ENHANCEMENT OF POWER QUALITY BY USING D-STATCOM

PRERANA TODKAR
Student, Electrical Dept. SETI, Panhala, India

YOGITA LOHAR
Student, Electrical Dept. SETI, Panhala, India

ASHISH TAWADE
Student, Electrical Dept. SETI, Panhala, India

SUPRIYA POWAR
Student, Electrical Dept. SETI, Panhala, India

V. T. METKARI
Assistant Professor, Electrical Engineering, Dept. SETI, Panhala, India

ABSTRACT:

The main concern of consumer in power system is the reliability of supply that is, the continuity of electricity. Now a day, quality of electricity supply is very important for consumers. At the generating plant it generates voltages almost perfectly sinusoidal at rated magnitude and at rated frequency. The power quality problems starts from transmission system and stay at the end of distribution system. And these power quality problems faced the consumers.

The electrical and electronic equipments are failure when faced one or more power quality problems. Hence, now a day power quality is serious problem in power network. To overcome this problem the device D-STATCOM is used. These power quality problems are overcomes by using various FACTS devices.

KEYWORDS: Voltage source converter (VSC), PWM generator, Microcontroller, MATLAB Simulation.

I. INTRODUCTION:

Power quality is more serious problem in power network system. To overcome this problem many FACTS devices are used such as DVR, D-STATCOM and UPFC etc. DVR is related with the voltage and which is connected in series with the system. D-STATCOM is related with the current and which is connected in shunt to the system. And UPFC is the combination of both DVR and D-STATCOM devices [4]. So that to improve the power quality D-STATCOM is used. It reduces the effect of load on the magnitude of bus voltage and it keeps the voltage at desired level.

D-STATCOM is the FACTS device which is used to overcome the power quality problems and it is connected in parallel to the system. D-STATCOM is the shunt device and which is based on the voltage source converter (VSC). The main advantage of D-STATCOM is that it can generate or absorbs the reactive power required to the distribution system. D-STATCOM is used to minimize the harmonics present in the system. Also it minimizes the voltage sag and voltage swell problems. It also used to overcome the effect of poor power factor.

II. POWER QUALITY PROBLEMS:

Due to inherent non- linearity of power electronic devices, they draw harmonics and reactive power from the supply. In multiple phase systems such as 3 phase system they could also cause unbalance and draw excess neutral currents. Due to these reactive power loads, unbalance, harmonics and excess neutral currents it leads to low efficiency of system and poor power factor. Apart from this, power system also confronts transients like voltage sags, swells, and flickers etc. [5]. These transient problems impact voltage at distribution level. Various Power Quality Problems are as listed below-.

- Voltage swell / over voltage
- Voltage dip / under voltage
- Harmonic distortion in Voltage and current signals
- Voltage and current transients
- Voltage flicker

A. VOLTAGE SWELL / OVER VOLTAGE:

The instantaneous increase in rms voltage supplied by mains beyond normal tolerance for the duration more than one cycle up to few seconds [6].

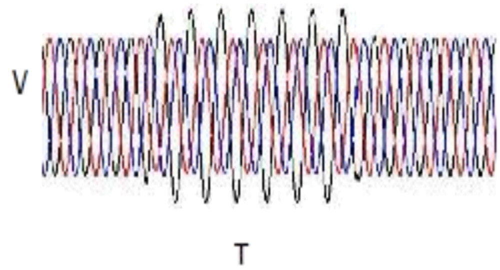

Figure 1 .Voltage swell / over voltage

B. VOLTAGE DIP / UNDER VOLTAGE:

A brief drop in the rms voltage, about 10-90% of nominal line voltage. It lasts for 0.5 cycles to 1 minute [6].

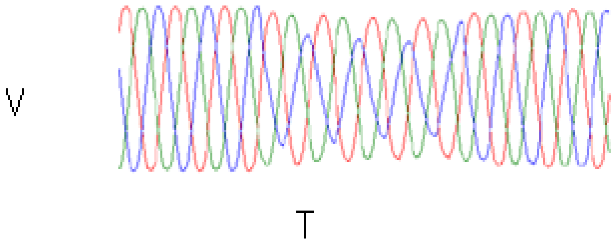

Figure 2 .Voltage dip / under voltage

C. HARMONIC DISTORTION IN VOLTAGE AND CURRENT SIGNALS:

These are Sinusoidal voltages or currents with frequencies that are integer multiples of the frequency at which the system is designed to operate i.e. termed as fundamental frequency up to 50-60 Hz. These harmonics rise due to nonlinear characteristics of devices and loads connected to the system.

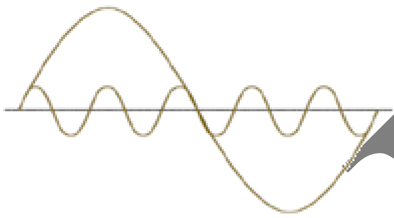

Figure 3.Harmonic Distortion

The waveform represents the sum of different sine-waves with different magnitude and phase, with frequencies that are multiples of power system frequency. Harmonics are resultant of electrical machines that work beyond knee of the magnetization curve, DC brush motors, arc furnaces, rectifiers ,welding machines, and non-linear loads that include power electronics equipment including SMPS, data processing equipment etc. Harmonic distortion levels are depicted by calculating total harmonic distortion (THD) that measures the overall harmonic spectrum with magnitudes and phase angles of each single harmonic component [9].

D. VOLTAGE AND CURRENT TRANSIENTS:

1) Impulsive Transients: It is a brief single directional variation in current, voltage or both on a line. Switching of inductive loads or switching in distribution system, lightning strikes are most common causes of impulsive transients.

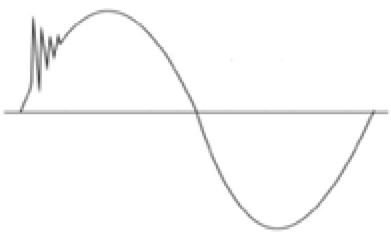

Figure 4. Impulsive Transients

2) Oscillatory Transients

It is a bidirectional variation in voltage, current or both on a line. Main reason behind these is power factor correction capacitors or transformer Ferro resonance.

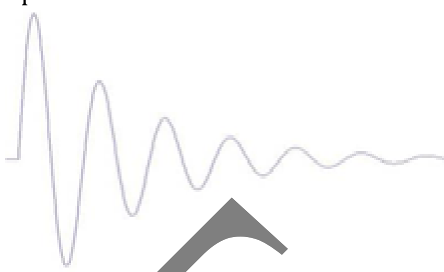

Figure 5. Oscillatory Transients

E. VOLTAGE FLICKER:

In this voltage exhibits alterations in magnitude or/and phase angle in a time scale of seconds or less.

III. BASIC OPERATION OF D-STATCOM:

The D-STATCOM is shunt connected power electronic device and which is used in distribution system. It is connected nearer to the load. D-STATCOM injects the reactive power at the point of common coupling (PCC). The schematic block diagram of D-STATCOM is shown in Fig.6

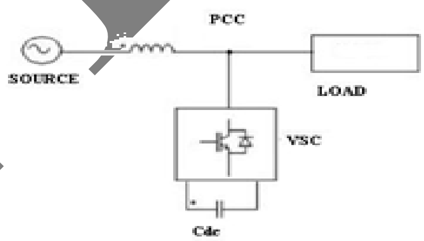

Figure 6. Basic diagram of D-STATCOM

The D-STATCOM is same as per the voltage source converter (VSC) it consists of switching devices such as MOSFETS or IGBTS.

DC link capacitor- it is connected in parallel to the voltage source converter (VSC) or D-STATCOM, which is capable to generate or absorbs the reactive power required to the load.

Coupling transformer- it is placed in between the distribution system and D-STATCOM to provide isolation between distribution system and D-STATCOM. Harmonic filters - it minimize unwanted harmonic produced by VSC and keep this harmonics within specific limit.

Control scheme- It controls all signals. It is required to control the D- STATCOM [3].The operation of D-STATCOM is similar with the synchronous compensator. The AC side of voltage source converter (VSC) is connected to the point of common coupling (PCC) and the DC side of voltage source converter (VSC) is connected to the capacitor which is charged by battery source. If the output voltage of voltage source converter (VSC) is equal to the AC terminal voltage then the D-STATCOM is not operates. If the output voltage of voltage source converter is greater than the AC terminal voltage then the D-STATCOM is operates as a capacitive mode and it provides the reactive power to the system [1], [2]. And if the output voltage of voltage source converter is less than the AC terminal voltage then the D-STATCOM is operates as an inductive mode and absorb the reactive power from the system. i.e.

Output of VSC > AC terminal voltage- (Capacitive mode)

Output of VSC < AC terminal voltage- (Inductive mode)

So that it achieves the load compensation. Hence, the power factor correction, harmonic filtering and load balancing are maintained. Our main objective is to improve the power quality by using of D-STATCOM.

1. Simulation of D-STATCOM
2. Hardware implementation on D-STATCOM

Following blocks required for simulation

A. Voltage Source Converter (VSC)

A voltage-source converter (VSC) according to the compensation required offers the regulated output voltage in terms of magnitude and phase angle to result in either leading or lagging reactive current. It uses semiconductor technology to perform its operation [8]. It helps in conversion of DC voltage stored in storage device to AC output.

Features of VSC-based transmission:

- Independent control of reactive and active power
- Reactive control independent of other terminal
- Simpler interface with ac system
- Provides continuous ac voltage regulation
- No commutation failures

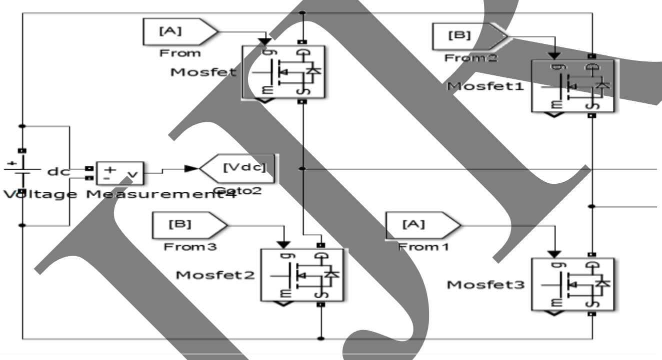

Figure 7. Voltage Source Inverter

The converters are built with the IGBT/Diode block which is the basic building block of all VSCs. The IGBT/Diode block is a simplified model of an IGBT (or GTO or MOSFET)/Diode pair where the forward voltages of the forced-commutated device and diode are ignored. You may replace these blocks by individual IGBT and diode blocks for a more detailed representation. VSCs are controlled in open loop with the Discrete PWM Generator block available in the Extras/Discrete Control Blocks library [7].

B. PWM Generator

The PWM generator is used to generate the gate pulses for the MOSFET's of the VSI. Here, the sine and the triangular waveforms are generated. The sine wave which is of 50Hz is compared with the triangular wave of 20 kHz. According to the comparison, the PWM pulses are produced. These pulses are given to gates of thermoset's. By varying the modulation index, the magnitude of the converter output will vary and as well as by varying the phase angle of the modulating wave, the converter output voltage phase angle will also vary [7].

Figure 8. PWM Generator

C. PI Controller

PI controller gains are tunable either manually or automatically. The PI Controller block output is a weighted sum of the input signal, the integral of the input signal, and the derivative of the input signal. The weights are the proportional, integral, and derivative gain parameters. A first-order pole filters the derivative action.

Configurable options in the PI Controller block include:

- Controller type and form
- Time domain (continuous or discrete)
- Initial conditions and reset trigger
- Output saturation limits and built-in anti-windup mechanism.

IV. MATLAB SIMULATION:

The effect of D-STATCOM on the performance of a power system with RL load is studied under MATLAB environment. The real and reactive powers with voltage magnitude in the line as well as in the load are observed without D-STATCOM. The variations of power flow after the introduction of the D-STATCOM is noted. A PI-based controller is designed for the D-STATCOM and then its performance is studied using MATLAB.

A. SIMULATION WITHOUT D-STATCOM:

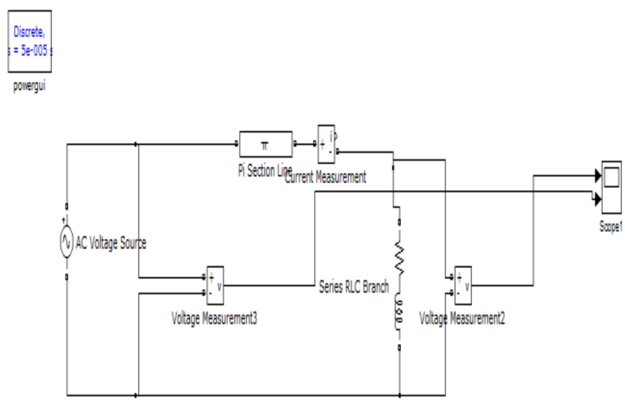

Figure 9. Simulation without D-STATCOM

B. WAVEFORMS OF SIMULATION WITHOUT D-STATCOM

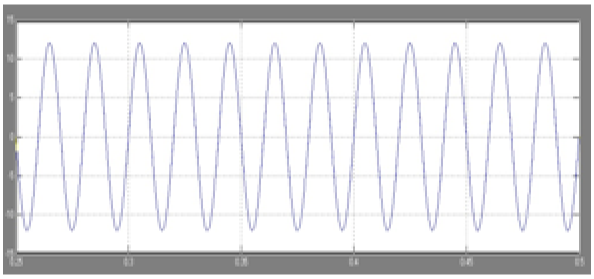

Figure 4. Input voltage

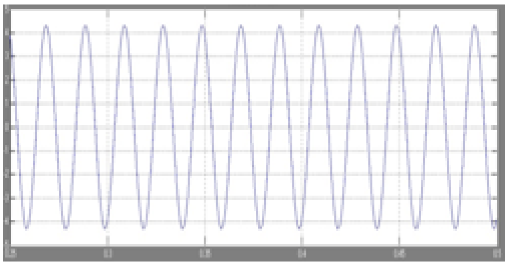

Figure 5. Output voltage

Above Simulation consists of RL load, the load will consume the voltage. As shown in above figure the input is given 12V, at load side we are getting 4.3V. So the RL load is consuming the voltage. D-STATCOM will compensate the voltage drop caused by RL load after connecting in system.

C. SIMULATION WITH D-STATCOM

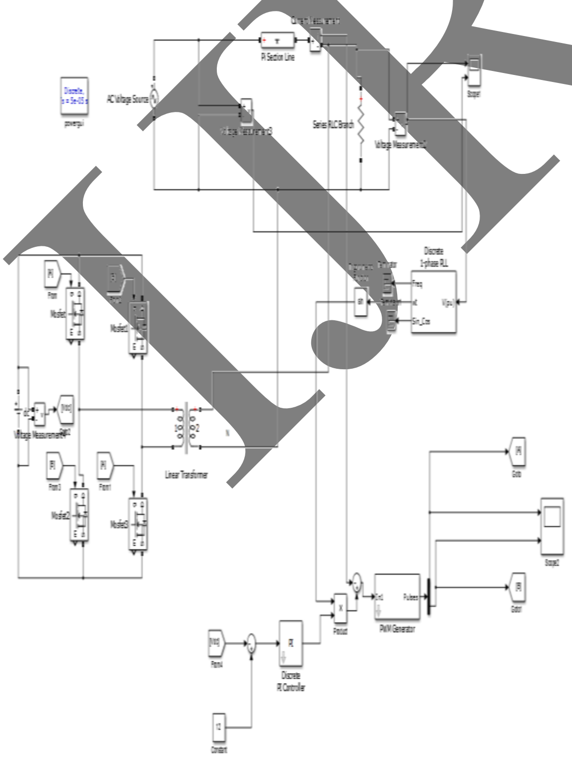

Figure 6. Simulation with D-STATCOM

D. WAVEFORMS OF SIMULATION WITH D-STATCOM

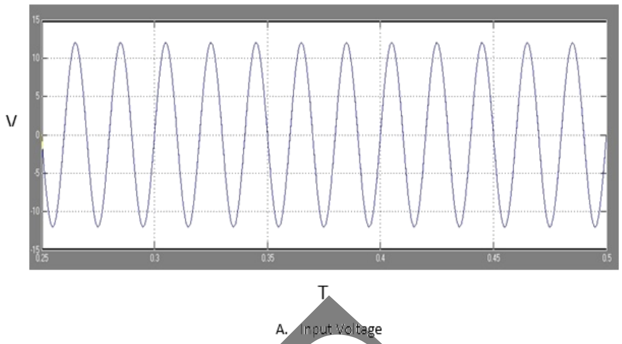

Figure 7. Input voltage

The output of system without D-STATCOM is 4.3V, after connecting the D-STATCOM in the system output is 11.3V. So we can said that D-STATCOM compensate the voltage sag caused RL load.

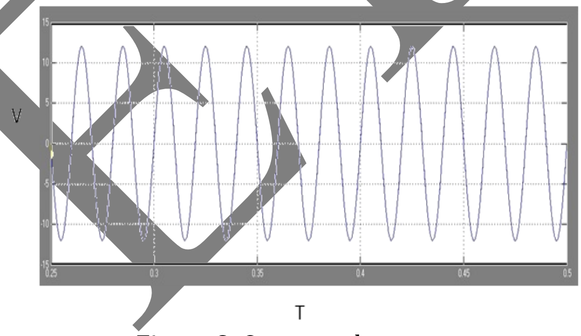

Figure 8. Output voltage

V. BLOCK DIAGRAM OF THE PROPOSED SYSTEM:

The block diagram of the proposed system is shown in fig. consists of AC source as an input voltage of the system, proposed inverter and load. The proposed inverter includes the PIC controller to generate PWM pulses, optocoupler used for isolation and driver ICs.

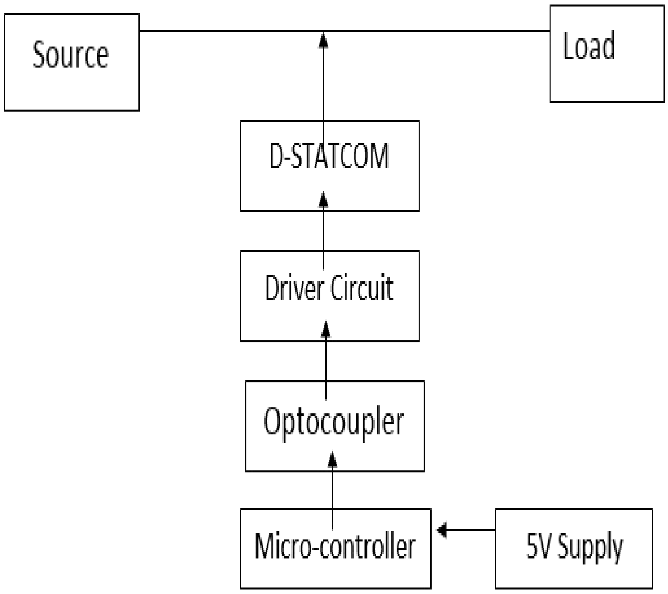

Figure 9. Block diagram of the proposed system

VI. HARDWARE IMPLIMENTATION OF D-STATCOM

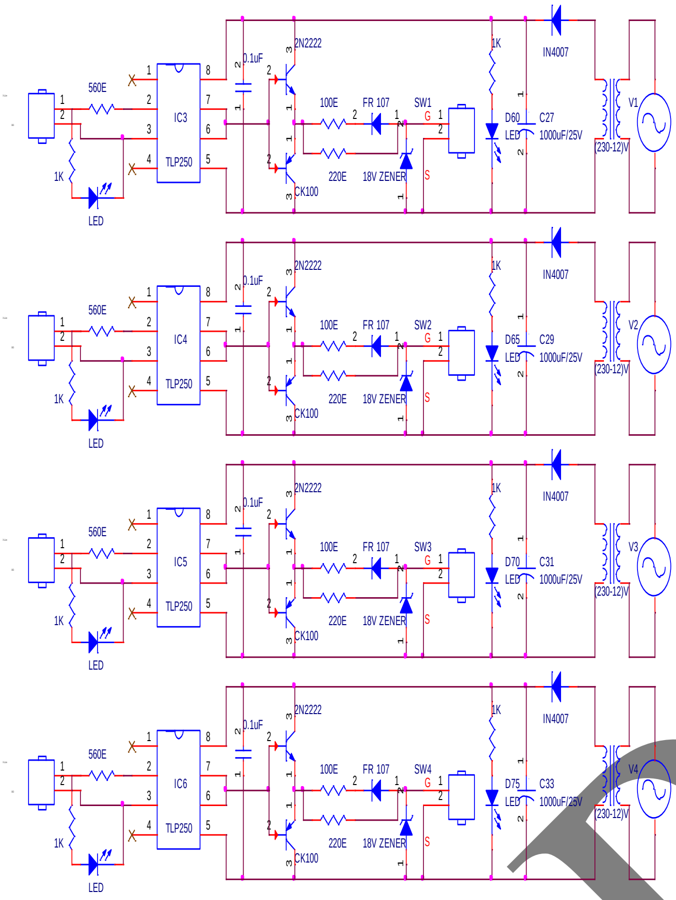

Figure 10. Hardware design

The hardware of D-STATCOM is implimented as per the above figure. The 5 volt DC supply is given to the microcontroller from power supply circuit. The output of microcontroller is fed to optocoupler. The main function of optocoupler is, provide isolation in between microcontroller and driver circuit (amplification system).Then output from optocoupler is fed to the driver circuit.The main use of driver circuit is to amplify the weak signal which is taken from optocoupler. Amplified signal apply to voltage source converter (VSC) and voltage source converter (VSC) is converts the DC supply into the AC supply. And now AC supply provide to the load through coupling transformer.

VII. RESULT ANALYSIS:

A. MATLAB SIMULATION

Parameter	Input Voltage	Output voltage
Without DSTATCOM	12v	4.3v
With DSTATCOM	12v	11.3v

B. HARDWARE

Parameter	Input Voltage	Output voltage
Without DSTATCOM	12v	2.4 v
With DSTATCOM	12v	10.9 v

VIII. CONCLUSION:

A simulink model of the D-STATCOM based on the VSC is designed 'RL' load is connected to the system. The D-STATCOM is connected between Source and Load. The results are taken in the power system model with and without the D-STATCOM for loads. For each type, the readings are taken for with and without the D-STATCOM and are compared. In the simulation, the output of system without D-STATCOM is 4.3V due to RL load, after connecting D-STATCOM in the system output is 11.3V. From the results of simulation we can conclude that D-STATCOM is able to compensate the voltage.

The hardware is identical to the simulation stated above. In hardware the system voltage is 12V, at output side voltage should be 12V, but practically it is not possible. In hardware the output of system without D-STATCOM is 2.4V. We have connected RL load, remaining voltage will be consumes by the load. After connecting the D-STATCOM in the system the output is 10.9V. From the observations we can conclude that 8.5V drop is compensated by the D-STATCOM.

REFERENCES:

1) "Implementation of D-STATCOM for Improvement of Power Quality in Radial Distribution System" Kolli Nageswar Rao1, C. Hari Krishna, Kiran Kumar Kuthadi3
2) "Applications of D-STATCOM Using MATLAB Simulation in Power System" Bhattacharya Sourabh.
3) "Application of PI controller based DSTATCOM for improving the power quality in a power system network with induction furnace load" Parag Nijhawan1*, Ravinder Singh Bhatia2, and Dinesh Kumar Jain3
4) "A Review of Compensating Type Custom Power Devices for Power Quality Improvement" Yash Pal, A. Swarup, Senior Member, IEEE, and Bhim Singh, Senior Member, IEEE
5) S.Khalid1 & Bharti Dwivedi2 Department of Electrical Engineering, I.E.T., Lucknow, India 'Power Quality Issues, Problems, Standards & Their Effects In Industry With Corrective Means' 1 Vol. 1,Issue 2,pp.1-11
6) Hendri Masdi1, Norman Mariun.M.Bashi MIEEE, A. Mohamed, SallehhudinYusuf"Design of a prototype D-STATCOM for voltage sag mitigation" in IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 20, NO. 9, April 2009.
7) M.Deepika, Mrs.S.M.Padmaja. "SIMULATION OF D-STATCOM BASED ON 5-LEVEL CASCADED H-BRIDGE INVERTER" in International Journal of Engineering Research & Technology (IJERT) Vol. 1 Issue 5, July - 2012 ISSN: 2278-0181.
8) Srinivas BhaskarKaranki, NageshGeddada, "A D-STATCOM Topology with Reduced DC-Link Voltage

Rating for Load Compensation with Nonstiff Source," in IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 27, NO. 3, MARCH 2012

9) Mani Bansal, Navneet Singh Bhangu, "Reducing Harmonics Distortion in Distribution Network Against The Induction Motor Drive Non Linear Load" in International Journal for Science and Emerging Technologies with Latest Trends.