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## INTELLIGENT SYSTEM FOR PROTECTING THE PUMPING UNIT FROM EXCESSIVE VIBRATION

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### Abstract

Vibration is one of the main threats to electric motors, which can lead to long-term failure and premature wear. To prevent such problems, automated and/or intelligent vibration protection systems for electric motors are widely used. This article provides an analysis of the causes of the occurrence of a water pumping unit, substantiates the importance of using intelligent protection against excessive vibration, solution methods and conclusions.

**Keywords:** *automated and/or intelligent protection, electric motor, vibration, reliability, equipment, maintenance*

### Introduction

In modern industrial processes, liquid pumping and gas pumping units play an important role. However, increased vibration can negatively affect the operation of pumping equipment, leading to wear, damage and reduced performance (Smith, J., 2017). Electric motors play a key role in various industrial processes, and their smooth operation is essential for efficient production operations. However, electric motors are subject to vibration, which can be caused by various factors such as load unevenness, imbalance of rotating parts, bearing wear and others (Rao, J. S., 2016). When analyzing the causes of vibration of the pumping unit, it turned out that these factors are connected and interact with each other. Basically, the following aspects of the reasons can be cited:

– **Electrical aspects.** The engine is the main equipment of the unit. Imbalances in the magnetic force within the motor and imbalances in the electrical systems often cause vibration and noise.

– **Mechanical aspects.** The quality of the rotating parts of the engine and water pump is unbalanced, and the installation quality is poor, the axis of the unit is asymmetrical, the swing exceeds the permissible value, the mechanical strength and rigidity of the parts is poor, the bearing and sealing parts are worn and damaged, and the critical speed of the pump is related to the unit. The resonance caused by the natural frequency will generate strong vibration and noise all the time.

– **Hydraulic aspects.** Uneven flow and pressure distribution at the pump inlet, pressure pulsation of the working fluid at the

inlet and outlet of the pump, displacement of flow and outlet, poor operating conditions and pump cavitation caused by various reasons are common causes of vibration of the pump unit.

– **Other aspects.** Unreasonable design of the unit's water intake channel or incompatibility with the unit, incorrect immersion depth of the pump, as well as unreasonable sequence of starting and stopping the unit will worsen the conditions for draining water, create vortices, cause cavitation or aggravate the vibration of the unit and the pump room.

All these impacts can lead to significant damage and premature failure of electric motors. To prevent such situations, it is important to use automated and/or intelligent protection systems.

### Formulation of the problem

The main task of automated motor vibration protection is to identify abnormal vibrations and take appropriate measures to prevent equipment damage (ANSI/EASA Standard AR100–2015, 2015). The automated control system for protecting the pump unit from increased vibration exposure sets itself the following tasks:

1. Determine abnormal fluctuations that exceed permissible standards.
2. Automatically shut down the motor or implement corrective measures when dangerous levels of vibration are detected.
3. Detection and measurement of increased vibration:
  - constant monitoring of vibration parameters of the pumping unit in real time;
  - analysis of the received data and determination of exceeding the limit values.
4. Response to increased vibration:
  - warning operators about dangerous vibration levels and possible damage to the pumping unit;
  - automatically taking measures to reduce vibration to prevent equipment damage and ensure safe operation.

### Results

In rotating equipment and flowing media, low-intensity mechanical vibrations are inevitable. Therefore, the manufacturing

and installation process of the unit should avoid interference caused by vibration as much as possible during the design, operation and control of the unit, and vibration damage should be kept to a minimum. When the pump room or unit vibrates, the reasons that may cause the vibration should be analyzed according to the specific situation, and after discovering the nature of the problem, effective technical measures should be taken to eliminate it. In this case, to solve problems in the control system for protecting the pump unit from increased vibration effects, it is proposed to use automated and intelligent protection using specialized systems and devices. To do this you need to do the following:

1. Installation of vibration sensors:
  - Placement of vibration sensors on strategically important parts of the pumping unit, such as pumps, motors and main mechanisms.
  - Connecting sensors to the monitoring system.
2. Monitoring and data analysis:
  - Continuous collection of vibration data using sensors.
  - Analysis of the obtained data to determine whether vibration limits are exceeded.
3. Warning and response:
  - Issuing warning signals to operators when vibration limits are exceeded.
  - Automatic response system to certain levels of vibration, including procedures for reducing the load on the unit, reducing the speed, adjusting operating parameters and/or emergency shutdown of the pumping unit (Shearer, J., 2018).

To implement the proposed approach, an 801S vibration sensor was selected (Figure 1), which has three outputs:

- Earth;
  - Nutrition;
  - Analogue signal output A0.
- Technical parameters of vibration sensors for ARDUINO:
- Supply voltage from 3 to 5 V;
  - Current consumption 4–5mA;
  - With or without a digital output;
  - With or without sensitivity adjustment.

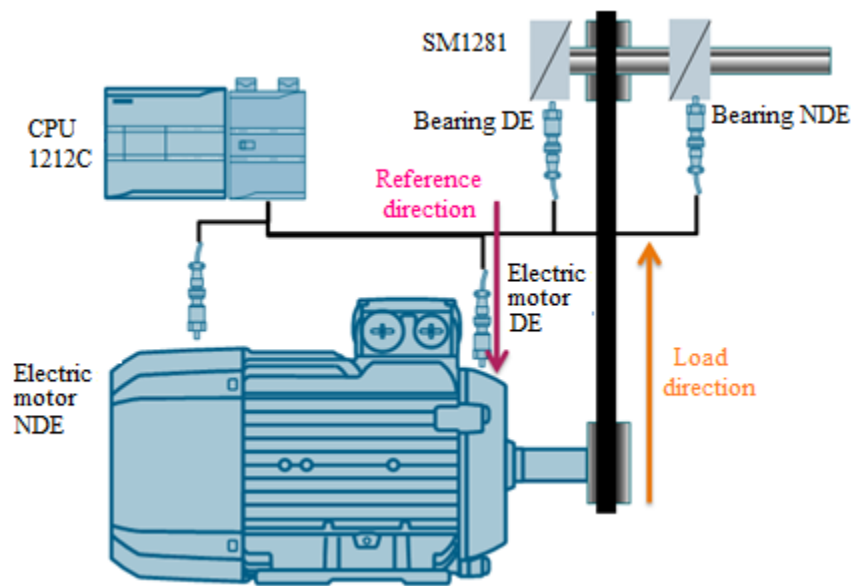
**Figure 1.** *Vibration sensor 801S*



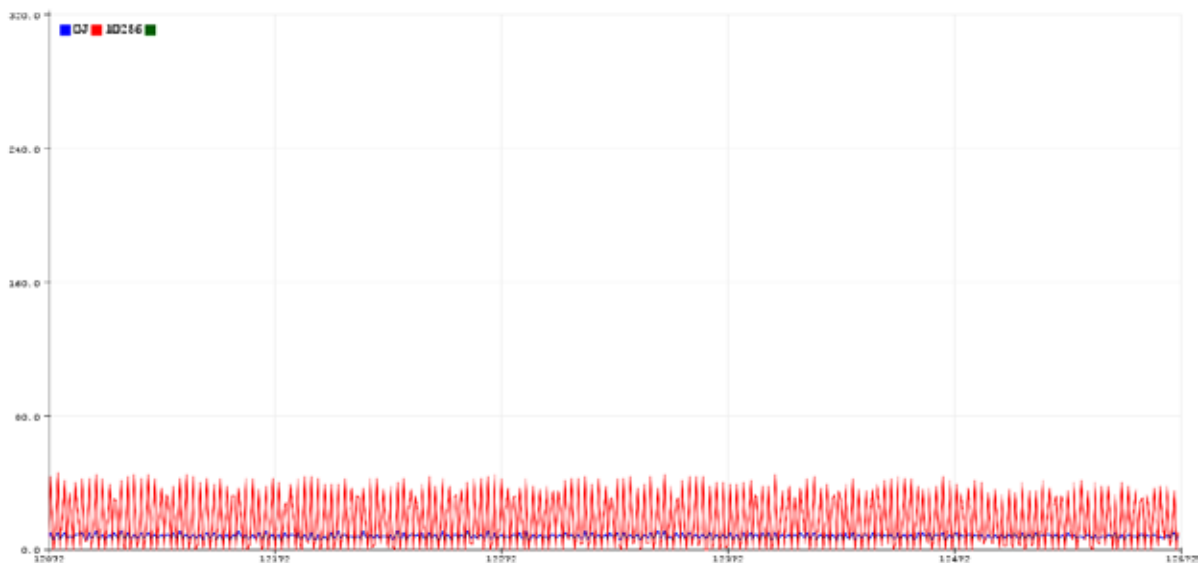
In Figure 2 shows a functional and technological diagram of the operation of the electric motor of a pumping unit for pumping liquids

and gases. In particular, this article discusses a pumping unit used in the process of treating municipal and domestic wastewater.

**Figure 2.** *Functional and technological diagram of the electric motor*



**Figure 3.** *Results of experiments of a pumping unit during vibration*





In Figure 3 shows the results of experiments on the pumping unit during vibration. For this purpose, a code program was com-

pleted to create a vibration sensor with a relay module in C++.

### **Discussion**

An automated control system for protecting a pumping unit from increased vibration is an integral part of modern industry. It ensures reliable and safe operation of pumping equipment, prevents damage and loss of

performance. By installing vibration sensors, monitoring and analyzing data, and alerting and responding to dangerous levels of vibration, the system provides effective protection for the pumping unit.

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