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Harmonic Monitoring and Design of Passive Filter for an Educational Institute

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ABSTRACT

The Power Quality is a major solicitude in order to utilize the electric power more efficiently. Harmonics play a major role in deteriorating the power quality.The work gives a report about the Harmonic Compliance of an educational institute using a Passive Harmonic Filter. Theharmonic compliance of an educational institute was done in order to bring the harmonics within the range of IEEE Std. 519-2014. To achieve this passive harmonic filter wasconnected at the PCC for the 3rd, 5th, 7th harmonic removal and its design procedure is described in this paper. The analysis was done in order to choose the harmonic order for which filter is to be designed. The design of the harmonic filter along with the information of the power system to which it is to be connected is also described.

Keywords: Power Quality, Harmonics, Passive Filter, THD, Point of Common Coupling (PCC)

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I. INTRODUCTION

The Institute of Electrical and Electronics Engineers (IEEE) Standard IEEE 1100 defines Power Quality as "The concept of Powering and Grounding sensitive electronic equipment in a manner suitable for the equipment" [3]. The increasing application of electronic equipment that can cause electromagnetic disturbances or that can be sensitive to this phenomenon, has heighten the interest in power quality in recent years. Various power quality issues include voltage sag, voltage swell, undervoltage, overvoltage, transients, flicker and one major issue that is Harmonics which is going to be focus of the paper. The IEEE standard 1159-2009 defines "Harmonics are sinusoidal voltages or currents having frequencies that are integral multiple of frequency at which the supply system is designed to operate (termed as fundamental frequency; usually 50Hz or 60Hz)" [2]. They distort the fundamental voltage and current waveform. Non-linear loads are the main cause of production of current harmonics.

Harmonics are generated when electricity is controlled by electronics. When the harmonic current flows from customer load side into the utility supply system the supply voltage is distorted. This harmonicdistortioncauses overheating which leads premature failure of operation of protective devices (such as fuses). This affects operation of electrical system. It also causes overheating of neutral wire, equipment and their failure[2].

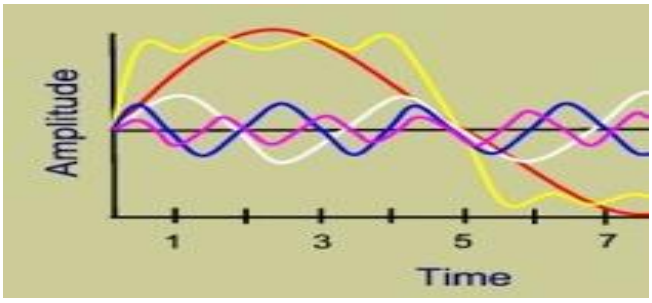

Fig no. 1 – Harmonically distorted wave

II. Harmonic Compliance Methodology

Any system whose harmonic compliance is to be done is necessary to be analyzed. Analysis of the power system includes thorough study of parameters like load current, reactive power, active power, per phase harmonic current, Total Harmonic Distortion (THD) for current and voltage, power factor, and total running load of the premises.

In this study the equipment used is Fluke 435-II three phase energy and power quality analyzer. This equipment is Class A equipment. The Fluke compiles with the IEC61000-4-30 standard.

Fig no. 2 – Fluke 435-II Power Analyzer

This equipment is to be connected at PCC. PCC is the point between the end users or customer and utility system where another customer can be served [1]. IEEE 519 is widely used standard for evaluation of harmonics. This standard recommends the limit for the voltage and current harmonic distortion at PCC. This standard should be applied only at PCC.

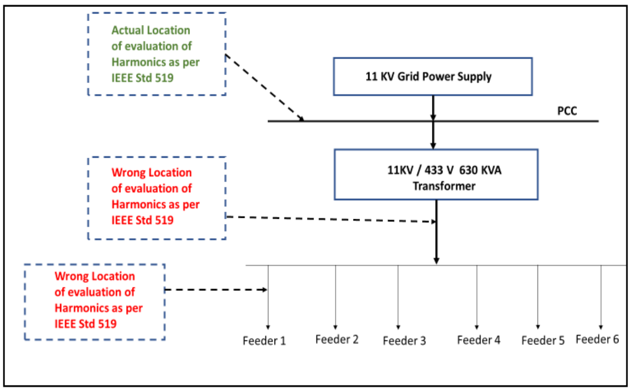

Fig no. 3 Actual location for measurements at PCC as per IEEE std 519-2014.

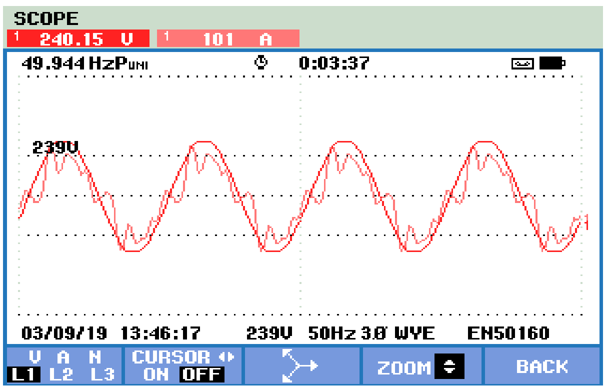

Fig no.4 Current and Voltage Distortion in R phase

Similarly, the distortion in other phases are available on the equipment which provides the feature of saving the data.

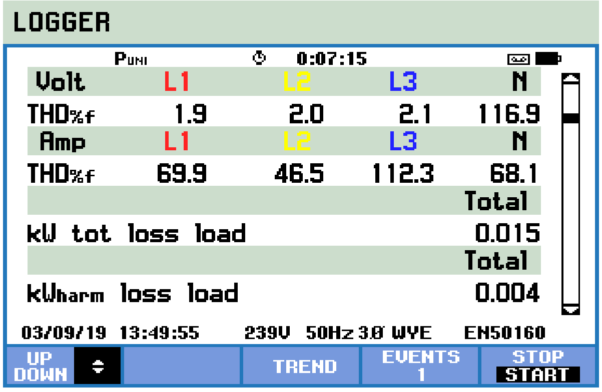

Fig no.5 Summary of recorded data

It also provides Logger mode where the summary of all the data recorded is displayed. In Logger mode, the time interval can be set according to the severity of the data to be recorded.

Once the data monitoring is done the software "Power Log" which is available with the Fluke instrument will help analyze the data in graphical form.

The Power Log Software provides with the features of viewing the data as per requirement. According to the figure harmonic current for 'B' Phase 5^{th} order is illustrated which is 31.19 A. similarly, for other phases can be analyzed.

From the analysis the harmonic current for 3^{rd}, 5^{th}, 7^{th} order was found to be dominant. Thus, the mitigation of these order harmonic current is necessary. The filter to be designed will be now be economical for the system.

Various mitigation techniques available such as Active filters, Passive filters, zig-zag transformer etc. out of the most economic filter and suitable for our study is 'Passive Shunt Harmonic Filter.'

III. Shunt Passive Filter

Before designing the filter we need to know what filter actually is. When the harmonics are present in the system the main tendency of harmonic current is to flow from harmonic producing load to the power source. This is illustrated in the figure below [4].

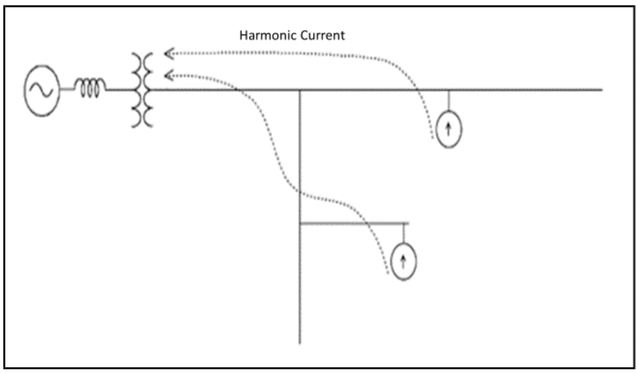

Fig no.6General flow of harmonic currents

The impedance of power system is normally the lowest impedance seen by the harmonic current thus the bulk of current flows into source [4].

Harmonic filters can alter this flow pattern for at least one of the harmonics such that the filter now provides the low impedance path and thus harmonics flow through them rather than returning to the source.

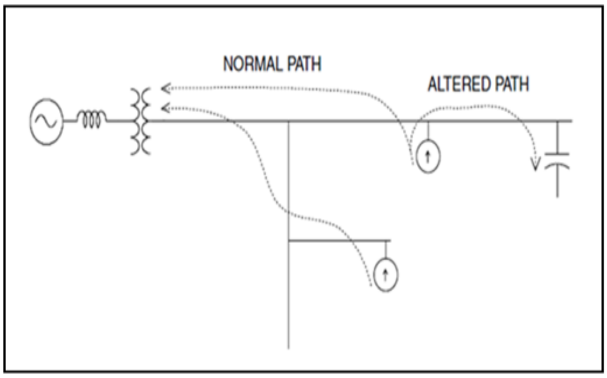

Fig no.7 Flow pattern after connection of filter

Passive filters are Inductance, Capacitance, Resistance elements are configured and tuned to control harmonics they are commonly used and are relatively inexpensive compared with other means of harmonics mitigation. Passive Filter has the most preferred type of filter that is 'Single Tuned Notch Filter'. This filter elements are series tuned in order to provide low impedance path to the flow of harmonic current. This filter is connected in parallel with power system. Thus, harmonic currents are diverted from their normal flow path on the line through filter [4]. Thus, for the design of this filter we need know the values of L and C.

IV. Calculations

1. To select tunning frequency

Thetunning is usually designed to reduce harmonic voltage and current distortion to meet specified harmonic performance criteria. To meet this criteria harmonic filter is tuned to lowest frequency of most dominant frequencies.

Harmonic filters are not exactly tuned to exact harmonic frequencies as tunning directlymay lead to undesirable consequences such as the low impedance at resonace can result in nearly all harmonic current at that frequency being absoebed by harmonic filter. The harmonic filter is required to be larger and more expensive than is needed to achieve the required harmonic performance [6].

It is often advantageous to tune harmonic filter to approximately 3% to 15% below the desired frequency. This tunning will provide for sufficient harmonic filtering.

2) A simple equation to calculate the capacitivereactance (for filter tuned to 'h' harmonics) at power frequency

$$X_c = \{h^2 \div (h^2-1)\}\ X_{eff}$$

where,

$$X_{eff}=\{\ (kV^2_{L\text{-}L\ sys}) \div Q_{eff}(MVAR)\ \}$$

A equation to calculate inductive reactance at power frequency is

$$X_L = (X_c \div h^2)$$

where,

$X_{eff}$is the effective reactance of the harmonic filter

$Q_{eff}$is the effective reactive power of the harmonic filter.

$V_{L\text{-}Lsys}$is the nominal system L-L voltage.

$X_c$is the capacitive reactance of the harmonic filter capacitor at the fundamental frequency.

X_L is the inductive reactance of the harmonic filter reactor at the fundamental frequency.

h is the harmonic order.

For our system, the load where the filter will be installed is approximately 98 kW. The total harmonic current produced by this load is approximately 31.9A. The facility is supplied by 630 kVA transformer with 5% of impedance.

The values of L and C are

Harmonic order	Size of capacitor 'C' (kVAR)	Size of Reactor 'L' (mH)	Harmonic current (A)
3	5	11.42	26.79
5	8	2.74	37.51
7	5	2.14	24.21

V. Conclusion

After the calculation the filter design can be implemented and filter can be connected at the required point. The expected results of the reduced THD is from 24% to the reduction to which is within the IEEE std 519-2014 5%. The expected result can be verified using simulation software ETAP before installing the filter.

REFERENCES

[1] IEEE Recommended Practice and Requirement for Harmonic Control in Electric Power Sytem, IEEE Standard 519-2014, 27 March 2014.

[2] IEEE Std 1159-2009, IEEE Recommended Practice for Monitoring Electric Power Quality.

[3] IEEE Std 1100-2005, IEEE Recommended Practice for Powering and Grounding Electronic Equipment.

[4] Roger C Dugan. and Surya Santoso, "Electrical Power System Quality" 2nd ed. McGraw-Hill, 10 Jan 2012.

[5] J.C.Das "Power System Harmonics and Passive Filter Designs" IEEE Press, April-2015.

[6] IEEE Std 1531-2003, IEEE Guide for Application and Specification of Harmonic Filters.

