International Journal of
Electrical Engineering and Futuristic Technology
A Peer Reviewed Journal

A D PUBLICATION

IJEEFT 01 (2017) 001-006

Voltage stability improvement in 2-bus system using Thyristor Switched Capacitor- Thyristor Controlled Reactor

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ABSTRACT: This paper presents analysis of voltage stability using Thyristor Switched Capacitor- Thyristor Controlled Reactor (TSC-TCR). Most of the commercial and industrial installations such as motor, large machines, air conditioners, etc, which draw large amount of reactive power and result in voltage instability. So it is required to improve the voltage stability. MATLAB simulation for single phase 2-bus system using TSC-TCR controller is done and their results are discussed. TSC-TCR controller not only improves voltage stability but also eliminates manual intervention.

Keywords: Voltage stability, Thyristor Switched Capacitor- Thyristor Controlled Reactor (TSC-TCR)

1. Introduction

Presently due to various constraints, it is observed that power system operates under heavily loaded condition. So, maintaining voltage stability plays an important role in smooth running of electric power utilities[1].

There are many causes of voltage instability. But, one of the root causes is insufficient reactive power support[2]. Voltage stability can be improved by using inductor and capacitor as capacitor supplies reactive power in case of heavy load condition and inductor absorbs the reactive power in lightly loaded or no load condition. However in case of rapidly varying and scattered load it becomes difficult to maintain voltage stability by manually switching on/off capacitors and/or inductors in proportion to variation of load. This drawback is overcome by using TSC-TCR.

2. Voltage Stability

Ability of the system to maintain voltage at all buses at predetermined level in normal condition and also in post disturbance condition is known as voltage stability[2]. Voltage stability problems can lead the power system to voltage collapse.

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3. Control range of TSC

In a pure capacitor, current leads the applied voltage by 90°. After 90° current reverses its direction. So we can control current between 0° to 90° in positive half cycle. So, control range of TSC is 0° to 90° in positive half cycle. And it is 180° to 270° in negative half cycle.

4. Control range of TCR

In a pure capacitor, current lags the applied voltage by 90°. So we can control current between 90° to 180° in positive half cycle. So, control range of TCR is 90° to 180° in positive half cycle. And it is 270° to 360° in negative half cycle.

5. Simulation and Analysis

This paper presents MATLAB simulation of single phase 2-bus system using Thyristor Switched Capacitor-Thyristor Controlled Reactor.

5.1. Project Model

Project model is shown in the Fig. 1.

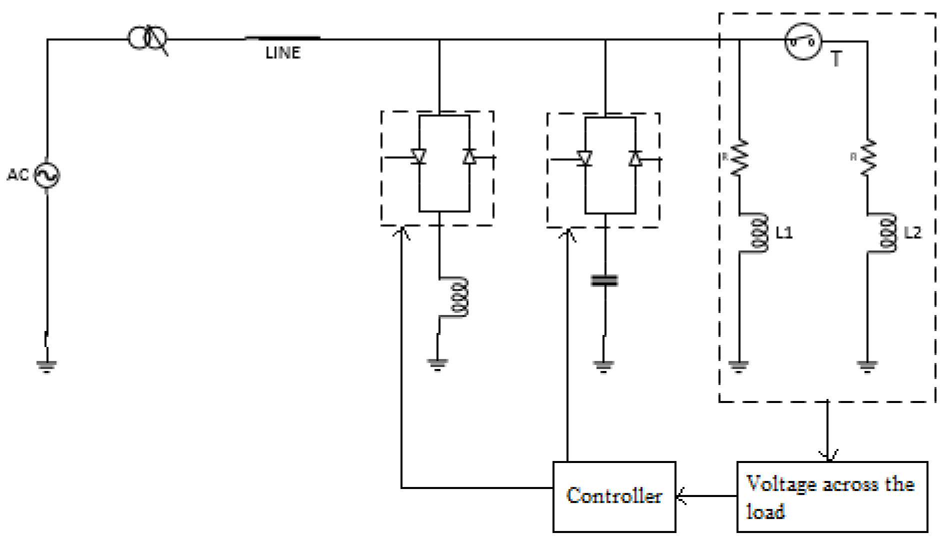

Figure 1 Project Model

Fixed load along with variable load is connected to alternating source through a transmission line. Voltage instability occurs due to reactive power loading. Voltage stability can be improved by introducing TSC- TCR controller. Here voltage is measured at load side which is compared with reference voltage. According to error signal amount of reactive power is supplied or absorbed using TSC- TCR controller. In case of heavy load condition, voltage drops below a certain value which causes voltage instability. In that case TSC is used to improve voltage stability as capacitor supplies reactive power. In case of light load or no load condition, voltage increases beyond certain value which causes voltage instability. In that case TCR is introduced to improve voltage stability as inductor absorbs reactive power.

5.2. Simulation and Analysis

MATLAB model of single phase 2-bus system is shown in the Fig. 2.

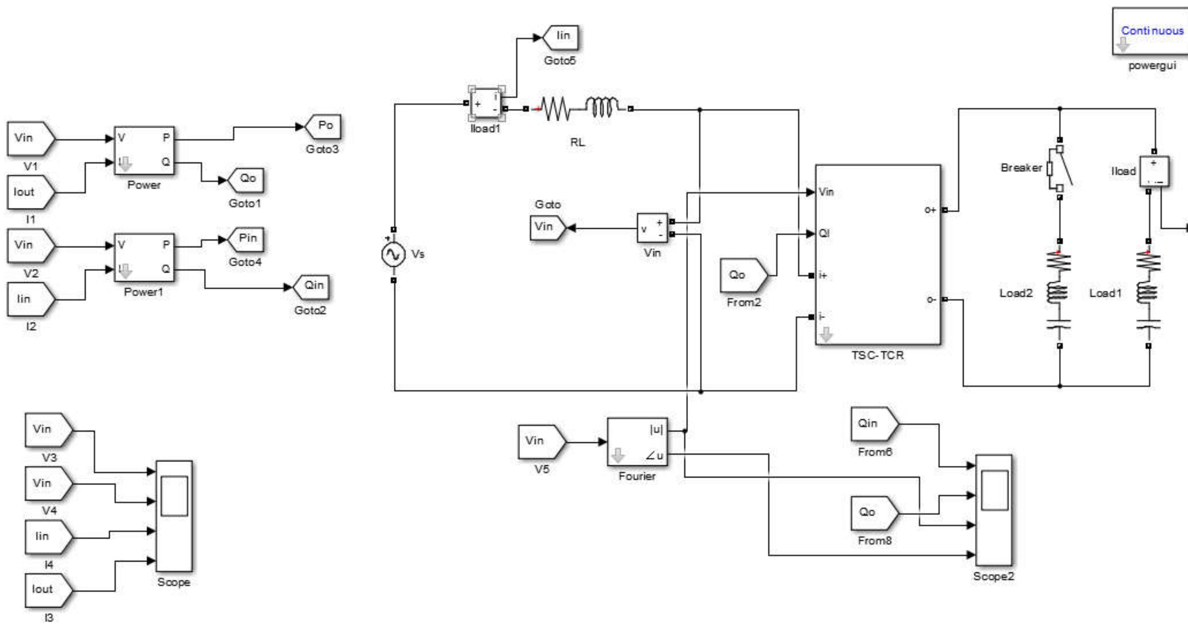

Figure 2 MATLAB model of 2-bus system

Load is connected to source through a transmission line. Iin and Iout are the input and output currents respectively. Vin is the voltage signal. Pin and Qin are the input active and reactive power respectively, which can be measured using Vin and Iin signals. Pout and Qout are the output active and reactive power respectively, which can be measured using Vin and Iout signals. Different subsystems are explained below.

5.2.1. TSC – TCR

TSC – TCR subsystem is shown in the Fig. 3.

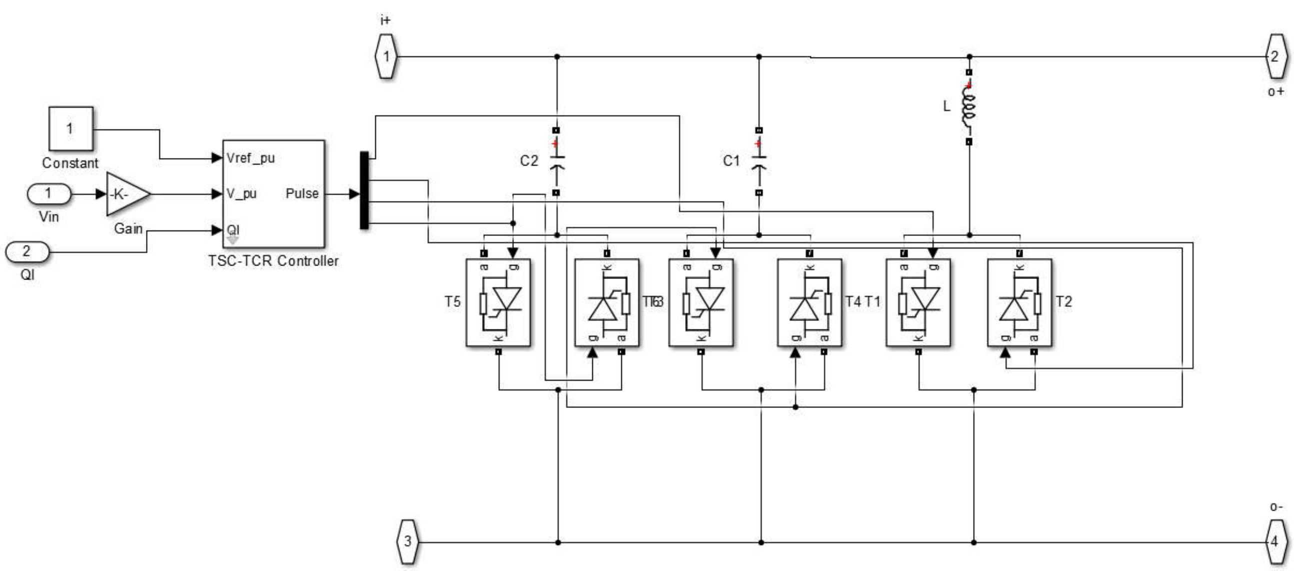

Figure 3 TSC- TCR

Here, capacitor and inductor are connected using anti parallel thyristor switches. Measured voltage is converted into pu. Voltage reference is taken at 230 V in this case. This value corresponds to the value at which voltage stability is required to be achieved.

5.2.2. TSC controller

TSC controller is shown in the Fig. 4.

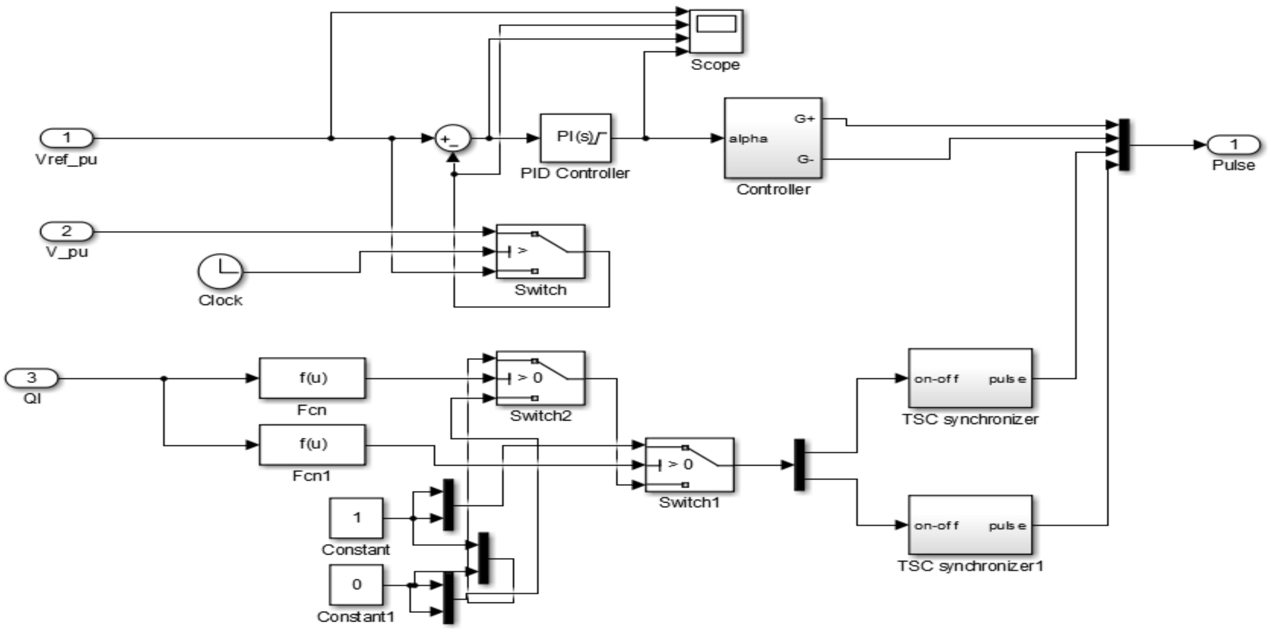

Figure 4 TSC controller

TSC is switched on according to the requirement of reactive power. If the reactive power requirement is low then only one of the two TSC is switched on. If it is high then both the TSCs are switched on. Here threshold value of 0.1 is set in the clock i.e. upto 0.1 sec TSC- TCR controller is bypassed and after that it is introduced.

5.2.3. TCR controller

TCR controller is shown in the Fig. 5.

TCR is introduced in case of light load or no load condition. PLL is used to measure frequency and phase angle of the Vin signal. Alpha is the firing angle. In case of inductor current lags the voltage by 90^0. Voltage and current are positive in between 90^0 to 180^0 in positive half cycle. Hence proper control can be achieved in this range. In case of negative half cycle this rage is 270^0 to 360^0. The same logic is developed in the TCR controller and pulses are given accordingly.

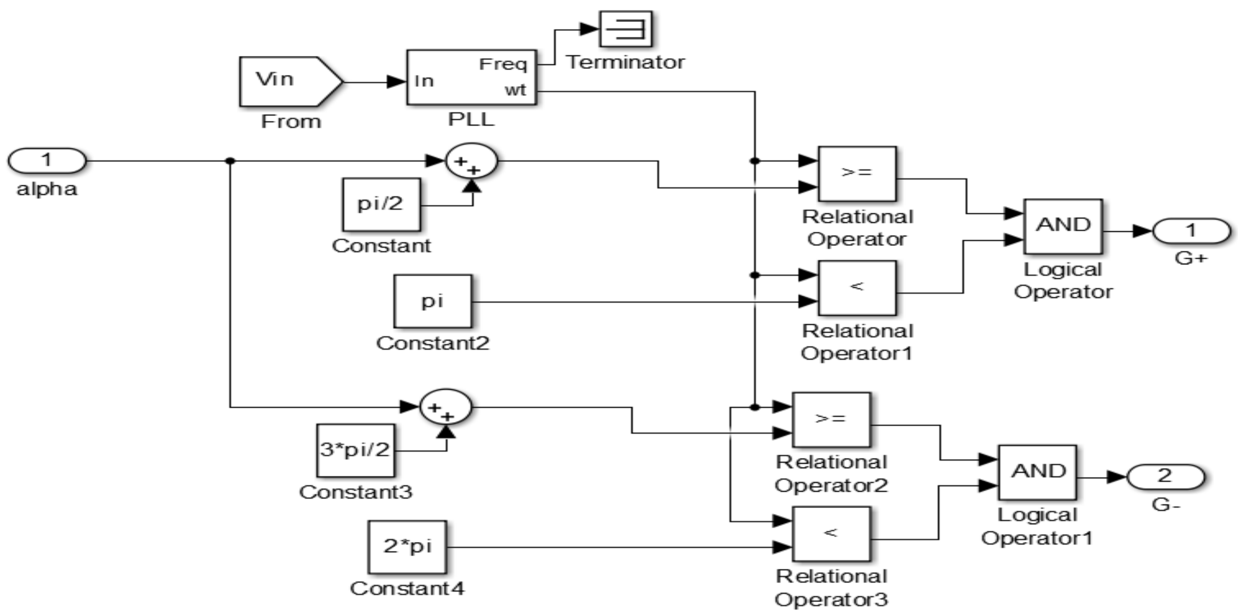

Figure 5 TCR controller

5.3. Waveforms:

Waveform of reactive power is shown in the Fig. 6.

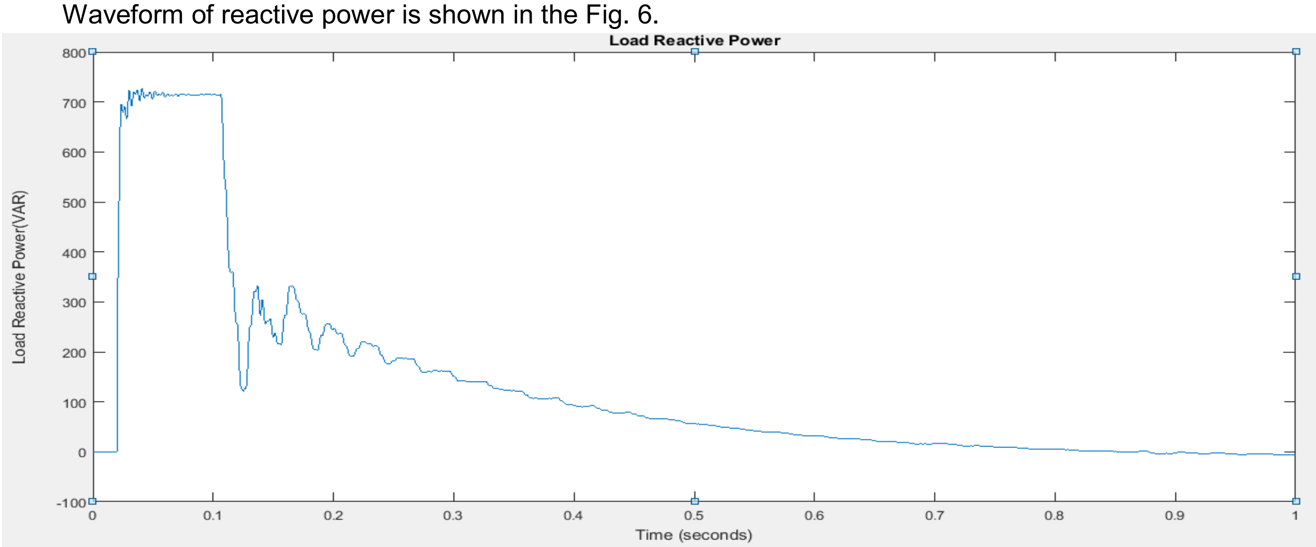

Figure 6 Waveform of reactive power

From Fig. 6, it can be clearly understood that before introducing TSC- TCR reactive power requirement is high i.e. 700 VAR. After introducing TSC- TCR controller (i.e. after 0.1 sec) reactive power compensation is achieved.

Waveform of voltage across the load is shown in the Fig. 7.

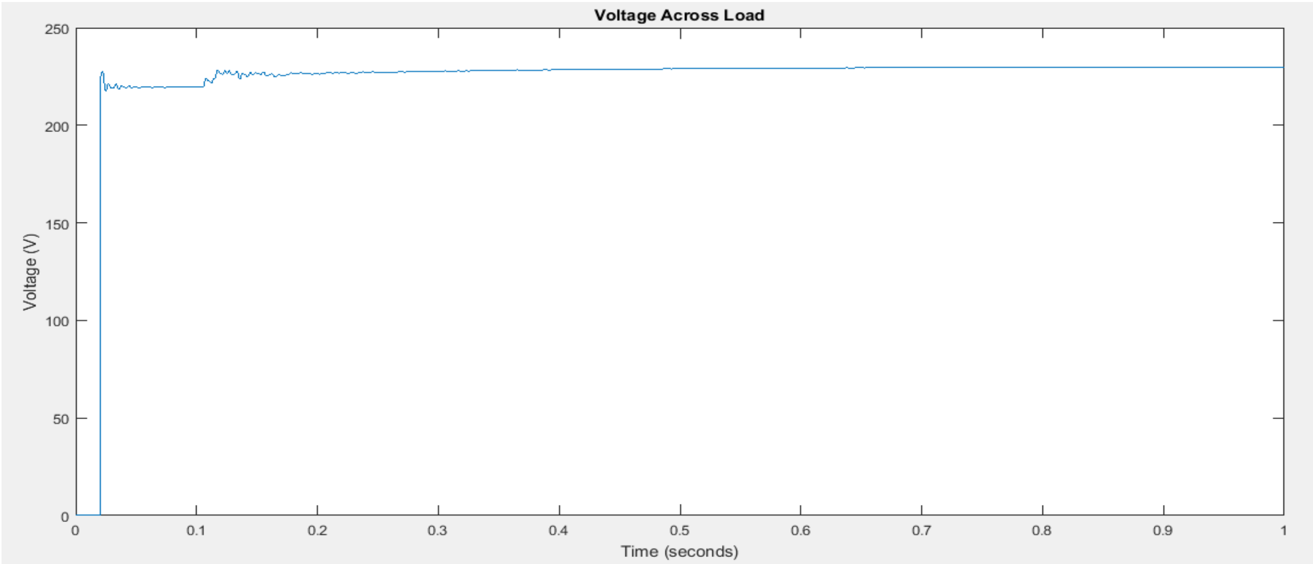

Figure 7 Waveform of voltage across load

From Fig. 7, it can be observed that voltage stability is achieved around 230 V.

Conclusion

It can be concluded that voltage stability can be achieved using TSC- TCR controller. The advantage of using TSC- TCR controller is that it can be able to supply as well as absorb reactive power according to requirement. Also, the use of controller eliminates manual intervention.

Acknowledgements

I would like to express my greatest appreciation to my supervisor Dr. Akshay A. Pandya for his encouragement, guidance and timely suggestions. The discussions held with him helped me a lot in materializing this work and also to grow up my knowledge. My sincere thank also to Dr.Bhupendra Parekh (Head of the department), Prof. Manish N. Sinha, Prof. Swapnil V. Arya for their valuable suggestions and comments. I would also like to thank the entire staff in the completion of this paper work in particularly their support, encouragement, understanding and precise suggestion. Finally, and most of all, I thank my parents, family and my friends.

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