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Power Loss Minimization In Distribution System Using Static VAR Compansator

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Abstract*—The main causes of harmonics are non-linear loads, such as converter (inverter & rectifier), static VAR compensator and solid state controlled devices.when these load interact with each other in the grid will create a new current harmonics that adversely affect on the quality of the grid. On the other hand wide range of using electronics equipment contribute too of increasing harmonics. Thus, its important to analysis and evaluate the various harmonics problems in the power system and introduce the appropriate solution techniques for elimination or mitigation of their effect. In our work we will analyses power distribution system have a heavy harmonics, there harmonics affects on power system quality. we will evaluate the value of total harmonic distortion, individual harmonic distortion and the power factor at the point that harmonic source are exists by implementing a harmonic load flow study by using the ETAP program. The 5^{th}, 7^{th} order of harmonics are more effect on the power system capacity and quality, thus we will use two methods for conciliation 5^{th}, 7^{th} order of harmonics. The first method by using Phase shift transformer 30^{o}. The second method by using two filter technique. Then the comparison between three cases, Base case, phase shift transformer and two filter technique.

I. INTRODUCTION

The power system are designed to operate at frequencies 50 or 60 HZ, which is called fundamental frequencies. Some type of loads produce current and voltage with frequencies that are integer multiple of the system fundamental frequency. These higher frequencies are known as power system harmonics. For example with the fundamental frequency of 50 HZ the third harmonic. Frequency is 150 HZ[1].

The harmonic current are present in modern electrical distribution system caused from non-linear load such as adjustable speed drive electronically ballasted lighting.

The harmonic current cause overheating transformer, motor, conductor, capacitor and all equipment connect on the power grid [2].

Harmonic were known a long time ago, as early as the 1890 it did not cause a lot of problem at that time because the electronic equipment was rare. Today‘s electronic devices are widely used and draw non sinusoidal current from ac power system, and this current interact with the system impedance creating voltage harmonic. The number of harmonics producing devices increased affect on efficiency and controllability of power system [3].

II. ETAP SIMULATION

The software, named ETAP, (electromagnetic transient analysis program) was used in the load flow Test system was used in each case. The data of test system was entered and stored as a ETAP. The harmonic bus voltage and line currents were obtained by running the ETAP program. Using program simulation, the phenomena of power system harmonics can be modeled and analyzed.

The power station harmonic analysis program provides you with the best tool to accurately mode model various power system components and devices to include their frequency dependency, nonlinearity, and other characteristics under the person of harmonic source.

The ETAP program has two analytical methods, harmonic load flow and harmonic frequency scan, wish are most popular and power full approaches for power system harmonic analysis

The collection of the data of given interconnected distribution system is the first step for studying any case in the distribution system.

By using those two this method, different harmonic can be computed and tablet.

Finally the results obtained by the ETAP program were compered in the three cases to check the accuracy of the new technique.

Case (1) Base case

Case (2) using phase shift transformer by 30^0 (5th and 7th order)

Case (3) using two filter technique together (5^{th} and 7^{th} order)

III. DATA SURVEY

The survey covered the following items:

- Type of loads
- Rating of loads
- Maximum service temperature
- Rating transformer power
- Total harmonic distortion
- The power factor and the target to improve it

IV. SYSTEM COMPONENT

The system contain linear and nonlinear loads

The system consist of

- Five buses
- Three transformer

T_1 three winding

15/10/ 5 MVA, 34.5/13.8/4.16 KV

T_2 10 MVA,34.5/13.8 KV

T_4 1.5 MVA,4.16/.48 KV

- Tow dc system

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The dc system consist of

1- Four buses
2- UBS 200 KW .48 KV AC, 125 V DC and supply load 120 KVA
3- Charger

AC rating 500 KVA, 0.48 KV

4-Inverter

AC rating 26.5 KVA, 0.12 KV

DC rating 25 KW, 250 V

5-DC machine 25 KW 250 V

6-DC load 124 KW 125 V, 50 KW 250 V

Performing a harmonic load flow using the ETAP program for case (1) base case

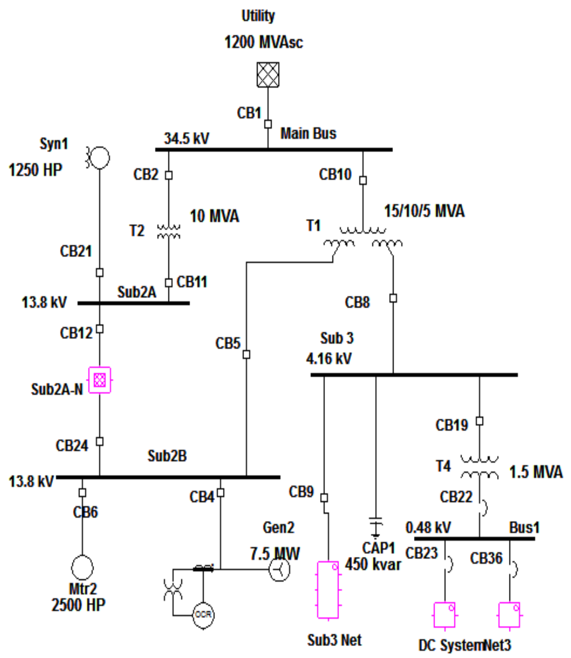

Fig.1: Base case

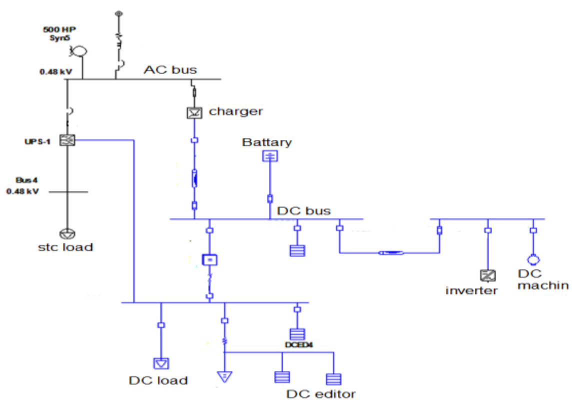

Fig. 2: DC system

A. *The studying at sub network 3 in fig.1*

TABLE I. The result of voltage distortion at sub3 for base case.

Harmonic order n	5	7	11	13	17	19	THD
%Harmonic distortion	0.56	0.59	0.86	0.98	1.3	1.9	3.49

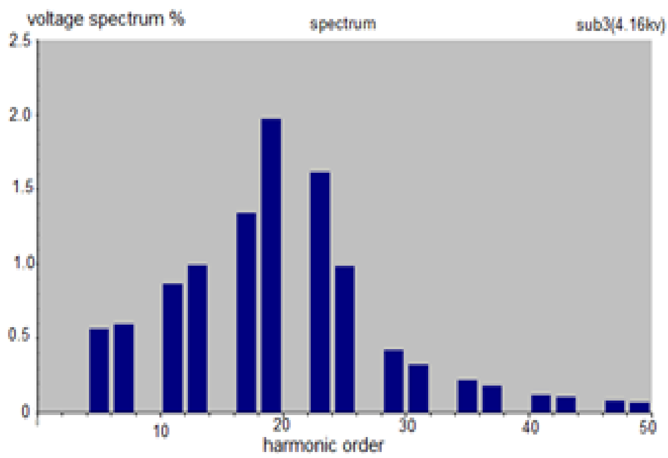

Fig.3: Spectrum of voltage distortion at sub3 for base case

B. TheStudying *at bus 1 in fig.1*

TABLE II.The result of voltage distortion at bus1 for base case

Harmonic order n	5	7	11	13	17	19	THD
%Harmonic distortion	4.3	4.36	5.4	5.5	5	5.5	18.4

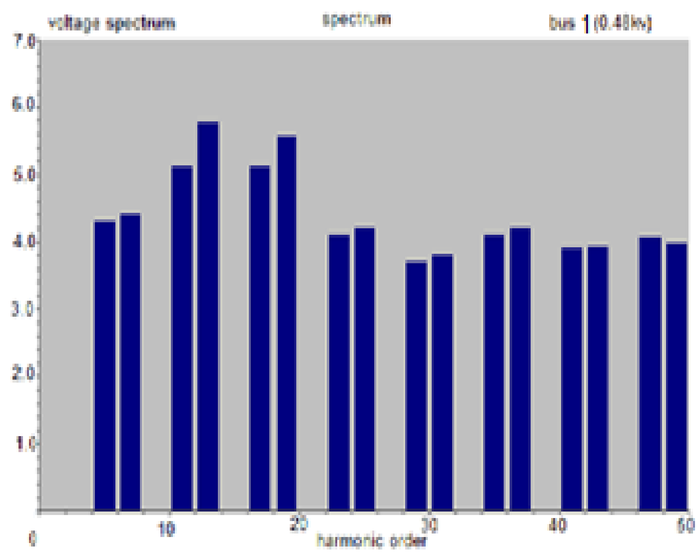

Fig.4: Spectrum of voltage distortion at bus1 for base case

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C. The studying at transformer no 4 in fig.1

TABLE III.The result of current distortion of TR4 for base case

Harmonic order n	5	7	11	13	17	19	THD
%Harmonic distortion	14.48	10.28	7.97	6.44	3.87	3.28	21.88

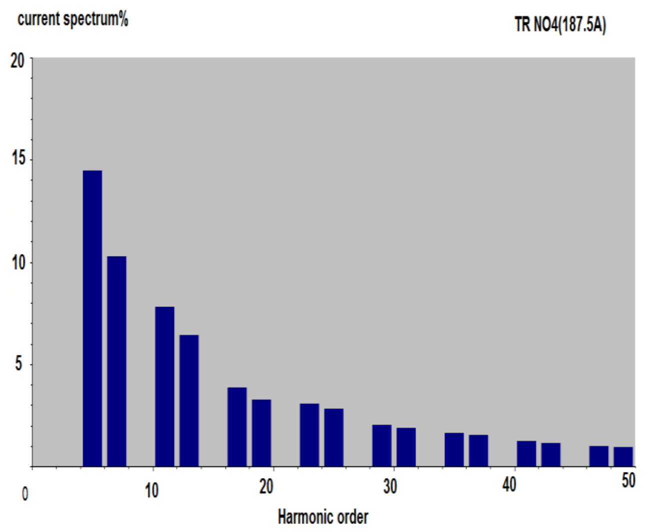

Fig.5: Spectrum of current distortion of TR4 for base case

Case (2) using phase shift transformer by 30^0 (5th and 7th order)

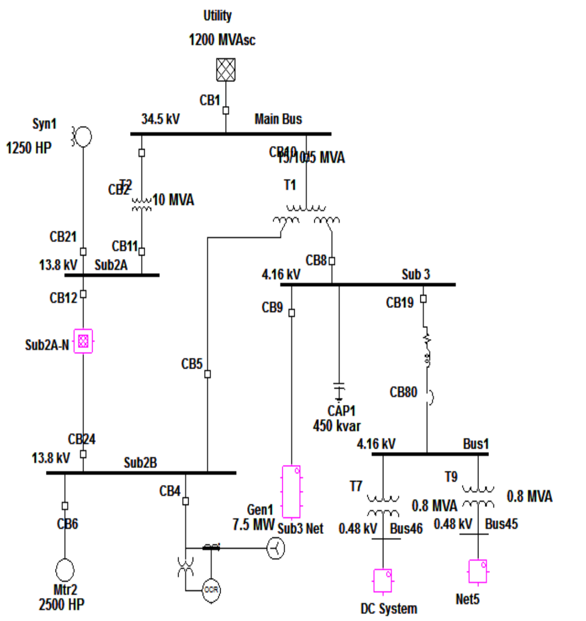

Fig.6: the system using phase shift transformer by 30^O (5th and 7th order)

A. The studying at sub network3 in fig.6

TABLE IV.The result of voltage distortion at sub3 using phase shift transformer 30^0 in fig.6

harmonic order n	5	7	11	13	17	19	THD
% harmonic distortion new	0	0	0.83	1	0	0	2.32
base case harmonic distortion	0.59	0.59	0.86	0.98	1.3	1.96	3.49

The 5thand 7th are completely removed at sub network 3 by using phase shift transformer 30^o and the THD reduced from 3.49 to 2.32%

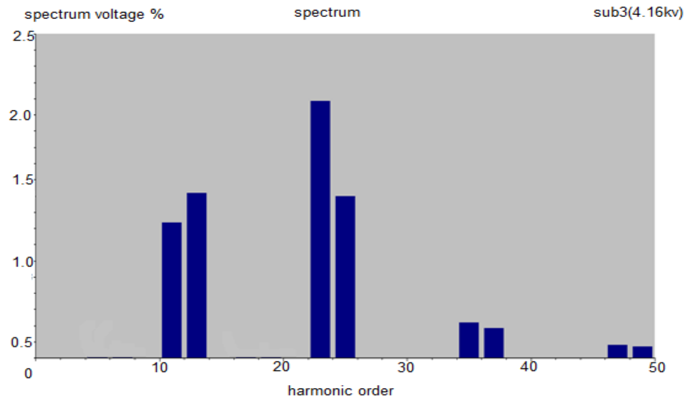

Fig.7: Spectrum of voltage distortion at sub3 using phase shift transformer 30^0

B. The studying at bus 45 in fig.6

TABLE V.The result of voltage distortion at bus45 using phase shift transformer 30^0

harmonic order n	5	7	11	13	17	19	THD
% harmonic distortion new	3.8	3.75	5.2	5.89	3.9	3.88	17.53
base case harmonic distortion	4.3	4.36	5.4	5.5	5	5.5	18.4

The phase shift transformer 30^o mitigate 5th and 7th harmonic order but not conciliation and reduce THD from 18.4 to 173.53

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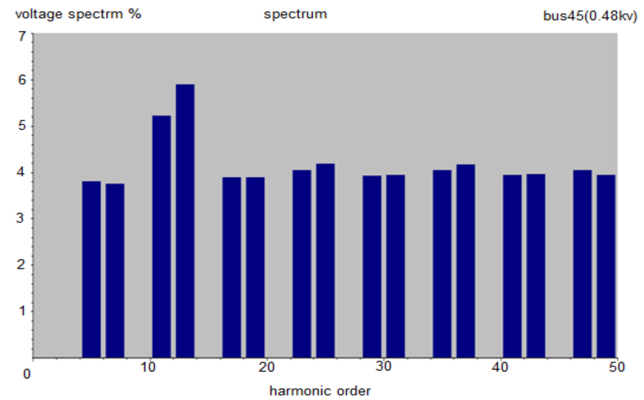

Fig.8: Spectrum of voltage distortion at bus45 using phase shift transformer 30^0

C. The studying at cable 37 in fig.6

TABLEVI.The result of current distortion of cable 37 using phase shift transformer30^0

harmonic order n	5	7	11	13	17	19	THD
% harmonic distortion new	0	0	1.55	6.6	6.6	6.17	11.19
base case harmonic distortion	14.48	10.28	7.97	6.44	3.87	3.28	21.88

The 5thand 7th are completely removed at cable 37 by using phase shift transformer 30^o and the THD reduced from 21.88 to 11.19%

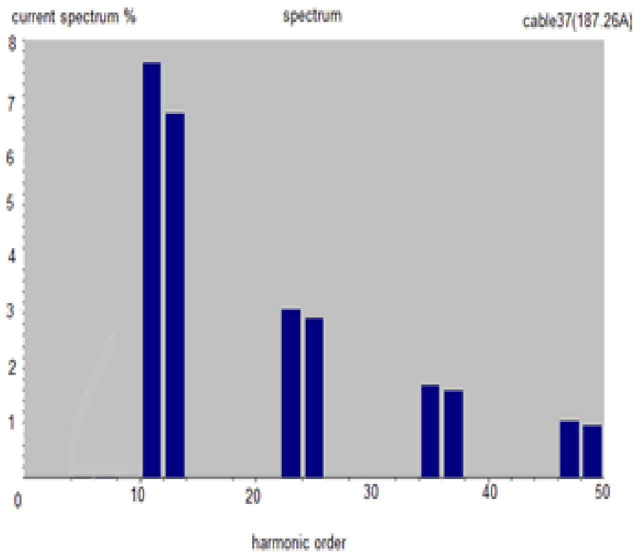

Fig.9: Spectrum of current distortion of cable 37 using phase shift transformer 30^o

Case (3) Using filter technique (5th and 7th order filter)

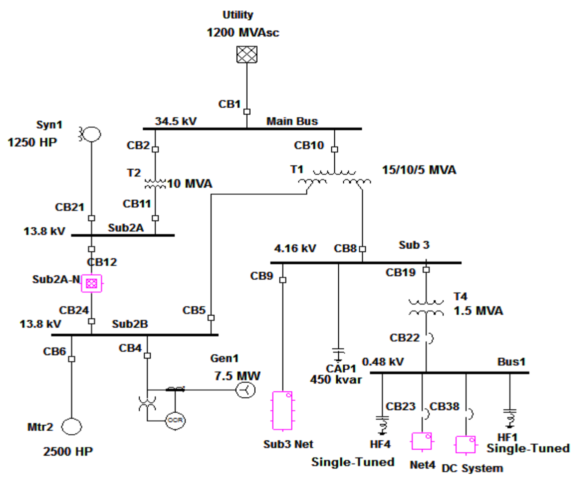

Fig.10: The system Using tow Filter technique (5th and 7th order)

- First design of filter for 5th harmonic order[4],[5]

$$Vc = Vn\frac{n^2}{n^2\_1}$$

$$Vc = 0.48 * \frac{5^2}{5^2\_1} = 0.5\ KV$$

Reactive power = reactive power for power factor correction * $\frac{1}{n^2\_1}$

Reactive power = 216 * $\frac{1}{5^2\_1}$ = 9 KVAR

Total reactive power for capacitor = 216 + 9 = 225 KVAR

$$X_C = \frac{KV^2}{MVAR} = \frac{0.48^2}{0.225} = 1.024\ \Omega$$

$$X_L = \frac{XC}{n^2} = \frac{1.024}{25} = 0.04096\ \Omega$$

- Second design of filter for 7th harmonic order

V_N = 0.48 KV, n =7, KVAR =216 KVAR

$$Vc = Vn\frac{n^2}{n^2\_1}$$

$$Vc = 0.48 * \frac{7^2}{7^2\_1} = 0.49\ KV$$

Reactive power = reactive power for power factor correction * $\frac{1}{n^2\_1}$

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Reactive power = 216 * $\frac{1}{7^2 - 1}$ = 4.5 KVAR

Total reactive power for capacitor = 216 + 2.5 = 220.5 KVAR

$XC = \frac{KV^2}{MVAR} = \frac{0.48^2}{0.2205} = 1.04486\ \Omega$

$XL = \frac{XC}{n^2} = \frac{1.024}{25} = 0.021324\ \Omega$

A. *The studying at sub 3 in fig.10*

TABLE VII.The result of voltage distortion at sub3 using filter technique

harmonic order n	5	7	11	13	17	19	THD
% harmonic distortion new	0	0	0.5	0.7	1	1.1	1.98
base case harmonic distortion	0.56	0.59	0.86	0.98	1.3	1.96	3.49

The 5^{th} and 7^{th} are completely conciliated at sub network 3 by using two filter technique

B. *The studying at bus_1 in fig.10*

TABLE VIII.The result of voltage distortion at bus1 using filter technique.

harmonic order n	5	7	11	13	17	19	THD
% harmonic distortion new	0	0	2.5	2.8	2.6	2.9	10.42
base case harmonic distortion	4.3	4.36	5.4	5.5	5	5.5	18.4

The 5^{th} and 7^{th} are completely conciliated at bus 1 by using two filter technique

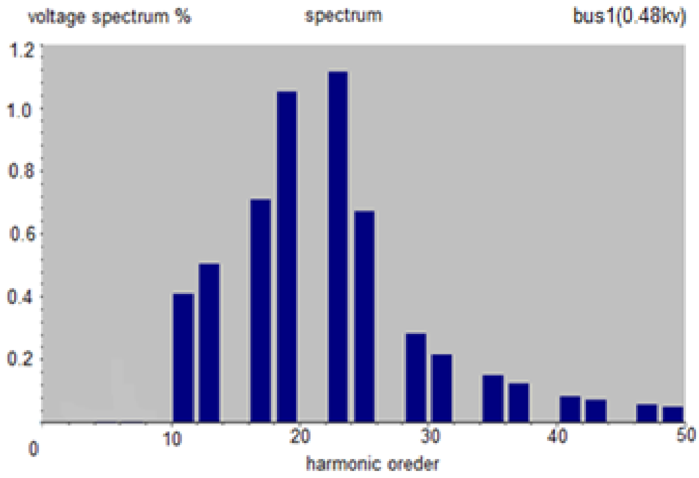

Fig.11: Spectrum of voltage distortion at bus1 using filter Technique

c. *The studying at transformer 4 in fig.10*

TABLE IX. The result of current distortion of TR4 using filter technique.

harmonic order n	5	7	11	13	17	19	THD
% harmonic distortion new	0	0	4.3	3.8	2.4	2	8.16
base case harmonic distortion	14.5	10.3	7.9	6.4	3.87	3.28	21.88

The 5^{th} and 7^{th} are completely conciliated at transformer no_4 by using two filter technique

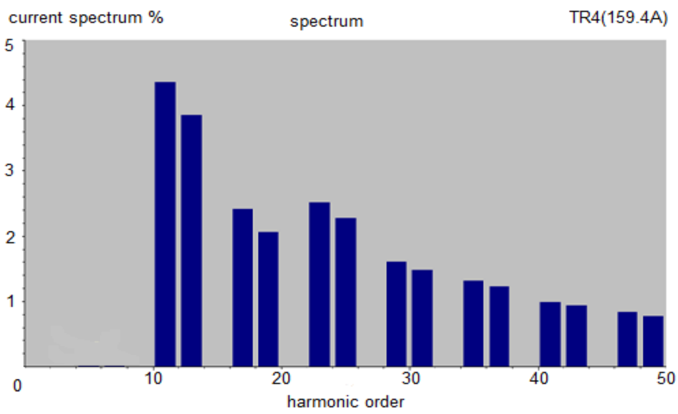

Fig.12: Spectrum of current distortion of TR4 using filter technique

V. CONCLUSION

In our work we will be studying cases of power grid using ETAP/ Simulink, Estimating total and individual

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harmonic distortion of voltage and current at buses that the harmonic sources exists on the power grid.We will study the comparator between phase shift transformer by 30^0 (5^{th} and 7^{th} order) with two filter technique together (5^{th} and 7^{th} order)

Were compered in the three cases to check the accuracy of the new technique.

Case (1) ETAP simulation for the Base case

Case (2) ETAP simulation for phase shift transformer by 30^0 (5^{th} and 7^{th} order)

Case (3) ETAP simulation for two filter technique together (5^{th} and 7^{th} order)

The studying interested in THD and the individual harmonic distortion of 5^{th} and 7^{th} harmonic order at the buses bus1, subnetwork3 where source of harmonic exist. Harmonic source is connected at transformer no 4, so the studying is before and after the transformer.

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