Prototype Modeling of Security System with Metal Detector

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***Abstract*-The security system provides the ease to people in order to manage their mall easier and this system is concern on the security of each item. This system will provide not only the items identification but also the anti-theft security. Nowadays, each items produced have a barcode that is printed on its surface as product code. The old system seems not to fully utilize the barcode on each item. This system combines the barcode with electromagnetic security strips in order to reduce the security cost. The barcode strip will be developed in two layers, the barcode and the magnetic strip. The system is working such as the customers self service in the library. The items need to be check at the counter before it been taking out from the store. If the item is not registered then, the alarm will give a warning when it passes through the electromagnetic gate. The LabVIEW program developed by National Instrument is found out to be the best selection as the wave recognition to this system. Identification of patrons and materials by barcode is a reliable technique and gave great service when combined with electro-magnetic security device.**

I. INTRODUCTION

Building security system especially in hypermarkets has alarmingly embarked an enormous research where engineering take place. There are few literatures have been put on whereby in recent years, visual surveillance systems have been increasingly used [1], [2]. A surveillance system is a closed-circuit television system used to maintain close observation of intruders or shoplifters. It is widely used nowadays to help a guard with consecutive sensing information. However, the concurrent observation of several monitors and the long-term exhausting visualization cause the problem of decaying attention. Furthermore, three major issues in the traditional surveillance systems affect their performance. Firstly, the object resolutions are changed due to the varying distances between the object and the camera. Therefore, it will cause the problem in object recognition since different sizes of the mask must be adopted to properly extract object features [3]. Secondly, the detection of the moving object becomes difficult when the camera is not fixed. The other issue is where operators rapidly become bored and lose concentration. It is therefore essential to devise and develop an efficient, automated surveillance system to overcome the problem for ensuring robust-security, where it can alert the operator when unregistered items appear in this surveillance area.

The project is developed to increase the security of the items or belongings. This system solves the problem of item taken out without permission in order to replace human reluctant and awareness. The system consists of metal strip and electromagnetic gate placed at the entrance of the building. The electromagnetic gate is made of a coil. The system will operate whenever the unregistered item passes through the gate. The metal strip will cause a small electric current induced in the metal. All metal detectors work according to the same basic principle. The entrance gate of the system, containing coils, emits an electromagnetic field which penetrates the ground. The detector senses any disturbance of this field by the presence of metal, and does so in three main ways which are eddy current, asymmetrical field strength and loss field strength.

II. PROPOSED DESIGN

Metal detectors are extensively used to find undesirable metal objects in many fields. In such a typical metal detector, the coils are coaxially arranged with the transmitting coil in the center and two receiving coils on the sides [4], [5]. The receiving coils are connected to a differential amplifier. When the magnetic field generated in the transmitting coil is disturbed by metal objects, the amplitude and phase of the output voltage of the differential amplifier change, and, thus, the existence of foreign metal pieces is detected. It is also capable to sense metallic items through dirt, rock, water, wood, concrete, and almost any nonmetallic barrier [6], [7]. However, if the area being searched contains high levels of minerals, like salt or iron, the minerals can shield metallic objects from some detectors.

There are three types of metal detectors in current use: induction-balance detectors, pulse induction detectors, and magnetometers. In this experiment, the *pulse induction* detector approach is used. Fig. 1 below shows flowchart of the overall process of the system.

In this investigation, randomize of the experiment that to be carried out and analysis were done according to the step discussed below.

1. To design the electromagnetic gate that will detect the presence of metal strip.
2. To implement the system using LabVIEW as the wave analyzer.

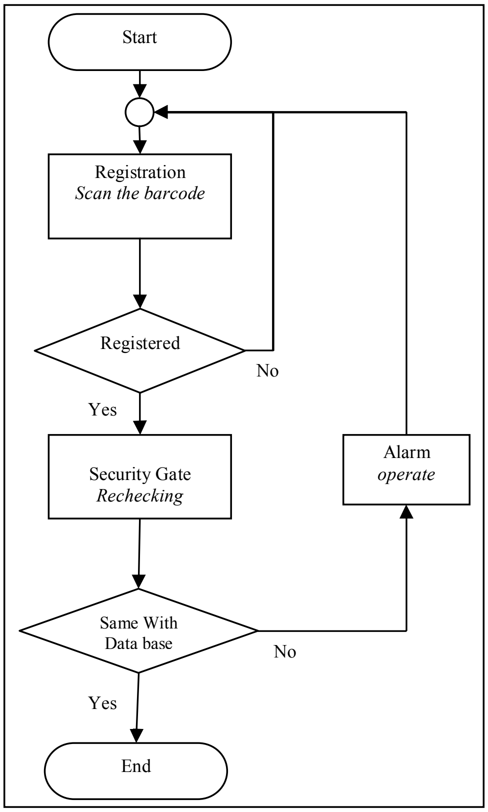

Fig. 1 Flow Chart of the Metal Detection Operation

A. The System and Developed Program

The purpose of the prototype system is to have an intelligent system that could monitor and secure the industry. In this system, the alarm will be activated automatically thus the user only set up the system and leaves it. This system will recognize the input signal of the system. The security system will check the registration number for every item. The system will operate it and give the signal only when the system operation detects the error.

Programming commands are related to feedback control in an automated system in that the program establishes the sequence of values for the inputs (set points) of the various feedback control loops that make up the automated system. A given programming command may specify the set point for the feedback loop, which in turn controls some action that the system is to accomplish. In effect, the purpose of the feedback loop is to verify that the programmed step has been carried out. The relationship of program control and feedback control in an automated system is illustrated in Fig. 2 below:

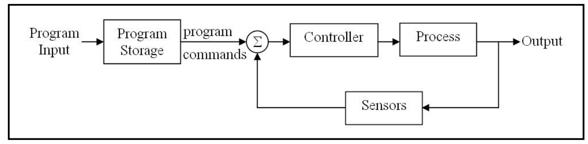

Fig. 2 Control System with Feedback

B. Coil Design and Calculation

An inductive sensor will tune in to inductive value ranging from 20 to 1000 microhenries. It is preferable that the combination of the loop and the lead-in inductance value has minimum of approximately 50 microhenries for stability [8], [9]. As a general rule, the loop inductance should be equal to or greater the lead-in inductance where this paper will comprehend the concepts of induction-balance detector in developing the electromagnetic gate.

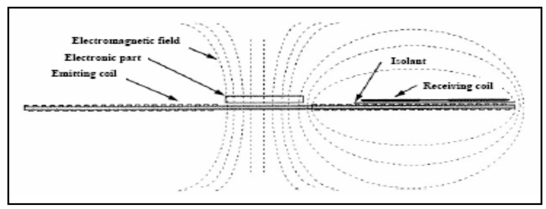

Fig. 3 Coil Position

On the induction coil the number of turn required in the loop is dependent on the loop size. The loop inductance can be calculated as follows:

$$L = P\frac{\left(t^2 + t\right)}{4} \qquad (1)$$

Where:

L = Inductance (Microhenries)
P = Perimeter (feet)
t = Number of turn

The model developed perimeter is P = 1 feet and number of turn is t = 4 and from the formula above 5 Microhenries.

$$Emf = -L\frac{\Delta I}{\Delta t}$$
$$Unit: \frac{volt\sec ond}{ampere} = henry \qquad (2)$$

From the above equation it shows that the voltage induces is actually electromotive force or EMF. Therefore the difference in the voltage is used to determine the current flow. However, the calculation is not done since the important part is the change in the voltage.

The current value is determined by using a current probe. The Tektronix TCP202, DC Current Probe, enables users to make direct readout AC current measurements, resulting in accurately displayed and recorded measurements. From the reading, the current value given is 0.365 mA. Therefore the resistor value can be determined since the current value is known. Fig. 4 shows the proposed design of the anti-theft security gate to be placed at the entrance of the building.

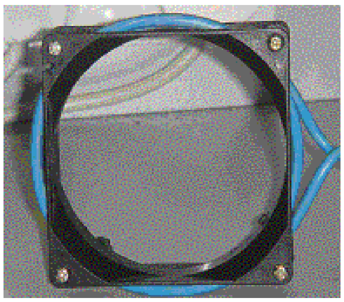

Fig. 4 Prototype of Security Detection Gate

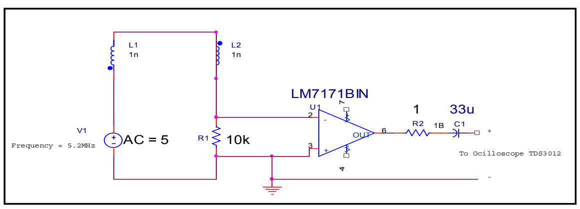

Fig. 5 Input Circuit Connection to LabVIEW

Fig. 5 above is the induction coil which operates as a sensor in the system. The input circuit connection is used as the measurement of the voltage drop. The data is send to the LabVIEW program for analysis. In this circuit, the ac voltage is used as the signal conditioning. The voltage supply to the inductor is 5 Volts, it depend on the op-amp used. The 1 ohm resistors are used as the second components for voltage drop across this circuit. The LabVIEW data acquisition is done by connecting the input wire to Oscilloscope channel across the resistors. The cable is connected to the input of the sensor.

III. Experimental Design And Discussion

There are three stages will take place in the development process where the first stage is to monitor the induce voltage in the circuit during a metal present and no metal present. The objective of the first procedure is to check the voltage drop across the sensors. Since the voltage fluctuating, the maximum value is changing. This is an important procedure in order to set the sensitivity of the system.

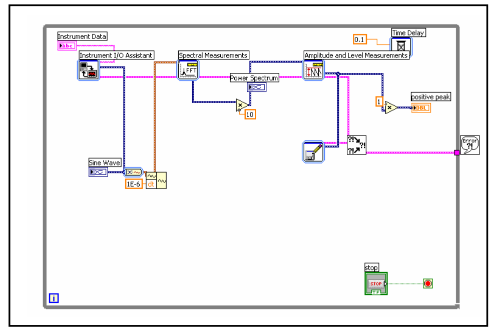

Fig. 6 waveform Analysis to measure Voltage Drop

Spectral Measurement function is used for second stage. It is used to change the input sinusoidal signal to FFT signal and make signal analysis to the input data. The result from this stage is in terms of magnitude and frequency. implements a Fourier transform at a discrete set of frequencies and from a time-domain waveform sampled at discrete times over a finite interval of time. Because of the finite interval, the FFT tends not to be very frequency-selective. The FFT behaves as though it was a bank of narrow-band filters followed by a bank of corresponding detectors that calculate the vector sum of all the signal components that each filter passes. In the case of the power spectrum, the result is scalar instead of vector data, and the detector just indicates the total energy passed by each filter. Again, because of the finite duration of the source data, the filters tend not to be especially selective. Windowing is a technique used to shape the time portion of measurement data, to minimize edge effects that result in spectral leakage in the FFT spectrum. By using Window Functions correctly, the spectral resolution of the frequency-domain result will increase.

The last procedure used is the Amplitude and Level Measurement where This function is performing voltage measurement for input signal. In this function, the input signal convert is to FFT form and the Amplitude and Measurement function is used to measure the amplitude of the FFT. The maximum peak in the amplitude measurement column is tick to have amplitude of the FFT.

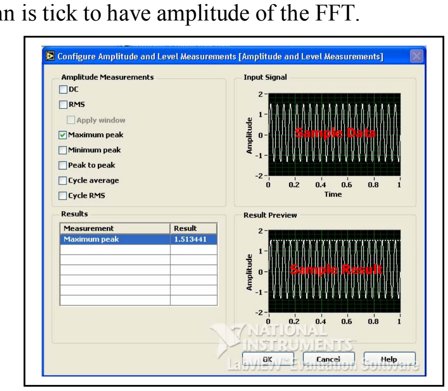

Fig. 7 Amplitude and Level Measurement configuration

After the experiment had been conducted, the data for the experiment is observed. The discussion from the graph produced can be divided into two parts. First part is the condition when no filter applied and the second part is when the highpass filter applied.

A. Without Filter Applied

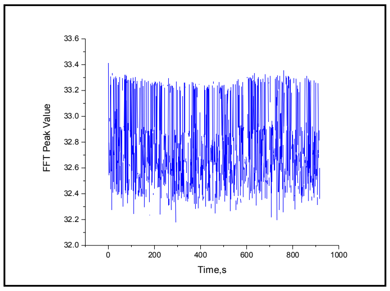

Fig. 8 FFT Fundamental peak value without filter

From the figure above, the FFT amplitude value is fluctuating in a vast way. The FFT amplitude value is taken in 5 minutes. From the graph, the maximum value is 33.41208 and the minimum value is 32.17566. The difference between the maximum and the minimum value is 1.23642 . The large difference will make the detection very difficult since the voltage induce when a metal passes the sensor will vary very much. This will create difficulty determine the limit value. In this model the limit value is named as lower bound and upper bound.

B. With Highpass Filter

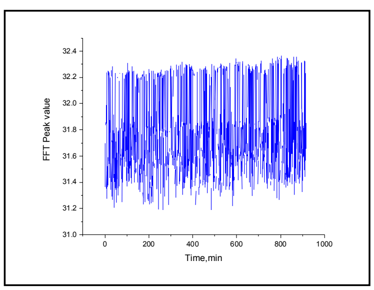

Fig. 9 FFT fundamental peak value with filter

The chart above is taken when a highpass filter connect at the output of the voltage follower in the circuit. The maximum value is 32.24235 and the minimum value is 31.18898. The FFT amplitude values reduce significantly and the difference is 1.05337. This will make the detection method easier since the value not varying too much. Therefore, the upper bound and lower bound limit can easily determine

C. During Stable State – Without Metal Across

The first analysis is done without metal present. This is as a limiter to see the performance of the inductance sensor. The performance is measure from the FFT amplitude value in a certain time limit. Below is a figure of the FFT amplitude value into a certain time limit. From the Fig. 10, the maximum value is at 32.42239 and the minimum value is 31.11574. The difference will be the threshold for the lower and upper limit boundary.

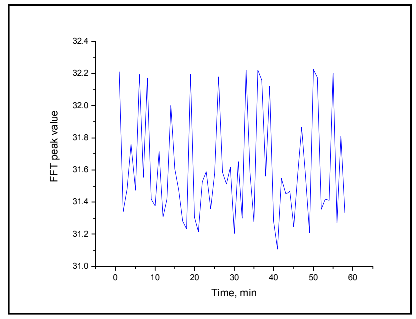

Fig. 10 FFT peak value without metal

D. During Unstable State – With Metal in the Induction Coil

The analyses are done with four size of steel. The steel used is round in shape. The diameter of the steel is 30 mm. The difference in size and thickness will bring out the identity of steel. This result will be used as the reference in determined steel as the security property.

i. Thin metal

The first steel size used is the steel with thin thickness. The thickness is 1 mm.

The minimum value is 31.2303 and the maximum value is 32.42443. In the metal present, the increment of the FFT value is too small. The difference between the maximum peak and minimum peak is 1.19413. This value will be used to determine the upper limit and lower limit in the database.

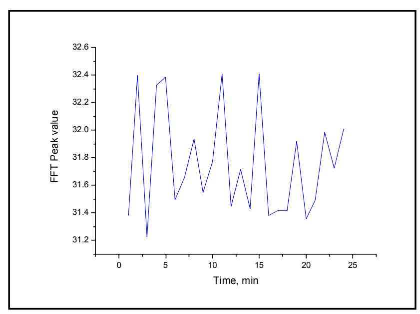

Fig. 11 FFT peak value with thin metal

ii. Thick metal

The second steel size used is the steel with thin thickness. The thickness is 2.1 mm. The minimum value is 31.23381 and the maximum value is 32.4432. In the metal present, the increment of he FFT value is greater than the thin metal. The difference between the maximum peak and minimum peak is 1.20939. This value will be used to determine the upper limit and lower limit in the database.

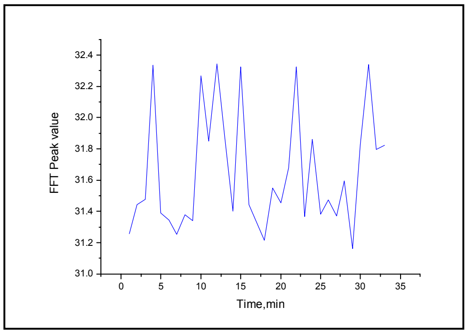

Fig. 12 FFT peak value with thick metal

iii. Short bar

The third steel size used is the steel with thin thickness. The thickness is 18 mm. The minimum value is 31.62259 and the maximum value is 32.66075. In the metal present, the increment of he FFT value is greater than the thick metal. The difference between the maximum peak and minimum peak is 1.03816 volts. This value will be used to determine the upper limit and lower limit in the database.

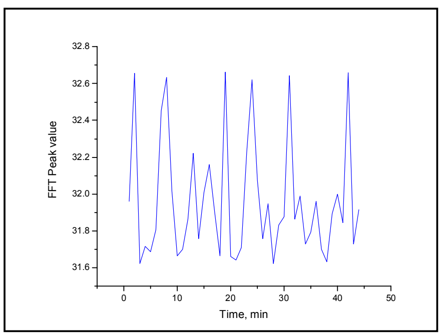

Fig. 13 FFT Peak Value with Short Metal Bar

iv. Long bar

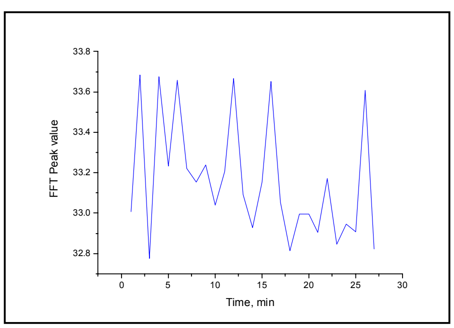

Fig. 14 FFT peak value with long metal bar

The third steel size used is the steel with thin thickness. The thickness is 117 mm. The minimum value is 32.72599 and the maximum value is 33.68568. In the metal present, the increment of he FFT value is greater than the thick metal. The difference between the maximum peak and minimum peak is 0.96009. This value will be used to determine the upper limit and lower limit in the database.

From the analysis above, the length of the metal can be used as a special property in each metal. Therefore, length properties can be used as special identity of the metal. In the preceding experiment the thin metal with thickness of 1 mm can be used as a security property in the items. However the metal needs to be differentiating by variation of the shape. The differentiating can be implemented by making holes to the surface of the metal plate. The hole can be either end hole or a punch.

The increase in the size also will decrease the different between the maximum and minimum FFT peak. This property can be used if the high level security is implemented. Therefore, the level of security can be determined with the size of the metal. The bigger the size, the secure it is.

IV. Conclusion

This project has introduced the development of the induction sensor by applying the voltage drop across the coil. The sensor is build with winding the coil around the plastic gate in order to reduce the cost without reducing the performance of the system. By applying several development steps, the suitable voltage limit had been identified. The AC voltage input to the oscilloscope as the intermediate to the personal computer is a simplified method for the successive of the model. The LabVIEW implementation as the controller and the detector is proving the implementation of expert system in process control of the induction sensor. The system basically gets the value from the inductance sensor. The value is analyzed and the decision making process is implemented. This output is use as the condition for the detecting the metal present. The aim to develop the security barcode system using inductance sensor and LabVIEW program is achieved.

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