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Stabilization of Voltage and Current in the Distribution Networks using APF and TSC

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ABSTRACT

Instability of voltage is a problem that has been occurring in recent years due to excessive exploitation from equipment and an increase in demand for load across the distribution system. Shortage of the reactive power in the power networks, especially distribution networks, pushes the system toward voltage instability and leads to voltage drop as well as voltage fluctuations in the feeder. One of the potential solutions for compensation is to install thyristor switched capacitor (TSC). Although TSC can reduce the total costs of compensation, the static error will reduce compensation. For this purpose, an active power filter (APF) can be applied to resolve errors resulting from TSC due to features of continuous compensation and quick dynamic response. In this research, the combined method was presented, including TSC and APF of a controllable active power injection and with appropriate switching based on the study of voltage drop in the radial distribution networks and improvement of power quality. The suggested model was executed by MATLAB software, whereby results of improvement and provision of the stability conditions (dynamic and static) of voltage and current were observed.

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1. INTRODUCTION

Inappropriate quality of electricity means existence of change, sinuosity, or disturbance in the quantities of voltage, current, and frequency. All lead to breakdown or malfunction of the subscribers' equipment. The term ‘electricity quality’ has found plentiful applications in industrial countries and electricity industry. The topic of electricity quality covers a large number of available sinuosity and disturbances in the network [1]. In other words, a new look at the sinuosity and disturbances present in the power systems shows itself as a new topic deliberation over which is counted as one of the most important cases studies of power systems.

Problems related to the quality of power have been discussed and studied for a while by researchers in the electricity industry [2]. On the other hand, today, the attention of electricity companies and their subscribers has been increasingly directed to the electricity quality. The above point covers many disturbances that exist in the electricity company. The subjects which are placed under the topic of discussion of electricity quality are not new concepts necessarily. On the other hand, considering the existence of numerous problems resulting from the undesirable quality of electricity, usage of appropriate ways to improve it appears necessary [3]. One of the most appropriate methods is to install thyristor switched capacitor (TSC). The application of TSC can reduce total costs of compensation, but the static error will reduce the compensation. For this purpose, we can apply an active power filter (APF) to resolve the error resulting from TSC because of continuous compensation features and quick dynamic response. APF is used extensively in the compensation of the active and harmonic power of distribution networks; but it is considerably expensive and its design is difficult.

Mobashsher et al. [4] introduced an Optimal Voltage Control (OVC) framework for island microgrids (MGs) as an integrated hierarchical control scheme. They started with the optimization of the bus voltage adjustment

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points in the third level, which were then effectively followed by a secondary control that controls the distributed energy sources. Regarding their primary level controllers, the control structure distributed here is proposed for both the third and secondary levels to benefit from higher reliability, avoidance of a breakpoint, and a relatively simple communication system. At the third level, a new distributed voltage protocol, based on Lyapunov's theory, is proposed to optimize power losses and voltage profile deviations in MG. To use such a multilevel controller in a real distribution system, further study is required. New power systems do not elevate abnormal voltages even for a short time as well. Voltage reduction commonly occurs as a result of excessive load leads to undesirable behavior and operation of the load, particularly induction engines. In the systems which are under heavy load, a decrease of voltage may suggest that the load approaches the durable stability limit (dynamic and heating), and or sudden voltage reduction may be established in response the connection of very large loads [5].

The excessive load has several origins. Decrease of load in specified parts of the daily load cycle leads to gradual voltage increase. If this excessive voltage is not controlled, it results in diminished useful lifespan of insulators. Sudden excessive voltage usually originates from the disconnection of load or other equipment of the system. In this research, through the study of voltage drop in the radial distribution networks and improvement of power quality as well as stabilization of voltage range of distribution networks within the limits of permitted changes, a combined method, including TSC and APF, was presented locally and diffusely through injecting controllable reactive power or proper switching.

This article uses TSC and APF, in a way that can reduce the total compensation costs as well as voltage and current fluctuations and harmonics. One of the most important options for compensation is to install thyristor switched capacitor (TSC) banks. Use of TSC can reduce total compensation costs, but static error lowers compensation. As such, Active Power Filter (APF) can be applied to eliminate TSC errors due to continuous compensation features and fast dynamic response. In this paper, first the influence of capacitor is examined on reduction of losses, parallel capacitor controlled by thyristor (TSC) and harmonic compensator of active power filters (APF). Then, in the fifth section, the proposed model is presented.

2. INFLUENCE OF CAPACITOR ON REDUCTION OF LOSSES

To examine how the capacitor influences the decline of losses, a feeder has been taken into consideration according to Figure 1.

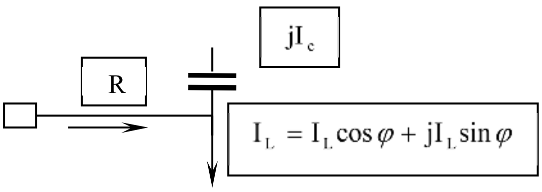


Figure 1. The effect of capacitors on loss reduction

In this figure, losses of active power of the feeder before installation of the capacitor are expressed as follows [1]:

$$P_{L0} = I_0^2 R = (I_L \cos\varphi)^2 R + (I_L \sin\varphi)^2 R \quad (1)$$

where, R is the resistance of feeder path, the amplitude of current load, and the difference between current and voltage. After installation of the capacitor, we have:

$$P_L = I^2 R = (I_L \cos\varphi)^2 R + (I_L \sin\varphi - I_c)^2 R \quad (2)$$

Thus, the rate of change in losses could be obtained from the following relation upon installation of the capacitor:

$$\Delta P_L = P_{L0} - P_L = 2(I_L \sin\varphi) I_c R - I_c^2 R \quad (3)$$

It is noted from Equation (3) that the change in rate of losses is a function of the reactive current in load ($I_L$sin) while active current in load ($I_L$cos) does not play a role in reduction of the losses. Thus, it can be concluded that installation of capacitor does not influence the losses resulting from active current of feeder and only affects the losses arising from reactive current of the feeder. Accordingly, in the problem capacitor placement, minimization of losses of feeder corresponds with minimization of losses of the reactive feeder.

3. PARALLEL CAPACITOR CONTROLLED BY THYRISTOR

Parallel capacitor controlled by thyristor (TSC) includes thyristor parallel and pair capacitors which connect and disconnect the capacitors. Figure 2 displays the façade of a TSC along with the number of the installed branches depends on the accuracy required by the compensator of active power. Considering numerous advantages of TSC, including simple designation and installation, TSC is preferred in many applications.

TSC can be used as support of feeding resource voltage, as well as for compensation of reactive power, harmonic filtering, etc. Typically, TSC is used for the compensation of reactive power. TSC injects capacitor reactive power into the system; thus, the power coefficient grows and voltage is controlled.

One of other objectives in using these tools is to improve transient stability. After examining the

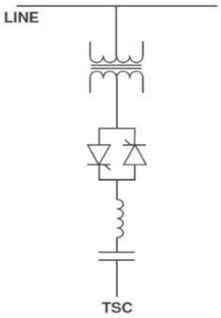


Figure 2. The main structure of TSC

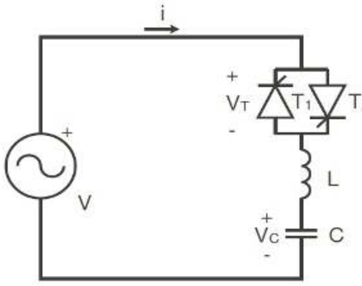


Figure 3. TSC Model with Seri Reactor

advantages of TSC, several studies have been carried out on how to improve transient response of capacitors switching. Many methods have been presented in order to control TSC switching appropriately for improving transient operation and controlling the reactive power. In order to eliminate series reactor and express a reactor-free model, some researchers have used GTO pair [6]. Yet, costs will increase and control will become more complex upon (installation of GTO. Some other control techniques have been presented to improve transient stability and control reactive power as well. TSC can be configured and framed as various topologies, including triangular connection of capacitors, star connection of TSC, thyristor pair, and diode connection. Triangular connection of the capacitor bank with various semiconductor switches of power has been explored in several studies [7, 8]. These topologies can be compared in terms of structure and decomposition of voltage as well as current components [9]. The performance of these topologies is almost equal. TSC is used for different systems, including distribution systems. With time sequence of switches, they can be used to regulate voltage and compensate reactive power [10-12]. When a capacitor is connected by a sinuous voltage source, the current of capacitor will undergo severe fluctuation in case the initial voltage of the capacitor's two ends is higher than feed quantity. As a result, these changes in the current must be limited. Therefore, a series reactor with capacitor is used in TSC. The moment voltage of feeding the capacity (U_m) is in the following form:

$$u(t) = \sqrt{2}V\sin(w_0 t + \alpha) \tag{4}$$

At time t=0, the switch with the initial value of the voltage current in zero capacitor is off. The value of moment current of the capacitor over time is obtained from the following equation:

$$\begin{aligned} i(t) = {} & \sqrt{2}I_{AC}\cos(w_0 t + \alpha) - nB_C\left[V_{CO} - \frac{n^2}{n^2-1}\sqrt{2}V\sin\alpha\right]\sin w_n t \\ & - \sqrt{2}I_{AC}\cos\alpha\cos w_n t \end{aligned} \tag{5}$$

$$\begin{aligned} & w_n = n w_0 = \sqrt{\frac{1}{LC}},\ n = \sqrt{\frac{X_C}{X_L}},\ B_C = w_0 C = \frac{1}{X_C} \\ & I_{AC} = \frac{V B_C B_L}{B_L - B_C} = \frac{V B_C n^2}{n^2 - 1},\ B_L = \frac{1}{X_L} \end{aligned} \tag{6}$$

The quantity of reactor is selected in such a way that n >3 in the above equation. Note that resistance of the circuit in this equation has been considered to be negligible. If switching occurs in the 90-degree fire angle, we will have the following:

$$\begin{aligned} & \cos\alpha = 0 \Rightarrow \sin\alpha = \pm 1 \\ & V_{CO} = \pm\sqrt{2}\,\frac{V n^2}{n^2 - 1} = \pm\sqrt{2}\,X_C I_{AC} \end{aligned} \tag{7}$$

TSC can be applied as a very useful element in the distribution system.

4. HARMONIC COMPENSATOR OF ACTIVE POWER FILTERS

Recently, extensive usage of power of electronic equipment has caused harmonic disturbances in the power distribution system to increase. Arched furnaces, computer feeding sources, drives for speed regulation, etc are non-linear loads generating these disturbances. In three-phase systems, they can lead to imbalance of voltage and current as well as higher passing current. Reactive load, lack of balance and harmonic injection are as examples of problems related to power systems. There are several controlling methods to control APF. Theory of moment reactive power is one of the controlling methods as an example which has been extensively used [13]. Another method is based on recognition of harmonics [4]. Many studies have been conducted on the harmonic detection via closed–ring method as well [14-16]. Two samples of the harmonic compensation circuits with parallel APF are shown in Figure 4. Z_M shows impedance of line, Z_L indicates nonlinear load, and $e_M(t)$ is source of system voltage. Figure 4(a) lacks feedback while Figure 4(b) is with feedback.

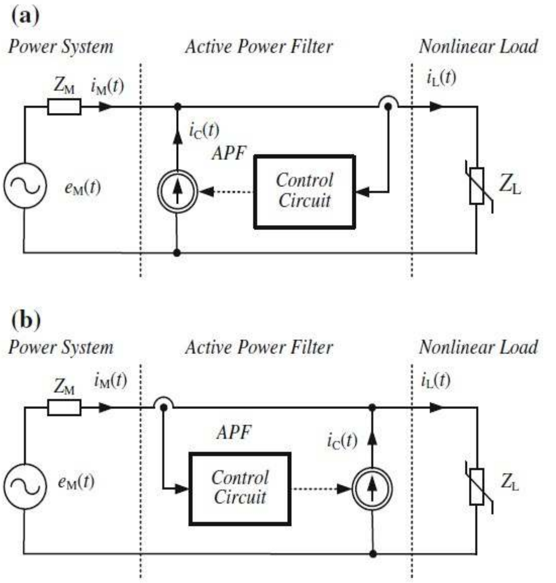


Figure 4. Harmonic compensation circuit with parallel APF (a) with feedback (b) without feedback

$$i_M(t) = i_L(t) - i_C(t) \tag{8}$$

In order to eliminate the harmonics, parallel APF injects current into the system. The current of line ($i_M(t)$) can be achieved from the following equation: Three-phase parallel APF is one of the best systems for harmonic compensation, reactive power, imbalance, voltage drop, and voltage bulge. Indeed, APF control algorithms are very expansive [1, 5, 17].

4. 1. Active Power Filter Analog circuits were used in the past [18] extensively, while digital circuits are used considerably nowadays in order to control accurately. Today, application of digital active filter has been substantially expanded. Usage of digital control systems enables usage of more complicated algorithms and process digital signals [19]. Considering dynamism of APF, dynamic problems must thus be studied. As expressed earlier, active filters are applied in series, parallel, and mixed forms. Figure 5 depicts a parallel APF circuit. The circuit of Figure 4 relates to 'with feedback' active compensator circuit. Parallel APF injects current into the network for harmonic compensation and will lead to elimination of the harmonics as well as compensation of reactive power. This current is obtained from the following equation:

$$i_C(t) = i_L(t) - I_{H1} \sin(2\pi f_M t) \tag{9}$$

where, I_{H1} is the first harmonic amplitude and F_M is the first harmonic frequency. In the complete harmonic compensation, current of line $I_M(t)$ will include the first harmonic of the line current:

$$i_M(t) = I_{H1} \sin(2\pi f_M t) \tag{10}$$

When the angle of phase between voltage of line $u_1(t)$ and current of line ($I_M(t)$) is zero, whereby the reactive power has been compensated well. In APF (Figure 5), three load currents of $I_{L1}(t)$, $I_{L2}(t)$ and $I_{L3}(t)$ are measured and, then, used to determine the quantity of compensation currents of $I_{C1}(t)$, $I_{C2}(t)$.

Three-phase inverter has consisted of a DC energy plus two C_1 and C_2 capacitors. The parallel APF control circuit is shown in Figure 6.

P-Q block diagram and parallel APF compensator for a three-phase system plus three balanced wires are shown in Figure 7.

Three-phase input signals of $I_{L1}(t)$, $I_{L2}(t)$, and $I_{L3}(t)$ are used as reference signals. The input signals of system (A-B) are calculated, using Clarke conversion, by the following method:

$$\begin{bmatrix} i_{L\alpha}(t) \\ i_{L\beta}(t) \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \cdot \begin{bmatrix} i_{L1}(t) \\ i_{L2}(t) \\ i_{L3}(t) \end{bmatrix} \tag{11}$$

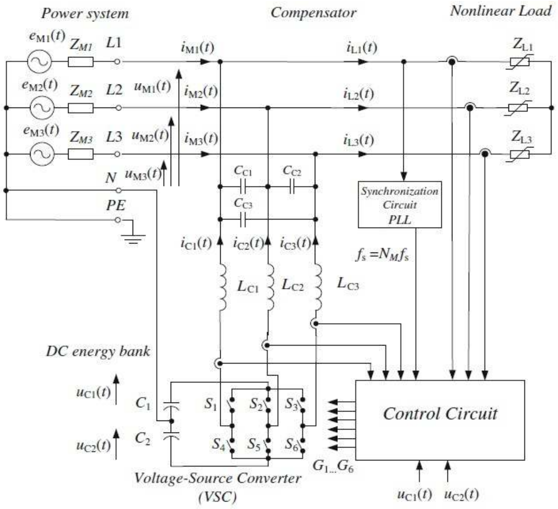


Figure 5. APF parallel three-phase compensator

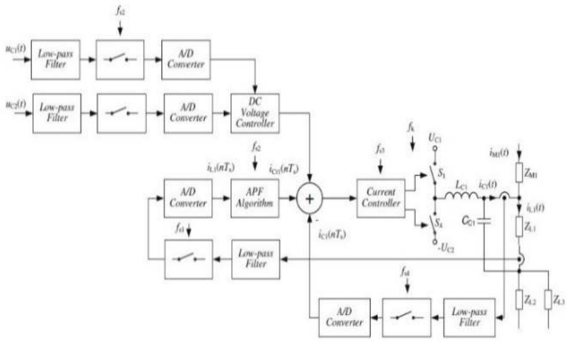


Figure 6. Parallel APF control circuit

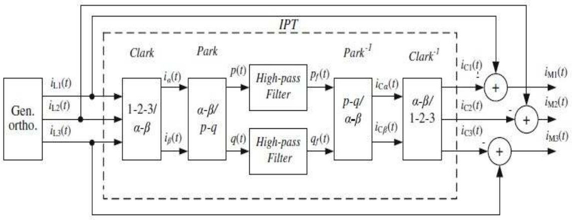


Figure 7. Block diagram of PQ and parallel to a three-phase three-wire APF compensation balance

After the conversion of P-Q park system:

$$\begin{bmatrix} p(t) \\ q(t) \end{bmatrix} = \begin{bmatrix} \cos(2\pi.f.t) & -\sin(2\pi.f.t) \\ \sin(2\pi.f.t) & \cos(2\pi.f.t) \end{bmatrix} \cdot \begin{bmatrix} i_{L\alpha}(t) \\ i_{L\beta}(t) \end{bmatrix} \tag{12}$$

From this change of system, 50 hertz component turns into DC components. Next, the DC component will be removed by a first rank upper-passing filter. Intensification frequency of the filter is equal to 10 hertz. Then, the achieved compensated signals of I_{C1}(t), I_{C2}(t), and I_{C3}(t) are converted into a three-phase system without 50HZ component, using Park reverse conversion (Figure 8):

$$\begin{bmatrix} i_{C\alpha}(t) \\ i_{C\beta}(t) \end{bmatrix} = \begin{bmatrix} \cos(2\pi.f.t) & \sin(2\pi.f.t) \\ -\sin(2\pi.f.t) & \cos(2\pi.f.t) \end{bmatrix} \cdot \begin{bmatrix} p_f(t) \\ q_f(t) \end{bmatrix} \tag{13}$$

And conversion of reverse Clarke:

$$\begin{bmatrix} i_{C1}(t) \\ i_{C2}(t) \\ i_{C3}(t) \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & 0 \\ -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \cdot \begin{bmatrix} i_{C\alpha}(t) \\ i_{C\beta}(t) \end{bmatrix} \tag{14}$$

5. SUGGESTED MODEL

The model presented in this work is a combination of TSC and APF application. APF as a filter, is harmonic which can, by itself, eliminate not only a specific harmonic but also a harmonic with each frequency. The basis of exploitation from APF is decomposition of components of the current fluctuation from the main current generating the load in a harmonic form and then obviating them. Using APF, the total reactive power cannot be compensated practically as the rate of power and costs of such compensation will grow considerably. TSC can be used as the main compensator of reactive power. Through combining these two elements, we will have an appropriate control. Figure 8 shows single-linear diagram of TSC and APF plus its connection to the power system. To feed the DC voltage, parallel capacitors have been connected to the converter. Note that if power system includes harmonic of voltage as well as harmonic of source, the tools must be used in the combined form to eliminate harmonic and reactive power control so that the best efficiency would be obtained. In this paper, combination of TSC and APF has been used to achieve the best performance optimally.

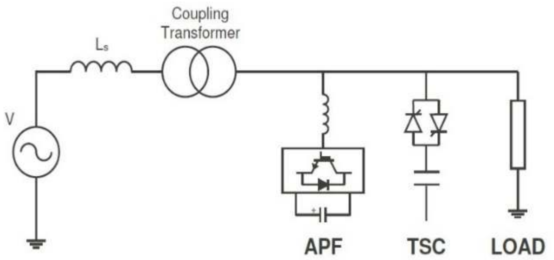


Figure 8. Single line diagram parallel with TSC and APF

Based on requirements, thyristors of each step must be stimulated appropriately. In this state, TSC includes six thyristors in each stair, in response to which the controlling system must be able to stimulate these six thyristors. The control system of these six thyristors has been displayed in Figure 9.

By combining TSCs and their triangular connection, the control system will be as Figure 10. In this controlling system, three blocks of Figure 9 are combined, where the stimulation pulse of all TSC thyristors of TSC is generated in three-phase triangle. Productive controlling system of each TSC, via the control system, is capable of controlling the reactive power required by the system. Figure 11 compares the input voltage firstly with the reference voltage and then productive signal generated for each TSC. Also, the productive signal for each TSC includes six signals in order to stimulate every single thyristor.

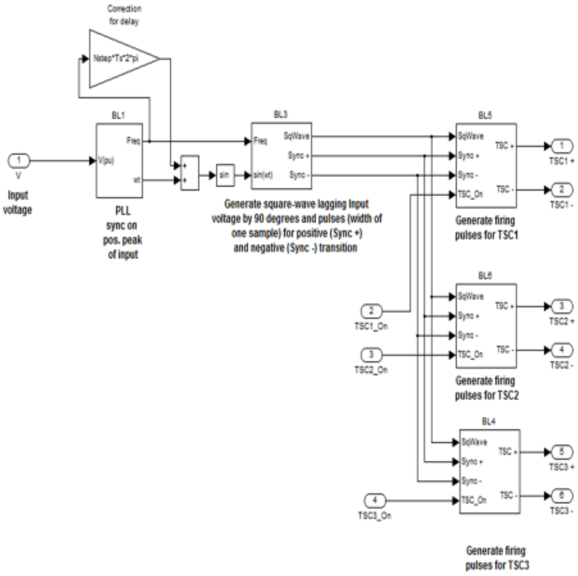


Figure 9. The control of any TSC unit

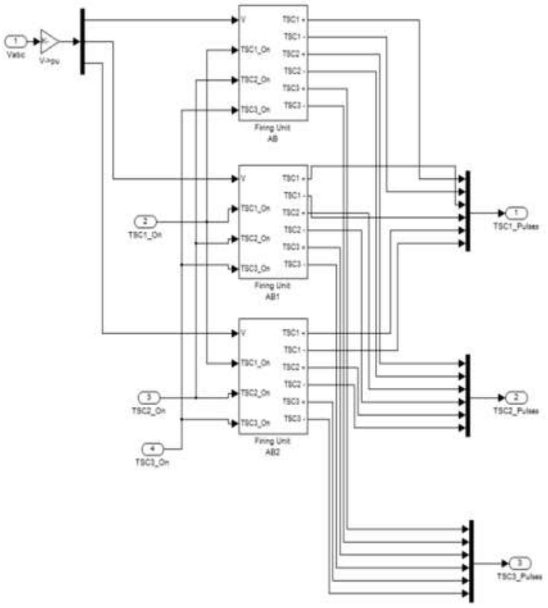


Figure 10. TSC model, control three-phase system

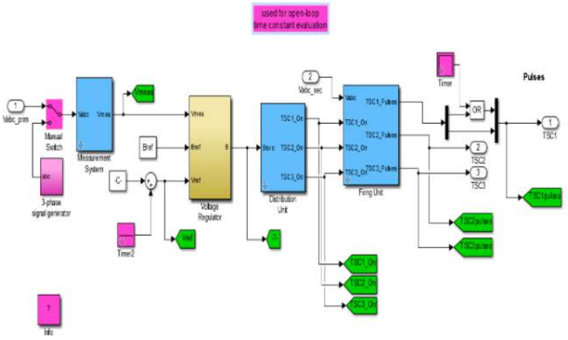


Figure 11. TSC model, control three-phase system with triangular connection

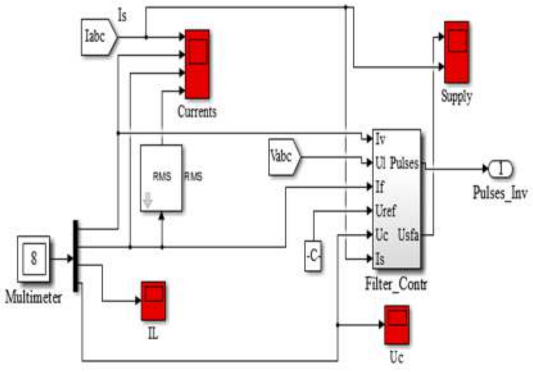


Figure12. APF model control three-phase system

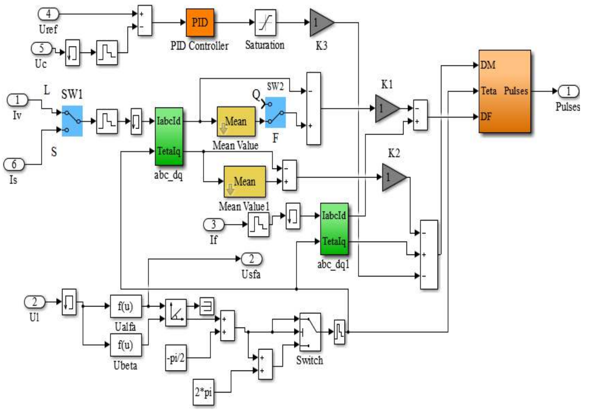


Figure 13. APF version control system in MATLAB

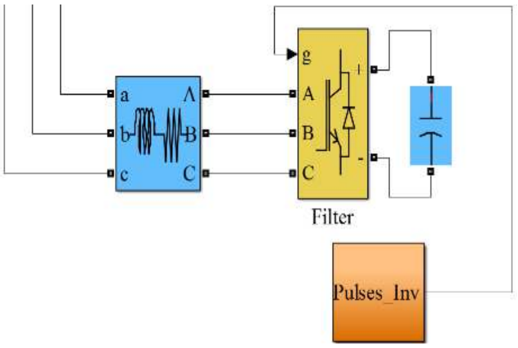


Figure 14. APF in MATLAB

Figures 12 and 13 reveals the controlling system model of the active filter. As expressed, the active filter will change the input voltage in a desirable shape being proportional to the reference voltage.

Using this controlling model, the voltage harmonics and system current can be eliminated. Controlling model controls the pulse required by the inverter connected to capacitor and generates a pulse which is in proportion to the harmonic of voltage and current. Thus, line harmonic can be controlled. In Figure 14, capacitor and inverter along with a self and series resistances are connected. Series passive element leads to damping of harmonic and its elimination. Note that the capacity of capacitor is variable, which is used to control voltage while current harmonics is considered to be 2 milli farad. Higher filter selective capacity is tantamount to greater capability and power of the filter to eliminate the harmonics.

As expressed, the presented model is a combination of APF and TSC in order to obviate harmonic and compensation of the reactive power. Indeed, the presented system includes a radial system. In order to express the performance better, the suggested method of loads is in linear and non-linear forms. The distribution system consists of a 20 to 0.4kW transformer plus three linear loads and one non-linear load. The power of three linear loads is 100, 60, and 90 kW, respectively while that of the one non-linear load is 50kW. The power of each TSC has been considered to be 30 kW. If required, the power generated by each TSC can be selected as a desired value. The model presented in Figure 15 is represented in the MATLAB software.

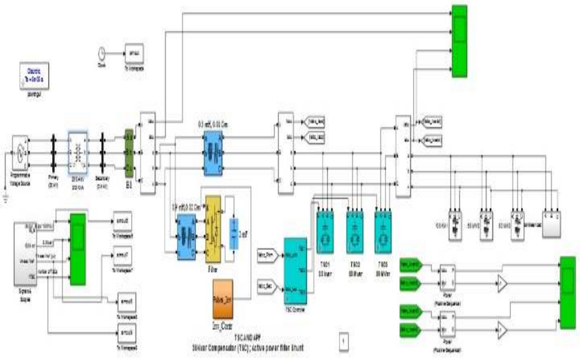


Figure 15. APF&TSC version control system in MATLAB

6. RESULTS OF SIMULATION

The presented model has been run in the Simulink environment using MATLAB software. Initially, this model is executed without using the suggested method and its results are compared with the results obtained from the model. The time required to express the optimum performance of such a structure has been selected for 3 seconds. In this state, the required TSC stairs are added to or subtracted from the system, and active filter always connects to the system and will lead to reduction of harmonics. As expressed, the power of each TSC is 30kW while the power of three linear loads is 100, 60, and 90 kW, respectively with the power of non-linear load being 50kW. Non-linear load leads to establishment of the voltage and current harmonic, whereby the voltage and current harmonic can be controlled well with a proper and combined performance. Figures 16, 17, and 18 display the quantity of voltage before compensation.

The harmonic sinuosity established in the voltage before compensation, in lieu of 20 cycles and at time of voltage durability, is equal to 8.06%. This produced harmonic shown in Figure 18 will lead to establishment of a high sinuosity in the shape of voltage wave. The effect of the harmonics established on the line voltage can be clearly seen in Figure 19.

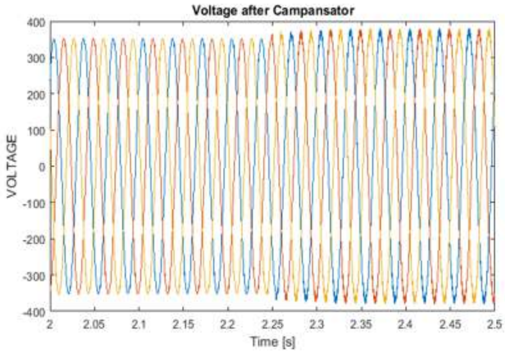


Figure 16. Line voltage before compensation

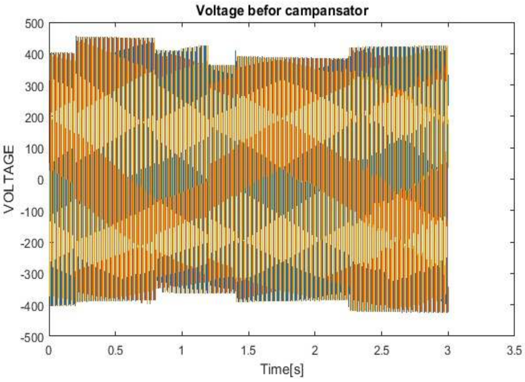


Figure 17. Vo Line voltage before compensation

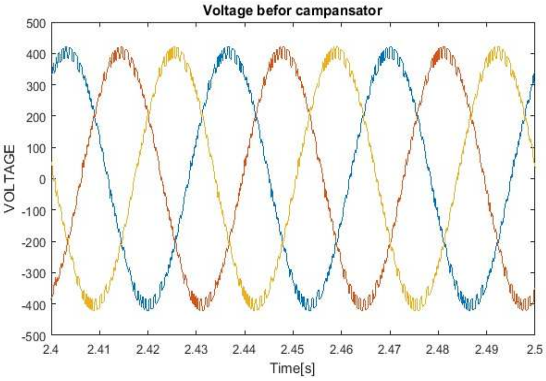
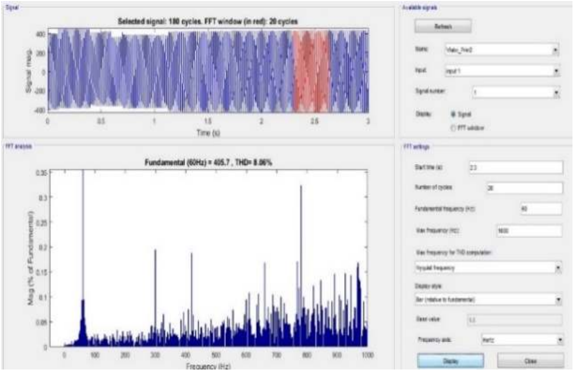


Figure 18. Line voltage before compensation


Selected signal: 180 cycles. FFT window (in red): 20 cycles

Fundamental (60Hz) = 405.7 , THD= 8.06%

Start time (s): 2.3
Number of cycles: 20
Fundamental frequency (Hz): 60
Max frequency (Hz): 1000
Max frequency for THD computation: Nyquist frequency
Display style: Bar (relative to fundamental)
Frequency axis: Hertz

Figure 19. High-voltage harmonic distortion of the line voltage before compensation

Meanwhile, the current will also have the wave shape with a high harmonic in these conditions. Non-linear load will lead to sinuosity of the wave shape. Figures 20, 21 and 22 reveal the shape of the current waves before compensation. Sinuosity of the shape of current wave has been measured, similar to voltage, in 20 cycles in stable state as shown in Figure 23. Within this time range, the measured harmonic sinuosity (Total harmonic Distortion) had 1.83%. Harmonic sinuosity of the current has been expressed in Figure 22.

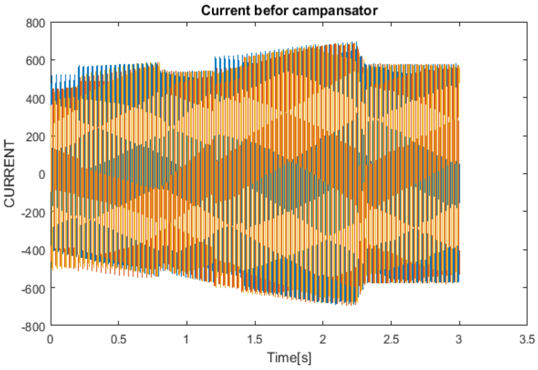


Figure 20. High-voltage line current to compensate THD

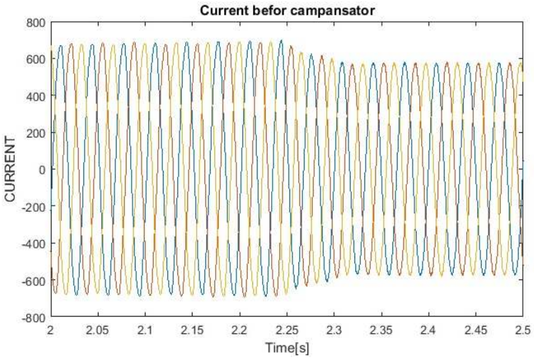


Figure 21. High-voltage line current to compensate THD

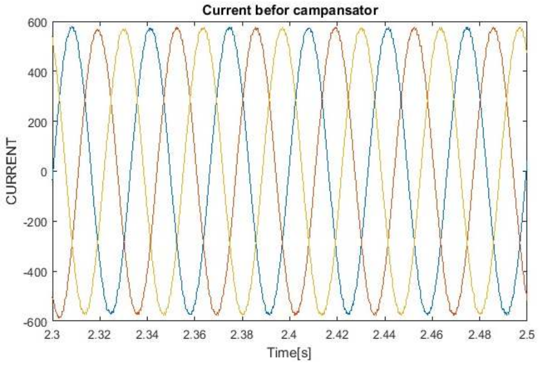
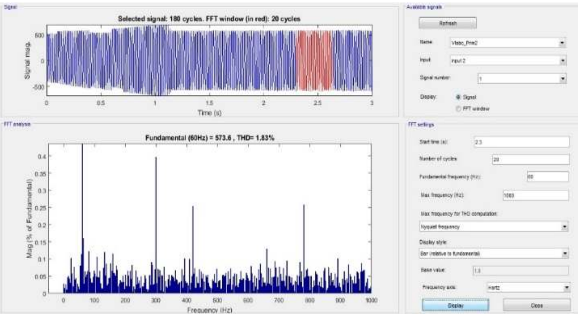


Figure 22. line voltage to compensate for the harmonic currents



Name: Vabc_Prim2

Input: input 2

Signal number: 1

Display: ● Signal ○ FFT window

Start time (s): 2.3

Number of cycles: 20

Fundamental frequency (Hz): 60

Max frequency (Hz): 1000

Max frequency for THD computation: Nyquist frequency

Display style: Bar (relative to fundamental)

Base value: 1.0

Frequency axis: Hertz

Figure 23. The line current before distortion compensation

As stated earlier, the presented model includes three steps of compensation of the parallel capacitor controlled by thyristor and as set of active filter. Steps of capacitor will lead to compensation of the required reactive power, and active filter will result in elimination and reduction of the system harmonics. In these conditions, capacitor steps determine voltage level, where the voltage level and line current can be controlled by increasing and decreasing the capacitor bank. Stairs of capacitor bank are shown in this model in Figure 24.

As displayed in Figure 25, in addition to that shape of voltage wave approaching the desirable voltage level of network, its harmonic sinuosity has decreased from 8.06 to 4.35. In other words, the established harmonic sinuosity became half, as shown in Figure 26.

After compensation, the current will have a wave shape with less harmonic sinuosity and lower current level. In this state, the line current more than 100 A has compensated less than the former state. This means that reactive power compensation along with active filter has led to improvement and reduction of level of line current. Considering this compensation, load voltage and current will become desirable as well. This reduction of current is shown in Figures 27, 28, and 29. In this state, harmonic sinuosity has dropped from 1.83 to 0.41 in Figure 30. Sinuosity of the line current in this state is one fourth before the compensation.

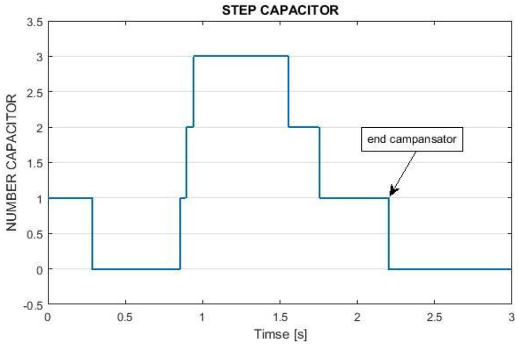


Figure 24. The added or subtracted capacitor steps for reactive power compensation

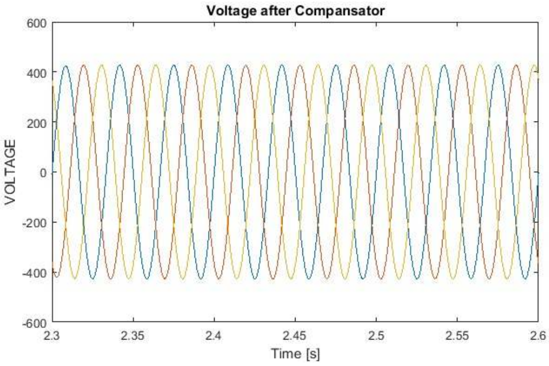
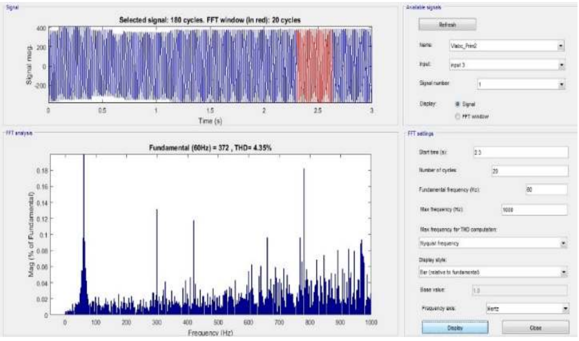


Figure 25. After line voltage compensation



Name: Vabc_Prim2
Input: input 3
Signal number: 1
Display: ● Signal ○ FFT window
Start time (s): 2.3
Number of cycles: 20
Fundamental frequency (Hz): 60
Max frequency (Hz): 1000
Max frequency for THD computation: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz

Figure 26. Line voltage distortion after compensation

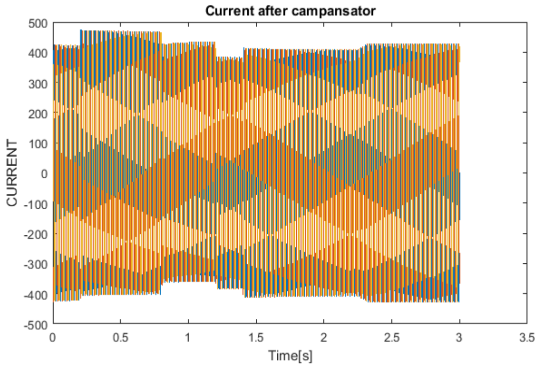


Figure 27. The current line after compensation

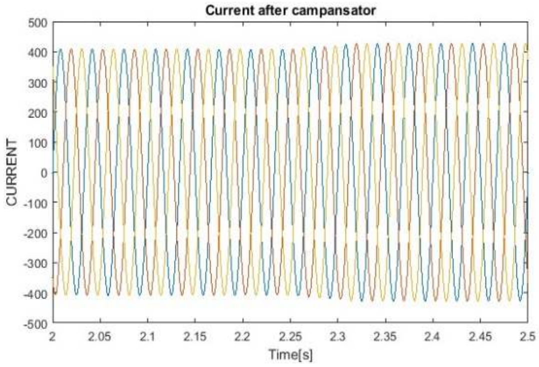


Figure 28. The current line after compensation

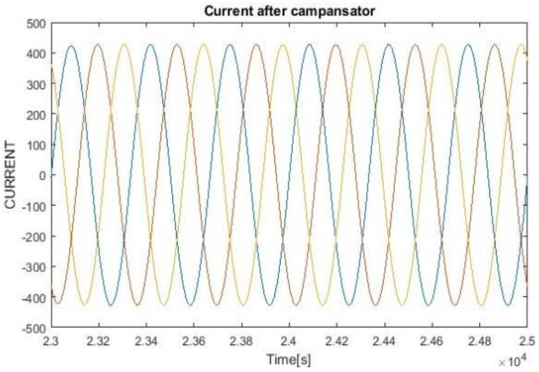
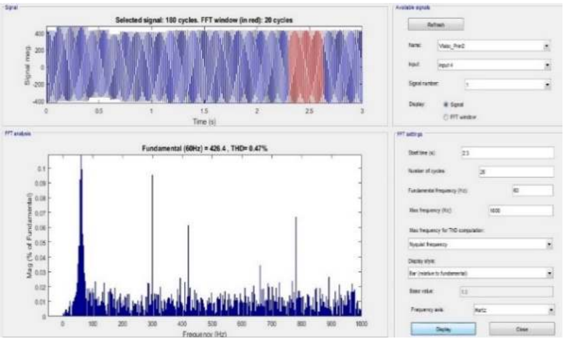


Figure 29. The current line after compensation



Input: input 4
Signal number: 1
Display: ● Signal ○ FFT window
Start time (s): 2.3
Number of cycles: 20
Fundamental frequency (Hz): 60
Max frequency (Hz): 1000
Max frequency for THD computation: Nyquist frequency
Display style: Bar (relative to fundamental)
Base value: 1.0
Frequency axis: Hertz

Figure 30. The line current after distortion compensation

7. CONCLUSION

Exploitation of electric equipment of the power system is always encountered with new challenges. In the distribution networks, in response to increase of demand for reactive power, the system is pushed towards instability of voltage drop and voltage fluctuations in the feeder. Usage of thyristor switched capacitor (TSC) can reduce total costs of compensation. We can apply this APF in order to eliminate error resulting from (TSC) due to continuous compensation features and dynamic swift response. APF is used extensively in the compensation of the reactive and harmonic power of distribution systems, but it is expensive heavily and its design is difficult. In this paper, a combined method, including TSC and APF, was presented locally and diffusely through injecting controllable reactive power and appropriate switching based on study of voltage drop in radial distribution networks to improve the power quality and stabilize the voltage range of distribution networks within the limits of allowed changes. The suggested model was implemented by MATLAB software, where results of improvement and provision of the stability conditions (dynamic and static) of the voltage and current were observed.

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Persian Abstract

چکیده

ناپایداری ولتاژ یکی از مشکلاتی است که در سال های اخیر و به دلیل بهره برداری بیش از حد از تجهیزات و افزایش تقاضا برای بار در سیستم توزیع رخ داده است. کمبود توان راکتیو در شبکه های قدرت به ویژه شبکه توزیع، سیستم را به سمت ناپایداری ولتاژ سوق می دهد و منجر به ایجاد افت ولتاژ و نوسانات ولتاژ در فیدر فشار ضعیف می‌شود. یکی از مهم‌ترین گزینه‌های پیشنهادی برای جبرانسازی، نصب بانک‌های خازن سوئیچ‌شونده با استفاده از تریستور (TSC) است. استفاده از TSC می‌تواند کل هزینه‌های جبران‌سازی را کاهش دهد اما خطای استاتیکی باعث کاهش جبران خسارت می‌شود. برای این منظور فیلتر توان فعال (APF) را می‌توان برای از بین بردن خطاهای حاصل از TSC به دلیل ویژگی های جبران پیوسته و پاسخ دینامیکی سریع اعمال کرد. در این تحقیق روش ترکیبی شامل TSC و APF تزریق توان اکتیو قابل کنترل و با سوئیچینگ مناسب با مطالعه افت ولتاژ در شبکه های توزیع شعاعی و بهبود کیفیت توان ارائه شد. مدل پیشنهادی توسط نرم افزار MATLAB اجرا شد و نتایج بهبود و تامین شرایط پایداری (دینامیک و استاتیک) ولتاژ و جریان مشاهده گردید.