702. Investigation of attraction force and vibration of a slipper in a tactile device with electromagnet

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(Received 20 October 2011; accepted 4 December 2011)

Abstract. This paper analyzes the formation of electromagnet control signal, i.e. what parameters of control signal should be used in order the person could discern electromagnet attraction and perceive the transformed information. The study reports results of the investigation of attraction force and demonstrates how persons perceive different signals.

Keywords: Braille device, electromagnet, control signal.

Introduction

It is of high importance to have a possibility to transform graphical information into perceptual form of information for blind or partially sighted persons. There are a large number of scientists who attempt to develop a practical information device that could perform correct transformation. Some devices as Braille pad [1], smart interactive tactile interface [2] and others can be mentioned. For example in [3] a device is presented, in which the sensor is realized as miniature electromagnet, which is scanned by finger on the touch sensitive screen with a layer of ferromagnetic film. All devices could be separated into these groups: audio equipment, sensory equipment and vision/perception devices. The present article provides information about control capabilities of sensory equipment and the approach used to transmit and interpret the information.

It is possible to create human finger motion speed over magnet surface if a magnet is used that can be switched on and off. Human finger moves a metallic slipper on magnet and this slipper could be attracted or stopped for a moment, when electric signal is generated in electromagnet. Information transmission could be realized by controlling magnetization and demagnetization of electromagnet.

N. McLagan thesis is dedicated for control of electromagnetic vehicle suspension [4]. Principles of electromagnet control and N. McLagan vehicle suspension are the same: an electromagnet generates traction force, which could stop moving object (metallic vehicle or slipper). There is power in our issue less and it do not stop vehicle or slipper at all, but just stop it for a moment and when this slipper move again.

Research object

The system under study consists of 5 elements: human finger, electromagnet, amplifier, signal generator and oscilloscope (Fig. 1).

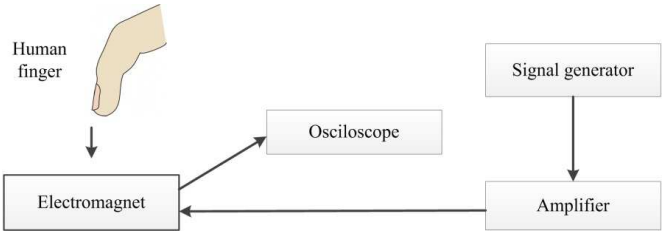


Fig. 1. Electromagnet investigation scheme

Electromagnet is connected to amplifier, which boosts signal level from signal generator. Oscilloscope shows signal parameters. This system is used to make a preliminary research of human perception of electromagnet oscillations.

Electromagnet. A custom-built electromagnet is used in this research. Magnet body is made of metallic tube with cut flank. A coil is made in opposite of this cut flank. Inside of cut flank a brass slipper with metallic spacer is placed. This metallic spacer is needed to feel traction force. Slipper's way along tube is about 9 cm. Scheme of cross-section of electromagnet is presented in Fig. 2.

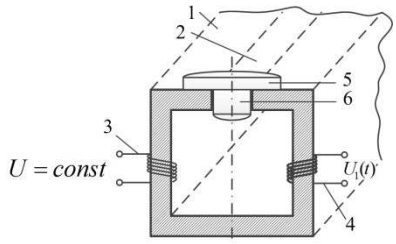


Fig. 2. Electromagnet cross-sectional scheme

Control signal. Sinusoidal signal is used to control electromagnet magnetization and demagnetization. The magnet is most powered when it is in the peak of the sine signal. Current is max at that moment and slipper is stopped a little bit. If slipper is moved at a steady speed, its motion is like twitched – suspended and loosened slipper to electromagnet surface.

Investigating human possible perception of suspension and loosen frequency – i.e. sine signal frequency, the person can feel 5-300 Hz of oscillation. Over 300 Hz oscillations are sensible, but are not so obvious. Slipper oscillations are not perceived when they exceeded 500 Hz limit.

A research was made on possible frequency of signal and signal formation deduction and it was assumed that there is a possibility to use various combinative information transmission methods when this information is different. It is possible to change frequency, period and oscillations quantity of the signal. It is possible to make transmission algorithm of visual information by making variation of these parameters.

Research results

T. Kaarasoja and J. Linjama have performed research on perception of mobile phone vibrations [5]. They found out that 180 Hz oscillation could continue from 50 ms to 200 ms. In another words, 5,5 ms period continual oscillations could transmit perceptual information then oscillation is between 50 ms and 200 ms. They were investigating electromotor of continual current with centrifugal mass, which oscillation frequency is of 180 Hz and they vary only duration.

In research of human perception of different oscillation frequencies, it was observed that the most appreciable oscillation for humans is in the range of 15-20 Hz and 150-200 Hz. In research also was fixed the perceptual frequency displacement value – width of range, which could be minimal for human perception of changes. It was determined that it is possible to increase frequency by smaller range, but it should be damped by biggest range. Larger displacement is more appreciable, i.e. a person feels better when the oscillation changes from 50 Hz to 100 Hz than in the case when it changes from 50 Hz to 70 Hz.

Signal formation. Transmission of different information is poor when it uses only continuous sine signal. Simple example: when frequency change step is 10 Hz and range of

frequency is 20-250 Hz, it is possible to transform only 24 different frequencies. It means that it is possible to transmit only 24 different colors.

Variations of information transmission increase when it is combined sine signal with its repeat length and sine periods number. This combination enables wide range of information variation in transmitting graphical information into sensing perception.

Sine signal graphics with different period and duration is presented below. Sine signal variations of frequency are showed in Figs. 3-4. Variation of period is provided in Figs. 5-6.

Duration 250 ms, 5 period

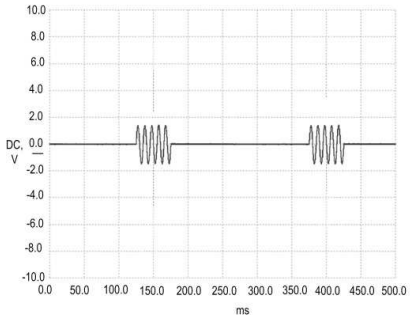


Fig. 3. F = 100 Hz

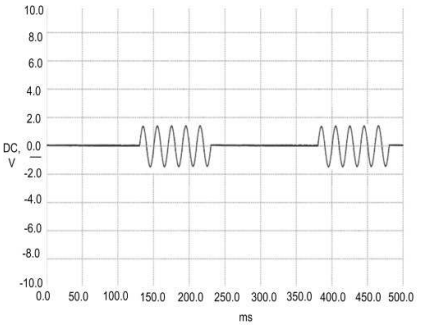


Fig. 4. F = 50 Hz

Duration 500 ms, signal frequency 100 Hz

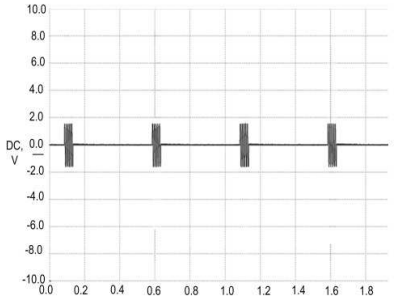


Fig. 5. N = 5

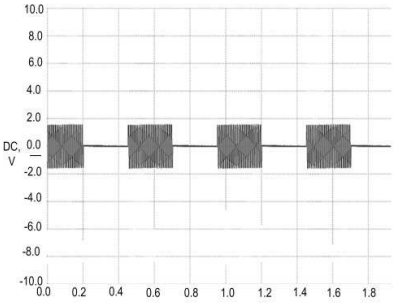


Fig. 6. N = 25

Attraction force. In this study we investigated electromagnet attraction force. Testing system consist of moving table with stepper motor, electromagnet model, metal plate –bracket with proximity sensor, oscilloscope, computer, signal generator and a supply. Scheme of the testing system is illustrated in Fig. 7.

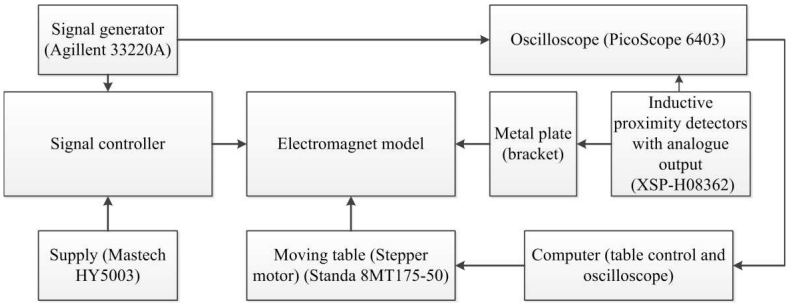


Fig. 7. Scheme of the experimental setup for testing the attraction force

The experimental setup allows us to establish how the attraction force depends on frequency. Electromagnet coil is supplied with current, which is chopped by signal from signal generator through the controller. This chopping is sensed like a vibration and a person is able to perceive it as information. Diagram in Fig. 8 shows that non-chopped supply current gives strong attraction force and human finger should use more power to move the slipper. When this current is chopped, the attraction force decreases.

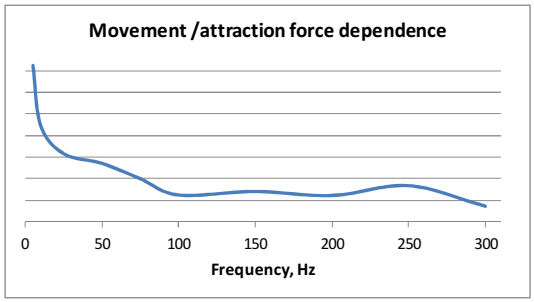


Fig. 8. Attraction force dependence on frequency

Human finger response. After analysis of attraction force human finger sensation test was performed. This test was performed by using accelerometer, which is mounted on slipper identically like a finger. Below an investigation scheme and oscilloscope diagrams are shown.

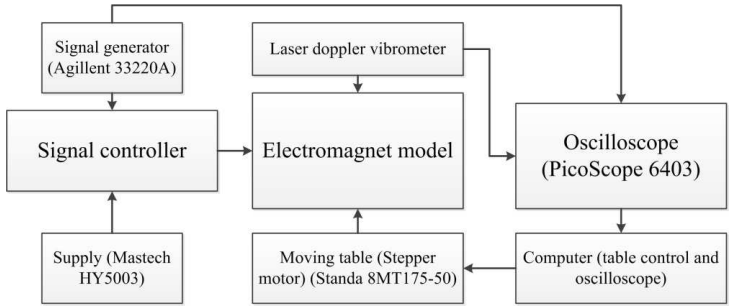
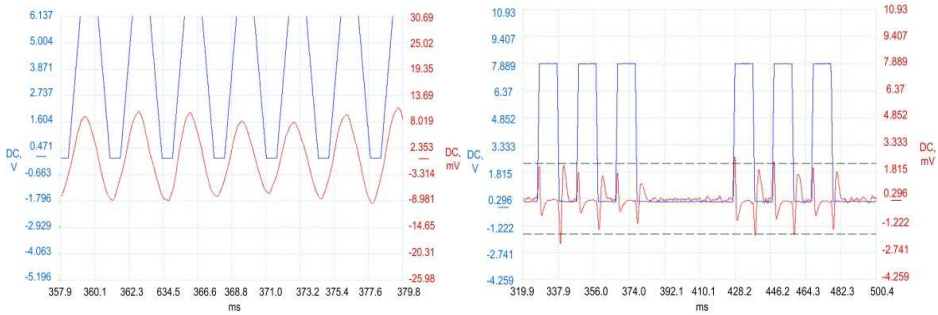


Fig. 9. Scheme of experimental study by using electromagnetic contact element (slipper)

Fig. 10 shows typical experimental results. There was alternating frequency and form (continual or burst) of control signal.



a) b)

Fig. 10. (a) Frequency – 300 Hz (top graph), finger response – bottom graph. (b) Frequency – 50 Hz (top graph); burst – 3 period; finger response – bottom graph; T = 0,1 s

Conclusion

After preliminary research of signal variation the following observations may by made: 5 Hz signal is discernible, but the perception is poor, 10 Hz signal is discerned better but the optimal frequency range is between 15-20 Hz and 150-200 Hz. Maximal discernible frequency is 300 Hz, however it is difficult to percept.

It is necessary to combine variations of sine signal, period and cycle count in order to have a wide range of information transmission. The range depends on how many of the periods, cycle count and frequency are used. Range is directly proportional to combined variation.

Attraction force dependency on frequency is evident from the measurements. Experimental study indicates that the frequency higher than 100 Hz does not have large influence on force reduction.

Human finger response test confirm the assumption that different chopping of control signal could lead to different perception of vibrations.

All these research take a lot of information about possibilities to use electromagnet for information transmission through sensual. This technology could be used in devices or systems designed for blind or vision impaired people.

Acknowledgments

This work has been supported by Research Council of Lithuania. Project No. MIP-042/2011.

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