Ferrenti Effect Compensation by Thyristor Switched Reactor (TSR) in FACTS

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Abstract— *The project is designed to implement FACTS by TSR (Thyristor Switch 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 (Ferranti Effect) due to which receiving end voltage may become double than the sending ends voltage (generally in case of very long transmission lines). To compensate this, shunt inductors are automatically connected across the transmission line.*

Keywords— TSR, FACTS

I. Introduction

A. Facts

A flexible alternating current transmission system (FACTS) is a system composed of static equipment used for the AC transmission of electrical energy.

It enhances the controllability of the system as well as the power transfer capability. FACT-system is very much efficient to reduce our existing problems and will increase both the power transfer capability and the techno-economic efficiency.

B. Ferrenti Effect

A long transmission line has a large capacitance. If such a line is open-circuited or connected to the very light load at the receiving end, the magnitude of the voltage at the receiving end becomes higher than the voltage at the sending end. This phenomenon is called Ferranti effect. When the voltage is applied at the sending end, the current drawn by the capacitance of the line is more than current associated with the load. Thus, at no load or light load, the voltage at the receiving end is quite large as compared to the constant voltage at the sending end.

C. TSR

To overcome the power quality problem of distribution system, we have number of power quality solution techniques by using FACTS controllers, which use newly available power electronics devices. TSR is one of them.

This method is used either when charging the transmission line, or, when there is very low load at the receiving end.

A shunt connected, thyristor-switched inductor whose effective reactance is varied in a stepwise manner by full- or zero conduction operation of the thyristor valve. Due to very low or no load a very low current flows through the transmission line. Shunt capacitance in the transmission line cause Ferranti Effect. The receiving end voltage may become double the sending end voltage (generally in case of very long transmission lines).

To compensate, Shunt inductors are connected across the transmission line.

II. Existing System

This effect is also overcome by this reactive power compensation technique. Reactive power is either generated or consumed in almost every component of the system, generation, transmission, and distribution and eventually by the loads. The impedance of a branch of a circuit in an AC system consists of two components, resistance and reactance. Reactance can be either inductive or capacitive, which contribute to reactive power in the circuit. FACTS has a lot to do with reactive power compensation, and indeed, that used to be the term utilized for the technology in the old days.

If we can minimize the flow of reactive power over the transmission system, we can make the system more efficient and put it to better and more economical use. To get the correct grid voltage, we need the right amount of reactive power in the system. If there is not enough reactive power, the voltage will sag. And vice versa, if there is too much of it, the voltage will be too high. So, to have it in the right amounts at all times, and in the right places of the grid, that is the task to be performed by means of Reactive Power Compensation. Reactive power (VAR) is required to maintain the voltage to deliver active power (watts) through transmission lines.

A. Disadvantage of Existing System

- Reactive power compensation has lagging power factor. But in present, we have required leading power factor.
- Reactive power compensation has more losses.
- The current carrying capacity is less in reactive power compensation, if we require more current then it will be uneconomical.

III. BLOCK DIAGRAM

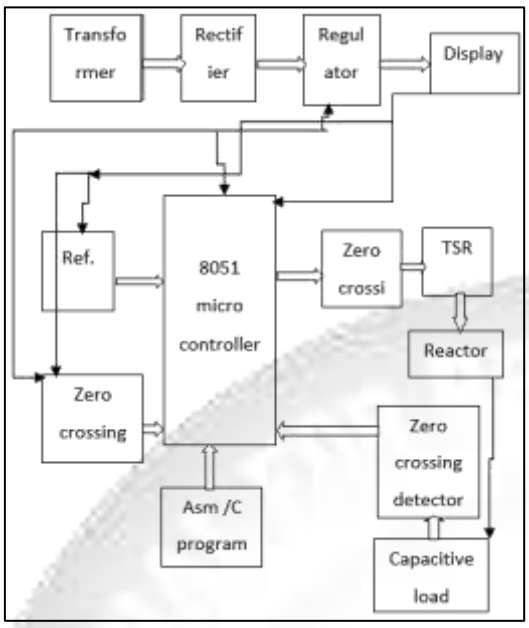

Fig. 1: Block Diagram

A. Components

1) Choke

In electronics, a choke is an inductor used to block higher-frequency alternating current (AC) in an electrical circuit, while passing lower-frequency or direct current (DC). A choke usually consists of a coil of insulated wire often wound on a magnetic core, although some consist of a donut-shaped "bead" of ferrite material strung on a wire. The choke's impedance increases with frequency. Its low electrical resistance passes both AC and DC with little power loss, but it can limit the amount of AC due to its reactance.

2) SCR

A silicon controlled rectifier or semiconductor-controlled rectifier is a four-layer solid-state current-controlling device. SCRs are unidirectional devices (i.e. can conduct current only in one direction) as opposed to TRIACs, which are bidirectional (i.e. current can flow through them in either direction). SCRs can be triggered normally only by currents going into the gate as opposed to TRIACs, which can be triggered normally by either a positive or a negative current applied to its gate electrode.

3) 8051 Micro Controller

Microcontroller is on chip true microcomputer. Intel 8051 is most popular microcontroller producing in world market. It has 64 kb external data memory, 64 kb program memory, and 256 bytes internal data memory. It increase reliability. Hardware is less because of single chip microcomputer. Smaller access time and speed is high.

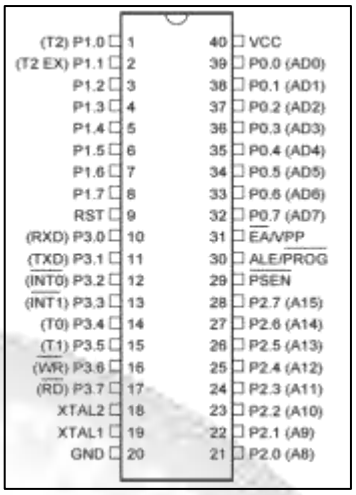

Fig. 3: 8051 Microcontroller

4) Transformer

A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. Electromagnetic induction produces an electromotive force within a conductor which is exposed to time varying magnetic fields. Transformers are used to increase or decrease the alternating voltages in electric power applications.

A varying current in the transformer's primary winding creates a varying magnetic flux in the transformer core and a varying field impinging on the transformer's secondary winding. This varying magnetic field at the secondary winding induces a varying electromotive force (EMF) or voltage in the secondary winding due to electromagnetic induction.

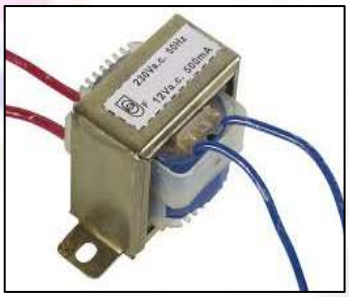

Fig. 4: Transformer

5) Voltage Regulator

A voltage regulator is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.

IV. RECTIFIER

A rectifier is an electrical device composed of one or more diodes that converts alternating current (AC) to direct current (DC). A diode is like a one-way valve that allows an electrical current to flow in only one direction. This process is called rectification. A rectifier can take the shape of several different physical forms such as solid-state diodes,

vacuum tube diodes, mercury arc valves, silicon-controlled rectifiers and various other silicon-based semiconductor switches.

Rectifiers have many uses, but are often found serving as components of DC power supplies and high-voltage direct current power transmission systems. Rectification may serve in roles other than to generate direct current for use as a source of power. As noted, detectors of radio signals serve as rectifier.

Fig. 5: Rectifier

V. WORKING

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 a very low current flows through the transmission line. Shunt capacitance in the transmission line cause Ferranti Effect. The receiving end voltage may become double the sending end voltage (generally in case of very long transmission lines). To compensate, shunt inductors are connected across the transmission line. The lead time between the zero voltage pulse and zero current pulse duly generated by suitable operational amplifier circuits in comparator mode are fed to two interrupt pins of the microcontroller where the program takes over to actuate appropriate number of opto-isolators interfaced to back to back SCRs at its output for bring shunt reactors into the load circuit to get the voltage duly compensated. The microcontroller used in the project is of 8051 family which is of 8 bit. The power supply consists of a step down transformer 230/12V, which steps down the voltage to 12V AC. This is improved to DC using a Bridge rectifier. The ripples are removed using a capacitive filter and it is then regulated to +5V using a voltage regulator 7805 which is required for the operation of the microcontroller and other components.

VI. PROPOSED SYSTEM

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 project is of 8051 family.

VII. FUTURE SCOPE

Further the project can be enhanced by using firing angle control methodology for smooth control of the voltage. Thus, this is better than switching reactors in steps where voltage control (also in steps) is not very precise.

VIII. APPLICATIONS

- Steady state voltage stability.
- Flicker mitigation.
- Power control.
- Damping of power system oscillation.
- Reducing generation cost.
- HVDC link application.
- Deregulated power system.
- Interconnection of renewable, distributed generation and storages.

IX. CONCLUSION

The project is designed to implement FACTS by TSR (Thyristor Switch 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 (Ferranti Effect) due to which receiving end voltage may become double than the sending ends voltage (generally in case of very long transmission lines). To compensate this, shunt inductors are automatically connected across the transmission line.

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