APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY (ACES)

NEWSLETTER

Vol. 13 No. 1 March 1998

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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.

AUTHORSHIP AND BERNE COPYRIGHT CONVENTION

NEEDED: ADVERTISING AND REPORTS EDITOR

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OFFICER'S REPORTS

PRESIDENT'S COMMENTS

This month will be my last as ACES president. I started through the chairs six years, or so, ago, and now it's time to relinquish the gavel. Before doing that, however, let me thank the excellent people who have served diligently on the Board of Directors, on the various committees, and who simply volunteered to get the job done without a particular title. Dick and Pat Adler continue to do a terrific job managing the operations, and gently reminding me that my PRESIDENT'S COMMENTS are due. I owe a special thanks to Dave Stein, who always exhibited a strong commitment to ACES, beyond his official capacity as editor-in-chief, and I thank each of you for your support of ACES. We hope that you are finding it professionally rewarding.

The ACES Journal and Newsletter, and the Annual Review are outstanding contributions to the Computational Electromagnetics Community, and now we are adding the first of what we hope will be a series of symposia of short courses and workshops. This attests to ACES scholarship, but we need to continue to further examine our role in CEM. There have been complaints that we are becoming too scholarly, and that we have neglected other aspects of applied computational electromagnetics. My feeling is that a little scholarship never hurt anybody, but we must return to our original role of being the "link between code developers and users." There are a number of aspects of applied computational electromagnetics that we must explore and develop. Perry Wheless is attempting to make inroads into the amateur radio community, for example, and that is a good idea. We need to develop better relations with the commercial segment, because that is the ultimate market for computational electromagnetics. Government funding of academic research is dwindling, and we must broaden our horizons. Your comments are always welcome here.

Duncan Baker, who is our current editor-in-chief, was recently honored by the IEEE with the rank of Fellow. He is the third ACES member whose nomination to IEEE Fellow was officially supported by Society, Ken Siarkiewicz and Stan Kubina being the others, so we are batting 1.000, which is not bad. Congratulations Duncan.

Enjoy the 14th Annual Review of Progress in Applied Computational Electromagnetics.

With best wishes,

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THE APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY, INC.

NOTICE OF THE ANNUAL BUSINESS MEETING

Notice is hereby given that the annual business meeting of the Applied Computational Electromagnetics Society, Inc. will be held on Tuesday 17 March 1998, in 102 Glasgow Hall at the Naval Postgraduate School, Monterey, CA. The meeting is scheduled to begin at 7:45 AM PST for purposes of:

1. Receiving the Financial Statement and Treasurer's Report for the time period ending 31 December 1997.
2. Announcement of the Ballot Election of the Board of Directors.

By order of the Board of Directors
Perry Wheless, Secretary

ANNUAL REPORT 1997

As required in the Bylaws of the Applied Computational Electromagnetics Society, Inc. a California Nonprofit Public Benefit Corporation, this report is provided to the members. Additional information will be presented at the Annual Meeting and that same information will be included in the July Newsletter for the benefit of members who could not attend the Annual Meeting.

MEMBERSHIP REPORT

As of 31 December 1997, the paid-up membership totaled 517, with approximately 32% of those from non-U.S. countries. There were 19 students, 77 industrial (organizational) and 421 individual members. The total membership has increased by 8% since 1 Jan 1997, with non-U.S. membership decreasing by 15%.

Perry Wheless, Secretary

MEMBERSHIP RATES EFFECTIVE 1 APRIL 1997

AREA	INDIVIDUAL SURFACE	INDIVIDUAL AIRMAIL	ORGANIZATIONAL (AIRMAIL ONLY)
US & CANADA	$65	$65	$115
MEXICO, CENTRAL & SOUTH AMERICA	$68	$70	$115
EUROPE FORMER USSR TURKEY SCANDINAVIA	$68	$78	$115
ASIA, AFRICA MID EAST, PAC RIM	$68	$85	$115

1997 FINANCIAL REPORT

ASSETS

BANK ACCOUNTS	**1 JAN 1997**	**31 DEC 1997**
MAIN CHECKING	13,957	13,394
EDITOR CHECKING	1,797	3,035
SECRETARY CHECKING	6,836	2,108
SAVINGS	101	107
HIGH RATE SAVINGS	41,541	43,346
CREDIT CARD	6,683	13,040
CD #1	10,457	11,028
CD #2	10,476	11,008
CD #3	10,481	11,033
CD #4	10,481	11,025
TOTAL ASSETS	$112,810	$119,124

LIABILITIES: $0

NET WORTH 31 December 1997: $119,124

INCOME

Conference	72,909
Short Courses	15,068
Publications	3,345
Membership	41,681
Software	891
Interest & misc.	11,633
TOTAL	$145,527

EXPENSE

Conference	55,188
Short Courses	10,180
Publications	24,250
Software	2,445
Services (Legal, Taxes)	6,058
Postage	14,256
Supplies & misc.	26,623
TOTAL	$139.000
NET INCREASE FOR 1997	$6,527

In 1996 the net decrease was $7,928. In 1997 we enjoyed a net gain of $6,527. Our current net worth, $119,124 is double that of five years ago.

Todd Hubing
Treasurer

PERMANENT STANDING COMMITTEES OF ACES INC.

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SOFTWARE PERFORMANCE STANDARDS	Donald Pflug	Rome Laboratory/ERST 525 Brooks Rd. Griffiss AFB, NY 13441-4505
HISTORICAL	Robert Bevensee	BOMA Enterprises PO Box 812 Alamo, CA 94507-0812

ACES PUBLICATIONS REPORT

Item 1. Duncan Baker and Adalbert Konrad are completing their highly successful tours of duty as ACES Journal Editor-in-Chief and Associate Editor-in-Chief, respectively, in March. This is just one of many grateful acknowledgments of their excellent service and dedication to ACES. ACES has been very fortunate to have expert and hardworking people like Duncan Baker and Adalbert Konrad at the helm of the ACES Journal. Duncan plans to attend the ACES '98 conference in Monterey in March, so please take a few minutes there and let him know how much you value his contributions to ACES Publications. I know you will also join me in congratulating both Duncan and Adalbert for their notable achievements with the ACES Journal since Duncan came on board in 1993 with vol. 8, no. 2 and Adalbert followed in 1994 with vol. 9, no. 2! Perry Wheless will continue as ACES Publications Editor-in-Chief until May of 1998, and Ray Perez will continue indefinitely as ACES Newsletter Editor-in-Chief. Drs. Ahmed Kishk and Allen Glisson will assume the Journal Editor-in-Chief responsibilities (which are many) and privileges (which are few) in March. It is also anticipated that Atef Elsherbeni will become the first director of "electronic technology management" in ACES Publications, provided an acceptably descriptive title for his duties can be coined between now and conference time! Effective immediately, authors should direct ACES Journal manuscript submissions to:

Dr. Ahmed Kishk or Dr. Allen Glisson
Department of Electrical Engineering
University of Mississippi
University, MS, USA 38677

The phone number for Ahmed is 601-232-5385 and his e-mail address is ahmed@olemiss.edu.
The phone number for Allen is 601-232-5353 and his e-mail address is aglisson@mail.olemiss.edu.
They share a common fax number of 601-232-7231.

Item 2. Since the last ACES Newsletter was issued, the ACES Publications Committee has formulated and approved the following:

ACES Publications Advertising Policy

Paid advertising in the ACES Newsletter may be purchased by individuals and companies for the promotion of CEM-related products and activities at the rates printed in each issue of the ACES Newsletter. ACES also accepts paid advertising in the form of "drop-in flyers" which are sent to the membership bundled with ACES Journal/Newsletter mailings. Drop-in flyer advertisers shall either (a) provide, at no cost to ACES, all printed materials to be distributed, or (b) negotiate directly with the ACES Managing Editor a mutually acceptable means and fee for reproduction by ACES.

Advertisers shall pay, in full, the extra postage expenses incurred by ACES in connection with the mailing of their materials. In addition, advertisers shall pay a service charge to ACES for each mailing, as follows: (a) small companies (defined as nine or less full-time equivalent employees) - $75 U.S. and (b) large companies (defined as more than nine full-time equivalent employees) - $200 U.S. "Small company" advertisers shall certify their status in writing to the ACES Managing Editor. By this fee differential, ACES actively seeks to encourage individual and small-enterprise development of software products of interest and utility to the Computational Electromagnetics community.

Only advertising of products and activities involving Computational Electromagnetics will be accepted by ACES Publications. Advertising by executive recruiters and placement agencies which is directed to the CEM community is considered acceptable as CEM-related. ACES reserves the right to refuse advertising which the ACES Publications Committee deems inappropriate for any reason.

Item 3. ACES Publications has reconsidered the matter of color printing, and concluded that the ACES Journal and ACES Newsletter will be printed in black and white, but authors will be encouraged to submit electronic versions of their color graphics, which will be posted on the ACES Web site for convenient reference by interested readers. The URL will be furnished to authors in advance so that they may include this as a footnote reference in their final camera-ready manuscripts.

Item 4. Until a better permanent arrangement can be devised, it has been agreed by the Publications Committee that it shall be a responsibility of the ACES Publications Committee Chair to coordinate with the Technical Program Chair of the Annual Review symposium in order to secure advance copies of the conference papers in a timely manner and, further, to arrange a review process by which ACES conference manuscripts are screened as a potential source of ACES Journal papers. Members of the Publications Committee are expected to make themselves available for participation in the process.

Item 5. In the future, members of the ACES Journal editorial board will be expected to contribute at least one paper to the ACES Journal during their term of appointment in order to be eligible for reappointment. The Journal Editor-in-Chief(s) may occasionally call for invited papers from members of the editorial board, which are to be identified as "invited" in the Table of Contents. Item 6. Both the ACES Journal and ACES Newsletter Editors-in-Chief shall routinely advise all authors of ACES capability to distribute software related to their papers, from ACES Web/ftp sites, and encourage their participation in this program.

Finally, our sincere thanks are extended to the Guest Editors who produced two outstanding ACES Journal special issues in 1997. The quality of these issues has contributed to the increasing influence of ACES as an outlet for technical information to the computational electromagnetics community worldwide. The Guest Editors for vol. 12, no. 1 were Joao Pedro Bastos, Adalbert Konrad, and John Brauer. The Guest Editors for vol. 12, no. 2 were Kurt R. Richter, David A. Lowther, and Georgio Molinari. When you next see one of these gentlemen, I hope you will remember their fine efforts on our behalf and congratulate them for a job well done. I look forward to seeing you in Monterey during the traditional third week of March!

Submitted by
W. Perry Wheless, Jr.
ACES Publications Committee Chair
30 January 1998

CEM activities of European Space Agency for antenna design

M.Sabbadini*

Since its early days the European Space Agency has been actively promoting the development of electromagnetic modelling tools for antenna design. Some of them, like GRASP from Ticra (DK), are used all around the world. More recently, with the increased interest in printed antennas for space applications several projects have been launched on this subject. Other activities yet are addressing the problem of electromagnetic interactions on the spacecraft, including the evaluation of antenna pattern distortions, multipath characterisation, passive inter-modulation risk assessment and inter-antenna coupling calculations for the prevention of interference on payloads and instruments.

The numerous developments have resulted, over the years, in a large library of antenna design tools.

Apart from GRASP, which was recently reengineered to include several advanced software technology solutions, Ticra has produced a complete range of tools for reflector antenna design for contoured and multiple beam antennas, reflector shaping, (COBRA, SCOPE, POS, POD) and many other tasks [1].

Queen Mary and Westfield College (UK) has recently delivered two tools for the modelling of waveguides arrays (circular and rectangular) accounting for the mutual coupling and its impact on the power distribution via a beam-forming network. They are also coupled to Ticra's SCOPE enabling coverage optimisation including the effect of mutual coupling [2].

Katholieke Universiteit Leuven (B) is now working at version 2.0 of MAGMAS, a general and very flexible tool for the analysis of planar printed antennas, capable of modelling single elements and arrays, including their feeding network [3]. The Electromagnetic and acoustic labs (LEMA) of the Ecole Polytechnique Fédérale de Lausanne (CH) are working to more specialised tool for printed antennas, tuned for high computational efficiency on specific structures, e.g. for large SAR arrays [4].

Eurospacetech (NL) and Ticra have both been working to general purpose optimisation engine to work in combination with external electromagnetic solvers. The first on a Genetic Algorithm based tool [5], the latter on one using a range of "classical" optimisation techniques suitable for antenna design problems (quasi-Newton, non-linear least squares, Minmax, L1, Watchdog, Nelder Mead simplex) [1].

Matra Marconi Space (F) has recently concluded the development of an updated version of their ESA-GTD tool, useful for the calculation of antenna interaction on the spacecraft at system level.

In parallel to all these "dedicated" development, recognising the need of a "Computer aided antenna engineering system", a large European team lead by IDS (I) and involving EPFL-LEMA (CH), Eurospacetech (NL), Politecnico di Torino (I), Space Engineering (I), Ticra (DK), Thomson-CSF/RCM(F), Universita' di Siena (I) and Universita' di Roma Tor Vergata (I) have been busy around the ANTENNA DESIGN FRAMEWORK (ADF), today available in version 2 [6]. ADF is a complete industry-oriented computer aided antenna design system that includes the large majority of the tools listed above plus a number of numerical modelling tools. It offers full capabilities for the modelling of antenna interactions on the satellite, with MoM, PO-PTD, UTD and ITD; modelling of small complex radiating or guiding structures with MoM, BEM, FDTD and a few dedicated solvers; design of reflector and array antenna; analysis of distributed antenna systems; plus a full range of processing and visualisation capabilities, including the possibility to use a commercial CAD (Bentley Microstation for the moment) to model complex objects or import geometrical models. Finally, it incorporates a database that handles all design data and a procedural capability to ease repetitive analyses and run optimisation cycles using the general purpose optimisation engines mentioned above. In-house research activities, normally related to satellite projects, tend to concentrate on antenna design, however ad-hoc modelling techniques are often needed for the development of new antenna technologies or to cope with new design problems. Often these studies are carried out by trainees and in co-operation with European University groups. Recent activities have been focusing on millimetre and sub-millimetre antennas, in particular on the modelling of integrated antennas using photonic band-gap materials [7]; on the efficient modelling of large arrays (e.g. SAR) and on the modelling of waveguide elements and arrays, including their exterior (flange and wall), both using a hybrid integral-asymptotic techniques [6]; on the application of Genetic Algorithms to the design of conformal arrays.

In the coming years, the intention is to consolidate the results obtained until now to better support European space industry on the commercial market. This implies refinement and engineering of the most used design tools, as already started with GRASP and other tools from Ticra, and further work on the ANTENNA DESIGN FRAMEWORK, mainly to increase the cohesion among the several different modelling tools and make the user interface more flexible and appealing.

At the same time a lot is yet to be done on the modelling side. As space industry enters into the mature age, the need of "clever" tools increases. In a nutshell the demand is for electromagnetic solvers that combine the synthetic force of analytical methods with the flexibility of numerical ones. There are many sides to this requirement: easier to use and more "physical" tools, quantification of modelling errors, efficient use for parametric analyses, sensitivity analyses and optimisation loops; scaleable modelling capability (accuracy vs. running time) to satisfy the need of different project phases.

The desire for a system in which you quickly define the geometry, using the same parameters that matter in the design, and then start playing around to optimise the design is growing stronger and stronger. In other engineering field this is a reality and so it should in antenna design.

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MODELER'S NOTES

Gerald J. Burke

This column will again follow the pattern of presenting NEC benchmark results and some NEC–4 news. We seem to be stuck in this mode, but some new information that became available just after the last column was put in the mail has answered some questions raised by that data and demonstrated the importance of the compiler, as well as hardware, in determining code running time. Larry Laitinen, at the University of Oregon, is still swamped in work fixing up his house, but has provided new data on a Pentium-II and some technical information on the new systems. Also, Roy Lewallen has again found a minor inconsistency in NEC–4, this time involving array dimensioning, and the fix is given at the end of this column.

The last issue of Modeler's Notes contained some running times for NEC–4 on several Pentium and Macintosh systems. Some aspects of the data were difficult to explain, such as the 200 MHz Power Macintosh being more than twice as fast as a 200 MHz Pentium. Also, the Pentium Pro was considerably slower than a standard Pentium in filling the MoM matrix, although it was faster in factoring the matrix. Just after putting that column in the mail I tried compiling NEC–4 with the new DEC Visual Fortran compiler, and got very different results for running times. Microsoft had sold their Fortran Powerstation compiler, then at Version 4, to DEC around last March. DEC has kept the Microsoft Developers Studio front end, and promises to maintain compatibility with other Microsoft products such as Visual C++, but apparently has replaced the compiler with their own.

The DEC compiler seems to be as easy to use as was the Microsoft product. It compiles and links NEC–4 in about one minute on a 200 MHz Pentium MMX. That was linking as a Standard Graphics Project to take advantage of the feature of opening input and output files with dialog boxes. As a simple Console Project it compiled and linked in about half a minute. For comparison, the compile time on a Power Mac using the Absoft F77 V. 4.2 compiler was about 10 minutes (scaling my 66 MHz Mac up to 200 MHz). Also, the DEC compiler will compile NEC-4 as a single file, while the Absoft compiler on the Mac requires splitting the code into separate subroutines and building a makefile, even for the smaller NEC2. The time to compile and link with the DEC compiler was independent of the dimensioned size of the program up to 5000 segments, double precision. The code produced was reasonably compact, with NEC4D taking 900 KB and NEC4S taking 816 KB on the disk. The Absoft compiled code for the PowerMac was 660 KB for NEC4D and 649 KB for NEC4S, but since that is for a RISC processor, it is surprising that it is not more.

Running times for the double precision NEC4 compiled with the DEC and Microsoft Fortran compilers are compared in Table 1 for a 1200 segment problem run in double precision. The input data used for testing is shown at the end of this section, and is the same as in the last Newsletter. The DEC compiled code is seen to be almost a factor of three faster than the code compiled with the Fortran Powerstation compiler, with both compiled with full optimization. Some of the specific optimization options available in the DEC compiler seemed to make minor differences in speed, although I have not explored these options completely. The Microsoft compiled code used for the last Newsletter was compiled for a blend of 486 and Pentium optimization, but it can be seen in Table 1 that the difference between the blend and pure Pentium optimization is small.

Table 1. Execution times in seconds for NEC–4 compiled with the Microsoft Fortran Powerstation V. 4 and DEC Visual Fortran compilers. All codes were run on a 200 MHz Pentium MMX with Asus 430 TX chipset.

Compiler/ Options	N	Prec.	Matrix Fill	Matrix Factor	Total Exec.
DEC A	1200	D	41.19	363.39	411.17
DEC B	1200	D	38.44	164.84	207.95
DEC C	1200	D	33.45	167.80	204.98
DEC D	1200	D	33.45	164.83	202.02
Microsoft A	1200	D	68.93	511.85	586.71
Microsoft B	1200	D	67.67	510.59	583.91

Compiler Opt.	DEC A	DEC B	DEC C	DEC D
Optimization	none	for speed	for speed	full
Math library	–	checked	fast	fast
inline	–	no	for speed	for speed
loop unrolling	–	no	4	4
Allow reordering of f.p. ops.	–	no	yes	yes

Microsoft A = Full optimization, blend for 486 and Pentium
Microsoft B = Full optimization for Pentium

Table 2 shows the running times of NEC–4 for 300, 600 and 1200 segment test problems run on several different systems. The 200 MHz Pentium MMX and Pentium Pro systems were tested for the last Newsletter using the Microsoft compiled code, and showed a dismal performance relative to the 200 MHz Power Mac. The DEC compiled code is seen to about match the Mac code compiled with the Absoft compiler. The columns "Fill Ratio" and "Factor Ratio" show the ratio of fill and factor times to the next smaller problem, so ideally Fill Ratio should be 4.0 and Factor ratio 8.0 as the problem size is doubled. The Microsoft compiled code in the last Newsletter showed a ratio of 12.28 for factor time in going from 600 to 1200 segments double precision, and I had guessed that this might result from limitations of the Pentium's cache size or speed. However with the DEC compiled code this factor ratio is close to 8, so apparently if cache was involved, it was the fault of the compiler.

Table 2 also includes results for a 266 MHz Pentium-II that Larry Laitinen has tested. This P-II had the new LX logic chipset, while the P-II results for 299 segments in the last Newsletter were for a system with the KX chipset. Larry was disappointed in the relatively small increase in speed in going to the LX chipset. For the Lahey F77 code running the 299 segment test the fill time was 1.7% faster and factor was 5.6% faster with the LX than with the KX. However, the Lahey F77 code was compiled with 386 rather than Pentium optimization, so these results may not be reliable. Larry now has a Lahey F90 compiler, and while he has not had much time to play with the optimization options, he has compiled NEC-4 with basic optimizations and supplied results included in Table 2. The Factor time with the Lahey F90 compiler is about equal to the time for the DEC compiled code for 600

Table 2. NEC–4 execution times in seconds for the 300, 600 and 1200 segments with various processors and compilers.

CPU/Compiler	N	Prec.	Matrix Fill	Fill Ratio	Matrix Factor	Factor Ratio	Total Exec.
Pentium MMX, 200 MHz	300	S	2.31		1.59		4.45
Asus 430TX	600	S	8.41	3.64	13.07	8.22	22.41
DEC compiler	1200	S	32.08	3.81	111.33	8.52	146.87
	300	D	2.31		2.03		4.94
	600	D	8.73	3.78	18.23	8.98	28.29
	1200	D	33.45	3.83	164.83	9.04	202.02
Pentium Pro, 200 MHz	300	D	2.20		1.70		4.17
Gateway P6-200 XL	600	D	8.24	3.75	14.12	8.31	23.01
DEC compiler	1200	D	32.19	3.91	112.26	7.95	143.93
Pentium-II, 266 MHz	300	D	1.642		1.242		3.255
LX Chipset	600	D	6.109	3.72	12.878	10.37	19.819
DEC compiler	1200	D	23.574	3.86	104.009	8.08	130.107
Pentium-II, 266 MHz	300	D	3.343		1.390		4.942
LX Chipset	600	D	13.218	1.58	12.827	14.85	26.590
Lahey F90 compiler	1200	D	73.001	3.88	276.372*	–	358.557
Pentium-II, 266 MHz	300	D	8.439		2.089		10.774
LX Chipset	600	D	34.684	4.15	31.032	14.85	68.214
Lahey F77 compiler	1200	D	134.566	3.88	247.484*	–	392.533
PowerMac 8600, 200 MHz	300	S	2.547		1.453		4.688
PPC 604e Processor	600	S	8.766	3.44	12.133	8.35	22.469
	1200	S	32.680	3.73	96.039	7.92	134.102
same	300	D	2.969		2.148		5.945
	600	D	10.555	3.56	17.164	7.99	29.516
	1200	D	40.320	3.82	153.148	8.92	200.516
DEC Alpha, 440 MHz	300	D	0.700		0.280		1.090
Mod. 21164, ev56	600	D	2.720	3.86	2.470	8.82	5.560
Compile opt: -O5	1200	D	14.700	5.44	51.770	20.96	70.980

* Out-of-core solution, MAXMAT=1000 for Lahey compiled code.

segments, but the results for 1200 segments cannot be compared, since the Lahey code was using disk storage for the matrix.

The Pentium-II results in Table 2 are seen to be faster than the Pentium Pro, but not by as much as would be expected for the difference in clock speeds. If the P-Pro time for factoring the 1200 element double precision matrix is scaled to 266 MHz it would be 84.41 seconds, while the 266 MHz P-II takes twenty percent longer. I have not researched this issue, but Larry's information is that the L2 cache for the P-II is on a PC board and operates at half the CPU clock speed, while the P-Pro's L2 cache is on a second chip on the CPU chip carrier and operates at CPU speed. Intel apparently has tried to compensate by doubling the cache size from 256 KB on the P-Pro to 512 KB on the P-II, but the results will depend on the type of code. Tight code with high cache hit rates on a P-Pro may make the P-II look bad, and that apparently is the case with matrix factoring. Of course, you cannot get a

266 MHz Pentium Pro, but some people I have talked to are waiting for the next generation of Pentium rather than investing in the current P-II for modeling work.

The DEC Alpha result in Table 2 was supplied by Brian Grant, running NEC–4 on one of the Alphas in a 16-processor cluster at LLNL. I don't know if the unexpectedly large increase in factor time from 600 to 1200 segments is a result of a small and very fast cache or a system limitation on larger jobs. The system is mainly tuned for batch jobs. At least the times are close to the Pentiums scaled by clock speed. Of course the gigabytes of RAM on these Alphas offer a big advantage over PCs for large modeling problems.

Input data used in the tests for 1200 segments follows. For 300 segments the second GM command was `GMO,2,...` while for 600 segments it was `GMO,5,...`

```
CE Timing test - Multiple parallel wires,  1200 segments
GWO,10,0.,0.,0.,0.,0.,1.,.001,
GMO,9,0.,0.,0.,.2,0.,0.,
GMO,11,0.,0.,0.,0.,.2,0.,
GE
EXO,0,5,0,1.,
XQ
EN
```

Roy Lewallen has found a minor inconsistency in dimensioning in NEC–4 in the arrays for voltage sources. In COMMON/NETDEF/, the arrays SVOLTS and NVSORA should be dimensioned to NSOMAX rather than NETMX. The corrected common block is shown below, and of course, should be changed at every place that it occurs in the code.

```
      COMMON/NETDEF/TLYT1(NETMX),TLYT2(NETMX),YN11(NETMX),YN12(NETMX),
     &YN22(NETMX),SVOLTS( NSOMAX),TLZCH(NETMX),TLLEN(NETMX),NVSOR,
     &NVSORA( NSOMAX),ISEG1(NETMX),ISEG2(NETMX),NONET,NETYP(NETMX)
```

As usual, if anyone can contribute modeling-related material for future newsletters, they are encouraged to contact our editor Ray Perez or Jerry Burke, Lawrence Livermore National Lab., P.O. Box 808, L-154, Livermore, CA 94550, phone: 510-422-8414, FAX: 510-423-3144, e-mail: burke2@llnl.gov.

TOPICS IN COMPUTER MODELING AND SIMULATION: A BRIEF REVIEW OF CEM TOOLS AND METHODS

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ABSTRACT

This article provides a brief overview of representative software codes and analytical methods often used in Computational Electromagnetics (CEM) computer modeling and simulation tasks. The codes and techniques discussed in this article are for the most part applicable to large, complex system electromagnetics assessments which include, but are not restricted to: inter/intra-platform Electromagnetic Compatibility (EMC); Radar Cross Section (RCS); determining structural influences on antenna radiation patterns, operations, and performance; and various other electromagnetic field scattering problems. Many of the codes and methods can also be used to predict component-level (i.e., subsystem, PC board, or device) radiated emissions or coupling.

The information presented in this article is excerpted in part from a chapter on computer modeling and simulation published in a *Study Guide on EMC Principles, Measurements and Technologies* [1]. The chapter discusses the importance and benefits of performing computer modeling and simulation as a complement to implementing good design practices and performing measurements. The *Study Guide* chapter also covers proven modeling and assessment methodologies as well as future perspectives on computerized simulation technologies. The present article is a condensed treatment of this subject.

BACKGROUND

Significant progress has been made over the past twenty years in advancing the state of the art in computer-aided analysis technologies for electromagnetics applications. This has been heralded by advancements in computer hardware, distributed and parallel computing systems, and the availability of "new and improved" computational algorithms. This trend has underscored the importance of computer modeling and simulation in today's product development and acquisition cycles.

The application of computer-aided analysis tools in conjunction with validated test and repair methodologies, as well as judicious use of design specifications provide a "balanced" approach to the electromagnetics problem-solving task. Computer simulations are performed for large, complex systems to establish a complete matrix of all potential electromagnetic interactions. This approach aids the analyst in rapidly identifying problem areas early on in a system's design. Problems may be resolved through redesign together with conducting a focused verification, qualifications, or acceptance test program.

This article focuses on the analytical concepts and approaches associated with CEM modeling and simulation. Representative computer programs and engineering formalisms are identified in the course of the discussion. The concluding section also discusses the application of Artificial Intelligence (AI) and Fuzzy Expert System (FES) software technologies to electromagnetics assessments.

The details of the individual codes, engineering formalisms, and the specific application of modeling methodologies to electromagnetics problem-solving are not dwelt upon in this article. The information presented is primarily intended to familiarize the reader with the arsenal of tools and array of options available for CEM computer modeling and simulation, and to guide the analyst in the selection of appropriate software tools.

In the *Study Guide*, methods for characterizing complex electromagnetic systems and developing system/component models using geometrical parameters, performance measures, and representative figures of merit in the computer modeling scheme are described in detail. The reader is referred to the *Study Guide* for details concerning these topics.

PARTIAL LIST OF EM/FIELDS CODES

Depending upon the application and level of fidelity desired, one or more of the following software codes can be used to achieve the goals of the electromagnetics analysis, where these represent only a partial list of available tools available from government, university, and industry sources:

- Intrasystem Electromagnetic Compatibility Analysis Program (IEMCAP)
- Specifications and EMC Analysis Program (SEMCAP)
- Shipboard EMC Analysis (SEMCA)
- Co-Site Analysis Model (COSAM)
- Interference Prediction Process (IPP)
- Transmitter and Receiver Equipment Development (TRED)
- Nonlinear Circuit Analyst Program (NCAP)
- Precipitation Static (P-STAT)
- Numerical Electromagnetic Code-Basic Scattering Code (NEC-BSC)
- Numerical Electromagnetic Code-Method of Moments (NEC-MOM)
- Aircraft Inter-Antenna Propagation with Graphics (AAPG)
- WIRE Models (XTALK, FLATPAK, SHIELD, GETCAP, WIRE, etc.)
- Electromagnetic Compatibility Frequency Assignment (EMCFA)
- General Electromagnetic Model for the Analysis of Complex Systems (GEMACS) and the Graphical Aids for Users of GEMACS (GAUGE)/Model Editor (MODELED)
- Electromagnetic Compatibility Predictions Program (EMCP)
- MININEC (reduced version of NEC-MOM)
- Apatch
- Xpatch
- Carlos 3D.

In addition to these codes, other specialized tools based on Finite-Element Analysis/Modeling (FEA/M) mesh methods are available for analyzing low-frequency static, quasi-static, and dynamic magnetic field effects. Examples of tools of this type include: the 2D/3D MacNeal-Schwendler Electromagnetic Analysis System (EMAS); the Integrated Engineering Software Corporation's family of Boundary Element codes [ELECTRO (2D), COULOMB (3D), MAGNETO (2D), and AMPERES (3D)] used to model linear, nonlinear, and permanent magnet material effects; Ansoft's finite-element codes [MAXWELL 2D/3D], ANSOFT, and ANSYS. Table 1 lists other software codes and their basic characteristics (many of which are FEA/M based). These codes are designed to run on most computer mainframes, minicomputers, personal computers and workstations.

The list of available codes presented is by no means exhaustive. Furthermore, only general characteristics (i.e., applicability, physics formalism basis) are indicated (Note: this is presented for information purposes only and is not to be construed as an endorsement of any product or company).

The reader should note that circuit analysis tools such as PSPICE may also be used to further the objectives of the electromagnetics analysis. Such tools are typically used to study embedded circuit, internal connector, and PC board responses due to incident fields on systems, current sneaking and voltage build-ups, and other "internal cavity" coupling effects. This approach is part of the "top-down" and "bottom-up" approach often referred to in complex system electromagnetics "end-to-end" assessments.

For the codes listed in Table 1 as well as the additional codes mentioned above, reference was made in certain cases to the underlying physics formalisms and inherent numerical solution methods. While the individual codes and techniques available utilize a proven and well-established set of formalisms, these are not described in detail here (a list of helpful references for further, independent study is provided at the end of this article). The physics formalisms include, but are not restricted to:

- Boundary Element Methods (BEM)
- Method of Moments (MoM) (e.g., GEMACS, NEC-MOM)
- Boundary Element Methods (BEM)

Table 1.

Representative Electromagnetic Analysis & Prediction Software

SOFTWARE/APPLICABILITY	COMPANY/SUPPLIER
MagNet - handles electrical, magnetic, & eddy current analysis	Infolytica
Maxwell Engineering Software (including SI Eminence) - handles electrical, magnetic, eddy current, & microwave analyses with links to Spice CAD modeling capabilities	Ansoft Corporation
MSC/Magnetic, MSC/Magnum, & MSC/Maggie - handle electric & magnetic field analyses	MacNeal-Schwendler Corporation
Petfem - handles electric & magnetic field analyses	Princeton Electro-Technology, Inc.
WEMAP - handles electric, magnetic, thermal, & eddy current analyses	Westinghouse Electric Corporation
ANSYS - handles structural & mechanical design, & has magnetic field analysis capability	Swanson Analysis Systems, Inc.
IDEAS - handles FEA/M-based thermal, structural, electric & magnetic analyses	Structural Dynamics Research Corporation
Magnus - handles magnetic analysis	Magnus Software
TSAR - handles Finite Difference Time Domain (FDTD) electromagnetics analysis	Lawrence Livermore National Laboratory
XFDTD - handles Finite Difference Time Domain (FDTD) electric field analysis	REMCOM, Inc.
FLUX - handles electric & magnetic analyses	Magsoft Corporation
MARC/MENTAT - handles FEA/M-based electrostatic & magnetostatic problems with infinite boundaries	MARC Analysis Research Corporation
PE2D, Carmen, and Tosca - handle electric, magnetic, & eddy current analyses	Vector Fields, Inc.
Stripes - handles computer-aided engineering (CAE) and electromagnetics analysis using the 3D Time-Domain Transmission Line Modeling (TLM) technique	KCC, Ltd.
EMFIELDS-3D, EMFIELDS-2D, ENEC, and EMIT - collectively handle 2D & 3D Finite Difference Time Domain (FDTD) & Moment Method/wire frame modeling & analyses	Seth Corporation
Motive, XTK, Quiet, PDQ, TLC - collectively handle the electromagnetics modeling & analyses of PC board layouts & design using boundary element, time-domain finite element, & transmission line techniques	Quad Design
EMA3DF, EMA3D, EMA3DCYL, EMAEXT, and EMAFDM in addition to others - collectively handle electromagnetics analyses based on Finite Difference Time Domain (FDTD) methods (applicable to PC boards & devices, airframe structures & antenna radiators	Electromagnetic Applications, Inc.
MAFIA - handles electric & magnetic analyses based on Finite-Integration-Algorithm (FIA)	Computer Simulation Technology, Germany
EMIT - handles EMI & radiation analyses for PC boards to antenna structures based on a general, full-wave, 3D electromagnetics solver technique	Altium, an IBM Company
High-Performance Engineering Suite including EMC Advisor & CAD Toolkit - handle PC board electromagnetic modeling & analysis based on transmission line & time-domain modeling methods	Recal-Redac
em^{TM} - synthesizes Spice models & handles electromagnetics analyses for lumped models of complex circuits used in PC board layouts	Sonnet Software, Inc.
MEGA - handles electric, magnetic, & eddy current analyses	University of Bath, England

- Method of Moments (MoM) (e.g., GEMACS, NEC-MOM)
- Geometrical Theory of Diffraction (GTD) (e.g., GEMACS)
- Uniform Theory of Diffraction (UTD) (e.g., NEC-BSC)
- Generalized Multi-pole Technique (GMT) (Moment Method type)
- Multiple Muli-pole Technique (MMP)
- Transmission Line Modeling (TLM)
- Finite Difference Frequency Domain (FDFD) (e.g., GEMACS)
- Finite Difference Time Domain (FDTD)
- Time Domain Moment Method (TDMM)
- Finite Volume Time Domain (FVTD)
- Shooting & Bouncing Rays/Physical Optics/Physical Theory of Diffraction (SBR/PO/PTD)
- Conjugate Gradient Method (CGM)
- Geometrical Optics (GO)
- Hybrid techniques (e.g., MoM/GTD, PO/MoM, etc.) (e.g., GEMACS)
- Discrete/bounded/conservative models (e.g., IEMCAP, SEMCAP).

One of the main drivers in the modeling, analysis, and design task is to properly allocate and manage the frequency spectrum. This can be initially addressed by performing system-level culls using one or more of the codes listed above. In principle, one first executes the electromagnetics analysis procedure using a conservative approach. This can be accomplished using IEMCAP, for example. When problem areas are predicted, one may then apply more rigorous computer tools and refined techniques to verify the extent of the problems and their corresponding solutions.

Refined computational methods could involve the use of GO/GTD formalisms and model representations, for example. This involves the use of perfectly conducting flat plates, smooth circular or elliptical cylinders, ellipsoids, cones/frusta, and endcaps assembled to represent the actual structure of interest.

Generally, high frequency ray tracing methods are used to compute various electromagnetic interactions for the structure. These include: creeping wave effects, vehicle shading and surface losses, boundary shadowing, edge diffraction, and surface reflections. The GO/GTD example is illustrative of the methods employed by AAPG, and more rigorously by the GEMACS and NEC-BSC codes.

Similar examples can be given using MoM and FEA/M physics-based modeling techniques where wire frame models are used to compute surface currents and resultant electromagnetic fields, in lieu of the coarser method offered by the GO/GTD physics at high frequencies. As a general rule, MoM techniques are typically applied (a) at lower frequencies where mesh densities are manageable, (b) when the structure is not too electrically large, and (c) when higher modeling fidelity and prediction accuracy are desired.

Hybrid models can also be generated to predict the electromagnetic scattering among plates, cylinders, wire meshes, and so on. This method, provided by GEMACS for example, is often useful depending upon the type of geometries (objects) that must be modeled and level of fidelity desired as a function of frequency or wavelength.

The next step might be to investigate the effects of leakage fields, currents and voltage buildups on individual electronic and electrical components embedded within large, complex structures. In this case, a combination of FDTD, FDFD, MoM, and FEA/M techniques could be applied to first calculate the exterior structure electromagnetic fields, superimpose such fields on interior components and subsystems, and then compute induced currents or voltages at critical points. Again, many of the codes cited above can be used to study different parts of the problem ranging from the computation of exterior fields, and cavity-coupled responses (e.g., cable pickup, power distribution system interference, etc.).

FUTURE CONSIDERATIONS

Although the aforementioned codes and formalisms are generally considered mature and validated, further work is in progress to enhance their numerical accuracy; to incorporate new, empirically-derived physics models; and in some cases, to make them more user friendly. One such code is IEMCAP. For example, some modifications that are anticipated to be made to IEMCAP to meet the needs of the 21st Century electromagnetics analyst will focus on:

- Implementing non-average power receptor and coupling models.
- Incorporating more accurate in-band models for complex aperture and antenna coupling for UHF to millimeter wave frequencies.
- Incorporating scaling/bounding models for total energy penetration through inadvertent points of entry, particularly out-of-band antenna and aperture models.
- Integrating nonlinear effects/response models to account for transmitter intermods and associated spurious effects, receiver intermods, cross mods, etc.
- Improved intravehicular propagation models that employ rigorous GTD/UTD formalisms.
- Expanding the list of emitter modulation models to include sophisticated transceiver technologies (e.g., spread spectrum).
- Development and implementation of graphical user interfaces and 3D pre/post-processor graphical editors consisting of menu-driven front ends, tutoring features for inputting data and in-depth system modeling as well as display rendering.
- Encompassing codes within an AI/FES system framework which could adapt the results of one (or more) analysis code(s) for the purposes of additional detailed modeling and assessment of embedded circuit responses, and to facilitate automated communications with other tools (e.g., SPICE, CAD tools) or databases.

Many of the aforementioned codes (e.g., GEMACS' GAUGE and NEC-BSC's Graphical Workbench) have implemented graphical user interfaces and robust pre/post-processing environments in response to user needs.

The benefits to be reaped by including such enhancements include, but are not limited to: increased modeling power; versatility and solution accuracy; reduced manpower requirements for systems modeling; fewer modeling errors and error-related impediments; overall reduced costs; and more readily achievable systems electromagnetics specification compliance.

Although these enhancements will certainly provide benefits to the user community, the problems associated with up-front data gathering for electromagnetics modeling and analyses are likely to persist for some time. This may be alleviated by establishing an accessible, "common" database library on systems, subsystems/equipments, and their associated characteristics. This could be facilitated by establishing an "integrated computational environment" based upon a predefined data format and standardized database structure. Once accessed, pertinent data could be tailored or modified quickly without having to rebuild the entire system database between one electromagnetics application and the next.

It is also noted that investigations are in progress on the application of AI and FES software technologies for CEM modeling and simulation [2, 3]. The primary advantage of the AI/FES approach is its ability to infer values, conclusions, and/or relationships and to support both rapid model prototyping and decision making. This approach enables the AI/FES system to assist the analyst in preparing input data, analyzing results, quickly identifying areas of concern and resolving problems. Some of the methods and benefits associated with the application of AI/FES technologies are further discussed below.

AI/FES Technologies for CEM

The development of electromagnetics predictive software using AI/FES technologies is paving the way for a new generation of user-friendly analysis tools. The basic reason for investigating AI/FES technologies for CEM is straightforward and of little surprise - although powerful electromagnetics analysis/prediction tools exist, none alone are able to address the potentially broad range of classical problem-solving concerns and applications; moreover, it is often difficult if not impossible to "communicate" the results of one tool to another without developing a series of translators. AI/FES tools have been purported and demonstrated to accommodate rapid prototyping, analysis, and solutions of real-world problems. Certain AI/FES tools are also being designed in a manner that facilitates communications among various software tools as well as external hardware systems.

An AI/FES tool can also facilitate modeling and simulation enhancements in a building block fashion. This means that one can upgrade the capabilities of the tool as needed by refining a Knowledge Base (KB). Individual engineering/physics and modeling/analysis rules-of-thumb can be integrated to the degree desired within an FES "shell." The shell permits the analyst to define applicable boundary conditions and excitation quantities using a set of rules, procedures, analytical formulas, and so on.

The premise upon which the use of the AI/FES tool is based is the knowledge engineering approach which involves: (a) initially describing the application starting with "general" knowledge of the problem and (b) providing a more specific or refined description of the application in conjunction with describing its behavior and applying problem constraints. The actual "knowledge" contained within the KB is derived from a combination of mathematical equations and relational heuristics. In describing the behavior of the application, the user must define formulas; rules to infer or reason about values for variables; rules to execute actions; and procedures to execute sequential processes.

Rules are defined within a KB to establish the necessary heuristics. For example, rules can be specified to verify whether specified constraints exist between two or more objects. If certain conditions are met, then the rule concludes the appropriate relationship between the objects. Rules are "fired" on the basis of forward and/or backward chaining methods. This is analogous to "*if-then-else*" constructs employed in higher-order languages.

Expert Systems for CEM

Several knowledge based capabilities have been or are being developed for CEM purposes. These include, among others, the Intelligent EMC Analysis and Design System (IEMCADS), the NASA-Lockheed Electromagnetic Analysis System, the Intelligent Computational Electromagnetic Analysis System (ICEMES), and the Electromagnetic Environment Effects Expert Processor with Embedded Reasoning Tasker (E^3EXPERT). In several of these designs the expert system engine is integrated as part of a pre- or post-processor stage to (a) reason upon imported data, (b) generate the CEM model, (c) launch an external electromagnetics analysis process, and (d) perform additional reasoning on computed outputs.

Once external programs complete their computations, results are returned to the expert system. The KB then sorts through the data to determine the information that is most pertinent to the analyst. If concerns are predicted, the KB can draw upon its rule base to isolate the root cause of the problem and suggest a range of possible solutions. Results can be communicated to the user graphically or through dialog boxes.

Finally, methods are being developed to automatically convert Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) data into electromagnetic structure models. This is being done for the Initial Graphical Exchange Specification (IGES), facet files, and other CAD file formats (e.g., DXF, STEP, splines, non-uniform relational B-splines or NURBS) associated with a number of popular CAD/CAE packages. Intelligent rules are being applied to infer relationships between CAD entities and canonical CEM objects.

SUMMARY

The role, importance and benefits of computer modeling and simulation for CEM were briefly addressed in this article. Electromagnetic software codes available from government, industry, academic and international sources were listed, and a short treatise on the application of AI/FES technologies was provided. This information is intended to provide a general, informative guide for the electromagnetics analyst. It is meant to familiarize the analyst with the arsenal of tools available for CEM computer modeling and simulations. The reader is encouraged to conduct further research to determine the most suitable application of individual codes and modeling methodologies for specific problems of interest.

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Perspectives in CEM

"Share Your Knowledge and Expertise with Your Colleagues"

by
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The theme of this year's ACES conference is "Share Your Knowledge and Expertise with Your Colleagues". The first things that came to mind when I read this theme were education and students. There is a major paradigm shift going on in engineering education. The focus of academia is moving from faculty and their teaching to students and their learning. This shift includes ample room for faculty to combine research and teaching activities. It also encourages student and industrial participation in the learning process. I could write many essays on the topic of education but I want to take this opportunity to discuss educational opportunities for students as sharing our knowledge and expertise. We need to work together on this issue. There is a great shortage of graduate students in the USA today. While industry shows a need for more Masters and Ph.D. students they are also sometimes the ones who are snatching some of our best and brightest students! The discussion below is meant to start you thinking about recruiting and retaining students in a global way. Hopefully something written here will inspire you to help with these issues. A fundamental problem has been that engineering faculty tend to focus on "how do I find good students for my program" rather than "how do we encourage students to study computational EM in general". When I send one of my best undergraduates to work with a colleague, the favor is not necessarily directly returned, however if we all work to keep good EM students in school, even if not in our own program, the favor should eventually come back to us. We need industry's help here too! The following are a series of activities you might think about engaging in (if you are not already!).

1) **We need to be educating students about graduate school.** They need to hear this information from us, at a personal level. I encourage all of you to spend some time in every class you teach discussing the opportunities available in engineering graduate school. We need to make students aware that it doesn't take forever, that engineering graduate students often have their tuition paid and get a stipend, and that above all it is possible! Many of our students are simply not aware of the opportunities. Without a family history or friend in a program, how would you learn about graduate school? It is not so much a lack of interest as a lack of knowing the opportunity exists. You will probably be surprised by how little they know! An excellent way to discuss this is to introduce yourself to your students and tell them how you made it through. Unconventional stories are well remembered and often make the students think, "hey, I could do that". This is a powerful first step.

2) **We need to get students interested in electromagnetics, especially computational electromagnetics, as undergraduate students.** We need to get undergraduates active in and excited about research in electromagnetics. Many professors I spoke to agree that it is possible to get undergraduates involved in research studies and projects. The availability of commercial EM simulation packages makes it possible to engage undergraduates in significant studies. They may not be ready to determine what studies to do with which tool, but they are certainly capable of running case studies for a graduate student. If you have an NSF grant be sure to ask your program manager about Undergraduate Research Opportunities (REU's) and take advantage of the additional funding. If students have the opportunity to participate in a meaningful research project, especially related to industry, chances are they will at least consider graduate school.
3) **Integrate research and teaching in your program.** I encourage professors to offer open ended design courses. For CEM folk, teach a computational design course. Give your course a title like "Computational Engineering" so that you can draw more than just students interested in EM. The course can be centered around the design process (formulating an open ended question into a design problem, going through design review, teamwork skills, timelines, etc...) and you can just happen to use EM as the way to introduce design. There are many resources available on the web for team management type issues. Encourage design problems from industry. Ask them for problems that they wish they had time to look into but haven't been able to. Ask them if they will be email mentors for a group that picks up their problem. There are many internet "lists" to solicit ideas from.
4) **Ask our industrial partners to help out.** Use our graduate students as interns and fund them as research assistants while they are finishing their graduate work. Work with their professor to find a suitable graduate dissertation adding something new to the field that your company is interested in. If you know you want to hire the student, make them an offer that is good for when they graduate, so we can finish educating them. Volunteer to be on education advisory boards and share what will make the student's educational experience more valuable to your company.
5) **Finally, we need to start sharing our students more.** Some of my best students want to go to a different school for graduate work. I very much appreciate this desire. I encourage and help them to prepare their applications and explain how to find RA's in EM. We, as a community, need to get better about doing this more formally. I am working on developing a web database that CEM professors and students could submit "ads" to. It is still in the early stages so I can't give you an address yet but I will let you know as soon as it is set up. The idea is that if I am looking for incoming graduate students interested in computational EM, I could post an ad encouraging students to look at my web site and then contact my students and myself if they are interested in my group. Students could post that they are interested in graduate school in EM and list the schools they have applied to as well as giving their web address. There are a lot of details to be worked out, but it is a start.

There is much more to be said on this topic, but hopefully I have given you a few things to begin thinking about. Thank you to the numerous faculty and industrial people who had discussions with me about this topic. Please feel free to email me ideas and/or comments on the issues of recruiting and retaining more EM graduate students.

The Practical CEMist

-Topics in practical Communications -

For this Practical CEMist installment, R.P. (Bob) Haviland, W4MB, has contributed a discussion of "Attaining design antenna performance in parasitic arrays." Bob reports that he worked on the method described in the paper when some of his HF quad antenna designs achieved their best front-to-back ratios substantially distant from the design points. He found part of the problem to the analysis software. In addition, the rest was traced to interaction with the X-frame supports used in the antenna construction. This led to a quad/co-planar Yagi element design which seems to provide an improvement in both gain and bandwidth.

Bob doesn't claim that the method is absolute, but the tests he has made suggest that it has merit. He invites feedback and constructive comments both from experimenters with a good antenna range available and practical CEM modelers interested in problems of this nature.

We will endeavor to find a time and place for an amateur radio social event at the upcoming ACES conference, 16-20 March 1998 in Monterey, CA. If you want to be included in the e-mail distribution list when these plans are finalized, please drop me a note at your earliest convenience.

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ATTAINING DESIGN ANTENNA PERFORMANCE
in Parasitic Arrays

R. P. Haviland, W4MB

Keywords: Antenna performance, Antenna calculations, Antenna measurements

Abstract

This paper describes a design, construction and test method intended to ensure that calculated parasitic antenna design performance is attained in physical antennas. The method is based on calculation of resonant frequencies of each antenna element, and measurement and adjustment of the resonant frequency of the physical elements as constructed and mounted. A further set of calculations and measurements can be made to give added confirmation of adjustment correctness.

Introduction

Especially in the field of amateur antennas, there is always a doubt that the antenna, as constructed, is performing properly. This is especially true if a small back-lobe is important, the most difficult antenna item to control, and one of increasing importance to amateurs as band use expands. Lacking measuring equipment, an antenna range, and even time, all that can be done at the usual amateur station is to depend "on the air" observations and reports, or at most, "on the air" measurements. Because the amateur bands are usually crowded, interference adds to the normal problems of antenna measurement. And if the conclusion is that performance is poor, considerable work is involved in correction.

The method described here was developed in an attempt "to get it right the first time". The method combines additional calculations during the design phase, and a set of measurements during construction. The calculations should be made with the "real earth"option, using the best estimate of ground conditions available [1,2].

Design Phase Additions

After a design of desired performance for the antenna at the design height is secured by use of NEC or the new MiniNEC or one of the commercial versions of either, proceed to the added set of calculations. These are based on use of a "grid dip" meter and a frequency-counter, used to measure and adjust the resonant frequency of each antenna element [3]. For calculation, each individual element is placed at the height to be used in the test phase. This can be any convenient height, but preferably at least 0.2 wavelengths above ground (greater than 12 feet at 20 meters), and as clear of other structures as possible.

Each element in turn is placed at the test height for the measurement phase, and its impedance is calculated at two frequencies. Interpolation or extrapolation to zero reactance gives the resonant frequency, and is easily done graphically. Additional calculation at this frequency can be used to increase accuracy.

Note that it is not necessary to consider such factors as element taper corrections or boom and clamp corrections. However, it is probably best to include these steps, and to use the results during construction as a time saver. Be sure that the design leaves room for adjustment, preferably by sliding joints rather than using hacksaws for "Yagi" tubing or spreader holes for quad element support.

Construction Phase Additions

The change in construction is to obtain a measurement of element resonant frequency, element by element. Mount the boom at the calculated height, and mount the element using all hardware. The measurement of resonant frequency by a grid- dipper is easiest if a special dipper coil is constructed for each band, shaped like a wire coat hanger [3]. The frequency counter is necessary to get sufficient accuracy. If it isn't sensitive enough for direct pickup, use a coax to a short probe near the dipper tuning capacitor.

If the measured resonant frequency is different than the calculated one, adjust the element length until they are the same. Then de-mount the element and proceed to the next one. Be sure to mark them so they will be returned to correct location when the antenna is finally assembled.

Sources of Problems

The most likely problem arises from the values of ground coefficients used. Review these, and consider trying to measure the conductivity [2,4]. You might like to try two test heights: try also the comparison between them for a few values of ground constants used in calculation. The influence of the ground is reduced as height is increased. It should be reasonably small for heights greater than 0.2 wavelengths.

Another source of problems is reflections from nearby objects,which includes buried wires or metal, and the person doing the measurement. Placing the instruments on a wooden step-ladder and reading by field glasses should reduce the problem. If work must be stretched over several days, you might consider making certain that the soil is damp, and use damp soil curve data for soil parameters.

Optional Confirmatory Steps

The calculations to be made, if the confirmatory steps are to be used, depend on the test equipment available [3,4]. Some possibilities are:

Equipment	Calculate
Station SWR meter	SWR vs frequency
Impedance Bridge	Drive impedance vs frequency
Field Strength Meter	Front and back Near field, at a convenient location on the axis of symmetry
RF Current Probe or RF Ammeter (4)	Element currents.

If necessary, the test and associated calculation can be with the boom vertical, with the reflector at the bottom and at least 2 feet above ground.

Additionally, calculate ratios to a reference point or element, since absolute values are difficult to measure. If a single frequency is to be used, make it the frequency of maximum F/Bratio. The remaining problem is linearity. This can be checked by running the tests at two or three power levels. The ratios should not change much as the level changes.

When this optional step is to be used, completely assemble the antenna, mount it at the test height, make the measurements, and compare with calculations. SWR and impedance values are likely to be close to calculated values. The most sensitive to mis-tuning should be the F/B ratio of the near field, but this is likely to be most affected by local objects, and be the most difficult to measure. It is not easy with the antenna mounted vertically.

If the measurements do agree, go ahead. Otherwise, do some cogitation about revision of calculations and measurements. Since this is in the nature of a confirmatory step you may decide to ignore the difference and go ahead, expecting better performance that by using the conventional approach, and being no worse off than the usual step of retuning based on tests at final altitude.

Results of Experience

There is no antenna range in the author's area. All experience so far is from back-yard measurements and on-the-air S-Meter readings. The added steps have helped move the maximum F/B values for two and three element quads to the design frequeny, or nearly so, and have explained why the original designs were so far off.

However, because of this lack of rigorous tests, all that really can be claimed of the technique at present is that it is promising. If you try it, the author would be interested in results.

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PATENT FUNDAMENTALS FOR ACES MEMBERS (PART II)

By Ray Perez

In my previous article concerning patent fundamentals we discussed the basics that we needed to know in order to find out if we had a credible patent and the procedures to follow to submit such a patent. In the second part (Part II) of this series of articles we were planning on addressing the particular subject of software patenting, a subject which I think is of great importance and curiosity to ACES members. However, I have decided to postpone the subject of patenting software till the next issue of the ACES Newsletter, and it will be called Part III. I have decided instead to write about two US Congress legislative bills which are presently under consideration which would produce, if approved, the most significant changes in the US patent laws since 1836. The discussion of this is important because these changes are significant enough to alter the flowchart we submitted in the previous issue of the ACES Newsletter. These new amendments will put the US Patent system in a more compatible way with other international patent laws.

The House of Representatives has passed H.R. 400 and the Senate Judiciary Committee reported legislative bill S.507. Both bills address the issue of something called "submarine patents". These bills were written and proposed at the urgent pleas for reform in the US patent process. The proponents of reform argue vehemently that the present system is chaotic. In theory, the patent procedures in the present US patent system (see flowchart in previous issue of ACES Newsletter) are designed to protect and reward the impecunious but ingenious solo inventor. In practice, the proponents of reform argue that these procedures tend to bestow the biggest rewards on a small number of individuals who are ingenious enough to manipulate the present system to their advantage.

Before we discuss the concept of submarine patents we outline other more bureaucratic proposals that are also part of the same legislative bills. Under title I of S.507, the US Patent and Trademark Office will become a governmental corporation headed by a director who would serve the US president. This corporation would still be under the auspices of the US Commerce department but liberated from many of the bureaucratic restraints that contribute to the delays and red tape that make the issuance of patents longer than necessary. Several patents and trademark offices should be formed and the commissioners of these separate offices should propose government changes subject to director oversight. Under H.R.400 Congress retains fee setting authority. Both bills include a management advisory committee of private citizens.

Now let's talk about the most important changes in the patent laws that deal with the so called submarine patents. What is a submarine patent? It's a patent submitted into the system with the sole purpose of serving as a "hook" for filing future patent infringement claims against a party that is not knowledgeable of such a patent. The Wall Street Journal recently published an article about a classical example of submarine patents. The article dealt with Mr. Jerome H. Lemelson, a prolific inventor in the field of photonics. Mr. Lemelson was a great inventor with about 500 patents (which is actually a word record) in his long career. The peculiar thing about his patents is that he never tried to commercialize any of them by raising capital and development products. Rather, he used his patents in the very profitable business of patent infringement claims. In 1992 he persuaded a Japanese automobile manufacturer to agree to pay him more than $100 million to avoid being sued for infringing on a portfolio of machine vision and image processing patents he had filed over a period of 30 years. Afterwards, he became involved in litigation against the main three US automakers over the same patents. This made the patent itself a measure of value rather than the products derived from the patents. These situations happen because the present US patent system allows an inventor to keep a patent application secret for as long as it takes the US Patent Office to act on it. This can be a very long time, and it can be intentionally prolonged if the inventor chooses to amend, re-edit, re-amend, and revise the patent after it has been filed. A company can spend a substantial amount of capital developing a product, only to learn that a similar and prior invention has already been patented without the company knowing anything about it. When the patent surfaces, the company faces the choice of either paying stiff licensing fees or becoming involved in costly litigation.

The patent reform legislation would eliminate these so called submarine patents by requiring that applications be published 18 months after they have been filed, even though the application has not been processed yet by the US Patent Office. This change would put the US in conformity with practices in Europe and Japan. Though this reform is supported by most businesses and the patent office itself, it is opposed by small inventors since it is their view that disclosing patent applications after 18 months of applying is an invitation for big corporations to figure out ways to re-engineer around the original patent, which as we discussed in the previous issue of the ACES Newsletter, is a valid way of filing for other patents. Under certain conditions and at the request of the patent owner the disclosure of patents could be delayed up to 5 years in the proposed system.

Title IV provides accused patent infringers with a defense and a royalty free license if they can prove that they were using the patented subject matter before the original application was filed. Some affirm that this decreases the motivation to file for patents. Others contend that this protects innocent parties to whom it never occurred that the subject matter was patentable. Title V provides for expanded third party participation in re-examination. If a newly discovered prior patent raises a substantial question on patentability, a competitor can request the patent office to review this new patent against the old patent. Currently, only the old patent owner has standing before the patent office, once the re-examination begins. A competitor, under the new reform, may file observations during the re-exam. This could bring more equity into the re-examination process; others think that this would allow competitors a way to harass patent owners.

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