Power Quality Enhancement of Three Phase Four Wire UPQC in Distribution System using Neural Network

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Abstract—The essential focus of this endeavor is examination of three phase four wire UPQC available for use structures by neural framework. The bound together power-quality conditioner (UPQC) is used to calm the current and voltage-related power-quality (PQ) issues in the meantime in three-arrange four-wire course structures. Among most of the PQ issues, voltage hang is a significant issue in three-arrange four-wire scattering systems. In this paper, another procedure is proposed playing out the plan parallel electrical cable trim. As such, despite when only a three-organize three-wire control structure is available at a plant site, the UPQC can do control line pay for presented loads that require a fair-minded channel to work. Not exactly equivalent to the control philosophies used in most of UPQC applications in which the controlled sums are nonsinusoidal, this UPQC uses a twofold pay technique, with the ultimate objective that the controlled sums are continually sinusoidal. Neural System controller have been used to make the proposed methodology online for least real power implantation with UPQC by using the PSObased data for different voltage rundown conditions. In the proposed system PI controller substituted by NN controller for better precision.

Index Terms— Active filter, dual control strategy, UPQC, Neural networks.

I. INTRODUCTION

The enthusiasm for power quality (PQ) improvement has been creating starting late, fundamentally due to the development of nonlinear weights related with the electrical power structure causing twists in the utility voltages at the motivation behind essential coupling. Other PQ issues, for instance, voltage hang/swell and voltage unbalances can moreover impact the most ideal undertaking of tricky equipment causing breakdown. In addition, additional philosophy should be considered in order to overcome PQ issues related with consonant flows delivered by nonlinear weights, load unbalances and responsive power mentioned by the pile.

A couple of strategies have been grasped to assuage PQ issues, which should be possible by techniques for dynamic electrical cable conditioners, for instance, UPQCs course of action [25] and hybrid unique power stations (APFs) and dynamic voltage restorers.

In three-arrange systems, they should be used for compensating consonant flows [20] or burden unbalances and weight responsive power pay [21]-[24]. Filling in as nonsinusoidal voltage sources or sinusoidal current sources course of action APF channels, which are set between the utility cross section and the stack, can compensate consonant flows, load unbalances and responsive intensity of the store, while the pile voltages are controlled. Thusly, for vanquishing utility PQ issues, UPQCs have been used reliant on different thoughts and courses of action [10], [13], [15], including single-organize structures [14] or in three-arrange applications, pondering three-arrange three-wire (3P3W) frameworks or three-organize four-wire (3P4W) systems [11], [12].

It is excellent that non-sinusoidal references are hard to be composed by PWM converters and require an extra exertion to accomplish exceptional execution in APF or UPQC applications. Then again, sinusoidal control references have been utilized in applications including uninterruptible power supply (UPS) structures with the ultimate objective that in the reinforcement movement mode the UPS system acts additionally to an UPQC playing out the game plan parallel power compensation. In this application, the plan converter is controlled to fill in as a sinusoidal current source rather than a non-sinusoidal voltage source, while in the parallel embellishment the parallel converter is controlled to function as a sinusoidal voltage source instead of a non-sinusoidal current source.

In addition, this twofold pay framework has also been attempted in UPQC applications [2][4]. Thusly, not exactly equivalent to the standard embellishment framework, which uses non-sinusoidal control references, the twofold compensating methodology uses simply sinusoidal references to control the PWM converters. Appropriately, the age of the control references is more straightforward to obtain, empowering the usage of simpler computations to accomplish this point.

It might be seen that, since the parallel converter is controlled to manage simply sinusoidal voltages [2], [3], the utility voltage parts that are not equivalent to the positive gathering portions will appear over the course of action coupling transformers, so they are in an indirect manner reimbursed without the need to register any non-sinusoidal compensation reference voltages..

Synchronous Reference Edge (SRF) based controller are executed in this paper to control the data flows and the yield voltages of the UPQC. Inciting a reduction in steadfast state botches when normal Relative
Indispensable (PI) controllers are picked to be executed in this equal reference plot, addressing another critical piece of elbworrow when the two fold compensation system is stood out from the standard one. The UPQC input flows are moreover controlled to be in stage with the utility voltages.

As such, the assessed utility stage edge (θ) got from the PLL is moreover used to deliver the sinusoidal information current references. At the point when the common 3pPLL suffers with utility voltage agitating impacts, for instance, sounds just as unbalances, a self-tuning channel (STF) [23] is used identified with the 3pPLL arrangement. The STF is set between the utility voltages and the 3pPLL arrangement, where the dapper repeat assessed from the 3pPLL is used to adjust the STF cut-off repeat, avoiding that assortments in utility repeat can interfere or impact its introduction. In [27] Devadasu et.al discussed the IDVR for power quality issues. Malathi et.al [28] discussed custom power devices for PQ improvement.

The guideline responsibility of this paper is to display the rational execution of a 3P4W apportionment structure reliant on UPQC topology, which has been as of late evaluated in [6] using diversions. Along these lines, if only a 3P3W power supply structure is open at a plant site, the realized UPQC can play out the electrical cable compensation despite when the presented single-arrange burdens require the fair-minded conduit to work.

In the feasibility of the UPQC-based 3P4W assignment structure was surveyed unmistakably by techniques for reenactment results, this paper expects to use the twofold reimbursing strategy use, with its innate ideal conditions, to achieve the going with purposes: i) smoother load symphonious flows; ii) compensate load responsive power; iii) reimburse burden unbalances; iv) repay utility voltage unbalances; v) spread utility consonant voltages; and vi) direct the yield voltages.

IL UPQC TOPOLOGY DESCRIPTION

The UPQC topology used to realize the twofold pay strategy presented in this paper is showed up in Fig.4.1. It is incorporated both Three-Leg and Four-Leg converters having a comparable DC-interface. The UPQC is related between a 3P3W power supply movement structure and a 3P4W plant site made out of a couple of sorts of three-phase and single-arrange loads. It is acknowledged that the single-organize burdens use the impartial conductor to work. For this circumstance, a 3P4W apportionment structure is basic, which is made out of three power converters and an unprejudiced conductor to feed the stores. Therefore, as can be noted in the UPQC-based 3P4W allotment structure showed up in Fig. 1, the fair current goes through the wire channel related with the fourth leg of the shunt 4-Leg PWM converter.

The 4-Leg PWM converter was picked to go about as the shunt APF, in light of the way that it can work with lower DC-associate voltage abundance when stood out from the 3-Leg PWM split-capacitor topology [2], [15]. Likewise, the 3-Leg split-capacitor topology requires an additional control hover to reimburse its regular DC-interface capacitor voltage unbalances. The power rating of the devices that structure its fourth leg is lessened, in light of the way that the present that courses through the unprejudiced conductor a great part of the time is low.

A. Dual Compensation Principle

In order to make the information flows sinusoidal, counterbalance and in stage with the utility voltages, in the twofold compensating methodology, the plan of PWM converter is controlled to fill in as a sinusoidal current source. For this condition, its impedance must be satisfactorily high to isolate the symphonious streams made by the non-straight loads. Then again, the parallel PWM converter in like way makes the yield voltages sinusoidal, adjusted, directed and in stage with the utility voltages. All things considered, it is controlled to fill in as a sinusoidal voltage source, to such a degree, that its impedance must be satisfactorily low to ingest the stack symphonious flows.

Fig. 1. 3P4W dispersion framework dependent on UPQC topology associated with 3P3W power framework arrange

Since the course of action and parallel converters have high and low impedances, independently, the stack consonant ebbs and flows stream typically through the parallel converter. In addition, compensation for weight unbalances is ensured by controlling the course of action converter to seek after sinusoidal and balanced references with the objective that the negative and zero gathering parts are changed.

III. MODELING OF SERIES AND PARALLEL CONVERTERS

A. Series Converter Forming

The state-space framework and the exchange elements of the arrangement converter in the dq-tomahawks are acquired dependent on a numerical model. The demonstrating is practiced thinking about that every single included inductance and protections are indistinguishable, as pursues: \( L_{sa} = L_{sb} = L_{sc} = L_f \) and \( R_{fsa} = R_{fsb} = R_{fsc} = R_f \).

By methods for Fig. 1, the conditions that speak to the framework are given by (1) and (2).

\[
\begin{align*}
\frac{\text{usab}_{\text{pwm}}}{\text{v}_{\text{Lfsa}}} + \frac{\text{usbc}_{\text{pwm}}}{\text{v}_{\text{Lfb}}} &= \text{v}_{\text{Lfsa}} + \frac{\text{v}_{\text{Lfsa}}}{\text{v}_{\text{Lfsb}}} + \frac{\text{v}_{\text{Lfsb}}}{\text{v}_{\text{Lfb}}} - \text{v}_{\text{Lfsb}} - \text{v}_{\text{Lfb}} \\
\frac{\text{usab}_{\text{pwm}}}{\text{v}_{\text{Lfsa}}} + \frac{\text{usbc}_{\text{pwm}}}{\text{v}_{\text{Lfb}}} &= \text{v}_{\text{Lfsa}} + \frac{\text{v}_{\text{Lfsa}}}{\text{v}_{\text{Lfsb}}} + \frac{\text{v}_{\text{Lfsb}}}{\text{v}_{\text{Lfb}}} - \text{v}_{\text{Lfsb}} - \text{v}_{\text{Lfb}}
\end{align*}
\]

where: \( \text{usab}_{\text{pwm}} \) and \( \text{usbc}_{\text{pwm}} \) are the particular PWM voltages.
From the equations \( usd_{\text{pwm}} \) and \( usq_{\text{pwm}} \), the state-space condition is given by

\[
\dot{x}_{sdq}(t) = A_{sdq} \cdot x_{sdq}(t) + B_{sdq} \cdot u_{sdq}(t) + F_{sdq} \cdot w_{sdq}(t) \tag{3}
\]

where:

\[
\dot{x}_{sdq}(t) = \begin{bmatrix} \frac{di_{ds}}{dt} \\ \frac{di_{dq}}{dt} \\ \frac{di_{dc}}{dt} \end{bmatrix}, \quad x_{sdq} = \begin{bmatrix} i_{ds} \\ i_{dq} \\ i_{dc} \end{bmatrix}, \quad u_{sdq} = \begin{bmatrix} u_{ds} \\ u_{dq} \\ u_{dc} \end{bmatrix}, \quad B_{sdq} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}, \quad F_{sdq} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}
\]

Hence, in view of Fig. 2(a), the exchange elements of the shut circle framework can be spoken to by (4), where \( Kp \) (d, q) and \( KI \) (d, q) are the corresponding basic and controller gains, and \( is \) (d, q) \( * (s) \) speaks to the persistent current references in the d-q organizers

\[
i_{i_{d(q)}}(s) = \frac{X_1(Kp_{d(q)}s + KI_{d(q)s})}{L_{f_{ds}}^2 + (R_{f_{ds}} + X_1Kp_{d(q)s})s + X_1KI_{d(q)s}} \tag{4}
\]

where: \( X1 = KPWMVDC \)

**Fig. 2. Sequence converter:** (a) Signal flow graph of the current regulators and average prototypical; (b) Ideal of the uncoupled system in SRF dq-axes.

**B. Parallel Converter Forming**

The state-space framework and exchange elements of the parallel converter in the dq0-tomahawks are acquired dependent on a numerical model. The displaying is cultivated thinking about that every included inductance, protections and capacitances are indistinguishable, as pursues:

\[
L_{fpa} = L_{fpa} = L_{fpa} = L_{fpa} = L_{fpa} = R_{fpa} = R_{fpa} = R_{fpa} = R_{fpa} = R_{fpa} = C_{fpa} = C_{fpa} = C_{fpa} = C_{fpa} = C_{fpa} = C_{fpa} =
\]

By methods for Fig. 1, the conditions that speak to the framework are given by (5), (6) and (7), as pursues:

where: \( up_{\text{pwm}}, up_{\text{pwm}}, \) and \( up_{\text{pwm}} \) are the individual PWM voltages

The capacitor flows of the yield channels \( (ic_{p}, ic_{p}, ib_{c}) \) and \( (ic_{p}, ic_{p} \) are given by:

\[
u_{up_{\text{pwm}}} = R_{fpa} \cdot i_{fa} + L_{fpa} \cdot \frac{di_{fa}}{dt} + u_{fa} + L_{fpa} \cdot \frac{di_{fa}}{dt} + R_{fpa} \cdot i_{fa} \tag{5}
\]
\[
u_{up_{\text{pwm}}} = R_{fpa} \cdot i_{fa} + L_{fpa} \cdot \frac{di_{fa}}{dt} + u_{fa} + L_{fpa} \cdot \frac{di_{fa}}{dt} + R_{fpa} \cdot i_{fa} \tag{6}
\]
\[
u_{up_{\text{pwm}}} = R_{fpa} \cdot i_{fc} + R_{fpa} \cdot \frac{di_{fc}}{dt} + u_{fc} + L_{fpa} \cdot \frac{di_{fc}}{dt} + R_{fpa} \cdot i_{fc} \tag{7}
\]

where: \( up_{\text{pwm}}, up_{\text{pwm}}, \) and \( up_{\text{pwm}} \) are the respective PWM voltages.

The capacitor currents of the output filters \( (ic_{p}, ic_{p}, ib_{c}) \) and \( ic_{p}, ic_{p} \) and \( ic_{p} \) are the currents of the inductors, and \( ic_{p}, ic_{p} \) and \( ic_{p} \) are the output currents considering \((5)(6)(7)\) the state-space equation is found as:

\[
\dot{x}_{pdq}(t) = A_{pdq} \cdot x_{pdq}(t) + B_{pdq} \cdot u_{pdq}(t) + F_{pdq} \cdot w_{pdq}(t) \tag{11}
\]

where:

\[
\dot{x}_{pdq}(t) = \begin{bmatrix} \frac{di_{ia}}{dt} \\ \frac{di_{ib}}{dt} \\ \frac{dv_{ia}}{dt} \\ \frac{dv_{ib}}{dt} \end{bmatrix}; \quad u_{pdq} = \begin{bmatrix} u_{pd_{\text{pwm}}} \\ u_{pd_{\text{pwm}}} \end{bmatrix}; \quad w_{pdq} = \begin{bmatrix} [i_{pd}] \\ [i_{pd}] \end{bmatrix}
\]

In this manner, in light of [11], the parallel converter normal model spoke to as a sign stream chart is appeared in the specked region of Fig. 3(a).

Along these lines, in view of Fig. 3(a), the exchange elements of the shut circle framework can be spoken to by [12] and [13], where \( Kpp_{d(q)} \), \( Kip_{d(q)} \) and \( Kip(0) \) are the relative and vital increases of the controllers (external voltage control circle). \( Kpp_{d(q)} \) and \( Kpp(0) \) are the corresponding additions (inward current control circle), and \( vL_{d(q,0)} \) \( * (s) \) speaks to the nonstop
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The currents of the filter capacitors \( i_{Cf}(d,q,0) \) shown in Fig. 3(a) are estimated considering the derivatives of the measured output voltages \( (u_{La,b,c}) \) and the respective capacitances \( C_{Ca,b,c} \) \[4\].

The fundamental structure square of every single organic cerebrum is a nerve cell, or a neuron as appeared in the Fig.5.

\[
\begin{align*}
\frac{v_L(0,s)}{v_2(d,q)(s)} &= \frac{X_1(s)\frac{d}{ds}v_L(0,s) + X_2(s)v_2(d,q)(s) + X_3(s)v_3(d,q)(s)}{X_1(s)\frac{d}{ds}v_L(0,s) + X_2(s)v_2(d,q)(s) + X_3(s)v_3(d,q)(s)} \\
\frac{v_1(d,q)(s)}{v_2(d,q)(s)} &= \frac{X_1(s)\frac{d}{ds}v_1(d,q)(s) + X_2(s)v_2(d,q)(s) + X_3(s)v_3(d,q)(s)}{X_1(s)\frac{d}{ds}v_1(d,q)(s) + X_2(s)v_2(d,q)(s) + X_3(s)v_3(d,q)(s)}
\end{align*}
\]

IV. PROPOSED NEURAL NETWORK CONTROLLER AND MODEL OF ARTIFICIAL NEURAL NETWORK

An Artificial Neural Network (ANN) is a data handling worldview that is motivated by the way organic sensory systems, for example, the cerebrum, process data. The key component of this worldview is the novel structure of the data preparing framework. It is made out of numerous exceptionally interconnected preparing components (neurons) working as one to take care of explicit issues. ANNs, similar to individuals, learn by precedent. An ANN is designed for a particular application, for example, design acknowledgment or information order, through a learning procedure. Learning in organic frameworks includes acclimations to the synaptic associations that exist between the neurons. This is valid if there should be an occurrence of ANNs also. The fundamental structure square of every single organic cerebrum is a nerve cell, or a neuron as appeared in the Fig.5.

V. SIMULATION RESULTS

a) EXISTING RESULTS

Fig 5.1 and 5.2 shows the MATLAB/SIMULINK diagram of the system and Controller subsystem with PI controller, fig 5.3 shows line voltage fig 5.4 shows line current ,Fig 5.5 shows load current, fig 5.6 shows load voltage and fig 5.7 shows shunt converter current. Here the fault occurs in load current at time period 0.06 sec to 0.18 sec as shown in figure 5.5. The shunt current is injected to the load current in the time period 0.06sec to 0.018 sec as shown in figure 5.7, finally we get the load current sinusoidal wave shape.
Fig 5.1 MATLAB/SIMULINK diagram of the system

Fig 5.2 Controller subsystem

Fig 5.3 Line voltage

Fig 5.4 Line current

Fig 5.5 Load current
b) EXTENSION RESULTS WITH NEURAL NETWORK CONTROLLERS

Fig 5.8 shows proposed controller subsystem with neural network controller, fig 5.9 shows line voltage fig 5.10 shows line current, fig 5.11 shows load current, fig 5.12 shows load voltage. Here the fault occurs in load current at time period 0.06 sec to 0.2 sec as shown in figure 5.11. The shunt current is injected to the load current in the time period 0.06sec to 0.2 sec.
Fig 5.13 shows the line current THD (0.32%) with PI controller as shown in fig 5.14. Fig 5.15 shows the load current THD (1.41%) with PI controller and it will reduce to 1.16% by using NN controller as shown in fig 5.16.
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V. CONCLUSION

Another present decay procedure, in view of recurrence area and SRF hypothesis, with roundabout current control and decreased number of current sensors for organized particular remuneration of various power characteristics and their blends has been examined for the shunt APF of three stage four-wire UPQC. A control methodology dependent on SRF hypothesis with neural system controller is connected for the control of the arrangement APF of UPQC. The watched presentation of the UPQC has exhibited the capacity of the proposed control system to specifically repay the music, the all-out source current harmonics, uneven stacking, in light of need to regard the constrained power limit of VSIs utilized for the shunt and arrangement APFs associated consecutive with normal DC connect capacitor. Moreover, by relief of client produced sounds just, the duty of the utility and clients at the PCC is ascribed. It is additionally seen that the proposed control plan has a quick reaction and can keep up the voltage and current music levels, along these lines adjusting to IEEE principles. The control plan of shunt APF has the benefit of adaptability in the determination of the power quality improvement for which the reference might be registered. Notwithstanding this the shunt APF remunerates the current based symphonious twists even under mutilated utility voltages, henceforth the task of shunt and arrangement APF are autonomous of one another. The reenactment results are appearing with PI and NN controller THDs.

REFERENCES


