A study of flat stick bamboo microwave absorber performance

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Abstract. Microwave absorber able to inhibit the reflection of electromagnetic radiation. Microwave absorbers are used in an anechoic chamber along with its wall, ceiling and floor for the electromagnetic compatibility (EMC) and electromagnetic interference (EMI) evaluation. This research is to develop a flat shape of biomass absorbers using an agricultural material. The main material used in constructing the flat absorber is a natural bamboo. The flat shaped absorber is chosen because it could reach the standard set in the specified industry and suitable to be used in the microwave frequency range. Cylindrical bamboo with different radius have been used for this study. Radius 0.2 cm for Design 1 and 1 cm for Design 2. The range of frequencies are set in the range from 1 GHz to 12 GHz. The result of microwave absorber is analyzed for its absorption performance. The generated result from the technique shows that the flat stick bamboo microwave absorber operates the best in Design 2 with 34.9% of absorption performance compared with Design 1. The overall results in different angles for both designs are analyze and compared.

1. Introduction

Malaysia is a developing country which actively involved in technology advancement and building constructions. The development in the telecommunication sector have been experiencing an excessive rapid growth. In recent years, the compatibility of electromagnetic compatibility (EMC) with electronic devices has become an issue. The EMC issue is thus becoming the fundamental importance to oversee both device performance and electromagnetic interference (EMI), especially when it may affect the safety of human health. A study done by J C Lin stated that, as referred to published epidemiological studies, there is an increasing in risk statistic of 40%-200% for having the brain cancer and tumour among heavy and/or long-term usage of mobile phones [1]. Emission relate to the ability of a device to cause interference in the environment. The purpose of controlling the level of emissions of a device is to ensure an appropriate electromagnetic environment. Specific absorption rate (SAR) is a value of energy being absorb by human tissue when exposed to radio frequency (RF) and the unit is watts per kilogram, W/kg. According to a standard set by IEEE, a basic restriction for most parts of the body is at 2 W/kg [2]. Susceptibility and susceptivity are the orientation of a device or a circuit to develop a fault due to noise, their opposite being called immunity. The application of the radio wave absorbing materials has been increased drastically [3]. It is crucial to measure the compatibility of electronic devices, computers and home appliances on its electromagnetic compatibility (EMC) and electromagnetic interference (EMI) in
an anechoic chamber [4, 5]. This is to ensure that operation does not influence the electromagnetic environment to extent the functions of devices and to prevent the systems from being adversely affected. In the meantime, this method can cut the cost of maintenance and construction, and also reduce the complexity of its operating system.

When an electric field and magnetic field comes in contact with each other, it will travel through the space to form an electromagnetic radiation. The heat was then produced when RF emission is occupied in great amounts with materials containing water [6]. Even though RF radiation is not the cause of cancer, there has been a concern on some forms of non-ionizing radiation as they have a potential effect that may possibly result in cancer and in some situations, it could damage the DNA cells like ionizing radiation.

In early 1930, many researchers began to actively search for a good electromagnetic radiation absorber. The first absorber designed was a simple resonant that can operate at 2 GHz [7]. Engineers these days, who work in microwave and millimeter frequencies have access to a wide-ranging variety of commercially presented materials. This multiplicity is in line in finding for material characteristics that are designed suitably for different application necessities. The researchers have stumbled over the years on the aspects of weight, thickness, wide operational bandwidth and resistance temperature of absorbers.

The microwave absorber is one of the major components inside the anechoic chamber used to abolish cast-back signal [8]. Due to the growing demand of anechoic chambers, there are many studies ongoing about the microwave absorbers. There are many types of absorber such as hybrid, walkway, wedges, pyramidal and flat top which most of them have magnetic permeability and dielectric constant. The permeability is known as a quantity measure of magnetic element of a material while the permittivity is a quantity measure of electric field of a material in the electromagnetic wave [9]. The anechoic chamber is built to completely soak up the reflections of electromagnetic waves. The size of targetted object and range of testing frequency are the parameters to determine the suitable size of anechoic chamber. The anechoic chamber is used to run experiments in free space conditions to make sure that no signals are reflected back. For example, all sound energy will travel away from the source with almost none is reflected back. It is used to check the reflection radiation of electronic devices.

Absorbers can be used to diminish the energy in an electromagnetic wave to eliminate unwanted radiation or stray that may possibly interfere a system’s process [10]. Another advantage of absorber is the ability to check the reflection in electronic devices to ensure the safety level for the users. Besides that, the oscillations causes by cavity resonance can be minimize by utilizing the absorbers. On the other hand, the absorber is mainly used to produce a free space condition by eliminating reflections in an anechoic chamber.

At the present time, in order to prevent radiation or any harmful to electronic appliances, many industries practice the uses of microwave absorber. Due to high radio frequency radiation in surroundings, it is impossible to completely evade from the exposure. People can take prevention by decreasing the exposure by eluding jobs that take place in high radiation, avoid using machine in such a long time and reducing the uses of the phone. The electrical appliances such as oven, refrigerator, portable heater and so on have to undergo the tests of EMC and EMI in an anechoic chamber before releasing them into the market to make sure that it is safe to be used.

In this project, the researchers have used the designated flat bamboo absorber placed in an anechoic chamber to carry out with the experiment. It is economical and can be owned by everyone. The use of bamboo in this project can fulfill the need of green technology. The bamboo contains the element of carbon and water to make a good microwave absorber. The carbon is a semiconductor material which allow a low quantity of charge flows through it. From this characteristic, carbon can be used as the material in the making of absorber [8]. So, an absorber using flat natural bamboo has been proposed to provide a solution for this matter.

The project aims to achieved three (3) objectives. The objectives of this project are first to design and simulate the modelling of the characteristic for flat absorber by using CST software. Next, to develop a flat shape of biomass absorbers using agricultural waste material which is natural bamboo.
Lastly, to analyze the performance of the designated absorber in terms of its absorption efficiency.

This project is recommended to examine the suitable dielectric properties value impact from flat shape of biomass absorbers using agricultural waste materials, that is a natural bamboo. A flat shape of the absorber will be used in this research to get a better performance in terms of its absorption efficiency. The essence of this study consists of dielectric test, characterization and simulation with different value of dielectric properties and lastly to measure its performance practically. The simulation, modelling and analysis of the properties and characteristic of the natural bamboo absorbers will be analyzed on the CST software. The important parameters derived from the CST software are the dielectric constant and the reflectivity coefficient using different values of dielectric properties.

There are a few project impacts that can be achieved from this project. The first project impact is the flat natural bamboo microwave absorber can act as an alternative eco-friendly safety level radiation measurement machinery. Besides that, it can reduce unwanted or stray signals radiated from electronic devices and other appliances. Last but not least, it provides an indication of a good absorbing performance.

2. Methodology

A study of characteristics and several parameters has been performed to identify factors that will affect the absorption performance. The basic material to be used as an absorber is a bamboo. Firstly, the design of the absorber is made by using the CST Microwave Studio software as a tool to perform absorber performance. The absorbent design uses CST with a frequency between 1 GHz-12 GHz.

The free space arch reflectivity measurement method technique is used to test the performance of microwave absorber. The structure of the arch is built from wood and shaped in semi-circular. The shape itself is mainly designed to enable certain proper angles to attach both transmitting and receiving horn-type of antennas. The absorber must be properly placed at the centre of the arch when the process of taking the measurement. The measurement was done for a frequency range between 1 GHz-12 GHz.

2.1 Design of absorber

The absorber was designed by using a cylindrical shape. Figure 1 shows the first design which has three layers and the dimension is 60 cm length x 60 cm of width. The radius for the cylindrical bamboo is 0.2 cm. The three layers were chosen so that there is no gap in between the layers. The second design is shown in figure 2 with three layers and the radius is 1 cm. The simulation result was generated by using the computer simulation technology (CST). While figure 3 and figure 4 shown are designs using bamboo.
2.2 Material of absorber
Bamboo can be used to make various kinds of things, especially as the construction material since bamboo is the most significant nature’s to act as a substitute for the threatened rainforest hardwoods. The advantage of bamboo is quick-growing and its percentage of biomass generation is incomparable by some other plants. Bamboo generates larger crops of raw because it is easy to be found especially in Malaysia [11]. It is used broadly for a varied range of purposes. No other plant material can compete with the utility of bamboo. The bamboo is used in many kinds of things, not to mention the traditional use of bamboo in the daily life of the early people. Bamboo have been broadly used in building applications like fences, flooring, ceiling, wall and also windows. The first design used a bamboo stick with a radius of 0.2 cm. The bamboo sticks were arranged to each other by using a cassava glue to stick them all together. The process of making cassava glue started with taking of tapioca starch and added to a hot water to make a glue. The cassava glue act as a bonding agent which hold the structure of the absorbers all together. As a result, the whole construction of the absorbers will be durable and strong enough to withstand any force applied onto it. Besides, the glue is made from natural product and it is environmentally friendly.

3. Result and discussion
3.1 Simulation result
From the result of simulation for Design 1 in figure 5, it shows that the flat absorber had a minimum absorption at -8 dB at 1 GHz. The maximum absorption hit -60 dB at the frequency of 3.8 GHz. Based on the simulation for Design 2 in figure 6, at 2.5 GHz of frequency, the minimum absorption level shown is at -3 dB and the maximum absorption is -45 dB in the frequency of 6.7 GHz.
3.2 Measurement result

From the measurement results of figure 7, it has been shown that the flat absorber of Design 1 had a minimum absorption at -2 dB at a frequency of 1 GHz. The maximum absorption reaches the value of -28 dB at a frequency of 2.1 GHz. For Design 2, it had a minimum absorption at -4 dB at 1 GHz. The maximum absorption struck -43 dB at 10.2 GHz. For figure 8, measurement for Design 1, at 1 GHz result showed that minimum absorption is -0.8 dB and the highest value of absorption is -17 dB at 10.2 GHz. Meanwhile, on the Design 2, the minimum absorption is -6 dB and maximum absorption is -28 dB at 3 GHz and 11.9 GHz respectively. Based on the measurement results in figure 9, it has shown that the flat absorber of Design 1 had a minimum absorption at -2 dB at 1 GHz. The maximum absorption hit -47 dB at 11.3 GHz. For Design 2, it had a minimum absorption at -4 dB at 1 GHz. The maximum absorption struck -27 dB at 4.1 GHz. In figure 10, measurement for Design 1, at 1 GHz, the result shown a minimum absorption at -3 dB and the maximum absorption is -46 dB in the frequency of 10.7 GHz. Meanwhile, Design 2 had the minimum absorption of -0.6 dB and maximum absorption of -13 dB at 2.4 GHz and 11.9 GHz respectively. Table 1 shows the result of minimum and maximum data for measurement of absorber in a frequency ranging from 1 GHz – 12 GHz.

![Figure 7. Measurement Results for 0°](image1)

![Figure 8. Measurement Results for 15°](image2)

![Figure 9. Measurement Results for 30°](image3)

![Figure 10. Measurement Results for 45°](image4)
4. Conclusion
The objective of the research to observe the performance of the flat stick bamboo absorber is achieved. The results of simulation and measurement show the flat stick bamboo absorber is capable to absorb unwanted signals excellently.

At the measurement level of 0 ° and 15 °, the Design 2 produced of a 1 cm radius of stick bamboo shows the best absorption results. While at 30 ° and 45 °, the best absorption is from the Design 1 which is 0.2 cm radius stick bamboo. As a result of this study, the absorption performance is due to different dielectric constants and the radius of the bamboo. The results are matched with characteristics in terms of its better absorption.

Different radius form different design of structure. The bigger the radius, the bigger the area of open surface. It may affected the absorption of performance of microwave absorber since the larger area let the absorber to accept high capacity of transmitted signal [12]. The open surface is known as porous structure which creates ample amount of solid-air border. If the excess RF signal travels on these border, a strong space polarization occur, resulting in high attenuation of RF wave [13]. However, based on the results for both designs, the absorbers behaviour are differ when difference approach of testing applied to it. [12]

Based on the observation, both sets of the absorber are stable in a wide range of frequency. This research proves that the flat stick bamboo is capable as a microwave radiation absorber.

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