MICROWAVE APPLICATIONS GROUP (GAM) ANNUAL RESEARCH REPORT 2018/2019

HEAD OF THE GROUP RESEARCH REPORT

Over the past year (September 2018 to July 2019), the group has continued working on one project awarded with national public funds, and it has successfully completed another project that was awarded with regional public funds. It is expected that at the end of this year, 2019 all the main objectives of the national project will be fully achieved.

In addition to this project, the group has also obtained national and regional public funding to hire some new researchers and PhD students, who are already collaborating with the group in its different research lines through formation grants and funds for hiring technical and support staff.

Furthermore, the group is also involved in two new European projects, to be developed in collaboration with other European universities and industries, for the training of young scientists and performing research activities in the space sector.

Apart from receiving public funding, the GAM activities were also funded through four technology transfer contracts agreed with industries and organizations, mainly subscribed with the European Space Agency (ESA) and space-sector companies.

Regarding the training capacity of the group, we should mention that one PhD doctoral thesis (in the area of remote sensing applications) has been successfully defended in the last year, and the group senior members are presently supervising others in different research areas.

It is fair to say, from the facts described above, that the quality of the group is growing year by year, therefore becoming a reference in the framework of their research areas (high-frequency components) and the space sector. A complete list of research activities and more details about the group can be found at: http://gam.webs.upv.es/, or http://www.iteam.upv.es/group/gam/.

1.- PROJECT ACTIVITIES

The COMM has continued during the last year with its main research lines. Also, new emerging activities have appeared. A short summary of the main advances carried out is presented below:

The main research lines in which the GAM group is currently working are listed below:

- Analysis and design of high frequency (microwaves and millimetre-waves) passive circuits implemented in guided, planar, and hybrid (waveguides integrated in dielectric and empty substrates, such as SIW, coaxial SIW, ESIW and ESICL) technologies, using micro-electro-mechanical systems (MEMs), as well as periodic materials (EBGs) and metamaterials.
- Electromagnetic study of dispersion/transmission problems in open space, in connection with the analysis and design of antennas and scattering (radar and remote-sensing) applications.
- Development of algorithms based on artificial intelligence techniques, for the automated synthesis and design of high frequency passive components (e.g. filters and multiplexers).
- Practical design of components (circuits and antennas) for high-frequency communication systems (e.g. wireless, space and mobile systems), including the modelling and experimental validation of high-power effects for satellite applications.

In all these research lines and activities, the group has obtained relevant public and private funding, through national and regional projects as well as through research contracts with industries, making feasible to keep on producing new and relevant results in the R&D topics mentioned above.

1.1.- ONGOING PROJECTS

COMPASSES Project: Technological Demonstrators for Filters and Multiplexers with Selective and Reconfigurable Responses in New Compact Waveguides for Space Applications

Currently, space communication systems provide a large number of services to our modern Digital Society. For this purpose, on-board payloads operating at lower microwave bands have been used and, since 2006, new satellites offering communication services in the Ka-band are available. Even though all these satellites are continued to be employed, recently, new emerging applications of space communications are forthcoming.

As relevant players in the space sector have

pointed out, future space communications must respond to the following new scenarios: data transmission from small platforms (pico- and nano-satellites with scientific and technological missions) in C-band (6 GHz), global Internet Access (from and to the entire planet) through mega-clusters of micro-satellites operating in Ku-band (12-14 GHz), civil and military -security and defence- applications with variable demand of performance (through reconfigurable payloads operating in high frequency bands as Ka, Q, V and W), and new remote sensing services in the sub-millimetre wave range (between 100 GHz and 1 THz).

To meet these emerging applications, future satellites will incorporate new and advanced communication payloads, whose equipment and subsystems (passive components such as filters, diplexers and multiplexers, as well as antennas) are going to require specific technological solutions that best fit to each particular scenario. Therefore, small satellite platforms will need more compact devices and with low manufacturing costs, payloads of next telecommunication satellites (in Ka, Q and V bands) will have to incorporate flexibility (capacity of reconfiguration of operational frequencies and bandwidths, as well as of coverage), whereas components of future space communications operating at higher frequencies (between 100 GHz and 1 THz) will need of manufacturing techniques with higher accuracies.

This joint project aims to offer solutions (through the design, implementation and experimental validation of specific technology demonstrators) to these challenges for the high-frequency equipment (passive components and antennas) of future satellite applications.

This project has been funded by the Programa Estatal de I+D+i Orientada a los Retos de la Sociedad, Ministerio de Economía y Competitividad, Gobierno de España.

SELECTOR Project: SMT Compatible Electromechanical Relay for Compact Redundancy Ring

Figure 1. SELECTOR Project Logo

SELECTOR project (funded as an H2020 Research and Innovation Action) is focused on the development of innovative passive components to increase the number of freely accessible space qualified passive components; thus, contributing to the European policy about "Reaching non-dependence in certain technologies that will open new markets to industries and will increase the overall competitiveness of the European Space sector".

SELECTOR aims at developing Surface Mount Technology (SMT) compatible electromechanical switches for space sector high miniaturization. These devises called "Miniature Electro Mechanical Relay" (MEMR), already exist for microwave industrial ground application like Automatic Test Equipment. SELECTOR will deliver MEMR as part of ESA portfolio European Preferred Part List (EPPL) so that this high integration, high performance passive component be available with non-restriction for the whole European industry. SELECTOR will also demonstrate a whole new approach of self-redundant microwave equipment called "Meta-equipment" based on microwave specific SMT board level assembly and MEMR components to minimize cost and improve integration. This demonstrator will address Very High Throughput Satellites (VHTS) emerging applications, where the new paradigm is the introduction of digital technologies dealing with very high number of RF chains. New evolution toward RF high power and high frequency capability will be implemented to open-up new sector of application within Space satellites (Navigation, earth observation), but also non-space sectors.

In the framework of this project, the GAM group is directly involved in the (theoretical and practical) evaluation of the new developed passive components in terms of high-power and high-frequency space applications.

This project has been funded by the H2020-RIA (Research and Innovation Action) Program

TESLA Project: Advanced Technologies for future European Satellite Applications

Figure 2. TESLA Network Logo

Space is key asset for Europe, which must continue to have a prominent role in this strategic sector. Since satellite payload RF components and systems are essential for delivering mission objectives and supporting ground equipment, new technologies and techniques are required to respond to emerging satellite applications and technology challenges.

To this end, TESLA ETN (European Training Network) will create a multidisciplinary research environment to develop the Advanced Technologies for future European Satellite Applications. It will collaborate with senior staff in academic and industrial sectors to conduct top research into new and enabling technologies for satellite flexible payloads, big constellation systems, satellite high-speed communications and remote sensing, as well as large satellite

platforms. TESLA will also implement a unique research program, with the objective to push the next generation of creative, entrepreneurial and innovative satellite communication developers, to enhance the European space economy and business through outreach activities for a wider economic and social impact.

This project has been funded by the H2020-MSCA-ITN-2018 (Marie Skłodowska-Curie Innovative Training Networks) Program.

2.- RESEARCH RESULTS

As a result of the joint research activity developed by this group in its research lines, during the last year of activity, more than 10 articles have been published in scientific journals with a high impact index (such as IEEE Transactions on Microwave Theory and Techniques, IEEE Microwave and Wireless Components Letters, IEEE Transactions on Antennas and Propagation, IET Proceedings on Microwave, Antennas and Propagation, IET Electronics Letters and Radio Science).

At the same time, the group has presented up to 19 communications in prestigious international conferences (such as IEEE-MTT Int. Microwave Symposium, IEEE-AP Int. Symposium on Antennas, European Microwave Conference on Numerical Electromagnetic Modeling and Optimization for RF, Microwave, and Terahertz Applications (NEMO), the 2018 European Microwave Week hold in Madrid, and the 2018 ESA Microwave Technology and Techniques Workshop), some of them as invited papers.

Finally, because of the research activity of the group developed in collaboration with companies and administrations of the aerospace sector, it has recently participated in the development of two new patents.

2.1.- FEATURED PUBLICATIONS

Some of the most recent and relevant publications of the GAM group in the last year are briefly summarized next:

Controlled Out-of-Band Rejection of Filters based on SIW with Alternating Dielectric Line Sections, Juan Rafael Sánchez Marín; Maria Carmen Bachiller Martin; Vicente Nova Giménez; Vicente Enrique Boria Esbert. IEEE Microwave and Wireless Components Letters. Vol. 29, pp. 258 - 260. 2019. ISSN 1531-1309. DOI: 10.1109/LMWC.2019.2902034

A study for managing the out-of-band rejection in a new topology of filters based on substrate integrated waveguide with alternating dielectric line sections (ADLSs) is presented in this letter.

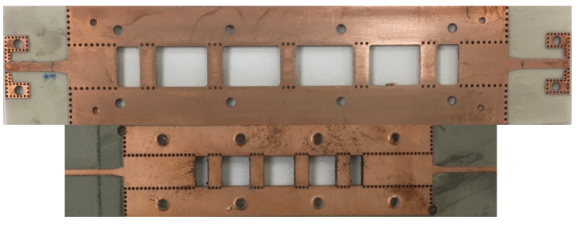


Figure 3. Manufactured filters. 13 GHz and five cavities filter with RO4003C (top) and 11 GHz and four cavities filter with TMM10i (bottom)

Compact Combline Filter Embedded in a Bed of Nails. Mariano Baquero Escudero; Alejandro Valero Nogueira; Miguel Ferrando Rocher; Bernardo Bernardo Clemente;Vicente Enrique Boria Esbert, IEEE Transactions on Microwave Theory and Techniques. Vol. 67, pp. 1461 - 1471. 2019. ISSN 0018-9480. DOI: 10.1109/TMTT.2019.2895576

In this paper, we propose a compact topology for high-frequency bandpass filters using coaxial cavities embedded in a bed of nails, including a complete design procedure combining equivalent circuit models and full-wave simulators.

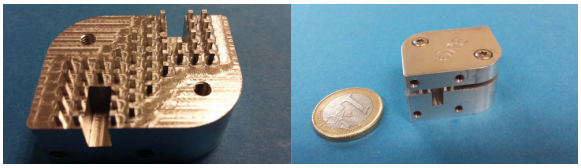


Figure 4. Filter base piece with periodic bed of nails, shortened cylindrical resonant nails, and input-output GGWs

Characterization of Nematic Liquid Crystal at Microwave Frequencies Using Split-Cylinder Resonator Method. Juan Rafael Sánchez Marín; Vicente Nova Giménez; Maria Carmen Bachiller Martin; Belén Villacampa; Alberto de la Rua; Rainer Kronberger; Felipe Laureano Peñaranda Foix; Vicente Enrique Boria Esbert. IEEE Transactions on Microwave Theory and Techniques. Vol. 67, pp. 2812 - 2820. 2019. ISSN 0018-9480. DOI: 10.1109/TMTT.2019.2916790

In this paper, a split-cylinder resonator method is used for the characterization of four different nematic LCs at two frequency points. This characterization includes the extraction of their complex dielectric permittivity values at these frequencies. The employed method allows to obtain the two extreme permittivity values without applying any external electric or magnetic field to polarize the LC molecules.

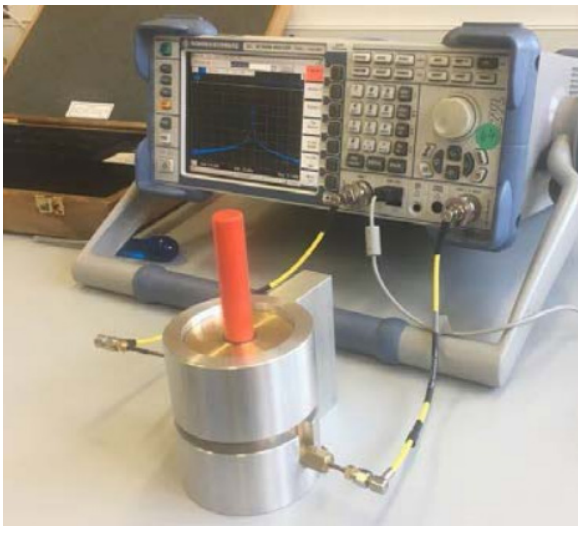


Figure 5. Measurement setup: VNA and split-cylinder resonator

Advanced Filtering Solutions in Coaxial SIW Technology Based on Singlets, Cascaded Singlets, and Doublets. Stefano Sirci; Miguel Ángel Sánchez Soriano; Jorge Daniel Martínez Pérez; Vicente Enrique Boria Esbert, IEEE Access. Vol. 7, pp. 29901 - 29915. 2019. ISSN 2169-3536. DOI: 10.1109/ACCESS.2019.2902956

The use of singlets, cascaded singlets, and doublets in a coaxial substrate integrated waveguide (SIW) technology is proposed in this paper, with the aim of implementing low-loss filters with very compact size and highly selective symmetric, asymmetric as well as dual-band responses.

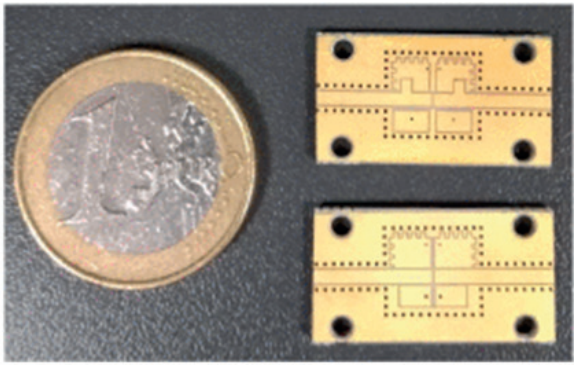
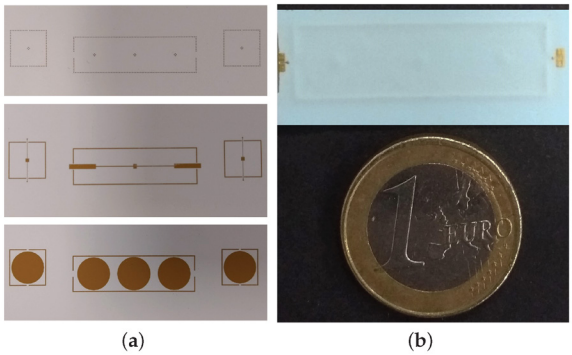


Figure 6. Photograph of filter prototypes: above filter DB2, and below filter DB1

A Novel Magnetic Coupling for Miniaturized Bandpass Filters in Embedded Coaxial SIW Stefano Sirci; Jorge Daniel Martínez Pérez; Vicente Enrique Boria Esbert. Applied Sciences (Basel). Vol. 9, pp. 1 - 14. 2019. ISSN 2076-3417. DOI: 10.3390/app9030394

In this paper, embedded coaxial substrate integrated waveguide (CSIW) filters with innovative magnetic couplings are presented and studied.



(a) (b)

Figure 7. (a) Some layers of the LTCC stack-up and (b) Three-pole BPF prototype

Empty SIW Technologies: A Major Step Toward Realizing Low-Cost and Low-Loss Microwave Circuits, Ángel Belenguer Martínez; Héctor Esteban González; Alejandro Lucas Borja; Vicente Enrique Boria Esbert. IEEE Microwave Magazine. Vol. 20, pp. 22 - 45. 2019. ISSN 1527-3342. DOI: 10.1109/MMM.2018.2885630

This review article summarizes much of the published material regarding Empty Substrate Integrated Waveguide (SIW) technologies, highlighting the main characteristics of each one of them.

Figure 8. Manufactured prototype of the back to back transition from microstrip to ESIW

2.2.- PATENTS

In the last year, the processing of the next two patents has been advanced:

José Manuel Merello Giménez; Maria Carmen Bachiller Martin; Vicente Enrique Boria Esbert; Mª Luisa Marín García; Vicente Nova Giménez; Juan Rafael Sánchez Marín

MÉTODO DE FABRICACIÓN DE DISPOSITIVO DE MICROONDAS BASADO EN GUÍA DE ONDA VACÍA INTEGRADA EN SUSTRATO

Pub. No.: P201830647

Pub. Date: 28/06/2018

Vicente Enrique Boria Esbert; Javier Ossorio Gracía; José Joaquín Vague Cardona; Marco Guglielmi

DISPOSITIVO DE FILTRADO Y CONMUTACIÓN DE MICROONDAS

Pub. No.: P201830514

Pub. Date: 30/05/2018