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# Design and Simulation of Reactive Power Compensation by Using Fixed Capacitor Thyristor Controlled Reactor

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**Abstract-**The objective of this paper is to develop a Model for the reactive power compensation of the unbalanced load by using FACTs device FC-TCR. TCR are widely used in industry, however the control of unbalanced and non-linear system using TCR control scheme doesn't give good performance at all operating points. Here, a model based predictive controller with model is designed and implemented for the Reactive power compensation of unbalanced load. In this paper reactive power and power factor are determined before and after compensation. The control of the FC-TCR is also provided in this paper. The FC-TCR Controller is used and simulated using MATLAB. In this paper simulation results are represented. As per variation of the firing angle of the FC-TCR the Compensation is obtained. The main objective of this paper will be to maintain currents balanced and unity factor with their voltages.

**Keyword-**Reactive power Compensation, Fixed Capacitor Thyristor Controlled Reactor, Power Quality, Power Factor improvement

## I. INTRODUCTION

Electric Power Quality is maintaining the different quantity of power distribution at rated magnitude and frequency. The causes for Poor quality is normally such as impulses, notches, voltage sag and swell, voltage and current unbalances, momentary interruption and harmonic distortions. The other major causes to lower power quality are harmonics and reactive power. Continue switching of the solid state devices is the main reasons for the harmonic generation and where as different non-linear loads cause to excessive drawn of reactive power from supply. Normally in day today life load used is inductive hence because of that power factor of the system becomes poor so to improve the power factor it is necessary to provide reactive power in to the system. This will be done by FACTS devices It is common experience that electric power of poor quality has savior effects on health of different equipment and systems. Unbalance is a common type of power quality problem[4].It occurs due to the deviation of Phase voltages and phase currents from their rated values with respect to magnitude and phase. During unbalance in three phase system Sequence components occur. For this reason unbalance is important for the sequence components present in the system. In this paper, we however, discuss fundamental load compensation techniques for unbalanced linear loads such as combination of resistance, inductance and capacitance and their combinations. Here load compensation is nothing but the providing anti parallel load to maintain the power factor. Reactive power balance can be obtained by the connective FACTs device in shunt with the system [3].Main reasons for using the FACTs device is

1. Low Power Loss. 2. Voltage Stability and voltage regulation. 3. Load ability of transmission line.
4. Dynamic and transient stability improvement. 5. Improves quality of power. [7]

Facts devices are those device that can be inserted into the system by in manner of series or shunt. Putting this device in shunt is beneficial than series. There are many types of FACTs Devices [5]

1. Series Device
2. Shunt device
3. Combined Series- Series Device
4. Combined Series- Series Device

Generally TCR provides compensation in only leading need but FC-TCR provides compensation in both leading and lagging requirement. Hence for this requirement we are using FC-TCR. Before going to simulation we have to get the working idea of FC-TCR. In this paper gate triggering for the FACTs device is provided by the pulse generator.

## II. FIXED CAPACITOR TCR

Fixed Capacitor Thyristor controlled reactor is nothing but the static VAR compensator i.e SVC.It is also called as absorber in which its output is changed as per the conditions [5]. Generally in this type of SVC the fixed capacitor is placed in shunt with the TCR. Hence we can say that this capacitor provides constant and continuous reactive power as per our requirement and TCR absorbs the reactive power which is more that our requirement [6]. Thyristor, IGBT, and MOSFET these types of power electronics devices are used for control of the capacitor [1]. Generally the fixed capacitor have harmonic filter that are filter out the harmonics. The firing of this thyristor is depends on the reactive power of system. Hence we can say that as per our requirement of reactive power thyristor can be fired. This is the basic of fixed capacitor thyristor controlled reactor. Below figure no.1 shows the basic structure of Fixed capacitor TCR.

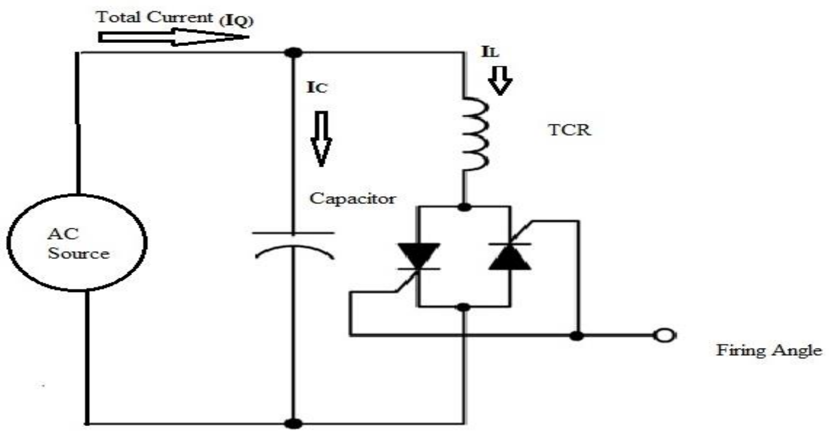


*Fig. 1 Fixed Capacitor TCR*

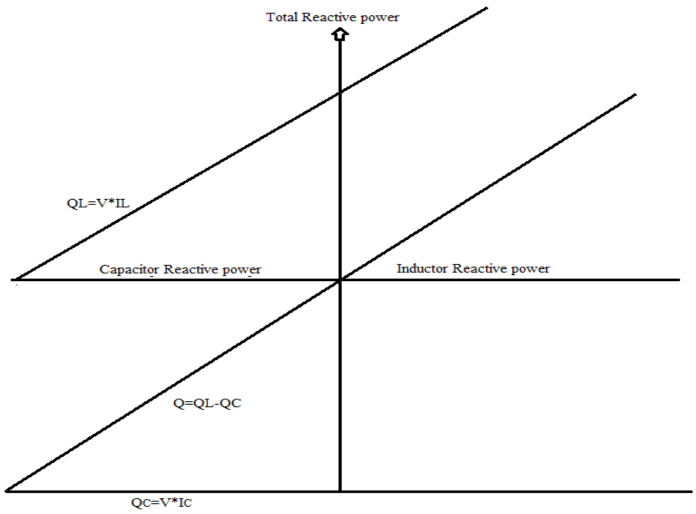


*Fig. 2 Reactive Power By components*

 

The concept for using Fixed Capacitor TCR for compensation is that TCR provide compensation in only lagging condition but this type i.e FC-TCR type of compensation provides compensation in both lagging and leading condition and hence we can attend the compensation in better manner.to cancel the extra power we can say reactive power TCR rating must be greater than Fixed Capacitor. For obtaining compensation current in reactor is need to be varied and this is done by Firing Delay Angle Control method. Practically this capacitor is fully or partially charged filter network. This Fixed Capacitor provides capacitive impedance at 50 Hz.but the main problem occurs due to this type of FACTs device is that it produces harmonics at fundamental frequency during compensation. Figure no. 2 shows Var generation of the system. Normally in compensation TCR Var generation is get opposed by the Fixed Capacitor (FC) to get total required reactive power.

## III. FIRING DELAY ANGLE CONTROL

Normally TCR consist of two way thyristor switch. This switch works in positive as well as negative half cycle simultaneously. Applying the gate pulse to the thyristor we can make thyristor in to conduction. For thyristor switching natural current zero and natural voltage peak is two type application methods. The current in TCR is controlled by mean of Firing delay angle control from maximum to minimum at the peak of applied voltage [1][5]. As per our previous discussion we can say during the TCR is off we have maximum capacitive reactive power or output. i.e. at α=90. Hence by decreasing this α we can control the value of current in TCR. As we increase the value of current in TCR the net reactive power in the Fixed Capacitor is decreased. Our capacitor provides constant value of reactive power. If we measure angle from the zero crossing of voltage then thyristor is varied from 90 to 180 degrees and if it measured from voltage peak then thyristor firing angle is varying from 0 to 90 degrees. Current in TCR control can be given by this equation

$$I_{Lf}(\alpha) = V/\omega L(1 - \frac{2}{\pi}\alpha - \frac{1}{\pi}sin2\alpha)\ldots\ldots\ldots\ldots\ldots..(1)$$

Where
V is applied Voltage
L is inductance of TCR
Ω is angular frequency of applied voltage
Simillarly the reactive admittance is expressed below

$$BL(\alpha) = 1/\omega L(1 - \frac{2}{\pi}\alpha - \frac{1}{\pi}sin2\alpha)\ldots\ldots\ldots\ldots\ldots(2)$$

This is Firing Delay Angle Control Method.

## IV. SIMULATION RESULTS AND DISCUSSIONS

For simulation Ac voltage source is 230 V Line parameters are R=0.01Ω, L=5μH and for fixed capacitor C=1100ρF and load parameters are R=20 Ω, L=10μH. The current and voltage blocks are used for measurement of current and voltage respectively. Instantaneous current is measured by the current block. Visual representation of measured voltage and current scopes are used. The real and reactive power is measured with the help of reactive power measurement block. Requirement of susceptance is also measured by the block. Here reactive power requirement is shown in the form of susceptance. Now here taking the rms value of current and voltage and then multiplying and dividing these math functions we get required susceptance. Although also taking Fourier block in simulation converting the magnitude to complex we can get respective susceptance of the systems

 

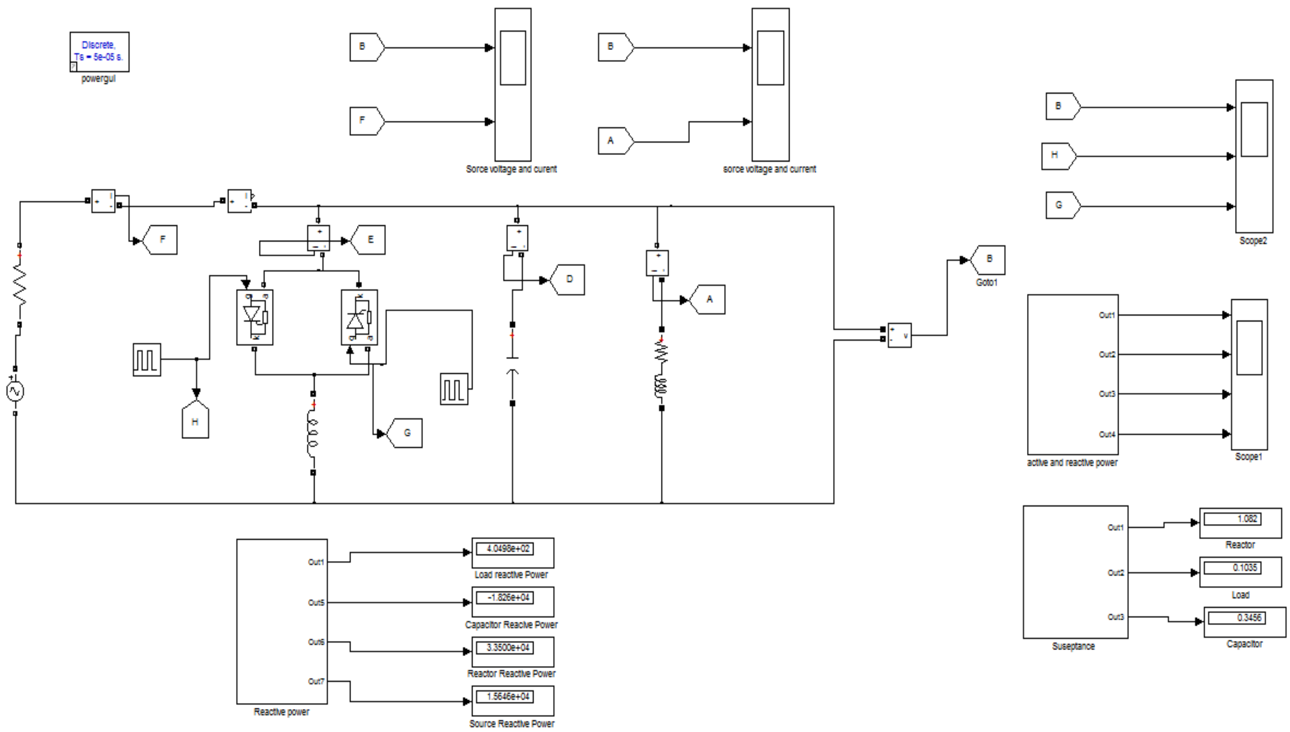


***Fig.3 Simulation block diagram***

. now below given are the waveforms of voltages and current obtained after simulation

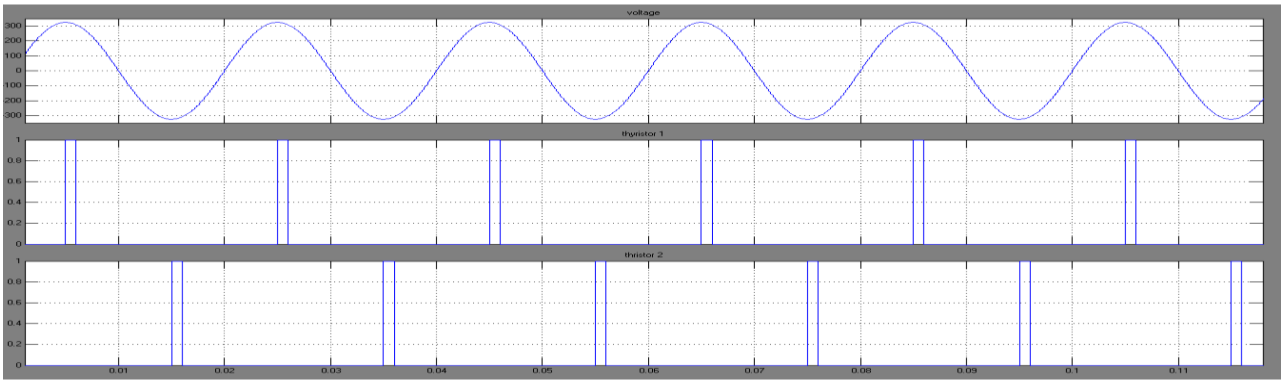


***Fig.4 thyristor switching***

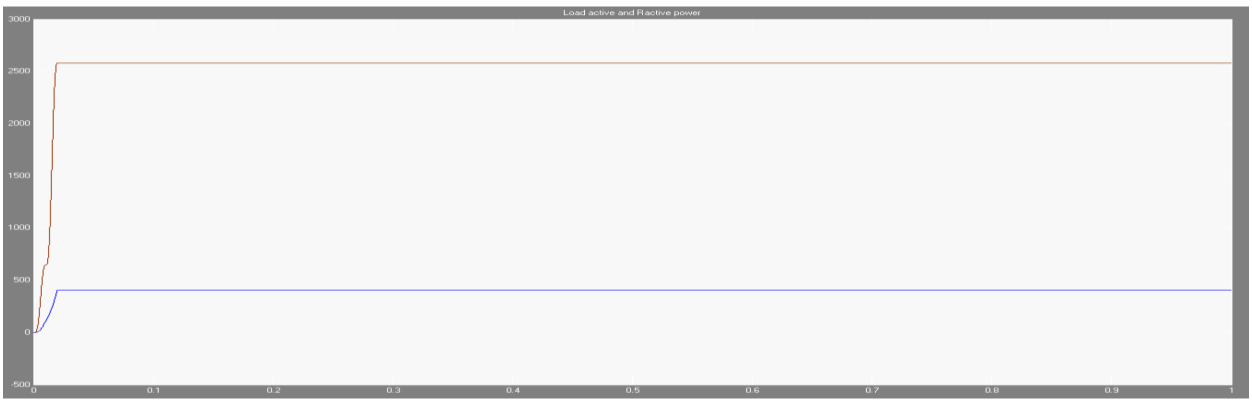


***Fig. 5 real and reactive power***

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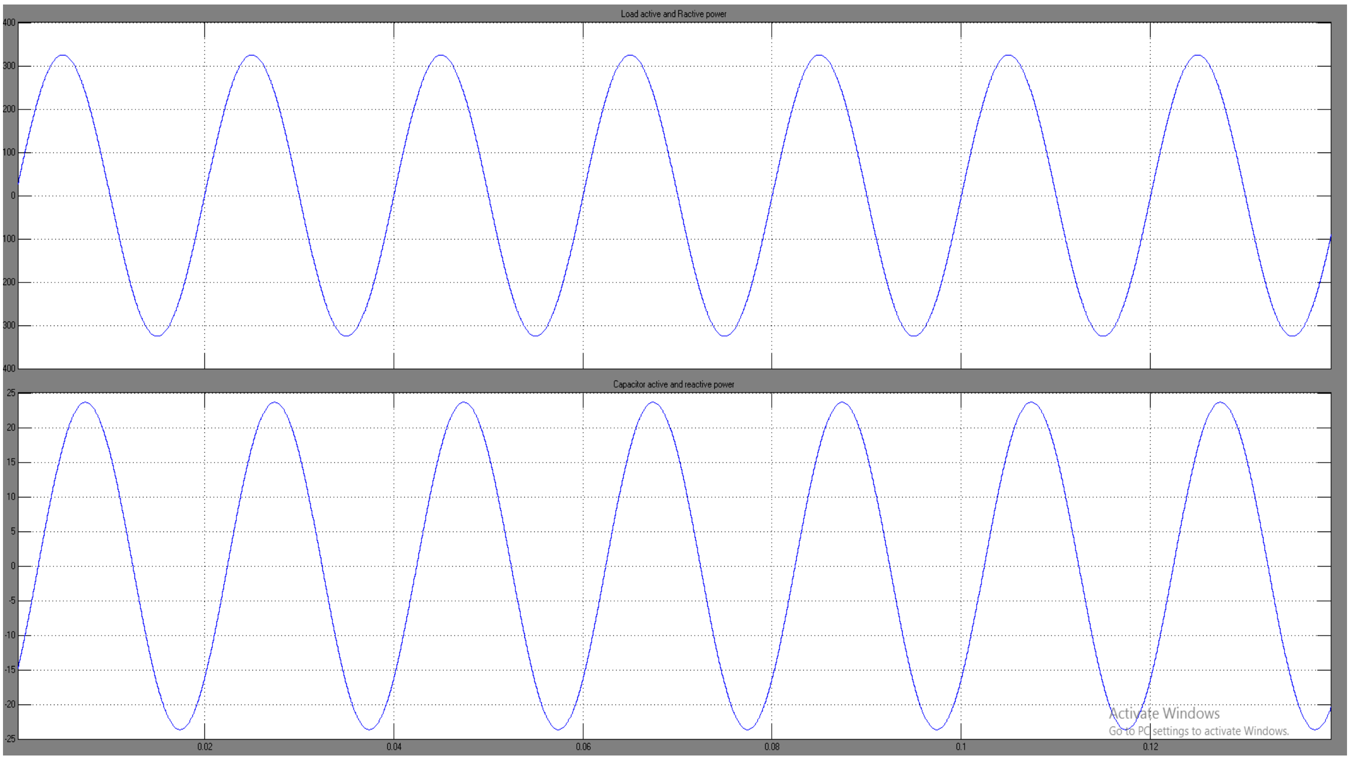


*Fig.6 line current and voltage before simulation*

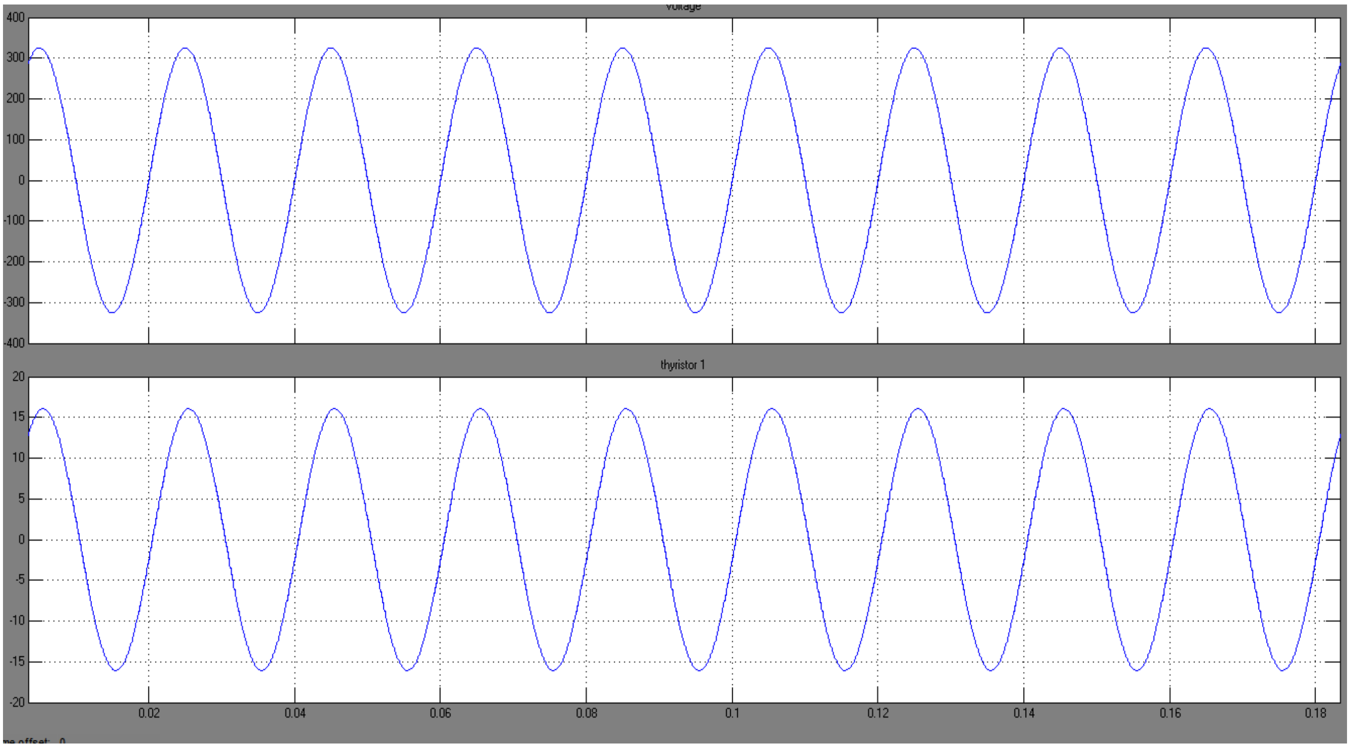


*Fig.7 load current and voltage after simulation*

 

## V. CONCLUSION

Hence from this research paper we concluded that FC-TCR will control the reactive power of the system. Reactive power can be varied by firing angle with the help of pulse generator and FACTs device. Reactive power can be efficiently controlled by combination of TCR and Fixed Capacitor. Hence from the simulation we can say that voltage and current become in phase and reactive power can be varied smoothly with the help of FC-TCR. Alternately we can say that this system can be useful for the improvement of the power factor and hence regulation of system.

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