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POWER FACTOR IMPROVEMENT BY USINGSTATIC VARIABLE COMPENSATOR

PROF S S DHAMSE (@gmail.com)

PRAJWAL BANSOD, TANVI SABLE, VAISHNAVI PAUL DEPARTMENT OF ELECTRICAL ENGINEERING GOVERNMENT COLLEGE OF ENGINEERING, JALGAON
(An Autonomous Institute of Govt. of Maharashtra) (2023-24)

1. ABSTRACT

This project aims to improve the power factor of transmission lines using a static variable compensator. Traditional methods using large rotating parts were inefficient and prone to damage. Static VAR Compensation under FACTS employs Thyristor Switched Capacitors (TSC) controlled by a programmed microcontroller. This system compensates the power factor using thyristor-switched capacitors, where the zero voltage and zero current pulses are fed to a microcontroller. Previously, power factor compensation relied on large machines like synchronous condensers or switched capacitor banks. Shunt capacitive compensation, where a shunt capacitor is connected to draw current leading the source voltage, improves the power factor for inductive loads. The program controls opto-isolators interfaced with SCRs to achieve near-unity power factor. The project can be further enhanced with thyristor-controlled triggering for precise power factor correction.

2. INTRODUCTION

The Flexible AC Transmission System (FACTS) applies power electronics solutions to AC power systems, enhancing power transferability and system controllability. FACTS devices, with ratings from tens to hundreds of gigawatts, regulate and control electrical parameters such as voltage, current, impedance, phase angle, and oscillation damping. These controllers can rapidly change system parameters, impacting the operation of traditional distance schemes and protective relays in transmission lines.As electrical power demand grows, energy efficiency becomes crucial. Inductive loads reduce voltage at the customer's point and increase system losses, lowering efficiency and potentially leading to higher electricity bills and penalties. This problem is often indicated by a low power factor. Corrective capacitors are widely used to supply reactive power and improve power factor. However, fixed capacitance can lead to overcompensation and voltage boosts, potentially damaging loads. A better method is needed to match the reactive power requirement as it changes. Power electronics, which controls electricity flow through switching or power semiconductors, offers a technique to improve power factor and compensate for reactive power dynamically.

3. LITRATURE SURVEY

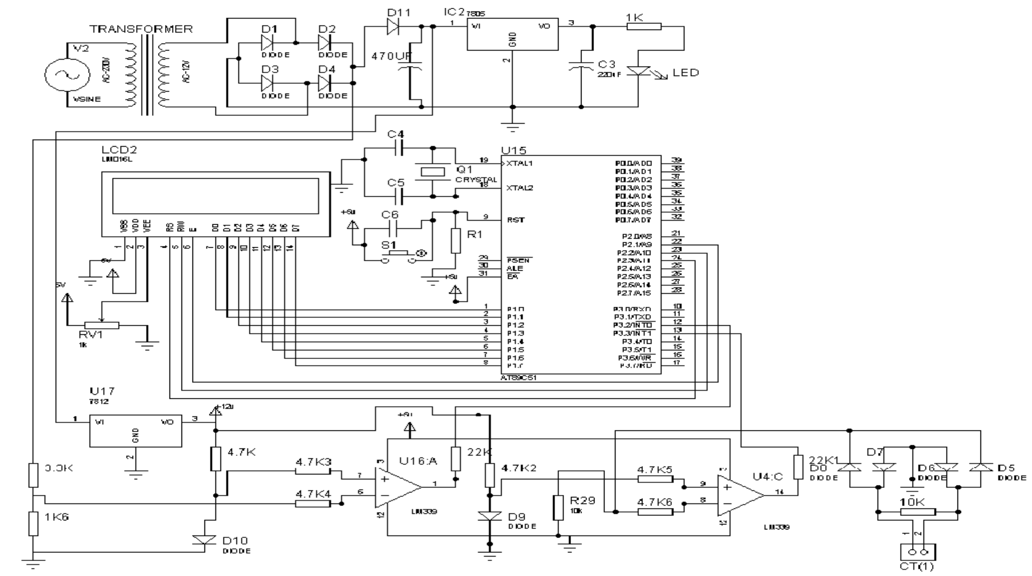
1. "Voltage Stability Profile Betterment and Reactive Power Quantity Adjustment with the Assistance of Static VAR" by A Siva Lakshmi, N Aparna, Ch. Pavan Kumar (IJARSET, Vol. 6, August 2019): This paper discusses the impact of Static VAR Compensators (SVC) on voltage stability in power systems. SVCs control reactive power flow to improve voltage stability. The proposed model adjusts the SVC's impedance based on the firing angle of the TCR.

2. "Comparative Analysis of STATCOM and SVC for Reactive Power Enhancement in A Long Transmission Line" by Nunna Sushma (IJCSE, Vol. 6, June 2018): This paper compares STATCOM and SVC in enhancing reactive power in long transmission lines. FACTS controllers, including STATCOM and SVC, improve power quality and control flexibility

3. "Mid-Point Siting of FACTS Devices in Transmission Lines" by B.T. Ooi et al. (IEEE Transactions on Power Delivery, Vol. 12, No. 4, October 1997): This paper discusses the optimal siting of FACTS devices like STATCOM, UPFC, and TCSC at the mid-point of transmission lines. Mid-point siting doubles power transfer capacity and allows independent reactive power control at both ends of the line.

4. "Improved Harmony Search Algorithm for Optimal Placement and Sizing of Static Var Compensators in Power Systems" by Reza Sirjani & Azah Mohamed (IEEE, 2011): This paper presents the Improved Harmony Search (IHS) algorithm for determining the optimal location and size of SVCs in power systems. The IHS algorithm, tested on a 57-bus system, showed better voltage improvement and lower power loss compared to the Particle Swarm Optimization technique.

4. CIRCUIT DIAGRAM



5. WORKING AND MODEL

This method is used when charging the transmission line or when there is very low load at the receiving end. Low current flow in the transmission line causes the Ferranti Effect, where the receiving end voltage can double the sending end voltage, especially in long transmission lines. To compensate, shunt inductors are connected across the line. Operational amplifiers in comparator mode generate zero voltage and zero current pulses, which are fed to microcontroller interrupt pins. The microcontroller then actuates opto-isolators interfaced with SCRs to introduce shunt reactors into the load circuit, compensating the voltage.

The project uses an 8-bit 8051 family microcontroller. The power supply includes a 230/12V step-down transformer, which converts the voltage to 12V AC. A bridge rectifier converts this to DC, a capacitive filter removes ripples, and a 7805 voltage regulator provides +5V forthe microcontroller and other components.

6. List Of Components

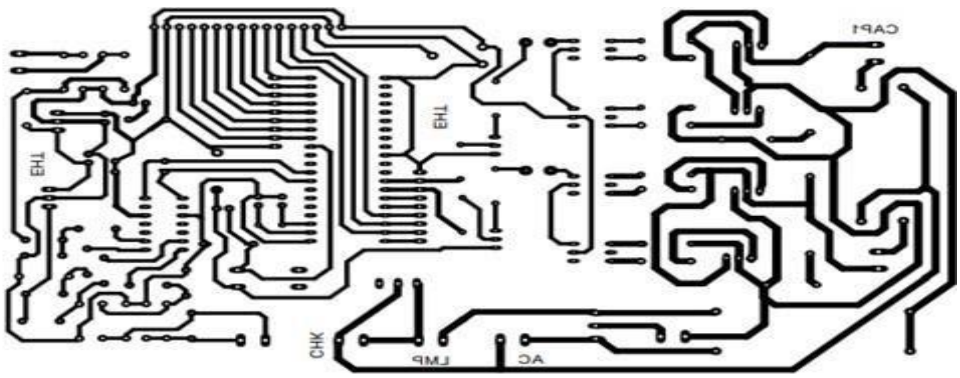
Sr .no	List of Components	Quantity
1	Resister	
	1K	6
	10K	1
	3.3K	2
	4.7K	1
	560ohm	6
	2.2k	4
	100ohm/2watt	1
	10watt	4

2	Capacitor	
	470mf/25v	1
	220mf/25v	1
	10microF	1
3	Integrated circuit	
	IC7812	1
	IC7805	1
	AT89S52	1
	339IC	1
	Opto isolator IC	4
4	IC base	
	40pin base	1
	14pin base	1
	6pin base	4
5	Diode	
	Zener diode	1
	IN4007	13
	red led	3
6	Transistor	
	BC55A	2
7	Connector	
	PBT	8
8	Switch	
	Push button	1
	Slide button	2
	7Segment display	1
	Transformer	2
	Bulb	1
	SCR	4
	AC cable	1
	Bulb holder	1
	Crystal	1

7. COMPONENTS DESCRIPTION

Pcb design

A Printed Circuit Board (PCB) supports and connects electronic components using conductive tracks, pads, and features etched from copper sheets on a non-conductive substrate. PCBs can be single-sided, double-sided, or multi-layered, with connections between layers made via plated-through holes called vias. Advanced PCBs may embed components like capacitors and resistors within the substrate.PCBs are used in nearly all electronic products, replacing methods like wire wrap and point-to-point construction.
Although PCBs require design effort, their manufacturing and assembly can be automated, making the process cheaper, faster, and free from operator wiring errors.



Transformer

Transformers convert AC electricity from one voltage to another with a little loss of power. Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high voltage to a safer low voltage.

Fig 4.1: A typical transformer

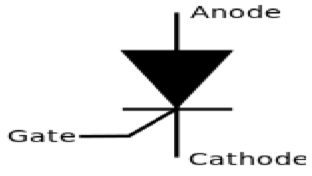
Microcontroller

The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4 KB of Flash Programmable and Erasable Read Only Memory (PEROM). Manufactured with Atmel's high-density nonvolatile memory technology, it is compatible with the MCS-51 instruction set and pinout. Its on-chip Flash allows for in-system or conventional reprogramming of the program memory.

Fig 4.5(a) Microcontroller

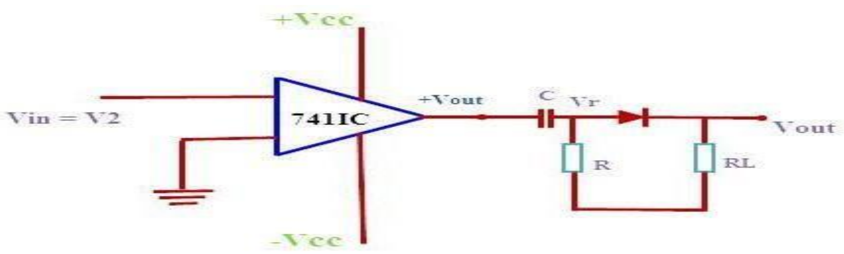
Silicon controlled rectifier

A silicon controlled rectifier (SCR) is a four-layer, solid-state current-controlling device. Developed by Bell Laboratories in 1956, the SCR was practically demonstrated in 1958 by Dr. Ian M. Mackintosh. The name "silicon controlled rectifier" is General Electric's trade name for a type of thyristor, developed and commercialized by a team led by Gordon Hall and Frank W. "Bill" Gutzwiller in 1957.SCRs are sometimes considered synonymous with thyristors, though some sources define SCRs as a subset of thyristors, characterized by at least four layers of alternating n- and p-type material. The term "thyristor" was adopted lateras the device gained international use.



Zero Crossing Detector

A zero crossing detector (ZCD) is a voltage comparator that switches its output between +Vsat and - Vsat when the input crosses zero voltage. Essentially, it is an operational amplifier comparing two voltages and changing the output accordingly. The ZCD produces an output switch when the input crosses the reference voltage (0V) and is connected to the ground.



8. RESULT AND DISCUSSION

Main components needed for the project are resistor, diodes, capacitors, transformer, Thyristors (SCRs), Capacitors and Reactors, Voltage and Current Sensor, Control System.

Assembling a Flexible AC Transmission System (FACTS) using a Static Var Compensator (SVC) involves several stages: planning, component acquisition, circuit assembly, control system programming, testing, and integration.

9. ADVANTAGES

- The flow of power is ordered. It may be as per the contract or as per the requirements of theutilities
- It increases the loading capability of the lines to the thermal capability
- It improves the stability of the system and thus make the system secure Provides secure Tie Line connection to the neighboring utilities and regions, thereby decreasing overall generationreserve requirements on both sides

10. DISADVANTAGES

- It is effective only during heavy loads
- Whenever an outage occurs on a line, with series compensation, the series compensation is removed. This may cause overloading of other parallel lines
- If series compensation is added to an existing system, it is generally necessary to have it on all the lines in parallel.
- One major drawback in the series capacitance compensation is that special productive devices are required to protect the capacitors and bypass the high current produced when a short circuitoccurs

11. APPLICATIONS

- Power control.
- Reducing generation cost.
- HVDC link application
- Reduces Power Losses and Improving Voltage Profile.
- Improvement in Power Factor.

12. CONCLUSION

The Flexible AC Transmission System (FACTS) enhances efficiency and stability by improving the power factor and reducing output voltage fluctuations. By using a capacitor bank, this system raises the power factor close to 1. Microcontroller-based, thyristor-driven static variable compensation outperforms traditional methods like synchronous condensers. Using thyristors eliminates contact pitting common in relay circuits, promoting a sustainable future with limited power sources and AC transmission lines. Static var compensators provide higher reactive power compensation, improving power quality, correcting the power factor, and maintaining constant voltage. Therefore, the AC transmission network needs dynamic reactive power control for a stable profile under varying load conditions and transients.

13. FUTURE SCOPE

As we know that the demand of power is increasing every day and we only have limited sources of energy. So, this project proposed improves power factor and increases 47 the efficiency of any system connected parallel to it. This circuit can be used in industries instead of using the old traditional techniques such as big synchronous generators which are costlier and damage prone. In comparison to these techniques our project is more reliable and cheaper. This will help us to sustain more power for our future needs in a more efficient way. It can be used in industries to improve the power factor of industrial loads. It might as well be used for domestic purposes where we need to improve the power factor of the system. It is a very reliable and compact design used for improvement of power factor and also cheaper than the traditional techniques used for this purpose.

14. REFERANCES

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