THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

Department of Electrical and Electronic Engineering

EEE 3112 EXPERIMENT NO. 03

TITLE: ELECTROMAGNETIC INTERFERENCE

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LECTURER'S COMMENTS

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1.0 OBJECTIVE

- ✓ To understand how electric and magnetic fields give unwanted signals in leads and circuits.
- ✓ To learn good design methods aimed at reducing interference signals.
- ✓ To avoid serious pitfalls when interconnecting equipment

2.0 EQUIPMENT AND SPECIMENS

1 AM/FM radio

1 “chicken cage”

1 oscilloscope

1 probe

1 coax –to banana converter

1 UNILAB signal generator

1 power supply

1 Ground plate

2 plastic tubes

1 ordinary cable with 1.kohm resistor in series

1 Shielded cable with 1.kohm resistor in series

1 Twisted pair cable with 1.kohm resistor in series

4 wooden blocks, $10\times 5\times 5$cm

Lab cables of different lengths

3.0 INTERFERENCE COUPLING

This first part consists of Basic experiment with an oscilloscope, signal generator and different kinds of cables (ordinary, shielded and twisted pair). Aimed to indicate the presence of the electromagnetic fields and create acquaintance within different ways of interference coupling (electric and magnetic field) under different conditions.

3.1 The Presence of Electric and Magnetic Fields

First we investigated the electric and magnetic fields around us by using an oscilloscope, a normal lab cable and a coil.

3.1.1 Electric Fields

The lab cable was connected to one of the oscilloscope inputs (you need a coax-to- banana converter) as shown in Figure 1 below and tried to find some electric signals on the screen.

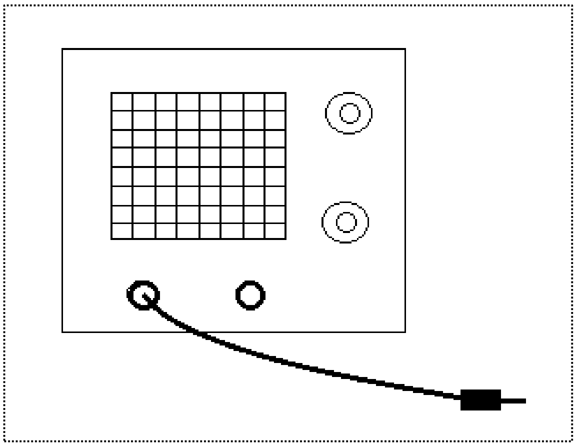

Figure 1 - Discovering Electric Fields

3.1.2 Magnetic Fields

To investigate the magnetic fields we used some kind of cable loop. To achieve a decent deflection on the oscilloscope a good idea was to use a loop with turns, a coil. Here 100 turns of enamelled copper thread around a bobbin was used as a coil. The coil connected to one of the inputs and the coil was moved around to find some signals. The coil was moved near the different parts of the oscilloscope until a maximum voltage was obtained. See Figure 2 below for the connections.

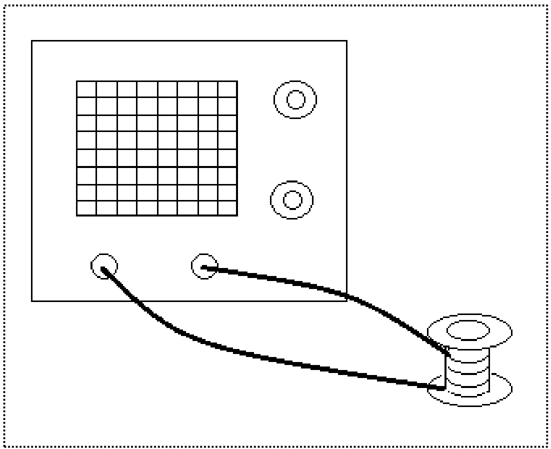

Figure 2 - Discovering Magnetic Fields

3.2 Capacitive and Inductive Coupling

To be able to investigate the capacitive and inductive coupling in a more controlled way the UNILAB signal generator was used as a source of interference by feeding a lab cable with signal and use an oscilloscope to measure the induced voltage in a parallel wire, terminated by a 1kΩ resistor. See Figure 3 below.

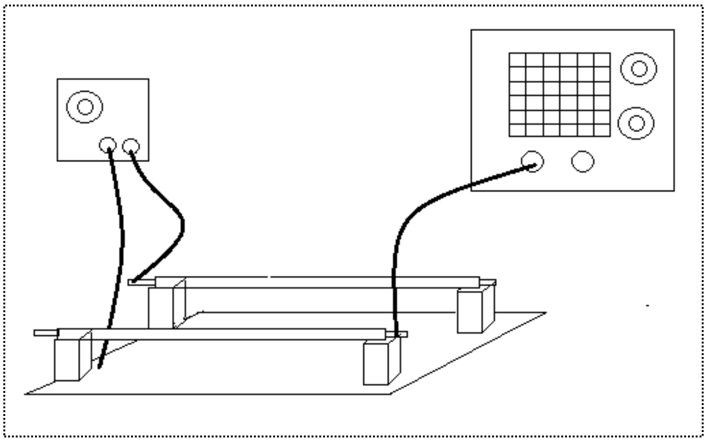

Figure 3 – Connections

3.2.1 Capacitive Coupling

PROCEDURE

- ✓ An ordinary lab cable was put into a plastic tubes and it was placed on one pair of 10cm high wooden blocks on the ground plane.
- ✓ One of the cable ends was connected to the 100Ω output of the signal generator.
- ✓ The other cable end was left free.
- ✓ The generator ground plane was connected.
- ✓ The unshielded cable was put in the other tube and place it on the other pair of 10 cm high wooden blocks, parallel with the other tube at a distance of 10 cm (centre to centre)
- ✓ The 1k Ω resistor was connected to the ground plane and the other end of the cable to the oscilloscope probe.
- ✓ The ground clip was connected from the probe to the ground plane.
- ✓ The signal generator was adjusted to 50 kHz sinusoid signal and maximum output level (about 6V).

a) The interfering voltage (peak to peak) received by receptor cable was measured.

b) The frequency was increased to 100 kHz and measured the interfering voltage (peak to peak) received by the receptor cable.

c) The wooden blocks were laid down so that the tubes were 5 cm above the ground plain. 10 cm distance was maintained between the two cables. The frequency was restored to 50 kHz and measured the interfering voltage (peak to peak)

d) The cables were moved 5 cm apart (centre to centre) and measured the interfering voltage.

e) Signal generator was switched to square wave and measured the interfering voltage (peak to peak).

f) The cables were connected according to Figure 4 a-d and measured the resulting interfering voltages (using sinusoid signal).

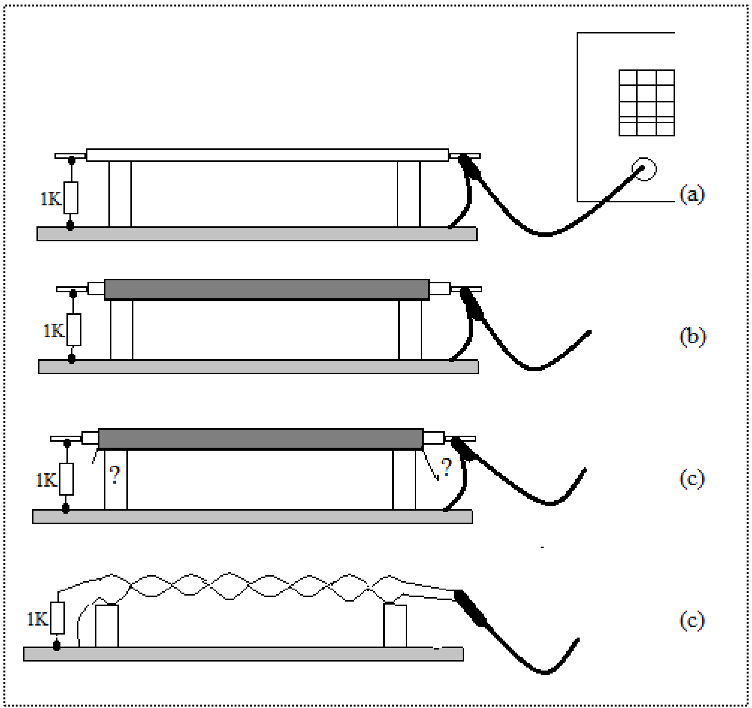

Figure 4 - Receptor Cable Connections

EVALUATION

The values and expectations from the preparation questions were compared with the obtained results from the experiments and comment on each specific point.

3.2.2 Inductive Coupling

Using the low impedance output (1Ω) on the UNILAB signal generator and the loose end of the interfering cable (transmitter cable) was grounded through a series resistance of 6.8Ω (9W).

Caution was taken to ensure that the loose end of the cable was not short circuited directly to the ground or else the signal generator would be damaged.

In this way, a considerable current would flow through the cable, through the resistor and back to the generator through the ground plane.

The receptor cables were connected as before.

PROCEDURE

The output level of the signal generator was adjusted so that there was 0.8 A, 50 kHz sinusoid signal. (The current was measured by measuring the voltage output, using the oscilloscope)

a) The interfering voltage (peak-peak) received by the receptor cable was measured.

b) The frequency was increased to 100 kHz and measured the interfering voltage (peak – peak) received by the cable.

c) The wooden blocks were laid down so that the tubes were 5cm above the ground plane.

d) 10 cm distance between the two cables was maintained. The frequency was restored to 50 kHz and measured the interfering voltage (peak- peak).

e) The cables were moved 5cm apart (centre – centre) and measured the interfering voltage.

f) The signal generator was switched to square wave and measured the interfering voltage (peak-peak).

EVALUATION

The values and expectations from the preparation questions were compared with the obtained results from the experiments and comment on each specific point.

3.3 Radio Frequency Interference

Throughout this part, an AM/FM-radio receiver was used as a receptor for electromagnetic radiation fields.

3.3.1 Faraday Cage

A simple shield (of faraday – cage type), was made of chicken-net. It totally enclosed the inner volume, and it was quiet close-meshed.

The wireless was adjusted so that a station (e.g. radio 4) was clearly heard. The radio was put in the chicken cage so that the cage completely enclosed it (keeping the antenna short and inside the cage).

3.4 Computer Interference

In close proximity to e.g. a computer, the radio would be interfered, due to the quick transitions in the square pulses (high frequency) and also because of other electronic devices like the CRT and disk- units etc in the computer. The radio was put close to the computer and the frequency was adjusted until the varying bit flow could be heard when a program was running on the computer.

4.0 RESULTS

The results of the experiment were recorded below.

Table 1 - Results of Capacitive Coupling

	10cm height 10cm apart 50kHz sine	10cm height 10cm apart 100kHz sine	5cm height 10cm apart 50kHz sine	5cm height 5cm apart 50kHz sine	5cm height 5cm apart 50kHz square
Measured voltage (peak-to- peak)	6.5mV	14.5mV	5mV	12mV	19mV
Calculated voltage	9.33mV	18.66mV	9.8mV	11.03mV	11mV

Table 2 - Results of Receptor Cable connections – Capacitive coupling

Figure 4	Receptor cable and connections	Interfering voltage (peak to peak)	Attenuation (dB)
a	Single cable	12mV	0
b	Shielded cable (Ungrounded)	10mV	-1.584
c	Shielded cable (Grounded)	3mV	-12.041
d	Twisted pair cable	5.5mV	-6.776

Table 3 - Results of Inductive Coupling

	10cm height 10cm apart 50kHz sine	10cm height 10cm apart 100kHz sine	5cm height 10cm apart 50kHz sine	5cm height 5cm apart 50kHz sine	5cm height 5cm apart 50kHz square
Measured voltage (peak to peak)	80mV	145mV	52mV	92mV	0.34mV
Calculated voltage	34.84mV	69.68mV	11.81mV	34.84mV	34.84mV

Table 4 - Results of Receptor Cable connections - Inductive coupling

Figure 4	Receptor cable and connections	Interfering voltage (peak to peak)	Attenuation (dB)
a	Single cable	92mV	0
b	Shielded cable (Ungrounded)	170mV	5.33
c	Shielded cable (Grounded)	85mV	-0.69
d	Twisted pair cable	85mV	-0.69

5.0 DISCUSSION

It was observed, from the experimental results, that cables with a larger separation distance of 10cm had a smaller capacitive coupling than the ones that had a smaller separation distance of 5cm. This is because the strength of the electric field is inversely proportional to the distance separating the two conducting plates (thickness of dielectric material). That is:

$$\boldsymbol{E} = \frac{\boldsymbol{V}}{\boldsymbol{d}},$$

Where E is the electric field strength, V is the applied voltage between the two conducting plates and d is the distance between the two plates.

It can be seen that, with voltage kept constant, when d is being varied, E will be approaching zero as d is approaching infinite. Thus, the longer the longer the distance (d) the lower the electric field strength and vice versa.

It was also observed that the closer the cables were to the ground, the greater the greater the interference voltage. The square wave was observed to produce higher amplitude of the interference voltage.

When the radio was placed in the chicken cage, the radio signal became poorer and only became slightly better when the antenna was protruded through the cage. This meant that there was magnetic interference trapped around the cage which interfered with the radio frequency.

6.0 CONCLUSION

The experiment was successful as the objectives were met. It can be concluded that electric and magnetic fields give unwanted signals in leads and circuits. Therefore there is need to design methods aimed at reducing interference signals.

7.0 APPLICATIONS

Electromagnetic interferences are real and the methods of reducing interference of signals require an understanding of the effects of interferences helps in the design of Electrical and Electronic devices that can provide a shield to the electromagnetic interference and also designing circuits that will not interfere with the signals of neighbouring equipment. For example, telephone lines that pass under a high voltage overhead line may experience interference. To reduce the electromagnetic interference, a shield is provided between the high voltage conductors and the telephone wires.

8.0 REFERENCES

1. HUGHES E. **ELECTRICAL AND ELECTRONIC TECNOLOGY;** 10th edition (2008); Pearson Education Limited, Edinburgh Gate, Harlow Essex CM20 2JE, England.
2. **EEE3112 ENGINEERING PRACTICE LAB MANUAL ;** University of Zambia, Lusaka, Zambia.