Radome enhancing multi-sector antenna radiation performances

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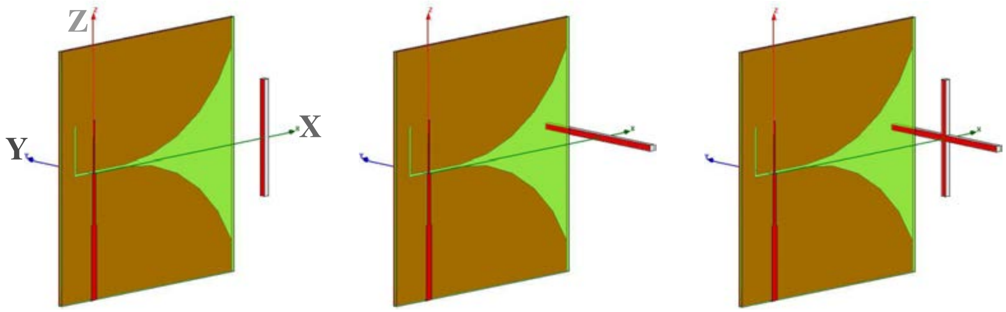
Introduction

To ensure protection from environmental conditions and human handlings, antennas are typically covered with volume dielectric radomes. However, it is normally considered that the presence of the radome in the near zone of the antenna radiation is a negative factor in electromagnetic sense. Indeed, antenna performances are changed by the presence of the radome: main beam is typically distorted, sidelobe levels get higher, and overall performance, first of all directivity, is affected [l-2]. This is partly due to the fact that such antenna systems are commonly not co-designed with the radome. This last is considered as a perturbation, we try afterwards to minimize its effect. In this paper, we introduce a new concept of use of the radome to improve antenna performances. The radome which is based on foam material is used as support of metallic elements that act as director or reflector for the multi-sector Vivaldi-type antenna. By a relevant design and location of these elements inside the radome, it is demonstrated in this paper that the antenna performances can be significantly improved. The approach has been validated with the design, realization and measurement of a 4-sector antenna system in the 5 GHz band.

Concept of metallic elements to modify radiation patterns

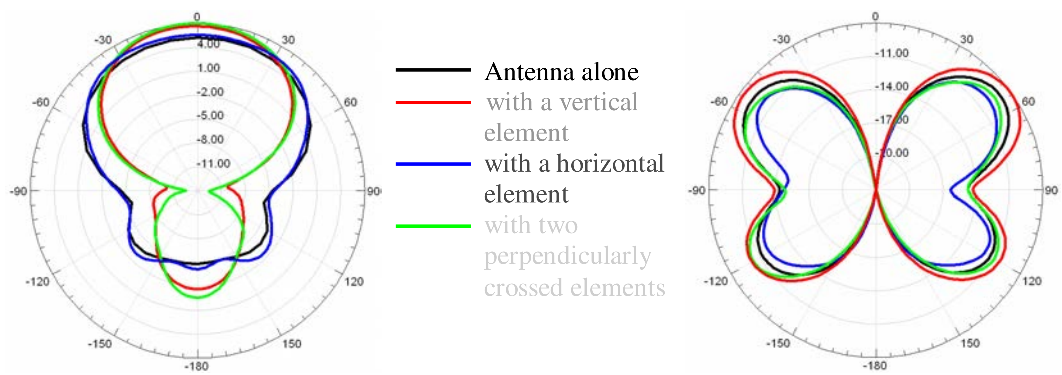
The novel concept of radome with inserted metallic elements is based on the Yagi-Uda antenna approach [3-4]. In this case, metallic elements are placed in front of a Vivaldi linearly tapered slot antenna (LTSA) type, as illustrated in Figure 1. Three cases are considered respectively. In the first one, vertical metallic patterns, placed in the E-plane (X-Z plane), increase antenna gain; they behave then like directors until a length of $\lambda/2$ and behave like reflectors beyond.
In the second case, the horizontal metallic patterns, parallel to the H-plane (X-Y plane), reduce the cross-polarization level. Finally, in the third case, the combination of two crossed metallic patterns increases the maximal gain from 5.8 dBi to 7dBi with a resulting reduction of the half power beamwidth from 125° to 80° in the azimuth plane (Figure 2a) and reduces the cross-polarization level of 2dB (Figure 2b). These results have been obtained without changing the antenna parameters. Nevertheless, these metallic elements, which are placed in the antenna aperture, change its electromagnetic environment and thus impair its input matching. In order to limit this parasitic effect, a disc pattern has been added at the junction of the two perpendicularly crossed metallic elements as illustrated

in Figure 3a. This central metallic disc improves the antenna input return loss, as shown in Figure 3b, without degrading the radiation patterns.



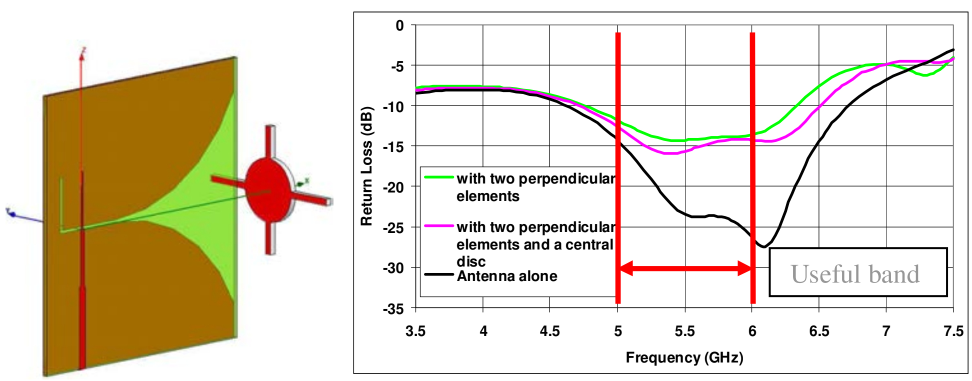
(a) (b) (c)

Figure 1: Vivaldi antenna with a vertical metallic pattern (a), a horizontal metallic pattern (b) and two perpendicularly crossed metallic patterns (c).



(a)Total gain (b)Cross-polarization levels

Figure 2 : Radiation patterns at 6GHz in the azimuth plane (X-Y plane).

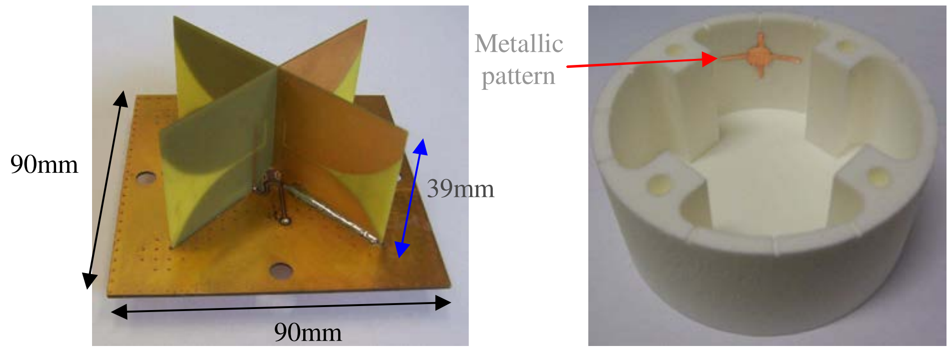


(a) (b)

Figure 3 : Vivaldi antenna with a new metallic element pattern.

Multi-sector antenna with radome: simulation and experimental results

In order to validate experimentally the “director” radome approach, this one has been applied to a 4-sector Vivaldi-type antenna (Figure 4a). More details on the design of this 4-sector antenna can be found on [5]. The antenna system is printed onto a FR4 substrate and the radome prototype, that supports the metallic elements (Figure 4b), is made of Rohacell HF71 foam material (ε_r=1.07, tan δ=0.02). The radome is placed onto the 3D multi-sector antenna in order to protect it (Figure 5) and so that the metallic elements are placed facing each Vivaldi antenna. Regarding the experimental performances, the central metallic disc added to the metallic patterns limits the matching impairment level in comparison with the matching level of the antenna without radome (Figure 6). Moreover, the measured radiation patterns confirm the benefits of this new concept that is to say, total maximal gain increases from 4.5 to 5.9dBi and cross-polarization level decreases of about 1.5dB in this example (Figure 7).



(a) (b)

Figure 4 : Four-sector antenna system (a). Radome with metallic patterns (b).

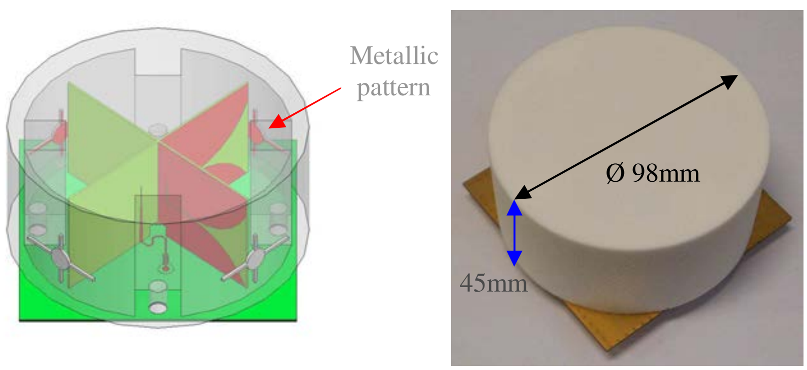


Figure 5 : Four-sector antenna system with a Rohacell HF71 radome.

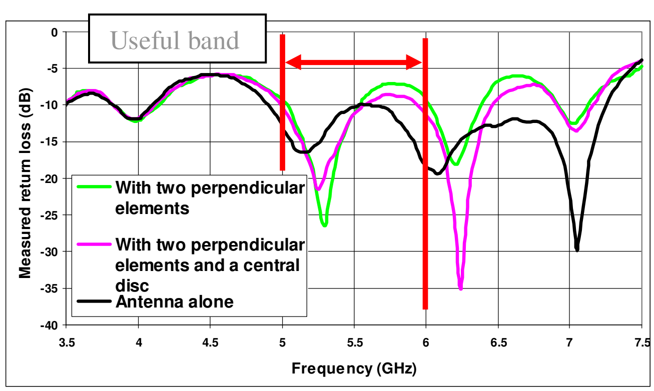
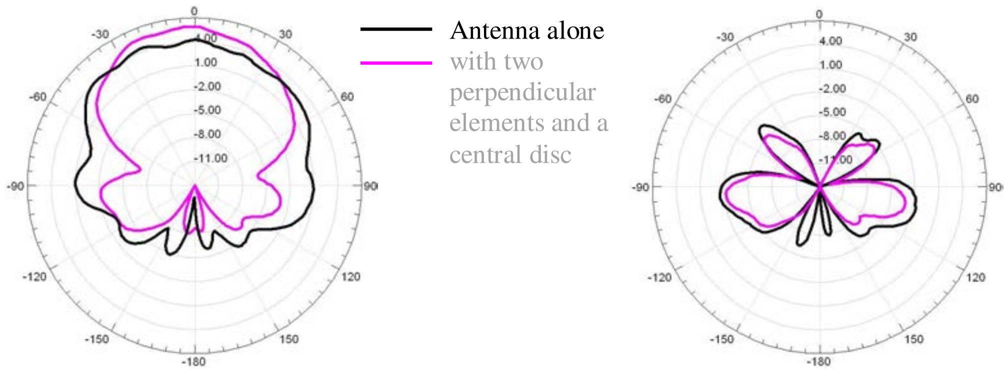


Figure 6 : Measured return loss of the multi-sector antenna system with several kinds of metallic elements.



(a)Total gain (b)Cross-polarization levels

Figure 7 : Measured total gain and cross polarization level at 5.5GHz in the azimuth plane (X-Y plane).

Conclusion

A novel and original concept of relevant radome has been introduced and validated by the design of a foam radome prototype applied to a multi-sector antenna. Metallic elements, directly positioned into the radome, allow to control the antenna radiation pattern. The fact of using radome to support the metallic elements makes it an integral part of the antenna system. Obtained measurements results on a realized 4-sector antenna system with optimized radome patterns showed significant gain improvement and a slight reduction of the cross-polarization level. These interesting results were obtained without modifying the initial antenna dimensions and without significantly degrading the antenna matching in the design frequency band.

References:

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