Detection Techniques for Electrical Wires Hidden Inside Non-Conductive Materials

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Abstract: Safety is a matter should be given priority in any circumstances whatsoever. A danger or disaster could have happened at home or place of work or anywhere else. Hazards resulting from electric shocks common in Malaysian society due to lack of knowledge about security measures and the lack of tools which can prevent the occurrence of the accident. Among the most common accident is when to nail or drill in the wall or floor. Risk of electric shock is high and it can cause injury to the public people and loss. To improve safety in the home or at work, a detection system of electrical wires that are usually hidden in the wall or floor has been developed. Have now there a few tools that can be used to detect electrical wires hidden in the wall or floor. Some of the tools can pinpoint the exact location of the wire. However, the relatively high price of these devices for use by the public. This research paper analyzes a number of methods used to detect electrical wires hidden behind materials. This analysis involves the detection of electrical wire with different sizes inside nonconductive materials, the quality of detection and detection of hidden wires alternating current flowing in the wire. The hardware was designed and developed based on the effect of magnetic flux cancellation of inductance and charge cancellation effects of capacitance. Developed hardware detection is able to show different readings depending on the electrical wire with and different sizes. Reading alternating current detection during electrical current on the wire there is also developed. An evaluation was conducted on hardware that is designed to determine whether it is able to detect hidden electrical wires and detect the presence of an electric current. The data obtained through the assessment carried out shows that these tools are able to detect the presence of electric current and the location of the hidden electrical wires inside nonconductive materials.

Keywords: detection device, hidden electrical wires, non-conductive materials.

I. INTRODUCTION

Beginning a remodeling project or simply drilling into a wall to hang a picture can seem simple enough, but steps must be taken before hand to determine if electrical wires are present within nonconductive materials. With the increasing demand for safety at home and at the workplace we need a detection system that predict potential hazards exists specially this hidden live wire inside nonconductive materials when you debug home electrical wiring, a tool that determines the location of hidden wires behind nonconductive materials comes in hardly and manually. People can hurt trebly or find death during the process drilling or driving a nail at nonconductive materials without knowing the present of hidden live wire in it. The wire and the nonconductive materials can be damage during the drill or drive nail by people. The problem why its happen because people don't know where the wire flow inside of nonconductive materials when they handle house work such as drilling, nailing and etc. The objectives of this work are analyze the data used in the presence of electric currents and electrical wire with different sizes, design a proto-type device that can detect electrical wires that hide inside nonconductive materials and its alternative current flowing presences and evaluate whether the proto-type build can detect hidden electrical wires inside of nonconductive materials and its alternative current flowing presences on it. This hardware has three circuits which are metal detector circuit based on the effect of magnetic flux cancellation of inductance, electric current detector based on the charge cancellation effects of capacitance and main circuit which combine the metal detector circuit and electric current detector circuit together for electrical wire detection inside nonconductive materials. For create this hardware the software implementation such Proteus for circuit simulation, microC compiler for compile C program to hex file for microcontroller which used in the hardware, PICkit2 software to burn hex file of C program to microcontroller and eagle software to draw schematic circuit and change it to PCB layout been used and hardware implementation such proto-type board testing for test circuit working function been used.

II. THEORIES AND REVIEW

The theories and concept was taken into account for the reference of building up the prototype.

A. The effect of magnetic flux cancellation of inductance of metal detector

The inductor of metal detector acts as sensor to detect surface wire when you bring it close to it. In this metal circuit has the tuned circuit which is parallel consisting of inductor and capacitor across it. When applied 5 volt to metal detect circuit, the current will enter to capacitor and the capacitor will be charged and produce voltage to coil of inductor. When the coil of inductor receives voltage supply to it and it will have current on it. So the coil of inductor produces magnetic flux around it. When any metal object bring close to the coil of inductor, the magnetic flux around in coil of inductor will collapse because magnetic flux cancel out with jump to metal object and make the metal object eddy current flowing material. It will cause reverse back voltage flow through the inductor's coil. And have reverse voltage at metal detect circuit [12].

B. The charge cancellation effects of capacitance of electric current detector

When alternative voltage flow through electrical wire and cost the charges to move back and forth in the surface wire and creating alternative current. Metal plate which connected to electric current detector circuit also has charges when given supply to it but it constant. When the metal plate which connected to electric current detect circuit with supply on it bring near to alternative current flowing surface electrical wire causes the charges of alternative current to continuously reverse their position. When it happen, the charges of metal plate which connected to electric current detect circuit will be cancel out with alternative current charges and cost reverse back voltage on the electric current detect circuit [14].

III. CONCEPTUAL DESIGN AND METHODOLOGIES

A. The Main Circuit

The main circuit schematic connects to two circuits which act as sensor which is metal detector circuit and electric current detector circuit and the circuits connected to analogue inputs which are RA0 and RA1 at PORT A. PORTB is connected to the 2x16 LCD. The configuration used is 4 bit communication. The variable resistor of 10 kilo ohm for LCD contrasts setting. The PORTC is connected to buzzer and led for indication. The PORTE is used for switches at RE0, RE1, and RE2. When the button is pushed it will be low potential. The clock speed used is 4 MHz at the oscillator pin 13 and 14. The power used is regulated by LM7805 from 9V to constant 5V. The figure 1 shows the main circuit schematic and PCB layout of it.
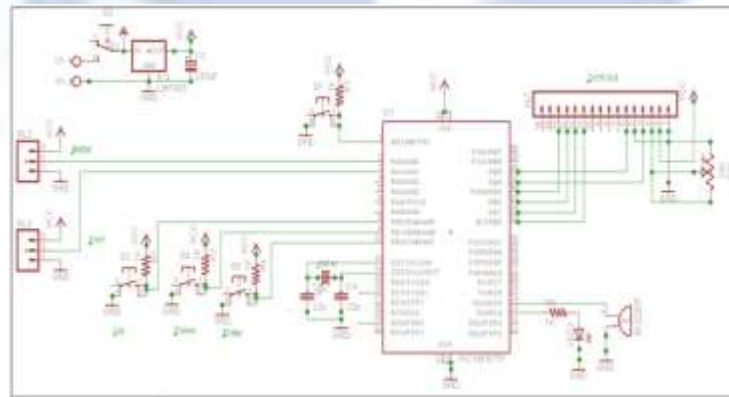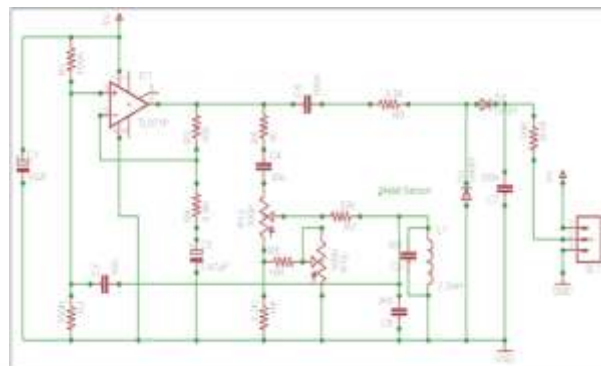

Fig 1: Main circuit schematic

B. The Metal Detector Circuit

This circuit has L1 value of 2.2 mille Henry and C6 and C8 create oscillation act as the frequency resonance. The value is the feed to pin 3 of TL071P non inverting pin. The cap C2 and C5 is to block dc and only allow ac signal to pass through. So normally the LC circuit creates a sinusoidal wave to the non inverting pin, the op-am TL071P act as non inverting amplifier to amplify the amplitude of the oscillation. The potentiometer R12 and R18 is to change the resistance to control the sensitivity of the oscillation signal strength. The value output is then fed to the 2 diode which is a half wave rectifier to

convert from ac wave to dc wave because PIC of ADC only read DC. The cap C7 is to stabilize the output in order to reduce ripple voltage so that the ADC can be more stable value. The figure 2 shows the metal detector circuit schematic and PCB layout of it.

Figure 2: Metal detector circuit schematic

C. The Electric Current Detector Circuit

This circuit consists of the metal plate. When the metal plate is near to a higher potential of electric source, the metal plate become capacitive and have electric charge reaction. The 16 Mega ohm resistor is to provide high impedance between the ground. Then impedance value will flow to base of transistor. The charge will then turn on the transistor. The 22 kilo ohm will provide voltage change and then be stabilized by 2 capacitors which are C1 and C2 to obtain a straight or stale value. The figure 3 shows the electric detector circuit schematic and PCB layout of it.
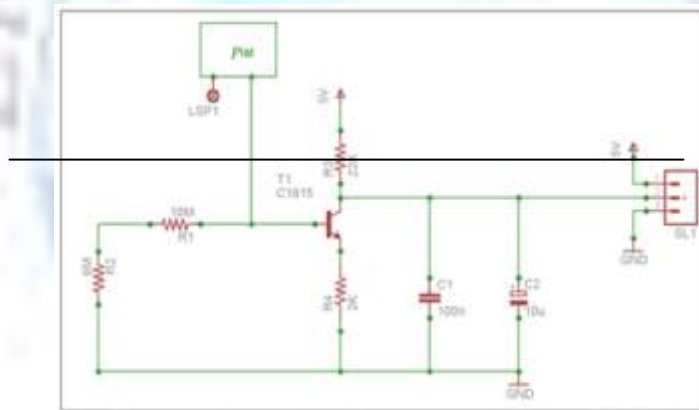
Figure 3: Electric current detect circuit schematic

D. Procedure to Test Reverse Back Volts of Metal Detector Circuit with 35mm Size Electrical Wire versus Distances Measurements

The testing was conducted with metal detect circuit. The inductor of metal detector will act as sensor to detect surface wire when you bring it close to it. When applied 5 volt to metal detect circuit, the current will enter to capacitor and the capacitor will be charged and produce voltage to coil of inductor in metal detector circuit. When the coil of inductor receives voltage supply to it and it will have current on it. So the coil of inductor produces magnetic flux around it. When 35mm size electrical wire bring close to the coil of inductor, the magnetic flux around in coil of inductor will collapse because magnetic flux cancel out with jump to the 35mm size electrical wire and make it eddy current flowing material. It will cause reverse back voltage flow through the inductor's coil. And have reverse voltage at metal detect circuit. The result can be seen on LCD when the step size decrease from actual step size provide by metal detector circuit.

Below is the method to calculate reverse back voltage which produce by metal detector circuit:

$$Vout = \frac{(D\ out1 - D\ out2)}{1024} \times 5V$$

Where,

D out1: The step size which produce by inductor's coil of metal detector before hit the surface wire and it appear on LCD in bits.

D out 2: The step size which produces by inductor's coil of metal detector after hit the surface wire and it appear on LCD in bits.

Total step size of PIC16F877A: 2^{10}= 1024 bits, V ref= 5 V and V out:Reverse back voltage

This test was conducted with measure reverse back voltage of metal detector with bring the inductor of metal detector far away with 2mm distance in gap with 35mm size electrical wire. Conduct this test until the maximum distance when there is no reverse back voltage on metal detector. This test will be conducted with other size electrical wire as well.

E. Procedure to Test Performance of Reverse Back Voltage of Metal Detector When Detect 35 mm Size Electrical Wire Hide inside Nonconductive Materials

There will be five nonconductive materials which are glass, wood, plastic, paper and brick use for testing performance of reverse back voltages of metal detector which will be put on the top of the electrical wire regarding its sizes. After that, use metal detector to detect wire and measure reverse back voltage by monitoring result on LCD. The steps measure the reverse back voltage is same as procedure D. This test also will be tested with three conditions which are nonconductive materials in normal and wet conditions and the electrical wire in wet condition.

F. Procedure to Test Electric Current Detector Circuit with Alternative Current (A.C) Flow Trough Electrical Wire versus Distances Measurements

This test was conducted with electric current detect circuit. When the metal plate which connected to electric current detect circuit with supply on it bring near to alternative current flowing surface electrical wire causes the charges of alternative current to continuously reverse their position. When it happen, the charges of metal plate which connected to electric current detect circuit will be cancel out with alternative current charges and cost reverse back voltage on the electric current detect circuit. The result can be seen on LCD when the actual step size produce by electric current detector circuit decrease. The method to calculate reverse back voltage of electric current detector circuit is same as metal detector circuit. This test was conducted with measure reverse back voltage with bring the metal plate which connected with electric current detector circuit far away with 2mm distance in gap from alternative current flowing electrical wire. Conduct this test until the maximum distance when they are no reverse back voltage on electric current detector. This test will be conducted with add 1200 watt power in load to alternative voltage supply which flow in electrical wire.

G. Procedure to Test Performance Of Reverse Back Voltage of Electric Current Detector Circuit When Detect Alternative Current (A.C) Flow Through Electrical Wire Hide inside Nonconductive Materials

The five same nonconductive materials which used in metal detector testing been used in this testing with put it on the top of the alternative current flowing electrical wire. The result can be seen on LCD when actual step size decrease which produced by electric detector circuit. The steps measure the reverse back voltage is same as procedure D.

IV. THE ANALYSIS & DISCUSSION

The investigative results of experiments on metal detector circuit to detect the electrical wires and electric current detector circuit to detect the alternative current when it flows through electrical wire has been achieved and obtained. First is the experiment on the testing reverse back volts of metal detector with 35mm size electrical wire versus distances measurement. Second is the experiment on the testing performance of reverse back voltage of metal detector when detect the 35mm electrical wire hide inside nonconductive materials. Third is the experiment on the testing electric current detector with alternative current flow trough electrical wire versus distances. Finally is the experiment on the testing performance reverse

back voltage of electric current detector when detect 1200 watt power in load flow through electrical wire hide inside nonconductive materials.

A. Result of Experiment in Table Form for 35 mm Size Electrical Wire versus Distances Measurement with Metal Detector Detection in Reverse Back Volts

Distance (mm)	Step size before metal detector detect surface wire	Step size after metal detector detect surface wire	Reverse back in step size produced when metal detector detect surface wire	Conversion of Reverse back in step size to voltage (mV)
0	403	22	381	1860
2	403	200	203	991.21
4	403	288	115	561.52
6	403	390	13	63.48
8	403	395	8	39.06
10	403	399	4	19.53
12	403	400	3	14.65
14	403	401	2	9.77
16	403	403	0	0
18	403	403	0	0
20	403	403	0	0

Table 1: Distances Versus Reverse Back Volts For 35mm Size Electrical Wire

Data reverse back volts from table of 35mm size electric wire versus distances, a graph was plotted using Microsoft Excel and flop down line for reverse back volts was obtained for that size of electrical wire versus distances as shown in figure 4.
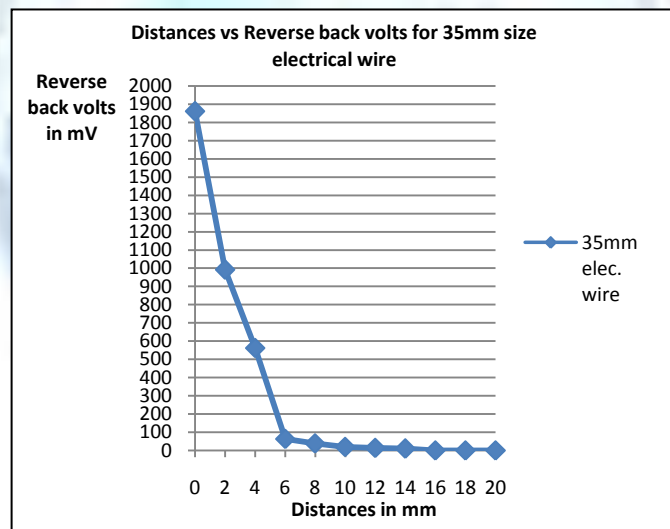
Figure 4: Distances vs. Reverse back volts for 35mm size electrical wire

B. Discussion for the Experiment on the Testing Metal Detector's Reverse   Back Volts with Electrical Wires Regarding Sizes versus Distances Measurement

From observations of this experiment, the metal detector's reverse volts become small value when distance increase from surface wire. The metal detector's reverse back volts become high value when distance decrease from surface wire. Second is size of surface wire influence the reverse back volts of metal detector. When size of surface wire becomes wider, the metal detector obtains higher reverse back volts. From observation of this experiment also obtain that the metal detector's distance of detection can go until 20mm. The electric wires can easily detect by the metal detector easily and the distance of detection also can go until 20mm. The widest size electrical wire has highest reverse back voltage values of metal detector versus

distances measurement. For example the 35mm size electrical wire has 1.860mV reverse back volts for 0mm distance and it distance of detection can go until 14mm with 9.77mV reverse back volts when use the metal detector for measurement.

C. Result of Experiment in Table Form for 35mm Size Electrical Wire versus Nonconductive Materials in Reverse Back Volts with 3 Conditions.

Types of nonconductive materials	Step size before metal detector detect hiding surface wire inside nonconductive materials	Step size after metal detector detect hiding surface wire inside nonconductive materials	Reverse back in step size of metal detector	Conversion of Reverse back in step size to voltage (mV)
paper	403	290	113	551.76
plastic	403	382	21	102.54
wood	403	396	7	34.18
glass	403	357	46	224.61
brick	403	400	3	14.65

Table 2: Nonconductive Materials In Normal Condition Versus Reverse Back Volts For 35mm Size Electrical Wire

Types of nonconductive materials	Step size before metal detector detect hiding surface wire inside nonconductive materials	Step size after metal detector detect hiding surface wire inside nonconductive materials	Reverse back in step size of metal detector	Conversion of Reverse back in step size to voltage (mV)
paper	403	356	47	229.49
plastic	403	356	47	229.49
wood	403	393	10	48.83
glass	403	395	8	39.06
brick	403	400	3	14.65

Table 3: Nonconductive Materials In Wet Condition Versus Reverse Back Volts For 35mm Size Electrical Wire

Types of nonconductive materials	Step size before metal detector detect hiding surface wire inside nonconductive materials	Step size after metal detector detect hiding surface wire inside nonconductive materials	Reverse back in step size of metal detector	Conversion of Reverse back in step size to voltage (mV)
paper	403	222	181	883.79
plastic	403	362	41	200.20
wood	403	389	14	68.36
glass	403	382	21	102.54
brick	403	400	3	14.65

Table 4: Nonconductive Materials In Normal Condition Versus Reverse Back Volts For 35mm Size Electrical Wire In Wet Condition

Data reverse back volts from table of electrical wire regarding with it sizes versus nonconductive materials, a bar graph was plotted using Microsoft Excel and increase bar was obtain when size surface wire became wider for electrical wires versus nonconductive materials with three conditions as shown in figure 5, 6 and 7.
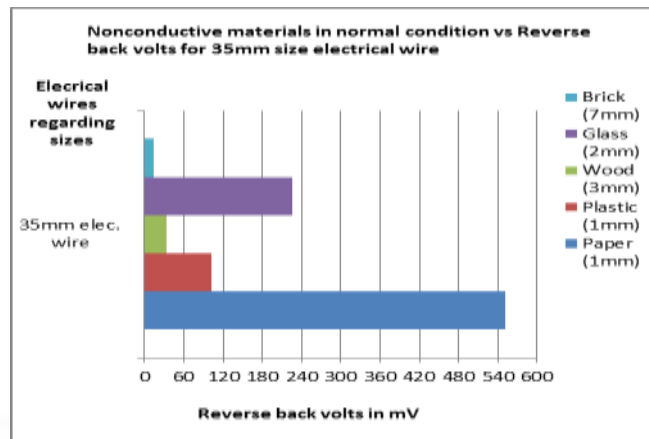
Figure 5: Nonconductive materials in normal condition vs. reverse back volts for 35mm size electrical wire
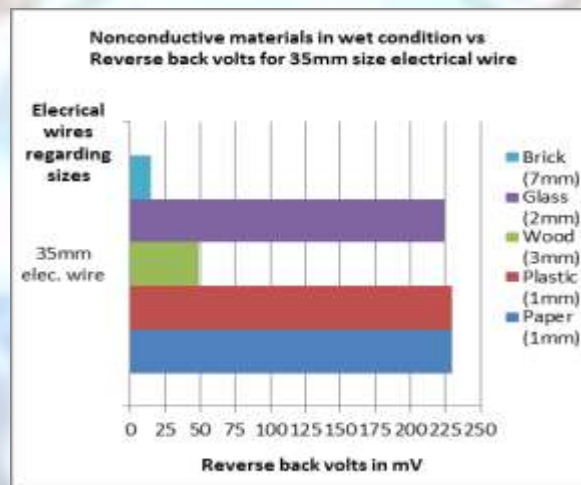
Figure 6: Nonconductive materials in wet condition vs. reverse back volts for 35mm size electrical wire
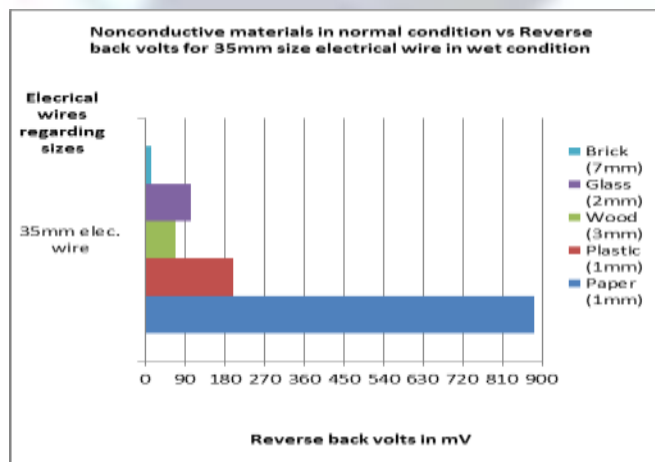
Figure 7: Nonconductive materials in wet condition vs reverse back volts for 35mm size electrical wire in wet condition.

D. Discussion of the Experiment on the Testing Performance of Reverse Back Voltage of Metal Detector with the Hiding Surface Wire In The Nonconductive Materials Measurement

From the observation of this experiment, the magnetic flux provide by metal detector can pass through the nonconductive materials such paper in size 1mm, wood in size 3mm, plastic in size 1mm, glass in size 2mm and brick in size 7mm. The reverse back voltage of metal detector will be better gain for widest surface wire which hides under nonconductive materials. There will be little bit interruption to reverse voltage of metal detector to detect wire when we measure it with nonconductive materials compare to measure reverse voltage without nonconductive materials. Another fact from observation of this experiment, the wet wire condition are more better then surface nonconductive materials wet condition for wire detection using reverse back voltage of metal detector. From observation of this of experiment also show the paper has the most highest reverse back volts value of metal detector for electrical wire because of small size in thickness (1mm) and the material build also very soft when use the metal detector for detect that type wire hide inside paper with three condition which are normal and wet conditions and the types wire hiding inside paper in wet condition for test. The brick has the most lowest reverse back volts value of metal detector for electrical wire because of biggest size in thickness (7mm) and the material build also very hard when use the metal detector for detect that type wire hide inside brick with three same conditions for test. For example when test metal detector with electric wire size 35mm which put inside the paper in normal condition and has 551.76mV of reverses back volts while for brick in normal condition it show 14.65mV of reverse back volts. The plastic (1mm), wood (3mm), glass (2mm) has the medium level of reverse back volts value of metal detector for electrical wire when use the metal detector for detect that type wire put inside nonconductive materials with three same conditions for test. For example when test metal detector with electric wire size 35mm which put inside nonconductive materials such plastic in normal condition has 102.54mV of reverses back volts, wood in normal condition has 34.18mV of reverse back volts and glass in normal condition has 224.61mV of reverse back volts. The electric wire also easily detect by the metal detector inside nonconductive material in three same conditions. Example when test metal detector with electrical wire size of 35mm which hide inside the paper in normal condition and has 551.76mV of reverses back volts.

E. The Results of Experiments on the Testing Electric Current Detector with Alternative Current (A.C) Flowing Electrical Wire versus Distances Measurement in Reverse Back Volts with 1200 Watt Power in Load

Distance (mm)	Step size of electric current detector before detect AC current flowing electrical wire	Step size of electric current detector after detect AC current flowing electrical wire	Reverse back in step size produced by electric current detector when detect AC current flowing electrical wire	Reverse back in step size to voltage (mV)
0	1021	926	95	463.87
2	1021	977	44	214.84
4	1021	1008	13	63.48
6	1021	1010	11	53.71
8	1021	1011	10	48.83
10	1021	1012	9	43.95
12	1021	1013	8	39.06
14	1021	1015	6	29.30
16	1021	1019	2	9.77
18	1021	1020	1	4.88
20	1021	1021	0	0

Table 5: Distances Versus Reverse Back Volts For 1200 Watt Power In Load Flow In Electrical Wire

Data reverse back volts in table form for distances versus reverse back volts for 1200 watt power in load at alternative voltage supply which flow in electrical wire, a graph was plotted using Microsoft Excel and flop down line for reverse back volts was obtained for 1200 watt power in load at alternative voltage supply which flow in electrical wire. The figure 8 shows distances vs. reverse back volts for 1200 watt power in load at alternative voltage supply which flow in electrical wire.
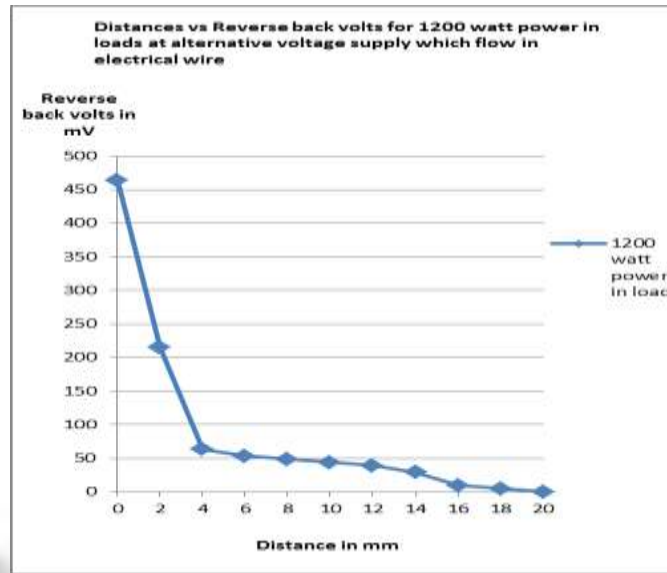
Figure 8: Distances vs. Reverse back volts for 1200 watt power in load at alternative voltage supply which flow in electrical wire

F. Discussion of the Experiment on The Testing Electric Current Detector With Alternative Current (A.C) Flowing Surface Electrical Wire Versus Distances Measurement In Reverse Back Volts

From the observation of this experiment, the value of reverse back volts of electric current detector decrease when bring far away the electric current detector from alternative current flowing surface electrical wires. While the reverse voltage of electric current detector increases when bring electric current detector close to alternative current flowing surface electrical wire. For example, when electric current detector detect 1200 watt power in load at 0mm distance and the electric current detector has 463.87mV of reverse back volts while for 18mm distance it has 4.88mV reverse back volts.

G. Result Of Experiment In Table Form For Reverse Back Volts Of The Hiding Alternative Current (A.C) Flowing Electrical Wire Hide Inside Nonconductive Materials In Versus 1200 Watt Power In Load To Alternative Voltage Supply

Type of nonconductive obstacles in normal condition	Step size of electric detector before detect the hiding AC current flowing wire in obstacle	Step size of electric detector before detect the hiding AC current flowing wire in obstacle	Reverse back in step size produced by electric detector when detect the hiding AC current flowing wire in obstacle	Reverse back in step size to voltage
paper	1022	945	77	375.98mV
plastic	1022	965	57	278.32mV
Wood	1022	989	33	161.13mV
glass	1022	980	42	205.09mV
Brick	1022	997	25	122.07mV

Table 6: Nonconductive Materials Versus Reverse Back Volts For 1200 Watt Power In Load Flow In Electrical Wire

Data reverse back volts in table form for nonconductive materials versus reverse back volts for increasing power in load to alternative voltage supply of electrical wires, a bar graph was plotted using Microsoft Excel and increasing bar for reverse back volts was obtained for 1200 watt power in load at alternative voltage supply which flow in electrical wire. The figure 9 shows nonconductive materials vs. reverse back volts for 1200 watt in load at alternative voltage supply which flow in electrical wire.
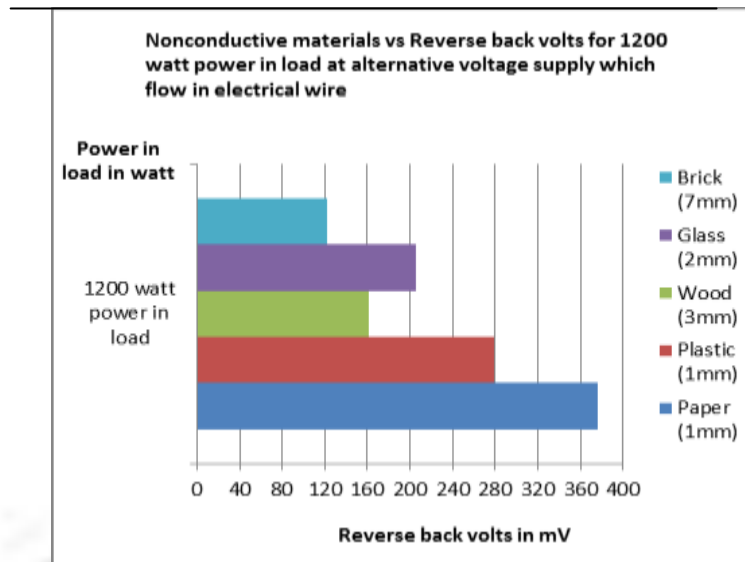
Figure 9: Nonconductive materials vs. Reverse back volts for 1200 watt power in load at alternative voltage supply which flow in electrical wire

H. Discussion Of The Experiment To Test Performance Of Reverse Back Voltage Of Electric Current Detector Circuit With The Hiding Alternative Current (A.C) Flowing Electrical Wire Hide Inside Nonconductive Materials Measurement

From observation of this experiment, the capacitance provide by electric current detector can pass through all the nonconductive materials such paper (1mm), plastic (1mm), wood (3mm), glass (2mm) and Brick (7mm) that use for conduct this experiment. The reverse back voltage of electric current detector will be better gain if highest power in load flows in electrical wire which hides inside nonconductive materials when use it to detect. For example, 0 watt power in load flows in hiding electrical wire inside paper has 166.01mV of reverse back volts compare to 1200 watt power in load flows in hiding electrical wire inside paper has 375.98mV of reverse back volts. There will be little bit interruption to reverse voltage of electric current detector to detect alternative current flowing electrical wire when we measure it put inside nonconductive materials compare to measure reverse voltage without nonconductive materials. The electrical wire hide inside paper is easily detect by electric current detector because the paper obtain highest reverse back volts by electric current detector when conduct the detection experiment and the paper also build in soft materials compare to other nonconductive materials. The electrical wire hide inside brick is most difficult to detect by electric current detector because the brick obtain lowest reverse back volts by electric current detector when conduct the detection experiment and the brick also build in hard materials compare to other nonconductive materials. For example, the 1200 watt power in load flows in hiding electrical wire inside paper has 375.98mV reverse back volts compare to the hiding electrical wire inside brick use same power in load has 122.07mV of reverse back volts. The hiding power in load flow in electrical wire inside other nonconductive materials such plastic, wood and glass have middle level of reverse back volts by electric current detector.

V. CONCLUSION

Regarding the result that monitor through by the experiments which done in section result and discussion, there has difference type of reading provided to 35mm size electrical wire for metal detector. For the electric detector also has different types reading as well when 1200 watt power in loads at alternative voltage flow in electrical wire. These two combinations of the circuits of the hardware that build can detect hidden electrical wire with successfully within the gap of 2cm with nonconductive materials. The software such Proteus for circuit simulation, microC compiler for compile C program to hex file, PICkit2 software to burn hex file of C program to microcontroller and eagle software to draw schematic circuit and change it to PCB layout and proto-type board testing for test circuit working function was successfully help to create the hardware and make it function well. The observation for analyze the hidden electrical wires detection inside nonconductive materials also successful by test some experiments which done in section result and discussion. With this proves that been provided, the hardware build can be concluded as successfully build or developed. Thus, the product of the research achieved the objectives.

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