FLEXIBLE AC TRANSMISSION BY USING THYRISTOR SWITCHING REACTOR

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ABSTRACT-

The circuit is designed to implement FACTS by TSR (Thyristor Switched Reactance). This method is used either when charging the transmission line or when there is very low load at the receiving end. Due to very low or no load, very low current flows through the transmission line and shunt capacitance in the transmission line becomes dominant. This causes voltage amplification due to which receiving end voltage may become double than the sending ends voltage. To compensate this, shunt inductors are automatically connected across the transmission line. In this proposed system the lead time between the zero voltage pulse and zero current pulse duly generated by suitable operational amplifier are fed to two interrupt pins of the microcontroller, where the program takes over to bring the shunt reactors to the circuit to get the voltage duly compensated. Back to back SCRs duly interfaced through optical isolation from the programmed microcontroller are used in series for switching the reactor (in our case a choke is used). The microcontroller used in the circuit is of 8051 family.
Keywords- FACTS, TSR, Reactive Power,

1. INTRODUCTION

1.1 Introduction

Flexible AC Transmission Systems (FACTS) refer to a family of technologies that enhance the efficiency, controllability, and stability of electrical power transmission and distribution systems. One of the key technologies within FACTS is the Thyristor-Controlled Series Reactor (TSR). TSR plays a significant role in improving the performance of power systems by controlling the impedance of transmission lines. The primary purpose of TSR is to regulate the line impedance and thus the line voltage of a transmission system. It consists of a series reactor connected in line with the transmission network and thyristor-based switching devices that control the reactor impedance. By adjusting the impedance, TSR allows the system operators to manage power flow, voltage regulation, and stability.

A thyristor switched reactor is used in electrical power transmission systems. It is a reactance connected in series with a bidirectional thyristor value. The value of thyristor is phase-controlled, which allows the value of delivered reactive power to be adjusted to meet changing system conditions. TSR can be used to limit the voltage rises on lightly loaded transmission lines. The current in TSR is varied from maximum to zero by varying the firing delay angle.A key element of Flexible AC Transmission Systems (FACTS) that improves power transmission efficiency, Controllability, and stability is the Thyristor-Controlled Series Reactor (TSR). It controls transmission line voltage by Adjusting line impedance. TSR is made up of impedance Control switching devices based on thyristors and a series Reactor. Operators can now modify the voltage, power flow, and Stability of the system. Reactive power delivery is adjusted by TSR using phase-controlled thyristors in response to system Conditions. It modifies firing delay angle to alter current, which Reduces voltage rises on weakly loaded lines

2. METHODOLOGY

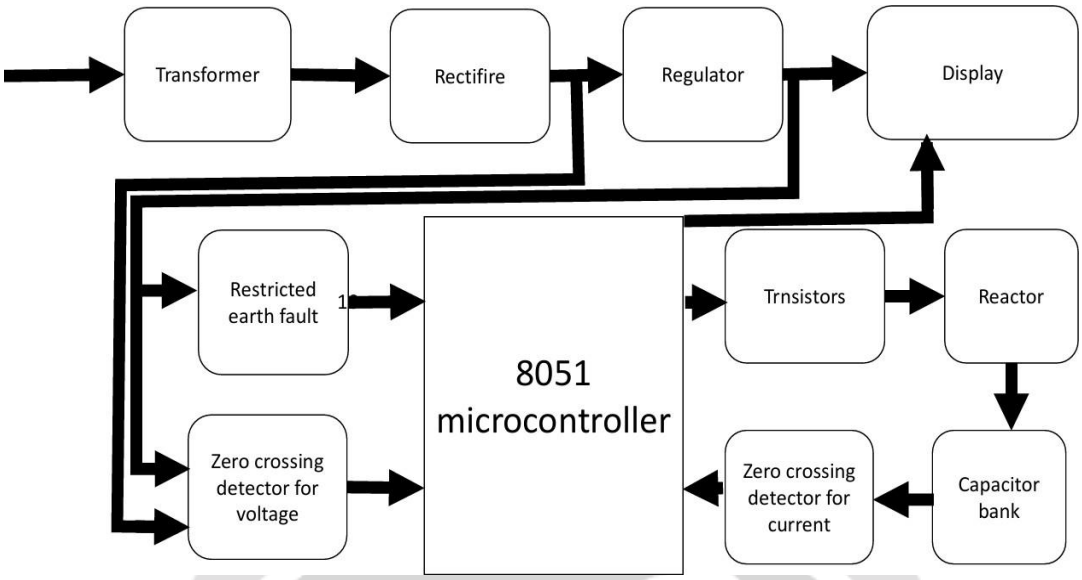


Figure 2.1: Block diagram of proposed system

Power Grid / Generator:

- Acts as the source of electric power.
- Delivers active and reactive power to the transmission line.

Transmission Line:

- Transports electricity over long distances.
- Suffers from voltage drops, power losses, and instability under varying load conditions.

Bus (Point of Common Coupling - PCC):

- Connection point for the TSR to the transmission line.
- Voltage at this point is monitored and regulated.

Thyristor Switched Reactor (TSR):

- The main controlling unit in the project.
- Consists of a reactor (inductor) connected in series with anti-parallel thyristors.
- The thyristors act as switches controlled by a firing circuit or microcontroller.

Reactor (Inductor):

- Absorbs reactive power (lagging VARs) when switched into the system.
- Used to counteract overvoltage conditions during low loads or capacitive effects.

Ground:

- Provides a return path for the current from the reactor.

Working Principle:

- When the load on the transmission line is light, the voltage may rise due to excess reactive power.
- The thyristors are fired at the right time to connect the reactor, which absorbs this reactive power and brings the voltage back to the desired level.
- During normal or heavy load conditions, the reactor is disconnected (thyristors off) to avoid unnecessary absorption of reactive power.
- The control circuit continuously monitors the system voltage and controls the thyristors accordingly.

2.1 Hardware implementation

This step involves material and component selection, hardware installation, and prototyping design. This project consists of using several electronic components. The main components used are Relay, Relay DriverULN2003, Transformer, Microcontroller At89S52, Thyristor, LCD, Inductive Load, etc.

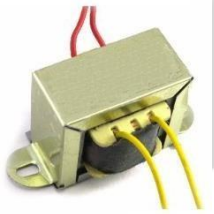
2.1.1 Relay

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.

Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal. Relays were first used in long-distance telegraph circuits as signal repeaters: they refresh the signal coming in from one circuit by transmitting it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

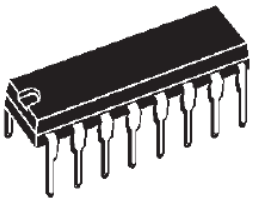
2.1.2 Transformer

The transformer is an electric device which transfers energy by inductive coupling between its windings. The transformer gives output of 12V, 12V and 0V. This transformer acts as a step-down transformer. The transformer core is made with the high permeability silicon steel.



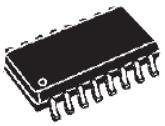
2.1.3 Relay Driver ULN2003

The ULN2001A, ULN2002A, ULN2003 and ULN2004A are high voltage, high current Darlington arrays each containing seven open collector Darlington pairs with common emitters. Each channel rated at 500mAand can withstand peak currents of 600mA.Suppressiondiodesare included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout.



DIP16

ORDERING NUMBERS: ULN2001A/2A/3A/4A



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ORDERING NUMBERS: ULN2001D/2D/3D/4D

2.1.4 Microcontroller AT89S52

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high- density nonvolatile memory technology and is compatible with the industry standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in- system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

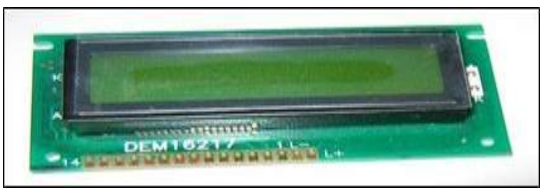
2.1.5 Thyristor [TSR]

A silicon-controlled rectifier (or semiconductor-controlled rectifier) is a four-layer solid state device that controls current. The name "silicon controlled rectifier" or SCR is General Electric's trade name for a type of thyristor. The SCR was developed by a team of power engineers led by Gordon Hall and commercialized by Frank W. "Bill" Gutzwiller in 1957.

2.1.6 Liquid Crystal Display (LCD)

The 44780 standard requires 3 control lines as well as either 4 or 8 I/O lines for the data bus. The user may select whether the LCD is to operate with a 4-bit data bus or an 8-bit data bus. If a 4-bit data bus is used the LCD will require a total of 7 data lines (3 control lines plus the 4 lines for the data bus). If an 8-bit data bus is used the LCD will require a total of 11 data lines (3 control lines plus the 8 lines for the data bus).

2.1.7 Inductive Load



A load that is predominantly inductive, so that the alternating load current lags behind the alternating voltage of the load. Also known as lagging load. Any devices that have coils of wire in there manufacture can be classed as inductive loads. E.g. motors, solenoids and contactor coils are a few. Example of resistive loads can be baseboard heaters, filament light bulbs, toasters and stove top elements.

2.2 Research Design

Provide an overview of Reduction of losses in transmission line and the need for advanced monitoring and control systems. The next path that unravels is firstly the method to be adopted the system to reduce the losses at its maximum level which further. The project called "FLEXIBLE AC TRANSMISSION USING TSR''.

Culminating towards making the said project in its utilization several components have been unleashed, some of which are mentioned so

1. Relay
2. Relay Driver
3. ULN2003
4. Transformer
5. Microcontroller At89S52
6. Thyristor

2.3 Hardware Testing

In electronics, a continuity test is the checking of an electric circuit to see if current flows (that it is in fact a complete circuit). A continuity test is performed by placing a small voltage (wired in series with an LED or noise-producing component such as a piezoelectric speaker) across the chosen path. If electron flow is inhibited by broken conductors, damaged components, or excessive resistance, the circuit is "open". Devices that can be used to perform continuity tests include multi meters which measure current and specialized continuity testers which are cheaper, more basic devices, generally with a simple light bulb that lights up when current flows.

An important application is the continuity test of a bundle of wires so as to find the two ends belonging to a particular one of these wires; there will be a negligible resistance between the "right" ends, and only between the "right" ends. This test is the performed just after the hardware soldering and configuration has been completed.

This test aims at finding any electrical open paths in the circuit after the soldering. Many a times, the electrical continuity in the circuit is lost due to improper soldering, wrong and rough handling of the PCB, improper usage of the soldering iron, component failures and presence of bugs in the circuit diagram. We use a multi meter to perform this test. We keep the multimeter in buzzer mode and connect the ground terminal of the multi meter to the ground. We connect both the terminals across the path that needs to be checked. If there is continuation, then you will hear the beep sound.

Power On Test:

This test is performed to check whether the voltage at different terminals is according to the requirement or not. We take a multi meter and put it in voltage mode. Remember that this test is performed without microcontroller. Firstly, we check the output of the transformer, whether we get the required 12 v AC voltage. Then we apply this voltage to the power supply circuit. Note that we do this test without microcontroller because if there is any excessive voltage, this may lead to damaging the controller.

Advantages

- FACTS increase the reliability of AC grids.
- They reduce power delivery costs.
- They supply inductive or reactive power to the grid and improve transmission quality and efficiency of power transmission.
- There is fast voltage regulation.

Applications

- Grid integration of renewable power.
- Implementation of HVDC converter terminal performance.
- Load compensation.
- Alleviation of voltage instability.
- Limit short circuit current.
- Mitigation of sub synchronous resonance.
- Improvement of system transient stability limit.

3.PHOTOGRAPH

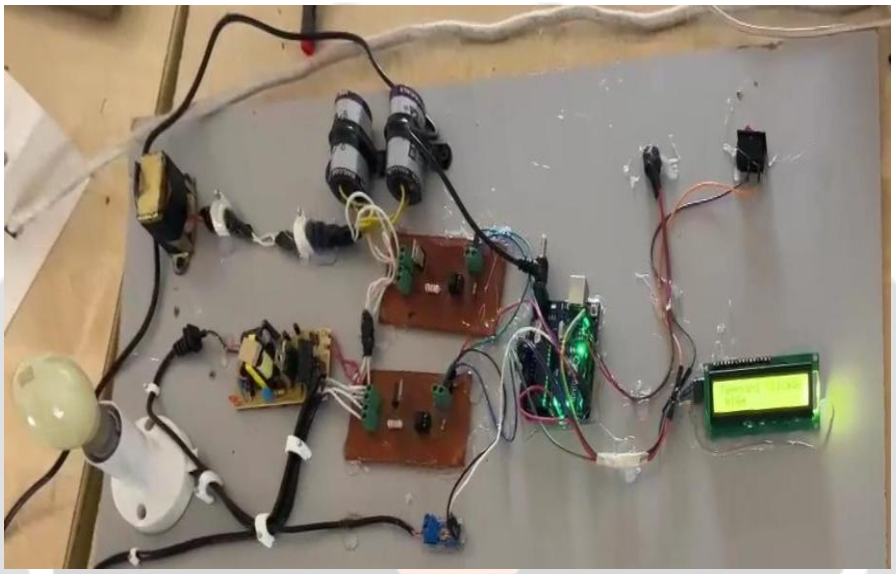


Figure 3.1: Complete Setup of Flexible AC Transmission Using TSR

3.1. Software Requirements

Keil Micro Vision (IDE)

Keil an ARM Company makes C compilers, macro assemblers, real-time kernels, debuggers, simulators, integrated environments, evaluation boards, and emulators for ARM7/ARM9/Cortex-M3, XC16x/C16x/ST10, 251, and 8051 MCU families. Keil development tools for the 8051 Microcontroller Architecture support every level of software developer from the professional applications engineer to the student just learning about embedded software development. When starting a new project, simply select the microcontroller you use from the Device Database and the µVision IDE sets all compiler, assembler, linker, and memory options for you. Keil is a cross compiler. So first we have to understand the concept of compilers and cross compilers. After then we shall learn how to work with keil.

Concept of Compiler

Compilers are programs used to convert a High Level Language to object code. Desktop compilers produce an output object code for the underlying microprocessor, but not for other microprocessors. I.E the programs written in one of the HLL like 'C' will compile the code to run on the system for a particular processor like x86 (underlying microprocessor in the computer). For example compilers for Dos platform is different from the Compilers for Unix platform So if one wants to define a compiler then compiler is a program that translates source code into object code.

The compiler derives its name from the way it works, looking at the entire piece of source code and collecting and reorganizing the instruction. See there is a bit little difference between compiler and an interpreter. Interpreter just interprets whole program at a time while compiler analyses and execute each line of source code in succession, without looking at the entire program.

Concept of Cross Compiler

A cross compiler is similar to the compilers but we write a program for the target processor (like 8051 and its derivatives) on the host processors (like computer of x86). It means being in one environment you are writing a code for another environment is called cross development. And the compiler used for cross development is called cross compiler. So the definition of cross compiler is a compiler that runs on one computer but produces object code for a different type of computer.

4.RESULTS

Parameter	Before TSR Activation	After TSR Activation	Remarks
Bus Voltage (p.u.)	0.92	0.99	Voltage improved toward 1.0 p.u.
Reactive Power (MVAr)	+50 (absorbing)	+10	Better compensation achieved
Power Factor	0.84 lag	0.97 lag	Improved closer to unity
Voltage THD (%)	1.1	3.3	Increased due to switching
System Stability	Fluctuating	Stable	Improved damping observed
Thyristor Switching Timing	N/A	Synchronized	Correct zero-crossing firing

5. CONCLUSION

5.1 Conclusion

The implementation of the Thyristor Switched Reactor (TSR) has effectively improved system voltage regulation and reactive power compensation, enhancing the overall power factor and system stability. While harmonic content increased slightly due to thyristor switching, it remains within tolerable limits for most utility standards (e.g., IEEE 519), or can be mitigated with appropriate filters. The TSR responded quickly and reliably to load changes, making it a suitable dynamic reactive compensation device for modern power systems.

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