Journal of Science Engineering Technology and Management Science
Volume 02, Issue 04, April 2024 *ISSN: 3049-0952*
www.jsetms.com *DOI: https://doi.org/10.5281/zenodo.15062435*

Nonlinear Loads Effect on Harmonics in the Laboratory

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To Cite this Article
Rohit, Shanmukh and Srinivasa Rao, "Nonlinear Loads Effect on Harmonics in the Laboratory", Journal of Science Engineering Technology and Management Science, Vol. 02, Issue 04, April 2025, pp: 23-26, DOI; https://doi.org/10.5281/zenodo.15062435

Abstract*: The research concentrated primarily on the meter side of customers because it investigated harmonic effects at K.Wai Perlis' Electrical System Engineering School laboratory. Magnetic fields from harmonic voltage frequencies rotate at the same speed as harmonic frequencies but harmonic currents inside equipment result in operational overheat and performance losses. This disruption produces mechanical noises and equipment vibrations which also causes overheating of equipment and operating efficiency reduction as well as voltage stress against insulation of equipment windings.*

The research employs Computers and Printers as well as Air Conditioners and Compact Fluorescent Lamps as harmonic-significant loads. The measurement process depends on the Fluke 435 Power Quality Analyzer. The harmonic current parameters fluctuate unpredictably due to the installation of different nonlinear loads. Through this research study the utility obtains substantial knowledge about harmonic effects on their equipment. The utility will gain knowledge about the expenses and performance losses which result from using these pieces of equipment. This paper presents information about harmonic investigation expenses through THD measurement as well as energy loss costs.

Keywords*: THD, cost, energy losses, nonlinear loads, and harmonics*

I. Introduction

Nonlinear electrical devices cause harmonic currents to enter the electrical network due to their nonlinear current-drawing behavior. The industry together with commerce and common consumers now face harmonic energy problems at a higher level than existed several decades ago. Every equipment in the laboratory has a similar level of harmonic impact including air conditioners, printers, laptops, personal computers and compact fluorescent lamps (CFLs). A power system obtains harmonics from various multiple sources. The saturation of magnetic cores generates harmonic production from distribution system transformers.

The effects from harmonic currents generate increased heating of capacitors as well as enhanced dielectric stress while reducing circuit breakers interrupting capability and creating skin effect on conductors thereby shortening lamp life and causing measurement errors in wattmeter and voltmeters in addition to overheating and pulsating torque along with noise from rotating machines among other results [8]. Harmonic currents applied to normal loads raise distribution system losses and loading costs money for end users. As losses increase the system capacity together with conductors and transformers decreases. The aging of power equipment including transformers advances rapidly because of increased loading that simultaneously generates heat [5–6].

The power industry has experienced harmonic distortion throughout its various phases because engineers identify this issue as among their primary concerns. Power equipment manufacturers adopted a conservative design approach while distribution transformers commonly operated under delta-grounded wye configurations thus preventing harmonic disturbances in previous years. Distribution network harmonic distortion continues to increase because industrial facilities are using more nonlinear loads.

II. Property Features and Equipment Modelling

Characterizing and modelling the harmonic source and every system component is a crucial step in harmonic analysis. As is well known, UniMAP's Power System Analysis & Control lab is equipped with computers, printers, air conditioners, and compact fluorescent lamps (CFLs), all of which can be comparable to medium-sized industrial equipment. Because personal computers reduce the voltage distribution system, they have greatly contributed to the harmonics problem. Because the third and fifth harmonics produce high-level individual distortions, the current THD for personal computers exceeds 100%.

A personal computer combined with its accompanying monitor only needs about 2 A to operate despite having hundreds of display units and computing machines in a standard high-rise building. The total current harmonic distortion of a facility would be directly impacted by this measure. The tungsten incandescent bulb marked the start of commercial fluorescent light development among small-scale illumination solutions. According to research fluorescent lights offer two to four times better human wavelength light production than standard incandescent lights do [3].

Non-linear gas discharge lamps cause extensive harmonics as a result of using magnetic or electronic ballast in fluorescent lighting systems [9]. The manufacturing industry has worked on various technological advances to develop air conditioner units with better energy efficiency. Power electronics technology powers the variable-speed air conditioner as an innovative heating and cooling system [7-8]. Single-speed induction motors operate the compressors found in most air conditioners so their cooling performance is fixed at a predetermined level. Research shows variable-speed air conditioners provide the same level of cooling service while costing less energy and requiring only 60% of the energy needed by single-speed air conditioners.

III. Research Method

The Fluke Power Quality Analyzer (Figure 1) along with the connection circuit instrument and switching board (Figure 2) became the instruments for conducting this research. The Power Quality Analyzer recorded all data related to harmonics. The data collection includes multiple variables such as frequency alongside voltage and harmonic distortion and both voltage harmonic and current harmonic values. The View software combined with USB platform transferred all data collected from the computer.

Fig 1: Power Quality Analyzer

Fig 2: The clamp connection for each phase

Fig 3: The connection for ground (earthing)

Fig 4: Power System Analysis and Control Laboratory

The results of the harmonic analysis of five days' worth of data from the laboratory's distribution board will be shown in this section. The differential harmonic distortion caused by nonlinear load equipment during laboratory operation is observed using data from five days of measurements. Two 4 HP and two 2 HP air conditioners, sixteen 48 W fluorescent lights, and fourteen computers make up the red phase loads. Two 4 HP air conditioners, fifteen 48 W fluorescent lamps, and twenty-two computers are needed for the yellow phase, while two 4 HP air conditioners, fifteen 48 W fluorescent lamps, and fourteen computers are needed for the blue phase.

IV. Results and Analysis

Data obtained from the measurement appears in Figures 5 and 6. The analysis of data points to unbalanced nonlinear loads between lines 1, 2, and 3 because they carry 3.597 A, 7.628 A, and 7.984 A respectively. The measurement shows that the voltage levels for lines one through three measure 444.8V, 444.0V and 444.8V respectively.

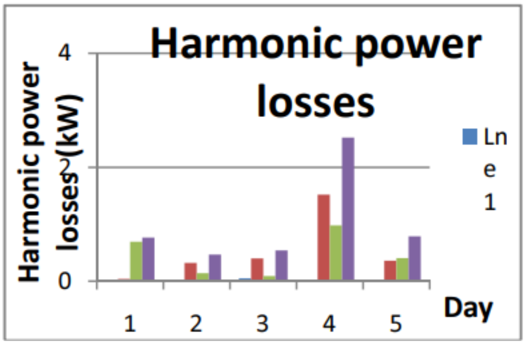

Fig 5: Total power loss during measurement

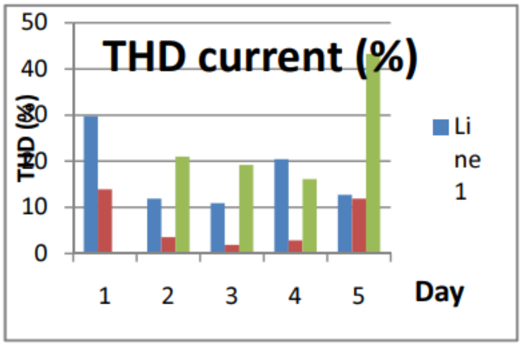

Fig 6: THD current of five days measurement

The overall harmonic distortion during measurement is displayed in graph figure 6 above. It demonstrates that line 3's loads, which are fluorescent lamps, are causing greater harmonic distortion every day. The fluorescent bulb must remain open throughout working hours whether the laboratory is operating or not.

V. Conclusion

The loads are nonlinear and imbalanced. Each channel's THD for voltage is less than IEEE222's standardization level, which is 4.22%, 4.22%, and 4.2% less than the system's 7%. Therefore, the system doesn't need a filter.

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