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Direct Feed Biconical Antenna as a Reference Antenna

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Abstract*— Antenna factor is the main parameter in EMC measurement. Therefore, accurate and low uncertainty antenna is important in order to gain a reliable antenna factor. Direct feed biconical antenna has low uncertainty because balun can be eliminated in the design. Furthermore, the biconical antenna has fix phase center. This paper focuses on type of connectors and antenna sizes that are suitable to be used as a calibration antenna. The return loss for frequency range between 200Mz to 2GHz was measured using network analyzer and found to vary between 10dB to 20dB.

Keywords- electromagnetic compatibility; antenna calibration; biconical antenna; antenna factor.

I. INTRODUCTION

Electromagnetic Compatibility (EMC) is a critical issue in electrical and electronic products such as IT equipment, audio video and household devices. The crucial aspect in the EMC measurement is the accuracy of the site measurement and antenna. Antenna requires low uncertainty parameters such as antenna factor. Therefore, calibrated antenna is required for high precision field strength measurement to determine the radiated disturbance of a particular product.

Calibration of EMC antennas to determine the antenna factors are usually accomplished by using one of the three methods:

i. Standard Site Method (SSM)
ii. Standard antenna method (SAM)
iii. Standard field method

In the SSM measurement, test site must be calibrated accurately using normalized site attenuation (NSA) method [1]. However, calibrated antenna factor is required in order to verify the test site as an ideal site. The disadvantage of this method is the requirement of a calibrated antenna for the site validation. Consequently the uncertainty for both antenna and site attenuation measurement (NSA) will increase. Generally, in SAM, the antenna factor of the reference antenna must be known accurately and can be determined using measurement technique [2].

Antenna calibration using SAM and SSM require a standard reference antenna. This interrelation means that either the antenna factor must be known precisely for antenna calibration or the testing site must be near field accurate for the antenna factor determination. Accurate antenna factor can be achieved if the reference antenna is a calculable antenna with low uncertainty.

In EMC antenna calibration, accuracy and low uncertainty are important to ensure each measurement is perfectly satisfactory. Nevertheless, imbalanced faults of the balun always happen to some of the biconical antenna[3]. This causes unwanted current to flow on the outer conductor of the coaxial cable. As an alternative, the balun imbalanced must be design properly to reduce the uncertainty. However, balun with low uncertainty is difficult to design and its usage can increased the uncertainty during the antenna factor determination.

II. DIRECT FEED BICONICAL ANTENNA

The feed point of the existing biconical antenna is positioned at the center of the antenna as shown in Fig. 1 (a). This classic design uses a balun that can affect the accuracy of the antenna factor. As an addition, the balun usage also could limit the operating frequency due to the limitation balun bandwidth. Therefore, in this paper some modifications have been proposed for reference antenna in order to reduce the uncertainty and increase the frequency range.

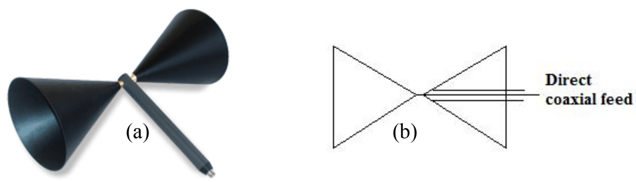


Figure 1. (a) Biconical antenna with balun, (b) Direct feed biconical antenna.

Fig. 1(b) shows the proposed biconical antenna with direct feed and no balun is required because the interfered radiation from coaxial cable is shielded by the cone itself.

A. Physical Characteristics

Our biconical antenna is fundamentally based on the conical antenna proposed by Papas and Kings [4]. For infinite biconical (very large *a*), the input impedance depends only on the flare angle, θ as shown in Fig.2. However, for finite biconical antenna, the input impedance is determined by the antenna height, *a* and flare angle, θ. Therefore, in order to determine the antenna size for 50 ohm input impedance, equations (1) to (4) can be used.

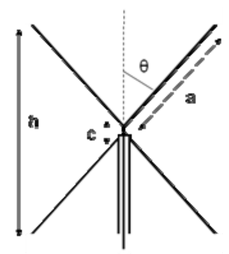


Figure 2. Physical characteristic of the direct feed biconical antenna. h= antenna height, a= antenna length, c= gap between cone, θ=Flare angle.

$$Z_{in} = 2x\left(Z_o \frac{1-\frac{\beta}{\alpha}}{1+\frac{\beta}{\alpha}}\right) \quad (1)$$

Where;

$$Z_o = 60 \ln \cot \frac{\theta_o}{2} \quad (2)$$

$$\frac{\beta}{\alpha} = e^{-2ika} \frac{1 + i\frac{60}{Z_o}\sum_{n=1}^{\infty}\frac{2n+1}{n(n+1)}[P_n(\cos\theta_o)]^2\zeta_n(ka)}{-1 + i\frac{60}{Z_o}\sum_{n=1}^{\infty}\frac{2n+1}{n(n+1)}[P_n(\cos\theta_o)]^2\zeta_n(ka)} \quad (3)$$

$$\zeta_n(ka) = \frac{h_n^{(2)}(ka)}{h_{n-1}^{(2)}(ka) - \frac{n}{ka}h_n^{(2)}(ka)} \quad (4)$$

Where k is a phase constant, $h_n^{(2)}$ is the spherical Hankel function of the second kind and $P_n(\cos\theta_o)$ is the Legendre Polynomial of order n.

Fig. 3 shows the variation of the input impedance with flare angles for 50 ohm system. It can be seen that the optimized flare angle is 65 degree. The input impedance (Rin + Xin) is verified by Simulation using CST-microwave studio and measurement using network analyzer as shown in Fig. 4. Both simulation and experimental results show good agreement with the analytical formulation.

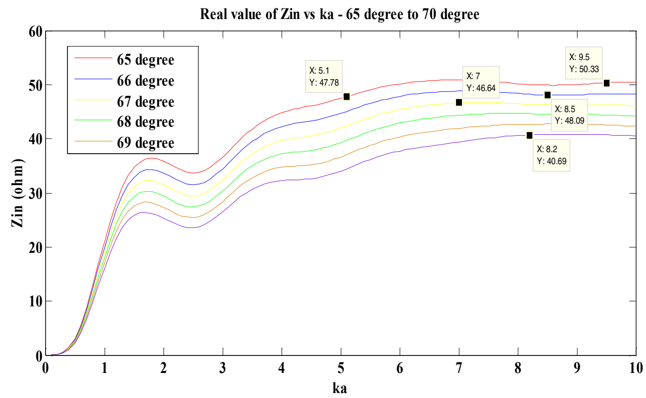


Figure 3. Various real input impedance (Rin) from 65 degree to 70 degree

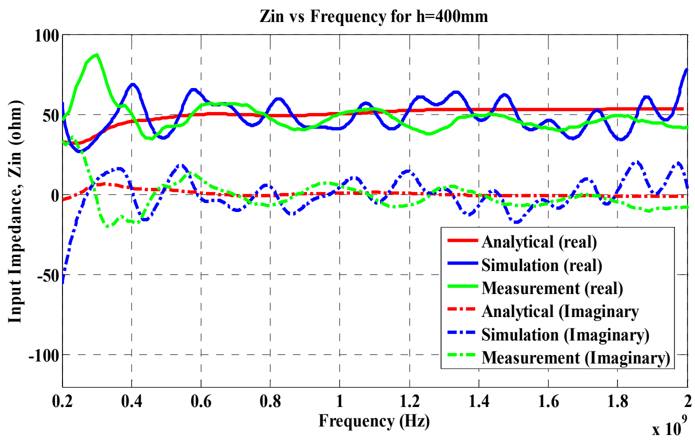
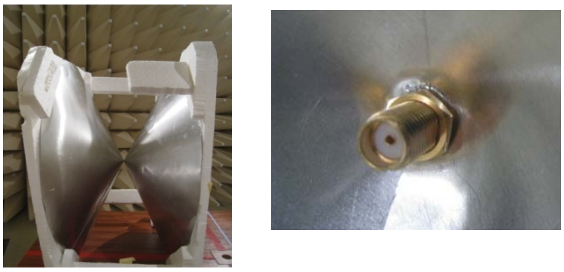


Figure 4. Input Impedance (Zin) for antenna height (h)=400mm

I. EXPERIMENTAL SETUP

All Measurements were conducted in a semi-anechoic chamber using network analyzer. The biconical antenna with direct feed as shown in Fig.2 was used for all measurements. The connector was tightly screwed to the first cone while the inner connector was directly attached to the second cone as shown in Fig. 5 (a).



(a) (b)

Figure 5. (a) Biconical Antenna Fabrication (b) SMA connector

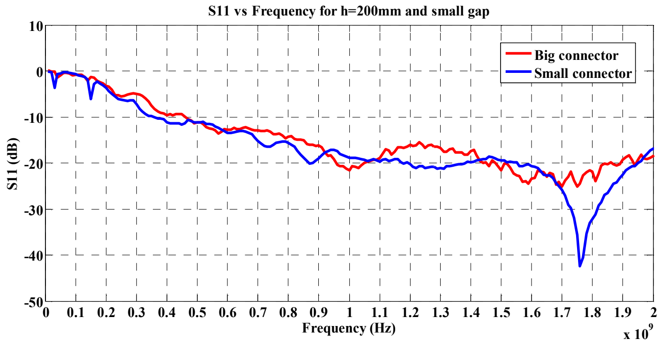


Figure 7. Return loss for h=200mm with different connector size.

The measurements were divided into two different sizes; height, *h*= 200mm and for *h*= 400mm. Both antennas were fabricated with 65 degrees flare angle to meet the 50 ohm condition. Each size was compared in terms of gap distance between cone, *c* and connector size being used. First, the return loss (S11) for two different gaps, c> 2mm and c< 2mm were measured. Second, the best gap between cones was chosen for each connector size.

In order to select the required return loss, small antenna, h= 200mm and big antenna, h=400mm were compared with the same gap and same connector size.

II. RESULTS AND DISCUSSIONS

The first step in this study is to analyze the small antenna with different connector sizes and different gaps between cones.

A. Small Antenna

Fig. 6 represents the result for two different gap sizes. It indicates that the gap between cones must be smaller than 2mm. Otherwise, there is a reflection from the antenna and worsen the propagation.

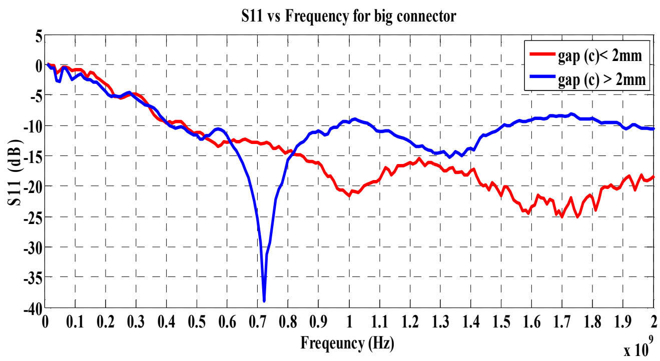


Figure 6. Return loss for h=200mm with different gap between cones.

The other important criterion in antenna design is the connector being used. Connector size has an effect to the antenna especially at high frequency. Fig. 7 shows the effect for small antenna with different connector size. SMA connector as a small connector is used for comparison with big connector (type-N connector). It can be seen that the small connector is better in terms of return loss compared to the larger connector as shown in Figure 7.

We can conclude that for the small antenna, the gap between cones should be smaller than 2mm and smaller connector (SMA) is preferred.

B. Large Antenna

For the large antenna, h= 400mm, and a=0.4325 m are chosen for this study. First, the gap between cones was studied. It indicates that the gap between cones must be smaller than 2mm as shown in Fig. 8. For gap greater than 2mm, the antenna cannot radiate effectively because S11 is greater than 10dB.

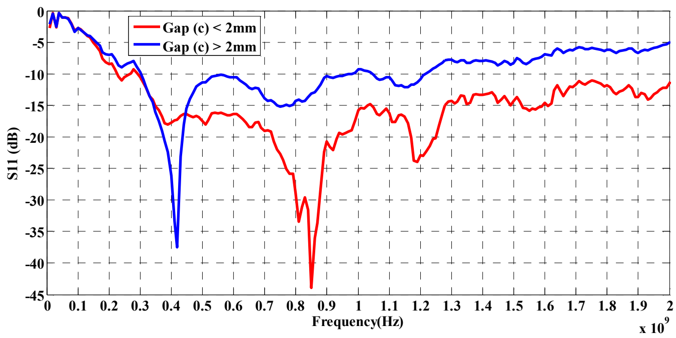


Figure 8. Return loss for h=400mm with different gap between cones.

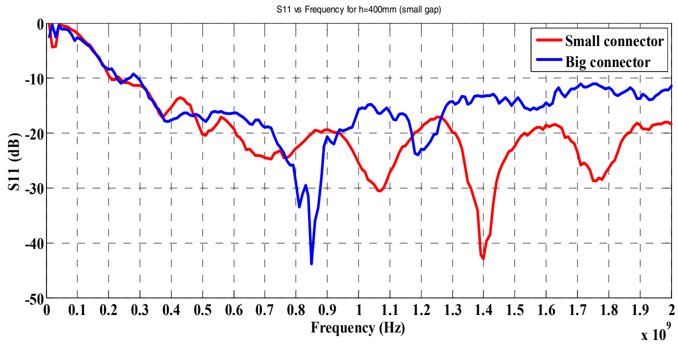


Figure 9. Return loss for h=200mm with different connector size.

Fig. 9 represents the comparison between small connector (SMA) and big connector (Type-N). It is obvious that the small connector gives higher S11 compared to the larger one. Especially at frequency greater than 1.3 GHz.

C. *Effect of Antenna Size.*

Fig. 10 shows the S11 for small antenna, h=200mm and big antenna, h=400mm. Previous analysis indicates that gap between cones and connector being use give an impact to the S11. Therefore, both cones use the same SMA connector and the gap between cones should not be greater than 2mm.
It is obvious that the larger antenna has better return loss between 200 MHz to 1.2 GHz but at frequency higher than 1.2 GHz, the return loss for both antennas are almost similar.

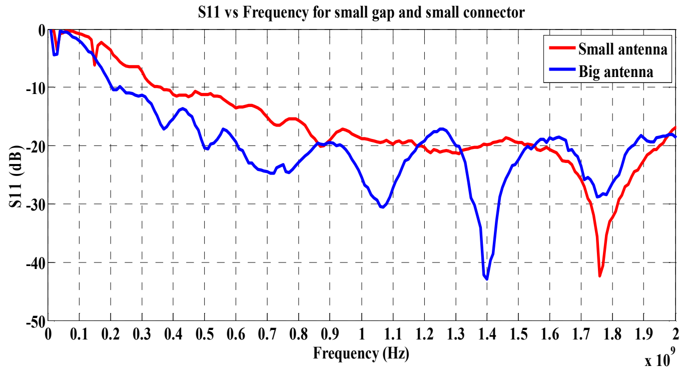


Figure 10. Return loss for different antenna size with small gap and small connector.

I. CONCLUSION

As a conclusion, bigger antenna with small connector (SMA) and small gap between cones give a better S11 and provide broadband behavior. This finding is important to ensure that the proposed antenna for antenna calibration will give accurate results. Only the best antenna design will be chosen for antenna factor determination. Due to the easy construction and without balun, this type of antenna can easily be fabricated for antenna factor calibration.

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