DEMAND SIDE MANAGEMENT BASED ON POWER QUALITY PARAMETERS WITH SPECIAL REFERENCE TO INDUSTRIAL LOADS

[1]Shimpy Maheshwari, [2]Arvind Dhingra

Electrical Engg Department, Guru Nanak Dev University
Ludhiana,India
Email: [1]shimpy_08@yahoo.co.in, [2]arvinddhingra@gmail.com

Abstract— The paper focuses on enhancement of system security and to enhance the system performance under load conditions through the optimal placement and optimal setting of harmonic filter. The goal of the methodology is so developed to alleviate/eliminate overloads on the system and to maintain the voltages at all load buses within their specified limits by use of harmonic filter. Load flow analysis of system is performed to calculate the various values of voltage and power flow at each bus. Simulation of this distribution substation with filter has been developed in Electrical Transient Analyser Program (ETAP) environment. The objective of the study is enhancement in voltage at various buses and the improvement in power flow with reduction in branch losses. This premise is attested on 12bus system to show the effectiveness of the method.

Keywords— demand side management, electrical transient analyser program (ETAP),harmonic filter (HF)

I. INTRODUCTION

Single tuned harmonic filter planning is formulated for the multi objective optimization in the industrial distribution system. the authors deal with the objective of harmonic filter planning which are minimization of total harmonic current distortion, total harmonic current distortion, total harmonic voltage distortion and harmonic filter investment cost using Goal attainment method based on simulation approach [1] .Harmonic models and describes about the design of harmonic filters for large industrial load with the help of simulation performed as a part of study[2].Harmonic measurements to calculate voltage and current ratings of the filter components are done using harmonic limits which are taken before filter installation and after filter installation to insure model accuracy and to confirm simulation results. [3].

EAFs and LF's are stated to be the most problematic industrial loads which create voltage fluctuations and harmonic in the system so the C-type 2nd harmonic filter is optimized in a new way The C-type 2nd order HF is so designed so as to suppress transient over voltage and harmonic filtering[4].Harmonic similarity metric is developed in the following paper to establish the efficient filter allocation to properly suppress the harmonic current in an industrial distribution system. Modelling & simulation is done using power system simulation software PSCAD[5].Control of Harmonic voltage and voltage distortion in power system done by single turned passive filters planning. To obtain the optimal size of the filter, the objective function is solved using genetic algorithm based optimizer[6]. Study is done using one line diagram testing of typical power distribution system empowering passive load, IM, ASD and correction using the power factor connection capacitor characteristic, design, & evaluation is done using single turned filter and system analysis before and after installing filter results are analysed[7].

Power quality is the quality of service (QOS) for electric power service providers to the customers or end users which covers variety of transient electromagnet phenomena in electrical distribution systems. Time frequency analysis is done[8].Power Quality is a parameter used to quantify the quality of power supply and serve as basis of comparison of the different disturbance on power network [9].

An interactive method for analysis and design tool can be done using the electrical transient analyser program (ETAP) It is a user friendly interface and Human Machine interface which makes use of common database, technical models and traps errors and give estimate parameters[10].Analysis and study of power system are important parts of electrical engineering. Simulation of 132 KV grid is done in ETAP This research paper is focused on the detailed analyses, parameter configuration, result values and monitoring by use of ETAP. which provides fabulous speeds to generate output reports, graphs and performs accurate numerical calculation of large integrated power system. Off-line monitoring is done which includes voltage at each bus, current flowing in each branch, active and reactive power flow, branch losses, power factor harmonic distortions etc of large systems[11].

II. 12-BUS INDUSTRIAL DISTRIBUTION SYSTEM

An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

A. One Line Diagram

The Electrical Transient Analyser Program (ETAP) is used for the model testing of the 12-bus system which consists of twelve voltage buses, three generators,15 transmission lines and twelve loads consecutively one at each bus. The one line diagram of three phase power system to be studied as test system for strategic harmonic filter placement is shown in figure 1.The system used in 12 bus balanced distribution system .It is the variation of the system, which was extracted from a common system being used in many examples and calculations . For effective demonstration additional amount of loads are applied and configured to the buses for voltage transformations to the original system.

The voltage at the buses ,rating of the generators and resistance, reactance of the transmission line etc. And other parameters all are configured in the ETAP environment edit mode. The single line diagram upon configuration is as shown in figure consists of whole system under test.

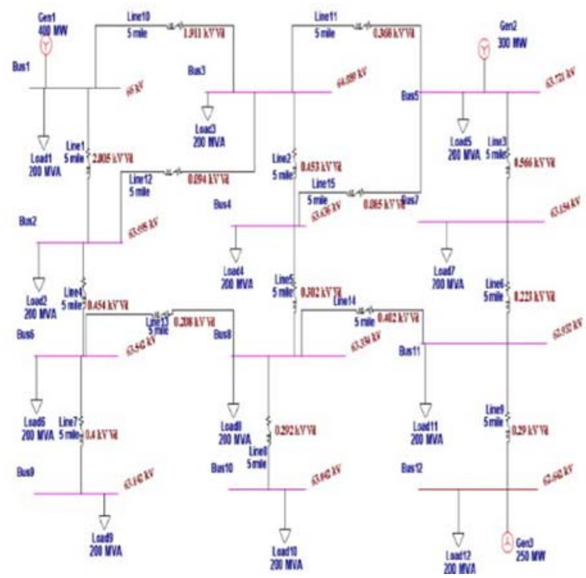


Figure 1 load flow diagram of industrial 12-bus power system

The system under load gets instable as the voltage dips at the voltage bus. The generator 1 is made the swing bus, whereas generator 2 and generator 3 are voltage control generators. Except at Bus 1 all other voltage buses voltage distorts on application of load. Bus 2-11 is all marginally unstable and bus 12 is unstable. So to stabilize the power system network use of harmonic filter is done.

III. HARMONIC FILTER

The optimal planning of large passive-harmonic-filters set at high voltage level based on which, the types, set numbers, capacities and the important parameters of filters are well determined to satisfy the requirements of harmonic filtering. Four types of filters, namely single-tuned filter, second-order, third-order and C-type damped filters are selected for the planning.

Many studies have shown that harmonics may produce adverse effects on power systems, communication systems, and various other effects. Various methods can be applied to reduce the harmonic currents on consumer side, in which the shunt passive harmonic filters are most often used as low cost devices and can provide the reactive power compensation to systems simultaneously.

Before applying the passive harmonic filters, the planning of filters should be drawn out first, which determines the types, set numbers, capacities and the important parameters of filters to satisfy the requirements of harmonic filtering and reactive power compensation (improvement of power factor). The filter can be set at high voltage level or low voltage level. In general, because most of nonlinear loads are set at low voltage level, and the low voltage system has a high and stable source impedance, thus the performance of harmonic filter set at low voltage level is better than that of high voltage level. When the harmonic filter with large capacity (up to I MVA) is required.

The filter set at high voltage level is the preferable choice in large consumers. On the other hand, the source impedance of high voltage system is usually very low and varies complex. The planning of filters is critical to the performances of filters, and usually single type of filter is difficult to meet the requirement of harmonic filtering at high voltage system with complex harmonic situations. This paper proposes the optimal planning of large-passive-harmonic filters.

The compensators and filters used in these studies are LC tuned type. Various types of filters, i.e. four types of filters namely single-tuned filter, second-order, third-order, and Ctype damped filters. In this paper, the planning of filters is formulated *as* an optimization problem with C-type 3rd order filter.

The passive harmonics filters are composed of passive elements: resistor *(R)* ,inductor *(L)* and capacitor *(C)* .The common types of passive harmonic filter include single-tuned and double-tuned filters, second-order, thirdorder and C-type damped filters. The double-tuned filter is equivalent to two single-toned filters connected in parallel with each other, so that only single-tuned filter and other three types of damped filters are presented here. The circuit of the 3rd order c type is as shown in figure 2 in which the C-type damped filters have two capacitors with one in series with resistor and inductor, respectively. Two capacitors of thirdorder damped filler have typical same capacitance(in pF) for simplifying design and unifying stock.

The capacitor *C* and inductor *L* of C - damped filter are designed to yield series resonance at fundamental frequency for reducing the fundamental power loss. At high frequency, the single-tuned filter is inefficient in harmonic filtering because of the impedance of filter increasing with frequency monotonously .On the other hand, the damped filters impedance approaches to the value of resistance at high frequency, so that they have a better performance of harmonic filtering at high frequency.

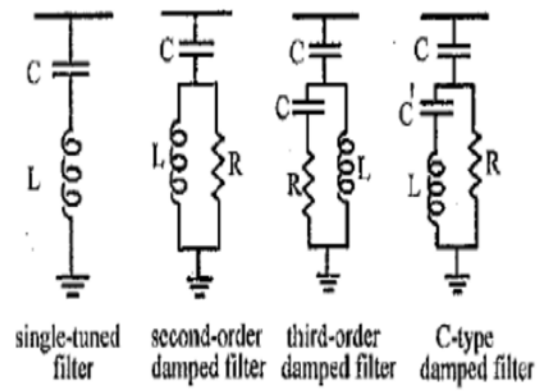


Figure 2 Various filter Types

The phenomenon of enlargement of low frequency harmonics will be mitigated even eliminated by the damped filters with proper parameters. Hence, the damped filters are suitable for reducing complex harmonics, i.e. in many large harmonics distributed on wide frequency range.

IV.MODELLING AND SIMULATION FOR POWER QUALITY

The simulation model of the industrial power system under test in the electrical transient under test in the ETAP is shown in figure 1 .The parameters are set in the edit mode. The loads at the buses are fixed power loads ,which take as input real power, reactive power, rated voltage and rated frequency. The factor taken into consideration is the 1.) voltage dip 2.) transmission branch losses .These two parameters are given priority as backbone of the proposed harmonic filter optimal placement and rating the load flow analysis is done in the ETAP environment which displays all the values as we want of the voltage magnitude and losses, the kw kvar rating etc .The system when stable, the colour code of buses is in black, turns pink when marginally stable and red for for completely unstable

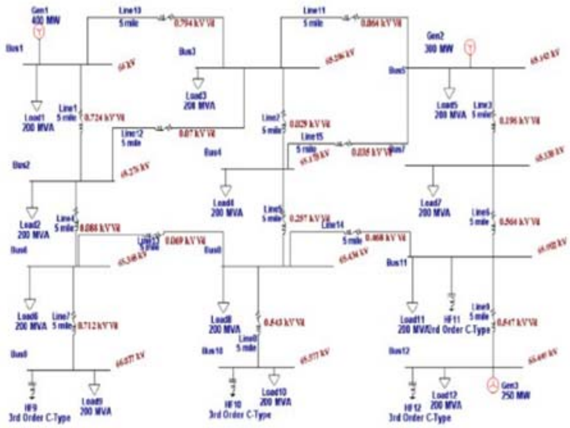


Figure 3 Filter Placement Without Optimisation

In figure 3, the harmonic filter of 3rd order C-type is placed at the buses with minimum voltage which are bus 9 ,10,11 and 12.and we can analyse and check the voltage improvement by load flow analysis.

V. STRATEGIC FILTER PLACEMENT APPROACH

Filters are of various types as described earlier. To properly place a harmonic filter bank, a strategy has been devised .in this section, the strategy is developed considering power system to maintain generality for a broad range of application.

A. Power system stability

The representation by colour code of the buses and the voltage display in figure help us to judge the stability of the system according to the IEEE -519 limits of stable voltage are shown as calculated

Table 1

VALUES OF SYSTEM FOR STABILITY ANAYSIS

Alert	Critical(%)	Marginal(%)
Loading	100	95
Undervoltage	105	102
Overvoltage	95	98

The purpose of the displayed values of voltage in system can be tested with or without the optimal placement of harmonic filter on load without loads undertaking various parameters. The stability factor helps us in judging the placement of the harmonic filter. The unstable system bus-12 with the minimum voltage disturbing limits of stability is alarming so we use a filter there and accordingly at other buses near to bus -12 with more voltage fluctuation, so HF is further placed at bus 9-12.

B. Optimal placement of Harmonic filter

The bus which is most unstable is bus-12 with the minimum voltage dip so we first place harmonic filter at bus 12 and then further perform load flow and check the system again for the bus voltages. The system buses are checked upon the voltage and the one with minimum voltage after placement of HF at bus 12 is again targeted for placement of filter which then is bus 9.Further we test again by conducting the load flow analysis and calculate the bus voltages and the one again with the minimum voltage ,we place the HF which is now at bus 10 .Similarly , which comes out to be bus 7.Now as the voltage is between its satisfactory limits the system is stable upon placement of harmonic filter of third order C- type at various places in which two capacitors and two inductors are to be configured for the stabilization of the voltage parameters.

The harmonic filter placement now in figure 5 is done by using the load flow calculations which gives the voltage profile of the system at all buses and also gives the voltage drob at transmission lines.Now, we place the filter at the bus which is most affected by the load ,means the bus with minimum voltage which is bus 12 so we place the filter at bus 12. Then accordingly step by step we perform load flow and come to know where the harmonic filter needs to be placed .filter placement on bus 12 followed by filter on bus-9,tehen on bus 10 and finally on bus 7 and the system becomes totally stable.

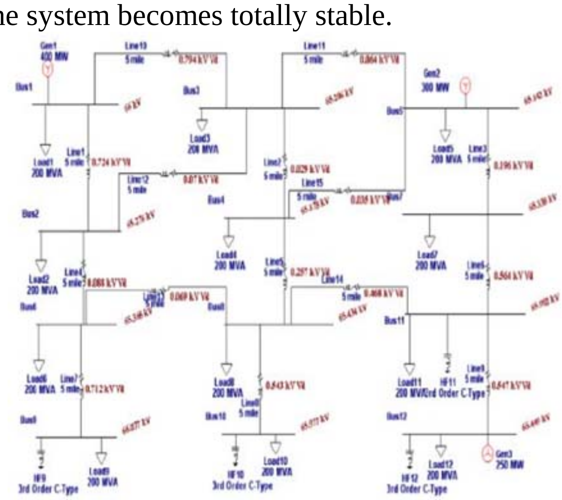


Figure 4 Optimal Filter Placement

V. RESULTS AND DISCUSSIONS

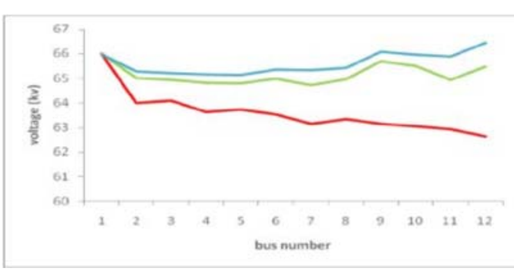
The variation of voltage with respect to location of harmonic filter atvarious buses can be represented in the form of graphs as under, which show the improvement in the actual voltage upon loading and after applying harmonic filter with and without the optimal placement .The improvement of voltages at the buses is shown in table 1 and improvement in branch losses is shown in table 2. These values are as generated by the load flow analysis in the ETAP environment. Also, the graphs predicted for the table are using MSexcel for simplicity and clarity upon the results we get after improvement.

Table 2

Voltage Probile Before And After Improvement At Bus

Bus no.	Voltage profile		
	On load voltage flow at buses	Without optimal placement of HF	With optimal placement of HF
1	66	66	66
2	63.995	65.276	64.999
3	64.089	65.206	64.937
4	63.636	65.178	64.807
5	63.721	65.142	64.782
6	63.542	65.365	64.984
7	63.154	65.338	64.714
8	63.334	65.434	64.948
9	63.142	66.077	65.692
10	63.042	65.977	65.487
11	62.932	65.902	64.922
12	62.642	66.449	65.461

The voltage profile is analysed and graph predicting the voltage is shown in figure 5 which is drawn with the help of MS-excel to show the improvement of voltage upon use of harmonic filter when applied and when not applied.results can be easily analyzed from the graphs.



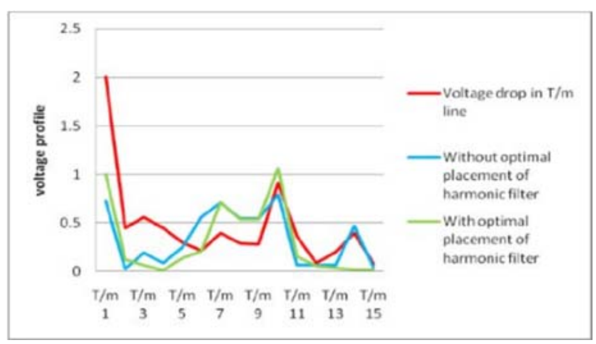
Graph 1 Voltage At Each Bus

Analysis of voltage at transmission lines is also analysed by load flow studies using ETAP .the values of voltage drop at each line is as shown in table 2. And also the change in voltage values upon improvement using the harmonic filter.

Table 3

Voltage Profile At Transmission Lines

Transmission line no.	Voltage profile of transmission lines		
	Voltage drop in T/m line	Without optimal placement of harmonic filter	With optimal placement of harmonic filter
1	2.005	0.724	1.001
2	0.453	0.029	0.13
3	0.566	0.196	0.068
4	0.454	0.088	0.015
5	0.302	0.257	0.141
6	0.223	0.564	0.208
7	0.4	0.712	0.708
8	0.292	0.543	0.539
9	0.29	0.547	0.538
10	0.911	0.794	1.063
11	0.368	0.064	0.155
12	0.094	0.07	0.063
13	0.208	0.069	0.036
14	0.402	0.468	0.026
15	0.085	0.035	0.025



Graph 2 Voltage Drop At Transmission Lines

The voltage drop at transmission lines is shown in graph 2 for analysis of the change on employing harmonic filter. The graph obtained is made from the values calculated using load flow analysis as shown in the above table and the graph is plotted using MS-excel so as to clearly check upon the values of voltage obtained after the placement of harmonic filters.

VI.CONCLUSIONS

The industrial load which distorts the system voltage is stabilized using harmonic filter placement .The voltage which is marginally stable and unstable is stabilized using harmonic filter which is of third order C-type harmonic filter which is placed and tested using Load Flow Analysis in the Electrical Transient Analyzer Program (ETAP) environment.

Parameters of harmonic filter, sizing and location is done by keeping a check at the voltage profile through the Load Flow Analysis. Simulation is done on the system without and with optimal placement of harmonic filter which gives us desirable results.

ACKNOWLEDGMENT

The author would like to express special thanks to Mr. Arvind Dhingra for his valuable guidance and encouragement in the work and for his contribution on preparing the final version of this paper. I would also like to acknowledge department of electrical engineering, Guru Nanak Dev Engineering College, Ludhiana India for their constant support.

REFERENCES

[1] Jiazhu Xu; Junfeng Bai; Longfu Luo; Yong Li; Rehtanz, C., "Research on suppression of harmonic instability adopting even harmonic filters in FCC-HVDC," Power System Technology (POWERCON), 2010 International Conference on , vol., no., pp.1,4, 24-28 Oct. 2010.

[2] Liao, W.B.; Chen, Y. -L; Wang, S.-C., "Goal-attainment method for optimal multi-objective harmonic filter planning in industrial distribution systems," Generation, Transmission and Distribution, IEE Proceedings- , vol.149, no.5, pp.557,563, Sep.

[3] Marz, M.B., "Harmonic simulations for filter design at a large industrial load," Power Engineering Society Summer Meeting, 2000. IEEE , vol.2, no., pp.1080,1087 vol. 2, 2000.

[4] Cem Özgür Gerçek, Muammer Ermis, Arif Ertas, Kemal Nadir Köse, and Özgür Ünsar, IEEEEAFs ,"Design, Implementation, and Operation of a New C-Type 2nd Harmonic Filter for Electric Arc and Ladle Furnaces"

[5] Philip E. C. Stone, Jingjiang Wang, Yong-June Shin, and Roger A. Dougal, Senior Member, IEEE "Efficient Harmonic Filter Allocation in an Industrial Distribution System" .

[6] GaryW. Chang, Shou-Yung Chu, and Hung-LuWang "A New Method of Passive Harmonic Filter Planning for Controlling Voltage Distortion in a Power System", IEEE jan 2006

[7] Tosak Thasananutariya and Somchai Chatratana "Planning Study of Harmonic Filter for ASDs in Industrial Facilities" IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 45, NO. 1, JANUARY/FEBRUARY 2009

[8] Yong-June Shin, Edward J. Powers, Mack Grady, and Ari Arapostathis, "Power Quality Indices for Transient Disturbances" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 21, NO. 1, JANUARY 2006 .

[9] Lin and Alexander Domijan "On Power Quality Indices and Real Time Measurement" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 20, NO. 4, OCTOBER 2005

[10] Brown, K.; Shokooh, F.; Abcede, H.; Donner, G., "Interactive simulation of power systems: ETAP applications and techniques," Industry Applications Society Annual Meeting, 1990., Conference Record of the 1990 IEEE , vol., no., pp.1930,1941 vol.2, 7-12 Oct. 1990

[11] Khan, R.A.J.; Junaid, M.; Asgher, M.M., "Analyses and monitoring of 132 kV grid using ETAP software," Electrical and Electronics Engineering, 2009. ELECO 2009. International Conference on , vol., no., pp.I-113,I-118, 5-8 Nov. 2009