Research activities of Spanish antenna groups

Manuel Sierra-Pérez
UNIVERSIDAD POLITÉCNICA DE MADRID
Av Complutense 30, 28040 Madrid. E-mail manuel.sierra.perez@ upm.es

1. Introduction

When we look at the history of electricity and electromagnetism in Spain we discover that the most important Spanish researchers are generally out of the official institutions or stable research groups until the 20th century [1] [2]. In the 20th century most of the scientific research is done in stable research institutions and universities and the most important electromagnetism research centres in Spain are located in the Faculty of Physics of the most important universities, the National Scientific Research Council (CSIC) and the School for Telecommunication Engineering created in 1923. But the greatest impulse of research in the antenna and radiowave propagation field is done after 1960 reaching the first national URSI conference in 1980. After that year, the relation between groups and the number of research groups is continuously growing and the relation to industry is also increasing. When Spain joins the European research organizations (COST, ERC...) and the European Union in 1985 the research support experience a fast growing and the participation in the European research structures.

In the antenna design field, there exist some specializations although most of the groups have dome specific projects in almost all the antenna analysis and design fields. Here, we have selected the most important and characteristic area related to each of the research groups and institutions.

The easiest way to classify the research work in antennas is the selection between antenna analysis, design and measurement. After that the selected frequency bands technology, the type of antennas and the related circuits can be a good criterion to describe the variety of research work and specialization between groups.

2. Antenna analysis

Although many research groups made their own software applications to solve specific problems, some of them have been especially dedicated to complete commercial applications or to give special services in the antenna analysis and optimization.

Prof. Catedra (Fellow of IEEE) leaders a group in the University of Alcala (UAH) with important experience in the application of Method of Moments (MM) and General Theory of Diffraction (GTD) applied to solve especially large electromagnetic models. [3]. From this group was born the company New Fassant, dedicated to commercialize the software products.

Also in the field of MoM, Prof. Rius from the Technical University of Catalonia (UPC) has done a great contribution to the field of antenna and microwave circuit analysis [10].

Other groups directed their effort in other analysis methods like Finite Differences Time Domain (FDTD), in the University of Granada (UG), directed by professor R. Gomez, also involved in the design of broadband Grown Penetrating Radar Antennas [4].

The HEMCUVE team, formed by two groups from the University of Extremadura (UEx) and the University of Vigo (UVigo), work in the high performance computing of large-scale problems in electromagnetic using supercomputers and novel acceleration methods (nested-FMM-FFT, MLFMA-FFT) and high precision analysis and design of nanostructures [5].

Technical University of Madrid (UPM) and UEx work together in the ECAM group specialized in application of spherical waves to antenna problems and fast full-wave analysis of finite arrays on a ground plane. Prof. Zapata and Rubio leader the groups [7].

In the Faculty of Physics at University of Seville (US), prof. F. Medina and his collaborators have been working for many years in special materials and metamaterials modelling for microwave circuits and antennas. [8].

Prof. Rebollar in the Dep. of Electromagnetism of the UPM, direct of a group with large experience In the field of Mode Matching theory for waveguide and horns propagation models. [9]

In the field of analysis and optimization of antenna arrays, Prof Ares (Fellow of IEEE) leaders a group in the University of Santiago (USC) specialized in the synthesis of planar antenna pattern with irregular footprints and low sidelobe levels combined with low dynamic range. [6].

I am sure I forget someone in the field of computational electromagnetics applied to antenna analysis. More information can be found in some national conferences like EIEC (http://www.eiec.it.pt/indexsp.htm) and URSI (http://www.ursi2011.org/index.htm).

3. Measurement systems

In the field of antenna measurement and other kind of measurement systems, each group own some facilities but only a small number of groups work in the design of measurement systems.

Probably the oldest and most important research group in this area is the Radiation Group from the UPM, directed by Prof. Besada. They are specialized in the design of anechoic chambers and near field antenna measurement systems. They are also well related with international organizations like AMTA and EurAAP. [11]. In fact Prof. Sierra-Castañer is the EurAAP Antenna Measurement Working Group leader.

Connected to the computational electromagnetism, University of Oviedo (UOvi) works in the antenna analysis and electromagnetic scattering complex problems. The leader is Prof. Las Heras. These methods have been specially applied to the inverse radiation problem. [12]

In the field of MIMO measurement with reverberation chambers, the group of Prof. David Sanchez, from Polytechnic University of Cartagena (UPCt), created a company (EMITE) and can demonstrate high experience in this field as in the MIMO design. This group is also working in the microwave heating and radio-electric emissions measurements. [13].

Special interest for UPC takes the microwave measurement systems for civil engineering structures evaluation. This system is used to measure internal characteristics of steel fiber reinforced concrete. The leader of this activity is Prof. Jofre (Fellow of IEEE). [14]

In the measurement of propagation channels, Prof Riera from UPM is active in this field microwaves and millimeter-waves propagation in the troposphere and measurement system design [15].

4. Antenna Design

All the antenna research groups in Spain have been working in some specific antenna design and prototype construction. It is very difficult to enumerate all the research activities in all the groups because it will take a long time and extension. Perhaps the best way is to proceed in the reverse way and to underline the group or groups specialized or with prominent results in some specific type of antennas and technologies.

3.1 Reflector and horn antennas

Many groups have been working in reflector design but the most important group in the area is managed by Prof. A. Garcia-Pino from the University of Vigo. They have been working for many years in the design of conformal reflector antennas for a great variety of applications up to millimetre wave bands. [15].

Horn antennas are also a classical design where every group has some contribution, but the most important contribution to this development came from the Public University of Navarra. The group headed by Prof. C. Del Rio is working also in many projects about antenna arrays and metamaterials for millimetre wave bands. [17].

3.2 Broadband and multiband antennas

Now the research on wideband antennas in the microwave bands is very important to the development of wideband communication systems. It is also very important the study of

multisystem reduced size antennas, used mainly in mobile communications. In this field some contributions appear in the national congresses, but probably the most important come from the Technical University of Valencia (UPV), with broadband antenna designs heading by Prof Ferrando [18] and from UPC laddered by Prof. Romeu in the field of fractal and multiband antennas [19]. In this area of multiband antennas is important to mention a relatively new group directed by Prof. Parron from the Autonomous University of Barcelona (UAB), [24]

3.3 Array antennas.

Array antennas are one of the most attractive design areas in the last years and many people is involved in some of these type of antennas. In the passive array design area is possible to find many groups in the UPM (Prof. Sierra-Perez [20]), UPV (Prof. Valero-Nogueira [21]), mainly in the slot and printed antenna arrays. A new group in a relatively new research centre at Autonomous University of Madrid (UA) is also working in this area, directed by Prof. Masa-Campos [22]. Prof. Camacho-Peñalosa is also working in this area from the University of Malaga (UMa).

Other specific area is the leaky wave antennas, sometimes structured as an array but many times associated to low speed propagation waves in radiating lines. In this area, the recent work done by Prof Alvarez-Melcon in the UPCt is especially important. [25].

Prof. Encinar (Fellow of IEEE), from UPM, leaders a group with a very important contribution to reflectarray antenna research. They were the winner of the 2007 Schelkunoff award to the best paper in the IEEE TAP. [26], [27].

3.4 Active antennas and MIMO systems.

We consider active antennas as those that can modify the pattern and are associated to some active elements. In this sense the most important contributions came from the UPM in scan and digital processing active antennas for satellite communications (Radiation Group coordinated by Prof. Sierra Perez [28]), UPC in the field of reconfigurable millimetre wave antennas. (Daniel Rodrigo [29]) and UPV in the study of reconfigurable antennas with MEMs (Prof. Ferrando [30]). The implementation of LTCC technology in this laboratory may give a strong impulse to the active array research in microwaves and millimetre waves.

In the MIMO systems it is difficult to distinguish between the antenna design, signal processing and propagation models. An important group working in the MIMO systems and measurement is in UPM (Prof. De Haro [31]). Other groups involved in the MIMO measurement and channel measurement work in UPC (Prof Romeu [32]) and in UPCt (Prof Juan-Lacer [33]).

Acknowledgments

This document was prepared as an actualization of the Antenna Research Activity in Spain, published in 2006 as a work included in the Spanish Antenna Network (RESA) [34].

References

[1] Romeu, J.; Elias, A. "Early proposals of wireless telegraphy in Spain: Francisco Salva Campillo (1751-1828)" IEEE APS Int. Symp., 2001. Vol.1, Pages:10–13, 2001

[2] Yuste, A.P.; Palma, M.S. "Scanning our Past from Madrid: Leonardo Torres Quevedo" Proc. of the IEEE, Vol. 93,n.7. Pages 1379– 382, 2005.

[3] Catedra, M.F. et all "New Physical Optics Approach for an Efficient Treatment of Multiple Bounces in Curved Bodies Defined by an Impedance Boundary Condition" IEEE TAP V56 n 3 p 728-736. 2008.

[4] Gomez Martin, R.; Morente, J.A.; Salinas, A."Time-domain analysis of an array of straight-wire coupled antennas." Electronics Letters. Volume: 22, Issue: 6 Pages: 316 – 318 1986.

[5] Taboada, J.M et all "High Scalability FMM-FFT Electromagnetic Solver for Supercomputer Systems" IEEE Antennas and Propagation Mag., V.51, I.6. Page(s):20–28, 2009.

[6] Ares, F. et all "Synthesis of Very Large Planar Arrays for Prescribed Footprint Illumination". IEEE TAP, Vol.: 56, Issue: 2. Page(s): 584 – 589, 2008.

[7] J. Rubio, et all, "Generalized-Scattering-Matrix Analysis of a Class of Finite Arrays of Coupled Antennas by Using 3D-FEM and Spherical Mode Expansion", IEEE TAP pp.1133-1144. 2005.

[8] Medina, F.; et all "Study of Extraordinary Transmission in a Circular Waveguide System". IEEE Trans. on MTT, Volume: 58 , Issue: 6, Page(s): 1532 – 1542. 2010.
[9] Ruiz-Cruz, J.A.; et all "Optimal configurations for integrated antenna feeders with linear dual-polarisation and multiple frequency bands" IET MAP, Vol.5, n. 8, Pages: 1016–1022. 2011.
[10] Tamayo, J.M.; Heldring, A.; Rius, J.M. "Multilevel Adaptive Cross Approximation (MLACA)". IEEE T. on Antennas and Propagation, V. 59 , I. 12, Page(s): 4600 – 4608 2011.
[11] Cano-Facila, F.J.; et all "Novel Method to Improve the Signal-To-Noise Ratio in Far-Field Results Obtained from Planar Near-Field Measurements" IEEE AP Mag. V53 P. 215-220, 2011.
[12] Laviada, J.; et all "Generation of Excitation-Independent Characteristic Basis Functions for Three-Dimensional Homogeneous Dielectric Bodies" IEEE TAP, V59, P. 3318 – 3327. 2011.
[13] Valenzuela-Valdes, J.F. et all "Accurate Estimation of Correlation and Capacity for Hybrid Spatial-Angular MIMO Systems" IEEE Trans. on VT V 58, n 8, P 4036–4045 2009.
[14] Roqueta, G.; Jofre, L.; Romeu, J.; Blanch, S. "Microwave Time-Domain Reflection Imaging of Steel Fiber Distribution on Reinforced Concrete" IEEE TIM, V 60, n 12, P 3913 – 3922. 2011.
[15] García-del-Pino, P., Riera, J.M., Benarroch, A., "Tropospheric Scintillation With Concurrent Rain Attenuation at 50 GHz in Madrid", IEEE TAP, Vol. 60, no. 3, pp. 1578-1583, March 2012.
[16] Martinez-Lorenzo, J.A. et all "Zooming and Scanning Gregorian Confocal Dual Reflector Antennas" IEEE TAP, V 56, n 9, P 2910–2919. 2008.
[17] Teniente, J.; Gonzalo, R.; del Rio, C. "Low Sidelobe Corrugated Horn Antennas for Radio Telescopes to Maximize" IEEE TAP, V. 59, I. 6 , Part:1, Page: 1886–1893 2011.
[18] Antonino-Daviu, E. et all." Modal Analysis and Design of Band-Notched UWB Planar Monopole Antennas" IEEE TAP V 58, n 5, P 1457–1467. 2010.
[19] Romeu, J.; Rahmat-Samii, Y. "Fractal FSS: a novel dual-band frequency selective surface" IEEE TAP, Volume:48 , Issue:7, Page(s):1097–1105. 2000.
[20] Garcia-Aguilar, A et all "Low-Profile Dual Circularly Polarized Antenna Array for Satellite Communications in the X Band" IEEE TAP, Vol:60, Issue: 5, Page(s):2276–2284 2012.
[21] Herranz-Herruzo, J.I. et all. "Optimization technique for linearly polarized radial-line slot-array antennas using the multiple sweep method of moments" IEEE TAP, V52, n4, P 1015–1023 2004.
[22] Masa-Campos, J.L.; Sierra-Perez, M. "Linearly Polarized Radial Line Patch Antenna With Internal Rectangular Coupling Patches" IEEE TAP, V 59 , n 8, Page(s): 3049 – 3052 2011.
[23] Navarro-Tapia, M. et all "On the Actual Possibilities of Applying the Composite Right/Left-Handed Waveguide Technology to Slot Array Antennas" IEEE TAP, V60 n5, P2183–2193 2012.
[24] Ramirez, M.; Parron, J.; Gonzalez-Arbesu, J.M.; Gemio, J. "Concentric Annular-Ring Microstrip Antenna With Circular Polarization" IEEE AWP Letters, V 10, P 517 – 519 2011.
[25] Garcia-Vigueras, M. et all "A Modified Pole-Zero Technique for the Synthesis of Waveguide Leaky-Wave Antennas Loaded With Dipole-Based FSS" IEEE TAP V58, N6, P1971–1979 2010.
[26] Encinar, J.A. et all "Dual-Polarization Dual-Coverage Reflectarray for Space Applications" IEEE TAP. Volume: 54 , Issue: 10 Page(s): 2827 – 2837 2006.
[27] Wenfei Hu; et all"94 GHz Dual-Reflector Antenna With Reflectarray Subreflector" IEEE TAP, V57 , N 10 , Part: 2, p 3043–3050 2009.
[28] Montesinos, I.; Sierra-Perez, M.; Fernandez, J.L.; Martinez, R.; Masa, J.L. "GEODA: Adaptive antenna of multiple planar arrays for satellite communications" EuCAP 2009. Page(s): 773 - 777
[29] Rodrigo, D.; Jofre, L. "Frequency and Radiation Pattern Reconfigurability of a Multi-Size Pixel Antenna" IEEE Trans. on Antennas and Prop., Vol. 60, Issue 5, Page 2219 – 2225. 2012.
[30] Sanchez-Escuderos, D. et all "Reconfigurable Slot-Array Antenna With RF-MEMS" IEEE AWP Letters, V10, p 721–725 2011.
[31] Gomez-Calero, C.; et all "A 2 2 MIMO DVB-T2 System: Design, New Channel Estimation Scheme and Measurements With Polarization Diversity" IEEE TB, V 56 , n2, p 184–192 2010.
[32] Valdesueiro, J.A.; Izquierdo, B.; Romeu, J. "On 2 2 MIMO Observable Capacity in Subway Tunnels at -Band: An Experimental Approach" IEEE AWP Letters, V9 p 1099-1102 2010.
[33] Molina-Garcia-Pardo, et all "MIMO Channel Capacity With Polarization Diversity in Arched Tunnels" IEEE AWP Letters, V8 p 1186-1189 2009.
[34] M Sierra Pérez. "Antenna Research Activity in Spain" Ed. Fundetel. ISBN 84-7402-336-X. Spain 2006.