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DEVELOPMENT OF A ROTATION ACQUISITION SYSTEM FOR GENERATOR SETS USING ARDUINO PLATAFORM

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Abstract. *This work aims to develop a low-cost acquisition system for monitoring the rotation of a diesel generator set using the Arduino® platform and LabView software that can be applied to any generator set. It was used to reach the objective the inductive proximity type sensor of the manufacturer Schneider Electric ™; the Arduino® Mega 2560 system board; ROBO CORE, Protoboard 840 manufacturer's test card. The software was developed in JAVA, which makes it multiplatform through the NetBeans 8.0 development environment and using a mysql 5.6.17 database. In conclusion, it is possible to create a low-cost, easy-to-buy acquisition system for rotation for other generator set quantities and for other types of system, contributing to greater advancement and equality within science.*

Keywords: Rotation, Generator Set, Arduino®; LabView.

1. INTRODUCTION

Diesel generator sets are equipment widely used to generate electricity to meet the demand for temporary or permanent electrical installations in continuous, emergency or rush hour situations (Masseroni and de Oliveira, 2012; Sothea and Kim Oanh, 2019). For the electric generator to operate within the grid frequency it is necessary that the diesel engine operates at constant speed regardless of the variation of the applied electric load.

The speed governor is the equipment responsible for maintaining engine operating speed by supplying axle load fluctuations through injected fuel control. Currently the control of most speed governors in the market is mechanically performed and in some cases the generator sets have an electronic system for monitoring and speed control, these systems in turn add considerable values to the application.

The efficiency of a genset depends on several factors to be obtained from the genset, among them, according to Heywood (2018) we have the electric power and the rotation of the motor shaft, as well as, for fuels, lower calorific value (PCI). and the specific mass (ρ) corrected by the temperature at the pump inlet. Such parameters are obtained through acquisition systems, which at a high market value, which increases the difficulty of researching the area in the country.

Thus, this work aims to develop a low-cost acquisition system for monitoring the rotation of a diesel generator set using the Arduino® platform and LabView software that can be applied to any generator set.

2. THEORETICAL REFERENCES

2.1. Acquisition system

Data acquisition means the collection, storage and processing of data that represent the physical or chemical quantities of a particular environment under study. The conversion of these quantities into electrical energy is the responsibility of sensors, devices capable of sensing a certain characteristic of the environment and translating it into an electrical signal. These signals are then processed and transformed into data that will be stored in nonvolatile memories for later consultation. Figure 1 shows a simple scheme that exemplifies the process described above.

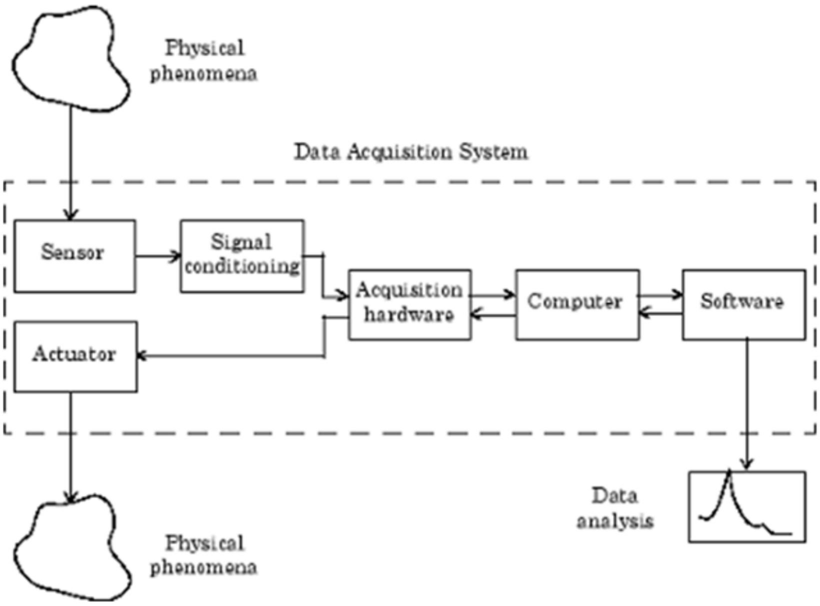

Figure 1 - Acquisition system example.

Literally, we can define the word sensor as 'what you feel'. In electronics, a sensor is known as any component or electronic circuit that allows the analysis of a particular condition of the environment, which can be as simple as temperature or light; a little more complex measure like the rotation of an engine or the distance of a car to a nearby obstacle or even events far from our daily lives, such as the detection of subatomic particles and cosmic radiation. (PATSKO, 2006)

The volume of fluid that flows through a cross section per unit of time is called volume flow (CENGEL et al., 2007). Flowmeters work to calculate the volume of a given fluid passing through a cross section. However, there are times when the important thing is to measure the total volume that went through a particular section and not just the instantaneous volume. In these cases, positive displacement volumetric flow meters are used. These devices are based on counting the loading and unloading operations of the measuring chamber. Where for each completed cycle a square wave pulse is emitted. The signal generated by these sensors is then counted over a known interval of time - pulse frequency - by the controller or totalizer that performs specific processing according to the specifics of each meter to determine the volumetric flow of that small space. time. These pulses are still totaled to know the total volume of liquid that has passed through that section.

2.2. Arduino

In 2005 the city of Ivrea in Italy witnessed the emergence of a project aimed at academic use that aimed to create low cost, flexible and easier to use tools with respect to the prototyping systems employed at the time. The Arduino was created from the perspective of free hardware and soon gained fame reaching over 50,000 boards sold in just 3 years.

In practice, according to Mcroberts (2011), an Arduino is a small computer that you can program to process inputs and outputs between the device and the external components connected to it. It is then physical computing, that is, a simple electronic prototyping platform able to feel the world around it, receiving inputs from a wide range of sensors, and acting on this same environment through actuators.

Arduino makes electronic prototyping extremely easy and it favors not only beginners, but also more experienced professionals who can get their projects done faster. Another point that contributes to the use and choice of Arduino as a development platform is the concept of free hardware, to which it was developed. Allowing its use and distribution at no additional cost to the project.

However, Arduino does not yet offer the robustness that other programmable logic controllers have. PLCs are more reliable, have several industry certifications and many safety features. That is, these controllers are best suited for industrial applications.

3. MATERIALS AND METHODS

3.1. Hardware

For designing the speed acquisition system, the first step was to select the appropriate sensor for measuring the motor shaft speed. The sensor is inductive proximity type by manufacturer Schneider Electric ™ (2016), its characteristics are described in Table 1.

Table 1. Features Inductive Proximity Sensor

Type	Inductive Proximity Sensor
Name	XS5
Size	35 mm
Material	Metal
Output Signal Type	Discreet
Signal Cable	3 wires
Nominal Detection Distance	2.0 mm
Output Type	NPN
Supply Voltage	12-24 VDC
Detection face	Front
Switching frequency	5000 Hz
Voltage drop	2 V
Current Consumption	≤ 20 mA (No Load)
Enclosure Material	Nickel plated brass
Ambient temperature for operation	-25 ° - 70 ° [C]

The Sensor was installed in the combustion engine housing near the flywheel, so that the front face of the sensor was approximately 2 mm from the teeth of the rack as shown in the diagram in Figure 1.

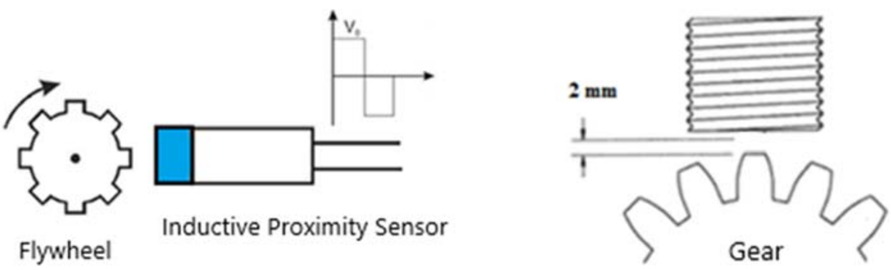

Figure 2. Proximity Sensor Placement

The inductive proximity sensor is NPN type, the principle of operation of the inductive sensor is from a variable electromagnetic field that is generated by the oscillator together with the coil at the end of the device. When a metallic material penetrates this field, small eddy currents are induced. With induction in the metal, a decrease in field energy occurs and, consequently, in the amplitude of the signal from the oscillator. When this signal becomes too low, the trip circuit senses the change and changes the output voltage. Providing a high- or low-level logical response that can be used for process control. The sensor used was powered by a 12 volts direct current source, the signal is normally open as shown in Figure 2 which simply indicates the internal composite circuit in the sensor, in the presence of metallic material the sensor closes with the negative of the source.

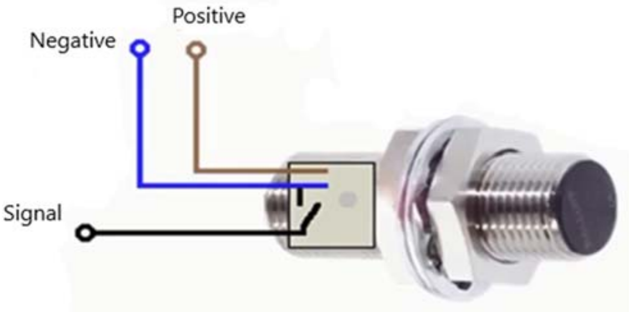

Figure 3. - Operating scheme Inductive sensor

The development board used was the Arduino® Mega 2560 (Figure 3), which, according to Thomsen (2014), is a larger version of the Arduino® board with ATmega2560 microcontroller and 54 digital ports, of which 15 can be used as PWM, plus 15 analog ports, ”featuring a 16 MHz clock, USB connection and external power connector. Ideal for more elaborate projects that require large numbers of inputs and outputs.

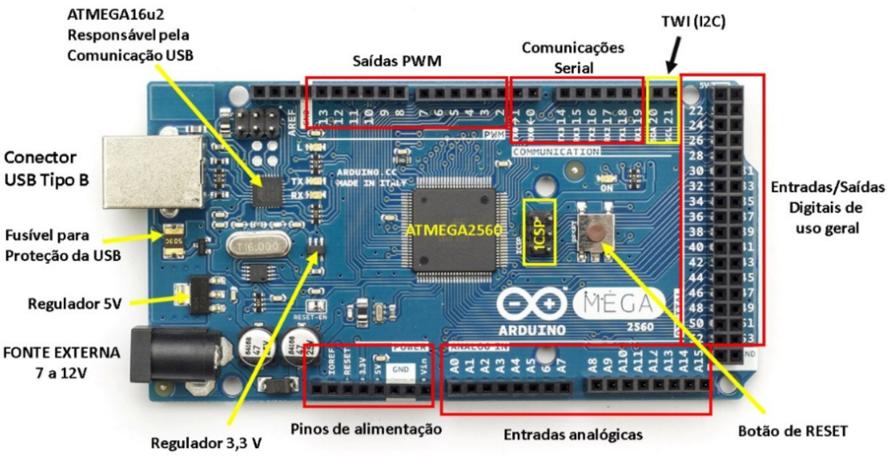

Figure 4. Arduino Mega 2560

Figure 4 shows the interconnection of the inductive sensor with the Arduino® acquisition board, where the sensor supply is observed and the signal is interconnected to the Arduino® digital pin 47 in parallel with a positive 5-volt voltage signal. from Arduino himself.

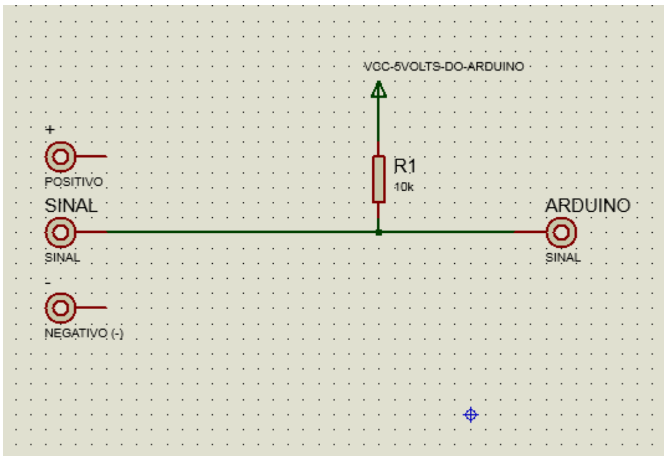

Figure 5. Arduino interconnection scheme

3.2. Software

The program was developed from the Arduino® IDE itself, using the FreqCounter library designed in the work of (PJRC). The system was developed in JAVA, which makes it multiplatform through the NetBeans 8.0 development environment and using a mysql 5.6.17 database. It has no installation procedure and is performed through the NetBeans IDE.

3.3. System validation

To validate the system, a test system was set up according to the following diagram.

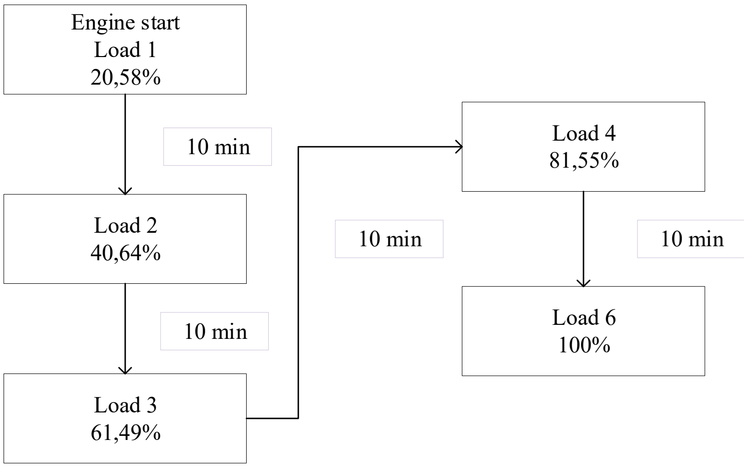

Figure 6 - Test layout.

To perform the test, the generator set was started and after the engine stabilization time, ten minutes, according to Figure 5, 5 different speed ranges were defined for the acquisition of the rotation readings through the digital tachometer (Figure 6) and through According to the Arduino® based acquisition system, the read ranges ranged from approximately 850 to 1800 rpm, all readings were recorded every 10 seconds.

Figure 7. PH-200LC Digital Tachometer

4. RESULTS

In Figure 7 we have the comparative graph of the readings of the rotations through the digital tachometer and the acquisition system with Arduino®. For each reading range 18 readings were recorded for each measurement system (Arduino® / Tachometer).

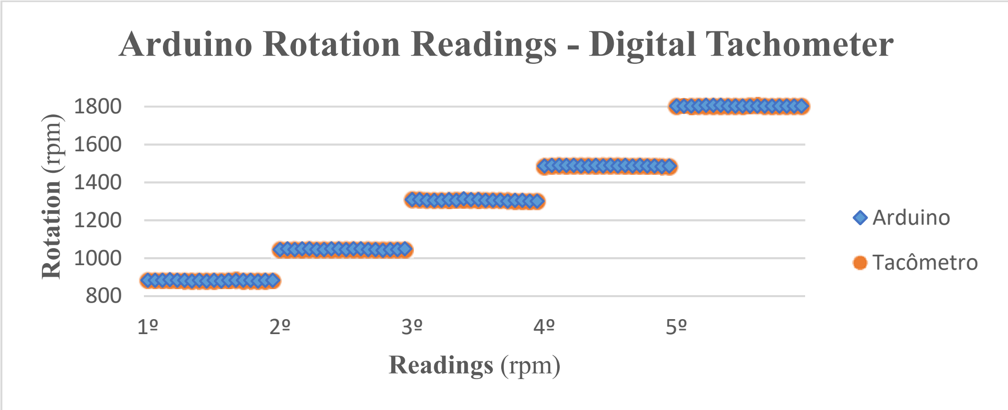

Figure 8. Comparative graph of readings with Arduino and Digital Tachometer

As can be seen in the figure above, the measurement results at all loads were analogous, proving the high degree of reliability of the proposed system.

Table 2 indicates the relative errors for minimum, medium and maximum for the five (5) distinct speed ranges applied to the generator set.

Table 2. Read Error Analysis Through Arduino and Tachometer

Cummins 4 Cylinder Engine Speed Reading Error Analysis					
Rotation regime	1º	2º	3º	4º	5º
Min Relative Error	-0,272	-0,344	-0,245	-0,168	-0,177
Average Relative Error	0,07	0,16	0,02	0,06	0,05
Maximum Relative Error	0,419	0,478	0,451	0,242	0,255

From the data presented, it can be said that the efficiency of the proposed system is remarkable, since the measured errors do not exceed 1%.

5. CONCLUSION

From the data presented, it can be concluded that it is possible to create a reliable, low cost and easy acquisition system, for rotation, for other generator set quantities, and for other types of system, contributing to further progress. and equality within science.

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