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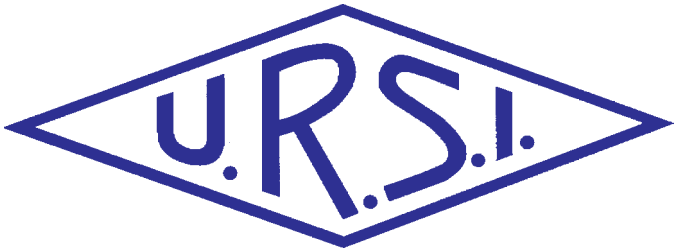

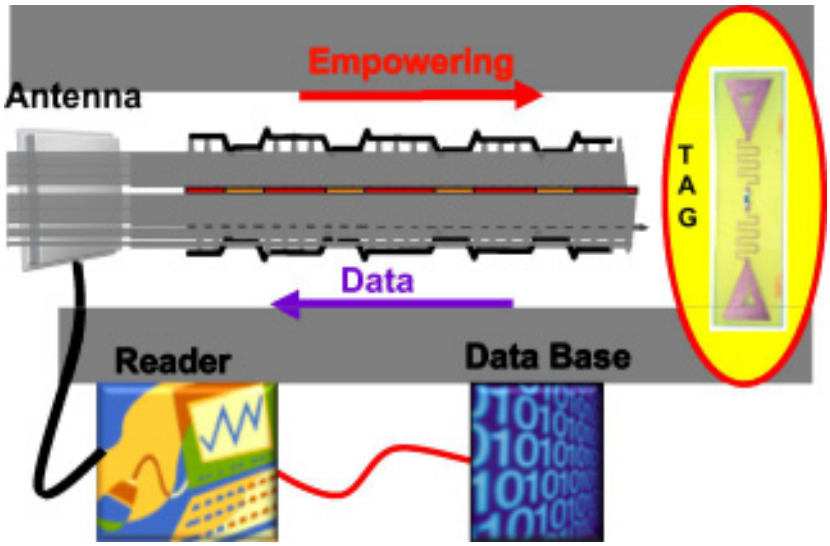

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Editorial

This issue has two *Reviews of Radio Science*, book reviews, a conference report, an In Memoriam for one of our colleagues, and some very important calls for papers.

Our Papers

RFID has become ubiquitous and pervasive: you find it everywhere, and the number and types of applications are growing at amazing rates. The Commission D *Review* by Smail Tedjini and Etienne Perret provides a fascinating, up-to-date look at the evolution and current status of RFID tag design, and related system considerations. The paper begins with a brief history of the organizations and standards that shaped the development of RFID. It then provides an overview of RFID systems: how they work, and how their main components interact. The focus of the paper is on RFID tags. These are described in considerable detail, including the major factors affecting their design and their performance. The chip that provides intelligence to an RFID tag is then reviewed. This includes consideration of the most modern ways of integrating the chip into the tag, and some of the design tradeoffs associated with various types of integration. The paper then describes "chipless" RFID systems. These function analogously to an optical barcode. There are several basic principles used to make chipless tags, and these are reviewed, along with their strengths and weaknesses. Various types of RFID readers are surveyed, followed by an overview of the many applications for RFID. The paper ends with a discussion of possible future trends in the field.

The efforts of Pierre-Noel Favennec and Phil Wilkinson in bringing us this paper are gratefully acknowledged.

There has been a tremendous amount of research devoted to the health effects of exposure to radio-frequency electromagnetic fields. Substantial numbers of such studies have produced results that are at least inconsistent, and sometimes contradictory. This underscores the need for a common approach and specifications for methods and systems for *in vitro* exposure to RF fields. Such specifications are the topic of the Commission K *Review* by G. A. Lovisolo, F. Apollonio, L. Ardoino, M. Liberti, V. Lopresto, C. Marino, A. Paffi, and R. Pinto. The paper begins with a brief history of the development of RF exposure guidelines and recommendations. The authors then review the main biological parameters relevant for RF *in vitro* exposure. This is followed by an extensive and insightful review of RF exposure systems. This includes descriptions of radiating structures, propagating structures, and resonant structures. The authors also discuss approaches that can be misleading. Based on the review, the paper identifies two priorities that must shape the key requirements for structures for *in vitro* exposure: the well-being of cells, and a clear knowledge of the electromagnetic dose delivered to the samples. The authors then carefully examine each of these requirements. The paper concludes that an optimum exposure system does not exist. However, the authors put forward recommendations for designing and developing such a system. Anyone who has any interest in studies or results related to RF exposure will find important information in this paper.

The efforts of Joe Wiart and Phil Wilkinson in bringing us this paper are much appreciated.

Important Calls for Papers and Authors

The URSI 2010 Asia-Pacific Radio Science Conference (AP-RASC'10) will be held September 22-26, 2010, in Toyama, Japan. A call for papers for this important URSI conference appears in this issue. Of particular significance are the Young Scientist Awards and the Student Paper Competition that are part of AP-RASC'10. Descriptions of these also appear in this issue. I urge you to carefully consider these opportunities, to participate, and to urge your colleagues and students to participate.

The Istituto Superiore Mario Boella of Torino, Italy, has joined with URSI and SciTech Publishing to create a new book series on "Electromagnetism in Information and Communication." George Uslenghi is the Series Editor. The series will be published to honor the memory of Mario Boella, URSI Vice President from 1966-1969. A call for authors appears in this issue. I urge you to consider it.

The *Radio Science Bulletin* is going to have a special issue on "Computational Electromagnetics for Modeling Large Finite Antenna Arrays." The Guest Editor for this issue is Jin-Fa Lee, and the deadline for submission is February 26, 2010. A call for papers appears in this issue. Please consider submitting a paper.

Our Other Contributions

It is with great sadness that I report that Ernest K. Smith (N6HQK, Silent Key) passed away on October 21,

2009, at Frasier Meadows, Colorado, USA, with his family present. Ernie was tremendously active in URSI, both internationally and in the US, and he made major contributions to modeling and understanding ionospheric propagation. He was a wonderful friend, and served as Associate Editor for the Propagation Corner in the *IEEE Antennas and Propagation Magazine* (and its predecessor *Newsletter*) for 25 years. An In Memoriam for him appears in this issue.

Kristian Schlegel has brought us reviews of two books in the field of radio science. I think you will find these quite interesting. If you know of other books that you think should be reviewed in the *Bulletin*, please contact Kristian via e-mail at KS-URSI@email.de.

We also have a report on the International Radar Conference, held in Bordeaux, France, in October. Finally, the December issue of the *Bulletin* always includes an up-to-date directory of URSI. You'll want to keep this issue handy so that you can refer to it throughout the year.

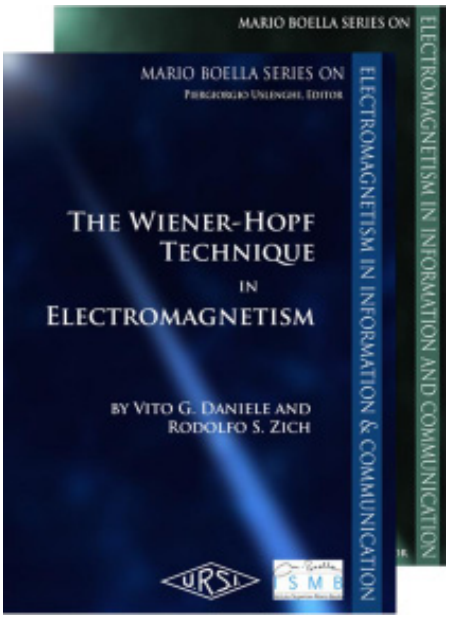
A New Year

The new year will be upon us about the time you receive this issue. I hope you'll consider submitting a paper to the *Bulletin* in 2010, and/or consider suggesting a topic for a special issue. I also wish you a most joyous holiday season, and a very happy, healthy, safe, and prosperous New Year!

Call for Authors

Mario Boella Series on Electromagnetism in Information and Communication
Piergiorgio L. E. Uslenghi, Series Editor

SciTech Publishing is proud to announce the initiation of a new book series in radio science. The series is sponsored by the Istituto Superiore Mario Boella (ISMB) of Torino, Italy, with a financial grant for each approved book going towards high-quality production and exceptionally reasonable prices. The series is scientifically cosponsored by the International Union of Radio Science (URSI).



This book series is devoted to applications of electromagnetism to all areas of radio science, with special emphasis on information and communication technologies. The series, consisting of both textbooks and in-depth subject monographs, is to honor the memory of Professor Boella, a Vice President of URSI from 1966 to 1969, who for half a century – beginning in 1929 – pioneered the development of electromagnetics, electronics, and telecommunications in Italy. The books will be in the general area of radio science and will include (but not be restricted to) topics that match the ten international commissions of URSI.

The series editor is Piergiorgio "George" L. E. Uslenghi of the University of Illinois at Chicago.

The Editorial Board includes Nader Engheta, University of Pennsylvania; Yahya Rahmat-Samii, University of California, Los Angeles; Werner Wiesbeck, Universität Karlsruhe; and Rodolfo S. Zich, Istituto Superiore Mario Boella, Politecnico di Torino.

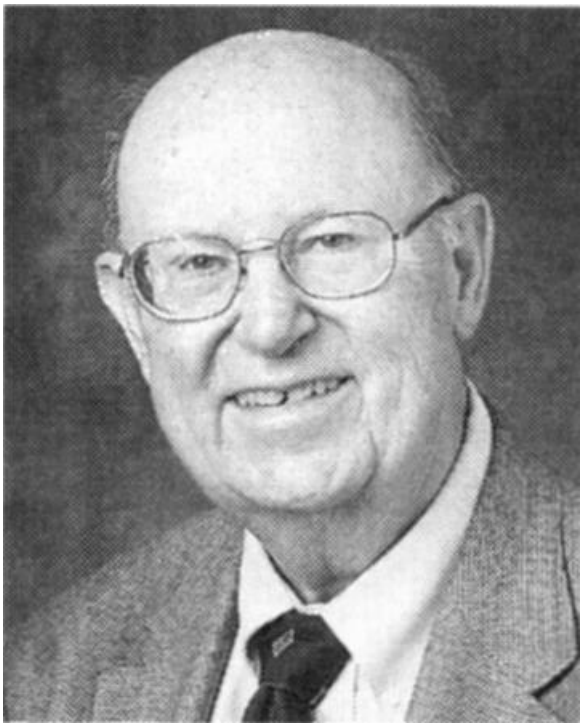
The initial titles in the series are *The Wiener-Hopf Technique in Electromagnetism* by Vito G. Daniele and Rodolfo S. Zich, and *Introduction to Wave Phenomena, Second Edition*, by Akira Hirose and Karl Lonngren.

Authors are encouraged to contact George Uslenghi (uslenghi@uic.edu) with your textbook or in-depth subject monograph ideas. For publishing information about the series, contact Dudley Kay, President of SciTech Publishing via e-mail: dkay@scitechpub.com.

IN MEMORIAM

Ernest Ketchum Smith
1922 - 2009

Ernie Smith was born in Beijing, China, of missionary parents. He lived there until 1940, when he moved to the United States to attend Swathmore College. After the Japanese invasion in 1937, and due to his interest in amateur radio, Ernie was recruited by Michael Lindsay (later, Lord Lindsay) to smuggle radio components out of Beijing to the Communist 8th Route army in the mountains west of the city. Coming to the United States in 1940, he graduated from Swarthmore in 1944 with a Bachelor of Arts in Physics. Drafted after graduation, he spent two years in the US Army's Ionosphere Utilization Unit. This was followed by three years with the Mutual Broadcasting System, where he became Chief, Plans and Allocations Engineer.



In 1949, he went to Cornell University for graduate work in ionospheric radio propagation. He received the Master of Science degree there in 1951. In 1952, Ernie joined the Central Radio Propagation Laboratory (CRPL) of the National Bureau of Standards (NBS) in Boulder. One of his contributions was the development of the Smith-Weintraub formula for the refractive index of the neutral atmosphere. In 1954, he returned to Cornell, and received the degree of Doctor of Philosophy (1956). Ernie was Prof. Henry G. Booker's first research student at Cornell, where Ernie worked on the "Worldwide Occurrence of Sporadic-E," published as NBS Circular 582, which has been a standard reference ever since.

On his return to NBS in 1956, he became successively Chief of CRPL's Ionospheric Research Section, Director of the Aeronomy Laboratory in the Environmental Science Services Administration (ESSA, the predecessor of the National Oceanic and Atmospheric Administration), and the first Director of the Institute for Telecommunication Sciences, then also in ESSA. In 1976, he retired from government service and joined the Jet Propulsion Laboratory (JPL). From 1976 through 1987 at JPL, he was manager of the NASA Earth-space propagation program. Thereafter, Ernie and his wife, Mary Lou, returned to Boulder, Colorado, where Ernie became a Professor Adjunct in the Department of Electrical and Computer Engineering at the University of Colorado, Boulder. Ernie continued work there on Earth-space propagation, under contract from JPL.

Ernie was active in international and US scientific and technical organizations. In particular, he was active in the Consultative Committee on International Radio (CCIR), a committee of the International Telecommunications Union (ITU), located in Geneva, Switzerland. Ernie received the Diplome d'Honneur from the ITU. He was also active in the International Union of Radio Science (URSI). He was instrumental in establishing the Booker Prize, which enables young meritorious scientists to attend the triennial URSI General Assemblies. He was a Fellow of the American Association for the Advancement of Science, and a Fellow of the Institute of Electrical and Electronic Engineers. He was a member of the University of Colorado Chapter of Sigma Xi, and of the American Geophysical Union. Ernie was particularly proud to be named to the Gallery of Distinguished Scientists, Engineers, and Administrators of the National Bureau of Standards in Gaithersburg, Maryland.

In addition to his technical activities, Ernie was active in numerous clubs and organizations, such as the United Nations Association, the Kiwanis and Torch Clubs, and in the Congregational Church. Ernie is survived by his wife of 59 years, Mary Lou Standish (a lineal descendent of Myles Standish), and by daughters Pricilla, Nancy (Nonny), and Cynthia (Cindy).

Ken Davies
E-mail: kendavies207@comcast.net

2010 Asia-Pacific Radio Science Conference

Toyama, Japan, 22 - 26 September 2010

Scope

The 2010 Asia-Pacific Radio Science Conference (AP-RASC'10) will be held at Toyama International Conference Center, Toyama, Japan on September 22-26, 2010. AP-RASC is the Asia-Pacific regional URSI conference held between the URSI General Assemblies. The objective of the AP-RASC is to review current research trends, present new discoveries, and make plans for future research and special projects in all areas of radio science, especially where international cooperation is desirable. A particular emphasis is placed on promoting various research activities in the Asia-Pacific area. AP-RASC was first held in Tokyo, Japan, in August 2001. It was subsequently held in Qingdao, China in August 2004. The AP-RASC'10 in Toyama, Japan will be the third AP-RASC.

Topics

Scientific sessions composed of oral and poster papers will be organized at AP-RASC'10 covering all scientific activities by URSI Commissions A-K.

Sponsorships

This Conference is sponsored by the International Union of Radio Science (URSI) and the Institute of Electronics, Information and Communication Engineers (IEICE), in cooperation with the Association for Promotion of Electrical, Electronic and Information Engineering; Science Council of Japan; the Institute of Electrical Engineers of Japan (IEEJ); Toyama City; Toyama Prefectural University; Toyama Prefecture; and the University of Toyama.

Location

Toyama Prefecture is located roughly equidistant from the three metropolitan centers of Japan: Tokyo, Osaka, and Nagoya. In addition to domestic flights from Tokyo and Sapporo, international service from major cities in the Japan Sea region, such as Seoul, Vladivostok, Dalian, and Shanghai, is also provided to reach Toyama: URL: http://www.pref.toyama.jp/ english/. The venue is the Toyama International Conference Center: URL: http://www.ticc.co.jp/english/

Important Dates

Abstract Submission Deadline: **March 31, 2010**
Acceptance Notification: May 31, 2010

All authors of both invited and contributed papers are requested to submit one-page abstracts in an electronic form via the conference Web site. The details on paper submission are available at the following Web site: http://www.ap-rasc10.jp/.

Young Scientist Programs

As in the URSI General Assemblies, the following two programs are planned for young scientists:

- Student Paper Competition (SPC)
- Young Scientist Award (YSA)

For details on the programs and application guidelines, please visit the conference Web site, http://www.ap-rasc10.jp/, or see the announcements in this issue.

Special Issue

An AP-RASC'10 special issue is planned to be published in *Radio Science* in 2011. Paper submission is subject to invitation by the Guest Editor, Professor K. Kobayashi, AP-RASC'10 Conference Chair, Chuo University, Tokyo, Japan.

Information

Conference Secretariat
AP-RASC'10 Secretariat
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3-1 Nemoto, Matsudo, Chiba 271-0077, Japan
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Web site: **http://www.ap-rasc10.jp/**

2010 Asia-Pacific Radio Science Conference Student Paper Competition

Any full-time university student from any country who is the principal (first-named) author and the presenter of a paper (oral or poster) at the 2010 Asia-Pacific Radio Science Conference (AP-RASC'10) can apply for the Student Paper Competition (SPC). AP-RASC'10 will be held at the Toyama International Conference Center, Toyama, Japan, September 22-26, 2010. Applications should be completed electronically on the AP-RASC'10 conference Web site at http://www.ap-rasc10.jp/ by the deadline of **March 31, 2010**. Every SPC applicant must submit his/her one-page abstract; full-length paper (10 pages); and a certification letter by his/her advisor; all in PDF format simultaneously via the paper submission Web page. The certification letter needs to be provided on the university letterhead and signed by the student's advisor. It must state that the author is a full-time university student for the PhD degree or a higher degree. In the case of multiple authors, the letter must state that the role of the authors other than the applicant was primarily advisory in nature. No other students are allowed as coauthors. In the preparation of full-length papers, the applicants should follow the instructions given on the conference Web site.

Applications will be peer-reviewed by the AP-RASC'10 SPC Committee, and five finalists will be selected when the review process has been completed. All applicants will be notified of the review results by e-mail on May 31, 2010. The five finalists must confirm that they will attend the conference. These finalists will receive free registration, a free banquet ticket, and free accommodation covering the full conference duration. Basic accommodation will be provided by the AP-RASC'10 organizers. The SPC finalists may arrange alternative accommodation, but such arrangements are entirely at their own expense. For the finalists traveling from outside Japan, financial support at a maximum of 1,000 Euro (in cash) will be provided to each of them upon his/her arrival at the conference site.

All the five finalists must check into the hotel on September 21, 2010, and present their contributions orally in the SPC Special Session (open to all AP-RASC'10 participants), scheduled in the afternoon of September 22, 2010. They also have to present their papers in regular sessions (oral or poster). It is required that the finalists attend the official conference Banquet on September 24, 2010, where the winners will be announced. At the SPC Special Session on September 22, 2010, members of the AP-RASC'10 SPC Committee will judge presentations by the five finalists, and select the three winners (first, second, and third prizes). The three winners will receive the following prizes at the conference Banquet on September 24, 2010:

- First prize: a certificate and 1,000 Euro (in cash)
- Second prize: a certificate and 750 Euro (in cash)
- Third prize: a certificate and 500 Euro (in cash)

In addition, the two non-winning finalists will each receive a certificate identifying him/her as a finalist. The SPC results will also be announced on the AP-RASC'10 Web site (http://www.ap-rasc10.jp/) and the URSI Web site (http://www.ursi.org) at the end of September 2010.

For any inquiries, please contact: Professor Kazuya Kobayashi, AP-RASC'10 Conference Chair, President, Japan National Committee of URSI, Chuo University 1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan; Fax: +81-3-3817-1847; Tel: +81-3-3817-1869; E-mail: kazuya@tamacc.chuo-u.ac.jp; or the AP-RASC'10 Secretariat c/o Dupler Corp., 3-1 Nemoto, Matsudo, Chiba 271-0077, Japan; Fax: +81-47-308-5272; Tel: +81-47-361-6030; E-mail: secretariat@ap-rasc10.jp.

2010 Asia-Pacific Radio Science Conference Young Scientist Awards

A limited number of awards are available to assist young scientists from both developed and developing countries to attend the 2010 Asia-Pacific Radio Science Conference. AP-RASC'10 will be held at the Toyama International Conference Center, Toyama, Japan, September 22-26, 2010. To qualify for the Young Scientist Award (YSA), the applicant

1. Must be under 35 years of age on October 1, 2010;

2. Should have a paper, of which he/she is the principal author, submitted and accepted for oral or poster presentation at a regular session of AP-RASC'10. Applicants should also be interested in promoting contacts between developed and developing countries. Applicants from all over the world, including regions that do not (yet) belong to URSI, are welcome.

Applications should be completed electronically on the AP-RASC'10 conference Web site at http://www.ap-rasc10.jp/ by the deadline of **March 31, 2010**. Every YSA applicant must submit his/her one-page abstract; full-length paper (four pages); CV; and list of publications, all in PDF format, simultaneously via the paper submission Web page. In the preparation of full-length papers, the applicants should follow the instructions given on the conference Web site.

Successful applicants will receive free registration, a free banquet ticket, and free accommodation covering the full conference duration. Basic accommodation will be provided by the AP-RASC'10 organizers. The YSA awardees may arrange alternative accommodation, but such arrangements are entirely at their own expense. Limited funds will also be available as contributions to travel costs of young scientists from developing countries.

Applications will be peer-reviewed by the AP-RASC'10 YSA Committee. All applicants will be notified of the results of the review process by e-mail on May 31, 2010. Successful applicants must confirm that they will attend the conference. It is also required that all the successful applicants attend the conference Banquet on September 24, 2010, where they will each receive a certificate. Awards will also be announced on the AP-RASC'10 Web site (http://www.ap-rasc10.jp/) and on the URSI Web site (http://www.ursi.org) at the beginning of June 2010.

For any inquiries, please contact: Professor Kazuya Kobayashi, AP-RASC'10 Conference Chair, President, Japan National Committee of URSI, Chuo University 1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, Japan; Fax: +81-3-3817-1847; Tel: +81-3-3817-1869; E-mail: kazuya@tamacc.chuo-u.ac.jp; or the AP-RASC'10 Secretariat c/o Dupler Corp., 3-1 Nemoto, Matsudo, Chiba 271-0077, Japan; Fax: +81-47-308-5272; Tel: +81-47-361-6030; E-mail: secretariat@ap-rasc10.jp.

Radio-Frequency Identification Systems and Advances in Tag Design

S. Tedjini
E. Perret

Abstract

Radio-frequency identification (RFID) is one of the most enabling technologies that continues to be considered in numerous applications. It is basically a wireless system exploiting the principle of communication by reflected waves. This paper reviews the principle of RFID systems, and discusses the main characteristics. Since the tag is the most constrained device in RFID – since it is usually does not have a battery, and is quite versatile and low cost – the paper reviews different tag designs, as well as some advanced results and proposals.

1. Introduction

The history of radio-frequency identification's (RFID's) birth and development has been described in numerous publications [1-4, 13]. It is generally said that the principle of RFID communication was presented by H. Stockman in 1948 [5], and the first application was the identify friend or foe (IFF) system [4] introduced and developed by Watson-Watt. The IFF system consisted of a transmitter embedded on each aircraft. When it received signals from ground radar stations, it began broadcasting a signal back that identified the aircraft. This signal was due to the reflection of the plane, and depended on its size and shape. RFID works on the same principle. A signal is sent to a transponder, which wakes up and either reflects back a signal (passive system), or broadcasts a specific identification signal (active system).

Advances in RF communication systems and radar continued through the 1950s and 1960s. Researchers and engineers worldwide presented many papers explaining how RF energy could be used to remotely identify objects. R. F. Harrington developed the electromagnetic theory related to the RFID application [6, 7]. Commercial activities exploiting RFID also began during the 1960s. Electronic article surveillance (EAS) was really the first commercial application. This was a "one-bit" tag, since only the presence or the absence of a tag could be detected [1]. In the 1970s, and under the impulse of microelectronic technology, companies, universities, and government laboratories were actively engaged in the development of practical applications of RFID. Thousands of applications can be found in the literature [8], among them animal tracking, toll roads, vehicle identification, factory automation, access control, identity papers, and logistics. Even if the interest was different between Europe and the US, the 1980s was the decade for mass deployment of RFID technology. The interest in the US was mainly for transportation and access control. In Europe, the greatest interests were for animal tagging, industrial applications, and toll roads. Since the 1990s, many technological developments have dramatically expanded the functionality of RFID. Advances in microelectronics, embedded software, and RF/ microwave-circuit integration are opening the doors to new RFID applications.

UHF RFID got a boost with the founding of the Auto-ID Center at the Massachusetts Institute of Technology [3]. Professors at MIT developed research on the possibility of low-cost RFID tags that could be attached to all items, in order to track them through the supply chain [9]. The idea is to use a single serial number, stored on the microchip, for each tagged item. Data associated with the serial number on the tag would be stored in a database, which would usually be accessible over the Internet. These developments turned RFID into a networking technology, by linking objects to the Internet via the tag. This was a huge evolution of RFID technology, and a significant enlargement in terms of possible applications. The Internet of Things (IOF) is an interesting example of these new applications [10].

Smail Tedjini and Etienne Perret are with Grenoble-inp/ LCIS, ESISAR, 50 rue de Laffemas, BP 54, 26902 Valence France; E-mail: Smail.tedjini@grenoble-inp.fr; Etienne.perret@grenoble-inp.fr.

This is one of the invited *Reviews of Radio Science* from Commission D.

Standards are very critical for many applications in order to ensure the interoperability of RFID systems, such as payment systems, ID documents, and tracking items in an open supply chain. During the last decade, many international standards have been defined under the supervision of the International Organization for Standardization (ISO). For example, they include ISO11784 (how data is structured on the tag) and ISO11785 (air interface protocol). The ISO has created a standard for the air-interface protocol for RFID tags used in payment systems, contact-less smart cards (ISO14443), and in vicinity cards (ISO15693); standards for testing the conformity of RFID tags and readers (ISO18047); and for testing the performance of RFID tags and readers (ISO18046) [11, 12, 13].

Due to its large domain of application – especially in everyday life – privacy and data security are topics of great impact, both for the technological side and societal interrogation. The security of RFID communications appeared very early with the aircraft IFF application: security breaches resulted in allied planes being shot down [40]. Basically, RFID is a wireless communication. Anyone can easily get unauthorized access to RFID data because they do not need line-of-sight, and communications must usually obey a given standard. Nowadays, many techniques have been developed in order to improve data security and ensure privacy. These include software and hardware protection, such as on-tag cryptography; communication techniques; denial of service; and physical protection [40].

2. RFID System Architecture

Any RFID system is composed of three main elements, as depicted in Figure 1. The most important element is the tag or transponder, which contains the information, or at least a part of it. The second element is the reader or the interrogator and its antenna. The latter can be integrated into the reader, or can be separated from the reader. The RFID reader emits a radio signal at a fixed frequency, which is used to power up the tag, and communicates with it using the backscattering technique. The third element is usually the database for the application, which can be of varying sizes and sophistication, depending on the processed data and security constraints. In some specific applications, the database is integrated into the reader. Due to RF signal properties, the reader is able to communicate through a large variety of material and obstacles, including conductors, but under restricted configurations in term of positioning. This reading ability over a wide range of propagation conditions differentiates RFID from optical barcode, and thus explains the huge interest for many applications.

RFID is fundamentally wireless communication, using radio waves of the electromagnetic spectrum. It operates in the unlicensed part of the spectrum known as ISM (industrial, scientific, and medical). The frequency, power limitations, communication protocols, and standards can vary for different regions in the world. This is particularly true for RFID in the UHF band. The operating frequencies are grouped in different bands. The data rates and reading ranges are quite different from one band to another. Table 1 summarizes the RFID bands and some of their practical characteristics.

RFID is a very specific technology that obeys a number of standards and regulations. There are many other wireless technologies, such as ZigBee, Bluetooh, Wi-Fi, and, more recently, UWB. These technologies are designed for very different uses and therefore have different functionalities; however, there is shared ground among all. Applications based on "mixing" these technologies are being developed in many labs. Among them, the real-time locating systems (RTLS) [14] and the Internet of Things (IOF) [10] are exploiting RFID properties.

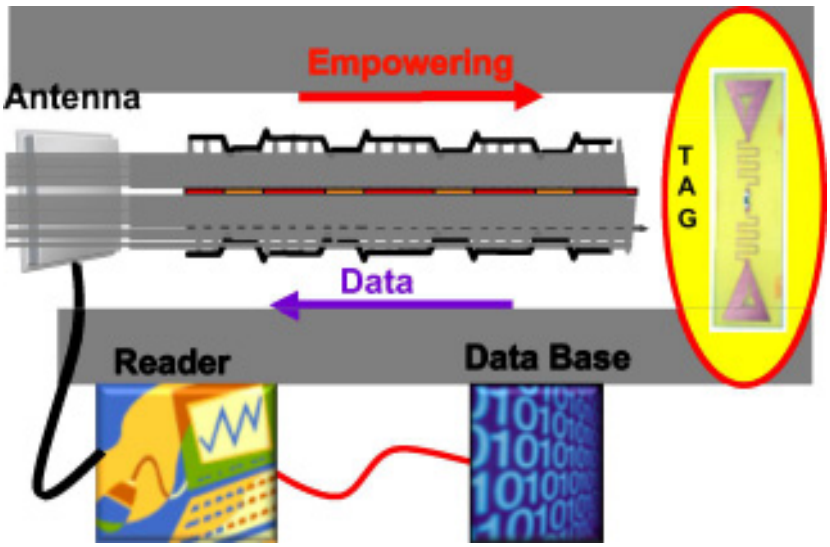

Figure 1. The elements of RFID systems

	LF	HF	UHF	Microwave
Band	125 kHz, 134 kHz	13.56 MHz	433 MHz, 865 MHz, 956 MHz	2.45 GHz, 5.8 GHz
Typical reading range	30 cm	1 m	<10 m passive tags, up to 100 m active tags	Up to 10 m
Typical data rate	<1 kbps	Tens of kbps	10 - 100 kbps	100 kbps
Main characteristics	Short range, low data, penetrates metal	Good range, good rate, penetrates water	Very good range, high rate, can't penetrate water or metal	Very good range, high rate, can't penetrate water or metal
Applications	Animal ID, car	Smart label, contactless card, access control, security	Tracking, logistics, automation	Moving objects

Table 1: RFID bands and their main characteristics

3. RFID Tags

The tag is certainly the most important element in any RFID system. Even if the overall performance of the application depends on the characteristics of each component, the performance of the tag is the limiting parameter. Most of the constraints are applied to the tag. This leads to a large variety of tag architectures, with quite different physical shapes and electrical configurations. In all cases, the tag is mainly composed of two elements: the antenna, which ensures the wireless communication, and a device that memorizes the information. The latter can be an integrated circuti (IC), but certain configurations without an IC are known as chip-less tags. They roughly operate like optical barcode, but do not require line-of-sight communication, and thus can be interrogated over obstacles. The other distinctive parameter is the manufacturing technology. In order to meet the low-cost requirement, organic printed electronics, based on thin-film-transistor circuits (TFTC), are being considered. Much progress have been made, and all-printed HF tags have been recently demonstrated [16, 22]. A possible classification of the different tag families is given in Figure 2.

The most available tags are the passive HF and UHF configurations. Many manufacturers exist worldwide, and can be found elsewhere [3].

Passive, low-cost tags are of great interest in numerous applications. Considerable advances have been made in the design of these tags, but there is still very active worldwide research and development, in order to improve the performance, lower the cost, and implement new applications. We should make a distinction between LF, HF, and UHF tags. Indeed, for LF and HF tags and readers, the metallic strap that is the interface between the integrated circuit and the reader strictly speaking is not an antenna, but a coil. The physical principle of data transfer is not based on propagating electromagnetic waves, as in UHF, but on the variation of the quasistatic magnetic or electric field. The

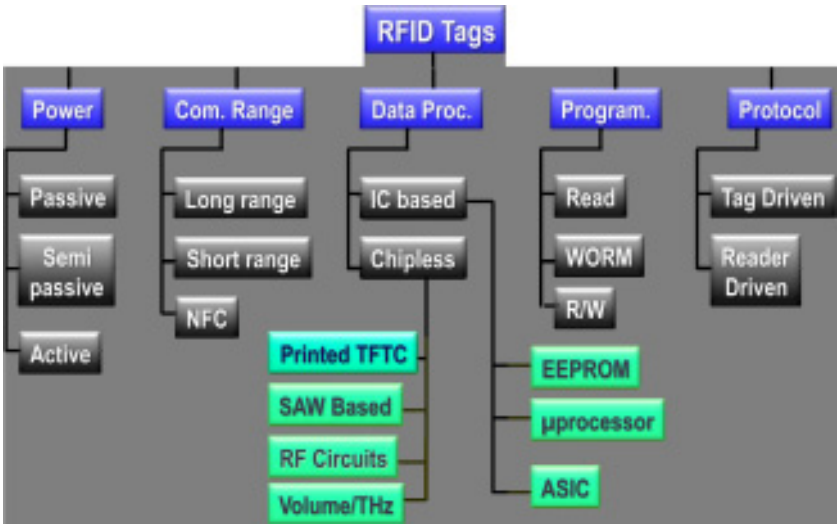

Figure 2. RFID tag classification.

objective is to maximize the coupling (inductive or capacitive) between the transponder and the reader. As inductive coupling represents the physical operation of the majority of HF tags, coils are often used as an antenna for both the transponder and the reader. The coil is modeled by an equivalent *RLC* circuit, and the electrical characteristics of the chip are supplied by the manufacturer. For coil design, the transition from geometrical to electrical parameters is obtained thanks to analytical formulas [2]. An optimization step, using an electromagnetic simulator, should complete the design phase. HF RFID is a robust technology, which greatly facilitates its full-scale deployment. It has been mature for several years: the advantages and limitations in terms of applications are actually well established.

The design of UHF tags is more complex and time consuming because there are no realistic analytical formulas linking the geometric parameters to the electric model. Moreover, one can notice that RFID UHF frequencies are not the same worldwide, which adds complexity, since interoperability is needed. The antenna design is thus the most decisive part, and may be considered the heart of a UHF RFID system. The antenna has to recover enough energy to power up the chip, and at the same time, it must backscatter enough energy towards the reader. It is thus necessary to optimize the power transferred from the antenna to the chip so that some power is re-radiated from the antenna to the reader. In practice, it should be noted that given the sensitivity of readers compared to tags, the power arriving at the tag is the important parameter. Since the reader is powered, unlike the tag, the reader will always be able to collect information if the tag receives sufficient power. The general design approach of UHF RFID antennas is entirely based on this principle. However, in some specific cases, the reader just receiving the backscattered waves from the tag is not a sufficient condition for proper operation. Indeed, the two encoding states (0 and 1 at baseband) must be distinguished by the reader. To do this in practice, the measurement of the differential radar cross section (or Delta RCS), i.e., the difference of the radar cross section for each state, should be done to get the information on the robustness of the communication [23, 24].

Considering the design phase of the transponder, the antenna design necessarily comes after the choice of the chip. For the RFID UHF antenna designer, the chip specifications may be summarized in two parameters: the impedance (Z_{IC}), and the minimum operating power of the chip (P_{ICmin}). We must also take into account the size of the chip, as well as the assembly process. Indeed, parasitic elements – which can be modeled by capacitance, C_{as}, and resistance, R_{as} – are associated with each assembly/packaging process. The chip impedance has to be modified to include the parasitic elements. Additional losses of around 1 dB could affect the minimum operating power. It can be seen that the problem is actually more complex than it seems to be. Indeed, the data transfer is based on the change of either the amplitude or phase of the re-radiated signal. This depends on whether the real or reactive part of the impedance changes. It results in the existence of two chip impedances, given as Z_{IC0} and Z_{IC1}. These impedances are functions not only of the frequency, but also of the power supply to the chip.

Unlike the frequency dependence of Z_{IC0}, chip suppliers do not provide information on Z_{IC1}. Indeed, the integrated circuit front-end impedance is depicted as a serial equivalent circuit, with a capacity (C_{IC}) and a resistance (R_{IC}). It is important to note that not having any information on the second state of the chip, Z_{IC1}, will limit the design. The tag's performance is characterized by two parameters: P_{min} and ΔRCS. However, only the optimization of the activation power, P_{ICmin} can be obtained by simulation. Very little information is available regarding the power-dependent impedance. The impedance values are therefore given for a specific power: generally, the minimum operating power. Furthermore, all these parameters are relatively difficult to measure, and generally vary according to the communications protocol, i.e., the type of query sent to the chip (writing, reading mode).

Besides chip specifications, materials used in the realization of the antenna are also vital inputs for designing an antenna. In most applications, the choice is governed by the cost of the material. In the case of passive tags, standard manufacturing processes are used, and very-low-cost dielectrics are preferred (essentially, very thin plastic material of polyethylene terephthalate (PET)). For the same reason, aluminum is often preferred over copper. Obviously, this choice is based on cost, and not on the electromagnetic characteristics that affect the performance of the tag. Moreover, the field of RFID applications is wide, and it is clear that tags can be applied to many kinds of object, with different shapes and materials. For cost reasons, the label antenna should thus mostly be used in the largest possible number of environments: different objects to track, different tag densities, tags made to work on plane or slightly curved media, etc. [17, 18].

Operating Frequency	**Minimum Operating Power Supply (P_{ICmin})**	**Input Impedance (*Z*)**	**Input Parallel Capacitance (C_{IC})/ Resistance (R_{IC})**	**Parallel Assembly Capacitance (C_{as})**
840-960 MHz	−15 dBm up to −18 dBm	$24 - j195$	890 fF/1.7 kΩ	~ 100 fF

Table 2: Typical input parameters for antenna design

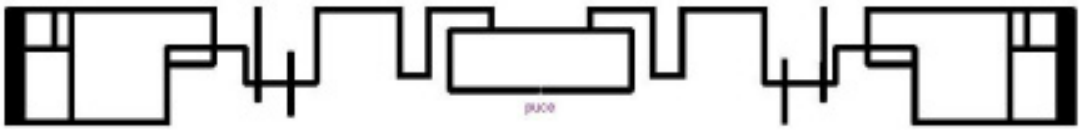

Figure 3. An example of automatic tag design using a genetic algorithm. One can notice the generation of a loop connected to the RFID chip for matching purposes.

There are several tag dimensions that are more or less "standard" (9×1 cm^2, 9×3 cm^2, 7×7 cm^2). However, compared to the UHF wavelength (31 cm at 960 MHz), these dimensions are quite small, and designers of RFID antennas must implement efficient miniaturization techniques [19]. RFID UHF antennas are mainly planar dipole antennas, in order to have omnidirectional space coverage. The most popular method of miniaturization is to simply to fold the arms of the dipole in order to get the desired template, as well as good EM features. As the material of the item to which the tag will be applied is not known, traditional antenna-design approaches cannot be directly applied. Indeed, designers are supposed to realize an antenna without knowing the direct environment of the tag. Moreover, these different materials directly impact the performance of the label. The solution is to try to design tags that are robust to their environment, as much as possible. However, most of the time these "universal" tags are optimized in open space (taking into account the dielectric slab), with the idea of maximizing the operating bandwidth of the transponder. Afterwards, the effects of substrates can be investigated by applying tags to various dielectrics. The impact of the direct environment on the label can be evaluated by using a set of reference materials. This design-approach principle is based on the fact that the presence of a dielectric in the vicinity of an antenna tends to shift down the operating frequency. Thus, the more the frequency range is in free space, the better will be the tag's performance in the practically disturbed environments.

All the constraints mentioned above are very important compared to the degree of freedom, so compromises are to be made. We can notice that miniaturization constraints imply a reduction in the antenna's bandwidth, and therefore limit the scope of the tags. This is why the antenna design is one of the most critical aspects in passive UHF systems. We are not arguing that this exercise is impractical. However, it can be said that this fact contributes to the lack of reliability of the UHF technology, and is sometimes observed in practice. This also explains why the design of UHF RFID antennas remains largely empirical, and requires much expertise.

Typical parameters for antenna design are given Table 2. These parameters are the operating frequency; the minimum operating power of the chip, P_{ICmin}; the IC's input impedance and its equivalent-circuit parameter values (C_{IC}, R_{IC}); and the IC's parallel parasitic capacitance. P_{ICmin} can be sued to evaluate the performance of the tags. The goal is to design an antenna able to power the chip over the largest frequency range. EM simulators must therefore be used. The structures under consideration are mostly planar, so commercial two-and-one-half-dimensional EM simulators are often used. The next question concerns the design approach that should be adopted to achieve the antenna's specifications. To start with, the design approach is rather based on the knowledge and experience of the designer. Such an approach can be described in two distinct steps. The first step is to resize a loop around the IC to compensate for its capacitive part. The system loop and chip will resonate around the desired UHF frequency, the same as for the HF tag design. The other advantage of the loop is that it will facilitate near-field communication. Indeed, in practice, readers that are used to write the tags are most of the time positioned in the near field of the antenna. This method presents the greater advantage of preventing cross-reading. The second step consists of adding metal strips, such as dipoles, to the loop. The radiating element could be either physically connected to the loop, or positioned near the loop, in order to achieve EM coupling. The coupling between the loop and the radiating element is crucial. Indeed, the space between the two arms (conducted coupling) and the space between the radiating element and the loop (inductive coupling) are key parameters that have a direct

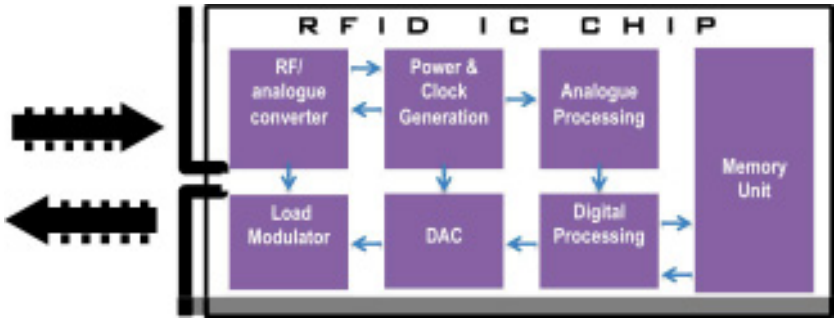

Figure4. An example block diagram of an RFID chip.

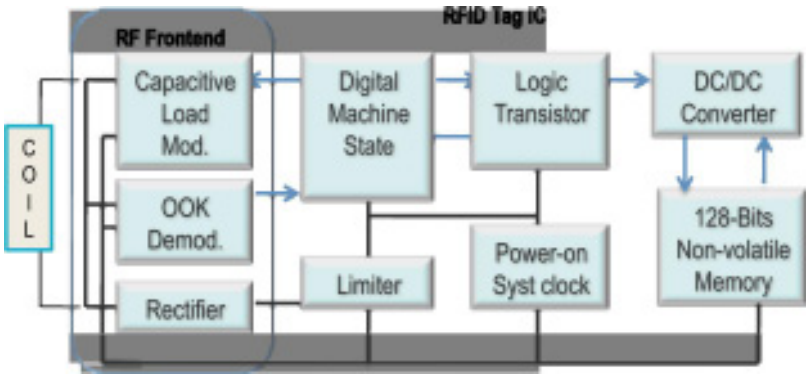

Figure 5. A block diagram of the fully integrated tag on-chip integrated antenna (OCA)

impact on the performance of the label. While the total length of the radiating element has an impact on the resonant frequency, this specific spacing can affect the bandwidth of the label's antenna. To reduce the tag's dimensions, the metallic strips can be folded back in a serpentine manner, resulting in meander lines or original shapes. To improve the bandwidth, rounded shapes rather than right angles are preferred. Finally, the antenna topology obtained is validated and optimized.

An innovative design approach, taking into account a complex environment during the design phase, has been developed. Original topologies of antennas are generated automatically, and selected according to the imposed constraints. Our approach is thus based on the advantages of combining the EM software and optimization processes. We use an optimization process based on the concept of genetic algorithms (GAs) to satisfy the constraints set during the design process. The optimization consists of an iterative process that first generates the antenna's shape, then simulates it, and finally evaluates its performance according to the imposed constraints. The antenna's shape thus changes during iteration based on an evolutionary principle. This is repeated until an antenna design that satisfies the project's specification (as well as possible) is obtained [18]. An example of a design is given in Figure 3.

4. RFID Chip

RFID tags are composed of an IC chip that memorizes the information. For passive tags, the IC chip has no battery, and it generates the needed power for biasing from the interrogation signal sent by the reader. This ability to harvest "ambient energy" is very specific to RFID. The IC chip thus has many functions, all integrated into the same circuit. A typical block diagram of the RFID chip is given in Figure 4.

Any RFID chip has an RF front end that has the function of receiving and transmitting (in fact, reflecting) the power emitted by the reader. In the receiving mode, the IC circuit must be matched to the antenna in order to collect enough power. To the contrary, in the transmitting mode, the load-modulation technique is used in order to generate two different levels of reflection, corresponding to the two signal states, for digital communication. The digital section is composed of a processing unit (state machine) and a memory unit. The memory can be electrically erasable and programmable read-only memory (EEPROM), static random-access memory (SRAM), or ferroelectric random-access memory (FRAM). The EEPROM is used in numerous applications, due to its low cost of manufacturing and large number of reprogramming cycles. Typical programmable memory sizes are from 96 to 2048 bits. Compared to EERPROM, FRAM chips show low reading power consumption and lower writing times. However, their manufacturing is more difficult [15]. More-complex tags are composed of a microprocessor-based chip. They are able to process more-sophisticated functions, such as authentication, as is necessary in smart-card applications. On the other hand, it is expected that transponders with sensors (temperature, vibration, pressure) and processing capabilities will be developed in the near future [20].

In order to lower the cost of IC-based tags, there are developments aimed to integrate the antenna and the chip, and to develop a technology that is able to realize the IC chip and the antenna in the same technological process. This will avoid the expensive process of a connection between the antenna and the RFID chip, as is the case for common tags. One way is to integrate the antenna on the top of the IC chip. In [21], a fully integrated tag, called OCA (on-chip integrated antenna), was presented. A passive-tag chip with 128-bit nonvolatile memory was realized using 0.13µm CMOS technology, and operating at 2.45 GHz, in the near-field regime. A block diagram of the IC section is shown Figure 5. The antenna was fabricated on the top of the chip using post-processing technology. It was a coil, fabricated on a thick, undoped silicon-glass (USG) layer, and connected with the underlying circuits through vias etched in the undoped silicon-glass layer. The integrated tag was smaller than $0.5\ mm^2$, with a thickness of 0.1 mm. With the reader generating an output power of 0.5 W, the RFID system was able to perform RF read/write 100-kbps bi-directional communication at a distance of 0.5 mm.

Another way to meet the challenge of cost reduction is to use one of the most-promising alternatives to silicon, i.e., printed organic electronics. Many advances have been

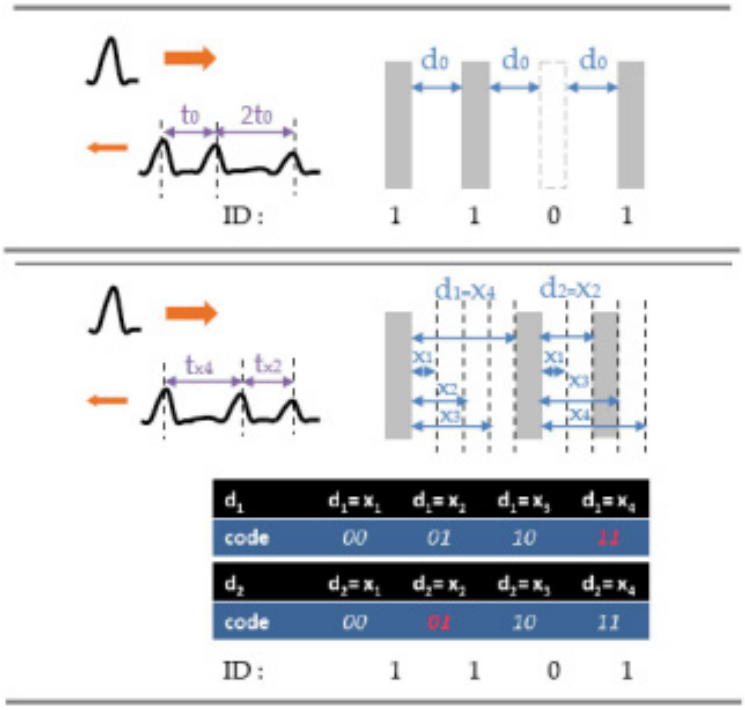

Figure 6. The interrogation pulse and reflected waves. An example of different ways to encode data using: (a) the presence or absence of a specific reflector, (b) the position between reflectors. In both cases, the data encoded correspond to the same ID: 1101.

accomplished over the past few years, and key electronic components have been developed, such as transistors and diodes. In [16], a multi-bit RFID transponder, based on polymer electronics, was presented. A four-bit organic CMOS chip was demonstrated, as well communication with the reader. In [22], there was another demonstration of an all-printed 13.56 MHz one-bit RFID tag. These recent developments are seen as important steps towards achieving truly low-cost RFID tags that are manufactured by the "kilometer." The final objective is to set up a manufacturing technology using only a gravure and ink-jet printer. This will allow completely roll-to-roll manufactured tags.

5. Chip-Less Tags

Many designers consider "chipless" as a very serious competitor to optical barcode, and many research and development projects have been dedicated to the development of this form of tag [15, 25]. The chipless tags, also called "RF barcode," are usually devices manufactured with low-cost components, and generally electromagnetic reflective or absorptive materials. Compared to passive tags, chipless tags generally have the following characteristics:

- low cost, at least in volume;
- contactless, short ranges of less than one meter;
- better reliability: thermal and mechanical behaviors much better than the tags integrating a chip.

However, these advantages should be balanced with the limited storage capacity (a few tens of bits) and the non-rewriteable characteristic (read-only tags) of these devices. Another drawback is the cost of the reader, which could be higher compared to chip-based readers.

Chipless tags are composed of different families, based on the various approaches among them:

- The acousto-optical properties of materials, more precisely, surface acoustic wave (SAW) devices [26]. This approach, already commercialized, is by far the most mature chipless RFID technology.
- Printed organic transistors. This prospective approach is mainly based on the same principle of passive RFID, and is gaining in interest due to recent developments [27].
- The electromagnetic properties of RF waves in passive microwave integrated circuits. Numerous approaches can be found in the literature [28-35]. This approach is in the developing stage.
- Electromagnetic signature of reflective surfaces. This approach is the most similar to optical barcode. It is based on implementing a specific geometry to a reflecting surface in order to generate a unique electromagnetic signature, as in radar. This approach is also under development [36].

The principle of information encoding, which consists of encoding the identification number of the tag, is based on the generation of a specific temporal or frequency footprint. This temporal footprint can be obtained by the generation of echoes due to the reflection of an incident impulse, as illustrated in Figure 6. In the frequency domain, one can

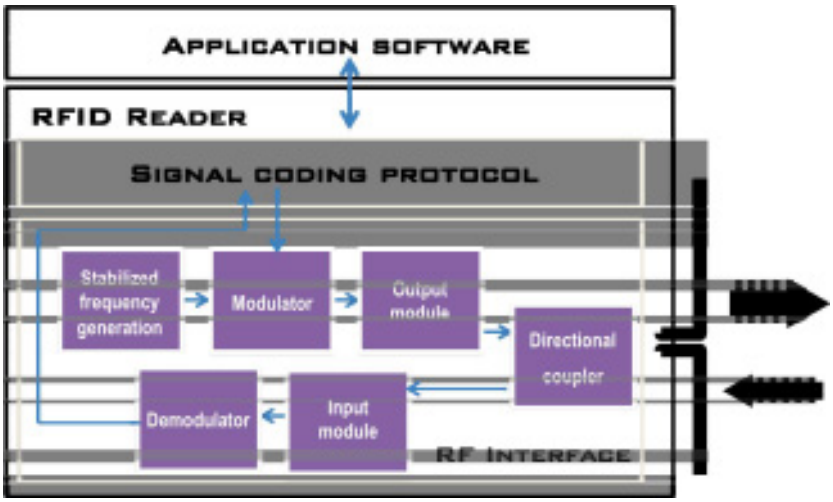

Figure 7. A typical block diagram of the reader. Some readers integrate the antenna and the database.

characterize the spectrum of the tag's backscattering. There are several ways to encode binary data.

Two easy-to-implement approaches for information encoding consist of the following:

- Locating the presence or absence of a specific signal that is known to occur at a given time or frequency (this is like using on-off keying modulation (OOK)).
- Measuring the gap (in time or in frequency) between two characteristic signals (this is like using a pulse-position modulation (PPM)).

The signals are generally electromagnetic waves; one can use the amplitude or the phase to encode the information.

In the temporal domain, the design of devices rests on the concept of reflecting signals due to discontinuities. These discontinuities can typically be due to a rough variation of the geometries of the transition line (microwave approach) or of the medium (optical approach). A simple technique is to place a number of discontinuities at different distances, in order to obtain a specific signal where the information is encoded by the temporal gap between the impulses. These discontinuities can be easily realized with localized [28] or distributed [29] capacitances, placed on a transmission line.

In the frequency domain, it is possible to encode the information by taking into account the amplitude variations in the frequency of the backscattering wave. Such work has been done by placing resonating elements near a transmission line [30, 31], or by exploiting the resonance frequency of a network of dipoles [32, 33]. Some studies have shown that it is particularly interesting to encode information using the wave's phase variations [34, 35].

The introduction of two-dimensional (i.e., volume and surface coding) structures could tackle some of the limitations of chipless structures. We also think that these different principles presented above can be transferred to higher frequencies, in order to offer miniaturized tag solutions with higher capacities. Recently, devices based on holographic principles [37] have been investigated. Such a solution requires imaging to read the information. In [38], we proposed a considerably simpler approach. The device rests on a specific spectral-signature recognition, which can be measured by a single detector. This specific spectral signature could be obtained thanks to multilayer structures.

On the other hand, mitigation of the clutter effect must be considered in RFID applications, and especially when using chipless configurations. In fact, passive UHF RFID systems are known to have reading distances of some meters, and can be very sensitive to the environment and to multi-user interference. Most of these limitations are due to the standard RFID CW-oriented communication. Using ultra-wideband (UWB) communication could avoid most of the previous effects. Indeed, UWB technology, characterized by the transmission of sub-nanosecond pulses, is very robust to multipath and to a large number of devices operating in a small area [50]. The use of a UWB signal is thus very attractive and enabling for chipless RFID.

6. Reader

An RFID reader/writer is a device used to interrogate an RFID transponder. The main function of an RFID reader is to collect the data stored in the tag. This information can be the EPC code (electronic product code) [42], information on the state of operation, or any other data contained in the internal memory of the tag. The second main function of the reader is to write information into the tag. In addition to this ability to code and decode the information received or sent from the tag, the reader ensures the link to middleware that is specific to the application and its physical environment. The middleware is the "embedded intelligence" of the reader: it notably allows filtering incoming tag data that has to be sent to the operating software. A typical block diagram of reader is given Figure 7.

In the case of passive UHF tags, the communication between the reader and the label antenna can be described as follows. The reader transmits a continuous wave (CW) that encodes no information to RFID tag to supply the tags. Indeed, the tag converts the received CW to dc power, and thus generates the biasing signals. Only the tags receiving enough energy – i.e., the tags near the reader – will be able to communicate. In addition, the CW is also used as a carrier signal. In this way, the reader sends a query to interrogate the transponder. The reader listens to the answers and drives the communications, for example, in order to eliminate or reduce tag collision. Finally, it sends only pertinent information upstream to the host.

If we set aside the tag's performance, the maximum reading range of the system is mainly determined by the emitted power and the gain of the antenna. Depending on the dimensions of the reader, the fact that it is portable or not, mainly two types of readers thus exist: proximity readers (having a range of a few tens of centimeters, often used for mobile applications), and short-distance readers (from 1 to 10 m). For a long-distance reader (up to a hundred meters), the use of active tags is required. Besides the reading range, the reading rate (which is the number of times that the reader can read a single tag per second) has to be considered. This parameter depends strongly on the embedded functionalities of the reader. Moreover, RFID devices have to meet the RF emissions limitations and power restrictions (3.3 W or 4 W EIRP, depending on the region of the world). If the application requires more power to properly operate, a solution can be to shield all of the system. For this, tunnel readers have been designed, in order to increase the reading rates in some specific RFID applications.

There is a wide variety of reader antennas, mainly depending on the application [39]. Indeed, antennas are selected based on the type of reading to be achieved, the reading conditions, the type of antenna labels, and the environment of the reader. The reader's antenna can be internal or external. Given the dimension restrictions, internal antennas generally present lower radiation gain. Antennas can be linearly or circularly polarized. In the case of UHF, tags are linear polarized most of the time, and applied with any orientation: thus, circularly polarized antennas are more popular. Depending on the application, different approaches are used to increase the reading rates. For instance, several antennas with a single reader can be a good solution to improve the coverage of a large area. A multiplexing approach is used to manage these different antennas. Finally, an RFID reader can have more or fewer functionalities, such as anti-collision technology, duplicate elimination, and output-power control. Self-adaptation to the environment to operate under optimal conditions can also be implemented for the most-sophisticated products.

As we can notice in Figure 7, the reader requires a device that separates the transmitted and the received signals. The performance of the reader will strongly depend on the isolation between the transmission and reception paths. Two main techniques exist. The first technique uses different transmitting and receiving antennas, located suitably apart from each other (known as bistatic). The second technique utilizes a single antenna and a device that separates transmitted and received signals (monostatic). This device can be a directional coupler or a circulator. In both cases, the isolation must be as high as possible, usually more than 20 dB, especially when the tags are moving. Perfect isolation is not achievable with any of those approaches. A leaking carrier is thus present at the receiver, and its reduction is needed. Several approaches have been studied [40]; some of them are used in radar applications [41].

7. Applications

The use of RFID as an enabling technology has been considered in a large variety of applications: thousands of study examples are in the literature [8]. Nowadays, no one really knows in what domain RFID will be applied in the future and the advantages it will offer, but the potentials for development and innovation remain very attractive.

Logistics is one of the domains in which the application of RFID is very desired, and major companies are developing pilots. Such pilots are usually based on the use of passive UHF tags, due to their quite good maturity. However, deployment of this technology in high volumes is still being held back by the relatively high cost of these tags, as well as some technical problems due to the characteristics of UHF signals. The environment (the object on which the tag is placed, as well as the nearby environment) in which the tags are used considerably affects their characteristics. In particular, when the tag is placed in an environment different from that for which it was specifically designed, the performance of the system can deteriorate rapidly, thereby limiting the potential for the technology. This explains why the design of UHF tags is still a challenging issue. Despite that, RFID and the EPC (electronic product code) [42] are gaining interest for the logistics pipeline. There they are expected to have a major impact on the efficiency of the whole chain, which also includes new business opportunities and strategies [43].

Battery-powered wireless sensors are the most common commercial wireless sensors used today. However, limited battery life and higher costs limit their deployment in some sensing applications. The use of passive RFID tags as an environmental sensor is a very attractive approach. RFID-tag-based sensors have several advantages, including low cost, capacity for ubiquitous deployment, and theoretically infinite lifetime, all of which are highly desirable properties. There are many examples where passive tags are used as sensors. In [44], it the wireless monitoring of the filling level of plastic containers with both low-dielectric-contrast (sugar powder) and high-dielectric-contrast (water) substances was demonstrated. In these cases, the sensed quantity was the effective permittivity of the box container

linked to the filling level. In [45], it was demonstrated that it is possible to wirelessly monitor low-voltage equipment in electrical distribution boards by using passive HF tags implemented in specific positions in the switchboards. Only standard tags were used to achieve a low-cost and robust solution, which fits existing switchboards very well. In [46], an RFID-tag antenna based on a displacement sensor was described. A metal plate was fixed to the bottom of a simply supported beam at a certain distance from an RFID tag. As the midpoint of the beam displaced under loading, the metal plate came closer to the RFID tag, modifying the tag antenna's impedance, and changing the tag's power properties. A dynamic range of about 2.5 cm and an accuracy of about 2 mm were reported. In [47], an UHF tag was used as a moisture sensor. The tag was embedded in layers of absorbent material, such as blotting paper. When the blotting paper absorbed the moisture, it detuned the tag's antenna. As the amount of moisture absorbed increased, the detuning increased, changing the tag's response. The tag could thus be used as a moisture sensor. In addition to the embedded tag, a second tag, located in free space, could be used to obtain a calibrated response.

The sensors described in the previous examples were constructed utilizing low-cost standard tags, and no additional costs were incurred for custom silicon manufacturing. In the four cases, the sensing capabilities were mainly due to the electromagnetic behavior of the tag's antenna. It was evident that specific a antenna design could be realized in such a manner that the sensitivity to a given environmental parameter was investigated and optimized. On the other hand, such sensor relied completely on the reader-transmitted power for tag operations and, in this sense, had a theoretically infinite lifetime. This directly addresses the concern about sensor life in infrastructure monitoring. Moreover, tag-reader and reader communication protocols could conform to existing standards, such as the EPCGen 2 Protocol [42], which provides the additional benefit of interoperability.

Moreover, the idea of sensor-oriented design has been extended to the concept of multi-port tags, i.e., tags integrating several antennas or several chips. Such a concept is very powerful: indeed, it adds calibrating and correction capabilities to the sensor, as was shown in [44].

Last but not least, one of the future applications of RFID is what is known as the Internet of Things (IOT). Basically, this is a network of Internet-enabled objects, together with Web services that interact with these objects. Underlying the Internet of Things there are wireless technologies and, in particular, RFID. The Internet refrigerator is probably the most descriptive and fun example of the capabilities offered by the Internet of Things. This is a device that monitors its contents, and notifies you of any of the alerts you decide (availability of products, limited date of use). It also could notify Web sites and establish shopping lists. Indeed, it could also helps you to take care of your physical condition and health, since it knows which foods are good for you, and it is connected to your doctor. Even if we are away from this level of sophistication, this concept could lead to very useful applications. Leading large companies are offering a range of RFID sensors and technology solutions to built Internet of Things applications [48].

8. Conclusion

Nowadays, RFID is a well-established technology, accepted and applied in a large variety of domains and applications. Technically, it has two main advantages: wireless communication and battery-less transponders. From the economic point of view, the tag, which is the most important device in any RFID system, is potentially low in cost. This cost continues to decrease, thanks to technological advances, and tends towards the optical barcode cost. The previous advantages are very attractive in many practical environments. This is the reason why RFID is considered in thousands of studies evaluating its implementation and benefits. However, different applications and environments require different tag functionalities and performance. Such needs explain why research and development programs are not only still intense, but continue to progress in order to overcome some technical limitations, and also to develop new high-performance tags for specific applications. All-printed tags are very attractive for high-volume scenarios, because of their potential low cost. On the other hand, chipless tags are gaining in interest, thanks to their robustness and very-low-cost characteristics. Moreover, the use of passive tags as sensors has been demonstrated by several authors. This ability to exploit the electromagnetic properties of tags gives birth to a new sensing paradigm. It opens the door to what is known as the Internet of Things, and very powerful and sophisticated applications. However, the technology is still in its infancy, and whether it will revolutionize everyday life remains to be seen.

Privacy and data security, as well as societal issues, were not discussed in this paper. However, today they are topics of great interest, as RFID applications are rapidly expanding from supply-chain management and inventory towards ID papers, payment, health care, safety, and medical applications. On the other hand, international RFID standards and interoperability requirements can cause serious security and privacy risks. Many security solutions have been designed using cryptographic hash functions or private-key encryption algorithms that require less hardware and power resources than public-key algorithms [49]. However, they cannot satisfy all the desired properties for general RFID systems, and more research and development is needed. It is evident that the privacy issues cannot be solved by technology alone, and education and legislation must be involved, too.

9. Acknowledgments

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Specifications of *in vitro* Exposure Setups in the Radio-Frequency Range

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1. Introduction

Research studies addressing the health effects of the exposure to radio-frequency (RF) electromagnetic (EM) fields began to increase in the last twenty years [1], issuing contradictory results. Therefore, the need for a common approach to the requirements of bioelectromagnetic research became evident.

In 1994, Wireless Technology Research (WTR) held a workshop to highlight the appropriate directions for development of *in vitro* (and *in vivo*) exposure systems [2]. In the same period, it was stated that the specific absorption rate (SAR), measured in W/kg, was the reference dosimetric quantity to be used for comparing effects observed under various exposure conditions [3]. In 1996, the EMF Project of the World Health Organization (WHO) fixed and emphasized these concepts in specific recommendations [4]. Such items, together with a deep discussion on quality assurance, were the main arguments of two COST workshops: "Exposure systems and their dosimetry," held in Zurich in February 1999 [5, 6], and "Forum on Future European Research on Mobile Communications and Health," held in Bordeaux in April 1999 [7].

Recommended requirements and guidelines for exposure systems were finally synthesized in [8]. In particular, the authors proposed the stages for the development of an exposure setup, according to a step-by-step approach, from "Working Hypothesis" to "Testing of Setup." They indicated a checklist of basic requirements for all exposure systems in terms of biological requirements, electromagnetic requirements, and other requirements, including blind study design and cost.

With reference to these issues, it is useful to remember the biological parameters – principally deriving from the biological protocol – relevant for RF *in vitro* exposure. These can be summarized in the following items.

- *Environmental conditions:* CO_2 concentration, temperature (37° C), and humidity (saturated). *Sample holder*: tubes, vials, flasks, *Petri dishes*, multiwells.
- *Cell distributions*: monolayer, suspension. *Statistical power*: number of cells/volume of biological samples.
- *Exposure times*: from a few minutes up to some days. *Times of sampling*: different times of exposure during the same experiment, kinetic studies or end-point with different timing.

In fact, biological requirements represent the starting point in the design of an *in vitro* exposure system. This is because they can be the most limiting requirements, especially when particular equipment (a microscope) and protocol procedures (cell handling) are needed, or specific environmental characteristics (temperature, pressure, etc.) are required [9-11].

2. Exposure Systems Review

For this review, the years from 1999 to 2005 have primarily been considered, i.e., the years when several European cooperative research projects were carried out. These projects were particularly important, since they instituted committees or expert groups to promote adequate quality control in all participating laboratories. In particular, the exposure systems adopted in the just-mentioned projects can be seen in Table 1. Due to their low cost and flexibility, the most used are TEM cells, rectangular waveguides, and short-circuited waveguides. Moreover, more than 50 papers regarding *in vitro* RF experiments, published in 15 journals,

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Table 1. A review of the European projects regarding in vitro biological experiments in the period 1999-2005

Project	Cell line	Exposure System	Vessel	Biological End-Point
PERFORM B *In-vitro* and *in-vivo* Replication Studies Related to Mobile Telephones and Base Stations	Human lymphocytes (24 h)	**Short-circuited waveguide** (900, 1750 MHz)	Petri dishes	Proliferation index, genotoxicity,
	ODC enzyme in L929 cells, (2, 8, 24 hrs)	**TEM Cell** (fan on/off) 900 MHz, **STUK resonator** (shorted-waveguide chamber, 900 MHz) **WPC (**900 MHz**)**	Petri dishes	ODC activity, apoptosis, proliferation, lipid peroxidation).
CRADA-CTIA Evaluation in human peripheral blood lymphocytes of the exposure to radio-frequency radiation by micronucleus frequency and cell proliferation	Human lymphocytes (24 h)	**WPC** (900 MHz, GSM signal)	Petri dishes	genotoxicity
RAMP: Risk assessment for exposure of nervous system cells to mobile telephone emf: from *in vitro* to *in vivo* studies	Neuroblastoma cell line	**WPC** (900, 1750, 1950 MHz)	Petri dishes	Proliferation, apoptosis, gene expression, differentiation
	hippocampal and cortical neural culture (from a few minutes to a few hours)	**TEM cell** (900 MHz)	Multiwell plates	apoptosis, gene expression, differentiation; activation and inactivation kinetics; changes in the ratio of the different calcium channel subtypes
	Rat neurons	**Coplanar waveguide** 900 and 1800 MHz	Petri dishes	changes in ionic currents (e.g. Ca^{++})
REFLEX Risk Evaluation of Potential Environmental Hazards from Low Energy Electromagnetic Field (EMF) Exposure Using Sensitive in vitro Methods	Human peripheral blood mononuclear cells (lymphocytes and monocytes) from young and elderly donors. Human newborn (5 days-8 months) thymocytes.	**Short-circuited waveguide** (1750 MHz, GSM DTX and Talk)	Petri dishes	spontaneous apoptosis, mitochondrial membrane potential, expression of membrane receptors, cytokine production, activation and proliferation, cell cycle and HSP 70 levels. apoptosis and differentiation
CEMFEC: Combined Effects of Electromagnetic Fields with environmental carcinogens	murine NIH 3T3 (fibroblasts) and L929 (fibrosarcoma) 1h on,1h off,1h on; 3h; 1h; 30 min;	**Rectangular waveguide** 900 MHz	flasks	Oxidative stress, Cell cycle and cell proliferation, Gene Expression, Apoptosis, Mitochondrial membrane potential modifications

have been reviewed [5-57]. In these articles, 32 different exposure systems were identified and more than 10 different end points were examined, with the aim of giving a useful classification. An attempt to organize all these exposure setups led us to present a classification of the systems reviewed in Table 2.

A first division can be made between two kinds of exposure setups: systems allowing a real-time analysis (i.e., for patch clamp experiments), and systems for an offline analysis. Afterwards, the exposure systems were classified according to their reference EM structure, and divided into three main families: radiating, propagating, and resonant. For each different family, the best and the worst SAR efficiencies among the reviewed systems were extracted from the papers and reported in Table 2. A short description of the different systems is presented according to the proposed classification.

Table 2. Classification of the reviewed exposure systems

<table>
<tr><th colspan="3">Exposure System</th><th>Number*</th><th colspan="2">Efficiencies (W/kg)/W</th></tr>
<tr><td rowspan="5">Real time</td><td rowspan="4">Propagating</td><td>Modified rectangular waveguide</td><td>2</td><td rowspan="4">WORST CASE

0.035
(Parallel plates at 700 MHz [53])</td><td rowspan="4">BEST CASE

3300
(Modified rectangular waveguide for pulsed fields at 9200 MHz [46])</td></tr>
<tr><td>Modified stripline</td><td>1</td></tr>
<tr><td>Parallel plates</td><td>1</td></tr>
<tr><td>Coplanar waveguide</td><td>1</td></tr>
<tr><td>Resonant</td><td>Modified short-circuited rectangular</td><td>1</td><td colspan="2">2 (at 1000 MHz [16])</td></tr>
<tr><td rowspan="10">Offline</td><td rowspan="2">Radiating</td><td>Horn rectangular</td><td>2</td><td colspan="2" rowspan="2">0.175
(Dielectric lens at 2000 MHz [17])</td></tr>
<tr><td>Dielectric Lens</td><td>1</td></tr>
<tr><td rowspan="5">Propagating</td><td>TEM/GTEM cell</td><td>7</td><td rowspan="5">WORST CASE

0.016
(RTL at 835 MHz [22])</td><td rowspan="5">BEST CASE

8.6
(Cylindrical waveguide at 1900 MHz [15])</td></tr>
<tr><td>Rectangular</td><td>5</td></tr>
<tr><td>Cylindrical</td><td>1</td></tr>
<tr><td>Radial Transmission Line</td><td>2</td></tr>
<tr><td>Other</td><td>2</td></tr>
<tr><td rowspan="3">Resonant</td><td>Short-circuited rectangular</td><td>3</td><td rowspan="3">WORST CASE

0.46
(WPC at 900 MHz [18])</td><td rowspan="3">BEST CASE

10÷50
(Short-circuited waveguide at 1800 MHz [27])</td></tr>
<tr><td>Parallel plates</td><td>1</td></tr>
<tr><td>Wire patch cell</td><td>2</td></tr>
</table>

* number of found exposure systems based on the same EM structure

2.1 Radiating Structures

The radiating structures usually consist of a commercial antenna, with the samples placed in the far-field zone. This kind of system allows large-scale experiments, because several samples can be simultaneously exposed. On the other hand, they need an electromagnetically compatible (EMC) arrangement, and present low efficiency (W/kg per 1 W of input power), due to the low incident-power densities involved, and a low uniformity of dose. If control of the environmental conditions is needed, the setup can become complex.

A radiating system is shown in Figure 1. This system is the only one among the several exposure systems examined that operates at millimeter wavelengths, and allows the simultaneous exposure of four Petri dishes [28]. Another system is comprised of a horn antenna, working at 2142.5 MHz, and a particular dielectric lens, which focuses the beam on the samples. The efficiency is low (0.175 W/kg), whereas the SAR inhomogeneity is high (>50%). This system allows the exposure of up to 49 Petri dishes. In this case, the environmental control is realized in an ad hoc manner, with two different forced-air flows placed in the culture room and in the anechoic chamber, to keep the environmental conditions stable [17].

2.2 Propagating Structures

The propagating structures generally allow the propagation of the field inside, and the samples are usually exposed to a uniform EM field. The main advantages of such systems are their versatility and the confinement of the EM field, since they are mostly closed structures. They require careful positioning of the sample. This suggests the use of an ad hoc sample holder, in order to guarantee the repeatability of the dose among different experiments [19].

Some of these need careful design. For instance, coaxial-to-waveguide transitions are often a critical point. Therefore, numerical design is necessary. The exposure

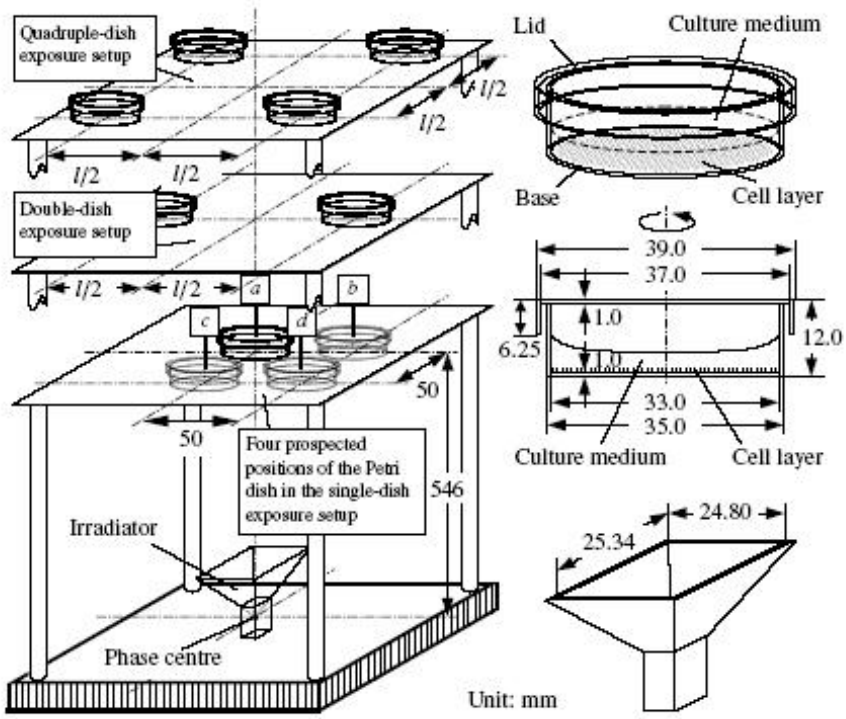

Figure 1. An example of a radiating system operating at millimeter wavelengths [28].

system used in [15] was a cylindrical waveguide, loaded with the sample. The efficiency is high (8.6 W/kg) and the dose homogeneity is good (>70%). However, due to the fact that only one Petri dish can be exposed at time, the whole system is constituted with six waveguides, in order to have enough statistical power. Moreover, this system allows only the exposure of cells that do not need CO_2. In fact, it does not fit in an incubator, and a particular arrangement has been set up to control the temperature in the sample.

In contrast, the TEM cell presents great versatility [21]. In fact, it can be easily placed in a standard incubator. Thanks to a proper ad hoc design, it can be used with several kinds of sample holders, such as the multiwell, used for the RAMP2001 UE Project (Contract No. QLK4-CT-2001-00463) (Figures 2a and 2b), and the flasks used for Perform B, a replication study related to the paper on ornithine decarboxylase activity in L929 cells [34].

Even the rectangular waveguide is a quite versatile structure, allowing the exposure of different kinds of sample

Figure 2a. Two TEM cells in an incubator.

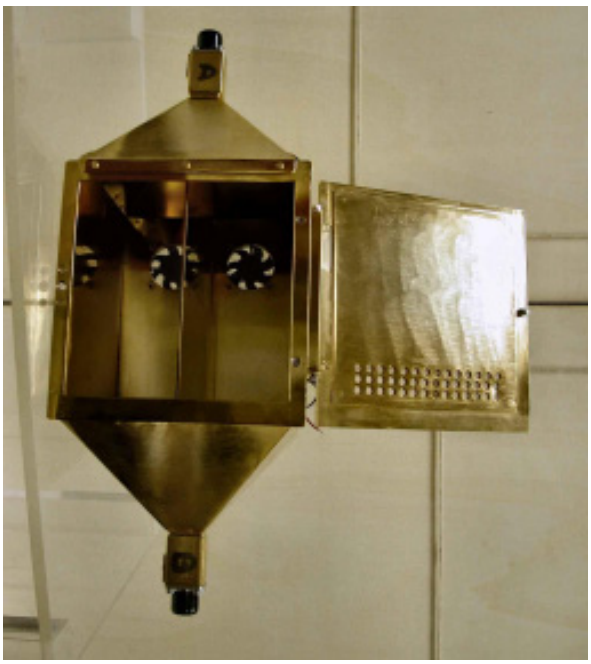

Figure 2b. To allow efficient air circulation, grids with external fans have been realized in the TEM cells.

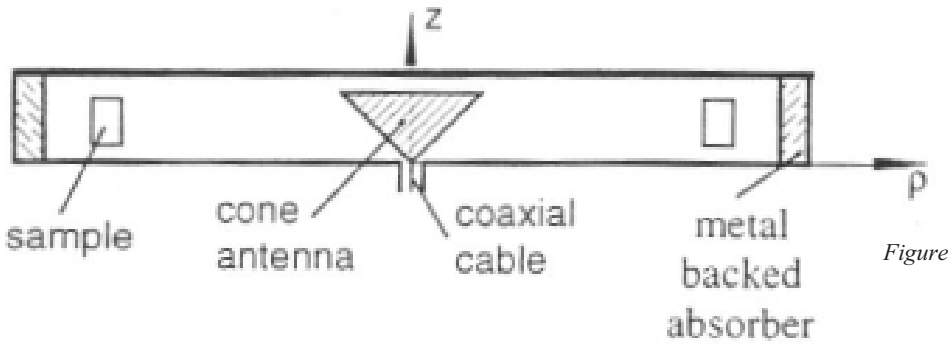

Figure 3. A longitudinal section of a radial waveguide.

holders: tubes [6], cuvettes [30], multiwells [50], flasks [55], and *Petri dishes* [41]. Nevertheless, both the TEM cell and the rectangular waveguide can hold only a reduced number of biological samples. Therefore, when simultaneous exposure of several samples under similar conditions is required, a radial transmission line (RTL) represents a suitable structure [22, 23]. A schematic view of a radial waveguide is given in Figure 3.

Another structure supporting a traveling wave is a plane transmission line, made of two parallel conductors with bent lateral edges to limit the EM dispersion [13]. An analog structure – a calibrated parallel-plate waveguide – has been properly modified with holes in two plates in order to allow real-time electrophysiological recordings in hippocampus slices [53].

For a similar application, i.e., a real-time analysis using the patch clamp technique, the coplanar waveguide reported in Figure 4 [19] was realized. Despite the fact that it is an open structure, it has been designed in order to obtain a field confinement limited to few centimeters, allowing the absence of electromagnetic interference (EMI) with laboratory equipment.

Finally, the wire-patch cell [18] is a particular structure (Figure 5) that could be considered a sort of tradeoff between a radiating and a resonant structure. Its main features are good homogeneity of dose in the samples and reduced size, allowing its placement in a standard incubator, when appropriate EMC arrangements are realized.

In Figure 5, an example from the BAS-MED ENEA laboratory can be seen. This is a double-blind setup with sham control, and with a shielding structure (the same for antennas of all frequencies, i.e. 900, 1800, 1950 MHz). This allows the placement of two devices in the same incubator. Local temperature control in the samples is performed by using two water spiral plate jackets [12], with constant-in-temperature water circulating inside.

2.3 Resonant Structures

Resonant structures are based on total reflection of the EM field, which implies standing waves inside the system. It is therefore possible to identify distinct regions with maximum electric (E) field or magnetic (H) field. In this way, it is possible to take advantage of different coupling phenomena – inductive or capacitive – to expose different kinds of cultured cells, monolayer or suspension. Moreover, such structures allow high efficiency, reducing the costs of instrumentation, in particular of the amplifier. In contrast, the positioning is very critical, due to the fact that the region

Figure 4. A coplanar waveguide as used in [19]

Figure 5. A wire patch cell [18] and the exposure system as used in [12].

of uniform field is extremely localized. The main advantage of this kind of structure – together with the high efficiency – is that it is a closed and compact system, enabling the placement of both the active and sham waveguides in the same incubator. Such a feature simplifies the fulfillment of the requirements regarding strict environmental control [27]. The temperature is usually controlled by forced air flow trough the guides (Figure 6).

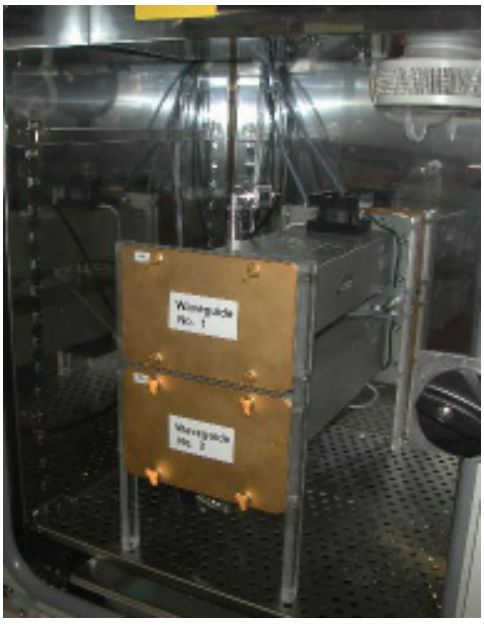

Figure 6. Rectangular waveguides shortened at one end, operating at typical frequencies of mobile communication standards [27].

Most resonant structures used in bioelectromagnetic experiments are rectangular waveguides shortened at one end, operating at typical frequencies for mobile-communication standards [24-27]. Generally, they provide the simultaneous exposure of a few Petri dishes with cell monolayers or cell suspensions inside [24-27]. However, they may be properly modified in order to permit perfusion of the sample, if required by the experimental protocol [16]. Figure 7 shows a waveguide with the cell-perfusion apparatus for online monitoring of catecholamine release [16].

2.4 Misleading Approach

In spite of the rigorous approach described in Section 1, and the establishment of the SAR as the "reference dosimetric quantity," sometimes it is still possible to find papers where

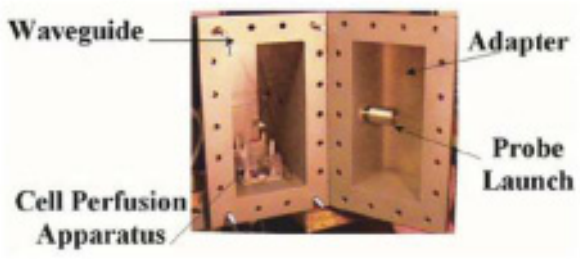

Figure 7. A shortened rectangular waveguide with a cell-perfusion apparatus as used in [16]

Sample Holder	Average SAR (mW/kg)	Standard Deviation (mW/kg)
60 mm Petri dish with 5 ml	0.71	0.41
35 mm Petri dish with 3.1 ml	0.12	0.098
T25 Flask with 5 ml	1.02	0.36
T75 Flask with 40 ml	0.34	0.19
14 ml Tube with 10 ml	5×10^{-3}	6.39×10^{-5}

Table 3. The average SAR values with standard deviations numerically calculated in the bottom layer of the considered holders exposed to a 900 M Hz plane wave, with an incident power of 1 mW/cm²

the incident power density is the reference quantity adopted to characterize the exposure. This is a potentially misleading approach, as synthetically reported in Figure 8 and Table 3. If we consider a plane wave at a frequency of 900 MHz, with a power density of 1 mW/cm^2 , incident on different targets of the same material, it can be seen that different values of SAR (Table 3) are obtained, depending on the sample holders. Different polarizations defined in Figure 8 were taken into account. The results were obtained numerically, using a commercial code (Computer Simulation Technology CST *Microwave Studio*, Darmstatd, Germany), based on the Finite Integral Technique. It is evident that the correct dosimetric quantity, SAR, is dependent on the shape, volume, and dielectric properties of the biological sample.

Another potentially misleading approach results from the fact that cellular phones have been used, placed in front of the biological target, turned on and calling, in order to perform the exposure. Of course, this is not acceptable [58], since it does not allow any control of the exposure conditions.

3. Updated Requirements and Underlying Principle

On the basis of the knowledge acquired by now, we can conclude that the principles underlying the future recommendations for *in vitro* research can be summarized by two priorities that must be the key requirements when *in vitro* experiments are carried out. The priorities are the well-being of cells, and the knowledge of the EM dose induced in the samples.

3.1. The Well-Being of Cells

In order to rely on the results achieved from an exposure experiment, the cells must be maintained in their usual physiological conditions. A single variation in one of the vital physiological parameters could induce an unpredictable imbalance, leading to an effect different from the true answer for the biological system. In particular, significant increases of temperature in the sample should be avoided. The well-being of cells is the primary condition when a possible cause-effect relationship has to be identified.

3.2 The Knowledge of the Electromagnetic Dose Induced in the Sample

Regarding the knowledge of induced dose, it is mandatory to assure the repeatability and reproducibility of results, even if different exposure systems are used. Moreover, it has been shown that phenomena of coupling between the external field and the biological sample are not simple. They are related to a great variety of factors, such as the frequency and polarization of the EM incident field, the properties of the biological medium, its volume, and the topology of the sample holder, which can induce very different levels of dose. Therefore, an accurate dosimetric characterization is a mandatory step of exposure-system design.

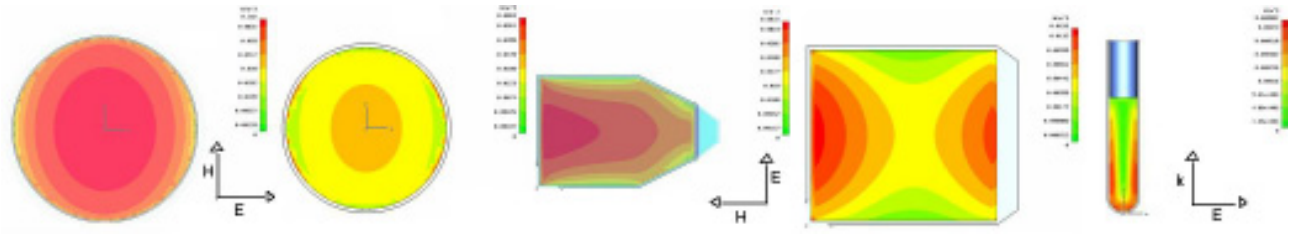

Figure 8. Different SAR distributions obtained considering a 900 MHz, 1 mW/cm2 plane wave incident on different sample holders.

3.3 Recommendations

In this context, the key issues of biological and exposure requirements, stated in [8], can be confirmed as inputs for exposure-system design. Starting from the two aforementioned basilar points, the fundamental steps are the choice of proper EM structure, its sizing on theoretical bases, its numerical design, and numerical dosimetry. As a last step, the setup needs an experimental dosimetry – that is unavoidable – for the verification of numerical simulations. However, different setups may be chosen, provided they meet recommended guidelines, with special regard to the dosimetric issue, and specific requirements coming from the biological protocol.

Therefore, the main consideration that comes from this paper is that an optimal exposure system does not exist. In fact, the system should be chosen or designed strictly related to the intended biological protocol. Moreover, since experimental protocols differ from endpoint to endpoint, setups cannot be standardized [59].

4. Conclusions

In past years, the criteria for improving the quality of bioelectromagnetic research has been pointed out, with particular regard to the exposure and the repeatability of experimental studies. Moreover, since 1999, several cooperative research projects have been carried out, giving a significant boost to the application of adequate quality control in all participating laboratories.

The available exposure systems, which were used in the period 1999-2005, were reviewed. Their features were examined in order to give a useful classification, and to suggest criteria for the choice of the setup.

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Conferences

CONFERENCE REPORT

International Radar Conference

Bordeaux, France, 12 – 16 October 2009

The International Radar Conference was organized in the framework of an agreement between the Institution of Engineering and Technology (IET in the UK), the Institute of Electrical and Electronics Engineers (IEEE), the Chinese Institute of Electronics (CIE), the Institution of Engineers Australia (IEAust), and the Société des Electriciens et Electroniciens (SEE in France). In 2009, the Institut Français de Navigation (IFN, France) also joined the group. The conference is held in France every five years and is organized by SEE.

Over 400 participants and more than 200 papers from 25 different countries proved the high interest of the radar community. Submitted and accepted papers were more or less equally distributed among universities, industry, and governmental agencies.

The plenary session (Figure 1) put emphasis on the current state of the art and the probable evolution of the domain. The main theme addressed by the speakers was "For a safer world," stressing a dual approach (military/civilian). The technical program covered all the main topics of radar research and techniques, such as active antennae, bistatic configurations, SAR, signal processing, UWB, STAP, radar management techniques, and low-frequency applications. Half of the papers were presented in oral sessions (Figure 2), and half in poster sessions. The latter gave real opportunities for fruitful exchanges. This was thanks to the manner in which the poster sessions were organized, which gave them large time slots and installed panels in the immediate proximity of the conference rooms.

The technical program also included a young author's paper competition for scientists and/or engineers in industry, under the age of 35 years.

Of the 30 sessions (oral and poster) covering most of the radar domain some themes were extensively discussed:

- UHF/VHF/HF including passive radars

- Multiple-input multiple-output (MIMO) techniques

- Sea clutter,
- Synthetic-aperture radar/inverse synthetic-aperture radar (SAR/ISAR),

- Space-time adaptive processing (STAP),

- UAS.

In addition, under the somewhat affected title "Emerging Radar Applications," several very promising works were reported (to mention only a few):

- "Tsunami Detection Using HF Radar WERA: A Simulation Approach" by Anna Dzvonkovskaya et al.

- "Wake Vortex X-Band Radar Monitoring: Paris-CDG Airport 2008 Campaign Results and Prospectives" by Frédéric Barbaresco et al.

- "Weather Hazards Interpretation and Forecast by Airborne Radar" by Jean-Paul Artis et al.

What is certainly true is that thanks to new technologies and accumulated experience in various sectors, radar techniques can now be applied in a cost-effective way to a larger variety of areas.

Papers on UHF/VHF/HF were equally divided in active and passive radar, as, for example:

- "Effects of Wind Power Plants on Passive Radar Operation" by Heiner Kuschel et al.

- "UHF Alerter Intended for the Protection Against Mortar" by Christian Cavallari and Morgan Brishoual

- "A Technique for Estimating the Detection Performance of a Skywave Over-the-Horizon Radar" by Mike Turley and Mark Tyler

MIMO techniques are attracting more and more research, for example:

- "MIMO Based Spatial Calibration of OTHR Transmit Array" by Gordon Frazer et al.

- "Waveform Design and Processing for Multichannel MIMO Radar" by Stephen Searle and Stephen Howard

- "A Sidelobe Reduction Technique for Enhancing Images of UWB Sparse MIMO Array" by Xiaodong Zhuge et al.

Sea clutter is still the subject of many studies. It is logical that knowledge of such a complex matter goes along with improvement of the performance of systems, as illustrated by:

- "Electromagnetic Wave Scattering from Sea and Bare Soil Surfaces Based on an Improved Two-Scale Model" by Naheed Sajjad et al.

- "Sea Spikes Suppression for High Range and High Doppler Resolution Radars" by Felicia Amato et al.

- "Experimental Validation of the Compound Gaussian Sea Clutter Model at Sub-Meter RangeResolution" by Javier Carretero-Moya et al.

- "Modeling of Radar Scattering from Oil Films" by Nicolas Pinel and Christophe Bourlier

SAR and ISAR techniques are now mature: it is not surprising that many papers were offered. Examples included:

"Defining Configurations for Bistatic SAR" by Daniel Stofer and Joan Broussolle

"ISAR Imaging of Ground Moving Vehicles Using PAMIR Data" by Patrick Berens et al.

"Advances in Bistatic Inverse Synthetic-Aperture Radar" by Marco Martorella et al.

When considering possible implementations of STAP techniques, it is clear that there are two main approaches: STAP before Doppler filtering (pre-Doppler STAP), and STAP after Doppler filtering (post-Doppler STAP). The paper, "The Relative Merits of Pre/Post-Doppler STAP," by Laurent Savy et al., aimed at collecting the various arguments of both points of view.

Several papers were dedicated to unmanned aircraft systems (UAS), providing new ideas for flight planning as well as payloads. This was probably due to the preparation of item 1.3 of the agenda of the next World Radiocommunication Conference (WRC, January 2012) on spectrum requirements, and possible regulatory actions to support the safe operation of UAS. Two examples:

- "UAV Flight Plan Optimized for Sensor Requirement" by Sophie Lentilhac and Marc Aasebo

- "Radar Systems for 'Sense and Avoid' on UAV" by Stéphane Kemkemian et al.

As usual, the conference was preceded on Monday by a set of tutorials presenting the state of the art in some particular areas. The conference was followed on Friday by several technical visits to local industries and organizations.

On Tuesday evening, conference participants were invited by the Town Hall for a wine-tasting party. On Wednesday evening, all participants were invited to visit a "Château" in the vineyard near Bordeaux. It was too late to gather in the grapes, but not too late to taste the results of previous vintage: that is exactly what was done until buses came to take participants back to Bordeaux and the conference. During the banquet, Erwin Gangl, Awards Chair (IEEE/AESS), took the floor to announce the IEEE/AESS Award winners: Prof. Yakov D. Shirman, 90 years old, who received the prestigious Pioneer Award. The evening was also an occasion to cheer the representatives of countries having supported the conference.

During the closing session on Thursday evening, the Organizing Committee (co-Chairs: Philippe Lacomme, Marc Leconte), the Program Committee (Chair: Marc Lesturgie), and the Local Organizing Committee (Richard Montigny) praised all speakers and participants for having made a success of this conference. This was also the occasion for the Awards Chair (Myriam Nouvel) to reward the winner of the young author's paper competition: Anna Dzvonkovskaya, for her paper, "Tsunami Detection Using HF Radar WERA: A Simulation Approach."

Philippe Lacomme and Marc Lesturgie invited the participants to the next conference, in France, in 2014.

It is said in Bordeaux that the 2009 vintage will probably be a very good one. We can testify that the 2009 International Radar Conference was a very good one in terms of scientific and technical interests, as well as for the friendly atmosphere. It is no doubt that all organizers are to be thanked for both.

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CONFERENCE ANNOUNCEMENTS

Second International Symposium on Radio Systems and Space Plasma (ISRSSP)

Sofia, Bulgaria, 25 – 27 August 2010

General

The huge developments in Information and Communication Technology (ICT) relate to Radio-Communication (RC) which in turn concerns the design of effective systems, including scientific, engineering and economic considerations. The explosive developments of sophisticated RC systems over the past years has opened new horizons in human development and requires more and more attention in both academia and business.

Covering the topics of URSI commissions C, G, H (toward space plasma) and Space Solar Power System (SSPS), the 2nd International URSI Symposium on Radio Systems and Space Plasma (ISRSSP 2010) brings together influences from these commissions.

More exactly, the scientific program of the symposium is concerned with the international development and application of the broad range of aspects: (i) Intelligent Methods of RC Systems and Signal Processing , (ii) Transionospheric Propagation , (iii) Methods for Analyzing Non-linear Interactions of Space Plasma, (iv) Radio Science Aspects of SPS Systems

It is not only that ISRSSP 2010 adopts the URSI research agenda but it also appeals to the URSI community for participation because it is believed that focused discussions prior to the URSI General Assembly would usefully support its productivity. Nevertheless, ISRSSP 2010 addresses also a broader audience including all those researchers and practitioners who are interested in the topics of the symposium. Their participation is expected to additionally strengthen the URSI-related research and the RC research developments. All this inspires the organizers

to go forward with this event, contributing to the dissemination of radio science -related knowledge.

Goal and Topics

The goal of this symposium is to focus on the broad range of aspects beginning from the intelligent methods of radio-communication systems and signal processing, transionospheric propagation, through the updated methods for analyzing non-linear interactions of space plasma, up to radio science aspects of space solar power systems. The symposium aims at contributing to the dissemination of research results, and supporting in this way the wider applicability of advanced radio-communication technology.

Topics of interest for the symposium include, but are not limited to:

- Radio-Communication and Telecommunication systems
- Spectrum and Medium Utilization
- Information Theory, Coding, Modulation and Detection
- Signal and Image Processing in the area of Radio Science
- Transionospheric Propagation
- Investigation of Space Environments via Satellite Observations
- Generation and Propagation of Waves in Plasmas
- Interaction between Waves and Wave Particles
- Plasma Turbulence and Chaos
- Spacecraft-Plasma Interaction
- Solar Power Satellite (SPS) Systems and related Radio Technologies
- Influence and Effects of SPS – Radio Science Aspects
- Further Directions in SPS Systems

Paper Submission

ISRSSP 2010 invites papers describing original contributions related to the topics listed above. Submitted papers should be in English, in format A4, no longer than 4 single-sided pages with text in one column and provided as PDF files. The independent print area is to be of 17 x 23.4 cm.

The ISRSSP papers will be published by INSTICC as a printed proceedings with ISBN and online on the INSTICC website (http://www.insticc.net).

Contacts

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6th International Symposium on Turbo Codes and Iterative information Processing

Brest, France, 6 – 10 September 2010

Brest, at the westernmost tip of France, is renowned for its deep well-protected natural harbour and its famous navigators. The 6th International Symposium on Turbo Codes & Iterative Information Processing will be held from Monday September 6th to Friday September 10th, 2010, in Brest, France. The symposium will be an opportunity to acquire a broad overview of the current status of advanced research in iterative information processing and its application to information theory and digital communications.

Paper Submission

All original contributions will be considered, in both the theoretical and the application fields. The non exhaustive list below gives possible topics for the paper submission:

Submission of papers deadline: March 15, 2010

Notification of acceptance: May 15, 2010

Final papers and preferential rate registration deadline: June 15, 2010

Organising Committee

General Chair:
M. Jézéquel, Télécom Bretagne, France

Vice General Chair:
R. Pyndiah, Télécom Bretagne, France

Technical Program Chair:
C. Douillard, Télécom Bretagne, France

Topics

- Error correction coding
- Turbo codes and LDPC codes
- Coded and turbo coded modulation
- Detection and turbo detection
- Equalization and turbo equalization
- Synchronization and turbo synchronization
- Multi-user detection

• Bounds, performance and convergence
• Algorithms for constituent codes
• Interleaving and graphs
• Fountain codes
• Network coding
• Cooperative communications
• Joint source channel coding and decoding
• Circuits and software
• Current applications and standards
• New applications of the "message passing" method

The title of the symposium has been modified in order to enlarge the scope of the conference. It encompasses new application areas of message passing algorithms (i.e. neurosciences, data fusion …).

The symposium will include regular papers for oral and poster sessions as well as invited papers. Accepted papers will appear in IEEEXplore. Some papers will be selected for publication of an extended version, in a special issue of the "Annals of Telecommunications" journal. Submissions.

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For information regarding registration, accommodation and transport, please check the symposium web site.

Authors are invited to submit a full manuscript (not exceeding 5 pages) before March 15, 2010 via the symposium web site at: http://conferences.telecom-bretagne.eu/turbocodes/Key dates

URSI CONFERENCE CALENDAR

URSI cannot be held responsible for any errors contained in this list of meetings.

December 2009

AEMC09 - IEEE Applied Electromagnetics Conference and URSI Commission B meeting
Kolkata, India, 14-16 December 2009

ICMARS 2009 - International Conference on Microwaves, Antenna, Propagation and Remote Sensing
Jodhpur, India, 19-21 December 2009
http://www.radioscience.org/ICMARS-2009FirstCircular.pdf

February 2010

META '10 - Second International Conference on Metamaterials, Photonic Crystals and Plasmonics
Cairo, Egypt, 22-25 February 2010
cf. Announcement in the Radio Science Bulletin of March 2009, p. 65.
Contact: Dr. Said Zouhdi, Laboratoire de Génie Electrique de paris, LGEP-Supélec, Plateau de Moulon, 91192 Gif-sur-Yvette Cedex, France, Fax+33 1 69 418318, E-mail: said.zouhdi@supelec.fr, Web: http://meta10.lgep.supelec.fr

March 2010

MicroRad 2010
Washington, DC, USA, 1-4 March 2010
Web: http://www.microrad2010.org/

8th International Nonlinear Waves Workshop
La Jolla, CA, USA, 1-5 March 2010
Contact: William E. Amatucci, Plasma Physics Division, Code 6755, Naval Research Laboratory, Washington, DC 20375, USA, Fax : 202-767-3553, E-mail : bill.amatucci@nrl.navy.mil

3rd Workshop on RFI Mitigation in Radio Astronomy
Groningen, The Netherlands, 29-31 March 2010
Contact: Prof. W.A. BAAN, Netherlands Foundation for Research, in Astronomy - Westerbork Observatory, P.O. Box 2, NL-7990 AA DWINGELOO, NETHERLANDS, Fax : +31 521-595 101, E-mail: baan@astron.nl

April 2009

AP-EMC 2010 - Asia-Pacific EMC Symposium
Beijing, China, 12-16 April 2010
Contact: Web: http://www.apemc2010.org

June 2010

CROWNCOM - 5th Int. Conference on Cognitive Radio Oriented Wireless Networks and Communications
Cannes, France, 16-18 June 2010
Contact : Jacques Palicot, SUPELEC, Avenue de la Bulaie, 53576 Cesson-Sévigné, France, Fax +33 299-844599, E-mail: jacques.palicot at supelec.fr

July 2010

SCOSTEP - STP12
Berlin, Germany, 12-16 July 2010
Contact: Prof. Dr. Franz-Josef Lübken, Leibniz Institute of Atmospheric Physics, Schloss-Straße 6, 18225 Kühlungsborn, Germany, Fax: +49-38293-6850, E-Mail: luebken@iap-kborn.de, http://www.iap-kborn.de/SCOSTEP2010/

COSPAR 2010 - 38th Scientific Assembly of the Committee on Space Research (COSPAR) and Associated Events
Bremen, Germany, 18 - 25 July 2010
cf. Announcement in the Radio Science Bulletin of December 2008, p. 73.
Contact: COSPAR Secretariat, c/o CNES, 2 place Maurice Quentin, 75039 Paris Cedex 01, France, Fax: +33 1 44 76 74 37, E-mail: cospar@cosparhq.cnes.fr, Web: http://www.cospar2010.org/ or http://www.cospar-assembly.org

August 2010

EMTS 2010 - International Symposium on Electromagnetic Theory (Commission B Open Symposium)
Berlin, Germany, 16-19 August 2010
Contact: EMTS 2010, Prof. Karl J. Langenberg, Universität Kassel, D-34109 Kassel, Germany, E-mail: info@emts2010.de , Web: http://www.emts2010.de

3rd International Communications in Underground and Confined Areas
Val d'Or, Québec, Canada, 23-25 August 2010
Contact: Paule Authier, Secrétaire, LRTCS-UQAT, Laboratoire de recherche Télébec en communications souterraines de l'UQAT, 450, 3e Avenue, local 103, Val-d'Or,Québec J9P 1S2, Fax: (1)(819) 874-7166, E-mail: lrcs@uqat.ca, Web: http://www.icwcuca.ca/welcome.asp

ISRSSP'10 - 2nd International Symposium on Radio Systems and Space Plama
Sofia, Bulgaria, 25-27 August 2010
Contact : E-mail: Blagovest Shishkov - bshishkov at math.bas.bg, Web: http://www.isrssp.org
cf. Announcement in the Radio Science Bulletin of December 2009, p.33-34 .

September 2010

ISTC2010 - International Symposium on Turbo Codes
Brest, France, 6-10 September 2010
cf. Announcement in the Radio Science Bulletin of December 2009, p. 34-36.
Contact: Télécom Bretagne, International Symposium on Turbo Codes, Département: Électronique, Technopôle Brest Iroise, CS83818, 29238 BREST Cedex, FRANCE, Tel: +33 2 98 00 10 28, Fax : +33 2 98 00 11 84, Email : istc at mlistes.telecom-bretagne.eu, Web: http://conferences.telecom-bretagne.eu/turbocodes/

Metamaterials 2010 - The Fourth International Congress on Advanced Electromagnetic Materials in Microwaves and Optics
Karlsruhe, Germany, 13-16 September 2010
Contact : Web: http://congress2010.metamorphose-vi.org/

ICEAA 2010 - International Conference on Electromagnetics in Advanced Applications
Sydney, Australia, 20-24 September 2010
cf. Announcement in the Radio Science Bulletin of September 2009, p. 62-63.
E-mail: Roberto.Graglia@polito.it, Web: http://www.iceaa-offshore.org/

AP-RASC - 2010 Asia-Pacific Radio Science Conference
Toyama, Japan, 22-26 September 2010
cf. Announcement in the Radio Science Bulletin of December 2009, p. 6-8.
Contact: Prof. K. Kobayashi, Vice President for International Affairs, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Tokyo 112-8551, JAPAN, Fax: +81-3-3817-1847, E-mail: kazuya@tamacc.chuo-u.ac.jp

October 2010

Commission F Microwave Signatures Symposium
Florence, Italy, 4-8 October 2010
Contact: Prof. P. Pampaloni, IFAC/CNR, Florence, Italy, Fax +390 555 226434, E-mail: p.pampaloni@ifac.cnr.it

December 2010

2010 Asia-Pacific Microwave Conference
Yokohama, Japan, 7-10 December 2010
Contact: Prof. Kiyomichi Araki, Chair, Steering Committee, c/o Real Communications Corp., 3F Shinmatsudo, Matsudo 270-0034, Japan, Tel. +81 47-309-3616, Fax +81 47-309-3617, E-mai: nweapmc at io.ocn.ne.jp, Web: www.apmc2010.org

An up-to-date version of this Conference Calendar, with links to various conference web sites can be found at www.ursi.org/Calendar of supported meetings

News from the URSI Community

NEWS FROM A MEMBER COMMITTEE

France

Journées Scientifiques

Paris, les 16 et 17 Mars 2010

Les Journées Scientifiques 2010 d'URSI-France, placées sous le haut patronage de l'Académie des sciences, auront pour thème « Propagation et Plasmas, nouveaux enjeux, nouvelles applications ». Ces journées se tiendront au Conservatoire national des arts et métiers (Cnam) à Paris les 16 et 17 mars 2010.

L'accent sera porté, en particulier, sur deux aspects faisant l'objet, compte tenu de leurs impacts sur les projets en cours, d'un renouveau des travaux sur les plasmas qu'ils soient naturels ou artificiels :

- **L'ionosphère et l'environnement** avec :
  - **Les effets des variations de l'ionosphère sur les systèmes radio** aussi bien pour les communications que pour les systèmes de localisation et d'observation
  - **Les couplages "transitoires" entre l'atmosphère et l'ionosphère** en particulier lors de phénomènes orageux ;
  - **L'observation de l'ionosphère et de ses irrégularités** par les systèmes satellitaires et les radars HF, VHF ou UHF ; effets des phénomènes sismiques ;
  - **La tomographie** et **la modélisation du milieu** ; effets des irrégularités sur la propagation transionosphérique (scintillations) ;
  - **La météorologie de l'espace** ; influence sur les prévisions ionosphériques et effets induits sur l'ionosphère ;
  - Et toutes les autres applications dans lesquelles l'ionosphère joue un rôle.
- **La turbulence dans les plasmas et ses implications électromagnétiques** avec :
  - Les observations et caractérisations de **la turbulence dans le vent solaire et les environnements** planétaires ;
  - **La turbulence dans les Tokamaks** et ses effets sur les phénomènes de transports d'énergie et de particules, un enjeu important pour le projet ITER ;
  - **La nature des fluctuations non linéaires** : structures cohérentes ou turbulence d'ondes, turbulence ou chaos, avalanches... ;
  - **La turbulence MHD et au delà**, les effets électroniques et cinétiques dans les plasmas sans collisions.

Organisation

Les Journées scientifiques se tiendront au Cnam, 292 rue Saint-Martin, Paris 3ème et débuteront le mardi 16 mars à 9h. Elles seront suivies le mercredi 17 mars, vers 16h par l'Assemblée générale d'URSI-France. Elles sont organisées autour de sessions orales ou posters animées par des spécialistes reconnus du domaine. Les sessions orales seront introduites par des conférences invitées présentant soit l'état de l'art, soit de nouveaux développements intéressant l'ensemble de la communauté. Les communications seront sélectionnées par le comité scientifique. La sélection tiendra compte de l'équilibre des sujets présentés dans chaque session. Sauf exception, la langue de travail est le français ; toutefois les planches accompagnant les présentations pourront être en anglais.

Comité Scientifique Comité d'Organisation

Présidents : Alain Bourdillon, IETR
Philippe Savoini, LPP
Gérard Belmont, LPP,
Yannick Béniguel, IEEA
Elisabeth Blanc, CEA
Roland Fleury, TELECOM Bretagne
Jean-Jacques Guitot, ANFR
Christian Hanuise, LPC2E
Pascale Hennequin, LPP
Pierre Laroche, ONERA, SEE
Patrick Lassudrie-Duchesne, TELECOM Bretagne
Milan Maksimovitch, LESIA
Christian Mazelle, CESR,
Frédéric Pitout, LPG
Alain Bourdillon, IETR
Philippe Savoini, LPP
Joël Hamelin, URSI-France

Alain Sibille, ENSTA-ParisTech
Hervé Sizun, URSI-France
Michel Terré, CNAM
Joe Wiart, URSI-France

Les textes des communications seront consultables en ligne sur le site d'URSI-France : http://ursi-france.institut-telecom.fr

Après avis du Comité scientifique, certains auteurs seront invités à remettre leur contribution pour publication, soit dans un numéro thématique « Propagation et Plasmas» des Comptes rendus Physique de l'Académie des sciences, soit dans la Revue de l'électricité et de l'électronique (REE). Responsables des publications : Alain Bourdillon, Philippe Savoini

Dates à retenir

- **11 janvier 2010 :** clôture de réception des propositions de communications. Ces propositions seront soumises en ligne via le site : http://ursi-france.institut-telecom.fr sous la forme d'un texte clair et concis d'une à deux pages, permettant une bonne évaluation scientifique. Toutes les informations concernant le format des propositions de communications seront disponibles sur le site.
- **8 février :** réponse du Comité scientifique aux proposants.
- **8 mars :** date limite de dépôt en ligne des textes des communications.
- **16 et 17 mars** : Journées scientifiques.
- **17 mars** : liste des textes sélectionnés pour publication.

Frais d'inscription

Une participation aux frais de 180 € est demandée à tous les participants. Elle comprend entre autres les collations et pauses café. Un tarif réduit de 80€ est accordé aux étudiants et seniors.

Pour 46 € supplémentaires le numéro thématique « Propagation et Plasmas » des Comptes rendus Physique de l'Académie des sciences, reprenant les principales contributions de ces journées, vous sera adressé dès sa parution début 2011.

Inscription et informations complémentaires

Vous pourrez trouver les modalités d'inscription et toutes informations utiles relatives aux Journées scientifiques 2010 sur le site d'URSIFrance : http://ursi-france.institut-telecom.fr

BOOKS PUBLISHED FOR URSI RADIOSCIENTISTS

Essential *MATHCAD* for Engineering, Science and Math, Second Edition

by Brent Maxfield, New York, Academic Press, 2009, ISBN-13: 978-0-12-374783-9; paperback, 528 pp. There are different version of this book available, with and without CD included: EUR 36.95; USD 49.95..

MATHCAD has become a very effective and powerful mathematical tool for students and professionals in science and engineering. I have been using *MATHCAD* in my teaching for almost 20 years. Compared to other computer-based mathematical tools, *MATHCAD* is easy to learn and relatively straightforward to implement. These facts became obvious when I reviewed *Essential* MATHCAD *for Engineering, Science, and Math, Second Edition*, by Brent Maxfield, published by Academic Press.

This is a very well written book. The topics are logically arranged, from basics to gradually complex mathematical tools. Anyone without prior experience with *MATHCAD*, or someone with some degree of working experience with *MATHCAD*, would greatly benefit from the book. All chapters follow a step-by-step approach that allows easy learning. Screen shots are provided throughout the book, which, in my opinion, should give readers visual clues in terms of what to expect from the program. Useful tips are provided throughout the book, as well.

Chapter 1 provides enough basic information for a beginner to start working with *MATHCAD* right away. Chapter 1 provides information on how to create and edit functions, how to use units, how to create arrays, how to use toolbars, and how to plot *x-y* graphs. Different types of variables and regions used in *MATHCAD* are defined and explained in Chapter 2. A very useful feature of *MATHCAD* is its built-in functions. Chapter 3 covers how to use the built-in functions. User-defined functions are also discussed in this chapter. Chapter 4 covers how to use and display units, both built-in and user-defined, in great detail. Chapters 1 through 4 form Part 1 of the book, and should provide a working foundation of *MATHCAD* to anyone who has taken the first-year university math courses from any science or engineering discipline.

More-complex mathematical tools and functions, including simple logic programming, are discussed in Part 2, which is comprised of Chapters 5 to 8. Symbolic calculations, solving equations, advanced programming, and calculus

including differential equations are covered in Part 3, comprised of Chapters 9 to 12. Part 4, comprised of Chapters 13 to 23, is primarily targeted towards advanced users. However, Chapter 20, "Microsoft *Excel* Component," would be useful to any user who is familiar with Microsoft *Excel*. The book has numerous examples: some are generic-science based, and some are engineering based. However, only civil engineering examples are provided.

Overall, I found the book easy to follow. With its step-by-step treatment of tools and procedures and numerous examples, the book can be used as a self-learning tool to learn *MATHCAD*.

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Electromagnetic Fields in Stratified Media

by Kai Li, Berlin, Springer, 2009, ISBN: 978-3-540-95963-2; 224 pp.; USD189.00.

This book extensively covers the analytical calculation procedure of the EM field of a dipole located in a stratified environment. The four chapters following the introductory chapter treat particular plane cases, distinguished by the number of layers (three or four layers) and by the orientation of the exciting dipole (vertical or horizontal). The fields of a dipole source over a dielectric-coated sphere (Earth) and over a multi-layered sphere are then treated. The two final chapters cover the transient field of a dipole on the boundary between two dielectrics, including the case where one of the layers is a one-dimensionally anisotropic medium.

While the analytical formulae are valid for a much larger set of situations, the results that are explicitly evaluated and shown in figures mainly focus on wave propagation when the material parameters fit some practical Earth-air or water-air situations. However, in general the author focuses more on the analytical formulae. This becomes evident by the following numbers: Of a total of 224 pages, the book contains 100 figures and 836 displayed (numbered) formulae, a significant part of them spanning several lines. In short terms: there are clearly more formulae than text.

In general, analytic EM field calculations deliver exact solutions within the framework of the model. However, if analytical results are compared against real-world measurements, accuracy discussions turn to questions about fitting the real world by the given model. This book does not cover any questions in that area. It simply solves the ideal mathematical model by means of analytical approaches, and remains in this model world.

For the plane-stratified environment treated in Chapters 2 to 5, this analytical approach consists of a spatial Fourier transform of the incident dipole field, resulting in a two-dimensional integral of plane waves. The reflection and transmission for each of these plane waves is easily performed, and the final result is then reduced to a one-dimensional integral over cylindrical waves. Depending on the thicknesses of the layers and their electrical properties, the analytical treatment of this final integral leads to an expression with a finite sum of terms. These are interpreted as the direct wave, the image reflected wave, the "lateral wave" (a term with a $1/r^2$ behavior, even in the lossless case, where r is the distance from the exciting dipole), and a number of "trapped surface waves" (essentially, waves guided inside the middle layers, showing a $1/\sqrt{r}$ behavior if no lossy materials are present). Both the nomenclature and the representation of the results is strongly based on the paper of King and Sandler (*Radio Science*, 1994). The final results are more or less complicated formulae for all the components of the electromagnetic field. The majority of the figures show the run of certain field components for particular material combinations, either along the distance from the source or along an elevation angle.

In the chapters on the "dielectric-coated spherical Earth," the analytical treatment includes the overall assumption of a large radius of the sphere and a comparatively small thickness of the coating. This allows a local treatment of the coating, as in the flat case. The results focus on low frequencies ($f = 100$ kHz up to a few MHz) along the real Earth surface, and treat distances up to 500 km away from the radiating dipole.

The remaining chapters go back to the flat environment. They treat the transient field of pulsed exciting dipoles (δ and Gaussian time pulses), located at the boundary between two media. The analytical computations are carried out over about 20 pages of formulae, starting with a Fourier transform ($\omega \rightarrow t$), and ending with a number of finite integrals that are analytically treatable.

Unless the reader is already an expert in this field, the book is designed to be read from start to end, and the reader should have some other papers at hand. This is because those papers are mentioned very often in the text, and it is assumed that the reader is familiar with their content. For example, if the aforementioned paper by King and Sandler is not available, it might be difficult to read only part of the book, or to extract single results. In fact, many of the symbols are defined only once, and at locations that are hard to find later on, or they are even defined only in cited papers. From this point of view, a complete list of symbols in some appendix would have been very useful. However, some of the symbols slightly change their meaning through

the text. For example, in the introduction, the air is in the region $z \le 0$, while later on, air is in the range $z \ge 0$. Another example is k_2, which denotes the wavenumber of layer 2 when the counting starts with zero in the air. In Section 8.2, k_2 mutates into the wavenumber in air.

Estimations of possible errors is a missing part. As already mentioned, the link from the mathematical model to the real world is not treated. However, even inside the mathematical model, one could perform some validation procedures or sensitivity analysis. For example, on page 73 there is the statement, "When the far-field conditions $\left|p_1^*\right| \ge 4$ and $\left|p_2^*\right| \ge 4$ are satisfied....," followed by five pages containing only five lines of text, plus six simplified multi-line formulae for the six field components. Nothing is said related to questions such as, "To which degree of accuracy are those formulae valid if, say, $\left|p_1^*\right| = 3.8$?"

In summary, the book is interesting for people with much interest in the details of advanced analytical electromagnetic treatments. It is essentially a summary of the well-known works on the propagation of electromagnetic waves along surfaces, starting from Zennek in 1907, Sommerfeld, Watson, Norton, Wait, King, etc., all the way up to the recently published work of the author, Kai Li, and his colleagues.

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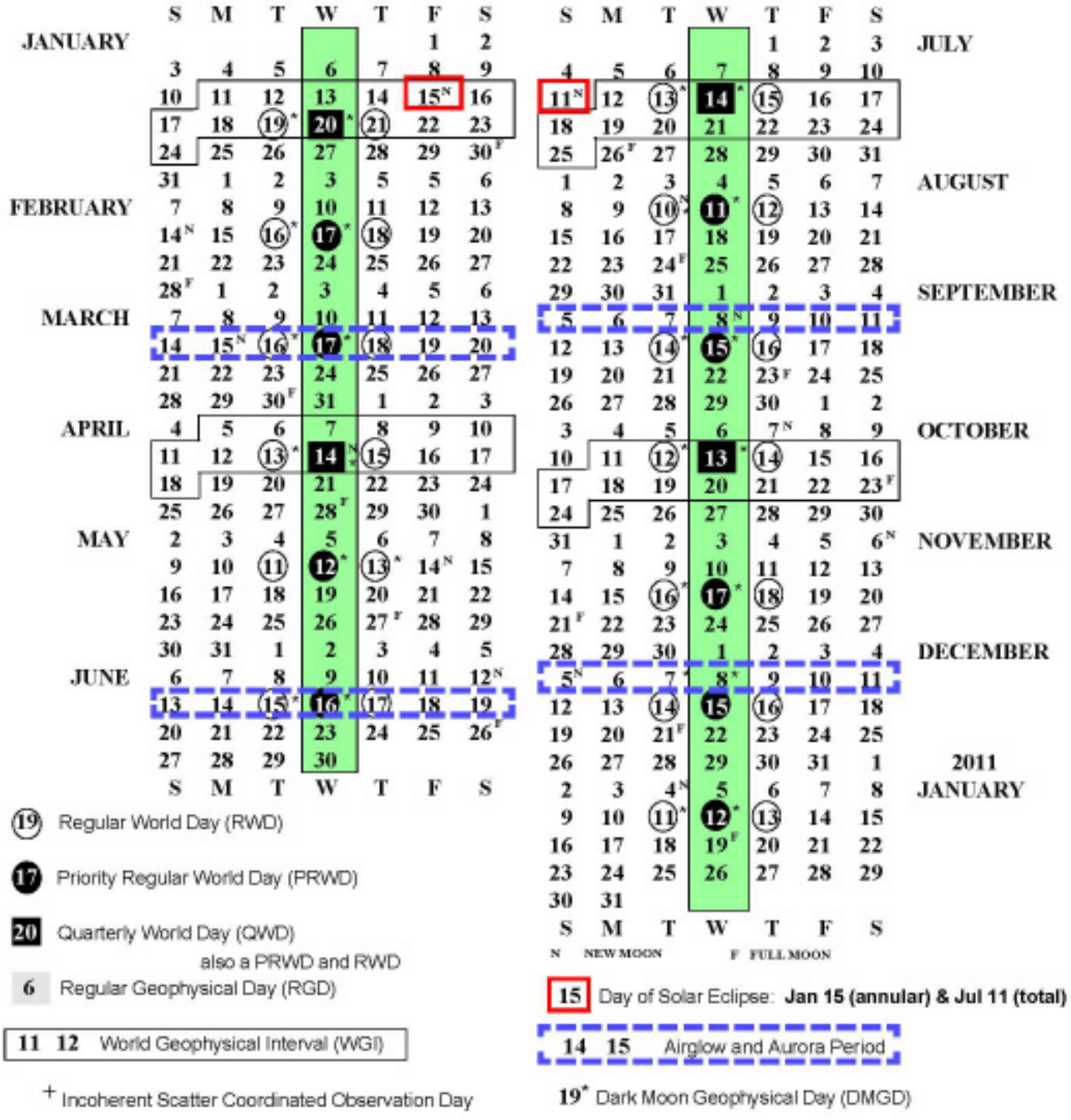
Request for Books

If any colleague knows of a book that would be appropriate for review in the *Radio Science Bulletin*, please contact Kristian Schlegel via e-mail: at KS-URSI@email.de.

International Geophysical Calendar *



This Calendar continues the series begun for the IGY years 1957-58, and is issued annually to recommend dates for solar and geophysical observations, which cannot be carried out continuously. Thus, the amount of observational data in existence tends to be larger on Calendar days. The recommendations on data reduction and especially the flow of data to World Data Centers (WDCs) in many instances emphasize Calendar days. The Calendar is prepared by the International Space Environment Service (ISES) with the advice of spokesmen for the various scientific disciplines. For some programs, greater detail concerning recommendations appears from time to time published in IAGA News, IUGG Chronicle, URSI Information Bulletin and other scientific journals or newsletters.

The Calendar provides links to many international programs, giving an opportunity for scientists to become involved with data monitoring and research efforts. International scientists are encouraged to contact the key people and join the worldwide community effort to understand the Sun-Earth environment.

The definitions of the designated days remain as described on previous Calendars. Universal Time (UT) is the standard time for all world days. Regular Geophysical Days (RGD) are each Wednesday. Regular World Days (RWD) are three consecutive days each month (always Tuesday, Wednesday and Thursday near the middle of the month). Priority Regular World Days (PRWD) are the RWD which fall on Wednesdays. Quarterly World Days (QWD) are one day each quarter and are the PRWD which fall in the World Geophysical Intervals (WGI). The WGI are fourteen consecutive days in each season, beginning on Monday of the selected month, and normally shift from year to year. In 2010 the WGI are January, April, July and October.

2010 Solar Eclipses:

a) **January 15, 2010. An annular solar eclipse** crosses Africa, the Indian Ocean, and Asia. The best observing locations are extreme southern India, northern Sri Lanka (if political problems are better by then), extreme southern Bangladesh, extreme northern Myanmar (subject to a different kind of political problem), and China (up to Qingdao). The beginning of the path crosses the southern tip of Chad, the Central African Republic, Congo, Uganda, Kenya (including Nairobi), and the southern tip of Somalia. Partial phases will be available in eastern Europe (including southern Italy low in the sky), all of Africa except the extreme west and the Cape Town region in the extreme south), and all of Asia up to eastern Japan and the middle of Java.

b) **July 11, 2010. A total solar eclipse** crosses the Pacific, hitting land mainly at Easter Island (Chile), and then low in the sky on the southern Chilean coast, with unfavorable weather conditions at that winter time of year. The eclipse will also be available by boat from some southern Pacific islands, especially south of French Polynesia. The small island Tatakoto in the Tuamoto Islands is near the centerline, as well as Kikueru and Tauere in the same group. The path also crosses the Pacific south of the Cook Islands, and crosses Oneroa and Ivirua. Partial phases near sunset reach Peru, Bolivia, Chile, Argentina, Uruguay, Paraguay and southern Brazil.

By Jay M. Pasachoff, Chair, International Astronomical Union Working Group on Eclipses, Based on calculations from Fred Espenak, NASA's Goddard Space Flight Center, and information from Jay M. Pasachoff, Peterson Field Guide to the Stars and Planets.

Eclipse References:

- Fred Espenak, Fifty Year Canon of Solar Eclipses: 1986-2035, NASA Reference Publication 1178 Revised, July 1987.
- Leon Golub and Jay M. Pasachoff, The Solar Corona, Cambridge University Press, 1998.
- Jay M. Pasachoff and Alex Filippenko, The Cosmos: Astronomy in the New Millennium, Brooks/Cole Publishers, 2002, 2004 and 2006.
- Leon Golub and Jay M. Pasachoff, Nearest Star: The Exciting Science of Our Sun, Harvard University Press, 2001.
- Jay M. Pasachoff, The Complete Idiot's Guide to the Sun, Alpha Books, 2003.

NOTE — **List of 2010 Meteor Showers being developed**

Real Time Space Weather and Earth Effects. The occurrence of **unusual solar or geophysical conditions** is announced or forecast by the ISES through various types of geophysical **"Alerts"** (which are widely distributed via the internet on a current schedule). Stratospheric warmings (STRATWARM) were also designated for many years. The meteorological telecommunications network coordinated by the World Meteorological Organization (WMO) carries these worldwide Alerts once daily soon after 0400 UT. For definitions of Alerts see ISES "Synoptic Codes for Solar and Geophysical Data", March 1990 and its amendments. For many years Retrospective World Intervals were selected and announced by MONSEE (Monitoring of the Sun-Earth Environment) and elsewhere to provide additional analyzed data for particular events studied in the ICSU Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) programs.

Recommended Scientific Programs (Draft Edition)

(The following material was reviewed in 2009 by spokesmen of IAU, IAGA, WMO and URSI as suitable for coordinated geophysical programs in 2010.)

Airglow and Aurora Phenomena.

Airglow and auroral observatories operate with their full capacity around the New Moon periods. However, for progress in understanding the mechanism of many phenomena, such as low latitude aurora, the coordinated use of all available techniques, optical and radio, from the ground and in space is required. Thus, for the airglow and aurora 7-day periods on the Calendar, ionosonde, incoherent scatter, special satellite or balloon observations, etc., are especially encouraged. Periods of approximately one weeks' duration centered on the New Moon are proposed for high resolution of ionospheric, auroral and magnetospheric observations at high latitudes during northern winter.

Atmospheric Electricity.
Non-continuous measurements and data reduction for continuous measurements of atmospheric electric current density, field, conductivities, space charges, ion number densities, ionosphere potentials, condensation nuclei, etc.; both at ground as well as with radiosondes, aircraft, rockets; should be done with first priority on the RGD each Wednesday, beginning on 6 January 2010 at 0000 UT, 13 January at 0600 UT, 20 January at 1200 UT, 27 January at 1800 UT, etc. (beginning hour shifts six hours each week, but is always on Wednesday). Minimum program is at the same time on PRWD beginning with 20 January at 1200 UT. Data reduction for continuous measurements should be extended, if possible, to cover at least the full RGD including, in addition, at least 6 hours prior to indicated beginning time. Measurements prohibited by bad weather should be done 24 hours later. Results on sferics and ELF are wanted with first priority for the same hours, short-period measurements centered around the minutes 35-50 of the hours indicated. Priority Weeks are the weeks that contain a PRWD; minimum priority weeks are the ones with a QWD. The World Data Centre for Atmospheric Electricity, 7 Karbysheva, St. Petersburg 194018, USSR, is the collection point for data and information on measurements.

Geomagnetic Phenomena.
It has always been a leading principle for geomagnetic observatories that operations should be as continuous as possible and the great majority of stations undertake the same program without regard to the Calendar.

Stations equipped for making magnetic observations, but which cannot carry out such observations and reductions on a continuous schedule are encouraged to carry out such work at least on RWD (and during times of MAGSTORM Alert).

Ionospheric Phenomena.
Special attention is continuing on particular events that cannot be forecast in advance with reasonable certainty. These will be identified by Retrospective World Intervals. The importance of obtaining full observational coverage is therefore stressed even if it is only possible to analyze the detailed data for the chosen events. In the case of vertical incidence sounding, the need to obtain quarter-hourly ionograms at as many stations as possible is particularly stressed and takes priority over recommendation (a) below when both are not practical.

For the **vertical incidence (VI) sounding program,** the summary recommendations are:

(a) All stations should make soundings on the hour and every quarter hour;

(b) On RWDs, ionogram soundings should be made at least every quarter hour and preferably every five minutes or more frequently, particularly at high latitudes;

(c) All stations are encouraged to make f-plots on RWDs; f-plots should be made for high latitude stations, and for so-called "representative" stations at lower latitudes for all days (i.e., including RWDs and WGIs) (Continuous records of ionospheric parameters are acceptable in place of f-plots at temperate and low latitude stations);

(d) Copies of all ionogram scaled parameters, in digital form if possible, be sent to WDCs; (e) Stations in the eclipse zone and its conjugate area should take continuous observations on solar eclipse days and special observations on adjacent days. See also recommendations under Airglow and Aurora Phenomena.

NOTE — List of 2010 Incoherent Scatter Observation Program being developed

Special programs: Dr. Ingemar Haggstrom, EISCAT, Box 812, SE-98128 Kiruna, Sweden; tel: +46 98079155;Fax: +46 98079159; e-mail ingemar@eiscat.se; URSI Working Group G.5. See the 2009 Incoherent Scatter Coordinated Observation Days (URSI-ISWG) webpage for complete 2009 definitions.

For the ionospheric drift or wind measurement by the various radio techniques, observations are recommended to be concentrated on the weeks including RWDs.

For traveling ionosphere disturbances, propose special periods for coordinated measurements of gravity waves induced by magnetospheric activity, probably on selected PRWD and RWD.

For the ionospheric absorption program half-hourly observations are made at least on all RWDs and half-hourly tabulations sent to WDCs. Observations should be continuous on solar eclipse days for stations in eclipse zone and in its conjugate area. Special efforts should be made to obtain daily absorption measurements at temperate latitude stations during the period of Absorption Winter Anomaly, particularly on days of abnormally high or abnormally low absorption (approximately October-March, Northern Hemisphere; April-September, Southern Hemisphere).

For back-scatter and forward scatter programs, observations should be made and analyzed at least on all RWDs.

For synoptic observations of mesospheric (D region) electron densities, several groups have agreed on using the RGD for the hours around noon.

For ELF noise measurements involving the earth-ionosphere cavity resonances any special effort should be concentrated during the WGIs.

It is recommended that more intensive observations in all programs be considered on days of unusual meteor activity.

Meteorology. Particular efforts should be made to carry out an intensified program on the RGD — each Wednesday, UT. A desirable goal would be the scheduling of meteorological rocketsondes, ozone sondes and radiometer sondes on these days, together with maximum-altitude rawinsonde ascents at both 0000 and 1200 UT.

During **WGI and STRATWARM Alert Intervals,** intensified programs are also desirable, preferably by the implementation of RGD-type programs (see above) on Mondays and Fridays, as well as on Wednesdays.

Global Atmosphere Watch (GAW): The World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) integrates many monitoring and research activities involving measurement of atmospheric composition. Serves as an early warning system to detect further changes in atmospheric concentrations of greenhouse

gases, changes in the ozone layer and in the long range transport of pollutants, including acidity and toxicity of rain as well as of atmospheric burden of aerosols (dirt and dust particles). Contact WMO, 7 bis avenue de la Paix, P.O. Box 2300, 1211 Geneva, Switzerland.

Solar Phenomena. Observatories making specialized studies of solar phenomena, particularly using new or complex techniques, such that continuous observation or reporting is impractical, are requested to make special efforts to provide to WDCs data for solar eclipse days, RWDs and during PROTON/FLARE ALERTS. The attention of those recording solar noise spectra, solar magnetic fields and doing specialized optical studies is particularly drawn to this recommendation.

CAWSES (Climate and Weather of the Sun-Earth System). Program within the SCOSTEP (Scientific Committee on Solar-Terrestrial Physics): 2004-2008. Its focus is to mobilize the community to fully utilize past, present, and future data; and to produce improvements in space weather forecasting, the design of space- and Earth-based technological systems, and understanding the role of solar-terrestrial influences on Global Change. Contact is Susan Avery (susan.avery@colorado.edu), Chair of CAWSES Science Steering Group. Program theme areas are: Solar Influence on Climate, M. Lockwood and L. Gray (UK); Space Weather: Science and Applications, J. Kozyra (USA) and K. Shibata (Japan); Atmospheric Coupling Processes, F. Luebken (Germany) and J. Alexander (USA); Space Climatology, C. Frolich (Switzerland) and J. Sojka (USA); and Capacity Building and Education, M.A. Geller (USA). See the CAWSES website for more information.

Space Research, Interplanetary Phenomena, Cosmic Rays, Aeronomy. Experimenters should take into account that observational effort in other disciplines tends to be intensified on the days marked on the Calendar, and schedule balloon and rocket experiments accordingly if there are no other geophysical reasons for choice. In particular it is desirable to make rocket measurements of ionospheric characteristics on the same day at as many locations as possible; where feasible, experimenters should endeavor to launch rockets to monitor at least normal conditions on the Quarterly World Days (QWD) or on RWDs, since these are also days when there will be maximum support from ground observations. Also, special efforts should be made to assure recording of telemetry on QWD and Airglow and Aurora Periods of experiments on satellites and of experiments on spacecraft in orbit around the Sun.

Meteor showers. Of particular interest are both predicted and unexpected showers from the encounter with recent dust ejecta of comets (meteor outbursts). The period of activity, level of activity, and magnitude distributions need to be determined in order to provide ground truth for comet dust ejection and meteoroid stream dynamics models. Individual orbits of meteoroids can also provide insight into the ejection circumstances. If a new (1-2 hour duration) shower is observed due to the crossing of the 1-revolution dust trail of a (yet unknown) Earth threatening long-period comet, observers should pay particular attention to a correct determination of the radiant and time of peak activity in order to facilitate predictions of future encounters. Observations of meteor outbursts should be reported to the I.A.U. Minor Planet Center (dgreen@cfa.harvard.edu) and International Meteor Organization (visual@imo.net). The activity curve, mean orbit, and particle size distribution of minor annual showers need to be characterised in order to understand their relationship to the dormant comets among near-Earth objects. Annual shower observations should be reported to national meteor organizations, or directly to the International Meteor Organization. Meteoroid orbits are collected by the IAU Meteor Data Center.

The International Space Environment Service (ISES) is a permanent scientific service of the International Union of Radio Science (URSI), with the participation of the International Astronomical Union and the International Union Geodesy and Geophysics. ISES adheres to the Federation of Astronomical and Geophysical Data Analysis Services (FAGS) of the International Council of Scientific Unions (ICSU). The ISES coordinates the international aspects of the world days program and rapid data interchange.

This Calendar for 2010 has been drawn up by H.E. Coffey, of the ISES Steering Committee, in association with spokesmen for the various scientific disciplines in SCOSTEP, IAGA and URSI and other ICSU organizations. Similar Calendars are issued annually beginning with the IGY, 1957-58, and are published in various widely available scientific publications. PDF versions of the past calendars are available online.

The Geophyysical Calendar is published for the International Council of Scientific Unions with financial assistance of UNESCO for many years.

Additional copies are available upon request to ISES Chairman, Dr. David Boteler, Geomagnetic Laboratory, Natural Resources Canada, 7 Observatory Crescent, Ottawa, Ontario, Canada, K1A 0Y3, FAX (613)824-9803, e-mail dboteler at NRCan.gc.ca, or ISES Secretary for World Days, Ms. H.E. Coffey, WDC for Solar-Terrestrial Physics, Boulder, NOAA E/GC2, 325 Broadway, Boulder, Colorado 80305, USA FAX number (303)497-6513; e-mail Helen.E.Coffey at noaa.gov. Information about the calendar is also available on-line at ISES (see Geo-Calendar link).

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