Reactive Power Compensation In Transmission Line By Using Online Static Var Comensator With Fuzzy Control Method

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Abstract –

The Flexible AC Transmission System (FACTS) technology is a promising technology to achieve complete deregulation of Power System i.e. Generation, Transmission and Distribution as the complete individual units. FACTS is based on power electronic devices, used to enhance the existing transmission capabilities in order to make the transmission system flexible and independent in operation. The loading capability of transmission system can also be enhanced nearer to its thermal limit without affecting the stability. Complete closed-loop smooth control of reactive power can be achieved using shunt connected FACTS devices. Static VAR Compensator (SVC) is one of the shunt connected FACTS devices, which can be utilized for the purpose of reactivepower compensation. As the Intelligent FACTS devices make them adaptable, it is emerging as the present state of the art n technology. This paper presents the design and simulation of the Fuzzy logic control to vary firing angle of SVC in order to achieve better, smooth and adaptive control of reactive power in transmission systems. The design, modeling and simulations are carried

1. INTRODUCTION

Static VAR compensation

The Static VAR Compensator (SVC) is a shunt device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids [1]. The SVC regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the SVC generates reactive power (SVC capacitive). When system voltage is high, it absorbs reactive power (SVC inductive). A rapidly operating Static VAR Compensator (SVC) can continuously provide the reactive power required to control dynamic voltage swings under various system conditions and thereby improve the power system transmission and distribution performance. Installing an SVC at one or more suitable points in the network will increase transfer capability through enhanced voltage stability, while maintaining a smooth voltage profile under different network conditions. In addition, an S

Fixed capacitor

where the load does not change or where the capacitor is switched with the load, such as the load side of a Ideally suited for power factor correction in applications motor contactor. It is suitable for locations using induction motors, like food processing plants, or where small multiple loads require reactive power compensation. Each Fixed Capacitor Bank is designed for high reliability and long life. These products are designed for applications that do not contain harmonic generating VC can mitigate active power oscillations through voltage amplitude modulation

Fuzzy logic controller

Fuzzy logic is a new control approach with great potential for real time applications . Fig shows the structure of the fuzzy logic controller (FIS-Fuzzy Inference System) in MATLAB Fuzzy logic toolbox. Load voltage and load current are taken as input to fuzzy system. For a closed loop control, error input can be selected as current, voltage or impedance, according to control type . To get the linearity triangular membership function is taken with 50% overlap

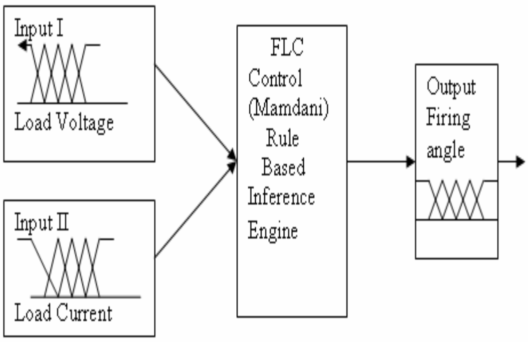
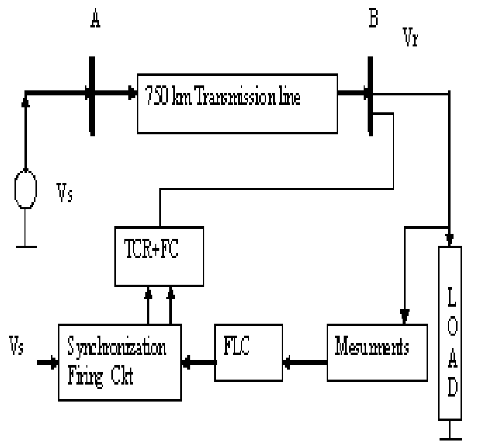


Fig 1.1 structure of fuzzy logic controller

The output of fuzzy controller is taken as the control signal and the pulse generator provides synchronous to the thyristors.

The Fuzzy Logic is a rule based controller where a set of rules represents a control decision mechanism to correct the effect of certain causes coming from power system . In fuzzy logic, the five linguistic variables expressed by fuzzy sets defined shows the suggested membership function rules of FC-TCR controller. The rule of this table can be chosen based on practical experience and simulation results observed from the behavior of the system around its stable equilibrium points.

EQUIVALENT CIRCUIT:



1.2 Single phase equivalent circuit and fuzzy logic control structure of SVC

2. Thyristor Controlled Reactor (TCR)

An elementary single-phase thyristor-controlled reactor (TCR) is shown in Figure (a). It consists of a fixed (usually air-core) reactor of inductance L, and a bidirectional thyristor valve (or switch) sw. Currently available large thyristors can block voltage up to 4000 to 9000 volts and conduct current up to 3000 to 6000 amperes. Thus, in a practical valve many thyristors (typically 10 to 20) are connected in series to meet the required blocking voltage levels at a given power rating. A thyristor valve can be brought into conduction by simultaneous application of a gate pulse to all thyristors of the same polarity. The valve will automatically block immediately after the ac current crosses zero, unless the gate signal is reapplied.

The current in the reactor can be controlled from maximum (thyristor valve closed) to zero (thyristor valve open) by the method of firing delay angle control. That is, the closure of the thyristor valve is delayed with respect to the peak of the applied voltage in each half-cycle, and thus the duration of the current conduction intervals is controlled. This method of current control is illustrated separately for the positive and negative current half-cycles in Figure (b), where the applied voltage u and the reactor current $I_L(\alpha)$, at zero delay angle (switch fully closed) and at an arbitrary a delay angle, are shown. When α=0, the valve *sw* closes at the crest of the applied voltage and evidently the resulting current in the reactor will be the same as that obtained in steady state with a permanently closed switch. When the gating of the valve is delayed by an angle α ($0 = \alpha < \pi/2$) with respect to the crest of the voltage, the current in the reactor can be expressed with $u(t) = V \cos \omega t$ as follows:

$$i_L(t) = \frac{1}{L}\int_{\alpha}^{\omega t} v(t)\, dt = \frac{V}{\omega L}(\sin \omega t - \sin \alpha)$$

Since the thyristor valve, by definition, opens as the current reaches zero the above equation is valid for the interval $\alpha \le \omega t \le \pi$ - a. For subsequent positive half-cycle intervals the same expression obviously remains valid. For subsequent negative half cycle intervals, the sign of the terms in becomes opposite.

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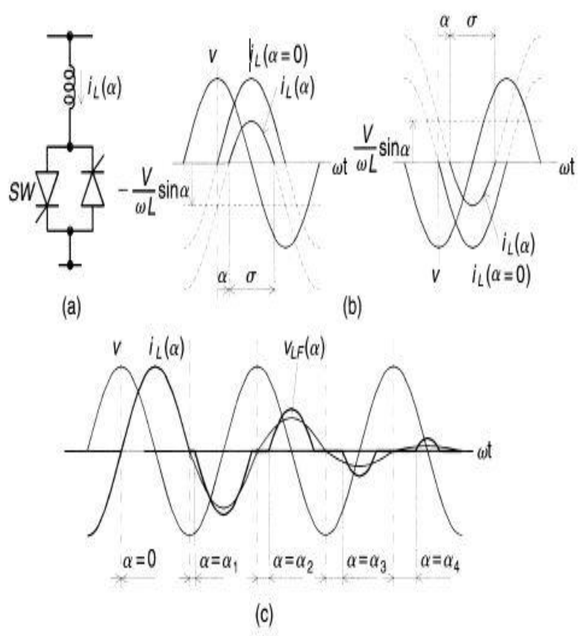

Fig.2.1 Basic thyristor-controlled reactor (a), firing delay angle control (b), and operating waveforms (c).

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3. SIMULATION CIRCUIT AND RESULTS

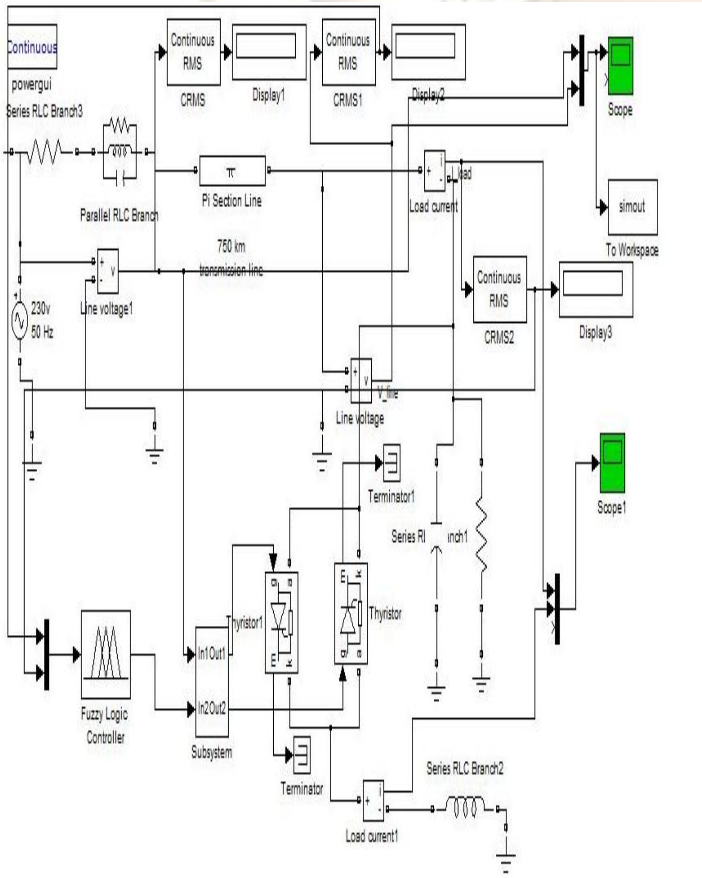
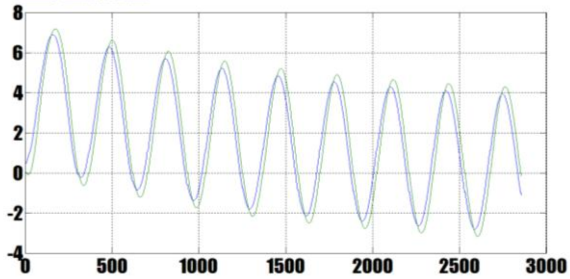


Fig.3.1 Circuit diagram of an SVC compensating device without using the fuzzy controller



3.2 waveforms representing the sending end voltage and the receiving end voltage without compensation.

The above waveform represents the sending end voltage and the receiving end voltage. From these two wave forms we have clearly observed that there is a voltage sag i.e, the Voltage across the load has reduced .This infers that the voltage that is transmitting at the sending end and the voltage which is at the receiving end are not same.

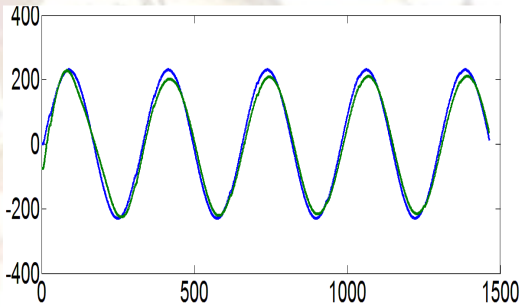


Fig 3.3 waveforms representing the sending and receiving end after compensation without use of fuzzy controller.

The above waveform shows the voltages across sending and receiving end after the compensation. From these two waveforms we noticed that the voltage gets compensated.

In this the load voltage is increased than the sending voltage ,this means that it gets over compensated and after some time load voltage falls down which means that under compensation. Since the thyristors present in the svc are triggered manually such that it is not continuous.

The above waveform shows the voltages after compensating svc with the help of the fuzzy controller. From these two we have clearly observed that the sending end voltage and the receiving end voltage are same. This infers that the compensation is done abruptly with the Static VAR Compensator.

Table: Load voltage before and after compensation

Tr Line Parameters for Lt=.10mh/km Ct =0.1μf/km R.= 0.001Ω		Before compensation For Vs= 230V (p-p)		After Compensation For L= 0.19H C= 8μ f For Vs= 230 (P-P)		
R Ω	V_S (rms) Volts	V_R (rms) Volts	I_R rms Amp	V_R (rms) Volts	I_R (rms) Amp	α.
200	230	270.8	0.54	228.2	2.032	90
190	162.6	268.1	0.67	162.4	2.036	100
180	162.6	268.0	0.89	162.	2.099	102
170	162.6	261.1	1.30	162.7	2.182	103
160	162.6	258.1	1.43	162.4	2.198	105
150	162.6	256.1	1.59	162.3	2.232	106

CONCLUSIONS

This paper presents an "ONLINE FUZZY CONTROL SCHEME FOR SVC" and it can be concluded that the use of fuzzy controlled SVC (FC-TCR) compensating device with the firing angle control is continuous, effective and it is a simplest way of controlling the reactive power of transmission line. It is observed that SVC device was able to compensate both over and under voltages. Compensating voltages are shown in Fig.3.3. The use of fuzzy logic has facilitated the closed loop control of system, by designing a set of rules, which decides the firing angle given to SVC to attain the required voltage. With MATLAB simulations [4] [5] and actual testing it is observed that SVC (FC-TCR) provides an effective reactive power control irrespective of load variations.

The transmission line without any compensation was not satisfying the essential condition of maintaining the voltage within the reasonable limits. The effect of increasing load was to reduce the voltage level at the load end. At light loads, the load voltage is greater than the sending end voltage as the reactive power generated is greater than absorbed. At higher loads the load voltage drops, as the reactive power absorbed is greater than generated, as shown in Table. Fig.3.2 indicates unequal voltage profiles. Fig.3.3 clearly shows the firing angle and inductor current control.

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