# IMWS-Bio 2014

Queen Mary University of London

# IEEE International Microwave Workshop Series
## Final programme and abstracts

**Canary Wharf, London, United Kingdom**
**December 8-10, 2014**

**2014 IEEE MTT-S International Microwave Workshop Series on:**
RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-Bio 2014)

**www.imws2014.org**

IEEE

MTT-S

APS

IET The Institution of Engineering and Technology

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# Conference General Chairs Message


## IMWS2014 General Chairs

Yang Hao
*Queen Mary University of London, UK*
Gianluca Lazzi
*The University of Utah, USA*


## About IMWS-Bio 2014

The 2014 IEEE MTT-S International Microwave Workshop Series on RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-Bio 2014) will be held on 8-10 December 2014 in London UK. The conference is technically co-sponsored by IEEE Microwave Theory and Techniques Society (MTT-S) with Queen Mary University of London (QMUL) being the main organising institute. The meeting is intended to provide an international forum for the exchange of information on state-of-the-art research in bio-electromagnetic, RF and wireless technologies for medical systems and healthcare services and ICT initiative bridging the science of microwave and EM with biomedical applications.
IMWS-Bio 2014 will bring together world-renowned expertise, industrial stakeholders and distinguished speakers who will be invited to deliver keynote speeches on technology trends and significant advances in relevant topics.
The IMWS is an initiative promoted by the MTT-S Members and Geographic Committee, to complement the existing workshops of the MTT-S International Microwave Symposium. The purpose of this new platform is to boost and promote MTT-S technical and educational activities, as well as MTT-S international exchanges and collaboration.

It gives us a great pleasure to welcome all of you to the 2014 IEEE MTT-S International Microwave Workshop Series on RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-Bio 2014) to be held at Hilton London Canary Wharf, London, UK from 8th December to 10th December 2014. IMWS-bio 2014 is being organised and hosted by Queen Mary University of London. This workshop is technically co-sponsored by IEEE, IEEE MTT Society, IEEE AP Society and the IET. We would also like to thank our sponsors and exhibitors specially our Gold Sponsor, CST AG. The organising committee has put together a comprehensive technical program to facilitate the exchange of information on the progress and advancements of RF and wireless technologies for biomedical and healthcare applications, along with a memorable and entertaining social program.

The IEEE IMWS is an initiative promoted by the MTT-S Transnational Committee (now renamed Members & Geographic Committee), to complement the existing workshops of the MTT-S International Microwave Symposium. The purpose of this new platform is to boost and promote MTT-S technical and educational activities as well as MTT-S international exchanges and collaborations. The IEEE IMWS-Bio 2014 has kept the tradition of the previous edition and will bring in a unique mix of high-quality keynote, invited and contributed papers. In particular, we urge you to make the best out of our keynote and invited talks, featuring innovative and enabling technologies on RF and wireless technologies for biomedical and healthcare applications, by world-class speakers from the industry and academia. The workshop also serves as a great networking opportunity for both informal and formal discussions and collaborations.

We would like to take this opportunity to thank all the individuals and organisations, who have provided their support and help to IMWS-bio 2014. We wish all the participants will benefit from the technical activities and enjoy the social events in the Workshop.

Yang Hao
Queen Mary University of London, UK
*General Chair*

Gianluca Lazzi
The University of Utah, USA
*General Co-Chair*

# International Advisory Committee Chairs Message

**International Advisory Committee**

*Chairs:*
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Koichi Ito
Erchin SerpedinAmin

*Members:*
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Christopher Paul Hancock
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**Finance Chair**
Robert Foster

**Publicity Chair**
Yue Gao

**Awards Committee Chair**
Xiaodong Chen

**Local Arrangements Chair**
Yasir Alfadhl

**Conference Secretaries:**
Ke Yang

The international advisory committee for the 2014 IEEE MTT-S International Microwave Workshop Series on RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-Bio 2014) is pleased to introduce to you a truly international and multidisciplinary event that brings together scientists, researchers, industry experts and healthcare providers to exchange and discuss innovative and blue sky ideas that will shape the future of biomedical and healthcare technologies and applications.

The keynote speakers, the invited papers and the interactive poster and regular oral sessions will provide attendees with unique opportunity to explore the latest in antennas, RF and microwave devices, imaging techniques, mm-wave and THz systems and many more as they are applied in the interdisciplinary domain of biomedical applications.

We are sure that you will enjoy this event and let us welcome you again to this second edition of IEEE MTT-S IMWS-Bio workshop and to the most exciting European city ... London!

Yiannis Vardaxoglou
Loughborough University, UK
IAC Chair

John L. Volakis
The Ohio State University, USA
*IAC Co-Chair*

Koichi Ito
Chiba University, Japan
*IAC Co-Chair*

Erchin Serpedin
Texas A&M University, USA
*IAC Co-Chair*

# Technical Programme Committee Chairs Message

## Technical Programme Committee

*Chair:*
Akram Alomainy

*Co-Chairs:*
Kenneth Tong
Clive G. Parini

*Members:*
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Apostolos Georgiadis
Aydin Farajidavar
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Shaoying Huang
Simon Cotton
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Tian Tong
Toni Bjorninen
Thomas Ußmüller
William Scanlon
Wonbin Hong
Xi Lin Chen
Yasi Alfadhl
Yang Hao
Yiannis Vardaxoglou
Yue Gao

On behalf of the Technical Programme Committee (TPC) for the 2014 IEEE MTT-S International Microwave Workshop Series on RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-Bio 2014), we would like to thank all reviewers for their time and rigorous reviews of the papers submitted to the Workshop, and session chairs for bringing the Workshop to reality.

The IMWS-Bio 2014 received substantial numbers of paper submission from 23 different countries including invited papers and regular papers. Each paper was reviewed by at least three expert reviewers and the final decisions were made at the TPC meeting held in London in September 2014. Among all the submissions, twenty-two invited papers and 30 regular papers were accepted for oral presentations and 40 regular papers were accepted for poster presentations. The TPC is very pleased with the quality of the submissions and we trust that you will find many papers interesting and informative.

The technical sessions will be divided into oral and poster sessions. The oral sessions will be split into two parallel tracks spanning over three days. In addition to the regular sessions, we are honoured to have eight renowned experts as plenary speakers with internationally recognized expertise in antennas, microwave, RF devise, wireless technologies and biomedical/healthcare systems. Another highlight is the IET sponsored best student paper awards and also the Wiley sponsored best regular paper award. They were nominated by the TPC after considering reviewers' review reports and will be further carefully evaluated by the Awards Committee during the conference through an interactive poster and quick-fire presentation sessions.

The TPC has worked hard to generate a diverse and well-organized technical program, which covers nearly all topics on the RF and Wireless Technologies for Biomedical and Healthcare applications. On behalf of the TPC, we would like to express our sincere thanks to all authors for their contributions to the workshop. We would like to express our sincere appreciation to all TPC members, sub-committee chairs, reviewers, panelists, session chairs, and all who have been involved for their effort and dedication in finalizing this technical program. In particular, we would like to thank the IEEE MTT-S for their strong support to this workshop.

Akram Alomainy
Queen Mary University of London, UK
*TPC Chair*

Kenneth Tong
University College London, UK
*TPC Co-Chair*

Clive Parini
Queen Mary University of London, UK
*TPC Co-Chair*

# Sponsors and Exhibitors Information

The 2014 IEEE MTT-S IMWS-Bio 2014 organising committee would like to thank the following sponsors and exhibitors for their participation and support for this conference.

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## CST – Computer Simulation Technology (Gold Sponsor)

Entire areas of healthcare rely on the use of electromagnetic fields, and especially the complex interactions between these fields and the body. CST develops and markets high-performance software for the simulation of electromagnetic fields in all frequency bands, from static to optical, and our simulation tools are widely used in the design of medical equipment. Medical applications that CST software is currently used for include:

- MRI coils
- X-ray tubes
- Pacemakers
- Radio-frequency ablation and diathermy
- Dosimetry
- Electro-stimulation
- Particle accelerators

We help reduce costs and shorten development times, reducing the design risk and improving the overall performance of devices, especially for new or cutting edge products. Today, we enjoy a leading position in the high-frequency 3D EM simulation market and employ 240 sales, development, and support personnel around the world. http://www.cst.com/medical

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## ANSYS, Inc (Bronze Sponsor)

ANSYS is dedicated exclusively to developing engineering simulation software that fosters rapid and innovative product design. Our technology enables you to predict with confidence that your product will thrive in the real world. For more than 40 years, customers in the most demanding markets have trusted our solutions to help ensure the integrity of their products and drive business success through innovation.

In addition to our Structural/Thermal and Fluids solutions, our breadth of electronics products is driving the need for high-fidelity RF and microwave simulation. For more information, please visit us at www.ansys.com/uk or email us at uk-marketing@ansys.com

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## IEEE Antennas & Propagation Society (AP-S)

The IEEE Antennas and Propagation Society (AP-S) is one of the technical Societies of the Institute of Electrical and Electronics Engineers, the world's largest professional association for the advancement of technology. The Society's field of interest includes the following: antennas, including analysis, design, development, measurement, and testing; radiation, propagation, and the interaction of electromagnetic waves with discrete and continuous media; and applications and systems pertinent to antennas, propagation, and sensing, such as applied optics, millimetre and sub-millimeter wave techniques, antenna signal processing and control, radio astronomy, and terrestrial and space-based communication, including wireless, mobile, satellite, and telecommunication. The Society publishes the IEEE Transactions on Antennas and Propagation, the online journal IEEE Antennas and Wireless Propagation Letters, and the IEEE Antennas and Propagation Magazine; organizes the annual IEEE International Symposium on Antennas and Propagation; has over 70 Chapters worldwide. The Society Web site is located at http://www.ieeeaps.org.

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# Sponsors and Exhibitors Information

## Emblation Microwave (Bronze Sponsor)

Emblation Microwave is a global leader in the design and supply of compact microwave generators for medical applications. All OEM systems are solid-state, fully customisable and available at a range of frequencies and power levels. In addition to medical device development, generators can also be used for research/bench testing and Emblation can assist with probe design for any application.

Website: http://www.emblationmicrowave.com/

## The Institute of Electrical and Electronics Engineers (IEEE)

The Institute of Electrical and Electronics Engineers (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. There are more than 430,000 IEEE members in over 160 countries around the world. IEEE members are engineers, scientists, and allied professionals whose technical interests are rooted in electrical and computer sciences, engineering, and related disciplines.

IEEE publishes nearly a third of the world's technical literature in electrical engineering, computer science, and electronics. This includes approximately 170 transactions, journals, and magazines published annually. In cooperation with John Wiley and Sons, Inc., IEEE also produces technical books, monographs, guides, and textbooks.

## The Institution of Engineering and Technology (IET)

The Institution of Engineering and Technology was formed by the Institution of Electrical Engineers (IEE) and the Institution of Incorporated Engineers (IIE) and now has more than 150,000 members worldwide. It is the largest professional engineering society in Europe and the second largest of its type in the world. It has offices in London, Beijing, Hong Kong, New Jersey and Bangalore.
The history of the Institution can be traced back to 1871 and information about this can be found in the Library and Archives.

We represent the profession of electrical, electronic, manufacturing and systems engineering and related sciences; act as the voice of the profession in matters of public concern and assist Government to make the public aware of technological issues; set standards of qualifications for professional electrical, electronics, software, systems and manufacturing engineers; accredit degree courses in subjects relevant to electrical, electronic, manufacturing and information engineering at universities and colleges around the world and many more international tasks and objectives.

# Sponsors and Exhibitors Information

## IEEE Microwave Theory & Techniques Society (MTT-S)

The IEEE Microwave Theory and Techniques Society (MTT-S) is a transnational society with more than 11,000 members and 150 chapters worldwide. The Society promotes the advancement of microwave theory and its applications, including RF, microwave, millimeter-wave, and terahertz technologies. For more than 60 years, the MTT-S has worked to advance the professional standing of its members and enhance the quality of life for all people through the development and application of microwave technology.

The Microwave Theory and Techniques Society focuses on the theory and applications of radio-frequency (HF, VHF/UHF, microwave, millimeter-wave and terahertz), guided-wave and wireless technologies, as they relate to nanostructures, devices, integrated circuits, multi-circuit assemblies, components, packages, transmission lines, sub-systems, and systems involving the generation, amplification, processing, modulation, control, transmission, reception, detection and demodulation, and effects of electromagnetic energy transport. The Society website is located at http://www.mtt.org/.

## Queen Mary University of London (QMUL)

Queen Mary University of London (QMUL) is a public research university located in London, United Kingdom, and a constituent college of the federal University of London. It has around 17,000 full-time students and 4,000 staff and an annual turnover of £350 million, of which around £100 million is from research grants and contracts. Queen Mary is organised into three faculties – the Faculty of Humanities and Social Sciences, the Faculty of Science and Engineering and Barts and The London School of Medicine and Dentistry – within which there are 21 academic departments and institutes. It is one of the largest colleges of the University of London. Queen Mary is a member of the Russell Group of leading British research universities, the Association of Commonwealth Universities and Universities UK. Queen Mary is a major centre for medical teaching and research. www.wmul.ac.uk

The School of Electronic Engineering and Computer Science (EECS) at QMUL delivers world-class electronic engineering and computer science research and applies it to real-world problems. The current research grant portfolio of £38m equates to more than £500k for each research-active staff member. The School is home to over 70 academic staff, over 50 Post Doctorial Researchers and over 200 Research students. Eight School members hold prestigious research fellowships. The 2008 UK Research Assessment placed us in the top 20 UK universities for both Computer Science and Electronic Engineering. www.eecs.qmul.ac.uk and for the Antennas & Electromagnetics Group please check http://antennas.eecs.qmul.ac.uk

## Rohde & Schwarz GmbH & Co KG (Bronze Sponsor)

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# Sponsors and Exhibitors Information

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# Call for Papers – IEEE MTT-S Mini-Special Issue

## Call for Papers for the IEEE IMWS-Bio 2014 Mini-Special Issue

The IEEE Transactions on Microwave Theory and Techniques (IEEE T-MTT) will publish a Mini-Special Issue devoted to 2014 IEEE MTT-S International Microwave Workshop Series on RF and Wireless Technologies for Biomedical and Healthcare Applications (IMWS-Bio 2014) and also the IEEE BioWireleSS 2014 conference. Authors of all papers presented at IEEE IMWS-Bio 2014 are invited to submit an expanded version of their papers to the Mini-Special Issue. Every paper will be reviewed by T-MTT in the same manner as all other regular submissions to this publication.

## Important Message

Please be informed that the scope of T-MTT is different from IMWS-Bio 2014. If you are doubtful if your paper is suitable for T-MTT please write to the editor-in-chief of T-MTT or TPC chairs of IMWS-Bio 2014. In general, experimental validation is required in transactions papers.

Please note that:

1. Papers should be submitted through the T-MTT Manuscript Central site.
2. In the Cover Letter, please indicate that the submission is for the IEEE IMWS-Bio 2014 Mini-Special Issue.
3. The conference paper should be included with the submission as well.
4. The following note should be added to the footnote on the first page of the paper: "This paper is an expanded paper from the IEEE IMWS-Bio 2014, London".
5. The guideline for manuscript preparation can be found on the T-MTT webpage on the MTT Society website

The due date for the paper submission is April 1, 2015. The expected publication date of the mini-special issue is October 2015.

If you have any question, please contact us at the following address:

Guest Editors
Akram Alomainy
a.alomainy@qmul.ac.uk
Queen Mary University of London, UK

T-MTT Editor
J.-C. Chiao
jcchiao@uta.edu
University of Texas at Arlington, USA

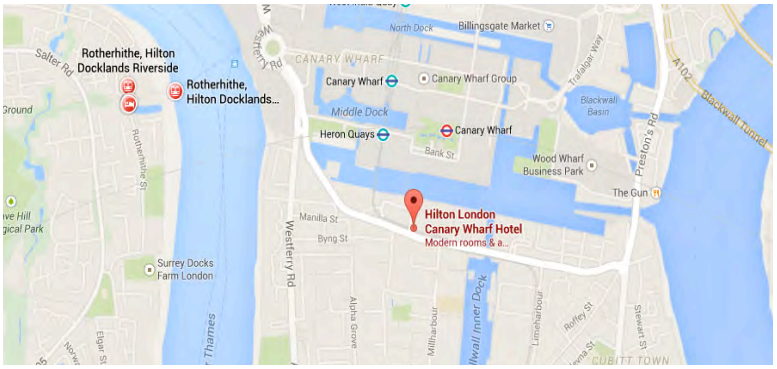
# Venue and Travel Information

## Conference Venue

The conference is held in Hilton London Canary Wharf.

<u>Address:</u>
South Quay
Marsh Wall
London E14 9SH
UK

Tel: +44-203-002-2300
Fax: +44-203-002-2350




## By Tube/Underground

From London City Airport, take the Docklands Light Railway to Poplar station. Change at Poplar for a DLR train to South Quay station. The Hilton London Canary Wharf hotel is next to the station.

Otherwise, take the underground to Canary Wharf Tube Station first. And then from the station, take the Jubilee Place main exit. Once out of the station turn left and proceed to the pedestrian traffic crossing. Cross the road and walk straight ahead towards the glass building, go through the glass building continuing to walk straight. Once out of the glass building walk up the little steps to cross over the footbridge, at the end of the footbridge turn left and walk straight and then turn right after first parking bays into Admirals Way. The hotel is situated towards the bottom of the road on your left hand side.

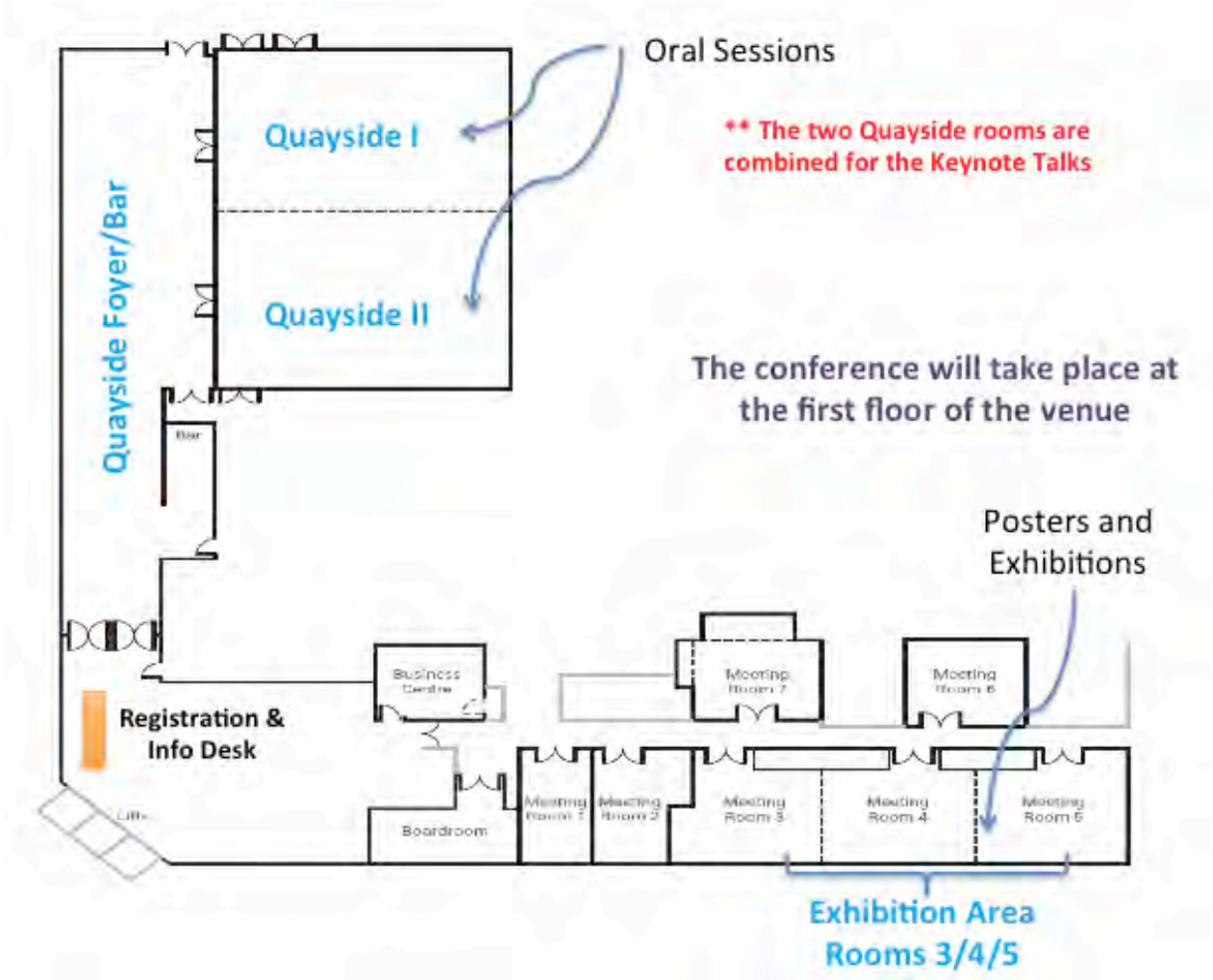
## By Taxi

*<u>City Airport:</u>*
Distance from Hotel: 4 mil.
Drive time: 15 mins
Typical Min. Charge: 20.00 GBP

*<u>Heathrow Airport:</u>*
Distance from Hotel: 22.5 mil.
Drive time: 58 mins
Typical Min. Charge: 70.00 GBP

*<u>Gatwick Airport:</u>*
Distance from Hotel: 44.8 mil.
Drive time: 62 mins
Typical Min. Charge: 90.00 GBP

# Conference Venue Floor Plan & WiFi Access




## WiFi Access

Name: BTOpenZone
Password: loncw214

# Registration & Telephone Numbers

## Registration & Information Desk

Registration & Information Desk will be available outside the Quayside Foyer (Conference area on the 1st Floor of the venue) at the following times:

- Sunday 7 December 2014 (6 pm to 8 pm)
- Monday 8 December 2014 (8 am to 6 pm)
- Tuesday 9 December 2014 (8 am to 6 pm)
- Wednesday 10 December 2014 (8 am to 2 pm)

The on-site registration fee is shown in the following table. If you have pre-registered, your name badge and Technical Program book will be ready for you to pick up during the above conference registration time. Please wear your name badge throughout the conference. Access will be prohibited to the exhibition, tea break, and technical sessions if a name badge is not present.

| IEEE IMWS-Bio 2014 On-site Registration Fees | |
|---|---|
| IEEE Member | GBP 530 |
| Non-IEEE Member | GBP 580 |
| IEEE Student Member | GBP 350 |
| Non-IEEE Student Member | GBP 400 |

Each (Regular and Student) registration is entitled to three luncheon coupons and each Regular registration is entitled to one banquet coupon.

Additional banquet coupons are also available at GBP 60 per coupon. Electronic version of the proceedings is also available at GBP 25 per copy.

## Useful Telephone Numbers

Country Code: 44
London City Code: 20
When dialling from within England, add a '0' before the city code and of course drop the country code.

*Important Telephone Numbers*
Emergencies: 999
UK operator: 100
International operator: 155
Directory information: 192
Tourist Information Centres
British Tourist Authority: 020 7808 3810
London Tourist Board: 020 7932 2000

# Session Information & Social Activities

## Instructions for Presenters in Oral Sessions

Speakers are requested to be in their respective session rooms at least 10 minutes prior to the commencement of each session. The duration of the invited paper presentation is 25 minutes. This includes 20 minutes for the presentation itself and 5 minutes for questions from the audience. The duration of the regular paper presentation is 15 minutes, which includes 12 minutes for the presentation itself and 3 minutes for questions from the audience. We could appreciate it if all presenters can adhere strictly to this time limit.

Presentation slides must be prepared using Microsoft PowerPoint or Adobe Acrobat. Speakers should bring their files on a thumb-drive and upload their file at least 10 minutes before the commencement of each session as well as report to their respective Session Chairs. A standard LCD projector (connected to a local PC) will be provided in each conference room.

All papers must be presented in person at the conference in order to be included in the proceedings published in IEEE Xplore©.

## Instructions for Presenters in Poster Sessions

The venue for the poster sessions will be inside the Exhibition Area (Rooms 3/4/5). Poster stands will be provided with foam boards for you to mount the poster. The size of the poster should be minimum A1 (841 mm x 594 mm). It is advisable that your poster be readable from 1.5 to 2 m away.

Please set up your poster at least 10 minutes before the start of the session. Speakers (presenting authors) are requested to stay at their posters during the poster session. After the session, posters must be removed by the speaker him/herself. All papers must be presented in person at the conference in order to be included in the proceedings published in IEEE Xplore©.

## Social Activities

There will be a welcome reception on Monday 8th December 2014 taking place at the Quayside Foyer/Bar Area in the conference venue on the 1st Floor from 18.00 to 21.00

- The reception is sponsored by the Institute of Engineering and Technology (IET)
- Interactive demonstrations merging both media, arts and technology will be presented during the reception

The conference banquet & award ceremony will be held on Tuesday 9th December 2014 in the Quayside Banquet hall on the 1st Floor of the conference venue and it will take place between 19.00 and 22.00

- The banquet will include a short introduction by the conference general chairs, pre-dinner talk by Prof. Peter Clarricoats, *CBE FRS FREng FIET FIEEE*, introduction to IEEE MTT-S IMWS-Bio 2015 in Taiwan and an interactive musical performance by musicians/researchers at QMUL.

# Conference Program at a Glance

| Time | Monday<br>8 December 2014 | Tuesday<br>9 December 2014 | Wednesday<br>10 December 2014 | |
|---|---|---|---|---|
| 08.30-09.00 | *Welcome & Opening Address by Chairs*<br>*Room: Quayside* | | | |
| 09.00-10.40 | MK1<br>Monday Keynote Session 1<br>*Room: Quayside* | TK1<br>Tuesday Keynote Session 1<br>*Room: Quayside* | WA1<br>Wireless Energy Harvesting and Power Transfer Techniques and Implantable Technologies for Biomedical Applications<br>*Room: Quayside I* | WA2<br>Microwave Technologies and Devices for Sensing, Diagnosis and Remote Patient Monitoring<br>*Room: Quayside II* |
| 10.40-11.00 | Coffee Break (*Quayside Foyer/Exhibition*) | | | |
| 11.00-12.40 | MA1:<br>Tissue Properties and Numerical Techniques for In/On-Body Communications<br>*Room: Quayside I* | MA2:<br>Wearable and Textile RF Antennas and Sensors for Healthcare and Medical Applications<br>*Room: Quayside II* | TA1:<br>Microwave Imaging and Diagnostic Tools for Medical Applications<br>*Room Quayside I* | TA2:<br>Advanced RF & Microwave Techniques and Methods for Medical Body Sensor/Area Networks<br>*Room: Quayside II* |
| | WPos1<br>Wednesday Poster Session<br>*Room: Exhibition* | | | |
| 12.40-14.00 | Lunch (*Quayside Foyer/Exhibition*) | | | |
| 14.00-15.40 | MK2<br>Monday Keynote Session 2<br>*Room: Quayside* | TK2<br>Tuesday Keynote Session 2<br>*Room: Quayside* | WP1<br>Integrated RF & Microwave Solutions for Medical Assistive and Preventive Technologies<br>*Room: Quayside I* | WP2<br>Microwave-Optical Monitoring Technologies and SAR Analysis Techniques<br>*Room: Quayside II* |
| 15.40-16.00 | Coffee Break (*Quayside Foyer/Exhibition*) | | | |
| 16.00-17.40 | MPos1<br>Monday Poster Session (incl. Student Contest Finalist)<br>Room: Exhibition | TP1<br>Mm-wave and THz Characterization of biological materials and tissue<br>Room: Quayside I | TP2<br>Microwave Ablation Treatments and Imaging Methods<br>+<br>Student Contest Finalists Presentations<br>*Room: Quayside II* | |

Note 1: The Welcome Reception will be held in Quayside Foyer/Bar from 18.30 to 21.00 on Monday, 8 December 2014. ***Sponsored by the IET.*

Note 2: The Banquet & Award Ceremony will be held from 19.00 to 22.00 on Tuesday, 9 December 2014

*** Please check page 11 of this program for details on registration & information desk timings*

# Keynote Session - Monday 08 December 2014

## Keynote Session 1 (09:00-10:40)

Chair: Prof. Yang Hao

Room: Quayside

| | |
|---|---|
| 09:00 – 09:50 | Textile Sensors for Non-Invasive Health Monitoring<br>*Prof. John L. Volakis*<br>*The Ohio State University, USA* |
| 09:50 – 10:40 | Wireless Radar Sensor Networks for Long-term Health Monitoring<br>*Prof. Dominique Schreurs*<br>*KU Leuven, Belgium* |

## Keynote Session 2 (14.00 – 15.40)

Chair: Prof. Gianluca Lazzi

Room: Quayside

| | |
|---|---|
| 14:00 – 14:50 | Therapeutic Applications of Microwave Antennas<br>*Prof. Koichi Ito*<br>*Chiba University Japan* |
| 14:50 – 15:40 | Retrospective View of Recent Progress in Antennas and Propagation for WBANs<br>*Prof. Peter Hall*<br>*University of Birmingham, UK* |

# Keynote Session - Tuesday 09 December 2014

## Keynote Session 1 (09:00-10:40)

Chair: Prof. Koichi Ito

Room: Quayside

| | |
|---|---|
| 09:00 – 09:50 | The Future of Medicine is Wireless: On-Body and In-Body Devices Transforming Healthcare<br>*Prof. Konstantica S. Nikita*<br>*National Technical Universtiy of Athens, Greece* |
| 09:50 – 10:40 | Advanced Wearable Antenna Development for Body Area Networks<br>*Prof. Douglas Werner*<br>*The Pennsylvania State University, USA* |

## Keynote Session 2 (14:00-15:40)

Chair: Prof. Peter Hall

Room: Quayside

| | |
|---|---|
| 14:00 – 14:50 | Recent Advances in Health and Safety Consideration of RF and Wireless Technologies<br>*Prof. James C. Lin*<br>*University of Illinois at Chicago. USA* |
| 14:50 – 15:40 | What next for reliable body sensor networking? Addressing the challenges faced by wireless communication systems in close proximity to the human body<br>*Prof. William G. Scanlon*<br>*Queen's Universtiy Belfast, UK* |

# Oral Sessions, Mon 8 December 2014 – 11.00-12.40

## MA 1
## Tissue Properties and Numerical Techniques for In/On-Body Communications

*Chairs: Prof. Dominique Schreurs, KU Leuven, Belgium and Dr Shaoying Huang, Singapore University of Technology and Design, Singapore*

*Room: Quayside I*

11:00 Dielectric Properties of Tissues and Their Applications: State of Knowledge (INVITED)
*A.Peyman,*
*Public Health England, Didcot, UK*

11:20 Non-invasive Magnetic Resonance Imaging (MRI) – Based Electrical Property Mapping for Human Tissues (INVITED)
*S. Huang*
*Singapore University of Technology and Design, Singapore*

11:40 Performance Evaluation for MIMO in Vivo WBAN Systems
*C. He, Y. Liu, T. P. Ketterl, G. E. Arrobo, R. D. Gitlin*
*University of South Flordia, Tampa, USA*

12:00 Numerical Investigation On the Dependence of On-Body Channel Characteristics on Anthropomorphic Variation of Human Body
*K. Ali, A. Brizzi, A. Alomainy*
*Queen Mary University of London, London, UK*

12:20 Accuracy of Asymptotic Techniques for On-Body Channel Characterisation at W Band
*A. Brizzi[1], A. Pellegrini[2], L. Zhang[1], Y. Hao[1]*
*[1]Queen Mary University of London, London, United Kingdom, [2]Cobham Antenna Systems, Leatherhead, United Kingdom*

## MA 2
## Wearable and Textile RF Antennas and Sensors for Healthcare and Medical Applications

*Chair: Dr. Maxim Zhadobov, Institute of Electronics and Telecommunications of Rennes, France and Prof Lei Zhao, Jiangsu Normal University, China*

*Room: Quayside II*

11:00 A Compact Wideband Dielectric Resonator Antenna for On-Body Applications (INVITED)
*S. I. Mian, K. Esselle*
*Macquarie University, Sydney, Australia*

11:20 Impact of Antenna-Fiber Alignment and Recurrent Stretching on the Performance of Passive UHF RFID Tags based on Textile Antennas
*X. D. Zhang[1], M. H. Yang[1], J. Virkki[1], T. Björninen[2], S. Merilampi[3], L. Sydänheimo[2], Y. C. Chan[1], L. Ukkonen[2]*
*[1]City University of Hong Kong, Hong Kong, Hong Kong, [2]Tampere University of Technology, Tampere, Finland, [3]Satakunta University of Applied Sciences, Pori, Finland*

11:40 On-Body Antenna with Reconfigurable Radiation Pattern
*S. Dumanli*
*Toshiba Research Europe Limited, Bristol, United Kingdom*

12:00 A Wearable Button Antenna with FSS Superstrate for WLAN Health Care Applications
*B. Mandal, A. Chatterjee, S. K. Parui*
*Indian Institute Engineering Science & Technology, Shibpur, Howrah, India*

12:20 Energy Harvesting Antenna for Various Communication Transceivers
*Y. Jung*
*Hanbat National University, Daejeon, Republic of Korea*

# Oral Sessions, Tue 9 December 2014 – 11:00-12:40

## TA 1
## Microwave Imaging and Diagnostic Tools for Medical Applications

*Chair: Prof. Amin Abbosh, The University of Queensland, Australia and Prof Dau-Chyrh Chang, Oriental Institute of Technology, Taiwan*

*Room: Quayside I*

11:00 Microwave Techniques as Diagnostic Tool for Congestive Heart Failure (INVITED)
*A. Abbosh, S. Ahdi Rezaeieh, K. Bialkowski*
*The University of Queensland, Australia*

11:20 Near Field Microwave Imaging with Power Gain Pattern Correction (INVITED)
*D. Chang, Y. Tsai*
*Oriental Institute of Technology, Taiwan*

11:40 Bio-Electromagnetic Simulation for Improved Medical Imaging (INVITED - Industry)
*T. Wittig[1], A. Bitz[2] and M. Klemm[3]*
*[1]CST AG, Darmstadt, Germany, [2]German Cancer Research Center (DKFZ), Heidelberg, Germany, [3]University of Bristol, Bristol, UK*

12:00 A Fast Electromagnetic Solver for Microwave Medical Imaging
*N. Simonov, S. Son, B. Kim, K. Lee, S. Jeon*
*ETRI, Dejeon, Republic of Korea*

12:20 Scalable magnetically mediated thermoacoustic imaging through coil tailoring
*X. Feng, F. Gao, Y. Zheng*
*School of Electrical and Electronic Engineering, Singapore*

## TA 2
## Advance RF & Microwave Techniques and Methods for Medical Body Sensor/Area Networks

*Chair: Dr. Costas C. Constantinou, University of Birmingham, UK and Dr. Simon Cotton, Queen's University Belfast, UK*

*Room: Quayside II*

11:00 A Measurements Based Comparison of New and Classical Models Used to Characterize Fading in Body Area Networks (INVITED)
*S. L. Cotton, S. Yoo, W. G. Scanlon*
*Queens University Belfast, Belfast, UK*

11:20 Autonomic Body Sensor Networks (INVITED)
*R. Yu, G. Yang, B. P. Lo*
*Imperial College London, London, UK*

11:40 Medical wireless body sensor networks at microwave versus mm-wave bands (INVITED)
*X. Li, Y. I. Nechayev, C. C. Constantinou*
*University of Birmingham, Birmingham, UK*

12:00 Ultra Wideband In Vivo Radio Channel Characterisation and System Modeling
*Q. H. Abbasi[1,4], M. Qaraqe[2], M. U. Rehman[3], E. Serpedin[2]*
*[1]Texas A & M University at Qatar, Doha, Qatar, [2]Texas A & M University, College station, United States, [3]University of Bedfordshire, Luton, United Kingdom, [4]Queen Mary University of London, London, United Kingdom*

12:20 Comparison of Inkjet-Printed and Microfabricated Loop Antennas for Implants in Wireless Brain-Machine Interface Systems
*E. Moradi, T. Björninen, L. Sydänheimo, L. Ukkonen*
*Tampere University of Technology, Tampere, Finland*

# Oral Sessions, Tue 9 December 2014 – 16:00-17:40

## TP 1
## Mm-wave and THz characterization of biological materials and tissue

*Chair: Dr Robert Donnan, Queen Mary University of London, UK and Prof Norbert Klein, Imperial College London, UK*

### Room: Quayside I

16:00 The power of VNA-driven quasi-optics to sense group molecular action in condensed phase systems (INVITED)
*R. Donnan[1], K. Tian[2], B. Yang[3], G. A. Chass[4]*
*[1]Queen Mary University of London, London, United Kingdom, [2]Semmelweis University, Budapest , Hungary, [3]University of Bolton, Bolton, United Kingdom, [4]Queen Mary University of London, London, United Kingdom*

16:20 Tissue-Equivalent Phantoms in the 60-GHz Band and Their Application to the Body-Centric Propagation Studies (INVITED)
*M. Zhadobov[1], A. Guraliuc[1], N. Chahat[2], R. Sauleau[1]*
*[1]Institute of Electronics and Telecommunications of Rennes (IETR), Rennes, France, [2]NASA Jet Propulsion Laboratory , Pasadena , United States*

16:40 Micro- and millimetre wave measurements of nanolitre biological liquids by dielectric resonators (INVITED)
*N. Klein, S. Hanham, T. H. Basey-Fisher, C. Watts, O. Shaforost1, W. J. Otter, S. Lucyszyn*
*Imperial College London, London, United Kingdom*

17:00 A Bottom-Up Cell Modeling Strategy Using Broadband Microwave and Millimeter Wave Dielectric Spectroscopy (INVITED)
*I. Ocket[1,2], S. Liu[2], T. Markovic+, J. Bao[2], B. Nauwelaers[2]*
*[1]Interuniversity Microelectronics Centre (IMEC), Leuven (Heverlee), Belgium, [2]KU Leuven, Leuven (Heverlee), Belgium*

17:20 Comparing Terahertz transmission response on pH-dependent Apomyoglobin proteins dynamics with Circular Dichroism
*J. Qiu[1,2], B. Yang[3], O. Sushko[1], R. W. Pikersgill[2], R. S. Donnan[1]*
*[1]Queen Mary University of London, London, United Kingdom, [2]Queen Mary University of London, London, United Kingdom, [3]University of Bolton, Bolton, United Kingdom*

## TP 2
## Microwave Ablation Treatments and Imaging Methods

*Chair: Dr Panagiotis Kosmas, King's College London, UK and Prof. Xiaodong Chen, Queen Mary University of London, UK*

### Room: Quayside II

16:00 Improving Patient Safety in Microwave Ablation Treatments (INVITED)
*G. Beale*
*Emblation Limited, United Kingdom*

16:20 Novel inversion tools to improve performance of the DBIM algorithm for microwave medical imaging (INVITED)
*P. Kosmas, Z. Miao*
*King's College London, London, United Kingdom*

16:40 Electromagnetic Acoustics Sensing and Imaging for Biomedical Applications (INVITED)
*Y. Zheng, F. Gao, X. Feng*
*Nanyang Technological University, Singapore, Singapore*

*** Please check the following page for the list of Best Student Paper Contest Finalists, who will be presenting quick-fire 5-minute summary of their work within the remaining period of this session*

# Oral Sessions, Tue 9 December 2014 – 16:00-17:40

TP 2
Student Contest Finalists Quick-fire Presentations

*Chair: Dr Panagiotis Kosmas, King's College London, UK and Prof. Xiaodong Chen, Queen Mary University of London, UK*

Room: Quayside II

17:00 A 90 GHz Liquid Sensing Substrate Integrated Cavity Resonator in LTCC for Microfluidic Sensing Applications
*S. Liu[1], I. Ocket[2,1], D. Schreurs[1], W. De Raedt[2], B. Nauwelaers[1]*
*[1]University of Leuven, Heverlee, Belgium, [2]Interuniversity Microelectronics Center, Heverlee, Belgium*

17:05 Investigative Analysis of the Influence of Different Simplified Human Body Models on a Miniature Ultra-Wideband Antenna
*M. Sharma, C. G. Parini, A. Alomainy*
*Queen Mary University of London, London, United Kingdom*

17:10 Numerical Characterization of In Vivo Wireless Communication Channels
*A. F. Demir[1], Q. H. Abbasi[2], Z. E. Ankarali[1], E. Serpedin[2], H. Arslan[1,3]*
*[1]University of South Florida, Tampa, United States, [2]Texas A&M University, Doha, Qatar, [3]Istanbul Medipol University, Istanbul, Turkey*

17:15 Fully-Passive and Wireless Detection of Very-Low-Power Brain Signals
*C. Lee[1], A. Kiourti[1], J. Chae[2], J. L. Volakis[1]*
*[1]The Ohio State University, Columbus, United States, [2]Arizona State University, Tempe, United States*

17:20 An Exploration of Ocular Glucose Levels with Flexible RF Biosensor Using Polyethylene Terephthalate
*R. Dhakal[1], Z. Chuluunbaatar[1], H. Park[2], Y. Jung[2], G. Cho[2], Y. H. Jo[3], S. S. Kim[3], N. Y. Kim[1]*
*[1]Kwangwoon University, Seoul, Democratic People's Republic of Korea, [2]Sunchon National University, Sunchon, Democratic People's Republic of Korea, [3]Kyung Hee University, Seoul, Democratic People's Republic of Korea*

17:25 A Non-invasive Magnetic Resonance Biomedical System
*R. Pradhan+, L. Yan[2], S. H. Yeung[1], Z. Yuanjin[1]*
*[1]Nanyang Technological University, Singapore, Singapore, Singapore, [2]Beijing Information Science and Technology University, Beijing, China, Beijing, China*

17:30 Rapid and Sensitive Detection of Glucose Based on Radio Frequency Resonator Fabricated Using Integrated Passive Device Technology
*K. K. Adhikari[1], Z. Chuluunbaatar[1], C. Wang[1], Y. Jo[2], S. Kim[2], N. Kim[1]*
*[1]Kwangwoon University, Seoul, Republic of Korea, [2]Kyung Hee University, Seoul, Republic of Korea*

17:35 A Compact Wideband Dielectric Resonator Antenna for On-Body Applications
*S. I. Mian*
*Macquarie University, Sydney, Australia*

# Oral Sessions, Wed 10 December 2014 – 09:00-10:40

## WA 1
## Wireless Energy Harvesting and Power Transfer Techniques and Implantable Technologies for Biomedical Applications

*Chair: Prof. Yongxin Guo, National University of Singapore, Singapore and Dr Yue Gao, Queen Mary University of London, UK*

*Room: Quayside I*

09:00 Wireless Data Telemetry and Power Transfer for Biomedical Applications (INVITED)
*C. Liu[1], Y. Guo[1,2], S. Xiao[3]*
*[1]National University of Singapore, Singapore, Singapore, [2]National University of Singapore Suzhou Research Institute, Suzhou, China, [3]University of Electronic Science and Technology of China, Chengdu, China*

09:20 A Wireless Power Transmission System for Robotic Capsule Endoscopy: Design and Optimization
*M. R. Basar[1,3], M. Y. Ahmad[1,3], J. Cho[2,3], F. Ibrahim[1,3]*
*[1]University of Malaya, Kuala Lumpur, Malaysia, [2]Inje University, Gimhae, Democratic People's Republic of Korea, [3]Center of Innovation in Medical Engineering, University of Malaya, Kuala Lumpur, Malaysia*

09:40 High-Efficiency Triple-band Ambient RF Energy Harvesting for Wireless Body Sensor Network
*Z. Liu[1,2], Z. Zhong[2], Y. X. Guo[2,3]*
*[1]NUS Graduate School for Integrative Sciences and Engineering, National University of Singapore, Singapore, [2]Department of Electrical and Computer Engineering, National University of Singapore, Singapore, [3]NUS Suzhou Research Institute , Suzhou, China*

10:00 Local Temperature Assessment produced by an Implantable Antenna for Intracranial Pressure Monitoring
*K. Psathas, K. Nikita*
*National Technical University of Athens, Athens, Greece*

10:20 A Dual-polarized Impulse Radiation Antenna for Cerebral Hemorrhage Detection Applications
*J. Li[1], H. Peng[1], B. Zong[2], Z. Yu[2]*
*[1]Shanghai Jiao Tong University, Shanghai, China, [2]ZTE Corporation, Shanghai, China*

## WA 2
## Microwave technologies and devices for sensing, diagnosis and remote patient monitoring

*Chair: Prof. Konstantina Nikita, National Technical University of Athens, Greece and Prof. Mikael Persson, Chalmers University of Technology, Sweden*

*Room: Quayside II*

09:00 Pre-hospital care for stroke and trauma (INVITED)
*M. Persson[1,4], J. P. Fhager[1,4], Y. Yu[1], T. McKelvey[1], J. Karlsson[3], M. Elam[2,3,4]*
*[1]Chalmers University of Technology, Göteborg, Sweden, [2]University of Gothenburg, Gothenburg, Sweden, [3]Sahlgrenska University Hospital, Göteborg, Sweden, [4]MedTech West, Göteborg, United States*

09:20 Real-time system for monitoring activity among the elderly using an RF SoC device with triaxial accelerometer data over a wireless sensor network
*W. Sriborrirux[1], P. Leamsumran[2], P. Danklang[1]*
*[1]Burapha University , Muang, Thailand, [2]BaesLab Co., Ltd., Bangna, Thailand*

09:40 Flexible Screen Printed Biosensor with High-Q Microwave Resonator for Rapid and Sensitive Detection of Glucose
*K. K. Adhikari[1], Z. Chuluunbaatar[1], H. Park[2], Y. Jung[2], G. Cho[2], Y. Jo[3], S. Kim[3], N. Kim[1]*
*[1]Kwangwoon University, Seoul, Republic of Korea, [2]Suncheon National University, Sunchon, Republic of Korea, [3]Kyung Hee University, Seoul, Republic of Korea*

10:00 Development of an Ultrasound Based 3D Facial Scanning System
*R. Ali, R. Saatchi, M. R. Rahman*
*Sheffield Hallam University, Sheffield, United Kingdom*

10:20 Machine-to-Machine Communications at Millimeter Wave Frequencies
*S. M. Mitani , T. Kanesan, R. B. Mohamad, S. B. Yaakob, N. E. Farid*
*TMR&D, TM Innovation Centre, Lingkaran Teknokrat Timur, , Cyberjaya, Malaysia*

# Oral Sessions, Wed 10 December 2014 – 14:00-15:40

## WP 1
## Integrated RF & Microwave Solutions for Medical Assistive and Preventive Technologies

*Chair: Dr John Batchelor, University of Kent, UK and Dr Yuanjin Zheng, Nanyang Technological University, Singapore*

*Room: Quayside I*

14:00 Skin-Mounted RFID Sensing Tattoos for Assistive Technologies (INVITED)
*J. C. Batchelor[1], O. O. Rakibet[1], C. V. Rumens[2], S. J. Holder[2]*
*[1]University of Kent, Canterbury, United Kingdom, [2]University of Kent, Canterbury, United Kingdom*

14:20 The Future of Miniaturized Wireless: Graphene Wireless Communications (INVITED)
*Dr Albert Cabellos*
*Universitat Politècnica de Catalunya, Spain*

14:40 Wireless Vectorcardiogram System Optimization using Adaptive Signal Processing
*C. A. Perumalla[1], G. E. Arrobo[1], T. P. Ketterl[1], R. D. Gitlin[1], P. J. Fabri[2]*
*[1]University of South Florida, Tampa, United States, [2]University of South Florida, Tampa, United States*

15:00 A High Power High Efficiency Integrated Solid-State Microwave Heating Structure for Portable Diagnostic Healthcare Applications
*A. Imtiaz, J. Hartley, H. Choi, J. Lees*
*Cardiff University, Cardiff, United Kingdom*

15:20 Six Layers Circular Microstrip Antenna Implanted in a Phantom of Vitreous Humor
*C. Prakash[1,2], R. Gangwar[1]*
*[1]College of Technology, Gobind Ballabh Pant University of Agriculture & Technology, Pantnagar, India, [2]Aryabhatta Research Institute of Observational Sciences, Nainital, India*

## WP 2
## Microwave-Optical Monitoring Technologies and SAR Analysis Techniques

*Chair: Dr. Kenneth Tong, University College London (UCL), UK and Dr Ilja Ocket, KU Leuven, Belgium and Dr Ilja Ocket, KU Leuven, Belgium*

*Room: Quayside II*

14:00 Development of a Hybrid Microwave-Optical Deep Muscle Warming Monitor (INVITED)
*A. Al-armaghany[1], K. Tong[1], T. Leung[2]*
*[1]University College London (UCL), London, United Kingdom, [2]University College London (UCL), London, United Kingdom*

14:20 Compare Study of SAR in CEMHM Model with Different Resolution Exposed to a Handset Antenna (INVITED)
*G. Chen[1], L. Zhao[2], Q. Ye[3], W. Yu[2]*
*[1]Jiangsu Normal University, Xuzhou, China, [2]Jiangsu Normal University, Xuzhou, China, [3]Jiangsu Normal University, Xuzhou, China*

14:40 Quadrature Channel Calibration with a Pendulum for Accurate Displacement Measurement with CW Doppler Radar
*M. Zakrzewski, K. Palovuori, J. Vanhala*
*Tampere University of Technology, Tampere, Finland*

15:00 SAR Evaluations of Head with Carotid Stent during MR Imaging
*M. Koizumi[1], R. Suga[1], K. Saito[2], K. Ito[2]*
*[1]Chiba University, Chiba, Japan, [2]Chiba University, Chiba, Japan*

15:20 New Wideband Textile Antenna for SAR Investigation in Head Microwave Imaging
*R. Yahya[1,2,] M. Kamarudin[2], N. Seman[2]*
*[1]Universiti Tun Hussein Onn Malaysia (UTHM), Batu Pahat, Malaysia, [2]Universiti Teknologi Malaysia, Skudai, Malaysia*

# Poster Session, Mon 8 December 2014 – 16:00-17:40

Monday Poster Session (MPos1) + Best Student Paper Contest Finalists
*Chair: Prof. Xiaodong Chen and Dr Qammer H. Abbasi*

Room: Exhibition (Rooms 3/4/5)

MPos1-1 A Circularly Polarised Antenna for a Wireless Blood-Flow Sensor
*M. S. El Atrash1, Y. Wang[2], [1]October University for Modern Science and Arts (MSA), Cairo, Egypt, [2]University of Greenwich, Kent, United Kingdom*

MPos1-2 Design of Continuous Non-Invasive Blood Glucose Monitoring Sensor Based on a Microwave Split Ring Resonator
*H. Choi1, J. Nylon1, S. Luzio2, J. Beutler1, A. Porch1, 1Cardiff University, Cardiff, United Kingdom, 2Swansea University, Swansea, United Kingdom*

MPos1-3 A Miniaturized Near-Field Sensor Based on a Double-Sided Spiral Split-Ring Resonator for Dielectric Characterization
*L. Benkhaoua, M. Benhabiles , M. Riabi, University Constantine, Constantine, Algeria*

MPos1-4 A K-Band Phase-Locked Loop in 0.18 um CMOS Technology for Vital Sign Detection Radar
*J. Cheng1, M. Wu1, H. Huang1, Y. Wu1, J. Tsai2, T. Huang1, 1National Taiwan University, Taipei, Taiwan, 2National Taiwan Normal University, Taipei, Taiwan*

MPos1-5 Diagnosis of Heart Disease by Using a Radial Basis Function Network Classification Technique on Patients' Medical Records
*M. Alsalamah, S. Amin, J. Halloran, Coventry University, Coventry, United Kingdom*

MPos1-6 Temperature Controlled Measurement Setup for Permittivity Extraction of Water up to 40 GHz from 10 to 40 °C
*T. Markovic1, S. Liu1, J. Bao1, I. Ocket2,1, B. Nauwelaers1, 1KU Leuven, Leuven, Belgium, 2Interuniversity Microelectronics Center, Leuven, Belgium*

MPos1-7 Neural Network-Based Tunable Microwave Filter Design for Re-Configurable Biomedical Hardware
*A. Ilumoka1, J. Gaudiana2, 1University of Hartford, West Hartford, United States, 2Sikorsky Aircraft Corporation, Stratford, United States*

MPos1-8 Modeling the Wireless In vivo Path Loss
*Y. Liu, T. P. Ketterl, G. E. Arrobo, R. D. Gitlin, University of South Florida, Tampa, United States*

MPos1-9 Microwave Antennas for Near Field Imaging
*S. Adnan1, R. A. Abd-Alhameed1, M. Al Khambashi1,2, Q. Yousuf1, R. Asif1,1, C. H. See3,3, P. S. Excell4,4, A. F. Mirza1, 1University of Bradford, Bradford, United Kingdom, 2AlZahra College for Women, Muscat, Oman, 3University of Bolton, Bolton, United Kingdom, 4Glyndŵr University , Wrexham, United Kingdom*

MPos1-10 Distribution Fitting for Real-Time Off-Body Channel Measurements
*R. Masood1,2, C. Person1, R. Sauleau2, 1Lab- STICC UMR CNRS 6285 CS 83818, Brest, France, 2IETR umr CNRS 6164, Rennes, France*

# Poster Session, Mon 8 December 2014 – 16:00-17:40

MPos1-11 A 90 GHz Liquid Sensing Substrate Integrated Cavity Resonator in LTCC for Microfluidic Sensing Applications
*(FINALIST) S. Liu1, I. Ocket2,1, D. Schreurs1, W. De Raedt2, B. Nauwelaers1, 1University of Leuven, Heverlee, Belgium, 2Interuniversity Microelectronics Center, Heverlee, Belgium*

MPos1-12 Investigative Analysis of the Influence of Different Simplified Human Body Models on a Miniature Ultra-Wideband Antenna
*(FINALIST) M. Sharma, C. G. Parini, A. Alomainy, Queen Mary University of London, London, United Kingdom*

MPos1-13 Numerical Characterization of In Vivo Wireless Communication Channels
*(FINALIST) A. F. Demir1, Q. H. Abbasi2, Z. E. Ankarali1, E. Serpedin2, H. Arslan1,3, 1University of South Florida, Tampa, United States, 2Texas A&M University, Doha, Qatar, 3Istanbul Medipol University, Istanbul, Turkey*

MPos1-14 Fully-Passive and Wireless Detection of Very-Low-Power Brain Signals
*(FINALIST) C. Lee1, A. Kiourti1, J. Chae2, J. L. Volakis1, 1The Ohio State University, Columbus, United States, 2Arizona State University, Tempe, United States*

MPos1-15 An Exploration of Ocular Glucose Levels with Flexible RF Biosensor Using Polyethylene Terephthalate
*(FINALIST) R. Dhakal1, Z. Chuluunbaatar1, H. Park2, Y. Jung2, G. Cho+, Y. H. Jo3, S. S. Kim3, N. Y. Kim1, 1Kwangwoon University, Seoul, Democratic People's Republic of Korea, 2Sunchon National University, Sunchon, Democratic People's Republic of Korea, 3Kyung Hee University, Seoul, Democratic People's Republic of Korea*

MPos1-16 A Non-invasive Magnetic Resonance Biomedical System
*(FINALIST) R. Pradhan1, L. Yan2, S. H. Yeung1, Z. Yuanjin1, 1Nanyang Technological University, Singapore, Singapore, Singapore, 2Beijing Information Science and Technology University, Beijing, China, Beijing, China*

MPos1-17 Rapid and Sensitive Detection of Glucose Based on Radio Frequency Resonator Fabricated Using Integrated Passive Device Technology
*(FINALIST) K. K. Adhikari1, Z. Chuluunbaatar1, C. Wang1, Y. Jo2, S. Kim2, N. Kim1, 1Kwangwoon University, Seoul, Republic of Korea, 2Kyung Hee University, Seoul, Republic of Korea*

MPos1-18 A Compact Wideband Dielectric Resonator Antenna for On-Body Applications
*(FINALIST) S. I. Mian, K. Esselle, Macquarie University, Sydney, Australia*

# Poster Session, Wed 10 December 2014 – 11:00-12:40

## Wednesday Poster Session (WPos1)

*Chairs: Dr. Khalid Rajab and Dr. Robert Foster*

### Room: Exhibition (Rooms 3/4/5)

WPos1-1 Molecular dynamics study on the electroporation process with different configurations of ions
*G. Jiang, Y. Alfadhl, X. Chen, Queen Mary, University of London, London, United Kingdom*

WPos1-2 Frequency Domain Method for Early Stage Detection of Congestive Heart Failure
*A. Zamani, S. A. Rezaeieh, A. Abbosh, The University of Queensland, Brisbane, Australia*

WPos1-3 SAR Calculations around Implanted Cardiac Pacemaker Induced by Wireless Radio Terminal in VHF Band
*K. Saito[1,2], Y. Endo[3], R. Akiyama[3], S. Watanabe[1], K. Ito[2], [1]National Institute of Information and Communications Technology, Koganei, Japan, [2]Chiba University, Chiba, Japan, [3]Chiba University, Chiba , Japan*

WPos1-4 Low Power Receiver for Medical Implantable Communication System using Delay Locked Loop
*H. Jang[1], H. Ma[1], F. D. Bien[1], D. Seo[2], J. Lee[2], H. Lee[2], [1]Ulsan National Institute of Science and Technology, Ulsan, Republic of Korea, [2]Eletronics and Telecommunications Research Institute(ETRI), Daegu, Republic of Korea*

WPos1-5 Ultra-Wideband On-Off Keying Transmitter with Multi-Pulses/Bit for Bio-Signal Detectors.
*Y. Bae, C. Cho, Korea Aerospace University, Goyang, Republic of Korea*

WPos1-6 Null Point Elimination Using Bi-phase States in a Direct Conversion Vital Signal Detection Radar
*Y. Chen, T. Chen, K. Sun, Y. Chiang, Chang Gung University, Kwei-Shan, Taiwan*

WPos1-7 60 GHz Channel Modeling Scenarios and Characterization for On-Body Sensors Applications
*N. Sarimin, R. Abdaoui, Institute Supérieur d'électronique de Paris, Issy les Moulineaux, France*

WPos1-8 Smart Antenna System Design for Localization of Wireless Capsule
*K. Reza, M. Yazed Ahmad, University of Malaya, Kuala Lumpur, Malaysia*

WPos1-9 Environmental Shielded TEM Chamber for Biomedical Testing
*M. E. Komnatnov, T. R. Gazizov, Tomsk State University of Control Systems and Radioelectronics, Tomsk, Russian Federation*

WPos1-10 An Improved Design of Microwave Biosensor for Measurement of Tissues Moisture
*M. T. Jilani[1,1], W. P. Wen[1,1], L. Y. Cheong[2,2], M. A. Zakariya[1,1], M. Rehman[1,1], [1]University Technology PETRONAS, Tronoh, Malaysia, [2]University Technology PETRONAS, Tronoh, Malaysia*

WPos1-11 Understanding and Characterising Nanonetworks for Healthcare Monitoring Applications
*N. Chopra[1], K. Yang[1], J. Upton[1], A. Alomainy[1], M. Philpott[1], Y. Hao[1], [1]Queen Mary University of London, London, United Kingdom, [2]Queen Mary University of London, London, United Kingdom*

# Poster Session, Wed 10 December 2014 – 11:00-12:40

WPos1-12 A Fast Interpolation Approach for the Calculation of Permittivity and Conductivity to Estimate the SAR
*S. Priyadarshi[1], S. Pitman[1], P. Glover[2], S. Shah[2], J. Ye[1], B. Hu[1], R. Letizia[1], [1]Lancaster University, Lancaster, United Kingdom, [2]University of Nottingham, Nottingham, United Kingdom*

WPos1-13 Electromagnetic modeling of metamaterial-based sensors
*L. La Spada, Queen Mary University of London, London, United Kingdom*

WPos1-14 Compressive Sensing Applied to Fingerprint-based Localisation
*Q. Cheng, M. Munoz, A. Alomainy , Y. Hao, Queen Mary University of London, London , United Kingdom*

WPos1-15 A Study on the Beamforming System with Reconfigurable Focusing Depth for Ultrasound-enhanced Thrombolysis
*H. Song[1], M. Kim[1], M. Cho[1], Y. Lee[1], I. Oh[1], J. Jung[2], H. Choi[2], C. Park[1], [1]Korea Advanced Institute of Science and Technology, Daejeon , Republic of Korea, [2]Daegu Gyeongbuk Institute of Science & Technology, Daegu , Republic of Korea*

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WPos1-16 A Numerical Assessment Methodology Based on Interference Voltage for Pacemaker EMI Triggered by Magnetic Resonance Wireless Power Transfer Coils
*T. Hikage, M. Shirafune, T. Nojima, Hokkaido University, Sapporo, Japan*

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WPos1-17 Design of a Tri-band Implantable Antenna for Wireless Telemetry Applications
*M. N. Shakib[1,2], M. Moghavvemi[1,2], W. N. Mahadi[1], M. R. Ahmed[3], [1]University of Malaya, Kuala Lumpur, Malaysia, [2]University of Malaya, Kuala Lumpur, Malaysia, [3]University of Canberra, Canberra, Australia*

WPos1-18 Microwave Imaging Using Frequency Domain Method for Brain Stroke Detection
*A. Zamani, A. T. Mobashsher, B. J. Mohammed, A. Abbosh, The University of Queensland, Brisbane, Australia*

WPos1-19 Microstrip applicator bandwidth enhancement using periodic structures.
*H. Halheit[1], T. Vuong[2], [1]USTHB University, Algiers, Algeria, [2]Grenoble INP MINATEC, Grenoble, France*

WPos1-20 Experimental Evaluation of Wearable Antenna Efficiency for Applications in Body-Centric Wireless Networks.
*A. Alomainy[1], T.H. Loh[2], [1]Queen Mary University of London, UK, [2]National Physical Laboratory, UK*

## Textile Sensors for Non-invasive Health Monitoring

Prof. John L. Volakis
*The Ohio State University, USA*

Remote health monitoring is expected to significantly reduce health cost by establishing a low cost approach for health monitoring. Even more importantly, body-worn sensors are expected to provide for a care free and non-invasive approaches to preventive care and in understanding disease progression. In the case of elderly and chronic neurological conditions, understanding brain signal activity can be vital in predicting or responding to dementia and epilepsy, among others. In this presentation we will focus on wireless sensors and devices for medical sensing and imaging. Textile imaging and diagnostic sensors for deep body imaging and electronic brain-machine interface will be presented. We will present wrap-around textile sensors as part of our normal clothing to identify tissue abnormalities by measuring deep tissue permittivity without being affected from variations among human bodies. Accuracies down to 2-4% in predicting the dielectric constant of deep chest tissues will be presented. Measurements using multi-probe sensors will be provided to validate this performance, along with their potential to replace much more expensive CT Scan imaging techniques. An electronic brain-machine interface system will be also presented capable of reading most of the neurological brain signals in a care-free manner and while the person is carrying out normal activity. This game-changing neurological sensor is based on a fully-passive and wireless neurosensing system for acquiring very-low-power brain signals, as low as 50μVpp in frequency-domain. The system has an impressive improvement in sensitivity of up to 22dB in sensitivity as compared to previously reported neuropotentials. This remarkable sensitivity is enabled by using an anti-parallel diode pair (APDP) implanted mixer that performs harmonic mixing with high conversion efficiency, and a pair of a highly-coupled interrogator and implanted antennas.

### Biography

John L. Volakis was born in Chios, Greece in 1956 and immigrated to the U.S.A. in 1973. He is currently the Chope Chair Professor at The Ohio State University, Electrical and Computer Engineering Dept. He also serves as the Director of the ElectroScience Laboratory with $10M in external research funding. He was on the faculty of the University of Michigan-Ann Arbor from 1984 to 2003. His research covers all aspects of electromagnetics, and includes antennas and wireless communications, electromagnetic compatibility and interference, propagation, design optimization, RF materials and metamaterials, multi-physics engineering, bioelectromagnetics, mm-wave front ends for GB communications, THz, radar scattering, and computational methods. His team has developed mainstream computational methods and antennas that have been transitioned to the market. More recently, his work focused on miniaturizing antennas and sensors, and his team introduced novel metamaterial and metastructures that transitioned to industry. His publications include 8 widely used books (Approximate Boundary Conditions in Electromagnetics, 1995; Finite Element Methods for Electromagnetics, 1998; the classic 4th ed. Antenna Engineering Handbook, 2007 and Small Antennas, 2010; Integral Equations for EM, 2011), 340 journal papers and over 650 conference papers. He has mentored nearly 80 doctoral students/post-docs, with 26 of them received awards at international conferences. His service to Professional Societies include: 2004 President of the IEEE Antennas and Propagation Society, twice the general Chair of the IEEE Antennas and Propagation Symposium, IEEE APS Distinguished Lecturer, IEEE APS Fellows Committee Chair, IEEE-wide Fellows committee member & Associate Editor of several journals. He is a Fellow of IEEE and ACES. Among his awards are: The Univ. of Michigan College of Engineering Research Excellence award (1993), Scott award from The Ohio State Univ. College of Engineering for Outstanding Academic Achievement (2011), IEEE Tai Teaching Excellence award (2011) and the IEEE Henning Mentoring award (2013), and IEEE APS Distinguished Achievement award (2014).

## Wireless Radar Sensor Networks for Long-term Health Monitoring

Prof. Dominique Schreurs
*KU Leuven, Belgium*

Radar techniques have been investigated in recent years to develop novel assistive technologies that enable and facilitate routine long-term health monitoring in home and clinical environments. In fact, exploiting the Doppler Effect, the mechanical movements of heart, chest (lungs), and body cause changes in frequency and phase of the wave reflected from the person, and in this way heartbeat, respiration rate, and motion speed can be measured non-invasively. Radar systems represent therefore a promising alternative to wire-based devices or wireless body sensor networks (WBSNs), which require sensors attached to the human body involving both discomfort and the need for actions by the person, who tend to forget wearing them.

In the last two decades the attention has been focused mainly on contactless vital signs monitoring using either CW (Continuous-Wave) Doppler radar or UWB-IR (Ultra-Wide-Band Impulse-Radio) radar. The limit of current research is that it is possible to monitor heartbeat and respiration rate under “ideal conditions”, that is, just on a single person constrained to be motionless (i.e., seated or lying down). However, these systems represent also potential tools for Sudden Infant Death Syndrome (SIDS) and sleep apnea monitoring, and in tracking accurately and systematically irregular heart or breathing patterns.

In the last few years, radar techniques have been investigated also aiming at in-door fall detection and tagless localization, meaning without any use of radio-frequency identification (RFID) tag attached to the person. At this scope, a full system has been designed and demonstrated. It consists of a sensor, combining radar, Zigbee, and microcontroller capabilities, and of a base station for data processing. A radar waveform, alternating a CW signal with a Stepped-Frequency Continuous-Wave (SFCW) waveform, is generated and sent to the target, while its reflected echo containing speed and absolute distance information, is collected by the receiver. The resulting baseband signals are digitized and transmitted wirelessly to the base station, consisting of a Zigbee module, and a digital signal processor (DSP), to determine remotely the target's absolute distances and to distinguish a fall event from normal movements (e.g., walking, sitting down, standing up, random movements). However, a single radar sensor is insufficient for practical and real situations. Depending on the position of a person in a room, his/her reflection can be obstructed by furniture. Moreover, due to the Doppler Effect, a radar is not able to detect the speed of a target moving perpendicular to the line of sight (LoS) of the antenna. These limitations can be overcome by means of a wireless radar sensor network (WRSN). In fact, by combining the measured information from several sensors, a better estimate of the motion is obtained. Moreover, a single radar can detect absolute distance so by using multiple sensors it is possible to detect position (like in a GPS system).

In this presentation, the latest developments in WRSN aiming at in-door contactless fall detection and tagless positioning are presented and discussed. Experimental results conducted in a real room setting with human subjects demonstrate the feasibility of the proposed approach in detecting fall events over all orientations and in performing in-door positioning.

### Biography

Dominique Schreurs received the M.Sc. and Ph.D. degrees in electronic engineering from the Katholieke Universiteit (KU) Leuven, Belgium. She was a post-doc fellow of FWO-Flanders, and has been Visiting Scientist with Agilent Technologies (USA), Eidgenössische Technische Hochschule Zürich (Switzerland), and the National Institute of Standards and Technology (USA). She is now Full Professor at KU Leuven. Her main research interests concern the (non)linear characterization and modelling of microwave devices

and circuits, as well as (non)linear hybrid and integrated circuit design for telecommunications and biomedical applications.

Prof. D. Schreurs is strongly involved in international professional organisations. She is IEEE Fellow and serves on the IEEE MTT-S AdCom, after election by the membership-at-large in 2008. She was Chair of the IEEE MTT-S Technical Committee on Microwave Measurements (MTT-11) in 2005-2008, and was vice-chair of the IEEE MTT-S Technical Coordinating Committee in 2009-2010. Now she is chair of the IEEE MTT-S Education Committee. She has been appointed as Distinghuished Microwave Lecturer for 2012-2014. She is also Associate Editor of the IEEE Microwave and Wireless Components Letters since 2010.

Prof. D. Schreurs also serves as Chair of the Technical Committee on the Executive Committee of the ARFTG organization. She was Technical Program Chair of the 2002 Fall ARFTG conference and 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.
She was also co-chair of the European Microwave Conference in 2008 and then initiated the IEEE Women in Microwaves event at the European Microwave Week. She is Associate Editor of the journal of the European Microwave Association, i.e., International Journal of Microwave and Wireless Technologies, since 2011.

Prof. D. Schreurs is reviewer for a wide range of international journals and conferences. She has been session chair at conferences regularly, and acted as judge for student competitions.

## Therapeutic Applications of Microwave Antennas

Prof. Koichi Ito
*Chiba University, Japan*

In recent years, various types of medical applications of microwave antennas have widely been investigated and reported. Typical recent applications include:

(1) Information transmission:
- RFID (Radio Frequency Identification) / Wearable or Implantable monitor
- Wireless telemedicine / Mobile health system

(2) Diagnosis:
- High intensity MRI (Magnetic Resonance Imaging)
- Microwave CT (Computed Tomography) / Radiometry

(3) Treatment:
- Thermal therapy (Hyperthermia, ablation, etc)
- Surgical device (Coagulation device, microwave knife, etc)

In this presentation, microwave techniques for treatment, which employ thermal effect of electromagnetic wave, are introduced. Firstly, a coaxial-slot antenna and an array applicator composed of several coaxial-slot antennas for minimally invasive microwave thermal therapy are overviewed. A few results of actual clinical trials by use of coaxial-slot antennas are demonstrated from a technical point of view. Other therapeutic applications of coaxial-slot antennas such as hyperthermic treatment for brain tumor and intracavitary hyperthermia for bile duct carcinoma are also introduced. Secondly, a few different types of surgical devices using high power microwave energy, including a new coagulation device which has two functions of coagulating and cutting biological tissue, are introduced. Heating characteristics of such microwave surgical devices are evaluated by numerical calculation and some experiments.

## Biography

Koichi Ito was born in Nagoya, Japan, and received the B.S. and M.S. degrees from Chiba University, Chiba, Japan, in 1974 and 1976, respectively, and the D.E. degree from Tokyo Institute of Technology, Tokyo, Japan, in 1985, all in electrical engineering. From 1976 to 1979, he was a Research Associate at the Tokyo I nstitute of Technology. From 1979 to 1989, he was a Research Associate at Chiba University. From 1989 to 1997, he was an Associate Professor at the Department of Electrical and Electronics Engineering, Chiba University. From 1997 to 2003, he was a Professor at the Department, and is currently a Professor at the Center for Frontier Medical Engineering, Chiba University. From 2005 to 2009, he was Deputy Vice-President for Research, Chiba University. From 2008 to 2009, he was Vice-Dean of the Graduate School of Engineering, Chiba University. Since April 2009, he has been appointed as Director of Research Center for Frontier Medical Engineering, Chiba University. In 1989, 1994, and 1998, he visited the University of Rennes I, France, as an Invited Professor. He has been appointed as Adjunct Professor to the University of Indonesia since 2010 and Visiting Professor to the Xidian University, China, since 2014.

His main research interests include analysis and design of compact antennas for mobile communications, research on evaluation of the interaction between electromagnetic fields and the human body by use of numerical and experimental phantoms, microwave antennas for medical applications such as cancer treatment, and antenna systems for body-centric wireless communications.

Professor Ito is a Fellow of the IEEE, a Fellow of the Institute of Electronics, Information and Communication Engineers (IEICE) of Japan, a member of the American Association for the Advancement of Science, the Bioelectromagnetics Society (BEMS), the Institute of Image Information and Television Engineers of Japan (ITE) and the Japanese Society for Thermal Medicine. He served as Chair of the Technical Group on Radio and Optical Transmissions, ITE, from 1997 to 2001, Chair of the Technical Committee on Human Phantoms for Electromagnetics, IEICE, from 1998 to 2006, Chair of the Technical Committee on Antennas and Propagation, IEICE, from 2009 to 2011, Chair of the IEEE AP-S Japan Chapter from 2001 to 2002, Vice-Chair of the 2007 International Symposium on Antennas and Propagation (ISAP2007), General Chair of the 2008 IEEE International Workshop on Antenna Technology (iWAT2008), Co-Chair of ISAP2008, an AdCom member for the IEEE AP-S from 2007 to 2009, an Associate Editor for the IEEE Transactions on Antennas and Propagation from 2004 to 2010, a Distinguished Lecturer for the IEEE AP-S from 2007 to 2011, General Chair of ISAP2012 and a member of the Board of Directors, BEMS, from 2010 to 2013. He currently serves as Chair of the IEEE AP-S Committee on Man and Radiation (COMAR) and a Councilor to the Asian Society of Hyperthermic Oncology (ASHO). He has been appointed as a member of the IEEE Life Sciences New Initiative (LSNI) Project Team since 2011. He has been elected as a delegate to the European Association on Antennas and Propagation (EurAAP) since 2012 and Chair of Commission K, Japan National Committee of URSI since 2014.

## Body-Centric Wireless Communications for Healthcare and Consumer Applications: From UHF to Mm-wave

Prof. Peter S Hall
*University of Birmingham, UK*

Body-centric wireless communications are now regarded as a well-established research field, with many research activities addressing different aspects related to antennas and propagation. In particular, on-body radio propagation is relevant to Wireless Body Area Networks (WBANs), defined by IEEE 802.15 Working Group as "low power devices and operation on, in or around the human body (but not limited to humans) to serve a variety of applications including medical, consumer electronics, personal entertainment and other". In healthcare, the constant increase in the number of elderly people in various western countries, together with a rise in obese and overweight subjects, is posing the problem of the rising costs of national health services. On the other hand, the spending reviews being carried out by many governments call for an optimisation of the expenses in this sector. Body-centric communication can provide continuous and cost efficient monitoring of patients and remote diagnosis systems, thus reducing the time and costs of hospitalisation.

### Biography

Peter Hall is Professor of Communications Engineering, leader of the Antennas and Applied Electromagnetics Laboratory, and Head of the Devices and Systems Research Centre in the Department of Electronic, Electrical and Systems Engineering at The University of Birmingham. After graduating with a PhD in antenna measurements from Sheffield University, he spent 3 years with Marconi Space and Defence Systems, Stanmore working largely on a European Communications satellite project. He then joined The Royal Military College of Science as a Senior Research Scientist, progressing to Reader in Electromagnetics. He joined The University of Birmingham in 1994.

He has researched extensively in the areas of antennas, propagation and and antenna measurements. He has published 5 books, over 350 learned papers and taken various patents. These publications have earned many awards, including the 1990 IEE Rayleigh Book Award for the Handbook of Microstrip Antennas.

Professor Hall is a Fellow of the IEE and the IEEE and a past IEEE Distinguished Lecturer. He is a past Chairman of the IEE Antennas and Propagation Professional Group and past coordinator for Premium Awards for IEE Proceedings on Microwave, Antennas and Propagation. He is a member of the IEEE AP-S Fellow Evaluation Committee. He chaired the 1997 IEE ICAP conference, was vice chair of EuCAP 2008 and has been associated with the organisation of many other international conferences. He was Honorary Editor of IEE Proceedings Part H from 1991 to 1995 and currently on the editorial board of Microwave and Optical Technology Letters. He is a past member of the Executive Board of the EC Antenna Network of Excellence. He recently received the LAPC IET James Roderick James Lifetime Achievement Award.

## The Future of Medicine is Wireless: On-Body and In-Body Devices Transforming Healthcare

Prof. K. S. Nikita
*National Technical University of Athens, Greece*

Rapid advances in wireless communications, sensing technologies and sensor data analytics are opening new opportunities in medicine, and are promising to address the unsustainability of current healthcare provision models. Notably, healthcare challenges, including rising healthcare costs, aging populations and emerging disease threats rank among the most serious concerns in the world. Wireless technology can empower both patients and medical providers by providing round-the-clock health status information. Examples include wireless on-body (wearable, epidermal) and in-body (implantable, ingestible) medical devices that may be used as sensors, actuators, and/or drug delivery devices. Remote diagnosis, vital parameter control, elderly monitoring and chronic disease management are just some application examples. Exploitation of wireless technologies and sensor data analytics in healthcare can lead to healthier citizens, reduced hospital stays, and lower costs. In this talk, we will focus on transformational wireless technologies for healthcare, discussing their potential and challenges raised.

### Biography

Prof. Konstantina S. Nikita received the Diploma in Electrical Engineering and the Ph.D. degree from the National Technical University of Athens (NTUA), as well as the M.D. degree from the Medical School, University of Athens. From 1990 to 1996, she worked as a Researcher at the Institute of Communication and Computer Systems. In 1996, she joined the School of Electrical and Computer Engineering, NTUA, as an Assistant Professor, and since 2005 she serves as a Professor at the same School. She has authored or co-authored 190 papers in refereed international journals and chapters in books, and over 300 papers in international conference proceedings. She is editor of four books in English, and author of two books in Greek. She holds two patents. She has been the technical manager of several European and National R∓D projects. She has been chair of the program/organizing committee of several international conferences and she has served as keynote/invited speaker at international conferences, symposia and workshops organized by NATO, WHO, ICNIRP, IEEE, URSI, COMCON, PIERS etc. She has been the advisor of 23 completed Ph.D. theses, several of which have received various awards. Her current research interests include biomedical telemetry, biomedical signal and image processing and analysis, biological systems modeling and control, biomedical informatics, intelligent healthcare systems, medical decision support.

Dr Nikita is Associate Editor of the IEEE Transactions on Biomedical Engineering, the IEEE Journal of Biomedical and Health Informatics, the Wiley-Bioelectromagnetics, the Journal of Medical and Biological Engineering and Computing and a guest editor of several international journals. She has received various honors/awards, among which, the Bodossakis Foundation Academic Prize (2003) for exceptional achievements in “Theory and Applications of Information Technology in Medicine”. She has been a member of the Board of Directors of the Atomic Energy Commission and of the Hellenic National Academic Recognition and Information Center, as well as a member of the Hellenic National Council of Research and Technology. She has also served as Deputy Head of the School of Electrical and Computer Engineering of the NTUA. She is a member of the Hellenic National Ethics Committee, a Founding Fellow of the European Association of Medical and Biological Engineering and Science (EAMBES), a member of the Technical Chamber of Greece and of the Athens Medical Association. She is also the founding Chair and Ambassador of the IEEE-EMBS, Greece Chapter and Vice Chair of the IEEE Greece Section.

## Advanced Wearable Antenna Development for Body Area Networks

Prof. Douglas Werner
*The Pennsylvania State University, USA*

The rapid development of body area networks has made possible a number of electronic systems with revolutionary functionalities in a wide variety of diverse areas. Since wearable antennas operate in close proximity to the human body, the loading effect of lossy human tissue and the specific absorption rate of electromagnetic energy in the body are major factors that must be taken into account in their design. Other antenna properties such as efficiency (critical for low power on-body sensor applications), polarization, bandwidth, form factor, weight, and flexibility also need to be strategically considered. Therefore, integrated wearable antennas with high efficiency, low profile and small form factor must be specially designed for different operating frequency bands and wireless environments. Systematic investigations have been underway at Penn State to develop wearable antenna technology capable of meeting the unique and challenging set of requirements for integration with low power wearable medical sensors. In this presentation, we will review our progress and findings towards advanced miniaturized flexible wearable antennas as well as wearable antennas integrated with microwave circuits. The presentation will initially focus on the design and characterization of both narrowband and wideband compact wearable antennas, which are enabled by loading from highly truncated metasurfaces. Next, advanced wearable antennas with circular polarization and integrated narrowband and wideband filtering functionality (filtennas) will be presented, which are designed with the aid of powerful global optimization techniques. These innovations make the wireless data exchange more robust to human body motion as well as significantly reduce interference and cross-talk with other existing personal and commercial wireless systems. These custom designed multifunctional antennas outperform existing state-of-the-art commercial products, thus greatly improving the overall system performance while providing a smaller form factor.

### Biography

Douglas H. Werner received the B.S., M.S., and Ph.D. degrees in electrical engineering and the M.A . degree in mathematics from the Pennsylvania State University (Penn State), University Park, in 1983, 1985, 1989, and 1986, respectively.

He holds the John L. and Genevieve H. McCain Chair Professorship in the Pennsylvania State University Department of Electrical Engineering. He is the director of the Computational Electromagnetics and Antennas Research Lab (CEARL: http://cearl.ee.psu.edu/) as well as a member of the Communications and Space Sciences Lab (CSSL). He is also a faculty member of the Materials Research Institute (MRI) at Penn State. Dr. Werner was presented with the 1993 Applied Computational Electromagnetics Society (ACES) Best Paper Award and was also the recipient of a 1993 International Union of Radio Science (URSI) Young Scientist Award. In 1994, Dr. Werner received the Pennsylvania State University Applied Research Laboratory Outstanding Publication Award. He was a co-author (with one of his graduate students) of a paper published in the IEEE Transactions on Antennas and Propagation which received the 2006 R. W. P. King Award. He received the inaugural IEEE Antennas and Propagation Society Edward E. Altshuler Prize Paper Award and the Harold A. Wheeler Applications Prize Paper Award in 2011 and 2014 respectively. He has also received several Letters of Commendation from the Pennsylvania State University Department of Electrical Engineering for outstanding teaching and research. Dr. Werner is a former Associate Editor of Radio Science, an Editor of the IEEE Antennas and Propagation Magazine, a member of the American Geophysical Union (AGU), URSI Commissions B and G, the Applied Computational Electromagnetics Society (ACES), Eta Kappa Nu, Tau Beta Pi and Sigma Xi. He holds seven patents, has published over 600 technical papers and proceedings articles, and is the author of twelve book chapters with two additional

chapters currently in preparation. He has published several books including Frontiers in Electromagnetics (Piscataway, NJ: IEEE Press, 2000), Genetic Algorithms in Electromagnetics (Hoboken, NJ: Wiley/IEEE, 2007), and Transformation Electromagnetics and Metamaterials: Fundamental Principles and Applications (London, UK: Springer, 2014). He has also contributed chapters for several books including Electromagnetic Optimization by Genetic Algorithms (New York: Wiley Interscience, 1999), Soft Computing in Communications (New York: Springer, 2004), Antenna Engineering Handbook (New York: McGraw-Hill, 2007), Frontiers in Antennas: Next Generation Design and Engineering (New York: McGraw-Hill, 2011), Numerical Methods for Metamaterial Design (New York: Springer, 2013), and Computational Electromagnetics (New York: Springer, 2014). He was the recipient of a College of Engineering PSES Outstanding Research Award and Outstanding Teaching Award in March 2000 and March 2002, respectively. He was also presented with an IEEE Central Pennsylvania Section Millennium Medal. In March 2009, he received the PSES Premier Research Award. He is a Fellow of the IEEE, the IET (formerly IEE), and the ACES.

His research interests include computational electromagnetic, antenna theory and design, phased arrays (including ultra-wideband arrays), microwave devices, wireless and personal communication systems (including on-body networks), wearable and e-textile antennas, RFID tag antennas, conformal antennas, reconfigurable antennas, frequency selective surfaces, electromagnetic wave interactions with complex media, metamaterials, electromagnetic bandgap materials, zero and negative index materials, transformation optics, nanoscale electromagnetics (including nanoantennas), fractal and knot electrodynamics, and nature-inspired optimization techniques (genetic algorithms, clonal selection algorithms, particle swarm, wind driven optimization, and various other evolutionary programming schemes).

## Recent Advances in Health and Safety Consideration of RF and Wireless Technologies

Prof. James C. Lin
*University of Illinois at Chicago, USA*

Advances in radio frequency (RF) and wireless technologies and their applications are increasing at an accelerating pace. In addition to the familiar wireless communication domains of human-to-human and human-to-computer interactions, RF technologies are major enablers of the convergence scenario of Internet of Things (IoT), where connectivity of devices, systems and services embraces a wide variety of applications, domains and protocols involving humans, man-made objects or natural things. To ensure that exposure to RF energy does not produce any harmful health effects to humans, international organizations have recommended and national regulatory entities have set limits on the maximum local, partial-body, and whole-body absorption of RF energy. Nevertheless today, nearly 60 years after promulgation of the first guidelines, the subject of safety of RF exposure remains controversial. Clearly, availability of scientific data is a limitation. However, controversies on the interpretation of available data also contribute to the uncertainty. A case in point, the World Health Organization's International Agency for Research on Cancer (IARC) announcement acknowledged, while not entirely unanimous, published scientific papers report increased risks for gliomas (a type of malignant brain cancer) and acoustic neuromas (a non-malignant tumor of the auditory nerve on the side of the brain) among heavy or long-term users of cellular mobile telephones. Some other groups of epidemiologists reviewing the same papers concluded that the increased risk was entirely explicable by various biases or errors. In their judgment there is little possibility that cell phone use could increase the risk of glioma or acoustic neuroma in users. A fair summary of the biological research results would be that they do not conclusively demonstrate evidence that proves or disproves a health risk from cell phone exposure. It is factual that more studies show no health effect. However, except for animal studies, a majority of the studies were short-term investigations. That includes epidemiological studies of head and neck cancers in cell phone users. Note that the scientific progress made during the past decade in computational RF dosimetry in human anatomies has been exceptional. The sensitivity and resolution of present day computational algorithms and resources, and experimental measurement schemes can provide accurate dosimetry in humans with a spatial resolution on the order of 1 mm or less. A smaller dimension or volume is a scientifically more precise representation of localized RF energy absorption and a more biologically significant measure of RF field distribution inside the body or head.

### Biography

Prof. James C. Lin received the B.S., M.S., and Ph.D. degrees from the University of Washington, Seattle, in 1966, 1968, and 1971, respectively. He is currently a Professor of electrical engineering, bioengineering, and physiology and biophysics at the University of Illinois-Chicago (UIC), Chicago, where he was the Head of the Bioengineering Department, the Director of the Robotics and Automation Laboratory, and the Director of special projects in the College of Engineering. He is the author or an Editor of nine books. He has authored or coauthored more than 160 journal papers and book chapters. In addition, his columns with more than 100 articles on health and safety of wireless mobile communication radiation appear in four professional magazines. He is the Editor-in-Chief of the Bioelectromagnetics journal and has served as an Editor and a member of the Editorial Boards of several journals. He is listed in the American Men and Women of Science, the Who's Who in America, the Who's Who in Engineering, the Who's Who in the World, and the Men of Achievement.
Prof. Lin is a member of the Sigma Xi, the Phi Tau Phi, the Tau Beta Pi, and the Golden Key Honorary Societies. He is a Fellow of the American Association for the Advancement of Science and the American Institute for Medical and Biological Engineering. He was an NSC Research Chair from 1993 to 1997. He is

an IEEE Engineering in Medicine and Biology Society Distinguished Lecturer. He has served in leadership positions of several scientific and professional organizations, including the President of the Bioelectromagnetics Society, the Chairman of the International Scientific Radio Union Commission on Electromagnetics in Biology and Medicine, the Chairman of the IEEE Committee on Man and Radiation (COMAR), the Vice President of the U.S. National Council on Radiation Protection and Measurements, the Chairman of its Committee on Biological Effects and Exposure Criteria for Radiofrequency Fields, and the Chairman of the International Commission on Non-Ionizing Radiation Protection Scientific Committee. He has served on numerous advisory committees and panels for the Office of the U.S. President, the National Academy of Sciences, the National Research Council, the National Science Foundation, the National Institutes of Health, the Marconi Foundation (Italy), and theWorld Health Organization. He is the recipient of the d'Arsonval Medal from the Bioelectromagnetics Society, the IEEE Electromagnetic Compatibility Transactions Prize Paper Award, the IEEE COMAR Recognition Award, the CAPAMA Outstanding Leadership and Service Awards, and the UIC Best Engineering Advisor Award.

# Abstracts – TK2, Tue 9 December 2014

## What next for reliable body sensor networking? Addressing the challenges faced by wireless communication systems in close proximity to the human body

Prof. William G. Scanlon
*Queen's University Belfast, UK*

The topical interest in wireless devices, sensors and systems operating in close proximity to and in conjunction with the user's body continues to grow unabated. This presentation show how the unique, and often challenging, characteristics at the physical layer can be used to our advantage in developing new ideas and applications for wireless body sensor networking. This physical layer starting point can both inform, and can be exploited by, all layers of the stack to deliver optimum communications performance even under tight resource constraints. It is clear that further research on antennas and propagation, wireless communication protocols and even localisation and interference sensing and mitigation will be needed to ensure that future generations of body sensor networks will be reliable and robust. Nonetheless, the presentation will examine how the physical layer remains at the heart of efforts to improve wearable applications, for example, by optimising the use of the available spectrum and improving energy efficiency in both devices and systems.

### Biography

William G. Scanlon received the B.Eng. degree in electrical engineering (first-class honours) by part- time study and the Ph.D. degree in electronics (specializing in wearable and implanted antennas) from the University of Ulster, UK in 1994 and 1997, respectively. He was appointed as Lecturer at the University of Ulster in 1998, Senior Lecturer and Full Professor at Queen's University of Belfast (UK) in 2002 and 2008, respectively. As Director of Research for Wireless Communication Systems (WCS) he is responsible for 9 faculty members and over 30 doctoral students and researchers at Queen's and he also held a part-time Chair in Short Range Radio at the University of Twente, The Netherlands from 2009 to 2014. Prior to starting his academic career he had 10 years of industrial experience, having worked as a Senior RF Engineer for Nortel Networks, as a Project Engineer with Siemens and as a Lighting Engineer with GEC-Osram. His current research interests include personal and body-centric communications, wearable antennas, RF and microwave propagation, channel modelling and characterization, wireless networking and protocols and wireless networked control systems. He has published over 200 technical papers in major IEEE/IET journals and in refereed international conferences (H Index = 25). He served as keynote speaker for the NATO Military Communications and Information Systems Conf. (2010), the Intl. Conf. on Bodynets (2010) and the European Workshop on Conformal Antennas (2007). He Co-Chaired the International Workshop on Advances in Wireless Physical Layer Communications for Emerging Healthcare Applications at MobiHealth 2012 and the 2009 Loughborough Antennas and Propagation Conference and he has acted as invited speaker and session chair at numerous other international conferences. He has been a Series Editor of the IET Book Series on Telecommunications and Networking and he delivered the 2012 NATO Lecture Series on Next Generation Communications. Prof. Scanlon received a Young Scientist award from URSI in 1999, and he was a recipient of the 2010 IEEE H. A. Wheeler Prize Paper Award. He is Associate Editor for IEEE Antennas and Wireless Propagation Letters and the IEEE Journal of Translational Engineering in Health and Medicine and he is also a prolific reviewer for IEEE/IET journals and major conferences. He was a founding Director of WirelessLAB (Ireland) and is a member of the IEEE International Committee on Electromagnetic Safety (ICES). He is Managing Director and co-founder of Queen's spin-out ActivWireless Ltd.

### Dielectric Properties of Tissues and Their applications; State of Knowledge (Invited)

Azadeh Peyman
*Public Health England, Didcot, UK*

Dielectric spectroscopy has been a useful tool to provide insight into structure and composition of biological tissues. During the last few decades, a substantial amount of dielectric data for biological tissues have become available mainly used as an important input required in the dosimetry studies assessing the exposure of people to electromagnetic fields (EMF). This paper summarises and reviews the state of knowledge on dielectric properties of tissues, their variation as a function of age and pathological state of tissues. It also examines the impact of variation in dielectric data on the outcome of dosimetric studies in particular when single tissue exposures are considered..

### Non-invasive Magnetic Resonance Imaging (MRI) – based Electrical Property Mapping for Human Tissues (Invited)

S. Huang
*Singapore University of Technology and Design, Singapore*

Knowledge of the spatial distribution of electrical properties, namely dielectric constant, εr, and conductivity, σ, is valuable to various diagnostic and therapeutic technologies and for in vivo specific absorption rate (SAR) mapping in high-field magnetic resonance imaging (MRI). electrical property mapping (EPM) is crucial to the early detection of various cancers for the reason that electrical properties (EP's) of cancerous tissues at different stages are distinguishable from healthy ones. Moreover, EP's show high tissue contrast therefore EPM are good to show anatomical structures of human body. This talk introduces the up to date research on non-invasive magnetic resonance imaging (MRI)-based electrical property mapping for human tissues, from both the literature and the speaker's research group.

### Performance Evaluation for MIMO In Vivo WBAN Systems

Chao He, Yang Liu, Thomas P. Ketterl, Gabriel E. Arrobo, and Richard D. Gitlin
*University of South Florida, USA*

In this paper we present the performance evaluation for a MIMO in vivo WBAN system, using ANSYS HFSS and the associated complete Human Body Model. We analyzed MIMO system capacity statistically and FER performance based upon an IEEE 802.11n system model, with receiver antennas placed at various angular positions around the human body. We also analyzed MIMO system capacity with receiver antennas at the front of the body at various distances from transmitter antennas. The results were compared to SISO arrangements and we demonstrate that by using 2x2 MIMO in vivo, better performance can be achieved, and significantly higher system capacity can be achieved when receiver antennas are located at the back of the body and in front of the body.

### Numerical Investigation On the Dependence of On-Body Channel Characteristics on Anthropomorphic Variation of Human Body

Khaleda Ali, Alessio Brizzi, Akram Alomainy and Yang Hao
*Queen Mary University of London, United Kingdom*

A numerical investigation focusing on the correlation between on-body channel characteristics and the morphological variation of body is presented in the paper. The analysis has been carried out at 5.8GHz and a parallel version of Finite Difference Time Domain (FDTD) has been employed. Fifty digital phantoms are adopted in the simulation domain. Parameters explored for the concerned study are path loss and channel capacity. Results demonstrate that for models with similar dimensions around waist, a change of 50cms in height can cause a variation of 20% in path loss exponent and 35% in channel capacity per unit hertz.

### Accuracy of Asymptotic Techniques for On-Body Channel Characterization at W Band

Alessio Brizzi*, Alice Pellegrini†, Lianhong Zhang*, and Yang Hao*
** Queen Mary University of London, United Kingdom*
*†Cobham Antenna Systems, UK*

Wireless Body Area Networks (WBANs) are an established filed of research and continue to attract interest from both the scientific community and the industrial world. They have been extensively studied at frequencies up to X Band, including Ultra-Wide Band (UWB) applications. However, the interest in higher frequencies has been recently increasing, in particular for the realization of on-body systems at V and W band. The research on the on-body propagation channel at such frequencies is its infancy, and presents several challenges, such as the significant computational effort required by full-wave simulations. Given the large electrical dimensions of the human body at millimeter wave frequencies, asymptotic methods offer a promising alternative: however, their accuracy should be carefully evaluated. This paper presents a comparison between measured and simulated results for the path loss characterization of the belt-to-chest link at 94GHz.

# Abstracts – MA2, Mon 8 December 2014

A Compact Wideband Dielectric Resonator Antenna for On-Body Applications (Invited) Mian Shahzad Iqbal
*Macquarie University, Sydney, Australia*

This paper presents the design of an on-body wideband dielectric resonator antenna (DRA) for medical applications. The antenna is tested on a homogenous numerical phantom modeling a human arm. This low-profile antenna consists of three different dielectric segments and small metallic patches, which reside above a rectangular ground plane. It is excited by a coaxial probe. The volume of DRA is reduced by using multi-segment dielectric, and by adding a finite planar conducting wall. The proposed DRA has good radiation characteristics, and radiates power away from the body. It offers a predicted 10 dB return loss bandwidth of 74% between 4.4 and 9.7 GHz.

Impact of Antenna-Fiber Alignment and Recurrent Stretching on the Performance of Passive UHF RFID Tags based on Textile Antennas
Xiao Dong Zhang*, Ming Hao Yang*, Johanna Virkki†, Toni Björninen†, Sari Merilampi‡, Lauri Sydänheimo†, Yan-Cheong Chan* and Leena Ukkonen†
**City University of Hong Kong, Hong Kong, China*
*†Tampere University of Technology, Finland*
*‡Satakunta University of Applied Sciences, Finland*

Electrically conductive textiles are an enabling technology for the future wearable healthcare. In this work, we investigate the impact of antenna-fiber alignment and recurrent stretching on the performance of passive UHF RFID tags based on screen printed and conductive-fabric antennas. Our results show that on the non-uniform fibrous textiles, the antenna-fiber alignment is an important factor for the performance of the tag and its response to repeated stretching. Moreover, the tags fabricated with the two different methods were found to exhibit contrasting features in their response to the stretching.

On-Body Antenna with Reconfigurable Radiation Pattern
Sema Dumanli
*Toshiba Research Europe Limited, Bristol, UK*

On body antenna design is a challenging task due to the body being in the near-field of the antenna and the interaction between the two. The antenna should be designed to have a more application dependent gain pattern and to be less sensitive to near field effects of the body. For the case of on-body links, the antenna radiation should be directed along the body with an omni-directional pattern in horizontal plane of the antenna. It should preferably have vertical polarization. For the case of off-body links, the antenna radiation should be directed away from the body while the polarisation is not as critical as the on-body case. This paper presents a novel antenna design tackling the aforementioned challenges by exciting TM00 mode of a shorted rectangular patch antenna for the on-body link and exciting the TM01 mode for the off-body links. By means of a switching mechanism, either the on-body operation or the off-body operation is activated at 2.45 GHz with 64% and 75% efficiency respectively.

A Wearable Button Antenna with FSS Superstrate for WLAN Health Care Applications
Bappaditya Manndal, Ayan Chatterjee, Susanta Kumar Parui
*Indian Institute Engineering Science & Technology Shibpur,India*

In this article a compact miniaturized wearable antenna with the appreance of a button on clothing for WLAN applications is presented. The radiating elements of the antenna are made of copper sheet, whilst a transparent acrylic fiber sheet material is used as substrate and fed by a coaxial line through the ground place. The proposed antenna is simulated by Ansoft HFSS FEM based EM simulator and has been optimized to operate within the WLAN frequency bands with centre frequency of 5.25 GHz (5250 – 5850 MHz). a split ring-shaped slot based frequency selective surface (FSS) is designed to enhance the gain of the proposed antenna. The peak gain of the antenna is enhanced from 2.1 dBi to 5.1 dBi with the superstrate along with a bandwidth enhancement of 290 MHz. the antenna gets miniaturized around 34% by th slit.

Energy Harvesting Antenna for Various Communication Transceivers
Young-Bae Jung
*Hanbat National University, R.O.Korea*

In this paper, it is proposed the novel energy harvesting antenna which is composed of a main and a parasitic radiator. The parasitic radiator of the proposed antenna mainly receives the RF power radiated at the outside of 3-dB beamwidth form the main radiator, which does not contribute to the electrical performance of the main radiator. Thus, we can generate DC power using the dissipated RF energy that is radiated from the main radiator in various communication transceivers. The measured gain of the main radiator of the proposed antenna is 8.35 dBi, which is nearly identical to the gain of the printed dipole without the parasitic radiator. However, the parasitic radiator can gain a considerable amount of power from the main radiator due to the realized coupling performance of -12 dB. It was also verified by an EIRP test that the proposed antenna can be used as an antenna for actual wireless transceivers. We anticipate that the proposed antenna can be used as an assistant DC power means in various wireless communication transceivers.

### Microwave Techniques as Diagnostic Tool for Congestive Heart Failure (Invited)

Amin M. Abbosh
*The University of Queensland, Australia*

In recent years, microwave techniques have attracted a considerable interest as new diagnostic tools for many medical applications, such as the detection of breast cancer, brain stroke, congestive heart failure...etc. The motivation for building a new generation of microwave-based diagnostic systems is the need for portable, low-cost, non-ionized, and real-time diagnosis and monitoring tool to complement the traditional bulky and expensive tools that can only be used for screening in hospitals or major clinics. In this talk, Prof. Abbosh will explain the microwave imaging systems that have been built at the University of Queensland, the Microwave Imaging research group of the School of Information Technology and Electrical Engineering. The focus of the talk will be on torso imaging for heart failure detection. The talk will give details of the utilized antenna elements and arrays, artificial phantoms, data acquisition, and image formation algorithms. The recent results achieved in the aforementioned research areas and future challenges will be explained.

### Near Field Microwave Imaging with Power Gain Pattern Correction (Invited)

Dau-Chyrh Chang
*Oriental Institute of Technology, Taiwan*

The quality of image includes the resolution of pixel and contrast of the pixel. The better the quality of microwave image is with higher the resolution of image pixel and higher the image contrast. The contrast depends on the signal to noise ratio of the radar receiver. The resolution of pixel depends on the radar frequency. The higher the frequency the better the resolution of pixel will be. Unfortunately, the higher the frequency the smaller the signal to noise ratio will be. The phenomenon will cause the lower image contrast. In this paper, the formulation of bistatic near field microwave imaging. In order to obtain the better quality of microwave image, multiple frequencies with power gain pattern correction are developed. The results of microwave image with better resolution and higher contrast by both simulation and measurement are agreed.

### Bio-Electromagnetic Simulation for Improved Medical Imaging (Invited-Industry)

Tilmann Wittig
*CST AG, Darmstadt, Germany*

To avoid the application of ionizing radiation to the human body, microwave based imaging has become a topic of intensive research over the last years. This presentation will introduce and compare two major approaches in this domain: Ultra-Highfield Magnetic Resonance Imaging is based on the nuclear spin response, while Microwave Imaging applies ideas of radar arrays to medical imaging. Both approaches have in common that they are based on complex multi-channel antenna structures. Bio-Electromagnetic simulations are a key design tool for developing these devices, both to ensure their technical functionality, as well as to understand safety aspects inside the human body, which are still difficult to assess by measurement.

### A Fast Electromagnetic Solver for Microwave Medical Imaging

Nikolai Simonov, Seong-Ho Son, Bo-Ra Kim, Kwang-Jae Lee, and Soon-Ik Jeon
*ETRI, Republic of Korea*

This paper describes a fast electromagnetic solver that allows to accelerate significantly the microwave imaging program, which produce reconstruction of permittivity and conductivity distribution of the breast under examination for purpose of early concern detection. The reconstruction algorithm is based on the solution of inverse electromagnetic scattering problem using iteration method, which applies to solve a number of relative forward electromagnetic problems. The presented fast solver is developed for a precision microwave tomography that contain the circular array of probe antennas and operates in 3 - 6 GHz frequency band.

### Scalable Magnetically Mediated Thermoacoustic Imaging Through Coil Tailoring

Feng Xiaohua*, Gao Fei, and Zheng Yuanjin
*Nanyang Technological University, Singapore*

Microwave induced thermoacoustic imaging suffers limited penetration for high water content tissues and its system design is difficult to scale for different applications. To provide an alternative solution, magnetically mediated thermoacoustic imaging (MMTI) method is proposed here, which exploits alternating magnetic field of tens MHz to map the dielectric property of matter at ultrasonic resolution. Delivering energy via magnetic field emitting from a coil enables greater penetration as human body is non-magnetic and, the near field energy coupling nature further endows it with good scalability: by tailoring the coil, it allows the penetration and field of view to be scaled from imaging deep laid regions with large view to probing superficial ones within a small area. The coil design is thus critical for achieving scalable MMTI system, apart from affecting the system performance. We demonstrate here experimentally the signal generation performances of three different kinds of coils and showcase the scalable imaging capability of MMTI under two different scales. Furthermore, a 3-D imaging of a phantom using a small coil and mechanical scanning is presented.

### A Measurements Based Comparison of New and Classical Models Used to Characterize Fading in Body Area Networks (Invited)

Simon Cotton
*Queens University Belfast, Belfast, United Kingdom*

In this paper we compare a number of the classical models used to characterize fading in body area networks (BANs) with the recently proposed shadowed κ–μ fading model. In particular, we focus on BAN channels which are considered to be susceptible to shadowing by the human body. The measurements considered in this study were conducted at 2.45 GHz for hypothetical BAN channels operating in both anechoic and highly reverberant environments while the person was moving. Compared to the Rice, Nakagami and lognormal fading models, it was found that the recently proposed shadowed κ–μ fading model provided an enhanced fit to the measured data.

### Autonomic Body Sensor Networks (Invited)

Benny Ping Lai Lo
*Imperial College London, London, United Kingdom*

Following the evolution of computers, the size of the computer is getting smaller and smaller, one has predicted that miniaturised sensors will soon overtake the mobile phones/computers to become the next generation of computers. There are growing interests in Wireless Sensor Networks (WSN), Internet of Things (IoT) and Body Sensor Networks (BSN). In particular, BSN focuses mainly on the application of miniaturised sensors for healthcare and wellbeing applications. Although sensor miniaturisation can greatly minimise the obtrusion to the user and improve usability and compliances, it greatly limits the computational capacity of the sensors. With the growing number of sensors with very limited computation power, managing and configuring the sensor system could become a humanly impossible task. Adapting from the concept of Autonomic Computing, the concept of Autonomic Sensing was proposed, and the characteristic of an autonomic sensing system is described. An Autonomic Sensing system should be self-managed, self-configured, self-optimised, self-healed, self-protected, self-adapted, self-integrated, and self-scaled. In this talk, the concept of Autonomic sensing will be presented and follow by a discussion on its applications.

### Medical wireless body sensor networks at microwave versus mm-wave bands (Invited)

Costas Constantinou
*University of Birmingham, Birmingham, United Kingdom*

The different characteristics of wireless body sensor networks at 2.45 GHz and 60 GHz are discussed from an antennas and propagation perspective. Empirical channel measurements are analysed to inform the tradeoffs between single and multi-hop topologies, network intermittency and reliability, and inter body sensor network interference.

### Ultra Wideband In Vivo Radio Channel Characterisation and System Modeling

Qammer H. Abbasi*§, Marwa Qaraqe† , Masood Ur Rehman‡, Erchin Serpedin†
** Texas A & M University, Qatar.*
*† Texas A & M, University, USA.*
*‡ University of Bedfordshire, Luton, UK,*
*§ Queen Mary University of London, UK*

In this paper radio channel characterisation and level system modeling for ultra wideband (UWB) in vivo communication is presented at different distances and angle between the the implant and the on-body node. Path loss is calculated for different scenarios and time delay analysis is performed. In addition, UWB-OFDM (orthogonal frequency division multiplexing) based system modeling is used to calculate the bit error rate (BER) performance. Result shows that BER remains less then $1e-3$ for almost all cases up to 40 mm spacing between the implant and on-body node, when $Eb/No$ is above 6 dB.

### Comparison of Inkjet-Printed and Microfabricated Loop Antennas for Implants in Wireless Brain-Machine Interface Systems

Elham Moradi, Toni Björninen, Lauri Sydänheimo and Leena Ukkonen
*Tampere University of Technology, Tampere, Finland*

We analyze the performance of an inductive link between a cm-size loop antenna based on conventional circuit board fabrication and 6.5×6.5 mm2 planar loop antennas deposited on flexible platforms by inkjet printing gold nanoparticle ink and by electron-beam evaporation. The highly flexible antennas have been designed to provide wireless power and data telemetry for battery-free cortical implants in wireless brain-machine interface systems. The performance of the wireless link is analyzed through full-wave electromagnetic simulations in an anatomical head model and through measurements in a liquid head phantom.

## The power of VNA-driven quasi-optics to sense group molecular action in condensed phase systems (Invited)

Robert Donnan
*Queen Mary University of London, London, United Kingdom*

This talk introduces preliminary adventure for specialist quasi-optical circuits, driven by modern vector network analysers, to reveal the time-resolved energetics of condensed phased systems as they self-organise to adopt their low energy state. Examples are taken from the curing process of non-mercury-based dental cements and the solvation of proteins.

## Tissue-Equivalent Phantoms in the 60-GHz Band and Their Application to the Body-Centric Propagation Studies (Invited)

Maxim Zhadobov
*IETR, Rennes, France*

In the last years, the interest to millimeter-wave body-centric applications has significantly increased due to technological progress and some advantages offered by this frequency band. The presentation will highlight recent advances in the design of tissue-equivalent phantoms for body-centric propagation studies at millimeter-waves. Recently developed solid skin-equivalent phantom will be presented and compared to semi-solid prototypes in V band. The phantom has been validated through propagation studies using different antennas with or without textiles demonstrating that it can be successfully used for the body-centric propagation channel measurements.

## Micro- and millimetre wave measurements of nanolitre biological liquids by dielectric resonators (Invited)

Norbert Klein
*Imperial College London, London, United Kingdom*

A variety of dielectric resonator techniques from low GHz frequencies towards 100 GHz has been investigated with respect to their suitability for highly accurate dielectric measurements on liquids within microfluidic systems. Whispering gallery type dielectric resonators have been employed for frequencies from 10 to 40 GHz and 2D photonic crystal slab defect resonators for 100 GHz and beyond. Experiments on organic aqueous solutions and cell suspension were analyzed in terms of their potential for label-free biosensor applications.

## Bioliquid millimeter wave spectroscopy and its role in cellular modeling

Ilja Ocket[1,2]
*1IMEC, Leuven (Heverlee), Belgium*
*2KU Leuven, Leuven (Heverlee), Belgium*

Dielectric spectroscopy on liquids provides valuable information on the physical interactions between like or different molecules. Although the behaviour of many pure liquids composed of small molecules is fairly well known, and mixtures have been studied extensively, the interaction processes that underlie the dielectric behaviour of bioliquids (e.g protein solutions) is much less understood. Yet, understanding these interactions is crucial to e.g. interpret AFM-SMM images.
At the KU Leuven, our aim is to develop microwave and millimeter wave metrology tools to accurately determine the complex permittivity of nanoliter liquid samples. Performing these measurements at such a scale will enable the integration of these measurements in a lab-on-chip technology for automated screening. To extract more information from the dispersion behaviour of bioliquids, increased accuracy (via resonant methods) is needed as well. Of specific interest to cellular modeling are the so-called delta dispersions in roughly the 1-10 GHz region, which are likely indicative of cytoplasmic protein content.

## Comparing Terahertz transmission response on pH-dependent Apomyoglobin proteins dynamics with Circular Dichroism

Junyi Qiu*†, Bin Yang‡, Oleksandr Sushko*, Richard W. Pikersgill† and Robert S. Donnan*
** Queen Mary University of London, United Kingdom*
*† Queen Mary University of London, United Kingdom*
*‡ University of Bolton, United Kingdom*

Terahertz time domain spectroscopy (THz-TDS) was used to study the transmission responses of pH-dependent apomyoglobin (ApoMb) dissolved solutions in 0.2 – 2.2 THz frequency domain, the THz-TDS technique was also benchmarked against circular dichroism (CD) by studying pHrelated folding states changes of ApoMb protein. Results revealed that differences of pH-dependent ApoMb /water dynamics can be detected directly by the THz refractive index spectrum, and these differences are further proved to be caused mainly the effect of protonation of water and possibly water response leaded by protein conformation change.

## Improving Patient Safety in Microwave Ablation Treatments (Invited)

Gary Beale
*Emblation Limited, United Kingdom*

In medical microwave systems the measurement of forward and reflected power is often used as a safety mechanism to monitor treatments, detect and react to device failures, connection issues and potential misuse. Any inaccuracy in these measurements has the potential to result in either insufficient power being delivered - resulting in poor treatments and a perception of unreliability, or excessive power being administered – potentially causing serious patient injury.

The challenge facing product designers in the growing field of microwave ablation is how to accommodate the measurement of varying impedance and phase where using standard components that are generally calibrated for typical industrial applications, where the impedance match is fixed.

This presentation will discuss the growing requirement for safe, medical-grade microwave equipment to meet the needs of a challenging, ever-evolving regulatory landscape.

## Recent advances in microwave medical imaging based on the Distorted Born Iterative Method (Invited)

Panagiotis Kosmas
*King's College London, London, United Kingdom*

Electromagnetic (EM) inverse scattering algorithms are an essential component of quantitative microwave imaging (MWI) for medical applications. In microwave medical tomography, an array of antennas surrounds the region of interest inside the patient's human body. The scattered energy is recorded by the array and an EM inverse scattering algorithm processes the signals to form an image of the probed region by solving a non-linear inverse problem which reconstructs the complex permittivity of the interrogated tissue. An important family of iterative algorithms for solving this EM inverse scattering problem is based on the Distorted Born Iterative Method (DBIM), which is equivalent to Gauss-Newton optimization approaches. This presentation will first review the DBIM algorithm and its application to medical imaging for breast cancer applications. After a brief overview of the current state of the art by various research groups worldwide, the talk will focus on some recent advances in the solution of the DBIM algorithm that can improve significantly the performance of this technique for microwave medical imaging.

## Electromagnetic Acoustics Sensing and Imaging for Biomedical Applications (Invited)

Yuanjin Zheng
*Nanyang Technological University, Singapore*

The paper is to investigate the fundamentals of 'electromagnetic acoustics', and explore its potentials in bioelectronics. The recent developed technique including correlated microwave-acoustics imaging, temperature modulated thermoacoutics imaging, and photoacoustic resonant imaging will be presented. There applications on biomedical sensing and imaging will be demonstrated as well.

### Wireless Data Telemetry and Power Transfer for Biomedical Applications (Invited)

Yong Xin Guo[1,2]
*1National University of Singapore, Singapore*
*2National University of Singapore Suzhou Research Institute, China,*

In this talk, researches on wireless date telemetry and power transfer for biomedical applications are introduced. Firstly, different kinds of miniaturized implantable antennas for wireless date telemetry were designed for single-/dual-band applications. Also, implantable antennas for differentially feeding were designed to be easily integrated with the transmitter with differentially feeding outputs. Besides the studies of miniaturization technologies, an implantable antenna with circular polarization was studied for better communication quality. Additionally, studies of near-field magnetic coupling and far-field wireless power transfer for biomedical applications were investigated.

### A Wireless Power Transmission System for Robotic Capsule Endoscopy: Design and Optimization

M. R. Basar[a,b], Mohd Yazed Ahmad[a,b], Jongman Cho[b,c] and Fatimah Ibrahim[a,b]
*a Department of Biomedical Engineering, Faculty of Engineering, University of Malaya, Malaysia*
*b Center of Innovation in Medical Engineering, Faculty of Engineering, University of Malaya, Malaysia.*
*c Department of Biomedical Engineering, Korea.*

This paper presents an inductive coupled wireless power transmission (WPT) system for powering an endocopic robotic capsule. The proposed WPT system was designed and optimized through manipulation of the core material, the quality factor (Q) and the load impedance matching of the receiving coil (RC). A MnZn ferrite core with high initial permeability was employed. The Q of the 3D RC was optimized by choosing an optimum number of strands and turns. At the optimum design condition the system was able to deliver at least 376 mW of usable power to the load when magnetic field (H-field) of 105 A/m was applied at the frequency of 250 kHz. The uniformity of H-field generated by the power transmitting coil (PTC) was sufficient to achieve 86% stability of received power. The proposed system reduces the required level of H-field by 50% and increases the load power by 22.3% as compared to the existing study.

### High-Efficiency Triple-band Ambient RF Energy Harvesting for Wireless Body Sensor Network

Zhongtao Liu*†, Zheng Zhong*, and Yong-Xin Guo*‡
**Department of Electrical and Computer Engineering*
*†NUS Graduate School for Integrative Sciences and Engineering, National University of Singapore, Singapore*
*‡National University of Singapore Suzhou Research Institute, Suzhou, China*

This paper proposes a triple-band rectifying circuit for ambient RF energy harvesting, which can be served as a power supply for the central unit in Wireless Body Sensor Networks (WBSN). It fully utilizes the RF energy in ambient and converts it into DC power with high efficiency. It covers the public telecommunication bands of GSM-900, GSM-1800 and UTMS-2100, which are measured to hold the major RF energy in ambient. Simultaneous multiband energy collection helps in achieving high conversion efficiency, which is around twice that of the conventional separate single-band inputs. Measurement results show that 31.2% RF-to-DC conversion efficiency and 159mV output DC voltage are gained over a resistive load of 3.3 KΩ with an input RF power of -20dBm.

### Local Temperature Assessment Produced by an Implantable Antenna for Intracranial Pressure Monitoring

Konstantinos A. Psathas, Konstantina S. Nikita
*National Technical University of Athens, Greece*

This study focuses on the local temperature elevation produced by a biocompatible dual-band implantable antenna which is designed for intracranial Pressure Monitoring (ICP) application. A numerical analysis of the temperature elevation is being performed based on the Pennes Bioheat Equation (PBE) in both MedRadio and Industrial, Scientific and Medical Radio (ISM) band. The induced heat dissipation inside a human anatomical model is being examined. A maximum temperature elevation of 0.192 $^{o}$C is observed in the close proximity of the implantable antenna under compliance with the IEEE basic exposure limitations.

### A Dual-polarized Impulse Radiation Antenna for Cerebral Hemorrhage Detection Applications

Jing Li[1], Hong-Li Peng[1], Bai-Qing Zong[2], Zhong Yu[2]
*[1]Shanghai Jiao Tong University, Shanghai 200240, China*
*[2]ZTE Corporation*

A dual-polarized impulse radiation antenna (DP-IRA), with low profile and high gain, is presented in this paper for cerebral hemorrhage detection. To verify its detecting ability, interactions between the DP-IRA and human head models with amount-dependent bleedings are simulated. Simulation data shows that the antenna can detect cerebral hemorrhage as well as diagnose bleeding situation in a direct manner. So the antenna has great potential in future cerebral hemorrhage detection.

## Pre-hospital care for stroke and trauma (Invited)

Mikael Persson[1,4]
*1Chalmers University of Technology, Göteborg, Sweden*
*4MedTech West, Göteborg, United States*

Pre-hospital care for stroke and trauma remains one of the global challenges. , Each year around 15 million people each year suffer a stroke. Only a small fraction of stroke patients who could benefit from thrombolytic treatment reach diagnosis and treatment in time. To increase this low figure we have developed microwave technology aiming to differentiate hemorrhagic from ischemic stroke patients in a pre-hospital setting.

## Real-time system for monitoring activity among the elderly using an RF SoC device with triaxial accelerometer data over a wireless sensor network

Wiroon Sriborrirux*, Pariwat Leamsumran†, Panuwat Dan-klang*
**Burapha University, THAILAND*
*†BaesLab Co., Ltd., Bangna, Bangkok, THAILAND*

Real-time monitoring of the movement of elderly people can provide information about an individual's physical movement, degree of functional ability, and general level of activity. This paper describes the real-time monitoring of fall detection in elderly persons using acceleration data. We used a necklace tag device consisting of a Ultra high frequency (UHF) low-power RF system-on-chip and a triaxial accelerometer sensor. The necklace tag processes activity data using the triaxial accelerometer data and classifies types of risk postures, such as stumbling, forward fall, backward fall, and side fall, by calculating signal vector magnitude, angle, angular velocity, power, and spectral energy using a fast Fourier transform (FFT) technique. Because data processing takes place inside the necklace tag, the use of a centralised computer server is no longer necessary. Nevertheless, for daily recordings of activity, zone, and accident time, it is still important to store data at a data centre and to connect them with the patient's medical history. A scheme for continuous daily activity monitoring and fall detection was developed and had a recognition accuracy of more than 95%, demonstrating excellent fall detection and the feasibility of using the proposed method for daily activity monitoring.

## Flexitble Screen Printed Biosensor with High-Q Microwave Resonator for Rapid and Sensitive Detectionof Glucose

Kishor Kumar Adhikari[1], Zorigt Chuluunbaatar[1], Hyejin Park[2], Younsu Jung[2], Gyoujin Cho[2], Yong Hwa Jo[3], Sung Soo Kim[3], and Nam Young Kim[1]
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*3Dept. of Biochemistry and Molecular Biology, Kyung Hee University, Seoul, Korea*

This paper presents a rapid and sensitive mediator-free glucose biosensor based on microwave resonator implemented using circularly folded T-shaped uniform impedance resonators, screen printed on flexible polyethylene substrate. As a result of high-Q factor of 160, the proposed glucose biosensor features high sensitivity and ultralow detection limit of 71 MHz/mgmL-1 and 0.0167 μM, respectively, at a central frequency of 11.8 GHz, within linear detection range of 1 to 5 mg/mL. Additionally, the clear dependence of loaded quality factor (QL), return loss (S11), propagation constant (γ), and impedance (Z) on glucose level enables the effective multi-dimensional detection of glucose sensor.

## Development of an Ultrasound Based 3D Facial Scanning System

Ridita Ali*, Reza Saatchi†, Mohammed Rezwan Rahman‡
*Department of Engineering and Mathematics*
** † ‡ Sheffield Hallam University, Howard Street, Sheffield S1 1WB, United Kingdom*

A low-cost ultrasound transceiver was used to scan the faces of two manikins. Each manikin's head was placed on a computer controlled turntable. The transceiver was mounted in front of the manikin's head at a distance of 20 cm and the scanning was performed from forehead to the chin by turning the table. After a single horizontal scan, the sensor moved down by 1 mm. Three dimensional views of the two faces were produced from the data, although the quality of scans produced in this study was coarse.

## Machine-to-Machine Communications at Millimeter Wave Frequencies

S. M. Mitani, T. Kanesan, R. Mohamad, S. Yaakob and N. E. Farid
*Telekom Research & Development (TM R&D), TM Innovation Centre, Malaysia*

In this paper, for the first time, machine-tomachine (M2M) communications with optical millimeter wave technology is proposed for healthcare application. Optical Carrier Suppression (OCS) method is proposed with dual electrode-Mach Zehnder modulator (DE-MZM), where carrier suppression of > 25 dB was achieved. A 40 GHz carrier was successfully generated in electro optical method with the ability, not limited to, transmitting up to 1.486 Gbps. For a wireless transmission of 5 m distance, the bit error rate (BER) of 10-9 exhibits minor penalty compared to a back-to-back system.

### Skin-Mounted RFID Sensing Tattoos for Assistive Technologies (Invited)

John Batchelor
*University of Kent, Canterbury, United Kingdom*

UHF RFID technology is presented that can facilitate new passive assistive technologies. Tongue control for human computer interfaces is first discussed where a tag is attached to the hard palate of the mouth and the tag turn-on power is observed to vary in response to tongue proximity. Secondly, a stretchable tag is fabricated from Lycra fabric that contains conducting silver fibres. The application of strain to the elastic tag again causes the required power at the reader to activate the tag to vary in proportion. This elastic tag is proposed as a temporary skin mounted strain gauge that could detect muscle twitch in the face or neck of an otherwise physically incapacitated person. Either design might be applied to the steering function of a powered wheelchair, or to facilitate the control of a computer mouse. Better than 3dB isolation is achieved in the tongue switching case and approximately 0.25dBm per percentage stretch is observed for the strain gauge.

### The Future of Miniaturized Wireless: Graphene Wireless Communications

Albert Cabellos
*Universitat Politècnica de Catalunya, Spain*

Nanotechnology is providing a new set of tools to design and manufacture miniaturized devices such as sensors or on/off chips networks. Unfortunately, reducing the size of a classical metallic antenna down to a few micrometres would impose the use of very high resonant frequencies, from the near infrared to the optical ranges (tens of hundreds of THz). Graphene offers a new approach to radically downscale antennas thanks to its ability to support the propagation of Surface-Plasmon Polariton (SPP) waves in the terahertz frequency band. Graphene micro-antennas provide a better integrability for future miniaturized wireless systems and represents an enabling technology for applications such as Wireless NanoSensor Networks, Internet of Things and On/Off-Chip Wireless Networks. In this talk we will describe the fundamental properties behind graphene-miniaturized antennas as well as its applications.

### Wireless Vectorcardiogram System Optimization using Adaptive Signal Processing

Calvin A. Perumalla*, Gabriel E. Arrobo*, Thomas P. Ketterl* Richard D. Gitlin* and Peter J. Fabri‡
**Department of Electrical Engineering*
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We are designing an integrated wireless Vectorcardiogram (iVCG) that is of diagnostic quality, extremely small form factor, and is placed on the chest of the patient. In this paper, we consider the problem of transforming the three VCG component signals to the familiar 12-lead ECG for the convenience of cardiologists. We used an adaptive signal processing technique to obtain an ECG signal from the VCG measurements. The least mean-square (LMS) adaptive algorithm is employed to obtain the optimum 12x3 transformation matrix by minimizing the overall mean-square-error between the reference ECG (that is present during VCG configuration) signal and the ECG signal derived from the VCG. With this capability, the iVCG may become a truly transformative wireless medical device enabling continuous cardiac diagnosis.

### A High Power High Efficiency Integrated Solid-State Microwave Heating Structure for Portable Diagnostic Healthcare Applications

Azeem Imtiaz, Jon Hartley, Heungjae Choi and Jonathan Lees
*Cardiff University, Cardiff, UK*

This paper presents a novel approach for designing solid-state microwave heating arrangement designed for portable and field deployable microwave assisted health-care diagnostic application. In this method, the natural impedance environment of the resonant cavity has been considered as a function of temperature, and used to present the inherent optimal loading conditions to the 10W LDMOS power transistor for achieving high-efficiency operation over the operational bandwidth of the cavity resonator. Significant reduction in the output matching network complexity using simple microstip series lines and straightforward integration into a microwave resonant cavity makes this structure suitable or portable health-care diagnostic applications. Measurement results show more than 60% Power Added Efficiency, above 40dBm output power and above 20dB Gain over the targeted Bandwidth and expected temperature variation.

### Six Layers Circular Microstrip Antenna Implanted in a Phantom of Vitreous Humor

Chandra Prakash, R.P.S. Gangwar
** Deptt. of ECE, College of Technology, G.B.P.U.A.& T. Pantnagar, (India)-263145*

The proposed antenna is designed & simulated in Med-Radio band with finite element method (FEM) based high frequency structure simulator (HFSS) solver & fabricated for intraocular application for transceiver. This six layer antenna is encapsulated with poly dimethyl siloxane (PDMS) & entire antenna has been implanted inside the phantom of spherical vitreous humor at the size of human eyeball. The reflection coefficient of -30.13dB, -10dB bandwidth of 63.66 MHz, gain of -24.32 dB, 1 gm averaged SAR on vitreous body of 0.265 W/kg at incident power of 0.49 mW, reduction in size by 48% & very high efficiency of 6.90%at resonant frequency of 403MHz are obtained.

### Development of a Hybrid Microwave-Optical Deep Muscle Warming Monitor (Invited)

Kin-Fai (Kenneth) Tong
*University College London (UCL), London, UK*

Elevating the temperature in tissue leads to vasodilation and therefore an increase in blood flow to reduce the excessive heat in the region, a physiological mechanism known as thermoregulation. To allow the investigation into deeper tissue such as the muscle, a new hybrid microwave-optical system has been developed. The deep warming is provided by a novel microwave applicator, which has a microstrip patch design operating at 2.45 GHz with a superstrate interface layer to improve the coupling of electromagnetic (EM) waves into the skin. The thermal response is measured by an integrated optical probe which measures tissue oxygenation changes in deep tissue using the near infrared spectroscopy technique. The hybrid microwave-optical system has been built and tested on human calves in vivo. In the talk, we will present the development of this new type of non-invasive microwave applicator for deep tissue warming.

### Compare Study of SAR in CEMHM Model with Different Resolution Exposed to a Handset Antenna (Invited)

Lei Zhao
*Jiangsu Normal University, Xuzhou, China*

Specific absorption rate (SAR) is employed here to study the relationship between the radiation of a mobile handset and the Chinese electromagnetic human model (CEMHM) with different resolution. In the paper, 3D anatomically realistic CEMHM models with different resolution are presented by the first time. The highest resolution CEMHM model is built using the Chinese Visible Human (CVH) data set containing 3640 serial axial anatomical images. The SAR in CEMHM head models exposed a handset antenna was studied and a dipole antenna working at 900MHz is used as an exposure source. The simulation results show that the variation of maximum averaged 1g SAR values is more than 19% when the resolution changes up to 3.04x3.04x0.5 . And the variation of maximum averaged 10g SAR values is more than 15% (Compared with SAR in the finest model).

### Quadrature Channel Calibration with a Pendulum for Accurate Displacement Measurement with CW Doppler Radar

Mari Zakrzewski, Karri Palovuori, Jukka Vanhala
*Tampere University of Technology, Tampere, Finland*

A microwave radar sensor has been proposed for measurement of cardiac and respiratory activity in several applications. However for accurate displacement measurement with quadrature Doppler radar, the quadrature channel imbalance needs to be measured and compensated. In general, the requirement of hardware modifications is not practical for commercial radar sensor modules. In this paper, we show that the quadrature imbalance compensation is possible also with a simple set up. A freely hanging sphere is used as a pendulum to generate the calibration signal, and a previously presented ellipse fitting method is utilized to estimate the imbalance factors.

### SAR Evaluations of Head with Carotid Stent during MR Imaging

Mahito Koizumi*, Ryotaro Suga*, Kazuyuki Saito†, and Koichi Ito†
**Graduate School of Engineering, Chiba University, Japan*
*†Center for Frontier Medical Engineering, Chiba University, Japan*

Modern MRI systems employ highfrequency and high-powered radio frequency (RF) pulses. Given this, it is necessary to evaluate the specific absorption rate (SAR) of the irradiated human body. At once, making it more likely that subjects' implanted medical devices will affect MR imaging, potentially causing temperature increases in unexpected regions. Despite this, guidelines for evaluating the effects of such cases on the human body are still unclear. Therefore, in order to consider the safety of patients with implanted medical devices during MR imaging, it is necessary to comprehend the detailed SAR distribution within the human body. While many existing studies have addressed cases involving pacemakers, none have dealt with carotid stents. In Japan, 10,000 carotid endarterectomies and carotid artery stents are carried out each year. In this study, we evaluate the SAR distribution within the head embedding the carotid stents as an example of implanted medical devices.

### New Wideband Textile Antenna for SAR Investigation in Head Microwave Imaging

Roshayati Yahya*†, Muhammad Ramlee Kamarudin†, Norhudah Seman†
** Faculty of Electrical and Electronic Engineering,*
*† Wireless Communication Centre (WCC), Universiti Teknologi Malaysia (UTM), Malaysia*

In this paper, a wideband textile antenna for microwave imaging is presented. The antenna operates from 1.2 to 6 GHz at -10 dB level of the reflection coefficient magnitude. Whilst, the transmission coefficients of the two antennas are lower than -20 dB level. The SAR value when only one antenna is attached to the head phantom has been investigated. In addition, the maximum value of SAR is also obtained when two antennas are attached to the head phantom. The results show that the SAR levels are 0.047 W/kg and 0.022 W/kg at averaged 10 g tissues, respectively. Due to the values of SAR are far below the standard limit, thus this antenna is suitable to be used for microwave imaging.

*Mohamed El Atrash*, A Circularly Polarised Antenna for a Wireless Blood-Flow Sensor, October University for Modern Science and Arts University, Egypt

This paper presents a circularly polarised antenna for determining the speed of blood-flow, using Doppler effects at microwave frequencies. The structure consists of a double-feed patch antenna and a quadrature hybrid coupler in order to achieve circular polarisation and to isolate the reflected signal from the incident. The design was simulated and then fabricated. Both results were compared which showed a good agreement in terms of scattering parameters and radiation patterns.

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*Heungjae Choi*, Design of Continuous Non-Invasive Blood Glucose Monitoring Sensor Based on a Microwave Split Ring Resonator, Cardiff University, UK

In this paper, a design of truly non-invasive continuous blood glucose monitoring sensor which uses a pair of microwave split ring resonators is presented, operating around 1.4 GHz. The rings are made from silver coated copper wire. In addition to the sensing ring, a reference ring is added which operates at a higher frequency. This is used to take into account the temperature dependent expansion of the ring and to calibrate out any effects due to changes in temperature. The proposed sensor made up of the pair of rings is directly attached onto the skin in the abdominal area by using an adhesive patch. For validation, we have tested the proposed sensor simultaneously with two commercially available sensors (blood strip and continuous glucose monitor) over 12 hour periods with 3 food events, with encouraging correlation of our blood glucose results with those of the commercial sensors.

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*L. Benkhaoua,* A Miniaturized Near-Field Sensor Based on a Double-Sided Spiral Split-Ring Resonator for Dielectric Characterization, University Constantine, Algeria.

A new double-sided spiral split-ring resonator (DSS-SRR) is proposed and implemented as a near field sensor for measuring the relative permittivity εr of unknown materials. This sensor is based on the measurement of the resonance frequency shift of a tapered microstrip line fed DSS-SRR. In contrast to other sensors based on the use of conventional SRRs, the proposed sensor requires a very small amount of sample due to its miniature sensitive area, and it provides a high sensitivity with lower frequency due to the small electric size of the DSS-SRR. Examples of operation of the sensor with four dielectric samples are presented to reveal the potentiality of the DSS-SRR for biosensing applications.

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*Jen-Hao Cheng*, A K-Band Phase-Locked Loop in 0.18 µm CMOS Technology for Vital Sign Detection Radar, National Taiwan University, Taiwan.

In this paper, a low-power *K*-band phase-locked loop (PLL) for vital sign detection radar (VSDR) is presented. The proposed PLL was fabricated in 0.18 $\mu$m CMOS process. The transformer-feedback voltage-controlled oscillator (TF-VCO) is utilized to increase output swing and to alleviate noise issue. The cascoded frequency divider is adopted for low voltage and low power considerations. The measured phase-locked-loop phase noise at 20.2 GHz is -110 dBc/Hz at 10 MHz offset frequency and the corresponding reference spur is -58 dBc. The locking range covers a frequency band from 19.2–20.6 GHz. The PLL dissipated 38 mW (with buffers) at 1.8-V supply voltage and occupies the chip area of 0.46 $mm^2$.

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*Mashail Alsalamah,* Diagnosis of Heart Disease by Using a Radial Basis Function Network Classification Technique on Patients' Medical Records, Coventry University, UK.

Heart disease is defined as any abnormal heart condition, and it is prevalent in people today. Considering human body as one big system, many factors play role on this disease. Examining the body provides quite lot of data in many different ways, though understanding the signs in collected data about heart disease requires experience, knowledge, and time from physicians. Computer based expert systems are designed to reduce the burden on physicians by automation. One of the important components of expert systems is data classifiers, and in this paper, I present the use of Radial Basis Function Networks (RBFN) with a Gaussian function as data classifier for heart disease classification. The proposed method in the paper makes use of same training data after they are used for training to

reduce false classifications which makes this project unique in itself. For development and testing, I utilized patient records from Prince Sultan Cardiac Center-Qassim in Saudi Arabia. This paper discusses the use of RBFN for the classification of heart diseases, and it proposes a model system that forms data collection, processing, storage, and usage procedures.

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*Tomislav Markovic*, Temperature Controlled Measurement Setup for Permittivity Extraction of Water up to 40 GHz from 10 to 40 °C, KU Leuven, Div. ESAT – TELEMIC, Belgium.

The proposed system in this paper enables the temperature controlled permittivity extraction of liquids up to 40 GHz from 10 to 40 °C. The temperature controlled environment consists of a temperature controlled chuck, probe station and a CPW microwave sensor that is coupled to a miniature T-type thermocouple. A large thermal mass and a platinum wire resistor ensure a precise reference temperature. Challenges in the sensor fabrication and measurements are discussed and further improvements are proposed for higher accuracy measurements. Extracted permittivity of water agrees well with the empirical models available in the literature.

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*A. Ilumoka*, Neural Network-Based Tunable Microwave Filter Design for Re-Configurable Biomedical Hardware, Sikorsky Aircraft Corporation, Stratford, USA

A knowledge-based method for the design of tunable microwave filters for biomedical applications is described. The method uses a backpropagation neural network (BNN) for mapping RF filter responses to filter resistor, capacitor and inductor values. The BNN acts as an efficient circuit reconfiguration tool which when supplied with a set of filter responses calculates the required component values with high accuracy. To demonstrate the efficacy of the approach, a microwave high pass filter was tuned from 7GHz to 10GHz in steps of 0.2GHz. Filter hardware is reconfigured during tuning using varactor diodes, MOS resistors and tunable microinductors.

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*Yang Liu*, Modeling the Wireless *In vivo* Path Loss, University of South Florida, USA

Our long-term research goal is to model the in vivo wireless channel. As a first step towards this goal, in this paper we performed in vivo path loss measurements at 2.4GHz and make a comparison with free space path loss. We calculate the path loss by using the electric field radiated by a Hertzian-Dipole located inside the abdominal cavity. The simulations quantify and confirm that the path loss falls more rapidly inside the body than outside the body. We also observe fluctuations of the path loss caused by the inhomogeneity of the human body. In comparison with the path loss measured with monopole antennas, we conclude that the significant variations in Received Signal Strength is caused by both the angular dependent path loss and the significantly modified in vivo antenna effects.

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*S. Adnan*, Microwave Antennas for Near Field Imaging, Bradford University, UK

Near field imaging using microwaves in medical applications has gained much attention recently as various researchers have shown its capability and accuracy in identifying features of interest compared to well-known screening tools. This paper documents microwave imaging experiments for breast cancer detection. A simple phantom consisting of a plastic container with a low dielectric material imitating fatty tissue and a high dielectric constant object emulating tumor is scanned with a UWB microstrip antenna between 4 to 8 GHz. The measured results indicate that the prototype is a good candidate for imaging application.

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*Rizwan Masood*, Distribution Fitting for Real-Time Off-Body Channel Measurements, Lab-STICC, France

Distribution fitting for real-time off-body channel measurements is presented for narrowband ISM 2.45 GHz applications. The measured data statistics are compared with standard distribution functions such as normal, lognormal, etc. However, for real-time multipath channel measurements, the diversity of empirical data depending on the studied configuration makes difficult the selection of one specific distribution function as the best distribution. Therefore, we propose an innovative and robust algorithm to choose the best distribution function using goodness of

fit test (Kolmogorov-Smirnov). The statistics proposed here are based on 12000 real-time off-body channel measurements. Based on this study, multipath off-body channel can be modeled by a Gaussian/Normal distribution for scenarios involving a direct or line-of-sight path.

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*S. Liu*, A 90 GHz Liquid Sensing Substrate Integrated Cavity Resonator in LTCC for Microfluidic Sensing Applications, University of Leuven, Belgium

This paper presents a reflection-type 90 GHz sub-strate integrated cavity resonator sensor realized in LTCC technology for lab-on-chip microfluidic applications. A linearrelationship between the resonance frequency of the sensor and the permittivity of the material under test was observed from measurements on low-loss materials. Calibration curves are also obtained for water-isopropanol mixtures which show monotonic behaviours with respect to the isopropanol concentrations. Measurements of the sensor thus demonstrate that it is promising for lab-on-chip microfluidic sensing applications.

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*Manmohan Sharma*, Investigative Analysis of the Influence of Different Simplified Human Body Models on a Miniature Ultra-Wideband Antenna, Queen Mary University of London,UK

This paper presents numerical and experimental study of the influence of various types of simplified human equivalent phantoms and actual human body on the reflection coefficient and bandwidth of a miniature ultra-wideband antenna. Four multi-layered body models, with different geometries and cross-sections, along with both dispersive and non-dispersive characteristics have been used in the analysis. A sensitivity analysis of the UWB antenna to the distance from the body models and their sizes has been provided to assess the most suitable model in terms of accuracy and computational time. Measurements have also been carried out with the antenna placed in close proximity to a real human test subject and results have been compared.

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*A. Fatih Demir*, Numerical Characterization of In Vivo Wireless Communication Channels, University of South Florida, USA

In this paper, we numerically investigated the in vivo wireless communication channel for human male torso at 915 MHz. Results show that in vivo channel is different than the classical communication channel and location dependency is very critical for link budget calculations. A statistical path loss model based on angle, depth and body region is introduced for near and far field regions. Furthermore, multipath characteristics are investigated using a power delay profile as well.

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*Cedric Lee*, Fully-Passive and Wireless Detection of Very-Low-Power Brain Signals, Ohio State University, USA

A fully-passive and wireless neurosensing system is presented for acquisition of very-low-power brain signals. The system can detect neuropotentials as low as 50μVpp in frequency- domain. This is an improvement of up to 22dB in sensitivity compared to previously reported neuropotentials. Importantly, it implies reading of most known and useful brain signals. Currently, the system can also recover neuropotentials down to 200μVpp in time-domain. This remarkable sensitivity is enabled by: (a) an anti-parallel diode pair (APDP) implanted mixer that performs harmonic mixing with high conversion efficiency, and (b) a pair of highly-coupled interrogator and implanted antennas. The proposed neurosensing system creates transformational health-status monitoring possibilities for a very wide range of applications.

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*Rajendra Dhakal*, An Exploration of Ocular Glucose Levels with Flexible RF Biosensor Using Polyethylene Terephthalate, Kwangwoon University, Korea

This paper presents a minimally invasive, flexible and disposable RF Biosensor used for the detection of Ocular glucose level, employed with the RF resonator analyzed at 4.30 GHz. Linear relationship between glucose concentration in the tear and resonance frequency was obtained in a range of 1-7mg/dl. The new sensor was optimized to achieve very low detection limit of 0.25 mg/dl, which is required to monitor glucose levels in the tear

fluid with a sensitivity of 12 MHz/dl. Thus, a considerably lower shift in the resonance frequency was obtained with a maximum and minimum shift of 362 and 60 MHz for the maximum and minimum concentration of 7 mg/dl and 1 mg/dl ocular glucose level, respectively.

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*Raunaq Pradhan*, A Non-invasive Magnetic Resonance Biomedical System, Nanyang Technological University, Singapore

This paper proposes a pair of coils coupled by a magnetic resonance coupling, which effectively induced a current at the biological medium for potential biomedical applications. Calculations and field estimation was done using finite element modeling software. Ferrite cores were added to set-up which showed larger induced current density in the tissue (more than 2 times) due to eddy current generation, as compared to the coils without core. Further, experiments were conducted with an animal tissue placed between two resonating coils, which showed similar results with an induced current of 0.07 mA using 1NI coil. Also, 1.6 times larger current was induced in the tissue when ferrite cores were used as compared to air core.

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*Kishor Kumar Adhikari*, Rapid and Sensitive Detection of Glucose Based on Radio Frequency Resonator Fabricated Using Integrated Passive Device Technology, Kwangwoon University, South Korea

This paper reports a highly sensitive mediator-free glucose biosensor based on miniaturized radio frequency resonator fabricated on Gallium Arsenide substrate using integrated passive device technology. The level of electromagnetic coupling between coupled stepped-impedance resonators, which significantly determines the resonator characteristics, is perturbed enough by a glucose sample. As a result, the proposed glucose biosensor exhibits linear detection range of 1 to 5 mg/mL with ultrahigh sensitivity and ultralow detection limit of 0.37 GHz/mgmL$^{-1}$ and 0.0948 µM, respectively. Additionally, the quantities, such as propagation constant ($\gamma$), impedance ($Z$), resistance ($R$), inductance ($L$), conductance ($G$) and capacitance ($C$), estimated from the measured S-parameters, enable the effective multi-dimensional detection of glucose.

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*Mian Shahzad Iqbal*, A Compact Wideband Dielectric Resonator Antenna for On-Body Applications, Macquarie University, Australia

This paper presents the design of an on-body wide-band dielectric resonator antenna (DRA) for medical applications. The antenna is tested on a homogenous numerical phantom modeling a human arm. This low-profile antenna consists of three different dielectric segments and small metallic patches, which reside above a rectangular ground plane. It is excited by a coaxial probe. The volume of DRA is reduced by using multi-segment dielectric, and by adding a finite planar conducting wall. The proposed DRA has good radiation characteristics, and radiates power away from the body. It offers a predicted 10 dB return loss bandwidth of 74% between 4.4 and 9.7 GHz.

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*Guangwei Jiang*, Molecular dynamics study on the electroporation process with different configurations of ions, Queen Mary University of London, UK

The electroporation process is simulated by the software based on molecular dynamics method, by incorporating ions of different concentrations and categories. The distribution of the components after the equilibration stage would be examined and discussed. The pores formation speed under series of electric fields would be checked and compared. The results would be judged with the ones from other groups' simulation and experimental work.

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*A. Zamani*, Frequency Domain Method for Early Stage Detection of Congestive Heart Failure, University of Queensland, Austrilia

Congestive heart failure has one of the highest fatality rates in recent decades. Pulmonary edema is one of the most apparent symptoms of the afore-stated disease in which water accumulates inside the lungs, and therefore alters their tissues' properties. While microwave signals are able to detect these changes, received signals are extremely weak and noise contaminated. Therefore, a proper signal acquisition and processing techniques should be developed to enhance the reception of the reflected signals to magnify tissue variations. In that regard, a multi-static ultra wide band antenna array configuration as a data collection system and a frequency domain-based method as an imaging algorithm are proposed. The utilized array comprises twelve compact broadband taper slot antennas which are positioned around the girth of the torso to collect the reflected signals. To that end, an image reconstruction method is utilized to detect the changes in the electrical properties of the lungs' tissues. This method uses Mathieu function to calculate the scattered electric field and power inside the elliptical shape imaging region. The system's configuration, imaging method and obtained results are reported in this paper.

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*Kazuyuki Saito*, SAR Calculations around Implanted Cardiac Pacemaker Induced by Wireless Radio Terminal in VHF Band, National Institute of Information and Communications Technology, Japan

Recently, electromagnetic interference (EMI) of an implanted pacemaker induced by a mobile radio terminal has been investigated. However, there are few studies of specific absorption rate (SAR) around the pacemaker induced by the mobile radio terminal. In particular, the SAR in such a case due to the electromagnetic wave of very high frequency (VHF) band has not been investigated. In this paper, SAR distributions around a pacemaker model embedded into the torso model by a wireless radio terminal in VHF band, which are used in police officers, airport employees etc., are calculated. As a result of calculations, possibilities of increasing the SAR were observed.

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*Heedon Jang*, Low Power Receiver for Medical Implantable Communication System using Delay Locked Loop, Ulsan National Institute of Science and Technology, Korea.

This paper presents and implements a low power receiver for medical implantable communication system (MICS) using delay locked loop (DLL). Compared to current existing transceivers for MICS that use phase locked loop (PLL), the DLL offers the advantage of power consumption at the 402-406 MHz band. This work implemented a DLL with two channels, two mixers for switching channels, and a low noise amplifier (LNA). The DLL, mixer and LNA structure are simple in order to consume lower power. LNA input and output were also designed to match a 50-ohm impedance. The DLL and power consumption of the two mixers was 4.8 mW and the LNA was 2.3 mW..

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*Yoon Jae Bae and Choon Sik Cho*, Ultra-Wideband On-Off Keying Transmitter with Multi-Pulses/Bit for Bio-Signal Detectors, Korea Aerospace University, Korea.

This paper describes an IR-UWB OOK transmitter with multi-pulses per bit for bio-signal detectors which can be transplanted into the living body. The proposed IR-UWB OOK transmitter is implemented in 110 nm CMOS process where 1.33 $mm^2$ proto-type accomplishes a maximum pulse rate of 250 Mbps while consuming 11 mW from 1 V supply voltage. It consists of impulse generator, LC oscillator, delay cell and pulse shaping filter. The output pulse centering at 3.8 GHz provides multi-pulses per bit with 210 mVpp and 44 pJ/pulse with 0.65 GHz bandwidth. Pulses are repeated in every 4 nsec irrespectively of data rates.

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*Yuan-Pou Chen*, Null Point Elimination Using Biphase States in a Direct Conversion Vital Signal Detection Radar, Chang Gung University, Taiwan.

A novel noncontact heartbeat and respiration monitoring system that can eliminate the null point in the detection of vital signal is reported. The new type of vital signal radar is composed of a variable-gain low-noise amplifier, direct conversion mixer, biphase phase shifter, and local oscillator, which are all homemade circuits constructed with Si bipolar transistors. Moreover, the radar consumes less than 20 mA under a 3 V biasing voltage. A 2.4 GHz experimental prototype was fabricated to verify the proposed null point elimination method. Measurements show good agreement with the theoretical prediction that the radar can clearly detect heartbeat and respiration signals at any point within the detectable range of the radar. The proposed radar system was shown to be a low-power and cost-effective solution for vital signal detection without the problem of null point.

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*Nuraishah Sarimin and Rahma Abdaoui,* 60 GHz Channel Modeling Scenarios and Characterization for On-Body Sensors Applications, Institute Supérieur d'électronique de Paris, France.

Emerging trend in the usage of millimeter-wave bands within Wireless Body Area Network represents nowadays an increasing interest. In this paper, potential benefits of millimeter-wave frequencies and especially the 60 GHz band for wireless medical applications as well as potential therapeutic applications are discussed. In order to demonstrate the feasibility of 60 GHz Wireless Body Area Sensor Network, the modeling of the 60 GHz channel propagation around the body becomes mandatory. The channel characteristics will be taken into account for the system specifications and performances and show favourable environments for the desired applications.

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*Khondker Jahid Reza*, Smart Antenna System Design for Localization of Wireless Capsule, University of Malaya, Malaysia.

Smart antenna is recognized as an intelligent antenna system in modern wireless communication for its adaptive beam forming technique and direction of arrival (DoA) estimation features. However, this system is yet to be introduced extensively for biomedical applications. A sectoral sweeper based algorithm is proposed in this article for RF localization of wireless capsule inside the human gastro intestinal (GI) tract. This algorithm basically works using the alteration of task beam power level and direction of smart antenna array. It is proposed that, one transmitting antenna element of antenna array transmits signals towards the GI tract at a time and others will be in receive mode. The received signals are then processed based on space-frequency signal processing concept which is derived in this paper for cylindrical shaped antenna array. Particle swarm optimization model is developed to predict the 2D location of obotic capsule from the received information of smart antenna system with about 99% successful.

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*Maxim Komnatnov*, Environmental Shielded TEM Chamber for Biomedical Testing, Tomsk State University, Russia

A problem of microwave exposure of biological systems is considered. An urgent need to reveal mechanisms of thermal and nonthermal biological effects of radiation is emphasized. A concept of joint control of shielding, temperature, and humidity for object under exposure is proposed. To implement this concept use of an environmental shielded TEM chamber for biomedical testing is suggested.

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*Muhammad Taha Jilani*, An Improved Design of Microwave Biosensor for Measurement of Tissues Moisture, University Technology PETRONAS, Malaysia

In this contribution, a simple but highly sensitive biosensor based on microstrip ring-resonator is presented for tissues moisture evaluation. By incorporating high impedance ring, tight and enhanced coupling mechanism the proposed 1 GHz ring-resonator demonstrates significant change in the resonance frequency than normal resonator. Simulated and measured results are in good agreement. The proposed resonator gives 37% better performance than the conventional resonator.

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*Nishtha Chopra*, Understanding and Characterizing Nanonetworks for Healthcare Monitoring Applications, Queen Mary University of London, UK

Terahertz (THz) region of the electromagnetic spectrum has been of wide interest during the past few years. It has been regarded as the promising working band for Nanoscale Communication. In this paper, experimental investigations and analysis using THz-TDS (THz Time Domain Spectroscopy) system are presented and discussed. The study is focused on biological modeling of artificial skin and thereby extracting the refractive index values at the THz band. The paper also compares the results with already reported papers. The results are promising and in agreement with minor variation due to different growth process and experimental environment.

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*Sanjay Priyadarshi*, A Fast Interpolation Approach for the Calculation of Permittivity and Conductivity to Estimate the SAR, Lancaster University, UK

The conductivity and permittivity of biological tissue are critical to estimating local radiofrequency (RF) power deposition (also known as specific absorption rate SAR) for Ultra High Field Magnetic Resonance Imaging (UH-MRI). These electrical properties may also have diagnostic value as malignant tissue types have been shown to have higher permittivity and conductivity than surrounding healthy tissue [1]. Recently a new SAR calculation method of using the transmit B1+ map to obtain tissue electrical property has been proposed as a fast SAR calculation method, and has demonstrated great potential for practical applications. However the current numerical technique used in the B1+ map based electrical property calculation is based on a traditional Finite-Difference algorithm, and therefore it requires high-resolution original B1+ map to achieve accurate electrical property calculation. In this study, we have proposed the Spline interpolation of low resolution MRI B1+ map at 1.5T. The proposed method is robust in approximating complex shapes in medical images through curve fitting and therefore could provide sufficiently accurate approximation of the high resolution B1+ map through the low resolution raw data. This will prove to be useful in the fast real time estimation of local specific absorption rate without compromising the accuracy of SAR calculation. It is found that the Spline interpolation method helps in the reduction of MRI scan time and fast estimation of the SAR.

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*Luigi La Spada*, Electromagnetic modeling of metamaterial-based sensors, Queen Mary University of London, UK

In this paper metamaterial-based sensors electromagnetic modeling is presented. In particular, the interaction between the electromagnetic waves and such structures is analytically studied. The proposed sensors consist of array of resonant metallic structures, whose frequency response is modified through the variation of the surrounding dielectric environment. We consider different resonator geometries and the analysis is conducted through proper quasi-static analytical models. By exploiting the proposed analytical models, we study the structures resonant properties as a function of their geometric and electromagnetic parameters in order to optimize them and evaluate their sensitivity performances. Electromagnetic modeling represents a useful tool for the control and the enhancement of sensors properties, paving the way for new interesting sensing applications in a broad frequency range spectrum.

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*Qiao Cheng*, Compressive Sensing Applied to Fingerprint-based Localisation, Queen Mary University of London, UK

Accurate localisation has always been a hot topic for indoor environment. Recently, compressive sensing has been applied to fingerprinting based localisation and achieved good performance. This paper provides an overview of the state-of-the-art compressive sensing based indoor localisation techniques and an introduction to potential solutions to challenges faced by current systems. The main focus is on the drawbacks of the existing techniques and possible future development.

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*Takashi Hikage*, A Numerical Assessment Methodology Based on Interference Voltage for Pacemaker EMI Triggered by Magnetic Resonance Wireless Power Transfer Coils, Hokkaido University, Japan

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A numerical assessment methodology for active implantable medical devices (implantable cardiac pacemaker/cardioverter defibrillator) EMI triggered by magnetic resonance type wireless power transfer is introduced. A numerical estimation model that consists of magnetic resonant coils and a human torso phantom with a pacemaker and lead is constructed. By using three dimensional full-wave numerical simulation based on finite element method, interference voltage induced at the connector of the pacemaker inside the phantom is obtained. Our example includes different exposure scenarios in order to estimate the maximum interference voltage.

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*Mohammed Shakib*, Design of a Tri-band Implantable Antenna for Wireless Telemetry Applications, University of Malaya, Malaysia

In this paper, a miniaturized Egret-Beak shaped patch tri-band implantable antenna for Medical Implant Communication Services (MICS) (402-405 MHz), Wireless Medical Telemetry Service (WMTS) (1430MHz) and Industrial Scientific and Medical (ISM) (2.4-2.48GHz) band is proposed. The antenna is composed of an Egret-Beak shaped radiation patch and a ground plane. A shorting pin is directly connects from the radiating patch to the ground plane to reduce the size of the antenna. The antenna occupies a small size of 10x12mm2. The antenna is optimized to achieve the triple band designed antenna. The results indicates that the antenna can achieve 260MHz (74%) band for MICS, 150MHz (11%) band for WMTS and 680MHz (27%) band for ISM band. The proposed antenna (implanting in the arm) with significant impedance bandwidth and its compactness shows that the antenna is suitable for wireless telemetry applications.

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*A. Zamani*, Microwave Imaging Using Frequency Domain Method for Brain Stroke Detection, University of Queensland, Brisbane, Australia

Brain Stroke is the leading cause of disability and death in the world in which the supply of blood to the brain is stopped by a clot or burst of blood vessel. Microwave techniques have been investigated as a reliable solution for the immediate detection of brain strokes. To that end, an appropriate signal acquisition and processing method is needed to detect the damaged tissue using the extremely weak back scattered microwave signals from the imaged head. In that regard, a frequency domain method integrated with a multi-static ultra wide band antenna array is proposed. The utilized array comprises 24 tapered slot antennas which are located around the head to collect the back scattered signals in a multi-static mode. An image reconstruction method based on Mathieu function is utilized to predict the scattered electric field and power inside the elliptical shape imaging region. The system's configuration, imaging method and obtained results are reported in this paper.

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*Houda Halheit*, Microstrip Applicator Bandwidth Enhancement Using Periodic Structures, USTHB University, Algeria

The design of a rectangular microstrip applicator combined with periodic structures in order to obtain bandwidth enhancement is presented. The simulated results show that a significant improvement in bandwidth is achieved. The applicator has bandwidth of 2.5 % and 6 % respectively without and with periodic structures.

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*A. Alomainy*, Experimental Evaluation of Wearable Antenna Efficiency for Applications in Body-Centric Wireless Networks, Queen Mary University of London, UK

Wearable antennas are gaining increased attention from both industrial and research communities especially with the recent surge in number of applications for both consumer and military systems. However, accurate characterization of their performance when worn by the user is still a significant challenge with regards to both numerical and experimental evaluation considering measurement traceability and repeatability. In this paper, experimental evaluation of two flexible body-worn antennas working in the UHF band is presented and analyzed. Measurements were performed in the reverberation chamber to investigate the efficiency of the antenna structures when placed on a wideband physical phantom. Results demonstrated efficiency of around 50% for fleece-based wearable antenna, while a leather substrate based structure proved lossy with significantly reduced radiation efficiency. Measurement and simulation results show good agreement and the measurement settings applied in the reverberation chamber indicated a high level of repeatability and confidence in derived results and performance measures.

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# Notes

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