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A Review of Custom Power Devices for Power Quality Improvement of Distribution Network with Arc Furnace

Rohit Kumar
Ph.D., TIET, Patiala, India.
rohitsingla4286@gmail.com

Parag Nijhawan
Faculty, TIET, Patiala, India
parag.nijhawan@rediffmail.com

Sahaj Saxena
Faculty, TIET, Patiala, India.
sahaj.saxena@thapar.edu

ABSTRACT

An important concern for both power suppliers and customers in order to provide power quality is the self-regulating market of electric power. With regard to improvement in the power quality efforts have been made using various type of filters and custom power devices. In view of this, we present a comprehensive survey of compensating custom power devices mainly DSTATCOM (distribution static compensator), DVR (dynamic voltage restorer) and UPQC (unified power quality compensator) and complications related with the arc furnace load.

Key words: Custom Power, DSTATCOM, DVR, Power Quality, UPQC, Electric Arc Furnace.

1. INTRODUCTION

For power research community, power system power quality is a serious issue because of the following reasons:

(i) Electrical and mechanical equipment's are coupled together in process industries thereby generating the harmonic distortions.

(ii) Create impacts like disrupts production in industries leading to economical loss and generation capacity.

Many filters like passive filters, active filters, CVT, tap changers, etc. depicted in [1-2] take the responsibility to correct power quality issue but have limitations such as high transfer time, problems of cooling, losses. Another solution to this is custom power devices. This provides quality service of power to the consumers end. For resolving power quality issues, custom power devices namely reconfiguring type and compensating type have been introduced. But because of several shortcomings like high transfer time, cooling problem, losses which leads to reduced efficiency of reconfiguring type custom power devices. However, compensating type devices overcome all these problems occurring in reconfiguring type devices. DSTATCOM, DVR, UPQC are compensating custom power devices also used for power factor correction, for filtering purpose, load current balancing, regulation of voltage [1].

In this paper, we present an overview in the form of literature survey of the custom power devices for quality improvement of distribution network. The concept of arc furnace is also briefly illustrated.

2. LITERATURE SURVEY

Electric arc furnace (EAF) is used in industries for yielding steel. Due to strongly fluctuating and non-linear nature of EAF the consumed power variations are large. EAF effects the system power quality by its major effects like voltage fluctuations, low power factor and high harmonics at common coupling point as explained in [1-3]. Reference [4] presented lowering and energizing process of electric arc furnace. Reference [5] showed various models of status of EAF at different circuit situations. References [6-7] introduced reactive power compensation devices to avoid this problem. For this purpose high speed response compensators are required which are presented by [8-9].

Electric Arc Furnace

From scrap metals electric arc furnace (EAF) produce alloy steel. Reference [10-11] framed EAFs are heavy, strongly fluctuating and large nonlinear load in power system. Reference [12] presented consumed power large deviations due to the stochastic nature of EAF. Thus on electric supply system the extensive impacts of degrading due to very high amplitude of load currents is presented in [13]. Reference [14] depicted on the system quality of power, EAF has many bad effects like high harmonic current at point of coupling, voltage flicker and low power factor. Reference [15] showcased precautions to mitigate the bad effects of EAF on quality of power. References [16-19] proposed to avoid the bad effects caused by EAF the reactive power compensation devices is the best answer. Figure 1 shows the section and plan view of EAF which depicts how steel is yielded with the help of EAF.

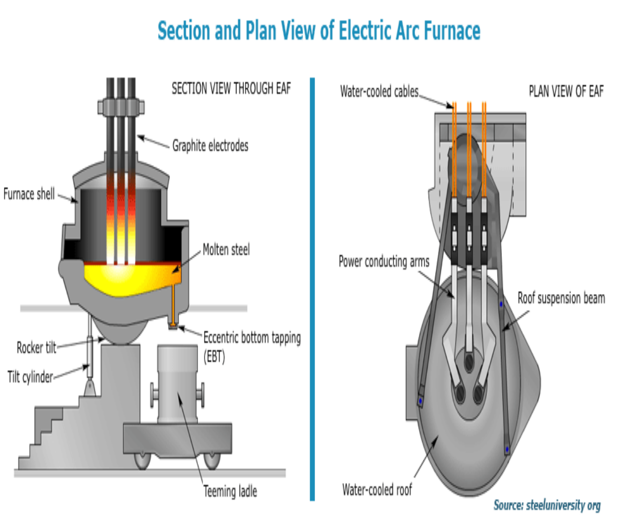

Figure 1: Electric Arc Furnace [10]

Power Quality

As per the IEEE definition [20], “Power Quality is the concept of powering and grounding electronic equipment in a manner that is suitable to the operation of that equipment and compatible with the premise wiring system and other connected equipment”.

Custom Power Devices

In today‘s environment, every person must be conscious of power quality and various problems of power quality presented by [21-25]. Due to deregulation of energy market power quality is becoming a main concern framed in [26-39]. Problems related to voltage magnitude and waveform distortion are occurred in majority in electric power distribution network. To achieve the goal of reactive power compensation we use custom power devices. Custom power devices has two categories namely network configuring and compensating type proposed in [40].

DSTATCOM

DSTATCOM for distribution network and STATCOM for transmission network are similar. DSTATCOM can operate in voltage or current control mode framed by [40-50]. DSTATCOM is shunt connected in the network presented by [48], [51-91]. [56], References [68], [70] showed voltage regulation whereas [91] presented harmonic filtering and load balancing decreases by DSTATCOM is explained in [87-88]. Figure 2 shows the schematic diagram of DSTATCOM which depicts how DSTATCOM is connected between source and load.

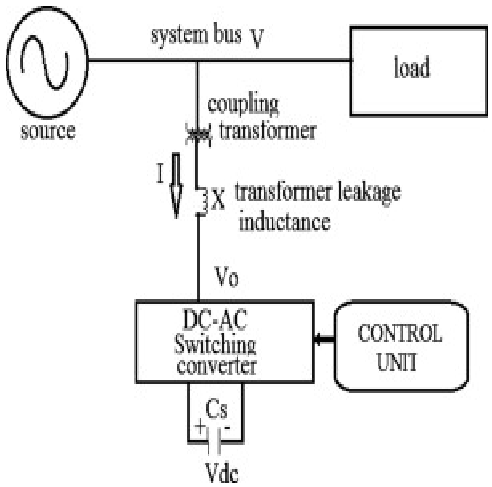

Figure 2: Schematic Diagram of DSTATCOM [40]

References [85, 86, 93, 94] showcased voltage flicker and voltage fluctuation can also be resolved with the help of DSTATCOM, when it is connected to distribution system. DSTATCOM modelling is explained by [57]. The control strategies for DSTATCOM are discussed and analysed in [58-61], [83]. The simulation study and various inverter topologies for DSTATCOM are offered in [62]. Reference [86] offered various control algorithms for load compensation of DSTATCOM. Having single stage VSI presented by [63-64] voltage fed type three phase, three wire DSTATCOM is developed at medium voltage level and higher capacity of power handling multilevel VSI elucidated by [65-66], cascaded multilevel VSI presented by [67], cascaded H-bridge proposed by [82], [87] and multipulse VSI presented by [80], [82], [95] for high voltage levels are employed. 250 KVAR DSTATCOM design and installation for distribution system is offered in [69]. In literature three phase, four wire DSTATCOM depicted in [74-76] are also developed and reported. Neural network base control is presented in [65] and three dimensional PWM based algorithm is presented in [66]. For three level selective harmonic eliminated PWM optimization method is showcased in [89]. References [78-80] elucidated DSTATCOM models for nonlinear and unbalanced loads along with their controls. Reference [81] presented dynamic performance of distribution system under the influence of DSTATCOM and AC generators. DSTATCOM application for renewable energy sources and for industrial system is showed by [94-95].

DVR

The device DVR is connected in series. The voltage sags seen by sensitive loads can be reduced with the help of DVR. Shielding of sensitive loads by a series connected device named DVR is elucidated in [47], [56-59], [96-108]. [96-98] proposed DVR pay off for rise or drop in supply voltage and series voltage injection. For the design of variable speed AC drives and other sensitive loads with DVRs a method for incorporating voltage sag rid though is presented in [99]. References [100-101] framed role of DVR installed in distribution system and for voltage sag mitigation supplying nonlinear loads. DVR with zero sequence injection capability for voltage sag mitigation is presented in [92]. Reference [103] explained voltage sag mitigation with photovoltaic based DVR. To control the dynamic voltage restorer operation hysteresis voltage control method is presented in [106]. Figure 3 represents the schematic diagram of DVR.

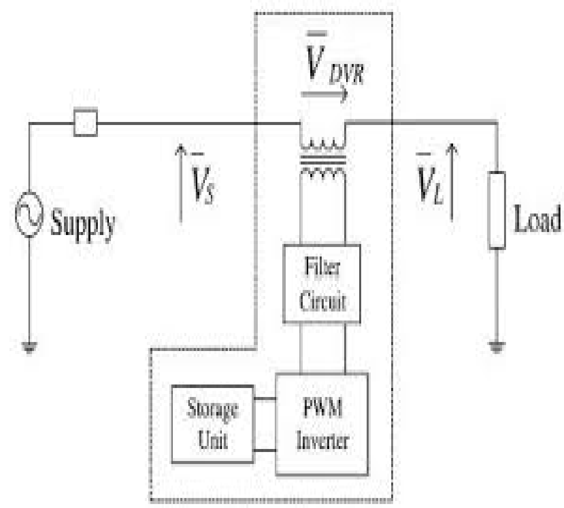

Figure 3: Schematic Diagram of DVR [47]

UPQC

In distribution system various power quality problems like unbalance voltage mitigation, power flow control, flicker reduction and sag compensation compensates by UPQC explained in [110-120]. In [113-117] for avoiding problem of stability, UPQC with nonlinear strategy of control, UPQC different strategies of control at load side, UPQC with novel method of control and UPS systems are presented. For injecting voltage in quadrature advance to the supply current control of SERC of UPQC is proposed in [112-118]. The schematic diagram of UPQC is presented in Figure 4 which shows UPQC unit, transformer, series inductors, parallel capacitors, loads etc.

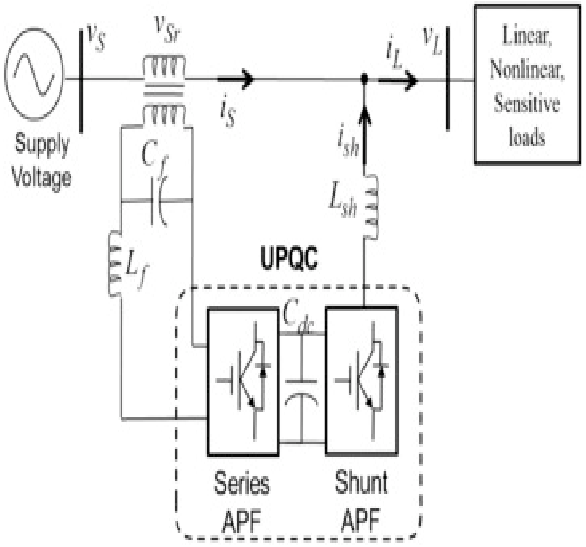

Figure 4: Schematic Representation of UPQC [110]

3. CONCLUSION

In this paper, we present a short introduction of power quality improvement through custom power devices. The survey is made without the comprehensive study of the various components and techniques. In short, we can mitigate different power quality problems of electric power distribution network with arc furnace load with the help of compensating type custom power devices, i.e. DSTATCOM, DVR, UPQC, etc. An attempt has been made to cover references in this study but error may be exist if some references are ignored.

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