THE USE OF THE IBM-PC COMPUTER IN ACCELERATOR DESIGN CALCULATIONS*

Judith Colman
Neutral Beam Division
Brookhaven National Laboratory
Upton, New York 11973

Abstract

For many reasons it is desirable to develop a "stand-alone" means of carrying out preliminary calculations in the various accelerator design fields. Work is in progress to allow the use of modified or subset versions of several well-known and widely used codes on the IBM-PC. Codes in preliminary operation include TRANSPORT, for beam-line design; the SUPERFISH code series, for cavity design; and RAYTRACE, for magnets. These codes are surpassing expectations in capabilities, speed of execution, and accuracy.

Introduction

A recent effort has been made to create versions of a number of accelerator design codes which can be run on an IBM-PC computer. Versions of four of the most widely used codes, TRANSPORT, POISSON, SUPERFISH, and RAYTRACE are now operating successfully on the IBM-PC, and other codes are being considered for conversion.

It is desirable to be able to carry out the majority of preliminary design calculations on an IBM-PC This can save a considerable amount of time, cost, and aggravation over the use of the same codes on a large computer where the capacity and more detailed calculations are often not needed.

General Concept

The object of converting codes to run on an IBM-PC is to create tools which can be used easily to perform as many of the tasks of the large computer codes as possible and with a reasonable accuracy. Since IBM-PC's can be configured in many ways and with a variety of peripheral equipment, it was decided to aim for codes which operate on the most basic configuration of PC that can handle the tasks. For this reason many "frills" which could be added or improved with additional equipment have been avoided in the basic code versions. Users are free to make use of special system features by creating their own versions.

The data input of each code has been kept identical to the large-computer version in order to allow the user to do preliminary calculations on the PC and then transfer the same data file to a large computer for final, more detailed calculations. With minor exception, the printed output is also identical to the large-computer versions to avoid confusion to the user.

IBM-PC Configuration

The following IBM-PC equipment/features are needed in order to run the codes.

- 640K memory; in the case of the PC-XT, this is normally the maximum 512K with the addition of the AST-6-pack.
- Hard disk; 10 M-Byte or larger.
- Printer with either wide (132 char./line) paper or compressed print (approx. 17 char./inch on 8 1/2" paper) capability, preferably both options.
- Floppy disk drive (360K or 1.2 M).

The 640K memory is required for the codes to run, but it may be possible to create smaller versions by reducing array sizes. The codes actually use a maximum of 576K and the remaining 64K is used for the standard length print buffer with the AST-6-pack.

The hard disk is required to store the ".EXE" modules since some are larger than will fit onto one 360K floppy disk. The ".EXE" modules are transferred from system to system by copying to multiple floppy disks using the DOS/BACKUP feature and loading using the DOS/RESTORE feature.

The 132 character printing is required for the printed output of most codes and this can be achieved with either a wide bed printer or compressed print. However, in order to provide rough graphics features, printer plot routines have been written and these make use of the compressed print feature. A printer without this feature will still print the plots but the grid will be extremely coarse.

The floppy disk drive is required to load the ".EXE" files.

Run Time/Accuracy

In general, run times have been found to be quite reasonable (<10 mins on a PC-XT) but obviously vary considerably with each individual case. The time and date are printed at the beginning of each run and time is printed at points throughout the codes where the large-computer versions have time prints and also at the completion of each run.

The accuracy achieved in comparison with output from the same data case on a large-computer is four significant figures in most codes. However, very small numbers, such as small second order terms in TRANSPORT which are less than approximately 10^{-6}, are of a similar order of magnitude as the large computer version but totally different in value.

Compiler

The FORTRAN compiler used for these codes is the IBM version of Professional Fortran by Ryan-McFarland (IBM 6024200).

Code Operation

Each of the codes operates in a similar way. All input is from one or more files which must be called INPUTn.DAT, where n is 0 through 9. INPUT0.DAT is always the basic input file, equivalent to the system input file on a large computer. INPUT1.DAT through INPUT9.DAT are additional input files when required by a specific code. No output is connected directly to the printer, but all output is directed into files OUTPUTn.xxx where n is 0 through 9 and xxx is either LIS or DAT. If the output file would normally be a

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print file, then xxx is LIS and where the output file contains data for use with another code, then xxx is DAT. The reason for storing the printer output in a file is so that the user has the option of using floppy disks as an archiving system rather than keeping large quantities of paper. The printer output file can be scanned for sections which are required or printed in full using a small code called FORTLIST which obeys the standard FORTRAN print control characters in column 1 of each output line. If output is printed using the DOS/TYPE or COPY commands (to the printer) then the control characters will be printed as the first character of each line instead of controlling the output formats.

For ease of operation batch command files have been created to run each of the codes. When using the batch files to run codes the user must avoid naming files in the same directory INPUTn.DAT or OUTPUTn.xxx; the batch files are set up to input and output files in names which are meaningful to the user.

Specific Codes

The following section describes specific codes which have been converted to run on the PC and limitations on each.

1. TRANSPORT

"A Computer Program for Designing Charged Particle Beam Transport Systems."

Written by: K.L. Brown, D.C. Carey, Ch. Iselin, and F. Rothacker.

Version: 5/85 from D. Carey, FNAL.

PC Changes and Limitations

(a) Changes: The PC version of TRANSPORT includes all options for 1st and 2nd order calculations. No 3rd order calculation is included.

(b) Limitations: The PC version of TRANSPORT has a limitation on the size of the problem. The capacity of 3129 elements in the model has been reduced to 1000 elements. The total number of data values entered has been reduced from 13160 to 4500.

Accuracy

4 significant figures (compared to CDC-7600).

Future Enhancements

A second output file will be added. This file will contain the values of specific items at every data point, whether printed or not. The file will then be available for printing a summary, or plotting as required by the user.

2. SUPERFISH

"Solves for the TE and TM resonant modes (fundamental of all higher frequencies) including field distributions in cylindrically symmetric radio frequency cavities."

Distributed by: Los Alamos National Laboratory.

Version: 2/85 from M. Menzel, LANL

PC Changes and Limitations

(a) Changes: None.

(b) Limitations: The PC version is limited to a maximum of 4000 mesh points. All other program limits remain the same as the large system versions.

Accuracy

4 significant figures (compared to CDC-7600) on all values except the differences of similar values.

Future Enhancements

None planned.

3. POISSON

"Solves by successive point over-relaxation, POISSON's (or Laplace's) equation for the vector (scalar) potential, with non-linear iron (dielectric) for two-dimensional or cylindrical problems. Calculates the derivatives of the potential (fields and gradients). Calculates the stored energy and performs harmonic (multipole) analysis of the potential."

Distributed by: Los Alamos National Laboratory.

Version: 2/85 from M. Menzel, LANL.

PC Changes and Limitations

(a) Changes: None.

(b) Limitations: The PC version is limited to a maximum of 4000 mesh points. All other program limits remain the same as the large system versions.

Accuracy

Variable, some values have 4 significant figures (compared to CDC-7600); other values are only accurate to the order of magnitude. This lack of accuracy in some of the values comes from frequent instances of the differences of similar values which result in a difference of less than 10^{-4} of the original values.

Future Enhancements

None planned.

4. AUTOMESH and LATTICE

AUTOMESH: "Prepares the input data for LATTICE."

LATTICE: "Generates an irregular trianglar mesh from the input data for the 'logical' and physical coordinates describing the problem."

Distributed by: Los Alamos National Laboratory.

Version: 2/85 from M. Menzel, LANL.

PC Changes and Limitations

(a) Changes: None.

(b) Limitations: The PC version of both AUTOMESH and LATTICE are limited to creating a mesh with a maximum of 4000 points. All other program limits remain the same as the large system versions.

Accuracy

4 significant figures (compared to CDC-7600).

Future Enhancements

Addition of a non-linear mesh option to both

AUTOMESH and LATTICE. This would be especially valuable in modelling RFQ type cavities for SUPERFISH where one region requires an exceptionally small mesh compared with the remainder of the model.

5. TEKPLOT

"Plots physical meshes from LATTICE generations and equipotential (field) lines from POISSON and SUPERFISH solutions."

Distributed by: Los Alamos National Laboratory.

Version: 2/85 from M. Menzel, LANL.

PC Changes and Limitations

(a) Changes: Plotting is very different from a large system and there are many ways of plotting on a PC. Because it is very system dependent, a very simple printer plot version of TEKPLOT has been created which should run satisfactorily on any system. In addition, a data file can be generated (in a pre-defined format) which users can then plot using any hardware and software configuration available to them.

(b) Limitations: The PC version of TEKPLOT is limited to a maximum of 4000 mesh points.

Accuracy

The accuracy of the information from LATTICE, SUPERFISH, or POISSON.

6. RAYTRACE

"A very general ion-optical computer code including routines for non-uniform magnets of various kinds, solenoids, Wein filters (ExB), electrostatic deflectors, and multipoles up to decapole."

Written by: S. Kowlaski and H.A. Enge, MIT.

Version: 10/85, Yale University.

PC Changes and Limitations

None.

Accuracy

At least 4 significant figures (compared with IBM 4341).

Future Enhancements

Some work has already been performed using code modifications to describe inhomogeneities in dipole magnets. This has not been included in the current PC version. This and other modifications may be added later.

7. HEATING5

"Designed to solve steady-state and/or transient heat conduction problems in one-, two-, or three-dimensional Cartesian or cylindrical coordinates or one-dimensional spherical coordinates."

Written by: W.D. Turner, D.C. Elrod, I.I. Siman-Tov, ORNL (ORNL/CSD/TM-15).

PC Changes and Limitations

(a) Changes: None.

(b) Limitations: Two versions are available:

- Single Precision - up to 6000 mesh points
- Double Precision - up to 4000 mesh points

Accuracy

3-4 significant figures (compared with CDC-7600).

Future Enhancements

None planned at present.

Other Codes Under Consideration for Conversion to PC Use

Other codes being considered for future operation on a PC are:

(a) The remainder of the POISSON code series, PANDIRA, MIRT, FORCE.

(b) PARMILA/PARMELA

(c) Any other useful codes which may be significant to the work being performed in the Neutral Beam Division of BNL.

Conclusion

Using PC-versions of the codes most used for accelerator design work reduces dependence on large facilities and reduces the costs associated with the use of such facilities. A user can easily make calculations at his own desk whenever required to do so in approximately the same total turnaround time as on a large system. It is also very easy to transfer the codes and data files from PC to PC for multiple users, remote consultations and meetings, and many other reasons.