A SENSOR ARRAY BASED ON PLANAR ELECTROMAGNETIC SENSORS FOR AGRO-ENVIRONMENTAL MONITORING

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Thanks to ALLAH S.W.T for giving me the strength to complete the project report and my master, to my beloved mother and father who always pray for me, to my wife lovely wife who stand by me and to my incoming child.

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ABSTRACT

Agriculture is one of the important sectors in the country however due to lack of management and knowledge, farmers usually ended up overusing pesticide and fertilizers which can cause negative effects to the environment. Based on this situation monitoring of the agro-environment is important in order to maintain the permanence of the soils. As to date, available methods for contaminations detection in agriculture soils commonly require tedious operational procedures which usually involve purchase expensive equipments. This project suggests an alternative method for the detection of contamination by developing a sensor array with the combination of planar meander and interdigital electromagnetic sensors for monitoring the content in agricultural soils and contamination. The main objective is to fabricate the sensor array using printed circuit board (PCB). For this project three new configuration of planar electromagnetic placement re introduced which are parallel, wye and delta. An experimental setup consists of frequency waveform generator, signal oscilloscope and Agilent software as the controller was developed to study on the output of the system. A set of experiments were conducted to determine the relationship between the sensor's output and the soil's parameters. The performance of the system was observed where the sensors were tested with soil samples taken with different concentration of water percentage. Based on the result, the sensor array can be expected to be used to measure the contamination in the soils and the data accuracy is compared.

ABSTRAK

Pertanian merupakan salah satu sektor yang memainkan peranan penting dalam pembangunan negara kita, namun disebabkan oleh kekurangan pengetahuan dan sikap sambil lewa, para petani selalunya menggunakan racun dan baja secara berlebigan dimana ini boleh memberikan kesan negative kepada alam sekitar. Berdasarkan kepada situasi ini, pengawasan terhadap alam sekitar adalah penting untuk memastikan kelestarian sumber tanah. Ketika ini, terdapat kaedah yang digunakan untuk mengesan pecemaran di sector pertanian kebiasaanya melibatkan prosedur yang rumit dan memerlukan pembelian peralatan yang mahal. Projek ini mencadangkan satu kaedah alternatif untuk mengesan pencemaran didalam tanah dengan menghasilkan *planar* sensor yang menggabungkan *meander* sensor dan *interdigital* sensor. Objektif utama projek ini adalah untuk menghasilkan sensor dengan menggunakan papan litar tercetak. Dalam projek ini tiga konfigurasi baru sensor telah dicadangkan iaitu selari, wye dan delta. Satu sistem eksperimen telah dibina dengan menggunakan penjana gelombang berfrekuensi, osiloskop and perisian Agilent sebagai pengawal utama untuk mengkaji keluaran sistem sensor tersebut. Beberapa set eksperimen telah dijalankan untuk mengetahui hubungan di antara keluaran sensor terhadap parameter-parameter tanah. Prestasi sensor diuji dengan kandungan air berbeza didalam tanah. Berdasarkan hasil ujikaji, kumpulan sensor ini dapat digunakan untuk mengukur pencemaran dalam tanah dah ketepatan data tersebut dapat diuji.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

C	-	Capacitance
I	-	Current
L	-	Inductor
PCB	-	Printed Circuit Board
R	-	Resistance
V	-	Voltage
X	-	Reactance
Z	-	Impedance
Ω	-	Ohm
∅	-	Angle

CHAPTER 1

INTRODUCTION

1.1 Introduction to Sensor

Sensor is a device that detects the parameter of show the quantity of the measured parameter. Example of sensor is such thermocouples that detect and sense the changes in the temperature. A transducer is a device that converts non electrical parameters into electrical signal such as voltage and current that are proportional to the physical value parameters that are being measured. Usually a transducer involve a sensor and signal conditioning circuit or instruments in order to translate or to read the value of the measurement. Figure 1.1 shows the block diagram of transducer used in measurement.

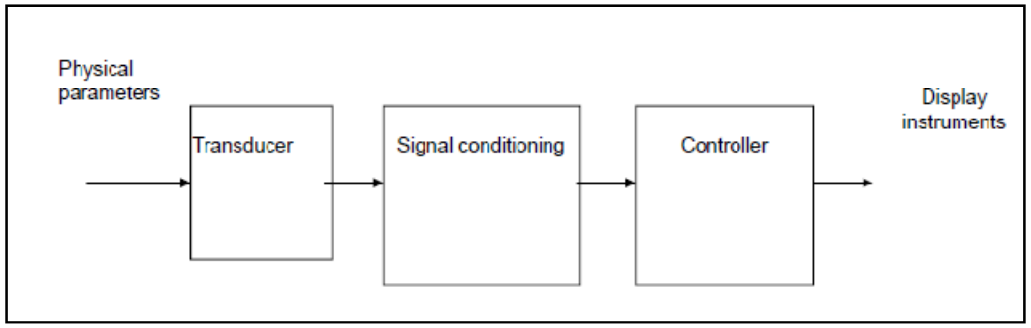

Figure 1. 1: Transducer Used In Measurement Block Diagram

Sensor and transducer development is a rapid need as both of the equipments are used in most all of the sectors and industry globally. The implementation of sensor in most of the industries can been see with the unprecedented growth of utilization of sensors in product and services, where sensors play an important role in gaining important information for monitoring and measuring process. A research done [1] show that the sensor influence of the industrial sector globally. Figure 1.2 shows how the sensors influence within the industries and market sector. The market sector which has most heavily used sensors in their process is the health care sector where consist of 20% of the overall sector. The second and third highest sector that influenced by the usage of sensor within the industries are food processing sector which consist of 12% and the environment sector which consist of 11% of overall market. Others area that implemented the sensor in their sector is such as agriculture (8%), chemical engineering (8%), domestic and other appliances (7%), security and defence (7%), transport (6%), and energy (6%). Less development or application of sensor is used or made in sectors such as construction/housing (3%), wood and textile (3%), IT/communication (4%), and metal and plastic processing (5%) [1].

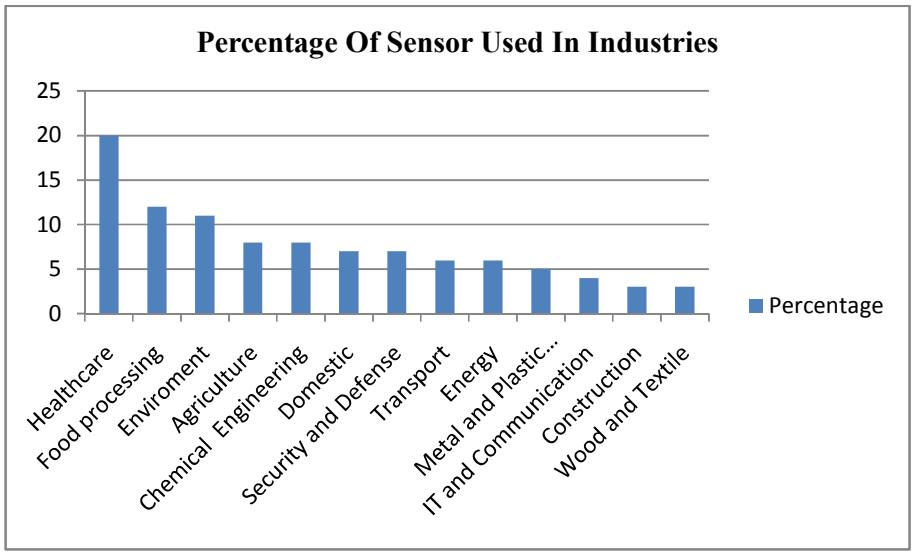

Figure 1. 2: Percentage of Sensor According To Industries

1.2 Environmental Sensor.

Environmental awareness has become one of the principal in technology and industries development within these recent years. The future growth for environment related sensor and environmental monitoring technologies are pre-ordained due to the awareness within the global economies player on their responsibilities of environmental impact or they may cause negative impact on themselves. This has made environmental sensor become a substantially high technologies business. Two major trends can be seen in influence of the environmental sensing and monitoring business, the first is that the design and engineering of sensor components and engineering are going for a technological revolution. Most of the individual sensors are moving forward toward miniaturization process. The advantages of development of smaller sensor are that by producing smaller sensor it lowers the material cost and also making the sensor to become more energy efficient, it also large distributed networks possible. And simultaneously environmental friendly aspect and clean-up are is more or less being imbedded into the policy-making agenda, the advance progress in nanotechnology, semiconductor and communication are supporting and facilitate the implementation and development of sensors product.

Environmental sensors factually come in thousands of types, design and forms. The sensors are usually base on a wide range of chemical and physical principles with variable types of outputs for monitoring process. The field applications of environmental sensors also tremendously varied. The areas of that has become the focus for environmental sensor include vehicles emissions, fossil fuels combustion, agricultural contamination, waste disposal for industrial and mine, ocean spilling and dumping, extreme change in climate and weather monitoring.

The second influential factor is the rapid development of environmental sensor and monitoring networks themselves. There is an outburst in the extent, capacity and numbers for the mention networks, where the figure show in 2010 where the value of global environmental sensor and is at $11.1 billion. Based on the current trendsetting

and forecast of future demand the environmental sensor market is expected to reach $11.3 billion in 2011 and $15.3 billion in 2016. Where it can be say that there will be a compound annual growth rate of 6.5% between 2011 and 2016. Shown in Figure 1.3, which the range of expenditure for sensor can be divided into terrestrial monitoring, atmospheric monitoring, oceanic monitoring, radon, GPS, remote sensing and new technology.

Sensor networks allow real-time data visualization and analysis, distributed sensing capacity, remote sensing data streams and integration of adjacent networks. The main factor that contributed to the development of the networks are the availability of computational capacity, the progress of massive data storage, the evolution of internet and the reduction in size of electronics components. At this point the establishment of environmental sensor network has been firm and large new network currently in development process where the new environmental network rage from continental monitoring scope until to those which only monitor on local situations. In terms of monitoring variables are including CO_2 combustion up to decadal shift in the temperatures. The current sensor also can monitor biological and physical activities, as well capable of measuring nutrient dynamics and groundwater fluxes. Due to these, the development of environmental sensor is seen to be more crucial from time to time.

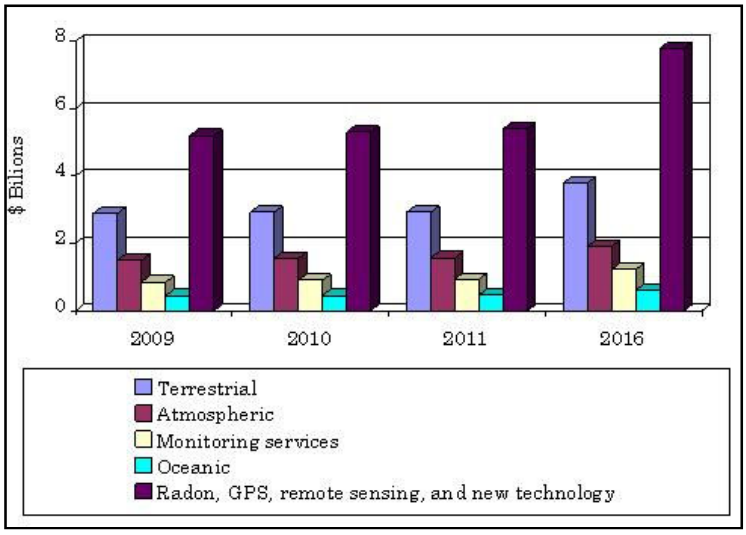

Figure 1. 3: Global Environmental Sensor and Monitoring Business by Market Category

1.3 Background of the problem

Soil is a valuable key natural source, where the 29 % of the world is cover by land while the other 71 % of the world is primarily ocean. In the world ecosystem, soil play an important role, which is to supports life and is a major requirement for maintain a sustainable development in terrestrial environments. The possibility of degradation in the aspect of quality for the topsoil layer play a particular interest as due to the topsoil layer are exposed to natural geochemical processes, anthropogenic activities and atmospheric deposition. Anthropogenic activities, especially in regions where agriculture, mining land and industrial uses are practiced have significantly altered natural background concentrations of the soils.

Soil contamination are a greater risk to the of individual who live in less industrialize and less populated rural are compared to those whose live in the heavily urbanized or industrialize area are due to the exposure of the contamination are higher in time aspect of quantity and time for the rural area [2]. The contamination of urban and agricultural soils by potentially toxic metals is also causing concern due to the possible adverse effects on the ecosystem. Due to this matter, an improved monitoring and understanding of the concentration of contamination in the soils in order to ensure a long-term sustainability of food production. It is essentials to study the major, minor and trace elements in the soils in order to understand the factor of nutrient deficiency, bioavailability, pollution and the possible effect that can occurred to food chains and geological eco-system. Therefore it is very important to have an ambient background concentration data such as development of sites , toxicity and bioavailability for potential uses [3].

The in order to safeguard human, animal and plant, there is need for assessment, prevention, control and development of contaminated land through regulatory organizations, which required continuous information on the soil condition. Thus, it is important for the regulators to set guideline/standard values as a component of environmental legislation for specific sites or wider geographical regions. One of the

most important objectives of background environmental monitoring is the identification of any anomalies and anthropogenically introduced contaminants in any environmental assessment program [4]. In Malaysia, there are currently no comprehensive soil reference values available in order to assess levels of potentially contamination of anomaly for various land uses such as industrial, recreational land, agriculture and development. Based on this there is need for technology to assess the contamination level of natural soil resources due to the process of industrialization, agriculture and urbanization of soils in Malaysia.

Agriculture sector plays the role as one of the most significant economy contributor in Malaysia where based on World Bank Indicator shows that around 24% of Malaysia soil is used for agriculture. Correspond to the volume of the soils that are used for agriculture, agro-environment monitoring is an important process in order to maintain the permanence of the soils. However, the contaminations in the soils have become a common thing in the agriculture soils due to the lack of knowledge within the farmers. Overused of pesticides and fertilizers in the soil can cause negative effect to the soil itself.

Although there are detection methods in assessing the contamination, there are few drawbacks. The detection usually involved laborious measuring step, this will cause the overall detection process consumes lots of time. Most of the detection process need to be done within the laboratory and in order to extract the contain of contamination within the soil and the process itself required controlled working condition and preparation of extra reagent or chemical, this cause the detection result cannot be obtain immediately. The detection process also are often expensive, this due to many components are required in order to develops the experimental process for finding out the soils contamination level and sometimes this process will required special equipment which are specially designed. These requirements will become the drawbacks as all the equipment are quite costly and are hard to be set up. Although all the detection method is can give good results, most of the equipment are quite bulky and the detection cannot be done on the site.

Based on the following drawbacks and hindrance of current detection method, there is need to develop a sensor which can be integrated as a low cost, convenient, and suitable for in-situ measurement system for soils quality monitoring, particularly pesticide and fertilizer effect on soils contaminations.

1.4 Objective of the study

Looking at important of soil monitoring for the permanence of the environmental, this research aims to achieve the following objectives:

1. To design and fabricate new planar sensor based on the combination of meander and interdigital sensor.
2. To investigate the characteristic of the new planar sensor array based on meander and interdigital sensor.
3. To conduct experimental work to determine relationship between the sensor output and soils parameter.

1.5 Scope of the study

In order to achieve the objectives of the project, that is to investigate the soil contaminations level due to pesticide and fertilizer used by the farmers for agriculture process based on planar electromagnetic sensor development. The scopes of the project need to be identified and implemented to make sure the aim is achieved. The scope of the project is as follows:

1. Designing the sensor array using printed circuit board (PCB) designer software and fabricating the sensor using printed circuit board (PCB). The scopes involve the study of sensor sensitivity by three different placements of the sensor array where the placements are parallel configuration, delta configuration and Y configuration.
2. Developing the experiment setup consists of frequency waveform generator as the input signal, signal oscilloscope to detect the output of the sensor and to develop output component analysis software by using Lab View to study on the characteristic of the sensor.
3. Carry out set of experiments that will be conducted to determine the relationship between the sensor's output and the soil's parameters, the suggested experiments is on the soils permittivity versus moisture, soils permittivity versus pesticide and soils permittivity versus fertilizer.

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