APPLIED COMPUTATIONAL ELECTROMAGNETICS SOCIETY (ACES)

NEWSLETTER

Vol. 4 No. 3 December 1989

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EDITOR'S COMMENTS

The editorial describing users groups for various EM computer codes is the first salvo of an initiative that has the potential to be extremely useful to code users. You will be receiving a separate mailing on that subject. This Newsletter issue also contains a description of a new method of moments code, and several other articles which I hope you will find interesting.

As always, I need Newsletter material from you: the ACES members. We are therefore offering a little bonus to Newsletter contributors as described in this issue. So write up modeling notes and other useful information and send it in. Feel free to call me for any discussions at (404)431-9494.

Paul Elliot
Newsletter Editor

ACES NEWSLETTER COPY INFORMATION

Issue	Copy Deadline
December	October 25
March	January 25
June	April 25
September	July 25

Send copy to 2817 Hall Drive, Smyrna, GA 30080 in the following formats:
1. A hardcopy.
2. Camera ready hardcopy of any figures.
3. If possible also send text on a floppy disk as a Microsoft Word, WordPerfect, or Wordstar file. If none of these three wordprocessors are available, then send it on a disk as an ASCII text file or in generic wordprocessor format. However in these last two cases please use as few carriage returns (hard returns) as possible (let the text wrap around). If it's not possible to send any electronic version at all, then please be sure the hardcopy is a good one (preferably camera-ready) so it can be scanned.

BERNE COPYRIGHT CONVENTION

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.

BONUS FOR WRITING NEWSLETTER ARTICLES

"Every man owes a part of his time and money to the business or industry in which he is engaged. No man has a moral right to withhold his support from an organization that is striving to improve conditions within his sphere." — Theodore Roosevelt

As has been often mentioned, each issue of the ACES Newsletter is looking for a few good articles. In addition to offering the opportunity to share your knowledge and experience, ACES will now also offer the following:

1. Photo and short biographical sketch of author will be printed.

2. Copy of all preceding modeling notes and technically oriented articles which have appeared in the Newsletter will be sent to author.

3. For accepted feature length articles the author may choose either a one year free membership to ACES, or a $50.00 discount on any software from the list below.

SOFTWARE	PRICE
NEEDS	$ 140.
NEEDS upgrade	$ 65.
MININEC (incl. GRAPS & Manual)	$ 45.
MININEC Fortran (no documentation)	$ 5.
Norton Commander	$ 49.
Norton Utilities, regular	$ 55.
Norton Utilities, advanced	$ 81.
Rightwriter	$ 76.
DESQVIEW 2.2	$ 69.
DESQVIEW 386	$ 109.
XTREE Pro (Disk Mgmt.)	$ 66.
Any software in ACES Lib.	$2 to $5 typical.

All pieces are encouraged although only feature length articles accepted for publication will receive the $50 software bonus or the free membership. The types of articles of interest include the following:

* Successful or unsuccessful EM computer modeling attempts.
* Hint, shortcut, observation, idea, or tip for EM modeling.
* Description of software you tried for modeling, plotting, graphics, technical word processing, etc.
* Description of computer program you wrote or modified.
* Description of meeting, symposium, or workshop.
* Computer graphics showing fields, currents and other EM observables.
* Discussion of algorithms and methods used for computational EM or computer hardware issues.
* Suggestions of how ACES could facilitate computational EM work.
* Book review.
* Any other article of interest to ACES members.

Send material to: Paul Elliot, Editor, ACES Newsletter, 2817 Hall Drive, Smyrna, GA 30080. Phone: (404)431-9494.

EDITORIAL

NEW USER'S GROUPS FORMING

The ACES Publications and Annual Symposia have been highly successful in maintaining a unique and much-needed focus on computational electromagnetics. However, if ACES is to maximize its responsiveness to the computational electromagnetics "practitioners", we must provide more than just a place to present and publish papers (and an excuse for an annual trek to Monterey). A unique focus is not enough; unique technical activities and member services are also needed.

In this light, it is useful to note that ACES began as a user group for the Lawrence Livermore (LLNL) Method of Moments Numerical Electromagnetics Code (NEC). This group met in 1985 as the first annual review of numerical electromagnetic code applications. Since that time, our membership has expanded to include many users of various other codes, some of which have widespread utilization.

In keeping with our original purpose, ACES is now forming user groups for these other codes. These user groups will provide code users with the support they would like and code developers with the infrastructure they need to deal with numerous users. Success in this undertaking will encourage other computational electromagnetics "practitioners" to join with us.

The details regarding user group formation and proposed activities will soon be sent to you. However, it is necessary to restate a key point: that no user group will be formed for a given code until a reasonable number of members indicate a desire to do so. Therefore, don't delay in indicating your interest in a particular code and corresponding user group -- or the group may never get formed. An enthusiastic response will indicate that ACES-sponsored user groups are an activity which the membership wants and supports.

Christopher C. Smith
Paul Elliot
James C. Logan

LETTER TO THE EDITOR OF ACES NEWSLETTER

The editorial on EM Education by James C. Logan appearing in the ACES Newsletter, Volume 4, No. 1, accurately focuses on some very important issues for ACES. EM Education is indeed in a critical situation nationwide and with the exception of a few institutions we continue to see a decline in 1) the number and variety of EM courses in the required undergraduate curriculum, 2) the number of electives for undergraduates and 3) opportunities for undergraduates to obtain some practical and exciting EM experiences. Each of these contributes to the decline not only in BS level EM Engineers but the real decline in US citizens enrolling in graduate education in EM.

Jim Logan concludes his editorial with some challenges to ACES. We believe the response to his questions should all be in the affirmative. ACES should indeed become involved in the development of CAEME. ACES members and most of the papers presented at the annual conference as well as those appearing in the ACES publications are real EM ENGINEERING! We believe that Engineering Departments should concentrate more on the engineering aspects of EM, leaving much of the abstract theoretical concepts to the Physics and Mathematics Departments. What better group than ACES could contribute to the enhancement of the engineering in EM? ACES members routinely treat the engineering aspects and can share these experiences and most importantly graphical oriented tools with the curriculum developers and implementers.

It is difficult at this point in time to recommend whether ACES short courses as presently structured are the appropriate vehicles for contributions to EM Engineering education. What we strongly urge is that an ACES Committee on EM Engineering Education be established before the next meeting with a charter to explore the depth of the problem, to develop strategies for the ACES membership to help in curriculum development and implementation and to coordinate ACES activities with related groups such as the PGAP Education Committee. We do not believe that there will be a duplication in efforts or results since our thrust should and would be more engineering oriented, concentrating on the applications solutions.

Prasad Gogineni
Julian Holtzman

Electrical and Computer Engineering
Learned Hall
University of Kansas
Lawrence, Kansas 66045

LETTER TO THE EDITOR

Several members have expressed to me their concerns that ACES might become another IEEE/APS and thereby lose much of its uniqueness and purpose. This concern is somewhat reinforced by our de facto character as a USA-based "high-frequency applications society", at least as seen by members of two other (informal) computational electromagnetics groups.

Representatives of these two groups have expressed interest in cooperative activities with ACES. As an official, organized professional society, we can accomplish many things with (and for) these two groups as we simultaneously enhance our own stature. In turn, this requires that we expand our own horizons as an INTERNATIONAL and INTERDISCIPLINARY professional society. From these roles derives much of our strength.

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To maintain our uniqueness and purpose and to maximize our responsiveness to unfulfilled needs, it is necessary that ALL OF US continue reaching out to individual professionals in various countries and with diverse areas of application-interest. Furthermore, while I enthusiastically support joint ventures with the IEEE/APS (as some of you have proposed), it is imperative that we establish similar ties with other professional societies in electrical engineering, physics, mathematics, and computer science -- to include those societies outside the United States. The ACES publications team has helped pave the way, but much remains to be done (and will happen only with active support from other ACES members).

In addition, it will be helpful if each member thinks of ACES as a society with interests including, but extending far beyond, radiation, propagation, and scattering. To think otherwise might place certain opportunities beyond our grasp. Even worse, if we impose unneccessary "boundary conditions" which inhibit the cross-flow of techniques among various areas of application, there will be no winners.

David E. Stein

OFFICER'S REPORTS

PRESIDENT'S REPORT

A most important ACES event will occur in the month of December. We will hold our first election by mail. We have embarked on this course to give everyone the opportunity to participate in the elections of officers. In past elections, only members present at the Symposium could vote. There was no provision to cast an absentee ballot. Elections by mail will also increase the time available for giving papers at our Symposium by reducing the time required to conduct ACES business during formal sessions. To be successful, however, we need the fullest cooperation of every member. I know that casting a ballot, especially this time of year, is not the first thing on your mind, but it only takes a few moments to make your choice and mail the ballot.

The Nominations Committee has submitted at least one name for each office. Information on each candidate is printed elsewhere in this Newsletter and will also accompany the ballot blanks in the mail. Write in candidates will be considered and spaces will be provided for them on the ballots. Please take the time to consider the candidates and cast your vote.

Try as we may, we have been having some difficulty with our publishing schedule. It is important for the success of our organization to publish regularly and on time. Our goal is to provide the most up to date technical information we can, keeping the lead time to publish papers as short as practical. It is especially important in the case of the Newsletter to publish on time so that information regarding ACES activities is available well before an event or a deadline. To this end, I have imposed changes in the publishing schedule which will require earlier submission of materials. The deadline for submissions for the March Newsletter will be January 25, for the June Newsletter April 25, and for the September Newsletter July 25.

There is a movement afoot to form computer code users groups under the auspices of ACES. The details are presented elsewhere in this Newsletter. Briefly, the users groups would focus on the issues relating to the application of particular computer codes. They will provide a source of code-specific user guidance and a mechanisn to efficiently pass along suspected problems from users to code developers and fixes from code developers to users. Chris Smith of Kaman Science Corporation in Colorado Springs, CO has volunteered to organize this effort. I expect time will be allotted at the ACES Symposium for the initial meetings of users. If you wish to get involved, please contact Chris Smith at (719)599-1500.

A few individuals have asked about forming local chapters of ACES. Is there any interest? If so, what would be the purpose and major activity? Is there enough local interest within a given city or a 100 mile radius, for example, to warrant a formal local or regional chapter? If you have a strong opinion on this subject or wish to help get this idea off the ground, please write a letter to the Newsletter Editor or contact me.

In closing, I want to wish everyone the very best during the Holiday Season and throughout the next year.

James C. Logan
ACES President

SECRETARY'S REPORT

This issue was produced using an HP ScanJet Plus with Aldus PageMaker 3.0. We are still lacking a good scientific/math font package that is compatible with Windows and PageMaker so we can redo equations as needed. (You Macintosh owners will rightfully chuckle at our struggle in this area, but we PC jocks have the edge over you in "real computing"). Any suggestions are most welcome. Cut and paste (with slips of paper) doesn't hack it for 4 Newsletters and 2-3 Journals per year.

The NEEDS 2.0 fixups are still being generated thanks to users who are willing to share their findings with us. By 15 January, we will distribute those which have been verified to current NEEDS 2.0 owners.

Richard W. Adler, Secretary

TREASURER'S REPORT

The ACES funds are divided into three separate bank accounts. ACES Main, ACES Editor, and ACES Secretary, to make transactions easier for the primary individuals carrying out monetary business, the secretary, editor and the treasurer. The treasurer keeps track of all monies and balances to these accounts as well as CD's and savings accounts. Balances follow for all accounts as of 31 October 1989:

ACCOUNT	CHECKING	SAVINGS
ACES Main	$ 5,086.40	$ 2,365.98
ACES Editor	$ 3,165.69	$ 25.00
ACES Secretary	$ 2,302.77	$ 25.00
CD #1		$10,510.61
CD #2		$10,510.61
SUB-TOTALS	$10,554.86	$23,437.20

Income-Expense activities follow for the year-to-date (1 January 89 to 31 October 89) for all three accounts.

MAIN ACCOUNT
Category Description

INCOME	
Advertising	200.00
Banquet Reservations	1,056.00
Cash Deposit	1,000.00
Transfer from CD	51,393.75
Outgoing Collection Item	747.88
Conference Registration	27,933.00
MFCU Dividends/Interest	502.36
Journal Sales	105.00
Membership	7,750.00
Miscellaneous Sales	6.00
NEEDS Sales	5,095.00
Proceedings Sale	1,940.00
Refund or Return to ACES	249.00
Transfer from Savings	100.00
Short Course Registration	6,237.00
Incoming Wired Funds	155.00
TOTAL INCOME	104.469.99

EXPENSES

Advertising Expenses	1,669.38
Awards Costs	95.55
Cash Withdrawal	1,000.00
Transfer to CD	30,000.00
Conference Printing	16,599.23
Conference Proceedings	790.00
Conference Refreshments	2,676.55
Conference Secretaries	2,337.00
Conference Supplies	1,570.21
O'Draft Fee	1.00
Editor Expenses	359.62
Transfer to Editor Acct.	2,000.00
Entertainment	452.79
J/NL Mailing	233.00
J/NL Printing	11,131.84
J/NL Secretary	2,092.95
J/NL Supplies	2,197.65
Postage Mailing	268.00
NEEDS Mailing	586.56
NEEDS Printing	112.70
NEEDS Secretary	1,404.38
NEEDS Supplies	470.11
Opening New Checking Accts	7,070.00
Office Equipment	4,525.68
Office Supplies	916.77
Printing and Xeroxing	394.78
Refund to member	420.00
Special Issue Printing	4,446.70
General Secretary Work	3,120.50
Short Course Instructors	3,820.00
Short Course Supplies	76.37
Computer Software	104.94
Taxes	1.70
Not Categorized Expenses	333.96
TOTAL EXPENSES	$103.289.92
OVERALL TOTAL	$1,180.07

EDITOR
Category Description

Income

MFCU Dividends/Interest	100.29
Transfer from ACES Main	2,000.00
Opening new Checking Acct.	3,500.00
TOTAL INCOME	$5,600.29

EXPENSES

Postage Mailing	1,617.87
Office Supplies	58.97
Stationary	264.77
Advertising Expenses	220.00
MFCU Service Charge	32.41
Telephone Expenses	240.58
TOTAL EXPENSES	$2,434.60
OVERALL TOTAL	$3,165.69

SECRETARY
Category Description

INCOME

MFCU Dividends/Interest	105.20
Opening new Checking Acct.	3,500.00
Refund or Return to ACES	10.84
Not Categorized Income	0.00
TOTAL INCOME	$3,616.04

EXPENSES

Advertising Expenses	195.00
Postage Mailing	14.00
NEEDS Mailing	11.12
Office Supplies	121.47
Printing and Xeroxing	214.44
Computer Software	716.75
MFCU Service Charge	40.49
TOTAL EXPENSES	$1,313.27
OVERALL TOTAL	$2,302.77

James K. Breakall

COMMITTEE ON ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS
(ad hoc)

As I am writing this there has been very little time for anyone to respond to my Letter to the Editor in the September 89 Newsletter. Let me share some more thoughts and experiences in this area.

It might seem illogical for those of us who are concentrating on analytical solutions to EM modeling problems to even consider the world of inexact solutions of AI. But the theories and tools being developed in the Expert System and Neural Network subtopics of AI are being used effectively in high-tech areas. Some books I found useful in exploring possibilities of AI for EM modeling are:

Crash Course in Artificial Intelligence and Expert Systems by L.E. Frenzel, Jr. , published by Howard Sams and Co.

A Guide to Expert Systems by D.A. Waterman, published by Addison-Wesley Publishing Co.

A number of Expert System and Neural Network shells are coming to the market place at reasonable costs. These shells allow one to be both knowledge engineer and programer without a great deal of knowledge or experience in AI. I have been experimenting with products from two companies:

KnowledgePro from Knowledge Garden, Inc. Nassau, NY.
NeuroShell from Ward Systems Group, Inc., Fredrick, MD.

This is not a particular endorsement for either of these products. They appeared in the magazine I now read on a regular basis (IEEE Expert, AI Expert and PC AI), got decent reviews and have a reasonable price tag. When I get a little farther into their use in EM Modeling I will put together a report for the ACES members.

I teach a couple of courses here at Ball in EM for non-RF engineers and even for non-engineers. I am developing a computer based version of these programs using the KnowledgePro package. This looks particularly attractive for instruction or information communication as it couples Hypertext, Expert Systems and Graphics capability into a single program. I can see this replacing the traditional text book or paper with a method giving more student/reader interaction and "live examples" of the ideas being presented. This appears to fit our slogan "The Link Between Developers and Users of Computational Electromagnetics Techniques".

With Virginia Stover's column from the computer scientist point of view and mine from an EM engineer point of view possibly we can spark some interest in applying this new and rapidly advancing area to EM modeling and the ACES mission.

Your interest, experience, etc. inputs are solicited as we feel our way through this new area for ACES. Possibly we should start thinking about a special session at our March 1990 meeting in Monterey.

Wayne Harader
Chairman, ad hoc, AI and Expert System Committee
Ball Communications System Division
10 Longs Peak Dr.
PO Box 1235
Broomfield, CO 80020-8235
(303)460-2289

PUBLICATIONS COMMITTEE

Imagine being able to read about the latest and greatest computational electromagnetics techniques in "digest" form without having to subscribe to several different publications and without having to read numerous papers in detail! Further suppose that in this era of information overload, a critical analysis of these techniques, from the standpoint of actual application, can help you separate "signal" from "noise."

Conversely, if YOU have developed new computational electromagnetics techniiques which are worthy of immediate, widespread, and interdisciplinary usage, think of the possibilities which such a "digest" can offer.

Imagine being able to "compare notes" with other users of your favorite codes — to the point of learning about newly-discovered bugs, fixes, limitations, and capabilities! If your experience with a particular code of interest is limited, imagine having ready access to experienced users as well as to code utilization guidelines and tutorials. Think about how published sample runs (I/O listings) and solved problems can benefit you, even for those codes with which you are already proficient.

On a related matter, imagine having, at your fingertips, published peer-reviewed software, comparative evaluations of code capabilities and limitations, and measured data (to support code validation efforts)!

Better yet, think about the labor-saving potential of published numerical grids for commonly-studied electrmagnetic scatterers and components — particularly for those members who do not have automatic (computer-generated) gridding capability! (Even if you do have automatic gridding capability, you may still have interest in validating its performance and in "comparing notes" with other users). Although certain grids cannot be made public, many others can be.

Imagine having all of these things, together with the latest news on I/O innovations and on hardware capabilities and limitations for particular electromagnetics modeling codes.

Best of all, imagine a world in which computational electromagnetics provides far greater insight into physical mechanisms — and becomes less of a lackluster exercise in "re-inventing the wheel".

Your publications team is working to make these great things happen. Already, Chris Smith has taken the lead in establishing new code user groups and in forging links with existing groups. Ruediger Anders is devising a new ACES Modeling Short Note Form which will serve as yet another cornerstone for the ACES Newsletter. Although the "Digest Project" has yet to be launched, Ed Miller has already pointed the way, in a sense, with "A Selective Survey of Computational Electromagnetics" (published in Vol. 2, No. 1 of the "old" ACES Newsletter). Several Editors — Adalbert Konrad, Hal Sabbagh, Wes Williams, Peter Excell, and Pat Foster -- have been arranging cooperative efforts with other professional societies and informal groups. (Jim Logan, Ed Miller, and Stan Kubina are doing likewise, in their capacity as ACES officers.) In addition, Wes Williams is arranging the inclusion of the ACES Journal in abstracting/indexing services. Meanwhile, new special issues of the ACES Journal are beginning to take form, under the leadership of Hal Sabbagh and Fulvio Bessi.

With the ACES Journal and the ACES Newsletter becoming highly acclaimed, we are also grateful for the efforts of Managing Editor Richard Adler, ACES Newsletter Editor Paul Elliot, Advertising Editor Mike Thorburn, and all of the ACES Journal Editors and authors.

Things have happened for one reason — people! People who recognized needs and expended effort to address those needs. People who realized that they could make a difference.

But even the combined efforts of all of these people are not enough! Your active support will make it possible to accomplish great things much more rapidly. Will you be one of us?

David E. Stein

MEETINGS COMMITTEE

As most of you know the ADCOM has decided to hold both the 1990 and 1991 Symposiums in Monterey in the Spring. The Meetings Committee has been directed to investigate the possibility of organizing workshops or short courses to be held in the Fall, preferably at a site in the eastern United States to balance the Monterey Symposiums geographically.

With Jim Breakall and Karl Kunz also located at Penn State, I suggest that we serve as the nucleus for a short course to be held at Penn State in the Fall of 1990. Penn State has excellent conference facilities which are available to ACES at quite reasonable costs. We are within about a 4 hour drive from Washington DC, Philadelphia, and New York City. Air transport includes frequent commuter flights from Pittsburgh and Washington Dulles airports. Hotel accommodations for short course attendees will be more than adequate (this assumes we avoid football weekends).

The short course topics being considered include use of NEC (of course), recent progress in time domain methods, and GTD (Ohio State is about a 6 hour drive, so we could expect to draw upon their talent).

If this seems reasonable to the ACES membership, I will proceed to determine suitable dates when the conference facilities will be available. Comments on the location, possible dates, and short course topics and/or lecturers interested in participating will be welcome.

Raymond Luebbers
Chairman, Meetings Committee
Electrical Engineering Dept.
The Pennsylvania State University
University Park, PA 16802
(814)865-2362

OTHER COMMITTEE REPORTS

You will shortly be receiving ballots by mail from the Elections Committee. Next issue (March 1990) we hope to include reports from the following committees:

- Software Performance Standards
- Software Exchange
- Constitution and Bylaws
- Awards
- Historical
- European Committee

EASOGS : A General-Purpose Method-of-Moments Electromagnetic Computer Modeling Code

E. Michielssen, K. Libbrecht, and H. Pues
Emerson & Cuming Europe N.V. (Grace N.V.)
Westerlo, Belgium

Abstract

EASOGS is a Fortran 77 computer program which can analyse arbitrarily shaped, perfectly conducting structures. These structures may be composed of an arbitrary number of surfaces and wires. The surfaces are assumed to be infinitesimally thin conductors and can be open or closed. The wires can have a finite (but electrically small) radius. Interconnections between two or more wires (wire-wire junctions) or between a wire and a surface (wire-surface junctions) can be specified at will. The surfaces are modeled by triangular patches and the wires by straight segments. Three types of excitation can be specified : (1) incident plane wave, (2) incident short-dipole radiation field, and (3) "delta-gap" voltage source(s). The program calculates the electric surface currents excited on the structure through a method-of-moments solution of the frequency-domain "Electric Field Integral Equation". From these surface currents, the program then further can calculate impedance, near-field and far-field quantities as specified. Some illustrative results for a typical test case are given.

This work was performed at ERA Technology Ltd. (last author), Katholieke Universiteit Leuven (all authors), Emerson & Cuming Europe N.V. (last author) and University of Illinois (first author). The program is being marketed from the Electromagnetic Communication Laboratory, University of Illinois, Urbana, IL 61801.

Introduction

A general-purpose method-of-moments electromagnetic analysis program has been developed in recent years and is now going to be marketed. The program is an extended and largely improved version of the software package described in [1]. The underlying theory and method-of-moments implementation technique are almost identical to those described in [2] which can be consulted as a background reference. The specific details of the theory, implementation, program structure and test results are given in [3]. This paper briefly reviews the integral equation formulation, the expansion functions, the potential evaluations, the incident field, the test procedure and matrix equation, the field calculations and the program validation. The test results given clearly illustrate the accuracy and usefulness of the program as well as some remaining weaknesses.

Integral equation formulation

The electric field integral equation (EFIE) has been formulated in the frequency domain using the two-potential description for an arbitraly shaped, perfectly conducting structure consisting of an arbitrary number of surfaces and wires. The surfaces are modeled by triangular patches and the wires by straight segments. The surfaces are assumed to be infinitesimally thin. A kind of thin-wire approximation is adopted for the wires. Each wire is assumed to have a constant radius. At one or both of its ends, a wire may be connected to a vertex of a triangulated surface model or to an end node of one or more other wires. In this way, a change in radius can also be modeled. As the surfaces may be open or closed, apertures can be modeled as well. Handles on surfaces are also allowed. Not allowed are intersecting surfaces or non-orientated surfaces (such as a Mobius strip). Concerning wire-surface interconnections, these may safely be located at surface edges or vertices. In summary, a great many of practical systems can be analysed encompassing applications in the field of antennas, radar

Expansion functions

The formulated EFIE gives a functional relationship between the incident field on the one side and the surface and wire currents on the other. To enable a method-of-moments solution, the total current is written as a linear combination of subdomain basis current functions with unknown expansion coefficients that have to be solved for. Four types of expansion functions are being used, particularly:

(1) one surface current function for every common edge of two adjacent triangles.
(2) one wire current function for every wire node except the end ones.
(3) one surface-wire junction current function for every such junction.
(4) m-1 wire-wire junction current functions for every junction of m wires (with $m \geq 2$).

Taken together, these expansion functions allow an accurate modeling of the current (even at edges and vertices) if proper care is exercised in the triangulation of the surfaces and segmentation of the wires.

Potential evaluations

Formulas have been derived for the evaluation of both the vector and scalar potential generated by every type of current expansion function used. The singular parts were removed from the integral expressions and evaluated analytically, whereas the remaining parts were evaluated numerically using simple five- or seven-point integration formulas. To effect the analytical evaluation, some results of [4] were used.

Incident field

Three types of excitation have been implemented:

(1) incident uniform plane wave with arbitrary polarisation and propagation direction;
(2) incident radiation field of an arbitrarily located point source consisting of three orthogonal short dipoles of independent current moment;
(3) an arbitrary number of delta-gap voltage sources to be located at wire nodes (including junctions).

The former two types are mainly useful to study RCS and EMC problems, the latter to study antenna problems.

Test procedure and matrix equation

The test procedure adopted to transform the integral equation into a linear set of equations is an approximated Galerkin procedure. Particularly, the procedure adopted lies about midway between simple point matching and a real Galerkin procedure. Hence, the matrix symmetry conditions

$$Z_{ij} = Z_{ji} \qquad i,j = 1 \ldots . N \tag{1}$$

where Z_{ij} is the matrix element on the i-th row and j-th column, and N is the number of unknowns, will only be satisfied approximately. This approximation will improve if N is increased, i.e. if the number of triangles and segments is increased. Very good results are usually obtained if the length of wire segments and triangle edges is less than one-tenth of a wavelength, the recommendation being one-twentieth. Of course, increasing the number of triangles and segments increases the order N of the matrix equation to be solved. This order N is given by

$$N = N_{ite} + N_{iwn} + N_{swj} + \sum_{m=2}^{\infty} (m - 1) N^{m}_{wwj} \tag{2}$$

where N_{ite} = number of interior triangle edges
N_{iwn} = number of interior wire nodes
N_{swj} = number of surface-wire junctions
N^{m}_{wwj} = number of m-wire junctions

The present program effects the matrix equation solution by performing a Gauss-Jordan inversion. Apart from very simple structures, it is this matrix inversion that consumes most of the computer time needed.

Field calculations

Once the "impedance" matrix has been inverted, the current distribution on the structure can be easily obtained for each specified excitation represented by its "voltage" vector. From these currents, the scattered electromagnetic field (both near-field and far-field) can be obtained in a straightforward way. Nearly the same type of approximations are used as in the evaluation of the matrix elements. To perform near-field calculations, the reciprocity theorem is invoked, whereas for the far-field calculations a direct approach is used.

In its present form, the program will calculate bistatic radar cross sections for a plane-wave excitation, and radiation patterns for a short-dipole or voltage-source excitation. In the latter case, it will also calculate input impedance and near fields if requested so.

Program validation

The program has been tested thoroughly with consistent good results. The test cases included straight and bent dipole antennas, Yagi-Uda antennas, crossed wire structures, flat plates, spheres, rectangular boxes and monopole antennas on plates or spheres. Particularly, the correspondence with other results given in [2], [5] and [6] was excellent. To illustrate the strengths (and also some remaining weaknesses) of the program, the input impedance and radiation pattern have been calculated for a 0.25 λ monopole (with a radius of 0.003 λ) on spheres of 0.1 λ, 0.2 λ and 0.3 λ respectively, with λ being the wavelength. The monopole was assumed to be excited by a delta-gap voltage source at the monopole-sphere-junction. The monopole was divided in 10 segments and the sphere in 96 triangles giving a total number of unknowns equal to 154, see Fig. 1. The results were compared with those of Tesche et.al. [7]. As Fig. 2 shows, the correspondence is very good for the real part of the input impedance but not for the imaginary part. This is due to the simplicity of the delta-gap model (Tesche et al. (7) used a magnetic current frill model). Figure 3 shows the different radiation patterns. It can be seen that the correspondence is very good for a 0.1 λ or 0.2 λ radius sphere but gets worse for a 0.3 λ radius sphere. This may indicate that a larger number of triangles should have been used in the 0.3 λ case. The deviation is certainly not due to interior resonances (giving rise to spurious solutions) as the sphere is still too small electrically. Besides, the program allows you to suppress these resonances by defining wire segments inside the closed surface.

Conclusions

A general-purpose method-of-moments electromagnetic analysis program for conducting structures has been developed which has a lot of interesting features and may find applications in various fields.

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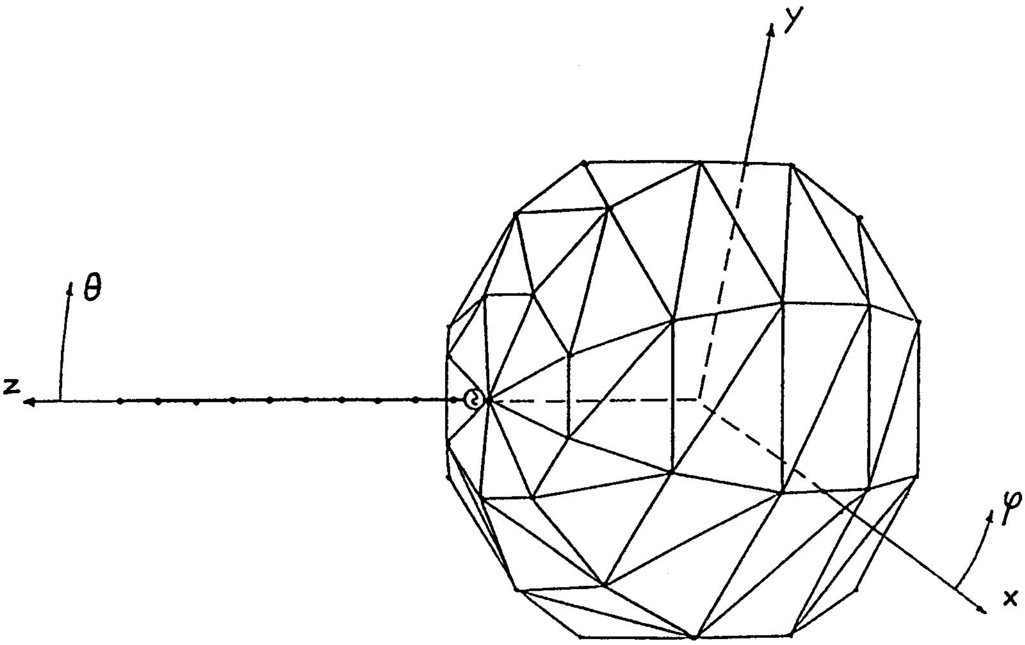


Figure 1. Monopole antenna on sphere showing segmentation of wire and triangulation of surface.

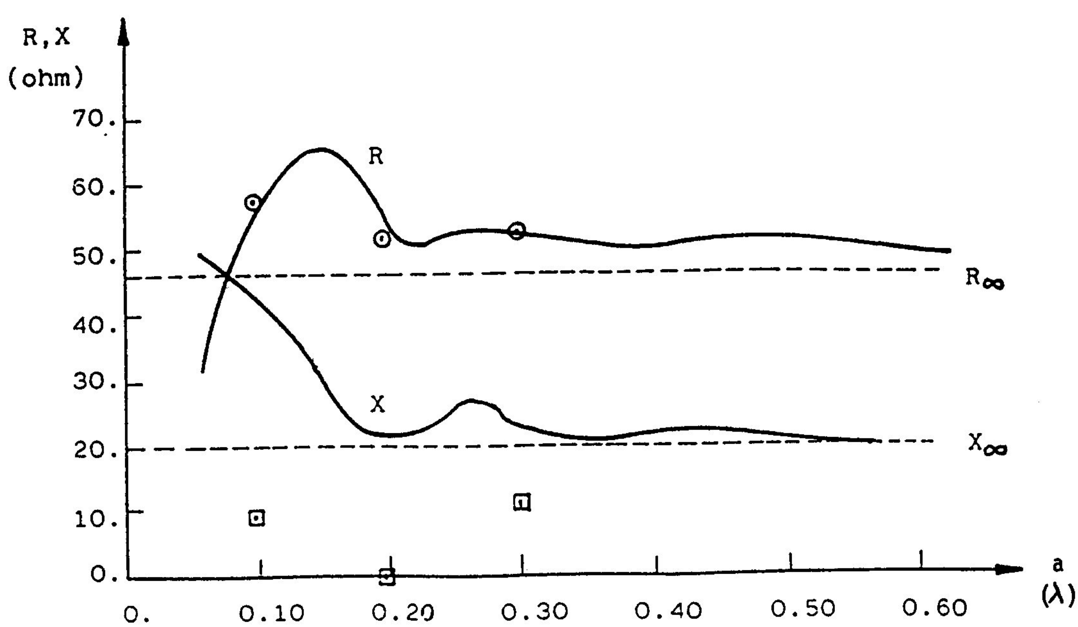
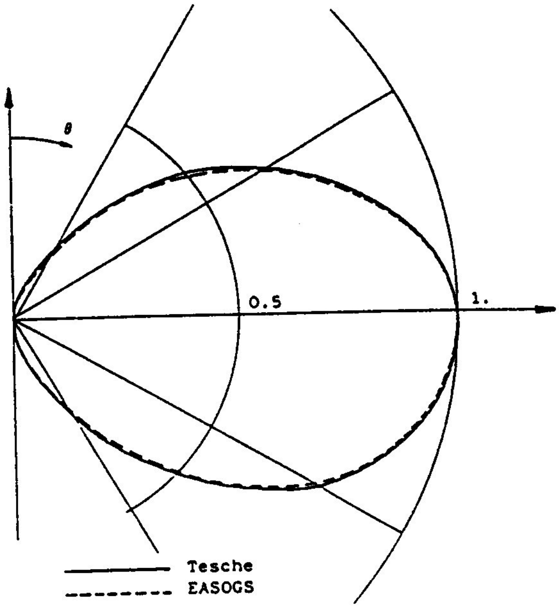
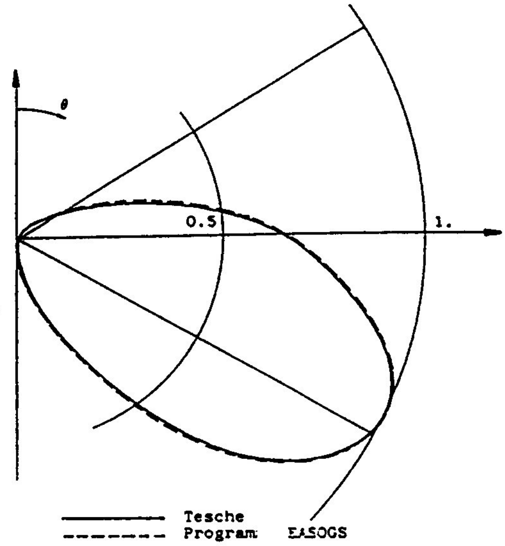


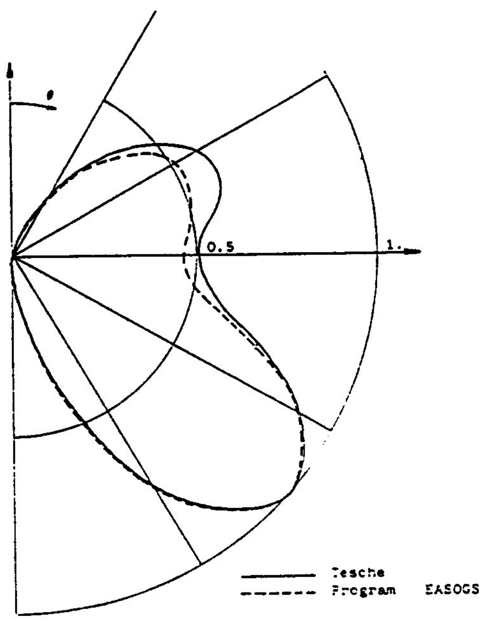
Figure 2. Real part (R) and imaginary part (X) of input impedance versus sphere radius (a).



a = 0.1 λ



a = 0.2 λ



a = 0.3 λ

Figure 3. Radiation patterns for different sphere sizes.

RENDEZVOUS WITH A COMPUTER SCIENTIST

Virginia Stover
University of San Diego
Department of Mathematics and Computer Science

Database Design

In the last issue I discussed the use of relational databases as a means of organizing and accessing data in a uniform manner. In this issue I'll discuss how to design a database in order to maximize its flexibility and reduce redundancy. Database design answers questions like "What tables should I have in my database?" and "What attributes or fields should these tables have?" The methods that I'll discuss are applicable not only to relational databases but also to hierarchical and network databases as well as to ordinary data structures like records and files.

One approach to database design is the method of "normalizing" relations. This sounds like it has something to do either with international politics or with sending weird family members to a psychiatrist. Actually "normalization" is the process of restructuring database tables in order to put them into an equivalent but somehow better "normal form". There is a hierarchy of five normal forms. First normal form (1NF) is the weakest. Second normal form (2NF) is better than first normal form. Third normal form (3NF) is better than second normal form, and so on. Also each normal form includes the previous one. Thus, a database in 2NF is also in 1NF. A database in 3NF is also in 2NF, and so on.

Recall that a relational database consists of a set of relations or tables. Each table represents a type of object or "entity". Each row of the table represents an individual element of that type, and each column of the table represents an attribute of that type. The rows of the table are roughly equivalent to the records in a file, and the columns are equivalent to the fields in a record.

For example, the following is a relation describing some mystery writers and their fictional detectives.

Mystery_Writers

Author	Nation'ty	Sex	Detective	Detective	Detective
AC Doyle	British	M	S Holmes		
D Sayers	British	F	P Wimsey		
PD James	British	F	Dalgliesh	C Gray	
A Christie	British	F	J Marple	H Poiro	Beresford
G Simenon	Belgian	M	J Maigret		
F Dannay	American	M	E Queen	S Holmes	
MB Lee	American	M	E Queen	S Holmes	
D Hammett	American	M	S Spade		
R Chandler	American	M	P Marlowe		
Rex Stout	American	M	N Wolfe		
Mark Twain	American	M	S Holmes		

Table 1

Notice that there is more than one column for the detectives' names since some authors wrote about more than one detective. There is a lot of wasted space, however, since many authors featured only one or two detectives. Furthermore, we can't be sure than three columns are enough for the detectives' names. In order to add another of Agatha Christie's detectives, for example, we would need to add another column to the table. In contrast, we can add another author by simply adding another row to the table. It is easier to add another row than another column, just as it is easier to add another record to a file than to add another field to each record. A better design for this table is to use a separate row for each author-detective pair, as follows:

Mystery_Writers

Author	Nation'ty	Sex	Detective
AC Doyle	British	M	S Holmes
D Sayers	British	F	P Wimsey
PD James	British	F	Dalgliesh
PD James	British	F	C Gray
A Christie	British	F	J Marple
A Christie	British	F	H Poirot
A Christie	British	F	Beresford
G Simenon	Belgian	M	J Maigret
F Dannay	American	M	E Queen
F Dannay	American	M	S Holmes
MB Lee	American	M	E Queen
MB Lee	American	M	S Holmes
D Hammet	American	M	S Spade
R Chandler	American	M	P Marlowe
Rex Stout	American	M	N Wolfe
Mark Twain	American	M	S Holmes

Table 2

This table is said to be in *first normal form.*

DEFINITION: A table is in first normal form if it does not contain any repeated attributes.

An author whose works feature N different detectives now appears in N different rows in the table. We can now add another row to the Agatha Christie's detectives by simply adding another row to the table.

Recall that a "key" for a table is an attribute or set of attributes which uniquely identifies a row in the table. In other words, the values of the key attributes determine the values of all the other attributes in the table. The key should be minimal in the sense that no proper subset also has this property. Each set of values of the key attributes can appear at most once in the table and cannot contain blanks. For example, a key for Table 1 is the author's name. The author's name uniquely identifies the row. The author's name also determines all of the other values in that row, namely, the author's nationality and sex and the author's detectives. In contrast, the detective's name is not a key for Table 1 since there are some detectives which are featured in the works of several different authors. For example, "Sherlock Holmes" appears in more than one row. Thus, knowing the detective's name is not enough to determine the author's name, nationality, or sex.

Notice, however, that the author's name no longer suffices as a key for Table 2 since some authors appear in more than one row. The key has to be expanded to include the detective's name. Thus, a key for Table 2 is the set {author, detective}. The author's name and the detective's name are enough to determine all of the other values.

Actually, Table 2 is in one sense better than Table 1, but it has some problems of its own. Look at Table 2 again. What do you notice? It should be apparent that there is more redundancy in Table 2 than in Table 1. The nationality and sex of each author are repeated for each author-detective pair. Thus, P. D. James' nationality and sex appear twice in the table, Agatha Christie's nationality and sex appear three times, etc. Again this is a waste of space. But there are other more serious problems. They include the following:

1. Redundancy: If P. D. James, for example, were to change her nationality (or sex), several changes would be needed to the database.

2. Inconsistencies: If we aren't careful it's possible that at some point P. D. James' nationality (or sex) could have a different value in different locations in the table.

3. Partial Information: We are unable to add a mystery writer whose works do not feature a detective. (Can you think of an example?) Notice that it is impossible to leave the detective's name blank since it forms part of a key for this table.

The basic problem with Table 2 is that the nationality and sex depend on only part of the key (the author's name) and not on the entire key (author and detective). This table is in first normal form but not second normal form.

> DEFINITION: A table is in *second normal form* if
> 1. It is in first normal form and
> 2. No non-key attribute depends on only part of the key.

The solution to this problem is to decompose the table into two separate tables, as follows:

Writers-Detectives

Author	Detective
AC Doyle	S Holmes
D Sayers	P Wimsey
PD James	Dalgliesh
PD James	C Gray
A Christie	J Marple
A Christie	H Poirot
A Christie	Beresford
G Simenon	J Maigret
F Dannay	E Queen
F Dannay	S Holmes
MB Lee	E Queen
MB Lee	S Holmes
D Hammett	S Spade
R Chandler	P Marlowe
Rex Stout	N Wolfe
Mark Twain	S Holmes

Table 2A

Writers

Author	Nation'ty	Sex
AC Doyle	British	M
D Sayers	British	F
PD James	British	F
A Christie	British	F
G Simenon	Belgian	M
F Dannay	American	M
MB Lee	American	M
D Hammett	American	M
R Chandler	American	M
Rex Stout	American	M
Mark Twain	American	M

Table 2B

Table 2A is formed by removing from Table 2 the attributes which depend on only part of the key (nationality and sex). Table 2B is made up of those attributes (nationality and sex) along with the key (author). Tables 2A and 2B are now in second normal form. (What are the keys for these tables?) Notice that we have eliminated much of the redundancy. Notice also that it is now possible to add a mystery writer to the database without adding a corresponding detective. Simply add an entry to the Writers Table but not to the Writers_Detectives Table.

Consider the following table that describes detectives, their occupations, and the cities and countries in which they work.

Detectives

Detective	Occupation	City	Country
S Holmes	private det	London	England
P Wimsey	aristocrat	London	England
Dalgliesh	policeman	London	England
H Rumpole	barrister	London	England
J Maigret	policeman	Paris	France
A Dupin	amateur det	Paris	France
S Spade	private det	San Francisco	USA
P Mason	lawyer	Los Angeles	USA
C Chan	policeman	Honolulu	USA

Table 3

The key for this table is the detective's name. This table is in first normal form since there are no repeated attributes. The table is also is second normal form since the key consists of only a single attribute. (Therefore, no attributes can depend on only part of the key). However, we have the same problems as before. The fact that London is in England, for example, is repeated in several places (redundancies and possible inconsistencies). Furthermore, we can represent the relationship between a city and its country only if a detective is based in that city (partial information on cities and countries).

The problem with Table 3 is the there is a dependency that does not involve the key. Namely, the country is dependent on the city. (Actually there are cities named "London" outside England, but for the purpose of this example, let's assume that cities have unique names). Thus, the name of the city determines the name of the country, but the city is not a key (or even part of a key) for this table.

The solution to this problem is to decompose Table 3 into two separate tables. The attributes which depend on something that is not a key (country) are removed from Table 3. The relationship between the cities and countries goes into a separate table.

Detectives

Detective	Occupation	City
S Holmes	private det	London
P Wimsey	aristocrat	London
Dalgliesh	policeman	London
H Rumpole	barrister	London
Maigret	policeman	Paris
A Dupin	policeman	Paris
S Spade	private det	San Fran
P Mason	lawyer	LA
C Chan	policeman	Honolulu

Table 3A

Cities

City	Country
London	England
Paris	France
San Fran	USA
LA	USA
Honolulu	USA

Table 3B

Notice that we have eliminated the redundancy, and we can now store information on any city-country pair whether or not we have a detective who works in that city.

Tables 3A and 3B are said to be in *third normal form.*

DEFINITION: A table is in third normal form if
1. It is in second normal form and
2. There are no dependencies of the form A determines B where A does not contain a key.

To summarize second and third normal forms,

> A table is in both second and third normal forms if each attribute in the table is dependent on the key, the *whole* key, and *nothing* but the key!

Third normal form usually suffices for most applications, and many people stop here. As I mentioned before, however, there are two other normal forms. Whereas second and third normal forms are concerned with relationships between two entities, fourth and fifth normal forms deal with relationships among three or more entities. Rather than run the risk of telling you more than you ever wanted to know about database design, I will not go into fourth and fifth normal forms any further. For those who are interested see [3] for a fairly nontechnical discussion of all five normal forms.

Notice that the theory of normalization can be used to evaluate how good a design is as well as to improve a bad design. It is a rigorous approach based on mathematical functions. There is a more intuitive method, however, based on the entity-relationship model. This method can be used to provide an initial set of tables for the normalization process and usually results in a good design by itself.

A database is really just a model of the real world. The first step in designing such a model is to decide what types of objects or entities are needed in the model and then to select the relevant characteristics or attributes of each type. To model the entities, a separate table is created for each entity type. The columns of the table are the attributes of that type. The next step is to model the relationships among entities.

Relationships between two entities come in many flavors. Some relationships are one-to-one, some are one-to-many, and some are many-to-many. For example, if each detective has at most one assistant, and each assistant works with at most one detective, then the relationship between detective and assistant is a one-to-one relationship. Given a table for detectives and a table for assistants, we can model the relationship between them by including a key for the detective in the Assistants Table, and vice versa, as follows:

Detectives

Detect	Sex	Natl'ty	Assist
Holmes	M	British	Watson
Wimsey	M	British	Bunter
Poirot	M	British	Hastings
Mason	M	American	Street
E Queen	M	American	R Queen
Marple	F	British	

Table 4A

Assistants

Assist	Job	Detect
Watson	doctor	Holmes
Bunter	butler	Wimsey
Hastings	police	Poirot
Street	sec'y	Mason
R Queen	police	E Queen

Table 4B

The attribute "assistant" in the Detectives Table is called a "foreign key" because it is a key for another table. Likewise, "detective" is a foreign key in the Assistant's Table. A foreign key must either match one of the keys in the other table or be blank (as it is for Miss Marple).

The relationship between a detective and the detective's assistant is probably a one-to-many relationship, however, since there are some detectives which have more than one assistant. (Each detective can have any number of assistants, but each assistant works with at most one detective). In this case, we include the detective's name in the Assistant's Table, but not the reverse.

Detectives

Detect	Sex	Natl'ty
Holmes	M	British
Wimsey	M	British
Poirot	M	British
Mason	M	American
E Queen	M	American
Marple	F	British

Table 5A

Assistants

Assist	Job	Detect
Watson	doctor	Holmes
Bunter	butler	Wimsey
H Vane	writer	Wimsey
Parker	police	Wimsey
Hastins	police	Poirot
D Street	Sec'y	Mason
P Drake	detect	Mason
R Queen	police	E Queen

Table 5B

As another example of a one-to-many relationship, consider Table 3 above. The entity-relationship/ model specifies that cities and their attribute "country" should appear in a separate table since cities and detectives are two separate entities. Therefore, Table 3 should be split into Tables 3A and 3B. Notice that the relationship between cities and detectives is one-to-many, so "city" appears as a foreign key in the Detectives Table.

The third type of relationship is many-to-many. An example of a many-to-many relationship is the relationship between authors and detectives. Some authors wrote about more than one detective, and some detectives appear in the works of several different authors. A many-to-many relationship requires a separate table made up of a key from each of the entities in the relationship. This is the Writers_Detectives Table (Table 2A) above. A key for Table 2A consists of the union of the two foreign keys, authors and detectives. The only other attribures that should appear in the table are attributes about the relationship itself. For example, we could add a third column to Table 2A containing the number of stories written by a particular author featuring a particular detective.

To complete our database design, we need to decide what relationships exist between entities (one - to-one, one-to-many, and many-to-many). Each relationship is then modeled using foreign keys. Finally, any other dependencies that exist among the attributes in each table are noted, and each table is decomposed, if necessary, into the desired normal form.

The decomposition of databases into normal form allows for more flexible and efficient storage of information, helps to ensure the consistency of the database, and enables updates to be made easily and safely. At the same time, however, we have not lost any of the original information. It is always possible to reconstruct the original tables again when needed. This is done using the relational "join" operation discussed last time. In this sense the decomposed tables are equivalent to the original tables. Thus, we are gaining all the advantages of normal form at the expense of a little extra time to perform certain queries on the database.

I should mention in closing that these methods are used for the *conceptual* or *logical* design of a database as opposed to its *physical* design. The conceptual design concerns how the database is organized from the user's point of view, whereas the physical design concerns how the information is actually stored. The physical design involves implementation-related issues such as the mapping of tables to files, the structure of files, indexing, clustering, etc. These issues can be addressed only after the conceptual design is complete.

Along the lines that it is actually much easier to design a database than to talk about it, try these techniques on your favorite electromagnetics database. (I'm a university professor. I can't help giving homework.) Convert your database third normal form. Remember that a database in 3NF but also be in 1NF and 2NF.

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REDUCING COMPUTER EYE STRESS

Paul Elliot

A book entitled Computer Eye Stress by Dr. Anthony Huchinson suggests the following simple measures for reducing eye stress due to the use of computers and VDT terminals:

* Dim room lights or use a glare screen to increase contrast.

* Adjust screen for maximum resolution and contrast, and for minimum flicker.

* Some computer monitors provide better character resolution. Typically CGA (color, not enhanced) is worst for character resolution. Better than CGA are EGA (enhanced color graphics adapter), VGA, or monochrome.

* Prop up the hardcopy with a copy-holder at the same distance from your eyes as the computer screen so your eye muscles do not have to constantly refocus at a different range. This constant refocussing is a cause of eye fatigue and eye stress.

MODELING NOTE

ANTENNA TERMINAL AND GENERATOR MODELS IN NEC

Paul Elliot
Georgia Tech Research Institute
Atlanta GA 30332

When calculating antenna input impedance using the Lawrence Livermore NEC method of moments computer code it is necessary to define a particular segment as the antenna terminal. The input impedance of the antenna is the input impedance of this segment. Accuracy is often enhanced by including in the model the impedance seen looking back towards the generator from the antenna terminal. Two NEC models (models A and B) are shown in Figure 1. The radiating portion of each model (labeled "dipole") consists of several wire segments. The transmission line option of NEC (TL option) was used to model the 130 ohm feed transmission line. Both models A and B are identical in the radiating portion and the transmission line specification of the models. They only differ in how the generator impedance is included. The antenna terminal will be defined to be at the end of the 130 ohm transmission line (at the opposite end from the dipole).

The input impedance seen looking back towards the generator from the antenna terminal had been previously assessed to be 80 ohms, and this impedance was included in one of two ways. In both cases these two or three generator segments were very short and located as far away from the radiating dipole segments as NEC would allow so there would be insignificant free space coupling from the radiating dipole. The exact location of the short generator segments is irrelevant as long as it is very far from the dipole. The only coupling between the generator segments and the radiating dipole is via the 130 ohm transmission line, whose electrical length is an input file parameter unrelated to the xyz coordinates of the segments connected by the transmission line.

The generator of model A consists of three short segments. They form a triangle so they only contact at their end points. One segment has the ideal voltage source, one carries the 80 ohm load, and one is used by the transmission line to connect to (that one is the antenna terminal). The NEC output file for model A shows input impedance for the voltage source segment under the heading "Antenna Input Parameters." The 80 ohm series load must be subtracted from the real part to get the input impedance of the antenna at the terminals. The impedance of the segments connected to the transmission line are also found in the output under the heading "Structure Excitation Data at Network Connection Points" but it is somewhat more inconvenient to use that data. However, the two sets of data are not always in complete agreement in which case the more accurate data is the Structure Excitation Data at Network Connection Points" since it is taken right at the input to the 130 ohm line.

The generator for model B requires one less segment since the segment with the 80 ohms is replaced with a network (NT) option. As in model A, the segments used for the generator are very short and very distant from the radiating dipole. In model B they are also loaded with very high resistances to further reduce coupled currents from the radiating dipole. For model B the input impedance is found under "Structure Excitation Data at Network Connection Points" for the antenna terminal (the segment connecting the transmission line and the network). However, the current on the segment is of opposite sign than the current entering the transmission line, so the sign of I, Z, Y and P should be reversed. A feature of model B not found in model A is that generator impedances other than 80 ohms could be tried without reinverting the NEC admittance matrix. However model A has the advantage of simplicity, and was therefore used more.

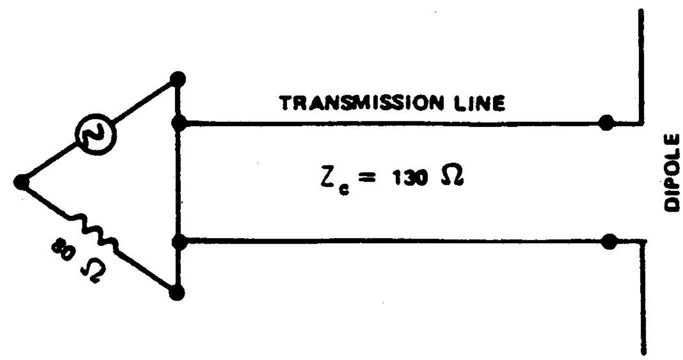
The VSWR or reflection coefficient from the dipole terminal back towards the generator may be obtained by placing the antenna input impedance on a Smith chart (normalized to 80 ohms in this case), or by calculated from formulas [R.E. Collins, Foundations for Microwave Engineering, McGraw-Hill, NY, 1966, pg.90].

This approach has been used for an array of dipoles to accurately predict the input impedance and dipole pattern in the array environment. To obtain this array input impedance all the dipoles may be excited simultaneously. An alternative procedure is to obtain the S parameters from the center dipole to each of the other dipole array elements. Then the array input impedance is the sum of the S parameters (each weighted by the complex excitation of the element). This alternative procedure helps detect errors in the model since it provides a check on the internal consistency of the model. Also, when actually measuring a prototype array a power divider is often unavailable, so all the elements cannot be excited at once and the alternative procedure must used. In that case the individual S parameters from the NEC model can be compared to the measured S parameters. In the NEC model the individual S parameters are obtained from the voltages and currents on the antenna terminal segment. Page 172 of Collins gives the required formulas.

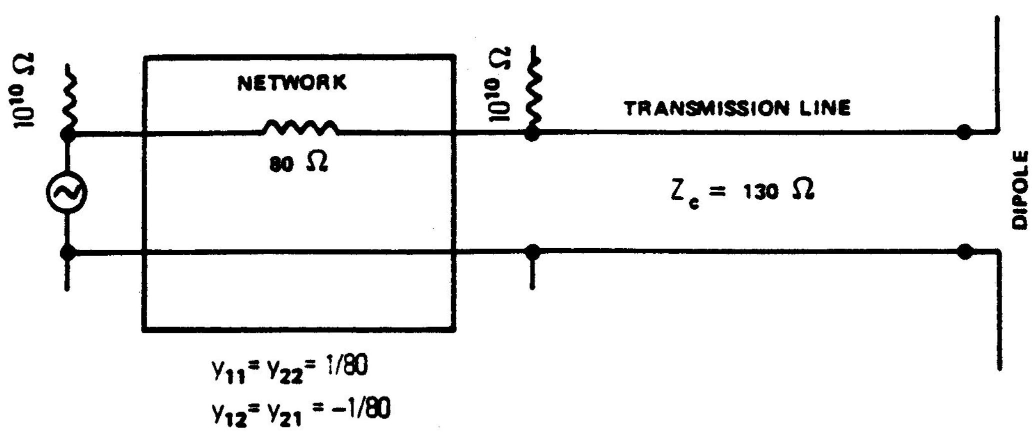
When modeling an array, attention must be paid to the reference direction of source and terminal segments in the input geometry to get the correct signs for the excitations and currents, since if the segment direction is reversed the sign of the current will also be reversed.

FIGURE 1. NEC MODELS OF FEED LINE AND GENERATOR IMPEDANCE

MODEL A.



MODEL B.



TECHNICAL WORD PROCESSING SOFTWARE

Paul Elliot

Technical Word Processors (TWP) are word processors with the capability to write documents containing mathematical equations, scientific symbols, and sometimes also foreign language characters. Regular word processors (WP) such as Wordperfect, Wordstar, Microsoft Word, etc., often have some limited TWP capability, which is being upgraded every few years. WordPerfect 5.1 has just been released and has considerably enhanced TWP capabilities compared to previous versions of WordPerfect. I think the TWP capability of regular WP will eventually rival that of dedicated TWP since several regular WP companies have considerable resources and market share. Several reviews of TWP have been published in recent years. In the world of microcomputers, such software reviews become quickly out of date, but the following summary and observations may be useful.

The July 1988 PC Magazine review of TWP recommended Total Word and T3. They felt that Total Word was a good word processor (WP) for regular text as well as for TWP. T3 was selected in part because it includes foreign language characters. The following were described in the PC magazine review as being easy to learn or use: Chiwriter ($80), Tech/Word ($75), Exp ($150), The Egg ($495, able to produce "any scientific expression"), and Spellbinder Scientific ($790, "powerful").

The "Screen of Stone" column by Ross Stone in the 6/88 issue of the IEEE-AP/S newsletter makes many interesting points regarding TWP. Also, in May 1987 the Boston Computer Society published a detailed review (approximately 150 pages long) of numerous TWP. Carl Hein of Boxborough, MA (508)263-0076 may be persuaded to send out copies, although he feels reluctant to distribute it because the review is already 2 1/2 years old. The review describes features but does not make overall recommendations. Another review appeared in the November/December 1987 issue of Computers in Physics.

Some TWP such as EXACT and Turbofonts are used as an add-on to your regular WP, so you can still do all your text writing and editing and page formatting using your regular WP (Wordperfect, Wordstar, Microsoft Word, etc). This approach offers four advantages:
1) Permits the use of the full array of features normally offered by a regular WP (e.g. landscape paper orientation).
2) Eliminates the need for you or your typists to learn some new WP editing commands.
3) It allows the document to be converted from your regular WP into another regular WP, for example from Wordperfect into Wordstar. This allows a wider range of people, such as newsletter publishers or design services departments, to work on or revise your paper. For a review of such WP conversion software see PC Magazine, June 23, 1987 issue.
4) It will allow an easy transition to future upgrades of regular WP when they have better equation writing capability: the upgraded equation editing features of regular WP can be phased in and put to use while still using the add-on TWP wherever necessary.

For some TWP the equations in the text are shown on the screen as they will appear on the hardcopy (What You See Is What You Get: WYSIWYG). For other TWP the text on the screen shows only special character codes, which will be then converted to equations when printed (i.e. not WYSIWYG). The WYSIWYG feature is definitely a convenience.

Seven TWP options are described below, including some of the more attractive options to me (using an IBM-AT clone). However, this is not an endorsement of any of these since I have personally only tried the first option. Most of the information is based on conversations with other users and published information.

1. Regular Wordprocessor as is (with no add-on capability) such as WordPerfect, Wordstar, Microsoft Word, etc: For those with only occasional need to type an equation into a document, the current capabilities of a regular WP may be adequate. Typically their TWP capabilities are limited and

cumbersome to use, but faster to learn if you are already using the WP for text. Also as mentioned above they are being upgraded from year to year, so their TWP processing capabilities should improve in the future. The WordPerfect 5.0 screen display is WYSIWYG only for non-proportional fonts, so I have found it important in the past to get a non-proportional font with math symbols for your printer (a non-proportional font will use the same amount of space for an i as for an m, a proportional font will use more space for the m). This may be corrected in WordPerfect 5.1 so it may be WYSIWYG for proportional fonts as well as non-proportional fonts. Figure 1 shows sample equations written with considerable expenditure of time using WordPerfect 4.2 on an IBM-AT, and printed using the non-proportional Hewlett-Packard K math cartridge on a laser-jet printer.

2. Interactive computation software such as MathCAD or MATLAB. I have not used these yet but they sound pretty good. Advantage: These will not only print your equations, but will also interactively perform calculations using the equations and produce plots (on screen or plotter). MathCAD is WYSIWYG. MATLAB is not WYSIWYG, but may be a little more powerful and may produce better 3D plots.

3. EXACT: Advantage: Is used as add-on to regular WP.
Problems: Is not WYSIWYG. Also may limit equation style.
Figure 2 shows sample EXACT output from the EXACT manual.

4. Turbofonts: Advantages: WYSIWYG. Is add-on to regular WP.
Problems: May be difficult to get working correctly with your word processor. Also may limit equation style (for example it is very difficult to extend a square root symbol over the arguments). Probably more difficult to use than Total Word or Exact.

5. Total Word: Advantages: WYSIWYG. Recommended by PC magazine 7/88. Problem: Is not an add-on to your regular WP.

6. Chiwriter: Advantages: WYSIWYG. Has been mentioned as a favorite by Ross Stone (IEEE-AP/S Newsletter Editor) who has tried numerous TWP. Problem: Is not an add-on to a regular WP.

7. Tex or PCTex (similar to MicroTex, TurboTex, and CommonTex):
Advantages: Superior quality output. Tex (pronounced "tech") was one of the first TWP available, so numerous typists have experience with it. Problems: Very difficult to learn. Not an add-on to regular WP.

$$I_d(\Delta) = -\frac{2}{\pi}\int_0^t \sin[\omega\Delta I_{d,im}(\omega)]d\omega$$

$$A = \int_0^{\pi} \omega_{\phi\pi}\ \zeta\phi\ d\zeta$$

$$\omega = 10^7$$

$$\zeta = 377\sigma\ e^{-jw\alpha^2\beta\gamma\delta\epsilon\zeta\eta\theta\lambda\mu\xi\pi\sigma\tau\psi}$$

$$\rho = \oint \omega\ \phi\ d\zeta$$

Figure 1. Sample WordPerfect Output.

Great fleas have lesser fleas
Upon their backs to bite 'em.
And lesser fleas have lesser still,
And so *ad infinitum*.

$$A = \pi r^2$$

$$\frac{2D^2}{\lambda}$$

$$\sqrt{\frac{D^3}{\lambda}}$$

$$\int e^{-x^2}\ dx$$

$$\sum_{i=0}^{n}$$

$$F(x) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x} e^{-\frac{1}{2}y^2} dy$$

$$(E_F)_\theta \simeq +\eta(H_F)_\phi = -j\omega\eta F_\phi$$

Figure 2. Sample EXACT Output.

THE 6TH ANNUAL REVIEW OF PROGRESS IN APPLIED COMPUTATIONAL ELECTROMAGNETICS

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