Design a Metal Detector by Using Beat Frequency Technique

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***Abstract* – Nowadays, many different types of metal detector are available ready built, some of which provide advanced functions and are microprocessor controlled. The intention is not to emulate the performance and features of this unit as top of the range detector often complex and costly. Several methods can be used in order to detect metal. This project is to conducting a metal detector which the metal detector can detect any metal by using the concept of beat frequency oscillator (BFO). This prototype consists of an oscillator producing an alternating current that passes through a coil producing an alternating magnetic field. The purpose to do this prototype is to make an easier to human for example to helps soldiers to find bombs or landmines that had been buried in the soil.**

I. INTRODUCTION

A metal detector is one of the sensor to detect the beneath soil which is the metal that hidden from human view. The metal detector works in the same sort of ways as geophysics, but instead of using the Earth's own electrical and magnetic fields. Nowadays, the development in technology created are many possible ways of detect metal, such as visual sighting, thermal image camera monitoring, radar detecting and beat frequency oscillator. This metal detector was developed based on Beat Frequency Oscillator (BFO) principle whereby a metal object in a close proximity to a search coil modifies the frequency of an oscillator.

BFO (beat frequency oscillator) metal detector use two oscillator, each of which produces a radio frequency. One of these oscillators uses a coil of wire winding that it is called as the search loop. The second oscillator is called reference coil oscillator. By adjusting the oscillator so their frequencies are very nearly the same, the different between them is made up audible as a beat note. This beat note changes slightly when the search loop is moved over or near to metal. The metal detector consists five parts of circuit; which is two Oscillators, Mixer, RC Low Pass Filter and audio amplifier circuit.

II. METAL DETECTOR

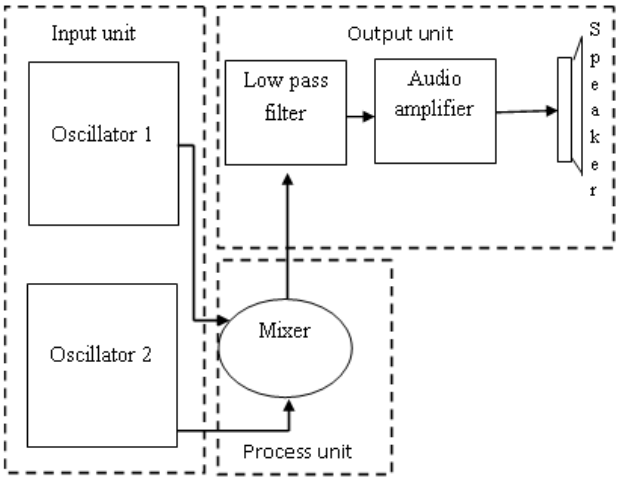

Fig.1: Block diagram of the metal detector system.

By referring the figure above, the metal detector system consist of three parts unit system as known as input unit, process unit and output unit.

A. Input unit

In the input signal have two circuits of oscillator and have two coils. The two oscillator circuits are same but have a different value of inductance. The oscillator circuit was combined together where the input of oscillator come out from the coil in form of frequency generated by approaching any metal at the coil.

1. Search Coil / reference coil

The input units have two coils where they are known as search coil and reference coil. For this part the design of the search coil is very important to get best relation to sensitivity of the detector. Before design the search coil

and reference coil, some parameter must be taken as important such as the size, shape, diameter of coil and the thickness of the wire [2]. One of achievement of this metal detector is to reach longer detecting distance. For this project the coil can detect any metal in 2cm only. Based on the theory, the size of the area and a distance of approximately covered by the magnetic field are directly proportional to detecting distance. For the metal detector project the circular shape was recommended.

2. Oscillator circuit

There are many types of oscillators all of them operate based on similar basic principle. Fig. 2 shows an oscillator circuit known as colpitts oscillator. The colpitts oscillator is very similar to the Hartley oscillator, except is its split capacitance instead of a split inductive device [1]. The function of the oscillator in this metal detector is to oscillate the signal from the search coil and reference coil that produced the beat frequency. The beat oscillations technique involves two differences of frequency. An alternating current flowing through the search coil creates a magnetic field around it. If the electromagnet is operated with direct current, the polarity of its magnetic poles remains fixed [2]. When the coil is placed near any metal sample, the eddy currents in the sample affect the magnetic field and thus the inductance of the coil and the frequency of the oscillator [3].

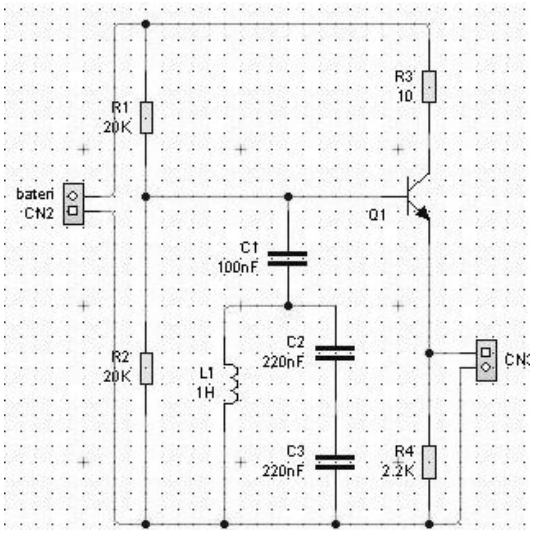

Fig. 2: Oscillator Circuit

B. Process unit

1. Mixer

Fig. 3 has shown the circuit of mixer. The purpose of the mixer in the metal detector is two mix two input signal to give the output sum and difference frequencies. The signal was come out from oscillator circuit where the pin 1 is come from search coil and pin 10 is come from reference coil. In the Beat Frequency Oscillator (BFO), two frequencies from circuit oscillator one and circuit oscillator two are fed into the mixer then the signal will pass to the low pass filter circuit.

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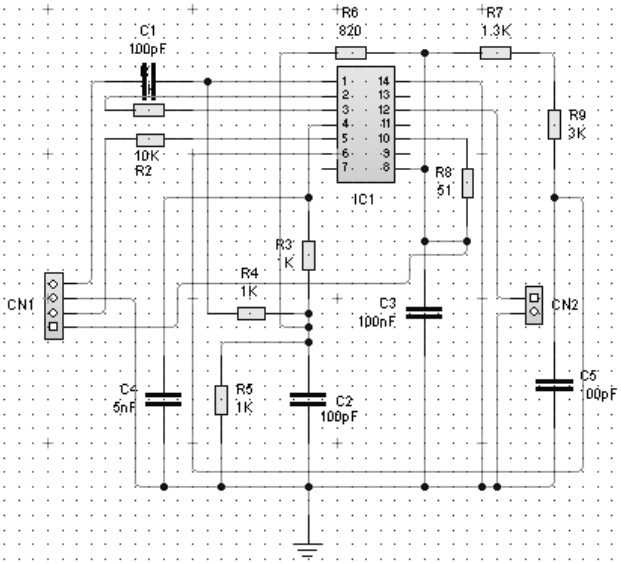

Fig. 3: Mixer Circuit

C. Output unit

1. Low pass filter

Normally the audible frequency range of human is between 20 Hz to 20 KHz. The output come from mixer is a combination of both difference and sum of the two oscillators. Based on the theory that have been learn about low pass filter, a low pass filter is required to filter out the high frequency that come out from mixer [4], which is the sum of the two inputs. The difference of two oscillators' operating frequencies should be small and within the audible range of human hearing. The RC filter was design where the resistance parallel to the capacitor [5].

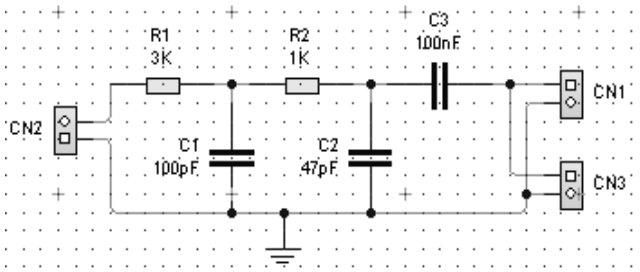

Fig. 4: RC Low Pass Filter Circuit

2. Audio Amplifier

An audio amplifier shown in Fig. 4 is required to amplify the difference of two oscillator frequencies to be audible. A low voltage audio power amplifier, LM386 is chosen to provide a gain of fifty with a variable resistor of 25KΩ for volume control.

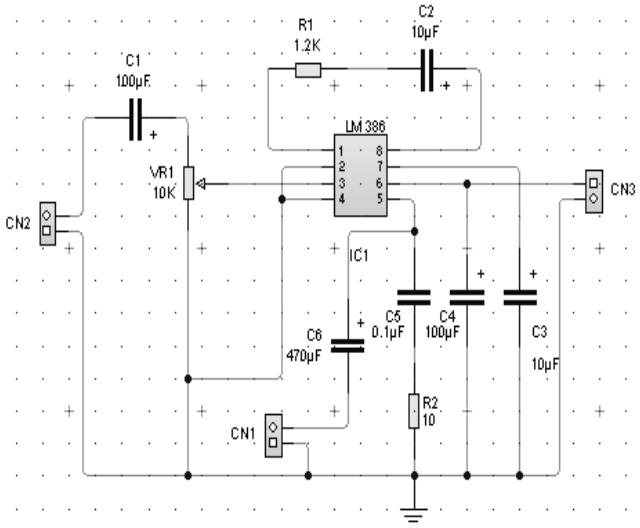

Fig. 5: Audio amplifier circuit

III. DISCUSSION AND RESULT

A few experiments had been done to ensure that the system is able to detect the metal. The system is tested by varying the distance and the value of the inductance search coil and monitored the changed of frequencies. Figure 6, 7 and 8 presents a graph of the performance of the metal detector with frequency respect to the distance with difference value of inductance at the search coil.

Table 1 shows the frequency at the various distances with the value of inductance for search coil L = 30.04µH. Fig. 6 shows the graph that frequency is directly proportional to distance between search coil and metal. The frequency increase slightly when the distance is increase.

TABLE 1
THE FREQUENCY AT THE VARIOUS DISTANCES WITH THE VALUE OF INDUCTANCE FOR SEARCH COIL L = 30.04µH.

Distance (cm)	Frequency (kHz)
0.0	185.430
0.2	185.536
0.4	185.536
0.6	185.708
0.8	185.834
1.0	185.994
1.2	186.080
1.4	186.152
1.6	186.194
1.8	186.272
2.0	186.300

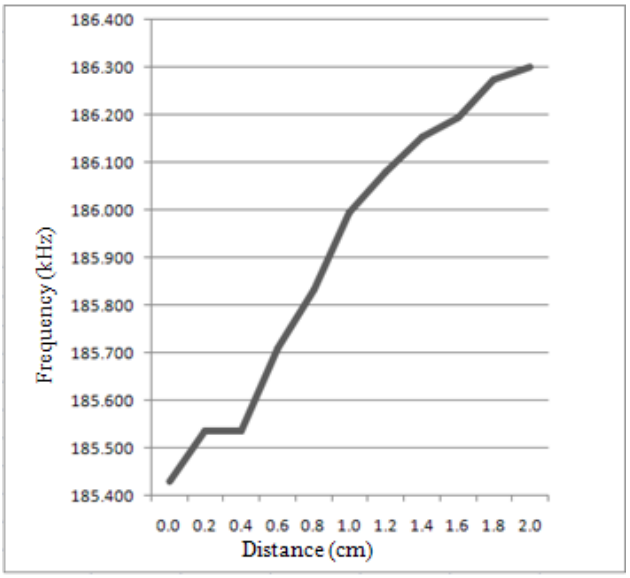

Fig. 6: Frequency versus distance for search coil of L = 30.04µH

Table 2 shows the changes of frequency when the inductance of search coil L = 30.04µH. According to the Fig. 7 presents the changes of frequency various to distance. At the 0 to 1.2 cm the frequencies remains constant but it still has a small changes of frequencies and at the 1.2 to 2.0 cm the frequency slightly increased when the distance is far from the search coil.

TABLE 2
THE FREQUENCY AT THE VARIOUS DISTANCES WITH THE VALUE OF INDUCTANCE FOR SEARCH COIL L = 11.349µH.

Distance (cm)	Frequency (kHz)
0.0	144.388
0.2	144.388
0.4	144.388
0.6	144.390
0.8	144.390
1.0	144.418
1.2	144.424
1.4	145.050
1.6	145.166
1.8	146.346
2.0	146.346

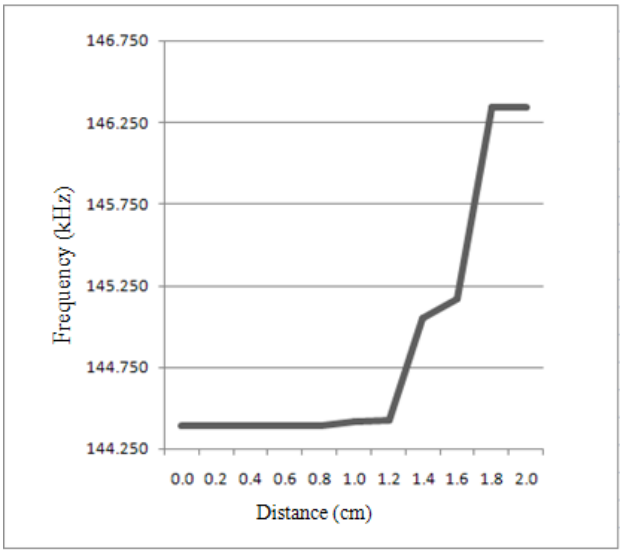

Fig. 7: Frequency versus distance for search coil of L = 11.349µH

Table 3 shows the changes of frequency when the inductance of search coil L = 2.06µH. For the Fig. 8 present the frequency increases rapidly when distance of metal is far from search coil with the value of inductance. It is increase rapidly at the distance 0 to 0.8 cm and remains constant from 0.8 to 2.0 cm.

TABLE 3
THE FREQUENCY AT THE VARIOUS DISTANCES WITH THE VALUE OF INDUCTANCE FOR SEARCH COIL L = 2.06µH.

Distance (cm)	Frequency (kHz)
0.0	188.512
0.2	307.586
0.4	343.118
0.6	343.946
0.8	343.608
1.0	344.440
1.2	343.252
1.4	343.162
1.6	343.008
1.8	343.008
2.0	342.688

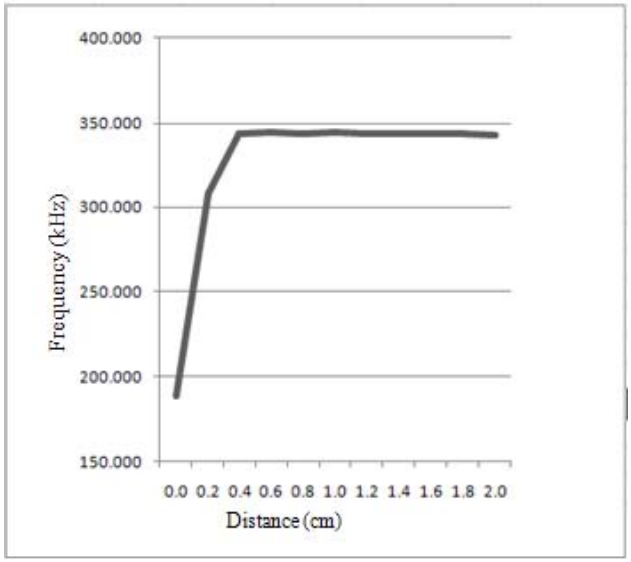

Fig. 8: Frequency versus distance for search coil of L = 2.06µH.

From the Fig. 6, 7 and 8 showed the differences of the graphs. The differences of graphs are because of the differences value an inductance. When the value of the inductance becomes smaller the sensitivity of the metal detector becomes more sensitive. It is proven by see the Fig. 8.

This inductance is one of important things where it can influence the sensitivity of the metal detector. Besides that, the diameter and number turn of a search coil has the

greatest impact on the detection range in comparison with shapes and thickness of coils. This is because the higher amount of magnetic field lines cut across the search coil. The other effect that can see is when any metal with high density approached the search coil the metal detector becomes more sensitive.

IV. CONCLUSION

As the conclusion, this project is to develop a device that can be detecting any metal by using beat frequency oscillator technique. This project is successfully done detect the metal in range 0 to 2 cm only. In order to make the metal detector becomes more sensitive and can detect in reach longer detecting distance, it should be use the lower value of inductance by consider the number turn, thickness and shape of search coil.

V. REFERENCES.

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