APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY (ACES)

NEWSLETTER

Vol. 8 No. 2 July 1993

TABLE OF CONTENTS

OFFICERS' REPORTS
Treasurer's - James Logan 3
President's Report - Hal Sabbagh 4

COMMITTEE REPORTS
About ACES Committees - Frank Walker 5
ACES Committees - Andy Peterson 6
User's Group Committee - Russell W. Taylor 7
ACES UK Chapter - A.K. Brown 8
Software Exchange Committee - Frank Walker 9
Software Exchange Committee - 11
Software Performance Standards Committee - Andy Peterson 13
ACES Editorial Board - David Stein 14
Financial Committee - James C. Logan 15
Investment Report - James C. Logan 19
Regional Activities Committee - Frank Walker 21
Awards Committee - John Rockway 23
Nominations Committee Announcement - Stan Kubina 25

CONFERENCE REPORTS
9th Annual Review of Progress - Perry Wheless 26
President's Annual Report - Hal Sabbagh 27

Handbook for Elections by Mail 28

"Changing Times for R&D and its Effect on Electromagnetics Research - Part II" - R. Perez 32

"On Analyzing Helices with NEC-2" - Isak Petrus Theron 35

"An Improved Version of the Computer Code "Dotig" for the Time Domain Analysis of Thin Wires Structures" - R. Gomez Martin et al 39

PERSPECTIVES
"A Career in Field Computation - A Personal View of Computational Electromagnetics" - Bill Trowbridge" 54

Book Review - Reinaldo Perez 61

Index to Computer Code References for Vol. 7 of the ACES Journal and the ACES Newsletter 63

Abstracts of ACES Journal Papers - Volume 7 64

ANNOUNCEMENTS
Compumag Conference 73
1994 ACES 10th Annual Review of Progress 74
ACES Membership Form 76

ADVERTISING RATES 77
ACES '94 Conference Posters Availability 77

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ACES NEWSLETTER COPY INFORMATION

Issue	Copy Deadline
March	January 25
July	May 25
November	September 25

Send copy to Paul Elliot at the above address in the following formats:

1. A hardcopy.
2. Camera ready hardcopy of any figures.
3. If possible also send text on a floppy disk. We can read any version of MICROSOFT-WORD and ASCII files on both IBM and Macintosh disks. On IBM disks we can also read WORDPERFECT and WORDSTAR files. If any software other than MICROSOFT WORD has been used on Macintosh Disks, contact the Managing Editor, Richard W. Adler **BEFORE** submitting a diskette. If it is not possible to send a Macintosh disk then the hardcopy should be in Courier font only for scanning purposes.

NEWSLETTER ARTICLES AND VOLUNTEERS WELCOME

The ACES Newsletter is always looking for articles, letters, and short communications of interest to ACES members. All individuals are encouraged to write, suggest, or solicit articles either on a one-time or continuing basis. Please contact a Newsletter Editor.

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The opinions, statements and facts contained in this Newsletter are solely the opinions of the authors and/or sources identified with each article. Articles with no author can be attributed to the editors or to the committee head in the case of committee reports. The United States recently became part of the Berne Copyright Convention. Under the Berne Convention, the copyright for an article in this newsletter is legally held by the author(s) of the article since no explicit copyright notice appears in the newsletter.

THE APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY

Treasurer's Report

June 29, 1993

The following figures include all transactions between January 1, 1993 and June 24, 1993:

ASSETS		
BANK ACCOUNTS	**JAN 1, 1993**	**JUNE 24, 1993**
MAIN CHECKING	1,802	30,267
EDITOR CHECKING	1,754	894
SECRETARY CHECKING	2,009	1,720
SAVINGS	296	296
CD #1	11,068	11,101
CD #2	11,068	11,101
TOTAL ASSETS	**$27,998**	**$55,379**
LIABILITIES	None	None
NET WORTH	**$27,998**	**$55,379**

INCOME	**January - June 1993**
CONFERENCE	61,316
PUBLICATIONS	108
MEMBERSHIP	14,077
SOFTWARE	1,510
INTEREST & MISC.	1,523
TOTAL	**$78,534**

EXPENSE	**January - June 1993**
CONFERENCE	26,149
PUBLICATIONS & FLYERS	9,878
SOFTWARE	234
SERVICES (LEGAL, TAXES)	755
POSTAGE	6,672
SUPPLIES & MISC.	7,465
TOTAL	**$51,153**

NET INCREASE FOR 1993	**$27,381**

James C. Logan, Treasurer

OFFICER'S REPORTS

PRESIDENT'S REPORT

The 9th Annual Review in March was a resounding success. Perry Wheless and his crew did an outstanding job. It was a personal, as well as professional, pleasure for me, because I finally got my wife, Sandy, to take a break from real estate and go with me. Fortunately, there were a couple of sunny days of the kind that she thrives on (and don't we all), and we took the beautiful 17 mile drive on one of them. Needless to say, she was impressed. And then we went to the aquarium, which was my first time there, also. Wow! The next time you're in Monterey, save time to see the aquarium. You'll like it, even if your skin wrinkles just thinking of water.

One of the highlights of the Review, in my opinion, was the special session on bioelectromagnetic effects, for this session was entirely underwritten by the Department of Energy, and consisted of invited papers. ACES is rapidly being recognized as an outstanding technical organization with an excellent set of publications, and to be a useful forum for presenting new research. That, to me, is the message of the bioelectromagnetic session, but then I tend to be proud of ACES, anyway.

Our outreach efforts are continuing: Russ Taylor reports that there is a setup with the Millimeter-wave/Microwave Advanced Computational Environment (MMACE) project BBS. We can send E-mail messages to the MMACE computer for request of files, etc., with the possibility of an FTP link in the future. Prof. Kenzo Miya, of the University of Tokyo, is interested in promoting joint activities between the Japanese Society of Applied Electromagnetics and ACES,and we are exploring some possibilities.

Now, let's talk a little business. The Board of Directors took a number of actions in Monterey, that I need to tell you about. We created the office of Executive Officer, and appointed Dick Adler to that position. His responsibilities are pretty much the same as before, except that he will no longer be the Corporation's Secretary. Perry Wheless was assigned that task. Dick's position on the BOD is now filled by Pat Foster, who hardly needs an introduction to the ACES membership. So now the Board consists of: Harold A. Sabbagh, President; Ray Luebbers, Vice-President; Perry Wheless, Secretary; Jim Logan, Treasurer; Pat Foster, Ed Miller, Jim Breakall, Frank Walker, and Andy Peterson. The Executive Committee comprises Harold Sabbagh, Ray Luebbers, Perry Wheless, Jim Logan, and Dick Adler.

ACES consists of volunteers, and the action of ACES is done, generally, at the committee level. If we are to grow, then the foundation of our growth must be at the committee level, and this means that we need active committees, chaired by active people. To ensure that this level of activity is maintained, the BOD has ruled that committee chairmen must convene their committees at least twice a year, once between each board meeting, and report to the BOD at each board meeting. Meetings can be by telephone or in person, and reports shall be in a written format suitable for publication in the Newsletter. When you accept responsibility for a committee, whether as a member or chairman, I hope that you will keep these ideas in mind. You really are the backbone of this organization.

And speaking of committees, I expect that there will be regular turnovers in coming years, as we attempt to continually generate new ideas by bringing in new blood. If you have an interest in serving ACES in some capacity, please let me know; we can use you.

Congratulations to Doug Werner, and his wife, Pingjuan, for receiving the 1993 ACES Best Paper Award. Doug and Pingjuan wrote to me to thank ACES for the award.

Finally, let me encourage you to start thinking about next year's review. It will be our tenth, and this requires something special. The symposium will be held in Monterey (as usual), from March 20 to 26 (as usual), at the Doubletree Hotel (which is unusual). The conference will be managed by Veda Coporation, under contract to the Air Force through Andy Terzuoli, who will be Conference Chairman. Veda will compile, format, print, and distribute the ACES 94 Proceedings at no cost to ACES, and will handle all publicity for ACES94 at no cost to ACES. These two functions by Veda will relieve ACES of expenses that are typically on the order of $20,000, so you see this is a very promising start to our tenth conference. The Doubletree is offering us special rates, but in order to take advantage of them, we must have a minimum number of rooms rented. That's where you come in; reserve March 20 to 26, 1994 for ACES in Monterey, and come to the Doubletree. It's near the aquarium. You'll love it.

Have a very pleasant summer.

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COMMITTEE REPORTS

ABOUT ACES COMMITTEES

There has been some concern among Board members lately about ACES committee activities or the lack of same. In order to address the issue Hal Sabbagh, Board Chairman and ACES President, assigned Andy Peterson to review ACES committee activities and make recommendations. Unfortunately, Andy was unable to attend the last Board Meeting as the result of the birth of his first child (congradulations Andy)). The Board of Directors took measures intended to promote committee activity and selectively eliminate non-functioning committees. There was an intent to achieve this objective without undue imposition of restrictive legislation such as committee chairmen term limits or committee performance criteria. The Board established requirements that committee chairs shall:

1) Convene their committees at least twice a year, once between each Board Meeting.
2) Report to the Board of Directors at each Board Meeting in a written format suitable for publication in the ACES Newsletter.

In addition, there will be a planned accomodation at future ACES Conferences for scheduled committee meetings.

These measures are intended to eliminate dormant committees by establishing a minimum level of activity and promoting committee accountability while also insuring Board awareness of committee activities. Meetings can be held by telephone or in person and written reports can be submitted to the Board in lieu of committee chair attendance at the Board Meetings.

You are encouraged to review ACES committee activities and determine if there is an area where you would like to become involved. Should you have helpful suggestions to or opinions of these measures please direct your comments to Andy Peterson or any member of the ACES Board of Directors. Thank you.

Frank Walker
Member, ACES Board of Directors

PERMANENT STANDING COMMITTEES OF ACES INC.

COMMITTEE	CHAIRMAN	ADDRESS
NOMINATIONS	Stan Kubina	Concordia U/ECE Dept. 7141 Sherbrooke St. West, Montreal, Quebec, CANADA , H4B 1R6
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AWARDS	Lee Corrington	USAEPG, Attn: Steep-Ct-E Ft. Huachuca AZ 855613-7300

MEMBERSHIP ACTIVITY COMMITTEES OF ACES INC.

COMMITTEE	CHAIRMAN	ADDRESS
CODE USER GROUP	Russell Taylor	McDonnell Douglas Helicopters, 5000 E McDowell Rd. Mesa, AZ 85205
SOFTWARE EXCHANGE	Frank Walker	Boeing Defence & Space Gp. MS 82-11 Box 3999 Seattle, WA 98124-2499
SOFTWARE PERFORMANCE STANDARDS	Andrew Peterson	Georgia Inst. of Technolog E E Dept. Atlanta, GA 30332-0255
AI & EXPERT SYSTEMS	Wayne Harrader	Ball Communications PO Box 1235 Broomfield, CO 80020
HISTORICAL	Robert Bevensee	10 Kent Ridge Crescent, SINGAPORE 0511

USERS GROUP

ACES now has two hosts for Electronic Bulletin Boards. One is a mail server in cooperation with MMACE Program (Millimeter-wave Advanced Computational Environment). It is hosted at NRL in Washington DC. I will explain shortly how to use them. The other is an anonomous FTP site hosted by the University of Missouri - Rolla. At this time we only have the sites set up - no software is available.

We plan to have two sites mirror each other - that is the same material will be on both machines and you can access it through which ever machine you are most comfortable using.

Ultimately we hope to distribute public domain or shareware software and to maintain our Modeling Handbook as well as a forum for discussion groups. If you have any public domain or shareware you would like to post to either of these machines, please let Randy Jost, Todd Hubing, or myself know. We will accomodate it.

Hopefully the Modeling Handbook will contain 1) A code directory containing a catalog of available codes including information on their information, availability, areas of applicability, machines on which they run and any other pertinent information - such as if it uses modules from commercially available codes. 2) Tutorials which include basic information on how to get started, as well as other commonly encountered but more subtly aspects not often revealed in the literature. 3) Checked cases comparing solutions with different codes or methods as well as experimental results. 4) Solved problems catalogued topically, rather than chronologically as they appear in the literature. This Modeling Handbook is more fully described in the July '91 ACES Newsletter.

To retrieve a file from the MMACE machine, send e-mail to

emlib@mmace.nrl.navy.mil

with the subject line

archive-request <file>

where <file> is the full name of the desired file. That file will be sent back to the sender via e-mail; binary files will be encoded in base64 (3 bytes become 4 printable characters) and files with lines longer than 75 columns will be wrapped after column 73 and have non-printable characters hexified. To get a directory of the archive, use the subject

archive-request directory

which will send back a list of all files in the archive. Further information on retrieving files can be had with the subject

man archive-request

This file archiver is an early software version that does not allow priviledged access, so on publicly accessible files under mmace/codes are available. Future versions will allow secure access, uploading, and eventually, full BBS services.

to access the machine at UMR set up an FTP session to

emclab@ee.umr.edu (131.151.8.246)

type "anonymous" when prompted for your user-id and type your e-mail user-id when prompted for your password. Type "cd/pub/aces" to move to the ACES directory.

Currently, the only file is the necdraw code that was distributed at the ACES symposium. I believe Randy Jost is planning to upload the ACES mailing list also.

If you want to post anything let me know.

If you have any problems, comments or complaints, call me or send me an e-mail message.

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ACES UK CHAPTER

ACES UK is continuing to expand its membership and is hoping to embard on one or two special events within the next 12 months which will help promote our society. Both of these are NEC oriented.

We are looking forward first of all at a NEC users course intended for those relatively new to the program which would be essentially "hands on" and concentrate on the "tricks of the trade".

Secondly, we are hoping for a one day meeting on MININEC sometime early next year. These events are designed to increase our profile and income as well as being useful to the UK Committee.

In addition, we will be holding our annual one day meeting in October of this year, in London.

Dr. A.K. Brown
Managing Editor

ACES SOFTWARE EXCHANGE

Current members of the ACES Software Exchange Committee

Committee Officers		Telephone	E-mail
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Randy Jost	Vice-Chairman	703 247-8415	Jost@wdc.sri.com
Todd Hubing	Secretary	314 341 6069	Thubing@ee.umr.edu
Members-at-large			
Dick Adler	Distribution	408 656 2352	55411304@mcimail.com
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Lorant Muth		303 497 3603	
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Malcolm Packer	SAIC	508 460 9500	Birst@ubar.saic.com
Andy Peterson	S/W Standards	404 853 9831	Ap16@prism.gatech.edu
John Rockway	NEEDS S/W	619 553 3791	Rockway@manta.nosc.mil
Ken Siarkowicz	Rome Labs	315 330 2465	
David Stein	Low Freq S/W	703 524 2117	74250.3402@compuserve.com
Russ Taylor	Code User Group	602 891 5539	Taylor%hyades.decnet@orion.mdhc.mdc.com
Andy Terzuoli	AF Inst Tech	513 255 3576	Terzuoli@galaxy.afit.af.mil

In an effort to comply with the new requirements for ACES committee reporting, this report will review the results of recent committee discussions and elections as well as identify current members and committee activity. Many of the member names listed have been collected by sign-up sheet at the annual conferences in the last few years. If you wish to join this committee or continue to participate as a software exchange committee member please contact the committee chairman and provide personal communication data so you can recieve committee correspondance.

Our semi-annual committee meeting was held in two sessions during the March '93 ACES Conference in Monterey. Rather than provide detailed meeting minutes from each meeting followed by more recent, and related events, I will attempt to report on meeting issues as a whole and incorporate events from both meetings along with more recent developments. Consolidated meeting issues from the meeting in room 113 Glasgow at 10 a.m. on Monday, March 21, and the meeting held at the NCO mess at 8 a.m. on Thursday, March 25, are presented as follows:

Co-chairman Frank Walker presided.

PRESENT: Dick Adler, Todd Hubing, Randy Jost, Jim Logan, Stephen Merrill, Malcolm Packer, John Rockway, Russ Taylor, and Frank Walker.

ABSENT: Andy Terzuoli, committee co-chairman.

SOFTWARE DISTRIBUTION:

Frank Walker identified the issue of ACES UK Chapter distribution of NEC2 and NEEDS. Discussion led to a proposal to: 1) leave distribution methods within the UK to the discretion of the UK Chapter; 2) allow regional market based pricing so long as cost to users is not less than in the US; and 3) offer 50-50 profit sharing between the UK Chapter and the parent ACES organization. The arrangement is intended to promote flexible marketing by the UK Chapter and local ACES software distribution to UK members. This issue was later approved as stated by the ACES Board of Directors.

In a related issue the Air Force has agreed to allow CAEME to distribute GEMACS version 3.7 as part of the CAEME software set. Documentation to support this version of the software is limited to the older version 3.7 Users Manual and Engineering Manual. Ken Siarkiewicz is currently investigating the possibility of releasing a portion of the newer GEMACS Source Book to public domain version 3.7 users. In discussion with Ken Siarkiewicz of Rome Laboratory, Frank Walker has confirmed that the same distribution authorization can be provided to ACES. Frank Walker will formally request GEMACS 3.7 distribution authorization from the Air Force and add this code to the ACES software distribution set. This public release of the older version of GEMACS is due to the efforts of Dr. Magdy Iskander and the CAEME software development effort. Thank you Magdy!

NEEDS/NEC2-386 UPDATE:

The topics discussed in regard to NEC2 and NEEDS updates include:
1) Update QUICK BASIC code to C++
2) Develop a WINDOWS interface
3) Develop an IGES standard interface to CAD packages
4) Develop model diagnostics similar to the MACVERIFY diagnostics for GEMACS
5) Develop an interface to other analysis codes such as JUNCTION, PATCH, and GEMACS
6) Improve visual I/O graphics.

After detailed discussions about development potentials with J. Rockway and Jim Logan, J. Rockway proposed that ACES not update NEC2-PC or NEEDS in competition with commercial efforts. J. Rockway further recommended that ACES encourage commercial software developers to improve these codes and not attempt this as an ACES funded initiative. Dick Adler pointed out that commercial developers may not provide the support of interest to ACES members due to the limited number of customers and low rate of return. The committee supports commercial development of software and is interested in encouraging commercially developed software upgrades where feasible. There are members of the ACES SoftX committee who are interested in ACES funded software development and upgrades to include NEC and NEEDS software. The committee is not prepared to propose specific software upgrades or address funding requirements with the Board of Directors at this time. Member comments are solicited and this issue will be discussed further at the ACES Board Meeting in Ann Arbor, Michigan, during the week of June 28 through July 2.

SOFTWARE SOURCE BOOK DEVELOPMENT:

Frank Walker has identified that ACES software distribution is being held up by the publication of the Software Source Book. The committee is in full agreement to continue the effort on the book. Malcolm Packer, Randy Jost, Todd Hubing, J. Rockway, and Russ Taylor have offered to help Frank Walker with the development of the Source Book and have formed a sub-committee to that end.

COMMITTEE ELECTIONS:

Discussion of staffing committee officer positions was conducted among the meeting attendees. Elections were held with Frank Walker elected as chairman, Randy Jost elected as vice-chairman, and Todd Hubing elected as secretary for the 1993-94 term.

In regard to future elections we wish to follow a more formal procedure to allow all active members to nominate and vote even if they are unable to attend the committee meeting at Monterey. Frank Walker will attempt to solicit nominations and conduct elections via E-mail prior to next years March committee meeting if committee members agree with this approach.

ANNUAL COMMITTEE MEETINGS:

The ACES Board of Directors has established requirements that committee chairs shall 1) convene their committees at least twice a year, once between each Board meeting, and 2) report to the Board of Directors at each Board meeting in a written format suitable for publication in the ACES Newsletter. These measures are intended to eliminate dormant committees by requiring a minimum level of activity, promoting committee accountability, while also promoting Board awareness of committee activities. Meetings can be held by telephone or in person and written reports can be submitted to the board in lieu of committee chair attendance at the Board meetings.

In order to fulfill the meeting requirement, Frank Walker will attempt to convene a committee meeting via conference telephone in mid June. All current committee members will be invited to attend but attendance will be required of the committee officers only. A meeting time will be established and coordination of availability to attend will be the responsibility of each member.

Frank Walker,
Software Exchange Committee Chairman.

SOFTWARE EXCHANGE

Minutes of June 14, 1993 Meeting

Attended by Telephone Conference Call:

Frank Walker, Chairman
Randy Jost, Vice-Chairman
Todd Hubing, Secretary
Dick Adler
Russ Taylor
Jim Breakall
Ken Siarkiewicz

Meeting commenced at approximately 1100 hrs EDT, 0800 PDT.

Due to a previous committment, Jim Breakall spoke first, so that he could "leave" the meeting. He noted that he has had a Penn State student working with a 3D wire graphic viewer called "3DV" for use as a front-end for NEC that runs under Windows on PC machines. The 3DV software was acquired via an Internet bulletin board from SIMTEL Graphics. It is capable of giving a graphical view of the geometry input file (wire-frame model) that is used by NEC-like programs. It can rotate the model and change the view. The screen redraw is very fast and screen dump capability is available for hardcopy. It does NOT allow you to zoom in on the model at present as this requires clipping algorithms that would greatly affect the redraw speed. The 3DV software source code is currently not available from the developer. Jim Breakall is negotiating with the developer for access to the source code and the right to further develop the code. Several individuals indicated that an ability to view the resulting EM output files and have various views of those is desirable. Jim Breakall also noted that he has a student that is possibly interested in reworking NEC with a Visual Basic program, under windows.

Randy Jost pointed out that if we are interested in supporting code development, we need to insure that the code can be distributed, as some software languages require permission to incorporate software tools or modules into other codes for distribution.

Dick Adler mentioned that he was aware of a NEEDS 3.0 package being developed as a Windows application and a DOS version of NEC 4.0. The work is being done by Dan Tam under contract to the Navy and will be done with Visual Basic. Dick will check to see if there are any restrictions.

Jim Breakall mentioned that Doug Werner had developed an exact solution for thin wires for the Method of Moments and the results would be available soon.

At this point Jim Breakall left the conference call.

Frank Walker then went through the minutes of the Committee Meeting held in Monterey at the ACES '93 Meeting, that he distributed by E-mail on May 28, 1993.

Frank proposed modifying the first paragraph on Software Distribution in the UK, to clarify that the issues presented with respect to ACES UK software distribution were later submitted to the ACES Board of Directors and approved. Motion made by Walker, seconded by Adler, passed.

Next, there was substantial discussion of the status of NEC2-PC and NEEDS, as well as the committee's position on encouraging further development of these packages. Adler indicated that source code for IGUANA and the antenna matching part of NEEDS is not available, as it was done under contract for a specific customer. Drivers for output devices may be available.

Adler estimated that it may cost approximately $5000 to get NEEDS/NEC2 to the point that it is ready for general distribution. He did not believe any commercial type development of these packages would probably take place, due to the low rate of return.

After much discussion, Adler agreed to put together a paper outlining the status of NEC2 and NEEDS, and what could be done with them, vis-a-vis an ACES distribution policy.

Several attempts at a viable motion were attempted. Essentially, they revolved around replacing the statement: "the sponsorship issue is unresolved". The following statement was adopted by the committee to represent the majority consensus: "There are members of the ACES Software Exchange Committee who are interested in ACES funded software development and upgrades, to include NEEDS and/or NEC software. The committee is not prepared to propose specific upgrades or address funding requirements with the BoD at this time".

The general feeling was that this fairly represented the members feeling at this time, and that this issue would be revisited when we had more information from Dick Adler's investigation of the situation. Frank Walker proposed that the first two paragraphs of the section on Committee Elections be edited to report only election results. Adler seconded the motion and it passed unanimously.

Ken Siarkiewicz discussed the status of distributing GEMACS v3.7 on an unlimited distribution basis. This version only has the capability to perform MoM and GTD calculations. The current version of GEMACS is v5.3, which has export restrictions.

ACES will request permission to distribute GEMACS v3.7. If someone requests the later versions, ACES will either take the paperwork and pass it on to Ken, or refer them directly to Ken. Ken will talk to those that are distributing GEMACS on a commercial basis, and see what their feelings are concerning: 1) ACES distributing the early versions, and 2) technical support issues. Ken will also check into the availability of distributing IEMCAP.

In a future planning the Software Exchange Committee should discuss ways that ACES can actively encourage and support software developers by providing a distribution channel for electromagnetic codes.

Adler mentioned that he has some capability to support software distribution functions.

Walker is collecting the information needed to get the Software Sourcebook going. The proposal is to have a first draft ready by ACES '94 and then put a more refined version together after receiving feedback from users.

Finally, Adler made a motion to adjourn and it was seconded by Siarkiewicz.

Recorded by:
Randy J. Jost, Software Exchange Committee Vice-Chairman

Submitted to the ACES Board of Directors by:
Frank E. Walker, Software Exchange Committee Chairman

SOFTWARE PERFORMANCE STANDARDS

During the March Validation Workshop at Monterey, in which 20 members attended, a survey was distributed and collected with questions concerning future directions of the SPS Committee. The objective of the survey was to reassess the Committee's activities after 5 years of operation, and identify future directions and focal points. I would like to share the results from the 7 surveys that I have received to date:

Almost all of the respondents specifically mentioned that the Committee should continue with its activities toward collecting a database of solved problems. All 7 felt that such a database was feasible, but the group split about 50-50 on the issue of whether the focus should be narrowed to a few areas of EM or kept very broad in scope. Most felt that the database should consist of a combination of collected publications such as the "ACES Collection of Canonical Problems" as well as an on-line computer-retrieval format.

Most of the respondents felt that the Committee should attempt to keep track of scattered publications describing appropriate benchmark problems, and perhaps publish a bibliography at regular intervals.

Finally, several respondents felt that the Committee should be doing more to promote aspects of validation other than a benchmark problems database.

In summary, those that responded to the survey felt that the original motivation for this Committee is still valid, and that the objective of developing a database of canonical problems is feasable.

The Committee has yet to establish a standard format for benchmark solutions, and the lack of a format has become a bottleneck on our activities. If anyone with interest or expertise in this area would like to propose a format, please get in touch with me!

Andrew F. Peterson
Chairman

ACES EDITORIAL BOARD

At 24 minutes after midnight GMT on 23 September 1993, I shall discontinue my service as ACES Editor-in-Chief / Publications Chairperson. As a concurrent or preliminary action, I shall divest myself of my other responsibilities as ***ACES Journal*** Editor and of my unofficial, de facto, and (in some cases) shared responsibilities as Publicity Officer, Principal Promotional Officer, Strategic Planner, Ombudsman, and Intersociety Relations "Ambassador." Other tasks call me now.

One of the greatest honors of my life has been the opportunity to serve with the distinguished members of the ACES Editorial Board, and I have never worked with a finer group of individuals anywhere. With publications comprising the near-totality of ACES membership benefits, the Editors, more than anyone else, have been bearing the primary responsibility of maintaining membership satisfaction between symposia. This they have accomplished not only by promptly and thoroughly reviewing ***ACES Journal*** papers but also by encouraging the submission of top-quality papers and ***ACES Newsletter*** articles, by arranging our inclusion in abstracting services, by organizing and editing Special Issues of the ***ACES Journal***, and by developing and continually refining the standards of publication for applied computational electromagnetics. For its part, the ***ACES Newsletter*** now sets the example in promoting long-needed dialog within the computational electromagnetics community. Its "Perspectives" articles and its annual code reference index are true pioneering ventures. As a result of our Editors' sustained efforts — and the continued support and confidence of our authors and subscribers (members) —both the ***ACES Journal*** and the ***ACES Newsletter*** have exceeded the expectations of our Founders and Charter Members and are well on their way to international preeminence.

Not content to satisfy the minimal requirements of service, many Editors have served as ACES Ambassadors to funding agencies, research agencies, and other professional societies worldwide. Other Editors have arranged much of our publicity, have given ACES almost all of our regional workshops, have created the now-independent ACES Code User Group committee, and have thereby inspired activity in other ACES committees. During my most discouraging moments in ACES, the enthusiasm of our highly-active Editors helped me to maintain my own. Above all, the Editors have accepted the difficult challenge of "blazing new trails" in preference to equally-vital but less-challenging service in well-established positions elsewhere. Now representing thirteen nations on five continents, their achievements within ACES are truly unequaled in any of the numerous other volunteer-administered organizations in which I have maintained membership. Even now, as I contemplate my six-plus years of service to ACES, I continue to ask myself whether "it all really happened."

Know that from the ranks of our Editors will arise several ACES leaders of the next generation. Those who renew their ACES membership year after year have placed their highest confidence in our authors and Editors and will never forget them.

For my part, I am eternally grateful for the opportunity to have been a member of this team. Admittedly, I had hoped to accomplish other things for ACES, and I regret not having had more opportunity to work with the newest members of the ACES Editorial Board. However, even if my services were not needed elsewhere now, the interests of professional societies such as ACES are not best served by entrenchment within or attachment to elected or appointed offices. I take with me several rewards of service, the highest of which include lifelong friends in Australia, Japan, Singapore, South Africa, Italy, Germany, Switzerland, France, the Netherlands, Sweden, the United Kingdom, Canada, and my own United States of America.

Since time immemorial, history has found ways to repeat itself. Therefore, I shall not be surprised if someday, under different circumstances, some of us serve together again. Meanwhile, if I can be of service to you or any other ACES member personally, please let me know — and feel free to contact me when you visit the Washington, D.C. metropolitan area.

David E. Stein
Editor-in-Chief

FINANCE COMMITTEE REPORT

June 24, 1993

I am pleased to report that ACES is within budget on most expense items and income is within 76% of the projected amount for the year.

INCOME SUMMARY:

ACES income for calendar year 1993 is compared to the 1993 budget amount in Table 1. If the difference is positive for an income entry, we have more income than planned; if negative, we have less income.

Two large differences show up under DONATION and DUES. At this date, ACES has not received the promised donation for guests. The entry for actual income is blank under DONATION. And so far, not all members have renewed their membership. We are only half way through the calendar year.

TABLE 1 - INCOME SUMMARY (1/1/93 - 6/30/93)

CONFERENCE:	ACTUAL	BUDGET	DIFF.
BANQUET	1674	1311	363
BOOTH FEES	1985	1500	485
DONATION		13809	-13809
REGISTRATION	41585	29250	12335
PROCEEDINGS	1904	1200	704
SHORT COURSE	14168	14037	131
SUBTOTAL	61316	61107	209
SHORT COURSE:	**ACTUAL**	**BUDGET**	**DIFF.**
REGISTRATION	14144	14037	107
NOTES	24	0	24
SUBTOTAL	14168	14037	131
PUBLICATIONS:	**ACTUAL**	**BUDGET**	**DIFF.**
JOURNAL	80	500	-420
NEWSLETTER	28	80	-52
SP. ISSUES		1000	
SUBTOTAL	108	1580	-472

TABLE 1 - INCOME SUMMARY (Continued)

MEMBERSHIP:	ACTUAL	BUDGET	DIFF.
DUES	14077	36221	-22144
SUBTOTAL	14077	36221	-22144

SOFTWARE	ACTUAL	BUDGET	DIFF.
NEEDS	1510	3000	-1490
OTHER	0		0
SUBTOTAL	1510	3000	-1490

INT. & MISC.	ACTUAL	BUDGET	DIFF.
INTEREST	71	850	-779
OTHER	1452	200	1252
SUBTOTAL	1523	1050	473
TOTAL	78534	102958	-23424

EXPENSE SUMMARY:

The expenses incurred so far in calendar year 1993 is compared to the 1993 budget amount in Table 2. The difference is positive if the actual expense exceeded the budget amount for an expense entry. A negative difference indicates we are under budget on the item.

Not all the expenses for the conference are accounted for. For example, the facilities bill and proceedings printing have not yet been paid.

Some expense items were not explicitly in the budget, but we were obligated to pay them to keep ACES running. These items were the conference telephone and the postage meter. I respectfully request the Board to approve these items.

Other expense items appearing in the budget have not yet incurred, so I have omitted them from this report.

To date, our expenses total about 50% of the projected total for 1993.

TABLE 2 - EXPENSE SUMMARY (1/1/93 - 6/30/93)

CONFERENCE:	ACTUAL	BUDGET	DIFF.
AWARDS	533	540	-7
BANQUET	1631	1406	225
FACILITIES		6000	-6000
FLYERS	525	9416	-8891
MISC.	355	587	-232
PROCEEDINGS	103	11153	-11050
REFRESHMENTS	3852	1650	2202
SECRETARY	7273	3594	3679
SPONSORED GUESTS		10099	-10099
SUPPLIES	1173	1706	-533
TELEPHONE	1492		1492
TRAVEL	578	578	0
SHORT COURSE	8634	6311	2162
SUBTOTAL	26149	53040	-27052

SHORT COURSE:	ACTUAL	BUDGET	DIFF.
INSTRUCTOR	7517	5765	1752
PRINTING	956	546	410
SUBTOTAL	8473	6311	2162

PUBLICATIONS:	ACTUAL	BUDGET	DIFF.
JOURNAL	5015	18001	-12986
NEWSLETTER	4203	11272	-7069
SECRETARY	660	836	-176
SUBTOTAL	9878	30109	-20231

SOFTWARE	ACTUAL	BUDGET	DIFF.
NEEDS PRINT.	0	62	-62
SECRETARY	160	336	-176
OFFICE	74	2008	-1934
SUBTOTAL	234	2406	-2172

TABLE 2 - EXPENSE SUMMARY (Continued)

SERVICES:	ACTUAL	BUDGET	DIFF.
ACCOUNTING	755	2781	-2026
SUBTOTAL	755	2781	-2026
POSTAGE	**ACTUAL**	**BUDGET**	**DIFF.**
FED EX	201	500	-299
METER	5707		5707
UPS	170		170
OTHER	594	1500	-906
SUBTOTAL	6672	2000	4672
SUPPLIES & MISC.	**ACTUAL**	**BUDGET**	**DIFF.**
MISC.	638	3642	-3004
MEMBERSHIP	5808	5612	196
BOD	468	1000	-532
SUPPLIES	543	2008	-1465
CU SERVICE CHG.	8	100	-92
SUBTOTAL	7465	12362	-4897
TOTAL	51153	102698	-51706

SUMMARY:

Table 3 gives our status for 1993. Shown is income minus expense for each item compared to the amount projected in the budget. A positive difference indicates we have exceeded the projection

The actual Conference earnings of $35167 includes gains from the short course. Keep in mind tha we have not paid all of our Conference bills yet and we have not received all of our expected income The net gain for our Society includes the gains and expenses from the Conference and Short Course But we are only half way through the year so our expenses will continue to grow faster than ou expected income.

TABLE 3 - STATUS (1/1/93 - 6/30/93)

INCOME - EXPENSE SUMMARY:	ACTUAL	BUDGET	DIFF.
SHT. COURSE	5695	7726	-2031
CONFERENCE	35167	8067	27261
SOCIETY	27381	260	28282

James C. Logan
Treasurer

Investment Report from the Finance Committee

June 29, 1993

As an action item from the March Board Meeting, the Finance Committee was entrusted to investigate and make recommendations for investment of our reserves in mutual funds. Currently, the ACES reserves consist of two $10,000 CD's earning about 4 interest. Not only is the return low, but premature withdrawal from CD's may involve substantial interest penalty.

Most bank accounts offer more liquidity with very little risk (they are Federally insured) but also with a low return. Money markets may offer a little higher return but with more risk (no insurance). Mutual funds have no insurance either. On the other hand, a mutual fund may increase our earnings with a minimal increase in risk and more liquidity than the CD's.

Usually, only banks, money markets and bond funds have checking privileges. But mutual stock funds may be sold with minimal or no penalty.

Unlike CD's and bank accounts, mutual funds do not offer insured deposits. When it comes to relative safety, size of the investment company is important - the bigger the better. Fidelity Investments is the largest mutual fund company with more than $165 billion under investment management - and Fidelity has an office in San Diego.

Mutual funds have varying investment strategies that involve differing amounts of risk. Money markets preserve the investment capital, have a fixed price per share (usually $1 per share) and pay out dividends much like a bank account. But mutual funds have a floating price per share and fluctuate with the stock market and the economy. So the price per share may rise or fall. Investment capital is preserved by following a low risk investment strategy usually at the sacrifice of return. Some mutual funds invest only in bonds - federal, state or municipal, etc. Some invest only in stock -blue chip, small companies, emerging technologies, etc. Each fund investment strategy dictates the mix of investments and hence the relative risk and return. Greater diversity usually leads to reduced risk while increasing return.

A no load mutual fund is to be preferred. A no load fund has no brokerage fees or up-front charges for transactions. There is usually a small fractional management fee per year (typically under 1%) on net assets.

I recently met with Mr. Wayne Sellar, financial representative of Fidelity Brokerage Services, Inc. in San Diego. Mr. Sellar recommends that we invest in bond funds that have a very low risk to capital and give a higher return than CD's. Because we are working with public money, he recommends the safest kinds of investments but with steady modest income. Two funds recommended by Mr. Sellar are Fidelity's Ginnie Mae Fund and Fidelity's Government Securities Fund.

Fidelity's Ginnie Mae Fund is a mortgage bond fund. The average 30 day yield on May 31 was 5.99% with an average maturity in 6.2 years (the shorter maturity, the safer). It is a no load fund with $2500 minimum investment and $500 minimum check writing. This fund invests at least 65% in Ginnie Mae's and other AA rated or better securities.

The 30 day yield on May 31 was 5.03% for Fidelity's Government Securities. The average maturity is 12 years. It is also a no load fund with initial $2500 minimum and $500 minimum check writing. This fund buys only U.S. Goverment securities.

On the other hand, if we are willing to ignore Mr. Sellar's advice and take more risk, we may be able to increase our return substantially. A recent article in the May 1993 Consumer Reports provides a rating system for mutual funds and describes the top performers. One of these top performers is Fidelity's Balanced Fund.

Fidelity's Balanced Fund strives for "as much income as possible, consistent with the preservation of capital, by investing in a broadly diversified portfolio of high-yielding securities, including common stocks, preferred stocks, and bonds". This is a no load fund with a $2500 minimum initial investment. It can be sold at any time without penalty. This fund is considered to be a conservative fund, but it has done very well over the past 5 years (16% in '88, 19% in '89, 0% in '90, 27% in '91, and 8% in '92). So far this year the rate of return is 13.6%, beating out the S&P 4.5% return. If we use the S&P as a measure of risk set at 1.0, Fidelity's Balanced Fund would be rated at 0.5.

I will have copies of the perspectus for all three funds at the June Board Meeting for those interested.

The choice of fund is up to the Board. Should we invest in only one fund or split our investment between two or more? We will be faced with another similar investment decision next March if all goes well at our big 10 Conference.

James C. Logan
Chairman

ACES REGIONAL ACTIVITIES COMMITTEE REPORT

Current members of the ACES Regional Activities Committee

		TELEPHONE:	E-MAIL:
Frank Walker	Chairman	206 773 8598	Walker@atomic.boeing.com
Dick Adler		408 656 2352	55411304@mcimail.com
Duncan Baker	S. Africa	27 12 420 31	Elo0004@upvm2.up.ac.za
Tony Fleming	Australia	61 3 253 615	E.vinnal@trl.oz.au
Adel Razek	France	33 69 411 80	
Hal Sabbagh		812 339 8273	Has@Sabbagh.com
David Stein		703 524 2117	74250.3407@compuserve.com

The charter of the Regional Activities Committee is to promote cooperative activities for ACES participation outside of Monterey. David Stein, Tony Fleming, and Duncan Baker have been traditional supporters of Regional Activities. David's proactivism has help promote the TEAM/ACES conferences and workshops. Tony's efforts led to the recent meeting in Australia. There may be others who have contributed "behind-the-scenes" but I do not have the historical perspective of the TEAM cooperative efforts that they have had. The best examples of Regional Activities include the following joint symposia that ACES has shared with TEAM (Testing EM Analysis Methods):

1. TEAM/ACES; Toronto, Canada; Oct. '90.
2. TEAM/ACES; Sandai, Japan; Jan. '91.
3. TEAM/ACES; Sorrento, Italy; July '91.
4. TEAM/ACES; Clayton, Victoria, Australia; Aug. '92.
   "Directions for the '90s" sponsored by Tony Fleming.
5. TEAM/ACES; Clairmont, CA.; Aug. '92.

The next opportunity for ACES to participate in a TEAM workshop will be at COMPUMAG in Miami in Nov. of this year.

The efforts of the Regional Activities Committee in the last year have been focused on an attempt to establish an ACES participation in the 1994 AP-S/URSI Conference in Seattle. As a result of terms pre-negotiated with Gary Miller, 1994 AP-S/URSI Conference Steering Committee Chairman, ACES presented the preliminary proposal to provide:

1) A minimun of 60 papers to be presented in single sessions over a three day period.
2) ACES short courses, to be conducted on the last day of the conference.
3) ACES vendor booths.

ACES proposed conference co-sponsorship with AP-S/URSI with ACES revenues limited to a portion of ACES author registrations, ACES short course registrations, and ACES vendor registrations. Further ACES revenue sharing in Conference profits was proposed to be phased-in at between 100% and 150% of projected AP-S/URSI conference revenues. These conditions were intended to assure AP-S/URSI that ACES would not adversely effect revenues or profit distribution.

Unfortunately, the AP-S/URSI Conference Committee decided that there was "too much overlap" between APS and ACES topics and rejected our bid for ACES participation in their conference. This is essentially the second time that like proposals have been rejected by APS/URSI for this reason.

Hal Sabbagh has suggested that we can offer ACES sessions on low-frequency computational electromagnetics to a future AP-S/URSI conference. In my estimation, a more sensitive issue than technical content are the terms of ACES participation in an AP-S/URSI conference. We in ACES simply have not developed an approach for ACES participation at AP-S/URSI conferences that has been sufficiently appealing to their conference steering committees although we have made the attempt twice, once for the Chicago conference and lately for the Seattle conference.

Duncan Baker and Derek McNamara are arranging an ACES workshop to be piggybacked onto the annual joint Antennas and Propagation and Microwave Theory and Techniques Syumposium sponsored by the Pretoria chapter of AP/MTTS, SAIEE, and the University of Pretoria. The ACES workshop is entitled, "Gaining Insight Through Computational Electromagnwetism". The AP/MTTS symposium will be held Aug 5th and the half-day ACES workshop will be held Friday morning, August 6th. The Pretoria ACES workshop was advertised in mailing sent to more than 2000 individuals who have shown interest in computational electromagnetics in the last few years. About 800 addressees were in North America while more than 1200 notices were mailed outside of the U.S. and Canada. This is the kind of exposure that ACES needs in order to promote greater international participation. The decision to hold an ACES workshop in conjunction with the AP/MTTS symposium at the University of Pretoria this year was inspired by the success of the workshop held by Tony Fleming in Australia last year.

Hal Sabbagh has pointed out that our new committee member, Adel Razel, has a significant background in low-frequency computational electromagnetics and that he and Alan Bossavite, a colleague at Electricite de France, are becoming more involved in high-frequency analysis as a result of interest in microwave drying of materials. Perhaps Messrs. Razek and Bossavite would be interested in promoting ACES activities in Europe.

I would like some assistance in making contacts in CEFC and COMPUMAG for the purpose of arranging joint ACES participation in activities with these groups. Hal Saggagh may be able to develop an ACES relationship with the MMACE, (Microwave and Millimeter-wave Advanced Computational Environment), effort for the purpose hosting ACES workshops or sponsoring ACES technical sessions.

Frank Walker
Chairman, Regional Activities Committee

AWARDS COMMITTEE

The Ninth Annual ACES Awards Banquet was held on March 24, 1993 at the Naval Postgraduate School in Monterey, California. Seven awards were presented to highly deserving individuals. The award categories are described in the following paragraphs. The recipients of the awards are identified, and the reason for the awards are presented.

MAINSTAY AWARD - This award is presented to recognize individuals who devote their time and talents over a sustained period to benefit the day-to-day functions and activities of ACES. Recipients need not be elected officers or committee chairmen, but they will generally be officers or members of one or more committees.

Pat Foster

In presenting you with this award, ACES is recognizing you for your continuous exemplary service in support of ACES activities and membership recruiting in the United Kingdom. In particular, ACES acknowledges your efforts for the ACES United Kingdom Chapter in reducing the expenses of membership for United Kingdom members and supporting the ACES Annual Review through assistance to conference chairmen.

Duncan Baker

In presenting you with this award, ACES is recognizing you for exemplary service in recruiting new international members and increasing international awareness of ACES activities and publications. ACES also recognizes your service as an associate editor of the Journal.

VALUED SERVICE AWARD - This award is presented to individuals to honor valued services or contributions to single events or functions of ACES. Recipients need not be elected officers or committee chairmen, but they will generally be officers or members of one or more committees.

Perry Wheless

In presenting you with this award, ACES is recognizing you for your untiring efforts as chairman which insured the success of the Ninth Annual Review of Progress in Applied Computational Electromagnetics.

Tony Fleming

In presenting you with this award, ACES is recognizing you for your exemplary service in arranging the first ACES-organized regional workshop outside the United States. In addition, ACES acknowledges your continuous outstanding efforts in promoting ACES within Australia and in establishing an ACES Australian Chapter.

ACES BEST PAPER AWARD - The ACES Best Paper Award is presented to authors of an exceptional paper in an ACES publication.

D.H. Werner and P.L. Werner

"An Exact Expression for the Vector Potential of a Uniform Current Cylindrical Antenna" by D.H. Werner and P.L. Werner was recently published in the Conference Proceedings for the Ninth Annual Review of Progress in Applied Computational Electromagnetics. This paper presents the implementation of an exact closed form expression for the general vector potential of a current radiator element. This work will significantly impact method of moments wire modeling by eliminating the need to perform numerical integration and extending the range of wire diameters that can be successfully modeled.

ACES TECHNICAL AWARD - The ACES Technical Achievement Award is presented to recognize individuals who demonstrate technical achievement in applied electromagnetics through activities other than ACES publications. Appropriate factors for consideration include efforts to support computational techniques, electromagnetic modeling software, code validation and distribution, and emphasis on applications, rather than electromagnetic theory.

Edgar "Buddy" Coffey

Since 1980, Buddy Coffey has been involved in extending the capabilities of the computational electromagnetics community. He has accomplished this by his contributions in several arenas, including technology development, formulation hybridization, computer code development, validation, distribution, and the development and conduct of training courses. The most visible evidence of his contribution is the GEMACS computer code. It is the only readily available, general application tool that hybridizes several formulations thereby allowing electromagnetic analyst the ability to study very specific elements of electrically large real world problems, the kind that are of importance to both the defense and the civilian communities. His grasp of the fundamental principles is the foundation of the hybridization scheme. Buddy also developed much of the design of the GEMACS code and directed its coding. Finally, he has demonstrated its ability to solve the difficult problems, especially those associated with the interaction between high performance antenna arrays and the complex airframes on which they are mounted. He has displayed a ready willingness to share his knowledge and talents to advance the state-of-the-art in computational electromagnetics, and science in general.

Ronald J. Marhefka

Ron Marhefka has been responsible for the development of the Numerical Electromagnetic Code, Basic Scattering Code (NEC-BSC). The NEC-BSC is a user-oriented computer code for the electromagnetic analysis of the radiation from antennas in the presence of complex structures at high frequency. The analysis is based on uniform asymptotic techniques formulated in terms of the Uniform Geometrical Theory of Diffraction (UTD). The size of the user community and the number of publications of NEC-BSC applications testify to the acceptance of the NEC-BSC as a standard in computational electromagnetic modeling (CEM). Ron Marhefka has contributed to this acceptance by computer code improvement, documentation, validation, and the conduct of training courses.

J.C. Logan
J.W. Rockway
Ad Hoc, Awards Committee

NOMINATIONS COMMITTEE ANNOUNCEMENT

We are pleased to notify ACES members that the Board of Directors has approved the handbook which outlines and formalizes the nominations and election procedures of the society.

It is presented in this issue in its entirety.

At the same time, members are invited and indeed urged to begin the nominations process for this election for three directors as outlined in this handbook. The names and terms of the present members of the Board are as follows:

NAME	TERM
James K. Breakall	1995
Dr. Pat Foster	1995
James Logan	1994
Ray J. Luebber	1996
Edmund K. Miller	1994
Andrew F. Peterson	1994
Harold A. Sabbagh	1996
Frank E. Walker	1995
W. Perry Wheless, Jr.	1996

It is most appropriate to acknowledge the exceptional effort of Jim Logan in the drafting of the handbook and his work, through several iterations, with Andy Peterson to arrive at its present contents.

Stan Kubina
Chairman

Names and addresses of Nominations Committee Members are:

Stan Kubina
Concordia University/ECE Dept.
7141 Sherbrooke St. West
Montreal, Quebec, CANADA H4B 1R6

Jim Logan
NRAD Code 824
271 Catalina Blvd.
San Diego, CA 92152

Andy Peterson
Georgia Inst. of Technology
School of Electr. Engr.
Atlanta, GA 30332-0255

THE 9TH ANNUAL REVIEW OF PROGRESS IN APPLIED COMPUTATIONAL ELECTROMAGNETICS CONFERENCE REPORT

The 1993 annual ACES Symposium, held in Monterey, California, March 22-26, was one of the most successful ever. This claim is based on several key indicators. First, a record number of 119 technical papers were presented in some 22 sessions; the symposium Proceedings was 938 pages. The quality of the papers was excellent. Of these, approximately thirty papers were presented in the Interactive Forum which was conducted Tuesday afternoon in the Barbara McNitt Ballroom in Herrman Hall on the Naval Postgraduate School campus. The setting and format of the Interactive Forum were extremely well received, and the papers in the Forum were carefully chosen on the basis of best match to the presentation mode of direct author-audience interaction. The quality of the Interactive Forum papers was equivalent to the podium presentation sessions, and many Forum authors used computer demonstrations and video tapes to vividly present their results. Vendor exhibits were also set up in the Ballroom on Tuesday afternoon and this combination of activities, accompanied by a wine and cheese buffet, was deemed highly successful.

Session topics for ACES'93 were as follows: Canonical Problems for Software Validation, Moment Method Theory and Applications, GTD/UTD/PO Analysis, Computational Electromagnetics - The Next Generation, Transients, High-Frequency Techniques and Asymptotic Solutions, Visualization and I/O Issues, Microwave Circuits, Time Domain Techniques I (featuring FDTD), Remote Sensing and Monte Carlo Techniques, Bioelectromagnetic Computations, Time-Domain Techniques II (featuring TLM), General Purpose Code Applications, CAEME, RCS, Multipole Techniques, Numerical Modeling in Complex Media, Low-Frequency Techniques and Applications, EMC/EMI, Antennas, and Finite Element Method and Applications at High Frequencies.

ACES'93 was fortunate to have the services of an outstanding group of session chairs and co-chairs. Their efforts were clearly reflected in the session papers and the conference attendance, and we are all grateful to them for the hours invested in making the ACES'93 Technical Program a great success. Special thanks are extended to those organizers who made first-time offerings of new topics available to this year's registrants.

The total registration for ACES'93 was approximately 208. This compares with approximately 145 in 1991 and 167 in 1992. Considering the economy and its effect on the computational electromagnetics community, the attendance at this year's conference was excellent. The registration figures reflect that CEM professionals view the annual ACES Symposium as an increasingly influential outlet, which merits their time and financial resources. A factor in the growth of the ACES Symposium is a willingness to actively incorporate constructive suggestions from the registrants; since there are great opportunities for further improvement, continuation and expansion of "customer" input is encouraged for future symposia.

Another timely and informative slate of short courses was organized by Dr. John Rockway. The short courses were: "Solving Practical Problems with GEMACS", "EM Modeling Using TSAR FDTD Code Suite", "The Generalized Multipole Technique (GMT) and the Multipole Program (MMP): Theory and Practical Use in Computational Electromagnetics", "CEM Modeling Options and Tradeoffs", "Wire Antenna Modeling: 20 Years of Successes, Failures and Lessons Learned, Modeling Guidelines and Some Useful Utility Programs", "TLM Techniques for Electromagnetic Wave Modeling", and "Reflector Antenna Code Modeling".

The Awards Banquet on Wednesday night was sold out, and was enjoyed by all. A large number of first-time conference registrants, as well as an increased international participation, bolstered attendance at the banquet. We were extremely pleased to have increased participation in ACES'93 from Germany, and the representation of many other countries, including Japan, wasnoteworthy.

The 1993 Symposium Program Committee is to be congratulated for a job well done. Again, I thank them for their outstanding performance and contributions to ACES. Finally, the active and substantial support of the Department of Electrical Engineering and the College of Engineering at the University of Alabama is gratefully acknowledged.

Volunteers for ACES'94 should contact Jodi Nix in Dayton, Ohio, at 513-476-3550 to offer their services. Also, Jodi will welcome any suggestions which continue the evolutionary improvement of the Symposium.

MINUTES OF THE ANNUAL PRESIDENT'S REPORT

President Hal Sabbagh convened the Annual Business Meeting of the Applied Computational Electromagnetics Society at 0730 PST on Tuesday, March 12, 1993, in Glasgow 102 at the Naval Postgraduate School. President Sabbagh presided. Board members present were Hal Sabbagh, Ray Luebbers, Perry Wheless, Jim Logan, Frank Walker, and Pat Foster. Also present was Executive Officer Richard Adler. Details of Hal Sabbagh's report follow:

ELECTION RESULTS: Three individuals were elected to the Board of Directors for three-year terms, effective March 23, 1993. They are Hal Sabbagh, Ray Luebbers, and Perry Wheless.

EXECUTIVE OFFICER: Richard Adler resigned from the Board of Directors on March 22, 1993, and has assumed the new position of Executive Officer. Pat Foster was appointed to the Board of Directors to replace Richard Adler, effective immediately.

BOARD OF DIRECTORS: Present members of the Board of Directors are Hal Sabbagh, Ray Luebbers, Perry Wheless, Jim Logan, Ed Miller, Andy Peterson, Frank Walker, Pat Foster, and Jim Breakall.

FINANCIAL REPORT: A brief financiap report was made, in accord with the minutes of the March 22 meeting of the Board of Directors. Richard Adler clarified that ACES has non-profit status with the State of California, but that non-profit status with the Federal government is granted in five-year temporary blocks of time with Federal non-profit status now in place through 1996.

ACES'94: It was announced that plans for next year's Symposium are underway, and that a site in Monterey away from the Naval Postgraduate School is under consideration. Jodi Nix of VEDA Corporation was introduced as facilitator for ACES'94. Interested parties were invited to contact Jodi Nix.

MARKETING DIRECTOR: The idea of a "Marketing Director" for ACES was put forth, and interested parties were urged to contact Hal Sabbagh. Also, Hal Sabbagh indicated that he will address the matter further in his President's Statement in the next ACES Newsletter.

INTRODUCTIONS: Members of the Board of Directors in attendance were introduced by Hal Sabbagh.

The President's Report was concluded by Hal Sabbagh at 0751.

Submitted by:
W. Perry Wheless, Jr.
ACES Secretary

ACES
Handbook for Elections by Mail

Approved by the ACES
Board of Directors on 29June 1993

This handbook provides guidance and instructions for the conduct of elections by mail for the Applied Computational Electromagnetics Society, Inc. (ACES). This handbook complies with the ACES Bylaws and the California nonprofit Corporation Law. This handbook is approved by the ACES Board of Directors.

AUTHORITY

ACES has the authority under the Bylaws to conduct elections by mail. The Bylaws give specific requirements for mailing and counting ballots that we must adhere to.

Article 4, Section 7 requires the elections of Directors to be by written ballot. Article 4, Section 10 authorizes elections by mail. Election of Directors by mail is naturally by written ballots under ACES, Inc.

ACES is required by Article 4, Section 11 to provide a reasonable nomination and election procedure. The procedure must be reasonable in the light of "the nature, size and operations" of ACES, i.e., we are allowed to make restrictions that will limit the cost of our elections. There are 4 elements required by Section 11:
(a) ACES must provide a reasonable means of nominating persons for election as Directors.
(b) ACES must provide a reasonable opportunity for a nominee to communicate his qualifications and his reasons for candidacy to the members.
(c) ACES must provide a reasonable opportunity for all nominees to solicit votes.
(d) ACES must provide a reasonable opportunity for members to choose among the candidates.
Each of these requirements is met by the guidance and instructions within this handbook.

BALLOTS

The ballots must clearly state the required return date for a ballot to be counted. The ballots will have provisions for write-in candidates. The ballots will have a provision for sealing and will require the signature of the voter on the outside for validating purposes, in a manner such that the signature may be removed to preserve the secrecy of the ballot.

Furthermore, ballots must be mailed in a timely manner to the address of record for each member in good standing as per Article 4, Section 4.

The Elections Committee is responsible for designing the ballot and counting the votes cast. The ACES Secretary is responsible for printing and mailing the ballots to members. After voting, the ballots will be returned directly by each member to the Elections Committee. The ballots are mailed out, one per membership, based on the master membership list kept by the Secretary, and updated by member supplied addresses. Corporate memberships get only one vote and it should not be cast by a person also having another membership vote.

The mailing date for distribution of the ballots is selected to allow ample time for the ballot to reach its destination and be returned to ACES, taking into account the furthest foreign destination.

Generally, candidate names are listed alphabetically. Short Candidate statements may accompany the ballots, when authorized by the Board. These statements may be edited by ACES to conserve costs and ensure equal and uniform treatment of nominees.

Only valid ballots may be counted by the Elections Committee, one ballot per member. Only qualified members, i.e. members in good standing at the time when the ballots are mailed, may vote. Any ballot marked "withhold" or marked in any manner to indicate that the authority to vote is withheld cannot be counted. Any ballot not post marked on or before the prescribed deadline cannot be counted. Any ballot not signed cannot be counted. Any ballot defaced so that the intent of the voter can not be readily discerned cannot be counted. Any ballot on which more than the prescribed number of candidates has been marked cannot be counted.

A ballot cannot be revoked or changed after it has been received by ACES of after it is deposited in the mail, whichever occurs first.

CANDIDATE STATEMENTS

ACES is required by Article 4, Section 11 to provide a reasonable opportunity for nominees to communicate their qualifications, etc. to the voters and to solicit votes. This is accomplished through four mechanisms, subject to certain limitations described below:
(1) ACES may subsidize a short statement from each nominee, to be included in the ballot; and
(2) nominees may submit additional material to ACES to be mailed, at their expense, to the membership; and

(3) nominees may purchase space in the Newsletter; and
(4) nominees may obtain the membership list for a fee, to be used to send his own elections related literature.
In any case, such literature must be reasonably concerned with the elections.

The Nominations Committee is required to verify the willingness of a candidate to run either by direct contact or via written correspondence. At that time, they should request from the nominee a written statement to explain his qualifications, etc. This statement is included with the ballot, subject to the option of the Board, to aid members in making their selection. Since this statement will be printed and mailed at ACES expense, ACES has the right to regulate contents, length and format. It should be made clear to each candidate that his statements are subject to editing as necessary.

ACES is not required to print and mail all material submitted by a nominee. When ACES pays the bill, ACES is only obligated to provide each nominee with an equal opportunity to state his case.

When candidate statements are included with the ballot, the length of the candidate statements will be no more than 500 words, unless otherwise directed by the Board, and the contents of the candidate statements will have the following sections:
GENERAL BACKGROUND (e.g., professional experience, degrees, employment, etc).
PAST SERVICE TO ACES (e.g., service on ACES committees or other contributions).
CANDIDATES PLATFORM (e.g., a short statement of the candidates views of major issues relevant to ACES).
OTHER UNIQUE QUALIFICATIONS (An additional but optional statement).

Candidate statements are submitted to the Nominations Committee. The Committee then has the right and the obligation to edit statements to provide equal content, length and format. If the statement submitted exceeds the permitted length, the Committee will truncate or otherwise edit it in order to reduce it to the allowable length. If portions of the candidate statements mandated by policy are omitted, the text "Statement not provided by candidate" will be printed in its place. All statements will be put into the same format and type face. Minor grammar and spelling will be corrected. Time permitting, each candidate is given an opportunity to review the edited version. The Committee provides a camera ready copy to the Secretary for printing and mailing.

A nominee may submit additional information and request ACES to mail it to the membership at the nominee's expense. But this request must be in writing and must include the full remittance for the estimated cost to ACES.

A nominee may additionally buy space in the Newsletter under existing procedures for commercial advertisement.

A nominee may also request from the Board in writing, to see and copy the membership mailing list, so long as his request is specific with respect to intended use and he pays ACES a fee set by the Board to at least cover any costs incurred.

DUTIES OF THE NOMINATIONS COMMITTEE

The Nominations Committee is a committee of the Board and it is appointed each year. The Committee need not be composed of Board members. Any qualified ACES member may be appointed to this committee.

The responsibilities of the Nominations Committee are (1) assist with the nominations of Directors to serve as officers, as directed by the Board, and (2) collect nominations of ACES members to serve on the Board, as outlined below.

The Nominations Committee is required to collect the names of qualified candidates to run for vacancies on the Board of Directors, either through volunteers or by soliciting individuals known to the Committee. Only one name per vacancy on the Board is required, although at least two or more is desirable.

Generally, three Directors are elected each year unless circumstances result in more vacancies.

Any ACES member in good standing, i.e. any member whose dues are fully paid and who is not constrained by due process by the Board for bad conduct, is qualified to run for office. Of course, any Board member whose term of office is not expiring is ineligible.

The Committee names will be published along with a solicitation for candidates in the first Newsletter following the March ACES Conference, prior to the deadline announced in the solicitation. Usually, one or more announcement are also made during the ACES Conference soliciting candidates.

Any qualified ACES member may place his own name in nomination by simply contacting the Committee. Candidates suggested by third parties will only be placed into nomination after the Committee has determined that the candidate is qualified and willing to serve.

The Nominations Committee will solicit candidate statements, to be included with the ballots, at the option of the board. The Committee will be responsible for editing the statements to ensure uniformity in contents, length and format. They will also prepare camera ready copies to be delivered to the Secretary for printing and mailing.

The Nominations Committee will submit in writing the slate of nominations to the Elections Committee and the Secretary.

DUTIES OF THE ELECTIONS COMMITTEE

The Elections Committee is appointed each year by the President, with approval of the Board of Directors. The appointment is for only one election; so generally the term is one year or less. Members of this Committee may not simultaneously be a candidate. A member of this Committee should not also be a member of the Nominations Committee.

The primary responsibility of the Elections Committee is to count the votes and report the results to the Board. The Committee is also responsible for designing the ballot. Past formats provide ample examples.

After voting, the ballots will be mailed by members directly to the Chairman of the Elections Committee using the address of his choice. After the designated closing date, the Committee will proceed to open the ballots, removing the signatures in a manner so as to obscure the identity of the voter. Only valid ballots will be counted. The election is over when one candidate for each vacancy has accumulated a majority for the ballots cast.

Invalid ballots are determined as follows: Any ballot not post marked on or before the prescribed deadline will not be counted. Any ballot not signed will not be counted. Any ballot defaced so that the intent of the voter can not be readily discerned will not be counted. Any ballot on which more than the prescribed number of candidates has been marked will not be counted.

The Elections Committee will issue a written report to the Board and return the ballots to the Secretary for storage. The results of the elections are official and may be made public when this Elections Committee Report is read into the minutes of the Board.

DUTIES OF THE SECRETARY

The duties of the Secretary as far as elections are concerned are as follows:

The Secretary is required by the Bylaws to keep an up-to-date master list of the names and addresses of ACES members "in good standing". Hence, the Secretary is naturally responsible for mailing out the blank ballots with any enclosures to members at the appropriate time. The Secretary, therefore, arranges for printing and mailing.

The Secretary will obtain the ballot design from the Elections Committee and camera ready copies of candidate statements from the Nominations Committee. The Secretary will also obtain from the Elections Committee, the address to be used by members to cast their ballot.

The Secretary will send one ballot per membership and certify such in writing to the Elections Committee. Alternative arrangements, such as FAX or electronic mail, for casting a ballot may be made with the Secretary, on a case by case basis, by members given special circumstances, such as time and distance delay due to mail delivery. In such cases, the Secretary must notify both the Elections Committee and the Board in writing.

The Secretary will receive and store the counted ballots from the Elections Committee until such time as the Board formally accepts the election results. This usually occurs at the March Board Meeting when the Elections Committee Report is read into the Minutes.

DUTIES OF THE PRESIDENT

The duties of the President as far as elections are concerned are as follows:

The President will appoint, with approval from the Board, a new Elections Committee and a new Nominations Committee each year. He will charge them with conducting their committees in accord with the Bylaws and this Handbook; and he may issue special instructions, as may be required by the Board. The President is responsible to ensure that the Nominations and Elections Committees adopt a timely schedule of events for conducting the elections. This is usually accomplished by approving a schedule similar to the one used in the previous year.

SAMPLE SCHEDULE

A typical schedule of events for conduction of elections is as follows:

1. The President appoints the Nominations Committee and Elections Committee at the Board of DIrectors Meeting in March, which is usually scheduled the day before the ACES Conference.

2. The President introduces the Nominations Committee to the Membership at the Members Meeting during the ACES Conference, formally opening nominations.

3. The Nominations Committee contacts the Newsletter Editor to ensure that the announcement, that nominations are open, is placed in the July Newsletter. The Announcement should include names and telephone numbers of Committee members and the closing date for nominations.

4. Nominations are formally closed on or before December 1.

5. Camera ready copies of candidate statements are prepared and submitted to the Secretary with sufficient time for printing, usually no later than December 15.

6. The ballot design is submitted to the Secretary no later than December 15.

7. The ballot and candidate statements are printed and mailed by January 10.

8. The ballots are returned to the Elections Committee on or before later than , no later than February 10. Ballots must be post marked on or before the designed date on the ballot.

9. Allowing time formmail delivery, the Elections Committee will open and count the ballots after March 1, but before March 15.

10. The Elections Committee will submit their written report to the Board on or before March 15.

11. The written report of the Elections Committee is formally accepted by the Board at the meeting usually scheduled one day before the ACES Conference.

12. The President announces the results to the Membership at the Members' Meeting during the ACES Conference.

CHANGING TIMES FOR R&D AND ITS EFFECT ON ELECTROMAGNETICS RESEARCH. PART II

Reinaldo Perez, ACES Newsletter Assc. Editor

Abstract

This article reviews the present economic and political situation for R&D and provide some thoughts at being competitive in the quest of R&D funds through the 1990's. In the November issue of the ACES Newsletter Part III (and last) of this series of articles will provide detailed information on R&D funding sources for electromagnetics.

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In Part I of this series of two article which was published in the March, 93 issue of the ACES Newsletter, we dealt with concerns about the future of R&D due to the changing nature of funding resulting from the economic and political conditions in this country and around the world. Since the article was written not only a new administration has arrived in Washington, but with it a new economic agenda. A clearer picture of R&D is beginning to take shape which should hold (barring extraordinary circumstances) for the next four years.

Because the federal budget deficit (as predicted in Part I) is the most pressing problem for future financial stability, the new administration has embarked in a $360 billion program of new taxes over the next few years in order to reduce the deficit. These taxes will be distributed as (some numbers are still debatable): 1) taxing Social Sec. benefits above $25K producing a $23 billion revenue, 2) DOD reduction of $76 billion, 3) energy tax of $72 billion, 4) taxing the "rich" (clintonian definition is household earning above $200K/year) earning $22 billion, 5) taxing foreign corporations for $28 billion, and 6) taxing american corporations for the rest ($140 billion). On a troublesome note however, an "investment" package which calls for $200 billion in new spending has already cleared the congress which may upset the efforts at deficit reduction. Actually the federal deficit will rise even more in the next two-three years before it shows signs of coming down, that's because about 60% of proposed cuts to help reduce the deficit will not come until after 1997 (after the elections). It is believed, the theory goes, that the impulse provided to the US economy by the $200 billion in new spending will propel the economic machinery to produce further revenues. This may sound as trickle-down wishful thinking but is the present path of the new administration.

On a positive note however, the new administration seems posed to provide more than just lip service to high technology initiatives. Presently industrial R&D accounts for 52% ($83 billion) of the total R&D effort in this country. Federal funding accounts for $43% ($71 billion) of R&D effort. The rest is provided by universities and non-profit groups. Of this new $200 billion spending program at least 10% ($20 billion) will be spent on high technology R&D raising the federal R&D portion to $91 billion. Who is going to get it? The answer may be yet illusive but there are some players and some prospective technologies posed to be the beneficiaries: a) the National Science Foundation with 5.7%/year increase, b) the National Institute of Standards and Technology with 18% increase this year alone, c) national laboratories for efforts at developing collaboration with industries and universities for the transfer of technology, d) funding to academic institution to increase by an amount of $5.7 billion. In general funds will be directed at technologies that will enhance industrial competitiveness over the long and short term. The objective is to stimulate civilian R&D. In the Reagan years up to 70% of R&D was spent in military technology; that number is suppose to go down to 50% which means R&D money previously targeted for military will now be spent on civilian technology. Key technologies to benefit from this new thinking are: electronics, communications, sensors, advanced machinery, and fields directly influenced by the need for more energy-efficient products and processes.

There are several trends in the politics of science and technology observed in the last few years which can teach us something about how we can maximized our efforst at being competitive with R&D funding.

1) "Big" Science, easier target to hit, but harder animal to fall:

Size alone does not define big science, actually it may have very little to do with it. By crude but persuasive measures, science has been growing exponentially, with a doubling rate of 15 or 20 years. If figures for financial support were available, they too undoubtedly would show exponential increase-and probably with roughly the same doubling time. If you think big science is determined by the number of expensive items on the budget section of your proposal, think again. To illustrate this point we need a bit of history.

In earlier times, scientists praised their most distinguished fellows not with superhuman qualities but with comparative attainments. Thus "the new Archimedes", "Democritus redivivus" and "philosophorum huius aetatis facile princeps". "The ornament of the world" and "the greatest man who ever lived"-honorifics applied to Newton--took the style as far as it could go. To be sure, Newton was associated with genius, but in the old sense of superhuman spirit. English visitors to Paris in the early 18th century had to assure the mathematician Guillaume-Francois-Antoine de l'Hopital that Newton ate and slept like an ordinary man. L'Hopital had imagined Newton to be "a genius, an intelligence entirely disengaged from matter. "Obituary notices of this time praised such scientists with expressions such as "clarity of thought and elegance of expression"..."rectitude so naive and unpremeditated that it made self-contradiction impossible"..."a total unfitness for self advancement except by his work". Such qualities may not be the most needed today by a high-power/budget conscious/deadline driven research leader in electromagnetics, but they were exactly the most sought about qualities in those days for persuading the public of the 18th century that the cultivation of scientific knowledge ranked with that of letters.

Something different happened in this early century with scientists such as Bohr, Einstein, Plank...etc. The great theorists of this time did credit one another for creativity and originality, as well as deep sensibilities. These are precisely the qualities of literary figures and painters. Plank praised Minkowski's "artistically formed nature", Albert Einstein's special "power of imagination" Einstein in turn talked about Plank's "truly artistic style and compulsion".

A quality frequently associated with the artistic genius is a craving for solitude. Despite Einstein's humanitarianism and Plank's sense of religious community, both were loners in their work.

In big science, in contrast, individuals must play for the team while simultaneously you can distinguish yourself as a very valuable team member. Achieving the right balance may be difficult. The combination of outstanding ability, devotion to the project, effectiveness in developing relationships with team members and sponsors (i.e. effective teamwork) makes up the special endowment, the peculiar creativity, of the big researcher. This is what counts today.

This thought make me remember the Superconductor Super Collider (SSC) being built in Texas. For many years is has been an easy target for congressional politicians for budget cutting purposes. Yet, it has survived (and likely to survived) all the storms. It has a good team of supporters that plays together, and plays well; from prominent high energy physicists in this country to politicians who rank on the who's who of Texas's legislature including members ofthe president's cabinet.

Next time you write a proposal for R&D money think about your team (including management). The better your team looks the better your chances are.

2) Listen to the Buzzwords: Back in the old days the philosophy of research was pretty much like exploring the woods of a national park. Management would hire the best people it could, give them the resources they needed, and let them loose to explore at wish hoping that new discoveries will enhance the prestige and profitability of the company; that is how the transistor, fiber optics, laser, solar cell, and information theory were invented. Today my management will scream my head off at such sacrilegious ideas of me wondering into the woods of knowledge. There's an invisible but real sign in most quarters of corporate america today that says: "thou shall not take wondering paths on your research, except those pointed at you by our most illustrious management and stock holders. Thou shall pay no attention to anything that looks curious or interesting in your research except that which will bring immediate application to our product line and smiles to our board of directors at their annual meeting".

Today the wisdom of government bureaucrats are telling us that in the 1990's the roads open to the woods of knowledge have signs that have such buzzwords as: 1) supercomputing interstate, 2) massively parallel processing turnpike, 2) communication highways, 4) AIDS research national road, 5) genome project road...etc. There are a few die-hards still wondering in the woods but one day they may run out of resources to plow their way through it. Things are not the same anymore but if you want to be part of the caravan always keep an keen ear to the buzzwords. That's the way it is.

Diversify: Drastic progress in technology will impose a pressure on practicing engineers and scientists for life-long learning. One of my physician friends made a comments: "engineering must be more difficult than medicine because of the rapid changes in technology. The human body has not changed for thousands of years". Although he was very modest to make such a remark, his statements indicates the importance of diversifying yourself in this fast changing technological world. If you have been a electromagnetic scientist for years and has worked on antenna design all your life; why not try to use your skills in something else? You can get involved in microwave networks, writing new software for electromagnetics...etc.

Total Quality Management: Let me illustrate this with an example. A few years ago, the FAA awarded IBM $1.5 billion contract for an upgrade of the air traffic control system, and there were protests from the losers. (The losers lost on appeal too). The winning proposal was about 50 volumes. The FAA brought in 100 people from outside the FAA to evaluate the proposals. None of these people knew what the real problems were, none were experts on air traffic control, none had the chance to consider the system as a whole. FAA wanted to give the job to IBM, and they did. IBM gave the FAA decision makers what they wanted-security. The issue was decided long before the proposals were received. In big proposals bureaucrats usually read part of the proposal; nobody reads the whole thing. Sometimes nobody reads any part of a small proposal.

On most jobs, the customer wants something. The winning proposal is the one that convinces the customer that it comes closest to giving what it wanted. You have to convince the customer that he is in good hands with your team, and that his worries will be minimal. If you don't provide a security blanket, you will loose to someone who does. This is the essence of quality management-TAKE GOOD CARE OF YOUR CUSTOMER. In Part III of this series a detailed list will be presented of DOD and Federal funding organizations that fund proposals in electromangetic research (among others).

In Part III of this series a detailed list will be presented of DOD and Federal funding organizations that fund proposals in electromagnetic research (among others).

On Analyzing Helices with NEC-2

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Introduction

One of the input cards in NEC-2 allows for the implementation of a helix structure [1]. The helix is modeled with a number of straight wire segments, the coordinates of which are calculated in the *HELIX* procedure. In the case of a helix generated by a constant ellipse in the xy-plane the x and y-coordinates are calculated as a function of z from the following lines in the procedure [2]:

```
X(I)=A1*COS(2.*PI*Z(I)/S)
Y(I)=B1*SIN(2.*PI*Z(I)/S)
X2(I)=A1*COS(2.*PI*Z2(I)/S)
Y2(I)=B1*SIN(2.*PI*Z2(I)/S)
```

Here `2A1` is the x-axis length and `2B1` the y-axis length of the ellipse; `S` the pitch length; `X(I)`, `Y(I)` and `Z(I)` the coordinates of the beginning of the I^{th} wire segment and `X2(I)`, `Y2(I)` and `Z2(I)` those of the end point. The helix axis is parallel to the z-axis.

This procedure generates the approximate helix with lines that begin and end on the curve specified by `A1`, `B1` and `S` which shall be called the generating curve. (The helix is inscribed in the generating ellipse.) In this paper only helices generated by a circle in the xy-plane will be considered. In Fig. 1 two circular helices with the same *generating* radius, t, are shown as seen along the axial direction. The only difference is that the helix in Fig. 1(a) has 5 segments per turn and the one in Fig. 1(b) has 8. Now define the *effective* radius to be the radius of the circle that is best approximated by the polygon. The sense in which the approximation is optimized will be discussed below. The dotted lines are circles of effective radii for each case. It is obvious that the second polygon has a larger effective radius than the first one.

This implies that for a given generating radius the effective radius of the helix increases when the number of segments is increased, resulting in calculations which will tend to converge very slowly.

Compensating for the radius

The *effective* radius will determine the size of the helix being approximated, thus the effective radius must be set equal to the radius of the required helix. Fig. 2 shows a single segment of a polygon approximating a helix with required radius a. The angle, θ, is calculated from the

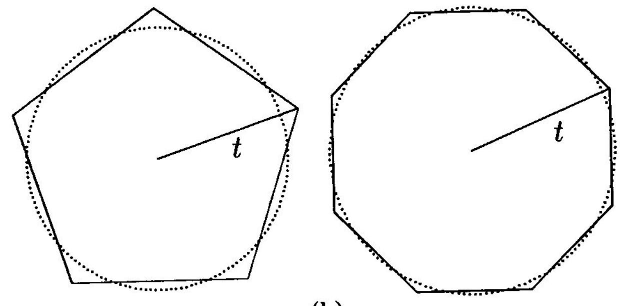

Figure 1: Comparison of polygons inscribed in a circle of radius t, which is not drawn. The "effective" circles for the two cases are dotted.

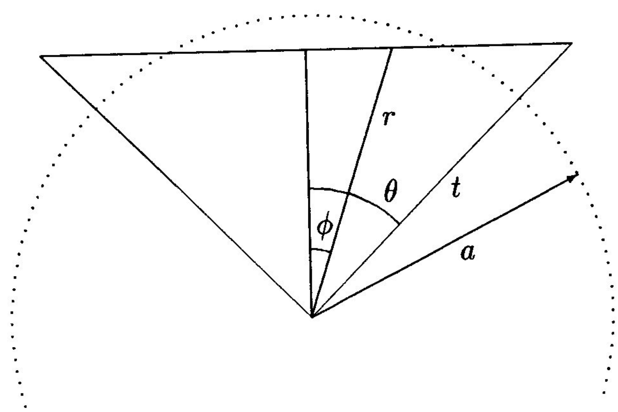

Figure 2: Diagram of a single segment associated with a generating circle of radius t, and part of the effective circle of radius a.

number of segments, n, per turn, thus $\theta = \pi/n$. The radius t of the generating circle must now be chosen to give a polygon with effective radius equal to a. Since the z-dependance of the helix is linear the calculations can be done in the xy plane.

The error Δr between the required radius, a, and the radius, r, from the center to a point (r, ϕ) on the wire segment at a fixed value of ϕ between -θ and θ is given by

$$\Delta r = a - r = a - \frac{t \cos\theta}{\cos\phi}.$$

This error can now be minimized in at least two ways. The first is to set the integral of the error equal to zero, viz.

$$\int_0^\theta \Delta r \, d\phi = a\theta - t\cos\theta \ln\tan(\pi/4 + \theta/2) = 0$$

resulting in

$$t = t_1 = \frac{a\theta}{\cos\theta \ln\tan(\pi/4 + \theta/2)}.$$

The other technique is to minimize the integral of $(\Delta r)^2$, namely

$$\begin{aligned} I &= \int_0^{\theta} (\Delta r)^2 d\phi = \int_0^{\theta} \left(a^2 - \frac{2at\cos\theta}{\cos\phi} + \frac{t^2\cos^2\theta}{\cos^2\phi} \right) d\phi \\ &= a^2\theta - 2at\cos\theta \ln\tan(\pi/4 + \theta/2) + t^2\cos\theta\sin\theta \end{aligned}$$

by setting its derivative with respect to t equal to zero:

$$\frac{\partial}{\partial t} I = -2a\cos\theta \ln\tan(\pi/4 + \theta/2) + 2t\cos\theta\sin\theta = 0,$$

which yields

$$t = t_2 = \frac{a\ln\tan(\pi/4 + \theta/2)}{\sin\theta}.$$

For more than 5 segments per turn the difference between t_1 and t_2 is less than 0.2%, decreasing rapidly for an increasing number of segments. Since 5 segments are still a very rough approximation to a circle, this difference is negligible and either approximation can be used. Utilizing the fact that the $\ln\tan(\pi/4 + \theta/2)$ term occurs in one numerator and one denominator, the geometric mean is taken, i.e.

$$t = \sqrt{t_1 t_2} = a\sqrt{\frac{2\theta}{\sin 2\theta}} = a\sqrt{\frac{2\frac{\pi}{n}}{\sin 2\frac{\pi}{n}}}. \qquad (1)$$

Note that for an infinite number of segments, or $\theta \to 0$, $t \to a$ as would be expected. It is interesting to note that using this as the radius for the generating circle gives a polygon with precisely the same area as a circle with the radius of the required helix, enclosing the same amount of flux.

Example

As an example the currents on a three turn helix excited by a plane wave are calculated. The incident plane wave is polarized along the axis of the helix and is incident in a plane orthogonal to the axis. The helix has a pitch length of 0.015λ, i.e. a total axis length of 0.045λ, and a radius of 0.022λ. The wire radius is 0.003λ. These values characterize a helix that resonates just above the frequency of the incident wave. The resultant current distribution is thus quite sensitive to the radius of the helix.

Fig. 3 shows the value of the current at the center element plotted against the number of segments for an analysis with the standard kernel. The values for the helix with the compensated radius converge much more rapidly than for the uncompensated case.

Conclusion

For the thin wire approximation the ratio of the segment length to the wire radius should not be less than about 2 [1, p.4]. When analyzing a helix without using the correction, a

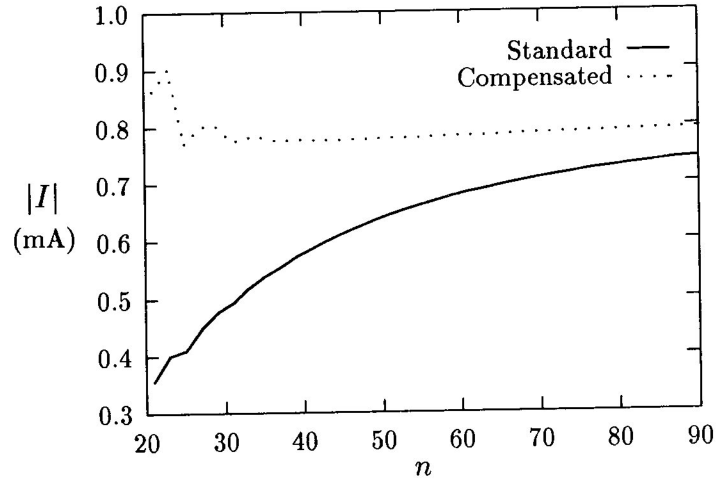

Figure 3: The currents on the centre element of a three turn helix.

very large number of segments might be needed to approximate the form of the helix wi sufficient accuracy. This could result in a segment length that violates this criterion.

It should, in principle, also be possible to apply this generating rule to elliptical helic For near circular helices it should be reasonable to use Eqn. (1) for each axis, with a t value of the semi-major and semi-minor axis respectively. In the case of highly eccent helices it would also be necessary to vary the length of the segments along the generati ellipse in order to get a good approximation, but the helix procedure in NEC-2 does n allow this to be done.

The modification to the helix radius can be implemented in the source code or in t input data file. It is suggested that the implementation be done in the input file in order leave the NEC-2 code standard.

Acknowledgement

The work was done as part of the author's doctoral research under supervision of Pr J.H. Cloete. The author also wishes to thank Prof. D.B. Davidson for his help in analyzi the NEC-2 source code as well as Dr. C.F. du Toit for very valuable technical discussion

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AN IMPROVED VERSION OF THE COMPUTER CODE DOTIG FOR THE TIME DOMAIN ANALYSIS OF THIN WIRES STRUCTURES

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ABSTRACT

DOTIG3 is a new version of the computer code DOTIG1 for the study, in the time domain, of the interaction of arbitrary transient electromagnetic signals with thin-wire structures. Although DOTIG1 provides very good results for the problems that have been studied, there are several aspects that can be improved. In this paper we describe the bases of this new code and its advantages on the previous one. Results of the new code and DOTIG1 are them compared to demonstrate the improvements in accuracy with DOTIG3.

1. INTRODUCTION

Numerical methods based on the solution of Time-Domain Integral Equations (TDIEs) are very useful for studying many practical transient electromagnetic problems. The time-domain approach may offer computational advantages and throw light on the problem in a way that is not possible using frequency-domain techniques [1]-[4].

The analysis of the interaction of a transient electromagnetic wave with perfect electric conductor (PEC) structures modeled by a net of interconnected thin wires is a kind of problem that is very well suited to be solved by means of a marching-on-in-time procedure using the method of moments (MoM). In this procedure, the time domain electric field integral equation (TD-EFIE) is discretized in space and time, and the unknown distribution of induced current at a time step is expressed in terms of previously-calculated current values, and in terms of the known incident field [5]. Frequency domain results can be obtained from the time domain results using Fourier inversion.

The formulation of the TD-EFIE and its solution by the MoM is in some way a logical extension of the methods generally used in the frequency domain [2]. In the case of perfect electric conductor bodies in free space, the EFIE can be obtained applying, at any time, the boundary condition on the surface S of the conductor to the total electric field

$$\hat{n}\times\vec{E}^{t}(\vec{r},t)=\hat{n}\times[\vec{E}^{s}(\vec{r},t)+\vec{E}^{i}(\vec{r},t)]=0 \tag{1}$$

where $\hat{n}$ is a unitary vector normal to the surface of the scatter S. The total field $\bar{E}^t$, at a point $\bar{r}$ on the surface of the scatterer and at time t, is the sum of the incident part $\bar{E}^i$ plus the scattered part $\bar{E}^s$. The incident field is defined in all space at any time and obeys the homogeneous (no sources) equation. The scattered fields are due to the time varying surface charge density σ and surface density $\bar{J}$ induced on all the points $\bar{r}'$ of the scatterer surface S at retarded times t', defined by

$$t'=t-R/c \tag{2}$$

where $\bar{R}=|\bar{r}-\bar{r}'|$, c the speed of the light and R/c the time it takes from a source point to the observation point. The scattered electric field $\bar{E}^s(\bar{r},t)$ computed from the surface induced sources, is given by

$$\epsilon_0\vec{E}^{s}=-\frac{1}{c^2}\frac{\partial\vec{A}}{\partial t}-\vec{\nabla}\phi \tag{3}$$

where the magnetic vector potential and electric scalar potential are defined as:

$$\vec{A}=\frac{1}{4\pi}\int_S\frac{\vec{J}(\vec{r}',t')}{R}dS' \tag{4}$$

$$\phi=\frac{1}{4\pi}\int_S\frac{\sigma(\vec{r}',t')}{R}dS' \tag{5}$$

being ϵ_0 the permittivity of the vacuum.

By substituting equation (3) into (1) and using the Lorenz condition, the following equation is obtained [6]

$$\hat{n}\times[\epsilon_0\partial_t\vec{E}^{i}(\vec{r},t)+\nabla(\nabla\cdot\vec{A}(\vec{r},t))-1/c^2\partial_t^2\vec{A}(\vec{r},t)]=0 \tag{6}$$

which is referred to as the vector potential integro-differential equation.

2. TIME-DOMAIN EFIE FOR A STRAIGHT THIN WIRE

When the body is a closed, straight, thin wire with the radius electrically small compared with the shorter significant wavelength of the spectrum of the excitation, the equation (6) becomes practically one-dimensional and it is possible to use the extended boundary condition [7] and to force only the axial component of the total field along the axis of the wire, that is

$$\hat{z}\cdot\vec{E}^{t}(\vec{r},t)=\hat{z}\cdot[\vec{E}^{i}(\vec{r},t)+\vec{E}^{s}(\vec{r},t)]=0 \tag{7}$$

where $\hat{z}$ is a vector tangent to the wire axis at position $\bar{r}$. To be rigorous, $\bar{E}^{s}$ must include the effect due to the exact distribution of currents and charges at the flat end-caps of the wire [2],[8]. However the normal is to consider null current distribution at the end caps of the wire. Using this approximation, in [6] a new almost exact derivation of the thin-wire EFIE is given that can be written

$$\hat{z}\cdot\vec{E}^{i}(z,t)=\frac{1}{4\pi\epsilon_o}\int_0^L\{\frac{\hat{z}\hat{z}'}{c^2R}\partial_{t'}I(z',t')+ \tag{8}$$
$$+\frac{\hat{z}\cdot\vec{R}}{cR^2}\partial_{t'}I(z',t')-\frac{\hat{z}\cdot\vec{R}}{R^3}q(z',t')\}dz'$$

where L is the length of the wire, $\hat{z}'$ is a vector tangent to the wire axis at position $z(\bar{r}')=z'$, $I(z',t')$ is the unknown current at source point z' at retarded time $t'=t-R/c$ defined as

$$I(z',t)=a\int_0^{2\pi}J_s(z',\phi,t)d\phi \tag{9}$$

and $q(z',t')$ is the charge distribution that can be expressed in terms of the current using the equation of continuity. Observe that the source points z' are located on the surface of the wire and the field points z on the axis (Fig. 1).

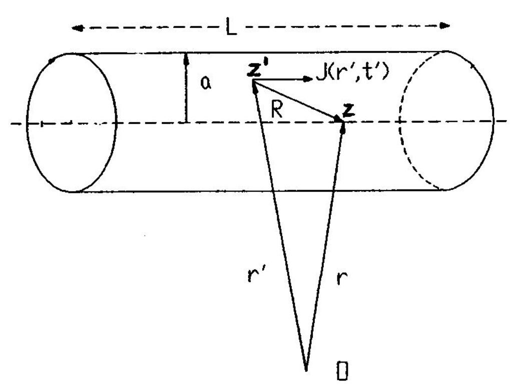

Fig.1 Coordinates for a straight wire

Equation (8), that we call "thin wire extended boundary condition" EFIE, coincides formally with the so-called "thin-wire reduced-kernel" EFIE derived in [2], [5], [9]. However it is worth mentioning that, to obtain the thin-wire reduced-kernel EFIE, it is necessary to assume that the flow of current is parallel to the axis of the wire, that the axially directed surface current density is uniformly distributed around the circumference and that the equivalent filamentary current I(z',t') is located on the axis of the wire. This interpretation is more restrictive and less rigorous than that given by equations (8)-(9). The solution of the "thin-wire reduced-kernel" EFIE is the option chosen by the computer programs in the time domain TWTD [10]-[11] and DOTIG1 [12]-[13]. The solution of the frequency domain version of the "thin-wire reduced-kernel" EFIE is the base of the codes NEC1-3 [14] and CHAOS [15].

In the frequency domain codes, to choose between considering the unknown filamentary current on the wire axis and the known incident field on the wire surface or vice versa is often left as arbitrary [14], [16]. In the time domain, because of the time variable [17], we must rigorously force the electric field on the axis of the wire. This means adding an additional delay of a/c to the exciting field, being a the radius of the wire. This is the option chosen in the computer program DOTIG3 [9] that, together with other changes that are summarized in the following section, extend the range of application of DOTIG1.

3. DIFFERENCES BETWEEN DOTIG1 AND DOTIG3

The computer program DOTIG1 solves the thin-wire reduced-kernel EFIE using the point-matching form of the moment method with the match points situated at the centers of the space-time intervals. The spatial and temporal variation of the current is represented by a two-dimensional Lagrangian interpolation of order two in each dimension (space and time) as the basis function. This allows us to transform the integral equation (8) into the linear system of equations (in matrix notation) [12],[13].

$$\tilde{E}_j^s+\tilde{E}_j^i=\tilde{Z}\tilde{I}_j \qquad (10)$$

Using (10) the I_j is calculated at the time t_j from the elements E_j^s of the tangential electric field scattered by currents of previous times and the elements E_j^i of the tangential applied electric field at the observation point and at time step t_j. Matrix $\tilde{Z}$ is a matrix of interaction whose elements are time-independent. They only depend on the geometry and on the electromagnetic characteristics of the structure.

DOTIG3 also uses the point-matching form of the moment method but, to avoid discontinuities in the magnitude of the current, the delta-function used as weighting functions are now situated at the ends of the spatial intervals. These changes provide more accuracy in the calculation of the parameters related to the near fields and extend the possibilities of DOTIG to study thicker wires [9].

The situation chosen for the matching points in the segments also affects the way of carrying out the treatment of junctions of interconnected thin wires. DOTIG1 forced first Kirchoff's law and Wu and King condition at the junction [18], by applying an overlapping wires scheme [15],[19] that was, in some way, asymmetrical and arbitrary. The collocation of matching points just at the ends of the wires allows DOTIG3 to force the junction conditions without needing to add any extra overlapped segments. This facilitates and improves the study of junctions and the modeling of complex structures by a net of thin wires. As a consequence, the new code is more efficient, stable and flexible than the previous one. In the next section results obtained with DOTIG1 and DOTIG3 are compared to demonstrate the improvements achieved with DOTIG3.

4. RESULTS

In this section we compare the results obtained with the computer codes DOTIG1 and DOTIG3 when applied to the study of different thin wire structures.

I) First, DOTIG1 and DOTIG3 were applied to study the currents induced on a wire scatterer of length l=1m. and radius a=6.74 mm. when it was illuminated by a gaussian pulse of the form

$$\vec{E}=\exp[-g^2(t-t_{max})^2]\hat{z} \tag{11}$$

parallel to the wire axis, with $g=5*10^9\ s^{-1}$ and $t_{max}= 4.28*10^{-10}$ s.

In order to compare how convergent both codes are with respect to the number of segments in which the wire is divided, two error criteria were calculated: the root mean square current I_{rms} and the normalized root mean square current error e_{rms} [20]. These variables are defined by:

$$I_{rms}=\sqrt{\frac{1}{N_sN_t}\sum_{i=1}^{N_s}\sum_{j=1}^{N_t}|I_{i,j}|^2} \tag{12}$$

$$e_{rms}=\sqrt{\frac{N_s^rN_t^r}{N_sN_t}\frac{\sum_{i=1}^{N_s}\sum_{j=1}^{N_t}|I_{i,j}-I_{i,j}^r|^2}{\sum_{i=1}^{N_s^r}\sum_{j=1}^{N_t^r}|I_{i,j}^r|^2}} \tag{13}$$

where N_s is the number of segments into which the structure was divided and N_t the number of time intervals calculated in each case. $I^r_{i,j}$ corresponds to a reference solution that was obtained dividing the wires into $N_s^r=80$ number of segments and computing $N_t^r=1200$ temporal intervals. It was the maximun number of segments allowed for getting a stable solution with DOTIG1.

Figs. 2 and 3 show respectively I_{rms} and e_{rms} versus the number of segments. The rapidity with which a technique leads to a stable solution can be estimated from the I_{rms} plot. It is desirable that the curves should approach a constant as soon as possible. As can be seen in Fig. 2, the I_{rms} obtained using DOTIG3 approaches a constant as quickly as DOTIG1. The e_{rms} plot in Fig. 3 also shows that although DOTIG1 needed a few segments less than DOTIG3 to achieve a solution with a low value of e_{rms}, the difference between both methods is not so significant. DOTIG1 and DOTIG3 gave an e_{rms} of about 0.1 with $N_s=35$ and 40 segments respectively. On the other hand, Fig. 3 shows that DOTIG3 behaves better that DOTIG1 when the wire is divided into more than 80 segments, the e_{rms} is lower than 0.1 in the cases studied ($80 < N_s < 150$) while the solution obtained using DOTIG1 was unstable and is not plotted in Fig.3.

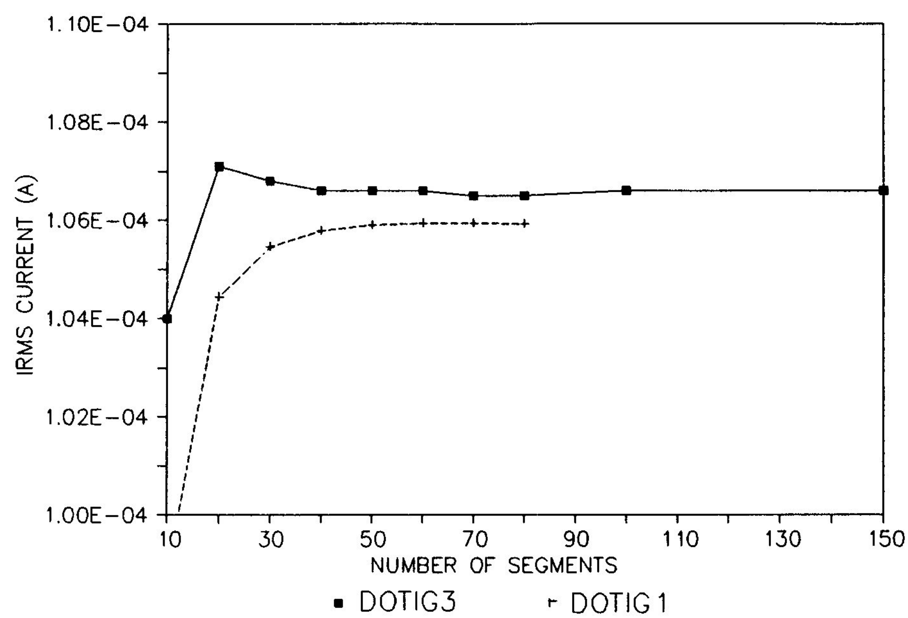

Fig. 2 Root mean square current versus the number of segments.

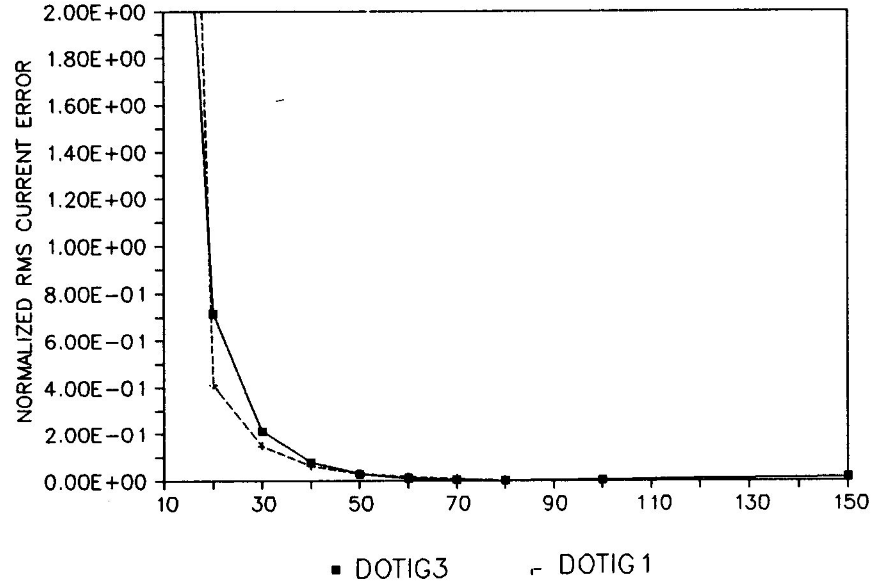

Fig. 3 Normalized root mean square current error versus the number of segments.

II) The behavior of DOTIG1 and DOTIG3 codes was also checked in the case of an isolated thin wire antenna of length l=1m and radius a=6.74 mm, fed at its center by a voltage

$$V(t)=e^{-g^2(t-t_{max})^2} \tag{14}$$

with $g=1.5*10^9$ s^{-1} and $t_{max}=7.2*10^{-10}$ s. The input admittance of the antenna was calculated by carrying out the Fourier transform of the time-domain current obtained with DOTIG1 and DOTIG3. Three discretizations were tested by dividing the wire into 80, 50 and 30 segments. Fig. 4 and 5 show the conductance and susceptance of the antenna versus frequency, computed with DOTIG1. The same results computed using DOTIG3 are presented in Figs. 6 and 7. It can be seen that DOTIG3 gives positions of the resonant frequencies of the antenna that do not depend on the number of segments into which it was divided. On the contrary, with DOTIG1 there are slight variations of these positions versus the number of segments, which it is not logical since they depend on the geometry of the antenna alone.

III) To show how DOTIG3 can deal with wires having a ratio of the wire length (l) to its radius (a) smaller than DOTIG1, an antenna of length l=1m. and radius a=0.03m was analized. It was fed at its center by the voltage source described in (14) and $g=3*10^9$ s^{-1} and t_{max} = $7*10^{-10}$ s. Fig. 8 shows the conductance and susceptance versus frequency calculated with DOTIG3 and theoretically by King Middleton [21]. DOTIG1 results were unstable and are not presented.

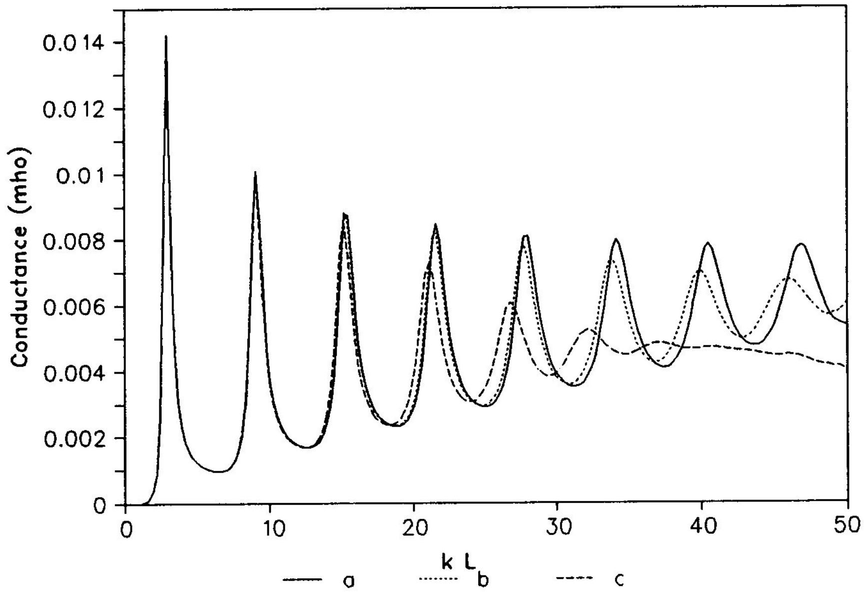

Fig. 4 Conductance of the antenna computed using DOTIG1. Number of segments: (a) 80. (b) 50. (c) 30.

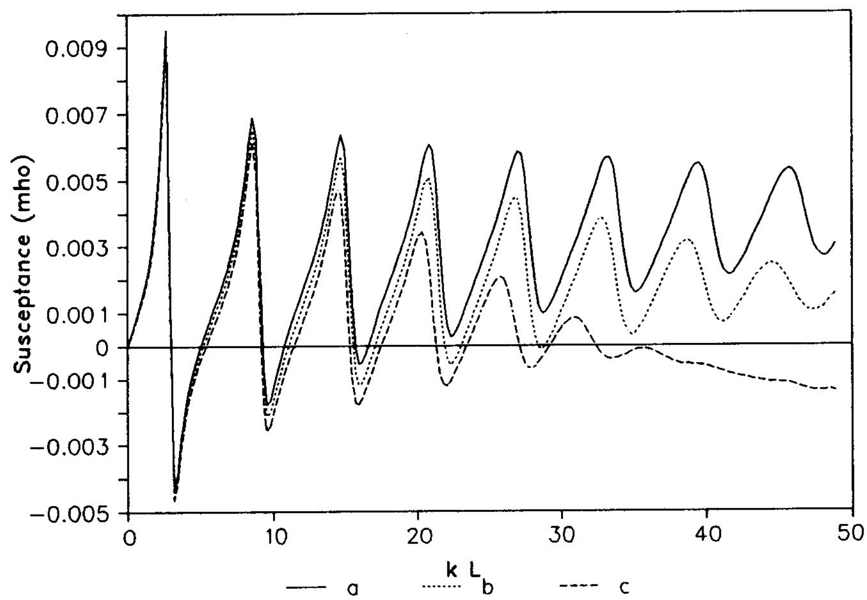

Fig. 5 Susceptance of the antenna computed using DOTIG1. Number of segments: (a) 80. (b) 50. (c) 30.

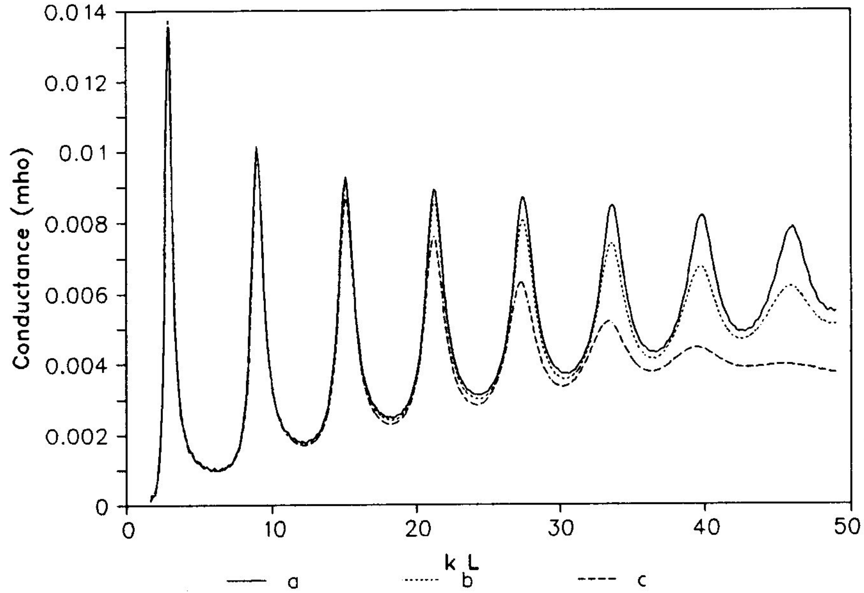

Fig. 6 Conductance of the antenna computed using DOTIG3. Number of segments: (a) 81. (b) 61. (c) 41.

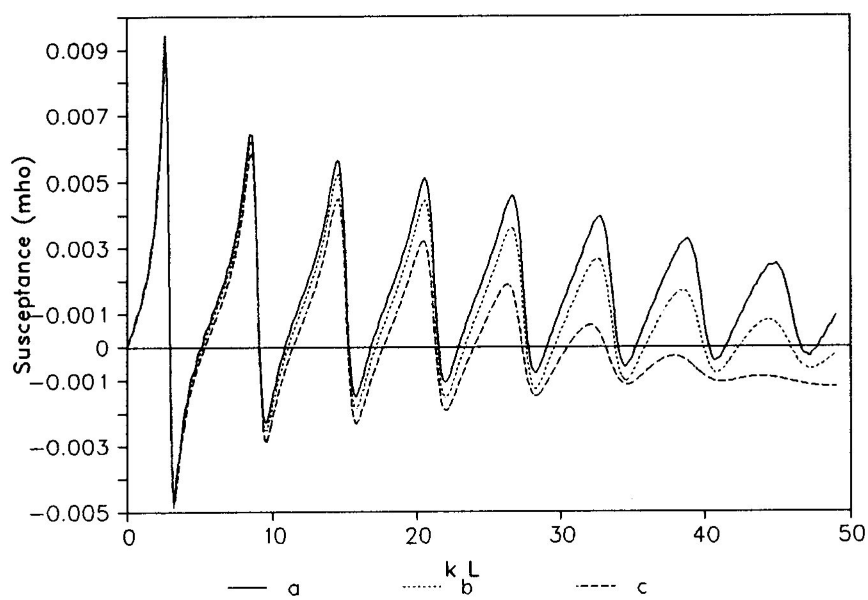

Fig. 7 Susceptance of the antenna computed using DOTIG3. Number of segments: (a) 81. (b) 61. (c) 41.

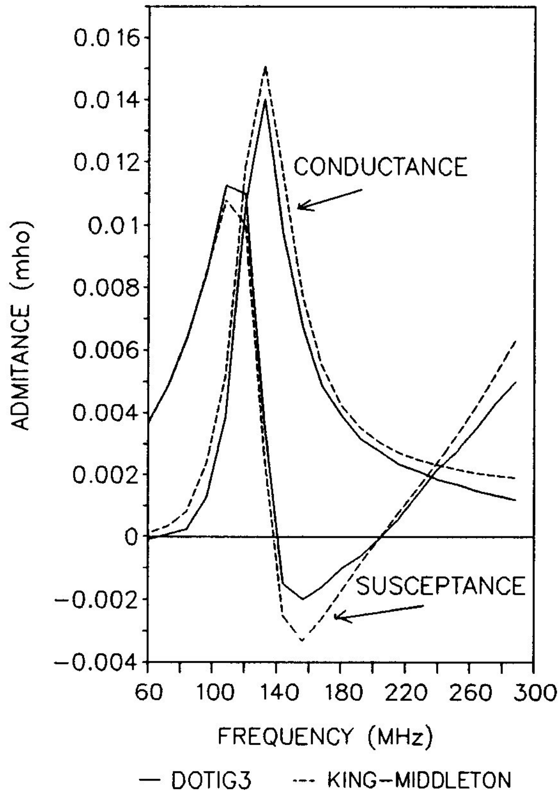

Fig. 8 Conductance and susceptance of an antenna (l=1m., a=0.03m.) versus frequency.

IV) The following structure analyzed was the stepped-radius wire (considering it as a junction of two wires with different radii) drawn in Fig.9, when illuminated by a gaussian pulse like (11) with $g=5*10^9\ s^{-1}$ and $t_{max}=9.2*10^{-10}$ s. The thickness of one wire was chosen double the size of the other wire. The current was calculated, with DOTIG1 and DOTIG3 at a point O on the structure situated 4.6mm from the junction. In order to compare with the frequency domain results given the computer code NEC2 [22] the current was Fourier transformed. Fig. 10 shows its magnitude at point O versus frequency. In this case, the results obtained with DOTIG1 and DOTIG3 agree closely with those obtained by NEC. When the ratio of the radius of the two wires was increased to 10, DOTIG1 became unstable, while DOTIG3 gave stable results.

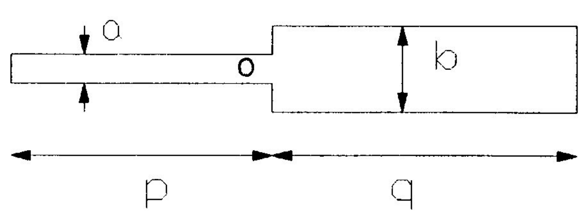

Fig. 9 Stepped-radius wire geometry. p= 0.3m, q= 0.2m, a= 0.002m and b= 0.004m.

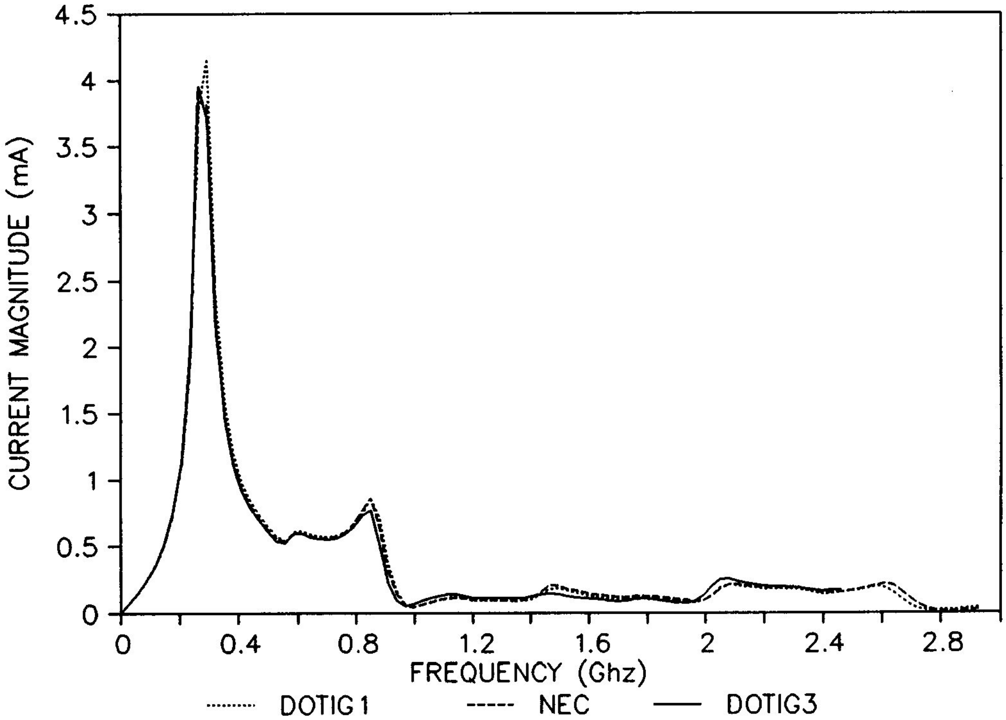

Fig. 10 Current magnitude at point O on the stepped-radius wire versus frequency.

V) The same analysis was made for a more complex body, the cubic structure plotted in Fig. 11, when the incident field was described by:

$$\vec{E}^{i}=2g(t-t_{max})\exp[-g^{2}(t-t_{max})^{2}]\hat{z} \tag{15}$$

with $g=10^9\ s^{-1}$ and $t_{max}=2.14*10^{-9}$ s. This incident field was chosen because it has not zero frequency component and, therefore, does not excite the circulating current that would exist on structures with closed-circuit parts. The current distribution at point (0,0.2,0) calculated with DOTIG1 and DOTIG3 versus time is presented in Fig. 12. The magnitude of its Fourier transform and of the field radiated in the direction $\theta=90º$ $\phi=-90º$ was computed and plotted respectively in Figs. 13 and 14 together with NEC2 results. Although there was a good agreement between all the codes, the main advantage of DOTIG3 is the flexibility to model the junctions between wires, since no overlapped segments were needed as was the case in DOTIG1. This simplifies the discretization of the structure into segments, decreasing the total number of unknowns.

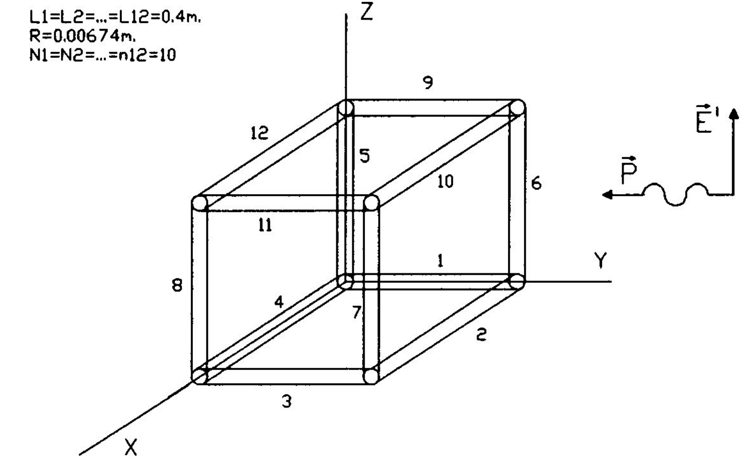

Fig. 11 Geometry of the cubic structure.

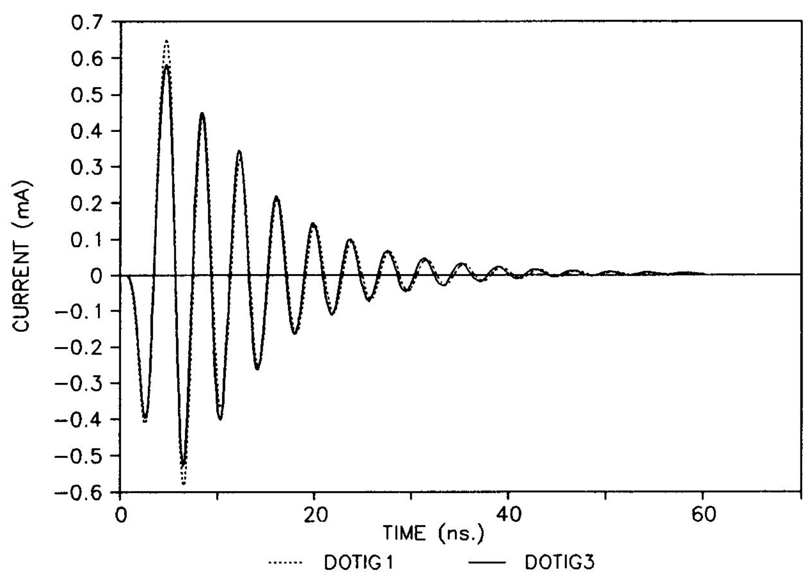

Fig. 12 Current distribution versus time at point (0,0.2,0) on the cubic structure.

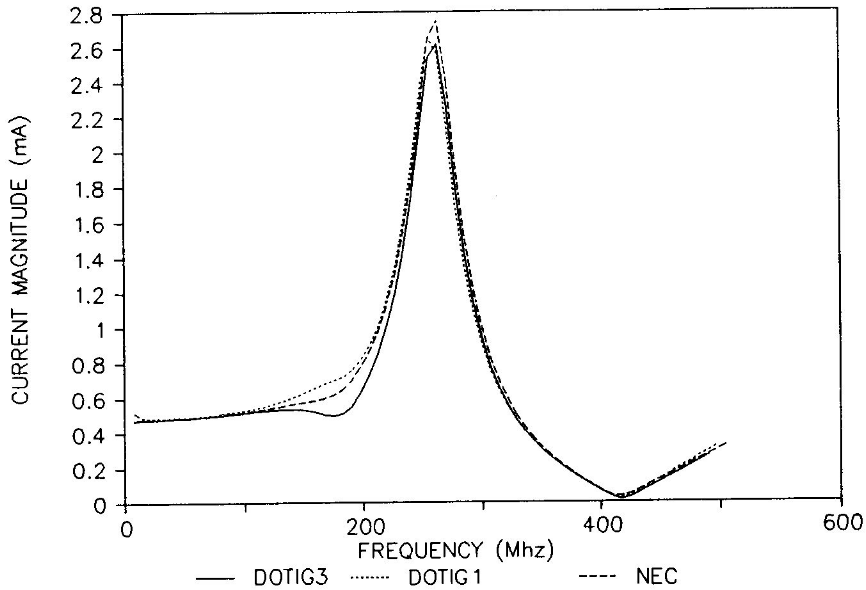

Fig. 13 Current magnitude versus frequency at point (0,0.2,0) on the cubic structure.

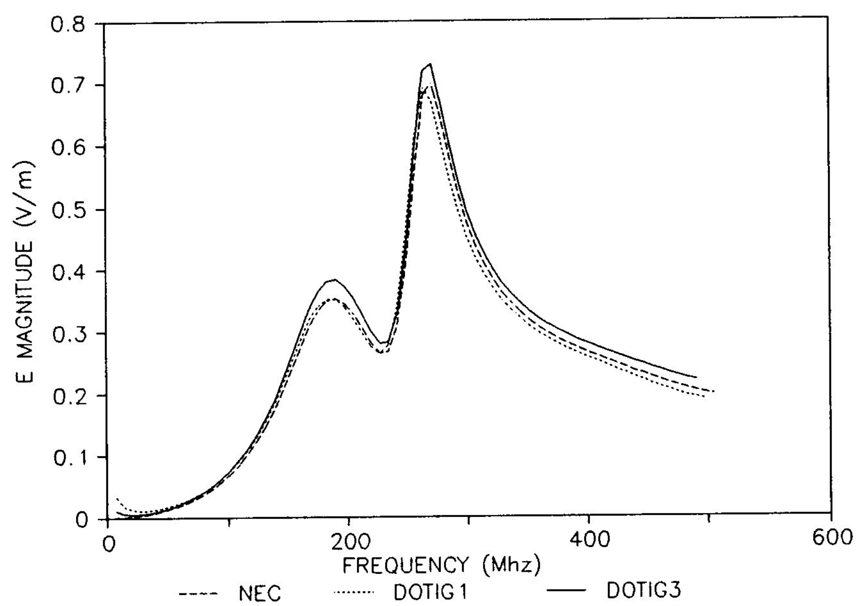

Fig. 14 Radiated field $\Theta=90$, $\phi=-90$ versus frequency. Cubic stru cture

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The ACES Newsletter continues this series of "Perspectives" articles to provide a forum for discussion of present and future needs in computational electromagnetics, areas of challenge, and potential electromagnetic solutions, and personal viewpoints on the subject. As a result of this discourse it is hoped that electromagnetics related problems and requirements can converge with prospective solutions. Perspectives from a wide range of applications and work settings will be represented, including international scientific institutions, educational institutions, government labs and agencies, and industry. Editors Dave Stein and Ray Perez are coordinating this effort. This issue features the following "Perspectives" article by C. W. "Bill" Trowbridge.

A Career in Field Computation
A personal view of computational electromagnetics

Bill Trowbridge

Introduction

This article attempts to give a retrospective view of my work and that of my closest colleagues in field computation. I make no apology for the bias which undoubtedly creeps in from time to time after all each and everyone of us has a story to tell and this is mine. I make no apology either for my comparative neglect of high frequency fields since this fascinating and important subject has only appeared on my horizon in recent years.

Early Days

I began by using conducting paper to estimate the electric field near the surfaces of the high voltage conductors in Van der Graffe generators. This was in 1958 after a period of training building vacuum systems and high voltage beam tubes. I had joined Douglas Allen's team at the Atomic Energy research lab at Harwell, Oxfordshire in 1957 after a ten year career in the merchant navy as a deck officer.

My translation to physics from navigation involved many years of intensive study mostly done off watch at sea. A splendid organization called the Seafarers Education Service helped me enormously by arranging tutors who gave me encouragement and guided me through the basics of mathematics and physics all done by correspondence from remote corners of the world in an age where sea travel was still the norm and it took many weeks to travel from home to Australia.

For some reason Doug Allen selected me for his team just beginning to design a new 6 MV Tandem electrostatic generator for accelerating charged particles. This machine utilized the idea of accelerating negative hydrogen ions through a vacuum tube from ground to a high voltage terminal at 6 MV at which stage the ions were passed through a thin foil or gas to strip off the two electrons so that the resulting protons could be further accelerated back to ground thus increasing their energy to 12 MEV. The voltage could be controlled by a feed-back loop utilizing the leakage charge from the high voltage terminal to 1 part in a million, hence this accelerator could provide charged particle beams at very precise energies for use in nuclear structure studies.

After obtaining a degree in mathematical physics by studying part time at the Polytechnic of Central London, now Westminster University, I was transferred to the ion-source group and began work on design problems associated with beam optics which of course involved field computation. Ralph Dawton, the leader of the ion-source group, was another prominent member of the new generation of scientists concerned with atomic physics that blossomed in the years immediately after WW2. In fact both Doug and Ralph had spent time in North America and were pioneers in accelerator physics. I was soon struggling with the problems of how to predict fields and field gradients to help with the design of lenses, bending magnets, and quadrupoles and so back to conducting paper and electrolytic tanks.

Analog Methods

Though some useful results could be obtained with conducting paper the technique was at best only an indicator of field behavior. The conducting paper itself was very anisotropic and a steady hand was required with the paint brush when drawing the electrodes. We had many an argument about how to correct the essentially XY symmetry results to axi-symmetry for round lenses. Never-the-less one learned a great deal particularly about boundary conditions and orthogonality. For instance when moving to magnetic problems instead of painting the conductor boundary, as in the electrostatic case, scissors were used to cut the boundaries for the magnetic poles. In this way the basic art of field computation could be mastered with simple materials.

To achieve better results we naturally moved on to the electrolytic tank and it was with some excitement that we took a kit of specially machined half-models of our electrostatic lens system to Cambridge to use the new tank at the Cavendish Laboratory. Not only would this allow good precision on fields using the latest electronics in the potentiometer circuits but it also claimed to be able to compute particle trajectories as well by measuring current paths. Indeed good fields were obtained and we were able to achieve some degree of optimization but unfortunately the trajectories were not reliable. Our first test was to validate the symmetry by firing a ray straight down the axis and to our dismay, instead of a straight path along the axis, the ray shot off to the tank edge! Although by many adjustments we were able to get some improvement, hand calculations from the field values proved to be the only reliable method.

One analog method for predicting particle trajectories that was successful for beam bending magnets was the use of alpha particles from a Cobalt-60 source. In this technique the entrance and exit positions of a beam could be checked against the first order optics theory for inclined pole edges.

On the completion of the Harwell tandem generator the team was asked to design and build a larger nuclear structure facility for the Clarendon Laboratory at Oxford. This was begun in 1960 by building a prototype machine at Harwell to investigate critical components to generate a voltage of 10 MV on the terminal. This introduced me to many other problems in field prediction which would not be amenable to analog methods. This meant the construction of costly models and prototypes to an extent not done by us before. Fortunately digital computing was becoming available and I was lucky and privileged to be in near the beginning of this revolution.

Early work with digital computers

My first experience with a real computer came with the Ferranti Mercury newly sited in a hut on the Harwell campus. It is quite astonishing to compare this device which exceeded a millisecond for a floating point operation and required a large room to house it with our modern 486 PC in a small box. We had to use Mercury Autocode as a programming language with the paper tape as the media. The team running this machine was led by Jack Howlett who later created the Atlas Computing laboratory nearby. This was a formidable team indeed pioneering the use of numerical methods in science and engineering. Current expertise and resources in computing in the UK owes much to the work of Jack and his colleagues. In order to make sense of results the paper tape was fed into a printer but it was remarkable how well the user support team could diagnose errors. On one occasion when I was trying to identify a bug I was told by an expert who read my tape by touch, as if it were Braille, that I had violated an arc tangent exception. One application I remember with pleasure arose in connection with the design of a magnetic spectrometer and in the analysis of ion beams from a Dawton Mercury Pool arc source. We needed to identify the impurity ions in the beam and the computer was used to tabulate the number of different species expected.

Using these resources we developed tables for magnetic fields in solenoids and other primitive coils by evaluating integrals and furthermore started to compute specific solutions to Laplace Equation by using both finite difference and Monte-Carlo methods. Our results were not always believed of course, a healthy scepticism of numerical results was essential then as it should be today. However an experiment usually confirmed the predictions and we began to benefit and spend less money on costly prototypes. By 1960 the IBM 704 was in place at Aldermaston soon to be replaced by STRETCH with FORTRAN as the high level language which greatly enlarged our horizons.

In order to carry out the design of the lenses for the ion beam focusing we developed a general purpose software package called PATHFINDER which was based on a general two dimensional Poisson code first developed at CERN(1963) by John Hornsby[1] but later extended by us to include general boundaries and particle ray tracing. Using this code we were able to design the ion optical system for the new accelerator. In all this work I collaborated with Jim Diserens who was a notable pioneer in the use of computers in field computation as well as an inventive experimenter.

By 1963 the group transferred to the newly formed Rutherford Laboratory where the work on nuclear structure and high energy physics research was to be concentrated. The machine at Oxford was in operation by 1965 and had achieved its design voltage of 10 MV and to some extent was a successful example of applied computing. Computers from now on were to play an increasingly important part in the design of accelerators and everything else.

For me a number of important events happened in the mid sixties. One was the high field bubble chamber project led by David Thomas which began with great enthusiasm but unfortunately, for many reasons, political, financial etc. turned out to be a paper study only; however, it spawned a number of activities which were to become very significant for us. At this time we acquired the TRIM program from LRL Livermore, TRIM was written by Alan Winslow[2] and was a tour de force in those days. He derived a numerical algorithm for solving Poissons Equation over an irregular triangular mesh in three ways (a) using a resistor network analogy, (b) a finite difference scheme and (c) a variational method. This last approach was in fact the finite element method in a different guise! So I think Alan Winslow was the first to develop a Finite Element(FE) package for non-linear electromagnetics applications.

Another event which in retrospect I feel was seminal was the 2nd International Conference on Magnet Technology at Oxford in 1967. I was strongly influenced by three papers given by pioneers from the USA. Firstly there was Andrew Halaczy, professor of electrical engineering at Reno, who described his work using integral equations for solving three dimensional field problems, next John Colonias, of LRL Berkeley, who using a CDC 6600 together with a CRT display showed user interaction with the boundaries and meshes produced by the field program TRIM, and finally Klaus Halbach, also from LRL, who amazingly presented inverse problem solutions using a least square technique with the TRIM program which he named MIRT.

At this same conference Alan Middleton and I presented some results on computing fields and mechanical stresses in high field superconducting coils and we needed to extend these calculations to include saturable iron and three dimensional geometries and I remember the long discussions with John Colonias on how to modify the TRIM program to do this, but the problems of 3D meshes seemed too daunting at that time. Nevertheless TRIM and its later extension POISSON continue until the present day to be used for two dimensional EM field problems.

It was about this time that we formed the Computing Applications group which brought together Jim Diserens, John Collie, Mike Newman and Alan Armstrong.

Integral Equations and Interactive Graphics

In 1969 the three strands mentioned above all came together at Rutherford laboratory, despite some opposition we acquired a device known as a COMPUTEK 400/15 Storage tube display which could be connected via a satellite computer (Honeywell DDP224) to a IBM 360/75 main frame to allow single user interactive computing. Using this environment the first version of GFUN was developed which allowed us to enter graphical primitives representing conductors and other materials in two dimensions.

In the first version semi analytic techniques were used to compute the fields which could be displayed on the screen. The geometric shapes could be modified interactively and new solutions obtained. To day of course this is routine but then it was considered rather novel and we received much encouragement. The interaction was achieved by using a new command language processor written by Mike Newman and subsequently this work, in itself, proved to be a rich development and the principles are still relevant today.

In 1970 I met Larry Turner for the first time at Argonne National Lab during the Bubble chamber conference and I discovered that he had been investigating field solutions using magnetization integrals independently of Professor Halaczy and in fact had some original ideas on how to extend this formulation. This was just what we needed in order to re-design GFUN to have, firstly a full non-linear algorithm for saturable materials in both 2D and axisymmetry and secondly a possibility of solving three dimensional problems without the burden of generating complex meshes. This is because the magnetization method is an integral equation approach and only requires a discretisation in the active parts of the model.

The next two years were delightful. Larry came to Oxfordshire to work with us and together we developed what we believed to be one of the first examples of a three dimensional non linear code using an interactive environment. We presented our results at the third Magnet Technology conference at Brookhaven in 1972[3]. Many of principles that we used in the design are still relevant to day and I think are worth quoting despite the somewhat dated terminology.

We used three criteria in deciding how to develop it.

- It should be easy for the magnet designer to use. Most of the work of data input should be done by the computer. The input data should be displayed for checking. Results should be displayed in a way to make interpretation simpler.

- It should be interactive. Calculating interactively saves the magnet designer time. His train of thought is not broken as it is when he must submit a job and wait minutes or days for the results. His ideas and doubts can be checked immediately. For example he can see from the picture if he has set up the problem incorrectly or awkwardly, or he can follow up anything interesting the graph of the field reveals. He can stop when a line of thought proves unprofitable.

- It should be available in both two-dimensional and three dimensional versions, which the user operates with similar commands. This criterion led to a choice of a direct calculation approach.

The third criterion goes on to emphasize the advantages of an integral equation approach for 3D problems at that time. The alternative approach to extend the finite element method to 3D which had recently been applied to electrical machine design by M V Chari and P. P Silvester[4], would entail the enormous problem of generating 3D meshes for both the active (iron, conductors) and free space (air) regions. Furthermore even in 2D the necessity for far field discretisation in an FE approach made the integral equation method more attractive at this time.

The team now concentrated on improving the algorithm, Jim Diserens added a new axisymmetric option and presented our results at the last of the Reno conferences presided over by Andrew Halaczy with antendees from most of the North American groups. This gave me the idea of trying to start an international forum for field computation which would bring together researchers from Academia, National Laboratories and Industry. Many other extensions to GFUN including eddy currents and the introduction of higher order basis functions were planned and it was at this stage that John Collie developed his methods for evaluating fields and potentials of linearly varying current or magnetization in a plane bounded region.

The work on superconducting magnets for particle accelerators, detectors and eventually MRI devices was well underway at Rutherford by this time and a number young graduates joined the lab to work in this area. One of these was John Simkin who began by using our techniques but he quickly established himself and was soon making major developments himself. He eventually joined the group and he and I began a partnership that is still in place today. We resolved to bring the idea of an international conference into being and we were strongly supported by David Thomas and also by our first European collaborator Simon Polak from the Philips company who was building up a similar group in Eindhoven. We drew up an international steering committee and had our first meeting at Rutherford Lab in 1974 and I was elected the first chairman with John as the secretary. The first Compumag conference was held in Oxford in March 1976 and was attended by over 200 delegates from 15 countries. The series then moved on to Grenoble, Chicago, Genoa, Fort Collins, Graz, Tokyo, Sorrento and now this year in Miami. At Compumag Oxford John Carpenter (Imperial College) one of the most outstanding theorist in EM fields had helped with the organization. His deep knowledge and enthusiasm have had a considerable influence on our work particularly as he supported our desire to investigate fully the choice of potential in field computations.

From Physics to Engineering and the Finite Element method

In parallel with our work on Integral methods we had experimented with the finite element method as an alternative for 3D field computations and in this we were helped by Olek Zienkiewicz the renowned international authority. Jim Diserens and I developed a simple code using vector potential. Thus began a very long collaboration with Olek and a series of very enjoyable visits to the University of Swansea in South Wales. We had already been using the Swansea code FINESSE for stress analysis in superconducting coils used in conjunction with our GFUN code for fields and electromagnetic body forces. We were able to apply these techniques to get a realistic estimate of the stress patterns arising in superconducting coils particularly in the design studies for the early Tokamak fusion devices in which failure studies were critical. We had long realized that for static fields the use of scalar potentials would be optimal and together with the Swansea group we discussed the use of the reduced scalar potential for a 3D field code. This was then implemented at Swansea by adapting a standard Poisson Equation solver[5] and the results compared with GFUN. Good results were obtained for the test problem. By 1976 the UK academic engineering community started a collaboration with Rutherford Laboratory on a significant and far reaching project known as the Interactive Computing Facility which had the broad aim of providing an interactive computing network based on the emerging multi and single user mini computers. In order to provide application engineering software support my group was further expanded to organize a special interest group for EM field computation and to implement a developing suite of software for engineering applications. The group consisted of a mix of industrial and academic engineers and brought together some of the most influential practitioners in the country came together to guide us. Most of the people involved had already supported the first Compumag conference and created a forum of expertise which led to a series of workshops on eddy currents, first national then international, which became a pattern still emulated throughout the wider international community.

It was during this period that we got to know the outstanding work of the McGill group under Peter Silvester who made several visits to us which began at Compumag Oxford and led on to our association with Ernie Freeman and Dave Lowther at Imperial College. The pioneering work of this group had a considerable influence, particularly in the emerging use of single user machines and the application of FE mesh generation and CAD techniques. There was also a finite element conference on EM fields held at Santa Margarhita (1976) in Italy where many of the major players had gathered and remember the debates on the relative merits of FE, TLM and Integral methods. Many of the papers from this conference were later published in book form and helped to publicize the work of a growing international community[6].

One of the results of this was an increasing awareness of the limitations of our 3D integral code for iron dominated problems and for eddy current effects. Encouraged by the early success of the Swansea collaboration John Simkin and I embarked on the FE software development that ultimately became the 3d statics code TOSCA[7]. We encountered a serious problem, known as field cancellation between the induced and conductor source fields, when using the reduced scalar potential and eventually we evolved a solution using a combination of Total & Reduced potentials. This allowed us to obtain excellent results for a wide class of problems which had proved difficult for GFUN. During the next few years we also developed a 2d general purpose code for static and low frequency fields which we called PE2D as well as a series of special purpose integral and boundary integral programs. This was a rich period indeed for us. John and I travelled extensively implementing the software at laboratories in the spirit of free exchange as was the custom in those days, particularly in the USA where we felt we were repaying a debt for the early encouragement many of the national labs there had given us. I particularly remember John implementing GFUN from a terminal over a modem line from our hotel room in Livermore as we did not have sufficient security clearance to go inside!

Marketing and wider issues

By 1979 the codes developed at RAL were being used at many laboratories, particularly in North America, and to provide a user forum we organised a series of user meetings. This proved too costly and time consuming for RAL to sustain. Accordingly the rights of these codes were assigned to a UK government agency called British Technology Group (BTG) who in turn set up a software marketing company called Compeda Ltd. A very experienced engineer with considerable marketing experience, John Whitney, joined this company to look after the software and he with our technical team promoted TOSCA and PE2D and secured a basic international market. Unfortunately by 1983 Compeda was sold by BTG and the new owners decided not to market our software. The following year John Simkin and I were resolved to set up a new company together with John Whitney to continue the marketing, support and further developments of the software and Vector Fields Ltd was registered in 1984. I am a very proud to have been involved in this exercise of technology transfer from the public to the private sector and although the business climate remains difficult and the economic future uncertain engineers and scientist will continue to require solutions of the field equations. At this point it is appropriate to record the contribution of three younger researchers to the work of the group, Chris Biddlecombe who had been with team since 1975 and has kept the software alive ever since, Chris Riley who had been with Compeda and now manages our US office and Cris Emson who also transfered from Rutherford and now looks after our development projects.

I shall end this short history of the RAL EM group by some personal speculations on the status of computational electromagnetics. The list of either unsolved or ineffectively solved problems is still growing. Most people would agree that the following are crucial:

- Hysteresis
- Non-Linear Eddy Current Transient Fields with motion
- 3D Adaptive meshing
- The generalised high frequency problem, radiation and cavities
- Advanced Physics, eg. HT superconductors
- Optimisation techniques

The community in recent years has also recognised the need for cooperation with computer scientists particularly in graphics and in advanced architectures. Another important development has been the establishing of standards to allow data exchange between codes for CAD and the other disciplines.

Probably there is no single technique that will be effective for the entire range of problems and in any case new approaches are being developed all the time and may change things radically. All of the standard methods fail sooner or later for some situation or other despite the subtle ingenuity and skill of the code developers. Someimes old methods receive a boost e.g the use of edge elements in numerical discretisations and their connection with differential forms which is leading us to a deeper understanding of fields and forces. In this connection I remember Professor Percy Hammond (University of Southampton) at the first Compumag conference giving a paper entitled "Is your computing really necessary?" in which he advocated the importance of duality priciples in bounding solutions to achieve effective estimates of global quantities like capacitance, inductance etc. without performing exhaustive numerical computation. These ideas have led him and others to explore the fundamentals of our subject with far reaching results. I would expect Integral methods to become increasingly important now we have (a) the possibily of parallel hardware to process what is essentially an intrinsically parallel problem and (b) the use of edge elements to model the materials.

Another very important and recent development has been the recognition that computer codes need to be validated. The notion that numerical results need error bounds is surprisingly recent and it is only within the last five years or so that codes began to have inbuilt error bounds on numerical solution! In this area the subject has benefitted enormously from the bench marking exercise first tentatively begun by the series of Eddy Current workshops in various parts of the world but formalised and given substance by the work of Larry Turner under the TEAM[8] initiative in close connection with Compumag and ACES.

There are now many groups, academic, laboratory and commercial, working on field computation in many countries and these are providing industry with the tools they need to progress the technology of design but it must always be remembered that most devices depend upon other disciplines and indeed it may not be the EM considerations that are the most crucial. It is often the mechanical or thermal effects that limit a devices performance. Most of us tend to regard our speciality as the most critical and sometimes progress has been held up because of the NIH (not invented here) syndrome but the community appears to be maturing and emerging as a well defined and responsible group which is encouraging for the future.

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BOOK REVIEW

"Computational Electromagnetics: Frequency Domain Method of Moments"

by

Edmund K. Miller, Louis Medgyesi-Mitschang, and Edward H. Newman (Editors)
IEEE Press, Ed. 1992, 528 pages, $69.95

Reviewed by: Reinaldo Perez, ACES Newsletter Assc. Editor

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Preamble

Among the services that we intend to provide our readers at the ACES Newsletter is to review new books being published that deal with the subject of computational electromagnetics. We hope you will benefit from this new service.

Computational Electromagnetic Methods (CEMs) is an area that has progressed considerably within the last 25 years due to the significant advances in hardware and software capabilities that have become available not only to the dedicated researcher but to any engineer in the field. Among all the methods in computational electromagnetics that are presently used today, the Method of Moments (MoM) stands out as the most widely used CEM in most analysis of microwave circuits, antennas and antenna networks, remote sensing, magnetics, and electromagnetic compatibility. This fact is simply evident by the number of papers on the MoM that appear in many engineering journals. In the last three years this editor has seen a "flurry" of books in CEMs, including the MoM. This development is a clear indication that CEMs have matured enough so as to migrate from journals into textbooks. Furthermore, the increased use of CEMs for analyzing certain types of electromagnetic compatibility (EMC) problems is a good indication of the transformation that EMC is experiencing from a discipline, which mostly relies on testing, to one where theoretical analysis is of increasing importance.

Among several existing books in the MOM, the book reviewed here is characterized by a compilation of 57 journal papers whose authors rank in the "who's who" of MoM history, from the 1950's to the present. The papers were chosen by the editors of the book as being representative of the evolutionary process of the MoM as a computational electromagnetic technique. The readers are advised, however, that because most journal papers are not of a tutorial nature, the usefulness of this book is more relevant to those already familiar with the MoM. References at the end of this review address the MoM at a more introductory level.

The book is divided into seven parts. The first six parts are devoted to different theoretical aspects of the MoM, while the last part of the book deals with numerical techniques. Part I contains nine papers dedicated to the basic theory behind the MoM. Among the most important papers are: a) "Reaction Concept in Electromagnetic Theory," by Rumsey, which describes certain types of integral equations used in MoM. Richmond used the reaction concept in its piecewise reaction formulation, b) "Origin and Development of the MoM for Field Computation", by Harrington (the "father" of the MoM), which illustrates the mathematical foundations of this technique, and c) "Effective Methods for Solving Integral and Integral-Differential Equations", by Wilton and Butler, which is a very well organized tutorial on the solution of integral-differential equations.

Part II contains seven papers whose emphasis is on the proper modeling of two-dimensional and three-dimensional surface currents in the MoM. A paper by Newman and Pozar, "Electromagnetic Modeling of Composite & Surface Geometries", describes the modeling of closed/open surfaces and attached wires using wire-grid modeling. The paper by Rao, Wilton & Glisson, "Electromagnetic Scattering by Surfaces of Arbitrary Shape", uses triangular patches for representing surface current distributions. Part III contains seven papers dedicated to the modeling of MoM problems using wire structures. The first three papers by Mei, Yeh and Mai, and Gee form the theoretical foundations of the use of electrical field integral equations for thin wire structures. These papers constitute the theoretical background for a widely used MoM code called Numerical Electromagnetic Code (NEC). This section also includes Richmond's paper, "Radiation and Scattering by thin-wire Structures in the Complex Frequency Domain" which is on the usage of piecewise sinusoidal reaction formulation for radiation and scattering by thin wires. This paper constitutes the foundation of Richmond's well known MoM code. Part IV explores the modeling of penetrable three-dimensional bodies. This section begins with an introduction of the volume-current approach, approximate treatment using the impedance boundary conditions, and various approaches for homogeneous and inhomogeneous bodies.

Part V treats the aperture problem in MoM by a variety of methods. Apertures can increase the scattering of otherwise smooth surfaces. Aperture problems can be formulated in terms of equivalent surface currents on the conducting surface which separates the two regions. However, since aperture area is usually much smaller than the conducting surface, it is more efficient to employ the MoM to solve for the equivalent surface current on the aperture. Two papers by Butler, et al., "Electromagnetic Excitation of a Wire Through an Aperture Perforated Conducting Screen", and "Electromagnetic Penetration Through Apertures in Conducting Surface", use a pair of coupled integral equations for the equivalent magnetic currents in the aperture and the equivalent electric currents on the conducting surface. A paper by Rahmat-Sammii describes the development of an integral equation for an EMP penetration through an aperture.

A major trend in CEM is in the use of "hybrid techniques" for solving different kinds of propagation problems as part of the overall problem. Part VI of the book outlines a series of examples where hybrid methods have been used. Most of the problems analyzed use a combination of MoM with Geometric Theory of Diffraction (GTD) for scattering from nearby edges. Alternate Green's functions go beyond the ones commonly used for infinite media by incorporating a special Green's function that satisfies the field boundary conditions over special surfaces, such as infinite plane, circular cylinders, or sphere. In all cases the objective is to reduce the number of unknown in the solution of MoM models. Problems discussed in this section include a monopole attached to a sphere, use of MoM with GTD in various ways, and the problem of infinite interface that arise when modeling antennas near the earth's surface.

It is obvious that because of the complex topology of several types of problems, hybrid methods become very attractive to the electromagnetic engineer. In this editor's opinion that hybrid methods and the use of novel processing techniques (e.g parallel processing) lie at the center of future advances in CEMs. The last section of this book (Part VII) addresses diverse aspects of computational techniques in the MoM, where such techniques include: a) numerical integration, b) proper use of testing and basis functions, and c) matrix evaluations such as banded-matrix, precondition and iterative methods.

The book can be recommended as a reference for those with a background in MoM and general knowledge of CEMs. For tutorial purposes the readers are advised to consider first the following reference materials.

"Field Computation by Moment Methods", R.F. Harrington, New York, MacMillan, 1068. This is the book that started it all. Written by the father of the MoM, it is the most quoted MoM book of all times.

"Antenna Theory and Design", W.L. Stuzman and G. Thiele, John Whiley and Sons, 1981. A popular and widely used book in antenna theory. It has a chapter devoted exclusively to the MoM with several examples. Since then other editions of well known antenna books (e.g by Kraus) have added chapters on the MoM.

"Computer Techniques in Electromagnetics", R. Mittra, ed. Pergamon Press, NY, 1973. A general book in CEM's but it has several chapters devoted to MoM techniques.

"Generalized Moment Methods in Electromagnetics", J.H.H. Wang, John Wiley and Sons, NY, 1991. For the serious minded MoM enthusiast.

INDEX TO COMPUTER CODE REFERENCES FOR VOL. 7 OF THE ACES JOURNAL AND THE ACES NEWSLETTER

This computer code index is updated annually in the second issue of each volume of the ACES Newsletter.

Legend:

AJ	Aces Journal
AN	Aces Newsletter
*	Pre- or post-processor for another computational electromagnetics code
**	Administrative reference only; no technical discussion (This designation and index do not include bibliographic references.)
page#	The first page of each paper or article in which the indicated code is discussed.

NOTE: The inclusion of any computer code in this index does not guarantee that the code is available to the general ACES membership. Where the authors do not give their code a specific name, the computational method used is cited in this index. The codes in this index may not all be general purpose codes with extensive user-orientated features - some may only be suitable for specific applications.

COMPUTER CODE	JOURNAL OR NEWSLETTER ISSUE AND PAGE	
CGFFT (weak form) code	AJ Vol 7, No 2	p. 26
FDTD (2D)	AJ Vol 7, No 2	p. 65
	AJ Vol 7, No 2	p. 85
FDTD (3D)	AJ Vol 7, No 2	p. 65
	AJ Vol 7, No 2	p. 72
	AJ Vol 7, No 2	p.179
FEM (3D code for bioelectromagnetics)	AJ Vol 7, No 2	p. 9
JUNCTION (parallel version)	AJ Vol 7, No 1	p. 48
MMP (3D)	AJ Vol 7, No 2	p. 43
MRBOR	AJ Vol 7, No 1	p. 5
N3D	AJ Vol 7, No 2	p 128
NEC2	AN Vol 7, No 1	p. 14
	AN Vol 7, No 2	p. 38
	AN Vol 7, No 3	p. 31
NEC4	AN Vol 7, No 2	p. 31
SIG5	AJ Vol 7, No 1	p. 24
UNAFEM	AN Vol 7, No 1	p. 17

ABSTRACTS OF ACES JOURNAL PAPERS

VOLUME 7

This compilation of abstracts is updated annually in the second issue of each volume of the ***ACES Newsletter***.

ELECTROMAGNETIC SCATTERING FROM RADIALLY OR AXIALLY INHOMOGENEOUS OBJECTS

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A computer program based on the method of moments approach is developed to compute electromagnetic scattering from axisymmetric objects. The object may consist of N linear isotropic homogeneous regions. These regions may be arranged axially and/or radially with the axis of symmetry. Surface integral equations (SIE) formulation, E-PMCHW, is used to formulate the problem. Other formulations can easily be incorporated in the computer code. Bistatic and monostatic Radar Cross Sections (RCS) for several benchmark geometries are computed. The computed results are verified by comparison with measured and exact calculated results. In some cases the self-consistency method is used to perform the verification. The measured and calculated data presented in this paper are expected to serve as benchmarks for other researchers in the field. **[Vol. 7, No. 1 (1992)]**

APPLICATION OF EQUIVALENT EDGE CURRENTS TO CORRECT THE BACKSCATTERED PHYSICAL OPTICS FIELD OF FLAT PLATES

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In the microwave case the physical optics (PO) method is frequently used for the analysis of complex structures which are modeled by flat plates of triangular or quadrangular shape. The study of the radar cross section (RCS) of an isolated panel, however, reveals deviations from experimental results which are due to edge diffraction effects not considered by PO. In order to correct the PO-field by an additive field term, the equivalent fringe currents (EC) of Michaeli have been used to derive the backscattering matrix of an isolated edge. By adding the matrices of the individual edges to the PO-matrix the RCS of a square flat plate with zero and finite thickness is analysed and the result is compared with measurements. The efficiency of the method is demonstrated for objects modeled by a higher number of panels and edges, namely a cylinder and a double dihedral. All computations were performed with the computer code SIG5 of the Institute. **[Vol. 7, No. 1 (1992)]**

APPLICATION OF PARALLEL PROCESSING TO A SURFACE PATCH / WIRE JUNCTION EFIE CODE

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A surface patch / wire junction EFIE method of moment algorithm, JUNCTION, developed by the University of Houston has been implemented in a transputer based parallel processing environment installed in a personal computer. This paper addresses transputer hardware and software options, the JUNCTION algorithm, techniques for parallelizing matrix analysis algorithms, and performance results. The transputer array was found to provide a flexible, low-cost, high performance desktop computing environment for method of moment analysis. **[Vol. 7, No. 1 (1992)]**

A RECURSIVE TECHNIQUE TO AVOID ARITHMETIC OVERFLOW AND UNDERFLOW WHEN COMPUTING SLOWLY CONVERGENT EIGENFUNCTION TYPE EXPANSIONS

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Eigenfunction expansions for fields scattered by large structures are generally very slowly convergent. The summation often consists of two factors where one factor approaches zero and the other factor grows in magnitude without bound as the summation index increases. Each term of the expansion is bounded; however, due to the extreme magnitude of the individual factors, computational overflow and underflow errors can limit the number of terms that can be computed in the summation thereby forcing the summation to be terminated before it has converged. In this paper an exact technique that circumvents these problems is presented. An auxiliary function is introduced which is proportional to the original factor with its asymptotic behavior factored out. When these auxiliary functions are introduced into the summation, we are left with the task of numerically summing products of well behaved factors. A recursion relationship is developed for computing this auxiliary function. **[Vol. 7, No. 1 (1992)]**

'H-ORIENTED' AND 'B-ORIENTED' METHODS IN A PROBLEM OF NONLINEAR MAGNETOSTATICS: SOME METHODOLOGICAL REMARKS

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Problems which depend on a small parameter in their formulation can often be studied by a perturbation approach. Whether the perturbation is "regular" or "singular" is important in many respects. In magnetostatics, due to some inherent duality, both kinds of perturbation may happen, depending on the chosen formulation ("b-oriented" vs. "h-oriented" methods). Singularly perturbed problems are numerically more difficult than regularly perturbed ones. We suggest that this might explain why, as some recent numerical observations seem to suggest, b-oriented methods should give better accuracy in a specific class of nonlinear magnetostatic problems at high permeability. **[Vol. 7, No. 1 (1992)]**

3D BIOELECTROMAGNETIC COMPUTATION ON FINITE ELEMENTS

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Finite element computation of electric and magnetic fields induced in the body by noninvasive electromagnetic sources is discussed. Attention is focussed on three-dimensional calculations for full-scale body models with significant levels of internal anatomical structure. The finite element solution strategy including the sparse matrix approach which allows computation of over 100K degrees-of-freedom on standard reduced instruction set computer (RISC) workstation platforms is outlined. The finite element mesh generation problem is also described. Representative examples of the level of meshing detail and the type of 3D bioelectromagnetic solutions that can be achieved using finite elements in the workstation computing environment are shown. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

COMPUTATION OF THREE-DIMENSIONAL ELECTROMAGNETIC-FIELD DISTRIBUTIONS IN A HUMAN BODY USING THE WEAK FORM OF THE CGFFT METHOD

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The problem of the computation of electromagnetic-field distributions in a strongly inhomogeneous human body is formulated in terms of an integral equation over the body. A weak form of the integral equation is discussed, in which the spatial derivatives occurring in this equation are integrated analytically. The resulting equation can then be solved very efficiently using the advantageous combination of a conjugate-gradient iterative method and a fast Fourier technique (CGFFT). Numerical calculations have been carried out for a strongly inhomogeneous, lossy radially layered sphere. A comparison with the Mie-series solution shows that the present weak form of the CGFFT method yields accurate results. The absorbed power density inside a CAT-scan generated model of the body of one of the authors is computed. It demonstrates that the present method can be considered as a comparatively simple and efficient tool for solving electromagnetic wave-field problems in strongly inhomogeneous media. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

MULTIPLE MULTIPOLE METHOD APPLIED TO AN EXPOSURE SAFETY STUDY

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A summary of the three-dimensional implementation of the multiple multipole method (3D MMP) is given, followed by discussions on the method's advantage and limitations on the basis of an example study. The advantages are seen in its quantitative validation capability, in its efficiency for smoothly shaped bodies and its achievable accuracy, in particular, near surfaces. However, MMP's greatest strength appears to be with problems with EM sources in the closest vicinity of lossy bodies. This is shown by a condensed presentation of a study investigating the RF exposure safety of UHF and VHF transmitters commonly used by radio and TV crews for onsite live reports. In addition to gaining knowledge about the locar SAR distribution, the goal of this study was to assess necessary safety distances for given threshold values. The presented study was performed with the 3D MMP software package on a 80386 based PC laptop extended by a 80860 board with 32 MB RAM. **(Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations)**

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Electromagnetic hyperthermia has been demonstrated to be a safe and useful adjuvant to ionizing radiation in the treatment of malignant tumors. However, applicators and systems for delivering the optimum treatment prescribed by the physicians are far from being available at present. Computer modeling can play a significant role in the design of better heating equipment and in improving the quality of the hyperthermia treatments currently being administered. There is an active ongoing research to develop suitable calculational models using a variety of numerical techniques. But several gaps exist in the current knowledge regarding the validity of these numerical simulations in the clinical context. The development of treatment planning systems similar to those used for radiation therapy requires resolution of these issues. Of the different numerical modeling approaches currently being developed, the finite-difference time-domain (FD-TD) technique has been extensively applied to calculate specific absorption rate (SAR) patterns in complex 3-D heterogeneous biological objects primarily because it is accurate and has a small computer burden relative to frequency-domain integral equation and finite-element techniques. Following a brief review of the historical development of numerical modeling of electromagnetic interaction with biological structures in the hyperthermia context, examples of recent calculations using FD-TD technique in realistic situations in electromagnetic hyperthermia are provided. It has been observed from 2-D calculations, that the water bolus, routinely used in the clinic to provide energy coupling and surface (skin) temperature control, and the inhomogeneous tissue structures significantly modify the SAR patterns compared to patterns computed in planar and homogeneous structures. In conclusion, future areas of work are identified and discussed. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

ANALYSIS AND COMPUTATION OF LEAKY-WAVE HYPERTHERMIA APPLICATOR

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The use of electromagnetic waves to induce hyperthermia in cancer therapy has been the subject of intensive research but obtaining good resolution at depth in the abdomen and pelvic regions remains a fundamental problem. This paper investigates the prospects for generating leaky-waves in tissue to improve field penetration and focussing at depth. An approximate analysis based on a planar structure illustrates the feasibility of obtaining good resolution at depth but leaky-wave action in a strict sense is not possible. Measurements on an applicator conformal with the phantom tissue simulated by a saline solution, demonstrate good resolution and penetration but hotspot regions are detected around the launcher region. A three dimensional finite difference time domain (FDTD) computation is performed in Cartesian, circular cylindrical and elliptic cylindrical coordinates to model all the effects for various geometries of the phantom region and different launching symmetries. The results illustrate the need for symmetric launching of the strip, computational convergence and mode diagnostic data, the shape of the focal region and the useful property of being able to shift the focal region by changing frequency. It is concluded that this new quasi-leaky-wave applicator concept is potentially capable of giving improved focal resolution at depth with some positional control and only one generator is required. Optimising the launching of the quasi-leaky waves on the applicator and preventing hotspot regions from creating unwanted tissue heating are remaining practical problems to address. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

EVALUATION OF CLINICAL HYPERTHERMIA TREATMENT USING TIME DOMAIN FINITE DIFFERENCE MODELLING TECHNIQUE

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The use of numerical modelling techniques, especially the time domain finite difference method, has improved the understanding of power deposition in human bodies undergoing cancer treatment with micwoave or radiofrequency waves. In this paper, clinical hyperthermia treatments are modelled with the time domain finite difference method. Quantitative assessment criteria are defined for the evaluation of computed power deposition patterns and are found to be useful in determining whether a particular treatment is likely to succeed. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

OPTIMIZING PLANAR SOURCE DISTRIBUTIONS FOR DEEP POWER DEPOSITION IN BIOLOGICAL TISSUE

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In non-invasive hyperthermia, penetration depth in high water content biological tissue can be increased up to 3 times using a focused instead of uniform surface electric field distribution. The focusing involves maximizing the field integral at a focal point by solving for the surface phase function which makes the integrand real and positive for all surface points. The resulting non-linear differential equation is solved in using a series approximation. A focused power deposition pattern is presented using this ideal planar distribution which is the theoretical optimum for high resolution hyperthermia cancer treatment. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

TWO-DIMENSIONAL TEMPERATURE RETRIEVAL IN BIOLOGICAL STRUCTURES BY MULTIFREQUENCY MICROWAVE RADIOMETRY: A SOBOLEV-SPACE SOLUTION

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The problem of retrieving a two-dimensional temperature distribution from radiometric data measured at various frequencies and for different positions of the sensing antenna around the body has been considered. The retrieval has been modelled as an inverse problem whose solution is investigated in a suitably defined functional space which takes regularity properties of temperature functions into account. The retrieval of hot spots in a cylinder at uniform temperature has been numerically analyzed, the examples being relevant in the hyperthermia treatment of malignancies. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

NON-INVASIVE ACTIVE THERMOMETRY WITH A MICROWAVE TOMOGRAPHIC SCANNER IN HYPERTHERMIA TREATMENTS

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In this work the active microwave tomographic imaging of tissue temperature changes induced in deep hyperthermia treatments is studied. The thermal images would allow to monitor and optimize the treatment, increasing its efficacy and avoiding the heating of healthy tissues. As some hyperthermia systems are based on a cylindrical geometry, it is possible to integrate a microwave imaging array in the same structure, providing a non-invasive tool for the monitoring and control. The application of this technique to deep hyperthermia treatments is investigated by numerical simulations and experimentally on two phantoms of thorax and pelvis, using a prototype for microwave tomography recently developed [Jofre et al, 1990]. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

ELECTRICAL IMPEDANCE TOMOGRAPHY IN THREE DIMENSIONS

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An algorithm is developed for electrical impedance tomography (EIT) of three-dimensional volumes using multi-planar electrode arrays. This algorithm is based upon the method of least squares, and uses one step of Newton's method to estimate the conductivity distribution inside the volume using electrical measurements made on the boundary.

An implementation of the algorithm for right cylindrical volumes is described. This computer code, called N3D, permits reconstructions with up to 2016 degrees of freedom. The code uses an initial guess consisting of uniform conductivity, allowing many of the computations to be done analytically.

Although the code does not reconstruct the conductivity distribution accurately (unless it differs very little from a constant), it does yield useful images at reasonable computational cost. The algorithm is demonstrated using three-dimensional resistivity distributions reconstructed from experimental data. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

COMPUTATIONAL METHOD FOR POWER LINE MAGNETIC FIELD EVALUATION

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The paper reports a model for the power line magnetic field evaluation. The obtained results for three different power lines (380 kV double circuit, 380 kV single circuit, 220 kV double circuit) was validated with measurement data. Calculated and corresponding measured data were found in good agreement. The influence of geometrical and electrical power line parameters, such as the spatial configuration of the conductors and line phase sequences, is evaluated and discussed. Data on the influence of adjacent line span on the field are also reported.

The method can be used for prediction of human exposure in epidemiological studies. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

SIMPLIFIED ANALYTICAL SOLUTIONS FOR MAGNETIC SIMULATION OF NEURONS

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Strong pulses of magnetic field are used to stimulate peripheral nerves and motor neurons in the cerebral cortex,. Such stimulation is used in neurology for numerous diagnostic purposes. The electric field induced in tissue along the neuron and its spatial derivative are the parameters determining neural response. Another important parameter influencing the efficiency of stimulation is the inductance of a coil producing the magnetic field, as it defines the current time derivative for a given pulse generator. For arbitrarily located coils of arbitrary shapes, a semi-analytical solution is presented to calculate spatial distributions of the electric field and its spatial derivatives in a semi-infinite tissue model. Analytical solutions are given for coils composed of linear segments parallel or perpendicular to the air-tissue interface. Expressions for inductance of coils having suitable geometries for neural stimulation are derived. Coils can be optimized for stimulation of nerves at given orientation and distance from the air-tissue interface. In the optimization, coil dimensions and shape are considered as they affect both the induced field and inductance. A quadruple coil consisting of triangular sections appears to offer some advantages over other shapes for stimulation of shallow nerves. For deep nerves spaces quadruple square and three-dimensional coils are preferred. Analyses described are useful in evaluating various options, gaining an insight into the physical phenomena involved, and as the first step before undertaking a numerical analysis of models more closely representing the tissue electrical and geometrical complexities.
[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]

ANALYSIS OF THE STIMULATION OF A NERVE FIBER SURROUNDED BY AN INHOMOGENEOUS, ANISOTROPIC, AND DISPERSIVE TISSUE

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A method for evaluating the threshold for electric and magnetic stimulation of nerves surrounded by an inhomogeneous, anisotropic, and dispersive tissue has been developed. The scalar potential distribution induced by a given electric or magnetic source is evaluated by using the Finite Difference Technique. Calculations are performed with a FORTRAN code, and for non dispersive tissues a spread-sheet is also used. Nerve fiber excitation is described by using the Frankenhaeuser-Huxley model in which the stimulating current density is obtained by extending the method proposed by Rattay. The analysis results predict that, with reference to the homogeneous case usually considered in literature, the larger differences in the current threshold are due to the tissue inhomogeneity, while the consideration of the dispersive properties of the tissues has less effect. **[Vol. 7, No. 2 (1992), Special Issue on Bioelectromagnetic Computations]**

COMPUMAG - Miami

The Ninth COMPUMAG Conference on the Computation of the Electromagnetic Fields will be held in Miami, Florida, USA, from October 31 to November 4, 1993. The aim of the Conference is to discuss recent developments in numerical computation of electromagnetic fields for the design and analysis of electromagnetic devices. The focus of the conference is on several areas in applied electromagnetics including static fields, quasistatic fields, wave propagation, optimization, material modeling, coupled problems, numerical techniques, software methodology, and applications in various other areas.

Papers presented at the Conference will be selected from the submitted papers through a review process. Accepted papers will be published in the Conference Record. Extended versions of these papers will undergo another peer review in accordance with the rules of the IEEE Transactionson Magnetics, in which the accepted extended papers will be published.

The four-day technical program of the Conference will feature:

- more than 350 technical presentations
- 3 panel sessions on parallel computing
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- design optimization
- invited presentations.

More than 25 companies and research organizations will have technical and commercial exhibitions related to applied electromagnetics. Major sponsors of the Conference will be acknowledged by their displays and also in the Conference publications.

Following the Conference, the final ACES/TEAM Workshop of the IVth Round will be held on November 5-6, 1993, at the same venue.

The site selected for the Conference is the Hotel-Intercontinental Miami; located in the heart of the city, overlooking Biscayne Bay and Port of Miami with elegant cruise ships, Bayside marketplace with its numerous shops and restaurants, and cosmopolitan Downtown Miami.

An exceptional social program has been planned for all guests and participants to relax after a hard day of technical sessions and presentations.

Accompanying persons will also find out that there are many daily activities scheduled for them including shopping at the biggest outlet mall in the world, sightseeing tour in the ArtDeco district in Miami Beach, airboat ride in the Everglades National Park, and of course the golden beaches of Florida.

Several post-conference excursions have been arranged to other attractive locations. These include the central Florida area (for Disneyworld, Universal Studios, and Cape Canaveral Space Center), Key West, Caribbean Islands.

If you or your company would like to participate in COMPUMAG - Miami activities, please contact the COMPUMAG -Secretariat (see the information column on the left for address) to receive an Exhibitor's Application Kit, to request Company Sponsorship information, or to be placed on the mailing list if you would like to attend the Conference.

THE APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY

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The 1994 Annual Review of Progress in Applied Computational Electromagnetics will be the tenth yearly Symposium to bring analysts together to share information and experience about the practical application of EM analysis using computational methods. All aspects of computational electromagnetics analysis will be represented but particular emphasis at the 1994 Symposium will be placed on general purpose code application, code performance analysis, and validation. Attendance and professional program paper participation from non-ACES and from outside North America are encouraged and welcome. The Symposium features four areas of interest to the EM analysis enthusiast: short courses, demonstrations, vendors' booths and technical paper sessions which are solicited from all areas of electromagnetic computation. The Symposium will also include invited speakers and interactive forums.

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THE APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY

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- Code validation
- Code performance analysis
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- "Tricks of the trade" in selecting and applying codes and techniques
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- Partial List of Applications:

antennas	*eddy currents*
static fields	*radar cross section*
shielding	*bioelectromagnetics*
EMP,EMI/EMC	*power transmission*
charge transport	*inverse scattering*
microwave components	*MMIC technology*
Fiberoptics	*remote sensing & geophysics*
communications systems	*plasmas*
particle accelerators	*generators and motors*
wave propagation	*non-destructive evaluation*
Dielectric & magnetic materials	*networks*

- Partial List: Techniques:

frequency-domain & time-domain techniques
integral equation & differential equation techniques
finite differences and finite element techniques

diffraction theories	*physical optics*
modal expansions	*perturbation methods*
hybrid methods	*moment methods*

TIMETABLE

October 1, 1993	Summary Submision Submit four (4) copies of a 300-500 word summary to the Symposium Chairman (Address on other side of this form)
November 17, 1993	Authors notified of acceptance
January 12, 1994	Submission deadline for camera-ready copy, not more than eight (8) pages including all figures. For both summary and final paper, please supply the following data for the principal author - name, address, e-mail address, FAX, and telephone numbers for both work and home.

Registration fee per person for the Symposium for members is approximately $200. The exact fee amount will be announced later.

SHORT COURSES

Short courses will be offered in conjunction with the Symposium, covering numerical techniques, computational methods, surveys of EM analysis and code usage instruction. It is anticipated that short courses will be conducted principally on Monday, March 21, and Friday, March 25. Fee for a short courses is expected to be approximately $80.00 per person for a half-day course and $130.00 for a full-day course, if booked before March 4, 1994. Full details of 1994 Symposium will be available by November of 1993.

EXHIBITS

Vendor booths and demonstrations will feature commercial products, computer hardware and software demonstrations, and small company capabilities.

For information regarding ACES or to become a member in the Applied Computational Electromagnetics Society, contact Dr. Richard W. Adler, ECE Department, Code EC/AB, Naval Postgraduate School, 833 Dyer Rd, Rm 437, Monterey, CA. 93943-5121, telephone (408) 646-1111, Fax: (408) 649-0300. E-mail 5541304@mcimail.com. You can subscribe to the Journal and become a member of ACES by completing and returning the form below.

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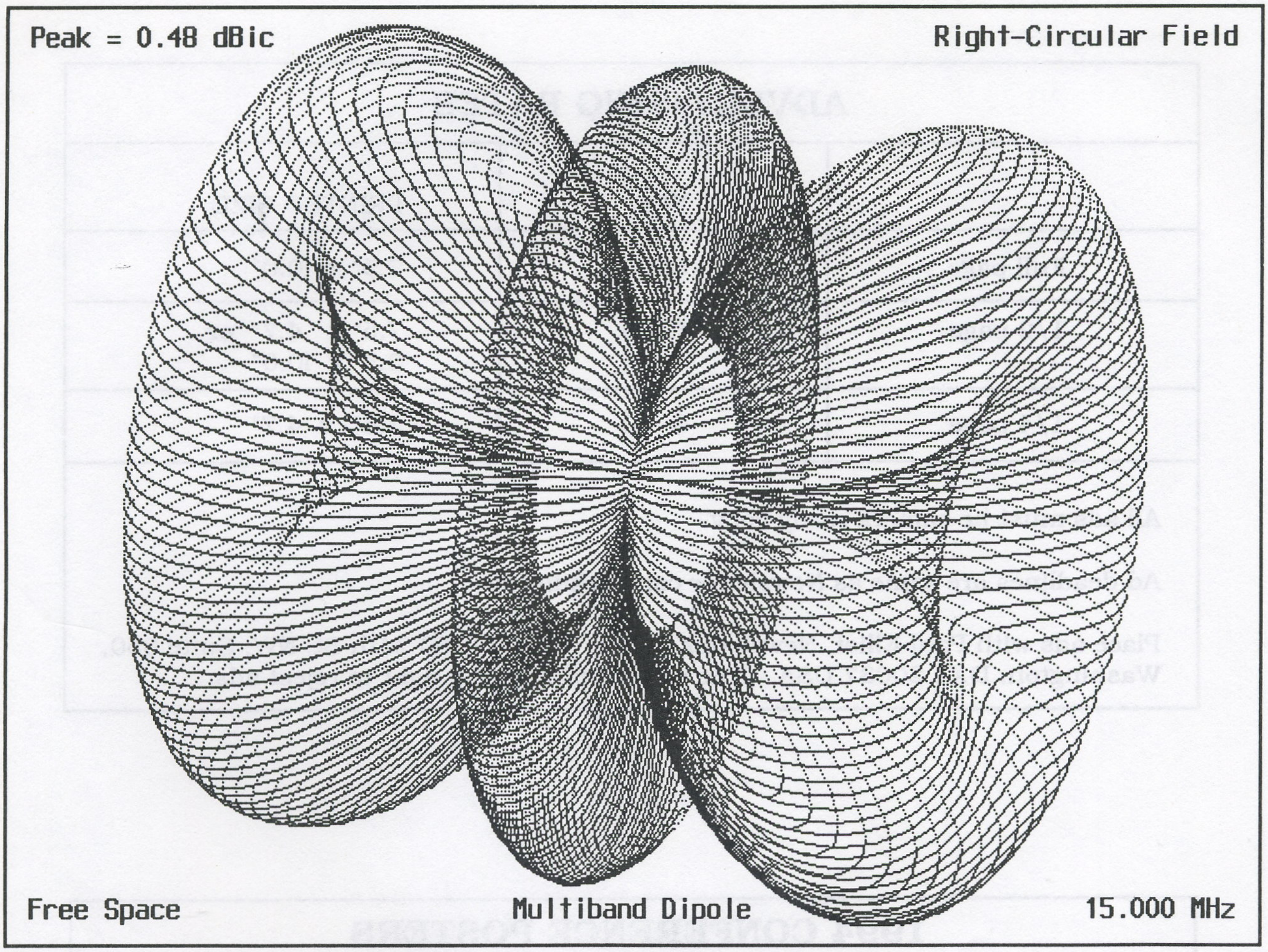

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