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Dynamic-Static Var Compensation for Improving Power Factor

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Abstract

In the industrial sector, the power electronics devices and various motoring loads are continuously running. Therefore, the power factor is reduced due to the inductive reactive power. Dynamic and static VAR compensation (denoted by DVC and SVC respectively) are the most commonly used method for improving power factors. In DVC, several capacitor banks are used. Each capacitor bank is connected to a network with a switch, which is controlled by a controller circuit. However, the controller circuit causes an over/under compensation phenomenon. Moreover, SVC consists of a thyristor-controlled reactor (TCR) and a fixed capacitor. The fixed capacitor results in over compensating phenomena due to changing load so that the TCR branch continuously consumes surplus reactive power. Therefore, it is suitable for only small load changes otherwise; it will be costlier for large load changes. In this project, the dynamic-static Var compensation (DSVC) is designed by combining SVC and DVC. DSVC provides smooth power factor control for a large load. MATLAB/Simulink tools are used for illustrating the implementation of DSVC in this paper.

Keywords: Compensation; Loads; DSVC; Power Factor

1. Introduction

The reactive load is the primary cause of voltage profile degradation in any power system [1]. For a power system to be considered stable and reliable, it must be resistant to momentary overloads, maintain a steady voltage, and have minimal transmission and distribution losses [1]. Shunt and series compensation are the two most common kinds of compensation. By connecting a capacitor in series with the transmission line, the total reactance is lowered, and therefore the voltage drop is minimized. Shunt compensation involves injecting reactive power into the line to lower the quantity of reactive power provided by the source. Shunt compensation is a direct-acting approach that rapidly alters the voltages at the receiving end. It also boosts the power factor [2]. The power factor correction methods used in the present day have several disadvantages, including switching operation and system sensing stability [3]. DSVC system will be used to address the problem. Due to the ineffective implementation of a method that could be used to improve the power factor, numerous sectors faced various economic and capital problems in the previous decade [3]. In industry; motors loads, high-intensity discharge lamps, electric furnaces, and other devices increase the system's VAR and cause low power factor operation. Due to the low power factor, there were issues with low efficiency, higher copper loss, higher heat dissipation, poor voltage regulation, and bigger conductor sizes, and the system's handling capacity is lowered [4]. Different strategies have been created for enhancing power factors, minimizing the value of reactive power consumption, and maximizing the value of useful(active) power with modernization in power systems. Static VAR compensator (SVC), a fixed capacitor, switched capacitor, synchronous condenser, static synchronous compensator (STATCOM), and dynamic synchronous compensator (DVC) are examples of these techniques [5].

SVC consists of a thyristor-controlled reactor (TCR) parallel with the fixed capacitor. In SVC fixed capacitors cause overcompensation phenomena for changing load by providing reactive power. TCR consumes surplus reactive power by adjusting the susceptance.

However, in DVC there are sets of capacitors

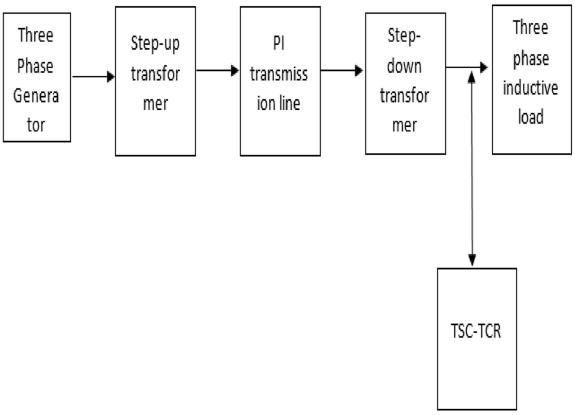

Fig 1 Diagram

banks connected in parallel to the circuit. Dynamic VAR compensation is what it's called. In DVC generally, a thyristor switch is used to switch on/off the capacitor banks (TSC).

DSVC Can be considered as a modified SVC model in which the TCR branch remains the same, and the fixed capacitor is replaced by the DVC model (TSC).
Because of the impedance of transmission lines and the lagging reactive power demand by most machines in consumer premises, the system's stability at the farthest reaches as well as transmission lines gets affected. Unnecessary voltage drops result in increased losses that must be supplied by the source, resulting in blackouts in the line due to the increased load.

On the load side, a low power factor causes energy loss, also penalty is charged for a low power factor. Overcompensation can cause the problem of the increasing receiving end voltage, and also can lead to damage to power source devices such as generators.
The objective of this project is to design and create a DSVC simulation model to improve power factors.
Some of the benefits that obtained by using power factor correction are I^2R losses in transformers and distribution equipment are reduced and also reduced voltage drop on lengthy wires.

2. Methodology

We had completed the simulation model of dynamic-static var compensation. Here we used thyristor switched capacitor, along with thyristor-controlled reactor in which thyristor firing angle is controlled by firing angle controller to improve the power factor of load side.

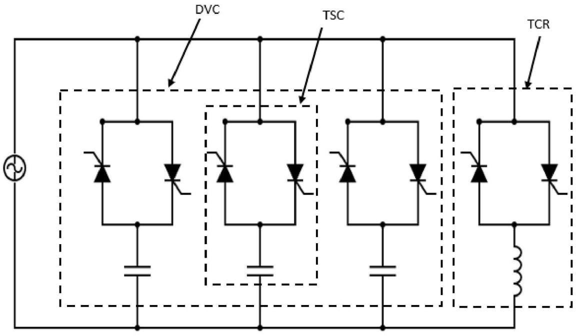

Fig 2 Block diagram

The block diagram for DSVC is shown above. In the block diagram several blocks such as a 3-phase generator, a pi transmission line, a 3-phase V-I measurement, controller, load measurement, and power measurement,

Fig 1 Combination of SVC and DVC (DSVC)3-phase load, Q and PF measurement, fixed capacitor bank, capacitor bank 1, capacitor bank 2 & reactor bank used to produce results.

MATLAB is used to simulate the DSVC model.
In which a step-up transformer (6.6/11KV) boosts the 6.6KV three-phase generator. A PI transmission line transports the power to the load center, where it is stepped down to 0.4KV via a step-down transformer (11/0.4KV). The power is sent to industrial loads that are largely inductive and require reactive power from the line, which is balanced by connecting the TSC-TCR branch.

2.1 Flowchart

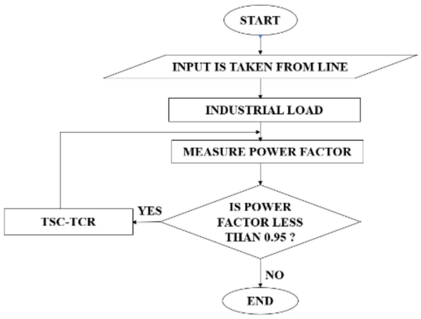

Fig 3 Flowchart

The figure shows the overall flowchart of the DSVC. Industrial load is supplied by input from the line. Parallel to the load thyristor-controlled reactor bank and thyristors switched capacitor banks are connected. The power factor of the load is measured and compared with reference value.

If the power factor is less than 0.95 then the control circuit operates the TSC-TCR branch. Switched capacitor bank parallel to load operate first which may lead to capacitive power factor. Then thyristor-controlled reactor bank consumes surplus reactive power and smooths out the power factor. If pf is greater than 0.95, the controller doesn't operate the TSC-TCR circuit.

3. Result and Discussion

When the reactive power demand of load is 4000 VAR, then reactive power is supplied by a fixed capacitor bank and capacitor bank 1 and capacitor bank 2, this causes overcompensation. Then the reactor bank smooth-out the over-compensation.

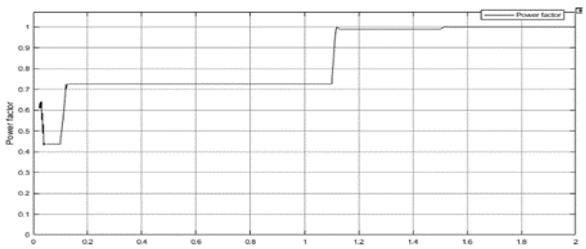

Figure 4 Power Factor Curve at 4000 VAR Load

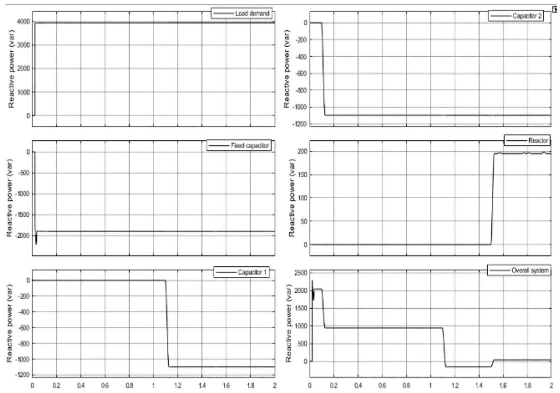

Figure 5 reactive power curve at 4000 load

Here if we use only DVC then due to the absence of the TCR branch, it causes overcompensation. Again only SVC is used then large reactor bank is required for smooth compensation . But DSVC eliminate both problems and provides smooth compensation.

4. Conclusion

This paper provides a combination of DVC and SVC structures. As we can see from the simulation results DSVC not only achieves a better response than DVC but also saves money by not using a huge inductor in the TCR branch as SVC does.

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