Design and implementation of TSC-TCR for reactive power compensation
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ABSTRACT:
A new kind of measure to control volt, SVC can rapidly and continuously adjust volt of installation area. This paper kind of SVC system that include TSC-TCR section through simulink of matlab. The simulation result show that TSC-TCR has good effect in maintaining voltage when the industrial load is steady moments it also have ability of stability control. KVAR given by TSC is absorbed by TCR. The firing angle range of TCR is selected in such way that harmonic produced. The completely work as an important devices of reactive power compensation in power maintain nearly unity power factor.

Keywords: Static Var Compensation (SVC), Simulation, Thyristor Switched Capacitor (TSC), Thyristor Controlled Reactor (TCR).

I. INTRODUCTION
Reactive power compensation is defined as the management of reactive power to improve the performance of ac power systems. The concept of reactive power compensation embraces a 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 [1].

For this purpose, a model of TSC-TCR was prepared which allowed full compensation of the system leading to a power factor of unity. The methods which are used are: reactive power compensation, unbalanced load compensation and minimization. The study the power factor improvement and the stabilization of the supply voltage of a supply network with an increased number of loads over the time by reactive power compensation methods. Thyristor switched capacitors (TSC) and thyristor controlled reactors (TCR) are method for static VAR compensation (SVC)[4].

II. REACTIVE POWER COMPENSATION

- REACTIVE POWER
We always reduce reactive power to improve system efficiency. If system is purely resistively or capacitance it make cause some problem in Electrical system. Alternating systems supply or consume two kind of power: real power and reactive power.

Real power accomplishes useful work while reactive power supports the voltage that must be controlled for system reliability. Reactive power has a profound effect on the security of power systems because it affects voltages throughout the system.

- BASIC CONCEPT REACTIVE POWER

1. Why We Need Reactive Power:
   - Active power is the energy supplied to run a motor, illuminate an electric light bulb. Reactive power provides the important function of regulating voltage.
   - If voltage on the system is not high enough, active power cannot be supplied. Reactive power is used to provide the voltage levels necessary for active power to do useful work.
   - Reactive power is essential to move active power through the transmission and distribution system to the customer. Reactive power is required to maintain the voltage to deliver active power (watts) through transmission lines.
   - Motor loads and other loads require reactive power to convert the flow of electrons into useful work. When there is not enough reactive power, the voltage sags down and it is not possible to push the power demanded by loads through the lines.

2. Reactive Power is a By product of AC Systems:
Transformers, Transmission lines, and motors require reactive power. Electric motors need reactive power to produce magnetic fields for their operation.
• Transformers and transmission lines introduce inductance as well as resistance
  [2] Must raise the voltage higher to push the power through the inductance of the lines.
  [3] Unless capacitance is introduced to offset inductance.

How Voltages Controlled by Reactive Power: Voltages are controlled by providing sufficient reactive power control margin to supply needs through.

  [1] Reactive power is present when the voltage and current are not in phase
  [2] One waveform leads the other.
  [3] Phase angle not equal to 0°.
    • Measured in volt-ampere reactive (VAR).
    • Produced when the current waveform leads voltage waveform (Leading power factor).
    • Vice versa, consumed when the current waveform lags voltage (lagging power factor).

4. Reactive Power Limitations:
  • Reactive power does not travel very far.
  • Usually necessary to produce it close to the location where it is needed.
  • A source close to the location of the need is in a much better position to provide reactive power versus one that is located far from the location of the need.
  • Reactive power supplies are closely tied to the ability to deliver real or active power.

DIFFERENT BETWEEN REACTIVE POWER ON POWER FACTOR
• BASICS OF POWER FACTOR:
  It is defined as the ratio of ‘active or actual power’ used in the circuit measured in watts or kilowatts (W or KW), to the ‘apparent power’ expressed in volt-amperes or kilo volt amperes (VA or KVA). The apparent power also referred to as total power delivered by utility company has two components.
  1) ‘Productive Power’ that powers the equipment and performs the useful work. It is measured in KW (kilowatts).
  2) ‘Reactive Power’ that generates magnetic fields to produce flux necessary for the operation of induction devices (AC motors, transformer, inductive furnaces, ovens etc.). It is measured in KVAR.
  A power factor of 0.72 would mean that only 72% of your power is being used to do useful work. Perfect power factor is 1.0, (unity); meaning 100% of the power is being used for useful work.

  Power Factor = \( \frac{\text{Active power}}{\text{Apparent power}} \)
  = \( \frac{\text{Active power}}{\text{Active Power + Reactive Power}} \)
  = \( \frac{\text{kW}}{\text{kW + kVAR}} \)

![Figure 1: Graphical analysis of power factor](image-url)

• FACTS DEVICES OF SVC (TSC-TCR)
  In Commercial and industrial electrical loads include induction motor driven equipment such as elevators, pumps, presses, DC motors, power transformers, welding machines, and arc furnaces are mostly inductive in nature. Inductive load consumes reactive power in addition to the active power to do useful work. Reactive power required by inductive loads increases the amount of apparent power (kVA) in the distribution system. This is important as a low power factor can waste energy, result in inefficient use of electrical power.

FACTS are devices which can be inserted into power grids series, in shunt, a both in shunt and series for reactive power compensation & hence for unity power factor control.
Available facts devices are:
1) Shunt Device :
   • Static VAR Compensator
   • Static Synchronous Compensator (STATCOM)
2) Series Device :
   • Thyristor Controlled Series Compensator (TCSC)
   • Static Synchronous Series Compensator (SSSC)

• Operation of SVC
SVC behaves like a shunt-connected variable reactance, which either generates or absorbs reactive power in order to regulate the PCC voltage magnitude. 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). SVC principle is supplying a varying amount of leading or lagging VAR to the lagging or leading system. By phase angle control of thyristor, the flow of current through the reactor is varied. Hence by varying the firing angle alpha from 90 Deg. to 180Deg. the conduction interval is reduced from maximum to zero.

- **TSC (thyristor switched capacitor)**
The TSC is one of shunt connected compensators used to provide rapid and continuous control of reactive power. TSC has advantages: stepwise control, cheaper devices, and no generation of harmonics and hence no filtering is required. A TSC defined as A shunt connected, thyristor switched capacitor whose effective reactance is varied in stepwise manner by full or zero conduction operation of thyristor valves.

- **TCR (thyristor control reactor)**
A TCR is one of the most important building blocks of thyristor-based SVCs. Although it can be used alone, it is more often employed in conjunction with fixed or thyristor-switched capacitors to provide rapid, continuous control of reactive power over the entire selected lagging-to-leading range.
• TSC-TCR:

The TSC–TCR compensators shown in Fig above usually comprises n TSC banks and a single TCR that are connected in parallel. The rating of the TCR is chosen of the total SVC rating. The capacitors can be switched in discrete steps, whereas continuous control within the reactive-power span of each step is provided by the TCR. Thus the maximum inductive range of the SVC corresponds to the rating of the relatively small interpolating TCR[6].

As the size of TCR is small, the harmonic generation is also substantially reduced. A situation in which all TSCs and, consequently, the associated filters are switched off, an additional no switchable capacitive-filter branch is provided[6].

➤ MATLAB SIMULATION:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1-phase</th>
<th>3-phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>For RL. load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nominal voltage</td>
<td>250 v</td>
<td>415v</td>
</tr>
<tr>
<td>Frequency</td>
<td>50 hz</td>
<td>50 hz</td>
</tr>
<tr>
<td>Active power</td>
<td>5000 w</td>
<td>5000 w</td>
</tr>
<tr>
<td>Inductive reactive power</td>
<td>3000 var</td>
<td>3000 var</td>
</tr>
<tr>
<td>For TCR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active power</td>
<td>0 w</td>
<td>0 w</td>
</tr>
<tr>
<td>Inductive reactive power</td>
<td>3000 var</td>
<td>6000 var</td>
</tr>
<tr>
<td>Capacitive reactive power</td>
<td>0 var</td>
<td>0 var</td>
</tr>
<tr>
<td>For TSC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active power</td>
<td>0 w</td>
<td>0 w</td>
</tr>
<tr>
<td>Inductive reactive power</td>
<td>0 var</td>
<td>0 var</td>
</tr>
<tr>
<td>Capacitive reactive power</td>
<td>C1=1500 var</td>
<td>C1=1000 var</td>
</tr>
<tr>
<td></td>
<td>C2=2000 var</td>
<td>C2=2000 var</td>
</tr>
<tr>
<td></td>
<td>C3=2000 var</td>
<td>C3=4000 var</td>
</tr>
</tbody>
</table>

Table - 1
• 3 phase simulation model of TSC-TCR

![3 phase simulation model of TSC-TCR](image)

Figure - 7

• Subsystem of TSC-TCR

![Subsystem of TSC-TCR](image)

Figure - 8

• Waveform of 3 phase without TSC-TCR

![Waveform of 3 phase without TSC-TCR](image)

Figure - 9
waveform of 3 phase with TSC-TCR

Figure - 10

Result analysis

<table>
<thead>
<tr>
<th></th>
<th>3 Phase</th>
<th>1 Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without compensation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active power (kw)</td>
<td>2090</td>
<td>4280</td>
</tr>
<tr>
<td>Reactive power (kvar)</td>
<td>1250</td>
<td>2535</td>
</tr>
<tr>
<td>Power factor</td>
<td>0.8556</td>
<td>0.8607</td>
</tr>
<tr>
<td>With tsc-tcr compensation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active power (kw)</td>
<td>4800</td>
<td>3450</td>
</tr>
<tr>
<td>Reactive power (kvar)</td>
<td>70</td>
<td>1390</td>
</tr>
<tr>
<td>Power factor</td>
<td>0.976</td>
<td>0.9276</td>
</tr>
</tbody>
</table>

Table - 2

III. CONCLUSIONS

An uncompensated power supply system the supply voltage decreases with an increase of load. Due to the rise of reactive power demand the power factor decreases with the load. By TSC-TCR which had been attuned to the arising load, a successful compensation was reached with a power factor of unity. Therefore a variable VAR compensation is needed a model of TSC-TCR was prepared which allowed full compensation of the system leading to a power factor of unity. MATLAB simulation, without compensation power factor is 0.812 & with 1phase TSC-TCR power factor is 0.9876 which is nearly to unity and 3 phase TSC-TCR power factor is 0.996.

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REFERENCES