



# RESEARCH OUTCOME

## SELECTED ABSTRACTS

### MMIC / RFIC

#### ■ Modeling inductive behavior of MOSFET scattering parameter S22 in the breakdown regime

C.-I. Lee, W.-C. Lin, and Y.-T. Lin

*IEEE Trans. Microw. Theory Tech.*, vol. 60, no. 3, pp. 502-508, Mar. 2012.

**Abstract**—A novel physical small-signal equivalent circuit for accurately modeling an unusual phenomenon of inductive S22 in the breakdown regime of RF metal-oxide semiconductor field-effect transistors is presented for the first time. To remove the low-frequency dispersion of the drain-to-source resistance extracted by a conventional approach, a new extraction method of equivalent circuit element values with the introduction of an inductive network is demonstrated in this paper. Excellent agreement between simulated and experimental data is obtained up to 26.5 GHz in the breakdown region. Therefore, this proposed physical model based on the avalanche breakdown mechanism can accurately be used to predict the RF circuit performance when impact ionization occurs.

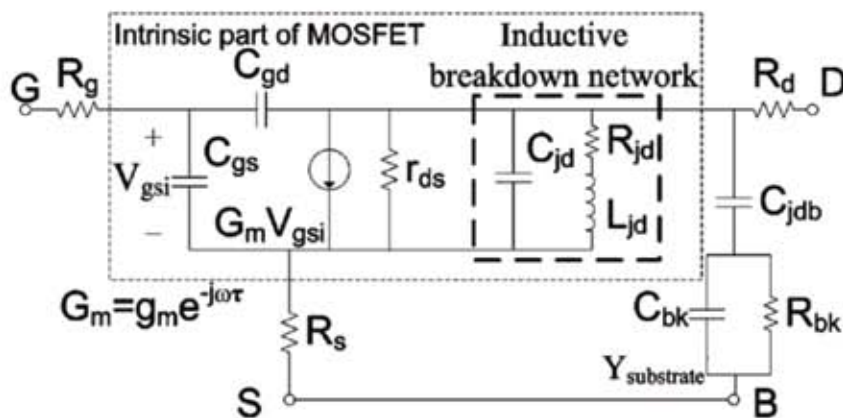
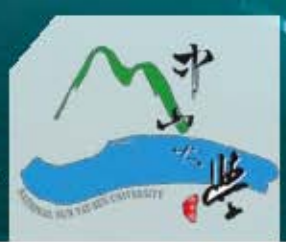


Figure: Modified small signal model of MOSFET with a physics-based inductive network.



## Antenna

### ■ Internal coupled-fed dual-loop antenna integrated with a USB connector for WWAN/LTE mobile handset

F.-H. Chu and K.-L. Wong

*IEEE Trans. Antennas Propag.*, Vol. 59, pp. 4215-4221, Nov. 2011

A coupled-fed dual-loop antenna capable of providing eight-band WWAN/LTE operation and suitable to integrate with a USB connector in the mobile handset is presented. The antenna integrates with a protruded ground, which is extended from the main ground plane of the mobile handset to accommodate a USB connector functioning as a data port of the handset. To consider the presence of the integrated protruded ground, the antenna uses two separate shorted strips and a T-shape monopole encircled therein as a coupling feed and a radiator as well. The shorted strips are short-circuited through a common shorting strip to the protruded ground and coupled-fed by the T-shape monopole to generate two separate quarter-wavelength loop resonant modes to form a wide lower band to cover the LTE700/GSM850/900 operation (704–960 MHz). An additional higher-order loop resonant mode is also generated to combine with two wideband resonant modes contributed by the T-shape monopole to form a very wide upper band of larger than 1 GHz to cover the GSM1800/1900/UMTS/LTE2300/2500 operation (1710–2690 MHz). Details of the proposed antenna are presented. For the SAR (specific absorption rate) requirement in practical mobile handsets to meet the limit of 1.6 W/kg for 1-g human tissue, the SAR values of the antenna are also analyzed.

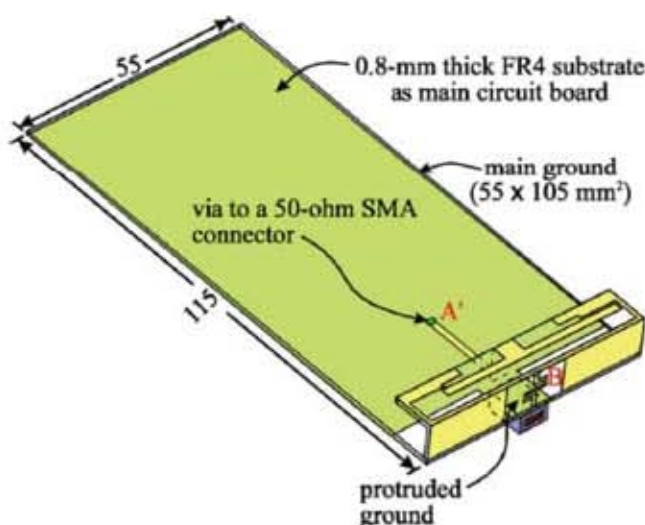


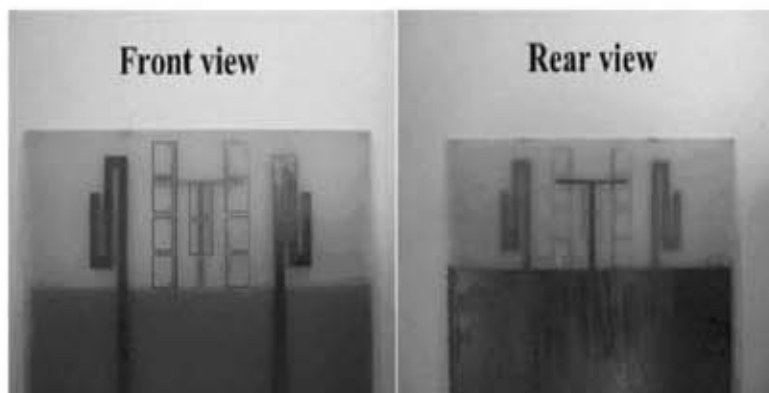
Fig. Geometry of the proposed coupled-fed dual-loop mobile handset antenna integrated with a USB connector.

### ■ Implementation of broadband isolator using metamaterial-inspired resonators and a T-shaped branch for MIMO Antennas

C.-C. Hsu, K. H. Lin, and H. L. Su

*IEEE Trans. Antennas Propag.*, vol. 59, no. 10, pp. 3936–3939, Oct. 2011

We develop a novel MIMO antenna with excellent broadband isolation performance in this communication. Metamaterial (MTM)-inspired resonators can function as insulators and are placed periodically into a compact MIMO antenna system for portable applications. These insulators only need a 0.18 wavelength. The broadband insulators can efficiently reduce the coupling of MIMO antennas. Isolation bandwidth under 20 dB can reach 8% with relative to the center frequency. Adding a T-shaped branch behind the insulators markedly improves the isolation bandwidth. An isolation bandwidth under 20 dB can achieve 19.3% relative to the center frequency. The effectiveness of the proposed insulators is validated by measurements.



## Microwave Measurement Technology

### In-plane mixed probe techniques to obtain the RF characteristics of the adaptor

K.-C. Lu, T.-S. Horng, and L.T. Hwang

*IEEE Electron. Comp. Technol. Conf.*, Jun. 2011, pp. 2033-2036.

In this study, a Short-Open-Load-Reciprocal (SOLR) calibration procedure is conducted to obtain the RF characteristics of an adaptor (the traces between the edge of the package and the SMA connectors) on a test board. The RF characteristics are used in a post-processing technique to obtain the true RF performance of the IC inside the package. Due to the unique physical configuration of the adaptor (closely spaced at one end), a mixed coplanar-to-connector measurement technique is needed to obtain the RF characteristics. To the knowledge of the authors, this problem has not previously been studied. After the RF characteristics of the adaptor are obtained herein, the RF performance of SMA connectors, either in-plane (horizontal), or out-of-plane (vertical), is extracted. We found that the horizontally and vertically oriented SMA connectors introduced additional delay, attenuation, and mismatch to the planar traces on the test board. The measurements were made up to 12 GHz.

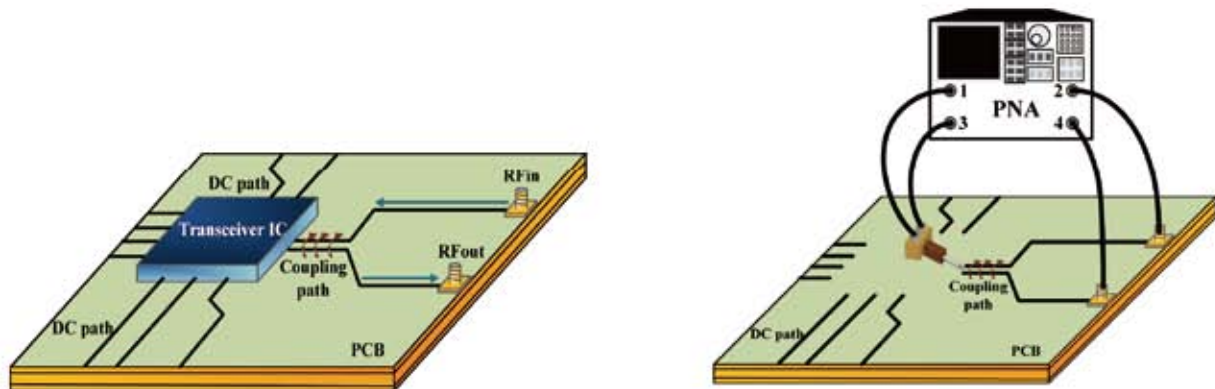


Figure: Adaptor with mixed probe-connector configuration and measurement of the adaptor's 4x4 s-parameter matrix.

## Microwave/Millimeter Wave Systems

### ■ Single-antenna Doppler radars using self and mutual injection locking for vital sign detection with random body movement cancellation

F.-K. Wang, T.-S. Horng, K.-C. Peng, J.-K. Jau, J.-Y. Li, and C.-C. Chen

*IEEE Trans. Microw. Theory Tech.*, Vol. 59, No. 12, pp. 3577-3587, Dec. 2011

This work presents a single-antenna self-injection-locked (SIL) radar to reduce the hardware complexity of continuous-wave (CW) Doppler systems. The theory provides a basis for determining the signal-to-noise spectral density ratio (SNDR) with the effects of clutter. Experimental results agree closely with the theoretical predictions, showing that the clutter does not affect the optimal SNR performance in an SIL radar. A single-antenna SIL radar array is designed to detect vital signs with random body movement cancellation. To this end, a subject is placed between two single-antenna SIL radars to measure the rates of respiration and heartbeat using Doppler shift, and the effects of random movement of the subject are cancelled by wireless mutual injection locking (MIL) of the two radars. In an experiment, a prototype of such a two-radar array with a spacing of 2 m was implemented at 2.4 GHz, providing accurate and reliable cardiopulmonary monitoring of a subject who jogged on a treadmill with random body motion of many centimeters.

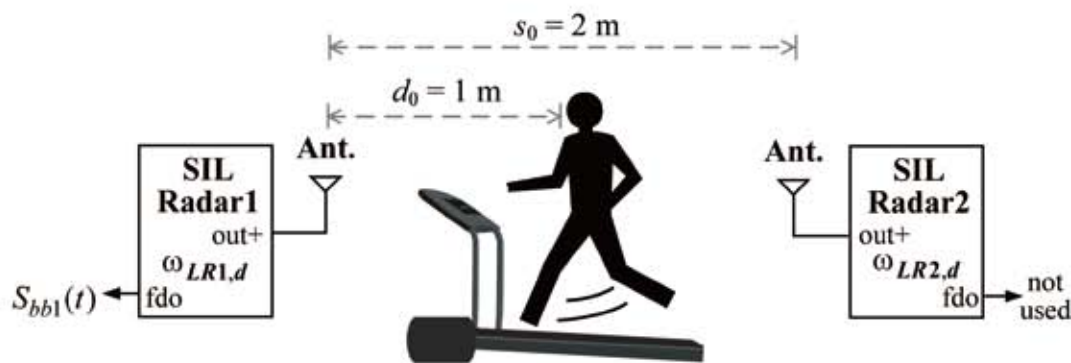
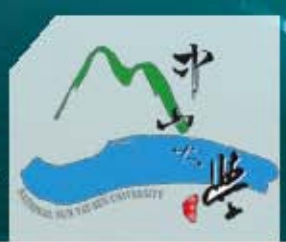


Figure: Experimental setup for using SIL radars to detect vital signs of a subject jogging on a treadmill.



## Computational Electromagnetics

### ■ A new scheme for the conformal FDTD method to calculate the radar cross section of perfect conducting curved objects

C.-M. Kuo and C.-W. Kuo

*IEEE Antennas Wireless Propag. Lett.*, Vol. 9, pp. 16-19, Jan. 2010

**Abstract**—The chief shortcoming of the conformal finite-difference time-domain (CFDTD) method is the global time-step reduction in order to avoid instability arising from small irregular cells. In this work, we introduce a new conformal scheme to overcome this problem for the CFDTD method. The time-step reduction is applied only locally to the small irregular cells, which is only 1/3 of that in the regular cells. In order to update the electric field at the interface between the small irregular cell and its adjacent cells, extra magnetic fields next to the small irregular cell are introduced. Through this scheme, the time-step reduction is limited to a few small cells, and the numerical simulation can be the most efficiently implemented in the FDTD framework. Numerical accuracy is verified by comparison with the conventional CFDTD method for the radar cross section (RCS) of perfect conducting curved objects.

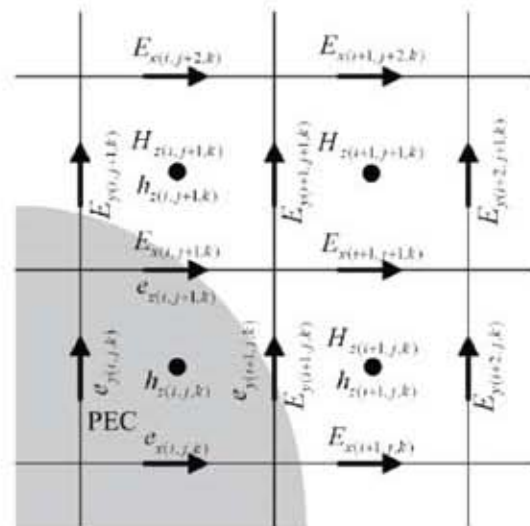


Figure: Cross-sectional view of the new conformal framework for the CFDTD method.

## PATENTS

### ■ A QFN with optimized signal transmission structures for millimeter wave applications

Inventor: L.-T. Hwang

Time: to be submitted in April 2012

In this invention, two ground current return paths in QFN (Quad Flat pack with No leads) configuration, with roughly identical inductance, and minimal mutual inductance due to the relative large distance between them, were disclosed. The total inductance of the structure will reach a minimal value. Since the capacitance of the signal wirebond(s) is physically very small, the reduced inductance will help to result in well impedance-matched signal transmission; thus, pushing the operating frequency to millimeter waves ranges.