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Analysis and Control of M3c Based IUPQC to Provide Additional Grid-Voltage Regulation

Ms.Kaluvala Narmada
M.Tech research scholar
Dept of Electrical & Electronics Engineering,
Chirala Engineering College,
Chirala, Prakasam (Dt), Andhra Pradesh, India.

Mr.A.Rakesh
Assistant Professor,
Dept of Electrical & Electronics Engineering,
Chirala Engineering College,
Chirala, Prakasam (Dt), Andhra Pradesh, India.

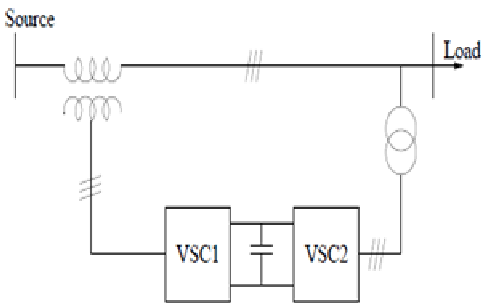
ABSTRACT & INTRODUCTION:

Medium / high voltage distribution power systems to enhance power quality, single- stage a unified power quality conditioner (IUPQC) is based on a modular multi-level matrix converter (M3C) is presented in this paper. M3C-IUPQC four equal arms and associated filter inductors are multilevel converter. M3C-IUPQC equivalent circuit was established, according to the principle of its operation and the power balance in each hand, theoretically analyzed, and the parameters of the design as well as the practice of sub-module inductance capacitance arm. Then the DC circulating current in each arm, which is used to balance the power of the temporary active M3C-IUPQC M3C-IUPQC voltages for an integrated control method to achieve balance so that the distinction from the hands of the Interior proposed to prevent the capacitor voltage. Finally, the effectiveness of the proposed control method is verified by 8 KVA rated model.

UNIFIED POWER QUALITY CONDITIONER:

DSTATCOM and DVR bus load voltage of the rule and control the quality of the source of the current force. In addition, DVR and connected to the STATCOM DC, DC Transient voltage source connected to the DVR through DSTATCOM shunt bus voltage in case of disturbances in the supply of energy to the load control. Such as device configuration (Unified Power Quality Conditioner (UPQC) called) as shown in Fig. 14.15.

UPFC is a versatile device that is similar to this. However, a UPQC control objectives are very different from one UPFC.



CONTROL OBJECTIVES OF UPQC:

Shunt to connect the converter to the following control objectives

1. No need to upload the source streams to balance the negative and zero sequence components injection
2. The need to replace the balance of load current by injecting harmonic currents
3. The required reactive current (at the fundamental frequency) to control power factor by injecting
4. to regulate the voltage on the DC bus.

The series aims to connect the converter to the following control

1. The source of the negative and zero in order to compensate them at the bus voltages, the voltage to the load through the balance of the needle.
2. by injecting harmonic voltages, the voltage of the source of the bus to isolate the load from the balance

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3. (at the fundamental frequency) active and reactive components required to load the bus voltage, the size of the injection depends on the source side of the power factor control

POWER QUALITY:

Contemporary container crane industry, like many other industry sectors, often the bells and whistles that can be achieved, colorful diagnostic displays, high-speed performance and is enamored levels of automation. These features and their directly or indirectly related to the operation of the terminal, the key to effective computer-based enhancements, despite the problems, we must not forget that building upon the foundation. Power quality is the mortar that bonds. The foundation blocks. Power quality installations in support of the new terminal operating economics crane, crane reliability, our environment, and electrical distribution systems, the initial investment will be affected. Natural resources. We are all aware, the container crane at an astounding performance requirements continue to increase. The next generation of container cranes, are already in the process of bidding, and 1500kilowatts of average power demand is 2000 - almost double the average. Demand three years ago. The rapid increase in electricity demand levels, population growth container crane, and crane rail converter retrofits and energy necessary to drive large AC and DC drives and control of the cranes in the near future will increase the awareness of power quality problem.

POWER QUALITY PROBLEMS:

For the purpose of this article, we shall define as the power quality problems:

When a failure or disoperation of customer equipment, the power problem, To draw up a financial burden on the user, or the adverse effects of the product Environment. " When applied to the container crane industry, electrical energy, which can degrade the quality of some of the issues:

- Power factor
- Harmonic Distortion
- Voltage transients
- Voltage sags or dips
- Voltage interval

Board of AC and DC variable speed drives used in container cranes, the total harmonic distortion of current and voltage are the leading causes. However, in the control of the South Central Railway will create the desired average power factor, DC SCR drives operate at less than this. In addition, the line of notching SCR commutate the nominal line voltage system interruption occurs and, depending on the size of the drives to be 3 to 4 times the peak transient voltage Creating recovery. This kind of disturbances in the power system frequency and intensity will change the speed of the drive. When the operating speed drives, AC and DC drives slowly through the harmonic current injection is very high. SCR DC drives, when the rate or base of its maximum value when the speed of the increase in the production phase, slow speed or acceleration and deceleration during the initial operating power factor is low. On top of the base speed, power factor remains essentially constant.

Unfortunately, container cranes and earth containers to locate the operator can spend considerable time at low speed. The poor power factor uses the power source or engine alternator puts more burden KVA demand. It is also the end of the harmful effects of low power factor loads can affect the stability of the voltage. Or intermittent work in the life of delicate electronic equipment. DC voltage transients by notching SCR AC-line voltage chopping drive, and high-frequency harmonic drive voltages and currents in all are important sources of noise and disturbance to sensitive electronic equipment. It's not the end of our experience, consumers often associated with power quality issues. Container cranes, but they do not know that these issues are fully addressed, or if the quality of electricity because there was no economic consequence.

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Prior to the creation of a solid-state power supplies, power factor, reasonable, and minimal harmonic current injection. The crane is to be multiplied with the population, increased demand for electricity at the rate of the crane, and static electricity exchange, has become a way of life and power quality problems begin to emerge. Harmonic distortion and power factor problems also surfaced, no one really prepared. Even today, the new gantry crane builders and electric drive system vendors bidding to avoid the problem. Rather than focus on understanding and awareness of the potential problems, power quality problem, either intentionally or unintentionally ignored. Power quality solutions to the problem are available. Although not free solutions, in most cases, they represent a good return on investment. However, power quality, if not specified, it most likely will not be delivered.

Power quality can be improved by:
- Power Factor Correction,
- Harmonic filtering,
- Special Line notch filtering,
- Transient voltage surge suppression,
- Proper earthing systems.

In most cases, specifying the person and / or the purchase of a container crane, electric power may not be fully aware of the quality issues. If this article accomplishes nothing else, we have to hope
The comprehensive examination.

THE BENEFITS OF POWER QUALITY:

Economics of the operation of the container terminal in the environment affect the electrical quality of the terminal, the terminal can affect the reliability of the equipment, and that will affect other users of utility services. Each of these concerns are explored in the following paragraphs.

1. Economic Impact:

The effect of the economic incentive for power quality is foremost a container terminal operators.

Has a significant economic impact, and can be expressed in many ways:

A. Power Factor Penalties:

BILLINGS's monthly utility companies have used a number of low power factor penalties. There is no industry standard when utility companies. Use one of the metering methods and computational power factor penalties will vary from company to another. Some utility companies actually use the meter kVAR times the number of hours consumed and the establishment of a fixed rate. KVAR demand for other utility companies to monitor and calculate the power factor. Demand for power factor falls below the value of the fixed limit, will be charged a penalty in the form of adjusting the peak demand charges. The container terminal equipment, servicing the utility companies do not invoke the power factor penalties. However, the port is a defined demand for their service agreement still need to be met in the minimum power factor. The utility company to continuously monitor the usage and monthly utility power factor or kVAR BILLINGS not reflect them; however, they reserve the right at any time to monitor the port service.

B. System Losses:

Harmonic currents and non-weight, low power factor by power factor penalties as a result of not only, but also to increase the power losses in the distribution system. These losses appear as a special item in your monthly utility billing, but you have to pay each month. Container cranes, are the leading causes of harmonic currents and low power factor. The power factor is based on the demands of today's typical high-speed container cranes, correction. Quay crane and the general state of the art on a monthly utility billing alone will be reduced to 10% from 6 to change the system that has been shown to reduce the risks. For most of the terminals, the operation is a significant annual cost savings.

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2. Equipment Reliability:

Poor power quality reduces the life of the machine or equipment and components affecting reliability. Harmonics, voltage transients, and voltage sags and swells, all power quality problems are in the system and are all interdependent. Harmonics affect power factor, voltage transients to harmonics, harmonic current injection in SCR DC induce the same things to create. Variable speed drives are responsible for poor power factor, voltage sags and swells with confidence to create a variety of the same drives, power factor. Harmonic distortion, harmonic currents, and using filters specifically designed to reduce the effects of the line ringing line.

3. Power System Adequacy:

When considering the installation of additional cranes to the existing power distribution system, a power system analysis should be done to determine the adequacy of the system to support additional crane loads. Due to the correction of the existing power distribution and power quality systems to be connected to the new or disqualification under the auspices of the cranes can be moved. In other words, without the risk of problems with power quality equipment in addition to otherwise support the additional cranes would be inconsistent with the existing electrical distribution system, applies to a workable scenario.

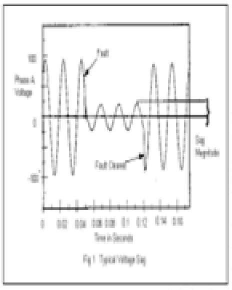
4. Environment:

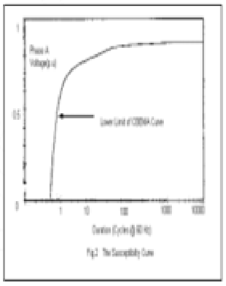
No problem, we can be as important an impact on the environment and power quality. Reduction of system losses and low demand, a reduction in power plant emissions and reduced our consumption of natural resources compared nm. The occupants of this planet, our natural resources and improve the quality of our air, it is our responsibility to encourage conservation measures

VOLTAGE SAG:

Voltage sags and momentary power interruptions will probably affect the industrial and large commercial customers are the most important PQ problem.

The power supply system is usually a mistake to replace some of these events are related. Interruptions occur when the wrong customer supply circuit. But the voltage sags caused by faults in the customer's going to be away from the site. Lasting only 4-5 cycles to smooth out the voltage sags can cause a wide range of customer equipment. If the industrial users to shut down two of their process, voltage sag and are equivalent to a momentary interruption. A typical example of the voltage sag is shown in fig 1. Voltage sags voltage sag susceptibility to the use of the equipment is based on the duration and size, and can define





Characteristics of Voltage Sags:

Voltage sags which can cause event impacts are caused by faults on the power system. Motor starting also results in voltage sags but the magnitudes are usually not severe enough to cause equipment mis operation

FUNDAMENTALS OF PAC CONCEPT:

AUPQCis one of the most suitable devices, voltage sag / swell to control the system. A UPQC rating voltage sag / swell will need to be governed by the percentage of the maximum amount of compensation [19]. However, the voltage difference (sag / swell) for a short duration power quality problem. Therefore, under normal operating condition, UPQC of the series inverter is not used to its true potential. UPQC PAC concept of power between the source and load voltages to control the angle of the load reactive power demand, the UPQC rating [15] indicate that the share without affecting the shunt and series inverters. Under steady-state condition, a rate mechanism of the phasor representing the PAC, as shown in Fig. 2 [15].

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Change the angle of the power supply voltage and load current I_ L as a result, the relative phase between the angle β may be referred to as the cause of development. In other words, with the PAC system, the series inverter reactive power demand and reactive power demand load sharing, reducing the support formed by the shunt inverter. The steady-state condition of a rate

$$|V_S| = |V_L| = |V_L^*| = |V_L'| = k. \quad (1)$$

Using Fig. 2, phasor_VSr can be defined as [15]

$$\begin{aligned}\vec{V}_{Sr} &= |V_{Sr}| \angle \varphi_{Sr} \\ &= \left(k.\sqrt{2}.\sqrt{1-\cos\delta}\right) \angle \left\{180^\circ - \tan^{-1}\left(\frac{\sin\delta}{1-\cos\delta}\right)\right\} \\ &= \left(k \cdot \sqrt{2} \cdot \sqrt{1-\cos\delta}\right) \angle \left(\frac{90^\circ + \delta}{2}\right) \quad (2)\end{aligned}$$

Where

$$\delta = \sin^{-1}\left(\frac{Q_{Sr}}{P_L}\right). \quad (3)$$

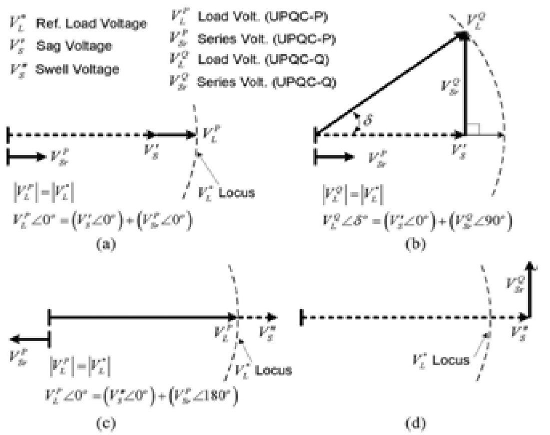

Fig. 3. Voltage sag and swell compensation using UPQC-P and UPQC-Q: phasor representation. (a) Voltage Sag (UPQC-P). (b) Voltage Sag (UPQC-Q). (c) Voltage Swell (UPQC-P). (d) Voltage Swell (UPQC-Q).

VOLTAGE SAG/SWELL COMPENSATION UTILIZING UPQC-PAND UPQC-Q:

1) Reactive power control methods - active power control system voltage sag can be replaced by. Fig. 3
2) UPQC- P active power control using the voltage sag compensation in return for the phasor representations [see Fig. 3 (a)] and UPQC- Q [see Fig, such as reactive power control. 3 (b)]. Fig. 3 (c) and (d) to replace the system UPQC-P wave and UPQC-Q shows the ability of the compensation. Q UPQC- for compensation using a voltage wave [see Fig. 3 (d)], not to inject through a quadrature component of the series inverter rated voltage does not intersect with the locus. Therefore, UPQC- effective policy system, is limited to replacement of the landfill. However, UPQC- P system to effectively compensate for the voltage sag on the system can swell. Furthermore, the landfill replaces an equal percentage, UPQC- more effective UPQC- P series injection voltage (V Q Sr> VP SR) logger is required intensity.
3) Interestingly, UPQC-Q also comes as a result of the angle between the load and source voltages will change, but this change is a function of the amount of landfill system. Therefore, UPQCQ load reactive power support to vary the phase shift can not be controlled. In addition, UPQC-Q is not valid at the time of the phase change of the voltage sag. Therefore, in this paper, the concept of the PAC, active power control system simultaneously with the voltage sag / swell of support for reactive power compensation and load UPQC achieve utilizing the integrated inverter of the series. The dual functionality of the series inverter UPQC new policy was implemented. Significant advantages over other methods are of UPQC.
4) 1) UPQC inverter series of two active power (voltage sag / swell compensation) and reactive power (load reactive power compensation for the name UPQC (complex power S) support) and hence simultaneously.

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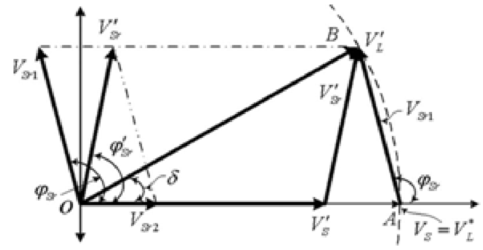

Fig. 4. Phasor representation of the proposed UPQC approach under voltage sag condition.

PAC APPROACH UNDER VOLTAGE SAG CONDITION:

A sag / swell condition occurs in the system, two inverters and reactive power supplied to the load as they should be in front of the landfill. In addition, the series inverter also by injecting the appropriate voltage of the voltage sag / swell should be replaced. In other words, regardless of the variation in the supply voltage inverter series between two voltages should be able to maintain the angle δ with the same power. However, the system load voltage sag at the time of the change, the PAC, the policy gives a different angle δ. Depending on the angle δ increase or decrease the growth of new or decreases in a row that the reactive power load.Thus, for the compensation simultaneously, to observe from Fig. 4, the series inverter is now a part of the amount to be supplied _VSr1 and _VSr2 vector. This process, however, the series inverter voltage _V _ Sr maintain the desired level of source voltage drop of the load voltage, load-magnitude appear across the terminal. Furthermore, the series inverter will keep sharing the load reactive power demand.Using the concept of the PAC for the load reactive power compensation

$$\vec{V}_{Sr1} = \vec{V}_L' - \vec{V}_S \quad (4)$$

$$V_{Sr1}\angle\varphi_{Sr} = V_L'\angle\delta - V_S\angle 0^\circ. \quad (5)$$

For voltage sag compensation using active power control approach

$$\vec{V}_{Sr2} = \vec{V}_L^* - \vec{V}_S' \quad (6)$$

$$V_{Sr2}\angle 0^\circ = V_L^*\angle 0 - V_S'\angle 0^\circ. \quad (7)$$

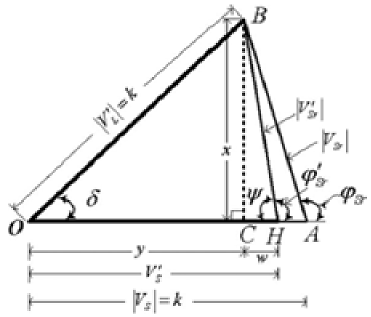

Fig. 5. Detailed phasor diagram to estimate the series inverter parameters for the proposed UPQC approach under voltage sag condition.

For simultaneous load reactive power and sag compensation

$$\vec{V}_{Sr}' = \vec{V}_{Sr1} + \vec{V}_{Sr2} \quad (8)$$

$$V_{Sr}'\angle\varphi_{Sr}' = V_{Sr1}\angle\varphi_{Sr} + V_{Sr2}\angle 0. \quad (9)$$

A. Series Inverter Parameter Estimation Under Voltage Sag:

In this section, the series of reactive power and voltage sag compensation inverter parameters were measured simultaneously in order to achieve load. Fig. 5 of the series to determine the detailed phasor diagram shows the injection voltage magnitude and phase.

Spot supply voltage is defined as the ratio of the difference of intensity of the load rated voltage and rated load voltage

is voltage fluctuations that KF is represented as the magnitude [19]

$$k_f = \frac{V_S - V_L^*}{V_L^*}. \quad (10)$$

Representing (10) for sag condition under PAC

$$k_f = \frac{V_S' - V_L'}{V_L'} = \frac{V_S' - k}{k}. \quad (11)$$

Let us define

$$1 + k_f = n_O. \quad (12)$$

To compute the magnitude of _V _ Sr, from ΔCHB in Fig. 5

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$$w = l(CH) = n_O \cdot k - y \quad (13)$$

$$|V'_{Sr}| = \sqrt{(k \cdot \sin\delta)^2 + (n_O \cdot k - k\cos\delta)^2} \quad (14)$$

$$|V'_{Sr}| = k.\sqrt{1 + n_O^2 - 2 \cdot n_O \cdot \cos\delta}. \quad (15)$$

To compute the phase of _V _ Sr

$$\angle CHB = \angle\psi = \tan^{-1}\left(\frac{x}{w}\right) = \tan^{-1}\left(\frac{\sin\delta}{n_O - \cos\delta}\right). \quad (16)$$

Therefore,

$$\angle\varphi'_{Sr} = 180^\circ - \angle\psi. \quad (17)$$

Equations (15) and (17) give the required magnitude and phase of series inverter voltage of UPQC that should be injected to

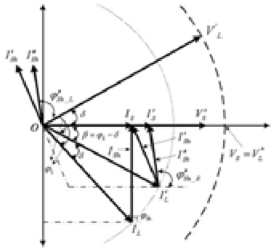

Fig. 6. Current-based phasor representation of the proposed UPQC approach under voltage sag condition.

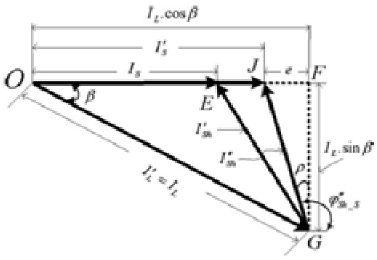

Fig. 7. Detailed phasor diagram to estimate the shunt inverter parameters for the proposed UPQC approach under voltage sag condition.

Achieve the voltage sag compensation while supporting the load reactive power under PAC approach.

B. Shunt Inverter Parameter Estimation Under Voltage Sag:

UPQC under voltage sag compensation mode inverter to operate the shunt current is calculated by the need to inject. Based on the phasor diagram of the various streams indicated in Fig. 6. Before the system voltage sag, UPQC shunt inverter load current I_ SH injection of reactive power compensation is considered to be using the PAC. Shunt inverter to compensate the load reactive power demand of electricity alone indicates the need to use a current-ish. To achieve voltage sag compensation. Active power control system to the source of the current I_ S increased supply.

Therefore, the load to inject reactive power and voltage sag compensation is necessary to support the series inverter, inverter shunt SH I__ need to deliver now. At the current fixed level of compensation for the resultant shunt DC The link will be to maintain the voltage. Therefore, it is necessary to shunt active power source and inverter, inverter and series shunt between inverters (DC link), the series is transferred to the load from the inverter and the facilities. Fig. 7 Shunt inverter and the phase angle of the current size of the injected phasor measurement refers to the diagram. The need to support the active force at the time of voltage sag, current source provides an additional resource

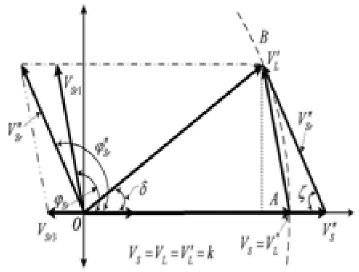

Fig. 8. Phasor representation of the proposed UPQC approach under voltage swell condition.

During voltage sag [19]

$$I'_S = \frac{I_L}{1 + k_f} \cdot \cos\varphi_L. \quad (18)$$

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Let

$$\frac{1}{1+k_f} = k_O. \quad (19)$$

Therefore,

$$I'_S = k_O \cdot I_L \cdot \cos\varphi_L. \quad (20)$$

In ΔGFJ (see Fig. 7)

$$I''_{\mathrm{Sh}} = \sqrt{(I'_L \cdot \sin\beta)^2 + [I'_L \cdot (\cos\beta - k_O \cdot \cos\varphi_L)]^2} \quad (21)$$

$$I''_{\mathrm{Sh}} = I'_L \cdot \sqrt{1 + k_O^2 \cdot \cos^2\varphi_L - 2 \cdot k_O \cdot \cos\beta \cdot \cos\varphi_L} \quad (22)$$

$$\rho = \tan^{-1}\left(\frac{\cos\beta - k_O \cdot \cos\varphi_L}{\sin\beta}\right) \quad (23)$$

$$\angle\varphi''_{Sh\_S} = \angle\rho + 90^\circ$$

$$\angle\varphi''_{\mathrm{Sh}\_L} = (\angle\rho + 90^\circ) - \delta.$$

Equations (22) and (25) give the required magnitude and phase angle of a shunt inverter compensating current to achieve the desired operation from the UPQC.

PAC APPROACH UNDER VOLTAGE SWELL CONDITION:

UPQC of a voltage wave at the time of the system for the phasor representing the PAC, as shown in Fig. 8. Active power control system is responsible for using the system to replace the wave VSr3 be a vector. Simultaneously compensation, the series inverter reactive power load on the system and replace it with a swell of support _VSr3 _VSr1 be part of the supply. As a result, the series is loaded into a voltage _V __ Sr reactive power to support the load voltage magnitude maintain the desired level. Voltage, active power control approach for compensation swell

$$\vec{V}_{\mathrm{Sr3}} = \vec{V}^*_L - \vec{V}''_S \quad (26)$$

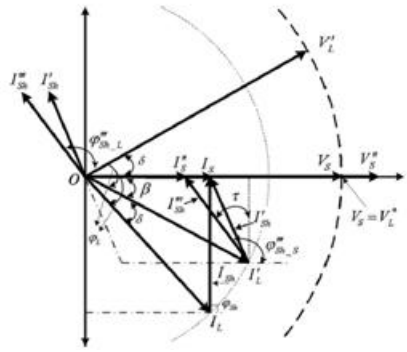

Fig. 9. Current-based phasor representation of the proposed UPQC approach under voltage swell condition.

$$V_{\mathrm{Sr3}}\angle 180^\circ = V^*_L\angle 0^\circ - V''_S\angle 180^\circ. \quad (27)$$

For simultaneous load reactive power and voltage swell compensations

$$\vec{V}''_{\mathrm{Sr}} = \vec{V}_{\mathrm{Sr1}} + \vec{V}_{\mathrm{Sr3}} \quad (28)$$

$$V''_{\mathrm{Sr}}\angle\varphi''_{\mathrm{Sr}} = V_{\mathrm{Sr1}}\angle\varphi_{\mathrm{Sr}} + V_{\mathrm{Sr3}}\angle 180^\circ. \quad (29)$$

For series inverter (see Fig. 8)

$$|V''_{\mathrm{Sr}}| = k \cdot \sqrt{1 + n_O^2 - 2 \cdot n_O \cdot \cos\delta} \quad (30)$$

$$\angle CLB = \angle\zeta = \tan^{-1}\left(\frac{\sin\delta}{n_O - \cos\delta}\right) \quad (31)$$

$$\angle\varphi''_{\mathrm{Sr}} = 180^\circ - \angle\zeta. \quad (32)$$

Fig. 9 UPQC under the condition that a voltage wave phasor representation for the different streams of the shows under the PAC. Using the active power control to compensate for the voltage wave, the source of its normal steady-state value of the current magnitude reduces. The reduced current I__ S is represented as a shunt inverter. Method to determine the series and shunt inverter. UPQC at the time of the voltage wave voltage sag in Section IV of the PAC, the parameters of the situation is similar to the pictures. Here are the most important equations.For shunt inverter (see Fig. 9)

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$$I'''_{\mathrm{Sh}} = I'_L \cdot \sqrt{1 + k_O^2 \cdot \cos^2\varphi_L - 2 \cdot k_O \cdot \cos\beta \cdot \cos\varphi_L} \tag{33}$$

$$\tau = \tan^{-1}\left(\frac{\cos\beta - k_O \cdot \cos\varphi_L}{\sin\beta}\right) \tag{34}$$

$$\angle\varphi'''_{\mathrm{Sh}\_L} = (\angle\tau + 90^\circ) - \delta. \tag{35}$$

It UPQC voltage sag and swell compensation using the equations are identical to the PAC can be noted. However, for a voltage sag and swell factor KF value of the voltage is negative for positive; So, we know the value of the voltage sag differs from the series and shunt factors Co. inverter size and phase angles, giving a variety of parameters, will swell conditions.

SIMULATION RESULTS:

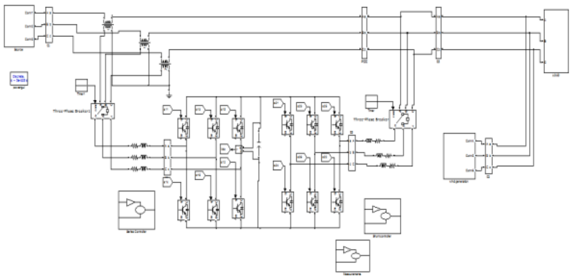

Fig.1.Base Paper Simulation Circuit

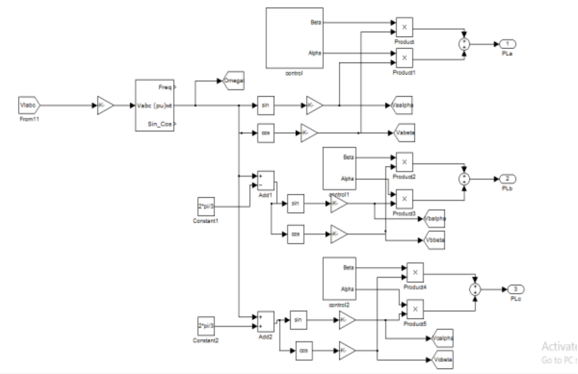

Fig.2.Active power estimation circuit

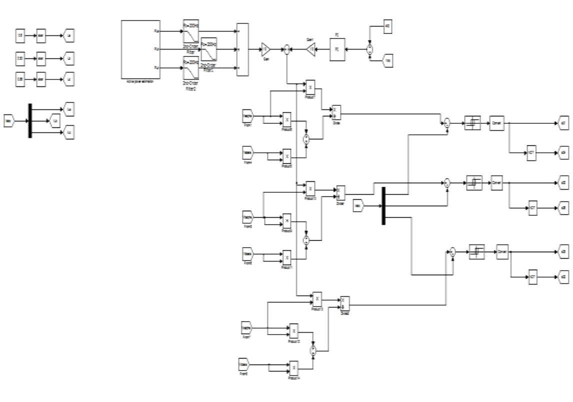

Fig.3.Shunt controller simulation circuit

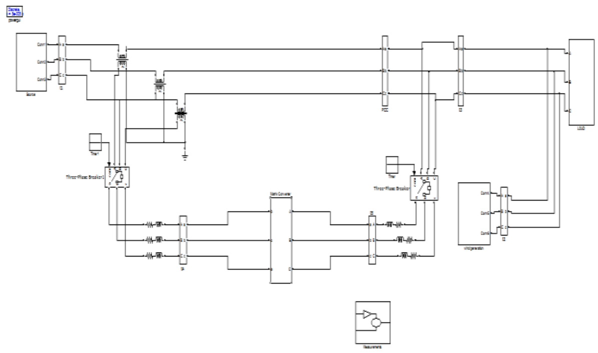

Fig.4.Extension Simulation Circuit

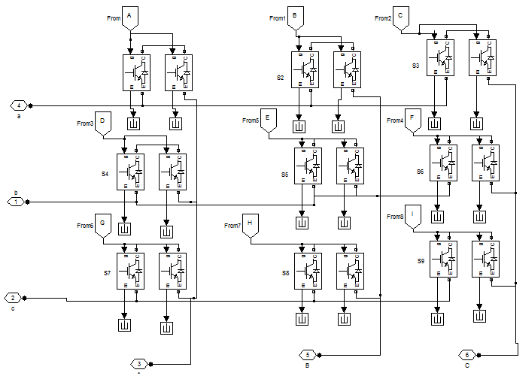

Fig.5.Simulation Configuration of Matrix Converter

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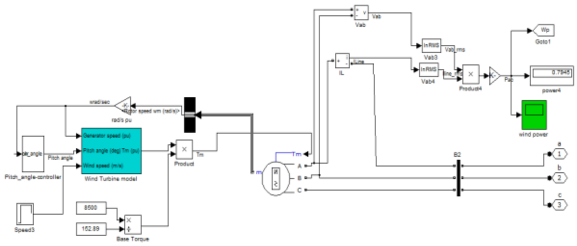
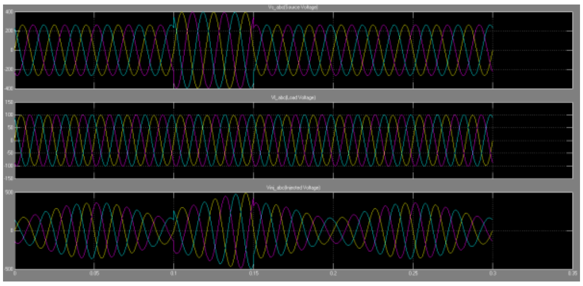
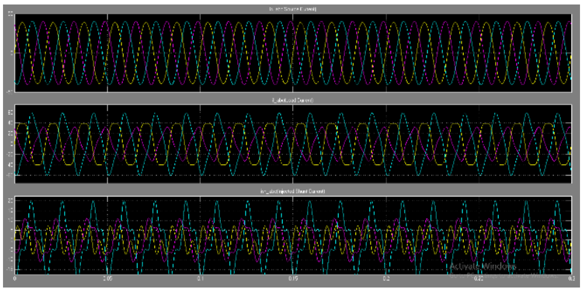


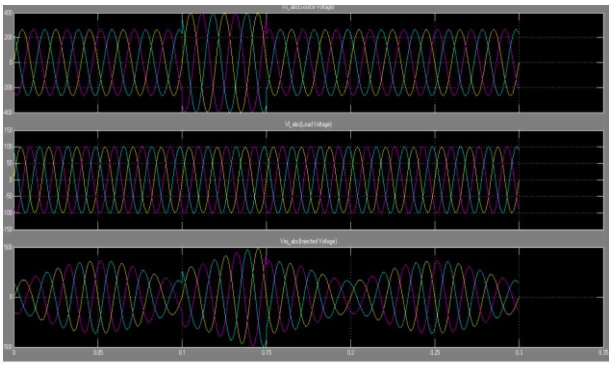
Fig.6.Wind generation simulation circuit



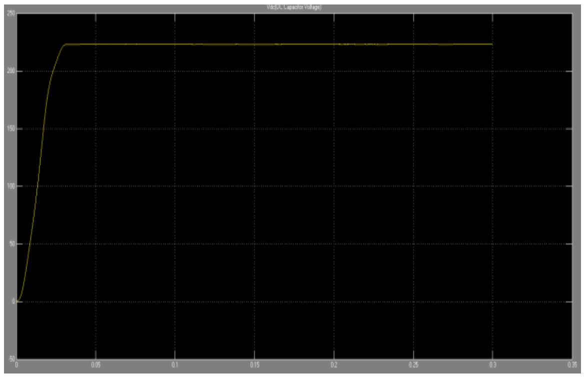
Base Paper Results: a) Source Voltage b) Load Voltage c) Series Converter Voltage



Results: a) source current b) load current c) shunt currents



Extension Results: a) Source Voltage b) Load Voltage c) Series Converter Voltage



UPQC link dc voltage

CONCLUSION:

A three-phase IUPQC configuration based on single-phaseM3C has been studied in this paper. The assembling of unified modules makes it possible to use low-voltage power devices according to an adequate number of sub modules, which allows the use at medium/high-voltage grid. The intermediate dc line in the back-to-back converters is avoidable, which is beneficial to simplify the encapsulation of the overall system. In addition, an integrated control strategy is proposed to balance the power distribution among different H-bridge arms based on special features of M3C-IUPQC. The operation of the M3C-IUPQC is confirmed through a downscaled simulation prototype.

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Author's Details:

Ms.K.Narmada received her B.Tech degree from Bapatla engineering college, Bapatla in 2014.She is currently pursuing M.Tech degree from Chirala engineering college, Chirala, University of JNTU Kakinada, Andhra Pradesh, India. Her research interest in switch gear and protection, also in protection in both transmission and distribution systems.

Mr.A.Rakesh completed his B.Tech and M.Tech degree from Chirala Engineering College, Chirala, University of JNTUK Kakinada. He is currently working as an Assistant professor in Chirala Engineering College, Chirala, JNTUK University His research area of interest in power electronics and power systems.