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A Compact, Circularly Polarized Antenna for Tri-band Operation Using a Ferrite Material

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***Abstract*— A single fed, compact and circularly polarized patch antenna operating in three frequency bands is proposed in the present paper. This patch antenna uses a polarized ferrite substrate which therefore has the property of naturally generating circularly polarized waves. A prototype measurement has been carried out for an experimental validation of the simulated results.**

Keywords—Miniaturization, ferrite, circular polarization

I. Introduction

In the current work, an appropriate method to acquire a good circular polarization and a tri-band operation while having a miniature antenna, is addressed. The idea is to consider a ferrite material as substrate. Ferrites, when they are polarized by a static magnetic field, are able to generate circularly polarized modes (RHCP and LHCP) at different frequencies [1], even if the antenna is excited through a single probe feed. In addition, due to the need for miniaturization, these magnetic materials are an interesting solution to reduce the size of antennas since they have a permeability greater than 1 combined to a high permittivity. Various studies have been reported in the literature on ferrite antennas, but with few experimental results. The present paper describes an experimental validation of a tri-band, circularly polarized patch antenna based on a ferrite substrate. The antenna is miniature on its two first modes.

II. Measurement Results of a Miniature, Tri-band and Circularly Polarized Patch Antenna

The designed antenna configuration is described in Fig. 1. The proposed design is based on a rectangular ferrite substrate Y39 (Yttrium – Aluminum) of 10,5mm×10mm×3mm with ε_r=14.4, $tan\delta$=2e-4, $4\pi M_s$=800Gauss and ΔH_{eff}=4Oe. The substrate is placed on a square ground plane of 20mm×20mm. The device is fed by a single coaxial probe and the ferrite is polarized using two permanent magnets providing an average internal magnetic field of about 1400Oe. The first magnet is placed on the top of the patch and the second one under the ground plane. Two steel plates are inserted between the magnets and the antenna elements in order to homogenize the internal magnetic field. All the simulated antenna performances are evaluated but only the measurement results are investigated in the present paper.

Considering the $|S_{11}|$ and axial ratio measured and depicted in Fig. 2, it can be observed that we have three modes at 3.3GHz, 3.9GHz and 7.54GHz, respectively. The axial ratio plot shows that the antenna presents a good boresight circular polarization. In fact, it is lower than 2.6dB for the two first working bands and 3.9dB for the third band where the $|S_{11}|$ is lower than -6dB. As to the radiation efficiency, the antenna radiates more than 79% of the accepted power on the first mode, 75% on the second mode and 95% on the third mode. The antenna can achieve an intrinsic gain of 1.8dBic, 2.6dBic and 3.7dBic at the three central frequencies. As to the antenna dimensions, the device presents a size of $\frac{\lambda_0}{9.1}\times\frac{\lambda_0}{8.7}\times\frac{\lambda_0}{26}$ at 3.3GHz, $\frac{\lambda_0}{7.7}\times\frac{\lambda_0}{7.3}\times\frac{\lambda_0}{22}$ at 3.9GHz and $\frac{\lambda_0}{4}\times\frac{\lambda_0}{3.8}\times\frac{\lambda_0}{11.4}$ at 7.54GHz which confirms that the antenna is quite miniature on its two first modes.

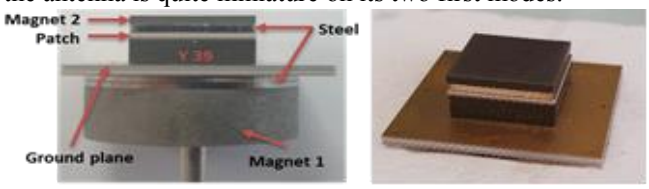

Fig. 1 The side (a) and front (b) views of the prototype.

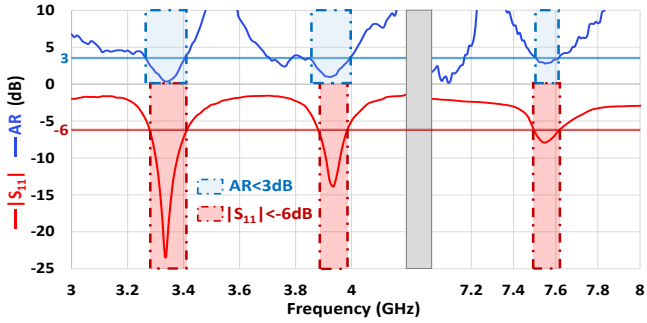

Fig. 2 The measured $|S_{11}|$ parameter and axial ratio (AR).

III. Conclusion

A comparative study of the simulated antenna performances and the measurement results will be presented during the conference. Indeed, further explanations about evaluating a ferrite antenna behavior will be detailed in two cases. The first one consists of simulating the antenna while considering a homogenous internal field and the second one is when the ferrite is magnetized using commercial magnets.

References

[1] D. M. Pozar, "Radiation and Scattering Characteristics of Microstrip Antennas on Normally Biased Ferrite Substrates", *IEEE* Trans. Antennas Propag., Vol. 40, no. 9, pp. 1084-1092, Sept. 1992.