and load hubs being interconnected through power transmission lines. The power system is a nonlinear system that operates in a continually changing environment, load, generator outputs, topology, and critical operating parameters change continuously. When controlled to a transient disturbance, the stability of the system depends on the nature of the interference as well as the initial working condition. The interruption can be small or large. A slight interruption in the form of load changes occurs continuously, and the system adjusts to changing conditions. The system must be able to operate correctly under these conditions and successfully met the load demand.

The objective of this Paper is to study the DSTATCOM and to improve the power quality so that it maintains Voltage magnitude close to nominal value by compensating the required amount of current to the distribution system from the storage element through DSTATCOM. The compensation resulting from the operation of the DSTATCOM is to be investigated.

Keywords: DSTATCOM, Grid, Topology, Optimization, Reactance.

I. INTRODUCTION

Economies of developed countries are generally influenced by rapid advances in energy system technologies. Electricity is a key input for the fast economic growth of any nation. The transmission and distribution networks are an essential link between power generation and energy consumption or utilization. The technology sophistication presently available does not match the consumer's power quality and reliability demands effectively. Transmission and distribution congestion make a centralized grid inefficient and less reliable. In addition to this, there is an increased risk of failure with increased peak demand. These factors added to increased power consumption due to population growth further stretch the traditional grid to its limits, raising severe concerns on the economic impact of blackouts and interruptions being seen today. While most recently, the Indian grid failure has affected half of the country with millions hit by power cut caused by excessive power absorption, leading to massive snags in rail transport and medical facilities. Smart energy devices lead to grid transformation, which has provided the chance of enhancing the efficiency of the grid at reduced tariffs.

It is also responsible for green i.e., clean power generation. In smart energy, the main concept is communication, which entails basically digital information technology to be used in different applications to power system network optimization. Whereas, a smart grid which is a commonly heard today, is the application of such topology for generation, transmission and distribution of electricity through its various building blocks like efficient meters, intelligent control devices and most importantly a communication system that enables a consumer to provide excess energy back to the grid.

A distribution system is an interface between bulk power and custom powers, which maintains a balance between two for the maintenance of continuous healthy operation of our system. The control of the distribution system usually means a system that is capable of enhancing the overall system efficiency by considering features like loss reduction and power quality control. In recent years, some of the distribution side equipment such as transformers, capacitor banks, synchronous machines, static volt-ampere reactive compensators (SVCs) and other compensating FACTS devices including DSTATCOM is applied for such controls. However, there are various challenges faced by the system with respect to smart-grid de-centralizing function which affects the power system, such as voltage and reactive power compensation (now known as Volt-VAR optimization), power factor correction (PF), distribution system automation (DSA), phase current balancing, low loss transformers (for efficiency improvement), small loss transformers and some energy storage facilities (at the consumer side).

For understanding power quality issues, we classify losses of distribution lines and transformers into resistive and reactive components. Among these losses, resistive losses cannot be avoided at any cost, while reactive power losses which arise from capacitive and inductive circuit properties (should cancel each other) can be avoided. But the increase in demand for reactive power at the load side increases the amount of current flowing through lines being responsible for energy losses. Distribution sides transformers often work at higher efficiency, almost 97% result negligible core losses are produced. However, total losses of transmission and distribution system together constitute 9% of the total losses from generation to the consumer's end. Another effect of significant current waveform distortion is caused because the utility supply has a finite impedance. The distorted current produces a voltage distortion due to the simple V=IR effect. This type of voltage distortion can, in turn, seriously affect other products powered from the same utility outlet. Various academic groups in the world are presently doing research into the control of DSTATCOM to remove power quality problems. In particular, with the evolution of the current wave of smart grid, many multinational electricity companies are taking an interest in DSTATCOM technologies with the hope of integrating such with the smart grid. These companies are Hitachi Europe, ABB, S & C Electric Company, GE, Schneider, and Siemens. Addressing the issues of Volt-VAR compensation & harmonic elimination aspect of solving the PQ problems at the distribution network is the theme of the present work.

II. LITERATURE SURVEY

Narain G. Hingorani. has explained the fundamentals of FACTS gadgets. All varieties of compensation devices that are connected in series, shunt, or both were covered. It recommended using FACTS devices in every field related to electrical energy. Power semiconductor devices increase the value of electricity by providing high speed, reliable switches and a variety of circuit configurations. This book gives readers a basic understanding of FACTS devices in depth. This book covers the fundamentals of compensating techniques as well as DSTATCOM.

Arindham Ghosh. has described all the power quality related problems arise in existing power system. Main problem of power quality is due to the use of power electronics devices. It describes basics of harmonics and there effects in the existing power supply. This book also describes the basic principle of DSTATCOM and use of it in different modes along with the effect of PQ problems on grid and there effects.

H. Akagi et al. have explained basic theory of active filters (shunt and series). In this book, basic concept of control scheme is also discussed. Along with basic concept role of other controllers are also described.

Kalyan K Sen. have described theory and modeling technique of FACTS device STATCOM using electromagnetic transient program simulation. This paper explains working of solid state VSI. This paper also verifies the function of STATCOM model by regulating reactive current flow through the tie line.

Dong Ju Lee et al. have described the simulation of STATCOM in this paper. Along with simulation part, this paper shows that STATCOM is better in continuous control of reactive power flow from other devices like SVC. This paper explains basic principle of STATCOM. It also verifies the basic operating characteristics by simulation.

Tariq Masood et al. have presented an analysis of STATCOM behavior against SVC controller. In this paper some operating parameters like stability, response time power losses and capability of real and reactive power exchange of STATCOM is compared with SVC. This paper concluded that STATCOM than SVC in improving transient stability.

Dong Shen et al. have analyzed performance of STATCOM under distorted system voltage. In this paper of STATCOM is done by per-unit mathematical model under system voltage. This paper showed 3-D curves to reveal relationship between main circuit parameters.

S. H. Hosseini et al. have described STATCOM as a synchronous condenser. In this paper transmission capacity and transient stability of system is increased by STATCOM. For validation of STATCOM performance, a 230kV line for a two machine transmission system is used as a system.

Wang Chao et al. have presented exact method of non-linear control to linearize then on-linear equations of STATCOM. In this paper, comparison of STATCOM operation under state control and using PI controller is compared.

M. Tavakoli Bina et al. have introduced average circuit model for STATCOM. This average circuit model produced mush faster simulation than produced by their exact models. This model is checked on both PSPICE and MATLAB environment to validate its performance.

Javid Akhtar et al. have presented status of active power based on power electronics devices. In this paper description of PQ problems is described and role of active power filters for mitigation of PQ problems is defined. A comparison of active filters to that of conventional techniques is also discussed.

Boon Teck Ooi et al. have implemented a novel topology for STATCOM control operation. Advantage of this topology is direct voltage control by controlling gating pattern and reduction in dc bus capacitor. Order of dominant harmonics is also high, which can be filter easily.

Jianye Chen et al. have proposed a STATCOM where thyristor used as switching device. This paper showed thyristor based VSC can supply reactive power also by firing angle.

III. METHODOLOGY

Voltage fall/dip at load terminals is one of the many prevalent issues with power quality that exist today. When the operating voltage falls below its actual rating because of the load's excessive reactive power consumption, this is known as a voltage dip. The functioning of sensitive loads will be impacted by voltage fall, which will lower system performance. Voltage dip is a three-phase phenomenon that affects both the phase-to-ground and phase-to-phase voltages in a three-phase system. A breakdown in the customer's building, an issue with the utility system, or a significant spike in the load current—such as when a motor or transformer is turned on can also result in a voltage dip.

Increased power quality is the driving force for today's advanced industry. Consumer consciousness regarding reliable power supply has progressed enormously in the last decade. This has led to an additional boost to the development of small distributed generation (DG). Small isolated DG sets have the ability to feed local loads and thus leads to improvement in the reliability of power with low capital assets. These systems are also gaining increased significance in isolated areas where transmission using overhead conductors or cables is unrealistic or prohibitive due to high cost and other circumstances. Small generation systems in rural areas, islands, hilly terrains, marine plants, aircraft, etc. can be efficiently utilizing even in developing kingdoms.

However, these DG sets possibly will have to be de-rated if induction motor loads are instantaneously started. One useful choice is to use DSTATCOM in shunt configuration with the primary system so that the full capacity of producing sets is efficiently consumed. DSTATCOM contains a voltage source converter (VSC), and it internally generates the required capacitive and inductive reactive power. Its control is identical fast and has the ability to provide adequate reactive power compensation to the system to which it is connected.

Before DSTATCOM, Thyristor based systems were proposed for reactive power compensation and were used for voltage flicker reduction due to arc furnace loads. However, due to the disadvantages of passive devices such as fixed compensation, large size, the possibility of resonance, etc., the use of original compensators such as DSTATCOM is growing to solve these power quality problems. The method of DSTATCOM for solving power quality problems due to voltage fall/dip, flickers, swell, etc., has been suggested. The purpose of DSTATCOM is to provide efficient voltage regulation at the point of standard coupling (PCC) and thus prevent significant voltage dips.

3.1 Voltage sag and factors creating of voltage sag

3.1.1. Voltage sag

When the operating voltage falls below its actual rating because of the load's excessive reactive power consumption, this is known as a voltage sag. System performance will suffer as a result, as sensitive loads will not function as intended.

Low voltage profiles, large reactive power flows, insufficient reactive support, and heavily loaded systems are the primary signs of voltage sag. Low-probability single or multiple contingencies often cause the collapse.

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Collapses frequently result in protracted system restoration times and prolonged supply outages for sizable customer bases. Plans designed to reduce sag must identify the signs of impending collapse early enough to take corrective action.

3.1.2 Factors creating voltage sag:

3.1.2.1. Short circuit faults

The most significant impact on voltage is caused by three-phase short circuits, both symmetrical and unsymmetrical. As shown in Fig. 1, the voltage divider prototype can be used to calculate the amount of voltage sag in the distribution system's radial model. The source impedance at the point of universal coupling (PCC) is represented by impedance $Z\mathbf{G}$ in this figure, and the impedance that connects the PCC to the fault point is represented by ZF.

$$V_{sag} = \frac{Z_F}{Z_F + Z_s}$$

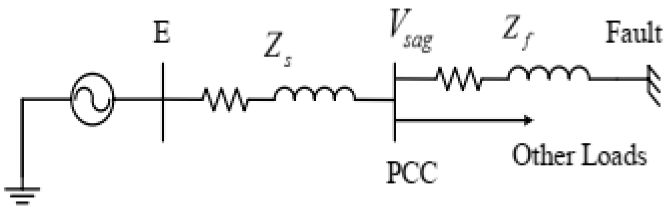

Figure 1: Voltage divider model for computing voltage sag in a radial distribution system

3.1.2.2. Distribution Transformer Energization

The distribution transformer draws its inrush current from the network when it is energised. First massive, the inrush current gradually decays to the small magnetising current after some time. Fig. 2 illustrates the equivalent of a single transformer and shows how to calculate the maximum value of the inrush current and the resulting voltage sag. The maximum inrush current (II) of Fig. 2 should not be greater than the following current.

$$I_{inrush\,max} = \frac{1}{X + X_P + X_{C,min}} E$$

where the source impedance is denoted by X. The minimum magnetising reactance of the transformer is represented by the venin reactance at the bus of the energised transformer and XC,in. Usually, the impedance XC,in is equal to $2(XP + XS)$ or $2XT$. Additionally, it is assumed that XT, which can be found on the transformer nameplate, represents the sum of the primary and secondary leakage reactances.

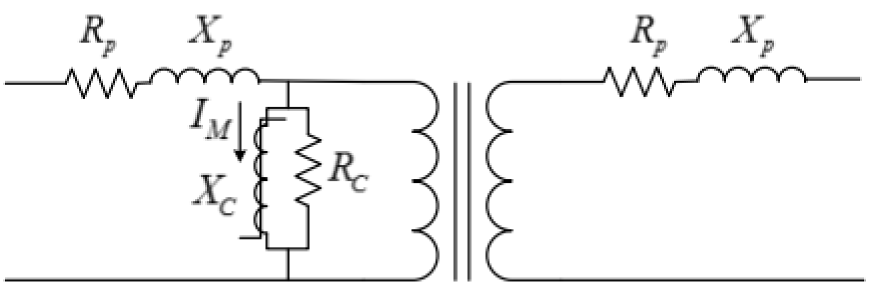

Figure 2: The equivalent circuit of the Transformer for the study of voltage sag

3.2 SOLAR POWER

The photovoltaic (PV) generation systems are estimated to increase significantly globally. PVs are a pretty source of renewable energy for distributed metropolitan power generation due to their relatively small size and noiseless procedure. PV generating technologies have the improvement that more units can be added to meet load increase demand. The basic block diagram of the grid connected PV, power generation system, is shown in Fig. The PV power generation system consists of the following major blocks:

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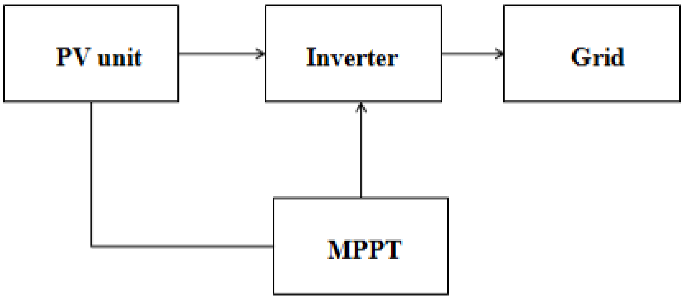

Figure 3: Schematic diagram of PV system

PV unit: A PV unit consists of a number of PV cells that convert the energy of light directly converted into electricity (DC) using the photovoltaic effect.

Inverter: Inverter is used to convert the DC output of the PV unit to AC power.

Grid: The output power of the inverter is given to the nearby electrical grid for power generation.

MPPT: In order to utilize the maximum power produced by the PV modules, the power conversion equipment has to be equipped with a maximum power point tracker (MPPT).

It is a device that tracks the voltage at where the maximum power is utilized at all times.

Proficiency is measured under standard conditions in the laboratory by the utilization of I-V curves. I-V curves are obtained by shifting the external resistance from zero (short circuit) to infinity (open circuit). Power from PV cell is the result of voltage (V) and current (I). At both open and shut circuit conditions, the power is zero. At same point in between (around the knee point) the conveyed power is a most extreme. The cell current is dependant on the measure of light energy (irradiance) falling on the PV cell and the cell's temperature.

As the irradiance diminishes then power decreases, as well as the peak point moves toward the left. So also as the temperature of the cell expands, the power yield brings down and the extreme power point again moves the left.

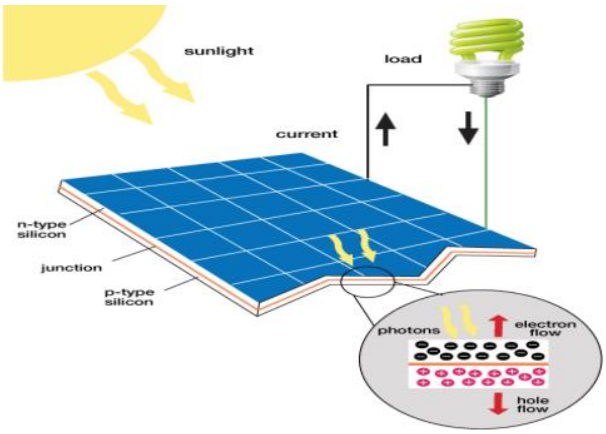

Figure 4: Photovoltaic operation

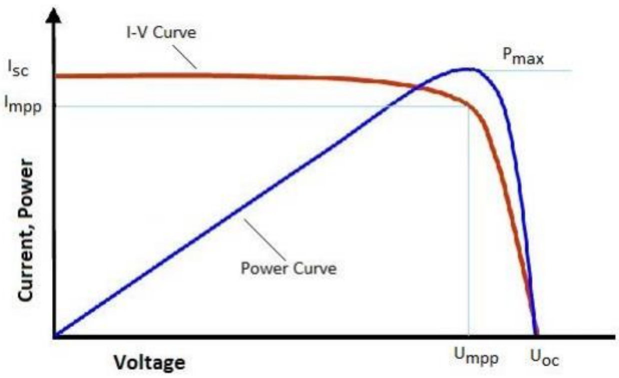

Figure 5: Typical P-V & I-V curve of a photovoltaic cell

3.3 PV CELL EQUIVALENT CIRCUIT

A perfect solar cell might be designed by a current source in parallel with a diode; in universe we don't get ideal solar cell, so a shunt resistance and series resistance part are added to the model.

The subsequent identical circuit of solar cell is appeared in fig below.

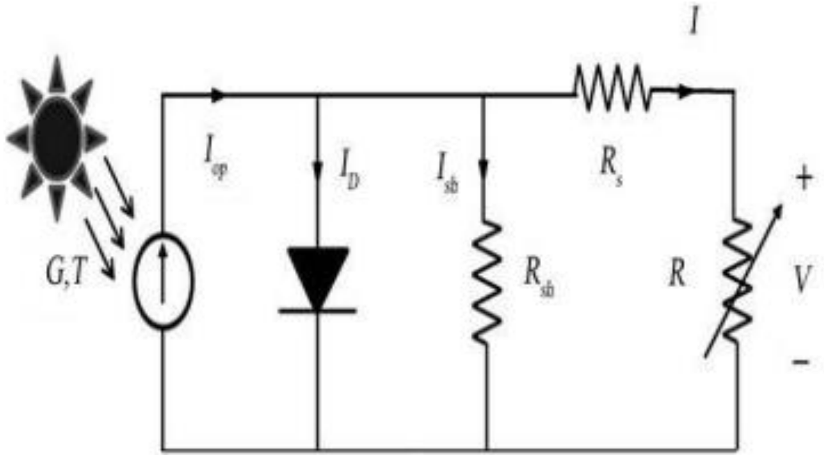

Figure 6: Equivalent circuit of solar cell

3.4 PHOTO VOLTAIC SYSTEM DESIGNING FOR MICROGRID:

The aim of the thesis is to model PV to get the required output voltage and excellent performance with respect to radiation and ambient temperature. The PV model is easy and straightforward.

The PV cell parameters

Module type: sun power SPR-305-WHT

Number of cells per module- 96

Number of series connected module per string-9

Number of parallel strings-40

Specifications of considered PV system under STC:

Voc = 64.2 V

Isc = 5.96 A

Vmp = 54.7 V

Imp = 5.58 A

Module parameters for one module

Rp =993.51 Ω

Tsat =1.1753 e^{-8}°C

Iph = 5.9602 A

Qd= 1.3 J/S

3.5 PHOTOVOLTAIC MODULE

Because of the low voltage production in a PV cell (nearby 0.5V), several PV cells are attached in series (for high voltage) and in parallel (for high current) to form a PV module for the aspired output. In case of incomplete or total shading, and at night there may be a necessity of separate diodes to evade reverse currents. The p-n junctions of mono-crystalline silicon cells may have sufficient opposite current characteristics, and these are not necessary. There is a wastage of power because of converse currents, which direct to the overheating of shaded cells. At higher temperatures, solar cells provide less productivity, and installers aim to offer proper coolness behind the solar panel. Usually, there are 36 or 72 cells in general PV modules.

The modules consist of the transparent front side, encapsulated PV cell, and backside. The front side is usually finished up of low-iron and tempered glass material. The proficiency of a PV module is less than a PV cell. This is because some radiation is reflected by the glass cover and frame shadowing etc.

3.6 BATTERY SUPER CAPACITANCE

Simulation mockup for battery working independently amongst DC system with hybrid energy storage by super capacitor and battery. In case of abrupt load variation, battery will quickly change its power of charging and discharging so as to accommodate loads. However, lower power density of battery indicates this cannot be satisfied by batteries. In such case when super capacitor is to provide abrupt variation to load power (i.e. high frequency component of load power), battery is only required to provide low frequency component of load power variation. Hence, it can substantially mitigate the impact on battery from abrupt load variation. This will reduce requirements of battery power density and improve dynamic response of the system. In the meanwhile, battery can better stabilize the voltage of DC busbar so that rate of current variation is reduced during charging and discharging. Hence, battery conditions will be well improved. This can reduce damage to battery and extend service life of battery.

Matlab Simulation for Hybrid Energy Storage by Super Capacitor-Battery

A. Simulation conditions

For DC system with hybrid energy storage, the capacity of batteries to be selected is 100 Ah. The capacity of the super capacitor is E2=0.5CU2 and E1=E2. The required capacity of super capacitor under different voltage levels can be obtained accordingly. For observation and measurement of impact on DC system by super capacitors of different capacities, assume the capacity will be 0.927F, 2.125F and 3.485F respectively. Based on the investigation, the resistance of load should be35ὃ. Set 1.12H for inductor L1and 0.56H for L2. Due to respective current limits for battery and super capacitor, set5ὃ and 15ὃ for resistor R and R1 .

B. Simulation on battery working independently

Build up simulation mockup by MATLAB/SIMULINK. For emergency load and abrupt load reduction amongst DC system at the typical substation, comparison on simulation and result should be made for super capacitors with different capacities [19]. Simulation mockup for battery working independently amongst DC system with hybrid energy storage by super capacitor and battery at the substation.

3.7 SATCOM AND DSTATCOM

A static synchronous compensator (STATCOM), also known as a static synchronous condenser (STATCOM), is a regulating device used on alternating current electricity transmission networks. It is based on a power electronics voltage-source converter and can act as either a source or sink of reactive AC power to an electricity network. If connected to a source of energy, it can also produce active AC power. It is a member of the FACTS family of devices. It is intrinsically modular and electable.

These compensators are also used to reduce voltage fluctuations.

A DSTATCOM is a shunt compensation device that provides an effective solution for reactive power compensation and voltage regulation. It comprises of a Voltage Source Converter (VSC), a DC capacitor, a coupling inductor or coupling transformer and a controller.

The main function of DSTATCOM is to provide reactive power as demanded by the load. Therefore, with the help of DSTATCOM source currents are maintained at unity power factor and reactive power burden on the system gets reduced. Due to the compensation of the reactive power by DSTATCOM source has to supply only real power.

3.8 SYSTEM REQUIREMENT

3.8.1 MATLAB PLATFORM

Millions of engineers and scientists worldwide use MATLAB® to analyze and design the systems and products transforming our world. MATLAB is in automobile active safety systems, interplanetary spacecraft, health monitoring devices, smart power grids, and LTE cellular networks. It is used for machine learning, signal processing, image processing, computer vision, communications, computational finance, control design, robotics, and much more.

MATLAB (matrix laboratory) is a multi-paradigm digital and computing environment and 4th-generation programming language. A proprietary programming language established by MathWorks, MATLAB permits matrix manipulations, plotting of utilities and data, implementation of algorithms, creation of user interfaces, and the interfacing with programs transcribed in other languages, including C-C++, C#,Forton, Java language and Python.

Although MATLAB is intended primarily for numerical computing, an optional toolbox uses the MuPAD symbolic engine, allowing access to symbolic computing abilities. An additional package, Simulink, adds graphical multi-domain simulation and model-based design for dynamic and embedded systems.

MATLAB was first accepted by researchers and specialists in control engineering, Little's specialty, but quickly spread to many other domains. It is now also used in education, in particular, the teaching of linear algebra, numerical analysis, and is popular amongst scientists involved in image processing.

The speaker verification system was implemented in Matlab with the help of several functions provided by Voicebox. The most important function was melcepst.m. It calculates the MFCCs of a signal. This function calls on several other functions also included in Voicebox. Dynamic Time Warping was implemented by using a source code-named dtw.m, which can be found on Matlab Central. It calculates the DTW distance of two vectors. Several built-in Matlab functions were also used, including functions for the graphical user interface (GUI) and transforming calculations. These source codes are documented in Matlab and on the Matlab website.

[http://www.mathworks.com/help/techdoc/ref/f16-6011.html]

This speaker verification program is implemented through a total of ten m-files, excluding melcepst.m (or the functions it, in turn, calls up) and dtw.m. The main file, where basically all the logic and flow of the program resides, is called MainGUI.m. It was created by using the GUIDE, Matlab's GUI building tool. The program logic is then mainly filled into the button press action parts of the MainGUI code.

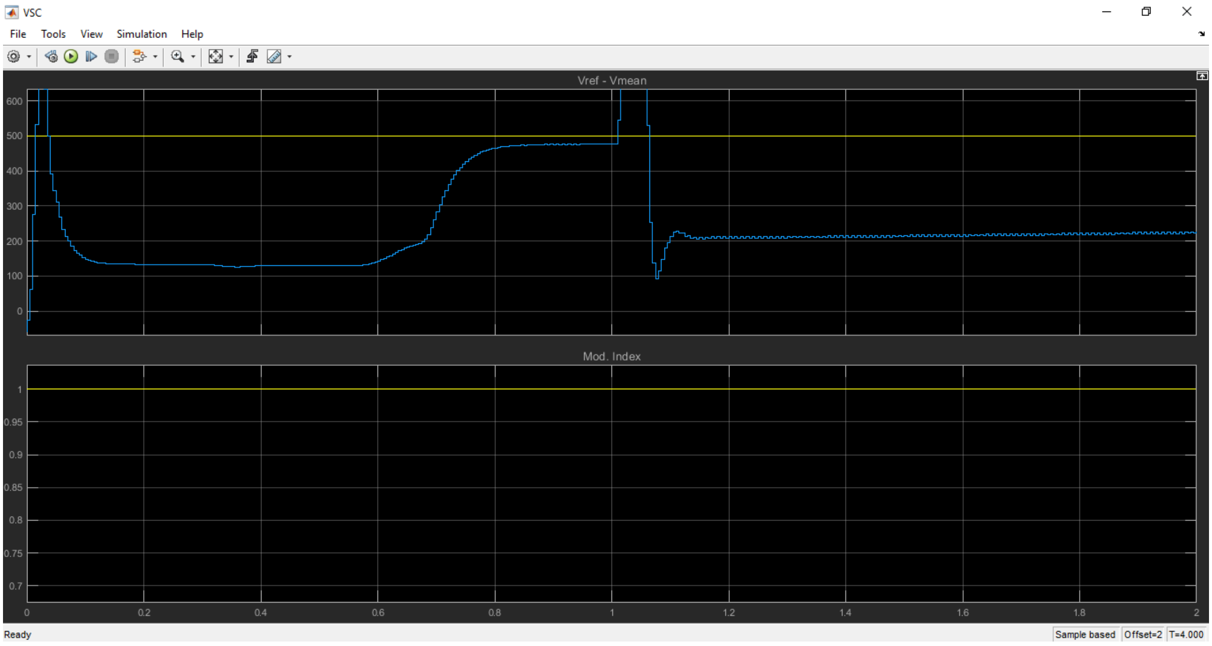

Figure 7: VSC Control Graph for Load Time

IV. RESULTS AND DISSCUSION

To observe how the proposed system performs in different scenarios—such as without DSTATCOM, with DSTATCOM, and with a supercapacitor supporting DSTATCOM—simulation activities are carried out in MATLAB/Simulink. The following is an independent description of these various cases:

Table 1: Variation of loading conditions with Three-phase fault

LOADS	ACTIVE POWER	REACTIVE POWER	%THD (V)	%THD (A)
Noload	4.5e+06	-1.6e+06	0.62	9.06
inductive	-5.6e+06	-1.7e+06	0.60	8.09

Inductive &pulse	-4.5e+06	-1.4e+06	0.48	9.22
Inductive, pulse& nonlinear	-4.6e+06	-1.4e+06	0.48	9.13

Table 2: Variation of loading conditions with three-phase faultand D-STATCOM

LOADS	ACTIVE POWER	REACTIVE POWER	%THD (V)	%THD (A)
Noload	-1.2e+06	4.3e+05	3.48	110.18
inductive	-1.1e+06	4.2e+05	0.89	141.10
Inductive &pulse	-1.2e+06	4.5e+05	2.23	158.76
Inductive, pulse& nonlinear	-1.2e+06	4.4e+05	0.92	167.65

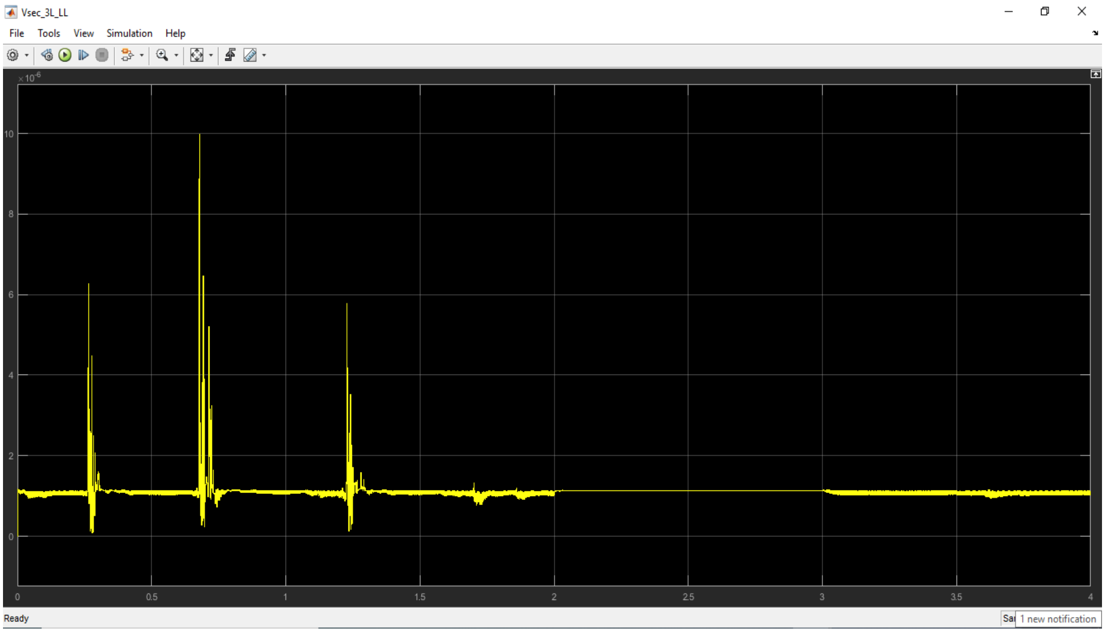

Figure 8: Vsec 3 Pahse Current Control during Load applied

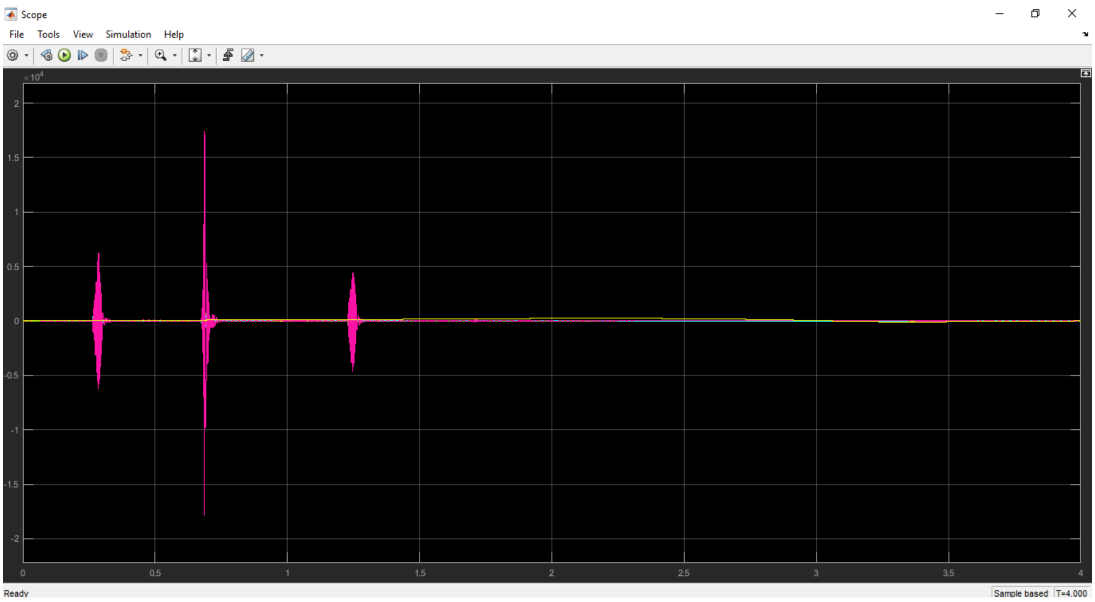

Figure 9: Graph of Induction load in 3 Phase grid

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V. RESULTS AND DISSCUSION

A MATLAB/Simulink environment has been used to model and simulate DSTATCOM. The use of distribution network transmission to drive non-linear, pulse, and reactive loads has been studied in relation to DSTATCOM operation. The efficacy of DSTATCOM within a distribution network is demonstrated by the simulation. The simulation illustrates how well an inverter performs in adjusting reactive power in situations where the supply voltage fluctuates. When the source voltage increases and decreases, the reactive current compensation is quickly reached. The abrupt change in source voltage is well received by the DSTATCOM. Additionally, the THD is significantly below the IEEE standard, indicating that the control algorithm does a good job of removing the harmonics.

VI. CONCLUSION

For a three-phase distribution system, a DSTATCOM has been designed and put into operation. It has been determined that a control algorithm based on the correlation and cross-correlation functions is appropriate for producing the DSTATCOM switching signals in a three-phase power system. Algorithms are implemented in this project to operate DSTATCOM and remove source current harmonics caused by reactive, pulse, and non-linear loads. Every power load is covered by the MATLAB simulation model, and the outcomes of the simulation are examined.

In order to maintain DC bus voltage, this system's tracking ability, harmonic elimination, and power factor correction are tested and compared. When source distortion is present, We examine these three algorithms. The investigation will now turn to the Microgrid as a system. Understanding the relationships between the sources is crucial. It is necessary to define their relationship with each other more precisely. In the event that everything proceeds as planned and the Microgrid system is created, the electronics will probably contain the order control. Specialised controllers can be used to maximise the use of each power source and obtain a more stable response. Once the mains and the power sources' interactions and relationships have been established, this should definitely be investigated and taken into consideration. The original sources found within the Microgrid are additional elements that could be further developed.

VII. FUTURE SCOPE

These FACTS devices (STATCOM, BESS, SSSC) will find use in a number of additional areas. Below is a list of some of the application areas

- Power quality improvement with BESS
- Damping of SSR (subsynchronous resonance) using BESS.
- Enhancement in power grid stability with BESS System
- Improvement of distributed generation stability using BESS

VIII. REFERENCES

[1] Hingorani, Narain G., Understanding FACTS : concepts and technology of flexible ACtransmission systems, IEEE Press Marketing.

[2] Arindam Ghosh, Power Quality Enhancement using custom Power Devices, KluwerAcademic Publishers.

[3] H. Akagi, E. H. Watanabe, and M. Aredes, Instantaneous Power Theory and Applicationsto Power conditioning, Hoboken, NJ: Wiley, 2007.

[4] Kalyan K Sen, "STATCOM - STATic synchronous COMpensator: Theory, Modeling, andApplications", 0-7803-4403-0/98/ 0 1998 IEEE.

[5] Dong JuLee ,EunWoong Lee, Jong Han Lee , Jong GyeumKim,"Simulation of StaticSynchronous Compensator (STATCOM)".

[6] Tariq Masood, R.K. Aggarwal, S.A. Qureshi, R.A.J Khan, "STATCOM Model againstSVC Control Model Performance Analyses Technique by Matlab", InternationalConference on Renewable Energies and Power Quality, Granada(Spain), 23rd to 25th March,2010.

[7] Dong Shen, Wenhua Liu and Zhonghong Wang, "Study on the Operation Performance ofSTATCOM under Unbalanced and Distorted System Voltage", 0-7803-5935-6/00) 2000IEEE.

[8] S.H.Hosseini and A. Ajami , "Transient stability enhancement of AC transmission systemusing STATCOM", Proceedngs of IEEE TENCON02.

[9] Wang Chao and Zhang Yao, "Approach on Nonlinear Control Theory for DesigningSTATCOM Controller", Proceedings of 2007 IEEE International Conference on GreySystems and Intelligent Services, November 18-20, 2007, Nanjing, China.

[10] M. Tavakoli Bina, and Ashoka K. S. Bhat, "Averaging Technique for the Modeling ofSTATCOM and Active Filters", IEEE transaction on power electronics, vol. 23, no. 2,March 2008.

[11] Javid Akhtar, Sinto George, "Modeling and Simulation of STATCOM for a power systemnetwork using MATLAB/SIMULINK", IOSR Journal of Engineering (IOSRJEN) ISSN:2250-3021 Volume 2, Issue 8 (August 2012), pp- 12-17.

[12] Boon Teck Ooi, Gem boos and Xiaogang Huang, "Operating principles of shuntSTATCOM based on 3-level diode-clamped converters", IEEE Transaction3 on PowerDelivery, Vol. 14, No. 4, Octo ber 1999.

[13] Jianye Chen, Shan Song and Zanji Wang, "Analysis and Implement of Thyristor-basedSTATCOM", International Conference on Power System Technology, 2006.

[14] Bhim Singh, Kamal AI-Haddad and Ambrish Chandra, "A review of active filters forpower quality improvement,"IEEE Transactions on Industrial Electronics, vol. 46, no. 5,pp. 960-971, October 1999.

[15] G. Casaravilla, F. Fnaiech, K. AI-Haddad and S. Rahmani," Adaptive linear combiners arobust neural network technique for on-line harmonic tracking," Proc. of 34lb AnnualConference of IEEE Industrial Electronics, 2008, pp.530-534.

[16] M. E. Baran and N. R. Mahajan, "DC distribution for industrial systems: Opportunities andchallenges," IEEE Trans. Ind. Appl., vol. 39, no. 6, pp. 1596–1601, Nov. 2003.

[17] M. E. Ropp and S. Gonzalez, "Development of a MATLAB/simulink model of a singlephase grid-connected photovoltaic system," IEEE Trans. Energy Conv., vol. 24, no. 1, pp. 195–202, Mar. 2009.

[18] K. H. Chao, C. J. Li, and S. H. Ho, "Modeling and fault simulation of photovoltaicgeneration systems using circuit-based model," in Proc. IEEE Int. Conf. Sustainable EnergyTechnol., Nov. 2008, pp. 290–294.

[19] O. Tremblay, L. A. Dessaint, and A. I. Dekkiche, "A generic battery model for the dynamicsimulation of hybrid electric vehicles," in Proc. IEEE Veh. Power Propulsion Conf. (VPPC2007), pp. 284–289.

[20] D. W. Zhi and L. Xu, "Direct power control of DFIG with constant switching frequency andimproved transient performance," IEEE Trans. Energy Conv., vol. 22, no. 1, pp. 110–118, Mar.2007.

[21] P. Garica Gonzalez and A. Garcia Cerrada, "Control system for a PWM-basedSTATCOM," IEEE Trans. Power Delivery., vol. 15, no.4, pp. 1252-1257, Oct. 2000.

[22] Li. Shengqing, Li. Weizhou, Xu. Wenxiang and Zeng. Huanyue, "The Direct CurrentControl Method of STATCOM and its Simulation," in Proc. Intelligent SystemDesign and Engineering Applications (ISDEA), Third International Conf., Jan 16-18. 2013, vol. no. pp.1426-1429.

[23] Li. Shuhui, Xu. Ling, and A. Haskew Timothy. "Control of VSC-based STATCOMusing conventional and direct-current vector control strategies," IEEE Trans.International Journal of Electrical Power & Energy Systems., vol. 45 pp. 175-186,2013.

[24] K. H. Ahmed, S. J. Finney, and B. W. Williams, "Passive Filter Design for ThreePhase Inverter Interfacing in Distributed Generation," in Proc. Compatibility inPower Electronics, CPE Conf., May 29 2007-Jun. 1 2007, vol. 7, pp.1-9.

[25] P. A. Dahono, A. Purwadi, and Qamaruzzaman, "An LC filter design method forsingle-phase PWM inverters," in Proc. Int. Power Electronics and Drive SystemConf., Feb. 21-24 1995, vol. 2, pp. 571-576.

[26] M. B. Delghavi and A. Yazdani, "A control strategy for islanded operation of aDistributed Resource (DR) unit," in Proc. Power & Energy Society General Meeting,PES IEEE Conf., 2009, vol., no, pp. 1-8.

[27] A. Yazdhani and R. Iravani, Voltage-Sourced Converters in Power Systems. IEEEPress, Canada: Wiley, Jan. 2010.