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POWER QUALITY IMPROVEMENT BY VOLTAGE SAG MITIGATION AND REACTIVE POWER COMPENSATION USING STATCOM THROUGH ARTIFICIAL NEURAL NETWORK ALGORITHM

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***Abstract*—Microgrids are becoming increasingly attractive to consumers as it allows utilization of easily available renewable energy sources. They are usually installed at consumer's sites i.e the distribution end. Due to high saturation of distributed generation units with different types of loads, microgrids can cause power quality issues. Some of them are voltage swells and sags, and low power factor which further require reactive power compensation. This paper presents the utilization of the custom power device specifically STATCOM in mitigating the problem of voltage sags occurring in microgrid. The performance of STATCOM, installed in microgrid, is analyzed for reactive power compensation to overcome these concerned issues. The design of a neural network controller using voltage as feedback for significantly improving the dynamic performance of converter. The performance is analyzed with the help of neural network controller and the simulation studies have demonstrated the effective influence of the STATCOM on the improvement of the voltage using MATLAB/Simulink.**

***Keywords*—Microgrid,Neuro controller, Reactive power compensation,STATCOM, Voltage sag**

I. INTRODUCTION

Power quality is defined as the interaction of electrical power with electrical equipment. If electrical equipment operates correctly and reliably without being damaged or stressed, then the electrical power is good quality. On the other hand, if the electrical equipment malfunctions and is damaged during normal usage, then the power quality is poor.

As a general, any deviation from normal of a voltage source can be classified as a power quality issue. Power quality issues can be very high-speed events such as voltage impulses, high frequency noise, waveshape faults, voltage swells and sags and total power loss. All type of electrical equipment will be affected differently by power quality issues. By analyzing the electrical power and evaluating the equipment or load, power quality problem is determined..

The power quality can be monitored by installing a special type of high-speed recording test equipment to monitor the electrical power. This type of test equipment will provide information used in evaluating if the electrical power is of sufficient quality to reliably operate the equipment. Monitoring will provide valuable data, however the data needs to be interpreted and applied to the type of equipment being powered.The first sign of a power-quality problem is a distortion in the voltage waveform of the powersource from a sine wave, or in the amplitude from an established reference level, or a complete interruption. The disturbance can be caused by harmonics in the current in the main voltage supply system.

Several procedures have been adopted to mitigate PQ problems, which can be carried out by means of dynamic voltage restorers, Static Synchronous Compensator, Static VAR compensator (SVC), Thyristor-controlled series capacitor (TCSC), Thyristor-controlled voltage regulator (TCVR), Thyristor-controlled phase-shifting transformer (TCPST), Unified power flow controller (UPFC).In this work voltage sag reduced by using STATCOM.

II. POWER QUALITY PROBLEM

The first signal of a power-quality problem is a disturbances in the voltage waveform of the powersource from a sine wave, or in the amplitude from an established reference level, or a complete interruption. The disturbance can be caused by harmonics in the current or by events in the main voltage supply system.

A. Voltage sag

Voltage sag is a sudden reduction of nominal voltage in a power system network. The causes of voltage sag are the electric motors draw more current when they are starting than when they are running at their rated speed, starting an electric motor. Sudden load changes or excessive loads can origin a voltage sag. Voltage sag happens when the rms voltage decreases between 10 and 90 percent of nominal voltage for one-half cycle to one minute. The duration of sag for a period of 0.5 cycles to a few seconds, and longer duration of low voltage would be called "sustained sag".

B. Causes and effects of sags

A common cause of sags for industrial customers is turning on large loads such as large motors. If using an across-the-line motor starter, the current draw when turning on a motor can be six times or more of its normal running current. The large and sudden current draw results in downstream voltage drops. Weather factors, such as lightning, wind, and ice, are also significant contributors to voltage sags.There are several reasons which cause a voltage sag to happen:

- Since the electric motors draw more current when they are starting than when they are running at their rated speed, starting an electric motor can be a reason of a voltage sag.
- When a line-to-ground fault occurs, there will be a voltage sag until the protective switch gear operates.
- Some accidents in power lines such as lightning or a falling object can be a reason of line-to-ground fault and a voltage sag as a result.
- Sudden load changes or excessive loads can cause a voltage sag.
- Depending on the transformer connections, transformers stimulating could be another reason for voltage sags happening.
- Voltage sags can arrive from the utility but most are caused by in-building equipment. In residential homes, voltage sags are occurred when refrigerators, air-conditioners, or furnace fans start up.

Due to the voltage uncertainty, the power system may experience voltage collapse, if the post-disturbance stability voltage near loads is below acceptable limits [1]. Voltage collapse is also defined as a process by which the voltage instability provides advantages of very low voltage profile in the essential part of the system. Voltage collapse may be total or partial blackout. Voltage sag in a short duration to decrease in rms voltage which can be caused by a short circuit, overload or starting of electric motors.

To minimize these effects in Electricity distribution system, different types of compensation devices have been proposed to increase the power quality. In this project voltage valuedeveloped by using compensation device is STATCOM (Static Synchronous Compensator).

III.PROPOSED SYSTEM

A. Design of STATCOM

The STATCOM (Static Synchronous Compensator) is known as a shunt-connected devices and reactive-power compensation device that is capable of generating and absorbing reactive power and output can be varied to control the specific parameters of electric power system. A solid-state switching converter useful of generating or absorbing independently controllable real and reactive power and its output terminals. It is fed from an energy source or energy-storage device at its input terminals.

By reactive-power generation and reactive power absorption in electronic processing of voltage and current waveforms in a voltage-source converter (VSC), STATCOM device capable for voltage sag mitigation.. Capacitor banks and shunt reactors are not need for reactive power generation and absorption, by using a STATCOM a compact design, or small footprint, as well as low noise and low magnetic impact. The interchange of reactive power between converter and ac system can be controlled by altering the amplitude of the 3-phase output voltage, Es, of the converter. In the steady state, VSCs operate with fundamental-frequency to switching the minimize converter losses. However, during transient conditions caused by line faults, a pulse width–modulation (PWM) mode is used to prevent the fault current from entering the VSCs measured. In this way, the STATCOM is able to withstand transients on the AC side without blocking. STATCOM uses IGBT as a power device. Connecting a single converter to a power transformer through an air-core phase reactor is possible by using high frequency pulse width modulation (PWM).

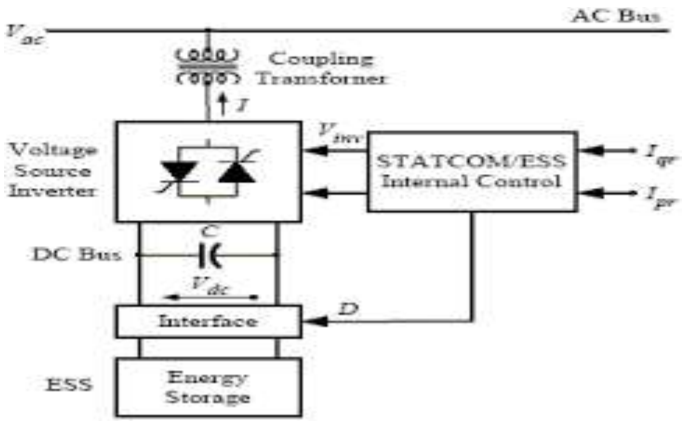


Fig 1: STATCOM Diagram

The insulated gate bipolar transistor (IGBT) is a three-terminal semiconductor device, for high effectiveness and fast switching. It switches electric power in many modern appliances: electrical cars, train and variable speed drives and refrigerators and air-cooler and even stereo systems with switching amplifiers. Since it is designed to quickly turn on and off, amplifiers that use it frequently synthesize complex waveforms with pulse width modulation and low-pass filters.

The IGBT combination of the simple gate-drive characteristics of MOSFET with the high-current and low–saturation-voltage capability of bipolar transistors by combining an isolated gate. The IGBT is used in medium- to high-power applications such as switched-mode power supply, traction motor control and induction heating for large IGBT modules typically consist of many devices in parallel and have very high current handling abilities.

Pulse width modulation refers to a method of carrying information on train of pulses and the information be enclosed in the width of pulses. The AC voltage is dependent on two parameters i.e. amplitude and frequency. It is essential to control these two parameters. In this project single pulse width modulation control technique used. The single pulse width modulation control, the width of the pulse is varied the inverter output voltage and there is only one pulse half per cycle. The advantages of this technique are the power loss in the switching devices is very low.

B. *Neural network Controller*

Artificialneuralnetwork isareplicationofourhumanbrain. The understanding, recognizing,classifying,clustering,errordetectionand correction are the sixth sense of human brain and this capability is incorporatedwiththehelpofartificialneuralnetwork. Thisisanemulation ofbiological neuralsystem. Neuralnetworkcanbesaidtoresemblehuman brainin followingthebelowmentionedthings. Back propagation algorithm is used to inject reactive power in system.The networkarchitectureis multi-layer feed-forward. Butduring learning process,itisafeedback network. Deltalearningruleisusedinthetraining phase.

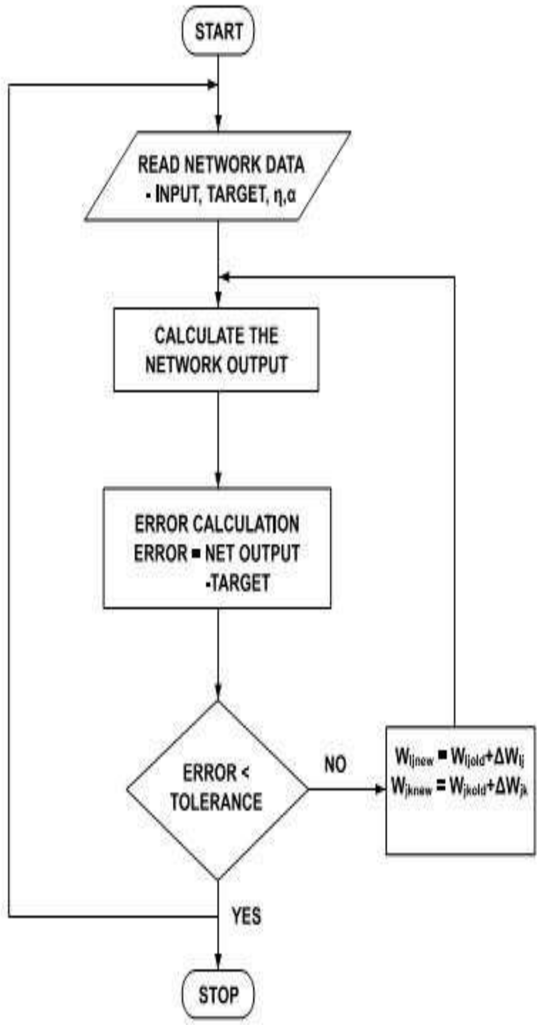
In thiswork,thelayersusedarethree. Theinputsusedaretheerror andchangeinerrorofthecurrents. Theoutputisthedqvoltages forproperfixing ofthedclinkvoltageofthecapacitorandreactivepower compensation. Inthehiddenlayer,therearefourneurons.

1. *Algorithm for the design of neural network controller*

- Theinputpatternsarepresentedto thenetwork.
- Theinputsaresenttothehiddenneurons withastrength ofW_{ij} .For thenetsumtan sigmoidalactivationfunctionisapplied.
- Thesignalsfrom thehiddenunitsaresenttotheoutputlayerwitha strengthofV_{jk} . Linearactivationfunctionisappliedandthefinaloutputis availableat theoutputneuron.
- Theoutputiscompared withthetargetanderrorgenerated is calculated.
- ThechangesinthehiddentooutputweightsΔW_{jk} iscalculatedand thenthechangesin theinputto hiddenweightsΔW_{ij}arecalculated.
- Theweightsareupdatedusingtheformula $W_{jknew}=W_{jkold}+\Delta W_{jk}$

$W_{ijnew}=W_{ijold}+\Delta W_{ij}$

2. *Flow chart for back propagation algorithm*



IV.SIMULATION AND RESULT ANALYSIS

By using simulation models we can obtain the performance characteristics of the system very easily and quickly for analysis purpose. Here, we consider the performance analysis of UPQC based power quality conditioning device.

A. Analysis

To prevent a voltage sag, STATCOM device useful to inject reactive power [9]. The compensation device only active when the system need it, otherwise this unit remain absent. The STATCOM gives reactive power through filter to power source. The main advantages for using filter is to eliminate noise.

The results of simulation shown in figure 4 and figure 5. Figure 4 clearly gives the output waveform of power system with voltage sag. The time period of voltage sag is between 0.5 to 0.6 sec. In this time period, power system lags voltage because of some disturbances. Due to disturbances, power system operation affects manyequipment[12].To avoid the damage in equipment, it is very important to compensate the sag.

The compensation of voltage value done by injecting reactive power to a system to improve power quality. Reactive power injecting to a system with a help of generating system. In between of compensation system and voltage sag system, filter unit used to avoid disturbance in voltages.

The compensation of voltage sag done in this project by STATCOM. The reactive power injection given to a system in order to reduce voltage sag. Figure 5 gives the output of voltage waveform after compensation.

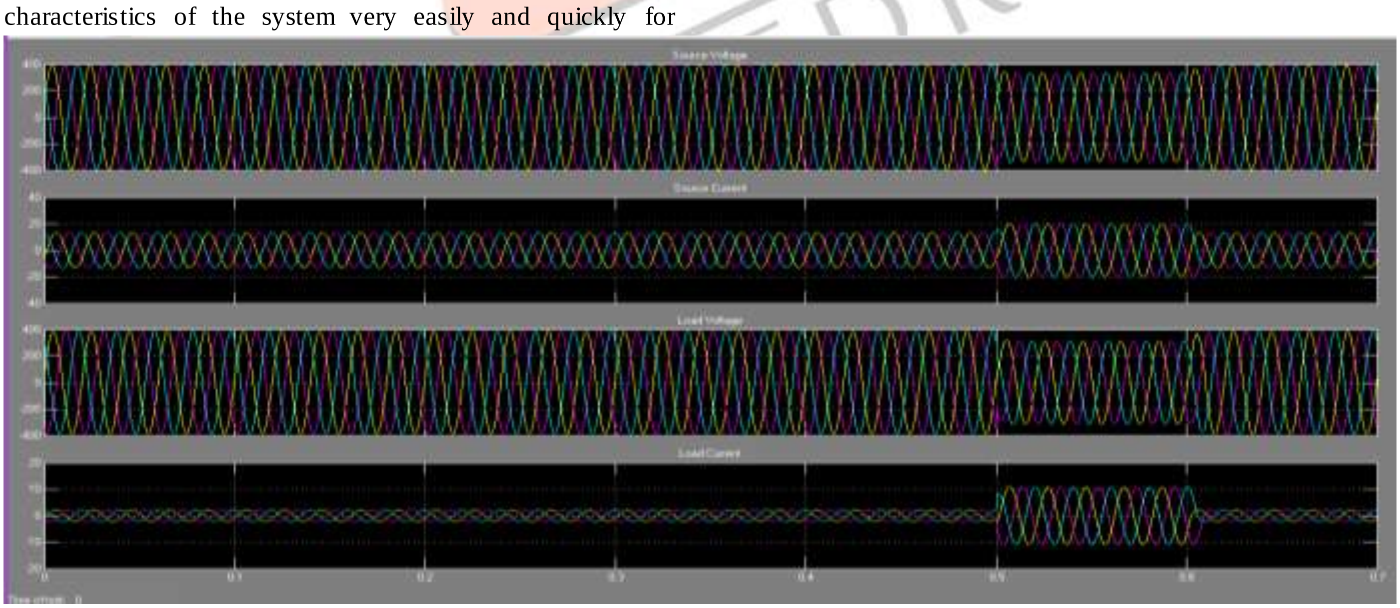


Fig 4: Waveform with voltage sag

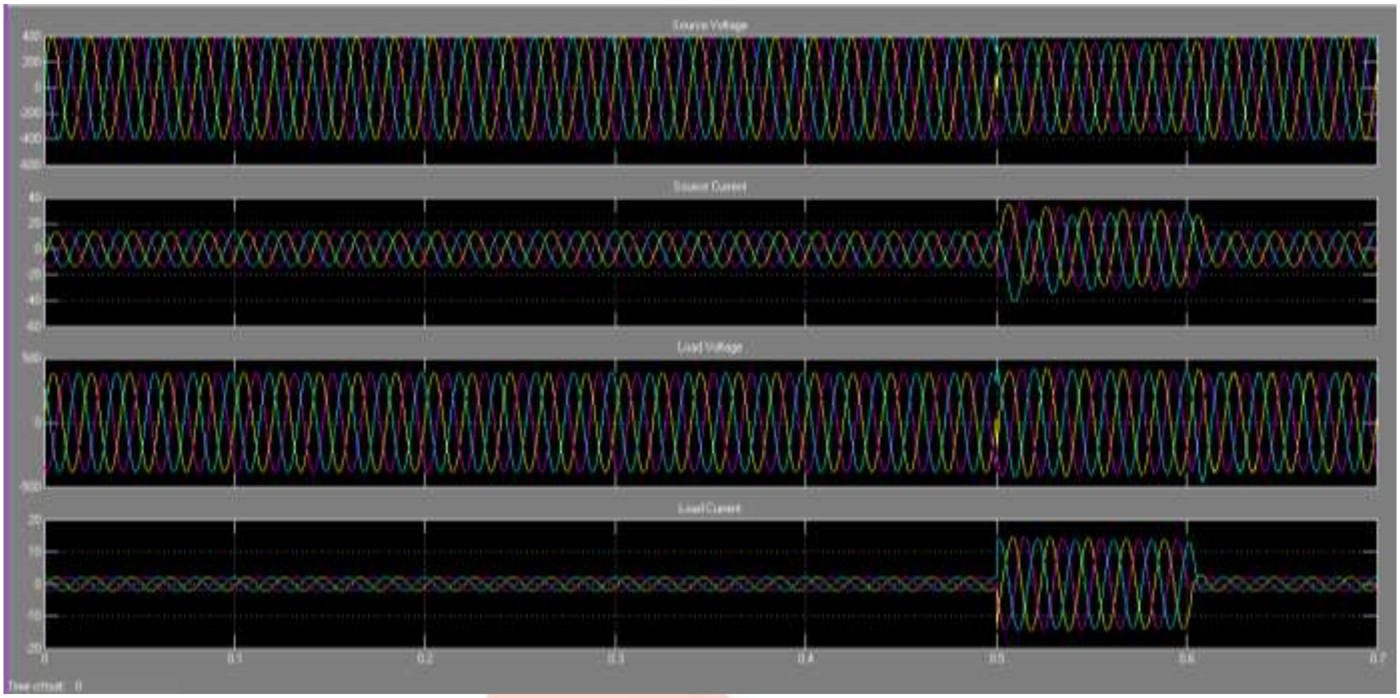


Fig 5: Waveform without voltage sag

V.CONCLUSION

In this paper, the effect of voltage sag on the microgridhas been studied and the role of STATCOM on the mitigation of the voltage dip have been found out. The simulations are carried out in MATLAB and its results are analysed with & without STATCOM connected in the microgrid.The performance of STATCOM is increased by using artificial neural network in the present technique. The harmonics is reduced and fault clearing time is increased by using artificial neural network. From the output shown in matlab simulation it has been proved that voltage sag can be reduced using neural network controller compared to PI controller.

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