

A Novel Unified Power Quality Conditioning System for Power Quality Improvement and Bidirectional Power Flow Control for Windmill

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Abstract

This paper proposes a new approach of unified power quality conditioner which is made up of a matrix converter to mitigate the current harmonics, voltage sags and swells and control the power flow with Bi directional capability for windmill. Matrix converter injects the compensation voltage on the load-side, so it is possible to mitigate the voltage sag/swell problems, resulting in an efficient solution for mitigating voltage and current related power quality problems. Thus, the proposed topology can mitigate the voltage fluctuations and current harmonics without energy storage elements and the total harmonic distortion produced by the system also very low. Due to the bidirectional power flow capability of matrix converter the proposed unified power quality conditioner capable to control the power flow of the windmill more over it also transfer power bi -directional. The space-vector modulation (SVM) is used to control the matrix converter. Matlab/Simulink based simulation results are presented to validate the approach storage elements and the total harmonic distortion produced by the system also very low. Due to the bidirectional power flow capability of matrix converter the proposed unified power quality conditioner capable to control the power flow of the windmill more over it also transfer power bi -directional. The space-vector modulation (SVM) is used to control the matrix converter. Matlab/Simulink based simulation results are presented to validate the approach.

Index terms— matrix converter, unified power quality conditioner, current harmonics, voltage sag/swell, non linear load, windmill, matlab/ simulink.

1 Introduction

Power quality is the set of limits of electrical properties that allows electrical system to function in a proper manner. Power quality problems produced by a large increase of the load current, like starting a motor or transformer energizing. The flexible AC transmission system (FACTS), improve the reliability and quality of power transmission system, the custom power devices enhance the quality and reliability of power that is delivered to customers [1]. The main causes of a poor power quality at customer side are harmonic currents, poor power factor, supply voltage variations, etc. [2]. In recent years the demand for the quality of electric power has been increased rapidly. Unified power quality conditioner (UPQC) is one of the best custom Power devices used to compensate both source and load side problems [3]. It consists of shunt and series converters connected back to back to a common DC link. It can perform the functions of both Dstatcom and DVR. Fig. ?? shows a basic system configuration of a general UPQC consisting of the combination of a series active filter and shunt active filter [4]. The main aim of the series active filter is harmonic isolation between a distribution system and a load. It has the capability of voltage flicker/ imbalance compensation as well as voltage regulation

4 PROPOSED UNIFIED POWER QUALITY CONDITIONER FOR WINDMILL

and harmonic compensation at the utility-consumer point of common coupling (PCC). The shunt active filter is used to absorb current harmonics, compensate for reactive power and negative-sequence current, and regulate the DC-link voltage between both active power filters [5].

Figure ?? : Basic structure of unified power quality conditioner Unified power quality conditioner consists the DC bus and its DC capacitor must be designed. Dec capacitor achieves two goals, i.e., to comply with the minimum ripple requirement of the DC bus voltage and to limit the DC bus voltage variation during load transients. But the proposed matrix converter based UPQC there is no need of DC capacitor.

All the series active filter is controlled by the voltage source converter. But voltage source converter has some draw back present. Due to switching loss, capacitor leakage current, etc., the distribution source must provide not only the active power required by the load but also the additional power required by the VSI to maintain the DC-bus voltage constant. Unless these losses are regulated, the DC-bus voltage will drop steadily. Moreover VSC based converter produces more harmonics and switching losses high.

The windmill is the most important non conventional energy source. Various wind turbine

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: generators available to convert wind energy to electrical energy. Particularly induction type wind turbine generator is commonly used for its rugged construction ,long life and more power handling capacity. This type of windmill affected by power quality problems like voltage sag,swell and current harmonics. [6] Induction type wind generator initially drawn current from the grid and deliver power through same grid.here the power is bidirectional. Many FACTS are used to solve the power quality issues in windmill [7] .Conventional unified power quality conditioner VSC based converter used,which is unidirectional. So conventional power unified quality conditioner not suitable for induction type windmill.

In this paper a matrix converter based unified power quality conditioner compensates voltage sag and swell and current harmonics compared and bidirectional power flow capability II.

3 Matrix Converter

In this paper proposes a matrix converter based unified power quality conditioner for wind mill instead of VSC based unified power quality conditioner. Although matrix converter was initially introduced as an AC Driver, due to its advantages may be used in voltage compensation applications like series active filter, DVR [8] and shunt active filter [9].

A matrix converter can operate as a four quadrature Ac-Ac converter circuit. The output voltage, frequency and its amplitude and also the input power factor can be controlled by utilizing the proper modulation method (SVM). The main drawbacks of this topology are the need for fully controlled bi-directional switches and complex algorithm to perform commutation. The nine matrix converter switches can be represented as a 3×3 matrix The relationship between load and input voltages can be expressed as [] [] T c b a C B A v v v S v v v =(2)

Input phase currents can be related to the output phase currents (9), using the transpose of matrix [] [] T C B A T T c b a i i i S i i i =(3)

III.

4 Proposed Unified Power Quality Conditioner for Windmill

The proposed unified power quality conditioner for wind mill is designed using a matrix converter is shown in figure ?. l abc are the smoothing inductor. C (abc) is the smoothing capacitor. One step up transformer is used for step up the matrix converter input voltage. So the matrix converter injects the significant current to PCC for current harmonic mitigation. In this paper, the step up transformer was simply modeled by a current source (i trans) and the focus to put on the control of the input current for the active filtering function. Because matrix converter transfer ratio is limited to 0.876.

In series part a unified power quality conditioner is designed using the same matrix converter topology. .Series filter removes the voltage ripples. The series transformer also called injection transformer which injects the appropriate voltage to the load to compensate the voltage and removes the harmonics. more over the series part control the power flow bi directionally by adjusting the matrix converter switching. d d d q d vRo vL L i L R i dt di ? + ? = (1 2 2 2 ? (9) q q q d q vRo vL L i L R i dt di ? + ? = (1 2 2 2 ? (10)

The active and reactive power of end generator is given in dq coordinates by? ? ? ? ? ? ? ? ? ? ? ? = ? ? ? ? ? ? q d d q d i i v v v Q P (11)

The active and reactive power P and Q are given by (??2) and (??3) respectively Since the rotating dq reference frame is based on the angle of the voltage at the PCC, the d and q load current components represent respectively the active and reactive components of the load current. The control objective is to compensate all the load current components except for the fundamental active load current component. Therefore a High Pass Filter (HPF) is introduced to filter out the fundamental component of the active current. Only the harmonic and reactive components remain in the current reference. The active current that is produced by the transformer also needs to be added to the active current reference as the matrix converter . Finally are obtained the references d* mc , q * mc and which are provided to the outer current control loop. All entities marked with asterisk are reference values as opposed to real/measured values.q d i v Q ? = (12) d d i v P = (13)

101 To control the current we use eq. (19)
 102 When eq. (20) is converted into the rotating dqreference frame, cross-coupling terms appear as shown in eq.
 103 (21). Which must be compensated. When transforming to the rotating dq reference frame again cross coupling
 104 terms appear $\dots = \dots d c q c f q m c d m c q m c d m c q c d$
 105 $c f v v C i i i i v v d t d C , , , , ' ' ? (20) \dots = \dots d m c$
 106 $q m c f q c d c p c c q m c d m c f i i L v v v i d t d L , , , 0 ? (21)$

5 Simulation Results

107
 108 In this work three phase matrix converter based unified power quality conditioner used to compensate the voltage
 109 sag/swell, current harmonics and control power flow and transfer power bi-directional for an induction wind mill
 110 connected network. The source voltage is 440 Vrms, 60Hz. Table 1 shows the proposed system main parameters.
 111 It includes source impedance parameters L and C values for passive branches used system has been simulated.
 112 All the simulation is performed by the Matlab/Simulink model in discrete form. The sample time of the discrete
 113 value is 3×10^{-4} sec a) Result for proposed UPQC based compensation for current harmonics

6 Conclusion

114
 115 In this paper investigated the use of matrix converter based unified power quality conditioner to mitigate the
 116 voltage sag/swell, current harmonics and power flow. This paper also analyzed the bidirectional power capability
 117 Unified Power Quality Conditions. This can be achieved by change switching of matrix converter .The proposed
 118 UPQC's Series active filter handles both balanced and unbalanced Situations without any difficulties and injects
 119 the appropriate voltage component to correct any abnormalities in the supply voltage to keep the load voltage
 120 balanced and constant at the nominal Value. Moreover this control the power to the load also. The proposed
 121 unified power quality conditioner is implemented to wind mill the power transfer also achieved. Moreover the
 122 shunt control system controls the remove the current harmonic of load. Based on simulation results the matrix
 123 converter based UPQC also mitigates the current harmonics efficiently with low total harmonic distortion, voltage
 ag and swell and control the power flow bidirectional. ^{1 2}

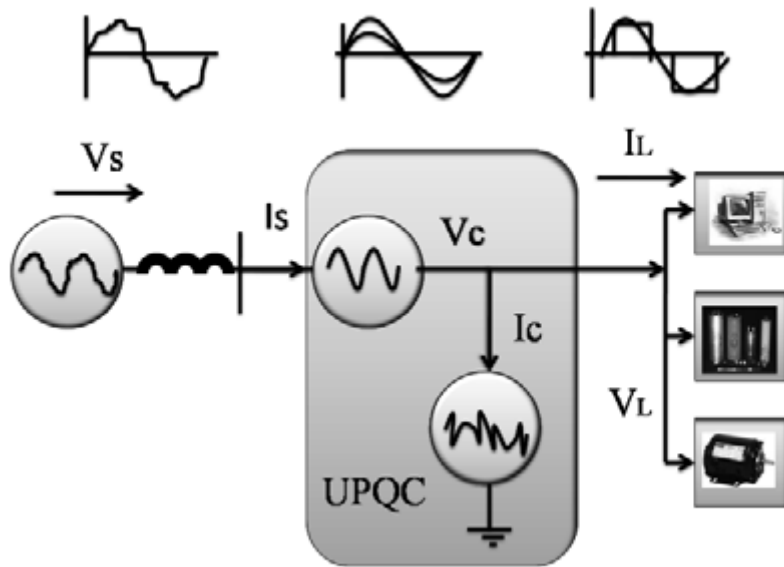


Figure 1: Figure 2 :

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Figure 2: Figure. 4

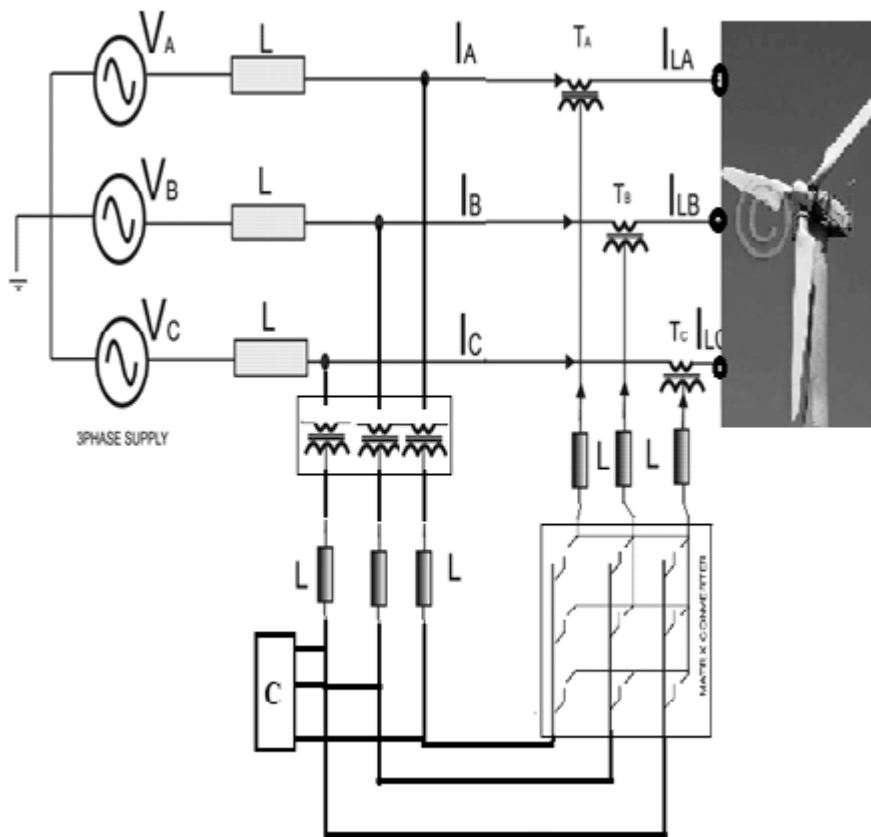
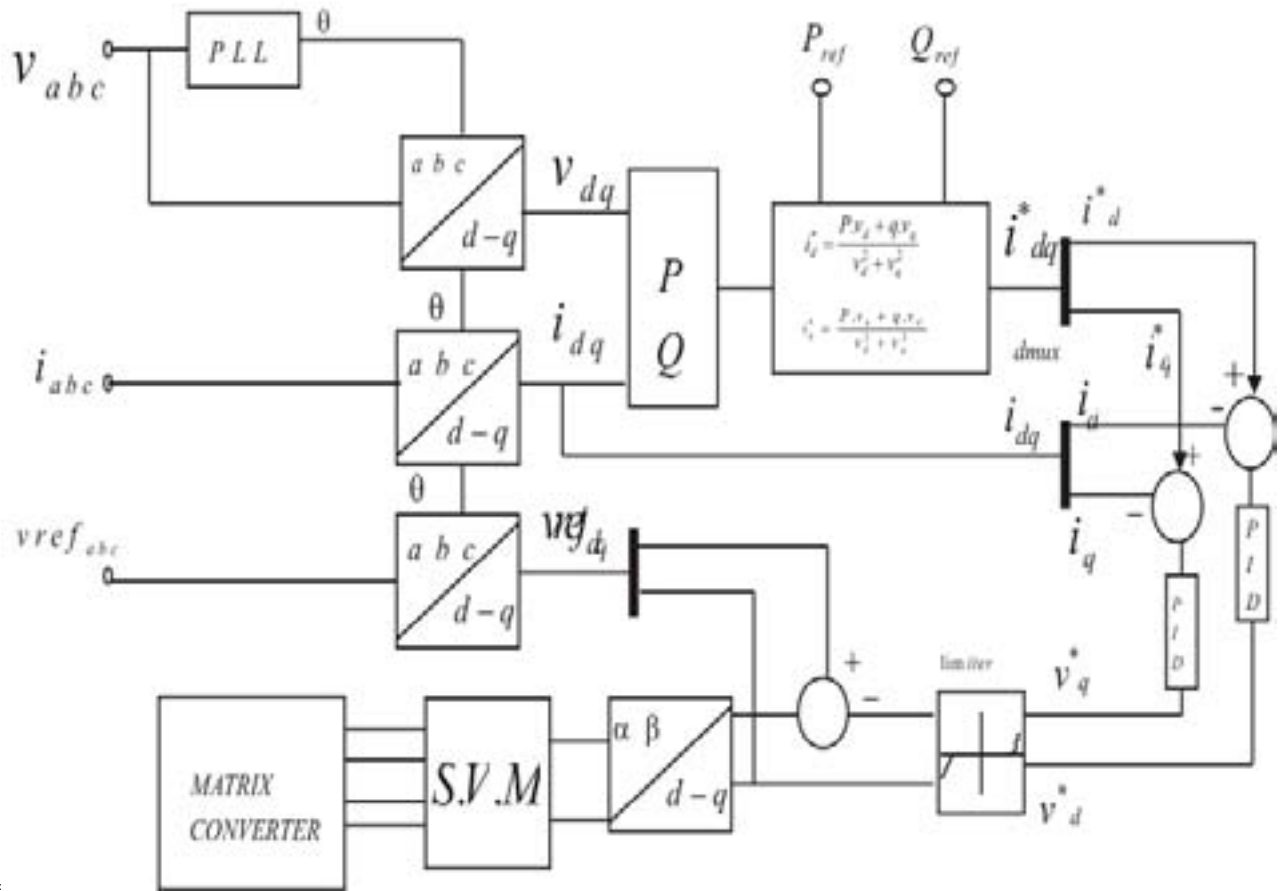
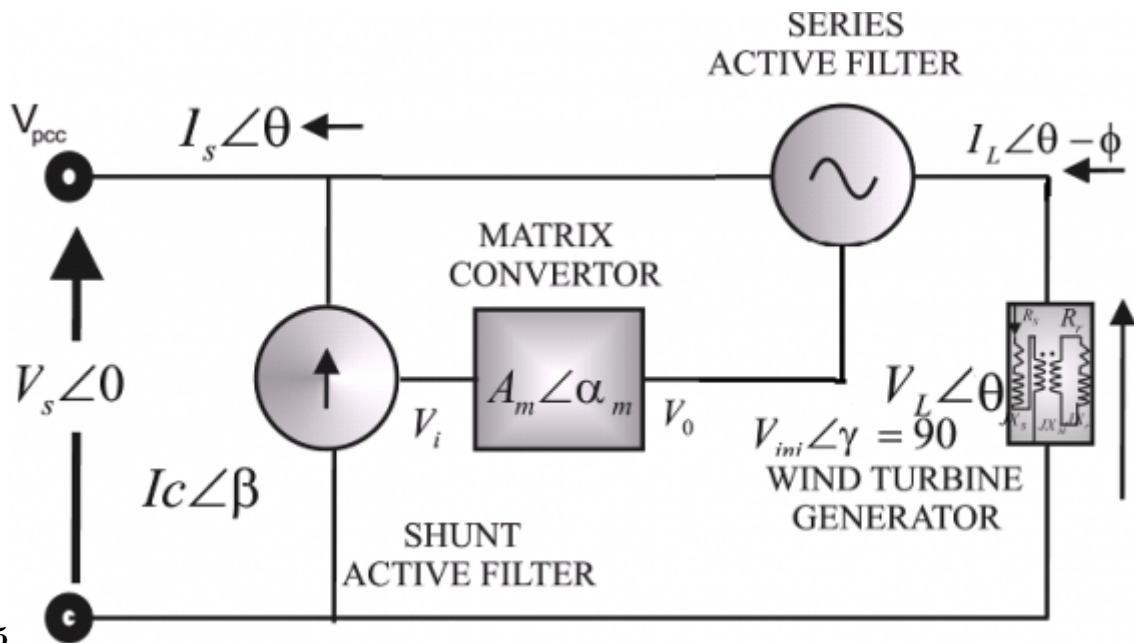


Figure 3:



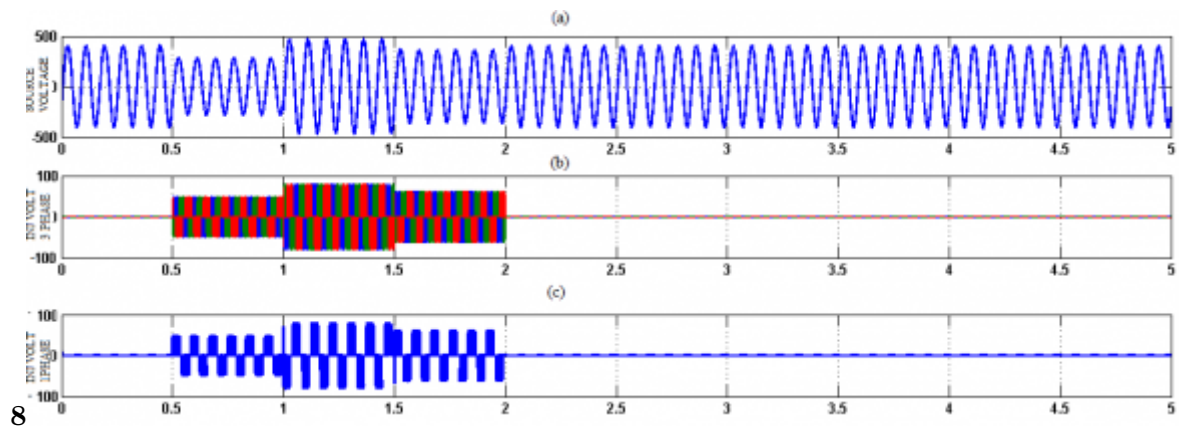
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Figure 4: Figure 4 :



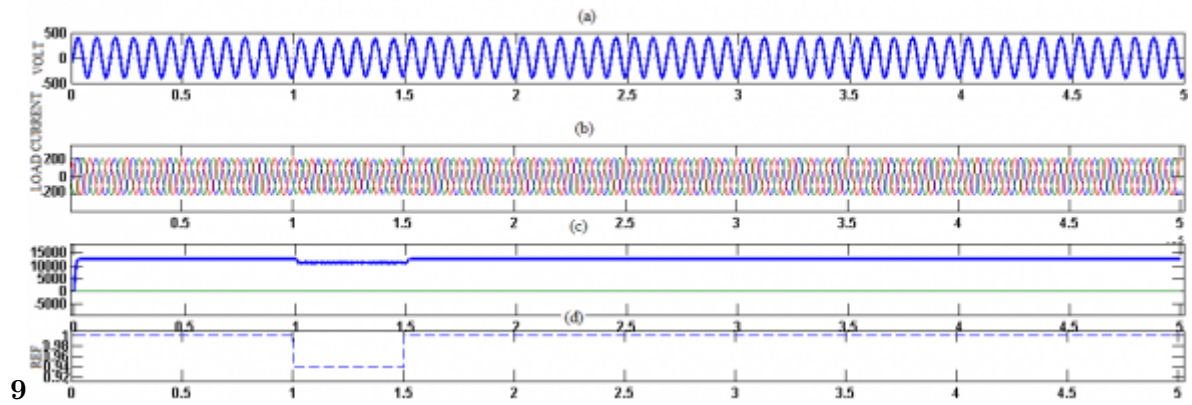
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Figure 5: Figure 5 :F



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Figure 9: Figure 8 :



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Figure 10: Figure 9 :

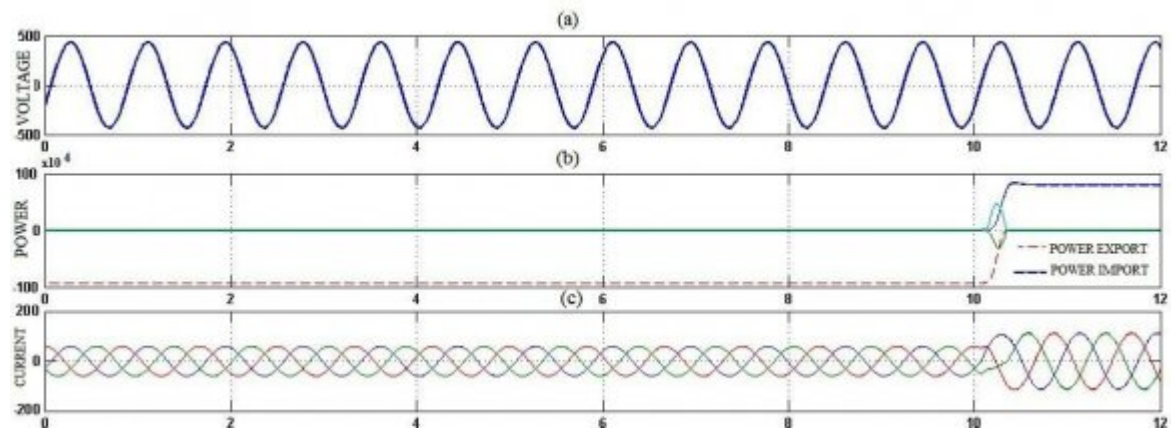


Figure 11:

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Figure 12: Table 1 :

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Figure 13: Table 1 .

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