

Development of a Supervisory System Integrated with Neural Networks for Fault Monitoring in Bearingless Machines

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1. Introduction

The graphical and numerical visualization of signals plays a crucial role in the analysis of dynamic system behavior, enabling the rapid detection of patterns and anomalies. In applications involving electrical machines, torque, current, and rotor position controls can be performed using Digital Signal Processors (DSPs), which feature communication capabilities that enable data and signal exchange with a computer.

Recognizing the importance of efficiently interpreting these signals to ensure the stability and performance of the control system, this article proposes the development of a supervisory system for monitoring and analyzing digital signals, using the TMS320F28379D DSP, applied to a control and drive system for a bearingless permanent magnet machine. Additionally, the acquired data will be used to organize a dataset that will serve as a foundation for developing machine learning techniques aimed at error classification in the system's processes.

To illustrate the operation of the proposed supervisory system, an operational flow is presented in Fig. 1. In this flow, the signals generated during the plant operation (comprising the bearingless machine, power drive system, and sensors) are processed by the DSP and subsequently transmitted via the Serial Communication Interface (SCI) through an FTDI module to a supervisory computer, where they are interpreted and displayed using the PyQt5 library (Comprehensive Python Bindings for Qt v5) in the Python programming language.

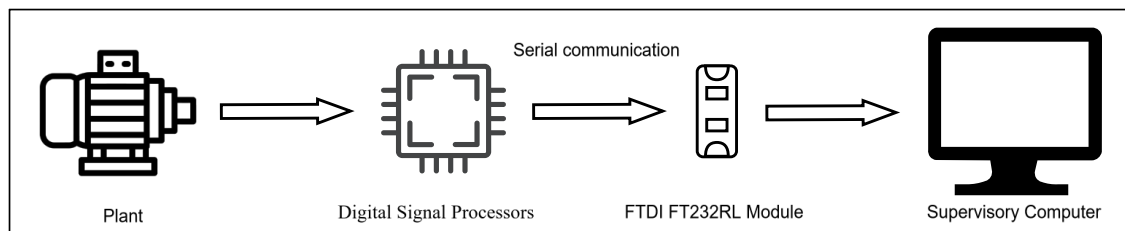


Fig. 1 – Test bench layout diagram.

2. User interface with PyQt5

To develop the supervisory system, Qt will be used, a free and open source framework for creating Graphical User Interfaces (GUI). Compatible with Windows, macOS, Linux and Android, Qt offers a comprehensive set of features that characterize it as a complete application development environment [1].

Originally designed for the C++ language, Qt stands out for its flexibility, allowing its use in other languages through bindings. Among these alternatives, PyQt5 is particularly notable as a library that integrates Qt version 5 with Python, providing an efficient solution that combines Qt's robustness with Python's simplicity. PyQt5 is widely used in interactive applications, including data visualization, experiment control, and simulations.

3. GUI Design

The graphical interface will be designed with a focus on user requirements, prioritizing ease of use and intuitive organization. To reduce the complexity of human-machine interaction, visual elements will be arranged clearly to ensure quick access to key functionalities, such as selecting the serial communication port.

Fig. 2 presents the initial design of the supervisory system screen, where, in addition to the mentioned element, there are parameters related to rotor speed and bushing positions, depending on the rotor's radial positioning. The motor sides are labeled A and B, with their X and Y displacement sensors. Additionally, a warning LED is present to signal when the bushing position deviates excessively from the expected reference.

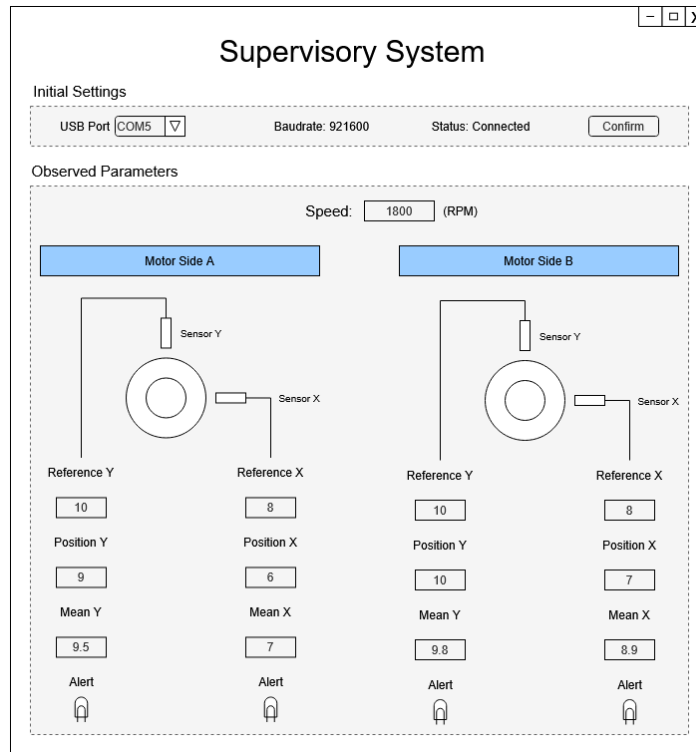


Fig. 2 – Supervisory System Interface Prototype.

4. Application of Neural Networks for Monitoring Bearingless Machines

Fault diagnosis methods based on computational intelligence, employing techniques such as Artificial Neural Networks (ANNs), Fuzzy Inference Systems (FISs), and Genetic Algorithms (GAs), have shown promising results in detecting and identifying faults in three-phase induction motors. These methods aim to enhance diagnostic accuracy by leveraging artificial intelligence's capability to analyze data and recognize patterns, enabling more precise and effective interventions in maintenance practices. [2].

In this context, the application of artificial intelligence in a supervisory system for bearingless machines represents a promising approach to enhancing the monitoring and maintenance of such equipment. This integration allows, for example, the generation of automatic alerts and more accurate fault prediction, contributing to the reduction of unexpected downtimes and an increase in operational reliability.

The system is being developed in modules. The initial stage of fault detection and recognition has already been implemented in conventional machines, and the next step is its application to the bearingless machine. The upcoming stages of the project include defining additional parameters to be displayed by the supervisory system, creating datasets of operational processes in bearingless permanent magnet machines, and developing machine learning techniques for error classification in the described processes.

References

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