Voltage Amplification Compensation by Thyristor Switched Reactor (TSR) In FACTS

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Abstract- *The project is designed to implement FACTS using TSR(Thyristor Switched Reactor) in power system. This method is used either at low load or charging of transmission line at the load side (Receiving side).Due to which small current flows through transmission line and shunt capacitance becomes too high in transmission line. This causes voltage amplification at receiving end due to which receiving end voltage becomes almost double of sending end voltage called Ferranti Effect. To compensate this we use shunt inductance is connected across the transmission line. This paper gives details information on Ferranti effect compensation using TSR.*

I. INTRODUCTION

A. FACTS

Facts is defined as Flexible Alternating Current transmission system uses modern power electronic based and other static controllers to enhance controllability and increase power transfer capability[8].

B. FERRANTI EFFECT

In medium or long transmission line due to low load or charging of transmission line in receiving end. A small current flows through transmission line at receiving side. This causes Ferranti effect in which receiving end voltage becomes nearly twice sending end voltage.

C. TSR

To enhance controllability and power quality problems a new technology come under FACTS technology is TSR (thyristor switched reactor).The current in TSR is continuously varied from zero to maximum by phase control in which the firing angle α is varied from 180° to 90°. The instantaneous current i_{TSR} over half cycle is given by

$$I_{TSR} = \frac{\sqrt{2}V}{X}(\cos\alpha - \cos\omega t)$$

Where V is the rms voltage is applied, X is the fundamental frequency reactance of reactor.

Whenever a thyristor switched inductor is connected in shunt and its effective resistance changes with the changing steps byitsconduction range betweenzeros to full. Since there is very low load or no load at the receiving end, a small amount of current starts to flow in the transmission line.The presence of this capacitance connected in shunt in the transmission line produces what we know as Ferranti Effect.Thus, the voltage received at the receiving end becomes almost double than the voltage sent from the sending end. This generally happens in case of very long lines of transmission. In order to compensate for the Ferranti Effect,we introduce inductance which connected in shunt across the transmission line.

II. EXISTING SYSTEM

In this project,the same concept is being implemented of Ferranti Effect compensation.We know that reactive power is produced or compensated in power system every time we use the power system .This also happens during the generation, Transmission and distribution of power in long distance lines .Reactive power is also generated through loads which areconnected at the receiving end.

Resistance and Reactance make the two components of impedance in a branch of an AC circuit.There are two types of reactance's which are either inductive or capacitive and they both contribute towards the reactive power in an AC circuit.Flexible AC transmission apart from Ferranti Effect compensation also contributes towards the reactive power compensation.

If by any means we are able to reduce the flow of the reactive power in the long transmission lines,we can achieve a more efficient system and also reduce the economy involved and it can be utilized in a better manner.Thus, in order to get the actual voltage at the load end, we need to use the right amount of reactive power in the AC system which can compensate the capacitance present in the transmission line.

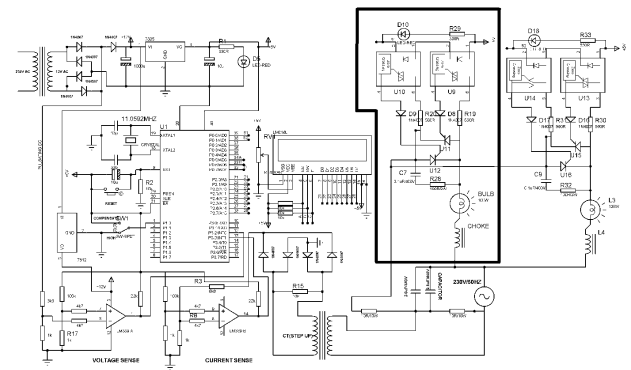
If the reactive power present is not enough to compensate for the virtual capacitance formed, there will be voltage sag contrary to the voltage swell formed if there is an excess of reactive power present to compensate for the virtual capacitance.Thus, we need to check that the reactive power given to the system in order to compensate for the current must be in right amounts at all points of time and also at the correct places required.This task is achieved by the reactive power compensation.We need the reactive power (VAR) so that we can maintain the voltage to discharge active power (watts) in the transmission lines.

DISADVANTAGES

There are certain disadvantages related to the existing system which are as follows-

1. There is a lagging power factor in reactive power compensation but in order to achieve a more efficient system we need leading power factor in present times.
2. There are more losses involved in case of reactive power compensation.
3. Reactive power compensation has also a disadvantage of a less current carrying capacity and if we require large currents then the system will be uneconomical to operate.

III. BLOCK DIAGRAM



Block diagram represents the proposed facts circuit.

IV. PROPOSED SYSTEM

The system which is proposed considers the time lead between the zero voltage and zero current pulse produced by operational amplifier and is fed to the two interrupt pins of the microcontroller, and then the program presides over to bring the shunt reactors into the circuit on the load side to compensate the voltage.SCRs which are placed back-to-back are interfaced by means of optical isolation from the on -chip microcontroller which is used in series for switching the reactor (choke is used in our case). The microcontroller which we have used in the proposed system is of 8051 family.

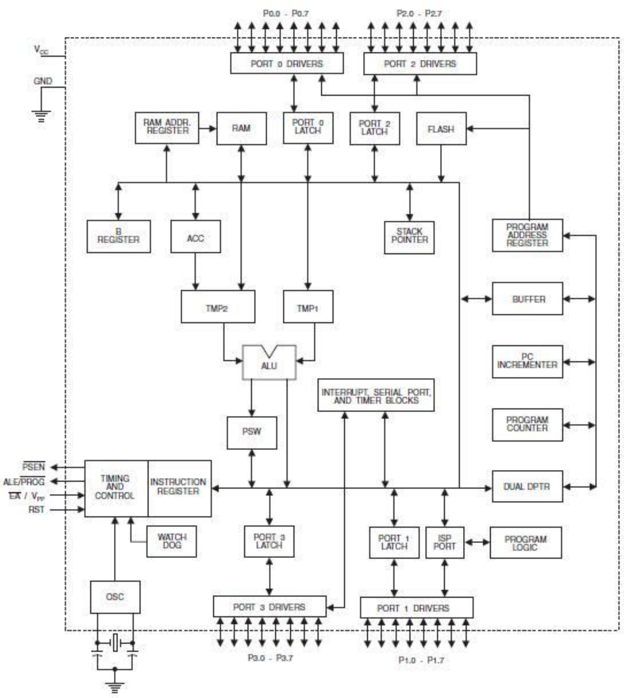
V. COMPONENTS

1. **SCR** - SCR is a silicon controlled rectifier or a semiconductor controlled rectifier which has 4 layers of solid state current controlling capacity.They are unidirectional devices and can conduct current in only one direction which is opposite when it comes to TRIACs which conduct current in both the directions that is they are bidirectional .They can be triggered in Normal Mode by the currents flowing in Gate terminal which is not the case in TRIACs which can be triggered in Normal Mode by either the negative current or a positive current which is applied to the Gate terminal of the TRIAC.
2. **CHOKE**- In power electronics, a choke is referred to as an inductor that is used in order to avoid or block the high frequency alternating current (AC) in a transmission circuit while allowing the lower frequency or direct current (DC) to pass. A coil of insulated wire which is wound around a core of magnet is present in a choke while in some cases a choke also consists of doughnut shaped "bead" of magnetic material wound on a wire. The impedance of the choke increases as we increase the frequency of the supply system. The low electrical resistance of a choke allows both the AC and DC current to pass with either low or no loss of power but the amount of AC current that can be passed through a choke is limited by reactance of the choke being used.
3. **VOLTAGE REGULATOR**-The voltage regulator is designed such that it can maintain a constant level of voltage automatically. The design of a voltage regulator might be a plane feed-forward design or it can incorporate a control loopwith a negative feedback. The voltage regulator uses a electromechanical mechanism, or electronic components based on the design of the voltage regulator. It is used to regulate either AC or DC voltages in a system of electric power distribution. The voltage regulators are installed along the distribution lines or at a substation in order for all the customers to receive steady voltage independent of the amount of power which is drawn from the line.

4. **MICROCONTROLLER**- A microcontroller is a true microcomputer present on chip the most popular microcontroller produced in the world is the Intel 8051 it has the following specifications-

- It has an on-chip external data memory of 64 kb
- It has the on-chip program memory of 64 kb and,
- The internal data memory comprises of 256 bytes.

Thus, the following features increases its reliability of use. The hardware in case of microcontrollers is very less since the on chip microcomputer is present. The speed of the microcontrollers is very high and the access time is very small.



BLOCK DIAGRAM OF ATMEL MICRONTROLLER

5. **TRANSFORMER**-Electric power transformer is a static device which transforms electrical energy from one circuit to another circuit without any direct electrical connection and with the help of mutual induction between two windings.It transforms power from one circuit to another without changing its frequency but maybe in different voltage level. Electromotive force is produced by the electromagnetic induction inside a conductor which is faced by the magnetic fields which are time varying.They are used to enhance or decrease the AC voltages in electrical power applications.

In the transformer's primary winding, there is a varying current which produces a magnetic flux which is varying in nature inside the core of the transformer. Also, a varying magnetic field is produced on the secondary winding of a transformer. Due to this varying magnetic field at the secondary winding, a varying electromotive force (EMF) or voltage is produced in the secondary winding of the transformer which is due to the electromagnetic induction.

6. **RECTIFIER-**A rectifier can be defined as an electrical device which comprises of a number of diodes which convert AC current to DC current. A diode is a one way or unidirectional valve which allows the flow of electrical current in a single direction. This process of flow of current in a single direction is called as rectification. A rectifier can attain different shapes and physical forms such as solid state diodes, mercury arc valves, vacuum tube diodes, silicon controlled rectifiers and also some silicon based semiconductor switches.

There are a number of uses of rectifiers but they are generally used to serve as parts of DC power supplies and HVDC power transmission systems. The process of rectification may also be used in roles apart from generating direct current (DC) to be used as a source of power. It is to be noted, radio signal detectors are also used as rectifiers.

VI. WORKING

The method of Ferranti Effect compensation is used when we are charging the transmission line or, when there is very low load present at the receiving end. Due to the presence of no load or very low load, a small amount of current flows in the transmission line. Ferranti effect is caused in the transmission lines due to shunt capacitance. Due to the presence of Ferranti Effect,the receiving end voltage might become double than the sending end voltage (in case of medium and long transmission lines). In order to compensate, shunt inductors may be connected in the transmission line. A lead time is generated between the zero voltage pulse and the zero current pulse by a suitable operational amplifier circuit operating in the comparator mode and is fed to the two interrupt pins of the microcontroller and then the microcontroller program presides over to actuate the required number of opto-isolators interfaced with SCRs connected back to back on the output side to bring the shunt reactors into picture, that is, on the load side to compensate the voltage. The microcontroller which we have used in the project belongs to the 8051 family and it is an 8-bit microcontroller. The power supply comprises of a step down transformer 230/12 V, and it steps down the voltage to 12 V AC. This 12V AC is then converted to DC by the use of a bridge rectifier. The harmonics are flushed out using a capacitive filter. The voltages are then regulated to +5 V by the use of a voltage regulator.The 5 V supply is needed for the microcontroller and other components to operate.

VII. RESULT TABLE AND CALCULATION

Following are the result table shows the different voltages at different conditions:

NORMAL VOLTAGE (V)	INCREASED VOLTAGE DUE TO CAPACITANCE (V_I)	COMPENSATED VOLTAGE (V_C)
230	233	212
233	236	225
236	238	229

- **SURGE INPEDANCE**

For balance reactive power in transmission system,
$X_C=X_L$……………………………….……….1
$X_C=636.94\Omega$
From Equation 1 We Calculate Inductance,
L=0.0020284mH
Surge impedance=$\sqrt{\frac{L}{C}}$=636.93Ω

- **VAR PRODUCED**

$=V^2/X_C$
$=230^2/636.94=83.0533$var

- **SURGE IMPEDANCE LOADING**

$= V^2_{L-L}/X_L$
=77.37KW

VIII. PROPOSED SYSTEM

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IX. FUTURE SCOPE

The project can be improved by controlling the firing angle of the SCRs. Firing angle control methodology can be implemented for an efficient control of the voltage which is better than switching the reactors in steps where the control of the voltage is not very accurate and is also in steps.

X. APPLICATIONS

1. Mitigation of flicker
2. Control of power
3. Stability of steady state voltage
4. Generation cost reduction Application to HVDC link
5. Power system oscillation damping
6. Interconnecting distributed generation and storages.

XI. CONCLUSION

The project has been modified in order to implement FACTs using TSR(Thyristor Switched Reactor). This method is used when the transmission line is being charged or when a very low load is present at the receiving end. Since low load or no load is present, very small current can pass through to the transmission system and thus the shunt capacitance present in the transmission system becomes dominant.

Due to this, amplification of voltage takes place(known as Ferranti Effect) which results in the increase in voltage at the receiving end. The receiving end voltage becomes double as compared to the sending end voltage(in case of medium and long transmission lines). In order to compensate for the same, shunt inductors are introduced across the transmission line automatically.

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