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Expert (Fuzzy Logic) System Approach for Better Power Distribution

M.Karthikeyan, Email: mkarthi.phd@gmail.com.
G.Rajalakshmi, Email: rajarasi26@yahoo.co.in

Abstract

Meeting the increasing demand for the electrical power without changing the existing infrastructure is a challenging issue. The transmission and the distribution are always struggling with losses in our ac power system networks. In this research an intelligent fuzzy logic approach is to be used for power system operation and control in distribution management. The VAR compensating devices like OLTC, SVC are to be controlled by the fuzzy expert system for modifying reactive power. The fuzzy membership functions, fuzzy rules are to be displayed. A co-ordination control between these VAR compensating devices using fuzzy logic control is to be discussed. An optimum location and the proper design of a capacitor banks for reducing the harmonic injection in the power system is to be suggested. The validity of this approach is to be given by the comparison graphs. All the simulations are to be carried out by MATLAB software. This research will investigate the effects of arising problems in an ac power system distribution without changing the existing infra structure. The various types of problems arising in a power system are to be listed. Among these the voltage stability in the buses has got the top priority. The solutions for reducing the power congestion created by these arising problems can be carried out.

Keywords

Reactive power compensation, Distribution generation, voltage control, FACTS, OLTC, SVC, STATCOM and fuzzy logic system

1. Importance of proposed topic

In rural electricity supply in India has been lagging in terms of service as well as penetration. Only 31% of the rural households have access to electricity, and the supply suffers from frequent power cuts and high fluctuation in voltage and frequency, resulting blackouts.

The demand supply gap is currently 7.8% of average load and 13% of peak demand at current prices, which are heavily subsidized, on average. For reduce the gap one way is to increase the generation capacity, it require a huge investment including the investment in transmission and distribution. The poor economical status of the utilities cannot implement to do this process immediately, because they have been struggle with a lack of revenue collected by the consumers. This is due to a skewed tariff policy of our state governments subsidizing the power supplied to agricultural consumers. In some states the power is free to agricultural subscribers. The electricity supply has been not metered for these subscribers, provides for wasteful consumption and theft. In our country agricultural consumption is over 30%of total consumption. The transmission and distribution losses are over 25% which are due to both technical and theft.

Considering the above facts made the topic become very vital, at least for reducing the technical problems without changing any infrastructure of our country power system distribution network.

1.1 Objectives of the Proposed Topic

The main aim of this research is to enhance the voltage stability using the co-ordination of VAR compensating devices controlled by fuzzy expert system. Fuzzy rules will be developed for the operation of OLTC, SVC and the Switching capacitor banks. Here fuzzy is used for its fast and accuracy only. This will reduce the distribution losses, and maintaining the desired voltage level in our power distribution.

2. Present situation of an ac power system distribution network in India

Rural electricity supply in India has been suffered with voltage stability and power quality problems. Only 31% of the rural households have access to electricity, and the supply suffers from frequent power cuts and high fluctuations in voltage and frequency, with so-called block outs and brownouts. The demand-supply gap is currently 7.8% of average load and 13% of peak demand at current prices, which are more subsidized, on average. In order to bridge this gap and meet anticipated growth, it is necessary to double the present capacity, i.e., install an additional generation capacity of 100,000MW by 2012. This would require a huge investment- s including transmission and distribution. It is merely not possible due to the poor financial status of our utilities due to their lack of revenues due to their poor tariff policy of our state government. Of the total power generated, only 55% of kilowatt-hours are billed and only 41% of this is collected.

In Tamilnadu, the power is free for agricultural subscribers. This coupled with the fact that the electricity has been supplied to irrigation pumps is not metered, provides for wasteful consumption and theft. Agricultural consumption is over 40%of the total demand in our State. Transmission and distribution losses are merely 40%. These losses are due to both technical problems and theft. The old power equipments used for irrigation always operate with a poor power factor causes problems in an ac power system.

For industrial and commercial consumers our government tariffs Policy, will made them, to go for capacitive power generation for their inductive loads. This is achieved by using diesel generators. In Tamilnadu, our Electricity board will not found any solution for agricultural loads in rural areas. If our utility trying to billing for agriculture, suddenly they would like to face the consequence of all formers and politicians opposition.One more major problem is conventional incandescent lamps which are largely used in rural areas in our country. These lamps commonly cause an increasing energy demand around rural areas. Discussions have been done for replacing these lamps with compact fluorescent lamps (CFL). This will commonly reduce the electricity bills of consumers and also will reduce the energy demand considerably. In the country Iran there is a subsidy for using CFL. But CFL will cause some crucial problems in network. They have been suffered with poor power harmonic injection to the network. Some buses are more sensitive to nonlinear loads like CFL.

2.1 Some identified problems in an ac power system

The common problems arising in an ac power system are:

- Poor power quality.
- Voltage unbalance.
- Transmission line losses.
- Harmonics generated by non linear loads, power electronic control devices.
- Centralized generation.
- Long transmission lines.
- No integration of renewable energy sources.
- Long grids (No micro or smart grids).
- Poor grid capacity.
- High power rapid impact loads.
- Assymetrical impact loads.
- Inevitable power system faults.
- Old equipments in agricultural fields, Industrial fields.
- Switching transients.
- Poor power factor maintained by customers.
- Negative sequence currents.
- Power swings.
- Natural causes like storms, lightning etc.,
- Theft (nearly 20% in India).
- Manual mal operation of devices.

Considering the above power network area problems, maintaining the desired voltage level in buses is a challenging issue. Normally voltage and reactive power are inter-related. Modifying reactive power will maintain the desired voltage buses as well as in transmission lines.

2.2 Sorting the Problems

These problems can affect the power system performances. These problems are especially related with power quality issues, since most of the power quality problems can be attenuated or solved with an adequate control of reactive power.

In general, the problems of reactive power compensation are viewed from two aspects: loads compensation and voltage support. In load compensation the objectives are to increase the value of the system power factor, to balance the real power drawn from the ac supply, compensate voltage regulation and to eliminate current harmonic components produced by large and fluctuating non linear industrial loads. Voltage support is generally required to reduce voltage fluctuation at a given terminal of a transmission line. The reactive power compensation in transmission systems also improves the stability of the ac system by increasing the maximum active power that can be transmitted. It also helps to maintain a substantially flat voltage profile at all levels of power transmission. Series and shunt VAR compensation are used to modify the electrical characteristics of ac power systems. Series compensation modifies the transmission or distribution system parameters, while shunt compensation changes the equivalent impedance of the load. In both cases, the reactive power that flows through the system can be effectively controlled improving the performance of the overall ac power system.

2.3 Traditional Methods

Traditionally, reactive power can be compensated by:

- Generator excitation regulation.
- Reconfiguration of system structure.
- Synchronous compensator.
- Change of voltage by transformer tap to adjust the power flow in the grid (OLT C).
- Series compensation capacitor.
- Switching in/out of the shunt reactor or shunt capacitor.
- Magnetic controlled reactor

3. Importance of reactive power compensation

VAR compensation is defined as the management of reactive power to improve the performance of an ac power system. The concept of VAR compensation embraces a wide diverse field of both system and customer problems, especially related with power quality issues, since most of power quality problems can be attenuated or solved with an adequate control of reactive power. In general, the problem of reactive power compensation is viewed from two aspects: load compensation and voltage support. In load compensation the objectives are to increase the value of the system power factor, to balance the real power drawn from the ac supply, compensate voltage regulation and to eliminate current harmonic components produced by large and fluctuating non linear industrial loads.

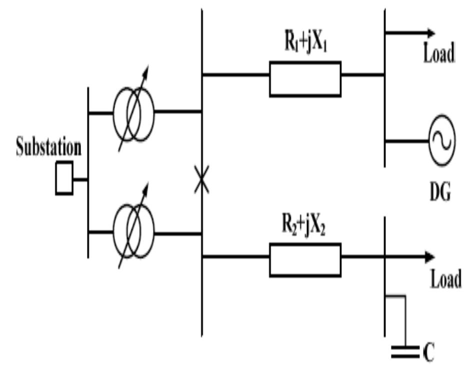

Fig 1.Simple System for Voltage control

Voltage support is generally required to reduce voltage fluctuation at a given terminal of a transmission line. Reactive power compensation in transmission systems also improves the stability of the ac system by increasing the maximum active power that can be transmitted. It also helps to maintain a substantially flat voltage profile at all levels of power transmission. It improves HVDC conversion terminal performance, increases transmission efficiency, controls steady-state and temporary over voltages, and can avoid disastrous blackouts.

3.1 Basic compensations to modify reactive power

Series and shunt compensation are used to modify reactive power. Series compensation modifies the transmission or distribution system parameters, while shunt compensation changes the equivalent impedance of the load. Generally loads are inductive in nature, needs a capacitive VAR compensation. In normal practice, Shunt capacitors with suitable reactive power limits are the excellent choice connected with buses to be maintained with suitable voltage profile.

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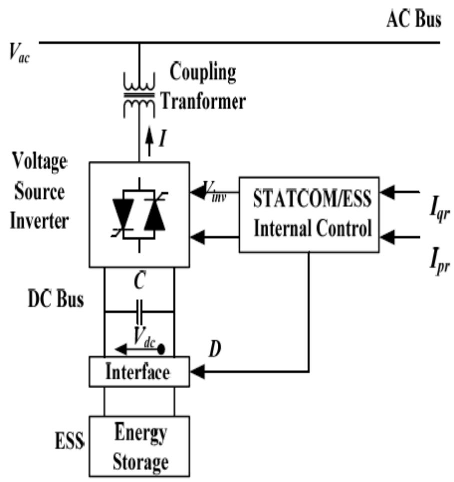

Fig 2. Statcom for reactive power compensation

Commercially they are known as capacitor banks placed at a substation in a distribution network system. They are economical with suitable life period for some years. In rural areas in India, shunt capacitor bank is a best choice for modifying reactive power. Also they have been eliminated the harmonics generated in an ac power system.

4. FACTS devices

Nowadays FACTS (Flexible AC Transmission System) devices are also been used in some places. They are very fast devices controlled by thyristors with suitable reliability [6]. In our India, especially in rural areas, these devices will be an excellent choice. But there is a difficulty of using these devices in our existing infrastructure of our power system in rural areas. It will need some initial investment to change our infrastructure.

Our Tamilnadu Electricity Board doesn't have the ability to change all our distribution networks in rural areas due to the lack of revenues. Statistics have been shown a number of rupees 40,000 crores (1$=57 rupees) is found as a loss per year. These above facts made a traditional compensation device like a shunt capacitor is our only economical as well as a best choice for rural networks for modifying reactive power.

Modern society has relied consistently on electrical power, requiring higher demands of power stability and power quality. High-power rapid impact loads, rapid growth of asymmetrical impact loads. E.g. electrified railway, increase in distributed wind power generation equipment, connections/disconnections of large load and inevitable power system faults, are adverse factors which can lead to considerable reactive disturbances in power system and affect power stability, power quality and economy of power grid operation. The over current and overvoltage sequences caused by these disturbances may damage the associated electrical apparatus.

To solve this problem, it is essential to adjust reactive power in the power grid expeditiously to achieve a reasonable power flow distribution, which is also very important in phase modulation, voltage regulation and over voltage restriction.

The traditional reactive power regulation methods before the invention of SVC are:

- Reconfiguration of system structure
- Generator excitation regulation
- Synchronous compensator
- Change of voltage by transformer tap to adjust the power flow in grid
- Series compensation capacitor
- Switching in/out of the shunt reactor or shunt capacitor
- Magnetic control reactor

Compared to these traditional reactive power compensation methods, the Static Var Compensator (SVC) has extensively gained a significant market value. This is as a result of its efficiency in supplying dynamic reactive power with fast response time and low-cost maintenance scheme.

The Static Var Compensator has different application topology, such as Thyristor Controlled Reactor (TCR), Thyristor Switched Capacitor (TSC), Thyristor Switched Reactor (TSR), and Breaker Switched Capacitor (BSC).The SVC mentioned is composed of TCR and BSC and also it deals with the need of SVC for power transmission, Distribution System, Wind power plant, Industrial consumers. The operating principle of SVC and the system configuration were explained. The functions and features are also discussed

4.1 OLTC

The other devices for modifying reactive power are the OLTC (On Load Tap Changer) and the distribution transformers with taps are commonly used in our ac transmission system. It is well known that the operation of on-load tap changers (OLTC s) has a significant influence on voltage instability. In fact, most of the current literature has concentrated on the contribution of OLTC s to voltage collapse. Faced with the evolution of the power system and operating condition, a better management of the voltage profiles and reactive power is essential in order to improve the power system security and reactive power resources utilization. It consists of three levels, which are tertiary voltage control, secondary voltage control and primary voltage control.

The primary voltage control involves keeping generator stator voltages at their set point values, by means of control actions of automatic voltage regulators (AVR) installed on generators. At this level control devices attempt to compensate rapid and random voltage variation by keeping generator terminal voltages equal to the set point values updated by the secondary control. The response time is in the range of seconds. The main objective of secondary control is to adjust and to maintain the voltage The main objective of secondary control is to adjust and to maintain the voltage profiles inside a network area. The controller of this level responds slow and large voltage variations. The time constant is in the range of minutes. Control actions in this level are carried out by VAR compensation devices like capacitors, synchronous generators, reactors, static compensators, OLTC transformers.

Every kind of compensation device has its unique control capability and characteristics. Generator can be adjusted continuously without the limit of adjustment number. Its response to the reactive power and voltage disturbance is fast. Shunt capacitors/reactors are used for flatting load conditions along the daily load curve, and OLTC transformers are used for improving reactive power distribution. The numbers of switching control of capacitors/reactors and adjusting of OLTC transformers are limited and their responses to the disturbance are slow.

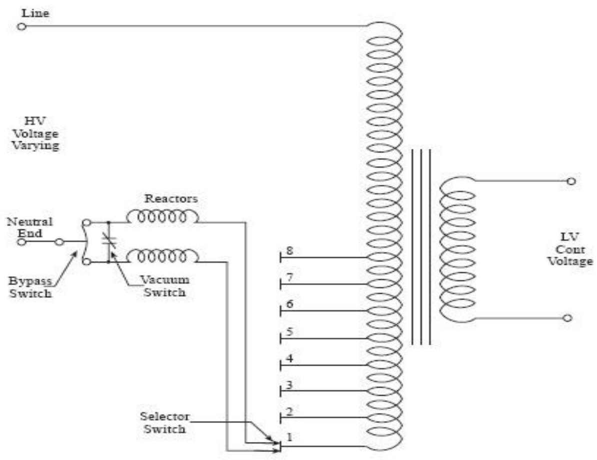

Fig 3. On load tap changer for reactive power compensation

OLTC is a single winding transformer, if you changing the tap position in OLTC at the time of violation of voltage profile in secondary of the OLTC. Simultaneously voltage variations occur in primary side of the OLTC but recently that variation has care taken by National Grid. We can't interrupt in primary side. In this research, a secondary voltage intelligent control method and implement based on fuzzy expert system is presented in order to augment voltage security and stability.

4.2 Why SVC?

A set of SVC system can be used to generate a constant varying inductive and capacitive reactive power with fast response time. So far, SVC system has been extensively used in electric power system and industrial loads.

In long distance transmission line, due to Ferranti effect, the voltage in the middle of transmission line will rise which will limit the transferred power. For solving this problem, the SVC is installed at the middle point or several points in the middle of transmission lines. Also the SVC can be connected to the terminal substation in the power distribution system.

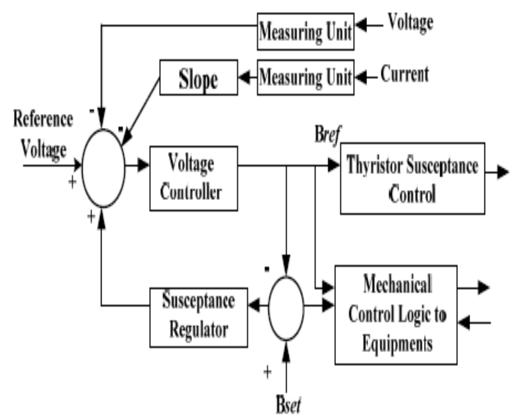

Fig 4.SVC for reactive power compensation

Benefits

- Regulates the system voltage.
- Increase the static stability and transient stability of power system.
- Increase the line transmission capacity.
- Restrain the power oscillation and the sub-synchronous resonance.
- Restrain the transient over voltage.
- Balance the three phase voltage.
- Control the voltage in DC converter station and provide reactive power.
- Reduce the reactive power exchange with system and improve system stability.
- Rapid and continues compensation of the reactive power, increase in the power factor and improvement in the power quality.
- Reduction in the power losses of distribution system.
- Used in combination of stepped-switchover capacitor bank to reduce the damage caused by frequent switching of capacitor bank.

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4.3 Expert systems (Fuzzy logic control)

The main contribution of the research is maintaining the system voltage, using fuzzy control logic. This thesis will give some idea for controlling voltage in buses, reducing distribution losses, improving load side power factor. It provides a solution for technical problems always arising in a power system. Intelligent systems methods help provide an additional tool in the development of applications for distribution power systems. These intelligent systems help model parts of the process that do not lead themselves to large numerical programs. Examples include dealing with uncertainty and heuristic applications. This summary outlines efforts to incorporate intelligent system techniques into distribution outage management. These efforts include using fuzzy logic to filter multiple sources of information related to outages as well as knowledge-based system to identify the location of an outage and then verify the outage status using meter polling. Such techniques allow us to process additional data providing more real-time analysis techniques for distribution systems.

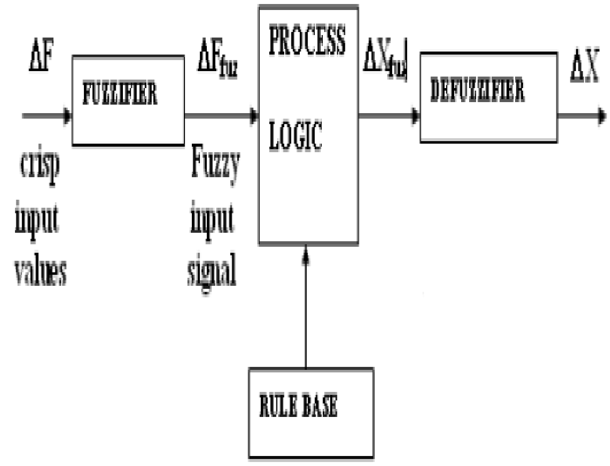

Fig 5. Structure of fuzzy load flow controller.

In order to realize optimal distribution between two types of energy in hybrid electric vehicle (HEV) and assure the reasonable operation of motor and battery, an optimal method based on energy fuzzy control strategy is presented. The proposed energy fuzzy control strategy is modeled in SIMULINK and incorporated into the vehicle simulation software ADVISOR. Then, to the lack of the traditional method of getting membership function and fuzzy rules, it is presented that using the genetic algorithm optimizes the membership function of the original fuzzy logic controller. Finally, using simulation compares the optimized fuzzy logic controller and the original fuzzy logic controller, and the results show that the optimized fuzzy logic control strategy is effective in improving the fuel economy of HEV. The results are provided for the feasibility of the technique includes fuzzy load flow solution for base and critical cases.The voltage stability is checked by formulating an index and the corresponding uncertainties input parameters are efficiently modeled in terms of fuzzy sets by using triangular membership function.

5. Conclusion

Collecting some substations data for a period of time duration and a proper analyzing the data is to be carried out. Fuzzy membership functions are to be developed. The fuzzy rules are then to be written for the individual and the co ordination of VAR compensating devices like OLTC, SVC and the switching capacitors etc.All these things are carried out by using MATLAB software only. The comparison between the fuzzy expert system and the conventional methods is to be displayed for the validity of this approach.

6.References

[1]. Anshu Bharadwaj and Rahul Tongia, Member IEEE, *"Distributed Power Generation: Rural India – A Case Study"*.

[2]. Mark Ndubuka NWOHU," *Voltage Stability Improvement using Static Var Compensator in Power Systems"*, Leonardo Journal of Sciences", Issue 14, 2009,p.167-172.

[3].S.K. Khadem, M.Basu and M.f. Conlon, *"Power Quality in Grid connected Renewable Energy Systems: Role of Custom Power Devices"*, International Conference on Renewable Energies and Power Quality ,2010.

[4].Adrian Timbus, Alexandre Oudalov and Carl N.M.Ho, " *Islanding detection in smart grids"*, IEEE transactions on power systems, 2010.

[5].A. Jefferson, *"Adaptive VAR Compensation –A Real Solution to Reactive Power Problems"*, IEEE Canadian Review-Autumn/Automne 1999.

[6]. *"Advanced Control Methods"'* , Conducted by the National Energy Technology Laboratory for the U.S. Department of Energy Office of Electricity Delivery and Energy Reliability, March 2007.

[7].Felix F. Wu, Khosrow Moslehi, Anjan Bose, " *Power System Control Centers: Past, Present, and Future*", Proceedings of the IEEE, Vol93, No.11, November 2005.

[8].Juan Dixon, Luis Moran, Jose Rodriguez, Ricardo Domke," Reactive Power *Compensation Technologies,, State – of – the- Art Review"*, Proceedings of the IEEE, 2011.

[9]. *"Solutions for Static VAR Compensator*", NR Electric Corporation Brochure

[10]. Yan Liu, NoelN.Schulz, " *Intelligent System Applications in Distribution Outage Management"proceedings* of IEEE, 2002.

[11]. Wang Yifeng, Zhang Yun, Wu Jian, Chen Ning, " *Energy management System Based on Fuzzy Control Approach for Hybrid Electric Vehicle*", IEEE transactions, 2009.

[12]. K.S.Pandya, S.K.Joshi," *A Survey of Optimal Power Flow"*, Journal of Theoretical and Applied Information Technology, 2008.