

Wideband Printed Planar Monopole Antenna Element for Wearable Application

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Abstract

The implementation of a wideband printed monopole antenna near a metallic shield is presented. A wearable antenna system application to probe the electromagnetic field, with frequency in the range 0.7-3.5 GHz (5:1 bandwidth), incident on a professional user is envisaged. A lossy foam layer is used between the shield and the antenna to absorb the shield reflection and avoid narrowing the bandwidth.

1. Introduction

Since the 90s there has been a permanent increase, with accelerated pace, in the deployment of mobile communication and Wi-Fi systems. With the advent of 5G a huge increase in the number of users and terminals as well as traffic is forecasted [1]. The deployment of new systems and the maintenance of existing ones demand the use of protective vests by professional workers. Moreover, the addition of new features in these vests, such as monitorization of the electromagnetic fields in the working space is under development [2].

To protect the workers from electromagnetic radiation hazard in their working environment their professional vests are lined with a protective metal shield. When the antennas are integrated in the vests near the shield their bandwidth decrease enormously. To avoid such bandwidth narrowing a layer of absorbing material is placed between the shield and the antenna. This papers presents the experimental characterization of the foam material used and the optimization of the corresponding layer thickness. Experimental reflection coefficient results are also included.

2. Antenna element configuration

The geometry of the single printed planar monopole element is shown in Fig. 1a. It consists on a modified octagonal patch monopole with coplanar waveguide (CPW) feeding [3]. It has been optimized to provide an input reflection coefficient below -10 dB in the frequency range 0.7-3.5 GHz. The typical monopole like radiation pattern is obtained with gain in the range 1.9-3.5 dBi [3]. Based on this element the dual-linearly polarized configuration composed of two orthogonal monopoles, shown in Fig. 1b, has been presented [3].

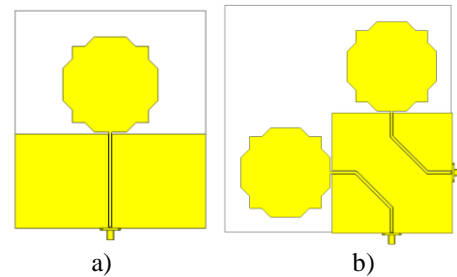


Figure 1: Antenna geometry, a) single monopole, b) dual-linearly polarized monopole antenna.

The work described in the present paper corresponds to the integration of the dual-linearly polarized monopole antenna element (Fig. 1b) with the metal shield, as shown in Fig. 2.

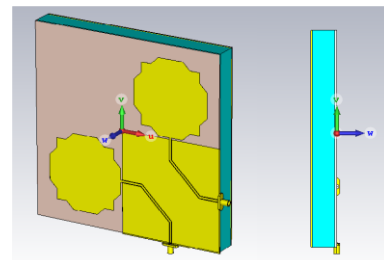


Figure 2: Dual-linearly polarized monopole antenna element with absorbing layer and metal shield.

3. Experimental characterization of the absorber

The absorber layer was obtained by slicing the planar region of an old anechoic chamber absorber panel. As the macroscopic characteristics (ϵ_r, μ, σ) of the panel are not homogeneous it was necessary to measure them. However, only ϵ and σ need to be measured since the panel material has normal magnetic behavior.

The real and imaginary parts of the relative (complex) electric permittivity, is defined as

$$\epsilon_r' - j\epsilon_r'' = \epsilon_r - j\frac{\sigma}{\omega\epsilon_0} = \epsilon_r (1 - j\tan\delta) \quad (1)$$

where ϵ_r is the relative electric permittivity, σ is the conductivity, ω is the angular frequency and $\tan\delta$ is the loss tangent. ϵ_r' and ϵ_r'' were measured using the free-space transmission method, where the transmission coefficient (amplitude or phase) of a link between two horn antennas is

measured with a VNA (Fig. 3), with and without the absorber layer in the middle.

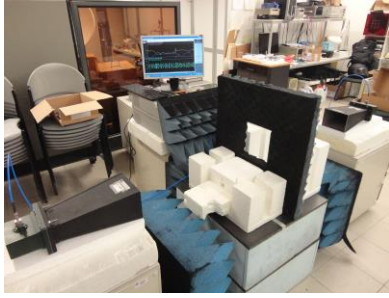


Figure 3: Setup for experimental characterization of the absorber.

The ϵ_r' and ϵ_r'' experimental results are shown in Fig. 4.

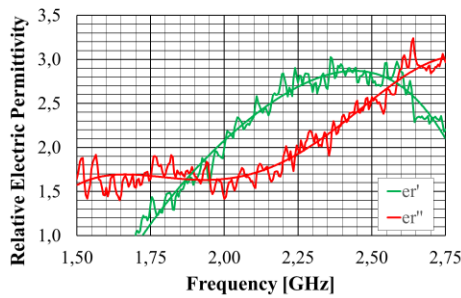


Figure 4: Experimental ϵ_r' and ϵ_r'' results.

These results have been used to calibrate the model of the absorber used in CST Microwave Studio. The ripple contained in the results is due to the reflections in the non-anechoic environment of the room.

4. Antenna optimization and test

The antenna geometry shown in Fig. 1b on top of the metallic shield and with the absorber layer in between them was simulated in CST Microwave Studio. Absorber thicknesses of 5, 10 and 15 mm have been simulated. The |S|-parameters' results obtained are shown in Fig. 5. The results of the free-space configuration (without shield and absorber) are also shown for reference.

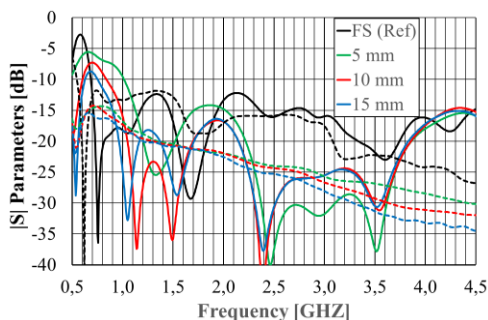


Figure 5: |S|-parameters simulation results for different absorber thicknesses, $|S_{11}|$ -solid lines, $|S_{21}|$ -dashed lines.

As it can be seen an absorber thickness of 10 mm provides and input reflection coefficient below -10 dB, except in the range 700-750 MHz where it is slightly above (-8.7 dB).

Moreover, mutual coupling is very low (below -14.3 dB) in all the cases.

Radiation efficiency and gain have also been simulated. As expected, due to the losses in the absorber, there is a substantial reduction of the efficiency and gain. Both decrease as frequency increases. The decrease is about 6 dB at 700 MHz and 9 dB at 3.5 GHz.

An antenna prototype, with a 10 mm thick absorber layer, has been fabricated and tested. The corresponding experimental S-parameters' results are shown in Fig. 6.

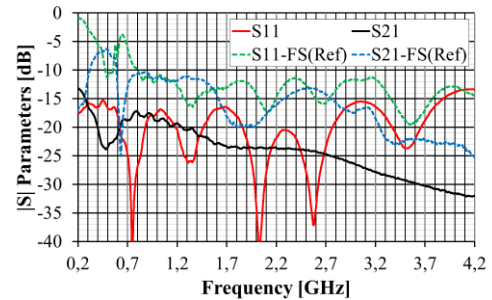


Figure 6: Experimental |S|-parameters' results.

The $|S_{11}|$ results of the antenna with metallic shield and absorber are considerably lower, compared with simulations, especially at low frequencies. This is due to a less accurate calibration of the absorber in that frequency region (a pair of horn antennas was not available for such frequency band). In the whole frequency band of interest both $|S_{11}|$ and $|S_{21}|$ are below -15 dB. This means it is possible to use a thinner (1 or 2 mm) absorber layer.

5. Conclusions

The paper presents the development of a dual-linearly polarized wideband monopole antenna element to be used in a professional vest lined with a protective metal shield. The use of an absorber layer is proposed to desensitize the antenna bandwidth from the presence of the shield. Input reflection coefficient and mutual coupling below -15 dB have been obtained with a 10 mm thick absorber layer sliced from an old anechoic chamber absorber panels. Naturally there is a substantial decrease (6 to 9 dB) in radiation efficiency and gain. However, this is not a problem for the envisaged application.

Acknowledgements

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References

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- [3] P. Falcão, C. Peixeiro, Dual-Linearly Polarized Wideband Printed Planar Monopole Antenna, *Proc. EuCAP*, Madrid, Spain, pp. 1-5, 2022.