Mitigating the Harmonic Distortion in Power System using SVC With AI Technique

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Abstract— The reactive power compensation in a power distribution network plays a vital role in improving voltage and power system stability. Flexible AC transmission system (FACTS) devices like Static Var Compensators (SVCs) are used to control reactive power generation or absorption in long transmission line. However, these SVCs will introduce harmonic current in to the system due to the operation of thyristor controlled reactors (TCR). This paper proposes minimize harmonic injected using svc & passive filter combination and modified AI technique approach to minimize the harmonics injected into the systems with the operation of TCR-TSC type SVC used in conjunction with fast-changing loads. Optimum triggering delay angles used to trigger thyristors in TCR are calculated using the proposed to achieve better, smooth and adaptive control of reactive power as well as harmonics. And define which system is best for minimum injected harmonic in power system.

Key words: Introduction, Harmonics, Passive filter,, Static Var Compensator (SVC), AI techniques (ANN), Simulation and Results, Experimental Setup and Result

I. INTRODUCTION

Harmonics and reactive power regulation and guidelines are upcoming issues and increasingly being adopted in distributed power system and industries. Vital use of power electronic appliances has made power management smart, flexible and efficient. But side by side they are leading to power pollution due to injection of current and voltage harmonics. Harmonic pollution creates problems in the integrated power systems.

Thyristor-controlled static var compensators (SVCs) are the commonly used FACTS device in modern power-supply systems for compensating loads due to low cost and simple control strategy. An SVC can consist of a thyristor controlled reactor (TCR) and a thyristor switch capacitor (TSC) and compensates loads through the generation or absorption of reactive power [3]. A continuous range of reactive power consumption is obtained by the operation of TCRs at appropriate conduction angles. However this operation results in the injection of harmonic currents into the power supply.

There are various techniques available in the literature to reduce the harmonics injected by TCR into the power system. Simplest method is to use appropriate harmonic filters with the TCR or introduce some technique to minimize harmonic generation internally.

II. HARMONIC

Harmonic distortion is not new and it constitutes at present one of the main concerns for engineers in the several stages of energy utilization within the power industry. In the first electric power systems, harmonic distortion was mainly caused by saturation of transformers, industrial arc furnaces, and other arc devices like large electric welders. The major concern was the effect that harmonic distortion could have on electric machines, telephone interference, and increased risk of faults from overvoltage conditions developed on power factor correction capacitors.

In the power system study, harmonics is more important. Here some problems due to harmonic in power systems are:

- Electrical equipments are operate uncertainly at same time of day
- Equipment damage at thunderstorm occur
- Circuit breakers are operate without overloading condition
- Frequency basis, electronic components are fail Automated system does not work properly

Harmonics in voltage or current waveforms can then be conceived as perfectly sinusoidal components of frequencies multiple of the fundamental frequency:

Fn= (h) x (fundamental frequency)

Where n is integer

For example: third harmonic is a harmonic component

Fn= (5) X (50) =250

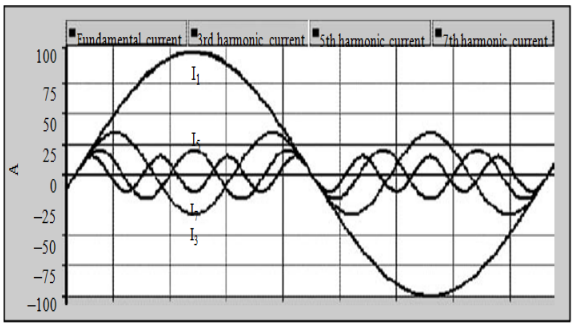

Fig .1: Sinusoidal 50-Hz waveform and harmonics.[9]

Figure 1 shows an ideal 50-Hz waveform with a peak value of around 100 A, which can be taken as one per unit. Likewise, it also portrays waveforms of amplitudes (1/7), (1/5), and (1/3) per unit and frequencies seven, five, and three times the fundamental frequency, respectively. This behavior showing harmonic components of decreasing amplitude often following an inverse law with harmonic order is typical in power systems [7].

These fundamental 3rd 5th and 7th harmonic equations are

$$Im = Im \sin(\omega t)$$

Where Im is the peak RMS value of harmonic current n.

III. PASSIVE FILTER

Passive filters are very much helpful for mitigation of harmonic component and used traditionally. Passive filters are used for the mitigation of harmonic in the electrical

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society for last 3 decades and there is a continuous development has been reported in this technique for the better use of filter and convert the filter more useful to achieve the optimum approach to utilization with reduced rating and cost [4].The performance of passive filter depends mainly on the system source impedance.Fig.2

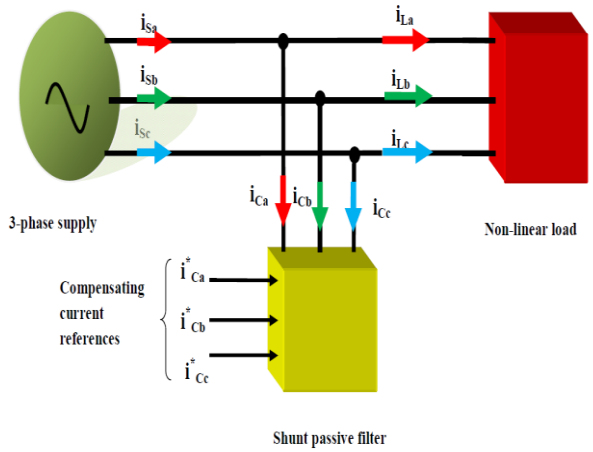

Fig. 2: Passive filter

There are various issues in the design of a passive filter for its proper functioning in harmonic reduction. The key issues are mentioned here:

A. Minimizing harmonic source current

The prime objective of the filter design is to minimize the harmonic current in ac mains. This is ensured by minimizing the filter impedance at the harmonic frequencies so that the harmonic filter acts as a sink for the harmonic currents.

B. Minimizing fundamental current in passive filter

To ensure that the installation of passive filter does not cause the system loading, the fundamental current in the passive filter is minimized by the maximizing the passive filter impedance at the fundamental frequency.

C. Environment and ageing effect

The capacitors with metalized film construction lose capacitance as they age. Similarly the manufacturer tolerance of the harmonic filter reactor may result in tuned frequency higher than the nominal. An IEEE Standard 1531[4] recommends that the passive filters are tuned at 6% below the rated frequency so that it will exhibit acceptable tuning at the end of its 20 year life.

The passive shunt filter consists of first order series tuned low pass filters for 5th and 7th order harmonics. For the series tuned low pass filters, the impedance is given by:

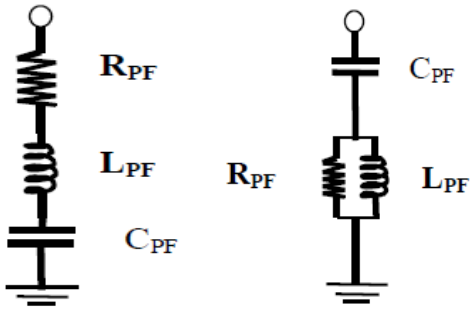

Fig. 3: Low pass Filter and High pass Filter

$$Zsh = \left[R + j(hXL - \frac{Xc}{h}\right]$$

$$XL = \frac{Xc}{h^2 n}$$

$$\text{Xc} = \left(\frac{h^2 n - 1}{hn}\right)\frac{X^2}{Qsh}$$

Where Qsh is the reactive power provided by the passive filter, h is the harmonic order of the passive filter; XL is the reactance of inductor. Xc is the reactance of the capacitor at fundamental frequency. The reactive power requirement may be initially assumed around 25% of the rating of the load. It may be equally divided among different filter branches. The values of series tuned elements may be calculated from eqn. (3.4). The quality factor for low pass filter (defined as QF =XL/R), is consider as 30 in this work to calculate the value of the resistive element.

The resonant frequency for the hth harmonic is given as:

$$Fh = \frac{1}{(2\pi hCL)}$$

Quality factor can be defined as

$$Q = \frac{L}{CR^2}$$

The values of filter components can be calculated from above equations. The design of the passive shunt filter is carried out as per the reactive power requirements. This filter is designed to compensate the requirements of reactive power of the system.

IV. STATIC VAR COMPENSATOR

The Static Var Compensator (SVC), a first generation FACTS controller is taken up for study. It is a variable impedance device where the current through a reactor is controlled using back to back connected thyristor valves. The application of SVC was initially for load compensation of fast changing loads such as steel mills and arc furnaces. Here the objective is to provide dynamic power factor improvement and also balance the currents on the source side whenever required.

The control system consists of followings:

(1) A measurement system for measuring the positive-sequence voltage to be controlled.
(2) A voltage regulator that uses the voltage error (difference between the measured voltage Vm and the reference voltage Vref) to determine the SVC susceptance B needed to keep the system voltage constant.
(3) A distribution unit that determines the TSCs (and eventually TSRs) that must be switched in and out, and computes the firing angle α of TCRs
(4) A synchronizing system using a phase-locked loop (PLL) synchronized on the secondary voltages and a pulse generator that send appropriate pulses to the thyristors

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The block diagram of a general TSC–TCR type of SVC control system.

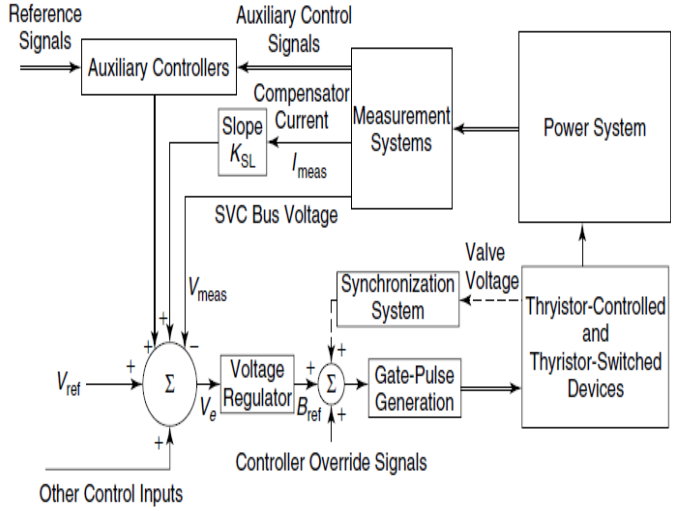


Fig. 4: A general schematic diagram of an SVC control system[9]

V. ANN APPROACH

The relationships between the inputs to the controller, i.e., phase wise active and reactive power demands and the outputs , i.e., the firing angles and the TSC step size are quite complex and it is difficult for a single neural network to approximate such a complex relationship. The proposed algorithm can be used for real time control of SVCs which are used to compensate unbalanced fluctuating loads. The neural network is trained to approximate the function of the fuzzy logic based SVC control algorithm in order to reduce the computational time. The structure of ANN controller used is shown in Fig.4

It was observed that the dependency of the outputs on the real power demands is minimal. It reflects only in calculation of the load bus phase voltages. Small change in load bus voltages doesn't much affect on the amount of reactive power absorbed or supplied by the TCR and TSC respectively. In order to reduce the complexity of neural network only reactive power demands are used as inputs to the controller. The neural network controller used contains a three layer feed forward neural network each of which takes load reactive power demands in each of the three phases as inputs. Each layer generates the optimum triggering delay angle al, a2 or a3 corresponding to the delta reactances Xab,Xbc and Xca respectively.

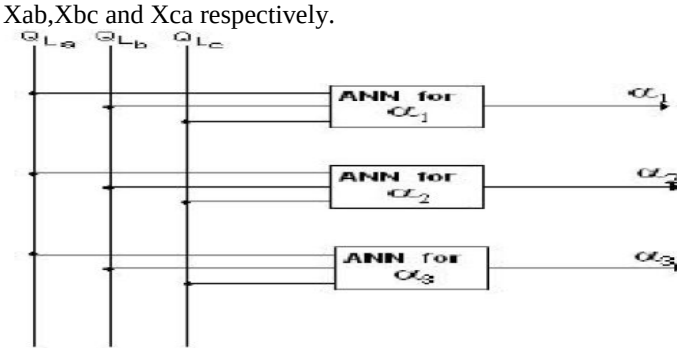
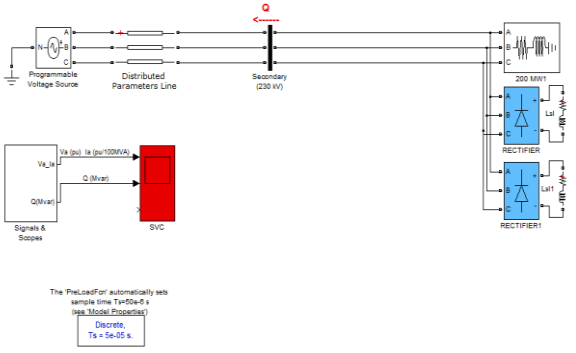


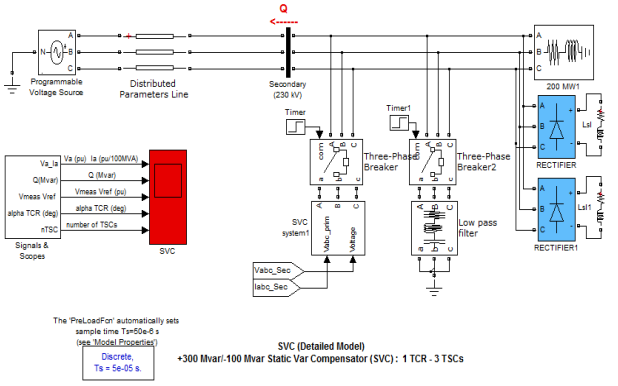
Fig. 5: Schematic diagram of the ANN controller

VI. SIMULATION AND RESULT

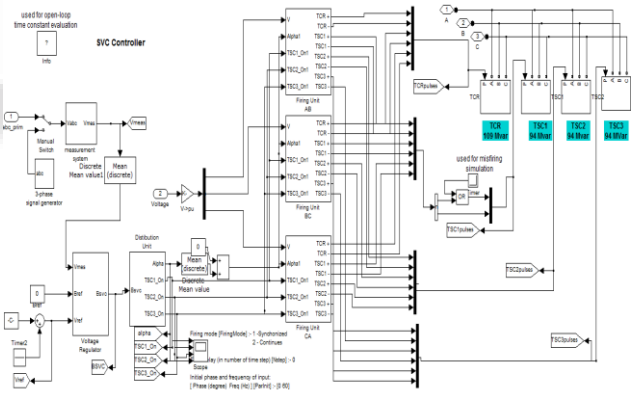
A. *Case Study-I (without svc):*



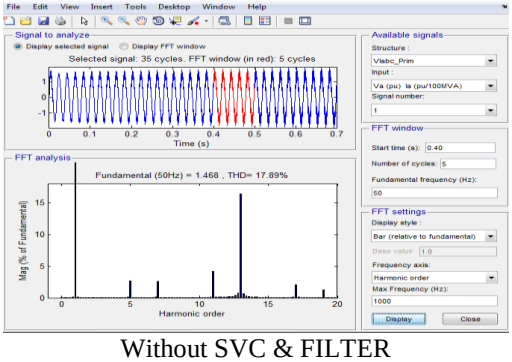
B. *Simulation of Case Study-I (With Svc):*



C. *SVC Model*



D. *A.C Voltage response % THD*



Without SVC & FILTER

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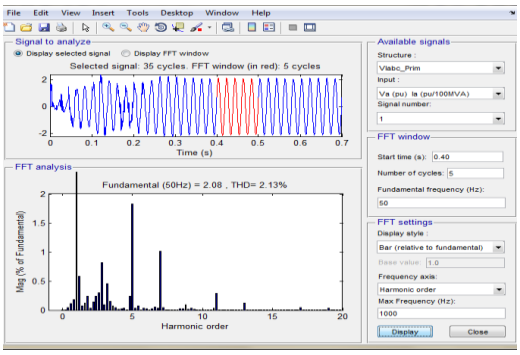
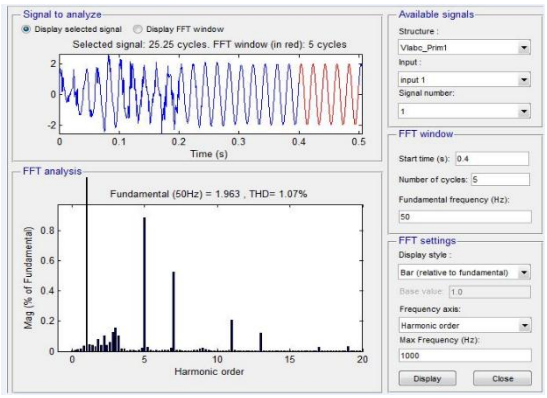
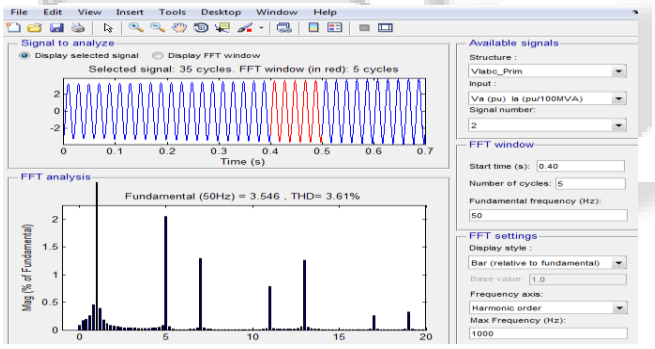


With SVC & FILTER

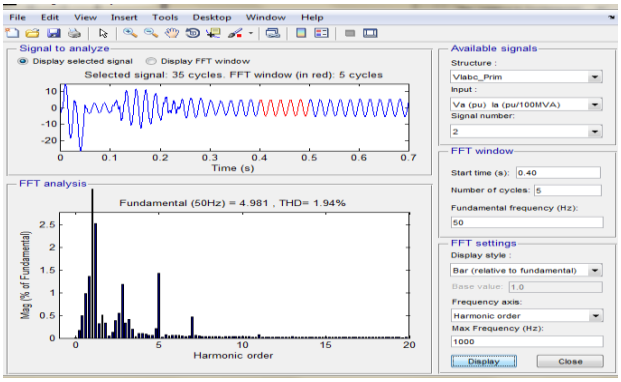


With SVC & ANN

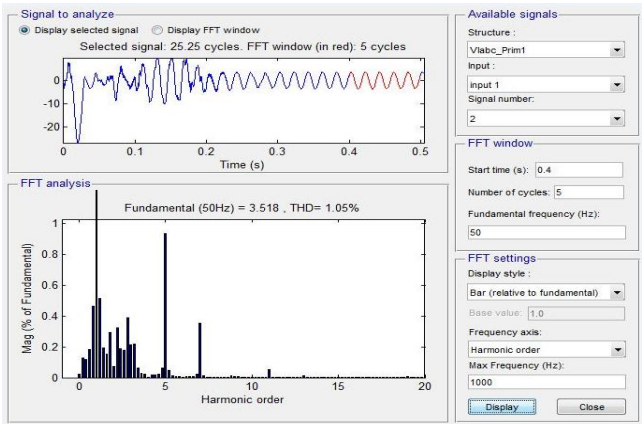
E. A.C Current Response % THD



Without SVC & FILTER



With SVC & FILTER



With SVC & ANN

VII. RESULT

MATLAB SIMULINK MODEL	VOLTAGE THD%	CURRENT THD%
Without SVC & Filter	17.94	4.44
With SVC & Filter	6.90	3.62
With SVC & ANN	1.07	1.05

VIII. CONCLUSION

After this simulation concludes that a thyristor controlled Static Var Compensators (SVCs) are popularly used in modern power supply systems for compensating loads. The operation of Thyristor Controlled Reactors at appropriate conduction angles can be used advantageously to meet the phase-wise unbalanced and varying load reactive power demand in a system. However, such an operation pollutes the power supply in another form by introducing harmonic currents into the power supply system. In this case minimum injected harmonics using SVC & Filter combination. AND Minimum injected harmonic using SVC with AI Technique Analysis of simulation results. Comparison of all the simulation results and define that SVC with AI Technique method is better compare that svc with filter.

REFERENCES

[1] George J. Wakileh, Power system harmonics, fundamentals, analysis and filter design, New York, Springer-Verlog Berlin Heidelberg, 2001, pp 81-103.
[2] IEEE recommended practices & requirements for harmonic control in electrical power systems, IEEE 519 standard, 1993.
[3] Arindam Ghosh and Gerard Ledwich, Power quality enhancement using custom power devices, London, Kluwer Academic Publishers, 2002, pp 55-111.
[4] B. Singh, K. A. Haddad and Ambrish Chandra, "A review of active filters for power quality improvement", IEEE trans. Industrial Electronics, Vol. 46, No.5, Oct.99.
[5] A.Elnady and Magdy M.A.Salama,"Unified approach for mitigating voltage sag and voltage

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flicker using the DSTATCOM", IEEE trans. Power Delivery, Vol.20, No.2, April 2005.

[6] D.Thukaram., A. Lomi and S Chirarttananon, "Minimization of harmonics under three phase unbalanced operation of static VAR compensators", Proceedings of the 12th International Conference on Power Quality, Chicago, U.S.A., 1999.

[7] Athula Rajapakse, Anawat Puangpairoj, Surapong Chirarattananon, and D.Thukaram, "Harmonic Minimizing Neural Network SVC Controller for Compensating Unbalanced Fluctuating loads", 10th International Conference on Harmonics & quality of power 2002, vol.2, pp 403-408, Oct. 2002.

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