0.65 - 7 GHz Ultra-Wideband Spherical Self-Complementary Antenna

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Abstract **- We propose a spherical ultra-wideband antenna based on the self-complementary structure. The antenna employs a loop comprising of two symmetric teardrop shaped arms conformally printed on a three-dimensional sphere. To enhance the impedance matching bandwidth, the capacitive and inductive loading techniques are applied by broadening the antenna's front part and adding shorting strips at the rear part, respectively. Simulation and measurement results show that the proposed antenna is capable of covering the frequency range of 0.65 - 7 GHz which is suitable as a testing antenna in a mobile handset measurement chamber.**

Index Terms **— ultra-wideband, self-complementary, three-dimensional volumetric antenna, wideband matching technique.**

1. Introduction

Ultra-wideband (UWB) antennas have increasing demands in various applications, for example, military and commercial wireless communication systems, imaging and detection systems for medical and security purposes, etc. One traditional application of UWB antenna is the testing (reference) antenna in an antenna chamber. Such antenna should have wideband operation to avoid the use of multiple antennas to cover chamber's working frequency range.

In this paper, we are particularly interested in designing a UWB antenna for a reverberation chamber (RC). The latter is known as an effective, reliable, and economic measurement facility for evaluating the performance of wireless communication devices [1]. An RC needs a wideband reference antenna for calibration and for evaluating the fading channel performance inside the cavity.

We propose a spherical self-complementary antenna as illustrated in Fig. 1. The self-complementary structure provides a constant input impedance when the antenna conductor and its complementary empty space have the same shape and size [2]. For the proposed antenna we employ a pair of teardrop shaped conductors which are conformally attached to a spherical surface. Furthermore, capacitive and inductive loadings are applied to enhance the bandwidth by broadening the antenna's front part and adding shorting strips at the rear part, respectively.

2. Antenna design

As depicted in Fig.1, the teardrop shaped loop is attached on a spherical mount (ABS plastic with $\varepsilon_r = 2.8$ and $\tan\delta = 0.01$) while maintain the self-complementary structure [3]. The diameter of the sphere is assigned to be D = 125 mm which is close to one-quarter wavelength at 0.6 GHz. To enhance the bandwidth, the area around the feeding part is broaden to diverse the surface currents path (capacitive loading), similar to the fat dipole implementation [4]. On top of this, shorting pins are added at the rear part of the loop to miniaturize the antenna (inductive loading), therefore, lowering the operation frequency range.

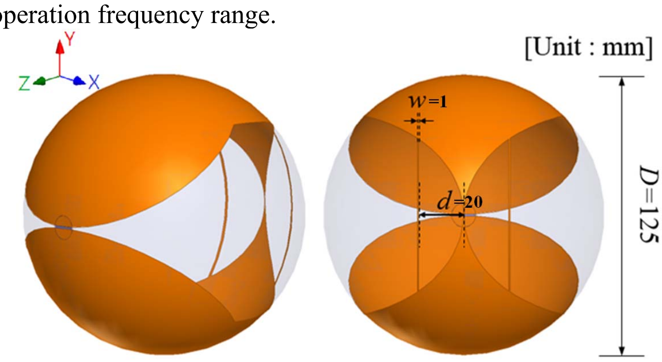

Fig.1 Antenna geometry

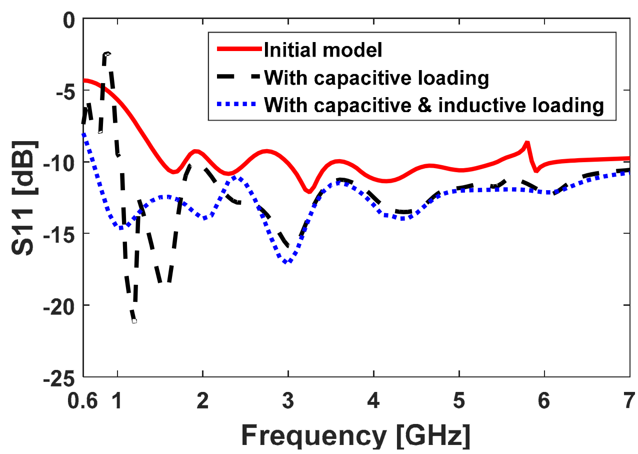

Fig. 2 S_{11} comparison

Fig. 2 is the S_{11} comparison demonstrating the effectiveness of capacitive and inductive loadings. The overall impedance matching condition was improved when the capacitive loading was applied and then, further improvement below 1 GHz was achieved by the inductive loading. After all, the $S_{11} \leq$ -10dB bandwidth covers 0.7-7 GHz, 10:1, close to the target bandwidth.

3. Fabrication & Measurement Results

In order to validate the optimized model, we proceeded to fabricate a prototype using 3-dimensional printer. Figure 3 shows the fabrication process and the antenna prototype. The ABS sphere with indents to identify the conducting and empty area was fabricated, and then copper tapes were attached on the frame.

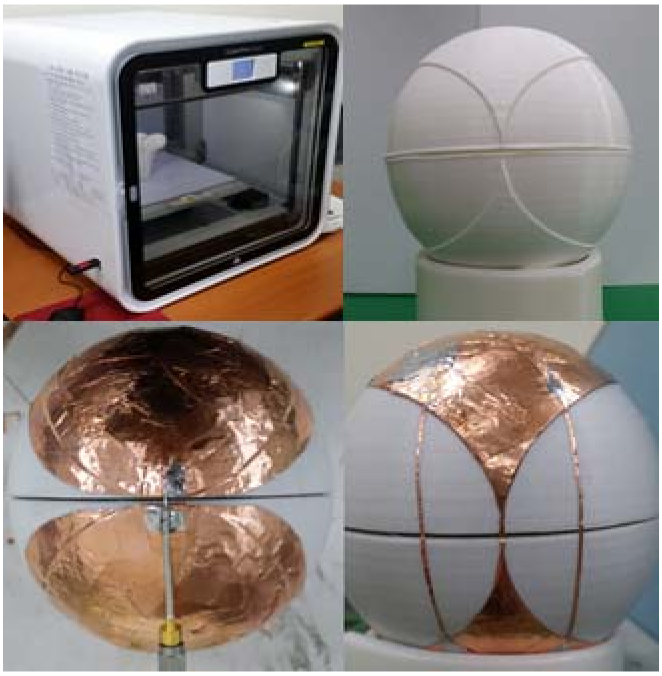

Fig.3 Fabricated prototype

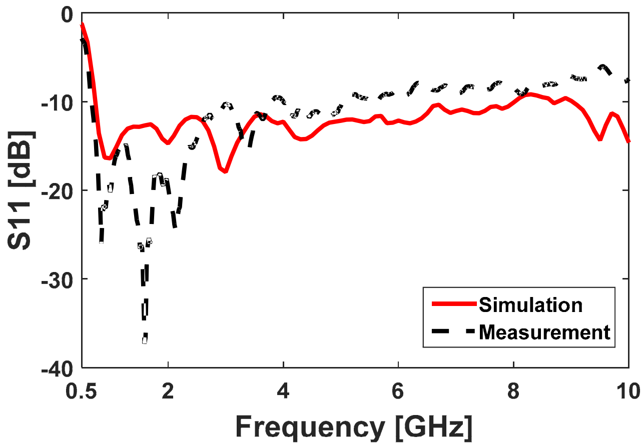

Fig.4 Measured and simulated S_{11}

Fig. 4 shows the measured results of S_{11} of the fabricated prototype. The measured S_{11} is lower than -9 dB at the frequency band of interest and has good agreements with the simulation data.

Fig. 5 shows the radiation patterns measured in an anechoic chamber at the frequency 0.61, 3.1, 4.9 and 7.2 GHz. The peak gain increases as the frequency goes up resulting the gain spans from 2.8 to 10.79 dBi at the frequency band of interest.

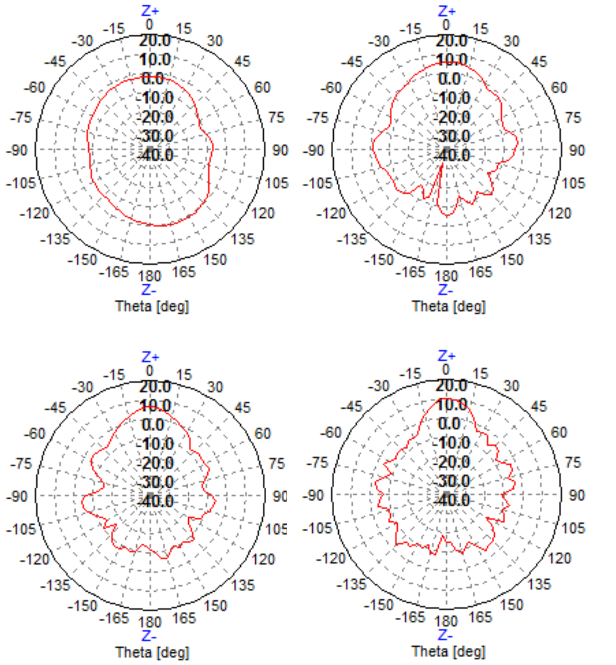

Fig. 5 Measured radiation patterns at 0.61, 3.1, 4.9 and 7.2.

4. Conclusion

A spherical ultra-wideband antenna employing self-complementary structure was investigated using full-wave simulations and measurements. The proposed antenna provides $S_{11} \leq$ -9dB reflection coefficient from 0.65GHz to 7GHz band, which satisfied ultra-wideband characteristic. The antenna gain was measured to be 2.8~10.79dBi along the operating band. For the future study, we intend to utilized hybrid coupler to stabilize and enhance antenna matching performance.

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