

WMA (IMS) Monday 08:00 – 17:00 BCEC Room 151AB
Tunable RF-Components and Modules for Wireless Communication Systems
Full-day workshop reviewed by MTT-13, MTT-8, MTT-20

Organizer(s):

Holger Maune, Technische Universität Darmstadt.

Robert Weigel, University of Erlangen-Nuremberg; AdCom, MTT-2, IMS TPC.

Rolf Jakoby, Technische Universität Darmstadt.

Georg Fischer, University of Erlangen-Nuremberg.

This workshop highlights the current research and development efforts in the design and the implementation of reconfigurable RF-frontends for wireless systems, in particular for terrestrial and satellite-based mobile communication. In the first part, it addresses the realization of different tunable components such as phase shifters, filters, duplexers, matching networks. The second part will focus on reconfigurable/adaptive antennas such as beam-steering antennas or reflect-arrays. The presented RF-components and modules are based on different materials such as novel tunable non-linear dielectrics or semiconductors and techniques such as RF-MEMS. Moreover, some of these devices are based on metamaterial design approaches.

Speakers:

1. Robert Weigel, University of Erlangen-Nuremberg

“Frequency Agile Ferroelectric Filters, Power Dividers, and Couplers”

Frequency agility and reconfigurability in front-end architectures has become an issue since mobile communication systems have a clear trend towards increased number of standards and frequency bands. Objective of this work is to demonstrate the potential of ferroelectric varactors for designing microwave circuits such as filters, power dividers and couplers with frequency agile characteristics. Such microwave circuits can be used in various ways in future reconfigurable transceiver architectures. Lumped element lowpass and notch filters with a tuning range of 30% and distributed tunable bandpass filters with improved selectivity are discussed. Furthermore, a novel approach for designing reduced size frequency agile power dividers and couplers is presented. Besides significant size reduction, a tuning range of more than 20% is achieved for those topologies. The implemented prototype circuits as well as the experimental results of linear and nonlinear measurements will be discussed.

2. Andrew Hunt, nGimat Co.

“Low Voltage and Low Loss Tunable Dielectrics for Phase Shifters/Phased Array Antennas and Tunable Filter Components”

Thin film ferroelectric BST based tunable microwave devices such as tunable filters and phase shifters can find applications in a wide variety of systems or subsystems such as electronically steered antennas, software defined radios, and wireless communications systems. However, the potential has yet to be fully explored, primarily due to the high loss of BST thin films. By controlling carefully the growth conditions, we have grown

epitaxial BST on sapphire. The film's loss tangent increases with frequency and is around 0.05-0.2 at 40 GHz. We improved temperature-permittivity properties through composition tailoring and designed an innovative capacitor architecture that improved intermodulation distortion performance and reduced DC bias voltage. Measured results of tunable filters and phase shifters at frequencies up to Ka-band as well as phased array antennas will be elaborated.

3. Spartak Gevorgian, Chalmers University of Technology
“Agile Ferroelectric Components in EC Project NANOSTAR”

The main results obtained in EC project NANOSTAR will be presented.

4. Holger Maune, Technische Universität Darmstadt
“Tunable Modules based on Ferroelectric Thick-Film Technology”

The development of cognitive radios (CR) is going to essentially reform the future wireless communications. As an enabling technology, reconfigurable RF frontends attract increasing research efforts. Such frontends are able to reconfigure adaptively their transmission and receiving parameters, on the purpose of simplified system architecture, efficient spectrum utilization and reduced power consumption. Tunable microwave modules based on Barium-Strontium-Titanate (BST) thick-film components have proven promising candidates through the development of various functional tunable modules. Recent advances in optimizing the microwave properties by doping the material and structuring of the BST thick-film will be briefly introduced. The presentation will focus on the efficient design methods, realization process, integration issues, functionalities and peripheral control of tunable modules, e.g. varactors, tunable phase shifters, tunable matching networks and tunable multiband antennas.

5. Georg Fischer, University of Erlangen-Nuremberg
“High-Q Planar Filter Platform Incorporating Macro MEMS Tuning Elements”

Duplex filters as used in infrastructure equipment for wireless networks require high selectivity and high power handling. This typically is contrary to tunability. The contribution shows a planar filter platform based on coupled Metamaterial Split Ring Resonators in suspended stripline configuration. A macro MEMS varactor device with piezoelectric actuation is introduced for tuning. Its characteristics are large tunability, large power handling and moderate Q factor. The degradation of the resonators Q factor is kept low as a loose coupling of the MEMS is assumed. Results of tunable passband characteristics are presented. The impact at system level measured by EVM and ACPR degradation is neglectable thanks to its mechanical inertia. An SDD (Symbolically Defined Device) model suited for ADS that captures the mechanical dynamics by a second order differential equation is presented that can be used with all simulation engines of ADS (S, HB, transient and envelope).

6. Christophe Caloz, École Polytechnique de Montréal
“Reconfigurability at Microwaves using Recent Metamaterial Concepts and Techniques”

Over the past few years, transmission line (TL) metamaterials, and more particularly composite right/left-handed (CRLH) TL metamaterials, have paved the way to a diversity of novel microwave concepts and applications. They have generated a myriad of unprecedented practical applications. In such TLs, the concept of “dispersion engineering,” either in the harmonic or pulse regimes, is most interesting for tunable components and antennas RF front-ends. After a brief introduction on CRLH metamaterials and dispersion engineering, this talk will present several corresponding tunable components and antennas. The former include multiband devices, uniform power dividers, true-time delayers, active diplexers, impulse delay lines, pulse position modulators, and pulse generators, while the latter include beam scanning and forming leaky-wave antennas, tunable resonant antennas, DOA systems, compressive receivers, and real-time spectrum analyzers.

7. Christian Damm, Technische Universität Darmstadt
“Artificial Lines for Matching Purposes”

In this contribution we will talk about tunable artificial lines and their use as matching elements by means of simple line transformers. The basic ideas and the extension of the classic transmission line transformer theory to the general case of artificial lines is shown in detail. This extension includes the band gap region of an artificial line into the usable region and enables the matching of arbitrary impedances to a given source impedance by a single transmission line transformer. The advantage of this approach as compared to classic matching approaches, e.g. double stub tuners is the simple closed form expression which determines the required line properties of the transformation line directly out of the load and source impedances. To confirm the theory, the design, build-up and measured results of a prototype are shown in detail.

8. Luca Marcaccioli, University of Perugia
“Tunable Components for Electronic Beam Steering and Smart Antenna Systems”

The work will present an overview of the activities of University of Perugia in the field of Smart Antenna Systems. During last years, a number of reconfigurable RF devices have been developed, such as phase-shifter, power divider, reconfigurable coupler, all of them suitable to be implemented in phased array with reconfiguration pattern capabilities. The use of RF MEMS switches have been also considered. In particular, the development of a novel SIW-based phase shifter for compact phased-array systems will be presented. Then, a technique for interference nulling to be applied in medium/large arrays will be illustrated. Finally, the most recent advances in MEMS-based electronic steerable reflectarray will be presented, in the frame of the ARASCOM project - European 7th framework program.

9. Etienne Girard, Thales Alenia Space

“MEMS-based Reflectarrays for Satellite Antennas: Design and Prototypes Development at Thales Alenia Space France”

Beam reconfigurability is a desired feature for space telecommunication antennas, as a step for greater flexibility. However the existing solutions (the direct radiating arrays) suffer from many drawbacks: very high cost, complexity, high power consumption, weight, volume. With the emergence of the MEMS technology, new antenna solutions are arising, which achieve reconfigurability at a moderate cost. Thales Alenia Space has and continues to work on circular and dual linear MEMS-based reflectarray that exhibits attractive performances. Two MEMS-based reflectarray element concepts has been designed for linear or circular polarization, manufactured and tested satisfactorily. It provides top-level RF performances (high phase quantization, low loss), high integration and compactness. This MEMS-based reflectarrays element is validated and patented. Various technological solutions for the implantation of the MEMS devices are currently being investigated and will be presented at the workshop.

10. Wolfgang Menzel, University of Ulm

“Investigation Methods for Reconfigurable Liquid Crystal Reflectarrays”

Reflectarrays have attracted increasing interest due to their advantages of planarity, low cost, low weight, and ease of fabrication. The benefits of this principle have also initiated the development of reconfigurable reflectarrays, e.g. based on tunable liquid crystal material (LC). Such novel approaches for reconfigurable antennas with their specific technology and sensitivity to manufacturing tolerances require methods to investigate amplitude and phase angle behaviour not only in simulations but also experimentally. In this workshop contribution, different experimental methods to characterize not only reflectarrays as a whole, but also their individual elements are presented, including farfield, nearfield, and quasi-optical measurement setups.