IWS 2013

International Wireless Symposium

(IWS 2013) • 14-18 April 2013 • Beijing, China

SUNDAY — 14 April 2013

0830 - 1230 Workshops & Short Courses	1330 -1730 Workshops & Short Courses
WS1: THz Material Growth, Device Fabrication and Modeling	
WS2: Measurement Developments for Future Wireless Technologies	
	WS3: Wireless Chip Development and Entrepreneurial Efforts in China
	WS4: Recent Advances in mmW, Submmwave and THz MMICs for Novel System Design
WS5: Power Amplifiers for Next Generation Cellular Communication (Full Day)	WS5: Power Amplifiers for Next Generation Cellular Communication (Full Day)
WS6: Wireless Power Transfer Technologies (Full Day)	WS6: Wireless Power Transfer Technologies (Full Day)
	SC3: Microwave Measurement Techniques in a Wireless Transceiver Design Cycle

Registration: 0700-1800

MONDAY — 15 April 2013

0800-0940 Technical Sessions	1200-1300 Panel Session	1330-1510 Technical Sessions	1540-1720 Technical Sessions
	Wireless Power Transfer: An Old Technology Sparks a Modern Revolution	MO3A: Technologies for Advanced Wireless Devices (FOCUS SESSION)	
MO1B: Wireless Communication and Networking Techniques			MO4B: Novel Low Noise Circuits and Design
MO1C: Filters I			MO4C: Filters II
MO1D: Low Power, Low Noise, and Ultrawideband Transceivers			MO4D: Printed Antennas

Registration: 0700-1800 • **IWS Plenary Session:** 1000-1200 • **Student Paper Competition Poster Session:** 1730-1900 • **IWS Welcome Reception:** 1730-1900

TUESDAY — 16 April 2013

0800-0940 Technical Sessions	1010-1150 Technical Sessions	1200-1300 Panel Session	1330-1510 Technical Sessions	1540-1720 Technical Sessions
TU1A: Filters III	TU2A: Wireless Data and Power Transceivers for Biomedical Applications (FOCUS SESSION)	Radiation Testing in Wireless Communication: Challenges and Solutions	TU3A: Control Devices	TU4A: Emerging Wireless Device and Design Techniques (FOCUS SESSION)
TU1B: Wireless Energy Transfer and Harvesting			TU3B: Emerging Wireless Devices, Techniques and Systems	
TU1C: High Efficiency and Wideband Power Amplifiers			TU3C: Novel Transceivers for Radars and Location Identification	
TU1D: Millimeter-wave and THz Techniques and Systems			TU3D: Antennas for Wireless Communications	

Registration: 0700-1800 • **Exhibition:** 1000-1700 • **Industrial Forum:** 1000-1700 • **Interactive Forum:** 1330-1630 (TUP1: Wireless Device, Circuit and System Components)
Chapter Chair's Meeting: 1800-2130

WEDNESDAY — 17 April 2013

0800-0940 Technical Sessions	1010-1150 Technical Sessions	1330-1510 Technical Sessions	1540-1720 Technical Sessions
	WE2A: Cognitive Radio Communications and Networks (FOCUS SESSION)		WE4A: RF Nanotechnologies for Next-Generation Wireless Communication (FOCUS SESSION)
WE1B: Frequency Synthesis, Power Combiners, and Behavioral Modeling of RF Power Amplifiers	SPECIAL SESSION: How to Write a Paper for IEEE MTT-S Journals and Navigate the Review Process	WE3B: Building Blocks for RF Integrated Front-end	
WE1C: Antennas and Transmission Lines		WE3C: Couplers and Dividers	
WE1D: Millimeter-wave and UWB Antennas		WE3D: Array Antennas	

Registration: 0700-1800 • **Exhibition:** 1000-1700 • **Industrial Forum:** 1000-1700 • **Special Session:** 1010-1130 • **Interactive Forum:** 1330-1630 (WEP2: Integrated Circuits and Antennas for Wireless Communication) • **Closing Ceremony:** 1730-1845 • **IWS Banquet:** 1900-2130

THURSDAY — 18 April 2013

0830-1230 Workshops & Short Courses	1330-1730 Workshops & Short Courses
WS7: THz Packaging Integration Technologies	
WS8: Advanced Modeling Techniques for Carbon-Based RF and THz Structures	
WS9: E-Band Technologies and Applications	
	WS10: Computational Multi-physics Methods and Applications for Advanced RF Micro/Nanoelectronic Devices and Interconnects
	WS11: White Space and Cognitive Radio: Technology and Market Opportunities
WS12: Digital Techniques for Power Amplifiers Linearity and Efficiency Enhancement (Full Day)	WS12: Digital Techniques for Power Amplifiers Linearity and Efficiency Enhancement (Full Day)
SC4: Implantable and Wearable Wireless Medical Devices and Systems	
	SC5: The Time-Doman Transform and its Applications

Registration: 0700-1600 • **Exhibition:** 1000-1500 • **Industrial Forum:** 1000-1200

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Exhibition Guide

IWS 2013 GENERAL CHAIR'S WELCOME

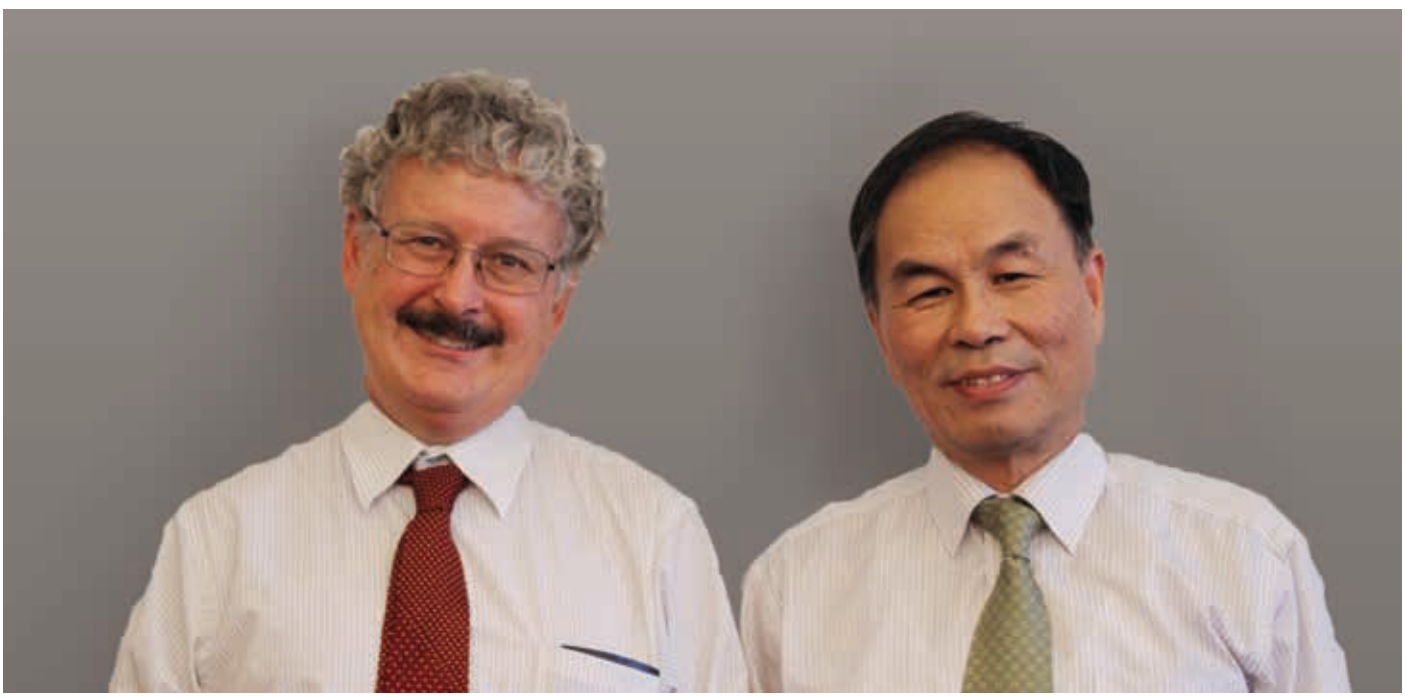
The International Wireless Symposium (IWS) is a new microwave conference sponsored by the IEEE Microwave Theory and Techniques Society debuting in 2013. Don't miss this first time meeting.

It will be an international event that will be held annually in China; the first will be held in Beijing, China. The focus is "everything that is wireless", including phones, Bluetooth, Zigbee, data, and a myriad of hardware, as well as regulatory and provider issues within the wireless community. Patterned after the very famous MTT-S International Microwave Symposium (IMS), the IWS will have a technical conference and a commercial exhibition. Because the market place for wireless technology, devices, and service is immense, the IWS will grow to be similar to the IMS. This year we will have over 160 papers presented in multiple parallel tracks, with over a hundred industrial and other exhibitors. The papers presented at IWS will be archived in IEEE Xplore. IWS will rotate between several locations in China, but will be an international event with participants from all over the world. The exhibition will include manufacturers and service providers from worldwide, with marketing happening in both directions: both into, and out from China. The IWS is intended to attract attendees and exhibitors from all parts of the wireless community, and will become a major global wireless event!

Let's look forward to Xi'an in 2014.

Zhenghe Feng, *General Chair*

Charlie Jackson, *General Co-Chair*



Welcome to IWS 2013 and Beijing,China!

Beijing, the capital of the People's Republic of China, is the center of the nation's politics, culture and international exchanges and a moden metropolis full of vitality. The world's earliest record of Beijing came from the travel notes by Marco Polo, the young Italian traveler in the 13th century. His description of people's civilized and well to do life in Beijing and his admiration for the beauty of the city has for hundreds of years attracted the reverie of numerous people about this ancient capital of civilization in the East.

Beijing literally means "the northen capital". The city construction of Beijing has a history of over 800 years dated back to the year 1153 AD when the Jin Dynasty (1115-1234) built Beijing as its capital later named "Zhongdu". Mongol armies seized Zhongdu in 1215. Kublai Khan rebuilt the city and gave it the Chinese (Han) name of Dadu or Great Capital as capital city called "Dadu" in Yuan Dynasty (1271 – 1368).

On 2 August 1368, Ming troops conquered Dadu and renamed it Beiping (Northern Peace). Zhu Yuanzhang was the founding emperor of the Ming Dynasty (1368-1644). When the Manchus founded the Qing Dynasty in 1644, they began to build suburban gardens, the most famous of which was Yuanmingyuan.

Qing Dynasty (1644 - 1911) left the city wall and palaces built in Ming Dynasty almost intact. So Beijing's city plan was first laid out in the Yuan Dynasty (1271 - 1368). Yet only after massive reconstruction during the Ming and Qing (1644-1911), did the city come as an architectural masterpiece as the capital of the Chinese empire.

Nanjing was officially made the capital of the Republic of China in 1928. Beijing was renamed Beiping, meaning "northern peace" or "north pacified". During the Anti-Japanese War, Beiping fell to Japan on 29 July 1937.

On 1 October 1949, the Communist Party of China, under the leadership of Mao Zedong, announced in Tiananmen the founding of the People's Republic of China and renamed the city back to Beijing. This date became China's national day.

TRANSPORTATION

Beijing Capital International Airport:

Beijing Capital International Airport is located in northeast of Beijing, capital of People's Republic of China. Over 70 domestic and foreign airline companies are participating in the operational business, including over 10 domestic companies and about 60 foreign companies.

Airport Enquiry: (86)10 64541100

Flight Enquiry: (86)10 962580 (RMB3/per minute)

PSB: (86)10 64597459

Airport E-mail: service@bcia.com.cn

Airport Website: http://en.bcia.com.cn/

Time Zone: GMT + 8

Address: Beijing Capital International Airport, Airport Road, Chaoyang District, Beijing 100621, China

Location: The airport is located 30km northeast of Beijing city center.

Airport code: PEK; Country Code: 86

Number of Terminal: Beijing Capital International Airport has three terminals (T1, T2 and T3) in operation.

When arriving at the airport, keep away from taxi drivers who approach you in the terminal or outside the terminal as they will ask for much more than the actual price. These are not approved taxi vendors.

Just follow the taxi sign and there is a taxi stand outside the each terminal. Drivers should use their meter; make sure that the driver puts down the flag. Beijing capital airport is located about 20km to the northeast of Beijing city center. Taxi charges from Terminal 3 at Beijing capital international airport to Beijing downtown: about CNY 130 inclusive of both a toll gate fee (CNY 10) and a fuel surcharge (CNY3). Taxi charges from Terminal 2 at Beijing capital international airport to Beijing downtown: about CNY 120 inclusive of a fuel surcharge (CNY3).

If you take a taxi to Beijing airport from downtown Beijing at rush hour (morning and afternoon), it is best to call a taxi several hours in advance of your departure time. Although the Metro is often quicker during peak hours, a taxi is much more convenient.

Beijing legitimate taxi license plates will be for the "Beijing B" otherwise it is a black taxi! After paying a legal taxi, you will get a legal computerized receipt in which you can find the taxi company's phone number while a black driver only offers you a hand-written receipt with which you will never find him! A black driver would charge you RMB 400 - RMB 500 for the airport downtown drive.

Beijing Capital Airport has three terminals - T1, T2 and T3. Each Terminal has its own airport taxi stand.

Additional Taxi Information:

There are approx. 70,000 taxis going in and around Beijing. Basically the taxi volume in Beijing could meet the increasing taxi market demand. But at peak hours, people find it extremely hard to hail a taxi on the streets.

Most of the taxi drivers can speak little English, you are advised to keep the name of your hotel written in Chinese or you may ask your hotel staff to write it down for you. So you are able to show it to a driver.

All legitimate taxis in Beijing use meters, so just get in the taxi and pay the fare when you get out. To avoid possible dispute, you are advised to take fapiao (receipts) which will be printed automatically for you.

Daytime: 0500 - 2300

· RMB 10 just for getting in for 3km
· RMB 2 charged for additional 1km after 3km
· RMb 3 charged for additional 1km after 15km

Midnight: 2300 – 0500

· RMB 11 just for getting in for 3km
· RMB 2.4 charged for additional 1km beyond 3km
· RMb 3.4 charged for additional 1km after 15km

· Waiting in a traffic jam or for the lights to turn green, it is charged as 1 kilometer per 5 minutes.

Very important notices:

1. Three yuan (CNY3) surcharge will be added beyond 3km to balance the oil hike according to the policy of the local government.
2. Taxi charges from Terminal 3 at Beijing capital international airport to Beijing downtown: about CNY 130 inclusive of both a toll gate fee (CNY 10) and a fuel surcharge (CNY3).

Taxi charges from Terminal 2 at Beijing capital international airport to Beijing downtown: about CNY 120 inclusive of a fuel surcharge (CNY3).

Note:

1) The Beijing Airport Expressway for Terminal 2 is free of charge into the city, but retains the CNY 5 fare toward T2 at Beijing capital airport.

2) The Beijing Airport Expressway for Terminal 3 is CNY 10 toll fee into the city, also CNY 10 fare toward T3 at Beijing capital airport.

Reminders:

1) Official taxis have a taxi sign on the roof, and on the dashboard on the passenger side is a placard with the drivers registration number. If this placard is missing then avoid it. At your destination, you should requrst a fappiao (a receipt, which is generated by the meter). If the meter isn't working, you can refuse to pay, and if the driver threatens to call the police, encourage him to do so. At this point he will write a hand-written fappiao, but make sure he (or you) writes down the car registration and the driver registration before paying your money for the taxi.

2) Please keep the address card from your hotel or written by your hotel staff in Chinese to show the taxi driver. A hotel card with the Hotel's name in Chinese for your return trip. So always carry a card from the hotel in the event you get lost in the city. Show the card to the driver and ask him to bring you there. Most of the drivers are not able to speak in English.

3) You can also charter a taxi (as a private your own car) for day trips to the Great Wall (which is around 1.5 hour drive from city) or just to transfer you around various locations like Forbidden City, Summer Palace, Temple of Heaven, Panjiayuan, Wangfujinging, etc. As long as it is within the city, most drivers are more than willing to let you charter their car for the day. A typical taxi will cost around RMB450 to RMB600 for an 8-hour day rental with driver. Each car can hold 4 comfortably. If you are sharing the car among 4, that is less than US$20 for a day.

4) Travelling around Beijing by taxi is quite easy. However, when it rains, it becomes a totally different situation. Keep in mind if you have a plane or train to catch, especially if you have an unchangeable ticket! Firstly, cabs can be very difficult to find in the rain. Secondly, many taxis will simply refuse to take on longer journeys, especially to the airport and they also will refuse to go anywhere if it involves driving on the 3rd Ring Road which is jammed completely in the rain! So check the weather report and it is better to plan to get to the station or airport three hours before check-in time if your ticket is unchangeable.

5) The bridge and road tolls will be paid by passengers. For a journey that takes longer than 10 kilo or running after 23:00, the fares will be charged at 50% more.

IEEE AND MTT-S MEMBERSHIP

IEEE:

IEEE is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity. IEEE and its members inspire a global community through its highly cited publications, conferences, technology standards, and professional and educational activities.

IEEE has:

- more than 400,000 members in more than 160 countries; more than 50 percent of whom are from outside the United States;
- more than 107,000 student members;
- 333 sections in 10 geographic regions worldwide;
- 2,110 chapters that unite local members with similar technical interests;
- 2,173 student branches at colleges and universities in 80 countries;
- 585 student branch chapters of IEEE technical societies; and
- 404 affinity groups - IEEE Affinity Groups are non-technical sub-units of one or more Sections or a Council. The Affinity Group patent entities are the IEEE-USA Consultants' Network, Graduates of the Last Decade (GOLD), Women in Engineering (WIE) and Life Members (LM).

IEEE:

- has 38 societies and 7 technical councils representing the wide range of IEEE technical interests;
- has more than three million documents in the IEEE Xplore Digital Library with more than eight million downloads each month;
- has more than 1,500 standards and projects under development;
- publishes more than 148 transactions, journals and magazines;
- sponsors more than 1,300 conferences in 81 countries while:
  - partnering with more than 1,100 non-IEEE entities globally;
  - attracting more than 387,000 conference attendees; and publishing more than 1,300 conference proceedings via IEEE Xplore.

MTT-S:

The IEEE Microwave Theory and Techniques Society (MTT-S) provides its 11,000+ members with access to leading technical information in radiofrequency, microwave, guided wave and wireless technologies, for wireless, sensing, digital, medical, and integrated smart and phased array antenna systems. Members receive access to the award-winning Microwave Magazine, discounts on registration for society conferences, including the International Microwave Symposium, networking opportunities, career development tools, and many other exclusive benefits.

Field of Interest (abridged): RF, microwave, guided wave and wireless technologies, for wireless, sensing, digital, medical, and integrated smart and phased array antenna systems.

The benefits of IEEE membership include:

- Discounted conference registration rates
- Subscriptions to the award-winning IEEE Spectrum and online access to IEEE Potentials
- Online access to the tables of contents and expanded abstract from over million IEEE documents with full text-searching capability
- Free IEEE e-mail alias with virus scanning and spam filtering
- The IEEE Financial Advantage - negotiated exclusively for IEEE members

Join the IEEE and MTT-S:

Web: http://www.ieee.org/membership_services/index.html

Phone: (US and Canada): + 1.800.678.4333

(Worldwide): + 1.732.981.0060

IEEE and MTT-S Membership Dues:

2013 IEEE Membership Dues:

Residence	Member Full Year	Member Half Year*	Student Full Year	Student Half Year*
United States	$185.00	$92.50	$32.00	$16.00
Canada (incl. GST)	$164.95	$82.48	$33.60	$16.80
Canada (incl. HST for NB, NF and ON)	$176.07	$88.04	$36.16	$18.08
Canada (incl. HST for Nova Scotia)	$178.85	$89.43	$36.80	$18.40
Canada (incl. HST for BC)	$174.68	$87.34	$35.84	$17.92
Africa, Europe, Middle East	$152.00	$76.00	$27.00	$13.50
Developing Nations e-Membership	$63.00	$31.50	n/a	n/a
Latin America	$143.00	$71.50	$27.00	$13.50
Developing Nations e-Membership	$54.00	$27.00	n/a	n/a
Asia, Pacific	$144.00	$72.00	$27.00	$13.50
Developing Nations e-Membership	$55.00	$27.50	n/a	n/a

*Half year rates apply to new members only. 1This amount represents base dues plus IEEE-USA assessment. In the United States, depending on region, an additional regional assessment is added that ranges from US$1 to US$5. 2 Except in Japan, where full year dues are US$169 and US$84.50 half year.

- All dues pricing is listed in US Dollars.
- IEEE membership runs from 1 January through 31 December.
- NEW applications received between 16 August 2012 and 28 February 2013 will automatically be processed at the full year dues rates. Services begin immediately.
- NEW applications received between 1 March and 15 August 2013 will automatically be processed for half-year membership ending 31 December 2013 at the half-year dues rates. Exception is when the applicant specifically requests their application be processed for the full year. However, we cannot guarantee availability of back issues of all publications for the first half of the calendar year.
- The e-Membership option is only available to higher grade members in developing nations.
- Membership in IEEE Technical Societies involves additional dues. See the table below for information on Society membership dues.
- All IEEE members are given online access to Potentials magazine as part of their basic IEEE membership. Student members in the U.S. and Canada receive Potentials in print as part of their dues. For Student members from all other countries and for IEEE Higher grade members who wish to receive a print subscription to Potentials, see rates provided below.

2013 MTT Society Membership Dues:

Society	Member Full Year	Member Half Year*	Student Full Year	Student Half Year*
IEEE Microwave Theory and Techniques Society	$17.00	$8.50	$9.00	$4.50

MTT-S dues include a subscription to IEEE Microwave Magazine. MTT-S members can also purchase subscriptions to the IEEE Transactions on Microwave Theory and Technology, IEEE Microwave and Wireless Components Letter, IEEE Transactions on Terahertz Science and Technology, IEEE/OSA Journal of Lightwave Technology, and IEEE MTT CD-Rom Collection. See IEEE Membership website for pricing.

ON-SITE REGISTRATION - 现场注册

On-Site Registration
现场注册

On-Site registration for IWS is in the main lobby of the China National Convention Center. Registration hours are:
国际无线会议现场注册可在中国国家会议中心主大厅办理。注册时间是：

Day	Time
Sunday, 14 April 4 月 14 日星期天	0700 – 1800
Monday, 15 April 4 月 15 日星期一	0700 – 1800
Tuesday, 16 April 4 月 16 日星期二	0700 – 1800
Wednesday, 17 April 4 月 17 日星期三	0700 – 1800
Thursday, 18 April 4 月 18 日星期四	0700 – 1600

Exhibit Only Registration
只参加展览注册

Exhibit only registration is available for FREE. This includes access to the Exhibition Tuesday, 16 April - Thursday, 18 April. The Exhibition is located in Hall 5 of the China National Convention Center (CNCC).
只参加展览的注册是免费的。展览注册包括4月16日（星期二）至 4月18日（星期四）免费参观展览。展览设于中国国家会议中心第五号馆。

Guest Tours
来宾旅游

There are 6 tours offered that will run daily. Each tour be day long, leaving at 0730. We will provide transportation from the hotel in the morning, guided tours of the route, and return to the hotel by 1800. Please refer to the Guest Tour Program section of this program book for further details and tour descriptions.
每天将提供六个游览路线。每个路线旅游都是一整天，我们将提供全程交通运输和导游陪同的旅游。早上7点30 分从酒店出发，下午6点回到酒店。请参阅到来宾旅游计划和景点描述了解详细信息。

Registration Fees - 注册费用

On-site registration fees are as follows:

		Member 中国电子学会 (CIE) or IEEE 会员	Non-Member 非会员
Complete Symposium 全场会议			
	Symposium registration fees include access to the Exhibition Tuesday – Thursday and the symposium proceedings. 会议注册费中包含参观周二至周四展览会和获取会议论文集的费用。	$430.00 ¥2750	$640.00 ¥4100
	Student pricing 学生	$220.00 ¥1400	N/A
	Retiree/Life Member 退休者/终生会员	$80.00 ¥500	N/A
Single Day 单天会议			
	Monday, Tuesday, or Wednesday 星期一，星期二，星期三	$220.00 ¥1400	$330.00 ¥2100
Exhibition Only 仅限展览			
	Exhibition Only Pass 仅限展览	FREE 免费	FREE 免费
Short Courses 短期课程			
	Short Courses 短期课程	$90.00 ¥600	$130.00 ¥850
	Short Courses Student/Retiree 短期课程学生/退休者/IEEE 终生会员	$60.00 ¥400	N/A
Workshops 研讨会			
	Full Day 全天研讨会	$170.00 ¥1100	$250.00 ¥1600
	Full Day Student/Retiree 全天研讨会学生/退休者/IEEE 终生会员	$120.00 ¥750	N/A
	Half Day 半天研讨会	$90.00 ¥600	$130.00 ¥850
	Half Day Student/Retiree 半天研讨会学生/退休者/IEEE 终生会员	$60.00 ¥400	N/A
Awards Banquet 颁奖晚宴			
	Awards Banquet 颁奖晚宴	$70.00 ¥450	$70.00 ¥450
Extra Proceedings 额外的会议论文集			
	Extra Symposium Proceedings 额外的会议论文集	$70.00 ¥450	$105.00 ¥650
	Extra Symposium Proceedings Student/Retiree 额外的会议论文集学生/退休者/IEEE 终身会员	$70.00 ¥450	N/A

IWS TEA BREAKS, LUNCHES & SOCIAL EVENTS

Sunday, 14 April 2013

Morning Tea Break
For Workshop & Short Course Attendees Only
300 Level Foyer, CNCC
0930-1000

Lunch
For Workshop & Short Course Attendees Only (Badges will be scanned)
300 Level Foyer, CNCC
1230-1330

Afternoon Tea Break
For Workshop & Short Course Attendees Only
300 Level Foyer, CNCC
1500-1530

Monday, 15 April 2013

Morning Tea Break
For IWS Technical Attendees Only
300 Level Foyer, CNCC
0940-1010

Lunch
For IWS Technical Attendees Only (Badges will be scanned)
300 Level Foyer, CNCC
1150-1330

Afternoon Tea Break
For IWS Technical Attendees Only
300 Level Foyer, CNCC
1510-1540

IWS Welcome Reception
All IWS attendees and exhibitors are invited to attend a reception hosted by IWS 2013!
Room 306AB, CNCC
1730-1900

Tuesday, 16 April 2013

Morning Tea Break
For IWS Technical Attendees Only
300 Level Foyer, CNCC
0940-1010

Lunch
For IWS Technical Attendees Only (Badges will be scanned)
Exhibit Floor, CNCC
1150-1330

Afternoon Tea Break
For IWS Technical & Exhibit Attendees Only
Exhibit Floor, CNCC
1510-1540

Chapter Chairs Meeting
All Chapter Chairs and their designated chapter representatives are cordially invited to attend!
Room 307B, CNCC
1800-2130

Wednesday, 17 April 2013

Morning Tea Break
For IWS Technical Attendees Only
300 Level Foyer, CNCC
0940-1010

Lunch
For IWS Technical Attendees Only (Badges will be scanned)
Exhibit Floor, CNCC
1150-1330

Afternoon Tea Break
For IWS Technical & Exhibit Attendees Only
Exhibit Floor, CNCC
1510-1540

IWS Banquet
A ticket is required for this event and can be purchased at registration.
Room 307AB, CNCC
1900-2130

Thursday, 18 April 2013

Morning Tea Break
For Workshop & Short Course Attendees Only
300 Level Foyer, CNCC
0930-1000

Lunch
For Workshop & Short Course Attendees Only (Badges will be scanned)
Exhibit Floor, CNCC
1230-1330

Afternoon Tea Break
For Workshop & Short Course Attendees Only
300 Level Foyer, CNCC
1500-1530

BEIJING, CHINA OFFERS GREAT OPPORTUNITY FOR YOU AND YOUR FAMILY TO SIGHTSEE WHILE AT IWS 2013!

A BRIEF OVERVIEW OF BEIJING:

Beijing is the capital of the People's Republic of China. The city has a long history that can be traced back to as early as 1045 B.C. The long history has left a variety of famous historical sites which possess great aesthetic and cultural value. The Great Wall, a huge project with construction started more than 2,000 years ago, meanders through mountains and valleys. The Forbidden City, the largest ancient architectural complex extant today, is a splendid crystallization of ancient Chinese architectural arts. The Summer Palace, an ancient royal garden with numerous styles of ancient buildings and gardens, is a virtual museum of traditional Chinese gardening.

Weather in April:

Please visit: **http://www.weather.com.cn/en/weather/101010100.shtml**

Tours:

1. **The Forbidden City and Tian'an Men Square**

The Forbidden City was the Chinese Imperial palace from the mid-Ming Dynasty to the end of the Qing Dynasty. It is located in the middle of Beijing, China. It now houses the Palace Museum. The complex consists of 800 buildings with 8,886 rooms. It covers 720,000 square meters. The Forbidden City was declared a World Heritage Site in 1987 as the "Imperial Palace of the Ming and Qing Dynasties," and is listed by UNESCO as the largest collection of preserved ancient wooden structures in the world.

The Tian'an Men Square is the geographical center of Beijing City. It is the largest city square in the world, occupying an area of 440,000 square meters (about 109 acres), and able to accommodate 1,000,000 people at one time. The square contains splendid and beautiful flowers and the red national flag flutters in the wind over it all. The raising of the national flag is something which should not be missed by visitors to Tian'an Men Square.

2. The Great Wall and Ming Tombs

The Great Wall of China is an ancient Chinese fortification constructed over 300 years, from the end of the 14th century until the beginning of the 17th century, during the Ming Dynasty, in order to protect China from raids by the Mongols and Turkic tribes. It was

preceded by several walls starting in the 3rd century BC against the raids of nomadic tribes coming from areas now in modern day Mongolia and Manchuria. The Wall stretches over a formidable 6,350 km (3,946 miles), from Shanhai Pass on the Bohai Gulf in the east, at the limit between China proper and Manchuria, to Lop Nur in the southeastern portion of Xinjiang Uygur Autonomous Region.

The Ming Tombs lie in Changping County, about 50 kilometers (31 miles) northwest of the urban area of Beijing. It is actually a tomb cluster of the Ming Dynasty (1368-1644), including thirteen emperor's mausoleums, seven tombs for concubines, and one grave for eunuchs. This cemetery is world famous because of the thirteen emperors buried here. Sitting at the foot of Mt. Yan and occupying an area of more than 120 square kilometers (29,653 acres), The tombs are extremely spectacular. It was placed on the World Heritage List in 2003.

3. The Summer Palace

The Summer Palace, Yiheyuan in Chinese, is the most celebrated imperial garden in China. The garden came into existence early in the 1750's and had once been a summer resort for the emperors. It is acclaimed as a museum of gardens in China, for a visit to this garden bestow on sightseers a glimpse of representative scenes all over China.

4. The Lama Temple and Temple of Heaven

The Lama Temple is the largest and best-preserved lamasery in Beijing. It was built in 1694 during the Qing Dynasty (1644-1911) as the residence of the Emperor Yongzheng (the third emperor of the Qing Dynasty) before he ascended the throne. In the year 1744, the residence was completely converted into a lamasery. This resplendent architectural complex is endowed with the style of an imperial palace, making it distinctive from others. It occupies an area of 66,400 square meters (16 acres) and is described as a mini-palace with yellow glazed tiles on the roof and red walls circling the group of buildings.

The Temple of Heaven (also Tiantan Park) is the grandest cult architecture complex in the world and a masterpiece of the Chinese people created in ancient times. It covers 2,700,000 square meters (667 acres). The temple was constructed in 1420 during the Ming Dynasty (1368-1644), and was enlarged during the Qing Dynasty (1644-1911). Emperors of the two dynasties used to worship heaven and pray for rich harvests, as the feudal emperors thought they were the son of the heaven.

Beijing City Daily Tours:

Tour Programs for 2013 IEEE MTT-S International Wireless Symposium for the convenience of you and your accompanying persons to enjoy your stay in Beijing, authorized and trusted by the organizing committee, visits to historic and scenic sites in Beijing have been organized by Zhongchuang Travel Service. Tickets available for purchase at the CNCC. You are suggested to register for the tour routes on your personal preference.

The schedule of daily tours covers variety of must-sees! Heard of, not experienced yet? Try now!

Date	Morning	Afternoon	Evening
13-April		No.1Hutong tour RMB240	No.2 Acrobatics RMB280
14-April	No.3 The Great Wall (lunch included) RMB280	No.4 The Summer Palace RMB220	
15-April	No.5 The Great Wall and The Ming Tombs (lunch included, Depart at 0830) RMB360		No.6 Chinese Kongfu RMB360 No.7 Beijing Opera RMB360
16-April	No.8 The Temple of Heaven RMB220	No.9 The Forbidden City and Tian'an Men Square RMB280	No.10 Acrobatics RMB280
17-April	No.11 The Great Wall and The Forbidden City (lunch included, Depart at 0830) RMB380		
18-April	No.12 The Lama Temple RMB220	No.13 The Forbidden City and Tian'an Men Square, Hutong tour RMB380	No.14 Chinese Kongfu RMB360
19-April	No.15 The Temple of Heaven, Hutong tour, the Summer Palace and Shopping (lunch included) RMB440		No.16 Beijing Opera RMB360

Note:

A. Morning tour: Depart at 0830

B. Afternoon tour: Depart at 1350

C. Evening Beijing Opera: Depart at 1750

D. Meeting Place: Lobby of Entrance C of China National Convention Center CNCC .

Post Conference Tours:

Conference participants may be strongly interested in many historic sites, scenic areas and recent developments in other regions in China. Following the Conference, tours will be specially arranged by Zhongchuang International Travel Service. First-class service will be provided. Please email: **tourpleasant@yahoo.com.cn** for the details.

Post-Conference Tour 1: Beijing-Xi'an-Guilin-Guangzhou-HongKong (Exit)

Date: 20 April – 25 April 2013

Cost: RMB8950 per person (Double Occupancy)
RMB9950 per person (Single Occupancy)

Itinerary:

D1 — Fly to Xi'an, Sightseeing: the Ancient City Wall, and the Provincial Museum.

D2 — Sightseeing in Xi'an, Terra-Cotta Warriors and Horses, Huaqing Hot Springs

D3 — Fly to Guilin, Sightseeing: Reed Flute Cave, Elephant Trunk Hill, and Diecui Hill

D4 — Sightseeing in Guilin, Cruise on the Lijiang River

D5 — Fly to Guangzhou. Sightseeing in Guangzhou, Dr. Sun Yat-Sen Memorial Hall, Ancestral Temple of the Chen Family, and Six Banyan Tree Temple.

D6 — Take express train to Hong Kong, where the tour will terminate.

Post-Conference Tour 2: Beijing- Hangzhou- Suzhou - Shanghai (Exit)

Date: 20 April – 25 April 2013

Cost: RMB5650 per person (Double Occupancy)
RMB6650 per person (Single Occupancy)

Itinerary:

D1 — Flight from Beijing to Hangzhou and stay in one Four Star Hotel.

D2 — Sightseeing in Hangzhou: Lingyin Temple , West Lake (known as paradise in human world), Temple of Yue Fei (national hero), Hangzhou to Suzhou by bus and stay in a Four Star Hotel.

D3 — Sightseeing in Suzhou: the Garden of Humble Administrator, the Garden of Lingering, and the Buddhist Temple of Hanshan. Suzhou to Zhouzhuang village (a famous old town)by Bus and stay in a Four Star Hotel.

D4 — Sightseeing in Zhouzhuang village, Zhouzhuang village to Shanghai by bus and stay in a Four Star Hotel.

D5 — Sightseeing in Shanghai: Jade Buddha Temple, Yuyuan Garden, Shanghai Museum, and the Bund.

D6 — After breakfast the tour will terminate.

Post-Conference Tour 3: Beijing-Xi'an-Beijing

Date: 20 April – 21 April 2013

Cost: RMB3750per person (Double Occupancy)
RMB3950per person (Single Occupancy)

Itinerary:

D1 — Fly to Xi'an and transfer to a Four Star Hotel, the Ancient City Wall, and the Provincial Museum.

D2 — Sightseeing in Xi'an, Terra-Cotta Warriors and Horses, Huaqing Hot Springs.
Fly back to Beijing in the evening and transfer to the hotel.

Post-Conference Tour 4: Beijing- Xi'an- Lhasa (Tibet) – Beijing (Exit)

Date: 20 April – 25 April 2013

Cost: RMB10500per person (Double Occupancy)
RMB11800per person (Single Occupancy)

Itinerary:

D1 — Fly to Xi'an, Sightseeing: the Ancient City Wall, and the Big Wild Goose Pagoda

D2 — Fly to Lhasa, transfer to hotel, half day adjustment to high altitude (3,500m

D3 — Sightseeing: Potala Palace, Jokhang Temple, Barkhon Street

D4 — Lhasa-Namtso-Lhasa, Driving 253 Km across the northern Tibet pastureland to this beautiful lake.

D5 — Free in the Morning, fly to Xi'an

D6 — Sightseeing in Xi'an, Terra-Cotta Warriors and Horses, fly back to Beijing in Evening

Remarks:

The following services will be offered:

1. Four Star Hotel accommodations with American breakfasts
2. Air-conditioning coach and English-speaking guide provided in each city.
3. All exit tickets (including ticket of the Express Train to Hong Kong should be arranged on your own.
4. Airport Construction fees are included.
5. An English speaking national guide is to be arranged for a group of more than 10 persons
6. Single room difference will be charged.
7. The price level of pre-tour and post- tours is on the basis of a group of 10 persons or above.

If you are interested in a tour please visit: **http://www.iws-ieee.org/en/tours.html**

Note:

1. The deadline of registration for post tour 1 and post tour 2 and post tour 3 is on 5 April 2013. Please acknowledge your attendance in advance by email.

2. For those who apply the post tour 4 to Tibet, for the transaction of Tibet Visa, The deadline of registration is on 25 March 2013. You must submit electronic photocopy (pdf) of ID page and visa page of your passport by emailing to **tourpleasant@yahoo.com.cn** , please mark IWS 2013.

3. If you are not able to register post tours before the referred dates or you have any other preferred routes rather than provided ones, please contact us to find the possibility of participation.

4. Download application form, please fill it out and submit it to us.

5. Mr. David Chang is responsible for the conference tour arrangements. Should you have any questions, please feel free to contact **tourpleasant@yahoo.com.cn** , please mark IWS 2013 or cell phone: +86 135-0103-7115, Please forward your application form as well.

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WELCOME FROM THE TECHNICAL PROGRAM CHAIR'S

On behalf of the Technical Program Committee of the inaugural IEEE International Wireless Symposium, we welcome you to Beijing and exciting IWS 2013 technical program.

IWS 2013 technical program features core technologies for the next generation wireless networks and systems by presenting up-to-the-last minute achievements in the areas of, but not limited to, Short-Range, Broadband, and Green Wireless Systems & Standards, Modulation, Coding & Signal Processing, Wireless Energy Transmission & Harvesting, Smart Grid, as well as their enabling RF, Microwave, Millimeter-wave & THz Technologies including Front-End Electronics, Antennas, Signal Generation & Power Amplification, Transceiver Techniques, Active/Passive Electronics & Components, and Antennas. The Technical Program Committee received 355 papers including 20 invited from 35 countries (5 continents) worldwide, indicating the vitality of this new conference and promise for further future growth. Based on our TPC recommendation, we will present 161 regular and invited papers – corresponding to an overall acceptance rate of 45% – scheduled for 24 podium sessions and 2 poster sessions over 3 days covering the complete range of IWS technical interests. Don't miss our daily Focus Sessions featuring invited talks on Technologies For Advanced Wireless Devices, Wireless Data and Power Transceivers For Biomedical Applications, Emerging Wireless Devices And Design Techniques, Cognitive Radio Communications and Networks, and RF Nanotechnologies for Next Generation Wireless Communications.

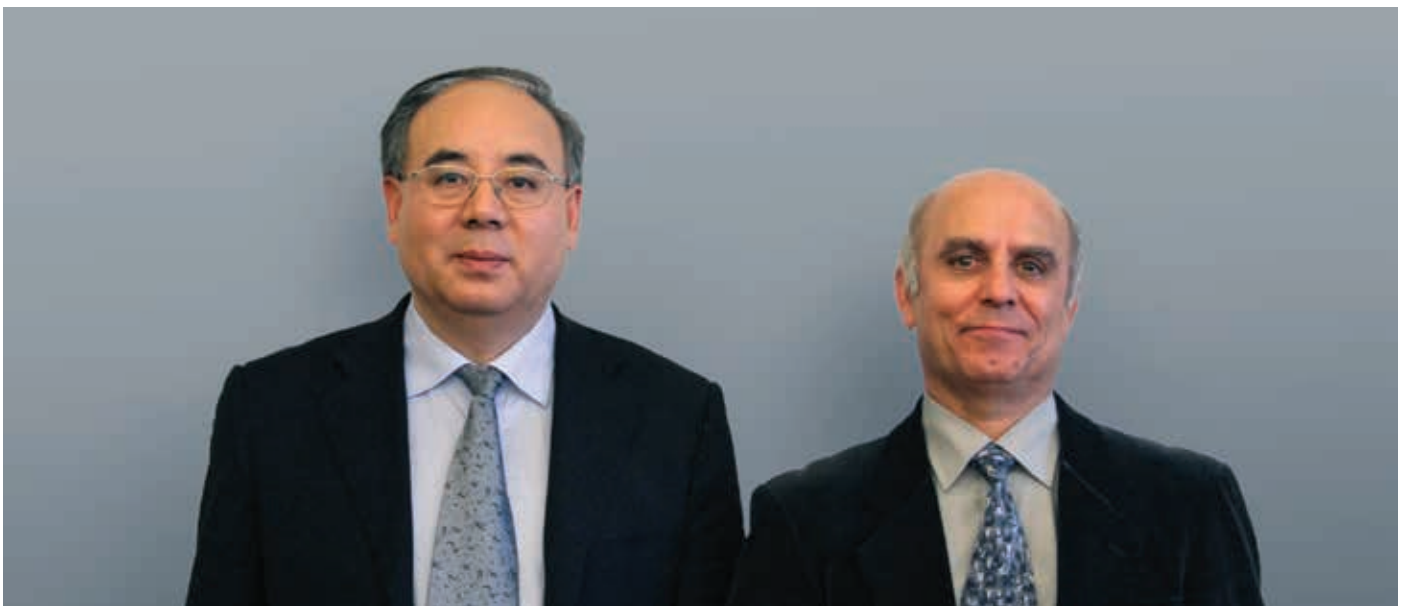
In addition to our technical podium/poster sessions, we also offer 12 workshops, 3 short courses, and 2 panel sessions, for in-depth discussions on device, circuit, and system aspects of wireless technology.

We would like to thank our 160 TPC members and subcommittee chairs for their hard work and invaluable time to review and select the papers. Without their selfless efforts it would have been impossible to form such a high quality technical program. We also would like to thank all the authors for submitting their papers to the symposium, and we regret if we were unable to accommodate many of the quality contributions this year. We hope that you will consider submitting your work to the subsequent IWS, scheduled for April 2014 in Xi'an.

Enjoy Beijing, and we look forward to seeing you all again in Xi'an.

Mohammad Madihian, *Technical Program Chair*

Wei Hong, *Technical Program Co-Chair*



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IWS 2013 PLENARY SESSION

Monday, 15 April 2013
1000-1200
Room 309, China National Convention Center

"Opportunities and Challenges of the Wireless China"
Prof. Wu Hequan, Vice-Director, *Advisory Committee for State Informatization of China, Executive Council of China Institute of Communications (CIC) and Chinese Institute of Electronics (CIE)*

Biography: Prof. Wu Hequan graduated from Wuhan Institute of Post and Telecommunications in 1964. He has worked in the China Academy of Post and Telecommunications of the Ministry of Post and Telecommunications since 1964. He was Vice-President and Chief Engineer of China Academy of Telecommunications Technology from 1997 to 2003. He has conducted research and development in optical fiber transmission systems and broadband networks. He takes charge to manage R&D projects on NGI and 3G as well as LTE since 2002. He was elected academician of Chinese Academy of Engineering (CAE) in 1999 and Vice-President of CAE from June 2002 to June 2010. He is currently Vice-Director of the Advisory Committee for State Information of China. He is also Vice-Director of an Executive Council of China Institute of Communications (CIC) and Chinese Institute of Electronics (CIE) respectively. Prof. Wu has been appointed technical director of the new generation broadband wireless mobile communications network, one of the 16 major projects in the Outline of the National Program for Long- and Medium-term Scientific and Technological Development (2006~2020) of China. He is the Director of Experts Committee of China's Next Generation Internet (CNGI) project, and is head of expert group of three network convergence of the State Council. Prof. Wu is director of expert group of IOT. He is a senior member of IEEE.

"**A Manufacturable, High Power RF Gallium Nitride (GaN) Technology Portfolio With 65V Operation And Enhanced Linearity**"
Dr. Jeff Shealy, Division Vice President, *RFMD*

Biography: Jeff Shealy is vice president and general manager of RFMD's Defense and Power Business Unit, where he is responsible for overall business strategy for the company's high power RF, Point-to-Point backhaul radio and international aerospace & defense business. Over the last decade, he held strategic management positions in the company's wide bandgap GaN R&D technology and wireless infrastructure business.

Prior to his career at RFMD, Dr. Shealy founded RF Nitro Communications, Inc., where he served as president and CEO until RFMD acquired the company in October 2001. Dr. Shealy is a Howard Hughes Doctoral Fellow and previously held R&D positions at Hughes Electronics. He received his M.B.A. from the Babcock School of Business Management at Wake Forest University and he holds a Ph.D. in electrical engineering from the University of California at Santa Barbara.

Dr. Shealy is a member of the IEEE Electron Device Society.

MONDAY FOCUS AND PANEL SESSIONS:

Monday, 15 April 2013 1200 – 1300 Room: 310

Panel Session: Wireless Power Transfer: An Old Technology Sparks a Modern Revolution

Electromagnetic induction, capacitive coupling, and microwave methods for wireless power transmission are technologies well understood in principle and have been successfully deployed in a range of industrial, commercial, and transportation applications for decades. Today, wireless power transfer technology is sparking a revolution in the mobile consumer electronic industry through the vision of ubiquitous power. There are strong demands for efficient designs for the power transmitting and power receiving units and the coupling elements. These are all subject to demanding form factor, regulatory, and commercial requirements. This panel introduces the current approaches and tries to address the issues and challenges as well as possible future trends.

Panel Organizer: Yongxin Guo, *National University of Singapore, Singapore*

Panel Moderator: Kamil Grajski, *Qualcomm, USA*

Panel Members:

1. Eric Giler, *Witricity Corporation, USA*
2. Kamil Grajski, *Qualcomm, USA*
3. Joshua Le-Wei Li, *University of Electronic Science and Technology of China, China*
4. Jenshan Lin, *University of Florida, USA*
5. Luca Roselli, *University of Perugia, Italy*
6. Manos Tentzeris, *Georgia Tech, USA*

Monday, 15 April 2013 1330 – 1510 Room: 311A

M03A: Focus Session – Technologies for Advanced Wireless Devices

Chair: Fred Schindler, *RF Micro Devices*

Co-Chair: Minkyu Je, *A*STAR*

Abstract: In the past decades, there have been amazing growth and development of mobile wireless devices. This evolution will continue in order to accommodate ever-growing demands in every aspect of the device - functionality, performance, battery life, size and cost. This focus session begins with the presentation of technology trends in mobile handsets especially from the perspective of challenges in RF front-end for multi-mode multi-band support. Various advanced architectures for the next-generation power amplifier for handsets are introduced in the second paper. The third paper presents reconfigurable and tunable filters with flexible frequency and bandwidth response controls. A new quadrature generation scheme based on a compact transformer-based structure is described in the last paper.

M01B: Wireless Communication and Networking Techniques

Monday, 15 April 2013
Room: 310
Chair: Zhen Bin, *Huawei*
Co-Chair: Charlie Jackson, *Northrop Grumman*

New application of mobile and short range wireless communication will be more and more widely used in future, such as at home, machine to machine, healthcare, internet of things. This session addresses technical breakthroughs including multi-Path interference reduction in passive NLTL RFID tags, capacity enhancement in vehicle to roadside networks, power consumption analysis of Bluetooth, ZigBee, and ANT sensor nodes, efficient optimal power allocation for MIMO MAC in cognitive radio networks, and study on multipath propagation characteristics for LTE Indoor Environment.

M01B-1 0800 – 0820
Capacity Enhancement in Vehicle to Roadside Networks Using ESPAR Technique

A. G. Anbaran, A. Mohammadi, A. Abdipour, *Amirkabir University of Technology, Tehran, Iran*

Abstract— In this paper, we investigate electronically steerable parasitic array radiator (ESPAR) smart antenna in a highway scenario, where roadside access points (APs) are installed on a highway to provide intelligent transportation System (ITS) services. We Consider vehicle-to-roadside (V2R) communication for a vehicle that aims to send data to the AP (uplink). A seven element ESPAR system as a beam former smart antenna in AP is used to eliminate the interference signals.. The simulation results indicate that ESPAR system can improve the average capacity of the link more than 2 bps/Hz.

M01B-2 0820 – 0840
Power Consumption Analysis of Bluetooth Low Energy, ZigBee, and ANT Sensor Nodes in a Cyclic Sleep Scenario

A. Dementyev[1,2], S. Hodges[2], S. Taylor[2], J. R. Smith[1], [1]*University of Washington, Seattle, United States,* [2]*Microsoft Research, Cambridge , United Kingdom*

This paper is intended to guide developers of wireless systems who are puzzled by the vast number of radio configuration parameters and options. We provide experimental data comparing power consumption of Bluetooth Low Energy (BLE), ZigBee and ANT protocols for a cyclic sleep scenario, in which a short-range and low-power wireless sensor node periodically sends a data packet to a remote 'hub' with intervening sleep intervals. Devices such as wearable health monitors often use this scenario to interface with a mobile phone-based hub. For all measured sleep intervals BLE achieved lower power consumption (10.1 uA, at 120 s interval), compared with ZigBee (15.7 uA), and ANT (28.2 uA). Power consumption differences can be attributed to the time taken for a node to connect to the hub after waking up and the use of sleep between individual RF packets. For the three protocols we determined a sleep interval at which the trade-off between power consumption and data rate is optimized

M01B-3 0840 – 0900
Multi-Path Interference Reduction in Passive NLTL RFID Tags

Y. Ma, E. C. Kan, *Cornell University, Ithaca, United States*

We propose a multi-path interference reduction method of continuous wave (CW) passive RFID for indoor ranging applications by adopting nonlinear transmission line (NLTL) tags. Because the power and phase information are contained within the second harmonic (SH) rather than the fundamental frequency, interference and phase errors caused by direct reflections of interrogating signal can be greatly reduced. We present both theoretical predictions and simulations, followed by experimental results to verify the effectiveness of the proposed approach.

M01B-4 0900 – 0920
Efficient Optimal Power Allocation for MIMO MAC in Cognitive Radio Networks

P. He[1], L. Zhao[1], J. Lu[2], [1]*Ryerson University, Toronto, Canada,* [2]*Tsinghua University, Beijing, China*

This paper considers a Cognitive Radio network, in which the unlicensed Secondary Users are allowed to concurrently access the spectrum allocated to the licensed Primary Users provided that their interference to the primary users satisfies certain constraints. Under ensuring the quality of service of the PUs, the precious spectrum resource can be utilized by maximizing the sum-rate and optimizing power allocation of the SUs. On the other hand, the multiple-antenna mobile user case needs further investigating for the problem mentioned above. Thus, we simply term this setting as MIMO multiple access channels in the CR Networks. To effectively and efficiently optimize the power allocation of the SUs, a tight pair of upper and lower bounds of the optimal Lagrange multiplier is proposed. Furthermore, a novel water-filling is proposed for the inner loop computation of the proposed problem. It is shown that the new water-filling can obtain the exact solution with a few finite computations.

M01B-5 0920 – 0940
Study on Multipath Propagation Characteristics for LTE Indoor Environment with Persons

Y. Wang, W. Lu, H. Zhu, *Nanjing University of Posts & Telecommunications, Nanjing, China*

Measurements for frequency domain characterization of indoor short range wireless channel with persons centered at 2.6 GHz Long Term Evolution (LTE) band were conducted by using a vector network analyzer. Based on the measurement data, the impulse response of the channel is obtained by using inverse Fourier transformation. The analysis results show that the optimized-fit distribution of small-scale magnitude statistics yields to Nakagami-m distribution, and the optimized-fit distribution for number of multipaths statistics is t-location-scale distribution.

M01C: Filters I

Monday, 15 April 2013
Room: 311A
Chair: Haiwen Lin, *East China Jiaotong University*
Co-Chair: Quan Xue, *City University of Hong Kong*

This session highlights novel filter designs for wireless communications, which include eighth-order pseudo-elliptic filters using quadruple-resonator arrangement, dual-passband filters using multilayer liquid-crystal polymer technology, tri-band frequency selective surfaces, switchable ferroelectric bulk acoustic wave filters based on barium strontium titanate thin films, and ultra-wideband bandpass filters based on transversal signal-interaction concepts.

M01C-1 0800 – 0820
In-line Eighth-Order Pseudoelliptic Filter using Dielectric Resonator Quadruplets Implemented using Bypassing Evanescent Modes

S. Bastioli, R. V. Snyder, *RS Microwave Company Inc, Butler, United States*

A new quadruple-resonator configuration for the design of in-line pseudoelliptic dielectric resonator filters is proposed in this paper. The proposed configuration uses waveguide evanescent modes bypassing the resonators to generate cross coupling between the non-adjacent ring-shaped TE01δ mode resonators. Specifically, fourth-order filtering functions with a pair of symmetric transmission zeros can be generated by this configuration. An in-line eighth-order C-band filter comprising a couple of cascaded quadruple-resonator configurations for the generation of four symmetric transmission zeros is presented. The experimental results of a manufactured prototype validates the feasibility of the proposed filter structure.

M01C-2 0820 – 0840
A Compact Dual-Passband Filter Using Multilayer Structure

Z. Hao[1], W. Hong[1], J. Hong[2], [1]*Southeast University, NanJing, China,* [2]*Heriot-Watt University, Edinburgh, United Kingdom*

This paper reports a compact dual-passband filter by using multilayer liquid crystal polymer technology. The investigated filter consists of two resonators on the middle metal layer, which can be independently designed for the two passbands. To achieve a compact size, the resonator for the upper passband is embedded in the resonator for the lower passband. Cross coupling between input and output ports is adopted in the design to improve the selectivity of the reported filter. Experiment is carried on to verify the predicted results and a well agreement is obtained. The proposed filter has a compact size and can be easily designed with flexible dual-passband response. It is attractive for the multiple bands communication system.

M01C-3 0840 – 0900
A Novel Low-Profile Tri-Band Frequency Selective Surface

D. Wang[1], Y. Chang[1], W. Che[1], Y. Chow[2,1], [1]*Nanjing University of Science and Technology , Nanjing, China,* [2]*University of Waterloo, Waterloo, Canada*

Based on a proposed approach, a novel low-profile tri-band frequency selective surface (FSS) is presented. The FSS consists of a two-dimensional periodic array of metallic square loops and complementary apertures arranged periodically, centered within a wire grid and an aperture grid respectively. A very thin substrate, with the overall thickness of 0.007 λ1, 0.013 λ2 or 0.0195 λ3, where λ1, λ2 and λ3 are the free space wavelengths of the three bands respectively, supports this whole structure. The proposed FSS provides: 1) three passbands separated by transmission zeros, 2) advantage of low profile, and 3) insensitivity to incident angles and polarizations. An equivalent circuit model is given for predicting and analyzing the frequency characteristics of this structure. Furthermore, a tri-band FSS with uniform band spacing is fabricated and measured. Good agreement between the simulated and measured results is obtained.

M01C-4 0900 – 0920
Intrinsically Switchable Ferroelectric Bulk Acoustic Wave Filters Based on Barium Strontium Titanate Thin Films

V. C. Lee, S. A. Sis, S. Lee, A. Mortazawi, *University of Michigan, Ann Arbor, United States*

Single-standard wireless transceivers are of limited use as multi-mode devices become ubiquitous. Adaptive and reconfigurable RF circuits are necessary to decrease size, cost, and power consumption as well as increase reliability and robustness of wireless devices. In this paper, the design, fabrication, and performance of acoustically coupled and electrically coupled filters based on the ferroelectric barium strontium titanate are discussed. In their off state, the input and output ports are isolated from one another. When switched on with the application of a dc bias voltage, a bandpass filter response is obtained.

M01C-5 0920 – 0940
Compact DSPSL Ultra-Wideband Bandpass Filter Based on Transversal Signal-Interaction Concepts

W. Feng[1], W. Che[1,2], Q. Xue[2], [1]*Nanjing University of Science and Technology, Nanjing, China,* [2]*City University of Hong Kong, Hong Kong, China*

A compact ultra-wideband (UWB) bandpass filter (BPF) based on transversal signal-interaction concepts is proposed in this letter. Two transmission paths with a wideband double-sided parallel-strip line (DSPSL) 180° swap and a 3l/4 transmission line are used to transmit signal from Port 1 to Port 2. Two l/4 shorted lines are introduced to improve the passband transmission characteristic. Two transmission zeros and good harmonic suppression can be achieved in the whole band. One prototype with 3-dB fractional bandwidth of 108% (1.35-4.6 GHz) is fabricated for demonstration, and good agreement is observed between simulated and measured performances.

M01D: Low power, Low Noise and Ultrawideband Transceivers

Monday, 15 April 2013
Room: 311B
Chair: Hongtao Xu, *Intel Corporation*
Co-Chair: Mohammad Madihian, *MEDIWAVE*

This session focuses on recent advances in low power and low noise transceivers using both III-V and CMOS technologies. One paper addresses a fully integrated broadband receiver front-end in InGaAs pHEMT technology. Two papers address CMOS mixers using either distortion cancellation for IIP3 improvement or wideband input baluns for bandwidth enhancement. The remaining papers describe advances in LTE baseband and transceiver architectures.

M01D-1 0800 – 0820

Low Noise Fully Single-Ended Broadband Receiver Front-End with InGaAs pHEMT Technology

Z. Sun, H. Yang, L. Zhang, Y. Yan, *Institute of Microelectronics of Chinese Academy of Sciences, Beijing, China*

This paper demonstrates a fully single-ended broadband receiver front-end using a 0.5μm InGaAs E-mode pHEMT technology. The receiver consists of a wideband low-noise amplifier (LNA) and a wideband mixer with active baluns. A modified Kukielka LNA with the added LC-ladder matching network for bandwidth extension and noise optimization is employed. A new switched transconductor mixer embedded with an active balun for the local oscillator (LO) signal is designed. Measured results show that the front-end can achieve conversion gain of 26-29 dB, double sideband noise figure of 2.6-4.4 dB over the entire frequency range of 0.7 to 5.2 GHz. Based on the proposed front-end, an image-reject receiver is also presented with an image rejection of 35 dBc within the bandwidth.

M01D-2 0820 – 0840

Low Power Highly Linear Inductorless UWB CMOS Mixer with Active Wideband Input Balun

H. Kassiri Bidhendi[1,2], M. Deen[2], [1]*University of Toronto, Toronto, Canada,* [2]*McMaster University, Hamilton, Canada*

A low-power, highly linear CMOS double-balanced mixer for UWB applications is presented. The mixer is designed based on well-known folded architecture and also benefits from DC isolation of RF (Radio Frequency) and LO (Local Oscillator) stages. Stacked NMOS-PMOS gm-boosting topology is used in the design of RF stage. To achieve very low power consumption, this stage is biased in sub-threshold region. Also an ultra-wideband active balun is designed and fabricated to generate differential inputs. The balun is separately characterized and its performance is reported separately as well as together with mixer. The design is implemented using 130 nm CMOS process and is operational from 3.1-10.6 GHz. The measured maximum conversion gain shows high values of 14.9 dB for mixer core. Also, the measured double sideband noise figure has a minimum value of 7.8 dB for mixer core and 12.9 when balun is added. In addition, input (RF and LO) port matching is achieved with reflection of more than 10dB.

M01D-3 0840 – 0900

+14 dB Improvement in the IIP3 of a CMOS Active Mixer Through Distortion Cancellation

M. Wang, S. He, C. Saavedra, *Queen's University, Kingston, Canada*

The derivative superposition (DS) technique is used to cancel the third-order intermodulation distortion (IMD) produced in a downconverter mixer. By providing separate bias currents to the mixer core and the distortion-cancelling circuitry, the IMD is reduced but the conversion gain remains nearly the same in the distortion-cancelling mixer compared to the baseline mixer without linearization. Measurements show that the distortion-cancelling mixer has an IIP$_3$ that is 14 dB above the IIP3 of the baseline mixer while the conversion gain drops by only -0.7 dB. The distortion-cancelling mixer only needs an additional 2.4 mW of dc power relative to the baseline mixer's power draw. The test chip was fabricated in a standard 130 nm CMOS process and occupies an active area of 0.1 mm2.

M01D-4 0900 – 0920

Design of a FPGA-Based Baseband for MIMO TD-LTE BTS

L. Ji, J. Zhou, J. Zhai, K. Zhou, *Southeast University, Nanjing, China*

A compact 2×2 MIMO analog baseband processing unit for the TD-LTE BTS transceiver system is presented in this paper. The designed system supports two independent transmitter and receiver. Data can be transmitted between the baseband and the digital baseband subsystem flexibly and conveniently by either the optical fibers or the LAN cable. The on-board FPGA can support the Common Public Radio Interface (CPRI) and the Gigabit Ethernet (GE) interface. It can also be used for some data processing such as the calibration, digital pre-distortion (DPD), etc. Measurement results of EVM with a 19.2MHz 16QAM signal and a 20MHz TD-LTE signal are 0.45%rms and 1.29%rms respectively, which verifies excellent performance of the baseband board. With RF board as well as power and controller board integrated together, the designed 2×2 compact MIMO analog baseband processing unit is implemented in the TD-LTE trial network successfully.

M03A: Technologies for Advanced Wireless Devices

Monday, 15 April 2013
Room: 311A
Chair: Fred Schindler, *RF Micro Devices*
Co-Chair: Minkyu Je, *Institute of Microelectronics, A*STAR*

In the past decades, there have been amazing growth and development of mobile wireless devices. This evolution will continue in order to accomodate ever-growing demands in every aspect of the device - functionality, performance, battery life, size and cost. This focus session begins with the presentation of technology trends in mobile handsets especially from the perspective of challenges in RF front-end for multi-mode multi-band support. Various advanced architectures for the next-generation power amplifier for handsets are introduced in the second paper. The third paper presents reconfigurable and tunable filters with flexible frequency and bandwidth response controls. A new quadrature generation scheme based on a compact transformer-based structure is described in the last paper.

M03A-1 1330 – 1355

Technology Trends in Mobile Handsets

T. Gillenwater[1], F. Schindler[2], [1]*RFMD, Greensboro, United States,* [2]*RFMD, Billerica, United States*

The mobile handset is well established as a business and consumer device, expanding beyond the foundation built on earlier mobile handset technology. The functions and capabilities of the handset are continually evolving. Handset providers, application developers and users are putting ever greater demands on handsets which simultaneously strain limited battery power and require higher data transfer. This results in ever more challenging requirements on the RF front-end of the handset. At the same time there are cost pressures that require functions to be provided ever more economically. This paper discussed these trends, the implications in front-end architecture, and some of the advanced implementations that address these dynamics.

M03A-2 1355 – 1420

Advanced Linear PA Architectures for Handset Applications

B. Kim, *Pohang University of Science and Technology, Pohang, Republic of Korea*

The handset PAs for advanced system, such as 4G and beyond, should handle signals with high PAPR. For amplification of the signals, efficiency of the PAs is degraded significantly due to the operation at a low power region. For the system application point, the PAs are required to have a multimode and multiband capability, also. These stringent requirements ask advanced design architectures of the PAs. These architectures are based on a highly efficient amplifier and try to maintain the high efficiency at a low power level. The representative architectures are ET technique, Doherty amplifier, class-S amplifier, LINC and some digital PAs.

M03A-3 1420 – 1445

Reconfigurable and Tunable Filters with Flexible Frequency and Bandwidth Response Characteristics for Wireless Handsets and Mobile Terminals.

Y. Deng, K. Wu, *École Polytechnique de Montréal, Montreal, Canada*

Various compact reconfigurable and tunable filters for wireless handsets and mobile terminals covering most of popular wireless bands are studied and demonstrated in this work. Techniques for center frequency tuning coupled with bandwidth control features including the enabling of increasing fractional bandwidth and constant absolute bandwidth (ABW) are shown. Techniques for bandwidth reconfiguration with widely variable bandwidth states, convenient control of inter-resonator coupling as well as input and output coupling, are investigated. Tunable filter capable of switching from dual band to mono-band, selectivity enhancement and independent control of both frequency bands is also illustrated.

M03A-4 1445 – 1510

A Passive Quadrature Generation Scheme for Integrated RF Systems

J. Park, H. Wang, *Georgia Institute of Technology, Atlanta, United States*

Abstract: This paper proposes a transformer-based quadrature generation scheme, which converts the RF input signal into the quadrature output signals. By employing multi-turn coil structure and new capacitive phase compensation on the through and coupling ports, the presented scheme can be implemented in a very compact footprint with high quality quadrature signal, making it feasible for cellular applications. Compared to conventional quadrature generation methods, this scheme provides low-loss, wide bandwidth, and most importantly robustness to process variations. As a proof-of-concept design example, we demonstrate a 2 GHz 8-turn transformer-based quadrature generation block implemented in a standard 65 nm CMOS process. The whole design only occupies 280 μm by 280 μm chip area. The detailed design parameters and the simulation results including quadrature balance, passive loss, input matching, and Monte-Carlo results under process variations are all presented.

M04B: Novel Low Noise Circuits and Design

Monday, 15 April 2013
Room: 310
Chair: Kenjiro Nishikawa, *Kagoshima Univ.*
Co-Chair: Kai Kang, *University of Electronic Science and Technology*

This session is focused on low noise circuits and their design method. Three LNA circuit papers, one low power limiting AMP/RSSI paper and one LNA design paper will be presented.

M04B-1 1540 – 1600
A 77-GHz LNA for Automotive Radar Application
Y. Lu, T. Luo, J. Chen, Y. E. Chen, *National Taiwan University, Taipei, Taiwan*
This paper presents a 77-GHz low-noise amplifier implemented in 65-nm digital CMOS process for automotive radar application. Due to the lack of high frequency transistor model, curve fitting of the measured S-parameters has been done to obtain accurate simulation results. The transistor model is modified with additional parasitic extraction and bias-dependent components. The LNA is composed of three cascode stages connected in cascade and the matching networks are composed of micro-strip transmission lines and MOM capacitors. The 77-GHz LNA achieves a power gain of 17.6 dB and average noise figure of 5.9 dB. The 3-dB bandwidth of the LNA is from 70 GHz to 87 GHz. The measured input and output return loss is better than 10 dB at 77 GHz. The LNA consumes 20 mW from a 1.2 V supply voltage.

M04B-2 1600 – 1620
Ultra Low-Noise Highly Linear Integrated 1.5 to 2.7 GHz LNA
J. Yao, X. Sun, B. Lin, *TriQuint Semiconductor, San Jose, United States*
This paper presents a wideband, fully integrated, low-noise amplifier with a noise figure of less than 0.5 dB. The device is fabricated in a 0.35µm GaAs enhancement-mode pHEMT process because of its positive threshold voltage and superior noise performance. The amplifier is housed in a low-cost 2x2 mm2 8-pin QFN plastic package with internal gate biasing and input and output matching. To our knowledge, this work achieved the best result of reported combination of low noise figure, OIP3 (40 dBm), and Linearity Figure of Merit (LFOM) of 15dB at a frequency range of 1.5-2.7GHz for sub-0.5 dB NF LNA, and integrated power-down function for system control.

M04B-5 1620 – 1640
A 1mW CMOS Limiting Amplifier and RSSI for ZigBee Applications
R. Luo, X. Bai, S. Diao, F. Lin, *University of Science and Technology of China, Hefei, China*
This paper presents a low-power intermediate frequency (IF) limiting amplifier (LA) and received signal strength indicator (RSSI). The LA and RSSI are designed for ZigBee receiver at 2MHz IF. To save power, two local loops for offset correction are used in LA chain and a sensitivity of -56dBm is achieved. Each LA gain stage employs cascade diodes load to avoid driving the diode load into velocity saturation region. The indication rang is 50dB within ±2dB linearity error. The core area is 0.11×0.31mm2 using a SMIC 0.18-µm CMOS technology. The overall power consumption is 1mW from a 1.8V supply voltage.

M04C: Filters II

Monday, 15 April 2013
Room: 311A
Chair: Mingyao Xia, *University of Electronic Science and Technology of China*
Co-Chair: Richard Snyder, *RS Microwave Co.*

This session continues to highlight novel bandpass filter designs, which include a miniaturized dual-band filter using a divide-by-2 spiral resonator and loaded open stubs, a differential filter with high common-mode rejection within the differential-mode passband using controllable common-mode transmission zero, a compact microstrip dual-band filter with quarter-wavelength stepped impedance resonators, a dual-band filter based on stub-loaded complementary compact microstrip resonant cell, and design methodology for a class of triple-mode filters using a patch-loaded cross resonator.

M04C-1 1540 – 1600
Miniaturized Dual-Band Bandpass Filter Using λ/2 Spiral-Resonator and Loaded Open-Stub
X. Luo[1], L. Jin[1], S. Sun[2], E. Li[3], [1]*Huawei Technologies Co., Ltd., Shengzhen, China,* [2]*The University of Hong Kong, Hong Kong, China,* [3]*A*STAR, Singapore, Singapore*
In this paper, a compact dual-band bandpass filter using the half-wavelength (λ/2) spiral-resonators and loaded open-stubs is proposed. First, the dual-resonances are employed by the λ/2 spiral-resonators. Secondly, the loaded open-stubs can not only adjust the second resonance for the designed limit, but also suppress the spurious for the upper stopband bandwidth extension. Thirdly, based on the λ/2 spiral-resonators with loaded open-stubs mentioned above, the spiral-coupled scheme is implemented, which employs a strong enough passband enhancement around the dual-resonances to achieve the dual-band bandpass filter. Then, a filter is implemented with good frequency responses and a compact size.

M04C-2 1600 – 1620
Differential Bandpass Filter with High Common-Mode Rejection Ratio inside the Differential-Mode Passband using Controllable Common-Mode Transmission Zero
J. Shi, J. Chen, H. Tang, L. Zhou, *Nantong University, Nan Tong, China*
Controllable common-mode transmission zero is proposed to improve the common-mode rejection ratio (CMRR) inside the differential-mode passband of differential bandpass filters. With the controllability of the common-mode transmission zero, the common-mode transmission zero can be moved into the frequency range of the differential-mode passband, and then the CMRR inside the differential-mode passband can be greatly improved. Two two-order filters using different resonators are designed to demonstrate the existence and controllability of the common-mode transmission zero. A four-order filter with two resistor-loaded stepped-impedance resonators (SIRs) and two resistor-loaded uniform impedance resonators (UIRs) are designed to get good selectivity of differential-mode passband and wide-band common-mode suppression besides the high CMRR inside the differential-mode passband. The design methodology and experimental results of the proposed filters are presented.

M04C-3 1620 – 1640
Compact Microstrip Dual-band Bandpass Filter with Quarter-Wavelength Stepped Impedance Resonators
S. Zhang, L. Zhu, *Nanyang Technological University, Singapore, Singapore*
In this paper, a compact microstrip dual-band Chebyshev bandpass filter based on λ/4 stepped impedance resonators is designed, which are serially coupled by the alternative J and K inverters. Appropriate impedances and lengths of λ/4 stepped impedance resonators are synthesized based on the values of chosen dual-band K inverter. The dual-band coupled-line is then synthesized to render required J couplings at two central frequencies. Finally, a 4th-order Chebyshev dual-band bandpass filter centering at 1.8 and 5.8 GHz with respective fractional bandwidths of 15.0% and 8.0% is designed and fabricated, and measured results show consistent mat h with the theoretical ones.

M04C-4 1640 – 1700
Dual-Band Bandpass Filter Based on Stub-loaded Complementary CMRC
W. Qin, Q. Xue, *City University of Hong Kong, Hong Kong, China*
A dual-band bandpass filter (BPF) is presented in this paper by applying the stub-loaded resonator technique to the recently-proposed quasi-lumped BPF, namely complementary CMRC (CCMRC). The CCMRC is a compact single-band BPF and consists of four resonators. Two stubs are attached at the center of the first and the fourth resonators respectively to obtain an additional passband, resulting in a dual-band filtering feature. The implemented dual-band BPF inherits advantages from the CCMRC, such as compact size, good passband performance and high selectivity skirt.

M04C-5 1700 – 1720
Design Methodology of a Class of Triple-Mode Bandpass Filters Using a Patch-Loaded Cross Resonator
R. Zhang[1], L. Zhu[1], S. Luo[2,1], [1]*Nanyang Technological University, Singapore, Singapore,* [2]*National University of Singapore, Singapore, Singapore*
A class of microstrip triple-mode bandpass filters (BPFs) using a patch-loaded cross resonator are modeled, designed and tested in this paper. First, a symmetrical equivalent LC network is developed for a symmetrical patch structure. The values of all the inductors and the capacitors are extracted by applying the even-odd mode analysis. Then, three 1-port networks are developed to analyze the resonant conditions of the corresponding modes. Finally, these first three resonant modes are used to form a passband with three transmission poles. To verify the proposed design methodology, two sets of filter prototypes with different loaded patches are designed, fabricated and measured in the end. The predicted results are well confirmed with the experimental ones.

M04D: Printed Antennas
Monday, 15 April 2013
Room: 311B
Chair: Alphones Arokiaswami, *NTU*
Co-Chair: Wen-Quan Che, *Nanjing University of Science and Technology*
In this session, printed antennas are focused, including small sierpinski bow-tie patch antenna, broadband planar antenna with circular polarization for RFID readers, and dual-band circularly polarized stacked microstrip antenna over RIS for GPS applications.

M04D-2 1540 – 1600
Broadband Planar Antenna with Circular Polarization for RFID Readers
Y. Yao[1], J. Yu[1], X. Chen[2,1], [1]*Beijing University of Posts and Telecommunications, Beijing, China,* [2]*Queen Mary, University of London, London, United Kingdom*
A novel planar antenna with broadband and circular polarization characteristics is reported which can be easily fabricated and embedded into RFID readers. Circular polarization radiation is achieved by introducing a cross branch at its corner. And the modified PIFA structure gives the antenna a broadband impedance bandwidth characteristic. For ease in integration with active devices and design facilitation, the radiating element and ground are etched on the same layer of the substrate. Simulated and measured parameters including return loss, axial ratio, and radiation patterns are presented to validate the proposed design.

M04D-3 1600 – 1620
Dual-Band Circularly Polarized Stacked Microstrip Antenna over RIS for GPS Applications
K. Agarwal[3], Y. Guo[3], N. Nasimuddin[2], A. Alphones[1], [1]*Nanyang Technological University , Singapore, Singapore,* [2]*A*STAR, Singapore, Singapore,* [3]*National University of Singapore , Singapore, Singapore*
A compact, dual band, circularly polarized (CP) multilayered stacked microstrip antenna over reactive impedance surface (RIS) is studied and presented in this paper. The CP radiation with compact antenna size is achieved by placing two asymmetric slit square patch (ASSP) and cross-shaped slotted square patch (CSSP) radiators over the RIS. Dual band is achieved by using the CSSP and ASSP stacked patches placed over RIS, fed by a coaxial probe at proper location to generate CP radiation. The measured results of the proposed antenna are 1.61% (1.235-1.255 GHz): L2 band and 1.25% (1.585-1.605 GHz): L1 band for 3-dB axial ratio bandwidth (BW), 2.00% (1.235-1.260 GHz): L2 band and 1.57% (1.580-1.605 GHz): L1 band for 10-dB impedance BW, and 2.68 dBic: L2 band and 4.46 dBic: L1 band for gain at the boresight for compact antenna overall volume of $0.26\lambda o \times 0.26\lambda o \times 0.018\lambda o$ at 1.2 GHz.

M04D-4 1620 – 1640
Design of an Internal Multi-band Loop Antenna for Multiple Mobile Handset Operations
C. Dai, D. Wu, Y. Wu, *Guangdong University of Technology, Guangzhou, China*
A compact internal multi-band folded loop antenna for GSM850/900/DCS/PCS/UMTS/ LTE2300/2500/ WLAN2.4GHz/WiMAX2.5GHz multiple mobile operations is proposed. The whole antenna structure proposed in this paper consists of a single folded meander loop track and a T-shape back-coupling element. The size of the total structure is $120 \times 60 \times 6.5$mm3, meanwhile the area left for the loop track is only $60 \times 15 \times 6.5$mm3. The compact structure makes it very suitable for small mobile phone applications. The design and optimizing of the performance of the proposed antenna are performed by using the simulator software HFSS. An actual model has been prototyped for testing. Measurement results and electromagnetic simulation ones are in good agreement, thus indicating that the proposed antenna can meet the actual demands.

M04D-5 1640 – 1700
4-Element Yagi Array of Microstrip Quarter-Wave Patch Antennas
J. Liu[1], Q. Xue[2], Y. Long[1], [1]*Sun Yat-Sen University, Guangzhou, China,* [2]*City University of Hong Kong, Hong Kong, Hong Kong*
A new kind of Yagi array of microstrip quarter-wave patch antennas is presented. The antenna array has a low profile and provides a high gain and a vertical polarization at endfire. Compared with previous Yagi array of microstrip half-wave patch antennas, the Yagi array of quarter-wave patch antennas has a smaller size and does not suffer the constraint in dielectric constant in the substrate. Besides, the presented Yagi array generates a main beam pointing closer to endfire than the Yagi array of half-wave patch antennas. Measured results show that the presented Yagi array with 4 elements would generate a peak gain of about 9.7 dBi, an endfire gain of about 4.5 dBi, and a bandwidth of 11.3% for a profile of 0.026 wavelengths. The front-to-back ratio of the Yagi array is higher than 10 dB.

STUDENT PAPER COMPETITION

Monday, 15 April 2013
1730-1900
Room 306AB

IWS 2013 is pleased to announce the finalists of the 2013 Student Paper Competition. The finalists will present their work in a special poster session on Monday night during IWS in addition to their oral presentation during the technical sessions. A special thank you to AWR for their generous contribution of the monetary awards for the winners. Please join us in congratulating all the finalists!

Monday, 15 April 2013
MO1D-2
Room: 311B
0820 - 0840
Low Power Highly Linear Inductorless UWB CMOS Mixer with Active Wideband Input Balun
H. Kassiri Bidhendi[1,2], M. Deen[2], [1]*University of Toronto, Toronto, Canada,* [2]*McMaster University, Hamilton, Canada*
A low-power, highly linear CMOS double-balanced mixer for UWB applications is presented. The mixer is designed based on well-known folded architecture and also benefits from DC isolation of RF (Radio Frequency) and LO (Local Oscillator) stages. Stacked NMOS-PMOS gm-boosting topology is used in the design of RF stage. To achieve very low power consumption, this stage is biased in sub-threshold region. Also an ultra-wideband active balun is designed and fabricated to generate differential inputs. The balun is separately characterized and its performance is reported separately as well as together with mixer. The design is implemented using 130 nm CMOS process and is operational from 3.1-10.6 GHz. The measured maximum conversion gain shows high values of 14.9 dB for mixer core. Also, the measured double sideband noise figure has a minimum value of 7.8 dB for mixer core and 12.9 when balun is added. In addition, input (RF and LO) port matching is achieved with reflection of more than 10dB.

Monday, 15 April 2013
MO4C-3
Room: 311A
1620 - 1640
Compact Microstrip Dual-band Bandpass Filter with Quarter-Wavelength Stepped Impedance Resonators
S. Zhang, L. Zhu, Nanyang Technological University, Singapore, Singapore
In this paper, a compact microstrip dual-band Chebyshev bandpass filter based on λ/4 stepped impedance resonators is designed, which are serially coupled by the alternative J and K inverters. Appropriate impedances and lengths of λ/4 stepped impedance resonators are synthesized based on the values of chosen dual-band K inverter. The dual-band coupled-line is then synthesized to render required J couplings at two central frequencies. Finally, a 4th-order Chebyshev dual-band bandpass filter centering at 1.8 and 5.8 GHz with respective fractional bandwidths of 15.0% and 8.0% is designed and fabricated, and measured results show consistent match with the theoretical ones.

Tuesday, 16 April 2013
TU1B-1
Room: 310
0800 - 0820
Towards Millimeter-Wave High-Efficiency Rectification for Wireless Energy Harvesting
S. Ladan, S. Hemour, K. Wu, *École Polytechnique de Montréal, Montreal, Canada*
This paper introduces a simple dual diode rectifier circuit in microstrip technology operating at K-band towards millimeter-wave applications. The designed rectifier circuit has a special architecture that enables the separation of the DC component of the rectified wave from the data-related IF channel. Diode characteristics are discussed for efficiency enhancement which is involved in accurate system simulations. Optimization procedure is carried out in order to maximize the RF-to-DC conversion efficiency. A measured efficiency of 40% for 35 mW input power is achieved for the designed circuit, showing an improvement in efficiency in comparison with previous works. The circuit presents potential applications in the design of integrated microwave and millimeter-wave systems for wireless power transmission and energy harvesting.

Tuesday, 16 April 2013
TU1C-3
Room: 311A
0840 - 0900
A Compact Fully Differential Doherty Power Amplifier
S. Chen, Q. Xue, *City University of Hong Kong, Kowloon, Hong Kong*
In this paper, a compact triple-transistor fully differential Doherty power amplifier (DPA) is investigated. Three active devices are combined in a very judicious way to amplify the differential signal in a way like what a typical Doherty amplifier does. Particularly, two out-of-phase carrier PAs are applied to operate in the low-power region for high efficiency. On the other hand, only one peaking PA is used in the high-power region, which shares its output evenly with the two carriers. The reduction of transistor number from four for a classic differential DPA to three greatly cuts down the realization cost and compacts the overall circuit. Theoretical analysis is given for deep understanding of the operation principle. To demonstrate the proposed technique, a prototype is implemented based on Cree's CGH40010 GaN HEMTs. Experimental result shows that 73% and 63% drain efficiencies are achieved at peak power and 6-dB back-off point, respectively.

Tuesday, 16 April 2013
TU1B-5
Room: 310
0920 - 0940
Design of Wireless Power Supply System for the Portable Mobile Device
Y. Zhou, X. Huang, J. Zhao, L. Tan, *Southeast University, Nanjing, China*
This paper illustrates a model of magnetic resonance coupled wireless power transfer(WPT) system with the set-distance and series-series capacitance compensation structure, optimizing the design of the transmission device and realizing the design of a small power rectifier regulator system. This wireless power supply system can achieve a stable DC power supply to support a 20W mobile TV. By adopting the topology of non-controlled rectifier and the flyback converter, the rectifier regulator system can achieve regulated output through voltage feedback. Over-voltage protection and output voltage filtering are also added to the system to improve stability. Finally, aiming at solving the problem of the drift of resonant frequency in the debugging process, two solutions are provided. By adjusting the frequency or the power of the power supply and setting the input voltage of the flyback converter as the feedback signal, both solutions can meet the power stability demand of the mobile TV.

Color Key Code: Monday | Tuesday | Wednesday

STUDENT PAPER COMPETITION

Tuesday, 16 April 2013
TU3C-1
Room: 311A
1330 - 1350
Improved Joint Radar-Radio (RadCom) Transceiver for Future Intelligent Transportation Platforms and Highly Mobile High-Speed Communication Systems
J. Moghaddasi, K. Wu, *École Polytechnique de Montréal, Montreal, Canada*
A mulitfunctional transceiver for integrated radar sensing and radio communication (or simply termed RadCom) systems is developed in the time domain. It is a robust alternative of the previous architecture for a smart system that operates jointly as radar or radio in consecutive time slots. Following a system design approach, a low-frequency prototype of the proposed transcevier is realized and its performance is evaluated. Within the radar mode, the added ability of target detection as well as improved range resolution against the previously demonstrated version makes the system suitble for driving assistance applications. Within the radio mode, it has proved a great capability of communication at a data rate of 25Mbps.

Tuesday, 16 April 2013
TU3A-2
Room: 309AB
1350 - 1410
Intrinsically Switchable Thin Film Ferroelectric Resonators Utilizing Electric Field Induced Piezoelectric Effect
S. A. Sis, V. C. Lee, S. Lee, A. Mortazawi, *University of Michigan, Ann Arbor, United States*
This paper presents bulk acoustic wave resonators using the ferroelectric materials barium titanate and barium strontium titanate. The electric field induced piezoelectric effect in these materials is utilized in the design of various types of intrinsically switchable bulk acoustic wave resonators. Both thickness mode and lateral mode resonator results, which have been demonstrated recently, are summarized in this paper. Significantly improved quality factors by means of forming a ferroelectric-on-silicon structure are also demonstrated

Tuesday, 16 April 2013
TU3A-5
Room: 309AB
1450 - 1510
A 10-200 MHz 360º Vector-Sum Phase Shifter using COTS Components for Wideband Phased Array Systems
W. Lim, X. Tang, K. Mouthaan, *National University of Singapore, Singapore, Singapore*
A 10-200 MHz wideband 360º phase control vector-sum phase shifter (VSPS) is presented. Broadband VSPS are commonly implemented in IC technologies for microwave frequencies. By using commercial-off-the-shelf (COTS) discrete components on PCB, a wideband VSPS design is proposed and experimentally demonstrated. An RMS phase error of less than 1.5º, input return loss larger than 15 dB and amplitude imbalance less than 1 dB are measured from 10 to 100 MHz. An RMS phase error of about 5º, a return loss around 10 dB and amplitude imbalance less than 2.5 dB are measured from 10 to 200 MHz. The board dimension is 8.4cm x 7.8cm.

Wednesday, 17 April 2013
WE3B-1
Room: 310
1330 - 1350
5 GHz-Band CMOS Direct Digital RF Modulator Using Current-Mode DAC with Idle Current
O. Wada, T. Tan, S. Tanifuji, S. Kameda, N. Suematsu, T. Takagi, K. Tsubouchi, *Tohoku University, Sendai, Japan*
A 5 GHz-band direct digital RF modulator using current-mode DAC with idle current is proposed and fabricated in 90-nm CMOS process. Since this modulator directly converts digital BB parallel input signal into RF signal, small die size and low dc operation can be achieved. To reduce the higher order distortion components at the RF output, idle current is provided to BB current output from the current-mode DAC. By providing idle current of 10% of full scale DAC output current, the 2nd and the 3rd order distortion components near 5 GHz-band carrier are reduced and the improvement of ENOB is achieved. As the results, measured ENOB of 6.36 bit (SNDR of 40.0 dB) with RF modulated output power of -28.4 dB is obtained at 5 GHz. The core size of the proposed modulator integrated circuit (IC) is 200µm x 200µm and the power consumption of core circuit excluding inverter inverter section for digital BB signal converter is 2.1 mA/1.2V.

Wednesday, 17 April 2013
WE3D-2
Room: 311B
1350 - 1410
A High-Directivity Phased Array for Secure Transmission
C. Tang, Q. Xue, *City University of Hong Kong, Hong Kong, Hong Kong*
A high-directivity phased array using combination of beam-steering technique and novel null tracking technique for secure signal transmission is presented. The proposed phased array provides super high directivity and constant data beamwidth for a wide scanning angle without alternating transmitting power. It achieves that by generating jamming signal with a null towards the direction of data signal's beam as well as a stable twin-beam tracking with the null. A 3X4 antenna array prototype is designed and fabricated. It demonstrates high signal-to-noise ratio directivity of over 25 dB, as well as a constant data beamwidth (S/N 12 dB) of 15° and a large jamming window (S/N 0 dB) to interfere the spy receivers for a wide scanning angle between ±27° for GSM1800 application.

Wednesday, 17 April 2013
WE3C-4
Room: 311A
1430 - 1450
A Novel Gysel Power Divider with Arbitrary Power Ratio for High-Power Application
H. W. Zhang, Q. Xue, *City University of Hong Kong, Hong Kong, Hong Kong*
A novel Gysel power divider with arbitrary power ratio for high-power application is presented in this paper. The power dividing ratio can be conveniently assigned by controlling the length of two branch lines without any changes in other branches. The characteristics of all the transmission lines in this divider are fixed to the same value based on the theoretical analysis, which will simplify the design procedure of unequal Gysel power. Besides, the power ratio in this Gysel power divider can be designed from 0 to infinite without employing high impedance transmission line, which is unrealized in the conventional Gysel power divider. In order to evaluate the performance of the novel Gysel power divider, two dividers with dividing ratios of 2:1 and 4:1 are fabricated and examined. From the results it can be observed that there is excellent agreement between the simulated and measured results.

TUESDAY FOCUS AND PANEL SESSIONS:

Tuesday, 16 April 2013 1010 – 1150 Room: 311A

TU2A: Focus Session – Wireless Data and Power Transceivers for Biomedical Applications

Chair: Minkyu Je, *A*STAR*
Co-Chair: Mohammad Madihian, *Mediwave*

Abstract: We are observing fast growing contribution of wireless technologies to emerging biomedical devices in two major ways. One is seamless connectivity which allows the device to communicate the captured/sensed biomedical information in an untethered manner. The other is a whole new way of powering the biomedical devices through the wireless power transfer, obviating the need of bulky batteries and power cables. The overview of unique challenges in designing the wireless power transfer system for biomedical devices is provided in the first paper. The following two papers address new design techniques for the biomedical data transmitter which needs to be highly efficient in terms of both the energy consumption and spectrum occupation. The last paper presents the overview of recent development in wireless body area network (WBAN) technology and its standardization, as well as the design and implementation of the energy-efficient body-channel communication transceiver which is one of three options for the WBAN physical layer realization supported by IEEE 802.15.6.

Tuesday, 16 April 2013 1200 – 1300 Room: 310

Panel Session: Radiation Testing in Wireless Communication: Challenges and Solutions

Abstract: Radiated test is a critical microwave and wireless technology and plays a crucial role in the wireless communication industry chain. Extensive tests and verification efforts are required for both establishing wireless communication testing standards and controlling the quality of wireless products. Radiated device manufacturers are constantly under test pressure through their R&D, part evaluation, manufacturing, and certification processes, in order to maintain and even expand their market position. This panel aims to address the current technology and demand on radiated tests in wireless communication industry, will debate the challenges faced, and explore the potential solutions and prospect industry development in the future.

Panel Organizer and Moderator: Yihong Qi, *DBJTECH Inc*. Canada

Panel Members:

1. Kefeng Liu, *Tri*-L solutions, *Canada*
2. Hongwei Kong, *Agilent Beijing, China*
3. Jim Drewniak/Jun Fan, *Missouri University of* Science and Technology, *USA*
4. Fred Yu, *DBJ Technologies, China*
5. Gou Lin, *China Academy of* Telecommunication Research (CATR), *China*
6. Lijun Zhao, *China Mobile, China*

Tuesday, 16 April 2013 1540 – 1720 Room: 311A

TU4A: Focus Session – Emerging Wireless Devices and Design Techniques

Chair Minkyu Je, *A*STAR*
Co-Chair Mohammad Madihian, *Mediwave*

Abstract: The next-generation wireless technologies request new devices and design techniques. This session presents an interesting mixture of recent development in emerging devices and their modeling, as well as advanced design techniques. We begin the session with the introduction of latest achievement in high-power THz sources based on nonlinear optical effects. The following paper reviews the recent development in the modeling framework of multi-gate MOSFETs which are becoming new mainstream manufacturing technologies providing a new platform for RF integration in advanced SOCs. Latest advances in power amplifier designs for both base station and handset applications are covered by the last two papers of the session.

TU1A: Filters III

Tuesday, 16 April 2013
Room: 309AB
Chair: Junhong Wang, *Beijing Jiaotong University*
Co-Chair: Ming Yu, *COMDEV International*

This session presents the latest research achievements of compact and switchable filters for microwave and millimeter-wave applications. With the help of new technologies, such as MEMS and silicon bulk micromachining, novel filter structures are proposed and advanced filtering performances are achieved. These include: a miniaturized filter based on new quadruple-mode ring resonator with overlapping structure with quasi-elliptic bandpass characteristics, a substrate-integrated waveguide filter with a transmission zero at the upper-side of the band and efficient rejection of adjacent-band interference, a MEMS-based filter that can be switched between the 60-GHz band and the E-band with better than 20 dB rejection, a quadruple ultra-wideband filter based on meandering stub-loaded ring resonator with a deep notch around 5.8 GHz, and a low-loss ultra-wideband filter based on silicon bulk micromachining with a compact size small group delay.

TU1A-1 0800 – 0820
Miniaturized Microstrip Quadruple-Mode Ring Resonator Filter with Quasi-Elliptic Passband
T. Lin[1], J. Kuo[2], S. Chung[1], [1]*National Chiao Tung University, Hsinchu, Taiwan,* [2]*Chang Gung University, Taoyuan, Taiwan*
A compact quadruple-mode ring resonator is proposed for synthesis of a quasi-elliptic bandpass filter. The resonator is composed of four half-wavelength rings connected to a single grounded via. For miniaturization, the ring areas are overlapped and the crossovers are implemented by short CPW sections in the ground plane. As a result, the resonator uses about 50% area of a conventional dual-mode ring resonator filter. Among the four rings, all coupling coefficients are of inductive type realized by shorted high-impedance and coupled-line sections. Two zeros are created by capacitive source-load coupling, and the response is synthesized by the coupling matrix method. Agreement between simulation and measurement results of a realized circuit validates the approach.

TU1A-2 0820 – 0840
Compact SIW Filter with Asymmetric Frequency Response for C-Band Wireless Applications
J. D. Martinez , S. Sirci, V. E. Boria, *Universidad Politecnica de Valencia, Valencia, Spain*
In this paper, the design of a low-loss compact filter with asymmetric response for 5.15 – 5.35 GHz wireless local area network (WLAN) applications is presented. The proposed filter implements a cross-coupled trisection topology that enables to conveniently add a transmission zero at the upper-side in order to reject strong interferers that could come from the close UNII-2e and UNII-3 bands (i.e. between 5.47 – 5.825 GHz). The filter is based on capacitively loaded circular coaxial resonators embedded into a dielectric material following a substrate integrated waveguide (SIW) approach. The designed filter shows good electromagnetic performance in terms of losses and out-of-band rejection while greatly reducing the device size.

TU1A-3 0840 – 0900
RF MEMS Millimeter-Wave Switchable Bandpass Filter
K. Chan[1,2], R. Ramer[2], Y. Guo[1], [1]*CSIRO, Marsfield, Australia,* [2]*University of New South Wales, Sydney, Australia*
A switchable bandpass filter that can operate between 60 GHz and E-band spectrum, capable of providing good channel isolation is presented. A RF MEMS SPDT is designed for the switching element between the two bands. Back-to-back cantilever switches are used for maximum isolation. New circuit models for the inductively coupled inverters and short circuit stubs are proposed. Measurement results show good correlation to our simulations. Better than 15 dB return loss and 5 dB insertion loss in both 60 GHz and E-band are measured. With the introduction of transmission zero, rejection between the two operational bands is better than 20 dB.

TU1A-4 0900 – 0920
Ultra-Wideband (UWB) Bandpass Filter Based on Stub-Loaded Ring Resonator
H. Zhu, Q. Chu, *South China University of Technology, Guangzhou, China*
An ultra-wideband (UWB) bandpass filter with a notch-band and wide upper stopband is presented in this paper. The UWB filter is realized using a ring resonator which is loaded with two sets of stubs, i.e. one is loaded in the center and two little stubs at the symmetrical side locations. The loaded stubs are used to create transmission zeros in upper stopband thus high modes are suppressed greatly. Moreover, two identical meandered resonators are inserted within the stub-loaded ring resonator, creating a notch-band around 5.8 GHz. Finally, two UWB filters with and without notch-band are simulated, fabricated, and measured results provide an experimental validation of predicted performance of the filter.

TU1A-5 0920 – 0940
Silicon RFIC UWB Bandpass Filter Using Bulk-Micromachined Trench Coupler
X. Huang, S. Lucyszyn, *Imperial College London, London, United Kingdom*
A low loss silicon RFIC UWB bandpass filter is reported. The filter exploits a novel metalized coupled trench structure, fabricated by advanced silicon bulk micromachining. The couplers can achieve more than -2 dB coupling, with good even-odd mode phase velocity balance, while having practical dimensions. The CPW filter is designed using well-know interdigtial filter design equations. The measured fraction bandwidth is 115%, with only 1 dB mid-band insertion loss at 6.4 GHZ and better than -11 dB return loss across the whole passband. The measured differential-phase group delay is less than 200 ps from 2.6 to 10.1 GHz. Being a monolithic filter, it has a compact area of only 3.5 x 5.5 mm^2

TU1B: Wireless Energy Transfer and Harvesting

Tuesday, 16 April 2013
Room: 310
Chair: Minkyu Je, *Institute of Microelectronics, A*STAR*
Co-Chair: Mohammad Madihian, *Mediwave*

The energy in the form of electromagnetic waves provides interesting and unique opportunities. The energy stored in the electrical form can be converted to the electromagetic energy and transferred to the remote site without power cables. Moreover, the electromagnetic enery in ambience can be harvested and converted to the electrical form to operate electronic devices. Papers in this session presents new devices, circuit designs and system implementations for emerging wireless energy transfer and harvesting applications.

TU1B-1 0800 – 0820
Towards Millimeter-Wave High-Efficiency Rectification for Wireless Energy Harvesting
S. Ladan, S. Hemour, K. Wu, *École Polytechnique de Montréal, Montreal, Canada*
This paper introduces a simple dual diode rectifier circuit in microstrip technology operating at K-band towards millimeter-wave applications. The designed rectifier circuit has a special architecture that enables the separation of the DC component of the rectified wave from the data-related IF channel. Diode characteristics are discussed for efficiency enhancement which is involved in accurate system simulations. Optimization procedure is carried out in order to maximize the RF-to-DC conversion efficiency. A measured efficiency of 40% for 35 mW input power is achieved for the designed circuit, showing an improvement in efficiency in comparison with previous works. The circuit presents potential applications in the design of integrated microwave and millimeter-wave systems for wireless power transmission and energy harvesting.

TU1B-2 0820 – 0840
Study of a Novel Compact Rectenna for Wireless Energy Harvesting
F. Zhang[1], F. Meng[1], J. Lee[2], Q. Wu[1], [1]*Harbin Institute of Technology, Harbin, China,* [2]*Kwangwoon University, Seoul, Republic of Korea*
A compact novel topology rectenna system is presented. The proposed rectenna is developed by decomposition a rectenna topology into two function parts, and then re-combination the two parts into a new topology to reach a very compact system size. The operation mechanism of the proposed novel topology rectenna is explained and analyzed. In addition, the proposed architecture is uni-planar, robust and compact, which lead to an easy design and realization at the required frequency ranges with a very low cost. A 2.45 GHz rectenna system is designed and measured to show their microwave performances.

TU1B-3 0840 – 0900
Efficient Wireless Power Transfer System by Using Highly Sub-wavelength Negative-Index Metamaterials
Y. Fan, L. Li, *Xidian University, Xi'an, China*
In this paper, we present a kind of highly sub-wavelength negative refractive index metamaterials for operation at radio frequencies. A dual layer design consisting of planar spiral and meandering line with metallic strips enables the metamaterials with the properties of effective negative permittivity and permeability simultaneously, i.e. negative refractive index. Moreover, its cell size is about 330 times smaller than the resonant wavelength. By applying one or two metamaterial slabs between the two traditional inductive coupling copper rings, the transfer mechanism will be changed to be resonant coupling. Therefore, both of the transfer distance and the transfer efficiency are improved significantly. Full-wave simulation results show that the miniature WPT system with proposed metamterials can work perfectly in improving the transfer efficiency and transfer distance.

TU1B-4 0900 – 0920
Experimental Study of Effects of Coaxial Cables in Magnetic Resonant Wireless Power Transfer System
S. Yu, L. Li, *Xidian University, Xi'an, China*
This paper analyzes the effects of coaxial cables in the magnetic resonant wireless power transfer (WPT) system. The experimental results show that the transfer efficiency of WPT system would change when different coaxial cables were connected to the source and load coils. Some special phenomena are revealed and a possible interpretation is proposed in this paper. Experiment results show that the proposed system can dramatically improve the efficiency and extend the power transfer distance. In the same size of MIT's helix, the efficiency of the WPT system increased to near 50% at the distance of 4.8 meters, while near 50% of 2 meters by MIT in 2007. In addition, we succeed to light a low voltage bulb at the distance of 4.8 meters.

TU1B-5 0920 – 0940
Design of Wireless Power Supply System for the Portable Mobile Device
Y. Zhou, X. Huang, J. Zhao, L. Tan, *Southeast University, Nanjing, China*
This paper illustrates a model of magnetic resonance coupled wireless power transfer(WPT) system with the set-distance and series-series capacitance compensation structure, optimizing the design of the transmission device and realizing the design of a small power rectifier regulator system. This wireless power supply system can achieve a stable DC power supply to support a 20W mobile TV. By adopting the topology of non-controlled rectifier and the flyback converter, the rectifier regulator system can achieve regulated output through voltage feedback. Over-voltage protection and output voltage filtering are also added to the system to improve stability. Finally, aiming at solving the problem of the drift of resonant frequency in the debugging process, two solutions are provided. By adjusting the frequency or the power of the power supply and setting the input voltage of the flyback converter as the feedback signal, both solutions can meet the power stability demand of the mobile TV.

TU1C: High Efficiency and Wideband Power Amplifiers

Tuesday, 16 April 2013
Room: 311A
Chair: Xin Jiang,
Co-Chair: Jianli Liu

In this session we have several papers describing high-efficiency power amplifier designs, mainly Doherty architecture in GaN and CMOS, and an ultra wideband MMIC design in GaN. The final paper in this session describes pre-distortion technique for Doherty PA for enhanced linearity and efficiency.

TU1C-1 0800 – 0820
Analysis and Design of CMOS Doherty Power Amplifier Using Voltage Combining Method

C. Zhao, B. Park, Y. Cho, B. Kim, *Pohang University of Science and Technology, Hyoja-dong, Nam-gu, Pohang, Republic of Korea*

A 1.75GHz CMOS Doherty power amplifier (PA) is presented. This Doherty PA uses voltage combining method that is different from the conventional current combining Doherty amplifier based on HBT. The output transformer is employed to combine the output power and realize the load modulation. The proposed CMOS Doherty PA is fabricated in 180nm CMOS process. Simulation results show that the output transformer acts as an impedance inverter and reduces the load impedance of carrier amplifier when the peaking amplifier turns, that meet the load modulation Doherty PA operation. The prototype achieves a maximum output power of +28.6dBm with a peak power-added efficiency (PAE) of 31.6% by using 3.4 V supply voltage. The PAE is kept above 25% over a 6 dB range of output power. It shows clearly the efficiency enhancement at the power back-off point due to the Doherty operation.

TU1C-2 0820 – 0840
Bandwidth Extension of GaN Doherty Power Amplifier: Effect on Power, Efficiency and Linearity

V. Camarchia[1], J. Fang[1], G. Ghione[1], A. Javan Khoshkholgh[1], J. Moreno Rubio[2], M. Pirola[1], R. Quaglia[1], C. Ramella[1], [1]*Politecnico di Torino, Torino, Italy,* [2]*Universidad Pedagógica y Tecnológica de Colombia, Sogamoso, Colombia*

The paper discusses the bandwidth extension of a second-harmonic tuned GaN Doherty power amplifier: the adopted strategy relies on output wideband compensation stages and input broadband matching. The single-band (3.5 GHz) and the wide-band (3-3.6 GHz) power amplifiers are compared in terms of building blocks design strategy. The performances, experimentally characterized in single- and two-tone conditions, are close to the state-of-the art for these applications, and confirm the validity of the bandwidth extension approach. In fact, output power of more than 43dBm and 6 dB back-off efficiency of around 40% are maintained by the bandwidth extension strategy, as well as intermodulation ratio values. Furthermore, digital baseband predistortion is successfully applied to both stages.

TU1C-3 0840 – 0900
A Compact Fully Differential Doherty Power Amplifier

S. Chen, Q. Xue, *City University of Hong Kong, Kowloon, Hong Kong*

In this paper, a compact triple-transistor fully differential Doherty power amplifier (DPA) is investigated. Three active devices are combined in a very judicious way to amplify the differential signal in a way like what a typical Doherty amplifier does. Particularly, two out-of-phase carrier PAs are applied to operate in the low-power region for high efficiency. On the other hand, only one peaking PA is used in the high-power region, which shares its output evenly with the two carriers. The reduction of transistor number from four for a classic differential DPA to three greatly cuts down the realization cost and compacts the overall circuit. Theoretical analysis is given for deep understanding of the operation principle. To demonstrate the proposed technique, a prototype is implemented based on Cree's CGH40010 GaN HEMTs. Experimental result shows that 73% and 63% drain efficiencies are achieved at peak power and 6-dB back-off point, respectively.

TU1C-4 0900 – 0920
Ultra Wide-Band, High-Power, High-Efficiency GaN Amplifier

A. K. Ezzeddine[1], A. H. Hung[2], E. Viveiros[2], H. C. Huang[1], [1]*AMCOM Communications, Inc., Gaithersburg, United States,* [2]*Army Research Laboratory, Adelphi, United States*

We report a high-performance GaN amplifier operating from 100MHz to 3,000MHz. The best results included 100W output power, 22dB gain with 40% power-added-efficiency from 100MHz to 3,000MHz. This performance is achieved by tailoring both the device impedance and by using unique wide-band circuit matching topology. Detailed design technique of both device and matching circuit will be presented.

TU1C-5 0920 – 0940
Generalized Twin-Nonlinear Two-Box Digital Predistorter for GaN Based LTE Doherty Power Amplifiers with Strong Memory Effects

O. Hammi[1], M. S. Sharawi[1], F. M. Ghannouchi[2], [1]*King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia,* [2]*University of Calgary, Calgary, Canada*

In this paper, a generalized twin-nonlinear two-box predistorter is proposed for the linearization of highly nonlinear Doherty power amplifiers exhibiting strong memory effects. The proposed predistorter is made of the cascade of a memoryless look-up table followed by a generalized memory polynomial function and thus can be seen as a two-box implementation of the generalized memory polynomial model. The generalized twin-nonlinear two-box predistorter is experimentally benchmarked against the generalized memory polynomial model. The linearization performances of both models when applied on a GaN based Doherty power amplifier driven by a 20MHz LTE signal, demonstrate the superiority of the proposed predistorter which achieves better linearity performance while requiring a lower number of coefficients. Indeed, an extra 5dB is obtained in the ACLR while the number of predistorter coefficients is reduced by more than 60%.

TU1D: Millimeter-wave and THz Techniques and Systems

Tuesday, 16 April 2013
Room: 311B
Chair: Fujiang Lin, *University of Science and Technology of China*
Co-Chair: Georg Boeck, *Technische Universtaet Berlin*

This session presents recent advances and applications in emerging millimeter-wave and THz techniques and systems. First paper proposes a new Schottky barrier diode model based on physical parameters. Second paper presents an approach of characterization of substrate material using complementary split ring resonator (CSRR). The next two papers are millimeter wave techniques and radar system for life remote measurement. Last paper in this session demonstrates the plasmonic oscillation in 2 dimensional electron gas at room temperature.

TU1D-1 0800 – 0820
Physical Based Schottky Barrier Diode Modeling for THz Applications

L. Yan[1], V. Krozer[2], R. S. Michaelsen[1], T. Djurhuus[2], T. K. Johansen[1], [1]*Technical University of Denmark, Copenhagen, Denmark,* [2]*Goethe University of Frankfurt am Main, Frankfurt , Germany*

In this work, a physical Schottky barrier diode model is presented. The model is based on physical parameters such as anode area, Ohmic contact area, doping profile from epitaxial (EPI) and substrate (SUB) layers, layer thicknesses, barrier height, specific contact resistance, and device temperature. The effects of barrier height lowering, nonlinear resistance from the EPI layer, and hot electron noise are all included for accurate characterization of the Schottky diode. To verify the diode model, measured I-V and C-V characteristics are compared with the simulation results. Due to the lack of measurement data for noise behaviors, simulated noise temperature is compared with the experimental data found from the open literature.

TU1D-2 0820 – 0840
Characterization of Substrate Material Using Complementary Split Ring Resonators at Terahertz Frequencies

X. Zhu[1], W. Hong[1], K. Wu[2,2], H. Tang[1], Z. Hao[1], H. Zhou[1], [1]*Southeast University, Nanjing, China,* [2]*École Polytechnique de Montréal, Montreal, Canada*

Abstract — This paper presents an approach of characterization of substrate material using complementary split ring resonator (CSRR). Frequency selective surfaces made from CSRR are excited with free space radiation. The dielectric properties of substrate material can be extracted from resonant frequencies and transmission loss at resonant frequencies. In order to verify the proposed method, the complex permittivity of Silicon substrate is measured from 110GHz to 180GHz by using backward-wave oscillator (BWO) spectrometers. And the measurement results show that the dielectric properties of Silicon substrate remain almost the same as that provided by semiconductor foundry at microwave frequencies.

TU1D-3 0840 – 0900
Vital Sign Detection Using 60-GHz Doppler Radar System

T. Kao, J. Lin, *University of Florida, Gainesville, United States*

Non-contact vital sign detection using 60-GHz radar offers various advantages such as higher sensitivity and smaller antennas compared to lower-frequency systems, however, the respiration amplitude comparable to wavelength causes strong non-linear phase modulation, and relatively small heartbeat amplitude results in detection difficulty. In this paper, theoretical analysis and simulation of 60-GHz detection are provided to address these issues. Both shallow and deep breathings are tested in the experiments, and the detection technique monitoring both the fundamental and second harmonic of respiration is proposed. The phenomena explained in the work can be applied to many millimeter-wave Doppler radar applications where target displacement is comparable to or larger than the wavelength to ensure robust detection.

TU1D-4 0900 – 0920
Experimental Investigation of the Effect of Clothes on the Propagation of Millimeter Waves over the Human Trunk

A. Brizzi, Y. Hao, *Queen Mary, University of London, London, United Kingdom*

Body centric wireless communications are now a well-established field of research. Most of the available work is focused on frequencies up to 12GHz, and covers various aspects concerning the communication, from signal propagation to antenna design. Recently, the interest over V and W bands has been growing, due to the presence of unlicensed portions of the spectrum, and the ever increasing availability of compact devices working at millimeter wave frequencies. The knowledge about the effects of the proximity of the human body on the communication channel at such frequencies is still extremely limited. This paper presents an investigation of the electromagnetic field propagation over the human trunk at 94GHz, also taking into account different clothes worn by the subject.

TU1D-5 0920 – 0940
THz Plasmonic Absorption in Periodically Patterned Semiconductor Ribbons

H. Zhang[1], M. Zhu[2], B. S. Rodríguez[2], H. G. Xing[2], [1]*Tsinghua University, Beijing, China,* [2]*University of Notre Dame, South Bend, United States*

In this work we provide a new outlook on plasmonic effects in periodically patterned semiconductor ribbons. Based on the classical electromagnetic theory we develop an analytical model to represent these effects and show that: 1. THz plasmons can be excited at room temperature in periodically patterned semiconductor 2DEGs (regardless of the semiconductor material); 2. its strength and frequency dependence heavily depends in the surrounding dielectric environment. Moreover, we discuss how the plasmon resonance frequency and extinction magnitude can be effectively tuned by controlling the electron concentration and pattern size, which shows great potential for THz signal modulation.

TU2A: Wireless Data and Power Transceivers for Biomedical Applications

Tuesday, 16 April 2013

Room: 311A

Chair: Minkyu Je, *Institute of Microelectronics, A*STAR*

Co-Chair: Mohammad Madihian, *MEDIWAVE*

We are observing fast growing contribution of wireless technologies to emerging biomedical devices in two major ways. One is seamless connectivity which allows the device to communicate the captured/sensed biomedical information in an untethered manner. The other is a whole new way of powering the biomedical devices through the wireless power transfer, ovbiating the need of bulky batteries and power cables. The overview of unique challenges in designing the wireless power transfer system for biomedical devices is provided in the first paper. The following two papers address new design techniques for the biomedical data transmitter which needs to be highly efficienct in terms of both the energy consumption and spectrum occupation. The last paper presents the overview of recent development in wireless body area network (WBAN) technology and its standardization, as well as the design and implementation of the energy-efficient body-channel communication transceiver which is one of three options for the WBAN physical layter realization supported by IEEE 802.15.6.

TU2A-1 1010 – 1035

Design Challenges of the Wireless Power Transfer for Medical Microsystems

T. Sun, X. Xie, Z. Wang, *Tsinghua University, Beijing, China*

In recent years, significant efforts have been made to develop the implantable applications. The increasing functions, performances, and operating time push up the power requirement of the implantable medical microsystems. This has led to the interest in the wireless power transfer (WPT) as a promise way to provide more energy. However, the WPT suffers from some problems including unsatisfied power efficiency, limited transfer distance, unpredictable reliability, thermal issues and other problems. Therefore, this paper investigate in-depth the design challenges of the wireless power transfer for medical microsystems. Both the design concerns at the primary and secondary sides are introduced in-depth. At last, this paper looks in the future and summaries several possible future challenges.

TU2A-2 1035 – 1100

Energy Efficient Transmitters for High Data Rate Biomedical Applications

C. Heng[1], Y. Gao[2], M. M. Izad[1], S. Diao[2], S. Cheng[2], Y. Zheng[2], M. Je[2,1], [1]*National University of Singapore, Singapore, Singapore,* [2]*A*STAR, Singapore, Singapore*

In this paper, we examine techniques to achieve both spectrum and energy efficient transmitters, targeting for high data rate biomedical applications. These applications benefit from asymmetric data link, where energy efficient high data rate transmitter and low data rate receiver are usually integrated. Injection locking LC oscillator and ring oscillator are employed here to achieve efficient PSK modulation. QPSK/O-QPSK/8PSK modulation with EVM of 6.4%/4.5%/3.8% have been demonstrated at data rate of 10Mbps~90Mbps with the lowest reported energy efficiency of 118pJ/bit and 17pJ/bit. Due to the architectural simplification, only active area of 0.28mm2 and 0.038mm2 are required for the transmitters.

TU2A-3 1100 – 1125

Towards a Versatile Energy-Efficient Wireless Transmitter Design for Bio-medical Applications

T. Lin, C. Lin, *National Taiwan University, Taipei, Taiwan*

This paper presents a versatile transmitter (TX) architecture. The core of this architecture is based on the phase selection (PS) operation, where the TX signal is generated by selecting proper phase to the TX output. The straightforward selection operation leads to energy-efficient data transmission. This architecture has been previously adopted in realizing energy-efficient TXs for various bio-medical applications. It has been demonstrated that these TXs can support various PSK and FSK modulations schemes and achieved good energy efficiency. In addition to highlighting some of previous works, new results of a 2.4-GHz TX that supports QAM scheme to enhance the spectral efficiency, is presented. Fabricated in a 90-nm CMOS process, the TX demonstrated an energy efficiency as low as 0.79 nJ/bit.

TU2A-4 1125 – 1150

Low Energy Wireless Body Area Network Systems

H. Yoo, J. Bae, *Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea*

As a key technology for short range communication around the human body, body area network has been recently emerged by combining medical, lifestyle, and entertainment applications. In this paper, we overview the WBAN technology and summary its status of the standardization which consists of common MAC layer and three types of physical layers (PHYs). Among three PHYs, we introduce an energy-efficient body channel communication (BCC) PHY, which uses the human body as a communication channel with equivalent circuit modeling via distributed RC circuits and theoretical channel analysis by solving the Maxwell's equations. Through the clear understanding of the body channel, we present 6 BCC transceivers, including a world-first WBAN transceiver satisfying all of the specifications for IEEE 802.15.6 standard. Finally, the MP3 player and healthcare demonstrations employing BCC transceiver are shown to verify the energy-efficiency and feasibility for wireless body area network systems.

TU3A: Control Devices

Tuesday, 16 April 2013

Room: 309AB

Chair: Jim Bao, *RF Micro Devices (Shanghai) Technology Co., Ltd.*

Co-Chair: James Hwang, *Lehigh University*

Modern radios are required to accommodate many different frequency bands. Low-loss switches, tunable filters, and other wideband active/passive components are critical to achieving frequency agility with excellent performance, low cost and compact size all at the same time. This session highlights the latest advances in MEMS switches, wideband phase shifters, tunable resonators and mixers. These advances can help overcome the technical barriers for MEMS switches and tunable filters to be commercialized, which can in turn lead to new radio architectures.

TU3A-1 1330 – 1350

Reliability of MEMS Capacitive Switches

J. C. Hwang[1], C. L. Goldsmith[2], [1]*Lehigh University, Bethlehem, United States,* [2]*MEMtronics Corporation, Richardson, United States*

This paper reviews the progress over the past decade in improving the reliability of MEMS capacitive switches. The emphasis is on mitigating the dielectric-charging problem as it currently limits the lifetime of these switches. The most critical is to distinguish charging of the dielectric surface from that of the dielectric bulk, and then mitigate them separately. Once surface charging is eliminated and bulk charging is greatly reduced, the switch lifetime can be prolonged almost indefinitely by using an intelligent closed-loop CMOS control circuit. This will facilitate the use of MEMS capacitive switches in military and commercial systems.

TU3A-2 1350 – 1410

Intrinsically Switchable Thin Film Ferroelectric Resonators Utilizing Electric Field Induced Piezoelectric Effect

S. A. Sis, V. C. Lee, S. Lee, A. Mortazawi, *University of Michigan, Ann Arbor, United States*

This paper presents bulk acoustic wave resonators using the ferroelectric materials barium titanate and barium strontium titanate. The electric field induced piezoelectric effect in these materials is utilized in the design of various types of intrinsically switchable bulk acoustic wave resonators. Both thickness mode and lateral mode resonator results, which have been demonstrated recently, are summarized in this paper. Significantly improved quality factors by means of forming a ferroelectric-on-silicon structure are also demonstrated

TU3A-3 1410 – 1430

A Novel Spur Stepped Impedance Resonator

P. Chu[1], W. Hong[1], K. Wu[2,1], [1]*Southeast University, Nanjing, China,* [2]*École Polytechnique de Montréal, Montreal, Canada*

This paper propose a novel Spur Stepped Impedance Resonator (SSIR). Developed from the classical Stepped Impedance Resonator (SIR) without additional or complicated circuit occupying, almost keeping the same compact size and quality factor, the SSIR has tunable spurious resonances while keeping fundamental resonance frequency almost unchanged, and a tapped SSIR will produce tunable transmission zeros without interfering with the fundamental resonance or the loaded quality. A simple demo application of SSIR on designing bandpass filter with extended stopband is proposed, fabricated and measured.

TU3A-4 1430 – 1450

16-GHz mHEMT Double-Quadrature Gilbert Down-Conversion Mixer with Polyphase Filters

Y. Hsiao[1], C. Meng[1], J. Su[1], S. Yu[1], G. Huang[2], [1]*National Chiao Tung University, Hsinchu, Taiwan,* [2]*National Nano Device Laboratories, Hsinchu, Taiwan*

A 16-GHz double-quadrature Gilbert down-conversion mixer with polyphase filters is demonstrated using 0.15-μm metamorphic high electron mobility transistor (mHEMT) technology. Due to the hgih cut-off frequency of mHEMT device, the image rejection Gilbert mixer has better power performance and works at high frequencies. The polyphase filters at RF and LO stages are employed to generate precise differential quadrature signals in the double quarture configuration while a four-stage polyphase filter of the IF stage filters out the unwanted image signal. A 32-dB image rejection ratio is achieved when RF and LO frequencies are designed around 16 GHz and an IF frequency is 32 MHz. The double-quadrature Gilbert down-converter has 1.7-dB conversion gain, -5-dBm IP1dB , and 5-dBm IIP3. The die size is 3.0 mm × 3.2 mm.

TU3A-5 1450 – 1510

A 10-200 MHz 360° Vector-Sum Phase Shifter using COTS Components for Wideband Phased Array Systems

W. Lim, X. Tang, K. Mouthaan, *National University of Singapore, Singapore, Singapore*

A 10-200 MHz wideband 360° phase control vector-sum phase shifter (VSPS) is presented. Broadband VSPS are commonly implemented in IC technologies for microwave frequencies. By using commercial-off-the-shelf (COTS) discrete components on PCB, a wideband VSPS design is proposed and experimentally demonstrated. An RMS phase error of less than 1.5°, input return loss larger than 15 dB and amplitude imbalance less than 1 dB are measured from 10 to 100 MHz. An RMS phase error of about 5°, a return loss around 10 dB and amplitude imbalance less than 2.5 dB are measured from 10 to 200 MHz. The board dimension is 8.4cm x 7.8cm.

TU3B: Emerging Wireless Devices, Techniques and Systems

Tuesday, 16 April 2013

Room: 310

Chair: Minkyu Je, *Institute of Microelectronics, A*STAR*

Co-Chair: Mohammad Madihian, *Mediwave*

New emerging devices, design techniques, and system concepts will open the door to the next-generation wireless technologies and solutions. This session presents an inkjet-printed silver nanoparticle technology for the RF/microwave microstrip structures, an isotropic three-dimensional composite right/left-handed metamaterial structure, an analytical current transport model of a graphene nanoribbon tunnel field effect transistor, a modified DC X-parameter model for nonlinear RF/microwave circuit designs, and an X-band miniature synthetic aperture radar system.

TU3B-1 1330 – 1350

Assessment of silver nanoparticle inkjet-printed microstrip lines for RF and microwave applications

V. Camarchia[1,2], A. Chiolerio[2], M. Cotto[3], J. Fang[1], G. Ghione[1], P. Pandolfi[3], M. Pirola[1], R. Quaglia[1], C. Ramella[1], [1]*Politecnico di Torino, Torino, Italy,* [2]*Istituto Italiano di Tecnologia, Torino, Italy,* [3]*Politronica Inkjet Printing S.r.l., Torino, Italy*

The paper describes the fabrication process, the technology assessment and the experimental characterization of silver nanoparticle inkjet-printed microstrip structures on allumina substrates for RF and microwave applications. The present technology allows, through the adoption of innovative silver-based inks and a special piezoelectric-inkjet printer, the direct printing of microstrip prototypes on alumina substrates. The electrical characteristics of the manufactured strips have been modeled, starting from measured data, and several samples of line-stub impedance matching sections have been realized and measured to verify the repeatability of the line characteristic and printing alignment accuracy. More complex structures, including soldered components and ground wrap-around connection, have been realized and tested, showing good agreement between simulations and measurements

TU3B-2 1350 – 1410

Isotropic 3-D Cubic CRLH Metamaterials Using Dielectric Resonators and Metallic Jungle Gym Structure

Y. Sato[1], T. Ueda[1], Y. Kado[1], T. Itoh[2], [1]*Kyoto Institute of Technology, Kyoto, Japan,* [2]*University of California at Los Angeles, Los Angeles, United States*

Isotropic three-dimensional composite right/ left handed (CRLH) metamaterial structure is proposed and designed. It is composed of conductive jungle gym structure and dielectric spheres with high dielectric constant. By adjusting the configuration parameters appropriately, balanced CRLH transmission structures are designed in the numerical simulation. The numerical results show that the wavenumber vector of the designed structures provides almost isotropic characteristics in a specific frequency region in the vicinity of Gamma point.

TU3B-3 1410 – 1430

Current Transport in Graphene Tunnel Field Effect Transistor for RF Integrated Circuits

M. S. Fahad[1], A. Srivastava[1], A. K. Sharma[2], C. Mayberry[2], [1]*Louisiana State University, Baton Rouge, United States,* [2]*Air Force Research Laboratory, Albuquerque, United States*

In this work, an analytical current transport model of a Graphene Nanoribbon (GNR) Tunnel Field Effect Transistor (T-FET) is presented considering drain source voltage (VDS), gate source voltage (VGS), carrier mobility (μ) and top gate dielectric (tOX). For a GNR width of 5nm at 0.275eV band gap, ON current of 1605 μA/μm is calculated with a very high ON/OFF current ratio of 10^7. Subthreshold slope of 7.07mV/decade is calculated from I-VGS transfer characteristics. Current saturation is observed for input voltage, VGS of 0.28V and beyond for varying VDS values. Performance of the proposed model is compared with the earlier published work and the projected ITRS2011 MOSFET requirements and it is found that considering proper device geometry and input voltages, GNRT-FET can demonstrate seven times lower power dissipation and eight times higher intrinsic speed in the upper GHz range than in conventional CMOS technology.

TU3B-4 1430 – 1450

Compact Behavioral Description for Generalized Loads using a Modified DC X-Parameter Model

J. Cai, T. J. Brazil, *University College Dublin, Dublin, Ireland*

A modified DC X-parameter model is presented. The model gives much better accuracy than a basic 50 Ω DC X-model. Compared with a full load-pull DC X-model, the presented model not only greatly decreases the model's file-size, but also provides comparably good accuracy. The optimization of the model is also presented, and based on this method both the model extraction time and the file-size are further improved.

TU3C: Novel Transceivers for Radars and Location Identification

Tuesday, 16 April 2013
Room: 311A
Chair: Zhangcheng Hao, *Southeast University*
Co-Chair: Mohammad Madihian, *MEDIWAVE*

This session focuses on novel techniques used in transceivers for radars and location identification. One paper describes a joint radar-radio transceiver for intelligent transportation platforms. Another paper focuses on the use of Doppler radar for small scale displacement measurements. The other papers address the use of low-IF heterodyne architecture in vital sign detection as well as a reconfigurable multiband RF receiver for compass and GPS applications.

TU3C-1 1330 – 1350
Improved Joint Radar-Radio (RadCom) Transceiver for Future Intelligent Transportation Platforms and Highly Mobile High-Speed Communication Systems
J. Moghaddasi, K. Wu, *École Polytechnique de Montréal, Montreal, Canada*
A mulitfunctional transceiver for integrated radar sensing and radio communication (or simply termed RadCom) systems is developed in the time domain. It is a robust alternative of the previous architecture for a smart system that operates jointly as radar or radio in consecutive time slots. Following a system design approach, a low-frequency prototype of the proposed transcevier is realized and its performance is evaluated. Within the radar mode, the added ability of target detection as well as improved range resolution against the previously demonstrated version makes the system suitble for driving assistance applications. Within the radio mode, it has proved a great capability of communication at a data rate of 25Mbps.

TU3C-2 1350 – 1410
Small-Scale Displacement Measurement with Passive Harmonic RF Tag Using Doppler Radar
X. Gao, A. Singh, O. Boric-Lubecke, V. M. Lubecke, *University of Hawaii , Honolulu, United States*
Measurement accuracy of the displacement from human cardiopulmonary activities has potential in predicting physiological information for the purpose of biomedical remote sensing and non-contact monitoring. In this paper, an RF frequency doubling tag was used for detecting small displacement with high accuracy. A heterodyne and a homodyne quadrature radar receiving systems were used to detect small scale tag motion and non-tagged motion from a distance, respectively. Arctangent demodulation algorithm and imbalance compensation technique were applied to the raw radar data for displacement estimation. Simulation and experimental results were compared, indicating that by using the frequency doubling tag, a better accuracy can be achieved for small displacement estimation with Doppler radar.

TU3C-3 1410 – 1430
A Configurable Compass/GPS Multiband RF Receiver
Z. Zhang, W. Li, W. Wen, X. Hou, D. Zhang, *Beijing Microelectronics Technology Institute, Beijing, China*
A configurable Compass/GPS multiband GNSS RF receiver with wide bandwidth in a heterodyne radio topology is implemented in a 0.35um SiGe BiCMOS process. By programming the synthesizer to generate different local oscillator (LO) signals, the proposed receiver downconverts GNSS signals in L1/B1/B2/B3 bands to an identical intermediate frequency (IF) of 46MHz. An automatic gain control (AGC) loop is adopted to improve the noise and anti-interference performance. The receiver achieves a total noise figure of less than 3.5dB and a maximum voltage gain of 112dB with 70dB dynamic range while consuming 32mA current from a 3.3V supply, with a die area of 3.5x3.8mm^2 including ESD protection pads.

TU3C-4 1430 – 1450
An Experimental Vital Signs Detection Radar using Low-IF Heterodyne Architecture and Single-Sideband Transmission
B. S. Jensen, T. K. Johansen, L. Yan, *Technical University of Denmark, Kgs. Lyngby, Denmark*
In this paper an experimental X-band radar system, called DTU-VISDAM, developed for the detection and monitoring of human vital signs is described. The DTU-VISDAM radar exploits a low intermediate frequency (IF) heterodyne RF front-end architecture and single-sideband (SSB) transmission for easier and more reliable extraction of the vital signs. The hardware implementation of the proposed low-IF RF front-end architecture and associated IF circuitry is discussed. Furthermore, the signal processing and calibration steps necessary to extract the vital signs information measured on a human subject are described.

TU3D: Antennas for Wireless Communications

Tuesday, 16 April 2013
Room: 311B
Chair: Kwai-Man Luk, *City University of Hong Kong*
Co-Chair: Qing-Xin Chu, *South China University of Technology*

In this session, antennas for wireless communications are focused, including miniaturized dual-band antenna using composite right/left-handed transmission lines for MICS and ISM applications, dual-band printed slot diversity antennas for wireless communication terminals, and system level performance of energy efficient dynamic mechanical antenna tilt angle switching in LTE-advanced systems.

TU3D-2 1330 – 1350
A Dual-Band Printed Slot Diversity Antenna for Wireless Communication Terminals
Y. Wu[1], Q. Chu[1], S. Yao[2], [1]*South China University of Technology, Guangzhou, China,* [2]*Shenzhen Power Supply Co., LTD, Shenzhen, China*
A dual-band printed slot antenna for wireless communication terminals is presented. It consists of two pairs of C-shaped slot and T-shaped slot and six pairs of slit. The C- shaped slots are fed by two 50-Ω microstrip lines. The antenna can provide two wide operating bands centered at 2.50GHz and 3.66GHz, to cover WLAN/2.5-GHz and the 3.5-GHz WiMAX bands respectively. The isolation of the prototype are less than -20dB and -25dB across the above bandwidth in turn, while six pairs of slits play an important role in reducing mutual coupling. Good performances of proposed antenna over the operating bands are also obtained. The discussion shows that the antenna can be considered as a good candidate for multiple input multiple output (MIMO) systems.

TU3D-3 1350 – 1410
A New Wideband Single-Fed Circularly Polarized Antenna
M. LI, K. Luk, *City University of Hong Kong, Hong Kong, Hong Kong*
A novel wideband single-fed circularly polarized antenna is designed based on crossed magneto-electric dipoles. By adjusting the shapes and dimensions of the crossed electric dipoles and magnetic dipoles carefully, circularly polarized radiation can be inspired across a wide operation band. Measurements on an antenna prototype reveal that the proposed design achieves a wide impedance bandwidth of 73.3% for SWR≤2 and 46.6% for SWR≤1.5. A 3-dB axial ratio bandwidth of 47.7% and a gain of 6.8±1.8dBi are covered by the SWR≤1.5 band. Moreover, radiation patterns exhibit good unidirectional radiation characteristic over the whole operating frequency band.

TU3D-4 1410 – 1430
System Level Performance of Energy Efficient Dynamic Mechanical Antenna Tilt Angle Switching in LTE-Advanced Systems
Y. Gao[1,2], Y. Li[1], S. Zhou[1], Y. Li[1], H. Yu[2], [1]*Tsinghua University, Beijing, China,* [2]*Information Engineering Institute, Zhengzhou, China*
Energy consumption in current cellular commu-nication systems becomes more and more critical with the demand for higher throughput and explosive growth of terminal equipment. However, the consumption is evitable in low traffic load time or area, e.g. in late-night. In order to reduce system energy consumption, power off low load base stations is an easy and effective way to reduce energy consumption, but lead to the problem of damaging the coverage performance. In this paper, we studied the effect of adjusting mechanical tilt angle and transmit power of base stations in an ergodic way after shut down adjacent idle base stations. Compared with traditional shutdown method, the changing of mechanical tilt and transmit power jointly can effectively help maintain coverage and lower system power consumption. Evaluation has been done under the LTE-Advanced system level simulation.

TU3D-5 1430 – 1450
Design and Evaluation of Dual-Band Antennas Aimed for Contactless Health Monitoring Radar
G. Pandey[1], P. Soh[1,2], M. Mercuri[1], G. A. Vandenbosch[1], D. Schreurs[1], [1]*Katholieke Universiteit Leuven, Leuven, Belgium,* [2]*Universiti Malaysia Perlis , Kuala Perlis, Malaysia*
This paper presents the evaluation of two antenna designs aimed for a Step Frequency Continuous Wave (SFCW) radar capable of non-invasive fall detection in a pseudo-static radar configuration. The performance of a dual-band rectangular planar monopole is compared against a conductor-backed coplanar waveguide (CBCPW) fed bow-tie slot antenna in free space. Two elements of the better performing CBCPW fed bow-tie antenna are then combined, separated by a metal plate, and evaluated on the level of SFCW radar operation. It is shown that the performance of the novel CBCPW fed bow-tie slot antenna is superior compared to the rectangular planar monopole antenna in terms of person scanning capability.

Tuesday, 16 April 2013
Room: 306AB
Interactive Forum I: Wireless Device, Circuit, and System Components
Chair: Fujiang Lin, *USTC*

P1-1
Electrical Modeling of Multi-Walled Carbon Nanotube (MWCNT)-Based Capacitors for High-Density RF Integration
W. Zhao[1], W. Yin[1], Y. Guo[2], [1]*Zhejiang University, Hangzhou, China,* [2]*National University of Singapore, Singapore, Singapore*
Modeling of multi-walled carbon nanotube (MWCNT)-based capacitors is performed in this paper. Their equivalent circuit model is modified with the impacts of quantum capacitance as well as kinetic inductance treated in an appropriate manner. Further, both effective capacitance and quality factor of the MWCNT-based capacitors are predicted even at ultra-high frequencies, and their self-resonance frequencies are also captured successfully.

P1-2
Optically Transparent and Flexible Graphene Planar Microwave Structures
N. Chamanara, D. Sounas, C. Caloz, *Ecole Polytechnique de Montréal, Montreal, Canada*
The sheet resistance of graphene has been recently reduced below the level of previous optically transparent conductive materials. With its additional advantage of mechanical flexibility and low cost, graphene is one of the best candidates for future transparent electronics. We investigate here the possibility of using graphene for transparent and flexible microwave structures. Specifically, we study the waveguiding and nonreciprocal properties of various planar microwave transmission lines, using the 2D finite difference frequency domain (FDFD) technique. It is shown that reciprocal graphene based structures of acceptably low loss levels are achievable using graphene sheets of the lowest available resistivity, on the other hand graphene based non-reciprocal structures are accompanied by prohibitive loss due to a fundamental trade-off between nonreciprocity and carrier density in graphene.

P1-4
Signal and Power Integrity Analysis for the Novel Power Plane of EBG Structure in High-Speed Mixed Signal Systems
H. Zhu, J. Mao, J. Li, *Shanghai Jiao Tong University, Shanghai, China*
In this paper, a novel power plane of electromagnetic bandgap (EBG) structure for wideband mitigation of simultaneous switching noise (SSN) in mixed signal systems is proposed. Complementary split ring resonator (CSRR) with inherent filtering characteristic is utilized for constituting EBG unit cells. From the simulated and measured results of the proposed EBG structure, a wideband suppression of SSN ranges from 0.56 GHz to 5.88 GHz is achieved with a high mitigation level of -40 dB. Furthermore, the influence of the proposed power plane of EBG structure on the signal integrity (SI) is investigated in the time and frequency domains, respectively. The results show that the SI performance can be improved significantly by using differential pairs for the signals.

P1-5
Wideband Out-of-Phase SIW Power Divider with Enhanced Stopband
K. Song, Y. Mo, S. Hu, Y. Fan, N. Chen, *University of Electronic Science and Technology of China, Chengdu, China*
A wideband multi-way out-of-phase substrate integrated waveguide (SIW) power divider with improved rejection band by using novel hybrid multiple-via probe and multiple radial slots has been presented in this letter. The novel hybrid multiple-via probe and multiple radial slots are employed to achieve wideband and improved rejection band respectively. An eight-way out-of-phase SIW power divider is designed, fabricated, and measured. Good agreement between simulated and measured results is obtained in the desirable frequency range. The measured average insertion loss of the eight-way power divider is approximately 9.3dB and return loss is greater than 15 dB from 3.5GHz to 8 GHz, as well as an rejection band with more than 25 dB attenuation from 9 GHz to 11.2 GHz . A maximum amplitude imbalance of ±0.3 dB and phase imbalance of ±3° are observed over the entire operating frequency range.

P1-6
Time Domain Analysis of Transmission Line Based on WLP-FDTD
Y. Li, X. Li, J. Mao, *Shanghai Jiao Tong University, Shanghai, China*
In this paper, a novel solution based on weighted Laguerre polynomials finite-difference time domain (WLP-FDTD) method is proposed for time domain analysis of interconnect modeled as a transmission line.Compared with finite-difference time-domain (FDTD)method, which is an explicit scheme and limited by Courant condition, the WLP-FDTD method is unconditionally stable since the solution is implicit. Numerical results show that the proposed WLP-FDTD solution is as accurate as but much faster than conventional FDTD-based solutions.

P1-7
Status and Design Challenges of Passive 60 GHz Bandpass Filters in Standard CMOS
K. Mouthaan, X. Lu, F. Hu, Z. Hu, A. Taslimi, *National University of Singapore, Singapore, Singapore*
A review of recently published 60 GHz passive bandpass filters in standard CMOS is presented. With data extracted from the reported measurement results of 28 filters, a comparison table and a set of figures are provided and discussed. The provided data may help designers to access the relative merits of their future designs. Potential future directions and design challenges for 60 GHz passive filters in CMOS are also identified.

P1-8
Tunable Dual-Band Bandpass Filter Using Varactor-Loaded Short-Ended Resonators
L. Gao, X. Y. Zhang, B. J. Hu, *South China University of Technology, Guangzhou, China*
A novel planar tunable bandpass filter using the centrally-loaded short-ended resonator is presented in this paper. Characterized by theoretical analysis, the proposed structure is founded to have the advantage that the fundamental frequency can be tuned while the second harmonic remains almost unchanged. By controlling the voltage, the lower passband can be tuned in a wide frequency range. To demonstrate the purposed idea, a dual-band bandpass filter is implemented with the tunable lower passband and fixed upper passband. The experimental results are presented to verify the proposed method

P1-9
Compact LTCC Bandpass Filters Using Vertically Folded Half Wavelength Resonator
C. Shao, H. Tang, L. Zhou, J. Chen, *Nantong University, Nan Tong, China*
In this paper, a pair of novel compact low temperature co-fired ceramic (LTCC) bandpass filters (BPFs) based on transmission line theory are proposed. The employed half wavelength (λg/2) resonator has been vertically folded to form a multi-layer transmission line resonator for minimizing the circuit size significantly. Since there is a virtual ground in the symmetrical plane of the multi-layer resonator, the characteristic of the resonator keeps almost unchanged. Transmission zeros have been realized near to the passband and in the stopband, which improve the selectivity and harmonic rejection of the BPFs. For demonstration, two BPFs centered at 3.1GHz and 10GHz are designed using the proposed resonator, and the circuit sizes are 5.1×3.9×1.8 mm3 and 4.0×3.9×1.5 mm3.

P1-10
Packaging Method for Metamaterial Based Microwave Devices
F. Ghezzo, Z. Zhao, R. Liu, *Kuang-Chi Institute of Advanced Technology, Shenzhen, China*
we describe the fabrication method used for packaging a 15cm x 15cm x 3cm polymer based beam splitter, a metamaterial device designed for operating at 17GHz. An injection molding technique was used to allow a low viscosity resin, curing at room temperature, to package ten FR4 substrate layers with metamaterial patterns on them. The metamaterial structures were designed and their distribution optimized on each layer in order to achieve the effect of splitting in two parts an electromagnetic wave impinging on the face of the component. A low dielectric and low loss epoxy resin for casting and suitable for packaging was selected as the injection polymer. The design of the electromagnetic behavior of the component took into consideration the full integration of the FR4 substrates into the polymeric host material. The measurements performed to verify the performance of the as-fabricated prototype device are presented and the results are discussed in this manuscript.

P1-11
Application of Neural Networks to Spurious Mode Modeling in the Design of Multiplexing Networks
S. Li[1,2], Y. Wang[1], J. A. Jesuthasan[1], M. Yu[2], [1]*University of Ontario Institute of Technology, Oshawa, Canada,* [2]*COM DEV Ltd., Cambridge , Canada*
A method of modeling spurious mode for microwave multiplexer design is presented. It is proved that the channel filter can be simplified to have the minimum structural features, yet still capable of modeling the effect of spurious mode accurately, which facilitates the application of neural networks in the multiplexer design. Model simplification and neural model development are detailed. The method enables fast and accurate simulation of the spurious mode over wide frequency range. Excellent agreements are observed between the results obtained from EM simulations and from the developed models.

P1-12
Design of Dual-band Bandstop Filter with Low Frequency Ratio
J. Qiu, F. Chen, Q. Chu, *South China University of Technology, Guangzhou, China*
This paper presents a dual-band bandstop filter by using stub-loaded resonators. The frequencies of the two stopbands are 1.6G and 2.4G, respectively, with the frequency ratio of 1.5. Several zero points are introduced, which significantly improve the skirt selectivity. The frequency ratio can be flexibly designed, and the fractional bandwidths of each stopband can be controlled conveniently. Moreover, high attenuation is achieved in both stopbands.

P1-13
An Ultra-Wideband (UWB) Bandpass Filter with Microstrip-to-CPW Transition and a Notch-Band
H. Zhu[1], S. Wong[1], S. Wen[2], Q. Chu[1], [1]*South China University of Technology, Guangzhou, China,* [2]*Nanyang Technological University, Singapore, Singapore*
An ultra-wideband (UWB) bandpass filter is proposed in this paper. The proposed structure composes of two pairs of microstrip short-circuited stubs which provide a microstrip-to-CPW transition, and a CPW resonator whose length is about half-guided-wavelength (λg/2) at 6.85GHz. A triple-mode UWB bandpass filter is produced using this microstrip-to-CPW transition structure. In order to suppress WLAN signals around 5.2/5.8GHz, a novel via-stub-loaded structure is designed. By adding this via-stub-loaded structure, a bandstop characteristic is formed as a notch-band whose position and bandwidth could be tuned easily. Simulation results indicate that the reflection loss is lower than -15dB in desired passband, and it also achieves a good performance of the notch-band around 5.2/5.8GHz. Finally, the proposed UWB bandpass filter is fabricated and measured. The measured results are in good agreement with simulated ones.

P1-14
Ultra-Wideband (UWB) Bandpass Filter with Three Transmission Zeros in the Notched Band
S. Wong, W. Liao, K. Wang, Q. Chu, *South China University of Technology, Guangzhou, China*
A compact ultra-wideband (UWB) bandpass filter (BPF) with three transmission zeros in the notched-band is presented in this paper. A dual coupled microstrip/coplanar waveguide (CPW) structure with slot-lines on the bottom are used. The notched-band is generated by a pair of small U-shaped slot-line on the bottom layer and a hollow microstrip resonator on the top layer, and three transmission zeros are achieved at frequency 5.85GHz, 5.9GHz, 5.95GHz without extra circuit size. The UWB bandpass filter (BPF) has been designed, fabricated and measured. The measured results agree with the simulated result closely.

P1-15
A Reconfigurable, Liquid-Metal-Based Low-Pass Filter with Reversible Tuning
W. G. Tonaki, W. Hu, A. T. Ohta, *W. A. Shiroma, University of Hawaii, Honolulu, United States*
A reconfigurable low-pass filter that uses reversibly actuated liquid metal as the tuning mechanism is demonstrated. Reversible tuning of up to eight cutoff frequencies is achieved by filling and evacuating the defected ground structure lattices with Galinstan liquid metal. Measurements of four of the cutoff frequencies show a 59% tuning range.

P1-16
Novel 4 Loops Coupler in Microwave Cavity Measurement of Permittivity
H. Zhang, B. Zeng, L. Ao, N. Li, Y. Fang, J. Guo, J. Han, *University of Electronic Science and Technology of China, Chengdu, China*
Electromagnetic coupling effects on a novel loop coupler in a TE011 circular cavity are studied theoretically and experimentally. This novel 4 loops coupler is developed for avoiding and suppressing the spurious modes in the TE011 circular cavity of the microwave permittivity measurement system. The operating principles and impedance of the novel 4 loops coupler are investigated. This method has the advantage of simple setting of the apparatus and fast tuning of the system. The experimental results are compliant with simulations.

P1-17
Dual-Band BandPass Filters Using SIRs with Open-Stub Line and Zero-Degree Feed Structure
Z. Xia[1,2], F. Liu[1], [1]*University of Science and Technology of China, Hefei, China,* [2]*Southwest University of Science and Technology, Mianyang, China*
A novel compact dual-band bandpass filter (DBPF) using SIRs with open-stub line and 0-degree feed structure is presented in this paper. The low-band is obtained by using hairpin type Stepped Impedance Resonators (SIR) split ring through electrical coupling And by tuning a pair of open-stub lines the high-band is realized too. In order to improve the stop band attenuation, zero-degree feed structure is implemented to introduce three transmission zeros. So the proposed DBPF has high selectivity, and is also simple in design and compact in structure. Finally the proposed filter is designed and fabricated, and the simulation and test results are in good agreement.

P1-18
Research on Picosecond EMP Suppression Filter
B. Yuan, Y. Gao, T. Peng, P. Zhu, *Shanghai Jiao Tong University, Shanghai, China*
Picosecond EMPs'bandwidth and energy energy spread in a wide microwave spectrum may increase exponentially as pulse-width decreasing under 100ps.Thus picoseconds EMPs could have potential interference on other devices. Usually, using a narrowband filter is a useful method for their suppression. However, due to the existence of their inherently parasitic pass-bands, the traditional microwave narrowband filters, when applied to picosecond EMPs' condition, lost their traits of narrowband.In this paper, we present the relationship between pulse-width and bandwidth, and that between pulse-width and ratio of energy spread in the microwave spectrum to whole energy, which give a practical guidance for suppression filter design. Also, a special high-pass passive device is designed to improve the traditional waveguide filter. The improved filter is easy to implement and experimentally validated to effectively attenuate undesired signals'amplitudes by -20dB in every parasitic pass-band.

P1-19
Fully Tunable Filter Design using Tunable Transformers and Multiple Mode Resonators
J. Mao[1,2], W. Che[1,3], W. Choi[2], K. Tam[2], Q. Xue[3], [1]*Nanjing University of Science and Technology, Nanjing, China,* [2]*University of Macau, Macau, China,* [3]*City University of Hong Kong, Hong Kong, China*
A fully tunable bandpass filter using tunable transformers and multiple mode resonators (MMRs) is proposed. The proposed tunable MMR makes it possible to realize wide-band tunable filters. Thus the tuning ranges of the center frequency and bandwidth are wide. The novel tunable transformer may help to get the desired external quality factor (Qe) while the center frequency or bandwidth is tuned. Thus a good passband performance may be got.

P1-20
Generation-Recombination Traps in AlGaN/GaN HEMT Analyzed by Time-Domain and Frequency-Domain Measurements: Impact of HTRB Stress on Short Term and Long Term Memory Effects
J. Tartarin[1,2], G. Astre[2], S. Karboyan[2], T. Noutsa[2], B. Lambert[3], [1]*Université de Toulouse, Toulouse, France,* [2]*CNRS, Toulouse, France,* [3]*United Monolithic Semiconductor, Villebon sur Yvette, France*
Wide bandgap GaN technology has emerged as a major actor among technologies devoted to high frequency, high power applications. However, GaN based transistors are still largely sensitive to damaging effects induced by interface or surface charges, generally assigned to charge processes induced by spontaneous and piezoelectric effects. This paper presents recent works in the field of reliability on AlGaN/GaN HEMT (High Electron Mobility Transistor), and is focused on the identification and location of activated defects using both pulsed electrical signatures (time domain meas.) and low frequency noise spectra (frequency domain meas.). These sets of measurements partially correlate and give evidence of short term as well as long term memory effects. High thermal reverse bias (HTRB) stress has been applied to a set of devices, and the evolutions of the transistors' electrical and low frequency noise signatures are investigated.

P1-22
Codebook Design and Link Level Performance of Closed-Loop 4x2 MIMO in HSDPA
T. Hiltunen[1,3], M. Lampinen[2], M. Valkama[3], [1]*Magister Solutions Ltd., Jyväskylä, Finland,* [2]*Renesas Mobile Corporation, Oulu, Finland,* [3]*Tampere University of Technology, Tampere, Finland*
The feedback quantization has a considerable impact on the performance of precoded four branch High Speed Downlink Packet Access (HSDPA) MIMO. With more transmit antennas, efficient quantization scheme is more important and more quantization loss needs to be tolerated. In this paper, the performance of four branch dual-codeword single-user MIMO is evaluated assuming two different types of compact codebooks. First of the studied codebooks is similar to the 4-Tx codebook used in Long Term Evolution (LTE) system and the second is a novel multi-granular codebook. An extension to the multi-granular codebook is also proposed. Simulation results are presented assuming cross-polarized antennas. The link performance is compared to Release 7 2x2 MIMO and 4x2 MIMO with unquantized feedback. The studies show throughput gains up to 66 % for the LTE codebook and up to 79 % for the multi-granular codebook compared to the 2x2 MIMO. The relative gains are highest at low geometries.

P1-23
A New Family of Low Correlation Zone Sequences in QS-CDMA Communication Systems
J. J. He[1], Q. Zeng[2], [1]*Carleton University, Ottawa, Canada,* [2]*Communications Research Centre Canada, Ottawa, Canada*
The paper addresses the problem of constructing signature sequences for quasi-synchronous CDMA systems. We employ two $\ell-ary$ sequences, i.e. ℓ symbols sequences, with ideal two-level autocorrelation and a Costas or Golomn Costas sequence to construct a signal set with long Low Correlation Zone length and low maximum magnitude of correlation values. We obtain an Low Correlation Zone (Np, p,p,N) signal set and an Low Autocorrelation Zone $(Np,p,p,1)$ signal set, where N is a positive integer and p is a prime number. We also get an LCZ $(p^m(p^m-1), p^m, p^m-1, p^m)$ signal set and an LACZ $(p^m(p^m-1), p^m, p^m-1, 1)$ signal set, where m is a positive integer.

P1-24
Wireless MIMO Systems Employing Joint Turbo-Like STBC Codes With Bit-Level Algebraically-Interleaved URSCs
F. Mehran[1], R. Maunder[2], [1]*University of Birmingham, Birmingham, United Kingdom,* [2]*University of Southampton, Southampton, United Kingdom*
In this paper, permutations constructed based on algebraic derivations which are of particular interests due to better error-rate performance as well as simpler and practical hardware implementations, have been used in designing high performance fully-systematic joint space-time turbo coding technology. This scheme enjoys the integration of twin-/triplet-antenna bit-level space-time (ST) codes with the binary turbo-like codes of unpunctured codecs. The conducted performance evaluations reveal that this scheme has superior flare performance and yields additional coding gains in waterfall region, compared with the row-column block interleaved systems.

P1-25
Submillimeter Diode on Single Barrier Nanostructure
N. M. Goncharuk, *Research Institute "Orion", Kiev, Ukraine*
Microwave diode on AlGaAs/GaAs single barrier nanostructure with electron tunnel injection through AlGaAs potential barrier and electron drift in GaAs transit layer is investigated in the framework of small-signal theory taking into account diode parasitic resistance. We consider both transit and injection time of electron since they are comparable and determine operating frequency of the diode. Calculated values of maximal negative conductance are near 200mS and 30mS for the diodes with operating frequencies 270GHz to 880GHz, respectively.

P1-26
Accuracy-Controlled Convergence Criterion for Full Wave Simulation
W. Ding, G. Wang, X. Chen, *Wuhan University, Wuhan, China*
Full wave electromagnetic (EM) simulations frequently encounter low-frequency breakdown: for decoupling of electric and magnetic fields in low frequency, the impedance matrix degenerates into near singular matrix and causes convergence problems. For absence of constraint between simulation accuracy and the convergence condition for iterative solver, excessively rigorous convergence condition were applied to ensure simulation accuracy, as a result, this way leads to over convergence, i.e., converge at unnecessarily high accuracy and simulation time doubly increases. By theoretically analyzing the impedance matrix, connection between simulation accuracy and the relative residual error is established, and an accuracy-controlled convergence criterion is proposed. Numerical experiments are included to demonstrate that this convergence criterion effectively avoids the occurrence of over convergence yet insures simulation accuracy; therefore the simulation efficiency is visibly promoted.

P1-27
Iterative Robust Beamformer with an Estimation of Uncertainty Level
T. Zhang, L. Sun, *University of Science and Technology of China, Hefei, China*
In this paper, a new design of the robust adpti-ve beamformer (RAB) is developed to overcome the increased computation cost of the traditional RABs. This approach in-troduces a suboptimal of the distance between the actual arr-ay steering vector (ASV) the presumed ASV in tandem with the iterative doubly constrained robust capon beamformer using fixed uncertainty level (Fu-IDCRCB). Then, the unce-rtainty level of the first iteration is updated by the optimal distance and then the estimated ASV of the first step is in the vicinity of the actual ASV. As a result, the coherent iterations are needed to search the actual ASV with smaller uncertainty set. Hence, this method convergences faster than the other beamfomers (BFs) and the simulation results shown that the effectiveness of the proposed BF.

TU4A: Emerging Wireless Devices and Design Techniques
Tuesday 16 April 2013
Room: 311A
Chair: Minkyu Je, *Institute of Microelectronics, A*STAR*
Co-Chair: Mohammad Madihian, *MEDIWAVE*

The next-generation wireless technologies request new devices and design techniques. This session presents an interesting mixture of recent development in emerging devices and their modeling, as well as advanced design techniques. We begin the seesion with the introduction of latest achievement in high-power THz sources based on nonlinear optical effects. The following paper reviews the recent development in the modeling framework of multi-gate MOSFETs which are becoming new mainstream manufacturing technologies providing a new platform for RF integration in advanced SOCs. Latest advances in power amplifier designs for both basestation and handset applications are covered by the last two papers of the session.

TU4A-1 1540 – 1605
Nonlinear Optical THz sources and Applications
K. Kawase[1,2], S. Fan[1], S. Hayashi[2,1], [1]*Nagoya University, Nagoya, Japan,* [2]*RIKEN, Sendai, Japan*
Among our research activities for high power THz sources, we can mention: Injection-seeded THz parametric generator (is-TPG); Cherenkov type phase matched optical rectification using LiNbO3 ridge waveguide, and collinear phase matched optical rectification using DAST crystal, etc. Recently, we have succeeded in the development of a high-peak-power, single-longitudinal-mode and widely-tunable is-TPG using LiNbO3 pumped by an amplified microchip Nd:YAG laser. The THz-wave output 1kW was assured by a calibrated pyroelectric detector. We also succeeded in a highly sensitive detection of THz-waves emitted from is-TPG using LiNbO3 as a detector.

TU4A-2 1605 – 1630
Compact Modeling of Multi-Gate MOSFETs for RF Designs
Q. Chen, *Agilent Technologies, Inc., Santa Clara, United States*
Multi-gate MOSFETs (MuGFETs) such as FinFET, tri-gate, and ETSOI MOSFETs are becoming the new mainstream manufacturing technologies and providing a new platform for RF integration in advanced SOCs. This paper reviews SPICE modeling infrastructure readiness for MuGFETs by examining major compact models for symmetric and asymmetric MuGFETs with an emphasis on RF applications. Comparative analysis and recommendations for improvement are provided.

TU4A-3 1630 – 1655
On the Bandwidth Performance of Doherty Amplifiers
L. C. de Vreede[1], J. R. Gajadharsing[2], E. W. Neo[2], [1]*Delft University of Technology, Delft , Netherlands,* [2]*NXP Semiconductors, Nijmegen, Netherlands*
Abstract — The theoretical bandwidth constrains of conventional symmetric and asymmetric Doherty amplifiers are evaluated and compared to those of the recently introduced novel three and 4-way Doherty amplifier configurations. Performance trends are identified and backed-up by practical results.

TU4A-4 1655 – 1720
Linearization Methods of RF CMOS PAs for Mobile Communications
S. Hong, T. Joo, B. Koo, K. Son, *Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Republic of Korea*
Several linearization methods of RF CMOS PAs are introduced in this paper. These are mostly based on adaptively controlling the biases of common source and common gate power transistors. The control signals are related with the input envelope signals in various manners. The other effort is shown for a power amplifier with linearizing driver which is made of a digital vector modulator. RF CMOS PAs for WCDMA and WLAN are demonstrated, as examples.

WEDNESDAY FOCUS AND SPECIAL SESSIONS:

Wednesday, 17 April 2013 1010-1130 Room 311B

Special Session: How to Write a Paper for IEEE MTT-S Journals and Navigate the Review Process
By George E. Ponchak

The careers of many people depends on their success in writing and getting their papers published. More important, the scientific process requires that scientific findings be published so that other researchers may build on your ideas or refute your findings. If authors are not able to publish their papers, then their careers are hurt and scientific progress slows and stops. Therefore, it is critical that researchers and engineers understand the process of writing and getting published their papers in reputable and cited journals and scientific conferences. However, often, authors' papers are rejected because they did not understand what reviewers, Associate Editors, and Editors are looking for in a paper, even if the technical results are good.

This presentation will cover the steps that an author should take to increase the acceptance rate of their papers in journals and conference. It will cover the reasons most papers are rejected and how an author should organize their paper to avoid those reasons. Lastly, it will present what steps you should take if your paper is rejected to get it published in the same journal or in a different journal.

About the Instructor: George E. Ponchak received the B. E. E. degree from Cleveland State University, Cleveland, OH in 1983, the M.S.E.E. degree from Case Western Reserve University, Cleveland, OH in 1987, and the Ph.D. in electrical engineering from the University of Michigan, Ann Arbor, MI in 1997.

He joined the staff of the Communications, Instrumentation, and Controls Division at NASA Glenn Research Center, Cleveland, OH in 1983 where he is now a senior research engineer. In 1997-1998 and in 2000-2001, he was a visiting professor at Case Western Reserve University in Cleveland, OH. He has authored and co-authored over 150 papers in refereed journals and symposia proceedings. His research interests include the development and characterization of microwave and millimeter-wave printed transmission lines and passive circuits, multilayer interconnects, uniplanar circuits, Si and SiC Radio Frequency Integrated Circuits, and microwave packaging.

Dr. Ponchak is a Fellow of the IEEE and an Associate Member of the European Microwave Association. Dr. Ponchak is Editor-in-Chief of the IEEE Transactions Microwave Theory and Techniques, he was the Editor-in-Chief of the IEEE Microwave and Wireless Components Letters from 2006-2010, and he was Editor of a special issue of IEEE Trans. on Microwave Theory and Techniques on Si MMICs. He founded the IEEE Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems and served as its Chair in 1998, 2001, and 2006. He was the General Chair of the 2011 IEEE Radio and Wireless Symposium and he was the Technical Program Chair of the 2010 IEEE Radio and Wireless Symposium. He served as Chair of the Cleveland MTT-S/AP-S Chapter (2004-2006), and he has chaired many symposium workshops and special sessions. He is a member of the IEEE International Microwave Symposium Technical Program Committee on Transmission Line Elements and served as its Chair in 2003-2005 and a member of the IEEE MTT-S Technical Committee 12 on Microwave and Millimeter-Wave Packaging and Manufacturing. He served on the IEEE MTT-S AdCom Membership Services Committee (2003-2005) and was elected to the MTT-S AdCom in 2010. He received the Best Paper of the ISHM'97 30th International Symposium on Microelectronics Award.

Wednesday, 17 April 2013 1010 – 1150 Room: 311A

WE2A: Focus Session – Cognitive Radio Communications and Networks

Chair: Wei Zhang, *University of New* South Wales
Co-Chair: Minkyu Je, *A**STAR

Abstract: Cognitive radio is an emerging technology that enables unlicensed (secondary) users to make use of the available unused spectrum of a specific licensed (primary) user for realizing dynamic spectrum access and thereby easing off the problem of spectrum scarcity. It has been considered for commercial use in many standardization activities, such as IEEE 802.22, IEEE 802.11af, and IEEE SCC41. The focus session on cognitive radio communications and networks presents some state-of-the-art cognitive radio research, highlight the research challenges and further explore innovative solutions in PHY and MAC layers.

Wednesday, 17 April 2013 1540 – 1720 Room: 311A

WE4A: Focus Session – RF Nanotechnologies for Next-Generation Wireless Communication

Chair: Erping Li, *A**STAR
Co-Chair: Dominique Baillargeat, *University of Limoges*

Abstract: New nano-materials, graphene nanoribbons (GNR) and Carbon nanotubes (CNT) exhibit unique electrical and mechanical properties. The recent researches demonstrated the potential applications in RF devices in wireless communication such as microwave, millimeter-wave and THz. This focus session presents the latest research results on high-performance carbon nanodevices for RF applications. The topics cover issues ranging from epitaxial graphene production technology, GNR based passive and active electronic devices, CNT sensing, to recent advances in modeling.

WE1B: Frequency Synthesis, Power Combiners, and Behavioral Modeling of RF Power Amplifiers

Wednesday, 17 April 2013
Room: 310
Chair: Qun Wu,
Co-Chair: Hua Quan

In this session on high power amplifiers and frequency synthesis, we have two papers on oscillator design and realization for microwave signal generation, two papers on novel power combining techniques to realize high-power outputs, and a paper on behavioral modeling techniques for power amplifiers.

WE1B-1 0800 – 0820
A Low-Power Ka-Band Frequency Synthesizer with Transformer Feedback VCO Embedded in 90-nm CMOS Technology

C. H. Yu[1], J. H. Tsai[2], T. W. Huang[1], [1]*National Taiwan University, Taipei, Taiwan,* [2] *National Taiwan Normal University, Taipei, Taiwan*

A 26.5-29.5 GHz frequency synthesizer (FS) using 90-nm CMOS technology is presented in this paper. To achieve the low-power consumption and low phase-noise performance, a transformer-feedback voltage control oscillator (TF-VCO) and a low suuply voltage injection-locked frequency divider (ILFD) and current mode logic divider (CML) are implemented. The frequency synthesizing is accomplished by the programmable multi-modulars frequency divider (MMD). The phase noise of proposed frequency sythesizer is measured by -77 dBc/Hz at 1 MHz offset. The power consumption is 24.2 mW.

WE1B-2 0820 – 0840
Multi-objective Optimization of Rotary Travelling Wave Oscillator (RTWO) With Neuro-Genetic Nondominated Sorting Algorithm

M. Aidoo[1], M. Harouna[1], A. Homaifar[1], N. S. Dogan[1], Z. Xie[1], H. Savci[3], P. Roblin[2], [1]*North Carolina A&T State University, Greensboro, United States,* [2]*Ohio State University, Columbus, United States,* [3]*Istanbul Sabahattin Zaim University, Istanbul, Turkey*

Rotary travelling wave oscillator (RTWO) represents a transmission line based technology for multi-gigahertz clock generation. RTWO design is a multi-parameter-multi-objective problem with tradeoffs of performance measures, power and phase noise. In this paper, non-dominated based genetic algorithm for multi-objective optimization is used to determine the Pareto optimal front of solutions for low power and phase noise with emphasis on variation of transmission line width and spacing. Optimization is followed by sensitivity assessment wherein Monte Carlo simulations and corner analysis are performed on the Pareto points with respect to process variations. The algorithm is validated in the design of RTWO whose frequency varies between 3 to 5GHz due to varying dimensions of coupled transmission line. The optimization is a two step process. A neural network is developed from experimental data to estimate phase noise and power with transmission line width and spacing as inputs.

WE1B-3 0840 – 0900
Design of a New Millimeter Wave Power Combiner Based on Multi-Way Ridged Waveguides

Y. Ning, W. Jiang, Q. Zhu, The 41*st Institute of China Electronics Technology Group Corporation, Qingdao, China*

A new millimeter wave spatial power combiner based on broadband multi-way ridged waveguides is designed. The device is composed of a multi-step impedance transformer and eight ridged waveguides. Since the ridged waveguides provide a consistent impedance transformation and a broad band working frequency, a millimeter wave solid-state power amplifier based on the combiner demonstrates an output power of more than 5 W at 40 GHz and greater than 10 W over the 30 GHz to 34 GHz band. Measured results show that all the ridged waveguides have the high uniformity of amplitude and phase, and the combiner has demonstrated operation over a broadband of 30 GHz to 40 GHz with more than 10 dB return loss and less than 0.8 dB insertion loss.

WE1B-4 0900 – 0920
The Spatial Power Combining Technique Based on Novel Antipodal Finline

Y. Ning, W. Jiang, W. Zhang, The 41*st Institute of China Electronics Technology Group Corporation, Qingdao, China*

This paper presents the spatial power combining technique based on new waveguide-to-microstrip antipodal finline array. The technique adopts the structure of broadband multi-way oversized coaxial waveguide which is mainly composed of a twenty-way gradually changed antipodal finline array. The new finline is designed of a complex function of a linear function, a triangular function and an exponential function. All the finlines have the high uniformity of amplitude and phase. Through the application to 6-18 GHz coaxial spatial power combiner, the new finline provides a broadband performance without any additional resonance frequency. Measured results show that the spatial power combiner has a high combining efficiency of 80% and high output power of more than 20 watts in frequency range of 6-18 GHz.

WE1B-5 0920 – 0940
Behavioral Modeling of Power Amplifier with Long Term Memory Effects using Recurrent Neural Networks

C. Zhang[1], S. Yan[1], Q. Zhang[2,1], J. Ma[1], [1]*Tianjin University, Tianjin, China,* [2]*Carleton University, Ottawa, Canada*

This paper describes recurrent neural network (RNN) technique for behavioral modeling of power amplifier (PA) with short and long term memory effects. RNN can be trained directly using the input-output data without the internal details of the circuit and the trained models can reflect the behavior of nonlinear circuit. Additional signals representing slow memory effects are extracted from the PA input and output signals and are used as extra inputs to RNN model in order to effectively represent long term memory. Examples of RNN modeling of power amplifier with short and long term memory effects are presented.

WE1C: Antennas and Transmission Lines

Wednesday,17 April 2013
Room: 311A
Chair: Yijun Feng, *Nanjing University*
Co-Chair: Cheng Wen, *Peking University*

This section explores new antenna and transmission-line designs. Innovations on dielectric microstrip, corrugated substrate-integrated waveguide and other novel transmission line structures will be presented. Designs on high-gain antennas including quadruple ridged horn antenna and cavity backed antenna array will also be discussed.

WE1C-1 0800 – 0820
A Transition of Microstrip Line to Dielectric Microstrip Line for Millimeter Wave Circuits

Q. Xue, L. Chiu, H. Zhu, *City University of Hong Kong, Hong Kong, Hong Kong*

A compact microstrip line to dielectric microstrip line (DML) transition is investigated, where DML is a dielectric waveguide that has quasi-planar structure line like conventional microstrip. DML is much more convenient to be used for various circuit constructions, comparing to other dielectric waveguides such as non-radiative dielectric guide and image guide. However, DML is not a standard transmission line. Transition is required for the measurement. In our experiment, the measured insertion loss of a section of DML with two back-to-back transitions ranges from 3.1dB to 5.3dB during 42GHz to 54GHz.

WE1C-2 0820 – 0840
CMOS 196 Pico-Second Variable Delay Line Incorporating Active Reflection-Load in K-band

H. Wu[1], C. Wang[2], P. Ko[3], J. Ma[1], C. Tzuang[1], [1]*Tianjin University , Tianjin, China,* [2]*MStar Semiconductor Inc., Zhubei City, Taiwan,* [3]*Garmin Corp., New Taipei City, Taiwan*

The monolithic variable delay line with the loss compensation is presented. The operation of the delay line relies on changing the impedance of two identical reflection-loads at the through and coupled ports of the directional coupler. The reflection-load is the composite network, consisting of a passive parallel resonator, and a frequency-selective negative resistor. The negative resistor maintains the quality factor of the resonator to reduce the variation on the insertion-loss of the delay line with different time delay. The circuit simulations and the on-wafer measurements based on the CMOS 0.13-um 1P8M technology validate the proposed circuit. The maximum time delay of the prototype is 196.2 pico-seconds at 24 GHz. The insertion-loss is 1.53 dB at 24 GHz, and the loss-variation is less than 1.3 dB.

WE1C-3 0840 – 0900
Half-Mode Corrugated Substrate Integrated Waveguide Mode Behavior

K. W. Eccleston, *University of Canterbury, Christchurch, New Zealand*

The half-mode corrugated substrate integrated waveguide (HMCSIW) uses an array of quarter-wave stubs in place of vias to artificially create an electric wall. This structure supports the TE0.5,0 mode encountered in the half-mode substrate integrated waveguide (HMSIW). The top conductor of the structure is isolated from ground at dc permitting integration of active devices at the open edge. An eigenvalue formulation was used to study the mode behavior of the HMCSIW. Simulations and experimental results for an X-band HMCSIW were used to validate calculations. Unlike the HMSIW, a spurious mode restricts monomode operation to one octave.

WE1C-4 0900 – 0920
Research and Design of Broadband Horn Antenna

J. Liu[1], Y. Zhou[1,2], J. Zhu[1], [1]*Nanjing University of Aeronautics and Astronautics, Nanjing, China,* [2]*City University of Hong Kong, Nanjing, China*

A novel design of dual-polarized broadband 6~18GHz horn antenna with low SWR (2), high gain (13dB~19.5dB) and high isolation (25dB) is presented. Moreover, the designed antenna exhibits excellent far-field radiation characteristics in the entire operating bandwidth without lobe splitting. Applying commercial software Ansoft HFSS, sensitivity analysis is taken with respect to the best antenna performance and manufacturing tolerance. Based on the results, we finally fabricated a sample, the measured results showed good performance.

WE1C-5 0920 – 0940
Millimeter-Wave Cavity-Backed Antenna Array with High Gain and Simple Structure

S. Qu, *University of Electronic Science and Technology of China, Chengdu, China*

Antennas in high speed wireless local-area network (WLAN) at 60 GHz is now becoming a hot topic, and high-gain properties are often preferred due to high transmission loss of the frequencies around 60GHz. In this paper, a 2-element cavity-backed antenna (CBA) array is proposed, which is excited by bowtie dipoles and fed by a transition from a coaxial line to parallel strip lines. The array prototype is fabricated and measured after the parametric optimization is performed. The measured and simulated results agree reasonably with each other, proving that the array can feature an impedance bandwidth of ~8.3% for SWR ≤ 2, a broad gain of 12.6 - 13.6 dBi, and cross polarization of around -20 dB.

WE1D: Millimeter-wave and UWB Antennas
Wednesday, 17 April 2013
Room: 311B
Chair: Michael Ling Chuen Ong, *I2R*
Co-Chair: Yan Zhang, *Southeast University*
In this session, millimeter wave and UWB antennas are focused, including gain improvement of mm-wave CRLH antenna, dual band-notched ultra-wideband MIMO antenna array, and millimeter wave high gain SIW antennas for Q-LINKPAN applications.

WE1D-2 0800 – 0820
Mm-Wave CRLH Antenna Gain Improvement by Matching with Reactive Stubs
G. Sajin[1], I. Mocanu[1,2], M. Carp[1], [1]*National Research Institute for Microtechnologies, IMT Bucharest, Bucharest, Romania,* [2]*Politehnica University Bucharest, Bucharest, Romania*
The paper describes a method of return loss (RL) reducing for a CoPlanar Waveguide (CPW) Composite Right/Left-Handed (CRLH) zeroth-order resonance (ZOR) mm-wave antenna by matching the radiating structure impedance ZS = RS + j XS to the characteristic circuit impedance Z0 = 50 Ohm. The working frequency is f = 40 GHz and the initial RL value was S11 = -16.21 dB, meaning a VSWR = 1.37. Using appropriate formulas, the resistive RS and reactive XS parts of ZS were found. The second step was to find the length l of a short-ended parallel reactive stub and the suitable point d for stub implantation in order to match the antenna to the characteristic impedance Z0. With these data, the layout of the antenna feeding line was modified by adding the appropriate matching stub. After that, the return loss at the feeding line input was S11 = -43.50 dB. The return loss was drastically improved, demonstrating effectiveness of the matching process.

WE1D-3 0820 – 0840
Dual Band-Notched Ultrawideband MIMO Antenna Array
Y. Yang, Q. Chu, J. Li, *South China University of Technology, Guangzhou, China*
A compact planar dual band-notched ultrawideband (UWB) MIMO antenna array is presented. The proposed antenna array consists of two same elements which act as 3.4/5.5GHz dual band-notched UWB antennas on a printed circuit board. The antenna array is fed by using two 50Ω coplanar waveguide (CPW) transmission lines with two feeding ports. By placing a central metal strip between two radiating elements, the mutual coupling can be reduced. The proposed antenna array is successfully simulated, designed, and measured showing broadband matched impedance, stable radiation patterns and constant gain in terms of isolation of |S21| -30dB. The calculated envelope correlation coefficient between two elements shows consistent diversity performance across the UWB bandwidth.

WE1D-4 0840 – 0900
A Simple Low-Profile Magneto-Electric Dipole Antenna Element
L. Ge, K. Luk, *City University of Hong Kong, Hong Kong , Hong Kong*
By combining a horizontal planar dipole and a vertically oriented folded shorted patch antenna, a new low-profile magneto-electric dipole antenna is presented. The antenna is simply excited by a coaxial feed which works as a balun. A prototype was designed, fabricated and measured. Simulated and measured results agree well. An impedance bandwidth of 45.6% for SWR≤1.5 from 1.86GHz to 2.96GHz was achieved. Stable radiation pattern with low cross polarization, low back radiation and an antenna gain of 8.1±0.8dBi was found over the operating frequencies. Also, the height of the antenna is only 0.169λ. In addition, the antenna is d.c. grounded which satisfies the requirement of many outdoor antennas.

WE1D-5 0900 – 0920
Balanced Dual Fed SIW Slot Antenna Array for Q-Link PAN High Gain Application
T. Y. Yang, W. Hong, Y. Zhang, *Southeast University, Nanjing, China*
A 16x17 slot antenna array based on SIW technique with a novel balance dual-feeding scheme. The proposed array consists of 16 longitudinal slot sub-arrays, and each sub-array has 17 radiation slots. Balanced dual feeding scheme is introduced to excite each sub-array from its both terminals with equal phase and amplitude to ensure the radiation pattern of the sub-array is stably steering to the normal direction over the entire operating band. Two 16-way power dividers are used to unit sub-arrays. Another T-shaped power-divider is used to combine the two 16-way power dividers into one port. Thus, the finalized antenna array has only one port but its radiation pattern is independent to frequency. The antenna array is implemented based on standard PCB process and both CPW-SIW and rectangular waveguide-SIW transitions are designed for the measurement. The measured maximum gain of the antenna array achieves 26.9 dBi, and the measured bandwidth of -10 dB is 40.5~43.5 GHz.

WE2A: Cognitive Radio Communications and Networks
Wednesday, 17 April 2013
Room: 311A
Chair: Wei Zhang, *School of Electrical Engineering & Telecommunications, University of New South Wales*
Co-Chair: Minkyu Je, *Institute of Microelectronics, A*STAR*
Cognitive radio is an emerging technology that enables unlicensed (secondary) users to make use of the available unused spectrum of a specific licensed (primary) user for realizing dynamic spectrum access and thereby easing off the problem of spectrum scarcity. It has been considered for commercial use in many standardization activities, such as IEEE 802.22, IEEE 802.11af, and IEEE SCC41. The focus session on cognitive radio communications and networks presents some state-of-the-art cognitive radio research, highlight the research challenges and further explore innovative solutions in PHY and MAC layers.

WE2A-1 1010 – 1035
Dynamic Resource Allocation in Cognitive Radio Two-Way Relay Networks Using Sequential Auctions
T. Wang[1], L. Song[1], Z. Han[2], J. Zhang[3], X. Zhang[3], [1]*Peking University, Beijing, China,* [2]*University of Houston, Houston, United States,* [3]*ZTE Corporation, Shenzhen, China*
In this paper, we consider a cognitive relay network, in which multiple pairs of secondary users (SUs) share the unlicensed spectrum by the overlay mode, and for each SU pair, the two ends exchange data via a common relay node that senses the spectrum and allocates the unused bandwidth. Here, we formulate the spectrum allocation problem as a multi-object auction and introduce the mechanisms of sequential first price auction (SFPA) and sequential second price auction (SSPA), where for each mechanism, the optimal bidding strategy is analyzed and the corresponding algorithm is given. Simulation results show that both the proposed algorithms cost only 25%~35% feedback overhead, but achieve about 95% total transmission rate (with SSPA having a slightly better performance), compared with the optimal algorithm.

WE2A-2 1035 – 1100
Capacity of the Broadcasting Phase of Time-Varying Two-Way Relaying
X. Chen, W. Chen, *Tsinghua University, Beijing, China*
In this paper, we mainly focus on the problem about the channel capacity and power allocation of the downlink process of a wireless two-way relay channel which is time-varying while the relay node has a total awareness of the channel side information. For situations differing about how receiving nodes know about messages for the other, we accordingly determine the channel capacities and the coding process using techniques such as network coding, superposition coding and nested coding; also the relay node should make corresponding strategies about power allocation with channel side information to attain the best average channel capacity, whose optimal solution in closed form is achieved using KKT conditions.

WE2A-3 1100 – 1125
Spatial Opportunity in Cognitive Radio Networks with Primary Transmitter Assisted Opportunistic Spectrum Access
X. Song[1], C. Yin[1], D. Liu[1], R. Zhang[2], [1]*Beijing University of Posts and Telecommunications, Beijing, China,* [2]*National University of Singapore, Singapore, Singapore*
This paper studies the opportunistic spectrum access (OSA) of secondary users in a large-scale overlay cognitive radio (CR) network. Particularly, a threshold-based protocol is investigated, where the secondary transmitter is allowed to access the spectrum only if the maximum signal power of the received pilots sent from the primary transmitters is lower than a certain threshold. To measure the resulting transmission opportunity for the secondary users by the proposed OSA protocol, the concept of spatial opportunity is introduced and evaluated by applying tools from stochastic geometry. Based on this result, approximations on the coverage probabilities of the primary and secondary networks under the proposed OSA protocol are characterized. Simulation results are provided to validate our analysis.

WE2A-4 1125 – 1150
Multiuser Diversity of Spectrum Leasing in Cognitive Radio Networks
C. Zhai, W. Zhang, *The University of New South Wales, Sydney, Australia*
In this paper, an adaptive spectrum leasing scheme is proposed for multiuser cognitive radio networks and multiuser diversity is analyzed. Based on two-path successive relay and decode-and-forward relay protocols, each cognitive user intelligently switches the spectrum leasing protocols to help the primary data transmission. As a reward, the spectrum is then leased to the cognitive user for secondary data transmission. The best cognitive user that achieves the largest secondary rate while satisfying the primary rate target is selected in the spectrum leasing. The multiuser diversity of the spectrum leasing scheme is analyzed and the throughout is shown to be proportional to loglog(m) for large number of m cognitive users.

WE3B: Building Bocks for RF integrated Front-end

Wednesday, 17 April 2013
Room: 310
Chair: Noriharu SUEMATSU, *Tohoku Univ.*
Co-Chair: Kenjiro Nishikawa, *Kagoshima Univ.*

This session is focused on various RF circuits which will construct RF ingetrated front-ends using CMOS RF-IC / module technologies. A novel CMOS dilrect digital RF modulator, a CMOS frequency divider, CMOS / module VCO's and a SOI CMOS antenna switch will be presented.

WE3B-1 1330 – 1350
5 GHz-Band CMOS Direct Digital RF Modulator Using Current-Mode DAC with Idle Current

O. Wada, T. Tan, S. Tanifuji, S. Kameda, N. Suematsu, T. Takagi, K. Tsubouchi, *Tohoku University, Sendai, Japan*

Abstract—A 5 GHz-band direct digital RF modulator using current-mode DAC with idle current is proposed and fabricated in 90-nm CMOS process. Since this modulator directly converts digital BB parallel input signal into RF signal, small die size and low dc operation can be achieved. To reduce the higher order distortion components at the RF output, idle current is provided to BB current output from the current-mode DAC. By providing idle current of 10% of full scale DAC output current, the 2nd and the 3rd order distortion components near 5 GHz-band carrier are reduced and the improvement of ENOB is achieved. As the results, measured ENOB of 6.36 bit (SNDR of 40.0 dB) with RF modulated output power of -28.4 dB is obtained at 5 GHz. The core size of the proposed modulator integrated circuit (IC) is 200µm x 200µm and the power consumption of core circuit excluding inverter inverter section for digital BB signal converter is 2.1 mA/1.2V.

WE3B-2 1350 – 1410
An Ultra-Compact SP4T Cellular Antenna Switch in 3.3V CMOS Thick-Film SOI

V. Blaschke, A. Unikovski, R. Zwingman, *TowerJazz, Newport Beach, United States*

This paper presents design and characterization results of an ultra-compact SP4T antenna switch fabricated in 3.3V CMOS thick-film SOI. Through "layout-driven" circuit design a small die size of 0.53 mm2 was achieved for a fully integrated switch die containing RF-section, I/O pads, ESD, decoder, level shifters and negative vss charge pump.

WE3B-3 1410 – 1430
A Wide Locking Range Q-Band Injection-Locked Frequency Divider

W. Liang, W. Hong, J. Chen, *Southeast University, Nanjing, China*

A Q-band divide-by-2 injection-locked frequency divider (ILFD) is presented in this paper. A common-centroid cross-coupled transistor pair structure is adopted to reduce the gate-drain capacitance for widening the locking range. The whole layout of the ILFD is simulated using a 3D electromagnetic (EM) simulator for a one-pass success, and a good match between the simulation and measurement results is achieved without using any tuning varactors. At an input power of 0 dBm, the ILFD achieves the input locking range of 34-50 GHz. The power consumption of the ILFD core is 7.7 mW at a 0.7 V supply voltage.

WE3B-4 1430 – 1450
A Low Phase Noise Local Oscillator Module for Instrumentation Application

W. Zhu, H. Meng, L. Mao, The 41*st Institute of China Electronics Technology Group Corporation, Qingdao, China*

In this paper we have developed a novel Local Oscillator Module for down conversion application in Signal Source Analyzer with low phase noise, which covers 3-10 GHz frequency range. The local oscillator is a multi-loop YTO based frequency synthesizer, which is implemented with ultra low phase noise OCXO low phase noise YIG-tuned oscillator, low conversion loss, and low noise sampling phase detector. In this project in order to have a good phase noise of local oscillator, key circuits have been analyzed, designed and implemented. The output signal of local oscillator has a pretty good phase noise, and the measured phase noise at 10 kHz offset is about -128dBc/Hz at 3.05GHz and -120dBc/Hz at 9.95GHz respectively. The frequency switching time is less than 2millisecond in the entire operating range.

WE3B-5 1450 – 1510
Design of a Ku-band Voltage Controlled Oscillator

Q. Guo, *University of Electronic Science and Technology of China, Chengdu, China*

In this paper, a Ku band voltage controlled oscillator with a frequency range of 220MHz is presented. By changing the traditional structure, combining the resonance with the active component through direct coupling, the oscillator becomes easier to oscillate; therefore the performance of the oscillator has been improved. The output power is 4.79dBm and 7.02dBm at 12.24GHz and 12.49GHz, respectively. The control voltage ranges from 1V to 12V. The phase noise is -66.73dBc/Hz@100KHz at 12.49GHz.

WE3C: Couplers and Dividers

Wednesday, 17 April 2013
Room: 311A
Chair: Erping Li, *Zhejiang University*
Co-Chair: Ho-Chung Huang, *AMCOM Communications Inc.*

Couplers and dividers are passive yet critical components of microwave systems. This session highlights innovative ideas for their design and implementation. These include a slow-wave coupler with 55% size reduction, a frequency-agile directional coupler based coupled transmission lines, a power divider with harmonic suppression, a Gysel divider with arbitrary power ratio, and a multiplexer with contiguous bands.

WE3C-1 1330 – 1350
Compact Hybrid Coupler Based on Mixed-Lattice Slow-Wave Transmission Line

J. Huang[1,1], Q. Chu[2,2], Q. Tan[1,1], [1]*Xiangnan University, Chenzhou, China,* [2] *South China University of Technology, Guangzhou, China*

Compact hybrid coupler utilizing the slow-wave structure has been proposed. The linear phase characteristic of the slow-wave structure was achieved by using the mixed structure of the lattice and pi-shaped topology. The fabricated coupler demonstrates the evident size reduction (55%) with a little performance degradation due to the linear phase characteristic of the slow-wave structure over wideband.

WE3C-2 1350 – 1410
Frequency-Agile Directional Coupler with Good Restraint Outside the Passband Based on the Coupled Transmission Line

Y. Cheng[1,2], L. Wang[1], J. Wu[1], Y. Fan[1], [1]*University of Electronic Science and Technology of China, Chengdu, China,* [2]*Southeast University, Nanjing, China*

A frequency-agile directional coupler incorporating the bandpass frequency response characteristic is proposed and characterized in this paper. This structure is modified from a conventional branch-line coupler and composed of two wide open-ended coupled lines. As such, it has good restraint performance outside the passband. Frequency tuning is achieved by modifying the electrical length of the open-ended coupled lines loaded with varactors. Measured results are in agreement with predictions, which validate the correctness of our theory and design.

WE3C-3 1410 – 1430
Dual-functional Power Divider with Harmonic Suppression

Y. Li, Q. Xue, *City University of Hong Kong, Hong Kong, China*

This paper presents a novel power divider integrated with bandpass filters (BPFs). It splits the power equally and selects the desired frequency spectrum at the same time. Besides, the device could suppress the harmonic in a wide band. The centrally loaded BPFs are employed to replace the impedance transformers of power divider. The isolation elements are placed at the center of the symmetric plane to produce the good isolation between output ports. The design is fabricated and measured and the agreement between the simulated and measured results demonstrates the method.

WE3C-4 1430 – 1450
A Novel Gysel Power Divider with Arbitrary Power Ratio for High-Power Application

H. W. Zhang, Q. Xue, *City University of Hong Kong, Hong Kong, Hong Kong*

A novel Gysel power divider with arbitrary power ratio for high-power application is presented in this paper. The power dividing ratio can be conveniently assigned by controlling the length of two branch lines without any changes in other branches. The characteristics of all the transmission lines in this divider are fixed to the same value based on the theoretical analysis, which will simplify the design procedure of unequal Gysel power. Besides, the power ratio in this Gysel power divider can be designed from 0 to infinite without employing high impedance transmission line, which is unrealized in the conventional Gysel power divider. In order to evaluate the performance of the novel Gysel power divider, two dividers with dividing ratios of 2:1 and 4:1 are fabricated and examined. From the results it can be observed that there is excellent agreement between the simulated and measured results.

WE3C-5 1450 – 1510
Formulation of Realizable Scattering Matrices for Multiplexers with Contiguous Bands

A. Garcia-Lamperez, S. Llorente-Romano, M. Salazar-Palma, *Universidad Carlos III de Madrid, Leganés, Spain*

Compact multiplexers are a class of multiport networks entirely formed by coupled resonators, with no additional elements, as junction structures or transmission line lengths. The synthesis of their coupling matrices require the formulation of scattering coefficients as rational functions that verify the realizability conditions. A solution is to approximate the reflection coefficients as the ones of isolated filters, and then to reconstruct the transmission coefficients. This approach is quite robust when the pass bands are clearly separated, but additional care must be taken when they are contiguous. In particular, phase offsets should be applied to the isolated filters responses. The effect of these phase shifts can be compensated after the coupling matrix synthesis.

WE3D: Array Antennas
Wednesday, 17 April 2013
Room: 311B
Chair: Le-Wei Li, *Uinv. of Electronic Science and Technology of China*
Co-Chair: Mingtuo Zhou, *NiCT*
In this session, array antennas are focused, including method of generating negative group delay in phase arrays without using lossy circuits, high-directivity phased array for secure transmission, and polarization-agile millimeter-wave phased array antenna for high throughput two-dimensional scan cognitive radio.

WE3D-1 1330 – 1350
Method of Generating Negative Group Delay in Phase Arrays without Using Lossy Circuits
W. A. Alomar, A. Mortazawi, *University of Michigan, Ann Arbor, United States*
A design technique for generating negative group delay (NGD) without the use of lossy circuits is reported. Furthermore, the lossless NGD circuit is employed in designing a serially fed antenna array. The NGD is generated by using an antenna and a T-junction power divider. The NGD circuit cancels out the positive group delay in serially fed arrays resulting in beam squint elimination.

WE3D-2 1350 – 1410
A High-Directivity Phased Array for Secure Transmission
C. Tang, Q. Xue, *City University of Hong Kong, Hong Kong, Hong Kong*
A high-directivity phased array using combination of beam-steering technique and novel null tracking technique for secure signal transmission is presented. The proposed phased array provides super high directivity and constant data beamwidth for a wide scanning angle without alternating transmitting power. It achieves that by generating jamming signal with a null towards the direction of data signal's beam as well as a stable twin-beam tracking with the null. A 3X4 antenna array prototype is designed and fabricated. It demonstrates high signal-to-noise ratio directivity of over 25 dB, as well as a constant data beamwidth (S/N 12 dB) of 15° and a large jamming window (S/N 0 dB) to interfere the spy receivers for a wide scanning angle between ±27° for GSM1800 application.

WE3D-3 1410 – 1430
A Phased CPW-CTS Array with Reconfigurable NRI Phase Shifter for Beam Steering Application
Y. Li[1,2], M. Iskander[2], Z. Zhang[1], Z. Feng[1], [1]*Tsinghua University , Beijing, China,* [2]*University of Hawaii, Honolulu, United States*
In this paper, a reconfigurable negative reflect index (NRI) phase shifter is proposed, and adopted in a 3-element coplanar waveguide (CPW) continuous transverse stub (CTS) antenna array to achieve beam steering capability. The NRI phase shifter consists of three pin diodes, two shunt inductors and one capacitor. 3-stage phase shifters with different components' values are combined to achieve 3-bit reconfigurable working states. By controlling the working states, 8 different beam steering angles can be achieved in the CPW-CTS antenna array with good impedance matching. Simulation results are shown to validate the design strategy.

WE3D-4 1430 – 1450
Millimeter-Wave Phased Array Antenna for High Throughput Two-Dimensional Scan Cognitive Radio
A. Guntupalli, K. Wu, *École Polytechnique de Montréal, Montreal, Canada*
This research presents two novel techniques for obtaining the pattern and polarization agilities simultaneously. 35 GHz dual linearly polarized (DLP) antenna array is designed and the gain for each polarization is measured to be 18 dBi with a cross-polarization level of 20 dB between the two polarization states. 60 GHz Dual circularly polarized (DCP) antenna array is designed and the gain for each CP state is obtained as 13 dBc with a cross polarization level of 15 dB. Analog phase shifter based on the Butler matrix is used to drive each state of polarization. The designed DLP and DCP phased array systems are able to form beams in two dimensional (2-D) scan space. These millimeter-wave phased array systems with polarization agility will satisfy today's cognitive radio front-end requirements.

WE3D-5 1450 – 1510
A Zero Index Metamaterial Lens for Gain Enhancement of Patch Antenna and H-plane Horn Antenna
Y. Lv, F. Meng, J. Fu, K. Zhang, Q. Wu, L. Zhu, F. Zhang, *Harbin Institute of Technology, Harbin, China*
A zero index metamaterial lens (ZIML) is proposed for antenna directivity and gain enhancement. The zero index metamaterial (ZIM) is constructed from both electric metamaterial with near-zero permittivity and magnetic metamaterial with near-zero permeability. The ZIM unit cell is numerically simulated. The scattering parameters show that there is a wide pass band where both permittivity and permeability are small enough to achieve wave collimation. Particularly, both of the two parameters are of the same value, which makes the relative characteristic impedance to be 1 and match that of air. A patch antenna and an H-plane horn antenna are also implemented to examine the directivity and gain enhancement ability of the ZIML. The E-plane radiation patterns are both sharpened greatly. The gain enhancement of the two antennas are 6.6 dB and 4.3 dB, respectively. The universality of the ZIML for the two antennas indicates a more flexible application of the ZIML compared with traditional ones.

Wednesday, 17 April 2013

Room: 306AB

Interactive Forum II: Integrated Circuits and Antennas for Wireless Communication

Chair: Fujiang Lin, *USTC*

P2-2

Reduction of Baseband Electrical Memory Effects using Broadband Active Baseband Load-Pull

M. A. Chaudhary[1], J. Lees[2], J. Benedikt[2], P. J. Tasker[2], [1]*Ajman University of Science & Technology, Ajman, United Arab Emirates,* [2]*Cardiff University, Cardiff, United Kingdom*

This paper presents an enhanced active baseband load-pull capability that allows constant, frequency independent baseband load environments to be presented across wide modulation bandwidths. This capability is critical in allowing the effects of baseband impedance variation has on the performance of nonlinear microwave devices, when are driven by broadband multi-tone stimuli, to be fully investigated. The experimental investigations were carried out using a 10W GaN HEMT device, under 9-carrier complex multi-tone excitation.

P2-4

Investigation on Gyrotropic Effect of Magnetically Biased Graphene Sheet in Rectangular Waveguide

J. Chen[1], L. Wu[1], W. Yin[2,1], [1]*Shanghai Jiao Tong University, Shanghai, China,* [2]*Zhejiang University, Hangzhou, China*

In this paper, the transmission and reflection characteristics of a rectangular waveguide loaded with a graphene sheet is investigated theoretically, where the graphene is biased with a static magnetic field and shows gyrotropy. According to the nonreciprocal S-parameters of the composite structure, significant coupling and conversion are observed among different guided modes. In order to clearly provide its physical laws, the influences of operating frequency, biased magnetic field and chemical potential of the graphene sheet are also explored carefully.

P2-6

A Novel Planar Beam Steering Antenna

Z. Lu[1,2], X. Yang[1], [1]*Shanghai University, Shanghai, China,* [2]*Jiangxi University of Science and Technology, Ganzhou, China*

In this paper a novel planar beam steering antenna controlled by reactive loads is proposed and designed based on the principle of electrically steerable parasitic array radiator antenna (ESPAR). The antenna prototype is designed using HFSS and the reactance values are optimized by the differential evolutionary (DE) algorithm. The main beam can be steered from -34? to 40? in the xoy plane by controlling the value of the loaded reactance. The frequency range of each state with S11 below -10dB is from 5.7GHz to 6.1GHz while the gain is from 3.5dBi to 4.9dBi.

P2-7

A Wideband Printed Loop Antenna with a Monopole Feed

G. Pan, Y. Li, Z. Zhang, Z. Feng, *Tsinghua University, Beijing, China*

Abstract — In this paper, we have proposed a printed loop antenna for wideband wireless communication. The proposed antenna is composed of a rectangular loop and a monopole feed. The performance of the proposed antenna was studied by numerical simulations. A wide impedance bandwidth of 97.3% (1.788-5.176 GHz) with S11 -10 dB is achieved. The other performance is also reported, including the radiation pattern and gain. The monopole-fed loop antenna shows the merits of simple structure and wide bandwidth.

P2-8

The Design and Analysis on Broadband Circularly-Polarized Slot Antenna

C. Li, H. Wu, L. Han, L. Yan, W. Zhang, *Shanxi University, Taiyuan, China*

A design of a broadband circularly-polarized (CP) slot antenna is proposed in this paper. The CP radiation of the slot antenna is excited by the proximity coupling of a microstrip line. To obtain a broad CP bandwidth, three CP modes contained in the CP band are excited. The results show that the proposed antenna can provide a CP operating bandwidth of 56% (3.17 GHz - 5.65 GHz) within an impedance bandwidth of 64% (2.96 GHz - 5.75 GHz).

P2-9

Wideband Dual-Polarized Base Station Antenna With High Isolation and Low Cross Polarization for LTE Communication System

X. Guo, Q. Chu, *South China University of Technology, Guangzhou, China*

A wideband dual-polarized antenna for LTE (Long Term Evolution) communication system is presented. The antenna is excited by inverted L-shaped strip feed line. A wide impedance bandwidth operating from the frequency 1.71 to 2.69 GHz with VSWR less than 1.5 is achieved. The isolation of the antenna between the two input ports is more than 40dB. Stable radiation pattern with low cross-polarized, low backlobe radiation and gain of 9dBi is found across the entire operating bandwidth.

P2-10

Modified Sierpinski Fractal Based Microstrip Antenna for RFID

Y. Wang, D. Li, L. Sun, J. Luo, *National University of Defense Technology, Changsha, China*

Modified Sierpinski fractal based microstrip antenna is designed for ultrahigh frequency (UHF) radio frequency identification (RFID). Combining the echniques of modified fractal shape and corner cutting, the antenna possesses the properties of miniaturization and broad band. The bandwidth is as twice as that of the rectangle antenna and the size is decreased by 10.1% comparing to the rectangle antenna. Simulation results are validated by comparing with experimental measurements. The impedance bandwidth for S(11) -10dB of the fabricated antenna whose size is 71×74×3mm3 is 873-923MHz (5.7%). The modified Sierpinski fractal based microstrip antenna is a charming candidate for RFID reader antenna for its miniaturization and wide band.

P2-11

Quadrifilar Helix Antenna with Cage for Axial Ratio Improvement and Wide Beam Characteristic

W. Lin[1], Q. Chu[1], S. Yao[2], [1]*South China University of Technology, Guangzhou, China,* [2]*Shenzhen Power Supply Co., LTD, Shenzhen, China*

A simple and novel technique to improve the axial ratio of quadrifilar helix antenna (QHA) and widen its beam width is presented. By adding a cage which consists of a loop and 4 sticks, the axial ratio performance is greatly decreases at the low elevation and the beam width is widened. An antenna for CNSS (Compass Navigation Satellite System, 2.492GHz) application is realized based on the technique. The axial ratio is below 4dB at the elevation of 5° and the 3dB beam width increases to about 180°.

P2-12

Impacts of Surface Waves on Performance of an EBG Resonator Antenna

N. Wang[1,2], L. Talbi[2], Q. Zeng[3], J. Xu[1], [1]*Northwestern Polytechnical University, Xi'an, China,* [2]*Université du Québec en Outaouais, Gatineau, Canada,* [3]*Communications Research Centre Canada, Ottawa, Canada*

This paper presents the impacts of the surface waves induced by the feeding microstrip patch antenna on the performance of EBG resonator antennas. It is found that the surface waves narrow down the radiation bandwidth, widen the half radiation beamwidth in the E-plane, leading to a considerable decrease in the directivity, which should be carefully treated and abstained in the design process.

P2-13

Microstrip-Line-Fed Wide Rectangular Slot Antenna for Multiband Operation

C. Hsu, P. Wu, *National United University, Miao-Li, Taiwan*

A design of planar rectangular slot antenna with microstrip-line-fed is presented. The proposed antenna has a simple structure consisting of a modified rectangular slot ground plane, microstrip-line-fed act as a tuning stub of the antenna, placed at the opposite side of the feed. The proposed antenna is developed, and its measured characteristics are good agreement with the simulated results. From experimental results, the antenna can generate two bands centered at about 1.8 and 5.8 GHz to cover the GSM system and Wi-Fi band. Good return loss and radiation pattern characteristics are obtained over the two operation bands.

P2-14

A High-Gain Low-Profile Antenna Design Based on Effective Material Parameters

D. Li, *A*STAR, Singapore, Singapore*

This work presents the design of a high-gain antenna with an integrated zero-index metamaterial superstrate. An effective material parameter extraction algorithm is developed for structures lying between two different materials, and is used to design the metamaterial structure, which is placed on a layer of spacer above a patch antenna. With such a metamaterial superstrate, the realized broadside gain of a microstrip patch antenna is increased to 80% of perfect aperture at the working frequency of 10 GHz.

P2-15

Balanced Implantable Slot-Dipole Composite Antenna for Multi-band Biomedical Applications

W. Lu[1,2], H. Zhu[1], [1]*Nanjing University of Posts & Telecommunication, Nanjing, China,* [2]*Southeast University, Nanjing, China*

Design concept of an implantable, balanced slot-dipole composite antenna is proposed and simulated. The antenna is composed of a tapered slot element and a symmetrical dipole and embedded in a planar stratified phantom. The reflection coefficiency, radiation pattern and gain of the antenna are simulated. It is shown that the antenna can operate at 402-405MHz, 433MHz, 902-928MHz and 2400-2500MHz bands for return loss larger than 10dB. The antenna should be useful for implantable, multi-band medical implant communication service (MICS) and industrial, scientific and medical (ISM) applications.

P2-16

A Differential Printed Antenna Design for Multiband Impulse Radio Transmitter at 60 GHz

C. Hamouda, R. Abdaoui, M. Villegas, B. Poussot, L. Cirio, J. Laheurte, *Université Paris-Est, Descartes, France*

We propose in this paper two microtrip planar antennas dedicated to a 60 GHz high data rate Impulse Radio Multi-band On Off Keying (IR-MBOOK) low power consumption transmitter architecture. The planar antennas were designed and simulated on a conventional and low-cost RT/Duroid 5880 substrate, and then are connected after two differential Power Amplifiers. The antennas serve for radiation as well as an out-of-phase power combiner. In this solution, the 57.05-63.7GHz dedicated band is separated into four balanced sub-bands. We propose the use of two differential planar antennas to cover the dedicated bandwidth on the transmitter architecture. An antenna covers the first 57.05-60.257GHz sub-band (band 1 and 2) and a second antenna covers the 60.257-63.7GHz sub-band (band 3 and 4). The planar antennas 1 and 2 were designed and simulated using the electromagnetic HFSS software and they give a maximum gain of 9.81 dBi and 10.03 dBi, respectively.

P2-17

Design and Investigation of Dielectric Resonator Antenna Oscillator (DRAO) in Electronic Toll Collection (ETC) System

J. Sun[1], Q. Hao[2], Z. Feng[2], W. Jiang[1], [1]*The 41st Institute of China Electronics Technology Group Corporation, Qingdao, China,* [2]*Tsinghua University, Beijing, China*

A novel dielectric resonator antenna oscillator (DRAO), which realizes dielectric resonator antenna (DRA) and dielectric resonator oscillator (DRO) simultaneously, is presented in this paper. The design procedure of the parallel-feedback type DRAO at dedicated short range communications band is discussed. Firstly, the DRA was three-dimensional simulated by HFSS. Then the DRO was designed based on the negative resistance theory, using the ADS software for optimization and nonlinear analysis. Finally, it was integrated in the on-board unit (OBU) of electronic toll collection (ETC) system. The experimental results of the OBU show that the performance of the DROA is well and it can be used in real ETC system.

P2-18

An Experiment to Extract the Dynamic Nonlinear Model of a Millimeter-Wave Communication System with Ultra-Wideband Signal

S. Zhang, H. Sun, W. Chen, Z. Feng, Z. Xiao, N. Ge, *Tsinghua University, Beijing, China*

This paper describes an experiment to extract the dynamic nonlinear model of a millimeter-wave communication system with ultra-wideband signal. The device under test consists of a pair of 60 GHz RF transmitter and receiver and the wireless channel between them. Input and output signal used to extract the behavioral model are baseband signals before imported to the transmitter and after demodulated by the receiver, respectively. The experiment is based on QPSK modulated signal with 200MHz bandwidth and 4.6dB peak-to-average power ratio (PAPR). With a model prototype of joint memory polynomials (JMPs), the normalized mean square error (NMSE) between the simulation and measurement output reached -22.4dB. To the authors' best knowledge, this is the first public of a behavioral model with such wideband signal.

P2-19

A Compact K-band FDD Transceiver Front-end

T. Chen, C. Yang, Y. Liu, X. Tang, *University of Electronic Science and Technology of China, Chengdu, China*

A compact K-band FDD transceiver front-end is implemented using Hybrid Integrated Circuits (HICs) technology. All devices are mounted on Rogers 4350 substrate with low cost Surface Mounted Technology (SMT). The K-band transceiver can transmit 13 dBm and receive -60 dBm to -20 dBm RF signal from 21.2 GHz to 23.6 GHz. With outside duplexer it can operate at full Frequency Division Duplex (FDD) which is very flexible in point-to-point radio communication systems. The whole module is boxed in a 230 mm×100 mm×8.5 mm metal cavity and the whole DC power consumption is only 10.2 Watt.

P2-20

Improved 'THz Torch' Technology for Short-range Wireless Data Transfer

F. Hu, S. Lucyszyn, *Imperial College London, London, United Kingdom*

This paper reports recent developments in the 'THz Torch' technology, for short-range wireless data transfer. The ultra-low cost 'THz Torch' concept was recently introduced as an ultra-secure non-contacting technology in the physical layer. Previous results reported a 10 bits/s link over a single channel, across a distance of 1 cm. In this paper, some fundamental limitations of this technology are analyzed and potential methods are proposed to further increase the data rate and working distance of the communications link. The improved single-channel system demonstrates a bit rate of 380 bits/s over a 1 cm range, which presents a factor of 38 improvement.

P2-21

Study of Amplification Stage Limitation of Rotary Traveling Wave Oscillators

M. Aidoo[1], Z. Xie[1], N. S. Dogan[1], H. Savci[1], P. Roblin[2], [1]*North Carolina A&T State University, Greensboro, United States,* [2]*Ohio State University, Columbus, United States*

In this work, an explanation for the frequency limiting factor through analysis and board level implementation of Rotary Traveling Wave Oscillator (RTWO) is proposed. We also established and demonstrate the relation between frequency limit and the amplification stage. To utilize RTWO for high frequency application, it was realized that, varying the ring size to achieve high frequency signals is governed by a length threshold which when exceeded contribute to signal instability and in some cases the possibility of no oscillation.

P2-22

Wideband High Gain 1-D EBG Resonator Antenna

N. Wang[1,2], L. Talbi[2], Q. Zeng[3], J. Xu[1], [1]*Northwestern Polytechnical University, Xi'an, China,* [2]*Université du Québec en Outaouais, Gatineau, Canada,* [3]*Communications Research Centre Canada, Ottawa, Canada*

This paper describes a technique to enhance the radiation bandwidth of the 1-D EBG resonator antenna. By adding one slab with a properly chosen dielectric constant underneath the other one, the 3dB gain bandwidth of the antenna is considerably increased. The proposed method is analyzed based on a transmission-line model and verified by simulations. It is shown that the antenna designed for verification achieves a 30% half gain bandwidth through 13.7GHz to 18.6GHz with a maximum gain of 14.8dBi, and also possesses a 34% impedance bandwidth for the voltage standing wave ratio less than 2 through 13.4GHz to 18.8GHz that covers the whole radiation bandwidth, as well as very low side lobes and cross-polarizations.

P2-23

A High Gain, Wide Band (2-10 GHz), and Low Noise Active Balun Merged Folded Mixer for the Full-Band UWB Application

X. Zhang, X. Cui, B. Wang, C. Lee, *Peking University Shenzhen Graduate School, Shenzhen, China*

A high gain, wide band (2-10GHz) but low noise mixer is presented and demonstrated. It uses a Gilbert type folded structure with an active balun as the input trans-conductance stage and a PMOS switch stage. Because of the structure, each stage can be separately set its bias current to achieve high gain and low noise. The implemented circuit in the 0.18um CMOS technology exhibits a high conversion gain (CG), 17.6dB at 4GHz and 8.1dB at 10GHz, a SSB noise figure (NF) of 15.6dB, an IIP3 of -3.4dBm to +2dBm, and an isolation of RF-LO of -144dB. The mixer power consumption is about 7.8mW under a 1.8V power supply.

P2-24

Wide Dyanmic Range 2nd Order Nested Envelope Tracking Power Amplifier with GaN Modulator

Z. Wang, *Nokia Siemens Networks, Beijing, China*

In this paper, a wideband envelope tracking base-station power amplifier with a 2nd order nested scheme utilizing GaN devices for both linear and current source array was presented, which boosts envelope tracking power amplifier efficiency over wide dynamic range. Tuneable peak efficiency points in the 1st order nested structure make a flexible efficiency adaptation for various wideband modulated signal besides efficiency boosting. Further, the 2nd order nested scheme was proposed to enhance power saving mode for base station, e.g. LTE/LTE-A, reducing the OPEX by lower power operation according various traffic profiles.

P2-25

A Broad/Dual-band Terahertz Metamaterial

W. Guo[1,2], L. He[1], X. Sun[1], [1]*Shanghai Institute of Microsystem and Information Technology, Shanghai, China,* [2]*Graduate University of Chinese Academy of Sciences, Beijing, China*

The design, fabrication and measurement of a broad/dual-band terahertz (THz) metamaterial based on gallium arsenide substrate are presented. The proposed Modified Split-Ring Resonator (MSRR) provides two distinct strong electrically resonances near 0.515 THz and 0.74 THz. Effective medium parameters show negative values of permittivity during two broad frequency bands of 0.492-0.693 THz and 0.727-0.811 THz. Measured results obtained from the Terahertz time-domain spectroscopy (THz-TDS) show good agreement with the simulation results. This metamaterial is expected to enhance the realization of broadband and multi-band functional materials and devices in THz regime.

P2-26

High Sensitivity RF Energy Harvesting from AM Broadcasting Stations for Civilian Infrastructure Degradation Monitoring

X. Wang, A. Mortazawi, *University of Michigan, Ann Arbor, United States*

In this paper, a high sensitivity RF energy harvester is presented with a potential application in powering wireless sensors for monitoring the degradation of civilian infrastructures. The harvester captures the ambient energy transmitted from the AM broadcasting stations and provides dc power to a sensor. The harvester discussed here can operate at input power levels as small as-39 dBm and generate a dc output voltage of ~2.5 V. Efficiency of the system is measured to be over 60% under the specified input condition.

P2-27

Performance Analysis on Wireless Communication System with Harmonic Frequency Channels Concept

P. Cheong[1], K. Wu[2], D. Deslandes[3], K. Tam[1], [1]*University of Macau, Macau, Macau,* [2]*École Polytechnique de Montréal, Montreal, Canada,* [3]*University of Quebec in Montreal, Montreal, Canada*

This paper presents a new concept of simultaneous data transfers with existence of multiple harmonic frequency channels. This proposed harmonic communication system reuse the intermodulation products generated by the intrinsic property of nonlinear devices, primarily the up-/down-converting mixers in the transceiver. In this case, duplicated data can be transferred through multiple frequency channels. Moreover, compact multiband components can be used to replace those single-band circuits in conventional multiband systems and therefore limiting the cost of such transceiver. In theoretical analysis, the optimal signal-to-noise ratio (SNR) performance can be enhanced by 3-dB whenever the number of frequency channels is doubled. As the consequence, the bit-error-rate (BER) performance can be improved, or in another point of view, the minimum required SNR for the receiver can be relaxed. The simulation results show good agreements with the theoretical ones.

WE4A: RF Nanotechnologies for Next-Generation Wireless Communication

Wednesday, 17 April 2013

Room: 311A

Chair: Erping Li, *Institute of High Performance Computing, A*STAR*

Co-Chair: Dominique Baillargeat, *University of Limoges*

New nano-materials, graphene nanoribbons (GNR) and Carbon nanotubes (CNT) exhibit unique electrical and mechanical properties. The recent researches demonstrated the potential applications in RF devices in wireless communication such as microwave, millimeter-wave and THz. This focus session presents the latest research results on high-performance carbon nanodevices for RF applications. The topics cover issues ranging from epitaxial graphene production technology, GNR based passive and active electronic devices, CNT sensing, to recent advances in modelling.

WE4A-1 1540 – 1605

Graphene Resonant Channel Transistor

Y. Xu, O. Li, R. Xu, *University of Electronic Science and Technology of China, Chengdu, China*

Two kinds of doubly clamped beam graphene resonant channel transistors (RCTs) with local gate configurations, fabricated by direct exfoliation and transfer are presented in this paper. The RCTs are actuated and detected directly by using a vector network analyzer. And the measurement results show that the exfoliation RCT and transfer RCT have resonant frequencies of ~34MHz at 77K and ~88MHz at 300K, respectively. The operation principle of radio frequency (RF) RCT is detailed in this paper. And a compact electrical equivalent circuit model has been given out based on the analysis of electromechanical model of doubly clamped beam and field effect transistor theory. The results show that excellent agreements have been achieved between the experimental results and the simulation results. With the proposed compact model, the RCTs can be useful for developing high sensitivity sensor, or in the perspective of high quality RF filters by using graphene nano-electromechanical systems(NEMS).

WE4A-2 1605 – 1630

Analysis of Signal Transmission along Graphene-Based Interconnect Structures

Y. Xu, X. Wei, E. Li, *Zhejiang University, Hangzhou, China*

The signal transmission along interconnect based on graphene nanoribbon (GNR) is studied in this paper. Equivalent circuit models are implemented to characterize the signal integrity of graphene-based interconnect. In the equivalent circuits models, the inter-layer mutual impedance (capacitance and inductance) between adjacent layers has been taken into consideration. Meanwhile, we proposed both equivalent circuit and full-wave method to analyze the effects of bended part of graphene-based interconnect. With the help of equivalent circuits, input/output voltage of different interconnect structures is explored. Moreover, eye diagram is utilized for further study of several kinds of graphene interconnects' signal integrity.

WE4A-3 1630 – 1655

Near Field Coupling and its Application to Plasmonic Devices

Z. Liu, D. Li, E. Li, *A*STAR, Singapore, Singapore*

The near field coupling effect between a metallic nanostructure and a superlens has been studied numerically. It is found that the coupling effect is significant and the field distribution is altered substantially by it. This effect has a wide range of potential applications, for example using this effect in plasmonic nanostructures we can design devices with novel functionalities, such as a nanoatenna-superlens system with mismatched permittivities.

WE4A-4 1655 – 1720

Carbon-Nanotube-Based RF Components with Multiple Applications

P. Franck[1,2], C. Yap[1,3], C. Brun[1,2], S. Pacchini[1,3], W. Chow[1,3], H. Li[1,3], D. Baillargeat[1], B. Tay[1,3], *[1]CINTRA , Singapore, Singapore, [2]XLIM , Limoges, France, [3]Nanyang Technological University, Singapore, Singapore*

Owing to their extraordinary electronic properties, carbon nanotubes (CNTs), as a building block, promise superior performance and novel functionalities for microwave electronic components. This review presents some of the last results obtained in three different fields of this fast moving area - antennas, interconnects and sensors. Electromagnetic and analytical models are used to evaluate and optimize component performance. Synergy between fabrication and simulation techniques allows the practical design of bundled-CNTs-based components. Opportunities are discussed from the fabrication of CNT materials (PECVD, CVD) to their implementation in components and systems by specific technological processes (Photolithography, Flip-Chip, Ink-jet printing, etc.). Actual performance of fabricated prototypes and expected improvement based on the CNTs implementation are presented.

IWS 2013 CLOSING SESSION

Wednesday, 17 April 2013

1730-1845

Room 309, China National Convention Center

Dr. Richard V. Snyder
President, *RS Microwave, Past President Microwave Theory and Techniques Society*

"The Golden Link"

Abstract: This talk will discuss the parallel between IWS and the early days of railroads in the United States, when many Chinese workers were involved in completing the transcontinental rail line linking East to West. When the rail line was completed, the final link was one made of gold, and it signified the economic revolution expected because of the new-found ease for the transportation of goods and services across the continent. Today, we have the brand-new International Wireless Symposium (IWS), an IEEE and CIE event also providing a potentially golden link for moving microwave technology, services and products readily to and from East and West, i.e. between China and not-China! I will pay tribute to the past but will anticipate the future, a time when technical achievement will be found anywhere and everywhere; a future in which technologists located anywhere and everywhere will easily share game-changing findings and developments. The result will be a commercial boon for everyone, the profitable exchange of products for the mutual good of humanity.

Biography: Richard V. Snyder is President of RS Microwave (Butler, NJ, USA), author of 89 papers, three book chapters and holds 19 patents. Dr. Snyder received his BS, MS and PhD degrees from Loyola-Marymount, USC and Polytechnic Institute of New York. In January 1997, he was named a Fellow of the IEEE and is now a Life Fellow. In January 2000, he received the IEEE Millennium Medal. He served as an MTT-S Distinguished Lecturer, from 2007-2010 and he was elected as MTT-S President for 2011. Dr. Snyder's vision of partnership with the RF & Microwave Community in China culminates with the realization of the first IWS in 2013, for which he serves as a key organizer and advisor. He is a member of the American Physical Society, the AAAS and the New York Academy of Science. Dr. Snyder teaches and advises at the New Jersey Institute of Technology and is also a Visiting Professor at the University of Leeds, in the U.K. He previously was Chief Engineer for Premier Microwave.

Greg Peters
Vice President and General Manager, *Agilent Technologies*

"Microwave Techniques and Technologies: A Bright Future"

Abstract: The application of microwave techniques and technologies have a bright future. This talk will examine the factors that enable new applications and opportunities and will create a bright future for those that are willing to invest.

Biography: Greg Peters started his career with Hewlett-Packard in 1984 and has held a variety of positions in the test and measurement industry. In his current role as Vice President and General Manager at Agilent Technologies Greg interacts frequently with industry leaders in the semiconductor, wireless and aerospace defense industries. Greg holds a bachelor's degree in electronics engineering from Iowa State University, an MBA from the University of Colorado, and has taken executive education classes from Harvard University.

SUNDAY WORKSHOPS

WS1: Sunday, 14 April 2013 Half Day: 0830 – 1230 Room 308

THz Material Growth, Device Fabrication, and Modeling

Organizers: Dr. Morgan Chen, *Huawei Technologies*
Prof. Milton Feng, *University of Illinois, Urbana-Champaign*

Abstract: Recent advances in THz regime offer new possibilities in the areas of biological molecular DNA identification, instrumentation, imaging for medical and security, and communications. Current applications use expensive, non-scalable techniques for existing THz systems. In order for this technology to mature, advances at device level need to occur. This workshop will describe the latest research results on THz devices. Topics will include growth, bandgap engineering, modeling, and characterization techniques on THz devices including InAs QW FETS on GaAs, HBTs on InP, III-V HEMTs, and carbon-based active devices.

Speaker List:
1. Prof. Jen-Inn Chyi, *National Central University - MBE Growth of InAs QW FETs on GaAs*
2. Dr. Barry Wu, *Agilent - Material Growth/Characterization for THz HBT*
3. Prof. Milton Feng, *University of Illinois, Urbana-Champaign - THz HBT Transistor and Modeling*
4. Prof. Jesus del Alamo, *Massachusetts Institute of Technology - THz III-V HEMT Technology*

WS2: Sunday, 14 April 2013 Half Day: 0830-1230 Room 311B

Measurement Developments for Future Wireless Technologies

Organizers: Liu Xinmeng, *National Institute of Metrology, NIM*

Abstract: Emerging Wireless Technologies have an impact on nowadays microwave characterization technologies, the change in paradigm from analog to digital and from RF to DC, has a strong impact in the way nonlinear microwave characterization is seen. This workshop introduces some important measurement developments for modern wireless technologies.

Speaker List:
1. Metrology Developments for Future Wireless Technologies - Prof. Nuno Borges Carvalho, *Universidade de Aveiro*
2. Application of Microwave Photonics to Future Broadband Wireless Systems: Implications or Measurement- Prof. Stavros Iezekiel, *University of Cyprus*
3. Towards Greener Smartphones with Microwave Measurements - Prof. Dominique Schreurs, *Ku Leuven*

WS3: Sunday, 14 April 2013 Half Day: 1330-1730 Room 308

Wireless Chip Development and Entrepreneurial Efforts in China

Organizer: Patrick Chiang, *Oregon State University, Fudan University*

Abstract: Fabless semiconductor companies, in both the US and in China, have seen disappointing results over the past decade.
However, there have been a few notable successes within China, such as Spreadtrum, RDA, and HiSilicon. This panel will discuss some of the unique challenges and advantages for starting a fabless company in China, such as government incentives, time-to-market, IP protection, labor pool, and access to customers.

Speakers List:
1. Prof. Zhihua Wang (*Tsinghua University*)
2. Dr. Ting Wu (*Norel Systems*)
3. Dr. Joy Laskar (*InSite Partners*)
4. Prof. Patrick Yue (*HKUST*)

WS4: Sunday, 14 April 2013 — Half Day: 1330-1730 — Room 311B

Recent Advances in mmW, Submmwave and THz MMICs for Novel System design

Organizer: Herbert Zirath, *Chalmers University*

Abstract: Diode based electronics has been the dominating technology for mmW/THz systems for decades, but is however now challenged by recent achievements in transistor based technologies such as InP HEMT, GaAs mHEMT, and InP DHBT. By using transistor based technologies, 'system on chip' solutions are now feasible at frequencies approaching 1 THz. Schottky diode based technologies has also been developed towards higher integration level, and super heterodyne receivers well above 1 THz have been demonstrated. For successful implementation of THz systems towards commercial applications, a low-cost packaging technology has to be developed. The purpose of this workshop is to present the status of different technologies which can play a role in future 'THz'-systems, including the role of the packaging.

Speakers List:

1. "Schottky Diode based Thz Electronics: Recent advances and Challenges" - Imram Mehdi, *JPL*
2. "mHEMT based THz MMICs" - Michael Schlechtweg, *Fraunhofer Institute for Applied Solid State Physics IAF*
3. "Recent development of InP based DHBT MMIC for millimeterwave/submmWave systems" - Herbert Zirath, *Chalmers University of Technology*
4. "Radiometers for Space-applications" - Anders Emrich, *Omnisys Instruments AB*
5. "Modern THz instrumentation for space science utilizing SIS and HEB devices" - `Vincent Desmaris/Victor Blitsky, *Chalmers University of Technology*
6. "SiGe: C Devices and MMIC's for Active Safety Systems" Franz Dielacher, *Infineon*`

WS5: Sunday, 14 April 2013 — Full Day: 0830-1730 — Room 309AB

Power Amplifiers for Next Generation Cellular Communication

Organizers: Yi-Jan Emery Chen, *National Taiwan University*
Nick Cheng, *Skyworks Solutions*

Abstract: The convenience and versatile applications associated with mobile communication render the technology evolving rapidly to quench the thirst for higher date rate. The latest deployment of the mobile communication infrastructure and market driven features place more requirements on RF power amplifier design in addition to output power, efficiency, and linearity. This workshop features the speakers from both industry and academia sharing their views of future design challenges for RF power amplifiers and detailing their solutions to these issues. The presentation will cover the research and advancement on several fronts, including cost effective PA development, high efficient PA architecture, multi-band multi-mode PA approach, linearization technique, and new challenge and requirement for LTE PAs.

Speakers List:

1. "Development and challenges for integrated CMOS PA and transceiver development" - Joy Laskar, *InSite Partners*
2. "Front-End Solutions for Smart Phones in Emerging Economies" - Reza Kasnavi, *Skyworks*
3. "Operation of a Highly Efficient Saturated Amplifier" - Bumman Kim, *Pohang University of Science and Technology*
4. "Requirements for Next Generation Handset PA Design from a System Perspective" - Xiangfang Mu, *Apple*
5. "Challenges and Solutions for Next Generation Cellular Infrastructure Doherty Amplifiers" - Joe Staudinger, *Freescale*
6. "Enhanced Outphasing Amplifiers" - Leo de Vreede, *TU Delft*
7. "Wireless Infrastructure PA trends and Digital Predistortion Systems" - Lei Ding and Roland Sperlich, *TI*
8. "Design Considerations and Challenges for Multimode Multiband Handset PA Modules"- - Nick Cheng and James Young, *Skyworks*

WS6: Sunday, 14 April 2013 — Full Day: 0830-1730 — Room 311A

Wireless Power Transfer Technologies

Organizers: Franklin Bien, *UNIST*

Abstract: Wireless power transfer (WPT) is a breakthrough technology to provide the energy to communication devices without the power units. With the remarkable progress being made recently, this technology has been attracting a lot of attention of scientists, engineers and R&D firms around the world. The concept of WPT traces back to the early 20th century when Nikola Tesla patented several techniques by which power could be transmitted. However, there was never strong demand for it due to the lack of applicable market such as charging a portable consumer electronics devices. Recently, the usage of mobile appliances such as cell-phones, PDAs, laptops, tablets, and other handheld gadgets, equipped with rechargeable batteries has been widely spreading. Additionally, environmentally friendly cars are being equipped with rechargeable secondary batteries that could benefit from WPT technologies. In this workshop at IWS 2013, fundamentals and theories that could facilitate the WPT technology is widely covered.

Speakers List:

1. "Magnetic Resonance Power Transmission to Small and Mobile Objects"- Mr. Takashi Komaru (*Denso Corporation, Japan)*
2. "Will Nonlinear Resonators Break the Performance Boundary of Conventional WRELs?"- Prof. Hisayoshi Sugiyama (*Osaka City University, JAPAN)*
3. "Magnetically Coupled Resonance Wireless Power Transfer (MR-WPT) with Multiple Self-Resonators"- Dr. Youngjin Park (*Korea Electrotechnology Research Institute-KERI, Korea)*
4. "Maximum Power vs Maximum Efficiency of Inductive power transfer systems" - Prof. Dai Xin (*Chongqing University, Chongqing, China)*
5. "Design of Wireless Power Supply System for Portable Mobile Device"- Prof. Xueliang Huang (*Dean, College of Electrical Engineering, Southeast University, China*)

SUNDAY SHORT COURSES

SC3: Sunday, 14 April 2013 1330 – 1630 Room: 310

Microwave Measurement Techniques In A Wireless Transceiver Design Cycle

Instructor: Prof. D. Schreurs (KU Leuven, *Belgium)*

Syllabus: The aim of the short course is to understand how microwave measurements are being adopted in the design cycle of an energy-efficient transceiver aimed for wireless applications. The course starts off by explaining the purpose of the various microwave measurement techniques, such as S-parameter measurements, noise figure measurements, loadpull measurements, modulated measurements, and vector large-signal measurements, in connection to both microwave transceiver design and design verification. Next, the attendees will gain insight in the architecture of the respective instrumentations, as well as in the corresponding calibration and, where applicable, de-embedding techniques. Finally, concrete examples will be provided, such as how to characterise multi-mode amplifiers and how to facilitate high-efficiency circuit design by adopting large-signal measurements.

This Short Course is the tutorial version of the instructor's DML talk "Towards greener smartphones with microwave measurements".

Learning objectives:

- Being able to know when to use which type of measurements in a transceiver's design cycle
- Having a high-level understanding on the architecture of microwave measurement instrumentation
- To understand the concepts and procedures of calibration and de-embedding

Method of presentation:

- Lecture using powerpoint slides.
- Hands-on material: it is planned to team up with one or more instrument manufacturers in order to borrow some hands-on material that they bring over for the exhibition.

Materials: Pdf file of powerpoint slides

Instructor biography:
Prof. D. Schreurs is full professor at KU Leuven, Belgium. As post-doc fellow, she was visiting scientist with Agilent Technologies (USA), Eidgenössische Technische Hochschule Zürich (Switzerland), and the National Institute of Standards and Technology (USA).

Prof. D. Schreurs is IEEE Fellow. She serves on the IEEE MTT-S AdCom since 2009, and is currently the Chair of the MTT-S Education Committee. She was Chair of the IEEE MTT-S Technical Committee on Microwave Measurements (MTT-11) in 2005-2008. She is Distinguished Microwave Lecturer for the period 2012-2014, and she is also Associate Editor of the IEEE Microwave and Wireless Components Letters.

Beyond IEEE, Prof. D. Schreurs also serves on the Executive Committee of the ARFTG organization. She was the organiser of the annual ARFTG/NIST Short Course on microwave measurements in 2007-2011. She was also the General Chair of the Spring ARFTG Conference in 2007 and 2012. In 2002, she was one of the initiators and is now still co-organizer of the successful NVNA Users' Forum, held 3 times/year.

Prof. D. Schreurs is reviewer for the IEEE MTT-S journal publications as well as for several MTT-S (co-)sponsored conferences. Prof. D. Schreurs is co-editor of two books, contributor to seven books, and (co-)author of about 100 journal papers and 300 contributions at international conferences.

Instructor contact information:
Prof. D. Schreurs
KU Leuven, Belgium
e-mail: dominique.schreurs@ieee.org

THURSDAY WORKSHOPS

WS7: Thursday, 18 April 2013 — Half Day: 0830-1230 — Room 308

THz Packaging Integration Technologies

Organizers: Dr. Morgan Chen, *Huawei Technologies*

Prof. Milton Feng, *University of Illinois, Urbana-Champaign*

Abstract: THz frequencies have been used for decades for imaging and high-resolution spectroscopy. In order for THz technology to mature, packaging integration advances need to occur to achieve lower costs, smaller footprints, and higher functionality. This workshop will describe the latest research results on THz packaging integration. Topics include design of THz substrate integrated waveguides, THz resonators and antennas based on carbon nanotube, development of a 280 GHz CMOS 4x4 phased-array with on-chip radiators, and silicon micromachining for THz horn and lens antenna architectures.

Speakers List:

1. Prof. Ke Wu, *Ecole Polytechnique de Montreal, and Prof. Wei Hong, Southeast University - Design of Substrate Integrated Waveguides for mmW and THz*
2. Prof. Lin-Sheng Wu, *Shanghai Jiao Tong University - Carbon-nano-based antenna and resonator for THz application*
3. Dr. Kaushik Sengupta, *Princeton University - Fully integrated THz circuits and Systems in Silicon*
4. Prof. Goutam Chattopadhyay, *Jet Propulsion Laboratory - Silicon Micromachined Integrated Array Instruments at Terahertz Frequencies*

WS8: Thursday, 18 April 2013 — Half Day: 0830-1230 — Room 311B

Advanced Modeling Techniques for Carbon-Based RF and THz structures

Organizer: Prof. Wen-Yan Yin, *Zhejiang University, Shanghai Jiao Tong University*

Abstract: This workshop will be focused on some advanced modeling techniques for carbon-based RF and THz structures. It consists of five parts as given as follows:

Speakers List:

1. "Carbon-Based Nanoelectronics: Device Physics, *Modeling, and Simulation"- Prof. Jin Guo, University of Florida, USA*
2. "Electronic Design Automation for Nano- Integrated Circuits"- Prof. ERPING LI, *RF and Nanoelectronic Research Centre, Zhejiang University, China*
3. "Electrodynamics and Quantum Transport in Graphene Nanoribbon devices"- Prof. Luca Pierantoni, *Università Politecnica delle Marche*
4. "Development of Lumped-element Circuit Models for Carbon-based Passives and Actives for RF/THz Applications"- Prof. Wen-Yan *YinCenter for Optical and Electromagnetic Research, Zhejiang University, CHINA; Center for Microwave and RF Technologies, Shanghai Jiao Tong University, CHINA*

WS9: Thursday, 18 April 2013 — Half Day: 0830-1230 — Room 309AB

E-Band Technologies and Applications

Organizers: Prof Xiao-Wei Sun, *CAS SIMIT, China*
Prof Y. Jay Guo, *CSIRO, Australia*

Abstract: Multi-gigabit wireless applications include backhaul and distributed antenna systems for the future mobile communications systems, enterprise connectivity, remote data storage and the short range wireless personal area networks (WPAN). The recent allocation of the E-band spectrum (71-76 and 81-86 GHz) in USA, Europe, Russia and Australia provides an opportunity for line of sight (LOS) links with medium range and high data rates, ideally suited for fiber replacement and backhaul applications. Current E-band commercial point-to-point wireless links are limited to speeds up to a few Gbps and use simple modulation techniques like amplitude shift keying (ASK) or binary phase shift keying (BPSK) with spectral efficiencies typically below 1 bit/s/Hz.

The purpose of this workshop is to present the market needs, the state of art and emerging technologies of E-Band communications systems. In particular, the workshop will be focused on spectral efficiency improvement, core chipsets, high power amplifiers, Giga-Bit signal processing, and system architecture.

Speakers List:

1. "On the Development of E-Band MMIC Design in Simit"- Jian Zhang, *Professor / SIMIT, CAS,*
2. "High Speed E-Band Wireless Communication Systems"- Xiaojing Huang, *Research Team Leader / CSIRO, AUS*
3. "A Multi-gigabit Signal Processing Technologies for Next Wireless Communication System"- Yueguang Rong, *Professor / UESTC*
4. "16-QAM-based E-band communication system with bit rate up to 10Gbps"- Woo-Jin Byun, *PhD/Director/Principal Researcher / ETRI, Korea*
5. "Millimeter-wave for future mobile networks"- Yinggang Li, *Senior Specialist / Ericsson*

WS10: Thursday, 18 April 2013 Half Day: 1330-1730 Room 308

Computational Multi-physics Methods and Applications for Advanced RF Micro/Nanoelectronic Devices and Interconnects

Organizers: Prof. Wen-Yan Yin, *Zhejiang University, Shanghai Jiao Tong University*

Abstract: Advanced RF Micro/Nanoelectronic Devices and circuits are inherently multi-physics in nature. Electrical analysis, in particular, does not exist in its isolation since interaction between multiple domains is required. Rather, other physical effects, like heat transfer and even mechanical stress, can have a large impact on their performance. For this reason, R&D of advanced RF micro/nanoelectronics devices, circuits and systems are now adopting tools that can help innovate beyond the more traditional limited scope of electromagnetics-only simulation tools, with all relevant physical field effects treated in some appropriate way.

This workshop will be focused on the presentations of several computational multi-physics methods and their successful applications for various RF micro/nanoelectronics devices, interconnects and circuits made of different materials, miniaturized passives with high performance, thin film active devices and 3-D interconnects or 3-D transmission structures arising in high density 3-D integration for wireless communication. Also, fundamental physical principles changing with scales will be introduced and discussed. From high frequency asymptotic approximation to quasi-static modeling, from classical electromagnetic phenomena to surface plasma and Casmir force, from electrical simulation to electrical-thermal co-simulation, this talk intends to review several key physical phenomena and corresponding mathematical models emerging from RF micro/nanoelectronics.

Speakers List:

1. "Computational Multi-physics Methods for Micro/Nanoelectronic Devices and Circuits" - Prof. Wen-Yan Yin, *Center for Optical and Electromagnetic Research, Zhejiang University, Center for Microwave and RF Technologies, Shanghai Jiao Tong University*
2. "Multi-scale and Multi-physics modeling: Their role in Integration"- Prof. M. Swaminathan; Joseph M. Pettit, *Professor in Electronics, Director, Interconnect and Packaging Center, School of Electrical and Computer Engineering, Georgia Institute of Technology*
3. "Scale with the Frequency?" - Prof. L.J. Jiang, *Dept. of Electrical and Electronic Engineering, The University of Hong Kong*
4. "Modeling of silicon devices used in mm-wave circuits" - Prof. Kai Kang, *School of Electronic Engineering, University of Electronic Science and Technology of China*
5. "Multi-physics Characterization of Reliability of RF Semiconductor devices" - Prof. Liang Zhou, *Key Laboratory of Ministry of Education of Design and Electromagnetic Compatibility of High Speed Electronic Systems, Center for Microwave and RF Technologies, Shanghai Jiao Tong University*

WS11: Thursday, 18 April 2013 Half Day: 1330-1730 Room 311B

White Space and Cognitive Radio: Technology and Market Opportunities

Organizers: Dr. Kyutae Lim, *Georgia Institute of Technology*

Abstract: The most obvious challenge for wireless and IT industry has been the fact that there is not enough spectrum to deal with mobile data traffic which will continue to grow exponentially. To support the continuing growth of data traffic on mobile networks, the U.S. Federal Communications Commission (FCC) has made unused wireless TV spectrum (commonly referred to as "white spaces") available for open, free and unlicensed use.
The white spaces spectrum is large and in the prime range (50MHz-698MHz). Google views white spaces as "Wi-Fi on steroids" and, Microsoft estimates that the market is worth $100 Billion in equipment and applications revenues. Cognitive Radio is considered as the key technical innovation to enable white space application and services.

In this workshop, various aspects of the white space communication services such as potential markets, status of regulation and standardization, and technical challenges will be presented and discussed.

Speakers List:

1. "Business and Market Impact of White Space"- Kursat Kimyacioglu, *Senior Executive, CTech Information Technologies*
2. "Standardization of White Space"- Dr. S.Yoon, *Senior Researcher, Samsung Electronics*
3. "Cognitive Radio Technology for White Space"- Prof. H. Kim, *Ulsan National Institute of Science and Technology*
4. "Broadband for White Space"- Prof. J. Kim, *Ulsan National Institute of Science and Technology*

WS12: Thursday, 18 April 2013 Full Day: 0830-1730 Room 311A

Digital Techniques for Power Amplifiers Linearity and Efficiency Enhancement

Organizers: Dr. Oualid Hammi, *KFUPM, KSA*
Dr. Wenhua Chen, *Tsinghua University, China*

Abstract: Radio Frequency power amplifiers (PAs) are key components in wireless transmitters as they affect the overall performance in terms of linearity and efficiency. Linearity specifications must be met in order to satisfy the regulatory spectrum emission masks. At the same time, power efficiency needs to be increased not only in order to reduce the capital and operating expenses of wireless communication infrastructure but also to reduce the carbon footprint of wireless communication systems. Thus, enhancing the PA efficiency is an important research avenue that will enable greener communication infrastructure.

Recently, the synergetic design of the RF power amplification stage and the digital signal processing led to high performance amplification systems in a wide variety of configurations such as conventional single input power amplifiers, envelope tracking systems, dual-input amplifiers as well as dual-band PAs. Digital signal processing techniques were successfully used to drive the amplifiers with the appropriate signals that will optimize the linearity and/or emulate power efficient mode of operation.

This workshop will thoroughly cover the various approaches that have been recently proposed for the enhancement of PAs linearity and power efficiency through digital signal processing techniques. It will illustrate how the performances of several power amplification structures can be improved by the use of proper signal processing techniques that can go beyond conventional digital predistortion. In the morning session of this full-day workshop, digital predistortion of single input PAs will be discussed from various aspects. The afternoon session will be devoted to dual-input power amplification systems.

Eight speakers with internationally recognized expertise in the area of power amplifiers design and linearization have agreed to contribute to this workshop as shown below in the list of presentations. The workshop is expected to attract a high number of attendees as this topic is of prime interest to researchers from academia and industry.

Speakers List:

1. "Nonlinear Distortions and Behavioral Modeling for RF Power Amplifiers"- T. Liu, *Ningbo University, China.*
2. "Multi-tone as a Characterization Tool Towards RF Linearisation"- D. Schreurs, *KU Leuven, Belgium*
3. "Single Input Single Output Digital Predistortion Techniques"- O. Hammi, *KFUPM, KSA*
4. "Holistic Procedure for Power Amplifier Nonlinearities Extraction for Digital Pre-distortion"- S. Bensmida, *University of Bristol, UK*
5. "Envelope Tracking Power Amplifiers for Handset Application"- B. Kim, *POSTECH, South Korea*
6. "Advanced Dual-input and Digitally-driven Doherty Power Amplifiers"- F. Ghannouchi, *University of Calgary, Canada*
7. "Digital Predistortion Techniques for Concurrent Dual-Band PAs"- W. Chen, *Tsinghua University, China*
8. "DPD for High Efficiency PAs using Dual-Input Modeling Approach"- C. Fager, *Chalmers University, Sweden*

SC4: Thursday, 18 April 2013 0900-1200 Room: 310

Implantable and Wearable Wireless Medical Devices and Systems

Instructor: J.-C. Chiao

Summary: Radio frequency identification has been utilized to increase efficiency and care quality in hospitals for patient information management, drug and equipment inventory, scheduling and staffing. To further improve healthcare, enabling new diagnosis and treatment while aiming to reduce costs, major technical challenges still exist. Limited sampling and acquisition of physiological parameters during the interaction period for caregivers and patients provide incomplete information about the patients. Better care with higher diagnosis accuracy can be provided if more and time-lapsed data can be obtained without causing patients discomfort or limiting their mobility.

Wireless technologies bring promising solutions to the aforementioned issues. Low-cost portable wireless electronics have made significant impacts to our societies. Furthermore, recent advances in micro- and nano-technologies provide unique interfacing functionalities to human tissues, and advantages such as miniaturization and low power consumption enabling novel applications in medicine and biological studies. Interfaces between biological objects and electronics allow quantitative measurement and documentation of physiological and biochemical parameters, and even behaviors. The interfaces also provide direct control or modification of cells, tissues, or organs by the electrical circuits making it possible to manage chronic diseases with a closed loop between biological objects and computers. With wireless communication, implantable devices and systems make the interfacing possible for freely behaving animals or patients without constrains, discomfort or limits in mobility. This increases the study or diagnosis accuracy in realistic environments as well as permits remote synthesis of physiological functions and delivery of therapeutic treatment.

In this short course, some of the advanced studies of implantable and wearable micro devices and systems designed for medical applications will be discussed.

Syllabus:

- Introduction of general medical applications
- General design and implementation challenges in biomedical applications utilizing RF and wireless communication
- Passive wireless sensors
- Wireless energy transfer
- Active wireless sensors
- Specific application examples:
  1. Endoluminal sensing applications
  2. Wireless body network for feedback mechanisms
  3. Neuronal signal sensing and recording
  4. Integration of treatment methods for chronic disorders
- Potential applications and their issues

Objectives To make audience familiar to the emerging medical applications that utilize wireless communication and wireless power transfer techniques. The objective is to inspire audience's thinking about conventional wireless communication techniques toward the problems in practical medical sensing applications. The outcome aims to give the audience a brief overview about the wireless implants and micro devices as well as the clinical issues.

Method of presentation: Powerpoint slides embedded with animation and videos

Handouts: Powerpoint printout and sampled reference papers

Instructors' biography and Contact Information:

J.-C. Chiao, Ph.D.
Professor of Electrical Engineering, *University of Texas at Arlington*
Adjunct Associate Professor of Internal Medicine, *University of Texas Southwestern Medical Center*
1+817-272-1337
416 Yates St., NH538, Arlington, TX, 76019 USA
jcchiao@uta.edu
http://www.uta.edu/faculty/jcchiao

Biography: J.-C. Chiao is a Janet and Mike Greene endowed Professor and Jenkins Garrett endowed Professor of Electrical Engineering and Joint Biomedical Engineering Program at UT-Arlington, and Adjunct Associate Professor of Internal Medicine at the University of Texas Southwestern Medical Center. Dr. Chiao has been chairs of several international conferences, vice chair for the IEEE MTT-S Technical Committee TC-10 Biological Effect and Medical Applications of RF and Microwave, member/vice-chair/chair in the IEEE International Microwave Symposium, RFMEMS, and Biological and Medical Technology TPRC committees. Dr. Chiao has been with the editorial board of the Journal of Nanomedicine: Nanotechnology, Biology and Medicine; and associate editor for ASME Journal of Nanotechnology in Engineering and Medicine. Dr. Chiao has published and edited numerous peer-reviewed technical journal and conference papers, book chapters, proceedings and books. He holds 5 patents in RF MEMS, MEMS optical, liquid crystal and wireless medical sensor technologies. Dr. Chiao was the recipient of 2011 Lockheed Martin Aeronautics Company Excellence in Engineering Teaching Award; 2011 Tech Titans Technology Innovator Award; 2012 Research in Medicine award in the Heroes of Healthcare; 2011 IEEE R5 Outstanding Engineering Educator; and the 2011 O'Donnell Award in Engineering, nominated by a panel of Texas Nobel Laureates, in The Academy of Medicine, Engineering and Science of Texas.

SC5: Thursday, 18 April 2013 1330-1630 Room: 310

The Time-Domain Transform and its Applications

Course Description: The Vector Network Analyzer (VNA) has become the primary tool of the modern RF and Microwave engineer for characterizing linear and non-linear responses of components, measuring in the frequency domain. But the VNA data can be transformed into the time domain through a special version of the inverse Fourier transform, providing an invaluable tool in analyzing characteristics of the RF circuits. While the transform has been utilized for many years, the theory and applications are not typically found in university courses. This short course will present the complete theory of the time domain transform and its application to RF measurements, derived from special conditions of the inverse Fourier transform. Extensive examples will be used to illustrate applications of the tool.

Method of Presentation: The course will be approximately 25% theory and 75% practical application, with extensive examples via slide presentations and live demonstrations of the principles presented. At the end of the presentation, attendees will be encouraged to reproduce the application results on the live test equipment at the short course.

Associated Material: The attendees will be provided with a copy of the slide presentation and examples (including simulation and real measured results) on a memory stick, along with a detailed 50 page application note on the material.

Objective: The objective of this course is to provide a complete, integrated course on the theory and use of the Time-Domain Transform in VNAs.

Outcomes: After the course, an attendee can effectively and intelligently use this important analysis tool, the next day, to improve measurements and understanding of their components.

Prerequisites: A basic understanding of S-parameters and the behavior of RF and microwave components, such as transmission lines, capacitors, inductors and resistors, and familiarity with the Smith Chart is presumed. No previous knowledge of Fourier transforms is required.

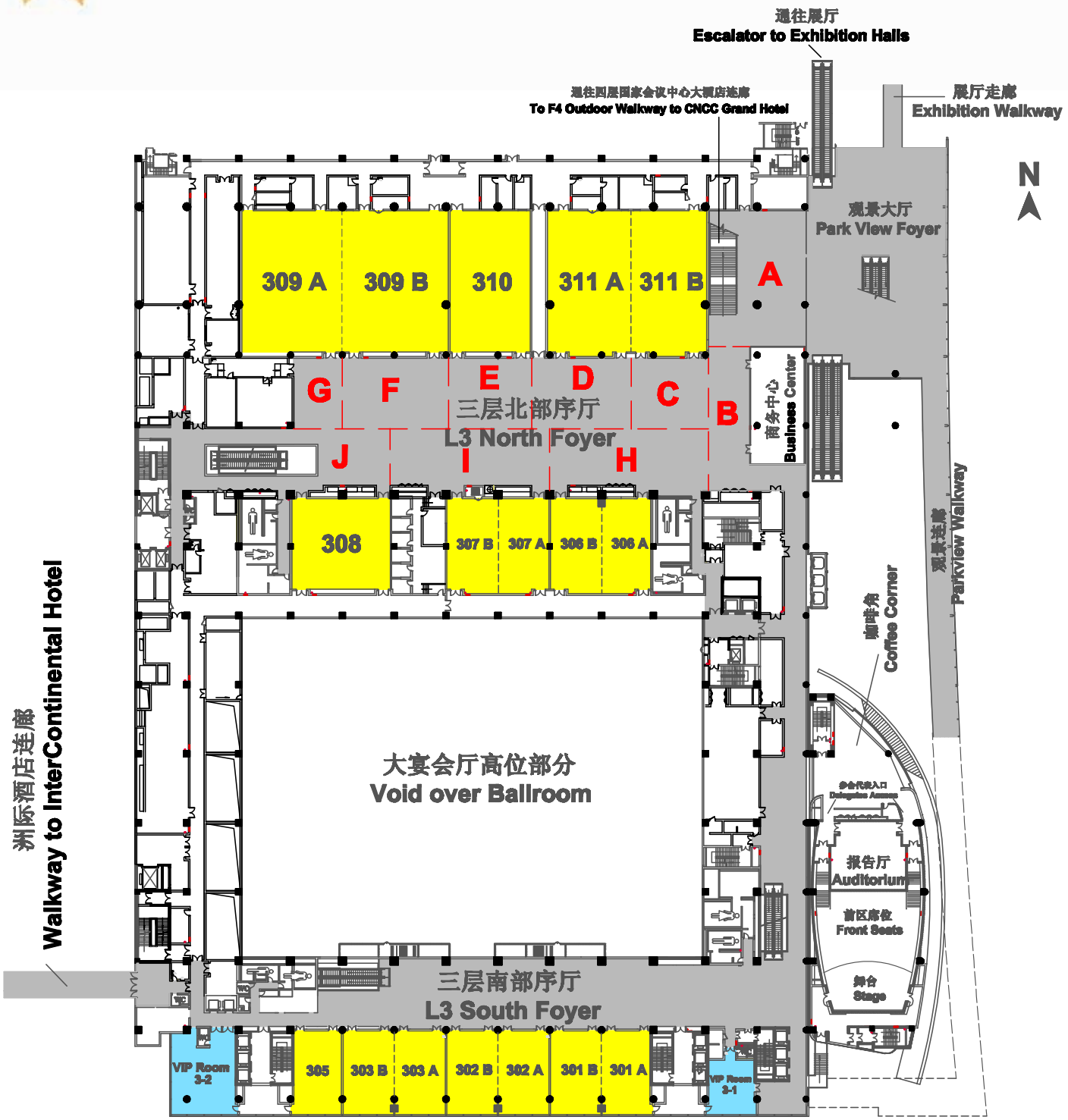
Syllabus: Time Domain Transforms:

- Introduction
- The Fourier analysis of Networks
  The continuous Fourier transform Even and odd functions and the Fourier transform
  Modulation (shift) theorem
- The discrete Fourier transform FFT (Fast Fourier Transform) and IFFT (Inverse Fast Fourier Transform)
  Calculating the DFT
  Chirp Z transform
- Fourier transform (analytic) vs. VNA time-domain transform
  Defining the Fourier Transform
  Effects of discrete sampling
  Effects of truncated frequency
  Windowing to reduce effects of truncation
  Scaling and re-normalization
- Low-pass transforms and band-pass transforms
  Low-pass impulse mode
  DC extrapolation
  Low-pass Step Mode:
  Band-pass mode
- Time-domain gating
  Gating Loss and Renormalization
  Gating Applications and Limitations
- Time-domain transforms of various networks
  Time-domain response of changes in line impedance
  Time-domain response of Discrete Discontinuities
  Time domain responses of various circuits
- The effects of masking and gating on measurement accuracy
  Compensation for changes in line impedance
  Compensation for discrete discontinuities
  Estimating an uncertainty due to masking.
- Time Domain Measurement Examples
  Measure discrete components: Inductors, Capacitors and Resistors
  Characterizing calibration standards using Time Domain
  Cable and Connector Measurements
  Removing connector effects from cable measurements
  Measuring cables loss from one-port measurements
  In-line connector measurements
  Fixture characterization and fixture removal
  Determining residual VNA errors
- Applying Time Domain Transforms to Filter Tuning
  Theory of Filter Reflection Response
  Tuning in the time domain
  Gating and Compensation
  Filter Tuning Application

Instruction Information:

Name: Joel Dunsmore, Ph.D. Affiliation: *Agilent Technologies*
Contact: joel_dunsmore@agilent.com +1-(707)-577-4042

Biography: Since graduating from Oregon State University with an MSEE (1983), Joel Dunsmore has worked for Agilent Technologies (formerly Hewlett-Packard) at the Sonoma County Site. He received his Ph.D. from Leeds University in 2004, where his thesis topic was "The Time-Domain Transform of Coupled-Resonator Filters with Application to Tuning". In 2008 he was promoted to the rank of Agilent R&D Fellow, working for the Component Test Division. He was a principle contributor to the HP 8753 and PNA family of network analyzers, responsible for RF and Microwave circuit designs and measurement methods in these products. Recently, he has worked in the area of non-linear test including differential devices, and mixer measurements. He has received 24 patents related to this work, has published numerous articles on measurement technology, as well as consulting on measurement applications. He has taught electrical circuit fundamentals at the local university and co-taught an RF course at the University of California, Berkeley, and presented several short courses and seminars through ARFTG, MTT, and Agilent. Most recently, he is the author of the newly published the "Handbook of Microwave Component Measurements" (John Wiley, Sept 2012, http://www.wiley.com/WileyCDA/WileyTitle/productCd-1119979552.html).



国家会议中心三层平面图
Floorplan of Level 3
China National Convention Center

IEEE

IWS INTERNATIONAL WIRELESS SYMPOSIUM

20-24 APRIL 2014, XI'AN, CHINA

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IWS 2014- First Call for Papers:

The 2nd IEEE MTT-S International Wireless Symposium (IWS 2014) will be held 20-24 April 2014 in Xi'an , China. This conference is held annually in China to provide an international forum for the presentation and exchange of the latest technical achievements in microwave circuits and hardware and RF systems related to the physical layer aspects of the existing and emerging wireless systems including but not limited to RFID, UWB, 802.15.4, WiGig, ZigBee, 6LoWPAN, Wireless HART, WiMi, WISA, Bluetooth, MIMO, WiMax, 5G and others. IWS 2014 will feature parallel session tracks, workshops and short courses, and technology exhibition showcasing the latest wireless commercial products. More information can be found at www.iws-ieee.org.

The IWS 2014 welcomes submission of new and innovative research/technology development in all areas of wireless systems including:

- Solid State Active and Passive Devices, Characterization, and Modeling
- On-chip, In-package and On-PCB Passive Components
- Signal Generation, Power Amplification, Linearization, and Processing Techniques
- Filter, Transmission Line, MEMS, and Packaging Techniques
- Advanced Satellite Communication Techniques
- Advanced Wireless Transceiver Architectures Techniques
- Emerging THz Circuit Techniques and Applications
- Innovative Antennas incorporating Wireless Circuits and Miniaturized/Metamaterials
- Cognitive, Software-Defined, and Multiband Reconfigurable Radios
- Power Line Communication and Visible Light Communication
- High-speed and Broadband Wireless Backhaul Systems
- Wireless Techniques for Automotive Applications and Intelligent Transportation Systems
- Microwave and Millimeter-wave Radio-Over-Fiber Technologies.
- Advanced Wireless Architecture/System Level Design, Modeling, Beamforming, and Simulation
- Advanced Modulation, Channel Coding, and Signal Processing for SISO, SIMO, MISO, and MIMO
- Wireless Techniques/Systems for Healthcare including Biomedical and Body Area Devices/Networks
- Wireless Energy Transmission and Harvesting
- Wireless Sensing, Positioning, Monitoring, and Imaging Devices and Systems
- Wireless Technology Regulations and Standards
- Public and Government Policy on Wireless Systems
- Wireless Safety Issues
- Green Technologies in Wireless Research and Development

Workshop and Short Course Proposals

Proposals for workshop and short course topics are solicited, and must be received by 19 August 2013. Details on the process and requirements can be found at www.iws-ieee.org.

Paper Submission Instructions

Authors must submit a Summary (not more than 4 pages including figures) electronically using the www.iws-ieee.org web page by 20 October 2013. Authors can indicate their preference for oral or poster presentation format but the Technical Program Committee reserves the right regarding final presentation format decision. Please note that the only accepted file format is PDF.

Submissions will be evaluated for originality, significance of the work, technical soundness, and interest to a wide audience. Authors will be notified by 20 November 2013. Final manuscripts of accepted papers (4 pages in length) must be received by 20 December 2013 to be included in the published Proceedings.

Student Competition Program

All accepted student papers will be considered for Student Paper Award. Details on the Student Competition Program can be found at www.iws-ieee.org.

Technology Exhibition

IWS 2014 features a major commercial exhibition of new technologies, software and equipment, to meet the growing demand for microwave and wireless infrastructure and systems. See www.iws-ieee.org for details.

NOTES

IWS INTERNATIONAL WIRELESS SYMPOSIUM

IEEE MTT-S

展览目录

展览开放时间：2013年4月16日至18日在
中国北京国家会议中心

EXHIBITION CATALOG

Exhibits Open: 16-18 April 2013 in Hall 5
China National Convention Center (CNCC) Beijing, China

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IWS 2013 Exhibiting companies as of 30 January 2013:

参展商名单

2013年1月30日，IWS 2013已确认的参展公司如下：

1603	**Agilent Technologies (China) Co., Ltd.** 安捷伦	Beijing	China	www.agilent.com.cn
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1231	**AMCOM Communications, Inc.** 北京金晟成达科技	Beijing	China	www.jsdelectronics.com
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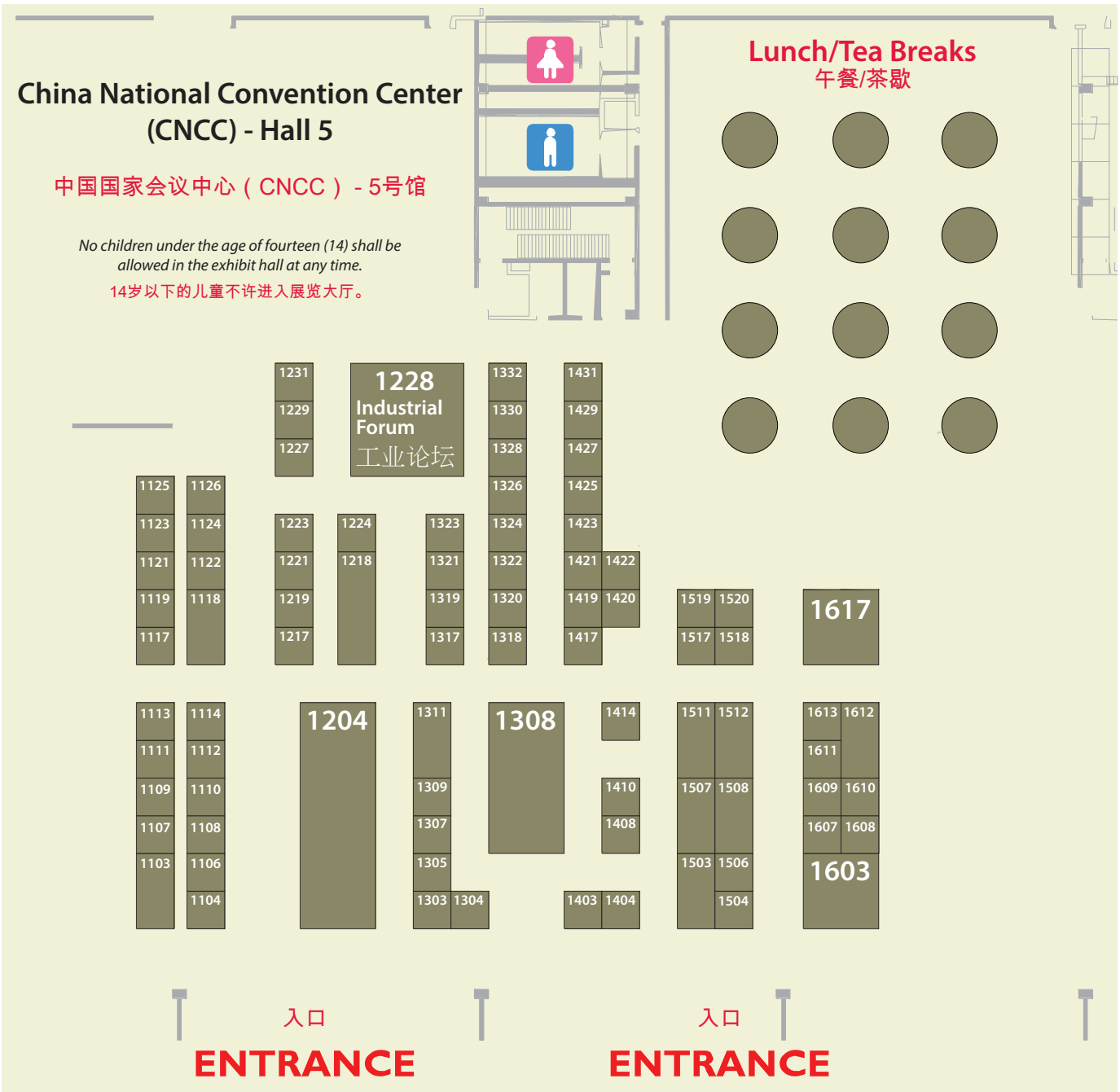
16-18 April 2013 in Hall 5
China National Convention Center (CNCC) Beijing, China

2013年4月16日至18日在
中国北京国家会议中心

Exhibit Hours:

Tuesday, 16 April	1000 – 1700	4月16日星期二，1000–1700
Wednesday, 17 April	1000 – 1700	4月17日星期三，1000–1700
Thursday, 18 April	1000 – 1500	4月18日星期四，1000–1500

展览时间：



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Industrial Forum Session Map

TIME	Tuesday, 16 April	Wednesday, 17 April	Thursday, 18 April
1000-1200	Agilent	Agilent	National Instruments China/AWR
1200-1300	Mini-Circuits	RFMD	
1300-1620	41st CETC	41st CETC	

For more detailed information on industrial forums visit:

All Industrial Forum Presentations will be given at Booth #1228 on the exhibit floor.

工业论坛会议地点地图

TIME	4月16日星期二	4月17日星期三	4月18日星期四
1000-1200	安捷伦	安捷伦	美国国家仪器/AWR
1200-1300	微型电路	射频微波器件	
1300-1620	四十一所中国电子科技集团公司	四十一所中国电子科技集团公司	

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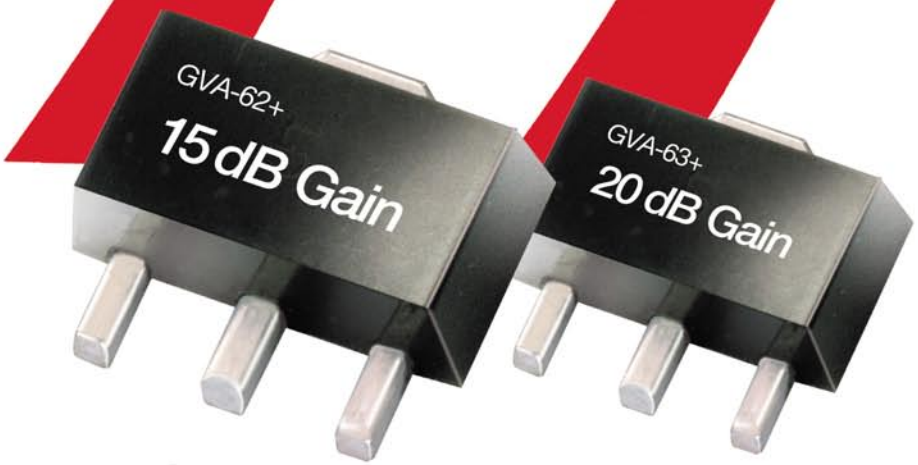

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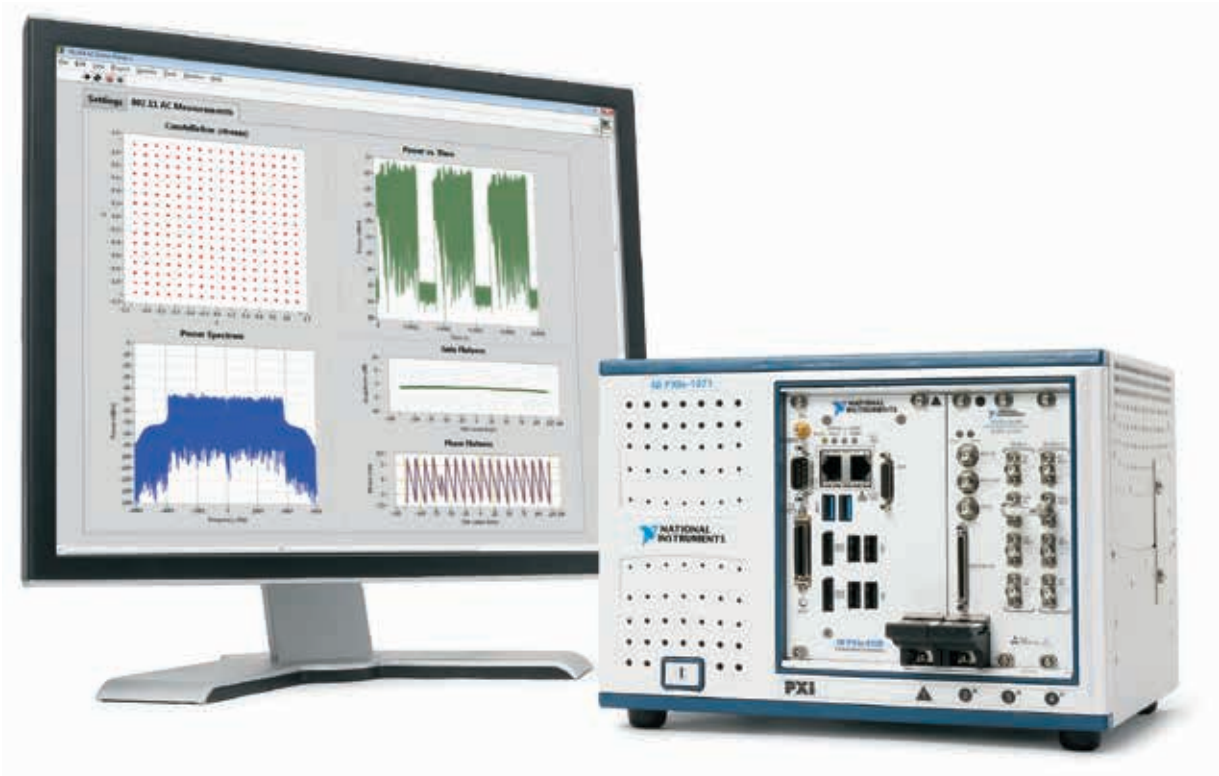

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