Annals of the „Constantin Brancusi" University of Targu Jiu, Engineering Series,
Supplement No. 1/2016

SYSTEM WITH MICROCONTROLLER USED TO STUDY THE INDUCTIVE SENSORS

Cercel Constantin, *„Constantin Brancusi" University of Targu Jiu, Romania*
Ilie Borcoși, *„Constantin Brancusi" University of Targu Jiu, Romania*

Abstract: In this paper is proposed a system with microcontroller used to study the inductive sensors that allowing to control movement, with a certain minimum precision, of the magnetic core of the sensor. The system comes with a data acquisition system designed to communicate with a PC or with other systems.

Keywords: system, microcontroller, inductive sensors, coil, core

1. Introduction

The inductive sensor proposed in the paper is not the type proximity sensors that is used to detect the position of metal objects. The output of an inductive proximity sensor has two possible states, therefore can be named an inductive proximity switch. The output of an inductive sensor has a many possible states and are used to various applications in automation technology. Because the sensor does not require physical contact it is particularly useful for applications where access presents challenges or where dirt is prevalent. Common applications of inductive sensors include metal detector, position detection, speed sensing, and distance measurement.
Inductive sensor operation is based on a variation of the inductance of a coil supplied with alternating current [1].
There are several variants adopted for inductive displacement sensors, of which the most common are:

- mobile core type;
- mobile "I" core type;
- two differential coils type.

The inductive sensor mobile "I" core type is based on geometrical change of the magnetic circuit of a coil, with a mobile "I" core (fig.1) [2].

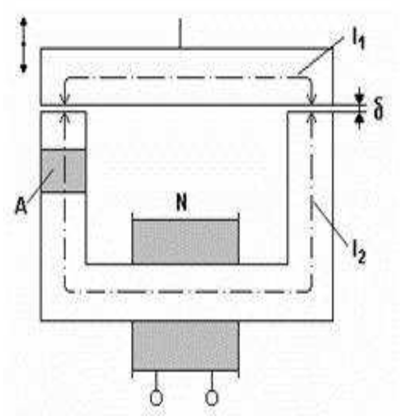

Fig.1. Inductive sensor with mobile "I" core

The inductive sensor mobile core type, shown in Figure 2, is much used in practice and consist in a coil inside which can move a ferromagnetic core with the same length as the coil.

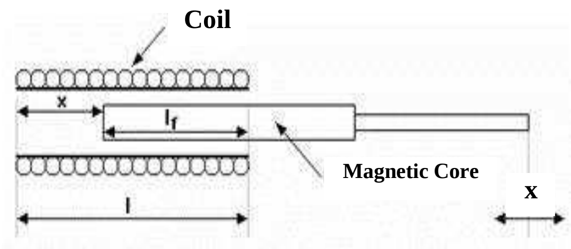

Fig.2. Inductive sensor with mobile core

The inductive sensor with two differential coils type is much easy to use and consists of two identical coils L1 and L2, each with length l, over which it can be moved a ferromagnetic core with the same length l, so when the inductance of one coil is maximum the other will be minimum (fig.3). The inductance change occurs due to the change of the magnetic circuit by moving of the mobile core or a part of the core [1].
We can say that the output of a differential transducer is proportional to the difference between the two inductance coils.

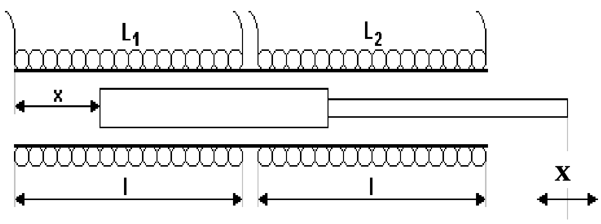

Fig.3. Inductive transducer with differential coils

2. The proposed system

The numeric system presented in this paper allows the tracing of the characteristics of the inductive displacement sensors model with two coils and a mobile ferromagnetic core.

The general structure of the proposed system is presented in figure 4.

This system has included the following components:

- a displacement control system to control movement with high precision of the mobile core;
- two oscillator circuit to generate the alternating signal;
- two frequency to voltage converters to transform the resonance frequency from the oscillator into a signal accepted by the analog to digital converter of the data acquisition system;
- a data acquisition system to measure the output signal from the sensor without affecting the measurement accuracy by introducing additional errors;
- a manual control of the movement in case we wants to make experiments with resistive sensors but without using software;
- two sensors with which it can be determined the starting positions and the final position of movement so that the system can be recalibrated according to the length of the displacement inductive sensors.

2.1 Displacement control system

Mobile core displacement is made by displacement system which transforms the rotation move of an action element in translation move. For the acting element there are more solutions: alternative current motor, continuous current motor, stepper motor, and brushless motor. Because in this application the rotational velocity and torque are small and also that it need a precision movement, was used a stepper motor.

The stepper motor directly converts the input signal, given in numerical form in a batch or incremental angular motion. In this way the movement of the object set is made in staple trips, fully consistent with the evolution of the discrete control signals. These properties allow stepper motors to control the discrete systems, which are remarkable advantage of not needing feedback loop to correct the movement. Regardless of the operating principle of a stepper motor, the control is achieved by switching its successive phase windings. For a stepper motor with variable reluctance following commands are possible:

- symmetric simple command or half-power;
- symmetric dual command or full power;
- symmetric or half-angle command step.

The stepper motor used is a 12VDC motor with five phases motor and the rotation step is 1.8 degree.

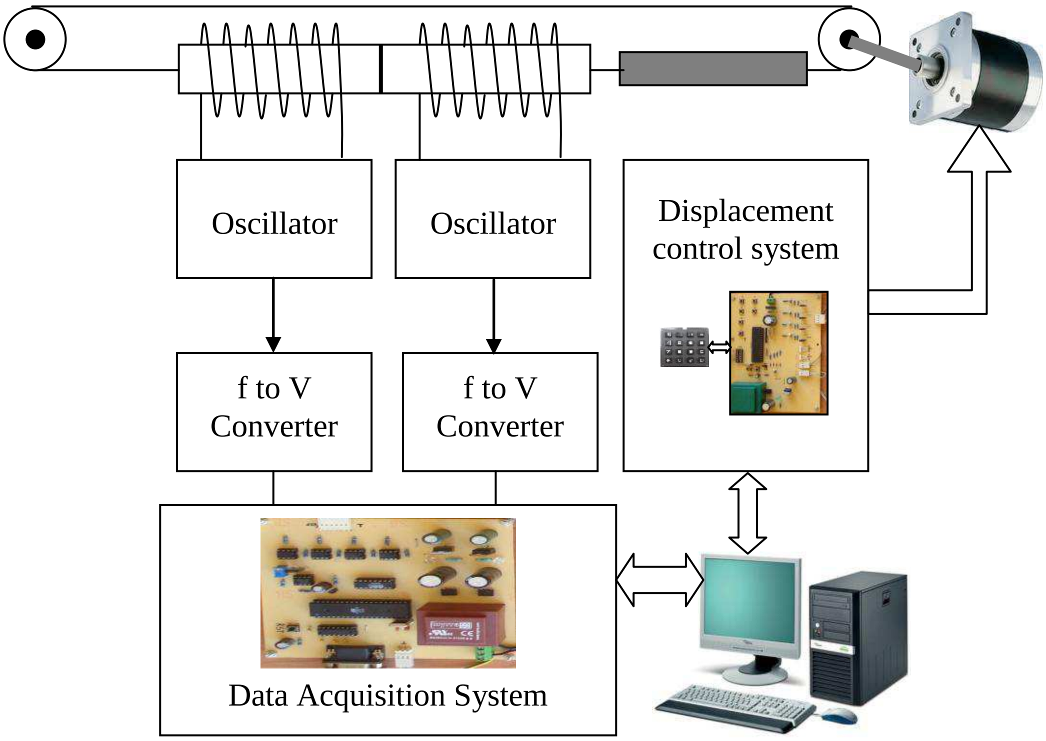

Fig.4. The system structure

The control system is realized with an AT89S52 microcontroller which controls the stepper motor and checks the two end position sensors for any stopping. These sensors are contact type with elastic lamella and were mounted on the mechanical system that can slide along the displacement system so that their position can be adjusted depending on the size of the inductive sensors tested.

For manual control mode of the mobile core movement, was connected to the microcontroller system a keyboard with 10 keys as matrix ordered by rows and columns.

With this keyboard can be controlled the actuator represented by the stepper motor to perform certain commands independent from the measurement and control application running on PC, so the displacement system can work in the absence of PC. Commands for the 4-phase stepper motor are connected to the microcontroller port P0.

For easy operation regardless of the command mode manually (using the keyboard) or automatically (using the application built in LabWindows) into the software application has been implemented a virtual keyboard with the same functionality as the keyboard connected to the control of movement system. So, both virtual and hardware keyboard contains 10 keys numbered from 0 to 9 and each key has a specific functionality, as follows:

- key 0, command to stop the stepper motor in upward movement;
- key 1, command the stepper motor to perform six steps, resulting in upward movement of the sensors core over a distance of 1 mm;
- key 2, command the stepper motor to perform 30 steps, resulting in upward movement of the sensors core over a distance of 5 mm;
- key 3, command the stepper motor to perform 60 steps, resulting in upward movement of the sensors core over a distance of 10mm;
- key 4, command the stepper motor to perform six steps, resulting in downward displacement of the sensors core aver a distance of 1 mm;
- key 5, command the stepper motor to perform 30 steps, resulting in downward displacement of the sensors core over a distance of 5 mm;
- key 6, command the stepper motor to perform 60 steps, resulting in downward displacement of the sensors core over a distance of 10mm;
- key 7, command the stepper motor to move the sensors core to perform upward displacement to the end of the race, up to the limiter;
- key 8, command the stepper motor to move the sensors core to perform downward displacement to the end of the race, down to the limiter;
- 9 key, command to stop the stepper motor in downward movement;

2.2 The Oscillator circuit

The oscillator circuit is a LC circuit based on an op-amp and has the structure as presented in figure 5. This is an easy way to measure the output of the inductive transducers.

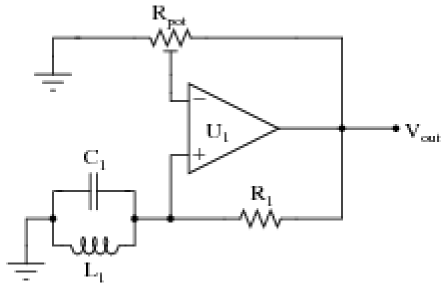

Fig.5. Oscillator circuit

2.3 The frequency to voltage converter

The AD650 V/F/V (voltage-to-frequency or frequency-to-voltage converter) provides a combination of high frequency operation and low nonlinearity previously unavailable in monolithic form[6].

The AD650 also makes a very linear frequency-to-voltage converter. Figure 6 shows the connection diagram for F/V conversion. Each time the input signal crosses the comparator threshold going negative, the one shot is activated and switches 1 mA into the integrator input for a measured time period (determined by COS). As the frequency increases, the amount of charge injected into the integration capacitor increases proportionately. The voltage across the integration capacitor is stabilized when the leakage current through R1 and R3 equals the average current being switched into the integrator. The net result of these two effects is an average output voltage that is proportional to the input frequency. Optimum performance can be obtained by selecting components using the same guidelines and equations listed in the Bipolar V/F

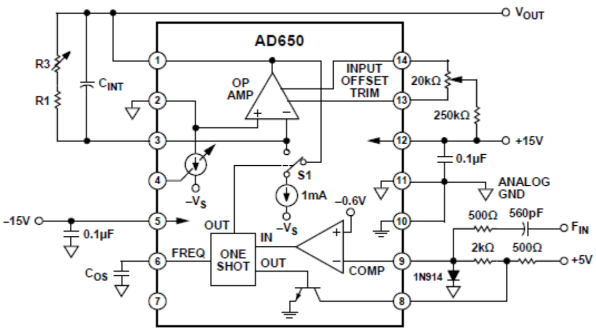

Fig.6. The f to V converter

section.

2.4 Data acquisition system

The data acquisition system was developed around a microcontroller core from ATMEL AT89S52 family using a 12-bit analog to digital converter ADS7841 and a MAX232 circuit for achieving communication between the acquisition system and the application software running on PC. Data acquisition system receives a command to perform measurements for each of the four input channels whenever the movement control system announces the software that he made a number of steps to the last command received.

The system operation will be as follow: from software of from keyboard is placed a command to perform a number of steps equivalent to a certain displacement. Once these steps have been taken by the displacement control system it announced the software application that the scheduled movement was executed. At this point the software communicates with the data acquisition system achieving a 12 bit analog to digital conversion for each of the four input channels. The acquisition system sends out to the software the conversion results. Thus ending a displacement – measurement cycle and the system is ready for a new cycle.

4. Conclusions

The proposed system was designed to achieve laboratory test and study for inductive sensors, but with few hardware and software changes can be used successfully into a monitoring and control application.

Using serial communication with a PC and a software application all values can be recorded, saved and exported for further processing.

References

[1]. Marius Birlea – Sensors Physics, (Fizica sensorilor), Technical University of Cluj Napoca, http://users.utcluj.ro/ ~mbirlea/

[2]. http://www.rasfoiesc.com/inginerie/electronica/STUDIUL-SENZORILOR-SI-TRADUCTO86.php

[3]. Grofu Florin, Cercel Constantin - „NUMERICAL SYSTEM FOR RESISTIVE DISPLACEMENT SENSORS STUDY", Annals of the „Constantin Brancusi" University of Targu Jiu, Engineering Series, Issue 3/2011, pag.46-57, ISSN 1842-4856

[4]. Steve Martin - Using the AD650 Voltage-to-Frequency Converter As a Frequency-to-Voltage Converter, AN 279, http://www.analog.com

[5]. A.V. Bakshi, U.A. Bakshi – Electronic Measurements and Instrumentation, Technical Publications Pune, 2008

[6]. http://microcontroller.ti.com/;

[7]. Austin Hughes - Electric Motors and Drives Fundamentals, Types and Applications, Published by Elsevier Ltd., 2006;

[8]. http://www.datasheetcatalog.org/datasheet/texasinstruments/ads7841.pdf;

[9]. Ian R. Sinclair – Sensors and transducers, Third Edition, 2001

[10] A. Deji and all Analysis and evaluation differential inductive transducer for transforming physical parameters into usable output frequency signal, International Journal of Physical Sciences, vol. 9 pp. 339-349, ISSN 1992-1950.