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Power Quality Improvement using FC-TCR (SVC) with Fuzzy Logic Controller

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Abstract

To transmit or distribute fixed amount of power at fixed voltage, the conductor have to carry more current at low power factor. This necessities a large conductor size. The large current at low power factor cause more copper loss in power system as well as increase kva rating of equipments. This low power factor also cause poor voltage regulation and reduce power handling capacity of power system. All these problems can be removed by static var compensator (svc). Fixed capacitor thyristor controlled reactor can be used for power factor correction, flicker reduction, and steady-state voltage control, and also have the benefit of being able to filter out harmonics from the system. In this paper FC-TCR with fuzzy logic controller is simulated using Matlab simulink.

Keywords: voltage stability, fuzzy logic controller, FC-TCR, power factor, power quality

Introduction

Power quality is one of the most important issues in power system. Harmonics is generated in power system is due to various sensitive load such as fluorescent lamp, rectifier or inverter operations, adjustable-speed drive, PWM pulse-width modulation, switch-mode power supply etc. Harmonic currents produced by nonlinear loads can interact adversely with the utility supply system. A nonlinear device is one in which the current is not proportional to the applied voltage . The interaction often gives rise to voltage and current harmonic distortion observed in many places in the system. Electronic power converter loads with their capacity for producing harmonic currents now constitute the most important class of nonlinear loads in the power system. Advances in semiconductor device technology have fueled a revolution in power electronics over the past decade, and there is every indication that this trend will continue. Equipment includes adjustable-speed motor drives, electronic power supplies, dc motor drives, battery chargers, electronic ballasts, and many other rectifier and inverter applications. A major concern in commercial buildings is that power supplies for single-phase electronic equipment will produce too much harmonic current for the wiring. DC power for modern electronic and microprocessor- based office equipment is commonly derived from single-phase full-wave diode bridge rectifiers. The percentage of load that contains electronic power supplies is increasing at a dramatic pace, with the increased utilization of personal computers in every commercial sector [1].

Voltage sags and interruptions are related power quality problems. Both are usually the result of faults in the power system and switching actions to isolate the faulted sections. They are characterized by rms voltage variations outside the normal operating range of voltages. Voltage *sag* is a short-duration (typically 0.5 to 30 cycles) reduction in rms voltage caused by faults on the power system and the starting of large loads, such as motors. Momentary interruptions (typically no more than 2 to 5 s) cause a complete loss of voltage and are a common result of the actions taken by utilities to clear transient faults on their systems.

An *overvoltage* is an increase in the rms ac voltage greater than 110 percent at the power frequency for a duration longer than 1 min. Over-voltages are usually the result of load switching (e.g., switching off a large load or energizing a capacitor bank). The over-voltages result because either the system is too weak for the desired voltage regulation or voltage controls are inadequate. Incorrect tap settings on transformers can also result in system over voltages. An *under-voltage* is decreases in the rms ac voltage to less than 90 percent at the power frequency for duration longer than 1 min. Under-voltages are the result of switching events that are the opposite of the events that cause over voltages. A load switching on or a capacitor bank switching off can cause an under voltage until voltage regulation equipment on the system can bring the voltage back to within tolerances. Overloaded circuits can result in under voltages also. [1]

All the above power quality problems can be over come by using fixed capacitor thyristor controlled reactor. And the firing angle of FC-TCR is controlled by supplementary controllers
That may cause flexible operation of thyristor.

Research Methodology

I. Control Concept oF SVC

The control concept of svc is based on controlling of shunt susceptance (B) which can be controlled by changing the firing angle of thyristor Fig. 1 illustrates a TCR SVC, including the operational concept. The control objective of the SVC is to maintain a desired voltage at the high-voltage bus. In the steady-state, the SVC will provide some steady-state control of the voltage to maintain it the high-voltage bus at a pre-defined level. If sudden load is increased the high-voltage bus begins to fall below its set point, in such a condition the SVC will inject reactive power (Qnet) into thereby increasing the bus voltage back to its net desired voltage level. If load is falls suddenly, then bus voltage increases, the SVC will (thyristor controlled reactor) will absorb reactive power, and the result will be to achieve the desired bus voltage. From Fig. 1, +Qcap is a fixed capacitance value, There fore the magnitude of reactive power injected into the system, Qnet, is controlled by the magnitude of –Qind reactive power absorbed
by the TCR

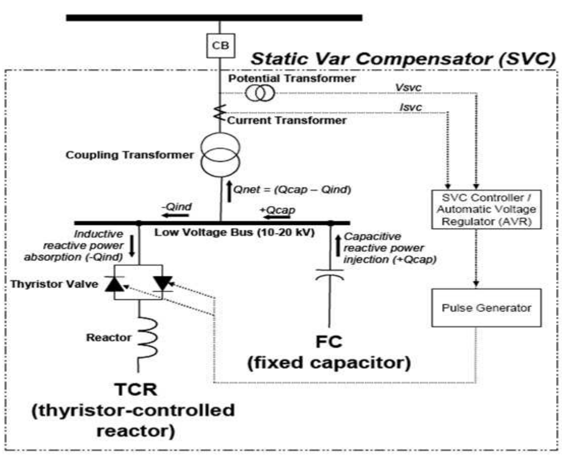

Fig.1: SVC with control concept

SVC is simulated by means of fixed capacitor thyristor controlled reactor (FC-TCR). Thyristor controlled reactor can be varied by means of varying of variable susceptance, B_{SVC}. The equivalent susceptance B_{equ} can be determined by the firing angle α of thyristor.

$B_{EQU} = B_L(\alpha) + B_C$ ………………….. (1)

Where

$B_L(\alpha) = \frac{1}{wL}\left(1 - \frac{2\alpha}{\pi} - \frac{1}{\pi}\sin(2\alpha)\right)$,

$B_C = wc$ and α varies from zero to 90^0

If real power consumed by svc is zero then $P_{SVC} = 0$

$Q_{SVC} = V^2 B_{SVC}$………….. (2)

Where, V is bus voltage magnitude. Since reactive power is function of square of voltage hence a reactive power generated decreases as the voltage decreases.
The basic FC-TCR type static var generator is shown in fig 2.

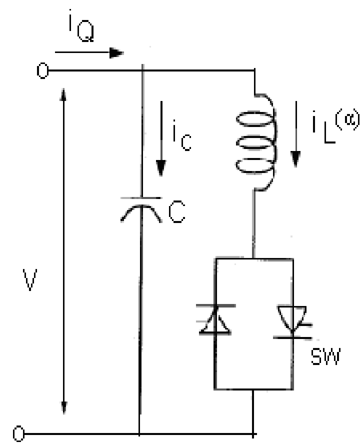

Fig.2 Basic FC-TCR type static generator [2]

Fuzzy Logic Interfacing

Mamdani based fuzzy logic interfacing rule is adopted for correction of power factor. Complex power is taken from power measuring block, in which power angle is taken as input of fuzzy controller. According to power angle control output (firing angle) is provided by fuzzy controller. When power angle is large firing angle is also large. Controlled output is supplied to variable delay circuit and it is supplied to thyristor. According to the output of variable time delay circuit firing angle of thyristor is changed. When power angle is very small then firing angle is also very small. When power angle is medium then firing angle is also medium. When power angle is large then firing angle is also large.

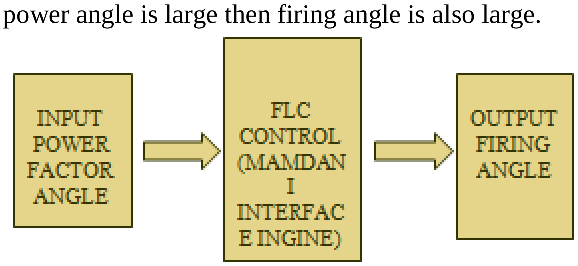

Fig.3 Structure of fuzzy logic controller

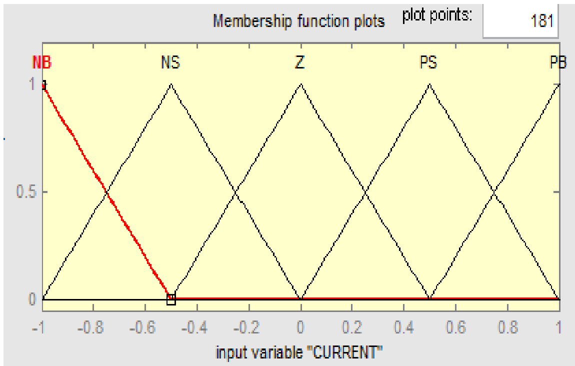

Fig: 4 Membership function plot for input variable "current"

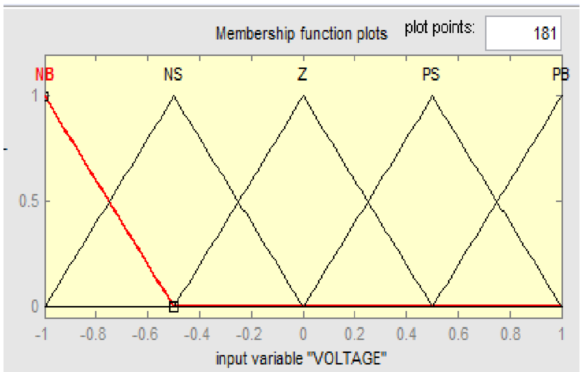

Fig: 5 Membership function plot for input variable"voltage"

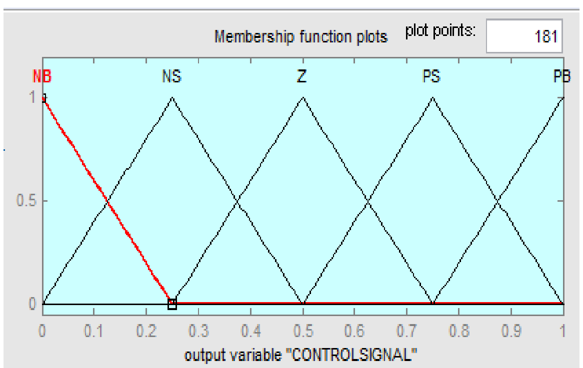

Fig:6 Membership function plot for output variable

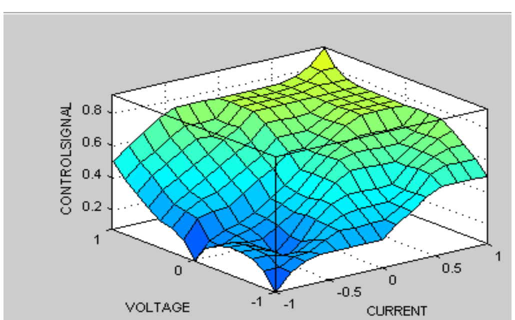

Fig: 7 Surface viewers for fuzzy controller

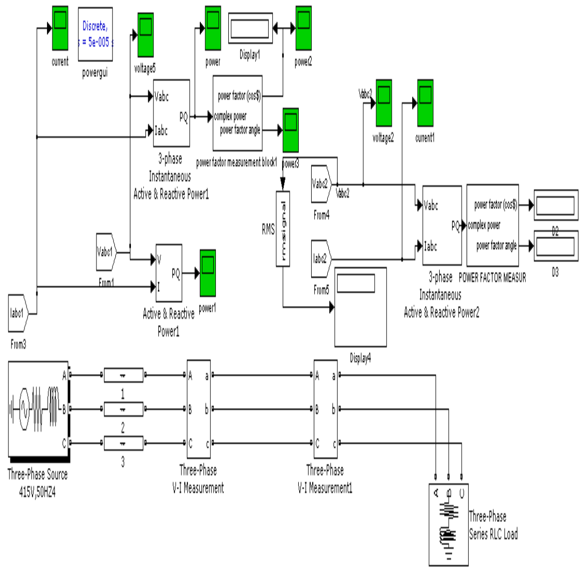

Fig: 8 simulation of distribution line without controller

Experimental Results

Matlab simution is done for various inductive loads at sending end voltage 415 volt. Variation of power factor and output voltage for various load with and without controller is shown in table.

TABLE: Effect of power factor with and with out controller

	WITH OUT CONTROLLER			WITH CONTROLLER		
LOADS (K.W)	VOLT.	Ө	P.F.	VOLT.	Ө	PF
P=2.50 Q=1.615	225.6	32.88	0.84	239.6	0.0177	1
P=3.50 Q=2.615	213.6	36.78	0.8011	239.6	0.0133	1
P=4.50 Q=3.615	205.3	38.80	0.7796	239.6	0.0105	1
P=10.0 Q=9.615	165.3	42.5	165.3	239.6	0.0046	1

The FFT analysis of nonlinear load is simulated which is shown below.

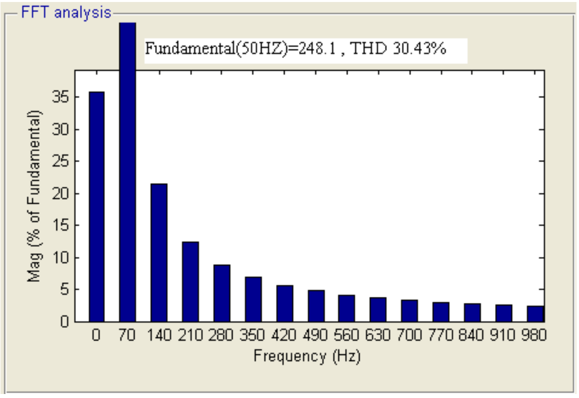

Fig: 9 FFT analysis of voltage with nonlinear load

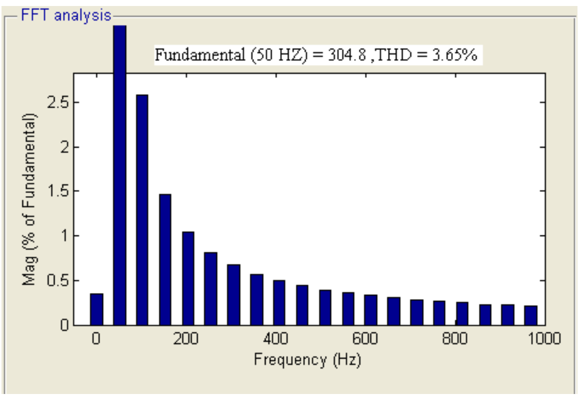

Fig:10 FFT analysis of voltage of nonlinear load with FC-TCR

Conclusion

From above table we conclude that 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. It is cost effective solution to maintain constant voltage and constant power for highly inductive load. FFT analysis with nonlinear load it is able to reduce the harmonics up to desired limit. With MATLAB simulations it is observed that SVC (FC-TCR) provides an effective reactive power control irrespective of load variation and also provide voltage stability.

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