Research Networking Programmes

Short Visit Grant ☒ or Exchange Visit Grant ☐

(please tick the relevant box)

Scientific Report

The scientific report (WORD or PDF file – maximum of eight A4 pages) should be submitted online within one month of the event. It will be published on the ESF website.

Proposal Title: IMPROVED DESIGN, FABRICATION AND TESTING OF FOCUSING DUAL-LAYER PILLBOX ANTENNAS

Application Reference N°: 7186

1) Purpose of the visit

The visit aimed in finalizing the pillobox antenna developed by the two institutions by improving the bandwidth of the design and the focusing capabilities, paving the way for the realization of a first prototype. The goal is to strengthen the collaboration between IETR and UNIPV, taking advantage of the complementary skills of the two teams: IETR has proposed pillbox antennas for 2D quasi-optical systems, while UNIPV has strong experience in the design and analysis of parabolic systems.

2) Description of the work carried out during the visit

Background
Focusing pillbox antennas can offer some of the advantages of normal reflector antennas, e.g., high-directivity beams, while exhibiting a very low profile and convenient manufacturing processes based on printed-circuit technologies [1]. For these reasons they are suitable for several applications, such as automotive radars and low-profile Satcom terminals (e.g., in-flight and high-speed train entertainment) [2].
However, these applications often require scanning capabilities [3]. Nevertheless, an efficient solution providing a continuous coverage while maintaining a high radiation efficiency is not achieved yet. An approach based on coaxial-like sources and Fabry-Perot cavities [4] was investigated in the framework of a research collaboration between IETR and UNIPV in 2014. This feed configuration reduces the mutual coupling amongst sources by exciting several out of phases leaky-wave modes between a partial reflecting

screen and ground plane made by vertical metallic vias in a parallel plate waveguide environment. In addition, the proposed feed may be used to focus and shape the energy over the pillbox transition (integrated parabolic reflector) to further improve the efficiency of the antenna.

Activities

During the visit different strategies to improve the antenna bandwidth and scanning capabilities were discussed. To this aim, two points made available due to this visit were instrumental to guide the most appropriate development. First, the possibility to analyze in detail the previous prototypes fabricated by IETR and the available manufacturing and measuring facilities was important to better understand the current state-of-the-art for this type of antennas. Second, during the visit the sending institution gave a seminar on advanced technologies for ground station that was important to present the methodologies developed by UNIPV for the analysis of complex reflector antennas [5, 6], which could find an application to achieve better performance for this type of antennas.
It was also clarified that both institutions are interested in developing this type of antennas for mm-wave imaging systems, in the case of UNIPV with a large relative operation bandwidth (2:1) and intended for bio-medical applications.

Particular care was given to study the scanning potentials and fundamental limits of planar antennas. The possibility to apply the strategy developed by UNIPV was discussed [5, 6], along with the possibility to use a commercial software available from UNIPV (Ticra GRASP) to verify and benchmark the antenna designs. In addition, it was discussed in detail two different options for the manufacturing technique. First, the Beam Forming Network (BFN) may be realized in Substrate Integrated Waveguide (SIW) technology to reduce the fabrication costs. Second, the entire structure may be realized using 3D printing techniques to further reduce the cost and to investigate the performance for this emerging opportunity. It was clarified that both UNIV and IETR can make available 3D printers, while UNIPV could exploit its in-house code BI-RME to speed up the design of the BFN in SIW technology [7]. At the same time the MoM-MM code developed by IETR could be used to a fast design of both the radiating and guiding structure [8].

With the aim to support the activities described above, it was agreed to strength the collaboration between UNIPV and IETR promoting a mutual exchange of Ph.D. students and Postdocs. The possibility to apply also for other funding opportunities supporting this type of initiatives was taken into account (Galileo Program: http://www.universite-franco-italienne.org/appel+a+projets-it-24-programma+galileo.html), and a co-tutoring agreement for MS and Ph.D. students was already signed.

SHORT LIST OF REFERENCES:

[1] M. Ettorre, R. Sauleau, and L. Le Coq, “Multi-Beam Multi-Layer Leaky-Wave SIW Pillbox Antenna for Millimeter-Wave Applications,” IEEE Transactions on Antennas and Propagation, Vol. 59, No. 4, pp. 1093–1100, April 2011.

[2] M. Ettorre, R. Sauleau, L. Le Coq, and F. Bodereau, “Single-Folded Leaky-Wave Antennas for Automotive Radars at 77 GHz,” IEEE Antennas and Wireless Propagation Letters, Vol. 9, pp. 589–862, 2010.

[3] E. Gandini, M. Ettorre, M. Casaletti, K. Tekkouk, L. Le Coq, and R. Sauleau, "SIW Slotted Waveguide Array With Pillbox Transition for Mechanical Beam Scanning," IEEE Antennas and Wireless Propagation Letters, Vol. 11, pp. 1572–1575, 2012.

[4] E. Gandini, M. Ettorre, R. Sauleau, and A. Neto, "Mutual Coupling Reduction of Fabry–Perot SIW Feeds Using a Double Partially Reflecting Pin-Made Grid Configuration," IEEE Antennas and Wireless Propagation Letters, Vol. 10, pp. 647–650, 2011.

[5] A. Giannini, F. Pelorossi, M. Pasian, M. Bozzi, L. Perregrini, P. Besso, and L. Garramone, "The Sardinia Radio Telescope Upgrade to Telemetry, Tracking and Command: Beam Squint and Electromagnetic Compatibility Design," IEEE Antennas and Propagation Magazine, Vol. 57, No. 1, Feb. 2015.

[6] P. Besso, M. Bozzi, M. Formaggi, and L. Perregrini, "A Novel Technique for High-Performance Correction of Beam Aberration in Deep Space Antennas", IEEE Antennas and Wireless Propagation Letters, Vol. 6, pp. 376–378, 2007.

[7] M. Bozzi, L. Perregrini, and K. Wu, "Modeling of Conductor, Dielectric and Radiation Losses in Substrate Integrated Waveguide by the Boundary Integral-Resonant Mode Expansion Method," IEEE Transactions on Microwave Theory and Techniques, Vol. 56, No. 12, pp. 3153–3161, Dec. 2008

[8] M Casaletti, G Valerio, J Seljan, M Ettorre, and R Sauleau, "A full-wave hybrid method for the analysis of multilayered SIW-based antennas," IEEE Transactions on Antennas and Propagatio , Vol. 61, No. 11, pp. 5575–5588, Nov. 2013.

3) Description of the main results obtained

The main results can be summarized as follows:

1.Setup of future work and collaboration between UNIPV and IETR

2.Detailed visit of IETR antenna prototypes and manufacturing/measuring facilities

3.A seminar on advanced technologies for ground station was given by UNIPV

4.The possibility to apply the design approach developed by UNIPV to study the aberration of ground stations to improve the performance of the planar antennas was discussed, also analyzing in detail the scanning potentials and fundamental limits for this type of structures

5.UNIPV to make available a commercial software (Ticra GRASP) to verify the antenna designs

6.The possibility to apply two different options for the manufacturing technique (SIW and 3D printing) was discussed in detail, clarifying that both UNIV and IETR can make available 3D printers. Besides, UNIPV could exploit its in-house code BI-RME to speed up the design of the BFN in SIW technology in parallel to the MoM-MM developed by IETR for multi-layer SIW structures.

7.A mutual exchange of Ph.D. students and Postdocs was agreed

8.The possibility to apply for other funding opportunities supporting this type of initiatives was taken into account (Italy-France Galileo Program)

9.A co-tutoring agreement for MS and Ph.D. students was signed

4) Future collaboration with host institution (if applicable)

A number of collaborations were addressed, and they are directly related to the results described above:
•On the design strategies for planar antennas
•On the development of novel SIW layout and manufacturing techniques for planar antennas
•Mutual exchange of Ph.D. students and Postdocs, also on the basis of other funding opportunities (Italy-France Galileo Program) and on the basis of a co-tutoring agreement for MS and Ph.D. students (already signed)

5) **Projected publications / articles resulting or to result from the grant *(ESF must be acknowledged in publications resulting from the grantee's work in relation with the grant)***

The publication potentials is very high because of the joint relationship between innovative design technique for planar antennas, novel manufacturing techniques, and the possibility to realize and measure high-frequency prototypes.
In any case, the publication activities are not detailed yet, and they will be clarified when the first prototype will be manufactured and measured.

6) Other comments (if any)