Design, Fabrication and Measurement of Microwave Absorbers

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1. INTRODUCTION

Anechoic chambers are popular indoor electromagnetic (EM) test facilities used for the measurements of EMI/EMC and antennas. By depending on the chamber structure and RF absorbers, the performance of anechoic chambers will be evaluated. In anechoic chamber, an absorber is used to absorb the reflected wave that occurs on the wall of the chamber [1]. Pyramidal-shaped absorber material is usually used for the frequency range from 1GHz to 40GHz [2]. The purpose of this study is to investigate the application of carbon powder as an absorbing material. Carbon is chosen due to its properties which is quite similar with ferrite and easy to get in local market with cheaper price. By adjusting the percentage of carbon loading, the better absorption from the absorber is determined.

2. DESIGN OF ABSORBER

Theoretically, the estimated range of frequency supported by the low cost absorber is from 1.5GHz to 15GHz, and the pyramidal shape is used in this project. From the literature review, the sides of the pyramids are able to reflect the incident wave when the pyramidal shaped absorber is larger compared to a lowest wavelength and the height of the pyramid is must greater than half wavelength. Thus, from the equation (1), the width of the low cost absorber is equal to the wavelength of the lowest frequency which is 1.5GHz whereas from equation (2), the height of pyramid is made larger than half wavelength of 1.5GHz because to ensure that the designated range of frequency for the absorber to be effective functioning is within the range. From the equation (3), the highest frequency supported by this pyramid is determined from the acceptable width of the pyramid’s tip. By considering the human error during the production process of the pyramid, the acceptable width of the pyramid’s tip is 2cm which is equal to the wavelength of the 15GHz frequency.

Width of the pyramid = wavelength of the lowest frequency supported , \( \lambda \)  
\[ \lambda = \frac{c}{f} \]  
where \( c = \) speed of light \((3 \times 10^8 \text{ m/s})\)  
\( f = \) test frequency at 1.5GHz
Length of the pyramid = half of the lowest wavelength
= $\lambda / 2$ (2)

Highest frequency supported by the pyramid = $c / \lambda$
where $c$ = speed of light
$\lambda$ = acceptable width at the tip (3)

The frequency tested is limited to 2GHz and 10GHz only due to the equipment limitation for measurement. Absorbers were made from polystyrene, which were cut into pyramidal shaped and then coated with carbon material. The dimension of the microwave absorber that has been designed is shown in Figure 1.

![Figure 1: Dimension of low cost pyramidal absorber](image)

3. ABSORBER MEASUREMENT

The measurements of absorbers were conducted to determine the performance of the low cost pyramidal absorber. The dimension of the sample to be tested is 60cmx60cm and to achieve the dimension required, nine absorbers were needed. The sample of nine absorbers is shown in Figure 2. When the reflection signal is at maximum level it shows the best location of absorber to be placed. The location of maximum reflection signal can be found when metal plate is placed in front of the antenna. The metal plate was adjusted until the maximum level of signal occurred. Then the absorber was placed at the location of maximum reflection occur when the metal plate was located. To reduce errors in the reflected signal, the direct path between the horn antennas is eliminated by placing a metal plate between the two antennas. For better measurement, the metal plate must be grounded so that the electromagnetic induce on the plate can flow direct to the ground. The measurements were conducted as shown in Figure 3. This measurement was conducted for frequencies, which are 8GHz and 13GHz. The average value then was calculated by adding all the data value and divide with number of data that have been taken as shown in equation (4). Before the absorption rate can be determine, the power transmitted is measured by connect directly the transmitter’s cable to receiver’s cable. The absorption rate then can be calculated by using equation (5).

$$Average\ Value(dBW) = \left[ \frac{Total\ PRx(dBW)}{No\ of\ Data} \right]$$ (4)

$$Attenuation(dBW) = P_{Tx}(dBW) - P_{Rx}(dBW)$$ (5)

where $P_{Tx}$ = Maximum power transmit
\[ P_{rs} = \text{Average power received for sample} \]

After all measurement to the sample of low cost absorbers have been made, the commercial absorber is tested. The available commercial absorber at UiTM Pulau Pinang is IP-045C which is produced by TDK RF solution Inc. The dimension of the commercial absorber is 60cmx60cmx45cm. Data result from the measurement for both absorbers are analysed and compared to determine the reliability and performance of the low cost absorber. The equation (6) is used to make comparison between low cost absorber and commercial absorber.

\[ \text{Percentage Difference} = | \left( \frac{P_C - P_L}{P_C} \right) \times 100\% | \]  

where \( P_C \) = Average Power received by commercial absorber  
\( P_L \) = Average Power received by low cost absorber

4. MEASUREMENT RESULTS

Figure 4 show that the higher percentage of carbon gives better absorption. The types of coating are dividing into two; oil based and water based. However the water-based coating results are below commercial absorber absorption. Oil-based coating gives better absorption compared to water-based coating, as shown in Figure 5. Oil-based coating gives absorption above 20 dB throughout the frequency range. Figure 6 shows that with oil-based coating, less amount of carbon is needed to give better result compared to water-based coating with more carbon.
5. CONCLUSION

The corresponding results show that carbon-coating can be used as an absorbing material. However, in order to improve the absorber performances there are a lot of factor to be considered such as the process of cutting the absorber, the equipment to used and etc. The results also should be verified by using commercial software such as CST and HFSS (High Frequency Structure Simulator) to determine the preliminary result.

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