



中山大学花都产业科技研究院
SYSU Huadu Industrial Science and Technology Institute

Final Program

IEEE International Conference on RFID-Technology and Applications 2016

September 21 - 23, 2016, Marriott Hotel, Shunde, Guangdong, China

Organized by
The IEEE RFID-TA 2016 Organizing Committee

Hosted by
SYSU – CMU Shunde International Joint Research Institute,
SYSU Huadu Industrial Science and Technology Institute

Sponsored by
IEEE Council on RFID

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RFID-TA2016

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Greetings from the General Chair

On behalf of the Organizing Committee of the 7th annual *IEEE* International Conference on RFID Technology and Applications 2016 (*IEEE* RFID-TA 2016), I have the privilege of inviting you to Shunde, Guangdong, China. Please join us September 21-23, 2016 at Marriot Hotel in Shunde. The Conference is organized with the support of the Sun Yat-sen University – Carnegie Mellon University Shunde International Joint Research Institute under the auspices of *IEEE* and the *IEEE Council on RFID*. The Conference will start off with a day of Educational Sessions and Tutorials that I hope you will find a valuable educational and training resource. The next two days of the Conference will include Invited Plenary talks and technical talks presented by experts from around the world. We will have a Best Paper Competition and a Best Student Paper Competition at the Conference as well.

Shunde is situated to the south of Guangzhou, adjacent to the Pearl River Delta. Its economy was once dominated by agriculture, fisheries and silk farming. Today, Shunde is known for industrial manufacturing and development, especially the manufacturing of furniture and electrical appliances; e.g., some well-known brands like Galanz, Kelon and Midea are made in Shunde. For the last few years, GDP per capita of Shunde demonstrates remarkable growth and has one of the best values of entire China. If you have time, I encourage you to visit some of the local attractions. The Conference hotel, the Shunde Marriott, is within walking distance from Shunfengshan Park, one of the "Ten Attractions of Shunde." The paifang inside the Park is called *China's No.1 Paifang* because of its massive size. The Pandas at the Guangzhou Zoo are also great fun to see.

Travelling to and from Shunde is easy with many different options. There are ferries and buses that go directly to Hong Kong, including an option to Hong Kong International Airport. Macau is easily accessible by train, taking less than an hour. Guangzhou is accessible by train, taxi or bus.

Our Organizing, Advisory and Technical Program Committees are dedicated to making this event a memorable experience for all of you. I wish all of you an unforgettable Conference and an enjoyable stay in Shunde.

With cordial regards,

L. Richard Carley, Ph.D.

IEEE RFID-TA 2016 General Chair



Greetings from the Technical Program Chairs

Dear colleagues,

On behalf of the Technical Program Committee, I welcome the participants of the 7th IEEE International Conference on RFID Technology and Applications 2016 (IEEE RFID-TA 2016) who have come to present their research and enjoy the social events in Shunde on September 21-23, 2016.

The beauty of RFID lies in the ever-growing number of real-life applications utilizing the technology as well as its technological flexibility. In the IEEE RFID-TA 2016 Program, we've tried to reflect this fact. We start our Technical Program with the special Company Keynote "RFID in Retail Revolution". Next, the Keynote and Plenary talks to be presented by the prominent researchers will be about an Integrated RFID and Sensor Systems, Printed Electronics in RFID Technology, Advanced Antennas for RFID Tags and Readers, and the Internet of Things (IOT) for Medical Applications. TPC of the IEEE RFID-TA 2016 has received 56 paper submissions. After a thorough review process, 37 papers have been accepted resulting in an average acceptance ratio of 66%. Our 46 TPC Members have provided a total of 126 reviews and I want to thank them for their dedication and support. We have the most paper submissions in RFID in IOT Applications and Advances in RFID Antenna Design followed by RFID Localization, Data Processing and Industrial Implementation. For the Poster Session providing the authors the opportunity to present both preliminary and completed research, 9 submissions have been accepted.

If you have a time to spare, I'd like you to experience the best Shunde has to offer. The Shunfengshan Park and Qinghuiyuan Garden, fine examples of Southern China-style of landscape art, are close to the Conference venue. Wonderful cuisine of Shunde voted "The City of Gastronomy 2015" by UNESCO is also not to be missed.

Thank you all for coming to IEEE RFID-TA 2016. We wish you a productive, interesting and memorable Conference.

I'm looking forward to seeing you in Shunde in September.

Andrey S. Andrenko
IEEE RFID-TA 2016 TPC Co-Chair



Organizing Committee

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Lei XIE – Nanjing University, China

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Gaetano MARROCCO	Harald VOGT
Andrea MICHEL	Junyu WANG
Hao MIN	Lei XIE
Jin MITSUGI	Jingtian XI

Program Schedule

Date	Time	Function	Location
Wednesday Sep 21, 2016	08:30 ~ 18:00	Registration	The Registration Zone
	13:30 ~ 14:15	Opening Ceremony	South Guangdong C
	14:15 ~ 14:30	RFID in Retail Revolution - First step of Decathlon RFID program / Mr. Jason Liang, Embisphere	South Guangdong C
	14:30 ~ 14:50	Coffee Break	South Guangdong C
	14:50~15:35	The Design of Passive Integrated Single-Chip RFID and Sensor Systems / Prof. L. Richard Carley	South Guangdong C
	15:35~16:20	Advanced Antennas for RFID Tags and Readers / Prof. Zhi Ning Chen	South Guangdong C
	16:20~18:30	Educational Tutorial on Grant and Technical Paper Writing / Prof. L. Richard Carley, Prof. Zhihua Wang, Dr. Pui-In Elvis Mak, Prof. Shahriar Mirabbasi,	South Guangdong C
Thursday Sep 22, 2016	08:45 ~ 09:25	Printed Electronics and RFID / Dr. George Xiao	Conference Room Peony
	08:45 ~ 09:25	IOT for Medical Applications / Prof. Z. Wang	Conference Room Ceiba
	09:30 ~ 10:10	Advanced Technical Writing for English-as-a-Second-Language Engineer / Dr. Narisa N. Y. Chu	Conference Room Peony
	09:30 ~ 10:10	Ultra-Low-Power Short-Range Radios for IOT / Dr. E. P.-I. Mak	Conference Room Ceiba
	10:10 ~ 10:30	Coffee Break	Coffee Break Room
	10:30 ~ 12:30	Technical Sessions A&B	Conference Room Peony & Ceiba
	12:30 ~ 14:00	Lunch	Buffet Restaurant
	14:00 ~ 15:20	Best Student Paper Competition, Technical Session C	Conference Room Peony & Ceiba
	15:20 ~ 15:40	Coffee Break	Coffee Break Room
	15:40 ~ 17:00	Best Student Paper Competition, Technical Session C	Conference Room Peony & Ceiba
18:00 ~ 21:00	IEEE RFID-TA2016 Banquet & Award Ceremony	Buffet Restaurant	

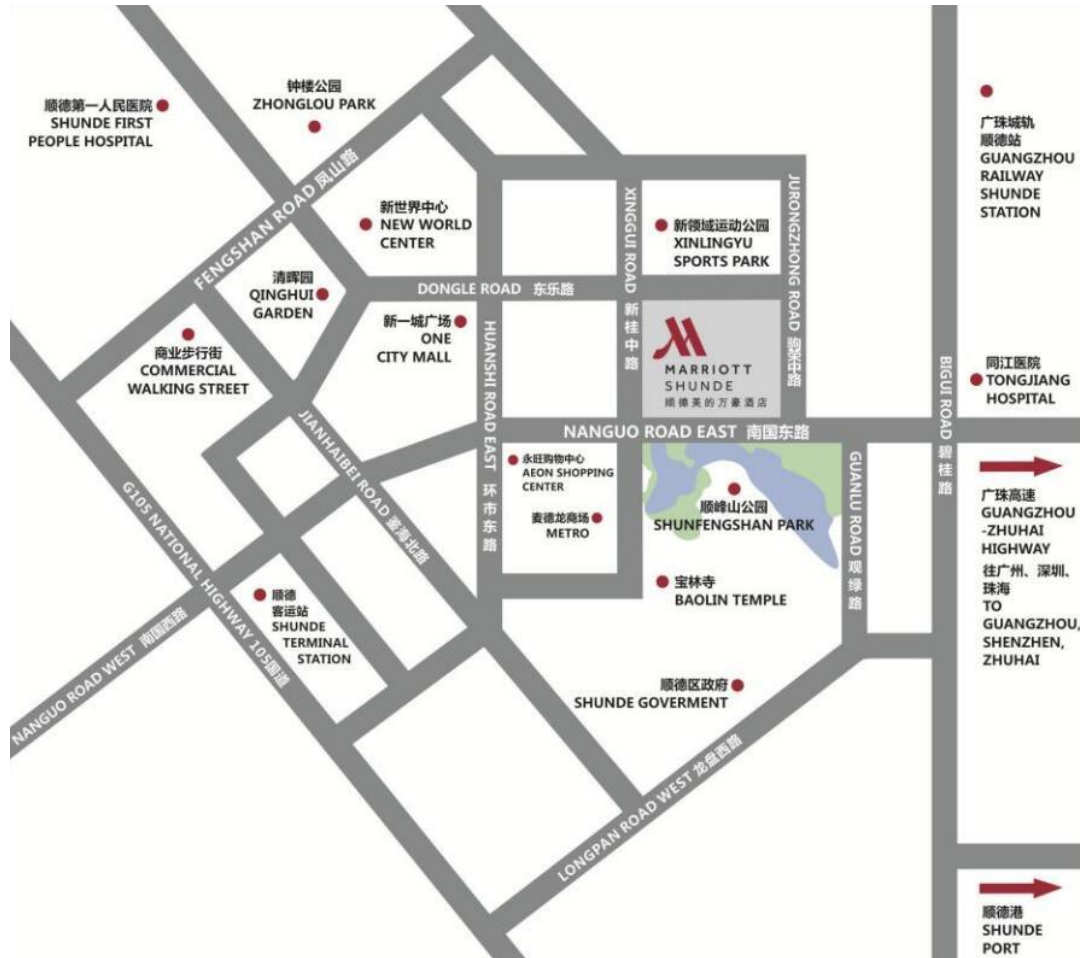
Date	Time	Function	Location
Friday Sep 23, 2016	09:00 ~ 10:20	Technical Session D	Conference Room Peony
	10:20 ~ 11:40	Coffee Break	Coffee Break Room
	10:20 ~ 12:00	Poster Session	Meeting Room Foyer
	12:00 ~ 14:00	Lunch	Buffet Restaurant

Technical Program

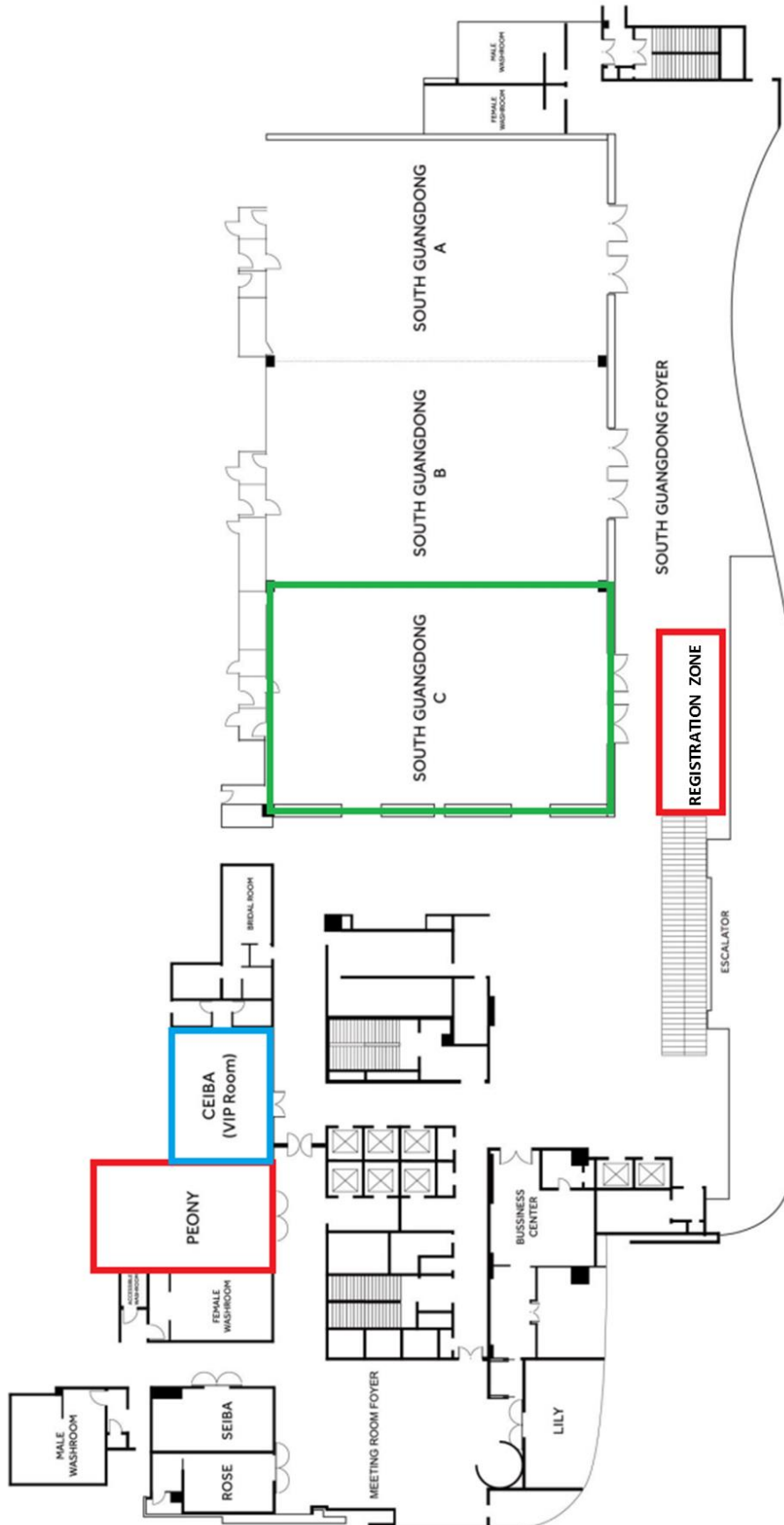
Wednesday, Sep. 21	The Registration Zone	
08:30 ~ 18:00	Registration	
Wednesday, Sep. 21	South Guangdong C	
13:30 ~ 14:15	Opening Ceremony	
14:15 ~ 17:50	Tutorials & Keynote Speeches	
Thursday Sep. 22	Conference Room Peony	Conference Room Ceiba
08:45 ~ 10:10	Plenary Session	Plenary Session
10:30 ~ 12:30	Technical Session A	Technical Session B
Thursday Sep. 22	Conference Room Peony	Conference Room Ceiba
14:00 ~ 17:00	Best Student Paper Competition	Technical Session C
Friday Sep. 23	Conference Room Peony	Meeting Room Foyer
09:00 ~ 10:20	Technical Session D	
10:20 ~ 12:00		Poster Session

Location of Marriott Hotel

Address: No.388 NanGuo Road East, Daliang, Shunde District, Foshan City, Guangdong Province, China



Conference Room Locations



Presentations

Session ID: Plenary Session
Session Title: Advances in IOT Technology
Date/time: 22 – Sep – 2016 (Thursday), 8:45 – 10:10
Location: Conference Room Ceiba
Chair: Andrey S. Andrenko

8:45-9:25

1. **Prof. Zihua Wang** (*Tsinghua University*), IOT for Medical Applications

9:30-10:10

2. **Dr. Pui-In Elvis Mak** (*University of Macau*), Ultra-Low-Power Short-Range Radios for IOT

Session ID: Plenary Session
Date/time: 22 – Sep – 2016 (Thursday), 8:45 – 10:10
Location: Conference Room Peony
Chair: Kai Wang

8:45-9:25

1. **Dr. George Xiao** (*National Research Council*), Printed Electronics and RFID

9:30-10:10

2. **Dr. Narisa N. Y. Chu** (*CWLab International*), Advanced Technical Writing for English-as-a-Second-Language Engineer

Session ID: A
Session Title: Advances in RFID Antenna Design
Date/time: 22 – Sep – 2016 (Thursday), 10:30 – 12:30
Location: Conference Room Peony
Chair: Andrea Michel

- (1570281952) 2.45 GHz Broadband Monopole RFID Reader Antenna Buried in the Ground of Parking Lot near the Curb
Yejun He, Minghai Chen (China)
- (1570281972) Analysis of Wearable Ungrounded Antennas for UHF RFIDs with Respect to the Coupling with Human-Body
Giovanni Andrea Casula, Giorgio Montisci, Andrea Michel, Paolo Nepa (Italy)
- (1570282333) Technologies for Secure RFID Authentication of Medicinal Pills and Capsules
L. Richard Carley, Gurkan Colak, Louis Chomas, Larry Pileggi, Kenneth Mai (USA)
- (1570281975) An Overview on Modular Antennas for Near-Field UHF-RFID Systems
Andrea Michel, Paolo Nepa, Marcos N. Pino (Italy, Spain)
- (1570283754) Tuning Mutually Coupled RFID Antennas for High Usage Scenarios
Ian Pratt, Shiyun Zhong (UK)
- (1570290453) Low Cost Coplanar UHF RFID Tag Antenna Using U-shaped Feeder for Metallic Applications
Karrar Naji Salman (Malaysia)

Session ID: B
Session Title: RFID in IOT Applications
Date/time: 22 – Sep – 2016 (Thursday), 10:30 – 12:30
Location: Conference Room Ceiba
Chair: Pui-In Elvis Mak

- (1570280699) Distributed Event-Based Resource-Oriented EPCglobal Middleware Using GPC
Yalew Tolcha, Daeyoung Kim (Korea)
- (1570282293) QR-Code Based Chipless RFID System for Unique Identification
Sriharsha Vardhan G, Ashudeb Dutta, Naveen Sivadasan (India)
- (1570282787) Modified Research on RFID-oriented ECC Point Multiplication over GF(2m) Field
Guohong Wei, Ya Wang, Qiuhan Wu (China)
- (1570284108) Energy Harvester for Wireless Sensor with RFID Interface
Andrey A. Uhov (Russia)
- (1570285529) Design of Internet of Things System for Library Materials Management Using UHF RFID
Dongying Li, Shundao Xie, Rongjun Chen, Hong-Zhou Tan (China)
- (1570282050) A Low Power EEPROM for Passive RFID Tag
Chong Lu, Yu Li, Jun-hui Ou, Hua-ling Wu, Hong-Zhou Tan (China)

Session ID: Student Competition
Session Title: Best Student Paper Competition
Date/time: 22 – Sep – 2016 (Thursday), 14:00 – 17:00
Location: Conference Room Peony
Chair: Andrey S. Andrenko

- (1570277595) A Novel Textile Dual-Polarized Antenna Potentially Used in Body-Centric System
Ye Kuang, Lan Yao, Wenwen Zhang, Dongchun Zhou, He Luan, Yiping Qiu (China)
- (1570289976) Sensor Integrated RFID Tags for Sustainable Wearable Electronics Applications
Ahmed Rasheed, Emad Iranmanesh, Andrey S. Andrenko, Kai Wang (China)
- (1570282050) A Low Power High Sensitivity RF Power Detector for Multi-Mode Active Tags
Hualei Zhang, Sizheng Chen, Tao Yang, Xi Tan, Na Yan, Hao Min (China)
- (1570277683) Wireless Control for Vision Impaired Based on Posture Effect of UHF RFID Cane
Wenyang Li, Wenhai Zhang, Kam Weng Tam (Macao)
- (1570287414) Differential Topology Rectifier Design for Ambient Wireless Energy Harvesting
Miaowang Zeng, Andrey S. Andrenko, Xianluo Liu, Bo Zhu, Zihong Li, Hong-Zhou Tan (China)
- (1570281947) A Novel Broadband Dual-Polarized Dipole Antenna Element for 2G/3G/LTE Base Stations
Yadong Yue, Yejun He (China)
- (1570281512) On the Measurements of Liquid Sensing Based on UHF RFID
Wenyang Li, Wenhai Zhang, Kam Weng Tam, Eddie Chiang, Ka Hing Chiang (Macao)
- (1570284204) Deployment of Localization System in Complex Environment Using Machine Learning Methods
Quanyi Hu (Macao)

Session ID: C
Session Title: RFID Localization and Data Processing and RF Design
Date/time: 22 – Sep – 2016 (Thursday), 14:00 – 16:30
Location: Conference Room Ceiba
Chair: Zhi Ning Chen

- (1570277826) The Effects of Single Bit Quantization on Direction of Arrival Estimation of UHF RFID Tags
Jordy Huiting, Andre Kokkeler, Gerard Smit (*The Netherlands*)
- (1570281113) An Anti-collision Algorithm Based on Task Scheduling Model in RFID System
Xu Jin, Shijie Zhou (*China*)
- (1570281432) A FVF based LDO with Dynamic Bias Current for Low Power RFID Chips
Yanhan Zeng, Hong-Zhou Tan (*China*)
- (1570284058) Monopulse Switching to Cancel Phase Offset in Array Antenna Comprising Multiple COTS SDRs
Masato Miyazawa, Jin Mitsugi, Yuusuke Kawakita, Haruhisa Ichikawa (*Japan*)
- (1570285189) Compact T-shaped Ring Bandpass Filter with Source-Load Coupled Structure for WPT
Zhouzhen Wu, Jun-hui Ou, Chong Lu, Andrey S.Andrenko, Hong-Zhou Tan (*China*)

Session ID: D
Session Title: RFID Industrial Implementation and Testing
Date/time: 23 – Sep – 2016 (Friday), 09:00 - 10:20
Location: Conference Room Peony
Chair: Kam Weng Tam

- (1570281276) A Tool for a Fast Evaluation of UHF RFID Installations,
Johannes Lechner, Willibald Gunthner (Germany)
- (1570282173) A Method to Make Accurate Inventory of Smart Meters in *Multi-Tags*
Group-Reading Environment
Yong Liang (China)
- (1570282852) Electric RFID Communication via Human Body
Takanori Washiro (Japan)

Session ID: Poster Session
Session Title: Poster Session
Date/time: 23 – Sep – 2016 (Friday), 10:20 - 12:00
Location: Meeting Room Foyer

- (1570276786) Performance Analysis of Systematic Linear Codes over AWGN Channels
Jia Liu (China)
- (1570277413) QoS based RFID System for Smart Assembly Workshop
Chuanying Zhai, Zhuo Zou, Yifan Qin, Ning Ma, Yuxiang Huan, Qiang Chen, Li-Rong Zheng, Hannu Tenhunen (Sweden, China, Finland)
- (1570278073) An Efficient and Provably Secure RFID Grouping Proof Protocol
Shu Chen, Vijay Varadharajan, Yi Mu, Willy Susilo (Australia)
- (1570278497) Piece-Wise Constant Models for RFID Traffic
Alaa Alkadi, Zornitza Genova Prodanoff, Patrick Kreidl (USA)
- (1570282421) A Lightweight Authentication Scheme for Transport System Farecards,
Mee Loong Yang, Ajit Narayanan, Dave Perry, Xiumin Wang (New Zealand, China)
- (1570283112) Design Frequency Synthesizer Chip for Wearable RFID and Biomedical Applications
Wen Cheng Lai (Chinese Taipei)
- (1570283997) The Use of Indoor Propagation Analysis and Asymptotic Method in a 433MHz Wireless System,
Tomasz Markowski, Michal Grabia (Poland)
- (1570290725) An Area-efficient Digitally-Assisted DC Canceling Loop for High Sensitivity UHF RFID Receiver,
Jing Liu, Qiang Guo, Yu Wang, Xi Tan, Hao Min (China)
- (1570293240) Improved RFID Tag Characterization System: Use Case in the IoT Arena
Riccardo Colella, Luca Catarinucci, Luciano Tarricone (Italy)

Presentations

Session ID: A
Session Title: Advances in RFID Antenna Design
Date/time: 22 – Sep – 2016 (Thursday), 10:30 – 12:30
Location: Conference Room Peony
Chair: Andrea Michel

10:30-10:50

1. 2.45 GHz Broadband Monopole RFID Reader Antenna Buried in the Ground of Parking Lot Near the Curb, **Yejun He, Minghai Chen** (*China*)

In this paper, a compact broadband monopole RFID reader antenna with operating frequency of 2.45 GHz is designed for vehicle inspection application. This reader antenna is buried in the ground of parking lot along the curb. The antenna comprises a planar loop monopole element which is fed by a microstrip line. The proposed antenna is simulated using HFSS (High Frequency Structure Simulator) as a 3D electromagnetic field simulator. The antenna is deployed on an FR4-Epoxy dielectric substrate with the dimension of 34 mm × 16 mm and the thickness of 1.6 mm. The permittivity and loss tangent of the substrate are 4.4 and 0.02, respectively. The measured results show that the characteristics of realized antenna have good agreements with the simulated ones. The bandwidth for the linear polarized antenna is more than 280 MHz (2.27-2.55GHz) and the return loss is less than -10dB.

10:50-11:10

2. Analysis of Wearable Ungrounded Antennas for UHF RFIDs with Respect to the Coupling with Human-Body, **Giovanni Andrea Casula, Giorgio Montisci, Andrea Michel, Paolo Nepa** (*Italy*)

A number of wearable antennas suitable for implementation of UHF-RFID tags have been presented in the open scientific literature. All of them are characterized by a high sensitivity with respect to the coupling with the human body, both on the input matching and on the antenna efficiency. This work presents a numerical investigation performed over a wearable, ungrounded, antenna configuration, which shows that the performance robustness can be related to the distribution of the electric and magnetic energy densities close to the antenna borders.

11:10-11:30

3. Technologies for Secure RFID Authentication of Medicinal Pills and Capsules, **L. Richard Carley, Gurkan Colak, Louis Chomas, Larry Pileggi, Kenneth Mai** (*USA*)

This paper addresses the problem of counterfeiting of medicines in the form of pills and capsules by proposing a novel micron-scale secure RFID tag that would be inserted into the pill or capsule during the manufacturing process. For secure identification and authentication,

a tagged pill or capsule would be scanned by a small inexpensive RFID reader, and key medicine information such as the drug type, manufacturer, and expiration date would be retrieved from a secure database. This application is enabled by an RFID tag integrated circuit (IC) incorporating an on-chip ID storage and custom security engine with a novel on-chip antenna (OCA) structure that has the potential to achieve an order of magnitude greater working distance at constant power level when compared to prior art passive single-chip silicon RFID tags with OCAs. This paper describes the proposed solution in detail and presents analysis, electromagnetic simulation, and circuit simulation results supporting its design and performance.

11:30-11:50

4. An Overview on Modular Antennas for Near-Field UHF-RFID Systems, **Andrea Michel, Paolo Nepa, Marcos N. Pino** (*Italy, Spain*)

In the framework of Near-field (NF) UHF-RFID applications, a large number of ad-hoc antennas have been proposed in the last decade. In particular, the authors recently proposed novel reconfigurable antenna configurations, the so-called Modular Antennas. In these layouts, a travelling wave antenna is combined with a low-gain resonating antenna, which shares the surface of the desktop reader antenna. Specifically, a spiral Travelling Wave Antenna (TWA) is used to generate a strong and uniform field in proximity of the antenna surface. Then, such a microstrip transmission line is used to feed the resonating antenna in order to extend the reading range up to few decimeters. Also, to make the antenna almost scalable, several antenna solutions have been proposed, so spreading the generated field in a large and arbitrarily shaped area.

11:50-12:10

5. Tuning Mutually Coupled RFID Antennas for High Usage Scenarios, **Ian Pratt, Shiyun Zhong** (*UK*)

RFID technologies are now commonplace with applications such as: cashless payments, access control, library book tagging and electronic passports to name but a few applications. This paper addresses one of the issues that is frequently encountered in near field RFID implementations which is the effects of placing resonant antenna heads in close proximity. This situation arises during the design of RFID tunnels or ePassport readers where there is a need to have two or more readers in close proximity in order to read a credential in differing orientations or locations. This paper shows that design of such systems can be accommodated provided coupling levels remain low.

12:10-12:30

6. Low Cost Coplanar UHF RFID Tag Antenna Using U-shaped Feeder for Metallic Applications, **Karrar Naji Salman** (*Malaysia*)

In this design, low cost coplanar slim tag antenna has been introduced for UHF band (860-960 MHz) which is designed for metallic objects. The tag antenna was proposed with proximity

coupled feeding; a transmission line fed by a U-shaped inductively coupled feed and two symmetrical coplanar ground layers. Furthermore, the U-shaped feeder configuration consists of two opposing symmetrical U-shaped structures to feed the tag antenna. The size of the antenna was $72 \times 42 \times 1.6 \text{ mm}^3$ at 915 MHz. According to the results, the gain for the tag antenna reached up to 2.3 dBi at 915 MHz. In addition, the bandwidth of the antenna is 15 MHz (907-922) MHz (the power reflection coefficient was lower than -3 dB), while the reading range reached up to 5.3 meters. Besides, the results obtained from the implementation showed very good impedance matching due to the flexibility generated by the U-shaped inductive feeder.

Session ID: B
Session Title: RFID in IOT Applications
Date/time: 22 – Sep – 2016 (Thursday), 10:30 – 12:30
Location: Conference Room Ceiba
Chair: Pui-In Elvis Mak

10:30-10:50

1. Distributed Event-Based Resource-Oriented EPCglobal Middleware Using GPC, **Yalew Tolcha, Daeyoung Kim** (*Korea*)

From its primal application in supply chain visibility using RFID, EPCglobal have expanded to embrace different IoT domains. With the interest of integrating diverse heterogeneous sensors/actuators (Things) for distributed mobile IoT applications, a middleware that can address the requirement of heterogeneity and scalability is inevitable. For mobile-connected devices, event based middleware suits well as it loosely associate them. Aside from that, a common set of abstraction (thing model) is needed among heterogeneous things and applications to facilitate data exchange. In this article, we introduce a resource-oriented event-based middleware into EPCglobal architecture for IoT framework. It specifically address interoperability and scalability by proposing a distributed Publish/Subscription model using Global Product Classification (GPC) as a resource description for smart devices. This paper describes extension of GPC and its usage as service description in resource modeling, resource oriented Publish/Subscription model, its evaluation and demonstration.

10:50-11:10

2. QR-Code Based Chipless RFID System for Unique Identification, **Sriharsha Vardhan G, Ashudeb Dutta, Naveen Sivadasan** (*India*)

A fully passive printable QR (Quick Response) code embedded chipless RFID (Radio Frequency Identification) technique is presented for secure identification of alive and nonalive amenity. A series of QR codes are printed in the form of a resonator in passive RFID tag, and the coded information is retrieved through frequency domain reflectometry method for identification. The design is demonstrated over the 3-10 GHz band with embedded multiple QR-code resonators on a single RFID tag. The tag comprises of QR Code resonators, cross polarized transmitting and receiving ultra-wide band (UWB) monopole antennas. As a proof of concept, a 42mm x 42mm size standard QR-code resonator is designed and later the design is compressed to 10.5mm x 10.5mm size on a single-sided FR4 PCB. The proposed method proved the tag read by reader from 2 meters of distance.

11:10-11:30

3. Modified Research on RFID-oriented ECC Point Multiplication over GF(2m) Field, **Guohong Wei, Ya Wang, Qiuhan Wu** (*China*)

In elliptic curve algorithm, point multiplication is the most core part. Its efficiency determines the execution efficiency of the algorithm. RFID label belongs to resource-constrained device,

and it has strict requirement to hardware resource occupied by algorithm execution. Combined with the characteristics of RFID device, the paper modifies modular multiplication, modular inverse algorithm and applies overall serial and part parallel method to redesign algorithm execution structure and realizes it over FPGA. The result indicates that the algorithm compromises on the occupied area and execution speed, so it's suitable for RFID device.

11:30-11:50

4. Energy Harvester for Wireless Sensor with RFID Interface, **Andrey A. Uhov** (*Russia*)

A mobile device for the environmental temperature and humidity monitoring has been developed. The device is powered from two sources - battery and energy harvester. Environmental parameters are transferred to an external computer by means of RFID link. This communication system does not require any external power supply that extends battery lifetime depending on the data acquisition rate. The harvesting system taking energy from mains wires has been assessed and proposed as a possible solution to a further extend the battery lifetime. Proposed harvester construction is based on collapsible current transformers made of a standard power inductor and additional magnetic circuit part.

11:50-12:10

5. Design of Internet of Things System for Library Materials Management Using UHF RFID, **Dongying Li, Shundao Xie, Rongjun Chen, Hong-Zhou Tan** (*China*)

With RFID applying in library, this paper develops an Internet of Things System for Library Materials Management using Android based UHF mobile reader (Android mobile reader) as its entry to increase the efficiency of library materials management. The functions of the Internet of Things System for Library Materials Management include user identification, inventorying, adding, refreshing, searching, and self-help borrowing & returning library materials.

12:10-12:30

6. A Low Power EEPROM for Passive RFID Tag, **Chong Lu, Yu Li, Jun-hui Ou, Hua-ling Wu, Hong-Zhou Tan** (*China*)

EEPROM is widely used in RFID passive tags and the power consumption restricts the reading distance to readers. In this paper, a novel structure of EEPROM is proposed to investigate the potential power reduction. From the analytical results of distribution on power dissipation of the conventional EEPROM, the charge pump and the sense amplifier take the most part. A novel cascaded structure of charge pump is applied to decrease the power consumption at 23.4% with grouping the units and modifying the frequency of input clock. Moreover, the active capacitance load is also reduced by inserting idle duty cycle. Then again, an improved sense amplifier with selective control gates is presented and the SA will share the bandgap with the charge pump. The power dissipation of SA is achieved at 370 μ W. This proposed 8k-byte EEPROM is designed and fabricated in SMIC 0.18 μ m 2P6M process and

the chip area is 0.93x0.93 mm². The measurement results from the test chip are demonstrated and compared with the conventional structure.

Session ID: Student Competition
Session Title: Best Student Paper Competition
Date/time: 22 – Sep – 2016 (Thursday), 14:00 – 17:00
Location: Conference Room Peony
Chair: Andrey S. Andrenko

14:00-14:20

1. A Novel Textile Dual-Polarized Antenna Potentially Used in Body-Centric System, **Ye Kuang, Lan Yao, Wenwen Zhang, Dongchun Zhou, He Luan, Yiping Qiu** (China)

Body-centric system which is generally used for monitoring and tracking is a technology involving RFID communication system. Currently, many researchers have investigated textile RFID tags integrated in the garments, however, few of them studies the wearable reader antenna. In this paper, a 1.8GHz textile dual-polarized antenna, which will be potentially used as a reader antenna, was designed and fabricated on the three-dimensional (3D) weaving machine with the basic materials of copper yarns and E-glass yarns. The two ports of the antenna achieved -10dB bandwidth of 33MHz (1810-1833MHz) and 52MHz (1765-1817MHz) respectively and the highest isolation value was -19.9dB. The cross polarization levels were less than -20dB in the E- and H-planes of the two ports of the antenna. The antenna gains of port 1 and port 2 were measured to be 3.5dBi and 4.1dBi respectively. The performance data above shows the adequate and proper antenna properties of this designed textile antenna.

14:20-14:40

2. Sensor Integrated RFID Tags for Sustainable Wearable Electronics Applications, **Ahmed Rasheed, Emad Iranmanesh, Weiwei Li, Andrey S. Andrenko, Kai Wang** (China)

The use of radio frequency identification (RFID) technology for the automatic identification and communication of physical parameters with on board integrated sensor attracts vast applications on a large scale ranging from mobile healthcare to logistics, supply chains, robotics and many others. Recently, sensor RFID tags have been considered in wearable electronics. However, these devices are still empowered by a battery. In this paper, we proposed and designed a self-sustainable sensor integrated RFID tag for wearable electronics applications. A PVDF integrated dual-gate thin film transistor (TFT) was used to harvest energy from daily human activities such as arm/finger movements. Numerical analysis and preliminary results of such energy harvester was reported in addition to system design of chip-based sensor integrated RFID tag.

14:40-15:00

3. A Low Power High Sensitivity RF Power Detector for Multi-Mode Active Tags, **Hualei Zhang, Sizheng Chen, Tao Yang, Xi Tan, Na Yan, Hao Min** (China)

This paper presents a low power high sensitivity RF power detector (PD) for multi-mode active tags. To achieve low power consumption and large detection range, two-branch common-source-type MOSFET transistors biased in subthreshold region are used. This power detector is fabricated in a 0.13- μm mixed signal CMOS process with power consumption of 216nW in idle state. Measured results at 900MHz show that the PD features a sensitivity of -51dBm. Power detector produces the mode-enabled signals to the multi-mode active tag according to the different received RF power. Therefore, the multi-mode active tag can be switched into idle mode, active mode, semi-passive mode or passive mode with a proper power consumption. The active mode enabled signal is produced when the received RF power is located in the range between -50dBm and -25dBm. The semi-passive mode enabled signal is produced when the received RF power is located in the range between -25dBm and -15dBm and the passive mode enabled signal is produced when the RF power is beyond -15dBm.

15:00-15:20

4. Wireless Control for Vision Impaired Based on Posture Effect of UHF RFID Cane, **Wenyang Li, Wenhai Zhang, Kam Weng Tam** (*Macao*)

This paper illustrates the posture effect on Ultra High Frequency (UHF) RFID tag detection. The originality is about the polarization characteristic of passive tag and reader antennas. Different orientation of the passive tag could make the polarization loss distinct, resulting in the variation of the Received Signal Strength Indication (RSSI), for instance, placed in horizontal and vertical orientation, will make RSSI distinct. With the variations of RSSI, a control mechanism of "On" and "Off" signals for Vision Impaired Person can be achieved. A prototype RFID system and test cane with tags are designed and tested to prove the feasibility.

15:40-16:00

5. Differential Topology Rectifier Design for Ambient Wireless Energy Harvesting, **Miaowang Zeng, Andrey S. Andrenko, Xianluo Liu, Bo Zhu, Zihong Li, Hong-Zhou Tan** (*China*)

In this paper, two types of differential topology rectifier are studied and designed for RF energy harvesting at GSM1800 band 1.83GHz. The proposed differential serial rectifier and differential doubler rectifier are with odd harmonics suppression characteristics. Radial stubs are utilized to filter the output harmonics, which makes the rectifier more compact. The rectifiers with Schottky diodes (SMS7630) are fabricated on Teflon substrate. Measured maximum efficiencies of two rectifiers are 49% @ 0dBm and 53% @ 2dBm, respectively. The results show that the rectifiers are efficient, power sensitive and compact. Application scenarios of proposed rectifier are demonstrated. The proposed rectifiers can be used in many RF energy harvesting systems, including RFID applications.

16:00-16:20

6. A Novel Broadband Dual-Polarized Dipole Antenna Element for 2G/3G/LTE Base Stations, **Yadong Yue, Yejun He** (*China*)

A novel broadband dual-polarized crossed-dipole antenna element with parasitic branches is designed for 2G/3G/LTE base stations. The proposed antenna mainly comprises a curved reflector, two crossed-dipoles, a pair of feeding strips, and two couples of balanced-unbalanced (BALUN) trans-formers. Compared to the traditional square-loop radiator dipole, the impedance bandwidth of the proposed antenna can be greatly improved after employing two parasitic metal stubs and two pairs of parasitic metal branches, and a better radiation performance of the proposed antenna can be obtained by optimizing the angle of the reflector. Simulation results show that the proposed antenna element can operate from 1.7 to 2.7 GHz with has an impedance bandwidth of $VSWR < 1.5$, the port isolation of more than 30 dB, a stable radiation pattern with half-power beamwidth 65.2 ± 5.6 degree at H-plane and V-plane, and a relatively stable dipole antenna gain of 8.5 ± 0.4 dBi. Furthermore, measured results have a good agreement with simulated ones.

16:20-16:40

7. On the Measurements of Liquid Sensing Based on UHF RFID, **Wenyang Li**, **Wenhai Zhang**, **Kam Weng Tam**, **Eddie Chiang**, **Ka Hing Chiang** (*Macao*)

This paper illustrates that a Radio Frequency Identification (RFID) for the liquor by Ultra High Frequency (UHF) RFID tag detection. RFID technology has been widely used in passive RFID application due to its flexible deployment and low cost. But for the absorbing material effects of RFID are quite complex for solving, for example, water and other liquors. The originality of this paper is based on the characteristics of Received Signal Strength Indication (RSSI). Different volume and the distance of the water of the cup will make the RSSI distinct. A prototype RFID measurement system are designed and tested to identify the feasibility for application.

16:40-17:00

8. Deployment of Localization System in Complex Environment Using Machine Learning Methods, **Quanyi Hu** (*Macao*)

Conferences are considered as an indoor environment for research with indoor localization that faces different challenges. In this paper, we design an indoor localization system in such a complex environment focus on machine learning algorithms with a large scale data. In this system, users can get information where a specified people locate in. Our system has two main sections: system design and algorithm approach. We use Bluetooth Low Energy devices to achieve communication and collect the information consist of people's name and corresponding RSSI data. To illustrate the advantages of machine learning algorithms using in this situation, a traditional algorithm will be proposed as a comparison. We also design and implement a Nine Rectangle-Grid localization system in a practical laboratory environment. Experiments on real-world environment and simulations show our system can live up to locate people with low cost, high accuracy and short computing time.

Session ID: C
Session Title: RFID Localization and Data Processing
Date/time: 22 – Sep – 2016 (Thursday), 14:00 – 16:30
Location: Conference Room Ceiba
Chair: Zhi Ning Chen

14:00-14:25

1. The Effects of Single Bit Quantization on Direction of Arrival Estimation of UHF RFID Tags, **Jordy Huiting, Andre Kokkeler, Gerard Smit** (*The Netherlands*)

Phased arrays can be used to estimate the direction-of-arrival (DOA) of UHF RFID tags. To save on energy consumption and hardware costs, in this paper we explore the possibility of using single bit analog-to-digital converters for our phased array setup. This setup consists of an off-the-shelf Impinj R2000 reader and a custom phased array with 4 receiving channels. The proposed system quantizes the baseband quadrature signals individually. As there is a direct relation between the correlation coefficient of a quantized signal and an unquantized signal, the error introduced by quantization can be corrected. The experimental results show that single bit quantization can be used for DOA estimation and the mean error increases only slightly. The proposed correction achieves better results than uncorrected quantized estimation, at the cost of the need for signal power measurements.

14:25-14:50

2. An Anti-collision Algorithm Based on Task Scheduling Model in RFID System, **Xu Jin, Shijie Zhou** (*China*)

The collision problem in the multiple Radio Frequency Identification (RFID) reader environment could cause the loss of data, and leads to the decrease of the time-efficiency and energy-efficiency of RFID system. To solve this problem, we propose a task model based on the resource competition to indicate the collision in RFID system, and present a new reader scheduling algorithm based on the reader's priority. Such algorithm considers the reader activation scheduling as a task scheduling problem on multiprocessor operating system with the task model, and solves it with the theory of maximal independent set (MIS). We also propose a dynamic reader scheduling schemes for practical requirements. As proved by simulation results, the schemes can be adopted to solve the collision problem in large-scale RFID system as well as scheduling problems in other network systems.

14:50-15:15

3. A FVF based LDO with Dynamic Bias Current for Low Power RFID Chips, **Yanhan Zeng, Hong-Zhou Tan** (*China*)

A low power flipped voltage follower (FVF) based output capacitor-less low-dropout (LDO) regulator, designed for the low power radio frequency identification (RFID) chips, has been proposed and simulated using a standard 0.18 μm CMOS process in this paper. Utilizing the

FVF structure and dynamic bias current technique, proposed LDO is able to achieve a fast transient response and the power supply ripple (PSR) is also improved to reduce the output ripple by additional measures. The simulation and measurement results show that proposed LDO can provide stable power supply voltage with a small ripple and good transient response. It has been applied to a passive transponder chip design, which was fabricated successfully based on 0.18 μm CMOS process.

15:40-16:05

4. Monopulse Switching to Cancel Phase Offset in Array Antenna Comprising Multiple COTS SDRs, **Masato Miyazawa, Jin Mitsugi, Yuusuke Kawakita, Haruhisa Ichikawa** (*Japan*)

This paper proposes an phase offset canceler for an array antenna, which comprises multiple low-cost commercial of the shelf (COTS) software defined radio (SDR) devices. The main challenge is the phase synchronization of SDR devices because each SDR device has its own phase offset when it produces IQ stream. We devise a simple yet effective method to cancel the phase offset of individual SDR device using a double pole, double-throw (DPDT) switch which is implemented between antenna and SDR device. The DPDT switch is controlled according to the frame timing of each IQ stream to produce two set of measurements, from which we can compute angle of arrival with a simple signal processing. We refer this mechanism as “Monopulse Switching”. We evaluated the working principle experimentally to reveal Monopulse switching successfully cancel phase offset to detect AoA without any initial calibration and achieves 2.8 degree measurement accuracy.

16:05-16:30

5. Compact T-shaped Ring Bandpass Filter with Source-Load Coupled Structure for WPT, **Zhouzhen Wu, Jun-hui Ou, Chong Lu, Andrey S. Andrenko, Hong-Zhou Tan** (*China*)

A T-shaped ring band pass filter using source-load coupling technique is proposed in this paper. T-shaped ring structure effectively utilizes the area and makes it easier to tune filter's center operating frequency, which is also helpful in expanding the bandwidth. Source-load coupling technique is used in the proposed design to increase the transmission zeros on the operating frequency in both sides so that the out-of-band rejection can be further improved. First, validation in simulation is carried out to prove the use of source-load coupling. Then a demonstrating filter has been designed, optimized, fabricated and measured. The filter has low insertion loss of 0.35dB, return loss of -18dB when operating in 2.47 GHz, and measurement shows good agreement with simulation. Such filter can be in good use in microwave power transmission in microwave-RFID application.

Session ID: D
Session Title: RFID Industrial Implementation and Testing
Date/time: 23 – Sep – 2016 (Friday), 09:00 - 10:20
Location: Conference Room Peony

9:00-9:25

1. A Tool for a Fast Evaluation of UHF RFID Installations, **Johannes Lechner, Willibald Gunthner** (Germany)

Impacts of the operation environment on the read field of passive UHF RFID applications can be decisive for the successful implementation of the systems. However, these impacts cannot easily be foreseen or detected. Therefore, it is necessary to verify the configuration of the installation regarding a reliable performance when putting the installation into operation. But the testing of a certain configuration can be a very complex and time consuming procedure, especially when approaching by trial and error. To support the evaluation of an installation's configuration and the detection of problematic areas within the read field, a new concept for a measurement tool is presented in this paper. The basic idea of the tool is to measure the spatial distribution of the field strength by tracking the measuring antenna's positions. For a quick understanding and analysis of the measurement's results, a 3D visualization is used. To evaluate the measurement tool, we conducted comparative measurements aimed at the detection of the weak areas of a read field at an RFID gate.

9:25-9:50

2. A Method to Make Accurate Inventory of Smart Meters in Multi-Tags Group-Reading Environment, **Yong Liang** (China)

RFID plays a very important role as auto-identification solution for many industrial applications. In electric power industry, UHF RFID tags are attached on smart meters, and a tag provides a unique electronic identification for a smart meter, so RFID is applied to make asset inventory for smart meters in a warehouse. However, there are just about 95% of tags that are readable for their reader because of the interference of PCB and electronic components in smart meter, thereby it has to take a lot of time to manually find out the non-responsive tags. This paper puts forward a feasible method of testing tag's performance according to multi-tags group-reading environment in the application of smart meter asset inventory, and verifies the feasibility of the method through inventory experiments, and finally gives out an optimized parameters to read 100% of tags with the sensitivity of -16.25dBm in a multi-tags environment. The method is suitable for the test of large quantities of smart meters that are densely packed in a plastic box. The proposed method can guide electric power companies to select tags and readers, and improve the efficiency of inventory for smart meters asset management.

9:50-10:15

4. Electric RFID Communication via Human Body, **Takanori Washiro** (Japan)

Communications of RFID are not limited only to magnetic inductive coupling between two coils. If the same transmission efficiency is obtained, RFID communications by electric inductive coupling between two electrodes can be accomplished. RFID with electric field coupling with electrodes instead of coils is developed by using as-is communication modules and ICs. Electric field signal can travel along dielectrics and/or conductors, and human bodies show characteristics of dielectric and conductor in high frequency. It means human body can carry RFID signal, and RFID transaction can be done through the body by hand touch. Electric RFID communication has a big potential to realize intuitive and natural interface of "machine to human" or "human to machine to human" communications.

Session ID: Poster Session
Session Title: Poster Session
Date/time: 23 – Sep – 2016 (Friday), 10:20 - 12:00
Location: Meeting Room Foyer

1. Performance Analysis of Systematic Linear Codes over AWGN Channels, **Jia Liu (China)**

In this paper, amended truncated union bounds on the bit error probability of systematic linear codes over additive white Gaussian noise (AWGN) channels are proposed, which can be used to evaluate the performance of the radio frequency identification (RFID) system. The proposed bounds are based on Gallager's first bounding technique (GFBT), where the "good" region is defined by a sub-optimal list decoding algorithm. The proposed bounds require only the knowledge of partial input output weight enumerating function (IOWEF) with truncated information weight, which can also be adapted to the codes when the IOWEF is not available and difficult to calculate but the weight spectrum is known. The proposed amended truncated union bounds improve the conventional union bounds and the recently proposed Ma bounds but have a similar complexity since they involve only the Q-function.

2. QoS based RFID System for Smart Assembly Workshop, **Chuanying Zhai, Zhuo Zou, Yifan Qin, Ning Ma, Yuxiang Huan, Qiang Chen, Li-Rong Zheng, Hannu Tenhunen (Sweden, China, Finland)**

This paper presents a quality-of-service (QoS) based RFID system for smart assembly workshop towards the industrial Internet of Things (IoT). Under the context of industrial IoT, every object in the assembly workshop is interconnected which enables automated monitoring of production environment, tracking of components/products, and control of machines and execution process. The proposed RFID system employs a gateway to coordinate the objects attached with RFID tags as a subsystem. is considered as a sub-system and a four phase communication protocol between the RFID tags and gateway promise QoS on demands of the varied functional sub-systems.

3. An Efficient and Provably Secure RFID Grouping Proof Protocol, **Shu Chen, Vijay Varadharajan, Yi Mu, Willy Susilo (Australia)**

RFID Grouping proof is a practical application for Internet of Things. It convinces an offline verifier that multiple tags are simultaneously scanned. Various solutions have been proposed but most of them have security and privacy vulnerabilities. In this paper, we propose an elliptic-curve-based RFID grouping proof protocol. Our protocol is proven secure and narrow-strong private. We also demonstrate that our grouping proof can be batch verified to improve the efficiency for large-scale RFID systems.

4. Piece-Wise Constant Models for RFID Traffic, **Alaa Alkadi, Zornitza Genova Prodanoff, Patrick Kreidl** (USA)

Available security standards for RFID networks (e.g. ISO/IEC 29167) are designed to secure individual tag-reader sessions and do not protect against active attacks that could also compromise the system as a whole (e.g. tag cloning or replay attacks). Proper traffic characterization models of the communication within an RFID network can lead to better understanding of operation under "normal" system state conditions and can consequently help identify security breaches not addressed by current standards. We consider the adaptation of two known piece-wise linear models for the purposes of modeling RFID command arrivals at a reader: Bayesian Blocks and Knuth's rule. Our preliminary results indicate that both methods could potentially be used to detect changes in system state (e.g. changes in the rate of command arrivals at a reader).

5. A Lightweight Authentication Scheme for Transport System Farecards, **Mee Loong Yang, Ajit Narayanan, Dave Perry, Xiumin Wang** (New Zealand, China)

Proximity Integrated Circuit Cards (PICC) are widely used for public transport fare collection. The stored contents in the card can only be accessed or modified after the card is able to authenticate the Proximity Coupling Device (PCD) or reader using a shared secret key. We propose a new authentication scheme that is not based on shared secret keys. Instead, authentication is based on the card and reader being able to compute an identical pairwise key using their own private keying material obtained from the same source. The scheme uses simple modular arithmetic operations over a small binary extension field achieving fast computation speed using the limited resources in cards. In addition, should the keys be stolen from the cards or readers, the security of the other parts of the system cannot be compromised.

6. Design Frequency Synthesizer Chip for Wearable RFID and Biomedical Applications, **Wen Cheng Lai** (Chinese Taipei)

The proposed frequency synthesizer was fabricated in a TSMC 0.18 μ m CMOS process for wearable RFID and biomedical applications such as integrated sensor at proposed ECG monitoring shirt with P-FCB electrodes. At 1 V supply voltage, measured results of the proposed prototype shows a wide tuning range from 2.23 to 2.47 GHz, corresponding to 10.2% , a phase noise of -111.16 dBc/Hz at 1 MHz offset from 2.4 GHz, a power consumption of 4.4 mW and a reference spur of -60.4dBc.

7. The Use of Indoor Propagation Analysis and Asymptotic Method in a 433MHz Wireless System, **Tomasz Markowski, Michal Grabia** (Poland)

The paper is a study of an active sensory technology network with a new DASH7 protocol. The main aim was to establish the basis for implementing localization of moving objects in real time. Due to its low power consumption, long range, and good permeability resulting from the

application of the DASH7 protocol, the technology under analysis can contribute to the development of a system of real-time localization equipped with advanced sensory features, while maintaining low manufacturing and implementing costs. An analysis of 433MHz signals, due to their multipath nature and the dynamic propagation environment, must be carried out in real time. This computational complexity of the application determines the use of approximate (asymptotic) methods.

8. An Area-efficient Digitally-Assisted DC Canceling Loop for High Sensitivity UHF RFID Receiver, *Jing Liu, Qiang Guo, Yu Wang, Xi Tan, Hao Min (China)*

An area-efficient digitally-assisted DC canceling loop is presented for high sensitivity single-chip UHF RFID readers. The proposed loop suppresses the DC blocker in RFID receivers by 41 dB with the aid of negative feedback. A delta-sigma modulator with 67dB dynamic range is implemented in the loop to enhance the sensitivity of the receiver. A reconfigurable digital loop filter with low cut off frequency is designed for compact chip area. The DC canceling loop is fabricated in a 0.13 μ m CMOS process. It occupies a silicon area of 1.69mm² and dissipates 24.3mW from a 1.2V supply. The proposed loop is demonstrated in an RFID reader prototype. A -70dBm sensitivity of the reader is measured in the presence of +5dBm self-jammer.

9. Improved RFID Tag Characterization System: Use Case in the IoT Arena, *Riccardo Colella, Luca Catarinucci, Luciano Tarricone (Italy)*

Radio-frequency identification (RFID) is one of the most promising technologies to enable new smart applications in the framework of the Internet of Things (IoT). Nevertheless, from the electromagnetic point of view, the performance of the RFID tags is generally dependent on the context, so that the selection of the most suitable tag for the specific application becomes the key point. In this work, a cost-effective but accurate characterization system for the performance evaluation of UHF RFID tags is first presented and then validated on the IoT-related relevant case of RFID-based interaction with buildings.

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