Review on Power Quality (Power Factor) Improvement Using FC-TCR

Deepank Agnihotri[1] and Dr. Samina E. Mubeen [2]

[1]M.tech Power System, Radha Raman Engineering College, Bhopal, M.P.

[2]Head of the Department of Electrical & Electronics, REC, Bhopal, M.P.

Abstract - The waveform of electric power at generation stage is purely sinusoidal and free from any distortion. power quality refers to maintaining a sinusoidal waveform of bus voltages at rated voltage and frequency, in this paper we discuss various issue related to power quality problem, give detail of main power quality problem their reason and their effect of our utility as well as consumer end. we also discuss how we can remove these power quality problem, and discuss about fects(fctcr) device ,their working and their advantage over other controller ,and discuss fuzzy logic controller for controlling fects device ,their advantage over other controller.

Keywords - Power Quality, Fuzzy Logic Controller, FC-TCR , FACTS.

I.   INTRODUCTION

Power quality basically means to maintain a sinusoidal waveform at rated voltage and frequency. but in present time due to the use of various sensitive non linear load such as adjustable speed drive , switched mode power supply , and many rectifier and inverter operation harmonics is generated in the system. These harmonic disturb the sinusoidal waveform of voltage and current .

The external mean of controlling of generation and absorption of reactive power is compensating device (shunt capacitor, series reactor) ,but present trend is to use power electronics device as a compensator due to their fast response and high current carrying capability. Flexible AC Transmission Systems (FACTS) technology is based on the use of power electronic controlled devices for allowing transmission circuits to be used to their maximum capability. The FACTS devices mainly used to control the flow of reactive power and hence control voltage, phase angle, and impedance of transmission line .

The SVG is a static var generator whose output voltage is varied so as to maintain or control specific parameter (voltagr,frequency) of the electric power system.SVG is a self sufficiently functioning device that draws controllable reactive current from an alternating power source thus svg

is a power amplifier that faithfully reproduce the reference signal at the desire power level..

In this paper FC-TCR is used as a shunt compensated device for controlling the power factor of the system. The current in the FC-TCR is varies by firing angle control of thyristor ,there are so many method for controlling the firing angle of thyristor like Boolean algebra but it require tough mathematical model and give slow response on the other hand Fuzzy logic controller Give the accurate and fast result and not require mathematical model.

Fuzzy logic is a branch of engineering that deal with the development of computer program based on the study of human intelligence and nature of human thinking. It is argued that human thinking does not always follows crispi yes or no logic (o,1 in Boolean logic) but it often vague uncertain indecisive or fuzzy.

II.   POWER QUALITY PROBLEM

Power quality mainly define as ,

"Any power problem manifested in voltage, current, or frequency deviations that result in failure or misoperation of customer equipment"[1]

1.1 CAUSE OF POWER QUALITY DETERIORATION

➢ Newer generation load equipment, with microprocessor based controls and power electronics device, these more sensitive to load variation.

➢ Natural causes like lightning, human mistake, falling tree branch on transmission lines or distribution feeders.

➢ Due to switch on or off large capacitor bank into the live system.

> ➤ Due to power electronic based load like invertors,ups etc.

> ➤ Due to use of adjustable motor drive, automatic gain control system.

1.2 TYPE OF POWER QUALITY PROBLEM

2.2.1 Transients

Transients ia a Surge that occure for very short time in the circuit ,

It can be classified into two categories,

> ➤ Impulsive transient-

It is a sudden, non–power frequency change in the steady-state condition of voltage, current, or both. It is unidirectional in polarity (primarily either positive or negative).[1]

> ➤ Oscillatory Transient-

An oscillatory transient consist of voltage or current whose instantaneous value changes polarity rapidly.

2.2.2 Long-Duration Voltage Variations

Long-duration variations encompass root-mean-square (rms) deviations at power frequencies for longer than 1 min. It can be either overvoltage or undervoltages. Overvoltage and undervoltages generally are not the result of system faults, but are caused by load variations on the system and system switching operations. Long-duration variations are typically displayed as plots of rms voltage versus time.[1]

2.2.3 Sustained Interruption

Voltage intruption for longer then 1 minut are often permanent and need human intervention to repaire the system to restoration.

Due to it supply intruded to utility for long time .

2.2.4 Short Duration Variation

Mainly caused by fault(short circuit)occure ,the load requiring high starting current is also responsible for short duration variation in the system.

It may be instantaneous ,mometary and temporary.

voltage drops (sags), voltage rises (swells), are two main type of short duration variation.

2.2.5 Waveform Distortion

It is defined as a steady-state deviation from an ideal sine wave of power frequency principally characterized by the spectral content of the deviation.[1]

 Types of waveform distortion

> ➤ DC offset-

The presence of a DC voltages and current in an ac system is called dc offset .

This can occure as a result of geometrical disturbance or electronic power convertor.[1]

> ➤ Harmonics-

Harmonics are sinusoidal voltages or currents having frequencies that are integer multiples of the frequency at which the supply system is designed to operate. [1]
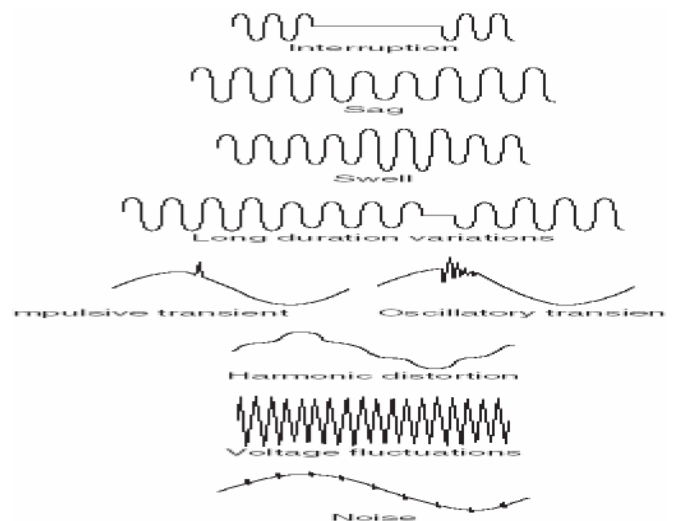

Fig 1 Wave shape during various types of power quality problem

2.3 SOURCES OF POWER QUALITY PROBLEMS

Major sources of power quality problems can be divided into two categories, depending on the location of the source in relationship to the power meter.

> ➤ Utility side of the meter includes, Switching operations, Power system faults, lightning.

> Other category is on the end-user side of the meter and includes Non-linear loads, Poor grounding, Electromagnetic interference, Static electricity.

2.4 EFFECTS OF POWER QUALITY PROBLEM

> The effects of power quality problems are many and varied. utility customer in an attempt to determine the cause of a power quality problem.

> However, most power quality problems manifest themselves as some effect on an end-user's electrical equipment.

> These symptoms include motors overheating, adjustable speed drives tripping off, computers shutting down, flickering lights, and stopped production.

> Effects of PQ problems can be best be understood by looking at the various types of loads that are affected by power quality problems, including computers, consumer products, lighting, meters, ferromagnetic equipment, telephones, manufacturing processes, and capacitors.

> Computers and computer-controlled equipment-freeze up and lose data. Most power quality problems on computers are caused by voltage variation.

III.   OVERVIEW OF FACTS CONTROLLER

It is necessary to operate power system effectively, without reduction in the systems security and quality of supply, even in the case of contingency conditions..   The compensator must be able to regulate the bus voltage for voltage support and improve transient stability, or control it for power oscillation damping . Capacitor generate or Reactor(inductor) absorb reactive power when connected to the ac power source. they have been used with mechanical switched for controlled var generation and absorption since the early days of Ac power transmission . continuous variable var generation or absorption for dynamic system compensation was originally provided by over or under exited synchronous machine and latter by saturating reactor in conjunction with fixed capacitor.[2]

The SVG is a static var generator whose output voltage is varied so as to maintain or control specific parameter (v,f) of the electric power system.SVG is a self sufficiently functioning device that draws controllable reactive current from an alternating power source thus svg is a power amplifier that faithfully reproduce the reference signal at the desire power level. SVG become SVc when it equipped with special external control which derive the necessary reference for its input from the operating requirement and prevailing variable of the power system to execute the desire compensation of transmission line.[2]

In 1980s the Electric Power Research Institute (EPRI) has introduced a new Technology known as Flexible AC Transmission System (FACTS). it overcome all the problem of mechanical controller and give reliable and high speed performance.

Due to use of these device controlling of reactive power and hence system voltage become very flexible and power transfer capability of line increase . Flexible AC Transmission system (FACTS) device are mainly used in present for controlling the power flow in the system. It control following parameter –

- Control of the Line impedance X i.e. with thyristor controlled series capacitor can provide a power ful means of current controlled.

- Control of angle with phase angle regulator which also control driving voltage ,provide a power ful means of controlling the active power flow.

- Control of reactive power with the help of FC-TCR ,hence control the system voltage up to desire level.[2]

3.1 TYPES OF FACT CONTROLLER

In general facts controller is divided into four categories.

Figure 2 shows the connection of different type of FACTS controller ,the working of these controller are as follows

3.1.1 Series Controllers

The series Controllers could be variable impedance such as capacitor, reactor or a power electronic based variable source. In principle all series controller injects voltage in series with the line as illustrated in Fig. 2(b). As long as the voltage is in phase quadrature with the line current, the series Controllers only supplies or consumes variable reactive power. [2]

Main series controller used in compensation network are

Thyristor controlled series capacitor(TCSC) , Thyristor switch series capacitor (TSSC) Thyristor controlled series reactor (TCSR) ,Static synchronous series comparator(SSSC)

3.1.2 Shunt Controllers

The shunt controller may be variable impedence , variable source, or combination of these.

In principle all shunt controller inject current into the system at the point of connection,as long as this current is in phase quadrature with the line voltage ,the shunt controller only supply and consume variable reactive power,any other phase relationship it also control real power .[2]

Main shunt controller used in compensation network are

Thyristor switched capacitor (TSC) , fixed capacitor thyristor controlled reactor(FC-TCR) Statcom, static var compensator (SVC)

3.1.3 Combined Series-Series Controllers

These are the combination of separate Series Controllers, which are controlled in a coordinated manner in multi line transmission system, as illustrated in Fig. 2(d).

This configuration provides independent series reactive power compensation for each line but also transfers real power among the lines via power link. [2]

Main series-series controller used in compensation network are

Inter Line Power Flow Controller (IPFC).

3.1.4 Combined Series-Shunt Controllers

These are combination of separate shunt and series controller, which are controlled in a co-ordinated manner Fig. 2(e) or a Unified Power Flow Controller with series and shunt elements Fig. 2(f). When the Shunt and Series FACTS Controllers are unified; there can be a real power exchange between the series and shunt controllers via power link.[2]

Main series-shunt controller used in compensation network are

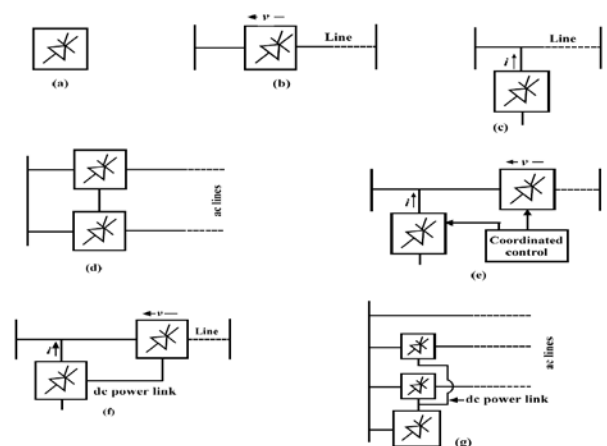Unified Power Flow Controller (UPFC).

Fig.2 Basic Types of FACTS Controllers : (a) general symbol for FACTS Controller, (b)series FACTS Controller, (c) shunt FACTS Controller, (d) unified series-series FACTS Controller, (e) coordinated series and shunt Controller, (f) unified series-shunt Controller, (g)unified Controller for multiple lines

3.2 STATIC VAR COMPENSATOR (SVC)

 Static Var Compensator provide fast –acting reactive power compensation in the system.

 The svc is an automated impedance matching device if the power system's reactive load is capacitive (leading), the svc will use reactors to supply VAR's to the system, bringing the system closer to unity power factor and lowering the system voltage. A similar process is carried out with an inductive (lagging) condition and capacitor bank's. Thus providing a power factor closer to unity and consequently a higher system voltage svc's are used both on bulk power transmission circuits to regulate voltage and contribute to steady state stability. They also are useful when placed near high and rapidly varying loads, such as are furnaces, where they can smooth flicker voltage.[2]

Static var generator (SVG) is a self sufficiently functioning device that draw controllable reactive current from an alternating power source ,the functional use of SVG is to provide a reference signal.

A static var generator become static var compensator when it is equipped with special external control which drive the necessary reference for tis input,from the operating requirement of power system to execute desire compensation to transmission line.[2]

Following are the SVS system mainly used in system

Thyristor controlled and thyristor switched reactor (TCR),thyristor switched capacitor(TSC),fixed capacitor thyristor controlled reactor(FC-TCR

3.3 PRINCIPLE OF FC-TCR

As shown in fig 3, the FC-TCR mainly consist of shunt connected reactor ,controlling of reactor is done by thyristor ,a fixed capacitor also connected parallel to thyristor controlled reactor . The current in rector varied by varying the firing angle of thyristor i.e. it depend upon the firing angle of thyristor,whereas fixed capacitor are work as a filter network which have necessary capacitive impedance so it generate the desire reactive power. it also provide low impedance at selected frequency to suppress harmonic produce by TCR.[2]

The Current in reactor is varied by firing angle control of thyristor. The fixed capacitor in practically is usually substituted fully or partially by a filter network that has the necessary capacitive impedance at the fundamental frequency to generate the required reactive power , but it provide the low impedance at selected frequency to shunt the dominant harmonics produce by tcr.[2]

From fig 4 the constant capacitive var generation of the fixed capacitor (Qc)is opposed by variable var absorber of the thyristor controlled reactor(Qr) to yield the total variable output (Q)required. At the maximum capacitor var output the TCR is off (α=90) to decrease the capacitive output the current in reactor is increase by decreasing firing angle(α) at zero var output inductive current =capacitive current and then capacitive and inductive var cancel out.

 With the further decreasing of firing angle inductive current became larger then capacitive current resulting in the net inductive output.at zero firing angle TCr conduct current over the full 180 resulting the maximum inductive var output that is equal to difference between var generated by the capacitor and those absorbed by fully controlled reactor .

FCTCR type var generator can be considered as a controllable reactive admittance which when connected to ac system , faithfully follow 9within a given frequency band and within a specific capacitive and

inductive rating) an arbitrary input (reactive admittance or current) reference signal.

Fig 5 shows the V-I characteristics ,the operating area of FC-TCR is define as the maximum attainable capacitive and inductive admittance and by the voltage and current rating of major power component .[2]
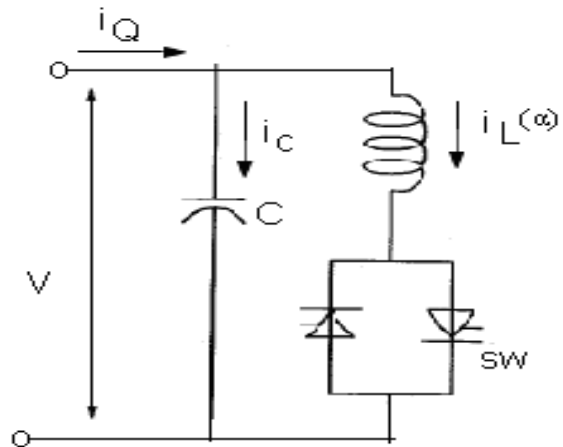

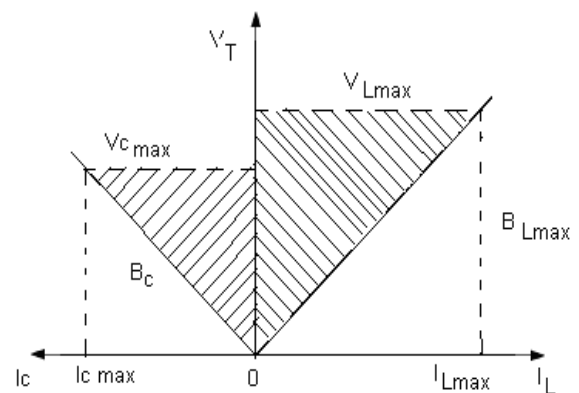Fig 3 FC-TCR type static generator

Fig 5 V-I   Characteristics of the FC-TCR

IV.   PRINCIPLE OF FUZZY LOGIC CONTROLLER

Fuzzy logic is a branch of engineering that deal with the development of computer program based on the study of human intelligence and nature of human thinking.

It is argued that human thinking does not always follows crispy yes or no logic (o,1 in Boolean logic) but it often vague uncertain indecisive or fuzzy.

Fuzzy logic has recently been applied in process control modelling estimation identification diagnostic stock market prediction , agriculture , military service etc.

In fuzzy set based on fuzzy logic a particular object a degree of membership in a given set that may be anywhere in the range of 0 to 1 .[10]

Fuzzy variable for temperature can be defined by qualifying linguistic variable (cold, mild, hot) fuzzy variable for speed (slow , medium ,high) for water level tank low,mediam,high.

Boolean Algebra – cold ,mild, hot

Fuzzy Logic Controller – zero ,very cold, medium cold. medium hot, very hot

If temperature below 10 it belongs completely to set cold(that is the membership function mf value is 1),wherever for 18 it is in the set cold by 60 % (mf=0.6) and to the set mild by 20 (mf=0.2) for 25 it is completely set mild (mf=10 as membership function for cold is zero.

Drawback of conventional l control is the requirement of mathematical model of the plant. the plant can be represented by transfer function of state space model.

In some cases the plant model can be developed very easily however it is not true for all the ease as there are many which are vague in nature .

For example mathematical model for washing machine or share market prediction can not be represented by simple equation .hence convention control model are suitable for application where standards model exist or can be developed easily.

Advantage of fuzzy =

1) It is based on human thinking and linguistic variable and does not require accurate mathematical model .

2) It is based on simple linguistic information and hence it is easy to understand.

3) It can work with imprecise input generally most of the input in real life is imprecise.

4) It can handle nonlinearty as it is difficult to model mathematic

As we know that reactive power injected into the system,is controlled by magnitude of reactive power absorbed by TCR .and the generation and absobtion of reactive power is control by controlling the delay angle of thyristor.

FC-TCR with fuzzy controller is able to maintain the power factor always constant at receiving end under normal condition as well as at large inductive load and does not effected with load variations.[10]

The importance of fuzzy logic derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature. In doing so, the fuzzy logic approach allows the designer to handle efficiently very complex closed-loop control problems. There are many artificial intelligence techniques that have been employed in modern power systems, but fuzzy logic has emerged as the powerful tool for solving challenging problems. As compared to the conventional PI, PID controllers, and their adaptive versions.[10]
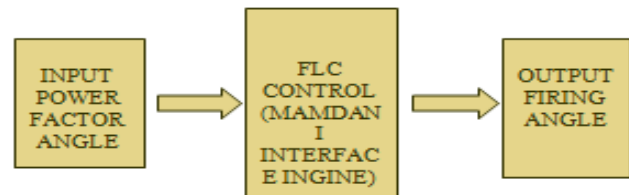

Fig 6 Fuzzy logic Controller

V.   CONCLUSION

From the above discussion it is clear that power quality is main issue in present time, due to various reason like non linear load, deregulation, and congestion quality of power is degraded. Hence for effectively used of our devices power system should be secure   properly. The FACTS devices is controlled the reactive power flow in power system , hence improve voltage stability in the system and quality of power improve. It is also clear that fuzzy logic controller has many advantage over other controllers , if we used fuzzy logic controller for controlling the firing angle of svc system, then it give the effective and fast response.

VI.   REFERENCES

[1]   "Electrical Power Systems Quality" R.C dugan, McGraw-Hill Companies.

[2]   Narain G. Hingorani, ―Understanding FACTS, Concepts and Technology Of Flexible AC Transmission Systems, by IEEE Press USA.

[3]   K.R. Padiyar , hvdc transmission system , Wiley eastern limited, new Delhi , india,1990

[4]   T.J.E. Miller, Reactive Power Control in Electric Systems, John Wiley (New York), 1982.

[5]   R.M. Mathur, Editor, Static Compensators for Reactive Power Control, Canadian Electrical Association, Cantext Publications, Win- nipeg, 1984

[6]   K.R.Padiyar and R.K.Varma, \Concepts of Static Var System Control for Enhancing Power Transfer in Long Transmission Lines", Electric machines and Power Systems, v.18, 1990, pp.337-358

[7]   K. R. Padiyar and R.K. Varma, \Damping Torque Analysis of Static Var System Controllers", IEEE Trans., Power Systems, v.6, n.2, 1991, pp.458-465

[8]   P. Kundur, "Power System Stability and Control", McGraw-Hill, 1994.

[9]   Y. H. Song and A. T. Johns, "Flexible ac transmission systems (FACTS)", The Institute of Electrical Engineers, London, 1999.

[10]   Modeling and Simulation using Matlab Simulink,Dr. Shailendra Jain.

[11]   Puranik Sahu "Voltage Stability Improvement using Static VAR Compensator With Fuzzy Controller in Power Systems" Department of Electrical Engineering ,Jabalpur Engineering College VSRD International Journal of Electrical, Electronics & Communication Engineering, Vol. 3 , 2(5): May, 2013.

[12]   G. Vishwakarma and N. Saxena "Enhancement of Voltage Profile by using Fixed Capacitor- Thyristor Controlled Reactor (FC-TCR)"Department of Electrical Engineering, Jabalpur Engineering College Jabalpur, (MP) International Journal of Electrical, Electronics ISSN No. (Online): 2(2): june-2013.

[13]   Ms. Shilpa Gupta "Reactive Power Control Using FC-TCR"Inderprastha Engineering College, Ghaziabad, India (IJITR) International Journal Of Innovative Technology And Research Volume No. 1, Issue No.

[14]   Durga Prasad Alampalli "REACTIVE POWER CONTROL BY STATIC VAR COMPENSATION" Department of Electrical Engineering, p.v.p.siddhartha institute of technology, India

[15]   N.V. Srikanth, R.S. Dhekekar "Design, Modeling and Simulation of Fuzzy Controlled SVC" Assistant Professor in the Department of Electrical and Electronics Engineering, National Institute of Technology, Warangal, India

[16]   Simulation and Comparison of Various FACTS Devices in Power System S.Sankar Assistant Professor in the Dept.of EEE, Lord Venkateswara Engineering College, Pulliyambakkam, TamilNadu. S.Balaji.

[17]   Shunt Compensator As Controlled Reactive Power Sources Robert Kowalak / Gdańsk University of Technology Robert Małkowski / Gdańsk University of Technology.

[18]   Design, Modeling and Simulation of Fuzzy Controlled SVC for 750 km (λ /8) Transmission Line N.V. Srikanth, R.S.Dhekekar Student Member IEEE, and M.Praveen Kumar.