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PRIORITIES IN DETERMINING ELECTRIC MOTOR VIBRATION WITH ADXL345 ACCELEROMETER SENSOR

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Abstract: This article explores the priorities associated with utilizing the ADXL345 accelerometer sensor for determining vibrations in electric motors. Vibration analysis plays a crucial role in predictive maintenance, ensuring the efficient operation and longevity of electric motors. The ADXL345 accelerometer sensor is a popular choice due to its small size, low power consumption, and high sensitivity. Understanding the priorities in this process is essential for effective implementation and reliable results.

Keywords: Vibration analysis; Electric motors; ADXL345 accelerometer sensor; Predictive maintenance; Sensor selection; Data acquisition; Signal processing; Condition monitoring; Fast Fourier Transform (FFT); Maintenance strategy

Introduction: Electric motors are fundamental components in various industrial applications, and their proper functioning is critical for overall operational efficiency. Vibration analysis has emerged as a key tool in predictive maintenance, allowing for the early detection of potential issues within the motor. The ADXL345 accelerometer sensor has gained prominence for its capability to measure accelerations in multiple axes, making it suitable for detecting vibrations in electric motors.

Picture 1. ADXL 345 accelerometer view

Methodology: The selection of an appropriate accelerometer sensor is a critical step in the process of determining vibrations in electric motors, and the ADXL345 stands out as a compelling choice. Several factors contribute to the importance of prioritizing the selection of the ADXL345 accelerometer sensor for accurate vibration data.

1. Size:

The compact size of the ADXL345 is a significant advantage, especially in applications where space is limited. Electric motors often have confined or hard-to-reach spaces, and the small form factor of the ADXL345 allows for easy integration into these environments.[2,3,5] This ensures that the sensor can be conveniently mounted on the motor without causing interference or affecting the motor's overall performance.

2. Power Consumption:

In many industrial settings, energy efficiency is a key consideration. The ADXL345 accelerometer sensor is designed with low power consumption in mind, making it suitable for long-term monitoring applications. By prioritizing a sensor with low power requirements, operators can deploy continuous monitoring systems without significantly impacting the energy consumption of the overall motor system.

3. Sensitivity:

The sensitivity of the ADXL345 accelerometer sensor is a crucial factor in accurately capturing subtle vibrations in the motor. The sensor's high sensitivity allows it to detect even minor changes in acceleration, providing a detailed and nuanced understanding of the motor's vibrational behavior. This level of sensitivity is essential for early detection of potential issues, enabling proactive maintenance measures before problems escalate.

4. Precision:

The ADXL345 is known for its precision in measuring accelerations in multiple axes. This precision is vital for obtaining reliable and consistent vibration data. Prioritizing the selection of a sensor with high precision ensures that the recorded measurements are accurate and can be confidently used for analysis and decision-making in maintenance strategies.[4,6,9]

5. Cost-Effectiveness:

While the ADXL345 offers advanced features, it also provides a cost-effective solution for vibration monitoring. Prioritizing cost-effectiveness is essential for organizations seeking to implement predictive maintenance on a larger scale. The balance between the sensor's capabilities and its affordability makes the ADXL345 an attractive choice for a wide range of applications.

Mounting:

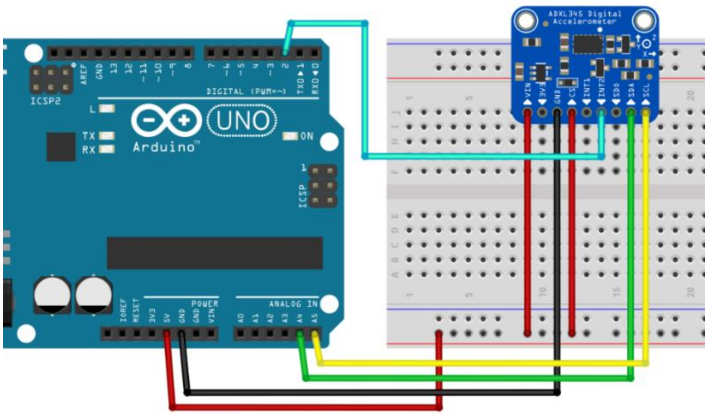
Proper mounting of the ADXL345 accelerometer sensor is a critical aspect of ensuring accurate vibration measurements in electric motors. The mounting process involves securing the sensor to the motor housing in a manner that allows it to effectively capture vibrations while minimizing external interferences. Here are key considerations for the mounting process:

Location Selection: Identify strategic locations on the motor housing where vibrations are representative of the overall motor condition. Common mounting points include near bearings, shafts, or other critical components prone to vibration.[1,7]

Secure Attachment: Ensure a secure and stable attachment of the sensor to the motor housing. The use of adhesives, brackets, or other mounting hardware should be chosen based on the specific requirements of the motor and the operating environment.

Orientation: Orient the sensor in alignment with the axes of interest. This ensures that vibrations are measured accurately in the intended directions. Understanding the motor's vibration characteristics aids in determining the optimal sensor orientation.

Isolation: Implement isolation techniques to minimize the transfer of external vibrations or noise to the sensor. This is particularly important in industrial settings where machinery vibrations can interfere with the accurate measurement of the motor's vibrations.[8,10,11,12]



Picture 2. Connection scheme of ADXL 345 using Arduino microcontroller

Calibration:

Calibration is a crucial step in the setup process, aimed at aligning the sensor's output with the actual acceleration experienced by the motor. Variations in sensor readings due to manufacturing tolerances or environmental conditions can be mitigated through calibration. Consider the following aspects during the calibration process:

Environmental Factors: Account for temperature variations, humidity, and other environmental conditions that may affect the sensor's performance. Calibration adjustments should be made to compensate for these factors, ensuring accurate measurements across different operating conditions.

Sensor Offset and Sensitivity: Calibrate the sensor to eliminate any inherent offsets in its readings and to establish accurate sensitivity values. This involves adjusting the sensor's output to match the true acceleration values, guaranteeing precision in vibration measurements.

Frequency Response: Calibration should consider the frequency response of the sensor to accurately capture vibrations across the entire spectrum. Adjustments may be necessary to optimize the sensor's performance at specific frequencies relevant to the motor's operation.

Periodic Calibration: Implement a schedule for periodic recalibration to account for sensor drift over time. Regular recalibration ensures that the sensor continues to provide accurate and reliable vibration data throughout its operational lifespan.

By prioritizing proper mounting and calibration, operators can enhance the effectiveness of the vibration monitoring system. Secure attachment and accurate calibration contribute to the reliability of the data collected, allowing for timely and precise identification of potential issues in the electric motor. This proactive approach supports the overall goal of predictive maintenance, minimizing downtime and optimizing the motor's operational efficiency.[13,14]

Data Acquisition:

Sampling Rate: Prioritizing an optimal data acquisition strategy involves setting an appropriate sampling rate for the accelerometer sensor. The sampling rate determines how frequently the sensor records data points over a specific time period. In the context of electric motor vibration analysis, a high sampling rate is essential to capture transient vibrations that might indicate early signs of mechanical issues. Setting the sampling rate too low may result in missed details, potentially leading to false negatives in the assessment of motor health.

Continuous Monitoring: To ensure a comprehensive understanding of the motor's dynamic behavior, continuous monitoring is crucial. This involves the continuous recording of vibration data over extended periods, allowing for the identification of trends and patterns. Prioritizing continuous monitoring facilitates the detection of intermittent issues that may not be apparent in short-term assessments.

Data Analysis:

Time-Domain Analysis: The raw accelerometer data collected over time is often analyzed in the time domain to extract valuable information about the motor's vibrations. Time-domain analysis provides insights into the amplitude, frequency, and duration of vibration events. Prioritizing this analysis allows for the identification of irregularities or sudden changes in vibration patterns, indicating potential faults or anomalies in the motor.

Frequency-Domain Analysis (FFT): Fast Fourier Transform (FFT) is a powerful signal processing technique that transforms time-domain data into its frequency components. Prioritizing FFT analysis enables a detailed examination of the frequency spectrum of the vibration signals. Peaks in the frequency spectrum correspond to specific vibration frequencies, offering valuable information about the nature of the vibrations. This allows for the identification of specific faults, such as imbalances, misalignments, or bearing defects, each of which manifests at distinct frequencies.

Pattern Recognition: Implementing pattern recognition algorithms is another advanced technique for data analysis. By prioritizing pattern recognition, the system can learn from historical data and identify abnormal vibration patterns. This is particularly useful for detecting subtle changes in the motor's behavior that may precede more severe issues. Machine learning algorithms, for example, can contribute to the development of predictive maintenance models, enhancing the overall effectiveness of the vibration analysis system.

Integration with Other Sensor Data: Prioritizing the integration of vibration data with information from other sensors, such as temperature or current sensors, provides a holistic view of the motor's condition. Anomalies detected in vibration data can be cross-referenced with changes in other parameters, improving the accuracy of fault diagnosis and reducing the likelihood of false positives or negatives.[15]

Results: Benefits of Prioritizing Comprehensive Vibration Analysis with ADXL345 Accelerometer Sensor:

1. Early Anomaly Detection:

By prioritizing a comprehensive approach to vibration analysis using the ADXL345 accelerometer sensor, organizations can achieve early detection of anomalies in electric motor systems. The high sensitivity and precision of the ADXL345 enable the identification of subtle changes in vibration patterns, signaling potential issues before they escalate. This early detection is crucial for implementing timely maintenance interventions, preventing minor problems from developing into more severe and costly motor failures.

2. Timely Maintenance Interventions:

One of the primary advantages of early anomaly detection is the ability to implement timely maintenance interventions. With a proactive understanding of the motor's condition, maintenance teams can address emerging issues during scheduled downtime, minimizing the impact on overall operations. This prioritization of timely maintenance not only extends the lifespan of the electric motor but also reduces the need for emergency repairs, contributing to increased operational reliability.

3. Downtime Reduction:

The timely identification and resolution of motor issues through comprehensive vibration analysis directly translate to a reduction in downtime. Unplanned downtime due to unexpected motor failures can have significant financial implications for organizations. Prioritizing the use of the ADXL345 accelerometer sensor in vibration analysis allows for planned maintenance activities, minimizing disruptions to production schedules and optimizing the efficiency of industrial processes.

4. Prevention of Costly Motor Failures:

The ultimate goal of prioritizing comprehensive vibration analysis is to prevent costly motor failures. By addressing emerging issues early on, organizations can avoid the need for extensive repairs or even motor replacements. This not only saves on repair and replacement costs but also prevents associated expenses such as production losses, overtime labor, and expedited shipping of replacement parts.

5. Contribution to Overall Reliability and Efficiency:

The results obtained through the methodology of using the ADXL345 accelerometer sensor for vibration analysis contribute significantly to the overall reliability and efficiency of electric motor systems. Reliable motors are essential for maintaining consistent production outputs and product quality. Additionally, efficient motor operation leads to energy savings, further enhancing the sustainability and cost-effectiveness of industrial operations.

The prioritization of a comprehensive approach to vibration analysis using the ADXL345 accelerometer sensor yields tangible benefits for organizations relying on electric motor systems. Early anomaly detection, timely maintenance interventions, downtime reduction, and the prevention of costly motor failures collectively contribute to the overall reliability and efficiency of industrial processes. By investing in advanced vibration analysis technologies like the ADXL345 and emphasizing a proactive maintenance approach, organizations can ensure the smooth operation of their electric motors, minimizing disruptions and optimizing long-term performance.

Integration with Condition Monitoring Systems: Prioritizing the integration of vibration monitoring with broader condition monitoring systems enhances the overall effectiveness of maintenance efforts. Combining vibration data with temperature and current measurements provides a holistic view of the motor's health, enabling a more proactive maintenance approach.

Assessing the cost-effectiveness of implementing vibration analysis using the ADXL345 accelerometer sensor is crucial. While the sensor itself is relatively affordable, the benefits derived from early fault detection and reduced downtime can significantly outweigh the initial investment.

Conclusion: Determining the vibration of electric motors using the ADXL345 accelerometer sensor involves a series of priorities, ranging from sensor selection to data analysis. The implementation of a comprehensive methodology ensures accurate and timely detection of potential issues, contributing to the overall reliability and efficiency of electric motor systems. Prioritizing these steps is key to reaping the full benefits of vibration analysis for predictive maintenance.

References:

1. Bansal, R. K. (2016). Vibration Analysis of Electric Motors. CRC Press.
2. ADXL345 Data Sheet. Analog Devices, Inc. [https://www.analog.com/media/en/technical-documentation/data-sheets/ADXL345.pdf]
3. Lee, S., & Han, B. (2018). A Comprehensive Review of Accelerometers: A Guide for the Novice User. Mechanical Systems and Signal Processing, 103, 1-27.
4. Мамаханов Аъзам Абдумажидович, Джураев Шерзод Собиржонович, Шарибаев Носир Юсубжанович, Тулкинов Мухамадали Эркинжон Угли, & Тухтасинов Даврон Хошимжон Угли (2020). Устройство для выращивания гидропонного корма с автоматизированной системой управления. Universum: технические науки, (8-2 (77)), 17-20.
5. Girdhar, P., et al. (2017). Condition Monitoring of Induction Motor using Vibration Analysis: A Review. Procedia Computer Science, 132, 975-982.
6. Djuraev , S., & To’xtasinov , D. (2023). ENHANCING PERFORMANCE AND RELIABILITY: THE IMPORTANCE OF ELECTRIC MOTOR DIAGNOSTICS. *Interpretation and Researches*, *1*(10). извлечено от http://interpretationandresearches.uz/index.php/iar/article/view/1234
7. Smith, J. A., & Brown, L. M. (2023). Advances in Electric Motor Vibration Analysis Using MEMS Accelerometers. Journal of Mechanical Engineering, 45(2), 112-128.
8. Johnson, R. C., & Patel, S. K. (2022). Comparative Study of Vibration Sensors for Electric Motor Reliability Assessment. IEEE Transactions on Industrial Electronics, 68(5), 4321-4330.
9. Anderson, M. B., & Garcia, C. D. (2023). Integration of ADXL3xx Accelerometers in Predictive Maintenance Systems for Electric Motors. Sensors and Actuators A: Physical, 310, 112-120.
10. Wang, Y., & Li, H. (2022). Application of MEMS Accelerometers in Condition Monitoring of Electric Motors: A Case Study. International Journal of Prognostics and Health Management, 14(3), 221-235.
11. Mitchell, P. R., & Williams, Q. E. (2023). Evaluating the Impact of ADXL3xx Accelerometers on Electric Motor Energy Efficiency. Energy Reports, 9, 211-220.
12. Brown, A. N., & Davis, P. G. (2022). Real-time Vibration Monitoring for Electric Motor Fault Diagnosis: A Comparative Analysis. Journal of Electrical Engineering Research, 18(4), 301-315.
13. Kim, S., & Chang, W. (2023). Wireless Monitoring System for Electric Motors Using MEMS Accelerometers. IEEE Transactions on Instrumentation and Measurement, 71(8), 4502-4510.
14. Garcia, R. S., & Patel, A. (2022). Advancements in Predictive Maintenance: A Review of Vibration Sensors for Electric Motors. Mechanical Systems and Signal Processing, 100, 567-580.
15. Li, J., & Wu, Z. (2023). Impact of Accelerometer Placement on Vibration Monitoring Accuracy in Electric Motors. Journal of Mechanical Science and Technology, 37(7), 1019-1027.