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# Reactive Power Compensation and Power Factor Correction by Reactive VAR Compensator

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## ABSTRACT

Power factor improvement for nonlinear loads is the point of interest for researchers in recent scenario. Power factor plays a major role in efficiency of electrical system. The Purpose of this paper is to power factor improvement by using proper control strategy. Simulation on MATLAB/ Simulink environment is conducted with resistive inductive load. The low power factor is highly undesirable as it causes an increase in current, resulting in additional losses of active power in all the elements of power system from power system down to the utilization devices. To compensate reactive power and improve the power factor by using a static VAR compensator, it consisting converter (2-level SCR) with capacitor bank. This work deals with the performance evaluation through analytical studies and practical implementation on an existing system consisting of a distribution transformer of 1phase, 50Hz, 230V/12V capacity.

***KEYWORDS:*** *Power factor correction; SCR; MATLAB/SIMULINK*

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## INTRODUCTION

Thyristor Controlled reactor (TCS) a set of electrical devices for providing fast-acting reactive power on high-voltage electricity transmission networks. SVCs are part of the Flexible AC transmission system device family, regulating voltage, power factor, harmonics and stabilizing the system [1]. Unlike a synchronous condenser which is a rotating electrical machine, a static VAR compensator has no significant moving parts (other than internal switchgear). Prior to the invention of the SVC, power factor compensation was the preserve of large rotating machines such as synchronous condensers or switched capacitor banks. The SVC is an automated impedance matching device, designed to bring the system closer to unity power factor [2]. SVCs are used in two main situations: Connected to the power system, to regulate the transmission voltage ("Transmission SVC") Connected near large industrial loads, to improve power quality ("Industrial SVC") in transmission applications, the SVC is used to regulate the grid voltage. If the power system's reactive load is capacitive (leading), the SVC will use thyristor-controlled reactors to consume VARs from the system, lowering the system voltage [3]. Under inductive (lagging) conditions, the capacitor banks are automatically switched in, thus providing a higher system voltage. Distributed Generation (DG) can be defined as electric power generation with in the distribution networks or on the consumer side of the network. To utilize interfacing converters to compensate harmonics an enhanced current control approach is introduced in. With inverter control, the active and reactive power requirement of the load can be satisfied [4].

**Modelling of static var compensator in power system:** Distributed generation (DG) units interfaced with static inverters are being applied and focused increasingly due to the fact that conventional electric power systems are being more and more stressed by expanding power demand, limit of power delivery capability, complications in building new transmission lines, and blackouts [5].

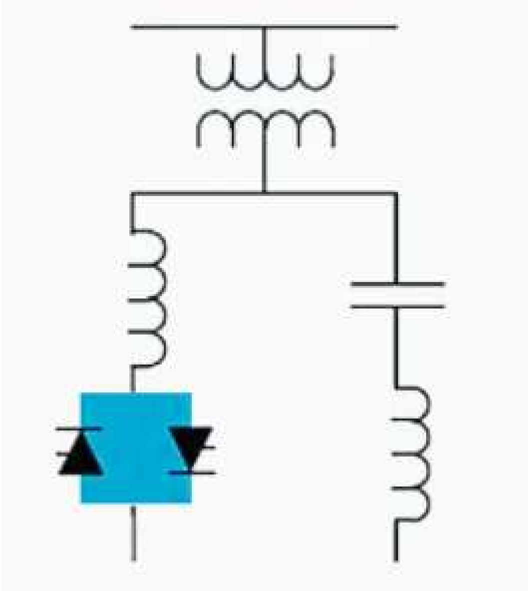

**Fig-1 Thyristor Controlled reactor**

Figure 1 shows the basic scheme of a static compensator of the thyristor-switched capacitor (TSC) type. First introduced by ASEA in 1971, the shunt capacitor bank is split up into appropriately small steps, which are individually switched in and out using bidirectional thyristor switches. Each single-phase branch consists of two major parts, the capacitor C and the thyristor switches Sw1 and Sw2. In addition, there is a minor component, the inductor L, whose purpose is to limit the rate of rise of the current through the thyristors and to prevent resonance with the network (normally 6% with respect to Xc). The capacitor may be switched with a minimum of transients if the thyristor is turned on at the instant when the capacitor voltage and the network voltage have the same value. Static compensators of the TSC type have the following properties: stepwise control, average delay of one half a cycle (maximum one cycle), and no generation of harmonics since current transient component can be attenuated effectively [16], [17]. The current that flows through the capacitor at a given time t, is defined by the following expression:

$$I(t)= \frac{V}{X_c-X_L}\text{Cos}(\omega t+\alpha) - \frac{V}{X_c-X_L}\text{Cos}(\alpha) * \text{Cos}(\omega t) + \left(\frac{V_m X_c Sin(\alpha)}{\omega L(X_c-X_L)}\right) * \text{Sin}(\omega t) - \frac{V}{\omega L}\text{Sin}(\omega t) \quad (1)$$

where Xc and XL are the compensator capacitive and inductive reactance, Vm the source maximum instantaneous voltage, α the voltage phase-shift angle at which the capacitor is connected, and ω the system resonant frequency ($\omega = 1/\sqrt{LC}$), V capacitor voltage at t = 0 -. This expression has been obtained assuming that the system equivalent resistance is negligible as compared with the system reactance [6]. This assumption is valid in high voltage transmission lines. If the capacitor is connected at the moment that the source voltage is maximum and V is equal to the source voltage peak value, Vm, (α = ± 90º) the current transient component is zero. Despite the attractive theoretical simplicity of the switched capacitor scheme, its popularity has been hindered by a number of practical disadvantages: the VAR compensation is not continuous, each capacitor bank requires a separate thyristor switch and therefore the construction is not economical, the steady state voltage across the non-conducting thyristor switch is twice the peak supply voltage, and the thyristor must be rated for or protected by external means against line voltage transients and fault currents[7].Table-1 shows the variation of power factor and frequency with reactive VAR injunction to line.

**Table-1variation of power factor and frequency with reactive VAR injunction to line**

| Sr | Reactive MVAR | Power Factor | Frequency (Hz) |
|---|---|---|---|
| 1 | 0 | 0.68 | 46 |
| 2 | 94 | 0.87 | 47.65 |
| 3 | 188 | 0.89 | 48.89 |
| 4 | 297 | 0.988 | 49.73 |

The MATLAB Simulink of grid connected load with TSC has been shown in fig-2. The flow of reactive VAR has been clearly indicated in given fig-2. The performance of designed system can also be check with variation in load. It has been seen that frequency drops slowly as load increases at constant reactive VAR.

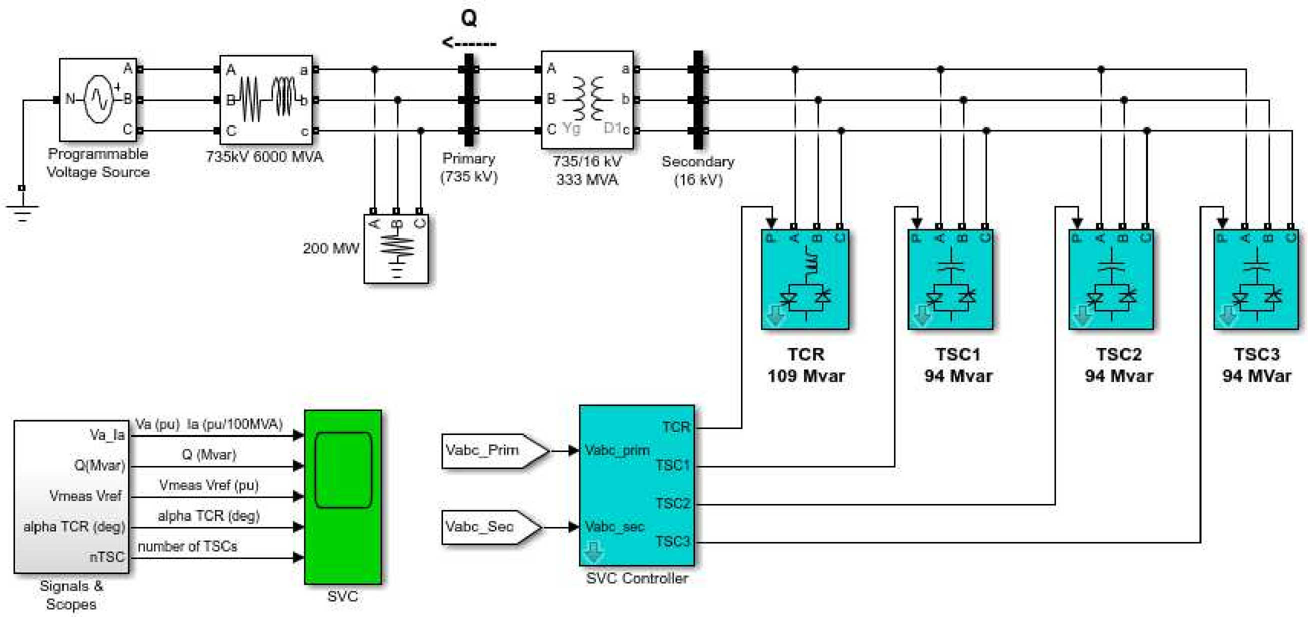


**Fig-2 MATLAB Simulink of Grid connected load with TCR**

The per unit grid voltage has been shown in fig 3 where as the reactive VAR supplied by TCS has been presented in fig-4.

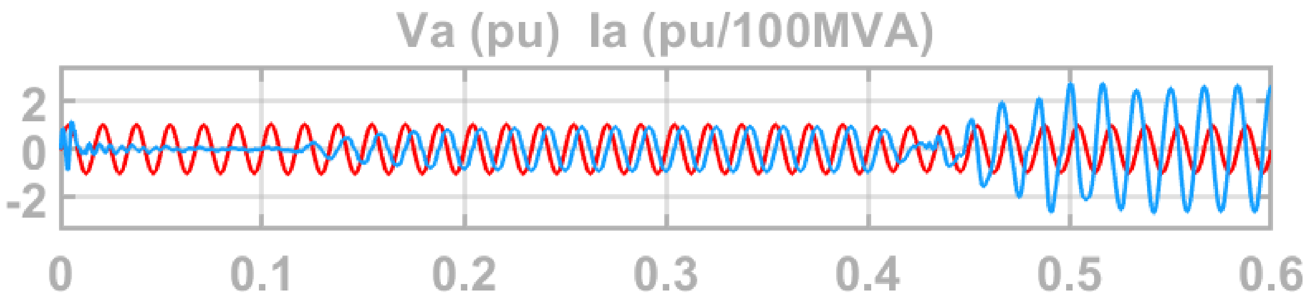


**Fig-3 Grid voltage (pu)**

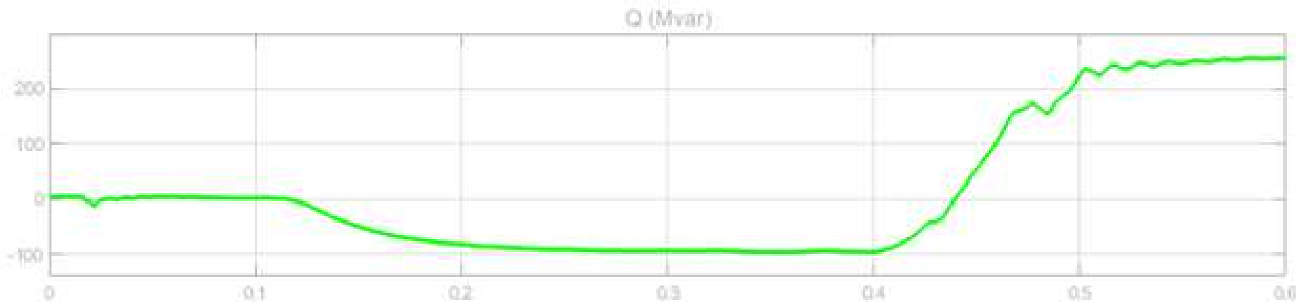


**Fig-4 Reactive VAR supplied by TCS**

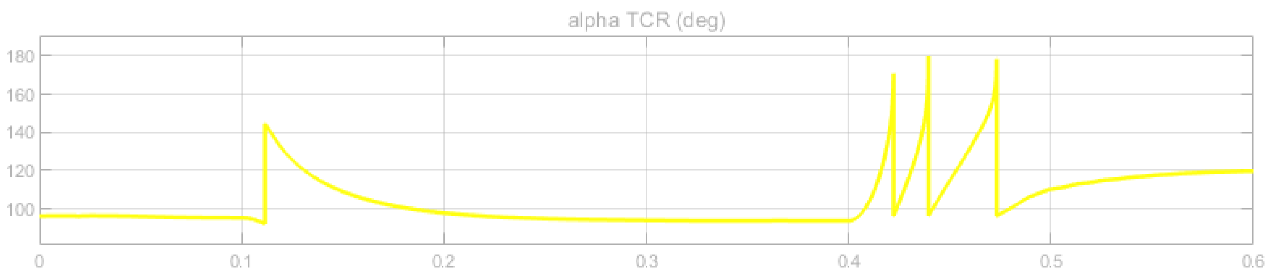


**Fig-5 Trigging angles of SCRs**

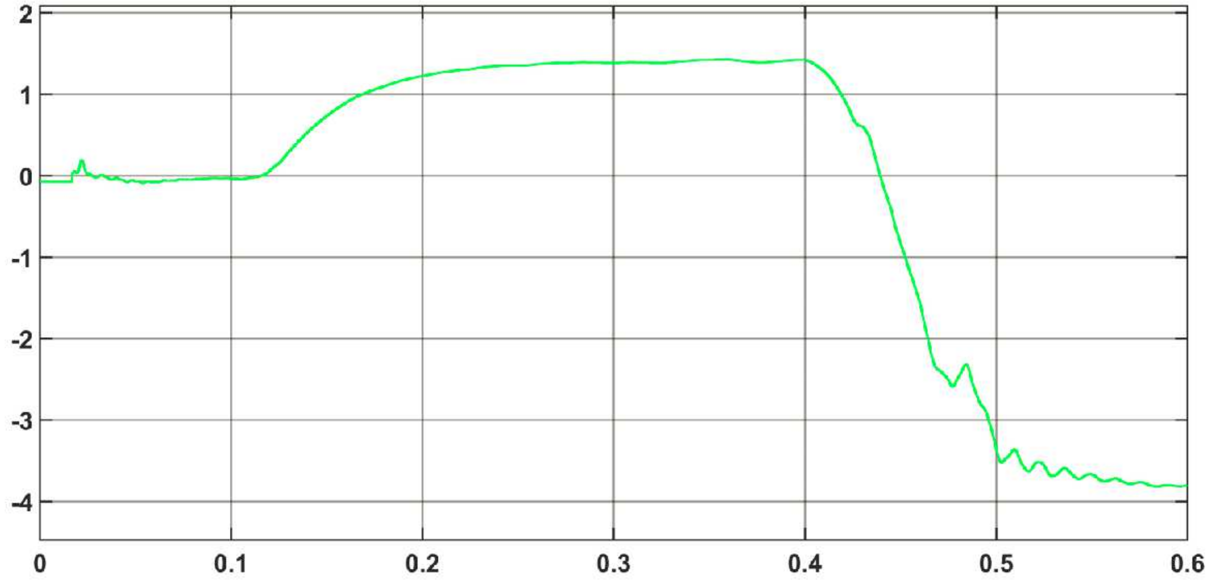


**Fig- 6 Active power of TCS**

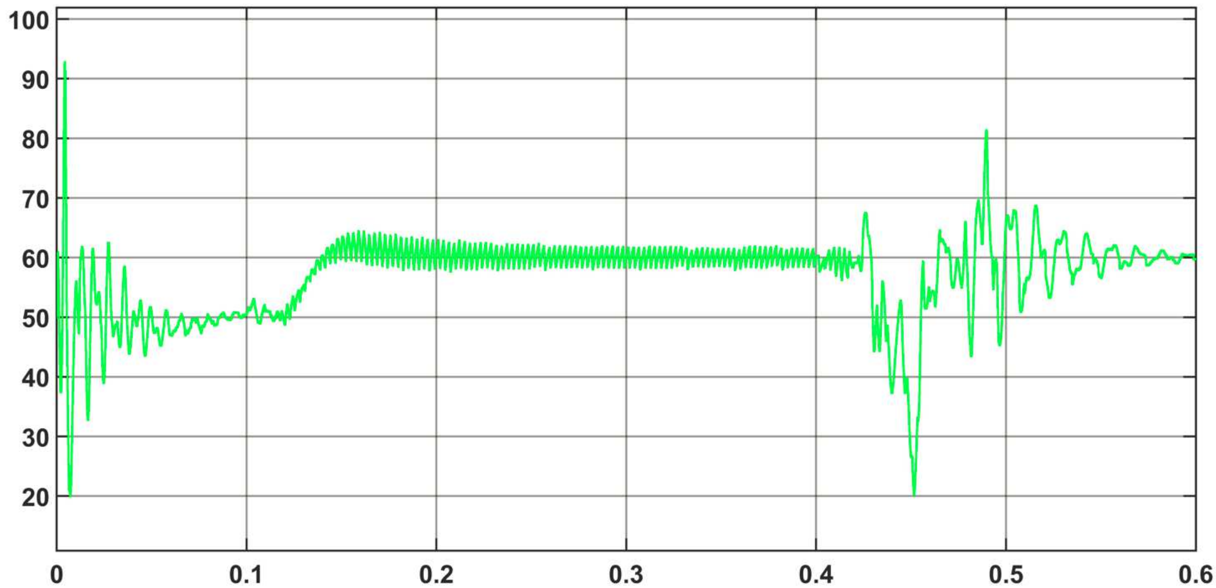


**Fig-7 Grid frequency**

At constant load power factor and frequency has been improved as injection of reactive VAR increases in transmission line shown in fig- 8 and 7 respectively.

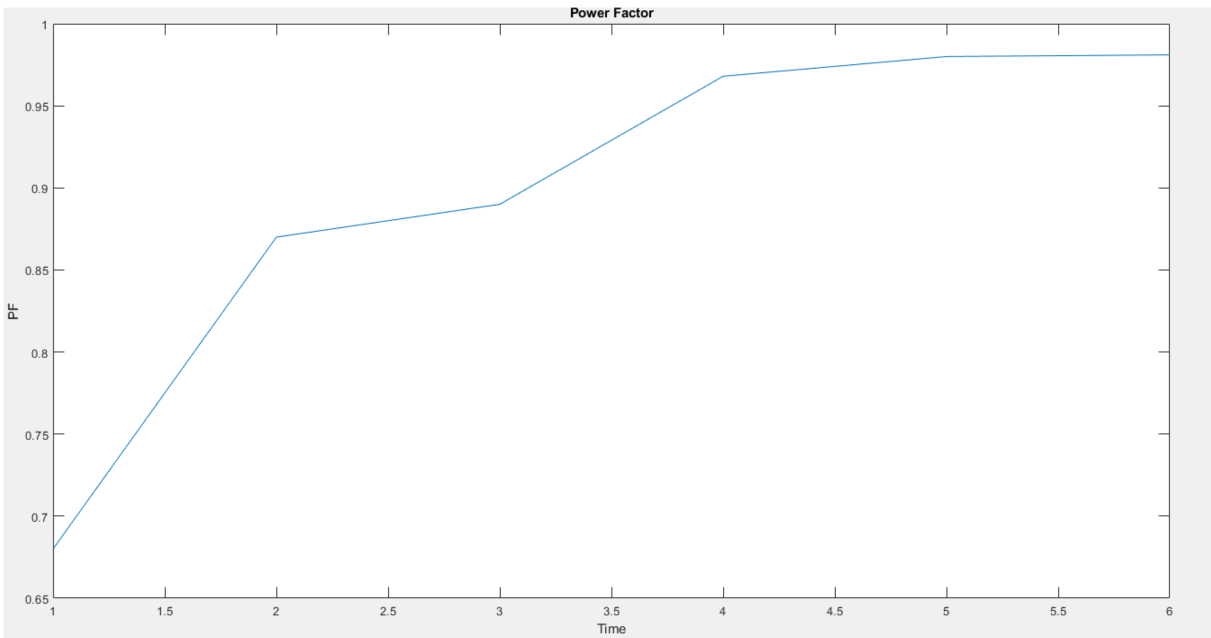


**Fig- 8 Power factor variation**

**Result:** In this paper, to improve the power quality and the efficiency, the power factor correction in the system is done by using SVC (Static Var Compensator) in load transient condition. The SVC is used TCR (thyristor-controlled reactors) and TSC (thyristor switch capacitor). The system power factor is become constant by using SVC in the PCC (point of common coupling), where it is changed dramatically in different load conditions. The introduction of new self-commutated topologies at even higher voltage levels will increase the impact of VAR compensation in future applications.

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