A Q-band Fabry-Perot antenna for access and backhaul communication networks

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***Abstract*—A Fabry-Perot antenna operating at Q-band is proposed for access and backhaul communication networks. The antenna consists of an air-filled cavity fed by a patch and delimited by a PRS made of a dielectric layer with small periodic patches. The FP antenna has been designed and manufactured. A gain of 15 dBi has been measured at 43.10 GHz.**

I. INTRODUCTION

The use of the frequency Q-band (40.5 to 43.5 GHz) can provide high performing and integrated network nodes for the wireless backhaul of future mobile radio and last mile access [1]. In this context, the Fabry-Perot (FP) antenna represents an attractive technology to provide an efficient directive beam pattern for point to point communication links. The FP antenna usually consists of a cavity, excited by a single or several EM sources and a partially reflecting surface (PRS), from which the leaky wave is radiating [2][3]. The FP antenna has interesting properties: it is low-profile, light weight and can be made at low cost. Compared to a standard patch array, the FP antenna does not require a complex beam forming network; since the excitation of the leaky wave inside the FP cavity is accomplished by a simple feed source.

In this paper, a compact Q-band FP antenna is proposed for access and backhaul communication network. This work has been carried out in the context of the FP7 European project SARABAND.

II. ANTENNA DESIGN

At Q-band, loss is a major concern. To limit the loss in the antenna, the proposed architecture maximizes the use of air dielectric layers in the antenna construction. Therefore, the FP cavity is filled with air. In addition, the patch exciting the FP cavity is within an air-filled cavity, which is integrated in the ground plane as depicted in Figure 1. The patch is fed through a coupling slot which is excited by a 50 Ohm microstrip line located underneath the antenna. The PRS is made of a dielectric slab with small printed periodic patches. The dielectric substrate used is Roger 5880. The thickness of the PRS and the patch substrates is 0.51 mm. The thickness of the microstrip line feed substrate is 0.254 mm.

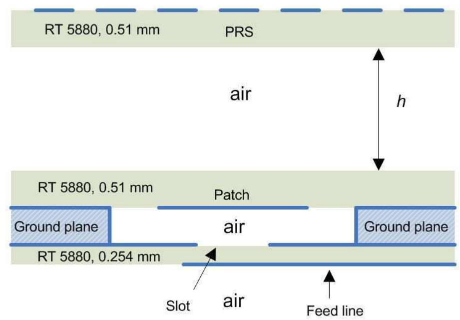

Figure 1: FP antenna configuration.

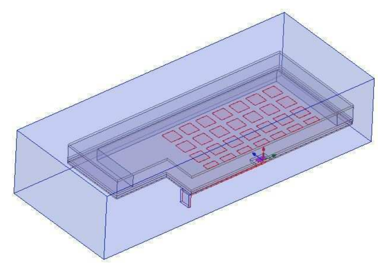

Figure 2: Model of one half of the FP antenna.

As a first approximation, the unit cell of the PRS has been modeled in an infinite environment and optimized to provide high reflection properties at 42 GHz; which is the intended design frequency.
The finite size PRS of the FP antenna is made of 7 × 7 small patches. Figure 2 presents the model of one half of the antenna. The symmetry in the geometry provides the possibility to analyze half of the model using a magnetic symmetry plane. The height (*h*) of the FP cavity has been optimized to obtain a highly directive pattern in the broadside direction.

To mechanically support the PRS from the edges of the antenna, an aluminium ring has been inserted in the FP cavity. Circuit and aluminium parts have been made and assembled using nylon screws. A 2.4 mm end-launch connector is used to feed the antenna from the side. The antenna is shown in Figure 3, mounted on a plexi glass support. The photo shows two adjusting pins, which have been used to align accurately the parts together.

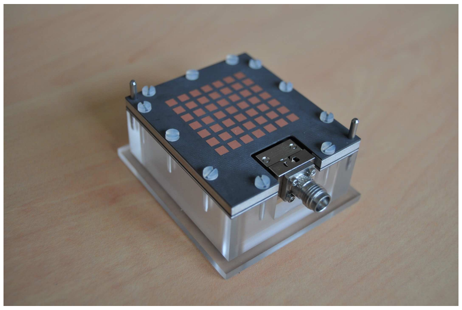

Figure 3: Manufactured Q-band FP antenna.

TABLE I. ANTENNA PARAMETERS.

PRS size = 30 mm ×30 mm
PRS periodicity = 4.20 mm × 4.20 mm
PRS patch size = 2.88 mm × 2.88 mm
FP cavity height (*h*) = 2.79 mm
Patch cavity size = 3.57 mm × 3.57 mm
Ground plane thickness = 0.5 mm
Coupling slot = 2 mm × 0.4 mm

III. ANTENNA PERFORMANCE

The S parameter measurements of the antenna have been performed using a TRL calibration kit, which has been specifically designed and manufactured for the antenna under test. The TRL calibration is used to remove the effect of the end-launch connector from the S-parameter measurements. The reference plane for measurements is then positioned on the microstrip feed line; a few mm away from the coupling slot feeding the patch in the cavity.

The reflection coefficient of the antenna without the PRS presents a deep resonance at 42.3 GHz (Figure 4). Measurement and simulation results fit well together. In the presence of the PRS, the agreement is degraded and an up shift of the resonant frequency is observed. A reflection coefficient level of -10 dB is noted around 43 GHz.

Gain measurements of the antenna have been performed using two calibrated horns. The gain is optimum at 43.10 GHz with a value of 15 dBi. The gain of the antenna without the PRS has been measured to be 7.4 dBi at 43.1 GHz. The addition of the PRS provides an increase of 7.6 dB on the antenna gain value. Over the frequency band 41.8 to 44 GHz, the FP antenna gain is greater than 10 dBi. The antenna bandwidth with respect to the maximum gain (Gmax) is:

- BW (at -1dB below Gmax) = 0.65 GHz
- BW (at -2dB below Gmax) = 1.00 GHz
- BW (at -3dB below Gmax) = 1.60 GHz

The radiation pattern of the antenna has been measured in both E and H-planes (Figure 5). The antenna produces a well formed main beam pattern, confirming the FP resonance effect.

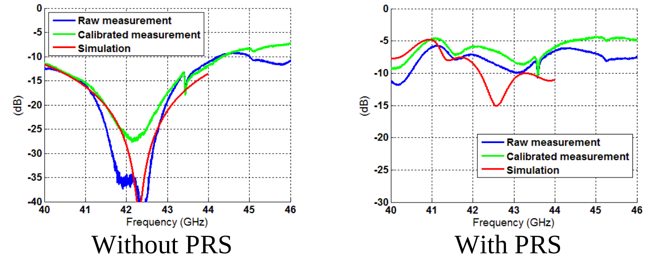

Figure 4: Reflection coefficient of the antenna.

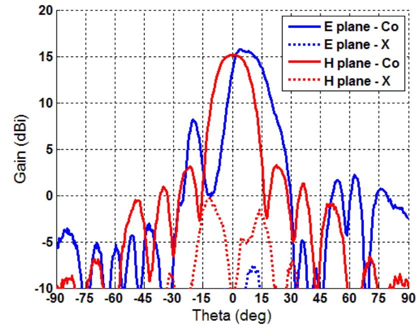

Figure 5: Measured gain pattern of the FP antenna at 43.1 GHz.

As expected by the antenna geometry, a smooth and symmetric H-plane pattern has been measured. In the H-plane, the -3 dB beamwidth is 18° and the first side lobes are 12 dB down from the maximum power. In the E-plane, the antenna dissymmetry due to the feed line, the connector and the feed cable, produces an asymmetric field pattern. In addition, maximum gain is not at broadside but occurs at about 3 degrees from broadside. Cross polarization levels are lower than -15 dB from the main beam.

To improve the antenna matching in the presence of the PRS, further optimisation is being performed.

IV. CONCLUSION

An air-filled Fabry-Perot antenna has been proposed for access and backhaul communication network in the Q-band. The antenna presents a directive beam pattern in the broadside direction with a gain of 15 dBi at 43.10 GHz. The presence of the PRS tends to degrade the reflection coefficient of the antenna. Further work is in progress to improve the matching of this initial design.

REFERENCES

[1] Website of the SARABAND project: www.saranbandfp7.eu

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[3] D. R. Jackson, P. Burghignoli, G. Lovat, F. Capolino, J. Chen, D. R. Wilton, and A. A. Oliner, "The fundamental physics of directive beaming at microwave and optical frequencies and the role of leaky waves", Proceedings of IEEE, vol. 99, No. 10, october 2