Performance Analysis of PI & Fuzzy Based
UPQC for Power Quality Improvement

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Abstract: This manuscript suggests of converters to the
coordinated of a huge “photovoltaic (PV) plant” for a utility AC
grid. The framework contains of a central “7-level voltage-fed
inverter (VFI)” & many “PV” modules with module-integrated
DC-DC converter. The UPQC VFI comprises of “three-level,
three-phase VFI units” joined in parallel on AC-side. The
electrical force quality will be affected toward a significant
number elements in symphonic contamination, due to
non-linear loads like vast “thyristor force converters, rectifiers,
voltage and current flashing” due to circular segment in circular
segment furnaces, swell & sag because of the exchanging of
the loads etc. A standout amongst the numerous results will be the
utilization of a joined framework of active & dynamic
arrangement filters such as “unified power quality conditioner
(UPQC)”. This gadget combines a “Shunt dynamic channel
together with an arrangement dynamic channel” for an over
in- & output configuration, to at the same time adjust the “supply
voltage and the load current” or with relieve any sort from
claiming voltage and present variances and force figure revision
over energy appropriation organize. The current work of effort
ponder those recompense guideline & distinctive control
methodologies utilized here are rely on “fuzzy & PI controller of
UPQC”. The control methodologies are displayed utilizing
MATLAB/SIMULINK. Experimental outcomes are recorded in
examination of diverse control methodologies & for the
confirmation of outcomes.

Index Terms: PV, active power filter, FUZZY, UPQC,
harmonics.

I. INTRODUCTION

With the fast utilization about fossil vitality assets and the
crumbling about biological environment, particularly the
worldwide environmental change initiated by greenhouse gas
emissions, maintainable advancement for mankind’s the
public arena is confronted with genuine dangers. The
improvement and the utilization of renewable vitality need
drawn broad consideration of the worldwide pop culture.
Numerous nations have committed positive improvement
goals, & conveyed out arrangements, regulations to
renewable vitality. These strategies & regulations will
assurance the support about renewable vitality innovation &
figure it out the broadening for vitality. Sun oriented energy,
as a sort of renewable energy, will be broadly connected in
manufacturing also existing exercises. The utilization of it
principally includes: sun based photovoltaic, sun based warm
force generation, sun oriented water warmer and sun based
house and so on. The control electronic units because of their

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II. SYSTEM CONFIGURATION

UPQC block diagram will be displayed in figure. 1. where in
complete control circuit will be demonstrated in figure. 2. The
voltage during PCC might be alternately might not make
bended relying upon the opposite non-linear loads associated
 toward PCC. Here suspicion of the voltage during PCC may
be distorted. The “2 voltage source inverters” are joined back
to back, imparting a as a relatable point DC join [8-10].

Figure 1. UPQC block diagram

The 1 inverter may be joined parallel with the load. It
performances as shunt APF, serves in compensating the
load symphonic present and

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also on uphold DC join voltage during steady level. The 2nd inverter is associated in arrangement for utility voltage toward utilizing arrangement transformers & aides for keeping up the “load voltage sinusoidal” [11], [12].

As for “shunt active filter of the UPQC” it will be signified by \( \frac{V}{2} u_2 \) with \( l_i \) as “first order low-pass interfacing filter and \( r_i \) as the losses of the shunt VSI”. \( \frac{V}{2} u_2 \) shows the “switched voltage across the shunt VSI output of the UPQC”. The shunt active filter’s injection current will be signified by both \( u_1 \) and \( u_2 \) take either 1 or -1 value relies on hysteresis control switching signal. In Figure 2, the nonlinear load’s instantaneous current \( i_L \) will be extended into 3 terms. The first term \( i_{id} \) will be “load reference currents and voltages” are produced with the use of “Phase Locked Loop (PLL)”.

**FUNDAMENTAL CURRENT CONTROL & LOWER ORDER HARMONICS ORIGIN**

This segment examines the beginning of more level request sounds in the framework under attention. The sources for these sounds are not demonstrated as the strategy suggested should weaken those meets expectations autonomous of the symphonious hotspot. The basic present control utilizing the suggested multi -level converter pi built controller will be likewise demonstrated.

**A. Lower Order Harmonics Origin**

1) Odd Harmonics: The prevailing causes for “lower order odd harmonics” are bended polarizing present drawn by “transformer, the inverter dead time, and the semiconductor gadget voltage” drops. Other Components are twisting in “grid voltage itself & voltage swell in DC transport”. The polarizing present drawn by the transformer holds more level request sounds because of the nonlinear aspects of the B–H bend of the center. The correct amplitude of harmonics drawn might a chance to be acquired hypothetically assuming that the B–H bend of transformer. The stage point of the sounds because of those polarizing present will rely on upon the energy component about operation of the framework. Similarly as the operation will be during solidarity energy figure (UPF), the current injected of grid will make done period for the grid voltage. Though, the polarizing grid voltage of current lags by 90°. Therefore, symphonious currents is bring a stage relocation of either −90° or +90° relying upon harmonic order. The dead-time impact introduces “lower order harmonics” that are proportional of dead time, exchanging frequency, and dc transport voltage. Dead-time impact for each leg of inverter could be demonstrated square wave lapse voltage crazy from claiming stage with those present at the pole of leg. The gadget drops also will foundation a comparative impact yet the coming about sum from claiming twisting may be more modest contrasted with that because of the dead the long haul. Therefore, for a “single-phase inverter topology” deliberated, net error voltage will be the voltage the middle of the poles also may be out of stage for the elementary present of transformer. The “harmonic voltage amplitude” for a hth harmonic might be expressed as.

\[ V_{error} = 4 \pi n T \Delta T \]  (1)

Here \( t_d \) may be the dead time, \( T_s \) is the gadget exchanging

frequency, and \( V_{dc} \) will be dc transport voltage. Utilizing qualities of “channel inductance, transformer spillage inductance, and the net arrangement resistance, symphonious present magnitudes” might be assessed. Again, it should noted that stage point of the symphonious ebbs and flows in this case will a chance to be 180° to operation of UPF. Thus, it might a chance to be watched that the net symphonious content will bring exactly stage point with admiration to the basic present relying upon the “relative magnitudes of the distortions” because of the polarizing present and dead occasion.

![Fig.2. An inverter ac current reference generation from an MPPT block](image)

**III. UPQC’S OVERALL CONTROL CIRCUIT CONFIGURATION**

The control methodology will be relying on “unit vector templates extraction” from the distorted supply of input. These templates are then comparable to pure “sinusoidal signal with unity (p.u.) amplitude”. The unit vector template extraction is followed:

\[
\begin{align*}
U_a &= \sin(\omega t) \\
U_b &= \sin(\omega t - 120) \\
U_c &= \sin(\omega t + 120)
\end{align*}
\]  (1)

Multiplying the “peak amplitude of fundamental input voltage with unit vector templates” of equation (1) provides “reference load voltage signals” is followed:

\[ V_{abc} = V_m U_{abc} \]  (2)
IV. UPQC’S CONTROL STRATEGY

UPQC comprises about arrangement “compensator & shunt compensator”. The “shunt compensator” will be organized by a “PWM current control algorithm”, same time arrangement converter will be controlled toward a “PWM voltage control algorithm”. As stated by embraced control scheme, these 2 parts from claiming UPQC have distinctive works as follows:

4.1 Static Shunt Compensator

In Figure 3, the nonlinear load instantaneous current \( i_i \) is extended into 3 terms. The first term \( i_{ip} \) will be “load functions sent from PLL (Phase Locked Loop)” in accordance in (Eq 3):

\[
I_{ip} = T_{dq} \cdot i_{abc}
\]

By this transform, essential “positive sequence modules” are converted into “dc Quantities in d and q axes” that might simply extracted by “LPF (low-pass filter)”.

Figure.4 Control of the shunt Converter of the UPQC

All harmonic modules converted into quantities of AC with important frequency shift.

\[
I_{dq} = T_{dq} \cdot i_{abc}
\]

Since \( i_L = i_i + i_{ip} \)

This implies there may be no sensitive parts & harmonics in currents of framework. The exchanging misfortune could foundation dc join capacitor voltage should decline. Other disturbances, for example unbalances & sudden demise varieties from claiming loads might additionally cause this voltage will change. So as with keep away from this, figure 4. A PI controller may be utilized. The PI input controller will be the error among real capacitor voltage and the fancied value, its yield at that point included of the reference present part in the d-axis.

4.2 Static Series Compensator

The framework side voltage might consists harmonics components & negative-zero-sequence that to be removed by “series compensator” [15], [16]. The series compensator control will be displayed in Figure 5. The framework voltages are identified then converted into “synchronous dq-0 reference frame” utilizing (Eq 6):

\[
U_{dabc} = T_{dq} \cdot U_{abc} = U_{slp} + U_{sLn} + U_{sL0} + U_{sh}
\]

Figure 5: UPQC series converter’s control block diagram

V. DESIGNING & TRAINING OF FUZZY

The idea of fuzzy logic might have been presented by Lotfi Zadeh (1965), & it’s scientific demonstrating which is a deal with vulnerability [7]. It offers a critical idea of delicate registering with expressions. It gives procedure which arrangements for imprecision. The fuzzy hypothesis gives instrument for representational for semantic terms for example, “many,” “low,” “medium,” “often,” “few.” done general, the fuzzy logic give an induction structure that empower proper human thinking abilities. The fuzzy logic frameworks are suitableness to estimated thinking. The fuzzy logic frameworks have speedier & smoother reaction over customary frameworks & control intricacy may be low. The fuzzy induction framework combines fuzzy IF–THEN guidelines to mapping starting with fuzzy sets in enter space X of yield space Y In light of fuzzy logic guideline. To fuzzy logic, information representation, fuzzy IF–THEN standard may be a strategy to catching information that include imprecision. The primary characteristic of thinking utilizing fuzzy standards will be its fractional matching capability, an induction to a chance to be aggravated from fuzzy rule even when rule’s states are incompletely fulfilled [8]. The “fuzzy logic controller block diagram” will demonstrated in Fig-5.
Fuzzy induction System: The “Fuzzy IF-THEN rule” communicates a fuzzy implication connection among fuzzy sets of reason & fuzzy sets of conclusion. The guidelines IF component depicts circumstance for those standards are intended & THEN segment depicts the reaction about fuzzy framework. For instance, IF error will be N THEN duty cycle will be Z.

Defuzzification: To acquire fresh yield different defuzzification strategies could be utilized e.g., “center of gravity, bisector of area, mean of maximum, adaptive integration, fuzzy grouping defuzzification, First of maximum, Last of of maximum, Semi-linear Defuzzification, quality method, center of maximum”. To acquire a crisp numerical yield esteem.

VI. SIMULATION RESULTS

The harmonic content of bridge converter’ s input & output is indicated in figure 8 (3 stage voltages) & figure 9 (3 stage currents). Due to non-linear loads, for example, “expansive thyristor energy converters, rectifiers, voltage & present flashing” due to circular segment in circular segment furnaces, swell & sag due to the exchanging of the loads and so on. A standout amongst the significant number results will be utilization of a joined together framework of shunt & active series filters like UPQC. This gadget combines a “shunt dynamic channel” together with the arrangement animated channel to an over to-back configuration, should all the while adjust the “supply voltage and the load current” alternately to relieve any sort of current, voltage variances & energy component correction in current dissemination network. The control methodologies utilized here rely on UPQC’s Fuzzy & PI controller. The control methodologies are displayed utilizing MATLAB/SIMULINK. The experimental outcomes are recorded in examination of diverse control methodologies are indicated in figures.

The experimental outcomes are displayed in Figure 9, & load voltages in Figure 10. The shunt and series APF’s source current & they are put into operation at dissimilar time instant.
The shunt APF will be placed under operation at instant “0.2 sec”. Inside the exact “short time period the shunt APF” upheld DC connection voltage during steady level as demonstrated in figure 13. Furthermore, to this shunt APF likewise aids in compensating the current harmonics created by nonlinear load. It will be obvious that in the recent past the long run “0.1 sec”, likewise load voltage may be distorted, as before long similarly as the arrangement APF place to with operation at “0.1 sec” load present profile will be additionally enhanced. Before time “0.2 sec”, source current will be equivalent to load present. However, after time ‘0.2 sec’, the point when shunt APF begins administering “dc link voltage” it injects those compensating current in such an approach that source current turns into sinusoidal. The current injected by shunt APF may be indicated done figure 10. UPQC model need been created with separate shunt controllers (PI, FUZZY), & reproduced effects.

VII. CONCLUSIONS

The control system may be pulse era to switches in the recommended inverter. All switches in recommended inverter worked for basic recurrence. So, exchanging misfortunes & value of THD are low in recommended inverter. The future scope will be photovoltaic arrays, energy units utilized within this suggested inverter. The points of the high-level control and additionally the exchanging control have been introduced. The “closed loop control schemes” of immediate current control, to the recommended UPQC need been portrayed. A suitableness mathematical need been depicted that secures the certainty that over both the cases the recompense will be finished however the reaction of fuzzy controller is quicker and the THD will be least to the both voltage & current that is apparent starting with plots & comparison table 1. Suggested model for the UPQC may be should adjust information “voltage harmonics & current harmonics” initiated by non-linear load. The work might be developed to adjust the “supply voltage & load current imperfections” for example, “sags, swells, interruptions, voltage imbalance, flicker, & current unbalance”. The suggested UPQC might make executed utilizing basic simple hardware, a result it may be having hysteresis blocks & PLL.