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Single Phase TSC Analysis

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ABSTRACT

A single-phase electric machine invokes a great reactive power demand in operation, resulting in a large voltage fluctuation in the supply system. Furthermore, the frequent and rapid operating characteristics of an electric welding machine cause a serious voltage flicker problem. The operation of welding equipment also generates significant harmonic current distortion, and distorts the voltage waveform of the supply system. Hence, this study focused on designing and applying a thyristor switched capacitor (TSC) bank for voltage flicker improvement. However, the single-phase TSC should also satisfy the reactive power demand and compensation speed, considering proper ratings of TSC to bear high harmonic distortion. This study shows the calculation results and discusses the impact of different capacities and different step numbers on TSC design. In addition, thyristor switches and a single-phase power factor controller were designed and implemented. The experimental results are also presented.

Key words: TSC, Thyristor valve, capacitor bank, Voltage stability

I. INTRODUCTION

A single-phase electric machine invokes a great reactive power demand in operation, resulting in a large voltage fluctuation in the supply system.[1] Furthermore, the frequent and rapid operating characteristics of an electric welding machine cause a serious voltage flicker problem[2]. The operation of welding equipment also generates significant harmonic current distortion, and distorts the voltage waveform of the supply system[3]. Hence, this study focused on designing and applying a thyristor switched capacitor (TSC) bank for voltage flicker improvement. However, the single-phase TSC should also satisfy the reactive power demand and compensation speed, considering proper ratings of TSC to bear high harmonic distortion[4]-[6]. This study shows the calculation results and discusses the impact of different capacities and different step numbers on TSC design[7]. In addition, thyristor switches and a single-phase power factor controller were designed and implemented. The experimental results are also presented.

II. LITERATURE SURVEY

The development of an optimal solution to network problems was initiated by the desire to find the minimum of the operating cost for the supply of electric power to a given load (Kichmayer 1958). The problem evolved as the so called dispatch problem. The principle of equal incremental cost to be achieved for each of the control variables or controllers has already been realized in the pre-computer era when slide rules and the like were applied.

A major step in encompassing not only the cost characteristics but also the influence of the network, in particular the losses were the formation of an approximate quadratic function of the network losses expressed by the active injections. Its core was the B-matrix which was derived from a load flow and was easily combined with the principle of equal incremental cost 19 thus modifying the dispatched powers by loss factors. The formulation of the problem must be considered as a remarkable improvement as shown by Squires, Carpentier, however, still there was no effective algorithm available. At that time the ordinary load flow made considerable progress (Tinney et al 1967, Scott 1974) and the capabilities of computers showed promising aspects.

Peschon et al (1968) proposed a method to minimize the transmission power losses by selecting of reactive power injections in to the systems and using transformer tap changing settings. They have included a suitable method to get the solution from a feasible optimal point, but it is more time consuming.

Dommel and Tinney (1968) presented a method to find the optimal power flow using a non linear optimization technique. They have used a non linear objective function of cost or losses using kuhn-tucker conditions, but control variables are not coordinated due to slow convergence. This is not suitable for large systems.

Hano et al (1969), proposed a new method of controlling the system voltage and reactive power distribution in the system. They followed the sensitivity relation ship between controlled variables and loss sensitivity indices and the implemented direct search algorithm to minimize the losses.

Narita et al (1971) developed the sensitivity analysis using method of base optimization technique to minimize the voltage deviation and minimize the system losses. To obtain successful operation they used voltage and reactive power regulating devices installed at various points. 20 Scott (1974) proposed power flow calculations to perform power system planning, operational planning and control. the OPF is solved by varities of methods i.e, successive linear programming method. Minimization of transmission losses can be achieved by controlling system devices such as generators, capacitors, reactors and tap changing transformers; it is possible to minimize the system losses by reactive power redistributions in the system.

Mamandur et al (1981) proposed an efficient algorithm to minimize the transmission loss. Considering the network performance constraints and the constraints on the control variables, they were applied a dual linear programming technique to find optimal adjustments to the control variables satisfying many constraints. This method is used to improve voltage profile and minimize system losses under operating condition. The result is showing to zigzagging due to slow convergence.

Shahidehpour et al (1990) discussed an overview of the reactive power allocation in electric power systems. Optimal reactive power control is the most important functions giving inadequate reactive power bring up some problems such as low voltage profile, extra loss and equipment overload. They have carried out to solve this problem, using nonlinear and linear programming methods.

Bhatele et al (1985) proposed a mathematical formulation of optimal power control problem to minimize and control the voltage profile. They have developed reduced gradient and Fletcher's update algorithm to solve this problem. In most of the studies, only they have considered system losses minimization. They are not considered light load conditions when the generators are under exited.

III. EXISTING METHOD

3.1 Ways of Improving Voltage Stability And Control

Reactive power compensation is often most effective way to improve both power transfer capability and voltage stability. The control of voltage levels is accomplished by controlling the production, absorption and flow of reactive power. The generating units provide the basic means of voltage control, because the automatic voltage regulators control field excitation to maintain scheduled voltage level at the terminals of the generators. To control voltage throughout the system we have to use addition devices to compensate reactive power . Reactive compensation can be divided into series and shunt compensation. It can be also divided into active and passive compensation. But mostly consideration will be focused on shunt capacitor banks, static var compensator (SVC) and Static Synchronous Compensators (STATCOM), which are the part of group of active compensators called Flexible AC Transmission Systems (FACTS). The devices used for these purposes may be classified as follows

- ✓ Shunt capacitors
- ✓ Series capacitors
- ✓ Shunt reactors
- ✓ Synchronous condensers
- ✓ SVC
- ✓ STATCOM

IV. PROPOSED METHOD

Thyristor switched capacitor:

Thyristor switched capacitor (TSC) is a type of equipment used for compensating reactive power in electrical power systems. It consists of a power capacitor connected in series with a bidirectional thyristor valve and, usually, a current limiting reactor (inductor). The thyristor switched capacitor is an important component of a Static VAR Compensator. A TSC normally comprises three main items of equipment: the main capacitor bank, the thyristor valve and a current-limiting reactor, which is usually air-cored.

1) Capacitor bank

The largest item of equipment in a TSC, the capacitor bank is constructed from rack-mounted outdoor capacitor units, each unit typically having a rating in the range 500 – 1000 kilovars (kVAr).

2) TSC reactor

The function of the TSC reactor is to limit the peak current and rate of rise of current (di/dt) when the TSC turns on at an incorrect time. The reactor is usually an air-cored reactor, similar to that of a TCR, but smaller. The size and cost of

3) Thyristor valve

The thyristor valve typically consists of 10-30 inverse-parallel-connected pairs of thyristors connected in series. The inverse-parallel connection is needed because most commercially available thyristors can conduct current in only one direction. The series connection is needed because the maximum voltage rating of commercially available thyristors (up to approximately 8.5kV) is insufficient for the voltage at which the TCR is connected. For some low-voltage applications, it may be possible to avoid the series-connection of thyristors; in such cases the thyristor valve is simply an inverse-parallel connection of two thyristors.

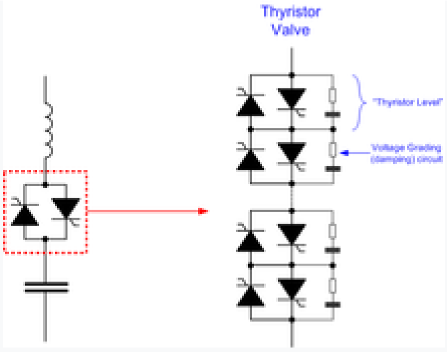


Figure 1

4) Typical TSC valve

In addition to the thyristors themselves, each inverse-parallel pair of thyristors has a resistor–capacitor ‘'snubber’ circuit connected across it, to force the voltage across the valve to divide uniformly amongst the thyristors and to damp the "commutation overshoot" which occurs when the valve turns off.The thyristor valve for a TSC is very similar to that of a TCR, but (for a given AC voltage) generally has between 1.5 and 2 times as many thyristors connected in series because of the need to withstand both the AC voltage and the trapped capacitor voltage after blocking.The thyristor valve is usually installed in a purpose-built, ventilated building, or a modified shipping container. Cooling for the thyristors and snubber resistors is usually provided by deionised water.

Special types of TSC

Some TSCs have been built with the capacitor and inductor arranged not as a simple tuned LC circuit but rather as a damped filter. This type of arrangement is useful when the power system to which the TSC is connected contains significant levels of background harmonic distortion, or where there is a risk of resonance between the power system and the TSC.In several "Relocatable SVCs" built for National Grid (Great Britain),[3] three TSCs of unequal size were provided, in each case with the capacitor and inductor arranged as a "C-type" damped filter. In a C-type filter, the capacitor is split into two series-connected sections. A damping resistor is connected across one of the two capacitor sections and the inductor, the tuned frequency of this section being equal to the grid frequency. In this way, damping is provided for harmonic frequencies but the circuit incurs no power loss at grid frequency.

Circuit Diagram of TSC:

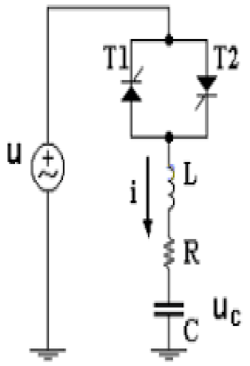


Figure 2

I

nternal structure of Microcontroller:

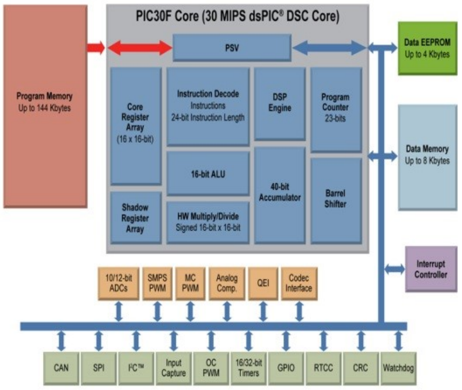
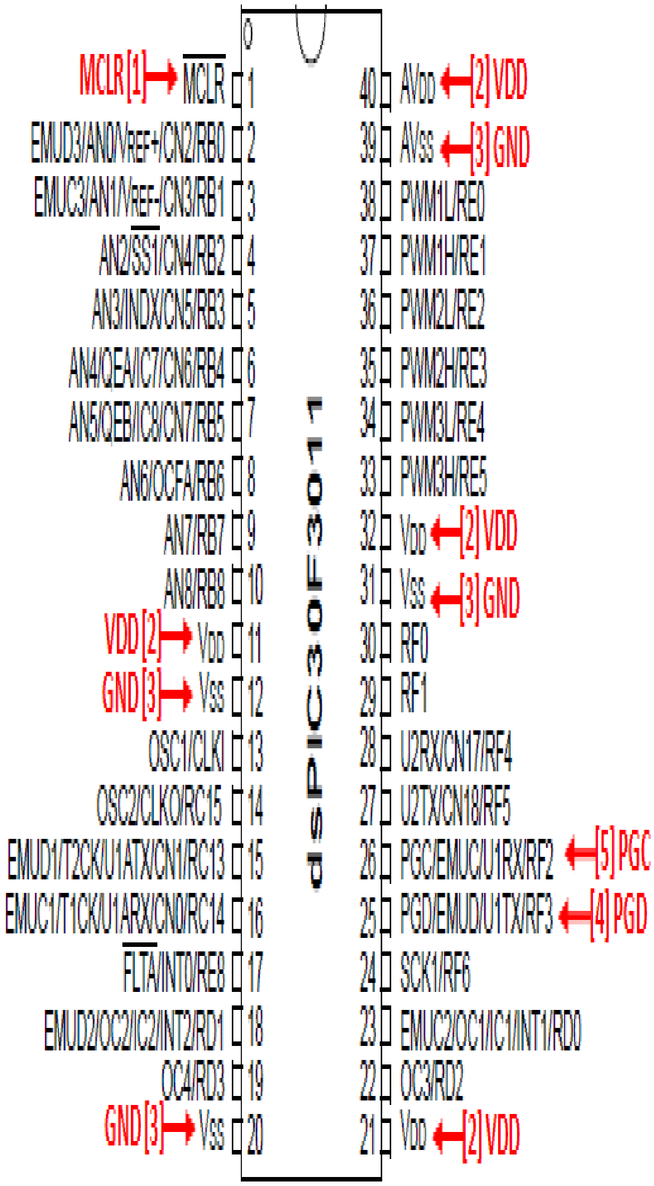


Figure 3

Dspic 30F 4011 pin details:



FFigure 4

Block diagram:

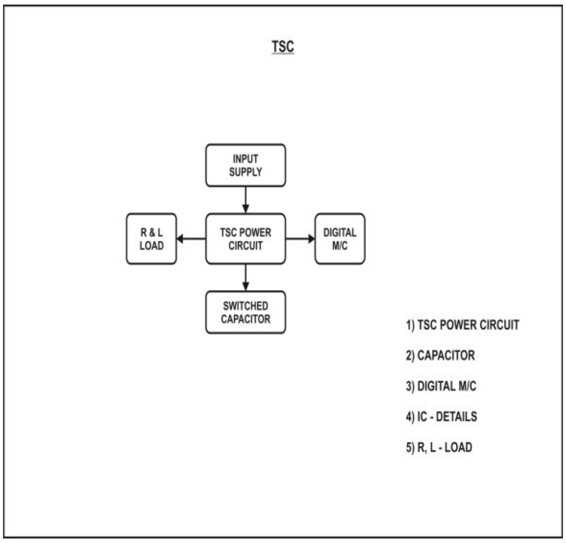


Figure 5

Hardware details:

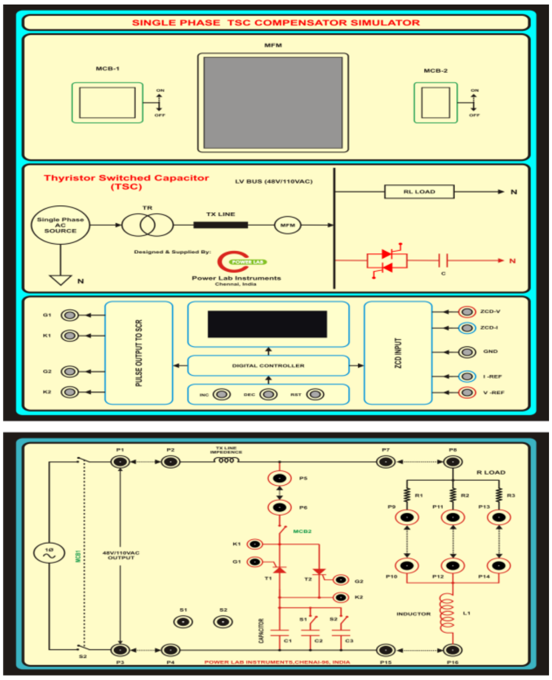


Figure 6

- ✓ This setup consist of Two number of ON/OFF mcb
- ✓ Dspic 30F4011 based Micro Controller
- ✓ Power factor meter
- ✓ Scr driver board
- ✓ Capacitor bank
- ✓ shunt Reactor
- ✓ R-L load
- ✓ Designed this setup is 110v

SCR Driver board:

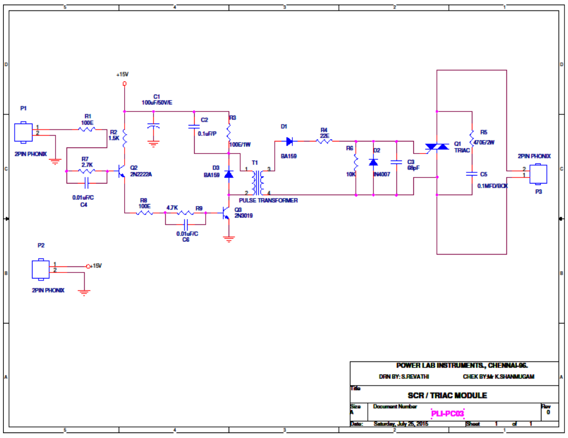


Figure 7

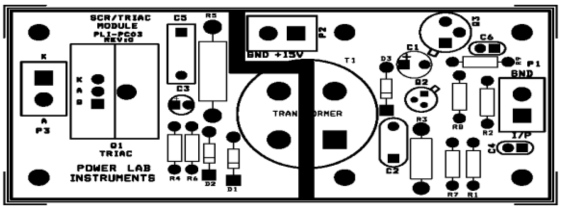


Figure 8

V. CONCLUSION

This presents switching of capacitor bank for power factor improvement. Power factor improvement is very useful. The microcontroller based Thyristor Switched Capacitor is providing a better power factor to nearly unity with light loading and can be maintained to around 0.9 with increase in system loading .

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