Power Quality Conditioning By Eight Switch and Twelve Switch Converter for Mitigation of Current Harmonics and Voltage Sag Compensation

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Abstract— Aim of this paper is to reduce the cost of power quality converter. Numbers of converter are used to control the power quality i.e 12-switch converter, 9-switch converter etc. Nine switch converter has an advantage that is less of number of switches as compare to 12 of the back-to-back converter. But some restrictions in the total attainable amplitude at its outputs, depending on the phase shift between its two terminal sets. With an appropriate design control scheme for nine-switch converter, it show favorable improvement of overall power quality & justify its role as a power conditioner at a reduced semiconductor cost. The proposed power conditioner presents a only eight switches, transformer-less hybrid filter, four-switch two-leg inverter and a six-switch dynamic voltage restorer & it is capable for voltage sag mitigation and another unit for current harmonic compensation.

Key words: PWM Converter, power quality, power conditioner etc.

I. INTRODUCTION

Currently industrial process required good quality of electric power so that they run satisfactory. But on other hand with increase in nonlinear load on grid such as diodes, thyristor & rectifiers, which contributes current harmonics in the grid which affect sensitive loads of industries. When there is a huge fluctuation of voltages and currents in power grid, it may occur miss-operation or performance errors of protection circuit or device, which may causes many financial losses. Another important issue related to power quality is the short duration voltage disturbances mainly the voltage sags, swells, harmonics, unbalances, and flickers. The main types of power quality problems are: voltage sags & swells, current harmonic distortion, unbalance voltages, flickers and frequency variations effect. Therefore we need to develop the device which are capable to mitigating harmful effect of current & voltage fluctuation in power grid system. The term \power quality" (PQ) has gained sign cant attention in the past few years. The advancement in the semiconductor device technology has made it possible to realize most of the power electronics based devices/prototypes at commercial platform. The improvement of power electronic technology makes it possible to realize many kinds of FACTS devices to obtain high quality electric energy and take proper control over power system.

UPQC is one of them. This paper deals with unified power quality conditioners (UPQC's) which aim at the integration of series active and shunt active filters. The aim of a UPQC is to compensate a supply voltage flicker or imbalance, reactive power, negative-sequence current, and harmonics. In other way, the UPQC is a circuit which has improving power quality at the point of installation on power distribution systems or industrial power systems. It is the most powerful solution for large capacity & sensitive load to supply voltage flicker or imbalance. It consists of a series active and shunt-active filter.

The shunt active power filter, consisting basically of a VSI with a large capacitor on its dc-link, It is considered as a good established solution to reduce the current harmonics to the fulfill standards limits. The major disadvantage of shunt active power filters is, high power rating components required for compensating high peak harmonic currents and their associated costs. The series-active filter eliminates supply voltage flicker or imbalance from the load terminal voltage. An another called hybrid filter. It is mixture of low rating active power filters with passive filters, which reduce the cost. It is an great effort to decrease the number of components of active and passive filters. In some other paper it was presented a hybrid filter consist a low power rating three-phase VSI connected to the load at a point of CC (common coupling) through a LC passive filter without any matching transformer. A LC filter absorb some current harmonic produced by the nonlinear load & an active filter improve the filtering characteristics of the LC filter.

By Reduced switch versions of the transformer-less hybrid filter, it achieved by eliminating one phase leg of the inverter and connecting the remaining phase to the negative pole of the dc-link. This is feasible because the capacitors of the LC filter block the dc components generated by the connection of one phase to the negative pole of the dc-link. The dynamic voltage restorer (DVR) is a device designed with the primary function to compensate voltage sags and swells & also design to perform additional features like reduce the transient voltage and voltage harmonic and protect a sensitive loads from unexpected shutdowns and malfunction due to power quality degradation. A traditional scheme of a DVR consists of an inverter connected in series to the grid through a coupling transformer. On the other side, a great effort has taken to reduce costs. An inverter DVR based on direct converters without any energy storage devices has been presented. It use a high frequency transformers with a benefit of reduce the size, weight, and cost of the whole structure.

II. OVERALL EXISTING SYSTEM

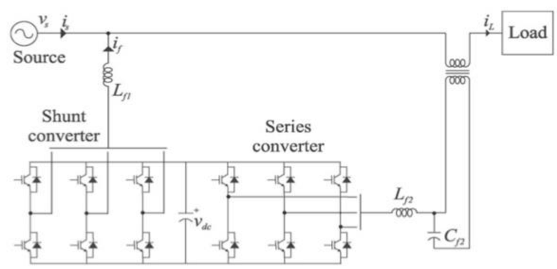

Fig. 1: Back-to-back two-level voltage source inverter

In existing system the back to back converter used for UPQC. The shunt and series converter has more input current to take the compensation. At normal time to mitigates the voltage sag & improve harmonics from both shunt and series converter. This makes more number of switching operates at high current. So the switching losses are high. The overall system efficiency is low.

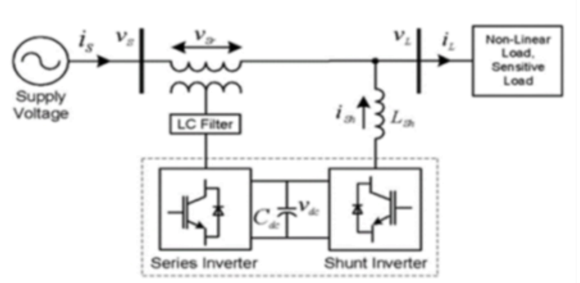

Fig. 2: One line Diagram of UPQC

In UPQC combines the operations of a DSTATCOM and a DVR together. The series component of the UPQC inserts voltage so as to maintain the voltage at the load terminals balanced and free of distortion. Simultaneously, the shunt component of the UPQC injects current in the ac system such that the currents entering the bus to which the UPQC is connected are balanced sinusoids. Both these objectives must be met irrespective of unbalance or distortion in either source or load side.

III. PROPOSED EIGHT-SWITCH POWER CONDITIONER

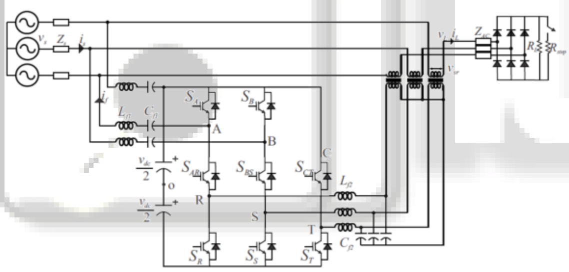

Fig. 3: Proposed eight-switch conditioner using the hybrid filter.

In regular converter, a series converter & shunt converter are controlled voltage sag & load current harmonics compensation. A development in topologies reduces the cost to large interested consumers. For that some topologies have been developed for the same purpose, like a nine switch converter has less switches than the twelve switch (traditional) converter, but it has some limitation, lower amplitude output voltage because of sharing of the intermediate switches and limited phase difference between the two sets of output.

As these limitations are compensate, by reducing amount of active switch. The proposed topology is an eight switches conditioner with hybrid filter in shunt converter. Aim is reduce the cost compared to twelve switch (traditional) power conditioners. The converter inject a signal to compensate the current harmonics and for a voltage sag, increase the range of the carrier dedicated to the series converter which inject the signal for a rated load voltage. The current harmonics compensation is done by a passive filter which is in series with an active filter. A 7th harmonic is tuned by passive filter, it have a low impedance around this harmonic & high impedance around the switching frequency. A 7th harmonic frequency is select because:

1) The 7th harmonic frequency tuned LC filter is less bulky and expensive than that 5th harmonic frequency tuned LC filter;
2) The 7th harmonic frequency tuned LC filter present lower impedance at the 11th and 13th harmonic frequencies than 5th harmonic tuned filter does;
3) The filtering characteristic for the 5th harmonic frequency can be significantly improved by the feed forward control.

A. Series Control of Eight-Switch Conditioner:

The aim of series control is provide rated voltages at the load terminals. To perform the control, the grid voltages are measured, giving information for the series control and for the phase-locked loop, responsible for generating the reference angle for the conditioner. To make effective control action for PI controllers load voltage are transform into *dq*.

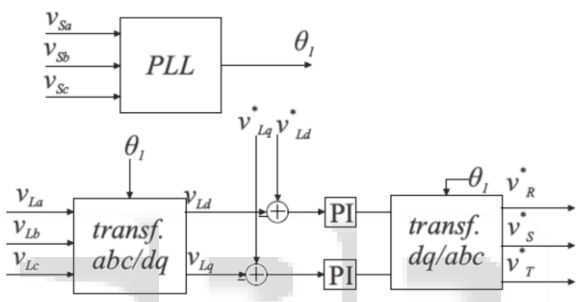

Fig. 4: Block diagram of the series control

By using inverse transformation the outputs of controller axes d and q are brought to the natural abc reference-frame The output reference voltages (v^*_R ; v^*_S ; v^*_T) are then normalized with respect to the voltage measured on the dc-link, v_{dc}.

B. Shunt Control of Eight-Switch Conditioner:

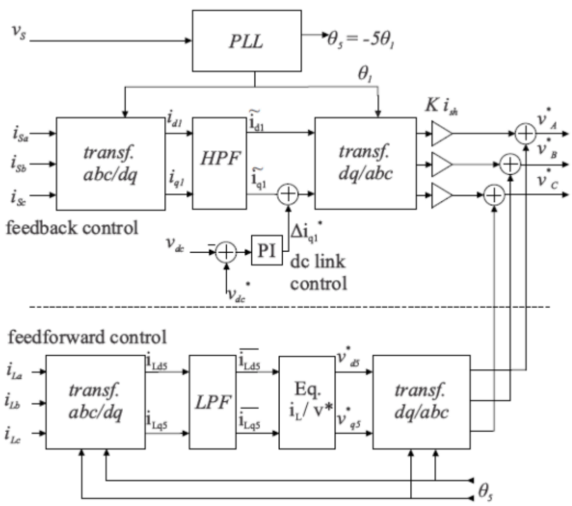

Fig. 5: Block diagram of the shunt control.

The control diagram of the hybrid filter is shown in Fig.5. The grid current & load current are measured to achieve the feedback and feed forward controls, respectively, and makes use of the phase-locked loop structure. The hybrid filter also controls the dc-link voltage.

In the feedback control, the transformation *abc-dq* in the fundamental frequency converts the three-phase grid currents (i_{Sa}, i_{Sb}, i_{Sc}) into the active (i_{d1}) and reactive (i_{q1}) instantaneous currents. The fundamental components in the grid correspond to the dc current and harmonic components correspond to ac part of id1 and iq1. Two high-pass filters (HPF) of first order with cutoff frequency of 16 Hz extract the ac components from i_{d1} and i_{q1}. Then the inverse transformation dq-abc produces harmonic components required for compensation.

IV. SIMULATION RESULTS OF THE PROPOSED CONDITIONER

The parameters used in the experimental results are shown in Table I: rms value of grid line-to-line voltages (V_s = 380V), grid frequency (f_s = 60Hz), switching frequency (f_{sw} = 20kHz), dc-link reference voltage (V_{dc} = 590V), dc-link capacitor (C_{dc} = 4700_F).

Parameter	Symbol	Value
rms value of grid line-to-line voltages	V_s	380V
Grid frequency	f_s	60 Hz
Grid impedance	Z_s	0.275 + j0.196 Ω
Switching Frequency	f_{sw}	20 kHz
dc-link reference voltage	V_{dc}	590 V
dc-link capacitor	C_{dc}	4700 μF
Hybrid filter capacitor(7^0 harmonic)	C_{f1}	54 μF
Hybrid filter inductor(7^0harmonic)	L_{f1}	2.9 Mh
Series converter capacitor	C_{f2}	30.7 μF
Series converter inductor	L_{f2}	0.8 mH
Load input impedance	Z_{AC}	0.100 + 0.498 Ω
Load resistor in the rectifier dc side	R_L	26.3 Ω
Load resistor for step change	R_{step}	52.6 Ω

Table 1: System Parameter

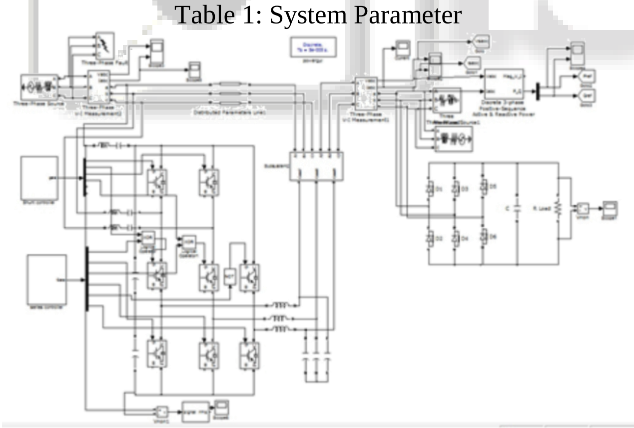

Fig. 6: Simulation of eight switch converter.

The first result shows the Source Side Voltage and Current, second result shows Load Side Voltage and Current. THD for 8 Switch Converter Is 3.80%

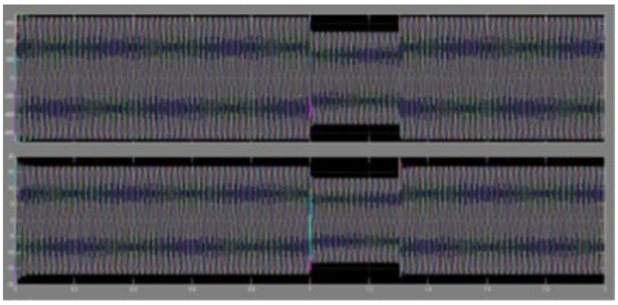

Fig. 7: Source Side Voltage and Current

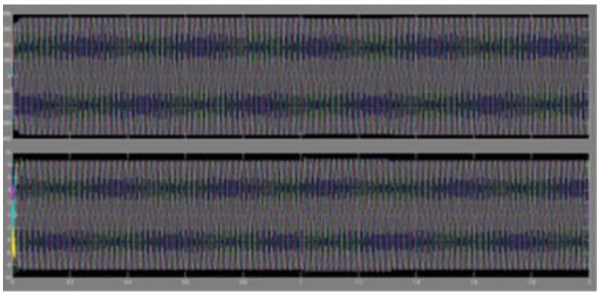

Fig. 8: Load Side Voltage and Current

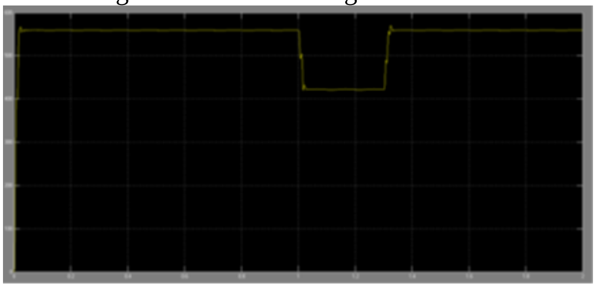

Fig. 9: Active Reactive Power

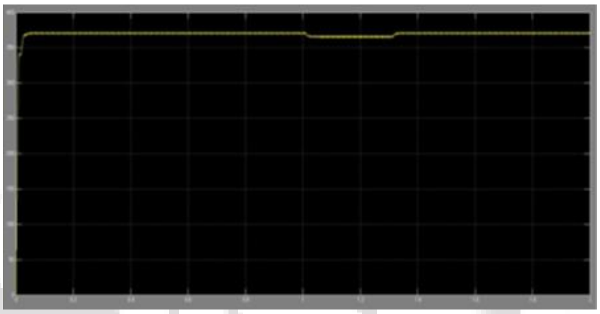

Fig. 10: Dc Link Capacitor Voltage

V. SIMULATION RESULTS OF THE EXISTING CONDITIONER

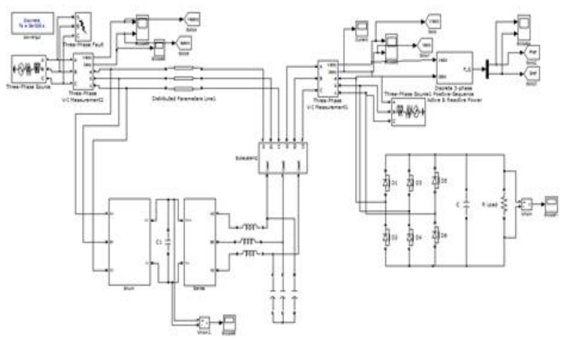

Fig. 11: Simulation Model for Twelve Switch

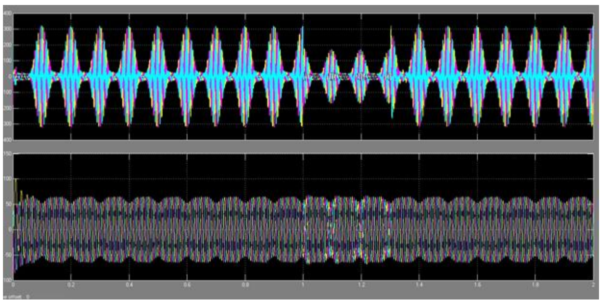

Fig. 12: Source Side Voltage and Current

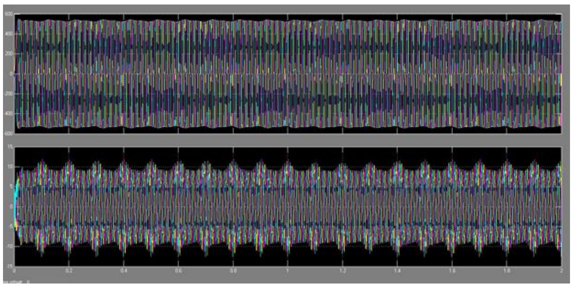

Fig. 13: Load Side Voltage and Current

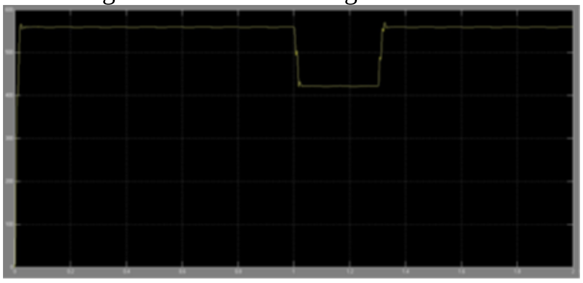

Fig. 14: Dc Link Capacitor Voltage

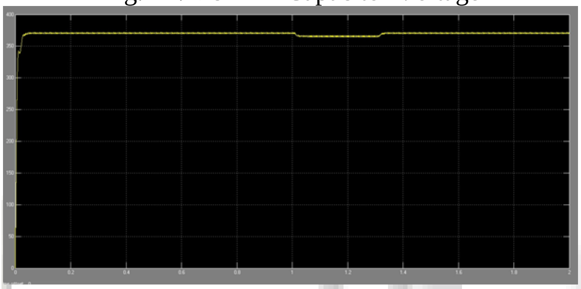

Fig. 15: Output Voltage

VI. CONCLUSIONS

This paper present a compression of eight switch Converter with twelve switch converter. The aim of eight switch converter is to reduce the cost of power quality converter. Experimental tests prove its feasibility. The eight switch converter gives a good result as compare to twelve switch converter. It fulfill the current industrial process requirement that good quality of electric power so that they run satisfactorily.

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