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Title	Authors with affiliation and country	Abstract
Design of a Passive UHF RFID Transponder Featuring a Variation-Tolerant Baseband Processor	Zheng Wang (Tianjin University, CN); Luhong Mao (Tianjin University, CN); Liying Chen (Nankai University, CN); Lei Li (Tianjin University, CN); Jinfeng Tian (TianJin University, CN); Ziqing Wang (Tianjin University, CN)	This paper presents the design of a passive UHF RFID transponder in compliance with the ISO 18000-6C protocol operating at the 915MHz ISM band. The proposed tag IC is implemented with several advanced low-power techniques aiming at extending the range of communication. Since the on-chip oscillator is particularly sensitive to process, voltage and temperature (PVT) variations, the baseband processor is designed as a frequency variation tolerant circuit in order to accommodate the fluctuation of the frequency from the local oscillator, which can decrease the percentage of failed chips and enhance the performance of tags working in critical conditions. The tag chip is fabricated using Chartered 0.18μm 1P6M standard CMOS process and occupies 0.54mm2 area. And the minimum power to read the assembled transponder (connect the chip with a dipole antenna) is -11.4dBm.
HF RFID Transponder with Phase Demodulator for Very High Bit-Rates up to 13.56 Mbit/s	Markus Auer (University of Technology, AT); Albert Missoni (TU Graz, AT); Walter Kargl (Infineon, AT)	Sending larger data volumes over an air interface requires high transmission rates and a demodulator to recognize this data. Amplitude demodulators have been used in past to detect data rates up to 848 kbit/s and phase demodulators have been used to achieve data rates of 424 kbit/s. This paper presents a 13.56MHz HF Transponder with a phase demodulator for very high bit-rates based on the passive near field principle. The integrated phase demodulator detects phase modulated signals with a bit-rate up to 13.56 Mbit/s at an operating range of 4 cm. On the transponder chip a complete RFID analog front end is integrated. It includes common HF-RFID antenna, for high data rates optimized shunt, phase demodulator and load modulator. A novel phase demodulator principle is introduced in this paper. It uses phase-locked loop (PLL) to obtain accurate time reference for the phase detectors. This allows recognizing the phase shift by the comparison of the incoming phase modulated data with the phase of the time reference. The phase demodulator reported here uses two phase detectors working in alternating mode. This solution allows recognizing phase shifts of the received data sent on double data rate compared to the solution with one phase detector. The demodulator was implemented in a 90nm Flash CMOS technology with a supply voltage of 1.5V and a power consumption of 0.56mW. Measurement results show that the phase demodulator is able to recognize very small phase changes down to 5 degrees at bit rate of 13.56 Mbit/s.

Supply Chain Control Using a RFID Proxy Re-Signature Scheme	Trevor Burbridge (BT Research, UK); Andrea Soppera (BT Research, UK)	The use of RFID tags allows many new approaches to the old problems of supply chain control and product anti-counterfeiting. Many of the schemes suggested to-date do not adequately meet the needs of the supply chain industry. Some require unjustifiable expense or performance and resilience issues, while others face deployment barriers where the party that deploys the technology is not the party the benefits. Many of the schemes, however, will ultimately fail because they inadequately address the issues of trust and business confidentiality. We present a supply chain control solution using the principle of proxy re-signatures to establish secure and verifiable supply chain paths. Critically our scheme does not require centralized run-time services and provides minimal visibility of supply chain operations to other parties.
Phase Based Spatial Identification of UHF RFID Tags	Pavel Nikitin (Intermec Technologies, US); Rene Martinez (Intermec Technologies, US); Shashi Ramamurthy (Intermec Technologies, US); Hunter Leland (Intermec Technologies, US); Gary Spiess (Intermec Technologies, US); Kodukula Rao (Intermec Technologies, US)	In this paper, we give an overview of spatial identification (determining position and velocity) of modulated backscatter UHF RFID tags using RF phase information. We describe three main techniques based on PDOA (Phase Difference of Arrival): TD (Time Domain), FD (Frequency Domain), and SD (Spatial Domain). The techniques are illustrated with modeling and simulation example in free space and in presence of multipath using a multi-ray channel model for amplitude and phase of the received tag signal in deterministic environment. We also present and discuss the experiments performed in a real RFID warehouse portal environment.
Helical Antenna for Handheld UHF RFID Reader	Pavel Nikitin (Intermec Technologies, US); Kodukula Rao (Intermec Technologies, US)	In this paper, we describe a compact high gain circularly polarized antenna for handheld UHF RFID reader. The antenna is an axial mode helix operating in a backfire mode with ground plane on top and reflector on the bottom. The described antenna has small footprint (85 mm in diameter) and delivers maximum linear gain > 6 dBil, standing wave ratio < 2, and axial ratio < 2 dB in 60 MHz band centered around 895 MHz (approximate bandwidth 7%). The antenna can be easily tuned to cover any desired portion of the global UHF RFID band (860-960 MHz). The antenna is an attractive solution for handheld readers to maximize tag read range while providing circular polarization. We also review existing antenna solutions for handheld readers and discuss link budget and forward and reverse link tradeoffs.

Integration of passive multivariable RFID sensors into single-use biopharmaceutical manufacturing components	Radislav Potyrailo (General Electric, US); David Monk (General Electric, US); William Morris (General Electric, US); Staffan Klensmeden (General Electric, SE); Hanno Ehring (General Electric, SE); Timothy Wortley (General Electric, US); Vincent Pizzi (General Electric, US); Jeffrey Carter (General Electric, US); Gerard Gach (General Electric, US)	Single-use biopharmaceutical manufacturing requires monitoring of critical manufacturing parameters. However, the lack of reliable single-use sensors prevents the biopharmaceutical industry from fully embracing single-use biomanufacturing processes. We report here an approach for passive radio-frequency identification (RFID)-based sensing that does not rely on costly proprietary RFID memory chips with an analog input but rather implement ubiquitous passive 13.56 MHz RFID tags as inductively coupled sensors with 16-bit resolution provided by a sensor reader. Developed RFID sensors combine several measured parameters from the resonant sensor antenna with multivariate data analysis and deliver unique capability of multiparameter sensing and rejection of environmental interferences with a single sensor. In this study we are integrating these RFID sensors into single-use biopharmaceutical manufacturing components such as buffer bags. Performance of these sensors for simultaneous solution conductivity and temperature sensing is discussed.
Passive gamma-resistant RFID tags integrated into gamma-sterilizable pharmaceutical components	Radislav Potyrailo (General Electric, US); Cheryl Surman (General Electric, US); William Morris (General Electric, US); Hanno Ehring (General Electric, SE); Timothy Wortley (General Electric, US); Vincent Pizzi (General Electric, US); Jeffrey Carter (General Electric, US); Gerard Gach (General Electric, US)	The single-use bioprocessing is an attractive new approach of biopharmaceutical manufacturing. Digital identification of single-use bioprocess components is critical to facilitate their asset management, to document electronic pedigree, and to provide authentication. This identification can be achieved using radio frequency identification (RFID) tags. In this study, we critically analyze the challenges for the gamma-sterilizable RFID tag technology to retain the reliable read/write ability of the tags after their gamma irradiation. In RFID tags, the gamma radiation induced loss of device performance (i.e. the ability to reliably write and read data from an integrated circuit (IC) memory chip) originates from two independent sources such as (1) radiation effects on the non-charge-based storage memory material and (2) radiation effects on the performance of analog and digital circuit components of an IC memory chip device. Our interdisciplinary knowledge of product design, analytical instrumentation, RF engineering, and Six Sigma statistics has resulted in the design and implementation of the tag interrogation concept that insures the high reliability of tag read/write after the gamma irradiation.

Selective quantitation *of vapors and their mixtures using individual passive multivariable RFID sensors*	Radislav Potyrailo (General Electric, US); Cheryl Surman (General Electric, US); William Morris (General Electric, US); Steven Go (General Electric, US); Yongjae Lee (General Electric, US); James Cella (General Electric, US); Kelly Chichak (General Electric, US)	We demonstrate passive (battery-free) radio frequency identification (RFID) devices for selective and sensitive chemical vapor sensing in the presence of ambient interfering gases. We developed two approaches for RFID sensing (1) when a sensing material is applied onto the resonant antenna to alter its impedance response and (2) when a complementary sensor is attached across an antenna and an integrated circuit (IC) memory chip to alter the impedance response of the sensor. In both approaches, these RFID sensors combine several measured parameters of impedance response with the multivariate analysis of these parameters. Thus, these individual sensors provide a unique capability of multiparameter sensing and rejection of environmental interferences. Sensitivity of developed RFID sensors provides detection of vapors at part-per-billion and part-per-million concentrations. Selectivity of developed RFID sensors facilitates selective quantitation of different individual vapors and their mixtures with a single sensor. Our passive RFID sensors were interrogated by the sensor reader at distances ranging from 0 to 33 cm and demonstrated their reliable operation even at the largest tested distance. In our sensing implementations, not the sensor but the sensor reader provides a 16-bit resolution and high signal-to-noise of the acquired signal. Rejection of interferences with a single sensor and the independence from costly proprietary RFID memory chips that have an analog input promise to impact numerous sensing applications.
Privacy-preserving Clone Detection for RFID-enabled Supply Chains	Davide Zanetti (ETHZ, CH); Leo Fellmann (ETHZ, CH); Srdjan Capkun (ETH Zurich, CH)	Counterfeit products cause financial losses and represent a health risk. Within RFID-enabled supply chains, where products are equipped with RFID tags, clone detection mechanisms based on tag traces can help in detecting counterfeits. These mechanisms assume that supply chain partners share (private) information to run trace analysis, and may suffer from supply chain dynamics, tag misreads, product recalls, and misdeliveries. In this work, we present a novel, effective, privacy-preserving clone detection mechanism for RFID-enabled supply chains. Our mechanism does not rely on knowledge of supply chain structures or products flow, it is robust to recalls and misdeliveries, and considers tag misreads while evaluating the presence of counterfeits. We propose privacy-preserving implementations of our mechanism that show better performance than if it is implemented within existing secure multi-party computation frameworks.
UHF RFID Transponder with Miniaturized Packaging and Interconnection	Laurent Dussopt (CEA, LETI, Minatec, FR); Jean Brun (CEA, LETI, Minatec, FR); Dominique Vicard (CEA, LETI, Minatec, FR); Francois Frassati (CEA, LETI, Minatec, FR); Benoit Lépine (CEA, LETI, Minatec, FR)	This paper presents the design and demonstration of UHF RFID tags based on commercial chips with wafer-level packaging and direct die-to-wire interconnection. The packaging and connection technology is presented and shown to have the potential to be a low-cost industrial process. The performances of the processed dies are characterized and compared to a standard wirebonding technology, showing no significant difference. Finally, several tags are demonstrated and exhibit read range performances in good agreement with the theory.

An Ultra-low Power Passive UHF RFID Transponder with Self-calibrated Clock Generator	Jinfeng Huang (Peking University Shenzhen Graduate School, CN); Xin Yang (Peking University Shenzhen Graduate School, CN); Jinpeng Shen (Peking University Shenzhen Graduate School, CN); Xiaoxing Feng (Peking University Shenzhen Graduate School, CN); Xin'an Wang (Peking University Shenzhen Graduate School, CN); Ru Huang (Peking University, CN)	A fully integrated, ultra-low power passive UHF RFID transponder complying with ISO/IEC 18000-6B protocol is presented. In order to provide an accurate clock for the baseband processor, an ultra-low power, self-calibrated clock generator is presented. Further, a low temperature-coefficient, power-efficient voltage reference is introduced. And several practical strategies are employed to further reduce power consumption of the baseband processor. The chip is fabricated in 0.18um mix-signal CMOS process with a die size of 0.75mm×0.75mm. Measurement results show that the proposed RFID transponder operates with a sensitivity of -10dBm.
Cryptographic Puzzles and Distance-bounding Protocols: Practical Tools for RFID Security	Pedro Peris-Lopez (Delft University, NL); Julio Hernandez-Castro (University of Portsmouth, UK); Juan Tapiador (University of York, UK); Esther Palomar (University Carlos III of Madrid, ES); Jan vanderLubbe (TU Delft, NL)	Widespread adoption of RFID technology is slowing because of increasing public concerns about associated security threats. This paper shows that it is possible to enhance the security of RFID systems by requiring readers to perform a computational effort test. Readers must solve a cryptographic puzzle --one of the components of the Weakly Secret Bit Commitment (WSBC) sent by tags-- to obtain the static identifier of the interrogated tag. The method we present is based on a simple concept already used in such cryptographic applications as anti-spam programs or TCP SYN flooding protection, yet not in an RFID context until now. The scheme provides privacy protection while being an effective countermeasure against the indiscriminate disclosure of the whole contents of a large number of tags. Then, we scrutinize the combined use of cryptographic puzzles and distance-bounding protocols. First, a classical and straight-forward solution is presented. Secondly, we introduce a cutting-edge approach that reduces WSBC drawbacks such as key delegation whilst gaining the advantages of employing distance-bounding protocols such as certainty of the distance between a tag and reader.
Real time detection and tracking of gauzes by RFID UWB Technique	Laura Pierucci (University of Florence, IT); Sergio Boncinelli (CESPRO, IT); Paolo Citti (University of Florence, IT); Enrico Del Re (University of Florence, IT); Gianni Campatelli (University of Florence, IT); Leonardo Bocchi (University of Florence, IT)	The paper presents the implementation of the GUID (Gauzes UWB Identifier) system to control the path of gauzes and other medical instruments during surgical operations. The system allows tracking of these devices during the entire surgery, with particular reference to real-time localization of gauzes within the patient's body. A precise localization of gauzes, available to the surgeon, permits an easy removal of these devices, which are sometimes difficult to identify by visual perception. The final objectives are the improvement of the patient safety, of surgeon working procedures, and the reduction of stress conditions of the surgical staff. The GUID prototype is based on RFID Ultra Wide Band(UWB) technology and the experimental phases were carried out in laboratory using the tags both in air and in biological tissue. The results show the performance of a correct identification of the tags and the accuracy of the calculated position with respect to the real position of the tags

Privacy Protection for RFID-based Tracking Systems	Chiu Tan (College of William and Mary, US); Lei Xie (Nanjing University, CN); Qun Li (College of William and Mary, US)	RFID technology is increasingly being deployed in ubiquitous computing environments for object tracking and localization applications. Existing tracking architecture usually assumes the use of a trusted server which is invulnerable to compromise by internal and external adversaries. However, maintaining such a trusted server is unlikely in the real world. In this paper, we consider the problem of adding privacy protection to object tracking systems built upon passive RFID tags, without relying on a trusted server assumption. Our protocol continues to protect user privacy in the event of partial compromise of a server. The protocol utilizes lightweight cryptographic primitives suitable for RFID tags, and also provide good query performance.
The "Weak Spots" in Stacked UHF RFID Tags in NFC Applications	Xiaosheng Chen (HK R&D Centre for LSCM Enabling Technologies, HK); Feng Lu (HK R&D Centre for LSCM, HK); Terry Ye (Hong Kong R/D Center for Logistics and Supply Chain Management, HK)	In near-field (NF) applications, stacked UHF RFID tags are known to be less readable than the stand-alone tags. It is also intuitively known that "weak spots" exist when more tags are stacked together, especially when the tags are placed closer to each other. However, "weak spots" in NF-RFID had not been theoretically analyzed in the past, nor had the phenomena been quantitatively measured. In this paper, we show that the "weak spots" are mainly the results of mutual coupling between the tag antennas in NF, we also demonstrate that the profiles of the weak spots are strongly determined by the separation between tags, and they are not monotonically distributed along the stack, i.e., weakest spots are not necessarily on the far end or the center of the stack. To verify our analysis, EM tool simulation and lab measurements are conducted, the results from theoretical calculation, simulation and experiments agree with each other nicely.
Embedded Passive UHF RFID Seal Tag for Metallic Returnable Transit Items	Matti Ritamäki (Confidex Ltd., FI); Antti Ruhanen (Confidex Oy, FI)	In this paper the novel passive UHF RFID seal tag for metallic returnable transit items (RTI) is presented. The tag design exploits the metal structure of RTI. Enhanced security encoding based on MD5 hash and AES algorithm is also presented, which enables authentication without online network connection. Up to 9m theoretical read distance was obtained with 19mm x 20mm x 57mm size tag. 100% read rate was reached with the stack of ten RTI containers in a 3.5m wide RFID portal.
A Data Transmission Technique for Passive Sensor Transponders in Medicine	Andreas Hennig (Fraunhofer, DE); Gerd vom Bögel (Fraunhofer IMS, DE)	The use of sensor transponder technologies in medicine opens valuable possibilities in therapy of human cardiovascular system diseases, for example cardiac insufficiency. This application is representative for future applications of miniaturized passively powered sensor transponder systems. In the past, load modulation was developed as a simple technique to transmit data from cheap id-transponders to a reader. But for an application described here and future applications, this technique is suboptimal. Higher read ranges and at the same time smaller antenna dimensions are necessary. In consequence, new techniques have to be found. First of all, the limitations of load-modulation technique are analyzed. Then conventional solutions are discussed. It is shown that existing solutions could not be used for this application. A new data transmission technique called "frequency conversion" is presented. With this technique data transmission over the required distance is possible. Measurements in a practical implementation verifies the performance of this technique.

Survey of Range Improvement of Commercial RFID Tags With Power Optimized Waveforms	Matthew Trotter (Georgia Institute of Technology, US); Gregory Durgin (Georgia Tech, US)	The power sensitivity of passive Radio Frequency Identification (RFID) tags heavily affects the read reliability and range. Inventory tracking systems rely heavily on strong read reliability while animal tracking in large fields rely heavily on long read range. Power Optimized Waveforms (POWs) provide a solution to improving both read reliability and read range by increasing RFID tag RF to DC power conversion efficiency. This paper presents a survey of the increases and decreases to read range of common RFID tags from Alien and Impinj with Higgs, Higgs 2, Higgs 3, Monza 3, and Monza 4 RFICs. In addition, POWs are explained in detail with examples and methods of integration into a reader.
Very High Data Rate contactless air interface: an innovative solution for Card to Reader link	Florian Pebay Peyroula (CEA, FR); Jacques Reverdy (CEA, FR); Elisabeth Crochon (CEA, FR); Thierry Thomas (CEA, FR)	An innovative Very High Data Rate contactless interface for communication from card to reader is described herein. The aim of this interface is to provide up to 10 Mbit/s bitrates to fulfill requirements of tomorrow contactless applications. Such performances would enhance the transfer rate as well as the data amount by more than an order of magnitude. The innovation described in this article, is to extend the subcarrier concept legacy to a more generic pattern description. This concept allows to increase datarates without loosing spectral efficiency. This new breakthrough makes possible the VHDR systems to reach bitrates up to 6.8 Mbit/s with an improved reliability. This interface has been demonstrated with prototypes card and reader prototypes at 13.56 MHz.
Towards Design of Robust UHF RFID Tag	Chaabane Hamza (Grenoble-INP LCIS, FR); Etienne Perret (Grenoble-inp, FR); Smail Tedjini (Grenoble-inp, FR)	The paper presents a robust UHF tag for RFID application. The antenna design for the UHF tag is obtained from an automated antenna design tool developed to obtain original topologies in order to satisfy real environment RFID constraints. The approach is completely automatic and requires very little human interactions during the design process. The obtained prototype was measured and compared with the NXP FF95-8 inlay. The inlays were tagged in many disruptive elements to evaluate their sensitivity to the real RFID environment. The proposed inlay shows read range stability wherever used in free space or tagged on an object. It has a small size of 0.28□ by 0.02□ in the UHF frequency band. Regardless of the environment, the read range is relatively constant (variations from 5 m to 8 m are observed) on the whole worldwide RFID frequency bands 860-960 MHz.
RFID-Based Electronic Voting: What Could Possibly Go Wrong?	Yossef Oren (Tel Aviv University, IL); Avishai Wool (Tel Aviv University, IL)	When Israel's Ministry of Internal Affairs decided to move to electronic voting, it chose to replace the traditional paper ballot with secure contactless smartcards. The system was designed around HF RFID technology to make voting stations easier to use and less prone to mechanical faults. However, in doing so the system was exposed to a powerful class of hardware-based attacks called relay attacks, which can extend the interrogation range of HF RFID tags far beyond the nominal range of 5 centimetres. We show how a low-budget adversary armed with a relay device can read out all votes already cast into the ballot box, suppress the votes of one or several voters, rewrite votes at will and even completely disqualify all votes in a single voting station. Our attacks are easy to mount, very difficult to detect, and compromise both the confidentiality and the integrity of the election system.

Accurate Localization of RFID Tags Using Phase Difference	Cory Hekimian-Williams (Florida State University, US); Brandon Grant (Florida State University, US); Xiuwen Liu (Florida State University, US); Zhenghao Zhang (Florida State University, US); Piyush Kumar (Florida State University, US)	Due to their light weight, low power, and practically unlimited identification capacity, radio frequency identification (RFID) tags and associated devices offer distinctive advantages and are widely recognized for their promising potential in context-aware computing; by tagging objects with RFID tags, the environment can be sensed in a cost- and energy-efficient means. However, a prerequisite to fully realizing the potential is accurate localization of RFID tags, which will enable and enhance a wide range of applications. In this paper we show how to exploit the phase difference between two or more receiving antennas to compute accurate localization. Phase difference based localization has better accuracy, robustness and sensitivity when integrated with other measurements compared to the currently popular technique of localization using received signal strength. Using a software-defined radio setup, we show experimental results that support accurate localization of RFID tags and activity recognition based on phase difference.
Interactive Packaging Solutions Based on RFID Technology and Controlled Delamination Material	Jie Gao (Royal Institute of Technology (KTH), SE); Zhibo Pang (Royal Institute of Technology (KTH), SE); Qiang Chen (Royal Institute of Technology, SE); Li-Rong Zheng (Royal Institute of Technology (KTH), SE)	Interactive packaging is an emerging research area in recent years. It brings people convenient and smart lives, reduces consumption of traditional packaging materials and direct or indirect labor costs as well. Being integrated in interactive packaging, Radio Frequency Identification (RFID) technology becomes one of the most proactive development enablers. In this paper, an interactive and intelligent packaging solution integrating passive RFID system and Controlled Delamination Material (CDM) is given at first. Package opening action is electrically controlled by the RFID system. CDM was primarily used in aerospace applications in the past and the conductor/adhesive joint can be easily opened by applying a little electric power on to the material. Some related works will be shown about the electrochemical characteristics of CDM in order to facilitate the system design. A demonstration system was developed and the test results have proved feasibility of the solution and shown the potential of low cost for mass production. Based on this solution, an interactive medication package for pervasive healthcare is further developed, using EPCglobal Gen2 RFID technology. It will make the medication being accessible for patient only at the prescribed dose and time, and medication taking information will be delivered as well. Such medication package will not only give unprecedented high patient compliance, but also improve the communication between patients and healthcare staffs.
A High-Efficiency CMOS Rectifier for Low-Power RFID tags	Alireza Sharif Bakhtiar (University of British Columbia, CA); Mohammad Sadegh Jalali (University of British Columbia, CA); Shahriar Mirabbasi (University of British Columbia, CA)	In this paper a high efficiency CMOS rectifier for radio frequency identification (RFID) tags is presented. A driver is used to drive the gates of the transistors in a cross-coupled rectifier with proper DC level to facilitate the design with standard-threshold-voltage (standard-Vth) transistors. Two biasing schemes are also proposed. One scheme is for a self-sufficient rectifier and the other one for a rectifier that allows the adjustment of the power that the rectifier shows its maximum efficiency. The rectifier is designed in a standard 0.13µm CMOS process and its performance is confirmed through post-layout simulations.

UHF RFID Based Tracking of Logs in the Forest Industry	Janne Häkli (VTT, FI); Kaarle Jaakkola (VTT, FI); Pekka Pursula (VTT, FI); Miika Huusko (VTT, FI); Kaj Nummila (VTT, FI)	This paper describes a prototype of a UHF RFID based log marking and tracking system developed for the challenging four-season outdoor conditions in Scandinavia. The RFID system comprises of novel pulping compatible EPC Class 1 Generation 2 transponders, and of robust readers with novel performance boosting features. A wedge-shaped transponder is inserted into the log end with a special tool so that it is protected and held firmly in place by wood during the transportation and processing of timber. A robust EPC-compliant RFID reader featuring an adaptive RF front end was developed for use in a harvesting machine. Readability tests at saw mills with test logs using specially adapted commercial UHF readers show nearly a 100 % readability for the transponders inside fresh moist logs.
Improving the Near-Metal Performance of UHF RFID Tags	Daniel Deavours (University of Kansas, US)	It is well-known that UHF RFID tag performance degrades when placed near metal. While the mechanisms for how dipole performance degrades near metal is known, it is generally not known how the parameters of the T-match change in the presence of metal, and what, if anything, can be done to improve near-metal performance. In this paper, we develop a set of expressions that describe the affect of antenna parameters on the input reactance of the antenna near metal, and a set of design principles that can be used to minimize the near-metal impedance mismatch. We conclude by demonstrating these principles with a simple antenna model yields a 12.7 meter free-space read distance, and a read distance of 7 meters when separated by a 3.2 mm HDPE foam dielectric spacer from a large ground plane.
Optimum Power Transmission of Wireless Sensors Embedded in Concrete	Shan Jiang (Florida International University, US); Stavros Georgakopoulos (Florida International University, US)	We present the feasibility and optimization of wireless powering of sensors embedded in concrete that relies on a plane wave propagation model. Transmission loss and propagation loss of RF wave penetrating into concrete at different humidity conditions are calculated for various frequencies, thus an optimum frequency range is identified for the wireless power transmission and is validated through antenna coupling full-wave EM simulations. The effects of reinforced bars to the propagation of RF power are also analyzed.

Non-Thermal Effects of Radio Frequency Exposure on Biologic Pharmaceuticals for RFID Applications	Ismail Uysal (University of Florida, US); Price Dehay (University of Florida, US); Erdem Altunbas (University of Florida, US); Jean-Pierre Emond (University Florida, US); Scott Rasmussen (Abbott Laboratories, US); David Ulrich (Abbott Laboratories, US)	Radio frequency identification (RFID) has been an emerging technology over the past decade with applications ranging from simple supply chain utilizations to sensory monitoring of heat and humidity sensitive products during transportation. RFID has direct implications for the area of pharmaceutical distribution especially for temperature sensitive products where they are tagged and tracked in their shipping environment. Per FDA CPG Sec.400.210, Drugs, Radiofrequency Identification, the FDA has not allowed RFID technology to be used for drugs covered under a Biologics License Application or protein drugs covered by a New Drug Application since the potential impact of radio frequency (RF) radiation on biologics and proteins is not well documented. The intent of this study is to determine the non-thermal effects on the protein structures of biopharmaceuticals by constant exposure to radio frequency energy at different wavelengths using twice the equivalent isotropically radiated power (EIRP) allowed by FCC in the United States. As a contribution of this study, the test setup and protocol provide a fundamental and universally applicable methodology which combine the hardware to generate and radiate high power RF signals at different frequencies and a temperature controlled dark anechoic chamber where the temperature and light sensitive products can be exposed to RF radiation. Five different frequencies are used which account for the majority of commercially available RFID systems adopting high frequency (13.56 MHz) or ultra-high frequency (433 MHz, 868 MHz, 915 MHz, and 2.4 GHz) radio waves as well as active or passive tags for communication. Multiple products from different pharmaceutical companies falling under three major protein groups and their integrity after exposure to 8 Watts EIRP RF radiation for a full 24 hours are investigated. The results show that even at twice the EIRP as regulated by FCC, the effects of RF energy on the purity of all the tested biopharmaceutical proteins remain undetectable after purity and potency stability-indicating assays.
Analysis and Synthesis of UHF RFID Antennas using the Embedded T-match	Naaser Ahmed Mohammed (University of Kansas, US); Ken Demarest (University of Kansas, US); Daniel Deavours (University of Kansas, US)	The T-match structure is commonly used to match an RFID chip's reactive impedance to a dipole. Models that describe T-match are known, but they are neither sufficiently accurate to model antennas nor to synthesize the antenna geometry. Here, we present the embedded T-match circuit model which is amenable to accurate analysis and synthesis.
Platform-tolerant PIFA-type UHF RFID Tag Antenna	Jingtian Xi (Hong Kong R&D Center for Logistics and Supply Chain Management, HK); Hailong Zhu (HK R&D Centre for Logistics and Supply Chain Management Enabling Technologies, HK); Terry Ye (Hong Kong R/D Center for Logistics and Supply Chain Management, HK)	Platform-tolerant tag antennas are desired for ubiquitous RFID systems. Metal-mountable or wideband tag antennas can not guarantee platform-tolerance. This paper presents the design approaches of platform-tolerant tag antennas. A compact PIFA-type UHF tag antenna is proposed accordingly. Simulation and measurement results are provided to demonstrate the platform-tolerance feature of the proposed antenna and to validate the design approaches presented.

RFID Diagnostics of Promotion Execution	Patrick A Hacker (RWTH Aachen University, DE); Christian Floerkemeier (MIT, US); Sanjay Sarma (MIT Auto-ID Center, US); Guenther Schuh (Fraunhofer Institute for Production Technology IPT, DE)	Previous studies have shown that many consumer goods manufacturers believe that their promotions are not well executed in retail stores. One common concern is that in-store promotions are not synchronized with television and online advertising campaigns. In recent years, RFID has been actively promoted as a tool to improve in-store promotion execution. This paper presents the results of a study in which promotional displays were tagged with RFID tags and tracked as they moved from a retail distribution center to a number of different retail stores. The analysis shows that only 28% of all displays are placed on the shop floor within +/-3 days of the official promotion launch. Our analysis suggests that by adjusting the timing of the delivery to the store the performance could be improved such that 87% of all displays are present on the shop floor within this time frame. The results confirm that RFID is a useful diagnostics tool to measure promotion execution performance and to identify business process shortcomings. The results also suggest that a continuous measurement via RFID is not required to improve performance.
Low Power Analog Circuit Design for RFID Sensing Circuits	Chenglong Zhang (Southern Illinois University, US); Haibo Wang (Southern Illinois University Carbondale, US)	This paper presents low power circuit design for voltage regulator and resistor to digital converter that are used in a RFID-like sensing circuit for measuring the resistance of a sol-gel sensor. The regulator circuit has simple circuit structure and consumes zero DC current (except the current drained by its load). The resistor to digital converter consists of a cascoded current mirror, reference resistor, and a charge-redistribution (CR) ADC circuit. The proposed circuit techniques reduce the size of the ADC capacitor array by half compared to traditional CR ADCs with the same resolution. The proposed techniques also significantly reduce the circuit power consumption with enhanced measurement accuracy. The proposed circuits and a RFID energy harvesting circuit for powering the proposed circuits are implemented using a 0.13um CMOS technology. Circuit simulations are presented to examine the performance of the proposed circuits.
RFID Tag Antenna Based Sensing: Does your Beverage Glass need a Refill?	Rahul Bhattacharyya (Massachusetts Institute of Technology, US); Christian Floerkemeier (MIT, US); Sanjay Sarma (MIT Auto-ID Center, US)	Liquid level detection in customer beverage glasses and liquor bottles in the service industry is important for maintaining quality of service and good approval ratings. Current sensing approaches rely either on visual inspection or expensive sensor electronics to detect liquid levels. In this study, we investigate how the paradigm of RFID tag antenna based sensing can be used as a low-cost alternative in the service industry, to detect the volume of liquid in a beverage glass by mapping a change in RSSI power measurements from RFID tags to the level of liquid in the glass. We demonstrate that this sensing technique when deployed in a real restaurant-like setting can be used to accurately predict the state of the glass over 80% of the time, and thus has good potential as a low-cost sensing methodology for applications in the restaurant industry.
Carrier Suppression Locked Loop Mechanism for UHF RFID Readers	Deogracias P Villame (University of the Philippines, PH); Joel Joseph Jr. S. Marciano (University of the Philippines, PH)	The receiver of a UHF RFID reader is exposed to strong carrier leakage signals due to antenna reflections and limited isolation of circulators and directional couplers. This strong interference limits the performance of the reader as the active components in the receiver become saturated. In this paper, an improvement on the front-end architecture of UHF RFID readers is presented to address this problem. An automatically-adjusted canceling signal is combined with the received signal to suppress the strong carrier leakage. The experiment results show that the constructed prototype can achieve high isolation and that the canceling signal can be routinely configured even during reader operations.

Blocking Reader: Design and Implementation of a Low-Cost Passive UHF RFID Blocking Reader	Gaurov Narayanaswamy (University of Texas Arlington, US); Shesh Kumar Jagannatha (University of Texas Arlington, US); Daniel W Engels (Revere Security, US)	In this paper, we present the Blocking Reader, a low-cost privacy protection device that prevents unauthorized reading of tags. The promiscuous nature of the 18000-6C tags means that the readers also pose a threat to personal security and privacy. Privately owned tags on a person will be read by all nearby readers without that person's consent thereby violating that person's privacy. A low cost privacy protection device worn on a person's body can be used as a Blocking Reader that prevents these unauthorized tag reads, preserving your privacy. Our low-cost Blocking Reader has been implemented based upon the Chipcon CC1101 chip, and we have characterized its basic read performance. Using a monopole antenna, the low cost device can be utilized as a blocking reader that prevents unauthorized reads of tags within 1m of the reader. Furthermore, when worn on a person's body, the low-cost device effectively acts as a Blocking Reader preventing all nearby readers from reading tags located on or in close proximity to the body.
Chipless RFID SAW Sensor System-Level Simulator	John Pavlina (University of Central Florida, US); Donald Malocha (University of Central Florida, US)	Chipless RFID SAW technology has been identified as a possible solution for NASA's long term needs for ground, space-flight, and space-exploration sensor requirements. SAW has many unique advantages over possible competing technologies, which include the following properties: passive, radiation hard, operable over wide temperature ranges, small, rugged, inexpensive, and identifiable. The purpose of this paper is to define a system simulation environment for SAW sensors; not on any particular sensor. For remote sensing, it is beneficial to be able to simulate effectively the sensor environment prior to fabrication. This paper will use previously presented orthogonal frequency coded (OFC) sensor tags. The parameters of interest are the transmitter, channel characteristics, target, and the receiver output. The simulations utilize a SAW device coupling of modes (COM) model and combined with the RF system parameters. This provides an accurate simulation tool for the overall system when performing analysis on important parameters, such as signal to noise ratio (SNR), SAW coding type, and range effects. System performance of a multi-frequency SAW RFID sensor system utilizing multiple targets will be discussed.
QAM Backscatter for Passive UHF RFID Tags	Stewart Thomas (Duke University, US); Matthew Reynolds (Duke University, US)	Traditional passive UHF RFID tags employ either ASK or PSK backscatter modulation to communicate data from memory or sensors on the tag to a remotely-located reader. These simple modulation schemes transfer data at a rate of one bit per symbol period, which for an integrated CMOS tag IC requires an on-chip oscillator with a frequency at least equal to the bit rate. Motivated by the fact that most modern UHF RFID readers already employ I/Q demodulation of the backscattered signal to account for backscatter phase rotation as the tag moves with respect to the reader, we propose a QAM backscatter method using no on-chip inductors that is compatible with a single-chip CMOS tag implementation. With QAM backscatter, tags transmit more than one data bit per symbol period, permitting tag designers to employ a lower power on-chip oscillator operating at a frequency equal to the (lower) symbol rate while maintaining the same data throughput as ASK or PSK, or alternatively to send data at a higher rate for a given on-chip oscillator frequency. We present the fundamental design equations required for arbitrary QAM backscatter modulators and present simulated bit error rate (BER) and error vector magnitude (EVM) curves for the operation of an inductor-free 4-QAM and 8-QAM modulator centered at 915MHz and evaluated over the 860MHz-950MHz worldwide UHF band.

RFID Tag Antenna Based Temperature Sensing	Rahul Bhattacharyya (Massachusetts Institute of Technology, US); Christian Floerkemeier (MIT, US); Sanjay Sarma (MIT Auto-ID Center, US)	Temperature monitoring is important in a number of fields, particularly cold supply chain applications. Most commercial wireless temperature sensors consist of transceivers, memory and batteries to maintain a temperature time history but this is expensive and allows for limited sensor deployment. In this paper, we propose a low cost temperature sensor based on the paradigm of passive RFID tag antenna based sensing. A simple mechanical method to permanently induce changes in RFID tag power characteristics upon exposure to temperatures greater than a threshold is presented. Critical temperature threshold violations can then be detected by monitoring received backscatter signal strength at a reader. The feasibility of the proposed hypothesis is examined via theoretical and experimental means. It will be shown that this sensing paradigm has the potential to greatly increase the pervasiveness of temperature sensing nodes and improve supply chain visibility and performance.
New Methods to determine the Impedance of UHF RFID Chips	Rainer Kronberger, (Cologne University of Applied Sciences, DE)	This document proposes two new methods which allow the determination of the chip impedance of an UHF RFID chip in different ways. The first method which is similar to existing procedures requires a network analyzer but no additional signal source. The second method is based on the extremely narrow wake up threshold of an RFID chip and the power mismatch between chip and source. By using a set of different and known source impedances also different wake up power signals will result. This allows the accurate calculation of the chip impedance exactly at the wake up threshold. In the simplest form a low cost impedance measurement system could be realized with a standard RFID reader system and few external rf components.