

Computer Program Descriptions

A Program Using the Successive Extrapolated Relaxation (SER) Method to Solve Laplace's Equation

PURPOSE: This program determines fields satisfying Laplace's equation with Dirichlet and/or Neumann boundary conditions. Subroutine SER may be applied to other iterative methods.

LANGUAGE: Fortran IV.

AUTHORS: W. Kinsner and E. Della Torre, Department of Electrical Engineering and Communications Research Laboratory, McMaster University, Hamilton, Ontario, Canada.

AVAILABILITY: ASIS-NAPS Document No. NAPS-02035. Copies of a source deck package may be purchased through the authors at \$15.00 (U.S.), within three years of publication.

DESCRIPTION: This program calculates the two-dimensional field satisfying Laplace's equation within an arbitrary shape boundary subject to Dirichlet and/or Neumann boundary conditions. The program utilizes the successive extrapolated relaxation method [1] superimposed on the successive overrelaxation method using the five-point difference operator. The required inputs are: the boundary conditions, the desired accuracy of the solution, the maximum number of iterations, and the initial values for the problem. The output includes the printed numerical results and an equipotential map of the solution.

The subroutine BOUND reads and generates the boundary conditions. The subroutines RASTER, DIAGON, REDBLK, SPIRAL, and CONOPT contain algorithms for scanning the array; the user can choose one of

them from the main part of the program. DINE determines the position of the Dirichlet and Neumann boundary conditions with respect to the interior of a given problem, and hence it simplifies the logic of the iteration process. INVA inserts initial values into the array. PRES prints the numerical results to seven significant figures, and MAP prints the contour map of equipotentials within given limits on the line printer.

A routine, available from the author, permits the output to be drawn by a Benson-Lehner plotter. This routine is not included in this package since it is not in standard Fortran, but will only run on a CDC 6000 series computer.

The subroutine SERMET produces the desired solution. It calls the subroutine SER which contains the algorithm for the SEOR method [1] and the algorithm for solving the partial differential equation. The subroutine SERMET computes the error of the solution using Carré's criterion [2] and it terminates computation either when a given accuracy is achieved or when a preset maximum number of iterations is exceeded. This subroutine optimizes the upper limit of extrapolation. Since optimization is used, if this subroutine is extracted from the program and applied to accelerate convergence of an iterative process, the coefficient matrix of the system equations must possess Young's Property A.

The program has been tested on a CDC 6400 computer. Storage requirements are approximately 30 K words for a problem with 20×20 lattice points and 53 K words for a problem with 50×50 lattice points. Running time depends on the presence of Neumann boundary conditions, scanning techniques, the size of a problem to be solved, as well as required accuracy. Typical values of running time are 4 s and 20 s for problems with 20×20 and 50×50 mesh points, respectively.

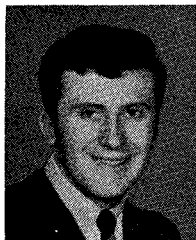
REFERENCES

- [1] E. Della Torre and W. Kinsner, "A successive extrapolated relaxation (SER) method for solving partial differential equations," Preliminary Rep. Included in the NAPS.
- [2] B. A. Carré, "The determination of the optimum acceleration factor for successive over-relaxation," *Comput. J.*, vol. 4, pp. 73-78, 1961.

Manuscript received September 22, 1972; revised November 22, 1972.

See NAPS document #02035 for 42 pages of supplementary material. Order from ASIS-NAPS c/o Microfiche Publications, 305 E. 46th St., New York, N. Y. 10017. Remit in advance for each NAPS accession number \$1.50 for microfiche or \$5.00 for photocopies up to 30 pages, 15¢ for each additional page. Make checks payable to Microfiche Publications.

Contributors



Peter Benedek (S'67) was born on December 15, 1946. He received the B.Eng. Elec. Hons. and M.Eng. degrees from McGill University, Montreal, Que., Canada, in 1969 and 1971, respectively, and the Ph.D. degree in 1972.

From 1967 to 1969 he was associated with RCA Victor in Montreal where he worked on the development of stripline microwave components for earth satellite ground stations and on an extended network simulation program.

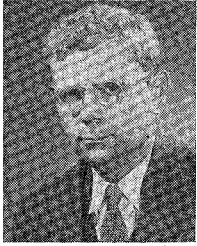
In 1969 he was involved in the creation of a computerized multiphasic health screening clinic, demonstrated at Man and His World in Montreal. Since 1969 he has been doing research in numerical methods in electromagnetic problems at McGill University, where he was awarded the Ph.D. degree in Electrical Engineering as a National Research Council Scholar.

Dr. Benedek is a member of Sigma Xi. In 1969 he received the IEEE Region 7 Student Prize Paper award.



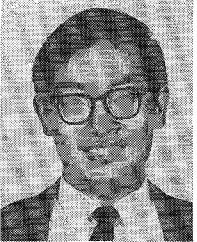
John A. Bradshaw (M'63) was born in Ann Arbor, Mich., in 1919. He received the B.A. degree in classics and sociology in 1941, and the M.S. and Ph.D. degrees in electron physics in 1948 and 1954, respectively, all from Harvard University, Cambridge, Mass.

From 1941 to 1946 he served in the U. S. Army Field Artillery, and from 1950 to 1952 as a Teaching Fellow at Harvard University.



From 1954 to 1962 he worked at the General Electric Research Laboratory, Schenectady, N. Y., on magnetron space charge, troposcatter propagation, and character recognition. Since 1962 he has been Associate Professor of Electrophysics at Rensselaer Polytechnic Institute, Troy, N. Y.

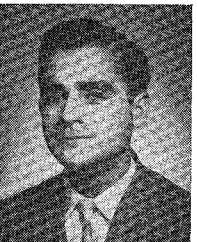
Dr. Bradshaw is a member of Phi Beta Kappa, Sigma Xi, The American Association for the Advancement of Science, and the American Association of Physics Teachers.



Y. Leonard Chow (S'60-M'65) was born in Fukien, China, on December 29, 1936. He received the B.Eng. degree in engineering physics from McGill University, Montreal, Que., Canada, in 1960, and the M.A.Sc. and Ph.D. degrees in electrical engineering from the University of Toronto, Toronto, Ont., Canada, in 1961 and 1965, respectively.

In 1964 he became affiliated with the National Radio Astronomy Observatory, Charlottesville, Va., as a Research Associate.

In 1966 he joined the Department of Electrical Engineering, University of Waterloo, Waterloo, Ont., Canada. During the summer months of 1970 and 1971, he worked on the design studies of supersynthesis arrays in the Radio and Electrical Engineering Division, National Research Council of Canada.



Kubilay İnal was born in Adana, Turkey, on March 13, 1944. He received the B.S. and M.S. degrees in electrical engineering from the Middle East Technical University, Ankara, Turkey, in 1966 and 1967, respectively. He is currently working toward the Ph.D. degree.

He was an assistant at the Middle East Technical University until 1968. He worked in the Turkish Scientific and Technical Development Council (TBTA) from 1968 to

1972, and joined the Staff of the Middle East Technical University as a Lecturer in 1972.

Mr. İnal is a member of the Turkish Institution of Electrical Engineers.



Peter Silvester (S'60-M'64), for a photograph and biography please see page 120 of the February 1973 issue of this TRANSACTIONS.

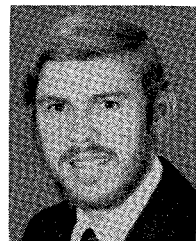


Canan Toker was born in Safranbolu, Turkey, on October 1, 1939. He received the B.Sc. (Hons.) degree and the Ph.D. degree in electronic engineering from the University College of North Wales, Bangor, Wales, in 1962 and 1965, respectively.

In 1965, he joined the Middle East Technical University, Ankara, Turkey, where he was responsible for establishing microwave courses and research laboratories. He served as a reserve officer in the Turkish Navy from

1970 to 1972. He is currently an Associate Professor in the Department of Electrical Engineering, Middle East Technical University, Ankara. His main research interests are in the fields of varactor diodes and parametric amplifiers, tunnel-diode mixers, harmonic generators, nonuniform transmission lines, and microwave filters.

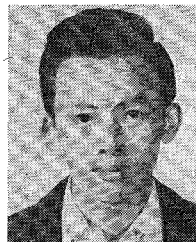
Dr. Toker is a member of the Turkish Institution of Electrical Engineers.



Rodney S. Tucker (S'72) was born in Melbourne, Australia, on March 14, 1948. He received the B.E. degree with honors in electrical engineering from the University of Melbourne, Melbourne, Australia, in 1970.

Since 1970 he has been working towards the Ph.D. degree at the Department of Electrical Engineering, University of Melbourne. His research is concerned with active and passive microwave integrated circuits.

Mr. Tucker is a student member of the Institution of Radio and Electronics Engineers, Australia.



Sien-Chong Wu (S'68) was born in Palembang, Indonesia, on March 7, 1942. He received the B.S.E.E. degree from the National Taiwan University, Taipei, Taiwan, in 1965, and the M.A.Sc. degree from the University of Waterloo, Waterloo, Ont., Canada, in 1968. He is currently working toward the Ph.D. degree at the University of Waterloo.

From 1965 to 1966 he was a Teaching Assistant in the Faculty of Engineering, Chiao Tung University, Hsin-Chu, Taiwan.

Since 1966 he has been with the Antenna and Microwave Laboratory, University of Waterloo, as a Research Assistant.