Reactive Power Control in Eight Bus System Using FC-TCR

doi:10.3991/ijoe.v6i1.1136

T.Vijayakumar[1], A.Nirmalkumar[2]
[1] Anna University, Coimbatore, Tamilnadu, India
[2] Bannari Amman Institute of Technology, Sathyamangalam, Tamilnadu, India

***Abstract*—This paper deals with the simulation of eight bus system having fixed capacitor and thyristor controlled reactor. The system is modeled and simulated using MATLAB.The simulation results are presented. The power and control circuits are simulated. The current drawn by the TCR varies with the variation in the firing angle. The simulation results are compared with the theoretical results.**

***Index Terms*—FACTS, TCR, MATLAB, FC, SIMULINK, REACTIVE POWER**

I. INTRODUCTION

In the control of Electric Power Systems, systems and procedures are used to compensate dynamically the detrimental effects of non-linear loads. The compensation process should be carried out without important alteration of source signal quality. Some benefits are expected using compensation reduction of losses in distribution lines, harmonic content minoration, and power factor improvement. The dynamic behavior of industrial loads requires the use of compensator that can be adapted to load changes. Unfortunately, the techniques frequently used for compensation are based on circuit controllers that alter the waveform of the signal subjected to control. Such is the case of the *static compensator* [1-2], which must perform harmonic cancellation, reactive power compensation, power factor correction, and energy saving. Although the static compensator is commonly used and studied under sinusoidal voltage conditions, waveforms corresponding to the controlled current present high harmonic content.

This paper focuses on the thyristor-controlled reactor [3]. as shown in Fig 1a. Compensation with TCR consists of controlling the current in the reactor L from a maximum (thyristor valve closed) to zero (thyristor valve open) by the method of firing delay angle control. The fixed capacitor (FC) and TCR constitute a basic VAR-generator arrangement (FC-TCR). The constant capacitive VAR generation of C is opposed by the variable VAR absorption of the TCR. The circuit model of FC TCR system is shown in Fig 1b.

Calculation of the firing angle can be made in the time domain [4] or in the frequency domain [5]-[6], using different approaches. Assuming the supply voltage to be sinusoidal, calculation of the firing angle is obtained with minimum complexity [1], [7]. However, the increase in $\alpha = \pi / 2$ to $\alpha = \pi$, produces increasing distortion of the current in the TCR branch, and consequently that of line current. It increases the rms value of the line current and the THD, and deteriorates the power factor.

The literature [1] to [9] does not deal with the simulation of 8 bus system with FC-TCR system. An attempt is made in the present work to simulate 8 bus system with FC-TCR system using MATLAB Simulink.

II. SIMULATION RESULTS

The simulation was done using Matlab Simulink and the results are presented here. Real and reactive powers with $\alpha = 162^0$ is shown in Fig 2b.Current waveform for single phase TCR circuit is shown in Fig 2a. The bidirectional switch is implemented using 4 diodes and 1 thyristor. The real and reactive powers with $\alpha = 144^0$ is shown in Fig 3b. The current through TCR with $\alpha = 144^0$ is shown in Fig 3a. It can be seen that the current can be varied by varying the firing angle. The current decreases with the increase in firing angle. Thus the reactive power can be varied by varying the firing angle. As the firing angle is increased, the forward bias on the SCR is reduced. Hence the current decreases with the increase in firing angle .The above firing angles are selected because control range of α lies between 90 and 180.

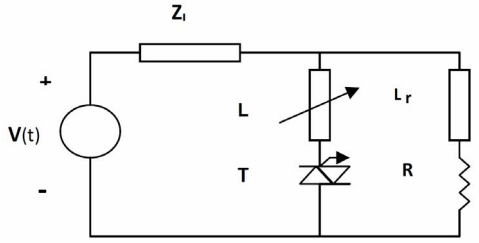


Fig 1a. Circuit of TCR

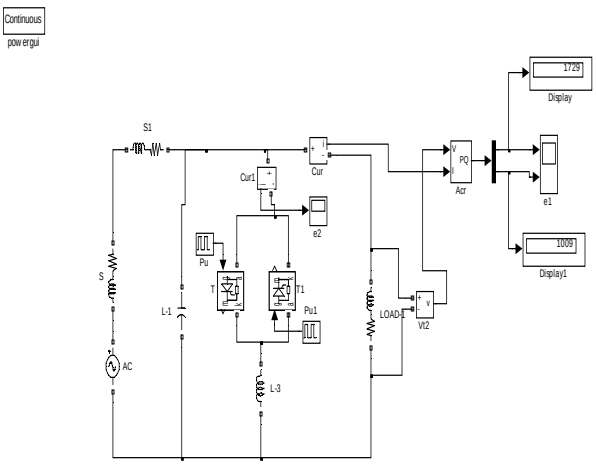
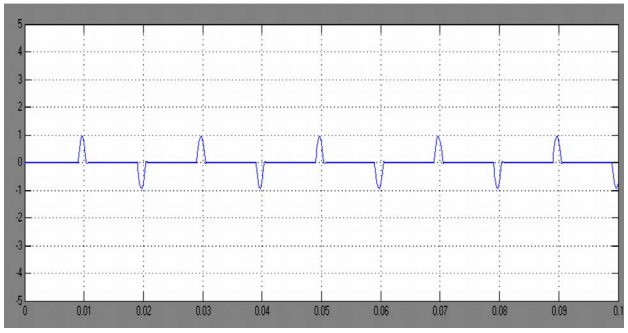


Fig.1b.Circuit model of FC- TCR



Time

Fig 2a TCR Current Waveform with Alpha = 162 Degree

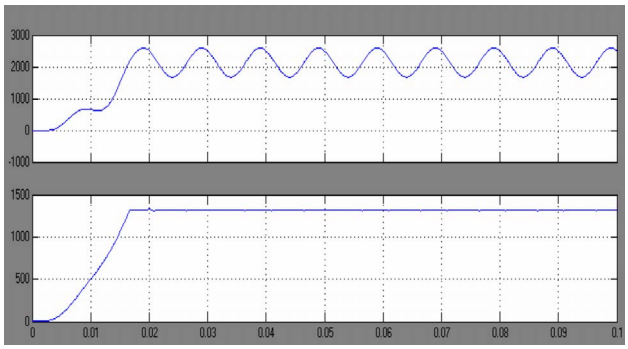


Fig 2b Real &Reactive Power with Alpha = 162 Degree

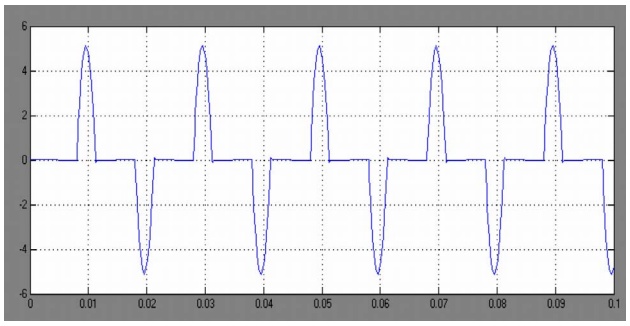


Fig 3a TCR Current Waveform with Alpha = 144 Degree

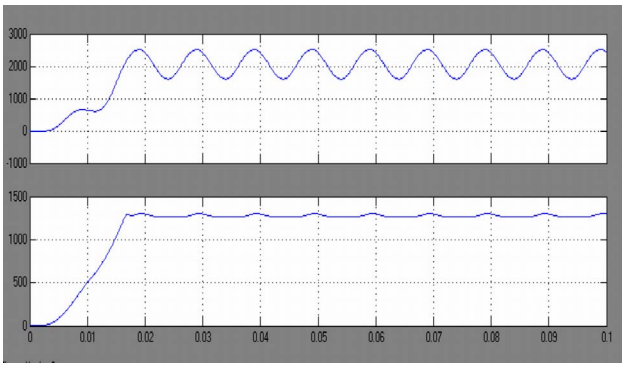


Fig 3b Real &Reactive Power with Alpha = 144 Degree

The circuit model of 8 bus system is shown in figure 4a.An additional load is connected in parallel with the load at bus 8. When the additional load is connected , the amplitude of the voltage decreases as shown in figure 4b.The voltage across the second load is shown in figure 4c.It can be seen that the additional load is connected at t=0.2second.

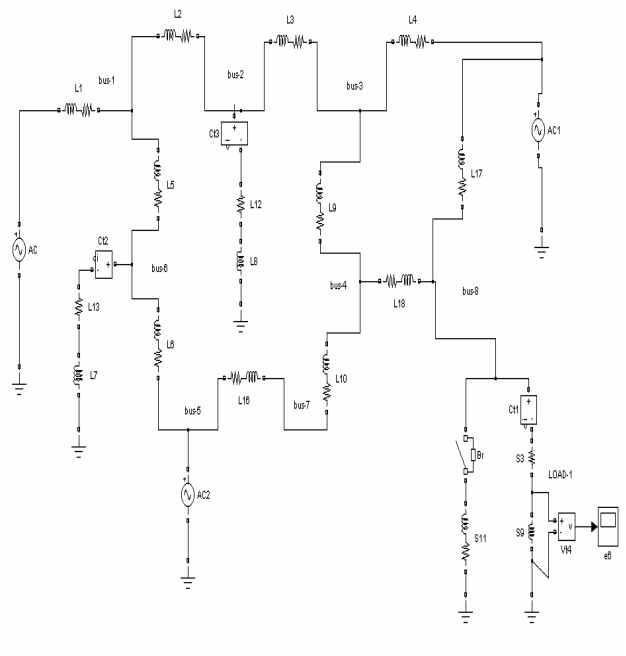


Fig 4(a) 8 bus system

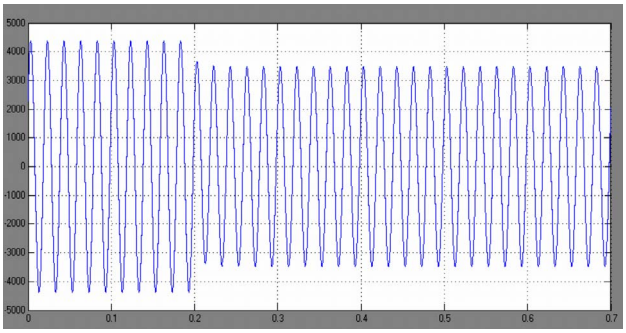


Fig 4(b) Voltage across load-1

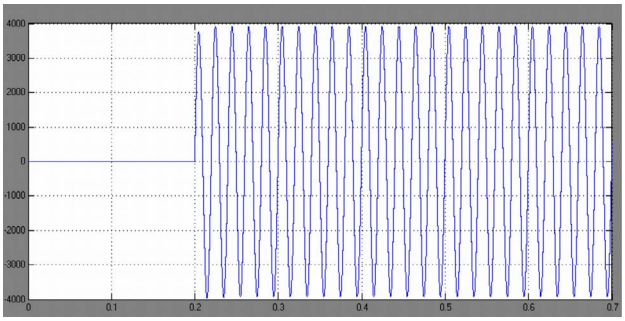


Fig 4 (c) Voltage across load-2

8 bus system with FC-TCR is shown in figure 5(a). The Section that consists of FC-TCR is shown in figure 5(b). The FC-TCR circuit alone is shown in figure 5(c).Voltage across load-1 is shown in figure 5(d). The reactive power at various buses with and without compensation is given in Table-1.It can be seen that the reactive power in the load buses increases by 2 % with the addition of a single FC-TCR system. The variation of reactive power with the variation in the firing angle is given in Table-2.The variation is also given in the curve shown in figure 5(e).It can be seen that the reactive power decreases with the increase in firing angle.

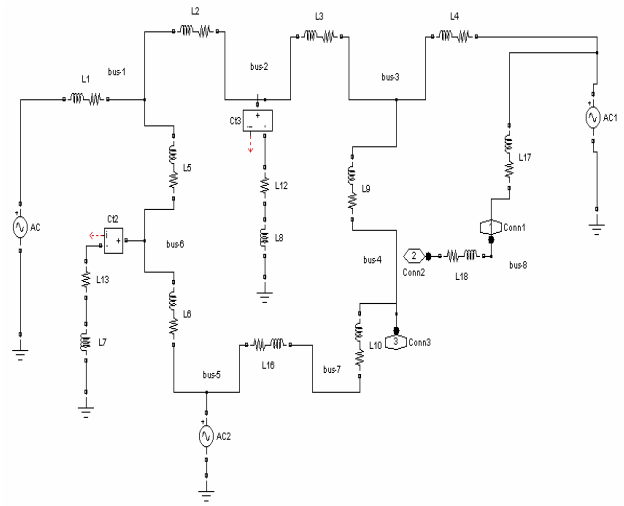


Fig 5 (a) 8 bus system with FC-TCR

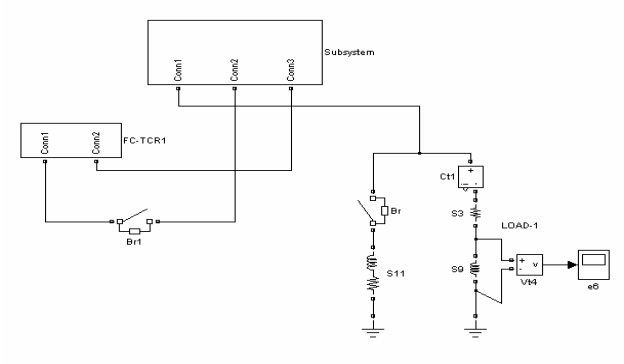


Fig 5 (b) Three bus system with FC-TCR

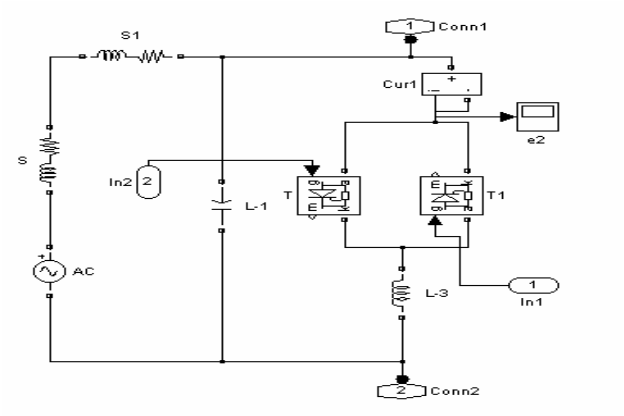


Fig 5 (c) FC-TCR Circuit

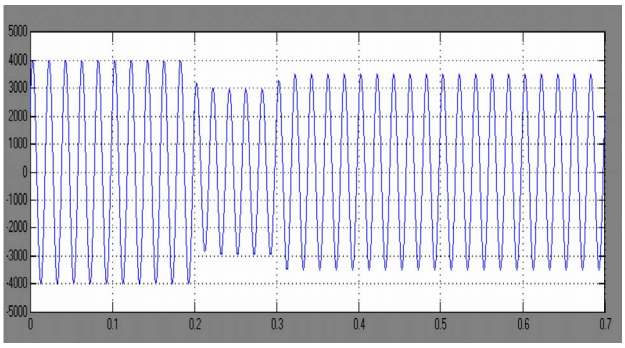


Fig 5 (d) Voltage across load-1

TABLE I.
IMPROVEMENT IN REACTIVE POWER

Bus No	Reactive Power(MVA) Without Compensation	Reactive Power (MVA) With Compensation
BUS-1	0.55	0.551
BUS-6	0.449	0.449
BUS-2	0.680	0.699
BUS-8	0.639	0.649

TABLE II.
VARIATION OF REACTIVE POWER

THETA (DEGREE)	REACTIVE POWER (MVA)
36	0.779
72	0.644
108	0.647

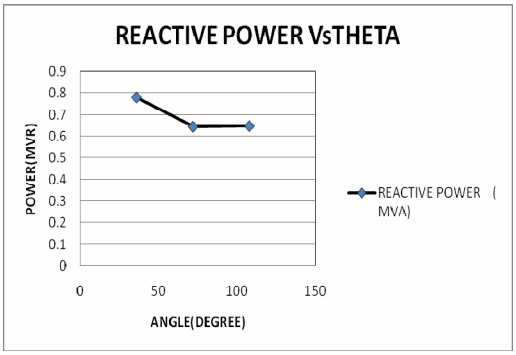


Fig 5 (e) Variation of Reactive power

III. CONCLUSION

The control of reactive power in 8 bus system using FC-TCR is analyzed. The variation of reactive power with the variation in the firing angle is studied. The range of reactive power control can be increased by using the combination of thyristor controlled reactor and fixed capacitor system. The circuit model for FC-TCR is obtained and the same is used for simulation using Matlab Simulink. From the simulation studies it is observed that the reactive power variation is smoother by using FC TCR system. Reactive power drawn by the load increases with FC-TCR since the bus voltage increases. The simulation results are in line with the predictions.

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AUTHORS

T.Vijayakumar (vijaypoy@gmail.com) has obtained his B.E. Degree from Bharathiar University and M.E. degree from Annamalai University in the year 1998 and 2001 respectively. He has 10 years of teaching experience. He is presently a research scholar in Anna University. His research area is reactive power control in power systems.

Dr. A. Nirmalkumar (ank_hod@yahoo.co.in) has obtained his B.E. Degree from Calicut University and M.E. degree from Kerala University in the years 1972 and 1976 respectively. He has completed his Ph.D in the area of Power Electronics from Bharathiar University in the year 1989. He has secured a gold medal from Institution of Engineers in the year 1989. He has 30 years of teaching experience. He is presently working as professor and Head of EEE dept, BIT, Sathyamangalam. His research area is reactive power control in power systems.

Received November 06, 2009. Published as resubmitted by the authors January 20, 2010.