

Brief Review Paper on the DSTATCOM for Power Quality Improvement

¹Ramavtar Dhakar, ²Prof. Sudeep Mohaney

Department of Electrical Engineering
Jabalpur Engineering college, Jabalpur

Abstract: The impacts on equipment manufacturers, customers & electricity suppliers are a key factor in recent times in terms of power quality. The variation in frequency, current, and voltage of a power system is described as the power quality. It refers to the widespread electromagnetic [EMI] phenomenon which at a certain time and location in the power system characterize the current & voltage. There are currently so many industries that use manufacturing and process unit technology. This technology necessitates a power supply device of higher quality and reliability. Industries such as semiconductors, manufacturing units, and computer equipment are highly sensitive to changes in power supply efficiency. PQ concerns involve a wide variety of network disturbances like the voltage, harmonics distortion, impulse transients, sags/swells, interruptions & flicker. Voltage swells and sags are more common than any other phenomenon of power quality. The most unfavorable PQ issues in the power distribution system are voltage sags/swells. The scope & aim of this paper is to analyze how power quality (PQ) occurs in distribution devices.

Keywords: Distribution Static Compensator (DSTATCOM), Custom power, Unified Power Quality compensator (UPQC), Power Quality (PQ), Dynamic Voltage Restorer (DVR).

I. INTRODUCTION

Since the late 1980s, the power system's power quality has been a major concern. Power Quality is of concern to all 3 parties involved in the power system, including equipment manufacturers, utility companies & electricity users. Electrical supply problems once considered tolerable through consumers & electrical utilities nowadays are widely regarded by daily equipment users as a problem. Power quality (PQ) is a concept that is difficult to understand. There are 2 types of power quality in electrical power systems: poor power quality and best power quality. Even in voltage and frequency tolerances, the power quality (PQ) will be used to characterize an always-available power supply, and it has a pure sinusoidal waveform for all devices, as most of the devices have been designed on this basis [13]. Unfortunately, the majority of technical equipment on the electric distribution grid distorts the voltage [12], resulting in low power quality (PQ). And thus other devices that have been designed to meet expected undistorted voltage and are therefore sensitive to power disturbances [11] that lead to decreased performance and cause elements of premature failure or odd operation. The problems with power quality (PQ) may be high and include demurrage costs, loss of customer trust, and damage to equipment in some circumstances. Indeed, power quality (PQ) is a significant point in the relationship b/w consumers & suppliers [12], but it can also become contractual gratitude that stress on enhancing power quality (PQ), performance[8], efficiency & availability, and these enhancements with benefits for both industrial customers (customized and flexible availability) & for suppliers utilities.

Facts Devices in Power Quality Improvement

The author's Lee et al. [20, 22] discussed enrichment of the quality of the voltage using FACTS in this part. A new approach has been developed to reduce voltage fluctuations. The usage of the Distribution Static Compensator was questioned by Lee et al. [24, 25]. The Distribution Static Compensator acts as various negative and positive series behaviors at the basic frequency. D-STATCOM is used for renovating a positive sequence voltage to its nominal value and for suppressing a negative sequence voltage at its adequate value.

In terms of voltage fluctuations at the site of installation, conductance command is effectively designed to minimize voltage variation results from the renewable energy's variable sources and load changes. Low voltage microgrids would be high voltage distortion, resulting in harmonic currents. In this analysis, the harmonic current is suppressed with a resonant current control & the basic current registered [20]. The following two inferences are made about the Distribution Static Compensator site.

- (1) When the Distribution Static Compensator is near to the source, the regulation of performance is worst.
- (2) The best regulation for performance is at the DSTATCOM's transmission line's end.

Lee et al. have expanded their work on [25] through prominent a Distribution Static Compensator that identifies admittance of positive sequence & conductance of negative sequence for voltage regulations at positive sequence & voltage overcome at negative sequence. Both the negative and positive series shunt admittances were effectively regulated with respect to the deviation of the proportion of imbalanced voltage and positive sequence voltage. In the event of variations in DG or load, the voltage quality may be maintained at a sustainable stage. To control the basic current within the Distribution Static Compensator & also suppresses harmonic current, the proportional resonant (PR) current regulator with unique harmonic compensation [19, 21] is executed.

II. Impact & Classification Of Power Quality Problems

The different kinds of disturbances have to be sorted by duration & magnitude to make the study of power quality (PQ) problems useful.

2.1. Under voltages

Short-term sub voltages are referred to as "Voltage Dips [IEC]", "Voltage sag" that [17, 18] is the decrease in the voltage supply followed through the voltage realization after a short time. Exorbitant loading systems, generation loss, incorrect setting of the transformer taps, and disturbance of the voltage regulation, cause a voltage. Low power factor loads and the usual lack of reactive power support contribute to the system. Under voltage, overload problems can also occur as equipment sets a higher current to sustain power o/p (for example. motor loads).

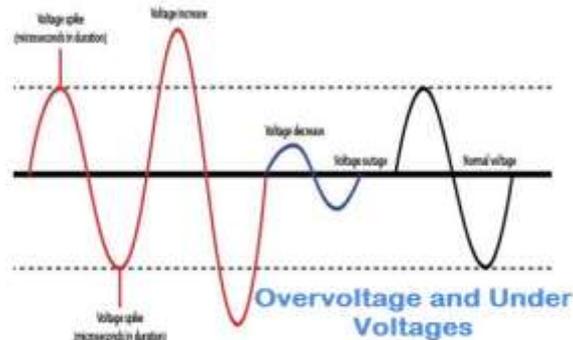


Figure 1: An example of Under Voltage.

2.2. Voltage Dips

A system failure is the main reason for voltage dips in a supply system, i.e. sufficiently that there is no remote electrically voltage regulation occurs. The use of large loads & the implementation of high inductive loads is another source occasionally.[18]. The consumer impact can vary from annoyance (non-periodic light flicker) to severity (connecting of motors & sensitive loads tripping).

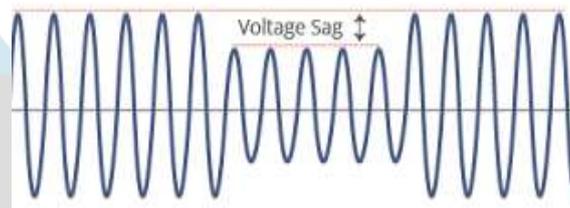


Figure 2: An example of voltage sag.

2.3. Voltage Spikes/Surges

Dips are the exact opposite of spikes/surges of voltage.: an increase in voltage that can be almost instantaneous (spike) or occur over a longer period (surge). The most common trigger is arcing on circuit breakers/contactors during lightning & switching strikes operations (circuit switching, fault clearance, especially switch off of inductive loads).

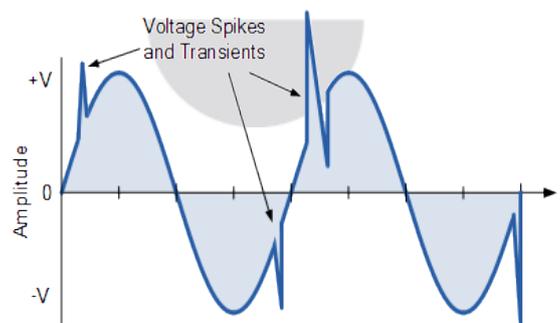


Figure 3: An example of Voltage Spikes/Surges.

2.4. FREQUENCY VARIATIONS

In small isolated networks, frequency variations high enough to reason problems are more likely to occur as a result of defective equipment. Certain causes include system overloads or governor failures, but a single governor failure on an interconnected network would not result in widespread disruptions.

2.5. Very short Interruptions.

For several milliseconds to 1 second or 2seconds total electricity supply interruption. Causes include: Especially as protective devices are opened and automatically reclosed to decommission a faulty system section. The major causes of failure are the insulator and lightning flash insulation.

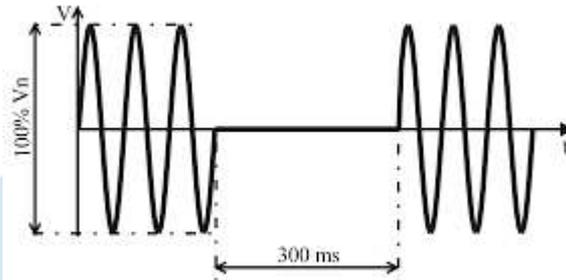


Figure 4: An example of Very short Interruptions.

2.6. Harmonic distortion

The waveforms of Voltage or current take on a non-sinusoidal shape. A waveform is made up of further sin waves of several stages & magnitudes with multiple power system frequencies. Reasons: Classic sources: machinery works directly above the knee magnetization curve (magnetic saturation), corrective machines, welding machines, brush motors, and arc furnaces. Modern sources: all non-linear loads, including data processing, power devices of ASD, mode power switch, high-efficiency lighting. Modern sources: all non-linear loads.

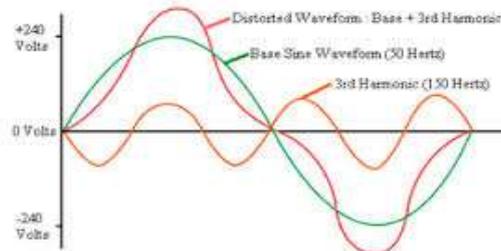


Figure 5: An example of harmonic distortion

2.7. Voltage fluctuation

Voltage oscillation, amplitude with frequency from 0 Hz to 30 Hz, modulated by a signal. Causes: Power motors are frequently starting and stopping (for example arc furnaces, elevators and loads oscillate. Consequences: Most of the results are usual under voltage. The more significant result is the screens and lighting flickering, which gives the illusion of a visual perception unsteadiness.

Solar Energy

Photovoltaic (PV) cells can generate solar electric power directly, or indirectly, by collecting and concentrating solar power (CSP) into steam produced by an electric turbine. The direct electricity generation from solar energy is dependent on the PV effect that corresponds to light-knocking photons in a higher energy state. While photovoltaics were initially used in power spacecraft, many PV generation plants are available for everyday use like remote sensing, grid insulated houses, boats, electric cars, water-extraction pumps & roadside emergency telephones.

System of Concentrating Solar thermal (CST) uses optical devices & sun tracking to concentrate a huge area of sunlight into a minor receiving area. A conventional power plant uses solar-concentrated energies as a heat source. There is a variety of technology for concentrating. A) solar shelves b) parabolic troughs c) solar towers d) linear fresnels are the main concentrate concepts of the system. High thermodynamic & therefore high temperatures efficiency are the main purpose for the solar concentrate.

1. Irradiation – For the current analysis, data from various sources was analyzed, & the source was defined dependent on the source's perceived accuracy.

2. Performance ratio – It is noted as depending upon irradiation, optimum tilt angle, the temperature of the air, design parameters, module quality, inverter efficiency, etc. The results were made using RET screen software based on the parameters above. The results were compared with certain data from the newly installed grid power stations in India.

3. Degradation – All manufacturers are guaranteed performance over 25 years, with a production of 90% over the first 12 years and up to 80% over 25 years. Different studies of the extent of modules degradation following long-term operation are conducted by globe-renowned institutions. These results are studied to achieve real results in the region.

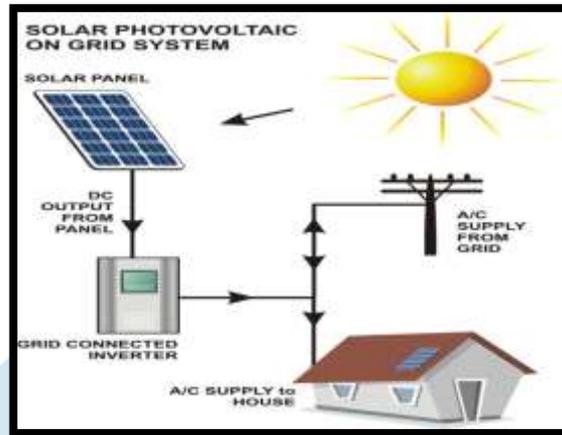


Figure 6. Solar power System

4. Life expectancy – Trends were analyzed in accelerated modular testing, cabling, inverter & structural support were analyzed.

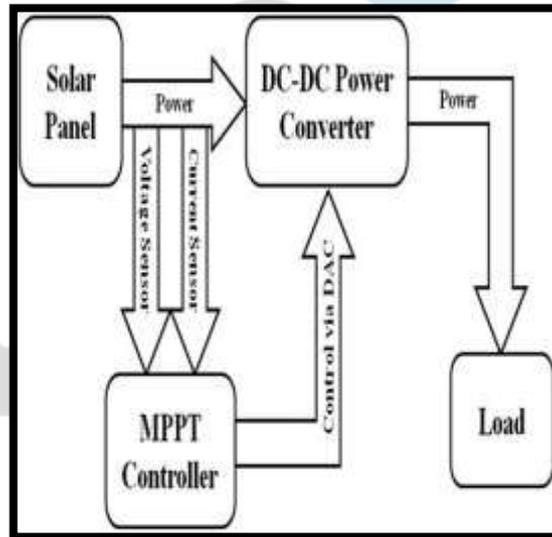


Figure 7. Block of control circuitry

1. Solar power plant technology
Two different categories of solar generation technology can be divided:
a) Thermal solar power plants
b) SPV technology.

2. Solar Photovoltaic (SPV) technologies
PV converters are semiconductor devices that transform directly a portion of solar radiation into electricity. Single crystal silicon is the most common PV cell material, however, there are several variations in design, manufacturing, and cell material techniques. Solar Photovoltaic cells are made of amorphous silicon cells, crystalline silicon like Copper Indium Gallium Diselenide (CIGS), Copper Indium Diselenide (CIDS) and Cadmium Telluride (Cd-Te), dye-sensitized solar cells (DSSC), and other novel technologies like carbon nanotube (CNT), quantum dots & silicon nanoparticle.

Table.1.Solar Module efficiency

S.No	Module	Efficiency
1	Thin film	12-14%
2	Polycrystalline	15-16%
3	Monocrystalline	16-18%

3. Solar power plants performance

Solar power plant performance is better marked through the capacity utilization factor (CUF), it is the real power generation ratio from the plant to extreme potential power generation throughout the year. The predicted output of the solar plant can be calculated using standard software and depends on design parameters. But, as many variables contribute to a plant's final output, the CUF varies across a wide range. The fact that panels are poorly selected, modules are derived at greater temperatures, certain design parameters such as ohms loss, atmospheric by factors like the mist & prolonged cloud cover can be considered. Thus, it is essential to list the different n factors related to variations in plant output. However, the plant performance is based on some parameters involving inverter losses, solar insulation levels, location, soil losses, climatic conditions of special temperature, technical cable losses, module mismatch, and losses of MPPT. Grid unavailability & module degradation may also result in losses due to aging.

Some of the above are defined through the manufacturer, as the power output dependency on temperature. is called the temperature coefficient. Key performance indicators are considered as:

- a) Site radiation
- b) PV system losses
- c) climatic & Temperature conditions
- d) Plant design parameters
- e) Inverter efficiency
- f) Module Ageing degradation.

a) Solar radiation basics and definition

The main driver is solar radiation of several biological, physical & chemical approaches on earth & the accurate and comprehensive data of solar radiation in a particular area in research and applications such as agriculture, architecture, oceanography, industrial sector, meteorology, ecology, environment, agronomy, limnology, etc. Data of solar radiation are also important inputs for the application of solar energy including PV power generation, building solar climate control systems, passive solar devices & solar heat collectors [3]. Numerous empirical formulae for calculating solar radiation with different parameters have been developed. A few works used the duration of sunshine, others use the relative humidity, temperature & sunshine duration whereas others used the no of rainy days, sunshine hours & the factor-dependent upon latitude & altitude. Accurate solar radiation data is the primary requirement for designing a solar energy project. The method used to measure data is essential for an accurate design. Instantly, or integrated for an hour or day in general, data can also be measured (irradiation). For beams, diffusion, or overall radiation as well as for horizontal or inclined regions, the data can be available. The measurement instruments used for these calculations must also be known.

b) Losses in PV Solar systems

The device losses estimated are all the system losses that make a power supplied to the grid smaller than that generated by PV modules. power inverters, Losses in wires, dirt components (sometimes snow), vary levels of insolation, ambient temperature, and others all contribute to this loss. We must account for all possible losses when developing Photovoltaic systems.

c) Reflection losses

At standard test conditions, the Photovoltaic module's power ratings are determined and need perpendicular incident lighting. Larger incidence angles occur in the area, results in greater reflection losses compared to nominal power rates allows for. Annual reflection losses relative to STC are around 1% for modules facing the equator with the tilt angle equivalent to the latitude, according to calculations.

d) Soiling

The accumulation of dust and dirt may lead to the soiling of solar panels. The material is in most cases washed off the surface by rainfall, but even after heavy rainfall dirt such as bird droppings may remain. The lower edge is the most important part of a module. Soiling takes place at the edge of the frame, especially with relatively low inclinations. In the shallow puddle b/w glass & frame and water collection often repeatedly accumulates and consequent evaporative dirt. This dirt minimizes the available power of the module, once it causes cells to be shaded. The losses are usually 1%, but power is restored by the cleaning of the modules.

e) Mismatch effects

The interconnections of solar modules in series and parallel are responsible for mismatch losses. Modules that have not identical characteristics or that have different conditions. The serious issue is Mismatch losses in modules & photovoltaic arrays due to the solar module with low o/p determines the o/p of the entire photovoltaic array under the worst conditions. Therefore, modules are very important to select when it comes to overall plant performance.

f) Maximum Power Point Tracking MPPT ()

Solar PV's power output changes with changes toward the sun, the level of solar insolation changes, and the temperature changes. There are only one maxima of power for the photovoltaic curve (voltage vs power.) of the module. This means that there is a peak power that corresponds to a specific current & voltage. Because of the low-efficiency module at the peak power point, the module should be operated, so that high loading power may be provided under different temperatures and conditions of insolation. This enhances the use of the solar photovoltaic module by maximizing power. The primary objective is to transfer peak power from the Solar photovoltaic module to the load via a dc-dc converter (step-up/step down). The Maximum PowerPoint Tracking ensures

that the output of the panel is always at its peak powerpoint. The solar power plant performance is increased considerably with MPPT. The maximum power point for the V-I curves below the solar monocrystalline solar module is reached at the intersection of current & voltage curves at varying amounts of radiation. In most situations, converter, transmission devices, cable losses, and inverter are simply detected.

g) Inverter efficiency

Solar photovoltaic inverters are a kind of electric inverters that switches the electricity from direct current (DC) in a photovoltaic range to alternating current (ACs) with or for the supply of home appliances. These inverters may either be stand-alone inverters for isolated systems or grid-tied inverters for connecting the power plant to the grid.

The inverter's efficiency is linked to how well the DC voltage is transformed into AC. The recently existing grid-connecting inverter operates efficiently between 96% and 98.5%, which is why the correct inverter must be chosen. Less efficient inverters are also available below 95 percent. Inverters are significantly less effective when used at the low end of their peak power. The majority of inverters are more effective in the power range from 30 to 90 percent.

V. Wind Energy Conversion System

The wind energy conversion system (WECS) contains the turbine which absorbs kinetic energy from wind, the drive train that increases the shaft's rotating speed, & the generator that transforms mechanical energy into electricity. This paper employs a wind turbine of variable speed, with the ability to continuously adjust the rotational speed of the wind turbine " ω " at wind speeds " v " (i.e. deceleration or acceleration). In accordance with the generator used, the more important assortments for variable-speed wind turbines are ECS equipped with Dual-Fed inductance Generator (DFIG) of the most common type. Reactive & Active power control has provided the opportunity to control the pitch with effective power transfer to the Grid as the wind power effects on the electric network are growing and make them very attractive. The stator (stationary) of the generation units is connected directly to the grid in these generator types and the rotor power is supplied by converters. There are three main parts of this model: wind turbine rotor, drive train, and generator. By producing torque, the wind turbine rotor transforms the wind's fine energy into mechanical energy. Because the energies in the wind are kinetic energy,

III. Voltage Stability Methods

A. Distribution Static Compensator (DSTATCOM).

The static compensator device is DSTATCOM (FACTS controller, STATCOM) based on a voltage source inverter (VSI). Which is used to sustain a voltage sags of the bus at an adequate stage through the distribution system receiving or supplying reactive power. With the aid of a coupling transformer, it is linked in shunt to the distribution network. The SLD of the Distribution static compensator is exhibited in figure 6. The DSTATCOM is composed of the voltage source inverter, energy storage unit, dc voltage, an ac filter & a coupling transformer.

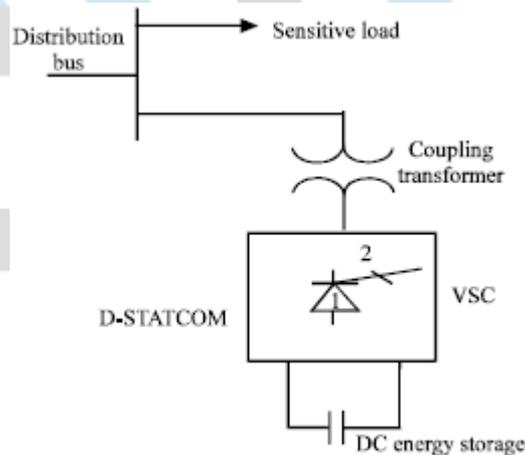


Figure 8: Schematic diagram of DSTATCOM

The VSI in a power circuit transfers from DC voltage to a controllable AC voltage and is connected through a coupling transformer to the AC distribution network. The Distribution Static Compensator also uses extensive renewable sources or energy storage to absorb and depend on active power. In accordance with the operating principle of DSTATCOM, the compensation required for the disturbance needs by the distribution system which continuously regulates and monitors the load currents and voltages. The angle b/w of the ac system and the voltage source inverter (VSI) voltage control the active power flow, while the difference between the amplitudes controls the reactive power flow in this scheme. Both current and voltage control modes are assisted by the DSTATCOM.

B. Static Series Compensator.

The Dynamic voltage restore is also known as a static series compensator (DVR). It is an electronic control device for high-speed switching power, also called the voltage boosters series. The custom-connected electronic device is a Dynamic Voltage

Restorer (DVR) that injects a regulated voltage dynamically into the distribution line to correct the load voltage through the coupling transformer. Figure 7 shows the wide-ranging diagram of the DVR block.

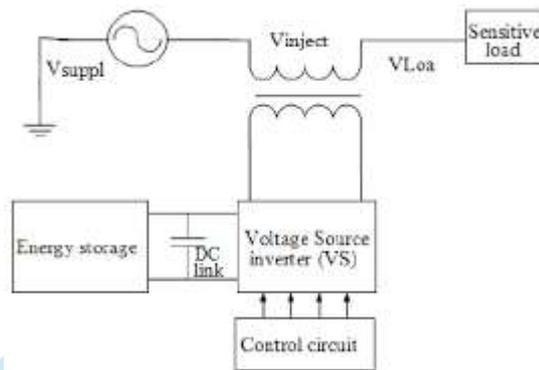


Figure 9: Schematic diagram of DVR

It includes a series coupling transformer, energy storage device, the voltage source inverter, the dc-dc boost converter & an ac filter. DC condensers are being used as a boost converter interface as an energy storage device. The voltage above dc capacitor is controlled through the boost converter, which is commonly used as a source of inverter voltage. The inverter method yields a voltage compensation introduced into the distribution device by a series matching transformer. voltage re-regulation is achieved by generating a reference voltage from the Dynamic Voltage Restorer (DVR) controllers, compared to the synchronized injected voltage & source voltage, to keep the load voltage to be constant. The energy storage components generate the essential voltage for synchronized injection. The AC filter eliminates effects on the coupling transformers winding & power electronics, switching losses in the generation of control signal techniques for the inverter voltage source inverter. If the supply voltage $V_s(t)$, the injection voltage of DVR is $V_i(t)$ & load voltage $V_l(t)$ is interconnected serially. The load voltage is as follows:

$$V_l(t) = V_i(t) + V_s(t)$$

Dynamic Voltage Restorer is therefore supposed to be the controlled frequency, phase angle, and amplitude external voltage source. The purpose of the Dynamic Voltage Restorer is to keep the phase angle, amplitude & load voltage.

C. Unified Power Quality Compensator (UPQC).

Shunt active and series conditioner are a common operation. Shunt active force of the current compensation filter strength, the active series voltage compensation strength filter strength enables the quelling of various problem power quality. For the Unified Power Quality Compensator (UPQC), the SLD is shown in fig 8. To compensate the active conditioner connected with a voltage shunt, an active force injected by a series compensator has to be absorbed into the set to compensate for the excess voltage active conditioner. Two forms of unified power quality compensator have been proposed in literature surveys. UPQC includes two types: unified power quality compensator at Left Shunt and Right Shunt UPQC. In terms of overall performance, the unified power quality compensator at the right-shunt outperforms the unified power quality compensator at the left-shunt. When Unified Power Quality Compensator is linked to 2 feeders, it is referred to as an Interline Unified Power Quality Compensator (IUPQC).

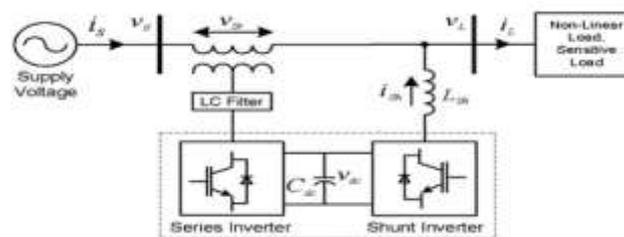


Figure 10: Schematic diagram of Unified Power Quality Compensator

VI. CONCLUSION

This paper gave a high-level overview of the power system that has been built in networks of power distribution to minimize numerous fluctuations of power quality including power factor reduction, flicker, current harmonics, dip, and voltage swells/ sag. To protect the entire plant, loads, and feeders, these control electronics devices are used in distribution systems. The Distribution Static Compensator (DSTATCOM) can give the best PQ in both distribution & transmission when linked in the shunt. The UPQC is the heart of power systems, regulating voltage & current problems at a similar time. The whole device worked together to create a custom power region.

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