

Flexible Ac Transmitter System Using TSR

Prof. Manoj. R. Wankhade¹, Miss. Amruta. V. Zanke², Miss. Mansi. N. Bharambe³, Mr. Pravin. R. Bunde⁴, Mr. Ganesh. V. Gomladu⁵

¹ Lecturer, Department of Electrical Engineering, Padmshri Dr. VBKCOE, Malkapur, Maharashtra, India

^{2,3,4,5} Student, Department of Electrical Engineering, Padmshri Dr. VBKCOE, Malkapur, Maharashtra, India

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ABSTRACT

The management of reactive power has become one of the most important aspects of the modern AC power transmission systems as a means of keeping voltage levels stable and at the same time improving the power factor. One of the main reasons for the use of Flexible AC Transmission System (FACTS) devices is to increase the performance and reliability of the electrical networks. This paper discusses the design and implementation of an Arduino-based Thyristor Switched Reactor (TSR) for reactive power control purpose. The proposed set-up comprises a switching arrangement based on TRIAC that is controlled through an opto-isolated driver. The synchronization of switching operations is achieved by the use of voltage zero-cross detection and current feedback while safe operation is ensured. The reactor is connected to or disconnected from the AC line instantaneously according to the demand for reactive power absorption. The system is a low-cost and educational prototype of a FACTS device that is appropriate for the use in academic and laboratory settings.

Keywords: -FACTS, Thyristor Switched Reactor, Reactive Power Control, Arduino, TRIAC

1. INTRODUCTION

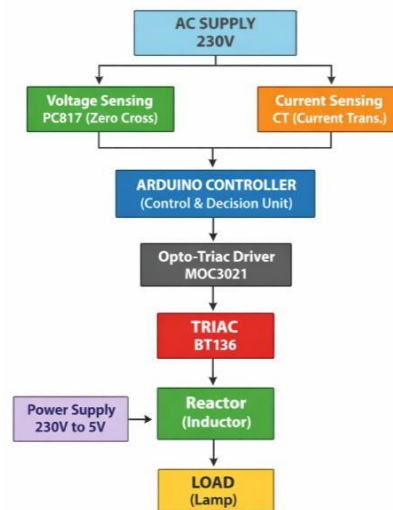
Voltage and reactive power control techniques that are efficient have become more popular because of the rapid increase in electrical loads and long-distance power transmission. Imbalance of reactive power results in the instability of voltage, raising transmission losses and poor power factor. The solutions that are conventional like fixed capacitors and reactors are not only inflexible but also do not have fast response times.

With the help of power electronic components, FACTS devices offer dynamic control of power system parameters. The Thyristor Switched Reactor (TSR), among these devices, is significantly important for reactive power management as it does so by the switching of the inductive elements into the transmission line. The microcontroller-based control's integration provides flexibility, precision, and reliability.

An Arduino-controlled TSR system is going to be the main focus of this project as it will be able to showcase the basic working principle of particularly the very expensive and complicated FACTS devices in a cost-effective and simplified way.

2. SYSTEM ARCHITECTURE

The proposed TSR system consists of a control unit, power switching unit, sensing circuits, and a reactive element. The Arduino microcontroller acts as the central control unit, receiving voltage synchronization and current feedback signals. Based on these inputs, it generates appropriate trigger pulses for the TRIAC through an opto-isolated driver.



3. PROBLEM IDENTIFICATION

Modern AC power transmission systems face significant challenges related to reactive power imbalance, voltage instability, and increased transmission losses due to the growing use of inductive loads such as motors, transformers, and industrial equipment. Traditional reactive power compensation methods, including fixed reactors and capacitors, lack flexibility and are unable to respond dynamically to continuously changing load conditions.

In many power systems, reactive power is either over-compensated or under-compensated, leading to poor voltage regulation and reduced power factor. Manual or mechanical switching of reactive components is slow, inefficient, and prone to wear and operational errors. Moreover, conventional compensation systems do not provide real-time monitoring or precise control, limiting their effectiveness in maintaining system stability. Commercial Flexible AC Transmission System (FACTS) devices offer advanced control but are expensive and complex, making them unsuitable for educational institutions and small-scale applications. Additionally, there is a lack of low-cost experimental platforms that demonstrate the practical working of FACTS devices such as Thyristor Switched Reactors.

Therefore, the identified problem is the need for a cost-effective, fast-responding, and programmable reactive power control system that can dynamically switch a reactor based on system conditions while ensuring electrical safety and reliability. An Arduino-based Thyristor Switched Reactor provides a practical solution to address these limitations by offering flexible control, fast switching, and an economical implementation suitable for academic and laboratory environments.

4. RESULTS

The Arduino based Thyristor Switched Reactor (TSR) system was built and then tested to be the proof of dynamic reactive power control in an AC power system. The system worked dependably under varying load conditions and presented stable performance throughout the continuous operation.

The zero-cross detection circuit delivered accurate synchronization with the AC supply, which was a safe and smooth triggering of the TRIAC. The opto-isolated driver guaranteed complete electrical isolation between the control and power sections, thus giving rise to enhanced safety and less noise interference.

A switch of the reactor to the AC line caused a distinct dip in the line current oscillations that were reflecting the absorption of reactive power. The power factor was marked improved as compared to the non-reactor compensated condition. Voltage drop at the load side was measured and found reduced thus it was indicated that voltage stability was improved.

5. CONCLUSION

The application of the Arduino-based Thyristor Switched Reactor (TSR) system has been a successful endeavor to illustrate the dynamic reactive power control in an AC power system. The proposed solution utilizes the combination of power electronics switching with microcontroller controls to effectively manage the linear power and in turn, the voltage stability. Synchronized triggering at zero-crossing points allowed for the gradual and safe reactor switching, while opto-isolation ensured very reliable electrical separation between the control unit operating at low-voltage and the AC mains at high-voltage. The experimental findings pointed out an improved power factor, less current variations, and greater system stability. Overall, the project offers a low-cost,

educational prototype that clearly demonstrates the action principle of FACTS devices in reactive power compensation applications.

6. FUTURE SCOPE

- The system can be extended to three-phase power systems for industrial and transmission applications.
- Closed-loop power factor correction can be implemented using real-time voltage and current feedback.
- Advanced controllers such as DSPs or FPGAs can be used for faster and more accurate control.
- IoT-based monitoring and data logging can be added for remote supervision and analysis.
- Multiple reactors can be integrated to achieve finer and step-wise reactive power control.
- Protection features such as fault detection and over-current tripping can be enhanced.
- The system can be scaled to higher power ratings using industrial-grade power electronic devices.

7. REFERENCES

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