Ph.D. in Information Technology: Final Dissertations

DEIB Seminar Room "Alessandra Alario"

February 23rd, 2017

2.00 pm

First Ph.D. presentation and discussion:

Luigi MAGGI – XXVIII Cycle

"Development of a FMCW Short Range Ground Based Radar"

Advisor: Prof. **Andrea Monti Guarnieri**

Abstract:

In the last decade, ground radar sensors, which are used for civilian applications, received an important technological evolution. Ground RADAR tools for monitoring and control are now an established reality in some areas such as open pit mining, and monitoring of medium-scale geological phenomena such as landslides and subsidence. However, the technology is still young and ground RADAR systems present several interesting research areas. One of the most interesting one, is certainly the analysis of advanced solutions for the antenna synthesis, in order to make imaging techniques RADAR increasingly efficient and reliable. The purpose of this activity is to define one or more solutions for the antenna synthesis of a radar system with particular attention to SAR image applications.

The ph.D. was funded in collaboration with Aresys s.r.l that is a spin-off of Politecnico di Milano and the main focus was the development an innovative FMCW RADAR in W band, more precisely at 77GHz. The other aim of the thesis is the investigation of Digital Beam Forming technique in order to improve the performance in terms of image ambiguity or, from other point of view, in terms of scan speed. Hence, the work has been based on all radar imaging techniques currently implemented in ground sensors that include: 1) synthesis of antenna through the movement of the sensor along a linear slide 2) synthesis of antenna through radiating elements array 3) Azimuth Digital Beamforming. In general, the three main solutions outlined can be hybridized in order to provide trade-offs that can respond to different application requirements. The work will provide a detailed benchmark of existing techniques highlighting the advantages and disadvantages of each application in the main bands of ground radar sensors (W), and in the particular case of SAR image, with particular attention to technological constraints and technical feasibility of the solution.

During the Ph.D. several campaigns have been carried out to evaluate the performance and reliability of the system in different scenarios and type of applications that are below reported: 1) SAR scan for Image Application; 2) Ranging Application as vibration and dynamic deformation.

Finally, an innovative approach has been defined and implemented in a prototype sensor RADAR currently available in ARESYS. The prototype was a based system of a product which will be lunched in 2017.

Second Ph.D. presentation and discussion:

Ahmed Hamada Radwan HANDOUK – XXIX Cycle

"Modelling, Design and Characterisation of Reconfigurable Terahertz Antennas Based on Graphene"

Advisor: Prof. **Michele D'Amico**

Abstract:

The crowded wireless communication bands in the gigahertz (GHz) frequency range and the ever -increasing demand for more bandwidth has motivated the exploitation of the terahertz (THz) band (0.1-10 THz). Antenna as a front component of THz systems is required to have a wide band, good radiation performances and sometimes switchable ability. To obtain the switchable ability of the antenna, the concept of a reconfigurable antenna was proposed. Reconfiguring an antenna is achieved through deliberately changing its frequency, polarization, or radiation characteristics.

Design of reconfigurable antennas provides an excellent opportunity to combine state-of-the-art technologies with the antenna theory in an attempt to obtain additional degrees of freedom in system performance. The main objective of this research is the development of design methodologies and their validation through the synthesis of reconfigurable antennas operating in the THz frequency based on the utilization of graphene, depend on the recent demonstration of the electric field effect in graphene, which have sparked enormous interest as a novel material in electronics. Therefore, it is significant to predict the performances of using graphene for applications in THz region.

We started working on modeling of the Graphene's properties in simulation tools then continued on designing and simulation several reconfigurable THz antennas based on graphene with the ability to provide reconfigurability of the frequency band and radiation pattern through its chemical properties. In addition we worked on array of split ring resonators (SRR) also made of graphene; this array actually behaves like a metamaterial, both bandwidth and radiation properties are optimized to obtain good results. Then reconfigurable beam antenna is proposed for THz application, which is based on a switchable high-impedance surface (HIS) using a single-layer of graphene. We deigned a beam reconfigurable THz antenna, which is based on a switchable Graphene High-Impedance Surface (G-HIS) that acts as a reflector for a primary radiator made of gold. We achieved a way to control the radiation properties over wide range of beam angles.

Finally, we measured the reflection properties of the antenna based G-HIS at two cases (biased and unbiased graphene) and it demonstrated the effect of the change of applied voltage in terms of the input impedance and the reflection properties.

Third Ph.D. presentation and discussion:

Valentina VERRI – XXIX Cycle

"Graphene Antenna Design for Terahertz Sensing and Communications"

Advisor: Prof. **Gian Guido Gentili**

Abstract:

The increasing demand for much higher speed wireless communication of the last few years, calls for advanced physical layer solutions and new spectral band. So, the operating frequency of the communication systems is extended to the millimeter/sub-millimeter wave region of the electromagnetic spectrum and the THz band becomes the key of the wireless technology. In this context, developments of new transceiver architectures that are able to operate at THz band frequencies and to exploit the very large available bandwidth are necessary.

One of the most recent alternatives to develop THz band compact devices is based on the use of graphene. Graphene has recently attracted the attention of the research community due to its novel properties and it is considered the wonder material of the 21st century. Thanks to its monoatomic thickness, graphene can be modeled as an infinitely thin surface of complex conductivity whose behaviour depends on the electro-chemical potential: this feature allows to realize reconfigurable devices where the unique tunable parameter is represented by the electro-chemical potential.

The purpose of this thesis is to present some applications based on the use of graphene. Graphene structures such as the Frequency Selective Surface or the Split Ring Resonator allow to realize beam or bandwidth reconfigurable antenna; implemented in the High Impedance Surface, allows to realize a phase shifter. Graphene-based antennas have some distinctive properties suitable for THz communications systems such as smaller size and the property of tunable effective surface conductivity for control the beam pattern.

PhD Committee:

Prof. **Michele D'Amico**, DEIB – Politecnico di Milano

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Prof. **Pietro Guccione**, Politecnico di Bari