# A Metamaterial-based Probe for EMC Measurements

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**Abstract**— In this work, planar probes for EMC — Electromagnetic Compatibility measurements are designed with metamaterials structures in order to improve its gain, bandwidth and resonance. Basically, three topologies are used (Jerusalem cross pair-JCP, fractal array and CSRR — complementary split ring resonator), in the square topology.

## 1. INTRODUCTION

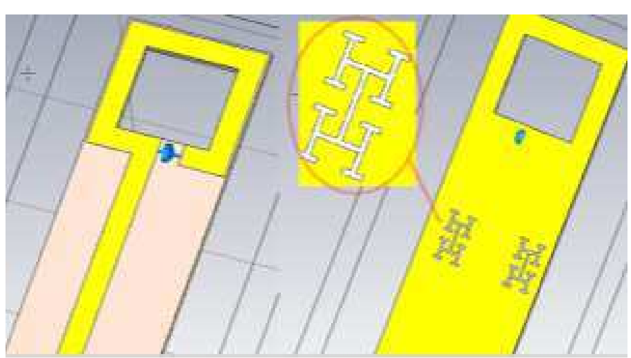
The electrical circuit of any electronic device generates some kind of noise, which can reach levels of power that interfere in undesired ways on the operation of the equipment around and the environment as a whole. Each device generates a characteristic noise, due to its electrical circuit [1]. Depending on the electromagnetic emission of these noises, other electronic devices can then receive the interference by a path of radiation or, much less frequently a direct electrical connection.

The necessity to control the electromagnetic emissions and interference between circuits and electronic devices becomes a crucial point to assure its correct operation inside an electromagnetic environment. Some approaches were designed to support the pre-compliance tests (EMC/EMI/EMS) setups. In this work, is shown the design of low cost planar probes with metamaterial patterns for EMC measurements.

Actually, metamaterial is a macroscopic composite of periodic or non-periodic structure, whose function is due to both the cellular architecture and the chemical composition [2]. Therefore, the behavior of a material, in the presence of an electric field, is determined by the macroscopic parameters, permittivity $\varepsilon$ and permeability $\mu$. Several metamaterial structures have been investigated along the last years. In particular, ones those are capable to provide artificial magnetic responses and electric walls. The artificial magnetic conductors can be obtained when a plane wave focus on the capacitive gap, while the artificial electric conductor is obtained through the opposite way.

In fact, the metamaterial pattern is applied to physical devices aiming to obtain specific responses. In [3] a CSRR structure is employed to a UWB antenna in order to provide a rejection characteristic in a desired frequency. On the other hand, in [4] metamaterial structures are applied to an UHF antenna and a better gain is obtained, while in [5] the periodic is structures are applied to the septum of a GTEM — Gigahertz Transverse Electromagnetic chamber, expecting a shift on the resonance frequencies.

In this context, to improve the performance in terms of gain, bandwidth, resonance, and provide a rejected band, three different topologies are employed in planar probes.



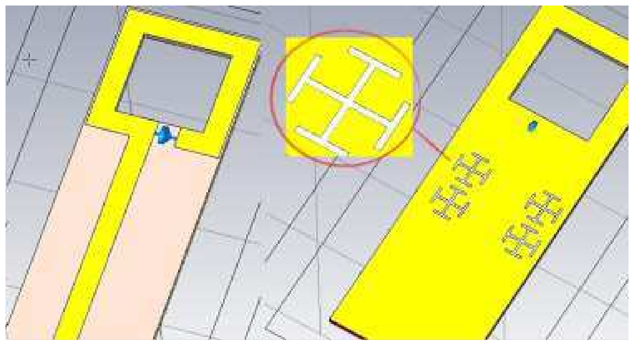
(a) (b)

Figure 1: Square planar probe with fractal cells and 2 cm of diameter: (a) top; (b) bottom.

## 2. PLANAR PROBES

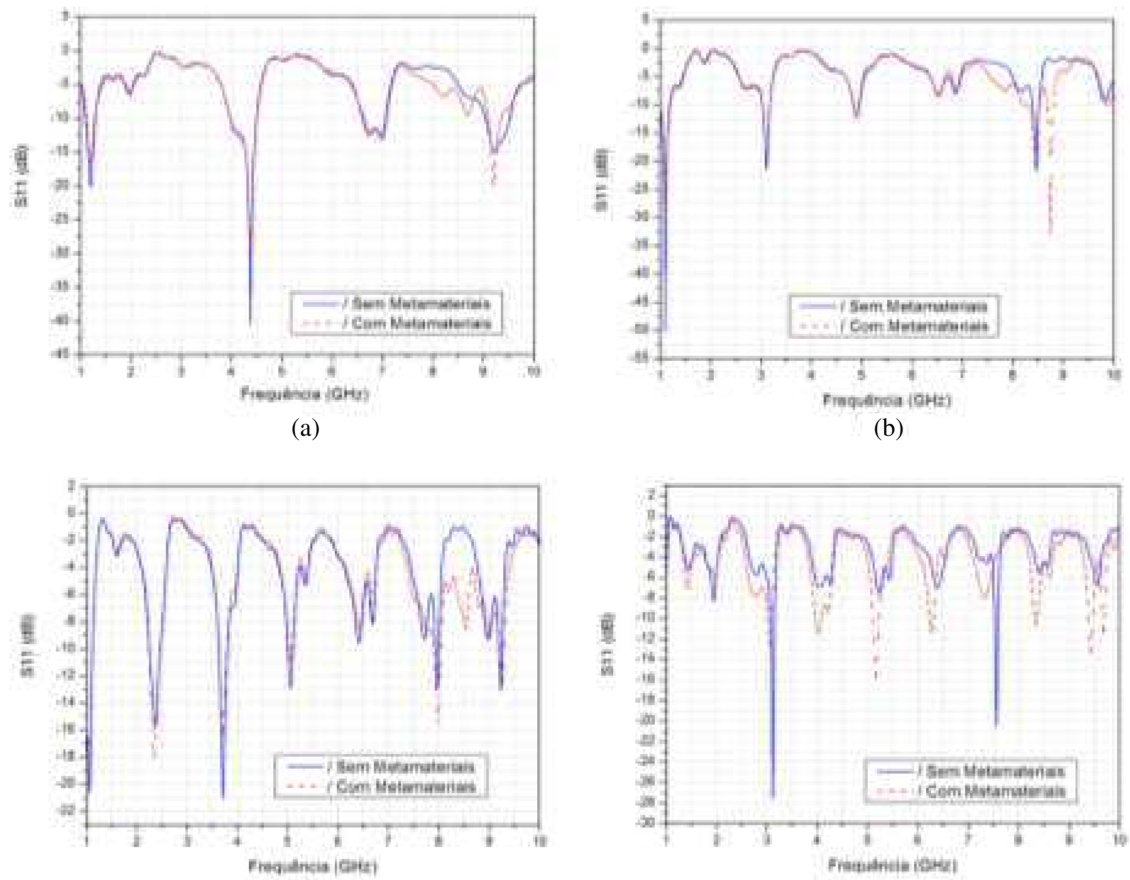
Generally, probes are designed in order to obtain low levels of disturbance in a wide range of applications. Thus, their shapes, balls or monopole and the variation of its diameter, are as a function of a frequency range, and if the field in question is electric or magnetic.

In this work, planar probes in square format are designed and improved in terms of bandwidth and gain with metamaterial technology. To minimize its impedance, a 50 Ω SMD resistor is used and the base of the probe has 6 cm of length. The diameter of the structures and the track width were varied in order to obtain the best response. The best combination consists of 5 mm of track width with 35 μm of thickness on the o ROGERS R3003 substrate with 1.5 mm of thickness with a full ground plane.



(a) (b)

Figure 2: Square planar probe with JCP cells and 2 cm of diameter: (a) top view; (b) bottom view.




(a) (b) (c) (d)

Figure 3: Comparison of $S_{11}$ parameter between planar probe with and without JCP cells: (a) 2 cm of diameter; (b) 3 cm of diameter; (c) 4 cm of diameter; (d) 5 cm of diameter.

Therefore, metamaterial technology were applied to the planar probes as the Fractal and Jerusalem Cross Pair patterns. In the next section, they are carefully shown.

## 3. METAMATERIAL PATTERN APPLIED TO THE PROBES

Several metamaterial structures have been developed along the last years. In particular, it provides artificial magnetic responses, electric walls and barriers. The CLL -Capacitivelly Load Loop, allows the creation of artificial magnetic and electric conductor, AMC and AEC respectively.

On the other hand, the Fractal pattern allows the increasing of the electrical length of the structure, keeping the physical length. The versatility of applications and the effects of the sub-wavelength, are the two main advantages of the fractal model in H-shaped.

Through the sub-wavelength properties, the overall system is capable to present a size smaller than the wavelength along of all resonance directions, so the structure can operate as a compact reflector. Its similarity with FSS — *Frequency Selective Surfaces* structures and also its simple modeling, amplifies the use of H-shape fractal structures.

Therefore, several planar probes were design with the fractal pattern. Basically, the metamaterial structures were placed on the top and on the bottom of the probes. In Fig. 1 is shown a square size planar probe with fractals H-shape structures on the bottom. Besides the Fractal pattern show good responses in several applications, no significant variation was obtained when it was associated to the planar probe. Thereby, the JCP pattern were applied.

In Fig. 2, the proposed structure is the planar probe with JCP cells, which provide an isotropic response to any polarized incident wave. In fact, in any orientation, its perpendicular components are responsible to provide a loop current near to the displacement current on the external arms of the unitary cell.

In Fig. 3 is shown the $S_{11}$ parameter of the planar probes with JCP cells as a function of its diameter. As expected, the efficiency of the metamaterial patterns are accentuated on the higher frequencies. Moreover, each configuration show a best resonance as a function of the diameter of the planar probe.

## 4. CONCLUSIONS

In this work, planar probes for EMC measurements were designed with metamaterials structures in order to improve its gain, bandwidth and resonance. Although it have been applied three different topologies in different strategic places on the planar probes, just the JCP cells showed efficiency, enhancing the resonance response in the high frequencies. Therefore, EMC measurements can be performed with this low cost planar probe.

## ACKNOWLEDGMENT

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