RESEARCH ARTICLE OPEN ACCESS

Harmonic Analysis in the Power System to Reduce Transmission losses and Save Energy

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ABSTRACT
This paper is about the harmonics related to the power system . How it affects the whole transmission, loads connected etc that is whole system.In the below article we have discussed about the harmonic limits for the power system required and the method to mitigate it from the power system . To reduse harmonics from the system we have used 48 pulse Statcom in the substation of 132KV/33KV .The source convertor is being applied to the 33KV side of the system. After the techno-economic analysis, their is about approximately Rs. 2 lakh yearly saving has been calculated.
Keywords - Harmonic mitigation in Power System, Power Factor Correction and Improve MVA Rating of transformer

I. INTRODUCTION

In any alternating current network, flow of current depends upon the voltage applied and theimpedance (resistance to AC) provided by elements like resistances, reactances of inductive andcapacitive nature. As the value of impedance in above devices is constant, they are called linearwhereby the voltage and current relation is of linear nature.

However in real life situation, various devices like diodes, silicon controlled rectifiers,PWM systems, thyristors, voltage & current chopping saturated core reactors, induction & arcfurnaces are also deployed for various requirements and due to their varying impedance characteristic,these NON LINEAR devices cause distortion in voltage and current waveformswhich is of increasing concern in recent times. Harmonics occurs as spikes at intervals whichare multiples of the mains (supply) frequency and these distort the pure sine wave form of the supply voltage & current.

Harmonics are multiples of the fundamental frequency of an electrical power system. If, for example, the fundamental frequency is 50 Hz, then the 5th harmonic is five times that frequency,or 250 Hz. Likewise, the 7th harmonic is seven times the fundamental or 350 Hz, and so onfor higher order harmonics.

Harmonics can be discussed in terms of current or voltage. A 5th harmonic current is simplya current flowing at 250 Hz on a 50 Hz system. The 5th harmonic current flowing through thesystem impedance creates a 5th harmonic voltage. Total Harmonic Distortion (THD) expressesthe amount of harmonics. The following is the formula for calculating the THD for current:

$$THD(current)=\sqrt{\sum_{n=2}^{n=n}\left(\frac{In}{I}\right)^2}\times 100$$

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When harmonic currents flow in a power system, they are known as "poor power quality" or "dirty power". Other causes of poor power quality include transients such as voltage spikes, surges, sags, and ringing. Because they repeat every cycle, harmonics are regarded as a steadystate cause of poor power quality.

When expressed as a percentage of fundamental voltage THD is given by,

$$THD(current)=\sqrt{\sum_{n=2}^{n=n}\left(\frac{Vn}{V}\right)^2}\times 100$$

where V1 is the fundamental frequency voltage and Vn is nth harmonic voltage component

II. LITERATURE SURVEY

1996 Multi-pulse methods are characterized by the use of multiple converters or multiple semiconductor devices with a common load. Fig. 1 & Fig. 2 given below depict the various techniques used widely for the reduction of harmonics.[1]

1998 Commercial availability of Gate Turn-Off thyristor (GTO)devices with high power handling capability, and the advancement of other types of power semiconductor devices such as IGBT's, have led to the development of controllable reactive power sources utilizing electronic switching converter technology [2].

2000 The interaction between these compensating devices and the grid network is preferably studied by digital simulation. Flexible alternating current transmission systems (FACTS) devices are usually used for fast dynamic control of voltage, impedance, and phase angle of high-voltage ac lines. FACTS devices provided strategic benefits for improved transmission system power flow management through better utilization of existing transmission assets, increased transmission system security and reliability as well as availability, increased dynamic and transient grid stability, and increased power quality for sensitive industries [3].

2000 When the StatCom is used as compensator, the move from capacitive to inductive mode, is very fast [4].

2000 The Static Synchronous Compensator (StatCom) is a shunt device of the Flexible AC Transmission Systems (FACTS) family it is based on power electronics devices to control voltage to compensate reactive power, and improve transient stability [5][4].

2001 One of the important requirements in high voltage power applications is that harmonics be kept at some satisfactory level [6]. One way of reducing the level of harmonics presents in the converter output waveforms is to increase the number of converters [7], [8].

2003 The Voltage Source Converter is the basic building block of FACTS devices such as StatCom and UPFC. Single phase voltage source converters can be inter-connected to form complex schemes. Combined with appropriate controllers, certain harmonics can be eliminated [9].

2004 The results of applying a StatCom are similar to those by a rotating synchronous condenser, but without its mechanic all inertia and slow time response [6].

2004 An elementary voltage source converter, based on a phase control scheme, consists of six self commute semiconductor switches. Each switch is shunted by a reverse parallel-connected diode; with a DC voltage source, the converter can generate a balanced set of three phase voltage waveforms at a given frequency, [10].

2004 By combining two 24-pulses VSC, phase-shifted 7.5° from each other, an equivalent 48-pulse converter [10]

2005 The 48-pulse convertor; It is formed by four three-level converter linked by four phase shifting transformers. The quality of the output voltage obtained from such converter. It can be deduced that the harmonics are reduced by increasing the number of pulses [7] [11]. This kind of converter give rises to a better voltage control on modern power systems [11].

2005 The StatCom basically consists of a step-down transformer with a leakage reactance, a three-phase GTO voltage source converter (VSC), and a DC capacitor [12].

2006 These technologies additionally offer considerable advantages over the existing ones, in terms of space reductions and performance .FACTS are a result of the development in the power electronics area and aim to rapidly control electrical signals [13].

2007 Losses in distribution transformers account for almost one third of overall transmission and distribution losses [4].

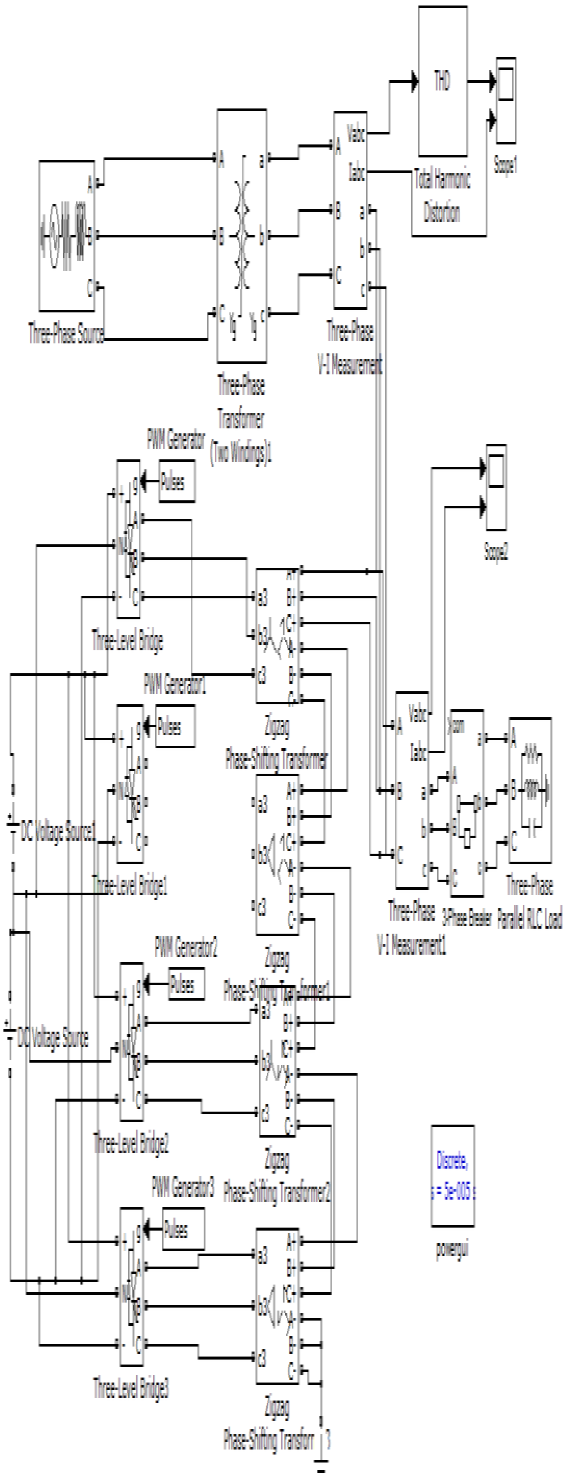
2008 The precise impact of a harmonic current on load loss depends on the harmonic frequency and the way the transformer is designed. In a transformer that is heavily loaded with harmonic currents, the excess loss can cause high temperature at some locations in the windings. This can seriously reduce the life span of the transformer and even cause immediate damage and sometimes fire. A number of methods exist to prevent overloading or failure of the distribution system, either by accommodation or elimination of the harmonic currents [14].

2008 Multi-pulse methods involve multiple converters connected so that the harmonics generated by one converter are cancelled by harmonics produced by other converters. By this means, certain harmonics related to number of converters are eliminated from the power source. In multi-pulse converters, reduction of AC input line current harmonics is important as regards to the impact the converter has
on the power system.[15]

III. METHODS OF HARMONIC MITIGATION

Many methods are being used to reduce harmonics in the present paper 48 pulse Statcom is being used to reduce harmonics in the power system

IV. SIMULATION MODEL

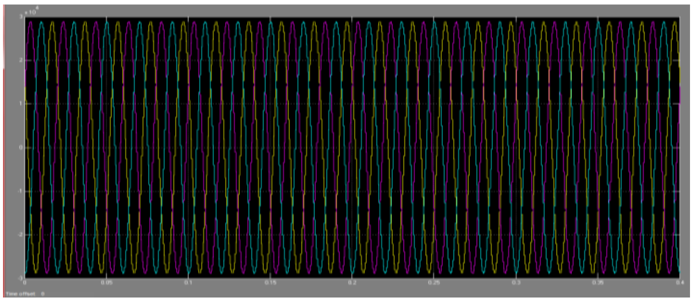


Symatic arrangement of 48-pulse voltage convertor with the 33KV power system

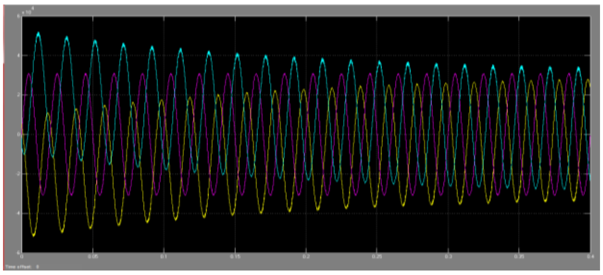
V. SYSTEM PARAMETERS

Sr.No.	Equipments list	Parameter description
1	Three –phase source	Voltage ph-ph =130KV
2	System transformer step down	40MVA,132/33KV
3	Three phase constant voltage at 33KV side	
	Voltage	31.36Kv
	Frequency	50Hz
4	Statcom	
	Frequency	50Hz
	Capacitance	3000 µF
5	4 numbers phase shift zig-zag transformer	1 MVA (each)
6	GTO switch	
	Snubber resistance	1e-5 (ohm)
	Snubber capacitance	1Inf
	Internal resistance	1e-4 (ohm)
	No. of bridge arm	3
7	4 number of pulse generator	12 pulse (each)

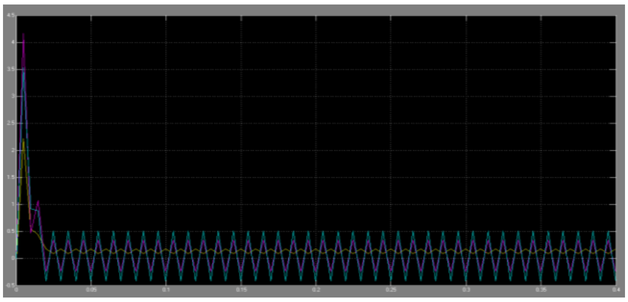
VI. SIMULATION RESULT



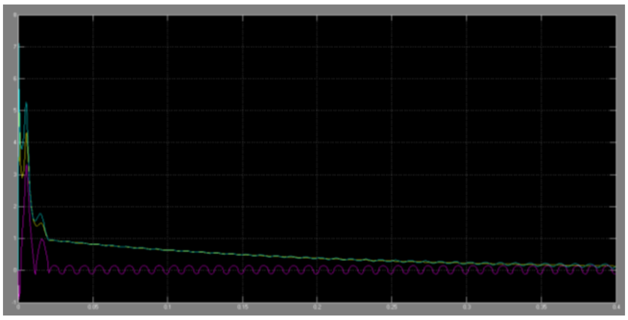
Voltage V_{abc} without Harmonic Correction(Y axis – Voltage in V, X axis - time in millisecond)



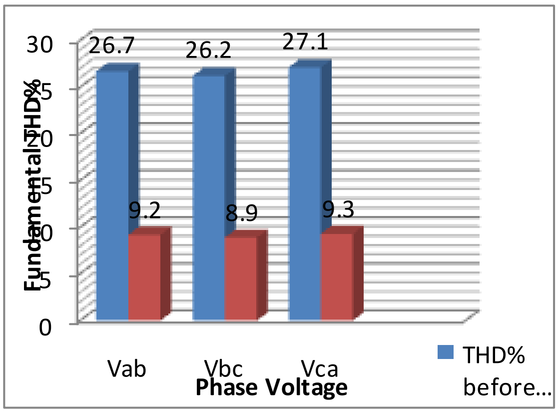
Voltage $Vabc$ after harmonic correction(Y axis – Voltage in V, X axis - time in millisecond)



THD graph of voltage $Vabc$ without harmonic correction(Y axis – THD, X axis - time in millisecond



THD graph of voltage $Vabc$ after harmonic correction(Y axis – THD, X axis – time in millisecond)



THD% Graph for phase Voltage

VII. CONCLUSION

The 48 pulse Statcom is a source convertor that is connected shuntly to the transmission system to improve the voltage contents in the system. The Statcom can also able to generate voltage waveform to reduce harmonic effects from the system.Statcom response is very fast i.e in few cycle it can able to pass from capacitive mode to inductive mode of operation. Statcom also help to increase the MVA rating of the transformer upto 6.5% by improving the power factor of the transmission line.

REFERANCE

[1] G.K.Dubey, S.R.Doradla, A.Joshi, R.M.K.Sinha,―Thyristorised Power Controllers , New AgeInternational publishers, July 1996

[2] CIGRE, “Static Synchronous Compensator”, working group 14-19,September1998

[3] N. G. Hingorani and L. Gyugyi, Understanding FACTS, Concepts, and Technology of Flexible AC Transmission Systems. Piscataway, NJ: IEEE Press, 2000

[4] Lazlo Narain G. Hingorani, Laszlo Gyugyi, « understanding FACTS concepts and technologie», book, john wiley and son, IEEE order N¨° Pc 5713, 2000.

[5] M.S. El-Moursi. A.M. Sharaf « Novel reactive power controllers for the StatCom and SSSC », *Electric Power*

[6] Vijay K. Sood, M.A.Pai and Ale Stankovic, « *hvdc and controllerfacts applications of static converter in power system* » Klower power.

[7] Ricardo Dávalos Marín « *Detailed analysis of a multi-pulse StatCom* »Pre-doctoral thesis, May 2003.

[8] Edvina Uzunovic « EMTP, Transient Stability and PowerFlow Models and Control of VSC Based Facts Controllers »thesis2001

[9] M. G. Molina and P. E. Mercado « The *Real Time Digital Simulation of a Single Phase Voltage Source Converter and its Application* »paper International Conference on Power Systems Transients - IPST2003 in New Orleans, USA. electronics and power system series, ISBN 1-4020-7891-9, 2004Kluwer academic publisher TLFe book

[10] M. G. Molina and P. E. Mercado « Controlling a staticSynchronous compensator with superconducting magnetic energyStorage for applications on primary frequency control », Latin American Applied Research argentina2004.

[11] Yakoub khadidja « Reduction of effects of the zero sequencevoltage in the ossociation of inverter multilevel applied to inductionmotor » thesis at Batna University, Algeria, 2005.

[12] Iswaran Sothandara Kumar « flexible alternating current transmission systems: static synchronous compensator (statcom) » thesis Curtin University of Technology, Western Australia, November 2005.

[13] Raymond Senzo Mkhize, Professor B.S. Rigby « *DSP-Based control of a StatCom* » Final Repor, university of KwaZulu-Natal faculty of engineering, november 2006

[14] Lowenstein, M.Z., "Eliminating harmonic neutral current problems", IEEE/PES Transmission and Distribution Conference and Exposition, 21-24 April 2008, pp. 1-4.

[15] Singh, S.Gairola, B.N.Singh, A.Chandra, andK.A.Haddad, ―Multi-pulse AC-DC Converter forImproving Power Quality: A Review IEEETransactions, On Power Delivery, Vol.23 No.1January 2008.