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Identification model of analog proximity sensor for a robot

Hoai Nguyen

Department of Mechanical Engineering, University of Technology and Education, The University of Danang, Da Nang city,Viet Nam

Abstract: In recent years, it should be noted that proximity sensors have been increasingly popular with its application for a robot. Despite its importance to control and operation of robots, it is now very versalite for identification of mobile devices. In this paper, testing model to determine dynamic performance of analog sensor is presented. By hand-made detecting system is built successfully, the number of magnetic metals and non-magnetic metals are tested. Experimental outcomes prove that with the same sensing distance (8mm), the shape of output signal on ferrous and non-ferrous are distinct. This is an integral element for approaching road of mobile robot with different obstacles.

Keywords: Identification model, Inductive proximity sensor, Static performance, Dynamic performance, Robot

I. INTRODUCTION

1. Analog proximity sensor

The number of proximity sensors use non-contact method to test the distance, and their advantage conclude a resistance to fouling and abrasion, water tightness,reasonable mechanical system maintenance price [1] and a long service life [2].Comparing with various capacitive proximity sensors, inductive proximity sensors (IPSs) have better sensitivity with a target of alloy steels. This is the key element for application on mobile robot.

There are a range of applications of IPSs at every aspect of life, such as industry areas, aviations and aerospace fields [3]. In addition, an IPS with a longer range when compared to its diameter is used for medicine. This sensor is intended to navigate doctors, while performing surgery to remove metal shrapnel from victims of bomb blasts, gun fire, land mines etc. Presently doctors depend upon imaging systems to locate shrapnel in the victim’s body before surgery [4]. Effectiveness of surgery and recovery solely depends on the doctors’ skill to trace the shrapnel. In some cases the shrapnel may be visible in the pictures, but it cannot save lives during surgery.

A high-frequency magnetic field is produced by coil L in the oscillation circuit. When a target approaches the magnetic field, an eddy current flows in the target due to electromagnetic induction [5]. As the targetsaccost the sensor, the induction current flow rises, which causes the load on the oscillation circuit to increase. Then, oscillation attenuates or stops. The sensor measures this change in the oscillation status with the amplitude detecting circuit, and outputs a detection signal. Operation principle of IPSs is shown in Fig.1

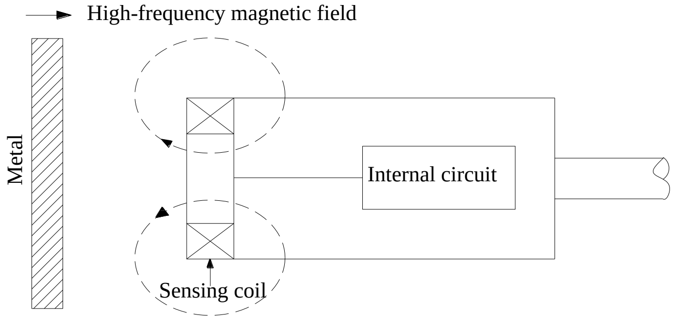


Fig.1. Operation principle of IPS

2. Theorical basic of IPSs with ferrous metal and non-ferrous metal

When it comes to selecting the correct IPS to use in your metal application, there is a major factor to consider. The composition of the metal being used in the process can greatly affect the functionality of the proximity sensor. On a basic level, all metals can fit into one of two categories, magnetic (ferrous) or nonmagnetic (nonferrous) [6].

Magnetic metals are pretty straightforward when it comes to selecting a sensor, as any IPS will detect this type of metal. However, nonmagnetic metals can get a little more difficult, as you would need to take into account the decreased sensing range found with these targets. The factor by which the sensing range is reduced, based on the target material, is called the reduction factor [7].

TABLE I. Reduction factor of a range of metals [7]

Material	**Reduction factor (mm)**
Steel	1
Aluminium foils	1
Stainless steel 303	0.85
Stainless steel 303	0.75
Aluminium	0.4
Brass	0.4
Copper	0.3

The table shows the typical values for the reduction factor of common materials. The smaller the reduction factor, the smaller the sensing range for that specific material. So when using a standard IPS with a nonmagnetic metal, sensing range will be decreased.

These sensors have no reduction in sensing distance when detecting nonferrous metal targets. Standard inductive proximity switches can be subject to a sensing range reduction of up to 70% when detecting materials with nonmagnetic properties [8]. The reduction factor sensors allow targets of various metals to be detected at the same range as any standard ferrous metal. Reduction factor 1 sensors will detect all types of metals with the provided sensing distance listed in its specifications.

Along with the standard inductive proximity sensors and reduction factor 1 sensors, there are also inductive sensors designed to detect only ferrous or only nonferrous targets. Sensors that detect only ferrous metals will completely ignore any nonmagnetic materials within the sensing range. Similarly, nonferrous only sensors will not detect any magnetic metals that are near the transducer face. This can be useful if you are sensing a ferrous metal that is embedded within a nonferrous metal or vice versa.

The nonferrous-metal type is included in the high-frequency oscillation type. The nonferrous-metal type incorporates an oscillation circuit in which energy loss caused by the induction current flowing in the target affects the change of the oscillation frequency. When a nonferrous-metal target such as aluminum or copper approaches the sensor, the oscillation frequency increases. On the other hand, when a ferrous-metal target such as iron approaches the sensor, the oscillation frequency decreases. When the oscillation frequency becomes higher than the reference frequency, the sensor outputs a detection signal.

The distance at which the oscillator will stall can be predetermined. When this condition occurs the trigger circuit changes the state of the output circuit. Changing state of IPSs is shown in Fig.2.

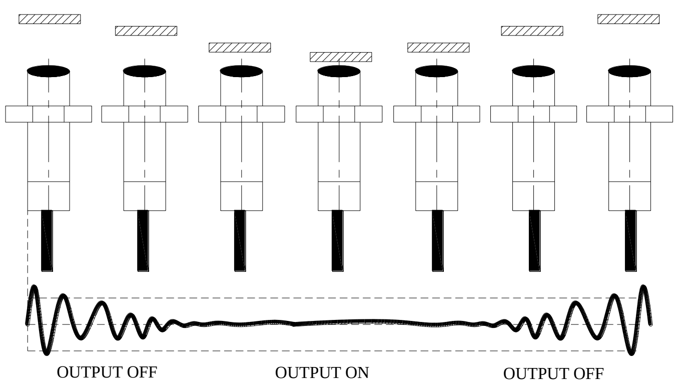


Fig.2. Changing state of IPS

II. STATIC PERFORMANCE OF ANALOG SENSOR

In this case, the metallic object is a metal tape. The inductance is the phenomenon where a fluctuating current, which by definition has a magnetic component, induces an electromotive force in the metal tape [9]. It is operating principle is based on a coil and oscillator. And an electromagnetic field is created in the close surroundings of the sensing surface. The presence of a metal tape in the operating area causes a dampening of the oscillation amplitude. These days, robot control control depend on identifying characteristic of various sensors. Therefore, to measure the static performance of an inductive proximity sensor is the key technology to improve the performance of a mobile robot. The first step of the static performance measurement is the determination of the sensing distance (h) and object thickness (d). The sensing object thickness by this research is the thickness (d) of the metal tape as shown in Figure 3.

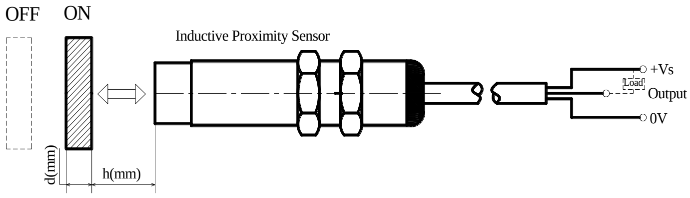
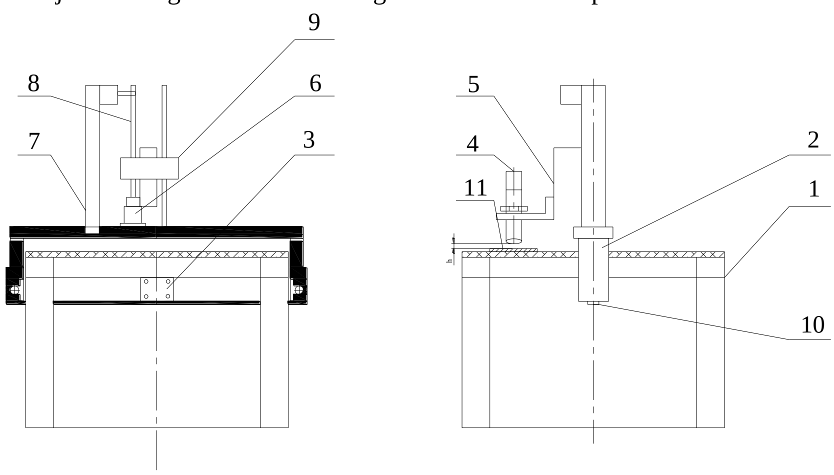


Fig.3. Typical inductive proximity sensor configuration [10]

III. TESTING SET-UP OF MEASUREMENT SYSTEM

Testing set-up of a measurement system is shownin Figure 4. A number of testing instruments are navigated on flat table (1), to determine sensing distance between of proximity sensor (4) and metal tapes (11). Step motor (6) is fixed on the racks (3), which attaches analog sensor to translational motion. During the movement of the sensor, in order to receive the output signal less noise, sensor must be held by holder (5). Feed screw (8) is used to adjust sensing distance according to various metal tapes.



1- Flat table
2- Sliding soles
3- Step motor mount
4- Proximity sensor
5- Sensor holder
6- Step motor
7- Feed screw holder
8- Feed screw
9- Pull rod
10- Scroll bar
11- Metal

Fig.4. Testing set-up of a measurement system

With this experiment, the stepper motor is adjusted at constant speed. Therefore, the movement speed of the sensor at different time intervals is also set at the same value. In turn, place different metal tapes on the testing table, corresponding to the sensing distance received in (9), the output signal will be displayed clearly on the screen. Observation of the results received, discussion and some conclusions will be synthesized.

IV. RESULT AND DISCUSSION

In this experiment, set the materials to 5 × 2 × 1 (length × width × thickness): Aluminum, steel, bronze on the test bench. The sensor's initial distance is 8mm, and the speed of the sensor does not change when passing through the material. The testing results is shown in Fig.5-7

1. Steel

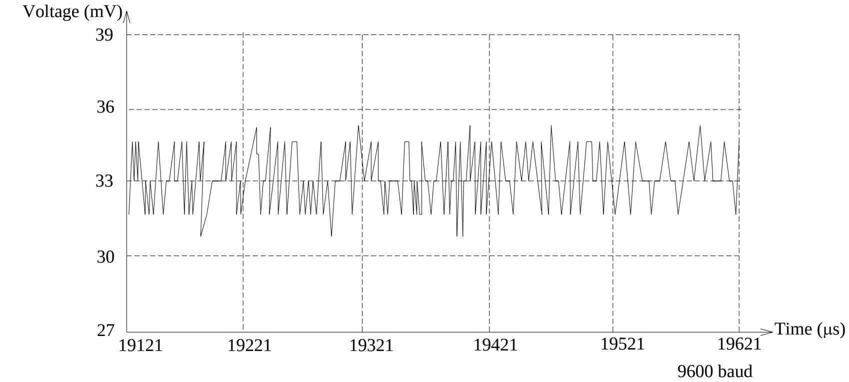


Fig.5. Relationship between output signal and time (Steel)

2. Aluminium

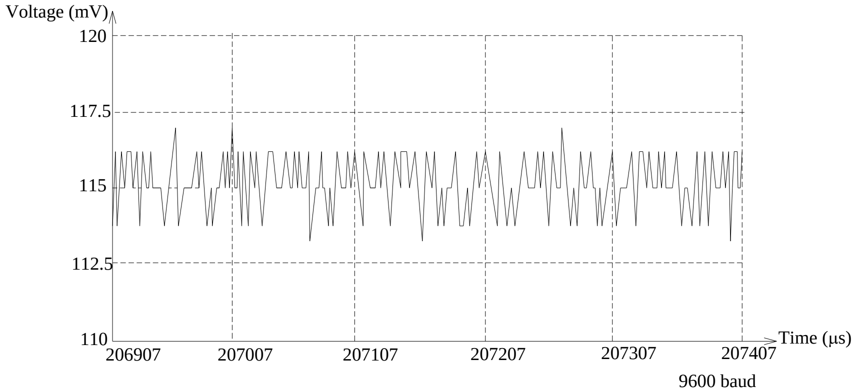


Fig.6. Relationship between output signal and time (Al)

3. Copper

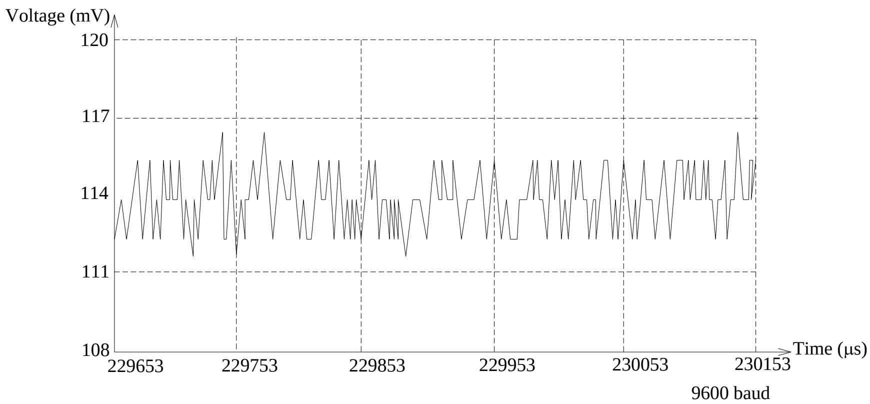


Fig.7. Relationship between output signal and time (Cu)

During the experiment, the received signal appeared very disturbed due to the vibration of the test table. With the same signal response time, the output voltage of aluminum and copper is approximately equal (115mV and 114mV). These results are perfectly consistent with the static performance of the sensor measured in [9].

Meanwhile, since stainless steel is non-magnetic metal, the shape of the output signal will be different from copper and aluminum.

With sensing distance is 8mm, most of the output signals are disturbed. This phenomenon can be controlled by anti-vibration for the model.

In addition, the output signal when measured on copper is less interfering than aluminum and steel. Differences in physical properties may cause this result.

V. CONCLUSION

In summary, for the dynamic performance of proximity sensor, the signals of metal tape that is made from ferrous and non-ferrous in materials are enormous differences, as indicated from the experimental results. During the measurement, the output voltage of aluminum and copper is approximately merit, which is four times the output voltage value of the steel when measuring the same condition.

In addition, the voltage change over time of aluminum is obvious, so this material is frequently used in the manufacture and operation of mobile robots.

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