Unified Power Quality Conditioner (UPQC) using MATLAB

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Abstract: *The theory and modelling of unified power quality conditioner(UPQC),which is a FACTS device is presented in this paper. The model consists of thyristor controlled capacitor banks, series-active filter and shund active filter. The series-active and shunt-active filters mainly compensates negative-sequence current and harmonics and the thyristor controlled capacitor banks is used to compensate the reactive power of power frequency. The UPQC is modelled using Simulink and is simulated using a software called MATLAB*.

Introduction

The term Power Quality has gained importance in last few years. Due to the advancement of semiconductor device technology it is possible to use it on a commercial basis. The most important and common issue for a power system engineer is Reactive Power Compensation in transmission as well as distribution level. We know well that in a distribution network there is distribution transformer , motor loads ,etc which demands reactive power. The type of load present in the network affects the reactive power demand.

We have already used capacitor banks which compensates the load reactive power demand, which is the most simplest and effective method. However this method has some drawbacks, such as, fixed compensation, resonance with nearby loads, bulky size, switching transient, etc.

Unified Power Quality Conditioner(UPQC)

There are to voltage source inverters in UPQC, they are connected back to back with a common DC link.

One of the inverters is controlled as a variable voltage source in series APF and the other as variable current source in shunt APF.

In the figure configuration of UPQC is depicted.

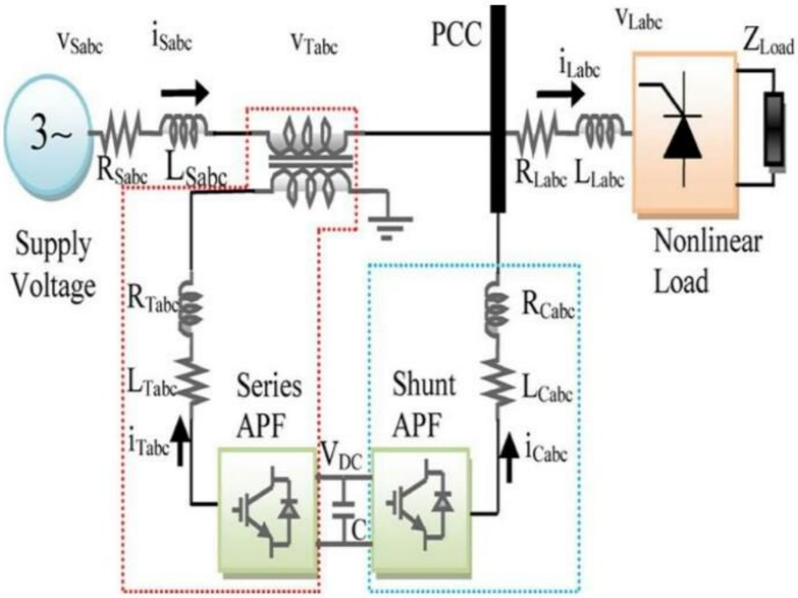


Fig1 UPQC Model

The shunt converter of UPQC needs to be connected more closer to the non linear load than the network side.

In the figure, the supply voltage Vs is unbalanced and distorted which requires high power quality, whereas, a portion of the total load comprises of non linear loads that injects huge amount of harmonic current into the network that needs to be filtered.

In the fig. i_L denotes all the non-linear loads that needs to be compensated. So, this shunt filter would compensate the undesired harmonic current and imbalances caused by negative and zero sequence components at fundamental frequency, also the load reactive power.

The same compensation could be done by series active filter for the supply voltage.

Hence, we see that with the help of UPQC both V_L (compensated voltage at load terminal) and I_S (the compensated current drawn from power supply) is balanced i.e., no unbalance due to zero or negative sequence components at fundamental frequency.

If the load reactive power is also compensated V_L and I_S would be sinusoidal and in phase.

UPQC Control Methods

A. Shunt Control Strategy

This compensates the current and the reactive power. This acts as a controlled current generator that the compensates the load current so that the source current drawn from the network could be sinusoidal, balanced and in phase with the positive sequence voltage.To take out the harmonics present in the supply voltage and current, we are going to use the SRF method.

For the removal of harmonics from current, the distorted current is converted into two-phase stationary co-ordinates using α-β conversion (as in p-q theory). Then this stationary quantity is converted into synchronous rotating frame with the help of cosine and sine function from the phase locked loop (PLL), the sine and cosine creates and maintains the synchronization with supply voltage and current. Just as the p-q theory, by the help of filters, the harmonics and the fundamental component can be separated and converted back to a-b-c frame i.e, the reference signal.

The conversion can be done by the help of following rquations:-

$I_{S0} = \frac{1}{\sqrt{3}}[i_{sa} + i_{sb} + i_{sc}]$………….(1)

$I_{s\alpha} = \sqrt{\frac{2}{3}}[i_{sa} - \frac{1}{2} i_{sb} - \frac{1}{2} i_{sc}]$………(2)

$I_{S\beta} = \frac{1}{\sqrt{2}}[i_{sb} - i_{sc}]$………….(3)

$V_{S0} = \frac{1}{\sqrt{3}}[V_{sa} + V_{sb} + V_{sc}]$………….(4)

$V_{s\alpha} = \sqrt{\frac{2}{3}}[V_{sa} - \frac{1}{2} V_{sb} - \frac{1}{2} V_{sc}]$…………..(5)

$V_{S\beta} = \frac{1}{\sqrt{2}}[V_{sb} - V_{sc}]$………….(6)

The source side instantaneous real and imaginary power components are calculated as:-

$P = V_{S\alpha}I_{S\alpha} + V_{S\beta}I_{S\beta}$……………….(7)

$Q = -V_{S\beta}I_{S\alpha} + V_{S\alpha}I_{S\beta}$……………...(8)

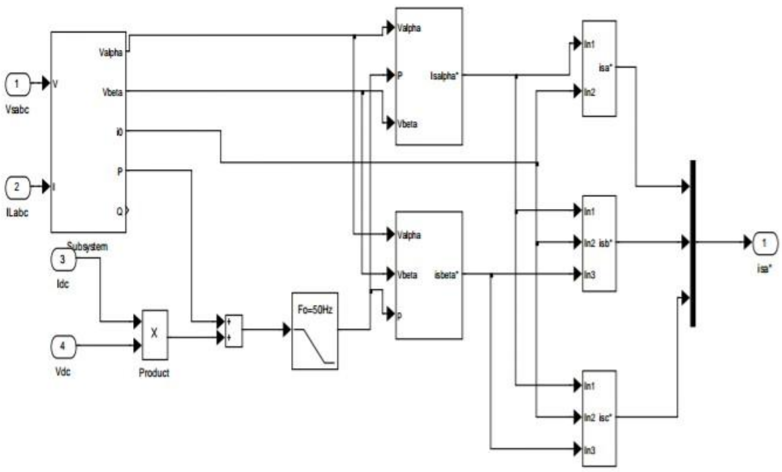


Fig2 PQ Theory Simulation

B.Series Control Strategy

The series active power filter is useful for voltage compensation. The compensated voltage is synthesized by PWM converter and is added to supply voltage, so that the voltage becomes sinusoidal and balanced.

The supply voltage V_{sabc} is converted into d-q-0 co-ordinates.

$V_d = \frac{2}{3}$ [V_a * sinwt + V_b * sin(wt - 2π/3) + V_c * sin(wt + 2π/3)]

V_q = 2/3 [V_a * coswt + V_b * cos(wt2π/3) + V_c * cos(wt+2π/3)

V_0 = 1/3 (V_a + V_b + V_c)

The voltage in d-axes has average and oscillating components of source voltages. This average voltage can be calculated by using second order Low Pass Filter. The switching signals are determined by comparing reference voltage and load voltage and also by PWM controller.

The d-q-0 is converted to V_{sabc} co-ordinates:

V_a = [V_d * sin(wt) + V_q * cos (wt) + V_0]

V_b = [V_d * sin(wt-2π/3) + V_q * cos(wt-2π/3) +V_0]

V_c = [V_d * sin(wt+2π/3) + V_q * cos(wt+2π/3) +V_0]

These three-phase load reference voltages are compared to load line voltages and errors are controlled by sinusoidal PWM controller to obtain the required switching signal for series APF IGBT switches.

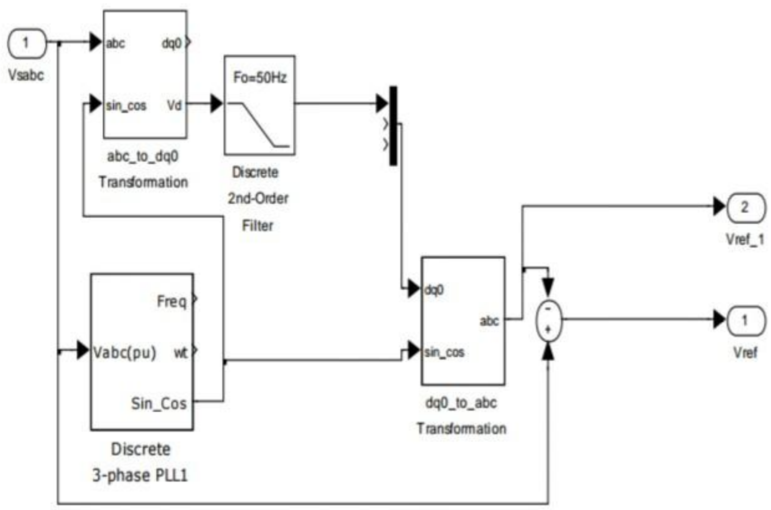
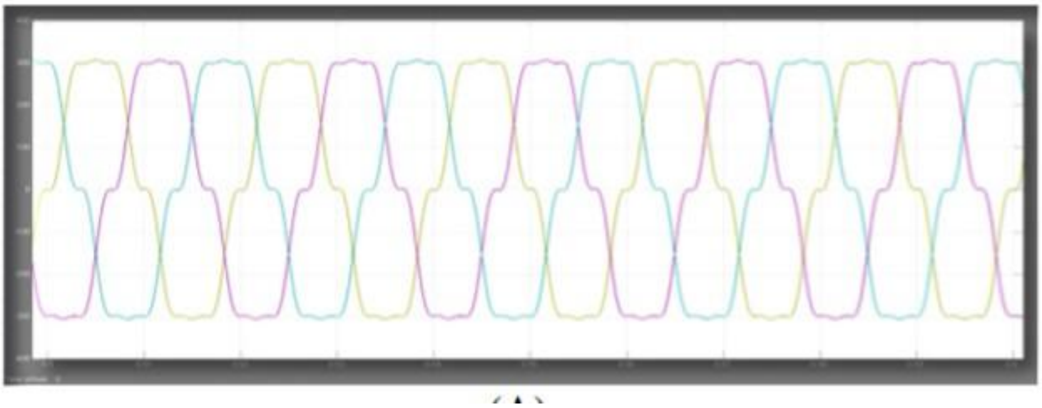


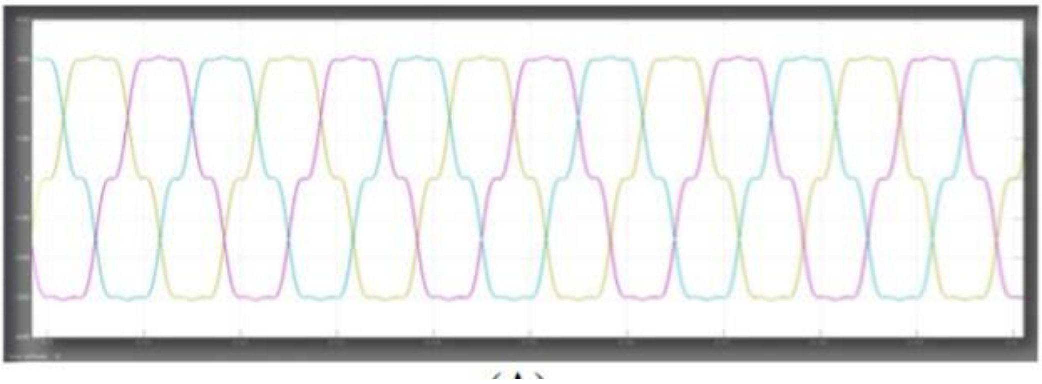
Fig3 D-Q-0 Theory Simulation

Effects of Simulation on the Components

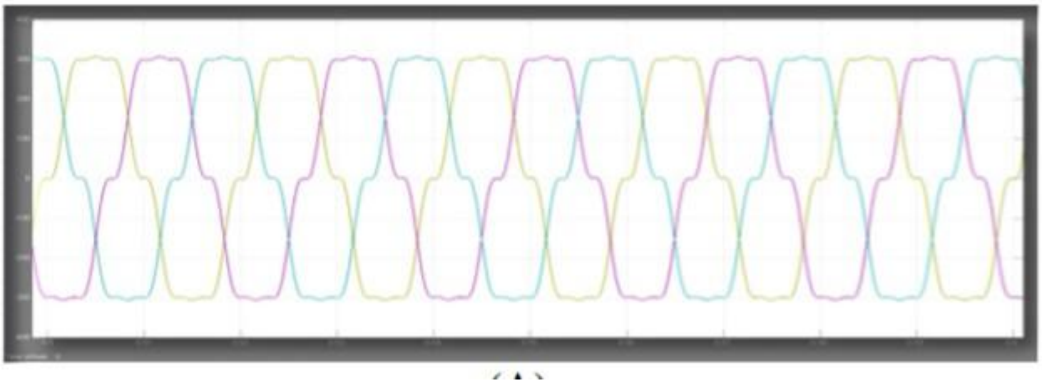
A. Source voltage V_{abc} :



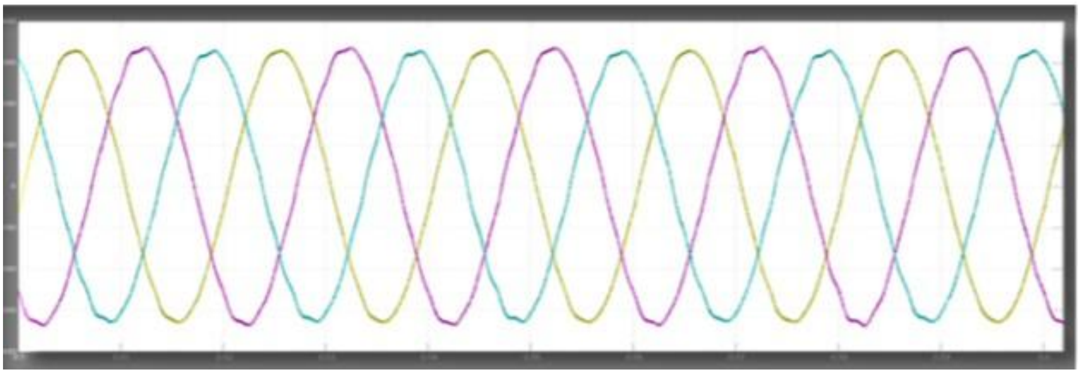
B. Load current I_{Labc} :



C. Source current I_{abc} :



D. Load voltage V_{Labc} :



Conclusion

With help of this model we are able to overcome the distortion and unbalance of load current in the power line, which is the main pain area for a power system engineer, and also the power factor is maintained to unity. The series APF differentiates the load voltage and the source voltage, and on the other hand shunt APF provides the three-phase balanced current for the load. The THD can be overcome by this UPQC system. The purpose of the project is to model and simulate the UPQC.

References

[1] H Akagi , E H Watanabe, and M Aredes, "*Instantaneous powertheory and applications to power conditioning".* Hoboken N J:Wiley-IEEEPress, Apr 2007.

[2] MetinKesler, EnginOzdemir, *" A novel control method for unfied power quality conditioner (UPQC) under non-ideal mains voltage and unbalanced load conditions",*978-1-4244-4783-1/10/2010 IEEE

[3] MetinKesler, EnginOzdemir, *"Synchronou-reference-frame-based control method forUPQC under unbalanced and distortedload conditions",* IEEE Trans. Industrial electronics, vol 58, no.9, September 2011