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A T T I

DELLA «FONDAZIONE GIORGIO RONCHI»

Numero Speciale 8 - Serie di Elettromagnetismo
su

XIX Riunione Nazionale di Elettromagnetismo (RiNEm)

Roma, 10-14 settembre 2012

A cura di
GIUSEPPE SCHETTINI e LUCIO VEGNI
(Università “Roma Tre”)

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A cura di
Giuseppe Schettini e Lucio Vegni
(Università “Roma Tre”)

Università degli Studi di Firenze

I volumi della Serie di Elettromagnetismo editi dalla Fondazione Ronchi, sono acquisibili in formato pdf all’URL del Laboratorio di Elettromagnetismo Numerico del Dipartimento di Elettronica e Telecomunicazioni dell’Università di Firenze all’indirizzo *http://ingfi9.det.unifi.it/*.

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Prefazione al Numero Speciale 8 Serie di Elettromagnetismo

La Fondazione Giorgio Ronchi, tramite i suoi Atti, ha contribuito costantemente alla pubblicazione di contributi che evidenziano le attività nazionali che si sviluppano nel settore dell'elettromagnetismo, a testimonianza della vivace operosità della nostra comunità scientifica. In questo contesto vale la pena ricordare che la Fondazione Giorgio Ronchi ha inoltre dedicato dal 2002 al 2010 alcuni numeri dei propri Atti alla "Serie di Elettromagnetismo". Mentre nei primi anni i numeri hanno avuto cadenza annuale, con la pubblicazione dei *Quaderni della Società Italiana di Elettromagnetismo* essi si sono necessariamente diradati per evitare inutili sovrapposizioni. La Fondazione ha inoltre pubblicato una selezione dei contributi scientifici alla Riunione Nazionale di Elettromagnetismo (RiNEm) tenutasi a Firenze nel 1996 e a Cetraro (Cosenza) nel 1998.

In questo contesto è importante ricordare che sempre sugli Atti della Fondazione Ronchi è stato recentemente pubblicato il lavoro, di P. Lampariello e G. Pelosi, dal titolo "La Riunione Nazionale di Elettromagnetismo: 30 anni di attività scientifica in Italia" (*Atti della Fondazione Ronchi*, LXVII, 2, pp. 197-224, Marzo-Aprile 2012).

Questo Numero Speciale degli *Atti della Fondazione Ronchi* è invece dedicato alla XIX Riunione Nazionale di Elettromagnetismo che si è tenuta a Roma dal 10 al 14 settembre 2012. Il Numero Speciale, coordinato da Giuseppe Schettini e Lucio Vegni (Università "Roma Tre"), è articolato in parti distinte. La Parte I è la raccolta dei sommari dei lavori presentati alla manifestazione, mentre la Parte II è relativa alle sessioni plenarie. La Parte III è invece dedicata ai Premi assegnati ai giovani ricercatori. Infine una "Galleria fotografica" relativa agli eventi è presentata nella Parte IV.

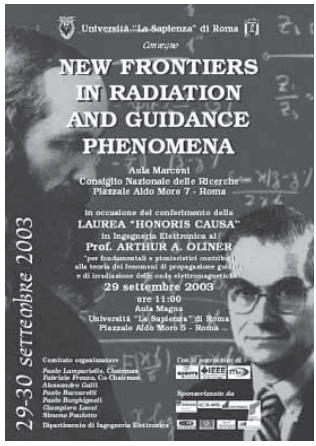
Per quanto riguarda l'immediato futuro la consueta riunione congiunta GTTI/SIEm, la cui ultima edizione si è tenuta a Taormina nel 2011 (Newsletter della SIEm, n. 5, ottobre 2011), si svolgerà prossimamente presso la sede di Ancona nel giugno 2013, mentre per la XX RiNEm sarà l'Unità di Padova della SIEm a organizzare l'evento che si terrà a Padova nel 2014, con il coordinamento di Andrea Galtarossa.

Paolo Lampariello
Presidente della Società Italiana di Elettromagnetismo

Atti della Fondazione Giorgio Ronchi
Serie di Elettromagnetismo

La *Fondazione Giorgio Ronchi* dedica dal 2002 un numero dei propri *Atti* alla "Serie di Elettromagnetismo". La serie ha lo scopo contribuire a testimoniare le attività nazionali che costantemente si sviluppano nel settore dell'elettromagnetismo, a testimonianza della vivace operosità di questa comunità scientifica. I contenuti dei volumi della serie, finora pubblicati, sono riportati di seguito. Dalla lista è escluso il presente Numero Speciale.

– *Atti della Fondazione Giorgio Ronchi*, **57**, 4, pp. 531-748, Luglio-Agosto 2002 [*Il metodo degli elementi finiti nelle applicazioni dell'ingegneria elettrica dell'informazione*, Cassino 19-20 Aprile 2001; *Modelli analitici e numerici per la diffrazione dei campi elettromagnetici*, Fisciano (Salerno), 18 Dicembre 2001; *Applicazioni delle reti neurali all'ingegneria elettrica ed elettromagnetica*, Firenze, 3-4 Aprile 2002].
– *Atti della Fondazione Giorgio Ronchi*, **58**, 3-4, pp. 301-555, Maggio-Giugno 2003 [*Circuiti, dispositivi e tecnologie per le microonde e le onde millimetriche*, Orvieto, 3-4 Luglio 2002; *Modelli analitici e numerici per la diffrazione dei campi elettromagnetici*, Fisciano (Salerno), 6 Dicembre 2002; *La progettazione della radiocopertura*, Padova, 11 Aprile 2003; *Materiali speciali e metamateriali per l'elettromagnetismo e le TLC*, Firenze, 16 Aprile 2003].
– *Atti della Fondazione Giorgio Ronchi*, **59**, pp. 1-307, Gennaio-Aprile 2004 [*Applicazione delle reti neurali all'ingegneria elettrica e dell'informazione*, Pavia, 26-27 Maggio 2003; *Strumenti e tecniche di misura per la protezione dell'uomo e dell'ambiente dai campi elettromagnetici*, Firenze, 28-29 Maggio 2003, *Laurea "honoris causa" in Ingegneria Elettronica conferita al Prof. Arthur A. Oliner dall'Università "La Sapienza" di Roma*, Roma, 29 Settembre 2003; *New frontiers in radiation and guidance phenomena*, Rome, September 29-30, 2003; *L'ICT e la ripresa: presupposti e fattori abilitanti*, Padova, 24 Novembre 2003].
– *Atti della Fondazione Giorgio Ronchi*, **60**, 1-2, pp. 1-416, Gennaio-Aprile 2005 [*MEMS a radiofrequenza*, Perugia, 5 Dicembre 2003; *Microwave radiometry and remote sensing applications*, Rome, February 24-27, 2004], *Schiere riflettenti stampate*, [Rende, 27 Febbraio 2004; *Interazione tra campi*



Locandina del Convegno *New frontiers in radiation and guidance phenomena*, Rome, September 29-30, 2003 (*Atti della Fondazione Ronchi*, **59**, pp. 1-307, Gennaio-Aprile 2004).

elettromagnetici e soggetti esposti, Roma, 1-2 Aprile 2004; *Materiali speciali e metamateriali per l'elettromagnetismo e le TLC*, Roma, 5 Aprile 2004; *La figura di Giorgio Barzilai nella ricerca italiana in elettromagnetismo e in elettronica*, Roma, 15-16 Aprile 2004; *Il metodo degli elementi finiti nelle applicazioni dell'ingegneria elettrica e dell'informazione*, Genova, 3-4 Giugno 2004; *"L'avventura della radio". Un viaggio nella storia, scienza e arte delle Telecomunicazioni "Collezione Patanè"*, Firenze, 4-28 Giugno 2004].

– *Atti della Fondazione Giorgio Ronchi*, **61**, 3-4, pp. 293-511, Maggio-Agosto 2006 [*Storia dell'Ingegneria - La nascita dell'Ingegneria "moderna" tra 800 e 900*, Firenze, Maggio-Giugno 2004; *Sardinia Radio Telescope (SRT): ricerche*

Dal Catalogo delle mostra "L'avventura della radio": ricevitore GEcoPHONE, General Electric Co., Ltd. Sigillo BBC-GPO n. 102 (*Atti della Fond. G. Ronchi*, **60**, 1-2, pp. 1-416, Gennaio-Aprile 2005).

e sviluppi della strumentazione, Cagliari, 13 Settembre 2004; *Caratterizzazione di antenne da misure di campo vicino*, Fisciano (Salerno), 10 Dicembre 2004; *Il Centro Interuniversitario MECSA: dieci anni di attività*, Orvieto, 12 Aprile 2005; *Tecnologie elettroniche ed elettromagnetiche per lo spazio*, Orvieto, 12-14 Aprile 2005].

Il Palazzo del Capitano del Popolo di Orvieto (dove si è tenuto dal 12 al 14 Aprile 2005 il Convegno "Tecnologie elettroniche ed elettromagnetiche per lo spazio" (organizzato dal Centro Interuniverstario MECSA) in una cartolina dei primi anni del secolo scorso (Collezione Giannini) (*Atti della Fond. G. Ronchi*, **61**, 3-4, pp. 293-511, Maggio-Agosto 2006).

– *Atti della Fondazione Giorgio Ronchi*, **63**, 1-2, pp. 1-235, Gennaio-Aprile 2008 [*Caratterizzazione di antenne*, Fisciano (Salerno), 7 Dicembre 2006 *Progettazione e sviluppo di moderni sistemi di antenna*, Fisciano (Salerno), 14-15 Maggio 2007].

Locandina del Convegno, organizzato dal Centro Interuniverstario MECSA, "Progettazione e sviluppo di nuovi sistemi di antenne", Fisciano (Salerno), 14-15 Maggio 2007 (*Atti della Fond. G. Ronchi*, **63**, 1, pp. 1-235, Gennaio-Febbraio 2008).

– *Atti della Fondazione Giorgio Ronchi*, **65**, 3, pp. 293-429, Maggio-Giugno 2010 [*Caratterizzazione di antenne*, Fisciano (Salerno), 23 Ottobre 2009].

Laura Ronchi Abbozzo - *Fondazione Giorgio Ronchi*

La Riunione Nazionale di Elettromagnetismo (RiNEm)

La Riunione Nazionale di Elettromagnetismo ha, come è noto, lo scopo di fornire una panoramica delle attività di ricerca applicata svolte in Italia nell'elettromagnetismo. Essa rappresenta un'occasione sia per un incontro sia per uno scambio di idee e di esperienze tra tutti coloro che sono impegnati nella ricerca nell'ambito dell'ingegneria elettromagnetica nelle Università, negli enti di ricerca e nelle industrie.

A partire dal 1976 il Gruppo di Ricercatori di Elettromagnetismo del Comitato Nazionale per le Scienze di Ingegneria ed Architettura del C.N.R. ha indetto, con cadenza biennale, la Riunione Nazionale di Elettromagnetismo Applicato o RINEMA (dall'edizione del 1992 ha preso il nome di "Riunione Nazionale di Elettromagnetismo", con l'acronimo RiNEm). Dall'edizione del 2002 le Riunioni sono state promosse dalla Società Italiana di Elettromagnetismo (SIEm).

Le Riunioni finora tenutesi sono elencate di seguito:

I. Facoltà di Ingegneria, Università de L'Aquila, L'Aquila 24-25 Giugno 1976 (Coordinatore della Riunione: Prof. Fernando Bardati, Università di Roma).

II. Facoltà di Ingegneria, Università di Pavia, Pavia, 2-4 Ottobre 1978 (Coordinatore della Riunione: Prof. Giuseppe Conciauro, Università di Pavia).

III. Facoltà di Ingegneria, Politecnico di Bari, Bari, 25-27 Giugno, 1980 (Coordinatore della Riunione: Prof. Roberto De Leo, Politecnico di Bari).

IV. Istituto di Ricerca sulle Onde Elettromagnetiche del C.N.R., Firenze, 4-6 Ottobre, 1982 (Coordinatore della Riunione: Prof.ssa Annamaria Scheggi, Istituto di Ricerca sulle Onde Elettromagnetiche del C.N.R.).

V. Centro Congressi dell'Hotel Billia, Saint Vincent (Aosta), 9-12 Ottobre, 1984 (Coordinatore della Riunione: Prof. Mario Orefice, Politecnico di Torino).

VI. Facoltà di Ingegneria, Università di Trieste, 22-24 Ottobre 1986 (Coordinatore della Riunione: Prof. Edoardo Carli, Università di Trieste).

VII. Villa Tuscolana, Frascati (Roma), 5-8 Settembre 1988 (Coordinatore della Riunione: Prof. Fernando Bardati, Università di Roma "Tor Vergata").

VIII. Capri (Napoli), 9-12 Ottobre 1990 (Coordinatore della Riunione: Prof. Giorgio Franceschetti, Università di Napoli "Federico II").

IX. La Cittadella, Assisi (Perugia), 5-8 Ottobre 1992 (Coordinatore della Riunione: Prof. Roberto Sorrentino, Università di Perugia).

X. Cesena (Forlì), 21-23 Settembre 1994. Fondazione "G. Marconi", Pontecchio Marconi (Bologna), 24 Settembre 1994 (Coordinatore della Riunione: Prof. Gabriele Falciasecca, Università di Bologna).

XI. Auditorum della Banca Toscana, Firenze, 1-4 Ottobre 1996 (Coordinatore della Riunione: Prof.ssa Laura Ronchi Abbozzo, Istituto di Ricerca sulle Onde Elettromagetiche "Nello Carrara", C.N.R.).

XII. Grand Hotel S. Michele, Cetraro (Cosenza), 28 Settembre-1 Ottobre 1998 (Coordinatore della Riunione: Prof. Giuseppe Di Massa, Università della Calabria).

XIII. Villa Olmo, Como, 25-28 Settembre 2000 (Coordinatore della Riunione: Prof. Carlo Capsoni, Politecnico di Milano).

XIV. Facoltà di Ingegneria, Università Politecnica delle Marche, Ancona, 16-19 Settembre 2002 (Coordinatore della Riunione: Prof. Tullio Rozzi, Università Politecnica delle Marche).

XV. Centro Congressi della Fiera Internazionale della Sardegna, Cagliari, 13-16 Settembre 2004 (Coordinatore della Riunione: Prof. Giuseppe Mazzarella, Università di Cagliari).

XVI. Starhotel President, Genova, 18-21 Settembre 2006 (Coordinatore della Riunione: Prof. Matteo Pastorino, Università di Genova).

XVII. Lecce, 15-19 Settembre 2008 (Coordinatore della Riunione: Prof. Luciano Tarricone, Università di Lecce).

XVIII. Benevento, 6-10 Settembre 2010 (Coordinatore della Riunione: Prof. Innocenzo Pinto, Università del Sannio a Benevento).

Copertina degli Atti della X Riunione Nazionale di Elettromagnetismo.

Per tutte le edizioni della RiNEm sono state rese disponibili o delle edizioni cartacee o dei CD-Rom dei lavori presentati (edizione di Cagliari, Genova e di Lecce). In alcuni casi sono state anche pubblicate delle selezioni dei lavori in libri o in riviste a carattere nazionale:

– *Italian Recent Advances in Applied Electromagnetics*, G. Franceschetti e R. Pierri (a cura di), Liguori: Napoli, 1991.

– *Atti della Fondazione Giorgio Ronchi*, L. Ronchi Abbozzo (a cura di), LII, n. 1, 1997.

– *Atti della Fondazione Giorgio Ronchi*, G. Di Massa (a cura di), LIV, 3-4, Maggio-Agosto 1999.

– *Quaderni della Società Italiana di Elettromagnetismo*, G. Mazzarella (a cura di), **1**, 2 Luglio 2005.

Copertina degli Atti della X Riunione Nazionale di Elettromagnetismo (Cagliari, 13-16 Settembre 2004).

Villa Olmo (Como), sede del Centro di Cultura Scientifica "Alessandro Volta", dove si è tenuta la XIII RiNEm, organizzata dal Politecnico di Milano.

XIX Riunione Nazionale di Elettromagnetismo (RiNEm)

Roma, 10-14 settembre 2012

Presentazione

Dal 10 al 14 settembre 2012 si è svolta presso il Dipartimento di Ingegneria dell'Università "Roma Tre" la XIX edizione della Riunione Nazionale di Elettromagnetismo (XIX RiNEm). La precedente RiNEm si era tenuta a Benevento nel settembre 2010.

Questa edizione della RiNEm, nel decimo anno dalla fondazione della Società Italiana di Elettromagnetismo (SIEm) e nel ventesimo dalla nascita dell'Università "Roma Tre", è stata ricca di relazioni, discussioni scientifiche, presentazioni di novità, ma anche di momenti sociali, per esempio durante i pranzi o le pause caffè e durante la cena sociale. La Riunione si è articolata in 18 sessioni orali e 3 sessioni *poster*, per un numero complessivo di 153 lavori presentati. Una sessione è stata organizzata dall'URSI (*Union Radio-Scientifique Internationale*).

Gli Atti della XIX RiNEm sono disponibili su CD-Rom (ISBN: 978-88-907599-0-1). Nella Parte I di questo Numero Speciale sono riportati solo i sommari dei lavori presentati alla manifestazione nell'ordine in cui sono presenti nel CD-Rom. In ogni caso le memorie complete sono anche reperibili all'URL della Società Italiana di Elettromagnetismo all'indirizzo *http://www.elettromagnetismo.it/*.

Molti dei lavori presentati sono stati in collaborazione con industrie, enti e università anche di paesi esteri, a testimonianza, assieme all'elevata qualità delle relazioni, della notevole vivacità intellettuale del settore. La partecipazione di un elevato numero di giovani, sia dottorandi sia studenti di laurea magistrale provenienti da varie sedi di tutto il Paese, ha mostrato la potenzialità di mantenere la suddetta vivacità in prospettiva nel tempo.

Sono stati presenti alla Riunione anche quattro ospiti stranieri che, in seduta plenaria, hanno illustrato argomenti di ampio e attuale respiro. Il Prof. Andrea Alù (University of Texas at Austin) ha presentato la sua attività sul tema "Metamaterials and plasmonics: from RF to optical applications"; il Prof. Sébastien Lambot (Université Catholique de Louvain) ha presentato sia la sua relazione "A closed form full-wave radar model for near-field layered media reconstruction", sia, a causa dell'assenza del Prof. Evert Slob (Delft University of Technology) per urgenti motivi familiari, anche la relazione su "Full waveform inversion as a two-step linear process"; il Prof. Leo Kempel (Michigan State University) ha invece illustrato l'argomento "Half-width leaky-wave antennas: a progress report"; infine il Prof. Marian Marciniak (National Institute of Telecommunications of Warsaw) ha presentato la memoria "Converged

optical and wireless communications for the future". Queste memorie sono riportate nella Parte II.

Il contributo di esperti provenienti dal mondo dell'Industria e da settori diversi dal nostro ha offerto lo spunto per ampliare la prospettiva culturale e sottolineare l'importanza non solo scientifica, ma anche per l'innovazione industriale e della società degli studi di elettromagnetismo. L'interazione con aree culturali differenti può consentire l'avanzamento di nuove idee sia in ambito scientifico sia in quello dello sviluppo produttivo che in questo difficile momento di crisi a livello mondiale ha certamente bisogno d'innovazione.

Nell'ambito della riunione sono stati assegnati alcuni premi, tutti per giovani ricercatori: il Premio Barzilai, il Premio Latmiral e il Premio Sannino. In particolare il Premio Barzilai è stato assegnato *ex-aequo* al lavoro "A size-tapered architecture for high performances isophoric direct radiating arrays" di A. F. Morabito e A. R. Laganà (Università Mediterranea di Reggio Calabria) e al lavoro "Model order reduction in finite element analysis of phased array antennas" di L. Ntibarikure (Università di Firenze). Il Premio Latmiral è stato assegnato al lavoro "Reflection symmetry to observe metallic targets at sea by a dual-polarimetric SAR" di F. Nunziata e M. Montuori (Università di Napoli "Parthenope"). Infine il Premio Sannino è stato assegnato alla memoria "The role of evanescent modes excited inside the longitudinal corrugations of mode filters" di S. Ceccuzzi e S. Meschino (Università "Roma Tre").

Nella Parte III sono riportate informazioni più particolareggiate sui vari Premi assegnati nell'ultima RiNEm.

Infine la Scuola di Dottorato, che viene in genere associata alle edizioni della RiNEm, si è svolta venerdì 14 e sabato 15 mattina. Le lezioni sono state tenute dagli ospiti stranieri. La prima mezza giornata è stata dedicata allo studio delle proprietà elettromagnetiche dei materiali, con Leo Kempel che ha presentato "Microwave Measurements of Materials", mentre Andrea Alù ha parlato su "Electromagnetic metamaterials: homogenization theory and applications". La mattina successiva si sono tenute altre due presentazioni su tematiche collegate con diversi settori culturali, in particolare Sébastien Lambot ha parlato sul "Ground-penetrating radar: from basic to advanced soil characterization methods", mentre Marian Marciniak ha tenuto una lezione su "Fibre story: how it serves optical and wireless communications?".

In conclusione ricordiamo che diversi studenti di laurea magistrale provenienti da varie sedi hanno partecipato gratuitamente alla Riunione, questo ci ha portato la particolare soddisfazione di vedere come i temi che coinvolgono persone che lavorano nell'elettromagnetismo da anni siano appassionanti anche per le nuove generazioni che si affacciano sul mondo scientifico e tecnologico.

Infine un particolare ringraziamento va al Comitato Promotore, al Comitato Organizzatore, al Comitato Locale, agli *sponsor* (Agilent Technologies, Ansys, CST, GAAS, SELEX SI) e agli *sponsor* tecnico-scientifici (IEEE, URSI, Centro Interuniversitario MECSA, SIEm).

Giuseppe Schettini e Lucio Vegni
Chairman della XIX RiNEm

PARTE I

Sommari dei lavori presentati alla XIX RiNEm

La XIX Riunione Nazionale di Elettromagnetismo (RiNEm), organizzata dalla Società Italiana di Elettromagnetismo (SIEm), si è articolata in 18 sessioni orali elecate di seguito:

- Microwave components I.
- Bioengineering I.
- Electromagnetic theory.
- Electromagnetic imaging techniques.
- Numerical methods in electromagnetics.
- Synthetic aperture radar.
- Microwave components II.
- Ground penetrating radar.
- Antenna arrays.
- Propagation and scattering.
- Bioengineering II.
- Antenna design and measurements.
- Optical fibers.
- Radio frequency identification.
- Photonic crystals.
- Wireless communications, networks and systems.
- Photonic and plasmonic technologies and components.
- Energy and environment.

Il numero complessivo lavori presentati è stato 153, comprese tre sessioni *poster*. Una sessione è stata organizzata dall'URSI (*Union Radio-Scientifique Internationale*).

Gli Atti della XIX RiNEm sono disponibili su CD-Rom (ISBN: 978-88-907599-0-1) e sono anche reperibili all'URL *http://www.elettromagnetismo.it/*.

SESSION 1 - MICROWAVE COMPONENTS I

Harmonic balance Finite Element analysis of third order intermodulation products in ferrite devices

L. NTIBARIKURE, G. PELOSI, S. SELLERI *(Università di Firenze)*

Results of a study of nonlinearities and intermodulation products for 3-port H-plane waveguide circulators are presented, based on a harmonic balance finite element analysis of the third-order nonlinearity in ferrites. Numerical results are derived for the field strength and the power level of the intermodulation signal.

Tuning diplexers with rational filters

M. Oldoni, G. Macchiarella *(Politecnico di Milano)*
F. Seyfert *(INRIA, Sophia Antinopolis Cedex, Francia)*

We describe an original technique to extract a polynomial model of the filters composing a diplexer based on the external measurements. This paper reports the theoretical basis and describes additional assumptions under which it can be applied successfully. Numerical examples are also shown to prove its practical behavior.

Synthesis strategy for broadband multiplexers

G. Virone, R. Tascone, O. A. Peverini, G. Addamo, Z. Farooqui, A. Tibaldi, R. Orta *(Politecnico di Torino)*

This paper presents a design method for wideband multiplexers. It is based on an aggregate discontinuity concept to keep the mutual loading effect of the various filters into account at the synthesis level. This method can provide the geometric parameters of the multiplexer starting from the desired polynomial frequency response. The performance obtained in the case of a waveguide diplexer with a 1.4% band separation bandwidth is discussed.

TM dual-mode cavity filters with symmetric and asymmetric filtering functions.

C. Tomassoni, R. Sorrentino *(Università di Perugia)*
S. Bastioli *(RS Microwave Co Inc., Butler, NJ, USA)*

In this paper we present TM dual-mode cavity filters exploiting nonresonating modes. The proper use of nonresonating modes allows filtering functions having a number of transmission zeros up to the number of poles. The design of such filters is very flexible in terms of number and position of transmission zeros, and both symmetric and asymmetric filtering functions can be obtained. Furthermore, with a moderate reduction of the Q-factor we can design TM filters extremely compact with respect to classical TE dual-mode filters.

An equivalent circuit for microwave discontinuities

L. Zappelli *(Università Politecnica delle Marche)*

An equivalent circuit for discontinuities exciting evanescent accessible modes is proposed. The key feature of this equivalent circuit is its capability for simplification if a port relative to an accessible evanescent mode is matched, or connected to a very long line. Circuit drawing is simple and fast and is based on a regular polygon with as many susceptances as the sides and the diagonals. Each side is connected with a line of electrical length to the terminal ports and, if the port refers to an evanescent accessible mode, a series reactance is added. This reactance is the key to the evanescent part of the circuit because it is able to cancel the effect of the evanescent mode if the port is matched or connected to a very long evanescent line, reducing the complexity of the circuit by one degree.

SESSION 2 - BIOENGINEERING I

DNA biosensor based on a double tilted fiber Bragg grating

A. Candiani, M. Sozzi, A. Cucinotta, S. Selleri R. Veneziano, R. Corradini, R. Marchelli *(Università di Parma)*
P. Childs, S.Pissadakis *(Foundation for Research and Technology-Hellas, Institute of Electronic Structure and Laser, Heraklion, Greece)*

A label-free DNA biosensor based on a double tilted fiber Bragg grating is presented. The outcladding of the fiber has been functionalized using peptide nucleic acid (PNA) probes able to recognize specific DNA strands. When the DNA binds to the PNA a refractive index change occurs at the cladding interface and the fringe visibility of the Fabry-Perot core-cladding closed loop cavity formed by the double tilted grating changes accordingly. The biosensor detects up to 10nM DNA solution, inducing a 10% modulation of the corresponding fringes visibility. The re-use of the fiber for multiple measurements and the selectivity of the sensor have been also demonstrated.

Wearable self-powered wireless units for ultraviolet radiation dosimetry

E. Pievanelli, A. Plesca, R. Stefanelli, D. Trinchero *(Politecnico di Torino)*

The protection of workers and individuals exposed to physical phenomena impacting on health, represents a challenge for the next future. An ideal solution is represented by the use of non-invasive, low cost, wearable and washable devices, able to detect continuously personal exposure and activate alarms in case of hazardous events. The devices are miniaturized in dimensions and weight and provided with a radio interface, forming a set of wearable mobile nodes in a wireless network. Furthermore, the node embeds energy harvesting techniques for self-powering. The wireless device can connect to a standard wireless networks (Bluetooth, ZigBee), as well as to Ad-Hoc ones, by means a dedicated skin antennas. As an example, the methodology is applied to assess UltraViolet (UV) exposure to prevent diseases due to under- or over- exposition to UV rays. The preliminary studies confirm the feasibility of the project.

From magnetic resonance imaging to water content evaluation of a human tissue

M. Cavagnaro, F. Frezza, R. Laurita, M. Tannino, L. Manganaro, M. Marini, P. Sollazzo, A. Stagnitti *("Sapienza" Università di Roma)*
V. Lopresto, R. Pinto *(ENEA, Casaccia, Roma)*

The scope of this article is to compare two methods to extrapolate the water content of human tissues from magnetic resonance imaging. Two different approaches to gain the same goal will be outlined and discussed in order to draw a roadmap for subsequent studies and refinements which will lead to dielectric properties finding. A quantitative benchmarking approach will be shown.

Health effects from cell phone radiations: the verdict of the Court of Appeal of Brescia

B. Bisceglia, V. Ivone *(Università di Salerno)*

The effect of mobile phone radiation on human health is the subject of recent interest and study. Many scientific studies have investigated possible health symptoms of mobile phone radiation. These studies are occasionally reviewed by some scientific committees to assess overall risks. The Court of Appeal of Brescia has recently recognized the occupational origin of a trigeminal schwannoma in a user of mobile telephones, and ordered the Italian Workers' Compensation Authority (INAIL) to award the applicant a compensation for a high degree (80%) permanent disability. We describe and discuss the salient aspects of this unprecedented ruling as a case-study in the framework of the use (and misuse) of scientific evidences in toxic-tort litigation. A comprehensive strategy to improve the quality of expert witness testimony in legal proceedings and promote just and equitable verdicts is urgently needed in Italy

Optimal focusing of vectorial fields subject to arbitrary upper bounds

D.A.M. Iero *(Università Mediterranea di Reggio Calabria)*

The paper introduces an effective method for the globally optimal focusing of vectorial fields by means of an array of antennas, which is of interest in a number of applications including microwave hyperthermia.

Gold nano-particles as a platform for biosensing

R. Iovine, L. La Spada, F. Bilotti, L. Vegni *(Università "Roma Tre")*

In this contribution, a bio-electromagnetic sensor, based on Localized Surface Plasmon Resonance (LSPR) effects operating in the near-infrared frequency regime, is proposed. It consists in a planar array of gold nano-particles deposited on a silica substrate. The adopted geometry of the nano-particles leads to an enhancement of the localized electric field and can be used, thus, for sensing applications. The proposed structure is optimized to achieve the highest possible performance in terms of sensitivity and is designed to detect organic compounds by refractive index (RI) measurements. Sensitivity performances are evaluated also by varying the polarization of an incident plane-wave. Full–wave simulations confirm the effectiveness of the proposed sensor design.

SESSION 3 - ELECTROMAGNETIC THEORY

Plane-wave scattering from cylindrical objects

K. Watanabe, Y. Nakatake *(Fukuoka Institute of Technology, Japan)*
G. Schettini *(Università "Roma Tre")*

This paper formulates the plane electromagnetic wave scattering problem of cylindrical objects buried under periodically corrugated surface. The structure under consideration is an imperfectly periodic structure, in which the structural

periodicity is locally broken, and the fields generally have continuous spectra in the wavenumber space. The present formulation is a spectral-domain method based on the pseudo-periodic Fourier transform, and combines the coordinate transformation method and the recursive transition-matrix algorithm.

A closed-form estimation of the mutual coupling matrix applied to uniform circular arrays

L. Infante, S. Mosca *(SELEX SI, Roma)*

It is known that the beamforming pattern is distorted in the presence of mutual coupling unless a mutual coupling compensation technique is used. In this paper we describe a fast procedure that provides an estimation of the dominant terms of the mutual coupling matrix for uniform circular array. The proposed method is obtained by perturbating the array elements with a single generic signal impinging on it from a known direction. By properly processing the array element signals an estimation of the mutual coupling matrix is provided.

A phase-center study of Fabry-Pérot cavity antennas

P. Burghignoli *("Sapienza" Università di Roma)*

The phase center is studied for Fabry-Pérot cavity antennas viewed as two-dimensional leaky-wave radiators, adopting both local and global definitions. Closed-form expressions are obtained for the phase-center location of broadside pencil beams, as a function of the attenuation constant of the leaky mode responsible for radiation and of the extension of the angular sector of interest. Numerical results that validate the proposed formulas are given for specific antenna structures.

An analytical model to quantify the efficiency of arrays composed by high-gain reflector antennas

M. Cametti, M. Bozzi, M. Pasian, L. Perregrini *(Università di Pavia)*

Arrays composed by high-gain reflector antennas used for deep space communications require a precise knowledge of the degradation that phase, amplitude and pointing fluctuations impose on the capability of the array to combine coherently the signal received from each antenna. In this paper an analytical model for the fluctuation of each parameter (phase, amplitude and pointing) is derived and it is used to predict the efficiency of an array composed by an arbitrary number of high-gain reflector antennas. The analytical models are verified by numerical simulations of an array designed for future upgrades of the European Space Agency ground segment.

Nonlocal transformation optics

G. Castaldi, V. Galdi *(Università del Sannio)*
A. Alù *(University of Texas at Austin, USA)*
N. Engheta *(University of Pennsylvania, Philadelphia, USA)*

We review our recently introduced nonlocal transformation optics framework based on coordinate transformations in the spectral (wavenumber) domain. Our approach allows a physically-incisive and powerful geometrical interpreta-

tion in terms of deformation of the equifrequency contours, and may pave the way to new intriguing developments in dispersion engineering of electromagnetic metamaterials.

Electromagnetic scattering of an elliptically polarized plane wave by a buried sphere

F. Mangini *("Sapienza" Università di Roma)*

A rigorous method to analyze the scattering of an elliptically-polarized plane wave by a perfectly-conducting sphere buried in a dielectric half-space is presented. The electric field components are expanded in spherical harmonic series. The scattered-reflected field is computed through the plane-wave spectrum of the scattered field, considering the reflection of each elementary plane wave. The interaction between the scattered-reflected field and the sphere is taken into account by expanding the field in spherical harmonic series, to impose the boundary conditions on the sphere's surface. The procedure leads to an infinite linear system giving the unknown coefficients of the scattered field. To achieve a numerical solution, a Matlab code is implemented, where a suitable truncation of the system has been performed.

SESSION 4 - ELECTROMAGNETIC IMAGING TECHNIQUES

Atmospheric visibility through optical images

M. Ferrara, P. Lucantoni, S. Mori, P. Nocito, F. Frezza, F. S. Marzano *("Sapienza" Università di Roma)*
G.M. Tosi Beleffi, E. Restuccia *(Ministero dell'Economia)*

From telecommunications to transport application, visibility is a fundamental quantity to be estimated. To this end, there are many different instruments basing their estimation on measures of optical attenuation or scattering through the atmosphere. Unfortunately, this kind of instruments provides reliable results only for certain range of distances and is quite expensive. In this work is presented an experimental study on the use of a video camera for visibility estimation. Collected appraisals will be compared with a method of literature and with the measures of the attenuation of the optical carrier provided by the Free Space Optics (FSO) wide area set up realized in Rome (Italy) by DIET-SapienzaUniversity and ISCOM-Ministry of Economic Development.

System-level analysis and optimization of task-oriented imaging systems

A. Liberato, P. Bassi *(Università di Bologna)*
A. Guagliumi, M. Gnan, D. Bruni, F. Canini *(Datalogic, Lippo di Calderara Reno, Bologna)*
L. De Marco *(Automotive Lighting Italia, Venaria Reale, Torino)*

The design of an electro-optical system such as a vision system is classically made by optimizing its constituting parts independently. However, because of the complexity of the overall system, the best performance of a single element

may not correspond to that of the complete processing chain. In this paper a tool named SLALOM, acronym of "System Level AnaLysis and OptiMization" is proposed. SLALOM is a C-based extension to optical design software that includes the modeling of the electronic subsystem not encompassed by the software itself. It consists in two complementary tools that share a common core and can be executed independently to perform lens design at system level, and to simulate the overall system performance.

Through-wall communication by means of an ultra wide permittivity antenna (UWPA)

D. Pinchera, M. D. Migliore, F. Schettino *(Università di Cassino e del Lazio Meridionale)*

In this contribution an antenna specifically designed for wireless Through-the-Wall communication is presented. By means of the presented system it is possible to transmit through walls with relative permittivity in the range 1-9 maintaining the reflections lower than -10dB. The antenna is simulated and experimentally tested in real working conditions, confirming its good performance.

TWI for a lossless unknown wall

R. Solimene, A. D'Alterio, R. Pierri *(Seconda Università di Napoli)*

A TSVD based procedure to characterize the wall transmission coefficient in the framework of through-the-wall imaging is introduced. The procedure works for a symmetric lossless wall and does not rely on optimization schemes but requires a multistatic configuration.

Differential microwave imaging from brain stoke monitoring

R. Scapaticci, I. Capatano, L. Crocco *(IREA-CNR, Napoli)*
L. Di Donato *(Università Mediterranea di Reggio Calabria)*

The adoption of microwave imaging as a tool for non-invasive monitoring of brain stroke has recently gained an increasing attention. With respect to such a framework, in this communication, we propose a simple and effective imaging strategy for brain stroke monitoring, based on a modified formulation of the linear sampling method, which allows a quasi real time monitoring of the disease's evolution. The performance of the imaging technique is assessed through numerical examples dealing with an anthropomorphic phantom.

Advancements in microwave breast cancer imaging enhanced by magnetic nanoparticles as contrast agent

G. Bellizzi, O.M. Bucci *(Università di Napoli "Federico II")*
I. Capatano, L. Crocco, R. Scapaticci *(IREA-CNR, Napoli)*

This communication deals with Microwave Imaging of breast cancer and aims at presenting ongoing advancements on a recently proposed methodology, which exploits Magnetic Nanoparticles (MNP) as contrast agent able to selectively target cancerous tissues by modifying their magnetic permeability. In this

framework, we discuss the performance of the imaging approach, in terms of reliability and sensitivity, against realistic conditions.

SESSION 5 - NUMERICAL METHODS IN ELECTROMAGNETICS

A vector finite difference approach to the computation of modes in circular waveguide

A. Fanti *(Università di Cagliari)*

We describe here a Vector Finite Difference approach to the evaluation of waveguide eigenvalues and modes for circular waveguides. The FD is applied using a 2D polar grid, in the waveguide section. A suitable Taylor expansion of the vector mode function allows taking exactly into account the boundary condition. The FD approximation results in a constrained eigenvalue problem, that we solve using a decomposition method. This approach has been evalutated comparing our results to the analytical modes of the circular waveguide.

Nested BiCGStab for non-Hermitian linear systems arising from discretization of the EFIE

G. Angiulli, D. De Carlo, A. Sgrò *(Università Mediterranea di Reggio Calabria)*

Although in the last years the BiCGStab has been employed with success to handle large linear systems arising from the the RWG MoM discretization of electromagnetic scattering problems formulated by EFIE, its nested version, the N-BiCGstab, has received little attention. In this work, a numerical study on its performances is presented. Results demonstrate that N-BiCGStab is, at least in the examined cases, faster and more robust than the standard BiCGStab coupled with diagonal or ILU preconditioning.

Efficient computation of periodic Green's functions for printed structures with vertical elements

G. Valerio *(Université de Rennes, France)*
S. Paulotto *(Maxtena Inc., Bethesda, MD, USA)*
P. Baccarelli, A. Galli *("Sapienza" Università di Roma)*
D.R. Jackson, D.R. Wilton *(University of Houston, Texas, USA)*

The vertical components of the mixed-potential Green's functions due to onedimensional (1-D) or bidimensional (2-D) phased array of dipoles in a layered medium are computed through suitable homogeneous-medium asymptotic extractions from the standard spectral series of Floquet's harmonics. The extracted terms can be expressed as potentials for a 1-D or 2-D array of half-line sources. Their computation requires a suitable modification of the Ewald method, thus resulting in new modified spectral and spatial series, having Gaussian convergence even in the case of complex modes and improper harmonics. Numerical comparisons have been performed to validate the proposed acceleration technique.

Analysis and design of passive waveguide devices by spectral element methods

O.A. Peverini, A. Tibaldi, Z. Farooqui, G. Addamo, G. Virone, R. Orta, R. Tascone *(IEIIT-CNR, Torino)*

This work will present a spectral-element method suitable for the efficient design of two-dimensional passive waveguide components. The method exploits different domain mappings in order to correctly model the singular behavior of the field close to sharp edges also in presence of curved sides. Several devices for satellite communication and scientific instrumentation have successfully been designed with the present technique. Detailed comparison between simulated and measured performance will prove the reliability of the method also when very demanding specifications are set on components design

An effective hybrid synthesis method for sparse plane wave generators

D. Pinchera *(Università di Cassino e del Lazio Meridionale)*

In this contribution a novel synthesis approach for Plane Wave Generators is presented; the advantages of the hybrid method used for the synthesis are its numerical efficiency and the effectiveness of the solution found. The layouts found by the algorithms present also the advantage of a reduced complexity and a simplified construction of the achievable layouts.

Model order reduction in finite element analysis of phased array antennas

L. Ntibarikure *(Università di Firenze)*

The model order reduction technique is applied to the finite elements analysis of phased array antennas, leading to fast and accurate computation of the radiation pattern in front of a beam steering process. Computational timings and approximation error of the reduced order model are shown for a patch antennas array, proving the noticeable advantages of the presented approach.

SESSION 6 - SYNTHETIC APERTURE RADAR

A novel high level SAR product: fractal dimension map

G. Di Martino, A. Iodice, D. Riccio, G. Ruello *(Università di Napoli "Federico II")*
I. Zinno *(IREA-CNR, Napoli)*

In this paper the analysis of fractal dimension maps obtained from Synthetic Aperture Radar (SAR) images is presented. For the first time, it is shown that it is possible to extract from SAR data information related only to the roughness of the observed surface, i.e. presenting low dependence on the parameters of the considered incident field. Both natural and urban scenarios are considered and the behavior of the maps in case of different sensor look angles is discussed.

DInSAR and neural networks for seismic source analysis

M. Picchiani, F. Del Frate, G. Schiavon *(Università di Roma "Tor Vergata")*
S. Stramondo, M. Chini *(Istituto Nazionale di Geofisica e Vulcanologia, Roma)*

Since the 1990s differential interferometry techniques have been applied to synthetic aperture radar images to measure the surface displacement field caused by earthquakes. Indeed the phase difference of the radar signals acquired after and before the event registers the variation of the electromagnetic path due to the displacement. Analytical formulation to model these changes in radar range exists, anyway the inverse problem, i.e. the retrieval of the seismic source parameters from the interferometric phase measured, is not of straightforward solution because of its intrinsic ill-posedness. A novel inversion technique, based on Neural Networks, harmonic analysis and non-linear principal component analysis, has been developed in previous studies obtaining encouraging results. Here the theoretical basis of the methodology is reviewed and applied to a new set of experimental data.

Oil spill detection using X-band SAR data

R.G. Avezzano, D. Latini, F. Del Frate *(Università di Roma "Tor Vergata")*
D. Velotto, S. Lehner *(Remote Sensing Institute, Wessling, Germania)*

The increased amount of Synthetic Aperture Radar (SAR) images acquired over the ocean represents an extraordinary potential for improving oil spill detection activities. To this purpose, the use of artificial Neural Networks (NN) has already been demonstrated to be profitable. However, the effective design of a NN algorithm relies on the availability of a statistically significant set of examples to be used for the training phase. In this paper the performance of NN is discussed for two different dataset provided by the last generation satellite missions: Cosmo-Skymed and TerraSAR-X. In the latter case, the use of an electromagnetic model has been considered to improve the statistical representation of the data. The results obtained are satisfactory as in both cases the overall accuracy of the classification, discriminating between oil spills and look-alikes, is more than 80%.

SAR tomography with optimized track distribution and controlled resolution

A. Capozzoli, C. Curcio, A. Liseno *(Università di Napoli "Federico II")*

In SAR tomography, the available information in the height direction is limited by the number of different tracks that can be flown in practice, so that the "few" possible acquisitions should be accurately selected. We present an approach for the design of the "optimal" constellation for the desired degree of resolution.

Future use of the data from the ESA Sentinel-1 mission for operational soil moisture mapping: a multitemporal algorithm

N. Pierdicca, L. Pulvirenti *("Sapienza" Università di Roma)*

The Sentinel-1 mission will offer the opportunity to obtain C-band radar data characterized by short revisit time, thus allowing the generation of frequent soil

moisture maps. This paper presents a multitemporal algorithm that exploits such a short revisit time to perform an operational soil moisture mapping. The algorithm assumes the availability of a time series of SAR images that is integrated within a retrieval algorithm based on the Bayesian maximum posterior probability statistical criterion. Preliminary results show that the performances of the multitemporal algorithm are better than those provided by a standard monotemporal one.

INDUSTRY LECTURE

Receiving sparse signals in radar systems: blind recovery at minimum rate

G. Prisco *(SELEX SI, Roma)*

MICROWAVE COMPONENTS II

Short-pulsed wavepacket propagation in ray-chaotic enclosures: a random-plane-wave model

G. Castaldi, V. Galdi, I. M. Pinto *(Università del Sannio)*

We review our recently proposed short-pulsed random-plane-wave statistical model of wavepacket propagation in a ray-chaotic enclosure. We show that this representation leads to analytical results that are in good agreement with predictions from full-wave numerical simulations.

The phase kurtosis index for reverberating chamber near LOS conditions

A. Sorrentino, M. Migliaccio *(Università di Napoli "Parthenope")*

This paper presents a simple and effective parameter able to unambiguously identify different channel conditions within a reverberating chamber (RC). The kurtosis index is first applied to characterize the phase of the received signal to discriminate the line-of-sight (LOS) or not (NLOS) conditions. Experiments undertaken over a large set of cases accomplished by emulating different propagation channel conditions at the RC of the Università di Napoli Parthenope, formerly Istituto Universitario Navale (IUN), confirm the soundness of thekurtosis index and its effectiveness from an operational point of view.

Analysis of the entropy in fast time domain simulations of reverberation chambers

G. Grandoni *(Institute for Research in Electronics and Applied Physics, University of Maryland, USA)*
V. Mariani Primiani, F. Moglie *(Università Politecnica delle Marche)*

In this contribution, we investigate the entropy growth in a mode-stirred cavity simulated by the FDTD method. The adopted reverberation chamber is efficiently stirred by paddles and excited by a Gaussian pulse. It is observed that the entropy starts growing quadratically in time, then it increases linearly dur-

ing the energy buildup, and it saturates after a few nanoseconds, when the onset of disordered fields occur. This allows for terminating the numerical simulations well before the Richardson time, as the asymptotic entropy is rapidly achieved. The analysis is based on the eigenvalues of the correlation matrix, calculated over a dense grid of spatial points, thus supporting the perspective of the reverberation chamber as a statistical multivariate process.

Design of cavity resonators for chemical reactions

G.A. Casula, P. Maxia, G. Montisci, G. Mazzarella, F. Desogus *(Università di Cagliari)*

We present in this work a microwave resonant cavity, used to evaluate the effect of the absorption of a low power electromagnetic field at microwave frequencies, designed using a commercial general purpose software for the electromagnetic simulation of three-dimensional high-frequency components.

SESSION 8 - GROUND PENETRATING RADAR

Civil engineering applications of ground penetrating radar (invited)

A. Benedetto *(Università "Roma Tre")*

Ground Penetrating Radar (GPR) is a sensing equipment that is based on the principle of scattering of electromagnetic waves. In particular GPR transmits a signal pulse that travels through the material essentially as a non dispersive wave. It is reflected or scattered by any change of impedance. The signal that is received back by GPR looks like the transmitted signal and its time delay as well as the differences in phase, frequency and amplitude depend on the depth, shape and electromagnetic properties of the scattering or reflecting object.

The origin of this inspection technique can be discovered in the first applications of the radio wave propagation above and along the surface of the Earth (for a review see[1]). Beyond the most diffused research in the field of communication, direction finding and radar, probably the first documented application in the field of civil engineering was oriented to identify the ground water table depth[2], supported in Egypt by the National Research Council for the geophysical prospection of underground water in the Egyptian deserts. During and after the Second World War the research in radio frequency applications received a large attention especially with reference to the sounding of geological materials. Notwithstanding these researches were devoted to military scopes (e.g.[3]), they have had some rel-

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evant impacts for potential civil engineering uses.A significant activity in the field of civil engineering started up in the sixties and has become mature in the seventies. The main surveys that were carried out using GPR investigated mines and underground deposit[4,5,6,7]. In this period, in the line of the lunar science missions, strong efforts have been spent to improve the available technologies that seemed very promising for the subsurface examinations[8,9,10]. At the end of seventies and from the eighties the use of GPR also for several applications in the field of civil engineering has increased massively. In 1978 Dolphin et al. documented probably one of the first archeological survey. Olhoeft[11,12] studied the electrical character of geological materials as well as the relationships between electrical conductivity and dielectric polarization.

A very important application of GPR in borehole configuration was the inspection of the nuclear waste disposal sites[13]. Another important and essential incentive to the research came from the military and humanitarian applications for mines detection[14,15]. The success of GPR performance in this field is remarkably whereas

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there is a considerable contrast in dielectric properties between the landmine and the host soil[16] *and attracted the most of the financial resources by governments all over the world but especially in the USA. Therefore the equipment was strongly improved and the applications beyond the military scopes increased. In particular, referring to the civil engineering applications, a first overview was given by Ulriksen in 1982*[17]*. Actually GPR is used in all the fields of civil engineering for inspection, monitoring and design purposes (e.g.*[18,19,20,21,22]*). The detection of utilities and buried objects as well as the inspection of road pavements and bridge decks as well as the measurement of moisture content in natural soils are the main applications of GPR in the civil engineering context. In addition very interesting examples of the use of GPR in structural, geotechnical engineering and railways inspections have to be mentioned.*

Estimation of the geometrical features of buried objects from GPR analysis

D. Comite, A. Galli *("Sapienza" Università di Roma)*
F. Soldovieri *(IREA-CNR, Napoli)*
G. Valerio *(Université de Rennes, France)*
P.M. Barone, S.E. Lauro, E. Mattei, E. Pettinelli *(Università "Roma Tre")*

The ability of a Ground Penetrating Radar (GPR) to detect and reconstruct the location, size and shapes of buried objects by means of inverse data processing is addressed in this work. The choices of the relevant electromagnetic parameters, geometries, and operational frequencies are related to the investigations performed in the framework of the planetary ExoMars mission. The study shows to what extent the use of a frequency-domain microwave tomographic inversion algorithm allows us to recognize different kinds of canonical geometries, even in critical conditions where the scatterers have size comparable to the wavelengths of the probing signal and can be located close to the antennas. An extensive analysis has been carried out starting from radargrams derived both by measurements (a "sand-box" experimental setup) and by simulations (numerical data from ad-hoc implementation of a CAD tool).

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Plane wave scattering by a perfectly-conducting circular cylinder buried in a lossy medium

F. Frezza, N. Tedeschi *("Sapienza" Università di Roma)*
L. Pajewski, C. Ponti, G. Schettini *(Università "Roma Tre")*

The 2D electromagnetic scattering of a plane wave by a perfectly conducting circular cylinder buried in a lossy medium, is presented. The problem of reflection and transmission of both the plane wave and the cylindrical wave at the interface with a dissipative medium has been faced taking into account the general case of inhomogeneous waves. The scattering problem has been solved with the Cylindrical-Wave Approach. The theoretical solution has been numerically implemented in a Fortran code and the numerical results have been compared with both the literature and simulations with a commercial software.

Effect of the height of the measurement line on the diffraction curves in GPR prospecting

R. Persico, G. Leucci *(IBAM-CNR, Lecce)*
F. Soldovieri (IREA-CNR, Napoli)

In this paper, the shape of the diffraction curves vs. the height of the observation line in the framework of GPR prospecting is analysed. Therefore, it is shown that the height of the measurement line is a critical factor.

Detection of metallic bodies in dielectric structure by microwave imaging - Experimental results

R. Monleone, M. Maffongeli, S. Poretti, A. Salvadè *(Swiss University of Applied Sciences)*
M. Pastorino, A. Randazzo *(Università di Genova)*

This paper reports experimental results concerning the inspection of dielectric structures in which metallic inclusions are present. The investigation is based on a microwave imaging approach and the measured data have been obtained by using a prototype of a microwave tomograph. The reconstructed images of the structures under test have been constructed by using a nonlinear inverse scattering procedure based on a truncated Landweber method. The reported results concern in particular the inspection of wood materials with cylindrical metallic inclusions.

SESSION 9 - ANTENNA ARRAYS

Design of printed UWB log-periodic dipole arrays

G.A. Casula, P. Maxia, G. Montisci, G. Mazzarella *(Università di Cagliari)*

A wideband microstrip log periodic array operating between 4 and 18 GHz (thus working in C, X and Ku bands) has been designed. The proposed solution is remarkably simple and shows both SWR and gain better than likely structures present in the literature. The same antenna can also be used as an UWB antenna.

The design has been developed using a general purpose and specialist tool for the 3D electromagnetic simulation of microwave high frequency components.

Tangram shaped subarrays for multiple beam array

S. Mosca, L. Infante *(SELEX SI, Roma)*

In phased array antennas which provide multiple beams using digital beamforming (DBF), the choice of the subarray shape is crucial. In this paper the shape of the subarrays is chosen according to an old Chinese puzzle game called Tangram. The choice of this shaping provides lower sidelobes with respect to square subarrays on offset beams obtained by means of DBF.

A size-tapered architecture for high performances isophoric direct radiating arrays

A.F. Morabito, A.R. Laganà *(Università Mediterraneo di Reggio Calabria)*

We propose a new architecture for high-gain isophoric arrays. The solution is able, by exploiting the feeds size as unique degree of freedom of the antenna design problem, to perfectly emulate the behaviour of given continuous aperture sources. Uniformly-excited arrays fulfilling by a wide margin the requirements recently established by the European Space Agency for the multibeam coverage of Europe are designed in a fast and deterministic fashion.

Implementation of a full-range varactor tuned element for the design of a reconfigurable reflectarray

F. Venneri, S. Costanzo, G. Di Massa, E. Marozzo, A. Borgia, M. Salzano *(Università della Calabria)*

The implementation of a tunable reflectarray element based on the use of an aperture-coupled patch is presented. A full phase tuning range is achieved with a single varactor diode and proved by simulations and measurements. A 3x15 X-band reflectarray is fabricated and tested to demonstrate the beam-scanning capabilities of the proposed configuration.

Co-polar and cross-polar pattern synthesis for reconfigurable antenna arrays

G. Buttazzoni, R. Vescovo *(Università di Trieste)*

A numerical method is presented for the power synthesis of co-polar and crosspolar patterns of phase controlled reconfigurable arrays. The method is suitable for arrays of arbitrary geometry, including conformal ones.

Hermite and Laguerre beamspaces for Ultra Wide Band antenna array processing

E.D. Di Claudio, G. Jacovitti *("Sapienza" Università di Roma)*
A. Laurenti *(GIAL, Roma)*

In this paper the use of 2-D Hermite-Gauss (HG) and Laguerre-Gauss (LG) expansions of the space-time signal delivered by an Ultra Wide Band (UWB) linear

antenna array is outlined. Signatures of UWB incoming signals are confined within a finite rank signal subspace, parametrized by their direction of arrival (DOA), just as the steering vectors of narrowband array signals. Fast calculation of UWB DOA is allowed by polynomial rooting. To show the potential of this approach, the statistical performance of a Conditional Maximum Likelihood (CML) DOA estimator for a single UWB source in presence of spatially and temporally colored Gaussian noise is estimated with simulation trials. It results that, with a proper choice of the expansion parameters, accuracy approaches the Cramer-Rao bound.

SESSION 10 - PROPAGATION AND SCATTERING

Preliminary assessment of site diversity schemes for earth-space optical links

C. Capsoni, L. Luini *(Politecnico di Milano)*
R. Nebuloni *(IEIIT-CNR, Milano)*

Free Space Optical (FSO) links enable high-speed data transfer from Earth Observation satellites or deep space (DS) probes directly to ground stations. The presence on-board of remote sensing instruments with ever increasing accuracy and resolution fuels the need for transmitting large amounts of data. This contribution investigates the impairments to optical beam propagation due to clouds by exploiting radiosonde observation (RAOBS) data collected in two European sites. Long-term yearly statistics of path attenuation are calculated by first distinguishing between different cloud types and, afterwards, by integrating their contribution to the total attenuation along each vertical profile of RAOBS data. Finally, the effectiveness of a site diversity scheme, simultaneously employing both FSO links, is assessed. Results indicate that a dual-site diversity FSO system with target availability of 10% would require approximately a 40-dB fade margin to counteract cloud attenuation.

A study of radiowave propagation into collapsed buildings for rescue of trapped people

A. Di Carlofelice, E. Di Giampaolo, M. Elaiopoulos, P. Tognolatti *(Università de L'Aquila)*

The paper deals with the localization of radio emitters into collapsed buildings after earthquake. A measurement campaign has been carried out in a typical European historical city, L'Aquila, which was recently stroke by a severe earthquake. Continuous wave radio transmitters operating at 434 and 868 MHz have been introduced under rubble and their signals have been measured at different points surrounding the debris to evaluate the path loss and the direction of arrival. An accurate reconstruction of the scenario has been also carried out using a laser scan. The obtained results demonstrate the possibility to localize a radio emitter under rubble with considerable accuracy.

The role of internal field approximation for scattering from layered rough interfaces

P. Imperatore *(IREA-CNR, Napoli)*
A. Iodice, D. Riccio *(Università di Napoli "Federico II")*

In this paper, the existing procedure to obtain the VPRT solution for scattering from rough multilayers is reformulated relying on a more physically sound way, avoiding the employing of the distribution theory. This also permits to shed light on the meaning of the involved approximation. Indeed, the "internal field approximation", arising in the context of electromagnetic cavities, is also implied.

Advances on inverse scattering methodologies and applications @ ELEDIA Research Center

M. Carlin, L. Manica, G. Oliveri, L. Poli, P. Rocca, A. Massa *(Università di Trento)*

A concise overview of the most recent advances on the inverse scattering techniques developed at the ELEDIA Research Center of the University of Trento is reported. Different approaches comprising Evolutionary Algorithms and Iterative Multi-Resolution Subspace-Optimization Techniques are discussed. The use of the Compressive Sensing strategies is also considered as a suitable paradigm for the regularization of "sparse" microwave imaging problems. Some representative numerical examples are reported to assess the features of the discussed methods.

A new framework for quantitative inverse scattering

L. Di Donato, T. Isernia *(Università Mediterranea di Reggio Calabria)*
I. Catapano, L. Crocco *(IREA-CNR, Napoli)*

In order to improve the accuracy and robustness of inverse scattering solution procedures, we introduce and address a new framework which is based on suitable 'synthetic' experiments. These latter, inspired and driven from the physical meaning of the Linear Sampling Method, allow to take advantage from some expected properties of the internal fields (and equivalent currents), thus allowing to simplify and speed up the inversion process. The broad applicability of the LSM allows dealing with a very wide class of unknown scatterers.

SESSION 11 - BIOENGINEERING II

Analysis and design of a UWB radar for non-invasive breath activity monitoring

P. Bernardi, R. Cicchetti, S. Pisa, E. Pittella, E. Piuzzi, O. Testa *("Sapienza" Università di Roma)*

The design and realization of an ultra wideband (UWB) radar for non-invasive breath activity monitoring is presented. The radar structure is described and the design and realization of its various subsystems is shown. Finally, measurement results are presented, evidencing a sensitivity suitable to monitor the breath activity by detecting thorax movements.

Radiated emission and susceptibility of breath monitoring system based on UWB pulses in spacecraft modules

P. Russo, V. Mariani Primiani, A. De Leo, G. Cerri *(Università Politecnica delle Marche)*

The paper describes some EMC aspects related to an UWB radar for monitoring astronauts breathing activity. Compliance to EMC space standards forces some design aspects, in particular the peak voltage and the pulse waveform, as well as the receiver immunity.

A novel thermo-ablative microwave multi-applicator system

G. Biffi Gentili, M. Linari *(Università di Firenze)*

A novel minimally invasive thermoablative system that utilizes an asynchronous array of up to four high efficiency microwave applicators is presented. The tumor ablation volume is optimized by adaptively distributing the available power among multiple applicators.

Effects of nanosecond pulsed electric field on the activity of a Hodgkin and Huxley neuron model

A. Denzi, F. Camera, A. Paffi, F. Apollonio, P. Marracino, G. d'Inzeo, M. Liberti *("Sapienza" Università di Roma)*
C. Merla *(ICEmB-ENEA, Roma)*

The cell membrane poration is one of the main assessed biological effects of nanosecond pulsed electric fields (nsPEF). This structural change of the cell membrane appears soon after the pulse delivery and lasts for a time period long enough to modify the electrical activity of excitable membranes in neurons. Inserting such a phenomenon in a Hodgkin and Huxley neuron model by means of an enhanced time varying conductance resulted in the temporary inhibition of the action potential generation.

Electromagnetic pulser for the investigation of cell membranes

A. Doria, G.P. Gallerano, E. Giovenale, G. Messina, I. Spassovsky *(ENEA, Frascati, Roma)*
A. Ramundo Orlando (CNR, Roma)

An electron based radiation source is presented with the aim of irradiating cell membrane models and biological cell membranes. The peculiarity of the device is that it can simultaneously generate short electromagnetic pulses, in themillimeter wave range, and electrostatic pulses with the same time structure.

SESSION 12 - ANTENNA DESIGN AND MEASUREMENTS

Design of circular corrugated horn with constant width corrugations

L. Lucci, G. Pelosi, S. Selleri *(Università di Firenze)*
R. Nesti *(Osservatorio Astrofisico di Arcetri-INAF)*

In this contribution a novel design for circular corrugated horns is presented. The high performances typical of corrugated feeds is maintained even if design is constrained to have the corrugations' width uniform along the whole horn. The constant width corrugation property has a direct consequence on the mechanical design and fabrication, coming out easier and cheaper than in the well-known case of optimized - non uniform corrugation width - horns. The proposed horn can hence be fabricated using a pile of equal thickness layers, only machining a single circular stepped hole on each. The easy extension to arrays is straightforward in what are called platelet horn arrays. A particular design for a 43 GHz corrugated horn is addressed and some results are shown.

What's new on antenna synthesis @ ELEDIA Research Center

E. Bekele, R. Chirikov, M. Carlin, L. Manica, G. Oliveri, L. Poli, P. Rocca, A. Massa *(Università di Trento)*

An overview of the innovative approaches for antenna design and optimization currently under development at the ELEDIA Research Center of the University of Trento are presented in this paper. The synthesis of non-conventional antenna arrays characterized by a non-regular disposition of the elements on the aperture, and arrays using time as an additional degree of freedom for beam shaping, as well as innovative methodologies for the synthesis of compact multiband and broad-band antennas are described. The effectiveness and potentialities of the proposed techniques are illustrated by means of some representative examples.

Printed CRLH omnidirectional loop antenna for mobile WLAN applications

A.D. Capobianco, E. Autizi *(Università di Padova)*
A. Locatelli, D. Modotto, C. De Angelis *(Università di Brescia)*
S. Boscolo, M. Midrio *(Università di Udine)*

A printed loop antenna for mobile WLAN applications at 2.4GHz has been designed, fabricated and characterized. The structure is based on a composite right/left-handed (CRLH) transmission line that guarantees to achieve in-phase current even along a non small loop. Numerical simulations and measurements performed in anechoic chamber on fabricated prototypes confirm that the antenna exhibits good impedance matching and the radiation pattern is truly omnidirectional in the plane of the board, with high radiation efficiency and horizontal polarization of the radiated field

A wearable UHF small patch antenna on a new magneto-dielectric material

M. Aldrigo, A. Costanzo, D. Masotti, V. Rizzoli *(Università di Bologna)*

A new UHF small patch antenna for a wearable application at 868 MHz, built on an innovative magneto-dielectric material, is presented. Exploiting the miniaturization properties offered by values of permeability greater than unity, a barium-strontium hexaferrite has been synthesized in order to achieve the best compromise between antenna dimensions and performances. Once the electrical

properties of the substrate were characterized, simulations and measurements of reflection coefficient and radiated far-field have been carried out, showing a good agreement and, consequently, a proof of the reliability of our design approach. Further improvements of the proposed design can be taken into account for applications in the 2.4 GHz ISM band.

Measurements of antenna factor with antenna impedance method

O. Losito, M. Bozzetti, G. Cannone, F. Prudenzano, L. Mescia, A. Di Tommaso, P. Bia, M. De Sario *(Politecnico di Bari)*
V. Castrovilla *(ITEL Telecomunicazioni, Ruvo di Puglia, Bari)*

In the fields of electromagnetic interference and electromagnetic compatibility, it is important to measure the strength of the electric field originating from electric devices. Knowledge of the antenna factor of a receiving antenna is necessary. In this paper, we discuss the antenna impedance method as a new calibration method measuring the free-space antenna factor. The experimental measurements are compared with both the standard field method and the data provided by the manufacturer of biconical, log-periodic and horn antennas. A good agreement with the technical regulation ANSI C63.5 is shown.

Spherical near-field to far-field transformation for quasi-planar antennas: an experimental validation

F. D'Agostino, F. Ferrara, C. Gennarelli, R. Guerriero, M. Migliozzi *(Università di Salerno)*

This work concerns the experimental validation of a near-field – far-field transformation with spherical scanning for quasi-planar antennas. Such a technique is based on the nonredundant sampling representations of the electromagnetic fields and on the optimal sampling interpolation expansions, and uses an oblate ellipsoid to model the antenna. It is so possible to remarkably lower the number of data to be acquired, thus reducing in a significant way the required measurement time. The effectiveness of such a technique is experimentally assessed at the UNISA Antenna Characterization Lab by comparing the far-field patterns reconstructed from nonredundant measurements on the sphere with those obtained from the near-field data directly measured on the classical spherical grid.

SESSION 13 - OPTICAL FIBERS

Applications of fiber optics dynamic Brillouin gratings in ultra wideband communications

L. Ursini, M. Santagiustina *(Università di Padova)*

By exploiting all-optical signal time differentiation and true time reversal, realized through dynamical Brillouin gratings in fiber optics, we propose a method to generate UWB Gaussian doublet (including higher-order) pulse and

the implementation of an UWB time reversal mirror. Numerical predictions are reported.

Large mode area fibers for high power and high beam quality lasers

M. Surico, A. Di Tommaso, P. Bia, L. Mescia, M. Bozzetti, O. Losito, M. De Sario, F. Prudenzano *(Politecnico di Bari)*

Four different high power ytterbium doped fiber lasers are designed and compared via a home-made computer code. Their effective mode areas and beam qualities are numerically evaluated. A novel aperiodic fiber microstructure, very promising in order to construct high power and single mode lasers, has been identified.

Fiber optic sensor for precursory acoustic signals detection in rockfall events: feasibility analysis

L. Schenato, G. Marcato, A. Pasuto *(Research Institute for Hydrogeological Protection, CNR, Padova)*
L. Palmieri, L. Vianello, A. Galtarossa *(Università di Padova)*
G. Gruca, T. van de Watering, D. Iannuzzi *(VU University Amsterdam)*

Two fiber optic sensors (FOSs) for detection of precursory acoustic emissions in rockfall events are proposed and experimentally characterized. Both sensors are interferometric, but the first one is made of a fiber coil that acts as sensing element, whereas the second sensor exploits a micro-machined cantilever carved on the top of a ferrule. Preliminary experimental tests aimed at comparing the performance with standard piezo-electric transducers show the viability of such FOSs for acoustic emission monitoring in rock masses.

Distributed fiber optic sensor for intense magnetic field mapping

L. Palmieri, A. Galtarossa *(Università di Padova)*
L. Schenato *(Research Institute for Hydrogeological Protection, CNR, Padova)*
M. Guglielmucci *(Istituto Superiore delle Comunicazioni e delle Tecnologie dell'Informazione, Roma)*

We describe a novel distributed fiber optic sensor, which is able to map both strength and orientation of intense static magnetic fields in the area spanned by the fiber. The sensor is based on Faraday rotation and on polarization analysis of the field backscattered by the fiber due to Rayleigh scattering. The small Verdet constant of standard silica fibers makes the proposed technique the most suited to intense magnetic fields.

A new pumping scheme for high power Tm-doped fiber laser

E. Balliu, A. Braglia, A. Califano, M. Olivero, A. Penna, G. Perrone *(Politecnico di Torino)*

Tm-doped high power fiber lasers are attracting an increasing interest for their perspective industrial and medical applications, despite their maximum output power is currently limited mainly by the lack of specific high power pump sources at the

most relevant Tm absorption peak. The paper presents a new pumping scheme that, exploiting another Tm absorption region, allows taking advantage of the enormous progress in terms of delivered power made by Yb-doped fiber lasers. Both Yb- and Tm-doped fiber lasers have been designed and realized in our labs, including some key components, such as the pump and output combiners. Preliminary results demonstrate that the proposed approach may be suitable for the realization of CW lasers able to emit well above 100 W at about 2 μm.

SESSION 14 - RADIO FREQUENCY IDENTIFICATION

Electromagnetic properties of passive RFID networks

G. Marrocco, S. Caizzone *(Università di Roma "Tor Vergata")*

The UHF passive Radio Frequency Identification technology generally enables an asymmetric interaction between the reader and the tag, the latter only being able to respond to the query of the reader through backscattering modulation. Very recently some experiments put into evidence the possibility to set up a tag to tag communication by using a simple illuminator. The key issues and the physical limitation of such a cross-link are here investigated both theoretically and numerically by fully accounting for the mutual coupling among the tags, their radiation properties and the impedance modulation.

Chemical loaded RFID antenna for humidity detection

S. Manzari, C. Occhiuzzi, A. Catini, C. Di Natale, G. Marrocco *(Università di Roma "Tor Vergata")*

Passive UHF RFID tags, besides item labeling, are also able to exploit capability to sense the physical state of the tagged object as well as of the surrounding environment. Here a new family of polymer-doped tags is proposed and fully characterized for the detection of ambient humidity. A sensitive chemical species based on PEDOT:PSS is used to load a shaped slot, carved into a folded-like patch tag. The communication and sensing capabilities of the resulting radiosensor are here investigated, showing how to control opposite requirements by a proper deposition of the sensitive material. The device could have several interesting applications in the assessment of the air quality and food conservation.

Performance evaluation of passive UHF RFID tags with software - defined radio

D. De Donno, L. Catarinucci, R. Colella, L. Tarricone *(Università di Lecce)*

Performance evaluation of passive Radio Frequency IDentification (RFID) Tags is a very challenging task and commercially available solutions for Tag testing are very expensive and not totally flexible. In this work, we propose a novel approach for the characterization of RFID Tags with Software-Defined Radio (SDR). We show how a cheap (below 1000$) and flexible SDR-based RFID Reader can be turned into an accurate tool for measuring the goodness of the conjugate

matching between the RFID chip and the antenna which primarilyaffects the Tag sensitivity. We test our platform by analyzing the performance of two built-in-lab Tags: measurements show a strong agreement with theoretical and simulation results.

Innovative prototyping techniques for UHF RFID tags

L. Catarinucci, R. Colella, L. Tarricone *(Università di Lecce)*

Radio Frequency Identification (RFID) technology is increasingly adopted in many contexts where tags customized for specific applications are needed. Nevertheless, in many practical cases, electromagnetic labs which realize RFID tags use either very rudimentary methods, by shaping the tag antenna on a copper film through a handy cutter, or photolithography methods based on rigid PCB. In this work two innovative prototyping techniques suitable for built-in-lab flexible tags based on are presented. The former is based on the joint use of solid ink printers and flexible PCBs, the latter consists of using a cutting plotter on adhesive copper. A rigorous electromagnetic validation is then proposed, demonstrating the appropriateness of the proposed solutions.

Localization of RFID-Tagged items on a conveyor belt

A. Buffi, P. Nepa, F. Lombardini *(Università di Pisa)*

A new knowledge-based method to locate tagged items on a moving conveyor belt is presented, which is based on a synthetic array technique. System performance is presented through a simplified numerical model and performance analysis is shown with particular attention to the effects of thermal noise and environmental clutter.

Near-field UHF RFID antenna for desktop reader

A. Michel, R. Caso, A. Buffi, P. Nepa *(Università di Pisa)*
G. Isola *(CAEN RFID, Viareggio)*

A travelling wave antenna for near-field UHF (865-928 MHz) RFID desktop reader applications is proposed. A meandered coplanar waveguide line is properly designed in order to get an almost homogeneous magnetic field amplitude; thus, the detection of a tagged item in an arbitrary position and orientation is possible, ensuring a high read rate. Results in terms of reflection coefficient, gain, and effective isotropic field factor are discussed. Finally, the overall RFID system performance is evaluated in terms of tag detection, considering commercial RFID tags.

SESSION 15 - PHOTONIC CRYSTALS

Slow light engineered photonic crystal waveguide: propagation and parametric gain properties

S. Roy, M. Santagiustina *(Università di Padova)*
S. Combrié, A. De Rossi *(Thales Research and Technology, Palaiseau, Francia)*

A. Wilinger, G. Eisenstein *(Technion, Haifa, Israele)*

The linear and nonlinear properties of GaInP photonic crystal waveguides engineered for slow light application are presented. A full vectorial mode analysis method has been used. The dispersion of the nonlinearity and of the losses is taken into account for estimating parametric gain in degenerate four wave mixing. Narrowband optical parametric amplification is achieved in the slow light regime.

Giant dispersive wave generation in double core photonic crystal fiber

D. Modotto, G. Manili, U. Minoni, S. Wabnitz *(Universià di Brescia)*
M. Andreana, V. Couderc, A. Tonello *(Université de Limoges, France)*

A soliton perturbed by higher-order dispersion terms can transfer power to a dispersive wave when they share a common phase velocity. This dispersive wave can be located several hundreds of nanometers away from the soliton carrier wavelength. We numerically study this phenomenon in a double-core photonic crystal fiber pumped at 1064 nm: the presence of a large quantity of short pulses due to the pump pulse break-up and the dispersion profile lead to the growth of a dispersive wave at 1535 nm whose amplitude is comparable to the pump. Preliminary experiments confirm our predictions.

Air-hole ring influence on the cut-off proprieties of 19-cell double-cladding photonic crystal fibers

E. Coscelli, F. Poli, A. Cucinotta, S. Selleri *(Università di Parma)*

Yb-doped double-cladding photonic crystal fibers have become key components for power scaling in fiber laser systems. A careful design of such large core active fibers is mandatory to obtain a single-mode behavior, a necessary requirement for high quality laser beams. In this paper the new avoided-crossing approach has been applied to investigate the cut-off properties of 19-cell photonic crystal fibers, by changing the number of air-hole rings in the fiber inner cladding. Simulation results have shown that, double-cladding photonic crystal fibers with larger inner-cladding provide better cut-off properties of the guided-modes, which can have positive effects on the amplification process in practical applications.

Filter design for OTDM and WDM receivers in PHC technology

S. Malaguti, G. Bellanca, S. Trillo *(Università degli Studi di Ferrara)*
S. Combrié, A. De Rossi *(Thales Research and Technology, Palaiseau, Francia)*

The always growing demand for high-bandwidth low-consumption data routing in the future communication, foregrounds the arrangement of new disruptive optical technologies. In the framework of the EU Copernicus project, we develop ultra-high performances signal-processing devices based on photonic crystal technology. Modeling, design and prototype fabrications of both, a WDM and an OTDM receiver will be proposed.

Fault detection in a dielectric grid

A. Brancaccio, G. Leone, R. Solimene, R. Pierri *(Seconda Università di Napoli)*

The canonical problem of detecting and localizing missing scatterers (faults) inside a known grid of small cross section dielectric cylinders is dealt with. The case of a TM scalar two-dimensional geometry is considered. The scattering by a fault is modeled as the radiation of a proper equivalent volumetric source, by exploiting the Green's function of the complete grid. An approximated linear model of the scattering is proposed, validated by means of numerical results, also in the case of two faults, and checked against model error and noisy synthetic data.

A computational approach to the optical characterization of photonic crystals and photonic glasses

A. Vaccari, A. C. Lesina *(Fondazione Bruno Kessler, Trento)*
L. Cristoforetti *(Provincia Autonoma di Trento)*
A. Chiappini, M. Ferrari *(IFN-CNR, Trento)*

The present paper describes a computational physics approach to the analysis of the light scattering from a three dimensional face-cubic centered lattice of spherical particles. The scattered electromagnetic field distribution is obtained after development of a parallelized FDTD (Finite Difference Time Domain) MPI code for the full numerical solution of the Maxwell's equations, with an impinging plane wave and assigned permittivity of the various spherical particles in the lattice. The aim is to numerically calculate the reflectance and transmittance of a crystal sample in the 500÷1000 nm wavelength range by determining, via the near-to-far field transforming Kirchhoff formula, applied to the FDTD scattered results, the angular distribution of the reflected and transmitted light. This study is suitable for the predictive optical characterization/simulation of large ordered photonic structures and, as a possible further development, of disordered distributions such as glasses.

SESSION 16 - WIRELESS COMMUNICATIONS, NETWORKS AND SYSTEMS

Research activities on antenna design for wireless communication networks at the University of Pisa

A.A. Serra, R. Caso, A. Buffi, A. Guraliuc, A. D'Alessandro, A. Michel, P. Nepa *(Università di Pisa)*

An overview of the most recent antenna research activities at the Department of Information Engineering, University of Pisa, in the area of antenna design for wireless communication systems at UHF and microwave frequencies, is presented. Main results are on planar microstrip antennas for wideband communication systems, for both base stations and subscriber units, integrated PIFAs for DVB-T receivers and GPS terminals, near-field focused microstrip arrays, wearable antennas for body-centric communications. Most of the activities on antennas design, characterization and prototyping have been carried out in collaboration with either SMEs or international research centers.

WSNs as enabling tool for next generation smart systems

F. Viani, M. Salucci, F. Robol, E. Giarola, A. Massa *(Università di Trento)*

The development of smart environments is becoming more and more feasible thanks to the rapid advances in wireless and networking technologies, along with ubiquitous computing and communications. Heterogeneous functionalities of integrated smart systems based on Wireless Sensor network (WSN) technology have been recently developed at the ELEDIA Research Center of the University of Trento. In this work, the most recent advancements developed at the ELEDIA Research Center in this framework are reviewed.

Hydrometeor scattering effects over near-infrared free-space urban links: model and experimental measurements

S. Mori, F. Frezza, F.S. Marzano *("Sapienza" Università di Roma)*
P. Lucantoni, M. Ferrara, P. Nocito, G.M. Tosi Beleffi, E. Restuccia *(Ministero dello Sviluppo Economico)*

Wireless communications through free space using optical carrier (Free Space Optics, FSO) represent a promising technology for peer-to-peer connections and urban area networks. Unfortunately FSO links are quite sensitive to atmospheric conditions. Extinction due to fog droplets and hydrometeors such as raindrops and snowflakes can drastically reduce the availability of the channel. In this work will present a parametric model to simulate droplets scattering effects over the FSO link. Experimental measurements will be shown for two study cases relative to the FSO wide area set up realized in Rome (Italy) by DIET-Sapienza University and ISCOM-Ministry of Economic Development.

Electromagnetic source localization in 3-D outdoor urban scenario using received signal strength

P. Imperatore *(IREA-CNR, Napoli)*
A. Iodice, D. Riccio *(Università di Napoli "Federico II")*

This paper investigates how, by using only received signal strength information, the radio-localization in urban scenario can be achieved with sufficient accuracy, by adopting a methodologically new approach that incorporates a priori information about detailed structure of the 3-D propagation environment. We first formally introduce the localization as a nonlinear inversion problem, then we reformulate it as a global nonlinear optimization one. Accordingly, suitable cost functions are considered and discussed, with reference to both collaborative and non-collaborative scenarios.

Design of the wireless front-end for remote administration of domotic equipment

R. Stefanelli, N. Carvallo, D. Brunazzi, D. Trinchero *(Politecnico di Torino)*

This paper introduces open-hardware wireless equipment designed for a medium scale Internet of Things and Internet of Services experiment, in a rural - digitally divided - village in the Italian Countryside. A wide band wireless net-

work has been built, to provide several remote services: Internet access, intelligent house (garden) control, security surveillance. Internet of Things and Internet of Services activities are realized by means of low cost, open hardware wireless technology. The results obtained during the first eighteen months of experimentation demonstrate a strong participation of the local population, a reduction of the house management costs, together with an increase of safety and security.

Wireless power transfer and near field magnetic communications by multi band resonators

M. Dionigi, M. Mongiardo *(Università di Perugia)*

Resonant Wireless Power Transfer (WPT) can be realized by using coils coupled via their magnetic fields; such systems can exchange energy in the mid-range. Information can also be exchanged via Near-Field Magnetic Communications (NFMC), which is currently receiving considerable attention for several possible applications. We present a structure that can be used for realizing both WPT and NFMC; this structure shows separate frequency channels for the simultaneous transmission of power and data. A test system with one band for power exchange and two separate bands for data transmission is designed, simulated, and measured to show the effectiveness of the proposed structure.

SESSION 17 - PHOTONIC AND PLASMONIC TECHNOLOGIES AND COMPONENTS

SAPPHIRE: a generic foundry platform for silicon photonics

F. Morichetti, A. Canciamilla, S. Grillanda, A. Melloni *(Politecnico di Milano)*
P. Orlandi, P. Bassi *(Università di Bologna)*
S. Malaguti, G. Bellanca *(Università degli Studi di Ferrara)*
M.J. Strain, M. Sorel *(University of Glasgow, United Kingdom)*

A Shared Access Platform to Photonic Integrated Resources (SAPPHIRE) is presented, which aims to become the first national infrastructure enabling a shared access of different users to a generic silicon photonic foundry. The platform is based on the concept of high-level circuit design for photonic integrated circuits (PICs), where complex architectures can be designed without a specific knowledge of either electromagnetic (EM) or technological issues, but simply operating at the circuit level on a selected set of elementary functional elements, named building blocks (BBs). The main roles of the SAPPHIRE platform in the foundry-Users interactions are discussed, as well as the concept of photonic BBs and circuit simulation. Results on a proof-of-concept device are shown to demonstrate the validity of the high-level circuit design for PICs.

Photonics interconnect technology for chip multiprocessing architectures: the Photonica project

A. Parini *(MIST E-R, Ferrara)*
S. Malaguti, G. Bellanca, S. Trillo *(Università di Ferrara)*
G. Calò, V. Petruzzelli *(Politecnico di Bari)*

A Network-on-Chip (NoC) is an architectural paradigm where several independent computational cores, physically located on the same chip, can execute multiple concurrent processes, thus exploiting the potentialities of shared computing inside a single VLSI processor. As the number of interconnected cores increases, the needs in terms of communication bandwidth and power consumption grow exponentially, imposing unrealistic constraints for a practical realization. To overcome these limitations, Optical Networks-On-Chip (ONoCs) seem to be a promising solution. The aim of PHOTONICA is to develop a design platform for photonic on-chip interconnections. In this paper some of the main results obtained during the first year of activity are presented.

Grating-assisted coupling to strip plasmonic modes: 3D numerical analysis

M.P. Bolzoni, G.G. Gentili *(Politecnico di Milano)*
S.M. Pietralunga *(IFN-CNR, Milano)*

Grating-assisted optical coupling into long-range modes of strip plasmonic waveguides is analyzed by a 3D numerical simulation with a full wave FEM software. A comparison with results obtained using the common 2D approximated analysis is shown, in case of 1D grating coupler and input Gaussian beam. Excited diffracted modal field distribution is calculated, as it evolves in propagation.

Design of plasmonic directional couplers

M. Grande, G. Magno, R. Marani, G. Calò, V. Petruzzelli, A. D'Orazio *(Politecnico di Bari)*

We propose and numerically investigate a novel kind of nanoscale plasmonic vertical directional couplers constituted by a polymeric waveguide and a surface plasmon polariton waveguide coupled through a metallic strip grating. By using finite-difference-time-domain simulations it is found that it is possible to design plasmonic couplers with high efficiency and very short coupling length in both visible and NIR range.

Second harmonic generation in plasmonic waveguides

F.M. Pigozzo, D. Modotto, S. Wabnitz *(Università di Brescia)*

In this work we demonstrate theoretically that modal phase matching for second harmonic generation can be obtained in AlGaAs plasmonic waveguides by means of the Type II interaction: one pump is carried by a plasmonic mode, whereas the other pump and the second harmonic signals are carried by optical modes confined inside AlGaAs layers. The phase matched wavelength can be tuned in the near infrared by changing the physical dimensions of the waveguides.

Representation of a Spiral Phase Plate as a two mode Quantum Phase Operator

F.A. Bovino *(SELEX-SI, Genova)*

We introduce a quantum-like representation of a Spiral Phase Plate as a two mode phase operator. The representation is based on the Newton binomial expansion and on properties of rational power of quantum operators.

SESSION 18 - ENERGY AND ENVIRONMENT

Microwave electromagnetic sensors to estimate water density within snow

A. Carta, R. Stefanelli, D. Trinchero *(Politecnico di Torino)*

The paper introduces a compact sensing topology based on a distributed alignment of electromagnetic radiators, deployed in a predefined distance to form an ad-hoc network, able to reveal the differential variation of humidity inside snowfields. By monitoring the relative attenuation among two separate alignements of vertical antennas, the relative permittivity and electrical conductivity of the snow can be deduced with sufficient precision. The two terms can be used as precise indicators of dramatic events such as avalanches and landslides. The simulation results show that the dynamic of the signal attenuation is enough to reveal the snow water density.

The potential use of microwave weather radar for volcanic ash monitoring

M. Montopoli *(University of Cambridge, United Kingdom)*
G. Vulpiani *(Presidenza del Consiglio dei Ministri, Dipartimento Protezione Civile)*
F.S. Marzano *("Sapienza" Università di Roma)*

In this work the experimental evidence together with modeling outcomes are considered to support the capability and shows the limitations of microwave weather radars to detect and monitor volcanic ash. Detection, classification and quantitative estimation of volcanic ash are the main challenges that scientist are facing to fully exploit the exiting weather radar systems. This paper briefly shows the state of the art on these aspects.

Laser scribing integration of polycrystalline thin film solar cells

M. Sozzi, C. Catellani, A. Cucinotta, S. Selleri, D. Menossi, R. Dharmadasa, A. Bosio, N. Romeo *(Università di Parma)*

The growing demand for high productivity in the thin-film module industry, together with the request for more and more efficient photovoltaic devices, requires high-performance laser-scribing. We report a study of laser-scribing on CdTe thin-film modules.

Antenna-plasma coupling calculations at lower hybrid frequencies by using a FEM code

S. Ceccuzzi, F. Napoli, L. Pajewski, G. Schettini *(Università "Roma Tre")*
A.A. Tuccillo *(Euraton-ENEA, Frascati, Roma)*

This paper illustrates how a commercial software can be successfully employed to solve coupling problems between cold plasmas and grill antennas at Lower Hybrid frequencies (1-8 GHz). The FTU conventional grill, presently installed in ENEA-Frascati laboratories, is used as a test case to calculate antenna scattering matrix and launched power spectrum. Owing to the high computational effort required by the simulations, a 2-D planar symmetry is enforced considering infinite length waveguides in poloidal direction. Simulation results are validated by comparison with experimental data in terms of average reflection coefficient, showing remarkable agreement. Pros and cons of the tool as well as possible improvements are discussed.

Novel inkjet-printed substrate integrated waveguide (SIW) structures for eco-friendly low-cost application

R. Moro, M. Bozzi *(Università di Pavia)*
S. Kim, M. Tentzeris *(Georgia Institute of Technology, Atlanta, USA)*

The implementation of Substrate Integrated Waveguide (SIW) structures in paper-based inkjet-printed technology is presented in this paper for the first time. SIW interconnects and components have been fabricated and tested on a multilayer paper substrate, which permits to implement low-cost and eco-friendly structures. Paper-based fabrication appears very suitable for the realization of SIW components, as it allows for arbitrary geometry, conformal shape, and multilayered configuration. Paper is a widely available, low cost material and, moreover, it is environmental friendly: for this reason, it is currently investigated for several potential applications in wireless systems and wearable devices.

Preliminary studies on the microwave pre-treating of lignocellulosic biomasses

A. Facchini, A. Zeffiro, P. Arcioni, A. Buttafava *(Università di Pavia)*

In this paper, a measurement setup to derive the complex permittivity of biomasses vs. temperature is presented. A TM_{010} cylindrical cavity resonator with heating system operating at 2.45 GHz has been designed. Complex permittivity is obtained by measuring transmission coefficient, while sample temperature is monitored by a thermocouple. Measurements of lignin, starch, cellulose and sewage sludge at room temperature are reported, as well as complex permittivity of lignin and cellulose in a temperature range of 25-200°C. Finally, the design of a microwave heater, intended to treat these materials in a pyrolysis process, is discussed.

POSTER SESSION I

The role of evanescent modes excited inside the longitudinal corrugations of mode filters

S. Ceccuzzi, S. Meschino *(Università "Roma Tre")*

Mode filters for high-power oversized rectangular waveguides are usually based on corrugations partially filled with absorbing materials. In this paper the modal content excited at the input of longitudinal corrugations is calculated through an approximate model, whose reliability and limitations are assessed by comparison with a full-wave commercial code. Wave amplitudes inside the absorbing material and power loss by Joule effect are computed by enforcing proper boundary conditions. Modes under cut-off are demonstrated to contribute to the total absorption when the lossy dielectric is located close enough to the waveguide slots. Useful guidelines for the design of mode filters are derived.

Electromagnetic scattering by a finite metallic cylinder

F. Di Murro, M. Lucido, F. Schettino *(Università di Cassino e del Lazio Meridionale)*

A full wave analysis of the electromagnetic scattering by a finite metallic cylinder is presented. The Electric Field Integral Equation (EFIE) related to the problem is solved by means of the Method of Moments (MoM) employing entire domain basis functions. Such functions have been chosen so as to reconstruct the correct edge behavior of fields and currents near the sharp edges of the cylinder. As a consequence, fast convergence of the series is obtained, only few expansion terms being necessary to achieve prescribed accuracy.

Volume and roughness scattering effects: a unified perturbative approach

P. Imperatore *(IREA-CNR, Napoli)*
A. Iodice, D. Riccio *(Università di Napoli "Federico II")*

We propose a comprehensive analysis for the evaluation of the scattering from randomly inhomogeneous semi-infinite media, including both interfacial roughness and volume inhomogeneities, by applying the methodological approach of the Volumetric Perturbative Reciprocal Theory (VPRT). A unifying perspective on the scattering phenomenon considered in its entirety is gained and an analytic scattering model is obtained.

Deep penetration of inhomogeneous plane waves in lossy media

N. Tedeschi *("Sapienza" Università di Roma)*

The incidence of an inhomogeneous plane wave on the interface between two lossy media is analyzed. The analytical expressions of the incidence angle of the phase vector, for which the transmitted wave has the phase or the attenuation vector parallel to the interface, are obtained. The transmitted wave with the attenuation vector parallel to the interface is physically interpreted, finding a wave in a lossy medium without attenuation away from the interface. The same effect ap-

pears at the interface between a lossless medium and a lossy one. In both cases the amplitude of the Poynting vector is analyzed to show the absence of attenuation away from the interface.

Analysis of propagation in coupled polygonal cross-section dielectric waveguides

F. Corsetti, M. Lucido, G. Panariello *(Università di Cassino e del Lazio Meridionale)*

Aim of this paper is the accurate and efficient analysis of the propagation in coupled polygonal cross-section dielectric waveguides. The problem is formulated as a system of surface integral equations and discretized by means of Galerkin's method with analytically Fourier transformable expansion functions factorizing the behavior of the fields on the wedges. The presented numerical results show the accuracy and the efficiency of the proposed technique.

Perturbative approach for scattering in random media via distribution theory for discontinuous test functions

P. Imperatore *(IREA-CNR, Napoli)*
A. Iodice, D. Riccio *(Università di Napoli "Federico II")*

We present the second-order volumetric perturbative reciprocal theory (VPRT), which has a direct theoretical interest to scattering in random and layered media including up to second-order effects. Distribution theory for discontinuous test functions provides the rigorous mathematical backbone of the general VPRT formulation, so conferring conceptual elegance to the theoretical construct.

A synthesis method for multi-section devices

F. Chiadini, A. Scaglione *(Università di Salerno)*
V. Fiumara *(Università della Basilicata)*

We propose a synthesis method to design quarter-wave multi-section devices which exhibit reflection properties approximating a given reflection spectrum.

A novel interpretation for the Kirchhoff scattering from classical and fractal surfaces

A. Iodice, A. Natale, D. Riccio *(Università di Napoli "Federico II")*

Electromagnetic models for surface scattering represent a handy analytical tool for any application founded on numerical methods which exploit the prediction of the scattered field. In addition, it is widely recognized that statistical scale-invariance properties exhibited by natural surfaces within a wide observation scale range are very efficiently described by means of fractal geometry and, of course, the better is the surface model employed to compute the electromagnetic scattering, the more accurate are the forecasts on the scattered field, provided that closed form solutions for the statistics of the field are attainable. Accordingly, here the focus is on the Kirchhoff scattering integral pertinent to a rough surface modeled as a fractional Brownian motion stochastic process. Such analysis led us

to reconsider the meaning of the Kirchhoff solution for the scattering from both classical and fractal surfaces, so allowing us to provide a novel physical interpretation of the Kirchhoff scattering integral in terms of the *probability density function of an equivalent rough surface.*

Random coupling model for wave chaotic cavities

G. Gradoni, T. M. Antonsen, E. Ott *(University of Maryland, USA)*

The quest of a physical model for complex electromagnetic cavities is a vivid topic in modern engineering. In this contribution, we present a derivation of the random coupling model that describes the coupling of an external radiation into and out of electrically large enclosures through apertures (ports). A connection between deterministic and statistical theories is demonstrated in terms of cavity admittance (impedance) matrix. Our model makes use of the wave chaos theory to extend, and preserve, the classical modal description of the cavity field in presence of irregular boundaries.

Two approaches to field focusing in unknown environments

L. Di Donato, D.A.M. Iero, T. Isernia *(Università Mediterranea di Reggio Calabria)*
I. Catapano, L. Crocco *(IREA-CNR, Napoli)*
G. Sorbello *(Università degli Studi di Catania)*

The paper introduces two effective methods, based on the Linear Sampling Method, to tackle the problem of focusing an electromagnetic field onto a target point in unknown environments. Besides its theoretical relevance, the problem is of interest in applications spanning from biomedical engineering to security monitoring.

Infrared absorption measurements using metamaterials

L. La Spada, R. Iovine, F. Bilotti, L. Vegni *(Università "Roma Tre")*

In this study, a low cost, compact metamaterial-based sensor, operating in the mid-infrared frequency range, is proposed. The sensor is able to detect the presence of (in)organic compounds by absorption measurements. In particular, the proposed sensor is designed to recognize the presence of water content in biological samples. For this aim a new analytical model is developed useful to describe the resonant behaviour of the sensor. Good agreement between the numerical values, obtained through full-wave simulations, and the theoretical ones, obtained by using the proposed model is achieved. Results confirm the possibility to use the proposed structure as a sensor for water content recognition in a high selective way. This sensor may find application in medical diagnostics, in the detection of normal and cancer tissue by water absorption measurements.

A study on the foundamental mode characteristics sustained by the plasmonic slot waveguide

F. Frezza, E. Stoja *("Sapienza" Università di Roma)*
P. Nocito *(Ministero dello Sviluppo Economico)*

We investigate and compare the characteristics of the fundamental guided mode sustained by a subwavelength plasmonic slot waveguide for three types of metals: gold, silver and aluminum. This is done in terms of mode effective index, propagation length, confinement and, as the mode under study is quasi-TEM, we also develop a transmission line model that can be employed in the design of optical components making use of slot waveguides.

YB - doped photonic crystal fiber laser

R. Ana Perez-Herrera, M. Lopez-Amo *(Universidad Pública de Navarra, Pamplona, Spagna)*
E. Coscelli, M. Sozzi, A. Cucinotta, S. Selleri *(Univeristà di Parma)*

An Ytterbium-doped Photonic Crystal Fiber (PCF) laser has been experimentally assembled. The issue of splicing PCFs with conventional fibers has been addressed, two solutions for splicing an air-clad Ytterbium-doped PCF with a conventional one have been proposed, and their losses have been measured. The performances of the laser have been evaluated.

FEM solver optimization for PCF design

C. Molardi, Masruri, E. Coscelli, F. Poli, A. Cucinotta, S. Selleri *(Università di Parma)*

The need to simulate electromagnetic field in complex optical devices, such as photonic crystal fiber, leads to use suitable numerical tools. Not always commercial software products cover this need. A full-vector modal solver, based on finite element method, has been updated and optimized for application to photonic crystal fiber design. First the electromagnetic problem is explained, paying attention to the numerical issues, such as fill-in, spurious solutions, memory requirement, and showing the chosen solutions to these issues. Then some tests have been displayed to prove the reliability of the solver, in particular a rod-type photonic crystal fiber has been simulated to investigate the solutions' correctness and the performance in term of required memory space and execution time. Finally the solver results have been compared with the results obtained from commercial solver.

A modified RC - FDTD algorithm for plasmonics in Drude dispersive media

A. Calà Lesina, A. Vaccari, A. Bozzoli *(Fondazione Bruno Kessler, Trento)*

A widespread approach in the FDTD analysis of dispersive media is the Recursive Convolution (RC) method. In the Drude version it shows a not so good accuracy in describing the electromagnetic field at the plasmonic resonance frequencies. We propose here a modified RC algorithm which, by minimizing

the time truncation error, guarantees a better accuracy of the solution at parity of memory requirements and number of time iterations. We test the modified RC algorithm proposed by analyzing the behavior of gold and silver noble metal nanospheres exposed to an optical plane wave with respect to the standard RC approach and the analytical solution.

Broadband optical parametric generation in LiTaO3

F. Baronio, M. Conforti, C. De Anglelis *(Università di Brescia)*
M. Levenius, K. Gallo, V. Pasiskevicius, F. Laurell *(KTH-Royal Institute of Technology, Stockholm, Sweden)*

We investigate theoretically and experimentally multistep parametric processes in broadband optical parametric generators based on periodically poled 1 mol % MgO-doped stoichiometric $LiTaO_3$. We demonstrate that parametric collateral processes may deplete or enhance spectral portions of the optical parametric generation output, depending on pump pulse duration.

Wind farm impact on primary radars

R. Tumolo, S. Immediata, G. Russo, M. D'Urso, and L. Timmoneri *(SELEX Sistemi Integrati S.p.A.)*

The growing need for renewable energy sources has led to an increasing massive utilization of wind energy. Each year new wind farms arise, consisting of wind turbines (WT) bigger and bigger. Wind turbines are a very complex source of radar clutter to characterize and have an impact on air traffic control particularly difficult to mitigate. Wind turbines are often enormous structures, able to both re-irradiate a significant portion of the radar energy, and, because of blades motion, give rise to a Doppler effect very similar to that due to a flying airplane. In this work the steps towards the development of suitable wind turbine clutter mitigation techniques are presented.

Embedded photonic sensors networks for large arrays diagnostic

P. Vinetti, M. D'Urso, M. Dispenza *(SELEX Sistemi Integrati S.p.A.)*

A feedback control network based on photonic sensors has been exploited to increase resiliency of large phased arrays for radar and space applications has been proposed. The sensor network is embedded in the antenna array front-end such to provide a a real-time control of the failures/calibration errors of system components. The feedback system dynamically acts on the weights of the Beam Forming Network thanks to accurate and effective synthesis methods, allowing minimizing the mismatch between the actual pattern and the reference one.

POSTER SESSION II

Analysis of a flat, dielectric - loaded, ion cyclotron, test antenna by using three electromagnetic codes

S. Ceccuzzi *(Università "Roma Tre")*
D. Milanesio *(Politecnico di Torino)*
G.L. Ravera *(Euratom-ENEA, Frascati, Roma)*

The present work compares the results coming out from the following three Ion Cyclotron antenna tools: HFSS, COMSOL Multiphysics and the TOPICA code. A simplified flat antenna geometry, working at 30 MHz, is used as benchmark. The comparison is carried out with respect to the scattering matrix and the RF potentials, i.e., the line integrals of the electric field along the flux tubes of the equilibrium magnetic field. Various operational configurations characterized by different antenna-load clearance are considered. Very good agreement can be observed among the codes for all the simulated configurations in terms of scattering parameters. RF potentials also match as regards to patterns, trends as well as absolute values.

Full-analytical procedure for the design of micro-magnetic radiators

R. Stefanelli, D. Trinchero *(Politecnico di Torino)*

Recently, small magnetic radiators are becoming more and more important for a large variety of applications involving the use of narrow transmission bandwidth in wireless sensor networks, data tracking, or environment monitoring, where they can be used not only in free-space conditions, but also inside complex electromagnetic media. As a matter of fact, the antenna is an essential component that impacts the efficiency of the transmission, the size of the device, and the bandwidth operability. In this paper an analytical procedure is introduced, that allows the design of magnetic antennas with arbitrary shape and extremely reduced dimensions. Since the design procedure is analytical, it can be efficiently applied to synthesize antennas in the free space, but also in general media. Simulations and measurements exhibit a good agreement.

Analysis of cylindrical frequency selective surfaces for antenna radomes

E. Di Salvo, F. Frezza *("Sapienza" Università di Roma)*
S. Mosca *(SELEX SI, Roma)*

An analysis technique is described for cylindrical frequency selective structures, useful for antenna radome applications. The structures are made by free-standing conducting rectangular patches, or slots. Approximate relations are employed to study in particular structures with many elements. A comparison is reported with previous results given in the literature. The opacity, or transparency, of the surface for a suitable frequency range is shown.

Matching techniques for efficient broadside radiation in 1D periodic printed leaky-wave antennas

P. Baccarelli *("Sapienza" Università di Roma)*
S. Paulotto *(Maxtena Inc., Bethesda, MD, USA)*
D.R. Jackson *(University of Houston, Texas, USA)*

Symmetric ϖ-matching networks are presented for suppressing the open stopband (OSB) and obtaining efficient broadside radiation in one-dimensional (1-D) periodic printed leaky-wave antennas (LWAs). The elimination of the OSB is achieved by matching the Bloch-wave impedance of the structure to a desired (non-zero) value at broadside frequency. Three different matching conditions can be applied. The effectiveness of the proposed techniques is demonstrated with numerical simulation on real structures.

A canonical problem in multibeam antenna synthesis

A.F. Morabito, L. Di Donato *(Università Mediterranea di Reggio Calabria)*

The problem of the optimal synthesis of 'four-color' multi-beam antennas is formulated and solved. The proposed approach exploits at best all the degrees of freedom of the synthesis scenario at hand, and allows formulating the design problem as a convex programming optimization. The achievement of the maximum feasible radiation performance is guaranteed in a large number of applications of actual interest.

Modified U-slot patch antenna with low cross-polarization for broadband applications

S. Costanzo, A. Costanzo *(Università della Calabria)*

The basic U-slot shape usually adopted for enhancing the bandwidth response of a microstrip patch antenna is properly modified in this work to significantly reduce unwanted cross-polarization effects. A wideband impedance matching is obtained by introducing a proper anular gap around the feed probe, in order to compensate for the large inductive reactance due to the presence of a thick substrate. A compact P-band prototype with a 15% bandwidth is realized and experimentally tested.

Direct far-field reconstruction from near-field data acquired through a helicoidal scanning

F. D'Agostino, F. Ferrara, C. Gennarelli, R. Guerriero, M. Migliozzi *(Università di Salerno)*

A near-field - far-field transformation with helicoidal scanning for elongated antennas, which allows the evaluation of the antenna far field directly from a nonredundant number of data without interpolating them, is here proposed. It relies on a nonredundant sampling representation of electromagnetic fields and employs a flexible source modeling suitable for long antennas to determine the number of helix turns. Instead, the number of data on each turn is fixed by the minimum cylinder rule, as in classical cylindrical scan, in order to reduce the

computational effort and simplify the mechanical scanning. Numerical results assessing the effectiveness of the proposed technique are shown.

A new compact monolithic patch antenna for dedicated short range communications systems

O. Leonardi, G. Sorbello *(Università di Catania)*
M. Pavone *(ST Microelectronics, Catania)*
T. Isernia *(Università Mediterranea di Reggio Calabria)*

Dedicated Short Range Communications (DSRC) is a novel short- to medium-range wireless protocol designed for automotive use. The DSRC signals are circularly polarized and allocated in the 5.8 GHz band. This communication describes the development of a monolithic and compact microstrip antenna with left-hand circular polarization intended for the On-Board Unit (OBU) equipment of a DSRC system. The 0.773λ0 x 1.16λ0 fabricated prototype exhibits a circularly-polarized gain of about 5.52 dBi with a Cross Polarization Discrimination (XPD) greater than 10 dB.

UWB multifunctional arrays based on versatile printed rhombic antenna configurations

A. Galli, S. Mazzocchi *("Sapienza" Università di Roma)*
G. Valerio *(Université de Rennes, France)*
M. Ciattaglia, M. Zucca *(SELEX SI, Roma)*

Based on recently-proposed Ultra-Wide-Band planar antenna configurations having strips in suitable rhombic shapes, innovative configurations of printed arrays are presented and tested for typical multifunctional applications (radar, communications, sensing) ranging from C to K bands. By means of advanced parametric analyses, the radiative features are analyzed to design single structures and then arrays with small and large number of elements. Attention is paid to low-cost, compact and light-weight solutions, also accounting for realization issues. Stimulating performances are observed in terms of matching and radiation patterns, as a function of frequency and of phase shift.

Sensing-oriented design methodology for passive RFID antennas

C. Occhiuzzi, G. Marrocco *(Università di Roma "Tor Vergata")*

RFID passive tags are nowadays starting to be considered more than simple labeling devices: by properly analyzing the two-ways communication link it is possible to collect information about the state of a tagged object, without any specific embedded sensor or local power supply. A design methodology is here proposed to simultaneously account for the opposite requirements of sensing and communication. The method is based on a proper representation of the antenna response to varying boundary conditions over an impedance chart that permits to identify the theoretical limit of the design and to fully shape the response of the tag.

A new localization method for UHF-RFID smart shelves

A. D'Alessandro, A. Buffi, P. Nepa *(Università di Pisa)*
G. Isola *(CAEN RFID, Viareggio)*

A new localization method for UHF-RFID smart shelves is presented, with reference to a pharmacy drawer for drug storage. Exploiting RSSI (Received Signal Strength Indicator) information during drawer opening and closing movements, tagged item location is estimated. During drawer movements, the relative position of tag and reader antenna changes, allowing for uncorrelated RSSI measurements. Measurements in a real scenario are carried out with commercial tags and reader antennas. Location performance is presented in terms of the probability of making a correct decision, when the drawer is subdivided into two regions.

Equivalent impedance retrieval of planar surfaces by open resonator technique

S. Costanzo, G. Di Massa, O.H. Moreno *(Università della Calabria)*

The use of an open resonator system with an optimized coupling transition to the feeding waveguide is proposed in this work to accurately characterize the equivalent impedance of planar surfaces from return loss measurements. A modeling circuit derived from a complete modal expansion is adopted to optimize the coupling as well as taking into account for the cavity losses. Two application contexts are considered as validation examples, namely the complex permittivity retrieval of thin substrates and the phase response characterization of microstrip reflectarrays. For both applications, successful K-band experimental results are presented.

Wireless power transmission links: experimental results at the electromagnetic laboratory of Lecce

G. Monti, L. Tarricone, F. Congedo, P. Arcuti *(Università del Salento)*

This paper presents some results concerning the design of wireless links for power transmission developed at the Electromagnetic Laboratory of Lecce. More in detail, a system for far-field communications using a rectifying antenna (rectenna) and one for near-field communications using inductively coupled resonators are presented. In both cases experimental results are given and discussed.

Time-modulated arrays for next generation cognitive radio systems – potentialities and envisaged solutions

P. Rocca *(Università di Trento)*

The potentialities and opportunities offered by time-modulated arrays as antenna systems for cognitive radio applications is analyzed and discussed in this paper. The easy reconfiguration of the radiation characteristics and the possibility to exploit the self-generated harmonic radiations for multiple channel communication purposes are obtained by simply controlling the on-off switching sequence modulating the static array excitations. The optimization of the radiation features are achieved by means of a customized optimization procedure based on an evolutionary strategy.

Array design in the correlation domain: a new paradigm

F. VIANI *(Università di Trento)*

A new paradigm for the design of antenna arrays is proposed in which the constraints and objectives are formulated in the "autocorrelation domain" rather than in terms of pattern features. Such an approach is motivated by the known relations between the radiating properties of antenna arrays and the autocorrelation of the associated weighting sequences. Thanks to such a property, the introduced framework enables the exploitation of already developed sequences with known correlation features coming from combinatorial theory. Moreover, it enables the formulation of new design problems which do not require the evaluation of array patterns for their solution. A preliminary example is reported to point out the potentialities of the proposed correlation domain paradigm.

Surveillance of wide zones with unattended ground sensors: from detection to alert

D. PAVONE *(OPTEL, Napoli)*
G. SORRENTINO, A. BUONANNO, M. D'URSO *(SELEX Sistemi Integrati S.p.A.)*

In this paper, we describe the experimental work and present an algorithm for vehicle and human detection using seismic sensors. For the vehicle detection, we propose a real-time algorithm able to calculate an adaptive threshold in order to lower the false alarm probability. For the human detection, instead, when the persons moving over ground, they generate a succession of impacts. Even in noisy environments, statistical measures of the seismic amplitude distribution, such as kurtosis, can be used to identify a footstep.

Digital multiple beams radars for airport monitoring and surveillance

A. BUONANNO, P. VINETTI, M.G. LABATE, M. D'URSO *(SELEX Sistemi Integrati S.p.A.)*
M. Albertini, L. Russo (Space Engineering S.p.A.)

Phased array radar is very important in modern radar development, and sub-array clustering for digital multiple beams is a fundamental enabling technology in phased array radar. Full digitization of each antenna T/R module in large phased array radar is typically impracticable, and digitization at sub-array level can provide digital beamforming capability to address high performance requirements of modern multifunctional radar. The paper discusses a novel approach to effective design the antenna front end of a MFC radar.

POSTER SESSION III

A novel approach for the sampling of fractal surfaces in remote sensing

D. RICCIO, G. RUELLO *(Università di Napoli "Federico II")*

Fractal geometry is widely recognized as the most suitable instrument for describing shape of natural surfaces. The fractional Brownian motion is widely used for

the description of the second order statistics of natural surfaces. In many applications, the backscattered field is of interest (instead of its averages); this computation needs appropriately describing the properties of surfaces as required by the correct representation and of the backscattered. Therefore, it arouses the needs for the synthesis of fBm surfaces. In this paper we propose an innovative physical based approach for determining the conditions under which a Weierstrass-Mandelbrot predictable process can be considered as an appropriate a convenient spectral sampling of an fBm whenever the surface description its backscattered electromagnetic field are in order.

Sub-array processing techniques applied to the detection of buried targets

S. Meschino, L. Pajewski, G. Schettini *(Università "Roma Tre")*
M. Pastorino, A. Randazzo *(Università di Genova)*

A sub-array processing (SAP) technique for the localization of conductive buried objects is proposed. A Direction of Arrival (DoA) approach is implemented by using two different methodologies: a bearing algorithm based on the conventional MUltiple SIgnal Classification (MUSIC) implementation is compared with a Kernel-based technique, such as Support Vector Machines (SVM). An array of sensors is considered and partitioned in sub-arrays. A dominant DoA is found for each sub-array. By triangulating the DoAs, a crossing pattern is derived and it is statistically processed in order to estimate the object position.

GNSS reflectometry for Earth's surface monitoring exploiting an open-loop approach

Y. Pei, S. Yi, J. Zhou, R. Notarpietro, P. Savi *(Politecnico di Torino)*
M. Pini *(Istituto Superiore Mario Boella, Torino)*

In the framework of the regional Italian project SMAT-F1, an experimental campaign using small aircraft flying an area above Vercelli (Piedmont, North Italy) was performed to remotely sense rice fields' flooding state by applying Global Navigation Satellites System Reflectometry (GNSS-R) technique. Both direct and reflected GPS signals (the latest exploiting a bistatic configuration) where collected by the receivers mounted on the aircraft. The reflected signal was processed using Delay Doppler Maps and Delay Waveforms (DM) to evaluate Signal to Noise Ratio (SNR) in order to investigate the correlation with soil moisture. Final results not only indicated high spatial correlation between powers measured considering two close specular tracks observed from two GPS satellites, but also shown great agreement between processed SNRs and the surface conditions, including flooding or not, fields or boundaries.

Spaceborne microwave interfeormetric radiometers: lunar sub-surface remote sensing, inverse problems and electromagnetic diagnostics

S. Pompili *(Thales Alenia Space, Roma)*
A. Di Carlofelice *(Università de L'Aquila)*
P. Romano *(Adaptive Micronano Wave Systems Group, Lausanne, Switzerland)*
C. Sciannella *("Sapienza" Università di Roma)*

In this paper we propose a mission concept, called Lunar Interferometric Radiometer by Aperture Synthesis (LIRAS), which addresses the high-resolution mapping and vertical sounding of the Moon sub-surface for planetary analysis and studies. This is done by taking advantage of the antenna aperture synthesis technique applied to a multi-frequency microwave passive payload. The final objectives of this study are to demonstrate the technical feasibility of the LIRAS project and then, with the aid of microwave simulations of Moon soil behavior and the synthetic antenna aperture, to present its preliminary design.

Detection of floods and heavy rain using COSMO-Skymed data

L. Pulvirenti, F.S. Marzano, N. Pierdicca, S. Mori *("Sapienza" Università di Roma)*
M. Chini *(Istituto Nazionale di Geofisica e Vulcanologia, Roma)*
L. Guerriero *(Università degli Studi di Roma "Tor Vergata")*

This paper presents a severe weather event that occurred in Northwestern Italy observed from space by the ©COSMO SkyMed X-band radar developed by ASI. The study presents a methodology to detect water surfaces, as well as areas in which heavy rain is present. The methodology is based on a combined use of electromagnetic scattering models and image processing techniques and uses also ancillary data, such as optical images, land cover maps and a digital elevation model (DEM).

Reflection symmetry to observe metallic targets at sea by a dual-polarimetric SAR

F. Nunziata, M. Montuori *(Università "Pathenope" di Napoli)*

A polarimetric model to observe metallic targets at sea in polarimetric Synthetic Aperture Radar (SAR) data is proposed. The model gives an understanding of the different symmetry properties that characterize sea surface with and without metallic targets in terms of the correlation between like- and cross-polarized channels. Experiments undertaken over C-band Single Look Complex (SLC) RADARSAT-2 SAR data confirm the soundness of the approach.

Electromagnetic characterization of speckle in SAR images

G. Di Martino, A. Iodice, D. Riccio, G. Ruello *(Università di Napoli "Federico II")*

New generation space-borne SAR sensors are acquiring images at very high resolution and their statistics, in many actual situations, do not match with those predicted by the fully developed speckle model. Most of the models for non-fully developed speckle are based on the concept of interference between scatterers within the radar resolution cell. The approach proposed in the present paper provides the analytical dependence of the number of scatterers on surface roughness and sensor parameters. The illuminated surface is represented here using fractal geometry.

Contrast source Bayesian compressive imaging by a minimum norm formulation

G. Olivieri *(Università di Trento)*

The problem of imaging sparse dielectric profiles from scattered field data is solved by means of a new multi-task Bayesian Compressive Sensing (MT-BCS) approach under the contrast-source-inversion (CSI) formulation. The proposed strategy is devoted to a twofold objective: on the one hand, to effectively exploit the a-priori *knowledge on the sparseness of the objects of interest, and, on the other hand, to suitably manage the complex nature of the unknowns during the solution process. Towards this end, a minimum-norm current expansion is adopted. A set of preliminary numerical results is reported to features of the arising method.*

Resolution of MEG inverse problem via reweighted l_1 minimization algorithm

M. Muzi *(Università "G. d'Annunzio" di Chieti-Pescara)*

The MagnetoEncephaloGraphy (MEG) inverse problem consists in the estimate of the cerebral current dipole distribution generating the induction magnetic field measured by a MEG device. In this work, a nouvelle approach to solve the MEG inverse problem under the hypothesis of a sparse solution is presented. This approach solves a recursive sequence of constrained weighted l_1-minimization problems. The weights used for the next iteration are computed from the values of the current solution acting, de facto, as an "auto-regularization" of the problem that improves the accuracy of the source estimate. The proposed method is tested on extensive simulation and on real MEG data.

Electromagnetic propagation inside a module of international space station: a numerical analysis

A. Di Carlofelice, E. Di Giampaolo, P. Tognolatti *(Università de L'Aquila)*

A numerical investigation of the electromagnetic pollution produced inside a model of a module of the International Space Station (ISS) by a radar UWB is shown. In particular, the work investigates possible narrowband interference and the level of the background noise introduced by an UWB radar because these phenomena may decrease the QoS of existing wireless networks and apparatus. This study is part of the project "Non Invasive Monitoring by Ultra wide band Radar of Respiratory Activity of people inside a spatial environment" (NIMURRA) which refers to a feasibility study of a ultra wide band (UWB) radar applied to the breath activity monitoring of astronauts.

Criterion for the optimal choice of the operative conditions in magnetic nanoparticle hyperthermia: uncertainty analysis

G. Bellizzi, O.M. Bucci *(Università di Napoli "Federico II")*

The aim of the paper is to assess the robustness of a recently proposed criterion, for the optimal choice of the operational conditions in Magnetic NanoParticle Hyperthermia (MNPH), against the uncertainty on the knowledge of the

thermal properties of the exposed tissues. In particular, the uncertainty on the induced temperature rise due to a rough knowledge of the thermal properties is analytically evaluated and the obtained results are compared to those numerically computed in the case of tumors hosted in a homogeneous healthy tissue.

Microwave treatment of tuff-stones. Structural analysis

B. Bisceglia, E. Avallone, A. Buonerba, E. Caliendo, F. Chiadini, A. Grassi, L. Incarnato, A. Scaglione *(Università di Salerno)*
L. Guerriero *(Seconda Università di Napoli)*

Non destructive and non invasive techniques are irreplaceable in order to preserve and to restore cultural heritage objects in its structure and shape. Microwave (MW) non invasive disinfestation methods allow intervening on the heritage goods with no alteration of the state of preservation. It is important to demonstrate that the MW treatment does not alter the structure of the goods, since this can influence its physical, chemical and mechanical properties. Aim of this work is to investigate about alterations of the structure of tuff-stones after MW disinfestation. The effects have been investigated by several techniques, such as X-ray diffraction, infrared spectroscopy and thermogravimetric analysis. The results show that the structure is not much influenced by MW treatment.

Signal transduction on enzymes: the effect of electromagnetic field stimuli on superoxide dismutase (SOD)

P. Marracino, M. Migliorati, A. Paffi, M. Liberti, G. d'Inzeo, F. Apollonio *("Sapienza" Università di Roma)*

Protein functions and characteristics can highly differ from physiological conditions in presence of chemical, mechanical or electromagnetic stimuli. In this work we provide a rigorous picture of electric field effects on proteins behavior investigating, at atomistic details, the possible ways in which an external signal can be transduced into biochemical effects.

Characterization of a microwave thermal ablation process

M. Cavagnaro, S. Franco *("Sapienza" Università di Roma)*
V. Lopresto, R. Pinto *(ENEA, Casaccia, Roma)*

Experimental measurements and numerical simulations are conducted with the aim of developing a numerical tool able to predict the very high temperature increases found in microwave thermal ablation procedures. Measurements of the temperature increase close to the microwave antenna have been performed. Measured data have been compared with numerical results obtained solving the bio-heat equation (BHE). The influence of the liquid refrigerating the antenna is put into evidence.

Artificial transmission line for wireless power transmission

G. Monti, L. Tarricone *(Università del Salento)*
M. Dionigi, M. Mongiardo *(Università di Perugia)*

In this paper a periodic network for wireless power transmission applications is presented. More in detail, the system here proposed consists of N inductively coupled LC unit cells. By using an artificial transmission line approach, useful design equations are derived and discussed. It is demonstrated that the wireless power link here presented exhibits a pass-band characterized by negative values of the phase propagation constant (i.e., a double negative passband). Comparisons with experimental data are also reported, thus validating the proposed analytical model.

Microwave design studies of linear accelerators for free electron laser photoinjectors

M. Dal Forno, R. Vescovo *(Università di Trieste)*
P. Craievich, C. Serpico *(Sincrotone Trieste)*

The front-end injection systems of the FERMI@Elettra linac produce high brightness electron beams that define the performance of the Free Electron Laser (FEL). The photoinjector mainly consists of a radiofrequency (RF) gun and of two S-band RF structures which accelerate the beam. Accelerating structures endowed with a single feed coupler cause deflection and degradation of the electron beam properties, due to the electromagnetic field asymmetry. Presently, a dual feed coupler is adopted to symmetrize the coupler field. In this paper, a new type of single feed structure with movable short circuit is proposed. It has the advantage of having only one waveguide input, and the dipolar componentof the coupler field is reduced. With the racetrack geometry, the quadrupolar component is reduced as well.

Analysis of the FAST ICRH antenna straps array with water load using HFSS code

G.L. Ravera *(Euratom-ENEA, Frascati, Roma)*
S. Ceccuzzi *(Università "Roma Tre")*

FAST (Fusion Advanced Studies Torus) is a compact tokamak with high toroidal magnetic field (8.5 T) and plasma current (up to 8 MA), proposed as a Satellite Tokamak for accompanying the International Thermonuclear Experimental Torus (ITER) programme. The project foresees an Ion Cyclotron Resonance Heating (ICRH) able to couple a RF power of 30 MW in the 60 – 90 MHz frequency range with six antennas. Each antenna consists of eight straps arranged in a four rows by two columns array. Its performances can be simulated with a good accuracy, using a commercial code as HFSS, replacing the magnetized plasma with a high permittivity dielectric. Salty water solution can advantageously be used as dummy load. The relevant parameters of the FAST ICRH eight straps antenna have been carefully evaluated in a large range of straps' loading by varying the distance between straps and dummy load. Power handling capability (given a maximum voltage sustainable in the cables), mutual coupling between straps and RF potentials have been studied.

Metamaterial activities at microwave and optical frequencies at "Roma Tre" University

M. Barbuto, A. Monti, D. Ramaccia, F. Bilotti, A. Toscano, L. Vegni *(Università "Roma Tre")*

In this contribution, we review some research activities recently developed at "Roma Tre" University in the field of metamaterials. In particular, we present several innovative devices with intriguing and unconventional features, working at both microwave and optical frequencies.

PARTE II

Sessioni Plenarie

In questa Parte è riportata una sintesi delle cinque memorie presentate alla XIX Riunione Nazionale di Elettromagnetismo (RiNEm) in Sessione Plenaria

I contributi sono:

Converged optical and wireless communications for the future, M. Marciniak (National Institute of Telecommunications, Warsaw, Poland)

Receiving sparse signals in radar systems: blind recovery ay the minimum rate, G. Prisco, R. Lalli, M. D'Urso, L. Timmoneri, F. De Stefani (SELEX Sistemi Integrati S.p.A.)

Full waveform inversion as a two-step linear process, E. Slob (Delft University of Technology, The Netherlands)

A closed form full-wave radar model for near-field layered media reconstruction, S. Lambot (Université Catholique de Louvain, Belgium)

Metamaterials and plasmonics: from RF to optical applications, A. Alù (University of Texas at Austin, USA)

Half-width leaky-wave antennas: a progress report, L. Kempel (Michigan State University, USA)

Converged optical and wireless communications for the Future

MARIAN MARCINIAK (*)

SUMMARY. – *The proposed converged network concept supports both circuit switched and packet switched traffic, real-time and non-real time services, and fixed and wireless communications. This is achieved by allocating necessary number of light wavelength channels for real time services according to the instantaneous demand, all remaining wavelengths are used for packet traffic. Transparency of the optical network allows to transmit Radio-over-Fibre signals on the dedicated optical wavelength channels as well.*

Key words: Converged communications, Radio-over-Fibre, Transparent network.

Nowadays communications target to transmit a variety of services as classical telephony, facsimile transmission, but also the Internet traffic, data transmission, radio and television broadcasting etc. Consequently, various transmission media are used as metal and fiber cables, and free space links for microwave, millimeter wave, and optical links. Owing to top performance of contemporary optical fibers there is a tendency to exploit optics as far as possible (1). Thus a question arises: do we really need separate networks for different services? Or separate fibers in a single network? Why do not use separate optical wavelengths in a single fiber for that?

Here we propose a novel non-conventional approach to the future optical and wireless hybrid transport network that is capable to support current kinds of traffic as real time voice, wireless, and packet traffic in a single converged network. This hybrid network concept distinguishes between real time and non-real time (packet or data) services. Those are physically transmitted on different optical wavelengths. Real time voice and wireless are carried on dynamically allocated

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wavelengths, according to instantaneous demand for real-time services. All remaining wavelengths are for the IP traffic. The two kinds of traffic are separated and interleaved in frequency (wavelength) domain, not in time domain. The microwave/millimeter wave signal transmission can be included in the transparent real-time part of the network by the means of modulating the optical carrier wavelength with the mobile signal in the 'Radio over Fiber' fashion. This is especially suited for transmitting 60 GHz signal which suffers of a high attenuation of 10dB/km in the air (2). On the other hand, the attenuation in silica glass fibres is below 0,2dB/km at $\lambda = 1{,}55\mu m$ (so called 3rd transmission window). This approach allows to profit fully from both sophisticated SDH technology developed for real time - voice circuit switched service, and from IP protocol developed uniquely for packet-switched traffic but exposed to Quality of Service constraints (3).

Table I classifies characteristics for real-time and non-real time traffic within a hybrid converged network.

Table I
Characteristics of real-time and non-real time traffic.

Basic principle	**Circuit-switched**	**Packet-switched**
Service	Real-time - Voice, Video, Radio-over-Fiber	Non-real time: Internet (incl. VoIP), data
Cell/packet length	Constant length cells	Variable
Latency	Unnoticeable	Allowed
lost data	No retransmission	Retransmitted
Quality of Service	Guaranteed by over-provisioning	Best-effort
Traffic	Deterministic	Statistic
Other	Instantaneous bandwidth (# of λs) controlled logically in IP routers	Intelligence
Transparency	Transparent	Incl. All-optical opacity
Bandwidth	Dedicated on demand	As wide as available
Security	Inherent	To be improved permanently

The converged network model resigns from the common approach to put the realtime traffic on top of packet network, and it claims to position them in parallel in the network rather. Consequently, it provides a space for inclusion of microwave signals via the Radio-over-Fibre technology. The model respects optimal conditions for Quality of Service and security requirements specific to different kinds of traffic, and it conserves the Quality of Service as well as security constraints for real-time traffic.

The presented hybrid optical & wireless network assures efficient use of the available bandwidth, and optimises the network availability for different traffic and services. This approach overcomes important drawbacks of an all-IP network, and it gently accommodates the real-time circuit-switched transmission of a high reliability and security with more flexible but highly vulnerable IP packet traffic.

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Receiving sparse signals in radar systems: blind recovery at the minimum rate

G. PRISCO (*), R. LALLI, M. D'URSO, L. TIMMONERI, F. DE STEFANI

SUMMARY. – *In scenarios in which the carrier frequencies are unknown to the receiver, or vary in time, a challenging task is to design a spectrum-blind receiver at the minimum rate. In this context, a compressive sampling based technique is proposed as a down conversion solution that does not need Stable Local Oscillator (STALO) signal, and so it makes possible to eliminate a substantial analog section, obtaining a significant reduction of both dimensions and costs. In addition, such a scheme allows the transmission-receiving system to manage multiple signals, placed at different carrier frequencies, at the same time, in order to make the radar system more robust against external jammers.*

Key words: Analog to digital conversion (ADC), compressive sampling (CS), radar receivers, spectrum blind reconstruction.

1. Introduction

In modern radar applications, an increasing number of functions is being pushed forward to sophisticated software algorithms, leaving only delicate finely tuned tasks for the circuit level. Sampling theory, the gate to the digital world, is the key enabling this evolution. Multifunctional wideband systems open a considerable gap with ADC devices. Furthermore one design goal is to put the ADC as close as possible to the antenna. Conversion speeds have become more and more difficult to obtain. Consequently, alternatives to high rate sampling are drawing considerable attention in both academia and industry. The most common way, especially in radar system, to avoid the sampling at the Nyquist rate, is the demodulation process wherein the signal is shifted from the high frequencies to the origin and then the lowpass version is first sampled uniformly in time. This procedure must be repeated for each band individually and in sequential mode.

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In radar systems it is useful to highlight the difference between operative and instantaneous band. The one represents the frequency range allocated for a specific system, in sense that no other deployments can use those frequencies. In general the operative band covers some hundreds of MHz. The second one instead is the effective bandwidth occupied by the radar signal at a given time, it is typically of the order of some MHz (e.g. 10 MHz), and so it can perform frequency hopping to defend itself against interference, jamming and other external signals. In this context, the radar system employs a small band inside a large allocated frequency range. This means that the frequency domain representation of such signals is intrinsically sparse.

Recently a number of "sampling" strategies have been proposed, exploiting the compressive sampling (CS) theory, an emerging research field for sampling and recovery sparse signals at the minimum rate. The mainstream line of CS papers studies sparsity for discrete and finite vectors (1). In order to locate and reconstruct the instantaneous bands used by the radar signal a more effective signal model is needed. Based on the analog multiband model, within this analog framework, which studies signals from a truly continuous domain (2), we propose a sampling-reconstruction procedure that can locate the carrier frequencies and reconstruct the spectrum content, in the operative band, through a modified version of the Modulated Wideband Converter (MWC) (3) avoiding the use of the mixer devices.

The paper is divided in Sections. The first Section is the introduction. In the Section II the proposed technique is presented. In the section III numerical results are shown. Conclusions follow.

2. Spectrum recovery scheme

For multiband signals, with N non overlapped bands of widths B, the minimal sampling rate is the sum of the bandwidths NB, given a fixed subspace description of known band locations [3]. If the Nyquist bandwidth actually occupied is assumed known, but not the band locations, the minimal sampling rate must be doubled to 2NB (4).

The traditional radar systems excites only one band at a time (N=2) and employ super-heterodyne demodulation scheme. The RF signal selection is performed by an agile Local Oscillator signal (STALO) that shifts the received signal around a lower frequency (see fig. 1). This analogical process is very expensive mainly because the STALO must be a very stable high frequency source. Typically STALO source and distributor represents one of the most expensive sections of the whole radar architecture. By using the MWC scheme [MWC], based on the fullyblind sampling framework, it is possible to extend the conventional demodulation to multiband inputs with unknown carriers.

The conversion stage from analog to digital consists of a front-end of m channels, as depicted in Fig. 2(a).

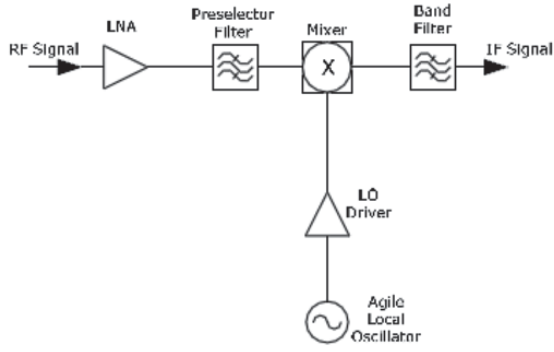


FIG. 1

Typical demotulator scheme with agile STALO.

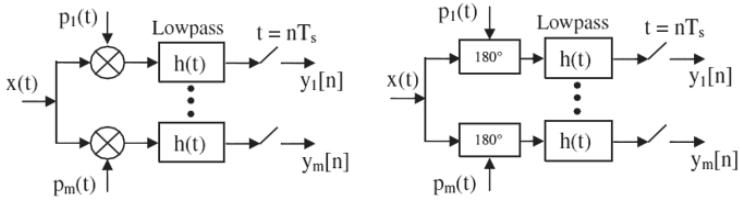


FIG. 2

Front-end schemes: (a) MWC, (b) scheme with phase inverter.

With reference to the scheme in Fig. 2(a), in the *i*th channel, the received RF signal $x(t)$ is multiplied by a periodic waveform $p_i(t)$ with period $T_p = 1/f_p$ that in each period is a piecewise constant function (different for each channel) that alternates between the levels ± 1, lowpass filtered by $h(t)$, and then sampled at rate $f_s = 1/T_s$. In the basic version the sampling period T_s equals the aliasing period T_p, each channel samples at rate $f_s \geq B$ and the number of hardware branches $m \geq 2N$, so that the total sampling rate can be as low as 2NB. These choices stem from necessary and sufficient conditions on the required sampling rate mfs to allow perfect reconstruction. Since $p_i(t)$ is periodic, it has a Fourier series expansion

$$p_i(t) = \sum_{l=-\infty}^{+\infty} c_{il} e^{j 2\pi l f_p} \qquad [1]$$

where c_{il} are a set of known coefficients. The result of the periodic mixing is the aliasing of the spectrum of $x(t)$, so that the product $\tilde{x}_i(t)$ contains shifted copies of the input spectrum $X(f)$

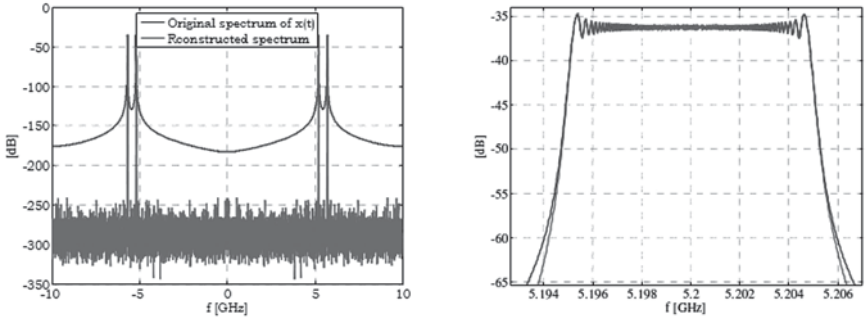
$$\tilde{X}_i(t) = \sum_l c_{il} X\left(f - l f_p\right) \quad f \in \left[-\frac{f_s}{2}, \frac{f_s}{2}\right] \qquad [2]$$

Equation [2] is the key to recovery of $x(t)$. By defining the unknown vec-

tor $z(f) = [z_1(f)\ z_2(f) \ldots z_L(f)]$ where $z_i(f) = X(f\text{-}lf_p)$, Eq. [2] in matrix form become $y(f) = A \cdot z(f)$. The sparsest solution $z(f)$ to such linear system provides the frequency carriers and the spectral behaviour of $x(t)$. The MWC requires to mix the input $x(t)$ simultaneously with the multiple sinusoids comprising the periodic waveforms, which poses an interesting circuit challenge. Since the mixing function $p_i(t)$ are a sign pattern it is possible, for non prohibitively high frequency, to replace the mixers with phase inverters (Fig. 2(b)).

3. Numerical Results

In order to show the performance of the proposed architecture it is reported the results obtained simulating the sampling and reconstruction of a test signal composed of two linear frequency modulated carriers placed at $f_1 = 5.2$ GHz and $f_2 = 5.7$ GHz, contaminated by white Gaussian noise with $SNR = 10$ dB. The signal consists of two pairs of bands ($N = 4$), each of width $B = 10$ MHz.



(a) (b)

FIG. 3

Original and reconstructed signals:
(a) whole spectrum, (b) zoom around the frequency f_1.

Coherently f_p has been chosen about 15 Mz (slightly greater than B) and $f_s = f_p$. The carrier locations are correctly carried out as it can be seen in Fig. 3(a) and the spectral content of each band are well reconstructed as showed in Fig. 3(b) for the band centered around the frequency f_1.

4. Conclusions

A new receiver architecture, for radar systems, based the fully-blind recovery of multi-band signals, avoiding the use of the STALO and mixer have been presented. The preliminary tests show that potentiality it is possible to manage multiple carrier frequencies in the operative band, enabling the radar systems

to operate with multiple antenna patterns at same time and make it more robust against external jammers.

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Full waveform inversion as a two-step linear process,

EVERT SLOB (*)

SUMMARY. – *Recently, Broggini et al. discussed several connections between wave field focusing, interferometry, and inverse scattering (1). In different ways it is demonstrated how to construct the 1D seismic wave field measured in the homogeneous upper half space and generated by a source in the interior of an unknown medium. The input data is a reflection measurement from a source and a receiver in the homogeneous upper half space. In seismic interferometry (2) a physical receiver is necessary inside the unknown heterogeneous medium and physical sources must be present in both homogeneous half-spaces in which the heterogeneous medium is embedded. As an alternative approach focusing theory (3) is applied to reflection data to construct the wave field recorded at the receiver from a virtual source inside the heterogeneous medium (1). Both methods do not require knowledge about medium properties other than assuming the waves propagate without dissipation. The important advantage of the second method over the first is that the location of the virtual source is obtained without having a physical receiver at that location. This creates data that is the starting point of the virtual source method of (4), but now without the need for borehole data. The data that is obtained from reflection data is a virtual Vertical Seismic Profile (VSP) data set. In a companion paper Wapenaar et al. showed how this could be extended to three-dimensional media (5). Once the 3D wave fields are reconstructed with a virtual source in the subsurface, a dual VSP can be created that allows directional decomposition at the subsurface virtual source depth level followed by multi-dimensional deconvolution to create a 3D internal multiple-free image (6). It is interesting that a number of successive data driven filter steps lead to creating wave fields as if they were generated, or measured, at locations where no physical source, or receiver, was placed and in addition lead to the construction of images free of internal multiples. The focusing theory of Rose, being a specific implementation of solving the Marchenko equation (7), is a linear data driven filter method of iteratively focusing a wave field at a specified one-way travel-time, or virtual depth level. This implies that the filter itself is a Green's function. In this talk it is shown that this filter contains the local reflection response for a source and receiver at the virtual depth level. For 3D wave fields in a horizontally layered medium the obtained image contains the local reflection coefficients as a function of one-way intercept time and horizontal slowness. This is a non-recursive method, because the depth levels can be chosen independently. The solution to the Marchenko equation is analyzed for plane waves incident at arbitrary angles of incidence on a horizontally layered model.*

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The image containing only local primary reflection coefficients at correct oneway travel times is extracted from the filter solution. Creating an image is the first step in an inversion approach. Once the image is obtained with local reflection coefficient amplitudes, the electric permittivity and magnetic permeability can be obtained from inverting the reflection coefficients for a number of slowness values. This is a direct matrix inversion solution that can be obtained in the least squares sense. The inversion step is recursive, because knowledge of the upper half space medium parameters is needed to start the scheme.

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A closed form full-wave radar model for near-field layered media reconstruction

SÉBASTIEN LAMBOT (*)

SUMMARY. – *A closed form near-field radar modeling approach for wave propagation in planar layered media is presented. The radar antennas are modeled using an equivalent set of infinitesimal electric dipoles and characteristic, frequency-dependent, global reflection and transmission coefficients. These coefficients determine through a plane wave decomposition wave propagation between the radar reference plane, point sources, and field points. Coupling between the antenna and layered medium is thereby inherently accounted for. The fields are calculated using three-dimensional Green's functions. We validated the model using frequency and time-domain radars with antennas operating in different frequency ranges. The antenna characteristic coefficients were obtained from near- and far-field measurements over a copper plane. The proposed model provided unprecedented accuracy for describing near-field radar measurements collected over water and sand layers with frequency-dependent electrical properties. Medium properties could be retrieved through full-wave inversion. The proposed approach shows great promise for non-destructive testing of planar materials and soils, e.g., using ground-penetrating radar.*

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Metamaterials and plasmonics: from RF to optical applications

ANDREA ALÙ (*)

SUMMARY. – *In this talk, I will discuss our recent progress and research activity in the fields of metamaterials and plasmonics, covering a wide range of topics, from theoretical approaches to model the anomalous wave propagation in metamaterials and plasmonic materials, to various applications at microwave and optical frequencies, including enhanced nonlinearities, sensing, imaging and energy harvesting. I will discuss our most recent theoretical and experimental results in these areas, including the concept of broadband 'plasmonic Brewster' light funneling (1) and 'epsilon-nearzero' metamaterials (2). I will also show our recent near-field and far-field experimental measurements of 3-D radio-frequency cloaking, which represents the first experimental realization of a metamaterial cloak in 3-D for a free-standing object (3). Finally, I will discuss the concept of twisted metamaterials and our experimental realization of ultrathin, broadband, planarized circular polarizers based on this idea, realized using stacked, lithographically printed optical metasurfaces (4). Physical insights into these exotic phenomena will be discussed during the talk.*

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Half-width leaky-wave antennas: a progress report

LEO KEMPEL (*)

SUMMARY. – *Microstrip leaky-wave antennas have been a scholarly topic of interest for nearly three decades. Seminal work includes that of Oliner (1) and Menzel (2). The former work presented an effective method for predicting the radiation properties of such antennas using the Transverse Resonance Method (TRM). The latter presented an effective method to physically realize such an antenna that utilized resonant and periodic slots near the feed. The slots provided a means to suppress the EH_{00} fundamental mode and hence provide power preferentially into the first higher-order (leaky) EH_{01} mode. Although an useful antenna, the microstrip leaky-wave antenna was difficult to match due to the need to either carefully design the slots so as to not excessively impact the radiating current distribution (and hence the polarization purity of the antenna) or feed using a balanced structure that requires two feed points with 180° (3) phase difference across the operational bandwidth of the antenna. Hence, in either case, the realized bandwidth is always significantly lower than the theoretical bandwidth. Schneider and Thiele introduced the concept of a half-width leaky-wave (HWLW) antenna to simplify the feed requirements (4). The inclusion of a metallic septum results in the potential for using only one feed point since the septum suppresses the fundamental mode but not the first higher-order mode. Significant improvements have been made on this aperture over the past five years that enhanced understanding of the properties of such an antenna and facilitated greater functionality. Specifically, the most significant contributions are: arrays (5), inhomogeneous substrates (6)-(7), and both passive and active reactive loading to control the radiation properties (8)-(9), and inductive wall modeling (10). During the evolution of this antenna design, better control over both bandwidth and radiation patterns has been obtained, and approaches to electronically controlling the beam has been investigated. The talk will present the results of these past five years and offer future perspective.*

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PARTE III

I Premi G. Barzilai, G. Latmiral e M. Sannino

(a)

(b)

(c)

FIG. 1

(a) Il Prof. Giorgio Barzilai (Università "La Sapienza" di Roma).
(b) Il Prof. Mario Sannino (Università di Palermo).
(c) Il Prof. Gaetano Latmiral (Università Parthenope di Napoli)

Premio Barzilai - Il Premio Barzilai è erogato dalla SIEm (Società Italiana di Elettromagnetismo) ed è conferito al migliore lavoro proposto da autori di età inferiore ai 35 anni. Giorgio Barzilai (1911-1987) fu l'iniziatore della Scuola di elettromagnetismo della Facoltà di Ingegneria dell'Università "La Sapienza" di Roma, dove diede vita al Corso di specializzazione in "Elettromagnetismo applicato" e poi al Dottorato di ricerca in "Elettromagnetismo applicato e scienze elettrofisiche". La sua attività scientifica svolta durante il cinquantennio 1935-1985 fu improntata al rigore metodologico e alla costante ricerca di finalità applicative, coniugando aspetti teorici e sperimentali. Dal 1976 al 1985 Giorgio Barzilai fu Presidente della Commissione Italiana dell'URSI. Nel 1978 fu nominato *Fellow* dell'*Institute of Electrical and Electronic Engineers* (IEEE) e nel 1985 ricevette la Medaglia del Centenario dell'IEEE.

Vincitori del Premio Barzilai sono risultati *ex-aequo* i lavori

A size-tapered architecture for high performances isophoric direct radiatùing arrays, A.F. MORABITO, A.R. LAGANÀ (Università Mediterranea di Reggio Calabria)

Model order reduction in finite elements analysis of phased array antennas, L. NTIBARIKURE (Università di Firenze)

Premio Sannino - Il Premio Mario Sannino è erogato da GAAS e dal Centro Interuniversitario MECSA in memoria di Mario Sannino, professore di Elettronica presso l'Università di Palermo. Il Premio è destinato alle migliori memorie di giovani ricercatori (età inferiore ai 35 anni), sui circuiti e dispositivi a microonde e onde millimetriche, presentate alla Riunione Nazionale di Elettromagnetismo.

Vincitore del Premio è risultato il lavoro

The role of evanescent modes excited inside the longitudinal corrugations of mode filters, S. Ceccuzzi, S. Meschino (Università "Roma Tre")

Premio Latmiral - Il Premio Latmiral è erogato dalla SIEm ed è conferito al migliore *poster* proposto da autori di età inferiore ai 35 anni. Gaetano Latmiral (1909-1995) è stato, insieme a Giorgio Barzilai e Mario Boella, tra i fondatori della ricerca in elettromagnetismo in Italia. Nacque a Roma e si laureò in Ingegneria Industriale al Politecnico di Milano. Durante il secondo conflitto mondiale contribuì in modo decisivo allo sviluppo del radar e di contromisure radar. Fu detenuto nel carcere militare di Tegel, dove stabilì un singolare sodalizio col teologo Dietrich Bonhoeffer, successivamente vittima del nazismo. Sfuggito alle persecuzioni razziali, nel dopoguerra svolse attività di studio e ricerca presso il CERN di Ginevra, l'Istituto Militare Superiore delle Trasmissioni, il Consiglio Nazionale delle Ricerche e in qualità di professore incaricato di Fisica nell'Università di Roma. Nel 1955 divenne professore di "Teoria e tecnica delle onde elettromagnetiche", presso l'Istituto Universitario Navale di Napoli.

Vincitore del Premio Latmiral è risultato il lavoro

Reflection symmetry to observe metallic targets at sea by a dual-polarimetric SAR, F. Nunziata, M. Montuori (Università di Napoli "Parthenope")

Fig. 2

La Facoltà di Ingegneria dell'Università di Napoli "Parthenope", intitolata a Gaetano Latmiral.

A size-tapered architecture for high-performance isophoric direct radiating arrays

ANDREA F. MORABITO, ANTONIA R. LAGANÀ (*)

SUMMARY. – *We propose a new architecture for high-gain isophoric arrays. The solution is able, by exploiting the feeds size as unique degree of freedom of the antenna design problem, to perfectly emulate the behaviour of given continuous aperture sources. Uniformly-excited arrays fulfilling by a wide margin the requirements recently established by the European Space Agency for the multibeam coverage of Europe are designed in a fast and deterministic fashion.*

Key words: Power Synthesis, Isophoric Antennas, Direct Radiating Arrays.

1. Introduction and motivations

Usual degrees of freedom in array synthesis are either the excitations of a fixed-geometry structure (1), or the locations and phase excitations of the fixed-amplitude radiating elements (2-7), or even both of them (8),(9). In particular, the second of these problems is of interest in the design of Direct Radiating Arrays (DRA) for communications from satellites (2-7).

In fact, arrays easily lend themselves to multibeam and reconfigurability applications, and allows to exploit in an optimal fashion the available power by requiring that all the (identical) amplifiers work under the same optimal conditions, thus resulting in equi-amplitude entry points (leading to the so-called 'isophoric' arrays) (2-7).

As a matter of fact, such a circumstance, together with the need to keep the number of amplifiers (and antennas) as low as possible, has stimulated research activities aimed at the optimal synthesis of sparse arrays (3), thinned arrays (5), and clustered (4) arrays.

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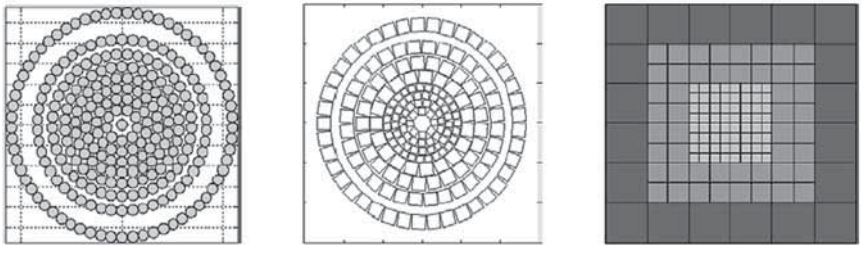
In all these cases, the quest for very low sidelobes can be fulfilled by emulating, through the array structure, an appropriate amplitude tapering on the antenna aperture (1-9). For example, 'density taper' procedures can be applied for the synthesis of sparse arrays (3).

On the other side, each of these architectures has its own drawbacks. By leaving aside (because of the available space) the case of clustered arrays, it has to be noted that in both cases of thinned and sparse arrays the quest for low sidelobes leaves empty a large portion of the aperture plane, thus resulting in a reduction of the antenna gain with respect to the theoretical limitations (6),(7). As the gain is of the outmost importance in satellite applications, such a circumstance led researchers of LEMMA, in connection with close co-workers, to develop first in (7) and then in (6) the chance to exploit two different kinds of radiating elements (see Fig.1b) in an otherwise sparse array architecture (see Fig. 1.a). In fact, exploitation of two kinds of 'aperture-like' elements allows both a better filling of the available aperture, and a better emulation of (tapered) reference sources. Notably, for the same 'filling' reasons, the exploitation of square (rather than circular) elements was also suggested in (7).

In this communication, we further elaborate the basic concept introduced in (7) in order to develop and optimize a 'size-tapered' architecture for high-gain isophoric DRA.

Interestingly, an apparently similar concept had been introduced in (9) (see Fig. 1.c). In such a case, however, complex excitations are also used as degrees of freedom, and the elements dimensions are fixed in advance rather than being synthesized in some optimal fashion. As a consequence, contents of (9) are indeed very different from what follows.



(a) (b) (c)

FIG. 1

Different DRA architectures: density tapering (a) (2),(3); density and element-size tapering (b) (6); excitations and element-size tapering (c) (9).

In fact, the proposed architecture exploits as degrees of the freedom of the synthesis problem only the elements dimensions, which are determined by the procedure described in the following Section.

2. The synthesis procedure

The proposed approach assumes that the single array elements are aperture antennas, and hence that feeds carrying the same overall power but having different dimensions produce, on their aperture, different field levels. Consequently, a smart positioning of elements having a different size can allow to optimally fill the space at disposal and, at the same time, to realize the desired tapering on the overall array aperture. By taking into account all the concepts above, the following four-step trategy has been devised:

1) choose the area A of the smallest DRA element to be employed;

2) synthesize a continuous source fulfilling at best the radiation requirements and having a quantized amplitude (see Fig. 2.a). The number of source levels will be equal to the number of feed's sizes to be employed;

3) identify the area of each DRA element in such a way to perfectly emulate, in each portion of the aperture, the continuous source coming out from step 2. In particular, feeds of area Q^2*A are placed in those regions where the aperture field's normalized amplitude is equal to $1/Q$. Note that feeds should emulate uniform-amplitude apertures, i.e., they should have an aperture efficiency as large as possible;

4) establish the elements locations and geometrical shapes such to 'completely' fill the aperture by just employing feeds having the areas identified in step 3.

3. Application to the design of satellite multibeam antennas

In order to test the devised procedure in an application of actual interest, we used it to solve the synthesis problem defined in (2), i.e., the design of an isophoric DRA for the multibeam coverage of the Europe from geostationary satellites (see (2)-(7) for a detailed description of the technical requirements). The achieved circular-ring DRA layout, fulfilling all the imposed constraints and being composed by 246 isophoric square feeds of areas 16, 25 and 64 λ^2, being λ the wavelength in free space, is depicted in Fig. 2.a. The corresponding directivity is shown in Fig. 2.b.

Notably, the proposed architecture resulted able to achieve a directivity behavior very close to the ultimate feasible performance of the reference continuous source. The relevance of the achieved result can be proved also by comparing it with the performance achieved by a DRA proposed by (6) (in which not only the elements size but also the elements location is exploited as a degree of freedom of the synthesis problem) and composed by a 12-units lower number of elements. In fact, while the DRA in (6) achieves a slightly better performance in terms of peak sidelobe level, the present solution provides better results in terms of minimum directivity guaranteed inside a spot of width 0.65°.

In particular, at the edge of a generic spot, the array shown in Fig. 2.a achieves a directivity equal to 46.2 dBi, which is 1 dB larger than the one provided by the

DRA in (6). Also, by evaluating the same directivity at a scanning angle of 1.12°, the result achieved by the DRA of Fig. 2.a, i.e., 45.8 dBi, turns out to be 0.8 dB larger than the one provided in (6).

Finally, the proposed solution allows to safely scan the beam, by still fulfilling all requirements on sidelobes, up to 1.68°. Such a circumstance allows to get a multibeam antenna realizing 37 different beams (as opposite to the 19 beams of (6)).

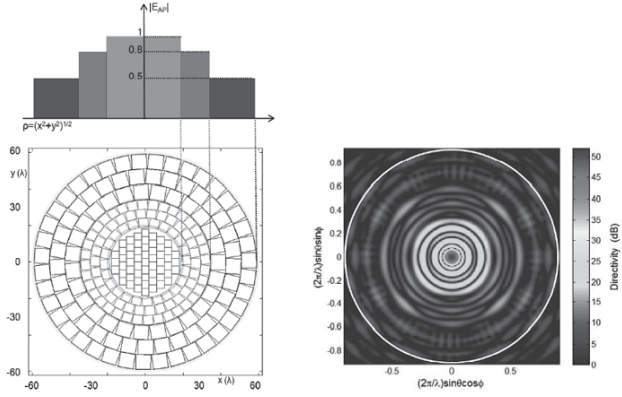


FIG. 2

Synthesis approach: (a) reference source distribution and corresponding DRA layout; (b) achieved directivity (θ and ϕ respectively denoting the elevation and azimuthal observation angles).

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Model order reduction in finite elements analysis of phased array antennas

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SUMMARY. – *The model order reduction technique is applied to the finite elements analysis of phased array antennas, leading to fast and accurate computation of the radiation pattern in front of a beam steering process. Computational timings and approximation error of the reduced order model are shown for a patch antennas array, proving the noticeable advantages of the presented approach.*

Key words: Finite elements, Phased array antennas, Model order reduction, Beam steering.

1. Introduction

In modern communication systems and many other applications such as radar utilization, large arrays of antennas are employed to form an electronically steerable antenna beam while completely avoiding mechanically moving parts. In order to adjust such a beam to the given dynamically changing needs, a large amount of consecutive full-wave field analysis runs would be necessary to process every emerging parameter set.

Due to the enormous computational effort that would be needed for such analysis, it is highly desirable to extract, in an off-line stage, a subset of information from those numerically accurate fully three dimensional results, enabling in an on-line stage, fast tuning of parameters at a lower accuracy level. In mathematical terms, the challenge is to reduce a very large linear system of equations, with typically millions of unknowns, to a comparatively small one with only thousands of unknowns, while necessarily keeping the relevant information. This kind of approach belongs to the group of model order reduction algorithms which are nowadays employed in many areas, in particular in electronic design processes (1).

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Due to its capability to handle materials inhomogeneity and geometrical complexity of modern antennas, to its formulation that allows antennas coupling analysis, the finite elements method results to be a suitable analysis tool for phased array antennas. Being usually truncated by means of absorbing boundary conditions, the domain of analysis is restricted to the near fields. Radiation patterns must hence be computed in a post-processing step from the knowledge of the tangential near fields on the enclosing surface boundaries.

The finite elements formulation for the near-field computation, the near-field to far-field transformation method and the model order reduction technique employed are presented in Section II. Section III shows results obtained from the analysis of a 3-by-5 patch antennas array. Section IV draws some conclusions.

2. Formulation

The analyzed boundary value problem (Fig. 1) consists of solving the vector Helmholtz equation for the electric field:

$$\nabla \times \frac{1}{\mu_r} \nabla \times E - k_0^2 \varepsilon_r E = 0 \quad [1]$$

with perfect electric boundaries conditions on Γ_E, absorbing boundary conditions on Γ_R and wave ports conditions (keeping only fundamental mode) on Γ_{WG}^p, $p = 1, \ldots, P$. k_0 is the free-space wavenumber, μ_r and ε_r are, respectively, the relative permeability and permittivity of the utilized materials. For the sake of simplicity, all metallic parts that compose the antennas array are assumed to be perfect electric.

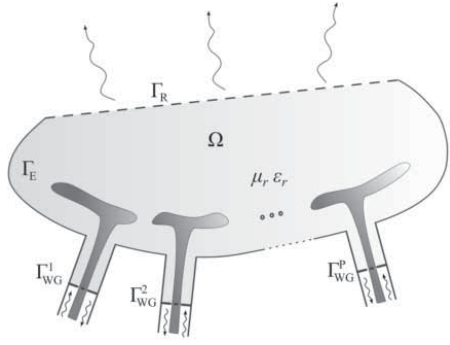

FIG. 1

Sketch of the phased array antennas finite element analysis domain Ω.

Upon applying the conventional Galerkin finite elements (FE) method with edge basis functions (2), a linear system of the form $[A]x = b$ is obtained, where $[A]$ is a sparse matrix, due to local character of the chosen basis functions. For the superposition principle, the right hand side b can be expanded into a sum of

vectors b_p as much as the number of ports, in order to extrapolate from the system the complex excitations enforced at each port, allowing to set the excitations of the ports for a beam steering operation.

As the radiation pattern is sought for, Stratton-Chu formulas in Kottler's form (3)-(4) are used to compute the far-field from the FE solution on Γ_R, then, with the knowledge of the accepted power at antennas ports, the antenna gain can be retrieved all over the observation directions. This near-field to far-field transformation can be viewed as the application of an operator c^H on the FE solution such that $g = c^H x$, with g the gain value in the selected observation direction and $[\cdot]^H$ is the hermitian transpose operator. For further reduction of the model [5], c has been approximated in terms of truncated Fourier series, reducing the number of operations to compute the pattern. c is thus written in terms of vectors c_q associated to a given harmonic function.

A projection-based model order reduction technique (1), (5-7) is finally performed by properly choosing independent FE solutions computed for different scan angle excitation. Those solutions, which constitute global basis functions for the reduced system, are collected in a matrix V that is used to project the full input (steering excitations)-output (gain) system matrices in the following manner:

$$[\boldsymbol{V}]^H[\boldsymbol{A}][\boldsymbol{V}] = [\tilde{\boldsymbol{A}}]$$
$$[\boldsymbol{V}]^H \boldsymbol{b}_p = \tilde{\boldsymbol{b}}_p \qquad [2]$$
$$\boldsymbol{c}_q^H[\boldsymbol{V}] = \tilde{\boldsymbol{c}}_q^H$$

leading to the reduced order system of full matrices of the form:

$$\begin{cases} [\tilde{\boldsymbol{A}}]\tilde{\boldsymbol{x}} = \sum_p i_p \tilde{\boldsymbol{b}}_p \\ g = \left(\sum_q o_q \tilde{\boldsymbol{c}}_q^H \right) \tilde{\boldsymbol{x}} \end{cases} \qquad [3]$$

where i_p are the complex excitations for each antenna element and o_q are the harmonic functions that expand the near-field to far-field transformation operator. The system matrices of Eq. (3) are now full matrices with an order as low as the dimension of the space spanned by V. The reduced system solution vector is related to the full system solution vector by $\tilde{x} = [V]^H x$.

3. Results

The array of 3 by 5 patch antennas shown in Fig. 2 has been analyzed with the proposed technique. The spacing between the antennas is of $\lambda_0/2$, λ_0 being the free space wavelength. First order basis functions have been chosen requiring, for a sufficient near-field accuracy, a mesh density of $\lambda_0/10$, leading to about

$3.6x10^5$ unknowns. 26 Fourier coefficients have been retained to approximate *c*, being enough for an approximation error in the gain of 10^{-8}, relatively to the full operator pattern results. The main error introduced at this point is only attributable to the finite elements approximation and the numerical integration technique employed for the implementation of Stratton-Chu formulas.

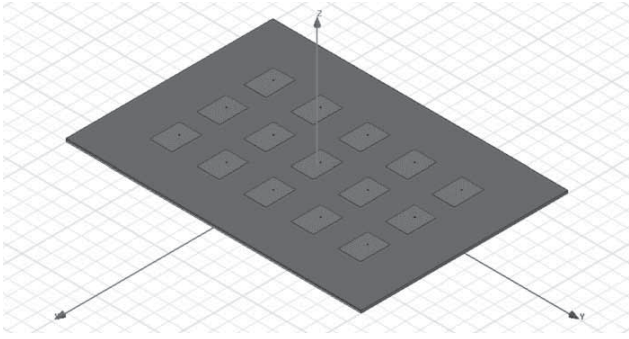

FIG. 2

Array of 3 by 5 coaxial-fed rectangular patch antennas analyzed for fast beam steering computations.

To reduce the model by Eq. [2], 15 FE independent solutions where needed, that is for 15 different scan angles, leading to a relative error of the gain as low as 10^{-11}, while 14 and less solutions would have introduced a non-neglectable error ($\sim 10^{-1}$). To validate the FE code, the simulation has been run with the commercial package Ansys HFSS. Results, shown in Fig. 3, validate the present formulation.

To emphasize the advantages of the model order reduction, timings in the pattern computations have been compared (Table I). Ansys HFSS requires about 35 s to compute the patterns of Fig. 3 while the present code requires only 150 ms, 233 times lower than Ansys HFSS times.

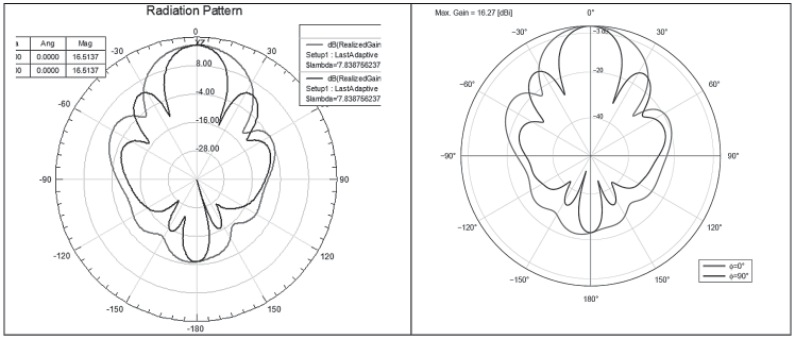

FIG. 3

Patterns computed on the XZ and YZ planes with (left) HFSS and (right) present FE code.

Table I
Computational requirements

	Ansys HFSS	**Present code**
Full system assembly and solution timings (off-line)	38 min	45 min
Total memory requirements for full system (off-line)	1.5 GB	625 MB
Memory requirements for reduced system (on-line)	–	1.5 MB
Radiation pattern computation timings (on-line)	35 s	150 ms

4. Conclusion

The model order reduction technique has been employed to speed-up the computation of the radiation patterns from finite elements analysis of phased array antennas. As the finite elements system has been parameterized in terms of port excitations, very fast computation of radiation patterns in front of a beam steering operation can be achieved.

It has been shown that the reduced order systems of dimensions as large as the number of array antennas contain all the necessary information to retrieve the patterns with an error as low as numerical one. Fourier expansion of the near-field to far-field transformation operator reduces computational effort while keeping reasonable accuracy for pattern evaluation.

It is worth noticing that the presented technique might render practical pattern shaping optimization algorithms applied to full-wave simulations.

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The role of evanescent modes excited inside the longitudinal corrugations of mode filters

SILVIO CECCUZZI (*,†), SIMONE MESCHINO (†)

SUMMARY. – *Mode filters for high-power oversized rectangular waveguides are usually based on corrugations partially filled with absorbing materials. In this paper the modal content excited at the input of longitudinal corrugations is calculated through an approximate model, whose reliability and limitations are assessed by comparison with a full-wave commercial code. Wave amplitudes inside the absorbing material and power loss by Joule effect are computed by enforcing proper boundary conditions. Modes under cut-off are demonstrated to contribute to the total absorption when the lossy dielectric is located close enough to the waveguide slots. Useful guidelines for the design of mode filters are derived.*

Key words: Corrugation, High-power microwaves, Mode filter.

1. Introduction

High-power microwave transmissions over long distances are realized through oversized waveguides in a number of applications like fusion engineering and accelerators. Even with a careful design of the relevant components, spurious modes are unavoidably excited and propagate, owing to the intrinsic overmoded nature of these transmission structures.

Mode filters are intended for absorbing the unwanted modal content, avoiding dangerous effects like trapped mode resonances. At high power corrugated waveguides, with corrugations partially filled with an absorbing material, are generally used. Their study, started and soon abandoned in the 1960s (1), has been recently resumed within the conceptual design of a 5 GHz heating and current drive system for the International Thermonuclear Experimental Reactor (ITER) (2, 3).

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In this scenario, a first approximate theoretical model was proposed in (4), where filter performance has been directly related to the reflection of modes propagating inside the corrugations. Here the role of under cut-off modes, excited at waveguide slots, is investigated using a rectangular waveguide with a longitudinal corrugation as a test case. Results can be generalized to different configurations.

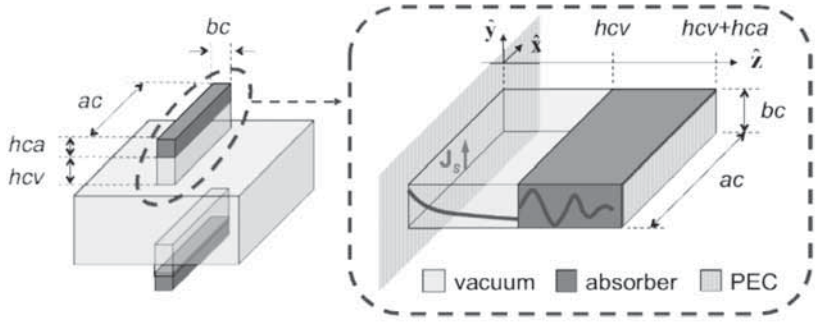


FIG. 1

Reference geometry.

2. Mode excitation

The leading idea behind this study is that modes under cut-off in vacuum-filled waveguides exhibit an imaginary part in their propagation constant (k_{zn}) when crossing lossy dielectrics. Referring to the geometry depicted in Fig. 1, these waves undergo an exponential decay in the vacuum region of the corrugation, but, if they reach the absorbing material without being excessively attenuated, they can give an effective contribution to the total absorption.

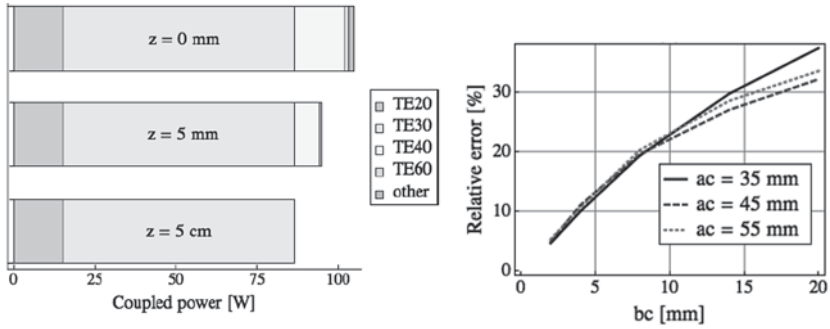
Modes excited at the input of the corrugation can be estimated starting from the magnetic field distribution at the wall of the un-slotted waveguide (perturbation method). The field for $z>0$ can be expressed as a summation over all possible TE and TM modes with eigenvectors h_{zn} and e_{zn} respectively:

$$E = \sum_n C_n^+ \left(e_n + e_{zn}\right) e^{-k_n z} + \sum_n C_n^- \left(e_n - e_{zn}\right) e^{k_n z}$$

$$H = \sum_n C_n^+ \left(h_n + h_{zn}\right) e^{-k_n z} + \sum_n C_n^- \left(-h_n - h_{zn}\right) e^{k_n z}$$

where C_n^+ and C_n^- represent the unknown amplitudes of forward andbackward waves. By filling the half-space enclosing the main waveguide ($z<0$) with a perfect electric conductor (PEC), equivalent surface currents can be derived as $J_s = 2 \cdot \hat{z} \times H|_{wall}$. At this point, the wave amplitudes C_n^+ can be approximately derived by an application of the Lorentz reciprocity formula as follows [5]:

$$C_n^+ = -\frac{1}{P_n}\int_{slot} E_n^- \cdot J_S dS \quad \text{being} \quad P_n = 2\int_{slot} e_n \times h_n \cdot \hat{z} ds$$



(a) (b)

FIG. 2

(a) Modal content excited by the TE_{20} mode (1 kW) in a corrugation with $ac = 100$ mm and $bc = 5$ mm. (b) Relative error between the TE_{20}-TE_{10} coupling predicted by this model and HFSS for different slot sizes.

This model has been applied to a standard waveguide WR-430 (cross-section 109.22 mm × 54.61 mm), working at 5 GHz and provided with a longitudinal slot having $ac = 100$ mm and $bc = 5$ mm. In this situation only 3 modes are above cut-off in the corrugation, namely the TE_{10}, TE_{20} and TE_{30}. The wave amplitudes of 150 modes with the lowest cut-off frequency have been calculated assuming that the main waveguide is fed with 1 kW of the TE_{20} mode. Results are reported in Fig. 2.a: it can be observed that a significant part of the power (almost 30%) is coupled to evanescent modes, in particular the TE_{40}, that exponentially decay going away from the aperture.

Similar computations have been performed when the WR-430 is fed by the TE_{01} mode that, together with the TE_{20}, is the main responsible for the excitation of longitudinal corrugations. These two modes are degenerate in the WR-430 and their H patterns are very similar close to the slot, so they excite the same modes.

Performed calculations are not self-consistent since wave amplitudes are derived from the unperturbed magnetic field in the main waveguide, but they are expected to be meaningful if corrugations are thin enough. Their reliability has been indeed checked as compared to a finite element solver (i.e., HFSS^{TM}) and shown in Fig. 2.b.

3. Mode absorption

The electromagnetic field in the absorber of Fig. 1 is given by an infinite set of TE and TM modes, whose wave amplitudes can be calculated by using the

proper boundary conditions as in [4]. Once they have been derived, the power loss in the lossy dielectric can be computed. It has been done for the same case of Fig. 2.a, using a doped Silicon Carbide (SiC) as absorbing material.

Results are plotted in Fig. 3, where the evanescent TE40 mode is seen to enhance the total absorption of a 15%, when the vacuum section of the corrugation is thin enough.

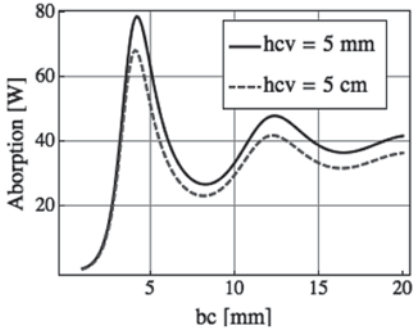


FIG. 3

Power absorption versus corrugation width for different vacuum depths when the main waveguide is fed by a TE_{20} of 1 KW. Silicon Carbide ($\varepsilon_r = 13.5$, $\tan\delta = 0.44$) has been used as absorber.

4. Conclusions

Evanescent modes coupled into a longitudinal corrugation from a rectangular waveguide have been demonstrated to play a role in the performances of mode filters, when the absorbing material is close enough to the slot. Their amplitudes have been estimated through an approximate model based on the perturbation method, whose reliability has been compared with a full-wave solver.

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Reflection symmetry to observe metallic targets at sea by a dual-polarimetric SAR

FERDINANDO NUNZIATA, ANTONIO MONTUORI (*)

SUMMARY. – *A polarimetric model to observe metallic targets at sea in polarimetric Synthetic Aperture Radar (SAR) data is proposed. The model gives an understanding of the different symmetry properties that characterize sea surface with and without metallic targets in terms of the correlation between like- and cross-polarized channels. Experiments undertaken over C-band Single Look Complex (SLC) RADARSAT-2 SAR data confirm the soundness of the approach.*

Key words: Polarimetry, SAR, Ship detection.

1. Introduction

Synthetic Aperture Radar (SAR) observation of metallic targets, i.e. ships and oil rigs, at sea relies on the fact that their backscattered signal causes a bright spot over SAR images. However, the information provided by the sole backscattered intensity, collected by a single-polarization SAR, is not generally sufficient to effectively observe metallic targets. To conceive more effective observation techniques, the interest towards polarimetric approaches is very much increased, supported also by new high-performances polarimetric SARs, e.g. the ones operated on-board of the ALOS, RADARSAT-2, TerraSAR-X and COSMO-SkyMed missions.

In order to reduce false alarms, recently, promising results have been obtained by employing physically-based polarimetric techniques (1). However, these algorithms often are quite complex to be implemented operationally and the choice of a suitable threshold is a non-trivial issue.

In this study, a new physically-based approach is proposed to observe man-made metallic targets in polarimetric SAR data. The approach exploits the intrinsic symmetry properties that characterize sea surface with and without metallic

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targets. Symmetry is a powerful concept that applies in various scientific areas such as quantum mechanics and crystallography. It has also applicative relevance in electromagnetics, in antennas and scattering (2). At more basic level, symmetries in electromagnetics include those in the Maxwell equations (e.g. duality and reciprocity (2)), those in geometric symmetry (e.g. rotation, reflection, translation, similarity (2)), and combination of these. An important symmetry property that characterizes natural background scenarios is reflection symmetry (2). Sea surface, being a distributed natural scene, is expected to satisfy reflection symmetry. When dealing with man-made metallic targets, being complex and man-made structures, they are expected to break reflection symmetry.

In this study, the correlation between like- and cross-polarized scattering amplitudes is exploited as a measure of the departure from the reflection symmetry. Hence, first the sensitivity of the proposed indicator to metallic targets at sea is investigated; then, a simple and very effective technique is proposed to observe targets at sea in polarimetric SAR data.

2. Methodology

The most logical way to deal with polarimetric scattering from a distributed and depolarizing target is by using the second-order products of the scattering matrix (3). This can be accomplished by using the covariance matrix that, under the backscatter alignment (BSA) convention and when reciprocity holds, is given by:

$$C = \begin{pmatrix} \left\langle |S_{hh}|^2 \right\rangle & \sqrt{2}\left\langle S_{hh}S_{hv}^* \right\rangle & \left\langle S_{hh}S_{vv}^* \right\rangle \\ \sqrt{2}\left\langle S_{hv}S_{hh}^* \right\rangle & \left\langle |S_{hv}|^2 \right\rangle & \sqrt{2}\left\langle S_{hv}S_{vv}^* \right\rangle \\ \left\langle S_{vv}S_{hh}^* \right\rangle & \sqrt{2}\left\langle S_{vv}S_{hv}^* \right\rangle & \left\langle |S_{vv}|^2 \right\rangle \end{pmatrix} \quad [1]$$

Herel, $\langle\cdot\rangle$ stands for ensemble average and S_{pq} is the generic the scattering matrix elements with $\{p, q\} = \{h, v\}$. C is a 3×3 Hermitian semi-definite positive matrix which consists of 9 independent parameters and has real and non-negative eigenvalues and orthogonal eigenvectors. Up to now, no hypothesis has been made on the scattering system but the linearity and the reciprocity. Therefore the 3×3 covariance matrix [1] is obtained. However, the number of independent parameters is reduced when symmetry properties are satisfied. This is the case of naturally distributed scenarios that generally satisfy reflection symmetry (4). It can be shown that a distributed scene, which satisfies this symmetry property, is characterized by the following covariance matrix:

[2] $$C = \begin{pmatrix} \left\langle |S_{hh}|^2 \right\rangle & 0 & \left\langle S_{hh} S_{vv}^* \right\rangle \\ 0 & \left\langle |S_{hv}|^2 \right\rangle & 0 \\ \left\langle S_{vv} S_{hh}^* \right\rangle & 0 & \left\langle |S_{vv}|^2 \right\rangle \end{pmatrix},$$

It should be noted that a direct consequence of reflection symmetry is that the correlation between like- and cross-polarized scattering amplitudes vanishes:

[3] $$\left\langle S_{vv} S_{hv}^* \right\rangle = \left\langle S_{hv} S_{vv}^* \right\rangle = 0$$

Hence, the modulus of the correlation between like- and cross-polarized scattering amplitudes r

[4] $$r = \left| \left\langle S_{hh} S_{hv} \right\rangle \right|$$

is the natural norm to measure the departure from the reflection symmetry case. When r tends to 0, the observed scene is characterized by the symmetry property and [2] applies, while for larger r values, departure from reflection symmetry is achieved and [1] applies.

It is now important to read reflection symmetry in marine physical terms. Sea surface, being a natural distributed target, is expected to satisfy reflection symmetry. As a matter of fact, $r \approx 0$ should apply. When dealing with man-made metallic objects, due to their complex shape that consists of plane, dihedral, and trihedral structures, as well as dihedral corner reflectors and thin wires, reflection symmetry is not expected to be still satisfied, therefore, r values significantly larger than the free sea surface one are expected.

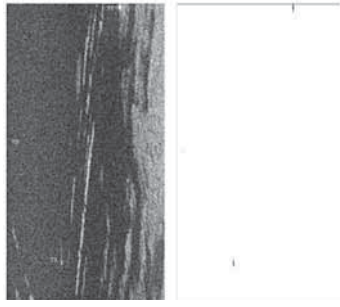
3. Experiments

In this section, the physical consistency of the proposed polarimetric model and the effectiveness of the polarimetric target detection approach are investigated. Actual polarimetric Single Look Complex (SLC) SAR data, acquired by the C-band RADARSAT-2 satellite mission, are considered.

A meaningful experiment, accomplished over a dual-polarimetric HHHV SAR data related to the acquisition of 13 May 2011 at 16:40:10 UTC (Product ID: PDS 01780080, image ID: 133029), is shown and discussed. The SAR data has been acquired off the Taranto coast, Italy.

The incidence angle ranges between 30° and 37°. The squared modulus related to an excerpt of the HH-polarized SLC SAR data is shown in Fig. 1.a, where three targets, labeled as T1 to T3, are present. Large marine-related features are also visible (see bright strips in Fig. 1.a) that make target detection a very chal-

lenging task. First, the sensitivity of the model to sea surface with and without targets is investigated by evaluating r (4) within region of interests (ROIs) belonging to the three targets (T1-T3) and to sea surface (not shown). r values are listed in Table I. It can be noted that sea surface and targets call for completely different and well-distinguishable (roughly two order of magnitude) r values. This implies that sea surface is well described by (2) while targets call for (1). Since targets and sea r values are well-separated and no feature associated with the marine strips is present in the r image, a fixed empirical threshold (equal to 0.002) has been employed to obtain the logical true-and-false binary output of Fig. 1.b. It can be noted that all the targets have been correctly observed and no false alarm is present.



(a) (b)

FIG. 1

RADARSAT-2 dual-polarimetric SLC SAR data related to the acquisition of 13 May 2011 at 16:40:10 UTC. (a) Excerpt of the HH-polarized squared modulus SAR data. (b) r-based filter's output.

Table I

r values measured within the ROIs of Fig. 1.a

ROI	Target	Sea
1	0.5323	0.005
2	0.1850	0.003
2	0.4568	0.007

4. Conclusion

A polarimetric model is proposed that gives an understanding of the symmetry properties of sea surface with and without targets in terms of the correlation between the like- and cross-polarized channels of a dual-polarization radar. The model's sensitivity is verified against actual dual-polarimetric C-band RADARSAT-2 SAR data. Then, a simple and very effective technique is proposed to observe targets at sea.

Acknowledgement

RADARSAT-2 data are obtained under the SOAR project entitled "Multipolarization approaches for oil spills and vessel detection in polarimetric SAR data." Italian Space Agency is also acknowledged for partially funding this study.

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PARTE IV

Galleria fotografica

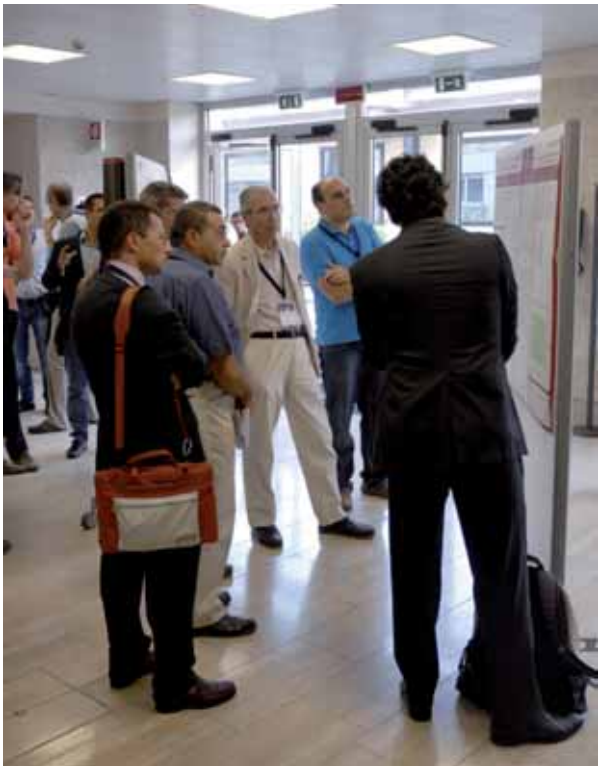
L'Università "Roma Tre", dove si è tenuta dal 10 al 14 settembre 2012 la XIX Riunione Nazionale di Elettromagnetismo (RiNEm).

Cerimonia di apertura della XIX RiNEm. Intervengono (da sinistra) Giuseppe Schettini (Università "Roma Tre"), Lucio Vegni (Università "Roma Tre"), Paolo Mele (Preside della Facoltà di Ingegneria dell'Università "Roma Tre", Paolo Lampariello (Università "La Sapienza" di Roma).

L'intervento di Gaetano Marrocco (Università di Roma "Tor Vergata") all'interno della sessione URSI.

Prima Sessione Poster. Si riconoscono (da sinistra): Vincenzo Galdi (Università di Salerno), Vincenzo Fiumara (Università della Basilicata), Claudio Gennarelli (Università di Salerno).

Prima Sessione Poster. Si riconoscono (da sinistra): Sorbello (Università di Catania), De Angelis (Università di Brescia), Migliaccio (Università di Napoli "Parthenope") e Lucio Vegni (Università "Roma Tre"). ➞



Un altro momento della Prima Sessione Poster. ➘

Un particolare della vista su Roma dall'Hotel Hassler, in cui si è svolta la cena sociale.

Un momento della cena sociale all'Hotel Hassler. Da sinistra: Marcello Bruni (Boeing), Alessandro Toscano (Università "Roma Tre"), Alfredo Luigi Caruso.

Presentazione plenaria del Prof. Marian Marciniak (National Institute of Telecommunications, Polonia).

Prof. Roberto Sorrentino (Università di Perugia).

Il Prof. Filiberto Bilotti (Università “Roma Tre” introduce la presentazione plenaria del Prof. Leo Kempel (Michigan State University, USA). →

Dr. Angelo Tuccillo (Associazione Euratom-ENEA). ↘