POISSON/SUPERFISH CODES FOR PERSONAL COMPUTERS

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Abstract

The Poisson/Superfish codes calculate static **E** or **B** fields in two-dimensions and electromagnetic fields in resonant structures. New versions for 386/486 PCs and Macintosh computers have capabilities that exceed the mainframe versions. Notable improvements are interactive graphical post-processors, improved field calculation routines, and a new program for charged particle orbit tracking.

Introduction

The Poisson/Superfish group of codes was developed for Los Alamos National Laboratory by R. Holsinger and K. Halbach[1-3] for field solutions in two-dimensions. The Poisson and Pandira programs use a conformal triangular mesh to find electrostatic or magnetostatic fields. They can handle non-linear and anisotropic materials. Superfish calculates resonant electromagnetic modes in two-dimensional resonant structures. Although the codes are venerable, they still find wide application in accelerator science because of their versatility and robustness.

The increased speed and available RAM on modern PCs makes them ideal platforms for the Poisson/Superfish programs. This paper describes the capabilities of versions of the programs for MS-DOS 386/486 and Macintosh computers. The Poisson running time for a typical problem (7000 mesh points) is 1-2 minutes on a 486 computer. Table 1 lists the array dimensions for an MS-DOS computer with 3 MB of extended memory or a Macintosh with 5 MB RAM. The technical core of the PC version is the public domain programs supported by the Los Alamos Accelerator Code Group[1,2]. The full collection of programs with mainframe capacities and extensive I/O support is sold at a nominal price under the name EMP 2.0 (Electric and Magnetic Field Design Package) by Field Precision of Albuquerque, New Mexico. A recently completed educational version will be distributed free-of-charge by the University of New Mexico to secondary schools and colleges.

References 1 and 2 describe the capabilities of the programs in detail. This paper summarizes the differences between the mainframe and PC versions. Advances in the PC version can be divided into two categories: 1) user convenience and ease of learning, and 2) technical improvements. The following sections address these areas.

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TABLE 1
Array Limits
386 and Macintosh Versions

Mesh points (POISSON)	30,000
Mesh points (PANDIRA-SUPERFISH)	25,600
KMax, LMax (PANDIRA-SUPERFISH)	160
Boundary segments (SUPERFISH-QCALC)	60
Electrical regions	60

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Making Poisson User-friendly

Successful software for personal computers must meet high standards. PC users expect turn-key software with attractive screen interfaces and built-in compatibility with a diversity of hardware devices. An individual user should be able to learn the software easily without counseling - the programs should have built-in help features. Although the mainframe versions of Poisson/Superfish are technically excellent, they are not particularly responsive to the user or easy to learn. Therefore, extensive effort was devoted to the human interface in designing the PC versions. Improvements include the following.

Instruction manual

A new step-by-step manual covers installation, theory of operation, and techniques. A broad library of examples on disk allows users to test their installation and provides them with templates for a wide variety of program applications.

Direct Autocad boundary input

Special menus and translation programs allow use of Autocad[4] (a popular CAD program) to prepare boundary input. The full capabilities of Autocad, including automatic computation of end points for lines and arc segments, can be applied to problem layout.

Improved input syntax

Input of boundary and electrical information has been completed revamped. Information is organized in a logical order with expanded mnemonics. Command lines are read by a forgiving free-form parser that immediately points out syntax or organizational errors.

Pop-up reference utility

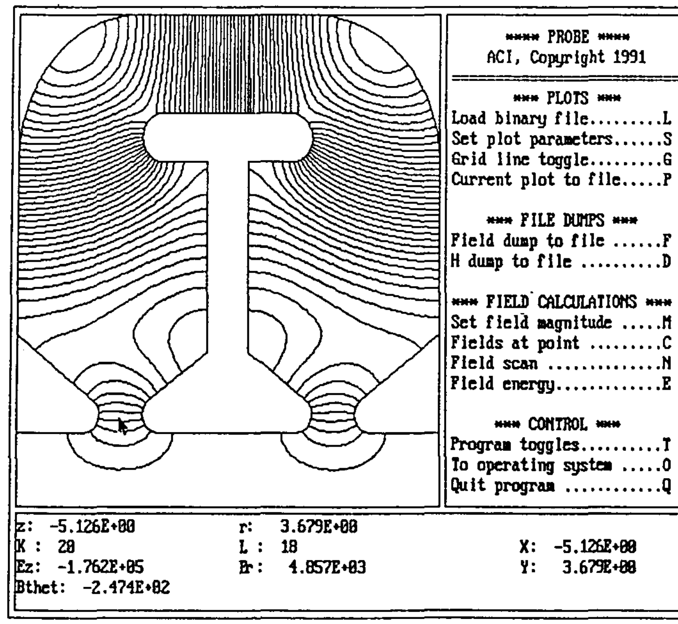
Pop-up utilities are called by keyboard interrupts on DOS computers. This feature gives access to information on input formats and parameters for all the programs within editors, word processors or CAD programs.

Improvements to the main technical programs

Several features have been added to the standard technical programs (Lattice, Poisson, ...) to make them more responsive. When calling the programs, the input file name can be given as a command line parameter. This helps in the creation of simple DOS batch files to control extended overnight runs. Furthermore, error messages have been expanded and translated to plain English. The screen display gives a continuous indication of program status and immediate notification of an error condition.

Interactive post-processors

In the standard mainframe version, options for field calculations are limited. Only text output is available. In Poisson, analyses are performed at the same time as the field solution and there is no convenient way to extract information from existing solution files. The post-processing program Sfout for Superfish finds fields only on boundaries. Two new programs were developed for the PC Version, VISION and PROBE. These programs allow interactive analyses of solution files. The programs operate in a graphical environment and support position input from a mouse. They record the history of each analysis session in an ASCII file for later incorporation into text files, user-developed programs, or spreadsheets. Figure 1 shows a reproduction of the colored screen display of PROBE for a Superfish analysis. The graphical window shows electric field lines and the mouse pointer arrow. The information window at the bottom shows position, logical mesh numbers, and field values. The program automatically adjusts to rectangular or cylindrical geometry and TE or TM modes.



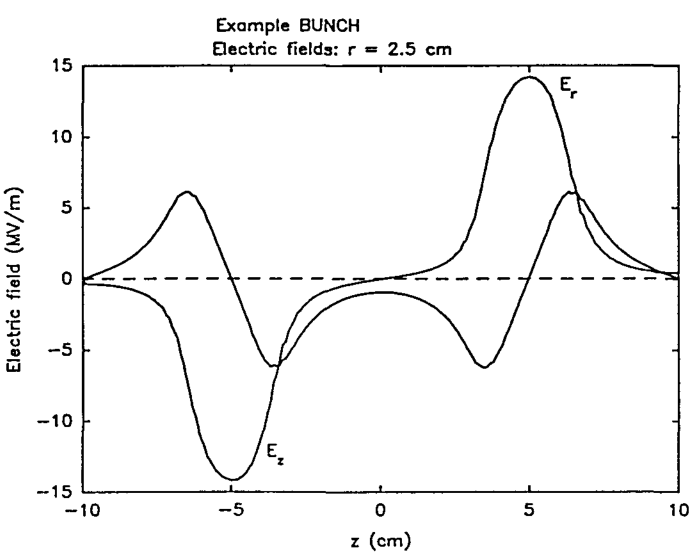
Technical advances to Poisson/Superfish

Technical advances to the Poisson/Superfish codes include expansion of existing programs and new programs the extend the capabilities of the code package. The key improvement is the addition of field calculation routines with second-order accuracy, high reliability and extended versatility. The harmonic potential routines of the mainframe version can handle only points in air gaps at positions far from electrodes, coils or dielectric boundaries. Furthermore, the routines may crash when there are large changes in mesh resolution. The field calculation method of the PC version works with any mesh at all points in the problem region, including the interior of non-linear materials. The method also gives the correct field discontinuities at dielectric or ferromagnetic boundaries.

The first step in the new field calculation routine is to identify the triangle that contains the target point. This process is challenging on an irregular mesh - the only totally reliable method is to search all triangles. For problems such as particle tracking that involve a sequence of nearby points, the routines switch to a fast local search mode. For widely spaced points, another option is a fast method that uses boundary coordinates to guess the triangle location followed by a search in the neighborhood.

The second step is to collect nearby mesh points. The search expands around the target triangle until from 6 to 24 valid points are obtained. To assure that all points are on the same side of a material boundary, valid points must be adjacent to at least one triangle that has the same material designation as the target triangle. After collection of points, a least squares fit determines a second-order Taylor expansion for the potential near the target point. The expansion gives an accurate interpolation of the potential and derivatives to find components of electric or magnetic fields. The standard outputs of the field calculation routines are the mesh coordinates (K,L) of the target triangle, the material properties at the target point (e or m), the interpolated potential, and vector field components.

The field calculation routines are the basis for the VISION post-processor (POISSON and PANDIRA), the PROBE post-processor (Superfish), and TRAK, a new particle orbit tracking program. Figure 2 shows a plot of the results of a PROBE field scan along the r = 2.5 cm line for the problem illustrated in Fig. 1. The post-processors have several other improvements, such as field energy calculations separately listed for the subregions of the problem. This makes it easy to calculate capacitance, inductance, and dielectric RF losses.



The most recent addition to the Poisson/Superfish codes is TRAK, a program for particle orbit tracking. The present version is limited to single-particle orbits without space-charge. The code structure is designed for future expansion, including self-consistent space-charge forces, field emission, and space-charge-limited emission. The present version of TRAK has application to the design of electro-optical devices and charged particle lenses.

TRAK has several unique capabilities compared with other particle tracking codes.

The program uses the standard Poisson conformal triangular mesh. This gives good field accuracy, even near irregular conducting boundaries.

It is possible to enter separate solution files to determine orbits in combined electric and magnetic fields. The two solution files need not have the same triangular mesh. Boundary input for the fields is simple, following the standard formats of the PC version.

There are broad options for stopping particle orbits, including accurate interpolations at stopping planes.

TRAK includes an advanced graphical post-processor for interactive construction of orbit plots with optional grid lines, equipotential lines and magnetic field lines.

Version 1 of TRAK is currently operational. Extension to self-consistent space-charge forces is anticipated in Spring of 1993.

REFERENCES

1. Los Alamos Accelerator Code Group, **Reference Manual for the Poisson/Superfish Group of Codes** (Los Alamos National Laboratory, LA-UR-87-126, 1987).

2. Los Alamos Accelerator Code Group, **User's Guide for the Poisson/Superfish Group of Codes** (Los Alamos National Laboratory, LA-UR-87-115, 1987).

3. K. Halbach and R.F. Holsinger, Part. Acc. **7** (1976), 213.

4. Copyright, Autodesk Inc., Sausalito, California.