Student Poster Session

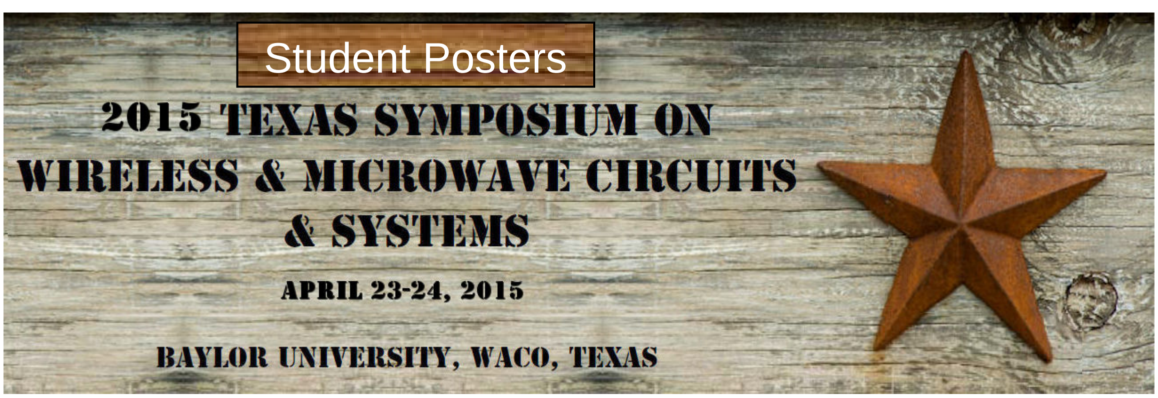
Thursday, April 23, 2015

5:30pm – 7:00pm

2015 Texas Symposium on

Wireless and Microwave Circuits and Systems

Baylor University



Student Poster Presentations

Baylor University

The Power Smith Tube for Simultaneous Load Impedance and Input Power Optimization in Power Amplifiers (1)

Student Authors: Joseph Barkate, Matt Flachsbart, and Zach Hays
Faculty Advisors: Prof. Charles Baylis and Prof. Robert J. Marks II, Baylor University
Sponsor: National Science Foundation (NSF)

Optimizing Radar Waveforms Using Generalized Alternating Projections (2)

Student Authors: Dylan Eustice and Casey Latham
Faculty Advisor: Charles Baylis, Baylor University
Sponsor: National Science Foundation (NSF)

Smith Tube Optimization for Adaptive Radar (3)

Student Author: Matthew Fellows
Faculty Advisor: Charles Baylis, Baylor University
Sponsor: National Science Foundation (NSF)

Improving the Performance of RSS Detection Using Wireless Open-Source Platforms (4)

Student Author: Yan Shi

Investigation of 433 MHz and 915 MHz On-Body Wave Propagations (5)

Student Author: Dong Xue
Faculty Advisors: Brian Garner and Yang Li, Baylor University
Sponsors: Collaborative Faculty Research Investment Program of Baylor University; Baylor Scott & White Health, Baylor College of Medicine

University of Hawaii

Electrokinetic Actuation of Non-Toxic Liquid Metal for Reconfigurable RF Devices (6)

Student Authors: Ryan Gough, Jonathan Dang, and Andy Morishita
Faculty Advisors: Aaron Ohta and Wayne Shiroma,
University of Hawaii at Manoa

The Power Smith Tube for Simultaneous Load Impedance and Input Power Optimization in Power Amplifiers

Joseph Barkate, Matt Flachsbart, Zach Hays, Charles Baylis, and. Robert J. Marks II
Department of Electrical Engineering
Baylor University

Faculty Advisors: Prof. Charles Baylis and Prof. Robert J. Marks II, Baylor University
Sponsor: National Science Foundation (NSF)

Abstract

Power amplifier design requires the consideration of many factors in its design process. Among these important factors included in the process is the load reflection coefficient Γ_L and the input power P_{in}. In typical power amplifier design an iterative process of a power sweep proceeded by a load pull is used. The goal of this process is to optimize the design to obtain a desirable power-added efficiency (PAE) and adjacent-channel power ratio (ACPR) at a reasonable Γ_L and P_{in}.

The Power Smith Tube introduced in this poster presentation is a means of a powerful tool to visualize PAE and ACPR over varying Γ_L and P_{in} where P_{in} is the z component in the three dimensional figure. With PAE and ACPR visualized inside the Power Smith Tube an intelligent search based algorithm can be realized to search through this three dimensional space quickly. This fast and intelligent search proposed is used a means to converge to an optimized Γ_L and P_{in} value and therefore effectively reduce the time and skill required to design a power amplifiers for both radar and communication systems.

Optimizing Radar Waveforms Using Generalized Alternating Projections

Dylan Eustice and Casey Latham
Department of Electrical and Computer Engineering
Baylor University

Faculty Advisor: Prof. Charles Baylis, Baylor University
Sponsor: National Science Foundation

Abstract

The radar ambiguity function, described as an autocorrelation of shifts in time and frequency, is useful for determining a waveform's accuracy at detecting targets in certain range-Doppler combinations. Our work proposes an algorithm which uses a generalized method of alternating projections to synthesize waveforms with desired ambiguity function properties.

In practice, it is often desirable to minimize the magnitude of the ambiguity function at range-Doppler combinations where targets other than the detection are likely to cause interference. This is a design problem which is typically solved by using a class of waveforms with “thumbtack” ambiguity function properties, or by choosing a weighted combination of waveforms from a precompiled catalog.

A method is presented which uses alternating projections between time, frequency, and range-Doppler domains to find a baseband radar waveform which is jointly optimized for both minimization criteria in a desired ambiguity function and spectral mask requirements. The waveform produced is completely independent of pre-existing waveforms, in that it is not reliant on a catalog of signals and is entirely a creation of the algorithm.

This work provides a computationally intelligent methodology to dynamically optimize detection in radar applications and a foundation for future work in joint circuit optimization for spectral compliance and efficient radar optimization.

Smith Tube Optimization for Adaptive Radar

Matthew Fellows
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Faculty Advisor: Prof. Charles Baylis, Baylor University
Sponsor: National Science Foundation

Abstract

Today's radar systems need to become smarter in order to deal with the stricter requirements on them due to the increasing number of wireless devices inhabiting the frequency spectrum. Adaptive Radar is a method for adapting a radar system to whatever new requirements are placed on it. The goal of the research presented in this poster is to empower adaptive radar systems to adapt to those new requirements while maintaining the best level of performance possible. Maintaining that level of performance requires two things: adapting the waveform for optimum target detection capability and adapting the load impedance for optimum power efficiency while keeping in compliance with the new requirements.

Improving the Performance of RSS Detection Using Wireless Open-Source Platforms

Yan Shi
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Abstract

Received signal strength (RSS) is a measurement of the power present in a received radio signal. Although RSS is inherently available in many hardware such as Network Information Centers (NICs) and smart phones, its detection performance may be disappointing, considering the various environmental factors and complex hardware design. In this work, we concentrate on enhancing the performance of RSS detection in terms of accuracy and stability based on wireless open-source platforms. To build an accurate mappings of RSS projected on a specific RSS detection platform, we implement two data fitting models by conducting rigorous experiments and compare their fitting performance. In addition, we also propose a multiple antenna evaluation approach to combat the effects of environmental factors by selecting reliable samples. The experiment results demonstrate that our proposed approaches are more efficient to improve the performance of RSS detection compared with the traditional single antenna approach.

Investigation of 433 MHz and 915 MHz On-Body Wave Propagations

Dong Xue
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Baylor University

Faculty Advisors: Prof. Brian Garner and Prof. Yang Li, Baylor University
Sponsors: Collaborative Faculty Research Investment Program of Baylor University; Baylor Scott & White Health, Baylor College of Medicine

Abstract

The wireless body area network (WBAN) is promising in medical applications such as remote health monitoring. A typical WBAN consists of wearable body sensor units (BSU) and a body control unit (BCU), where the BCU receives the signal from BSUs and transfers data to medical caregivers. Understanding on-body electromagnetic propagation mechanisms is essential for implementing a WBAN. Most of the previous studies focused on modeling and characterization of the body wave propagation at 2.45 GHz. However, electromagnetic wave propagations in other medical frequency bands (ISM), such as 433 MHz and 915 MHz, remain to be investigated.

In this presentation, on-body wave propagation is investigated for low medical frequencies such as 433 MHz and 915 MHz. The study applies the ground wave and creeping wave theories to calculate the approximate path gain, both along and around a human body. The formulas contain the characteristics of the human phantom shape and tissue properties. The analytical model is validated by FEKO simulation and measurements on a human male subject.

Our experimental and simulation data show good agreement with the theoretical predictions. Wave propagation along the body can be modeled as ground wave propagation on an infinite large ground with electrical properties equivalent to that of muscle tissue. Wave propagation around the human torso can be characterized as creeping wave diffraction around a cylinder-shape muscle phantom. The propagation characteristics of both on-body waves are extracted and explained.

Electrokinetic Actuation of Non-Toxic Liquid Metal for Reconfigurable RF Devices

Ryan Gough, Jonathan Dang, and Andy Morishita
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University of Hawaii at Manoa

Faculty Advisors: Prof. Aaron Ohta and Prof. Wayne Shiroma
University of Hawaii at Manoa

Abstract

Reconfigurable circuits have become a popular topic for wireless RF applications, promising increased capability with reduced cost and space. Conventional designs generally use semiconductor components or micro-electromechanical systems (MEMS) to alter the performance of the device. However, semiconductors can introduce nonlinearities and are lossy at higher frequencies while MEMS components can often require high actuation voltages.

An alternative is the use of liquid metal, which retains high electrical conductivity while it changes its physical shape. Fluidic conductors have extremely low loss, making them excellent candidates for high-Q applications, and their amorphous nature makes them adaptable, conformable, and capable of 'self-healing' if damaged. The smooth surface of liquid metal also holds promise for low-loss conduction well into the mm-wave frequency band.

However, the actuation of liquid metal has typically been pressure-driven, which necessitates the use of energy-inefficient micropumps. In addition, gallium-based alloys, although non-toxic and stable liquids at room temperature, rapidly oxidize when exposed to even small concentrations of oxygen. This oxide layer acts as a 'skin' on the surface of the liquid metal and will wet to most surfaces, inhibiting actuation and leaving behind a conductive residue.

This work seeks to achieve the high-performance reconfigurability of which liquid metal is capable in a manner that is low-voltage (less than 5V), low-power (microwatts to milliwatts), rapid (~100 mm/s), and repeatable. This is realized by electrically manipulating the naturally high surface tension of the liquid metal in order to induce dramatic deformations of the liquid-metal droplet. Immersion in an electrolytic carrier fluid works to both chemically reduce the oxide layer as well as to provide a medium by which the surface tension can be electrically varied.

By controlling the location and extent of the induced surface tension gradient, significant control over the liquid metal's shape and position can be exerted. Our research group has utilized these techniques to create a wide variety of reconfigurable devices, including frequency-tunable amplifiers, antennas, filters, phase shifters, and RF switches.

An Investigation of Dual-band Fabry-Pérot Resonant Cavity Antennas

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Faculty Advisors: Prof. David R. Jackson and Prof. Stuart A. Long
University of Houston

Abstract

Two-dimensional (2-D) leaky-wave antennas (LWAs) have the ability to easily produce highly directive pencil beams at broadside. One example of a 2-D LWA is the Fabry-Pérot resonant cavity antenna using a partially reflecting surface (PRS). Recent advances in the study of these structures include techniques for bandwidth enhancement. Often the bandwidth enhancement is achieved by use of a multi-layer PRSs. In some applications, multiband operation will suffice, and broadband operation is not needed. The goal of this work is to examine a dual-band version of the Fabry-Pérot resonant cavity antenna that uses an FSS patch layer over a ground plane to form a composite artificial ground plane that replaces the single metal ground plane of the conventional structure.

The main design principle of the general multiband Fabry-Pérot resonant cavity antenna is that each FSS layer in the structure has a resonance frequency at which it acts as a short circuit and hence behaves as a “virtual ground plane” at that frequency. Using multiple FSS layers allows for multiple resonance frequencies; this in turn allows the establishment of different frequencies at which the overall cavity structure is resonant, and hence, radiates a beam at broadside.

Reciprocity is used to calculate the far-field pattern of a source dipole inside the structure, in which a plane wave incidence is used to illuminate the structure and the field at the source dipole location is determined (T. Zhao, D. R. Jackson, J. T. Williams, H.-Y. Yang, and A. A. Oliner, IEEE Trans. Antennas Propagat., vol. 53, no. 11, pp. 3505-3514, Nov. 2005). A simple transverse equivalent network (TEN) model is used to calculate the field inside the structure due to the plane-wave incidence. In the TEN shunt admittances are used to represent the metal-patch PRS as well as the metal-patch FSS layer that is above the ground plane. The Transverse Resonance Equation is used to calculate the heights of the cavities of the dual-band structure for the initial design.

An iterative design procedure is introduced that determines the optimum resonance frequency of the PRS as well as the optimum location of the FSS layer in the artificial ground plane and the optimum dipole source location. The final design has equal directivities at two arbitrarily specified frequencies as well as equal radiated broadside power densities at these frequencies.

Properties of Microwave and Optical 2-D Periodic Leaky Wave Antennas

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Faculty Advisors: Prof. David R. Jackson and Prof. Stuart A. Long
University of Houston

Abstract

The radiation characteristics of a two-dimensional (2-D) periodic leaky-wave antenna at microwave and optical frequencies is examined here. The phenomenon of directive beaming at optical frequencies can be explained in terms of leaky plasmon waves. These plasmonic structures are thus similar to a periodic 2-D leaky-wave antenna, and the fundamental radiation characteristics of them can be explained using leaky-wave theory. The 2D periodic LWA and Plasmon structure are treated here as principally the same with frequency scaling.

Two-dimensional (2D) periodic leaky-wave antennas can be formed by a periodic arrangement of metal patches on a grounded dielectric layer, excited by a simple source such as a horizontal magnetic dipole in the middle of the structure. The dipole source launches a radially-propagating (cylindrical) TM0 surface wave, guided by the grounded substrate. This surface wave becomes a leaky wave due to the periodic patches, which perturb the surface wave and enable radiation from a higher-order space harmonic (Floquet wave) producing very narrow beams at broadside. A leaky-wave antenna operates by gradually leaking energy from a travelling wave which is a fast wave. For a periodic LWA, periodic discontinuities (in the form of periodic metallizations, slots, etc.) are introduced into the waveguiding structure, and the guided mode is perturbed into an infinite number of space harmonics known as Floquet waves. One of the Floquet waves, can be designed to be in the fast-wave region and thus becomes leaky, making the waveguiding structure a LWA.

The phenomenon of directive beaming at optical frequencies using a periodically corrugated plasmonic metal (e.g., silver) film can be explained and studied in terms of leaky plasmon waves. The goal of this investigation is to characterize the wave propagation and radiation characteristics of these types of 2D periodic leaky-wave structures for both microwave and optical frequencies, and to show how the beam properties can be optimized.

A Small-Size High-Gain 16GHz Tri-Resonance Bow-tie Microstrip Antenna

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Faculty Advisor: Prof. Taha İmeci, Istanbul Commerce University
Sponsor: Tübitak Research Corporation
(The Scientific and Technological Research Council of Turkey)

Abstract

In this work, a tri resonance edge-fed bow-tie patch antenna is designed, simulated, built and tested. The measured gains are 7.67 dB at 15.27 GHz and 10.42 dB at 16.15 GHz, representing the first demonstrated antenna with over 10 dB gain in less than 1cm size for a bow-tie microstrip structure operating at such frequencies. The resonance frequencies are chosen such that they could be used in many satellite communications applications in the 12-16 GHz band. A bow-tie shaped microstrip patch antenna for satellite communications is designed. The design is simulated with Sonnet Suites, a planar 3-D.

Related to the antenna design, an exact bow-tie shape is used but achieved very poor gain despite exhibiting a -20 dB return-loss at 15.38 GHz. By changing the feeding location from bottom (probe-feeding) to edge-feeding, after several iterations on the geometry, three resonances were obtained. The dielectric material used in the design is Rogers RT6010 with dielectric constant of $\varepsilon_r = 10.2$ and thickness of 1.28 mm. The dimensions of the antenna are 8.5 × 7.96 mm. Note that all bow-tie angles are 45°.

The antenna was fabricated and resonance frequencies were observed at 15.27, 16.15 and 16.375 GHz. While the first resonance frequency shows almost exact match, the last two frequencies are significantly off, with the antenna exhibiting relatively high gain at 16.15 GHz. When the simulated and fabricated results are compared to each other there is a frequency discrepancy between the simulated and measured results for the two higher frequencies.

As a conclusion, in this work a bow-tie shaped patch antenna for satellite communications with three resonances between 15 and 16 GHz was designed, simulated, built and tested. A parametric study shows that the antenna works well when the bow-tie angle is 45º. There is a perfect agreement with simulated and measured results at the first resonance frequency of 15.25 GHz. The proposed antenna is very compact, with less than 1×1 cm size, and demonstrates. 10.42 dB gain, which is superior to previously published designs of similar structure and frequency band.

High Gain Dual-Resonance Microstrip Antenna

Ahmet Safak Yavuzoglu
Department of Electrical Engineering
Istanbul Halic University

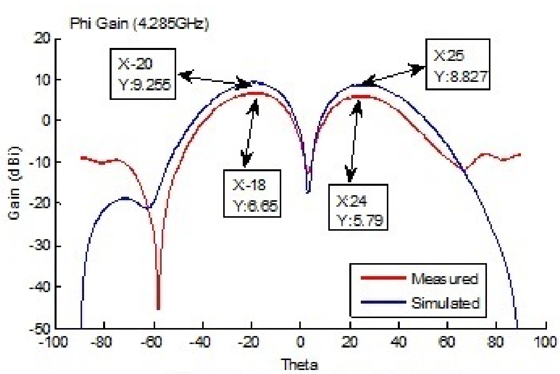
Faculty Advisor: Prof. Taha İmeci, Istanbul Commerce University
Sponsor: Turkish Military Electronics Company (Aselsan)

Abstract

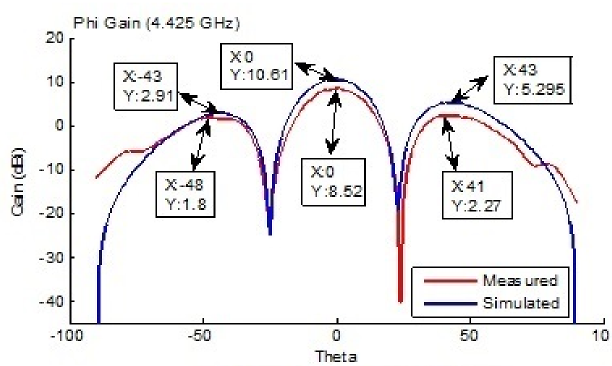
A high-gain, dual resonance microstrip patch antenna, which operates at 4.285 GHz and 4.425 GHz was designed and fabricated. The measured return loss is -21.2 dB and electric field phi-polarized gain is 8.5 dB. Cross-polarization levels are as low as -30dB. The work included planar 3-D simulations, a parametric study and implementation of it. Simulations were performed with Sonnet Suites which uses Method of Moments as an electromagnetic solution technique.

Emprical results were obtained for several variants invovling various strcutural changes.

In this work, a similar antenna is designed with only one port but as a result, dual-resonance is achieved with high-gain. Dual resonance high gain microstrip patch antenna is designed, simulated, built and tested. No transistors have been used. Design is modified by making an optimization on geometry. Dielectric constant is 2.2 and dielectric thickness is 0.8 mm. The antenna operates at 4.285 GHz and 4.425 GHz. Measurement result of minimum return loss is -21.2 dB and maximum electric field phi-polarized gain is 8.52 dB. 4.3GHz in simulation vs. 4.285GHz measured (0.35% error) and at 4.45GHz in Simulation vs 4.425GHz measured (0.56% error).



Radiation pattern for 4.285GHz.



Radiation pattern for 4.425GHz.

A Novel Dual-Band Quarter Wavelength Transmission Line with Asymmetrically Allocated Open-Stubs and Short-Circuited Stubs

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University of North Texas

Faculty Advisor: Prof. Hualiang Zhang, University of North Texas

Abstract

A novel microstrip quarter wavelength dual-band transmission line using asymmetric open and short-circuited stubs loaded resonators is demonstrated. At both ends of the transmission line, one open-ended and one short-circuited stubs are attached. Since different stubs are applied at the left and right sides of the transmission line, an asymmetric structure is achieved. The design can be satisfied for dual-band operations with the frequency ratio from 1.46 to 1.64.

To verify the design theory, a prototype transmission line working at 1 GHz and 1.46 GHz is designed. The transmission line's return loss ($|S_{11}|$) is 12.67dB and 12.15dB and its insertion loss ($|S_{21}|$) is 1.14 dB and 1.44 dB at the two design frequencies respectively. Numerical simulations are performed both in HyperLynx 3D EM and in circuit simulator ADS. It is found that numerical simulations through HyperLynx 3D EM can cause frequency shift for the return loss S_{11} and for the phase response S_{12}. By adjusting the length of the stub, the frequency shift can be reduced. The 90^o phase response of the designed transmission line can be achieved for low and high operating frequencies respectively. All of these results have clearly demonstrated the dual-band operation of the designed transmission line. On the basis of above consideration the proposed transmission line design can be applied to many different dual-band microwave systems.

Low-Power and High-Linearity CMOS Mixers for Millimeter Wave Applications

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Southern Methodist University

Faculty Advisor: Prof. Ping Gui, Southern Methodist University

Abstract

A low-power CMOS mmWave passive mixer based on a novel LO shaping technique using non-linear transmission line (NLTL) is proposed. The mixer employs a non-return-to-zero (NRZ) capacitive loaded sampling structure. The LO signal is reshaped by an NLTL before it is applied to the mixer, which alleviates the trade off between the mixer gain and linearity and decreases the noise figure (NF). The NLTL is constructed using series inductors and shunt varactors. It boosts the LO swing and re-shapes the LO pulses to have higher amplitude, narrower pulses, and sharper edges, resulting in higher gain, better linearity, and lower noise figure. Two mixers, one operated at 60GHz and the other at 120GHz, are designed using 65nm CMOS process. The simulation results show single-sideband NF of 5.9dB and 6.8dB, IP1dB of 0.9dBm and 1.4dBm, and a power gain of 1.2dB and 1dB, for the 60GHz and 120GHz mixers, respectively. Both mixers require a 0dBm LO input level and do not consume DC power.

A Low-Voltage Low-Power 25 Gb/s Clock and Data Recovery with Equalizer in 65 nm CMOS

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Lyle School of Engineering
Southern Methodist University

Faculty Advisor: Prof. Ping Gui, Southern Methodist University

Abstract

A novel low-power low-jitter 25 Gb/s clock and data recovery (CDR) circuit with an equalizer that can work at an ultra-low supply voltage of 0.6 V is proposed and implemented in a 65 nm CMOS process. A two-tank transformer-feedback technique is proposed in the 25 GHz LC-tank VCO to improve the phase noise performance at low supply voltage. Forward-body biasing (FBB) technique is proposed in the low-voltage signal path to reduce the threshold voltage of the transistors, thus increasing the signal amplitude and achieving low BER. The measurement results show that the CDR and equalizer can work under 0.6 V with 0.23ps/4.62ps (rms/pk-pk) of recovered clock jitter. The measured power consumption of the CDR with the equalizer is 48.8 mW (1.95 mW/Gb/s).

10 Gb/s VCSEL Driver IC in 130 nm CMOS

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Southern Methodist University

Faculty Advisor: Prof. Ping Gui, Southern Methodist University

Abstract

A low-cost and low-power 10 Gb/s VCSEL driver integrated circuit (IC) in 130-nm CMOS technology is proposed. The IC is based on a high-speed Distributed-Amplifier based modulator (DA modulator), which features carefully designed differential artificial transmission lines (T-lines) at both the gates and drains of the MOSFETs to cancel the parasitic capacitances so as to boost the bandwidth. A distributed-gate-ESD protection scheme has been utilized in order to minimize the jitter by balancing the group delays of the drain and gate transmission lines in the DA modulator. To compensate the channel losses and capacitive load at the output of the modulator, a frequency domain pre-emphasis, implemented by capacitive degeneration, is proposed. To minimize the die size, the number of DA stages in the proposed modulator has been optimized and T-coils and bonding wire parasitic inductors are utilized to implement the T-lines. The proposed DA modulator occupies an area of 0.69 mm^2 and the VCSEL driver IC has a total die size of 2 mm × 2 mm including the pads. Both electrical and optical tests are carried out in order to characterize the performance of the DA-based VCSEL driver IC. Measurements at a data rate of 10 Gb/s demonstrate a typical power consumption of 85 mW and an RMS jitter of 0.63 ps and 1.12 ps for the electrical test and optical test respectively.

40 GHz Laminate Power Divider Circuits using Integrated Resistors

Joel Arzola
Department of Electrical Engineering
University of Texas at Dallas

Faculty Advisor: Prof. Rashaunda Henderson, University of Texas at Dallas
Sponsor: Semiconductor Research Corporation (SRC)

Abstract

This poster describes the fabrication and performance of tantalum nitride (TaN) resistors fabricated on a multilayer substrate with FR4 and SU-8 resist. The SU-8 layer is used to minimize the surface roughness so that the integrated resistor metal can be patterned reliably. 40 GHz equal-split and four-way equal-split Wilkinson power dividers are demonstrated and show good agreement with simulated results. In addition a five-section broadband divider is fabricated using resistor values ranging from 50 to 1000 ohms.

Manufacturing Resistors on PEN Dielectric for Antenna Termination

Christopher Miller
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University of Texas at Dallas

*Faculty Advisor***:** Prof. Rashaunda Henderson, University of Texas at Dallas

Abstract

This poster summarizes the design and fabrication of tantalum nitride resistors to be used to terminate a broad-band coplanar waveguide fed bowtie aperture antenna. Polyethylene naphthalate (PEN) was used as a preformed dielectric layer. Due to adhesion and surface roughness issues, SU-8 photoresist was used as both a smoothing layer as well as a separation layer between the PEN and the tantalum nitride. Measurements of the resistors were made from 10 to 325 GHz and show a return loss of 20 dB or better can be achieved. This is indicative of a 50Ω load. The resistor termination is added to the antenna so that FTIR spectroscopy can be used for radiation pattern measurements up to 300 GHz. A properly terminated antenna will absorb incident radiation.

Sub-Terahertz CMOS Transistor Mixer

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University of Texas at Dallas

Faculty Advisor: Prof. Rashaunda Henderson, University of Texas at Dallas

Abstract

The design, layout, and simulation and measurement results of a transistor-based mixer at 200 GHz are presented. The mixer is designed in UMC 65nm technology having an RF input of 200 GHz and local oscillator (LO) input of 150 GHz. The mixer provides a conversion gain of 20 dB with 3 dBm LO power. The mixer is followed by a 50 GHz common source buffer. The power consumption of the mixer is 8 mW from a 1 V power supply. The chip size is 0.978 mm × 0.55 mm. This single transistor mixer can be used in the sub-THz gas spectrometer applications.