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POWER QUALITY MONITORING FOR INDUSTRIAL LOAD

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Abstract - Power quality monitoring is critical in ensuring the efficient and reliable operation of industrial systems. This paper presents a MATLAB-based simulation approach for power quality monitoring, providing a cost-effective and scalable solution for industrial applications. The idea behind this paper is to design and simulate a comprehensive power quality monitoring system that includes voltage and current measurement, harmonic detection, waveform analysis, and microcontroller-based data processing. This simulation environment allows for the evaluation of various power quality parameters and the optimization of system parameters for accurate assessment. The abstracted system integrates sensor data acquisition, signal processing algorithms, and communication modules within the MATLAB framework. Through extensive simulations and parameter tuning, the system can effectively detect and mitigate power quality issues such as harmonics, voltage sags, swells, and transients. This paper significance lies in its ability to offer a robust, cost-effective, and customizable solution for power quality monitoring in industrial settings, ultimately ensuring the longevity and reliability of critical equipment and processes. The presentation will provide insights into the design, simulation, and potential real-world implementation of this MATLAB-based power quality monitoring system.

Keywords –Harmonics, THD analysis, Fault correction, FFT analysis, Matlab simulation**.**

1. INTRODUCTION

Power quality monitoring for industrial loads is a critical aspect of ensuring efficient and reliable operations within industrial settings. The reliable and uninterrupted supply of electrical power is essential for the smooth functioning of industrial equipment and processes. However, various factors can affect the quality of this power, leading to potential disruptions and malfunctions. This necessitates a comprehensive monitoring system to assess and manage power quality effectively.

In this context, "Power Quality Monitoring for Industrial Loads" focuses on studying, analyzing, and managing the quality of electrical power supplied to industrial facilities. It involves monitoring various parameters such as voltage sags, voltage swells, harmonics, voltage unbalance, flicker, and other power disturbances that can impact the performance and longevity of industrial machinery. Understanding and improving power quality is vital for industrial facilities to enhance productivity, reduce downtime, prevent equipment damage, and ensure a safe working environment. Through continuous monitoring and analysis, it becomes possible to identify power quality issues, their causes, and implement appropriate solutions to mitigate their impact.

This paper delves into the significance of power quality monitoring in industrial settings, emphasizing the importance of adopting advanced monitoring technologies and methodologies. Additionally, it explores the potential benefits of maintaining high power quality levels, ultimately contributing to optimized industrial operations and cost-effectiveness. The subsequent sections will delve into the key components of power quality, monitoring techniques, challenges, and potential solutions to achieve an improved power quality for industrial loads.

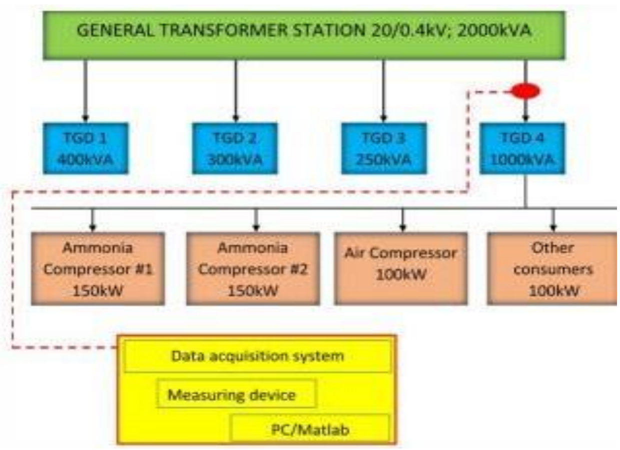


Fig 1. Block diagram of analyzed system

At last, the expense of force quality checking gear can be a test. Power quality observing gear can be costly, particularly when checking countless loads is vital. This can make it challenging for modern offices to legitimize the expense of executing a power quality checking framework. Not with standing these difficulties, power quality checking on modern burdens can be an important device for recognizing and relieving issues that can prompt gear harm, personal time, and lost efficiency. Via cautiously considering the difficulties in question, modern offices can carry out power quality observing frameworks that can assist them with further developing their power quality and decrease the gamble of issues. Here are a few explicit instances of difficulties that can be looked during a power quality observing venture on modern burdens: There is a need to screen countless loads. Modern offices frequently have hundreds or even a large number of burdens, every one of which can contrastingly affect power quality. This can make it challenging to figure out which burdens to screen and how to best screen them. The cruel climate where modern burdens are frequently located. Modern conditions are frequently dusty, filthy, and damp, which can make it challenging to introduce and keep up with power quality observing hardware. Furthermore, modern burdens can produce a ton of electrical commotion, which can disrupt the activity of force quality observing hardware.

The expense of force quality observing equipment. Power quality checking hardware can be costly, particularly when checking countless loads is fundamental. This can make it hard for modern offices to legitimize the expense of carrying out a power quality observing framework. The requirement for prepared staff to work and keep up with the power quality checking system. Power quality observing frameworks can be intricate to Power quality checking on modern burdens is a significant undertaking that can assist with distinguishing and moderate issues that can prompt gear harm, margin time, and lost efficiency. Notwithstanding, there are various difficulties that can be confronted while executing a power quality checking framework on modern burdens. One test is the enormous number of burdens that should be checked. Modern offices frequently have hundreds or even a huge number of burdens, every one of which can diversely affect power quality. This can make it challenging to figure out which burdens to screen and how to best screen them.

At long last, the expense of force quality checking hardware can be a test. Power quality observing gear can be costly, particularly when checking an enormous number of loads is vital. This can make it hard for modern offices to legitimize the expense of executing a power quality checking framework. In spite of these difficulties, power quality observing on modern burdens can be an important device for distinguishing and relieving issues that can prompt gear harm, margin time, and lost efficiency. Via cautiously considering the difficulties in question, modern offices can carry out power quality checking frameworks that can assist them with further developing their power quality and decrease the gamble of issues.

2. LITERATURE REVIEW

Ghanim Putrus 1 , Janaka Wijayakulasooriya 2 , Peter Minns 3 1, 3 School of CEIS, Northumbria University, Newcastle Upon Tyne NE1 8ST, UK 2 Department of Electrical and Electronics Engineering, Faculty of Engineering, University of Peradeniya, Sri Lanka ghanim.putrus@unn.ac.uk1 , jan@ee.pdn.ac.lk2 , p.minns@unn.ac.uk3 .“Power Quality” (PQ) is a generic term often used in relation with unwanted disturbances of the electricity supply. In recent years, there has been an increased number of PQ related problems. This is mainly due to the rapid growth in the use of equipment that generate PQ disturbances and also increase of equipment that are sensitive to these disturbances. This increased concern about PQ issues from both suppliers and consumers of electricity has increased the demand for advanced PQ monitoring systems. Each PQ disturbance has a unique wave shape resembling its characteristics. Therefore PQ disturbances could be identified by monitoring the voltage/current signal waveform and analysing its features. PQ monitoring instruments can vary from a simple true r.m.s. meter to advanced techniques that are capable of automatically capturing and classifying PQ events. This paper presents an overview of the characteristics, effects and causes of PQ events and addresses recent trends in PQ monitoring.

Proc. of the EPRI Power Quality Issues & Opportunities Conference (PQA’93), San Diego, CA, November 1993. - 1 - HARMONICS AND HOW THEY RELATE TO POWER FACTOR W. Mack Grady The University of Texas at Austin Austin, Texas 78712 Robert J. Gilleskie San Diego Gas & Electric San Diego, California 92123 Abstract- We are all familiar with power factor, but are we using it to its true potential? In this paper we investigate the effect of harmonics on power factor and show through examples why it is important to use true power factor, rather than the conventional 50/60 Hz displacement power factor, when describing nonlinear loads. Voltage and current harmonics produced by nonlinear loads increase power losses and, therefore, have a negative impact on electric utility distribution systems and components. While the exact relationship between harmonics and losses is very complex and difficult to generalize, the well established concept of power factor does provide some measure of the relationship, and it is useful when comparing the relative impacts of nonlinear loads–providing that harmonics are incorporated into the power factor definition.

International Journal of Electrical Engineering. ISSN 0974-2158 Volume 10, Number 1 (2017), pp. 33-45 © International Research Publication House http://www.irphouse.com Power Quality Analysis in Power System with Non Linear Load Vicky T. Kullarkar Vinod K. Chandrakar Department of Electrical Engineering G.H. Raisoni College of Engineering University of Nagpur, India vickykullarkar29991@gmail.com Department of Electrical Engineering G.H. Raisoni College of Engineering University of Nagpur, India vinod.chandrakar@raisoni.net. Abstract Increasing non-linear loads cause various undesirable effects and power quality problems. The use of power converters, electronic equipments and other non-linear loads are rapidly increasing in industry and also by consumers. These equipments draw non- linear currents from the AC mains as compare to traditional loads such as motors and resistive heating elements. This leads to the distortion of power system voltage and current & other problems. Here, the power quality with non- linear load is studied and total harmonic distortion (THD) is calculated under this condition by using Fast Fourier Transform (FFT) method. Harmonics is one of the major power quality problems in industrial and commercial power system. A harmonic of an electrical signal is defined as the content of signal whose frequency is an integral multiple of the fundamental frequency. IEEE Standard 519 Harmonics is defined as "a sinusoidal component of a periodic wave or quantity having a frequency that is an integer multiple of the fundamental frequency". Fast Fourier Transform (FFT) calculation method determines the total harmonic distortion (THD) contained within a nonlinear current or voltage waveform. Total harmonic distortions can be related to either current harmonics or voltage harmonics, and it is defined as the ratio of total harmonics to the value at fundamental frequency times 100%.

3. METHODOLOGY

Monitoring power quality for industrial loads is crucial to ensure stable and reliable electrical supply, reduce downtime, and maintain optimal performance. Here are several methodologies you can follow for a project titled "Power Quality Monitoring for Industrial Loads": [1]Literature Review: Start by conducting an extensive literature review to understand the existing power quality monitoring techniques, equipment, standards, and challenges related to industrial loads. Summarize key findings and identify gaps that your project can address. [2]Define Objectives and Scope: Clearly define the project's objectives, goals, and the scope of power quality parameters you intend to monitor (e.g., voltage fluctuations, harmonics, sags, surges, etc.) for industrial loads. Determine the specific industrial processes and types of loads that will be targeted.

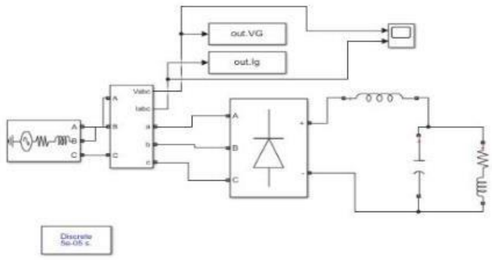


Fig2.THD Analysis

[3]Define Objectives and Scope: Clearly define the project's objectives, goals, and the scope of power quality parameters you intend to monitor (e.g., voltage fluctuations, harmonics, sags, surges, etc.) for industrial loads. Determine the specific industrial processes and types of loads that will be targeted. [4]Selection of Power Quality Parameters: Identify and prioritize the power quality parameters relevant to industrial loads, considering the impact on the equipment, production, and safety. Common parameters include voltage, current, frequency, harmonics, voltage sag/swell, flicker, and transients. [5]Data Collection and Sensors: Choose appropriate sensors and data collection methods to measure the selected power quality parameters accurately. Utilize instruments like power analyzers, voltage and current transducers, power quality meters, and data loggers. Calibrate and validate the accuracy of these instruments. [6]Monitoring System Design: Develop a monitoring system architecture specifying how data will be collected, transmitted, and stored. Decide on whether the system will be centralized or decentralized, wired or wireless, and how real-time monitoring and data analysis will be performed.

[7]Data Processing and Analysis: Implement algorithms and data processing techniques to analyze the collected data and extract relevant power quality information. Consider using signal processing methods, statistical analysis, and machine learning for identifying patterns, trends, and anomalies. [8]Visualization and Reporting: Create a user-friendly interface to visualize the power quality data in a meaningful and informative manner. Develop reports and dashboards that provide insights into the power quality levels and alerts for any abnormal conditions. [9]Integration with Industrial Systems: Integrate the power quality monitoring system with the existing industrial automation and control systems to enable timely response and necessary adjustments to maintain power quality.

[10]Testing and Validation: Conduct thorough testing and validation of the monitoring system in a controlled environment and, if possible, in a real industrial setting. Verify its effectiveness in accurately monitoring and addressing power quality issues. [11]Documentation and Knowledge Sharing: Document the project methodology, results, findings, and any recommendations in a comprehensive report. Share your

findings with the academic and industrial community through conferences, publications, or presentations. [12]Implementation and Deployment: Develop an implementation plan for deploying the power quality monitoring system in industrial facilities. Provide training to the relevant personnel for effective use and maintenance of the system. [13]Continuous Improvement and Future Enhancements: Propose recommendations for improvements, scalability, and future enhancements of the monitoring system to adapt to evolving industrial needs and emerging technologies.

4.EXPRIMENT:

Due to the particularity of the seventh interval, which refers to major load drop, this interval was chosen to share and to explain the analysis. By using the Matlab curve fitting tool – cf tool application, the time base functions of current and voltage (J(t) and V(t)) obtained during the measurement of the 7th interval, were combined into a new V(I) function that can be seen. The characteristics V(t) and I(t) are shown, where is visible that each load drop is accompanied by a voltage increase.

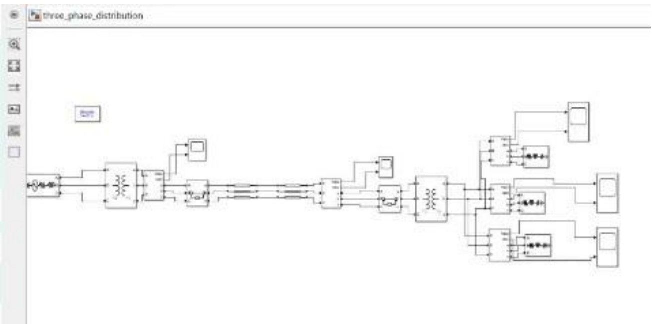


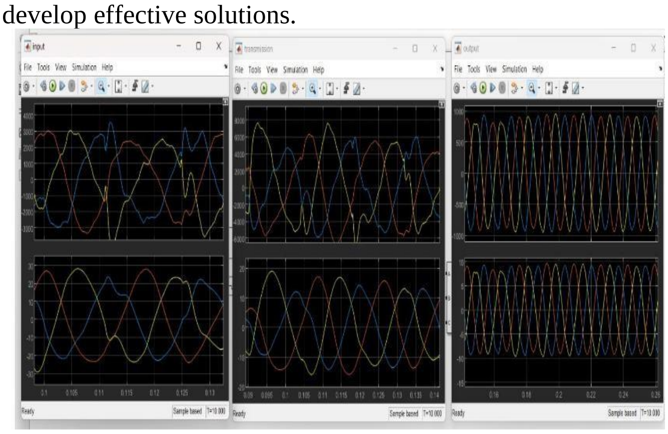
Figure 3. Real time simulation of power quality monitoring in Three Phase Distribution System

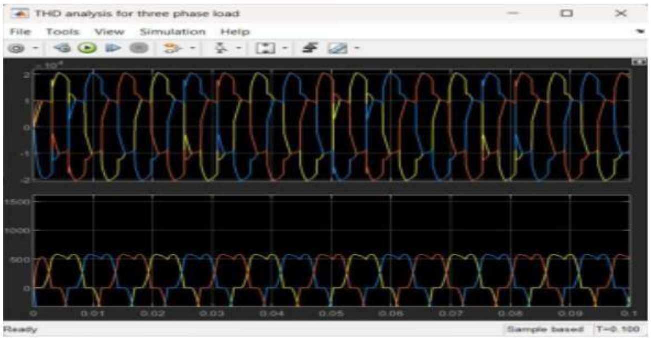
The application enables the creation of classic models, linear or nonlinear and having the ability to use user configured models, resulting polynomial regression models between variable and predictable response. The inflexion points obtained from data used are visible in the Fig. 3, each polynomial fit, up to the 7th degree were defined, being evaluated using GFS. When the polynomial degree increases, then the chance that specific regression polynomial augments proportionately approaching inflection points. Normally there are restrictions that limit the degree of a polynomial order, especially in a mathematical model.

Another tips in order to compare and to evaluate the fits, is to use the confidence bounds, which determines the accuracy of the coefficients. There are some inconveniences for the linear coefficients, referring to the pass crossing through zero of the bounds; in this case the coefficients are impossible to be calculated. In order to avoid this situation, for the current paper, a 95% confidence bound has been chosen. As a further step of the evaluating, the generated polynomial functions are compared using the goodness-of-fit statistics for parametric models, where the statistical parameters that were defined on section 2 are calculated for each polynomial function. Having the model's R-squared around 70%, the variance of its errors becomes 70% less than the variance of the dependent variable for the current data pattern. This value of the R-squared and the higher values of the SSE are a consequence to the fact that in the model proposed, the used data were collected directly in real-time, without filtering or other mathematical algorithms. It was defined that a model fits the data when the obtained values are close to the model's predicted values. After a statistical analysis of the parameters and after the comparison of them with the theoretical standard ones, the best-fit polynomial function is the one of the 5th degree

5.POWER QUALITY, FILTERING AND COMPENSATION RESULTS:

Power quality issues such as voltage sags, surges, harmonics, and transients can damage sensitive industrial equipment. Monitoring helps identify and mitigate these issues, reducing equipment downtime and repair costs. In industrial processes, maintaining a stable power supply is essential for consistent product quality and production efficiency. Power quality monitoring ensures that processes are not affected by voltage fluctuations or frequency deviations. Poor power quality can lead to energy waste. Monitoring helps identify inefficiencies, enabling companies to optimize their energy use and reduce operational costs. Many industrial facilities must comply with regulatory standards for power quality. Monitoring provides the data needed to demonstrate compliance and avoid penalties. In some cases, power quality issues can pose safety risks to personnel and equipment. Monitoring helps identify and mitigate potential hazards. Power quality monitors record data on voltage, current, frequency, and other parameters over time. The results are typically presented in graphical or tabular formats, allowing for analysis. Monitoring systems can detect and record power quality events such as voltage sags, swells, interruptions, harmonics, and transients. These results help pinpoint when and where issues occur. When power quality problems arise, monitoring data can be invaluable for troubleshooting. It helps engineers and technicians identify the root causes of issues and develop effective solutions.





Regular monitoring can reveal trends in power quality, enabling proactive maintenance. By addressing issues before they cause equipment failures, companies can extend the lifespan of their assets. Power quality monitoring can reveal inefficiencies in energy use, such as power factor correction needs or opportunities for load shedding during peak demand periods. This information enables companies to reduce energy costs. If regulations require adherence to specific power quality standards, monitoring results can be used to demonstrate compliance with authorities. This is crucial for avoiding fines and maintaining a good corporate reputation. Having a record of power quality data can be useful for insurance claims or legal purposes in case of equipment damage or business interruptions due to poor power quality. By analyzing historical data, companies can make informed decisions about infrastructure upgrades, capacity planning, and investments in power conditioning equipment.

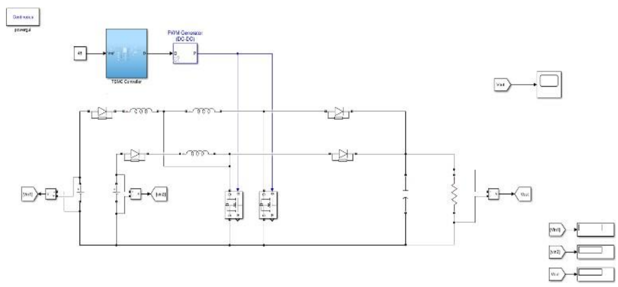


Figure 8

Power quality monitoring can detect and identify power disturbances and anomalies, such as voltage sags, swells, spikes, harmonics, and transients, in real- time. This early detection allows for prompt action to mitigate potential issues and prevent equipment damage or downtime. Power quality monitoring systems record extensive data over time, enabling in-depth analysis of power quality trends. This historical data can help diagnose recurring issues, optimize system performance, and plan for upgrades or improvements. By continuously monitoring power quality, industries can enhance the reliability of their electrical systems and reduce the risk of unplanned downtime. This is critical for industries with continuous manufacturing processes. Power quality monitoring can reveal energy wastage due to inefficient equipment operation or harmonics. Identifying these issues allows for energy-efficient measures and cost savings. Power quality monitoring helps industries comply with industry standards and regulations related to power quality. This is particularly important in sectors where regulatory compliance is mandatory. Monitoring power quality parameters can aid in load balancing, ensuring that power is evenly distributed among different loads. This prevents overload and reduces the risk of equipment failures.

8. CONCLUSIONS

In conclusion, Power quality monitoring systems can be complex to set up and maintain. They often require specialized equipment and expertise to install, calibrate, and interpret the data accurately. High-quality power quality monitoring equipment can be expensive, making it a significant upfront investment. However, the potential cost savings from improved power quality and reduced downtime can justify this expense. Monitoring systems generate vast amounts of data. Analyzing this data can be overwhelming, and it may be challenging to distinguish between normal variations and critical issues without advanced analytics tools. Some power quality problems may be intermittent and difficult to capture during short monitoring periods. Specialized monitoring strategies may be needed to identify these issues. Power quality monitoring primarily focuses on electrical parameters. It may not provide insights into other factors that can affect equipment reliability and performance, such as mechanical issues or environmental conditions. Power quality monitoring equipment requires regular maintenance and calibration to ensure accurate measurements. Failure to do so can lead to inaccurate data and misdiagnosis of power quality problems. Power quality data may contain sensitive information about industrial processes. Protecting this data from unauthorized access or cyber threats is essential.

Harmonics represent a growing concern in the management of the electrical distribution networks in nowadays. Significant savings can be achieved improving the electrical energy quality. A very important step into assuring these benefits is to understand the system requirement and its limitations. That's why the local operating conditions have to be analyzed before to implement a solution. Is mandatory the understanding of the harmonics effects that occur in the system, to know thes standards and regulations and how to comply with them

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