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Research of the Inductive Sensor of the Electropneumatic Clutch Control System for the Mechanical Transmission at Change of Ambient Temperature

Mykola Grygorovych Mikhalevich, Dziubenko Oleksandr, Dmitry Leontiev, Viktor Bogomolov, Valeriy Klimenko, Alexandr Yarita, and Olena Chevychelova Kharkov National Auto and Highway University

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Abstract

This article describes experimental research results of the inductive sensor of the electropneumatic clutch control system for the mechanical transmission. Inductive sensors are used to determine the position of the car body, the position of the controls and the position of the rod of the clutch control actuator. The design of the clutch pedal position sensor is proposed, which can be brought into line with the master cylinder to unify the clutch control systems. Complete unification of the automated electropneumatic clutch control system for trucks will allow creating modifications in which it is possible to completely abandon the use of brake fluid in the drive, which will improve the ergonomic and environmental performance of the vehicle. The advantages of such sensors are the ability to receive a signal in digital form without additional converters, the ability to work using only two wires, no contact between moving parts, resistance to aggressive environments and compact size. The disadvantage is the influence of ambient temperature on the electrical parameters of the sensor (inductance and resistance) and on the measuring circuit of the electronic control unit. The temperature effect creates significant deviations in the data received by the processor. During the laboratory experimental study, the influence of ambient temperature on the measurement data in the temperature range of −45°C + 45°C was determined separately for the sensor and for the sensor with the measuring system. Significant nonlinearity of the characteristic was determined. The effect of spontaneous operation of the clutch control system during changes in ambient temperature was experimentally obtained. The influence of temperature change on the measuring range of the inductive sensor is also revealed. The transfer characteristic of the sensor (%/mm) is determined. The approach that provides a stable transfer characteristic within the specified temperature range is proposed.

Introduction

Contact and non-contact sensors are used to determine the position of pedals. Typically, the pedal position sensor of resistive type has two variable resistors, and the data is transmitted in analogue form via six wires and is processed in the analogue-digital convertor (ADC) of the electronic control unit. In a similar way, the signal from non-contact Hall effect sensors is also processed in the ADC. The position of the clutch pedal can be determined by the non-contact method using the four options, namely [8]: - linearly located array of Hall sensors with one output channel that responds to changes in magnetic field lines (this requires a permanent magnet); - integrated circuit with two output channels (this requires a permanent magnet); - Hall sensors that detect certain positions of the clutch pedal (this requires a permanent magnet of small size); - inductive sensor (this does not require a permanent magnet). Among the four methods, the latter one is considered to be the simplest and cheapest method. It does not require a permanent magnet, only two wires are needed to transmit data. This method of obtaining data provides noise immunity, and the cost of the element base for measuring the signal is lower [1]. For an inductive sensor, the data is transmitted through two conductors without the need to use an ADC, since during signal processing a method of measuring time with a timer is used, and this way the data is immediately converted to a digital format. Such design of the sensor contributes to reducing wiring costs when using the system in rear-engined buses. Unlike a contact resistive sensor, an inductive one is not prone to sensing interfering signals and random bursts of the actual signal. Along with the advantages, this method of measuring the signal has its drawbacks. Thus, inductive sensors are connected to an oscillating circuit, which generates a sinusoidal signal with a resonant frequency of several kHz, which is sensitive to the characteristics of the components of the measuring circuit. First of all, the condenser is meant [2, 3, 4].

FIGURE 15 The relationship between the signals measured by the microcontroller that is formed for the control system depending on the pedal stroke

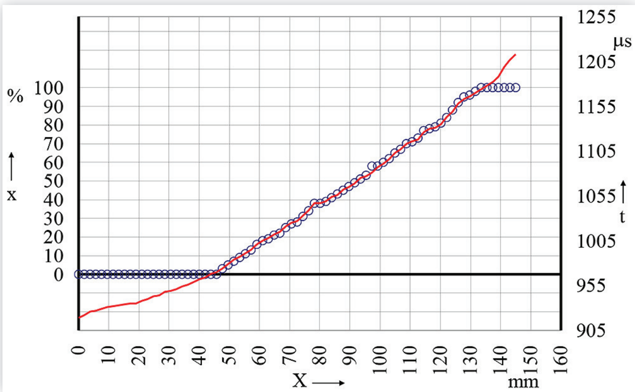


FIGURE 16 The set of actual characteristics of the clutch pedal position sensor within the temperature range of −40… + 40°C

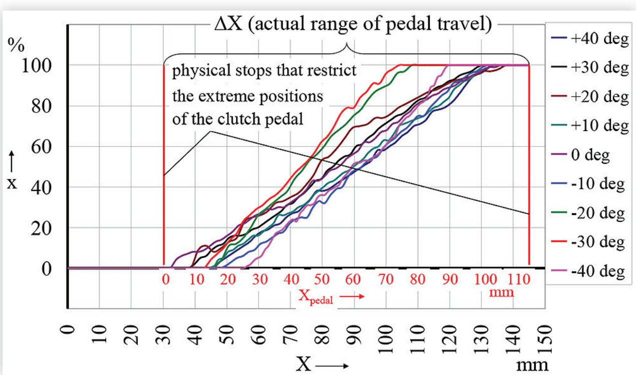
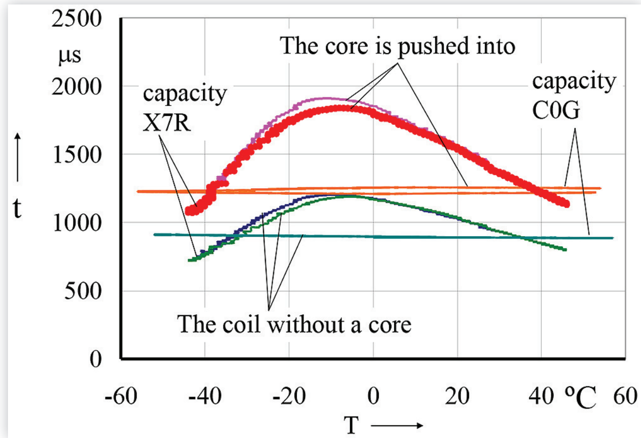


FIGURE 17 The duration of the period of the input signal from the clutch pedal position sensor at the extreme positions of the core depending on the temperature of the sensor, wires and electronic unit (NP0 capacitor in the measuring circuit)



the boundary curves do not coincide over the entire temperature range. According to the experimental studies, the movement of the vehicle starts when the position sensor of the clutch pedal is within 65… 60% of the stroke. Thus, standing start begins when the pedal reaches the range from 48 to 72 mm of the clutch pedal stroke. At this, the discrepancy of the beginning of the movement during temperature fluctuations reaches 24 mm.

The application of the capacitor with NP0 dielectric provides the pattern of the response characteristic of the measuring circuit shown in Figure 17. This characteristic allows us to increase the sensitivity of the sensor to the level of 0.34%/mm by increasing the pedal stroke and reducing dead zones at the extreme positions of the clutch pedal.

Uncertainty of the characteristic supposes that the curves marked in Figure 17 may change position in different samples of the ECU, which does not allow us to unify the curves in the production.

Conclusions

The proposed method of forming the boundary curves for the extreme positions of the clutch pedal sensor allows us to achieve a constant sensitivity of the pedal over the entire range of operating temperatures in theoretical terms.

Due to the discrepancy of the analytical representation of the boundary curves and the actual equidistant curves, there is a displacement of the clutch pedal characteristic within limits of 24 mm over the entire temperature range.

In the zone of –20… –30 °C a slight change in the sensitivity of the pedal is observed in the inactive area of the clutch pedal.

When using capacitors with NP0 dielectric, a sensitivity of 0.34% / mm was obtained. For a capacitor with X7R dielectric, this value is 0.87%/mm.

When using capacitors with X7R dielectric, the effect of capacity degradation over time should be taken into consideration and the system performance statistics should be provided to the microcontroller.

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Contact Information

Assoc. Prof., Mikhalevich Mykola Grygorovych
Ukraine
mkolyag@gmail.com

Assoc. Prof., Dzubenko Alexandr Andreevich
Ukraine
dzyubenko.alan@gmail.com

Assoc. Prof., Yarita Alexandr Alexandrovich
Ukraine
aleksandr.yarita@mail.ru

Sr. Researcher; Assoc. Prof., Leontiev Dmitry Nikolaevich
Ukraine
dima.a3alij@gmail.com

Professor, Klimenko Valeriy Ivanovich
Ukraine
valeriy.klimenko@gmail.com

Professor, Bogomolov Viktor Alexandrovich
Ukraine
bogomolov.viktor@gmail.com

Assistant Professor, Chevychelova Olena Oleksandrivna
Ukraine
chevychelova910@ukr.net

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