RESEARCH OUTCOME

SELECTED ABSTRACTS

MMIC / RFIC

A switchable single double-band low noise amplifier
C.-H. Wu, J.-R. Yang
This paper presents a switchable single/double-band, low noise amplifier (LNA) for WLAN and WiMax systems. The LNA uses wideband bandpass filters and a capacitor of reduced high frequency signals at input matching networks. At the inter stage, using a series resonator increases gain at high frequency. To obtain a small chip size, this study used two center tapped inductors and a switch. This study simulated design using a TSMC 0.18μm RF CMOS 1P6M process. The power gain of the LNA was 19.35 dB at 2.4 GHz, 19.33 dB at 3.5 GHz, and 17.3 dB at 5.2 GHz. Noise figures were 2.9 dB at 2.4 GHz, 2.37 dB at 3.5 GHz, and 2.35 dB at 5.2 GHz. The S11 and S22 were lower than -10 dB for all desired frequency bands. The power consumption was 6.97 mW. The total chip area was 0.82*0.87 mm².

Noise improvement of 3.5GHz CMOS UWB LNA with low power consumption
C.-C. Lu and J.-R. Yang
A single inductor matching network that carried low noise is designed to achieve the input wideband matching. This way has lower complexity that reduces chip area and holds the good reflection coefficient. Besides, the current reuse technique was used to achieve low power consumption. The design is simulated by Taiwan Semiconductor Manufacturing Company (TSMC) 0.18/μm RF CMOS process. Through a 4V/5.56mA supply, the LNA achieved the maximum gain of 16.69dB with gain flatness ± 0.5dB; input return loss lower than -10dB; and a minimum noise figure 2.6dB in 3-5 GHz.

3-10 GHz CMOS distributed amplifier low power and low noise and high gain low noise amplifier for UWB systems
J.-C. Chen and J.-R. Yang
TENCON 2010 - 2010 IEEE Region 10 Conf., Nov. 2010
This study presents a 3-10GHz ultra-wideband low noise amplifier (UWB LNA) with CMOS distributed amplification (DA) featuring low power consumption, flat response, high gain (S21), and low noise figure (NF). The DA UWB LNA is designed with standard 0.18μm CMOS technology. Low power consumption, flat and high gain (S21) were achieved through the use of a proposed two stage DA, and current-reused technique with a peaking inductor. An R2 terminating network for the gate transmission line, and an under-damped Q-factor for second-order NF frequency response achieved a flat response and low noise figure (NF). The LNA achieved S21 of 15.8±1.2 dB and an average NF of 3.4±0.36 dB with power dissipation (PD) of only 14.8 mW.
2 - 13GHz broadband CMOS low voltage mixer with active balun designed for UWB systems

I-C. Chen and J-R. Yang

2010 IEEE Int. Conf. Electron Devices and Solid-State Circuits (EDSSC)

This paper presents a 2 - 13GHz low-voltage broadband down-conversion mixer with an active balun for UWB radio. The mixer with an active balun is fabricated in the 0.18μm IP6M standard CMOS process. The mixer with active balun consumes 15.2 mW from a 1.2 V supply. This mixer was achieved by using a folded-mixer and a peaking inductor technique. This technique can double the 3 dB bandwidth at the output stage, so the high-frequency poles of the mixer could be pushed outside of the 2 - 13 GHz band range. The broadband mixer with an active balun achieves a conversion gain of 21 ± 0.6 dB and 14.9 - 16.5 dB on a double-sideband (DSB) noise figure and the input return loss is -12 dB. The output return loss is -10 dB. An input third-order intercept point (IP3) of -1.89 - -1.8 dBm. The mixer with active balun achieves with a supply voltage of 1.2 V and with a power consumption of 18.3 mW.

A 3-10 GHz low power ultra-wideband CMOS LNA

R-H. Chen and J-R. Yang


This study presents a 3-10 GHz ultra-wideband low noise amplifier (UWB LNA) with an interstage technique, featuring low power consumption, high gain (S21), and a low noise figure (NF). The low power consumption UWB LNA is designed using standard 0.18μm CMOS technology. Using the interstage technique (current reused topology with a peaking inductor) achieves low power consumption. The LNA achieves S21 of 13.2±1.8 dB and the NF is lower than 4.4 dB with power dissipation (PD) of only 3.24 mW.
A compact high-efficiency CMOS power amplifier with built-in linearizer

C.-C. Huang and W.-C. Lin


A compact high-efficiency CMOS power amplifier (PA) with built-in linearizer that works at 2.4 GHz using TSMC 0.13 µm technology for digital wireless communications applications is presented. The cascade configuration is utilized to overcome the low breakdown voltage problem and the hot-carrier effects for high power operations of CMOS devices. The linearizer design reduces the AM-AM quantities to extend the \( P_{\text{sat}} \) point while the AM-PM distortions are improved as well. The final designed PA exhibits \( P_{\text{sat}} \) of 20.6 dBm and 24.8% power-added-efficiency (PAE) with 35 dBm output-intercept-point in the third order (OIP3). The saturated output power is 22 dBm with 30% in PAE, while the chip size is less than 1 mm\(^2\).
SYSTEM APPLICATIONS

A Wearable Inertial Sensor Node for Body Motion Analysis

Y.-C. Kan and C.-K. Chen


A wearable wireless inertial sensor node for body motion analysis is designed and implemented. A triaxial accelerometer, a biaxial gyroscope and a yaw rate gyroscope are employed to sense the accelerations and angular rates of the object attached. These three ICs, a wireless mote, the power circuit and a modified printed inverted-F antenna are integrated on a four-layer printed circuit board. To achieve the compact size for comfortable wearing, the printed antenna is deliberately designed as small as possible while maintaining a reasonable antenna performance. The proposed inertial sensor node is also easily adaptable to applications with different power requirements because of the consideration of the periodic and moving-event wakeup in the software design. The static characteristics and Allan deviations of the implemented node are measured and analyzed. The false alarm rate of a moving detection based on Bayes rule is presented and a threshold is suggested. Finally, the raw data of several body motions are measured and those behaviors are observed apparently. The proposed inertial sensor node is compact and easily wearable; hence, it is feasible to be applied to the body motion analysis.
The Comprehensive Gateway Model for Diverse Environmental Monitoring upon Wireless Sensor Network

H.-C. Lin, Y.-C. Kan, and Y.-M. Hong


This study is aimed to establish a wireless sensor network (WSN) gateway model prior to the back-end server for diverse environmental monitoring applications. The design catalogs different sensor data with transmission load balance to incorporate heterogeneity of sensor signals, stability of data transportation, and expenditure of mobile communication. As considering a variety of sensor characteristics for environmental monitoring, the proposed WSN gateway is designed with three bridged functions, including serial listener, transaction logger and Internet listener, to enable analog and digital signal conversion, physical data classification, threshold determination, database redundancy and mobile communication. The criterion-based scheme is created for remotely updating thresholds of monitored data from the back-end server to the gateway. The model is built upon the embedded computer for low power consuming to perform efficient and stable applications. The comprehensive model design can be easily utilized for general WSN surveillance with expansibility and flexibility.
EMC/EMI

- **Analysis of Electrostatic Discharge Suppressors with Ultra-Low Capacitance Used for IC Protection**

  H.-Y. Chen, Y. Suo, C.-T. Kuo, and J. Qiu


  The TDMM was successfully used to analyze the capacitance, the electric field, and the ESD current of an ESD suppressor. The obtained capacitance was also validated by measurement data. It is found that the maximum electric fields in the air gap between two discharge electrodes for the air gap width of 5-50 μm are much higher than the threshold electric field for air breakdown. A maximum ESD current of 4.7 mA was obtained during an ESD event, which may be sufficient to cause a malfunction in a high sensitivity integrated circuit.

Antenna

- **Performance Improvement of a U-Slot Patch Antenna Using a Dual-Band Frequency Selective Surface with Modified Jerusalem Cross Elements**

  H.-Y. Chen and Y. Tao


  A dual-band FSS consisting of regular Jerusalem cross elements was first used to study its impact on the bandwidths and resonant frequencies of a U-slot patch antenna. Based on the simulation experience of the first partial study, another FSS with modified Jerusalem cross elements was proposed to improve the bandwidths, antenna gains, and return losses of a smaller U-slot patch antenna at 2.45 and 5.8 GHz for Bluetooth and WLAN applications, respectively. Measured data of the return loss, radiation pattern, and antenna gain of this smaller U-slot patch antenna were also presented. It is proven that the smaller U-slot patch antenna implanted with a FSS consisting of modified Jerusalem cross elements has a good performance with sufficient bandwidth and higher gain and is capable of dual-band operation.
Design of Periodic Antenna Arrays with the Excitation Phases Synthesized for Optimum Near-field Patterns via Steepest Decent Method


We present the design and realization of a microstrip patch array antenna, which is operated at 24 GHz band, and can be used in the applications of vital-signal detection with a higher resolution. The design uses the steepest descent method (SDM) to synthesize the excitation phases of the array such that the radiation has an optimum near-field pattern in the desired area. Both theoretical development of SDM formulations and experimental validations over the antenna prototype are presented.

Microwave Measurement Technology

Accuracy improvement for line-series-shunt calibration in broadband scattering parameter measurements with applications of on-wafer device characterization

C.-C. Huang, Y.-H. Lin and M.-Y. C. Chien


Error analysis and accuracy improvement for on-wafer line-series-shunt calibration in broadband scattering parameter (S-parameter) measurements are presented with complete modeling of the resistive series/shunt standards, rather than the simple lumped assumptions that were basic requirements in the previous studies. The associated parasitic effects in the models are estimated by the first-run results using lumped assumption. They are further updated iteratively, where higher order errors are analytically identified. Additionally, the de-embedded S-parameters are transformed for the reference impedance, based on the acquired characteristic impedance which may differ from the measurement system in broadband operations. The proposed algorithm and calibration data are demonstrated by pseudomorphic high electron mobility transistors (pHEMTs) with conductor-back coplanar waveguides (CPWs) built on GaAs substrates, with verifications of the thru-reflect-line (TRL) calibration results.
Microwave/Millimeter Wave Systems

- High-speed W-band integrated photonic transmitter for radio-over-fiber applications

N.-W. Chen, H.-J. Tsai, F.-M. Kuo, and J.-W. Shi


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Schematics of the integrated photonic transmitter

Building blocks of the integrated photonic transmitter

Photograph of the fabricated integrated photonic transmitter without the integration of the NBUCC-PD

Photograph of the fabricated integrated photonic transmitter with the integration of the NBUCC-PD

A 20-Gbit/sec wireless link between the integrated photonic transmitter and the last power detector

Measured BER at different transmission distance

The eye diagram of the 20-Gbit/sec wireless link
Computational Electromagnetics

- Microwave and Millimeter-Wave Attenuation in Sand and Dust Storms
  X.-Y. Dong, H.-Y. Chen, and D.-H. Guo

  The attenuation and phase delay due to sand and dust storms are obtained by using the effective material property technique and general formulation of the complex propagation factor. The validity of attenuation is verified by Ghoobial et al.'s formula. Attenuations obtained for various frequencies are shown in this study. It is found that the attenuation decreases sharply as the visibility increases. It is also proven that the attenuation is negligible except for frequencies above 30 GHz and for very dense storms. It is found that cross-polarization may be serious when a wave propagation path over 1 km has visibilities below 10 m, which may cause signal loss in microwave and millimeter-wave links. The effective material property technique and general formulation of the complex propagation factor have shown a quick and easy way of calculating the attenuation and phase delay due to sand and dust storms, which otherwise requires complicated and expensive methods of calculation and measurement.

- TD-UTD Solutions for the Transient Radiation and Surface Fields of Pulsed Antennas Placed on PEC Smooth Convex Surfaces
  H.-T. Chen, Prabhakar H. Patnake and Paul R. Rousseau

  A time-domain formulation of the uniform geometrical theory of diffraction (TD-UTD) is developed for predicting the transient radiation and surface fields of elemental pulsed antennas placed directly on a smooth perfectly conducting, arbitrary convex surface. The TD-UTD solution is obtained by employing an analytic time transform (ATT) for inverting into time the corresponding frequency domain UTD (FD-UTD) solution. An elemental antenna on the convex surface is excited by a step function in time and a TD-UTD solution is obtained first. The TD-UTD response to a more general pulsed excitation of the elemental current is then found via an efficient convolution of the TD-UTD solution for the step function excitation with the time derivative of the general pulsed excitation. In particular, this convolution integral is essentially evaluated in closed form after representing the time derivative of the general pulsed excitation by a small sum of simple signals whose frequency domain description is a sum of complex exponential functions. Some numerical examples are presented to illustrate the utility of these TD-UTD solutions for pulsed antennas on a convex body.
PATENTS

- **High Isolation Structure for Two MIMO Antennas**
  
  Patent Number: ROC M415431
  Inventor: M.-T. Hsieh and H.-Y. Chen
  Time: Nov 1, 2011.

- **Adjustable image rejections for multi-band wireless transceiver designs**
  
  Patent Number: ROC 13300009
  Inventor: C.-C. Huang, C.-P. Liang
  Time: 2010/9/1

  The proposed RF circuit design can be used in the super heterodyne architectures for the 3G mobile systems and the wireless local area networks (WLAN), operating at, for example, 2.0 GHz, 2.4 GHz, 5.2 GHz, and 5.9 GHz, respectively. If the IF frequency is chosen as 500 MHz, the image interference frequencies are then located at 1.0 GHz, 1.4 GHz, 4.2 GHz, and 4.9 GHz. This image rejection circuit can provide the independent adjustments for image rejections at 1.0/1.4 GHz and 4.2/4.9 GHz. That is, the image frequency rejection tuning for 1.0/1.4 GHz band does not affect the rejection frequency response at 4.2/4.9 GHz, and vice versa. The designed circuit can also be applied to the transmitter configurations, becoming the suitable for the RF transceiver applications of multi-band/multi-mode smart communicators such as handsets and personal digital apparatuses (PDAs).