

# Various Techniques to Reduce the Power Quality Problem in Modern Distribution System

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**Abstract**— Power electronics based devices are most essential part in distribution system. They have a various advantage but alternatively they also show many disadvantages. They draw harmonic current in conjunction with the fundamental power frequency which harms the distribution system. Because of large number of non-linear loadings, the occurrence of power quality issue can be reduced but cannot be completely eliminated. The following power improvement devices have been used to improve power quality related issues are static var compensator, STATCOM, DVR, active power filter, Unified power quality conditioner.

**Keywords**— ; STATCOM, Dynamic voltage Restorer (DVR), active power filter (APF), Unified power quality conditioner (UPQC).

## I. INTRODUCTION

As the technology paces with the era, a paradigm shift has been witnessed in the power electronics leading to the concept of multi-functionality. Hingorani [1] has introduced the concept of FACTS controller which were basically a VAR impedance-type controllers, controlled by varying the firing angle. PSSCs are network of power/semiconductor switches which provide power conditioning with high efficiency and reliability [2]. In Modern Distribution System (MDS) various PSSC based power conditioning devices namely; distribution static compensator (DSTATCOM), dynamic voltage restorer (DVR), and unified power quality conditioner (UPQC) are available which are installed both at load-end and source-end to improve Power Quality (PQ) of the system [3]. One of the commonly used PSSC is VSC which is a self-commutating DC-to-AC converter and is known as the backbone of the compensating devices [4]. As it can be employed to regulate reactive current by generation and absorption of controllable reactive power. The major attributes of STATCOM are quick response time, less space requirement, optimum voltage platform, higher operational flexibility and excellent dynamic characteristics under various operating conditions. These controllers are also known as Distribution compensator (DSTATCOM) [5], advanced static VAR compensator (ASVC), advanced static VAR generator (ASVG), STATicCONDenser (STATCON), static var generator (SVG), synchronous solid-state VAR compensator (S2VC) [6]. The VSC-based STATCOM (VSTATCOM) has arose as a qualitatively superior technology relative to other members of its family which provide shunt compensation. VSTATCOM is commercially available with high power capacity with simple converter control and robust design [7]. In this paper comprehensive review of DSTATCOM technology with its numerous topologies is presented along with its application in MDS to improve PQ. The proposed topology presents the concept of utilizing PV Power Generation System (PVPGS) as STATCOM under critical dynamic reactive power demand.

The conventional control uses non sinusoidal control references, while the compensating strategy used in this work uses only sinusoidal references to control the PWM converters [8]. As a result, the generation of the control references is easier to obtain, allowing the use of simpler algorithms to accomplish this aim.

## II. POWER QUALITY (PQ) DEFINITION

Power quality is the term which expresses the characteristics of supply voltage and current. Customer at end use demands good quality of power since the equipments connected are voltage sensitive long lasting fluctuation or any deviation in the supply voltage or current waveform may damage the connected load [9, 10]. The power quality problems arise at those typical locations where we connect the loads in the grid or distributed generation [11]. The PQ problems which a grid operator or designer has to look after are; voltage sag, voltage swell, harmonics, distortion, frequency deviation etc. any of the above issue may cause serious problem for the operation of power system and may lead to trouble to the end customer [12]. The best way to solve this PQ issues to install custom power devices at the point where these problems are generating. Custom power devices are power electronic devices which are designed to reduce PQ problems and are generally installed at the point where the PQ problem generates that is at the point of connected load, distribution side or at PCC of DGs [13]. Custom power device aimed to transmit power at high quality and is capable to solve many power quality related problems. UPQC is one such custom power device which is constructed with the help of two converters. One is connected in series with the source and another is connected in parallel at load side. UPQC can mitigate load current harmonics as well as source voltage and current distortion. It can balance load voltage at adverse nonlinear loading [14]. Some PQ problems which the distribution system suffers are presented in figure 1.

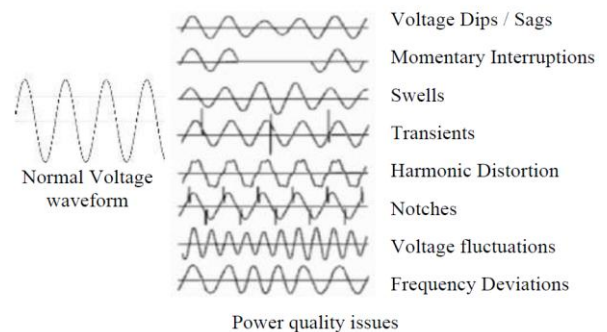


Fig.1 Schematic of DTC method

### III. CLASSIFICATION OF POWER QUALITY CONDITIONER

#### A. Static VAR Compensator

Static var compensators (SVC) control the ac voltage by generation and consumption of reactive power by using the passive elements like resistor and capacitor [14]. SVC particularly contains anti parallel thyristors along with the passive elements. If its thyristor switched capacitor then the passive element is capacitor and reactor in case of thyristor controlled reactor [15].

#### B. Active Power Filter

Active power filters also are largely used is they provide an extremely good answer for tackling the power quality issues inside the distribution system. These active power filters includes parallel AF and series AF and additionally the combination of the series and parallel active power filter i.e. termed as the hybrid active power filter [16]. Series active power filter particularly enables for mitigation of harmonics inside the voltage whereas shunt active power filter specially deals with the compensation of harmonics inside the load current [17].

#### C. STATCOM

STATCOM is one of the high-quality FACTS devices amongst all of the FACTS devices [18]. It could include a voltage source converter or a current source converter and provides a better response. It is used to maintain a good voltage profile and increase the stability. If it is used in the distribution system then it could be referred as D-STATCOM i.e. the distribution STATCOM [19]. It especially includes an inverter circuit, inductor, a capacitor acting as dc source, control circuit for reference current Generation. D-STATCOM facilitates in compensation of the load harmonic as it acts as a current source. Further to this it as many greater advantages like source current balancing, suppression of dc offset in the load and it help to maintain unity power factor. The single line diagram of D-STATCOM is presented in figure 2.

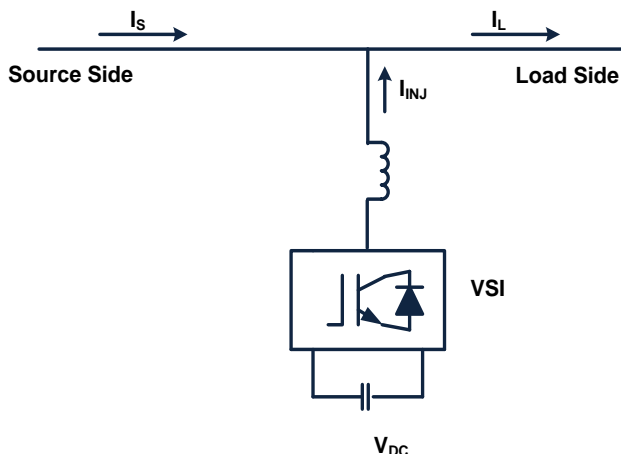


Fig.2 Single-line diagram of STATCOM

#### D. Dynamic Voltage Restorer (DVR)

DVR gives series compensation. It acts as a controller current source and provide sinusoidal voltage to mitigate the condition of voltage sag/swell and to regulate the output

voltage. It contains a voltage source inverter in series with the supply line that help to maintain a specific load voltage. The point where at outside dc voltage supply is used for VSI, the DVR can be used for compensation of voltage harmonics, management of load voltage, and to remunerate voltage imbalance [20]. The single line diagram of DVR is presented in figure 3.

#### E. Unified Power Quality Conditioner (UPQC)

In the context of improve the power quality UPQC play a vital role. Being a multitasking power conditioner UPQC can be utilized for compensation of several voltage disturbances, voltage flicker and it also give prevention to the harmonics in the load current and doesn't allow them to go into the power system and contaminate the quality of power [21]. This custom power device has the capability of mitigation of the issues affecting the working of sensitive equipment or loads. UPQC provide compensation to harmonics in current (shunt element) as well as that to the voltage (series part), controls the flow of power and also overcomes the disturbances in voltage like voltage swell, sag and many others. The important parts of unified power quality conditioner are shunt inverter, series inverter, dc link capacitor, shunt coupling inductor and series transformer as shown in figure 4.

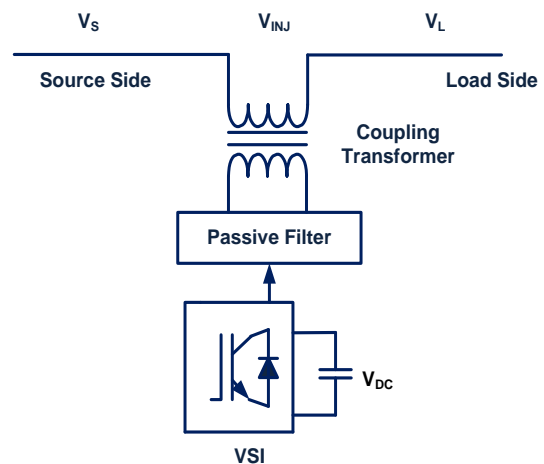


Fig.3 Single-line diagram of DVR

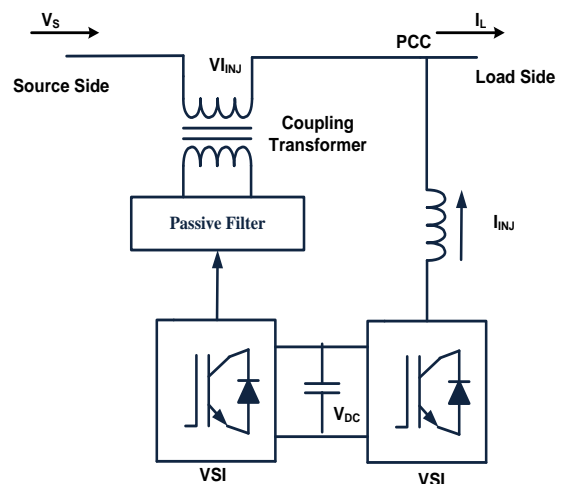


Fig.4 Single-line diagram of UPQC

## IV. CONCLUSION

In modern power system, power electronic has a very strong predominancy. There has been a versatile load profile available using Power Electronic Devices (PED). These devices are good in efficiency since losses are low in semiconductor devices, highly reliability, life span is long and demands low maintenance cost. But they have disadvantages like; harmonic injection, low Power Factor (PF) and overloading capacity is also low since they perform only at rated voltage and current. The adverse effect of PED is generation of current-related intrusion at their input, which injects noise into the utility system, and voltage intrusion at their outputs which may hinder the system stability and leads to various Power Quality (PQ) issues. The PQ issues generated due to non-linear and unbalance loading can also be rectified by designing a proper PED based Converter (PEC). PECs are network of power/semiconductor switches which provide power conditioning with high efficiency and reliability. In Modern Distribution System (MDS) various PEC based power conditioning devices are available which are installed both at load-end and source-end to improve PQ of the system. This research presents the application overview of widely adopted PQ conditioner in distribution system like; STATCOM, DVR and UPQC.

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