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# AKPLOT: A Plotter Routine for IBM PC, XT, and AT

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February 15, 1987

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## ABSTRACT

The AKPLOT software for the IBM PC, XT, and AT is an efficient and versatile tool that allows X-Y plotting of quantitative information. Features include IBM four-color graphics, which combined with 10 different symbols allows 40 different curves on the same grid, shrink or expansion of the graph size, any combination of log and linear X and Y axes, selective plotting from multiple curves of a previous run, interpolation and polynomial least-squares fit with any degree polynomial, and a 90-degree tilt of the entire graph. These options are independent, and can be invoked individually.

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# SECTION I

## INTRODUCTON AND CAPABILITIES OF AKPLOT

The current explosion of literature in most fields of technology brings with it the need for an efficient and versatile tool to depict quantitative information. The displays required are usually graphs of one parameter plotted against another.

A few years ago, such figures could be generated only with a mainframe computer or a minicomputer and whatever plotter resources the systems offered. Since the advent of low-cost microcomputers, almost every engineer or scientist has access to a 16-bit capacity computer and all the software support of FORTRAN, PASCAL, and other such languages that are used for number crunching. There are still obstacles, however, to satisfying the need for an X-Y plot that will present research results: few routines for personal computers are capable of plotting, and the scientist's research time is too valuable to be diverted for the sake of developing a plotting routine tailored specifically for his needs.

A new software for the IBM PC, XT, and AT goes a long way toward providing plotting capability with personal computers. This new software, AKPLOT, greatly increases the ability of the user to present data in graphic form with a minimum of effort. To take advantage of IBM color graphics, the software is written in the standard density graphics mode, which allows the use of four different colors for the plots.

AKPLOT is completely interactive and user friendly. There is, at the start of every plot, an interactive session by which AKPLOT gathers the inputs necessary to plot the desired graph. This session makes the job of entering commands and parameters as painless as possible for users at all levels of experience. If the user makes a mistake in the input -- as, for instance, an error in syntax or an input in conflict with the general directives of the routine -- AKPLOT will prompt the user to reenter the input. AKPLOT processes these parameters to produce the plot on the screen. After plotting the graph, the routine loops back to the interactive session to allow unlimited alterations by changing the parameters. This loop back avoids the need to create again the X and Y points that were input at the start of the program, thus making the execution of the program faster. With the graph to the user's satisfaction, a screen dump to a printer may be performed and a hard copy generated.

The capabilities of AKPLOT include

(1) Four-color graphics.
(2) Multiple graphs on the same grid.
(3) A shrink or expansion of the graph size.
(4) Three different types of grids.
(5) Any combination of log and linear X and Y axes.
(6) Forty different curves on the same grid using ten different symbols and four different colors.
(7) Selective plotting from multiple curves of the previous run.
(8) Zoom in on any area, curve, or curves of the previous run.
(9) Interpolation of all or selected curves of the previous run.

(10) Polynomial least-squares fit -- with any degree polynomial -- of all or selected curves of the previous run.
(11) Tilt of the entire graph by 90 degrees.
(12) Storage of plotted curves under desired titles for later reference.
(13) Modification of a displayed plot that was stored from a previous date.

These options are independent of each other and can be invoked individually.

## SECTION II

## INTERPOLATION AND LEAST-SQUARES FITTING

When data points are joined by straight lines (which is the most common practice) to form a graph, the graph has corners; these corners are especially noticeable when the graph is blown up to bring out details. Corners can be avoided only with a great number of X,Y pairs of points.

The number of pairs needed may not be possible, however, where the data are obtained from a one-shot experiment that produces too few points, or where the points are generated from a computer program that requires more time to produce the needed number than is available.

### A. INTERPOLATION

Where the data points available are not sufficient to produce a smooth curve, the AKPLOT uses an interpolation technique to generate virtual X,Y pairs to provide interpolation between points.

A step toward this technique is a tool named Lagrange's interpolation routine. This routine takes user-assigned consecutive X,Y pairs and generates (interpolates) values at the desired points. If interpolation between consecutive known points using "N + 1" points is desired, the following formula is used to generate the interpolated points:

$$f(x) = \frac{(x - x_1)(x - x_2) \ldots (x - x_N)}{(x_0 - x_1)(x_0 - x_2) \ldots (x_0 - x_N)} f(x_0)$$

$$+ \frac{(x - x_0)(x - x_2) \ldots (x - x_N)}{(x_1 - x_0)(x_1 - x_2) \ldots (x_1 - x_N)} f(x_1) \quad \ldots$$

$$+ \frac{(x - x_0)(x - x_1) \ldots (x - x_{N-1})}{(x_N - x_0)(x_N - x_1) \ldots (x_N - x_{N-1})} f(x_N)$$

where x,f(x) are the X,Y points known to the program. By judiciously selecting the possible N + 1 points to be used for the interpolation, AKPLOT provides the influence of almost N/2 points before the intended interpolated points and almost an equal number of points after the intended interpolated points. This interpolation technique does not change the original points supplied to the routine. It should be noted that while it is desirable to provide a maximum number of points to interpolate a desired point, execution time will increase quite rapidly with an increase in the number of points supplied. Where only two points are supplied to interpolate the remaining points, execution time is minimized, but the resultant linear interpolation may not meet the user's standards.

## B. LEAST-SQUARES FITTING

Fitting a curve to a set of points is somewhat different than interpolating points, although the processes are related. The method adopted here is the polynomial least-squares fit. The polynomials are generated by Gramm-Schmidt orthogonalization procedures. With N as the points in the set to which an M-degree polynomial ($M \leq N$) is to be fit, the desired polynomial is generated by the following formula:

$$P(x) = a_0 P_{N0}(x) + a_1 P_{N1}(x) + \ldots + a_M P_{MN}(x)$$

The orthogonal polynomials $P_{MN}(x)$ are generated by the following formula:

$$P_{NM}(x) = \sum_{i=0}^{M} (-1)^i \binom{M}{i} \binom{M+i}{i} \frac{(x)^{(i)}}{(n)^{(i)}}$$

The coefficients $a_i$ are generated as follows:

$$a_i = \frac{\sum_{x=0}^{N} f(x)\, P_{Ni}(x)}{\sum_{x=0}^{N} P_{Ni}^2(x)}$$

It should be noted that if the polynomial degree becomes larger than the number of points in the set, the result is simply a $M^{th}$-degree polynomial passing through the points. The routine does not change the original points, it only generates the new points and plots them. Because the newly generated points are not saved, the routine generates them fresh each time the curve-fitting operation is called for. The same is true for the interpolation routine. The least-squares fit routine may be used also for curve smoothing.

## SECTION III

## DATA PREPARATION

### A. THE FIRST SECTION

AKPLOT consists of three distinct sections. The first section, as shown in Figure 1, is the interactive session -- the initialization of the program. In this section, the user inputs all parameter values necessary for the plot routine, which is the third section of the program.

### B. THE SECOND SECTION

There are three different methods in the second section by which X-Y data may be supplied to AKPLOT. These methods are described below. During interaction, the first request displayed concerns which of these methods the user requires:

"ENTER 'COMPUTE' 'KEYBOARD' OR 'FILE' TO SUPPLY THE X AND Y VECTORS"

#### 1. Generating Vectors From the Language

To produce X and Y vectors using the basic programming language, enter 'COMPUTE' as the answer to the request above. By doing so, the second section, which facilitates computation of the X and Y vectors, will be displayed (see Figure 1). The FOR-NEXT loops started at line number 2130 compute these vectors. J is the count of the number of curves in the plot; I is the count of the number of points in the $J^{th}$ curve. Thus there is a total of M curves per plot and N points per curve. The values of M and N are gathered by AKPLOT from the interactive session. Because the necessary arguments for the X and Y vectors are supplied from the interactive session, the user must further supply only the formulas necessary to compute the X and Y pair. There is sufficient space for this: either lines 2130 to 9999, or a little more than 5 kilobytes of memory, whichever occurs first.

#### 2. Generating Vectors From the Keyboard

X and Y vectors can also be produced by use of the 'KEYBOARD' option of the request. When the control reaches the appropriate place in the program, it will ask the user for the X and Y inputs. At that time, the user should input one X,Y pair at a time, each pair separated by a comma. The data will have the form shown in Figure 2.

#### 3. Retrieving Previously Generated Vectors

To display previously generated X and Y vectors stored in a single file, enter 'FILE' as the response to the request. The control will then request the name of the file in which the user has stored the X and Y vectors. The response to this request will cause the control to open the named file and read X(I),Y(I) pair per read operation. Thus the user can create the file containing the pair X(I),Y(I) per row in the vector. The data should appear as that shown in Figure 2.

C. THE THIRD SECTION

The third and last secton, starting at line 10000, is the plotter routine itself; the user is cautioned not to alter this part. Any tampering may destroy AKPLOT's ability to plot.

| | | |
|---|---|---|
| Section I<br>Initialization<br>of AKPLOT | 10 | DEFSTR Z |
| | 20 | DIM |
| | 30 | ° |
| | 40 | ° |
| | | ° |
| | | ° |
| | 1290 | ° |
| Section II<br>User Input to<br>compute X and Y | 2130 | FOR J=1 TO M |
| | 2140 | FOR I=1 TO N |
| | 5000 | X((J-1*N+I)= |
| | 7000 | Y((J-1*N+I)= |
| | 9999 | END |
| Section III<br>AKPLOT Routine | 10000 | PLOTTER ROUTINE |
| | | ° |
| | | ° |
| | | ° |
| | 25000 | RETURN |

Figure 1. The structure of AKPLOT

| | X Vector | Y Vector |
|---|---|---|
| Curve #1 | X(1) | Y(1) |
| | X(2) | Y(2) |
| | ° | ° |
| | ° | ° |
| | ° | ° |
| | X(N) | Y(N) |
| Curve #2 | X(N+1) | Y(N+1) |
| | X(N+2) | Y(N+2) |
| | ° | ° |
| | ° | ° |
| | ° | ° |
| | X(2N) | Y(2N) |
| | ° | ° |
| | ° | ° |
| | ° | ° |
| | ° | ° |
| | ° | ° |
| | ° | ° |
| Curve #M | X(MN-N+1) | Y(MN-N+1) |
| | X(MN-N+2) | Y(MN-N+2) |
| | ° | ° |
| | ° | ° |
| | ° | ° |
| | X(MN) | Y(MN) |

Figure 2. Data vector arrangement

## SECTION IV

## RUNNING THE DEMONSTRATOR PROGRAM

To illustrate the capabilities of the AKPLOT routine, a demonstrator program is supplied. This program includes all the parameter values necessary for plotting; the user supplies none. The steps are:

(1) Turn the system on.
(2) Change directory to the one containing BASICA compiler.
(3) Load the basic compiler by keyboarding BASICA.
(4) Load the plotter routine by keyboarding LOAD "A:AKPLOT".
(5) Run the program by keyboarding RUN.

After running the program, a short request and response session follows. The first question displayed is "DO YOU WANT TO WORK WITH PLOT STORED IN A FILE?" Enter NO. The second question is "DO YOU WANT TO RUN THE DEMO?" Keyboard YES and press return. The plotter will then produce the plot of three sine waves of different amplitudes and frequencies in the linear X and Y scales. The plot is complete with axes titles and numbering, and a different color for each curve.

After the first plot is complete, the system awaits the user's signal for the second plot. To continue, press RETURN. The second plot is the same three sine waves, but in semilog scale: the X axis is in log scale and the Y axis is in the linear scale. Again, the plot will be complete in three colors and with axes titles and numbering. This time the graph is tilted 90 degrees and the grid will be dense. At the end of this plot, the plotter will terminate the session after the user presses the RETURN key. These two figures are displayed in Figures 3 and 4.

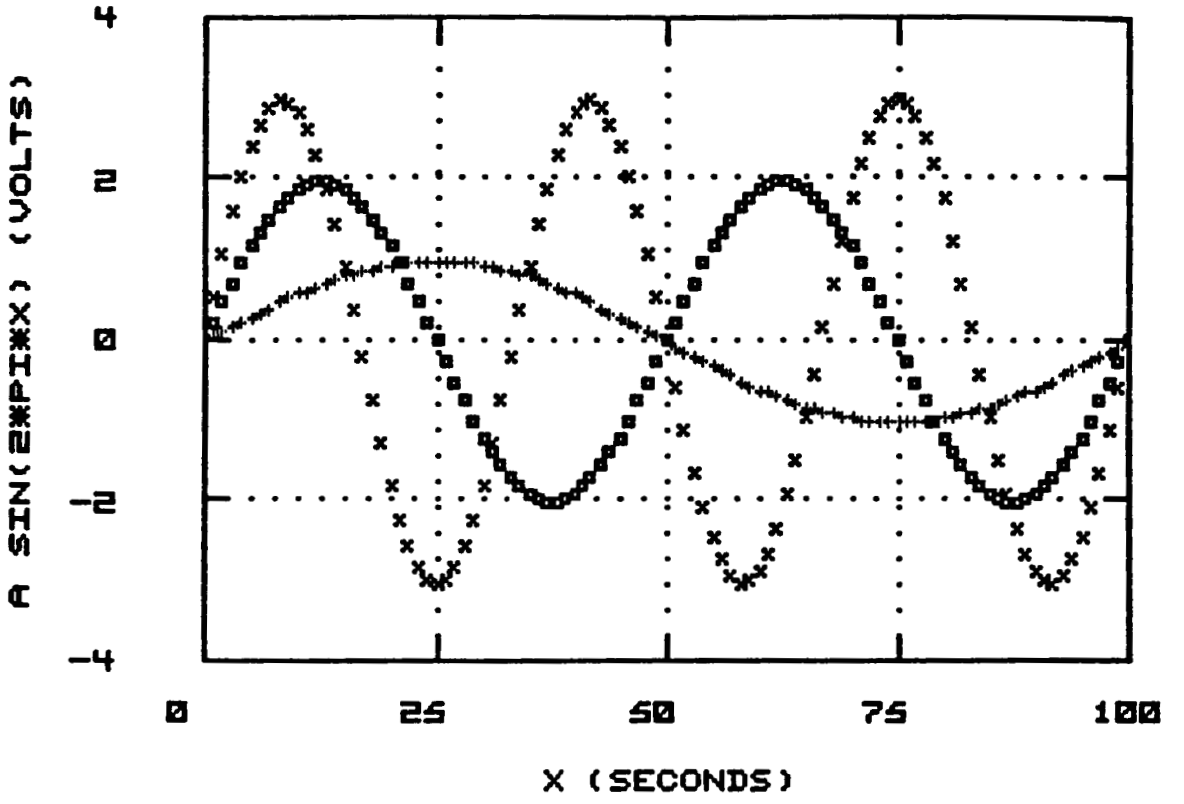


Figure 3. Demonstrator program in linear scale

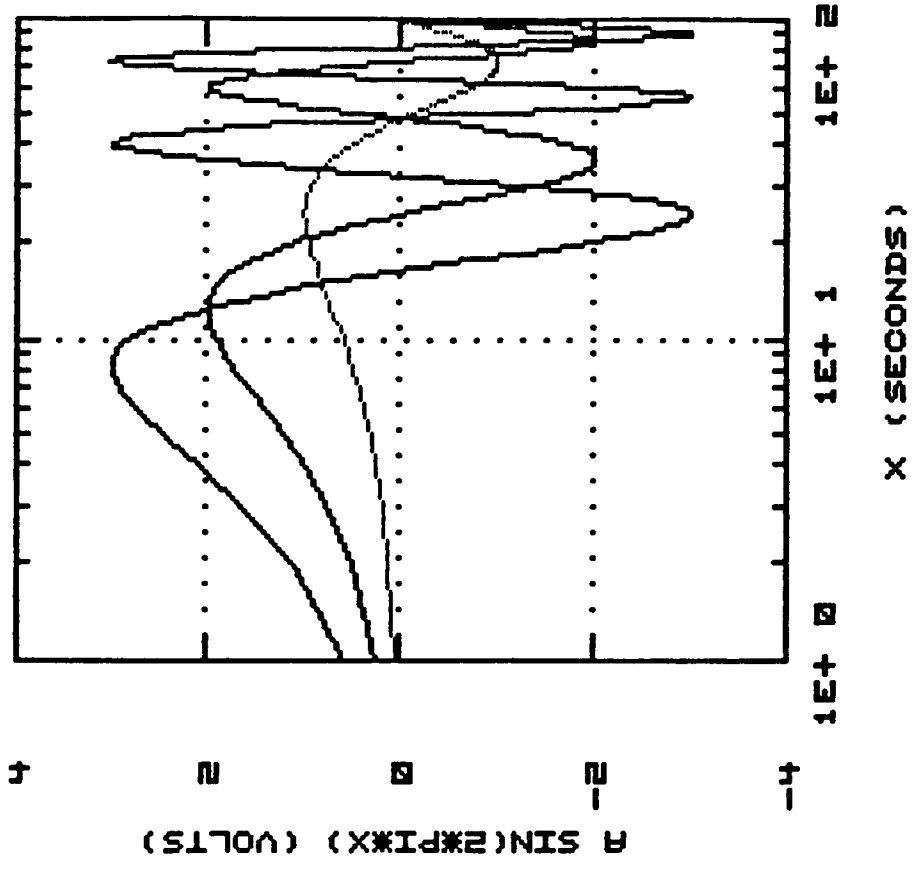


Figure 4. Demonstrator program in semilog scale

## SECTION V

## PRODUCING A USER-DEFINED X-Y PLOT

Where the user wants to plot M curves on the same grid, each curve having N points, the data must be prepared in accordance with one of the methods described in Section III: the data points are either computed in the AKPLOT program, or supplied via KEYBOARD or FILE.

The first five steps are the same as those described in Section IV. After running the program, the following requests and responses follow. The requests are tagged AKPLOT :. Any needed explanation is given right after the request and tagged NOTE :. Finally, the user response to the request is tagged USER. : Many of the requests are self-explanatory.

AKPLOT : DO YOU WANT TO WORK WITH PLOT STORED IN A FILE?

NOTE : This capability allows display of the stored output of a previous AKPLOT run. It should be noted that this question concerns a stored plot in a file; this should not be confused with file-stored X and Y vectors. If the user answers YES to this question, the program requests ENTER NAME OF THE FILE (the file that contains the plot). AKPLOT then displays the plot and allows changes. If the user answers NO to this question, the question and answer sequence resumes.

AKPLOT : DO YOU WANT TO RUN THE DEMO?

USER : NO.

AKPLOT : ENTER NUMBER OF CURVES TO BE PLOTTED :

USER : M.

AKPLOT : ENTER COMPUTE, KEYBOARD, OR FILE TO SUPPLY X AND Y VECTORS.

NOTE : The COMPUTE facility lets the user enter formulas to generate the X and Y vectors at the specified place (see Figure 1). This option requires input of these formulas before AKPLOT is run. The KEYBOARD option allows input of the X and Y vectors one at a time and separated by a comma. The FILE option opens a file to supply X and Y vectors. The user may create this file with any compiler such as FORTRAN; the only requirement is that the X,Y entries should be separated by at least one space. If the FILE option is selected, the next request is ENTER THE FILE NAME HOUSING X AND Y VECTORS; the request following this will be omitted.

USER : User should enter either COMPUTE, KEYBOARD, or FILE.

AKPLOT : ENTER NUMBER OF POINTS IN A CURVE :

USER : N.

AKPLOT : ENTER XMIN,XMAX,YMIN,YMAX FOR THE PLOT :

NOTE : XMIN AND XMAX refer to the range of the X axis and similarly YMIN and YMAX refer to the range of the Y axis to be plotted. It should be noted that XMIN at the most be equal to the minimum of the X data vector and XMAX at the least should be equal to the maximum of the X data vector. There is one exception, however: where the data is supplied by using the FILE option, and where the X vector is monotonic, the user may supply XMIN larger than the X-vector minimum and XMAX smaller than the X-vector maximum. By supplying minimum quantities smaller than the minimum of the data vectors and maximum quantities larger than the maxima of the supplied data vector, the size of the resulting curve will shrink.

USER : Supply the minimum and the maximum of the X and Y vector.

AKPLOT : DO YOU WANT THE 90-DEGREE TILT ACTIVE?

NOTE : This option turns the whole plot 90 degrees. There is an advantage to this option: On most screens, the horizontal dimension is larger than the vertical dimension; hence, more details on the Y axis can be seen if the 90-degree tilt option is chosen.

USER : Enter either YES or NO. Depending upon this input, the next appropriate branch of questions will be asked. For the sake of this program, assume the answer is NO.

AKPLOT : ENTER THE X AXIS LENGTH (MAX = 250) :

NOTE : The total number of pixels available in the horizontal dimension of the screen is 300; of these, 250 are available for plotting curves. The remaining 50 are necessary for other purposes. This option allows the user to expand or shrink the X axis length of the plot.

USER : Enter any number between 100 and 250. Below 100 is permissible but not recommended.

AKPLOT : ENTER THE Y AXIS LENGTH (MAX = 150) :

NOTE : The total number of pixels available in the vertical dimension of the screen is 180; of these, 150 are available for plotting curves. The remaining 30 are necessary for other purposes. This option allows the user to expand or shrink the Y axis length of the plot.

USER : Enter any number between 100 and 150. Below 100 is permissible but not recommended.

AKPLOT : ENTER THE GRID STYLING SELECTED :

NOTE : There are three grid styles possible. These are given below.

| User entry | Grid style |
|---|---|
| 0 | No grid |
| 1 | Less dense |
| 2 | Dense |

USER : Enter either 0, 1, or 2.

AKPLOT : ENTER NUMBER OF MAJOR DIVISIONS ON X AXIS (0 IF LOG SCALE) :

NOTE : This option lets the user select either LINEAR scale or LOG scale for the X axis. If LINEAR is needed, enter the number of divisions desired on the X axis. If LOG is needed, enter 0. Entering 0 automatically subdivides the X axis for the LOG scale. CAUTION: the number of divisions should be less than or equal to 5; otherwise, axis numbering may overlap.

USER : Any number $\leq$ 5 including 0.

AKPLOT : ENTER NUMBER OF MAJOR DIVISIONS ON Y AXIS (0 IF LOG SCALE) :

NOTE : Same as for the X axis above.

USER : Any number $\leq$ 5.

AKPLOT : DO YOU WANT INTERPOLATION?

NOTE : This option permits the user to interpolate between the given points by the Lagrange interpolation technique. Please note that to use interpolation, the X axis data points should be in monotonically increasing or decreasing order. Generally, the X-axis points are monotonic in nature. An exception to this general rule is the phase plane plots obtained in control systems where the X and Y points are not monotonic in nature. In such cases, the plotter routine may not interpolate, but it will still plot whatever points are given to it. It should also be noted that for values of X and Y below $10^{-3}$, interpolation is not recommended because the errors inherent in rounding off may give wrong answers and hence a wrong plot.

USER : User should enter either YES or NO. For the sake of completeness, we assume the answer is YES.

AKPLOT : ENTER 1 FOR THE CURVE TO BE INTERPOLATED; ENTER 0 FOR EACH CURVE NOT INTERPOLATED:

NOTE : This option permits the user to interpolate selected curves from the total of M curves. The X and Y vectors for the curves are entered in a particular order as described in the data preparation section. Enter 1 for the curve(s) to be

interpolated and 0 for the curve(s) to be untouched. Enter 1s and 0s in the same order as the data for the curves.

USER : Enter 1s and 0s as desired. In all there will be M inputs.

AKPLOT : ENTER THE NUMBER OF DATA POINTS USED IN INTERPOLATION:

NOTE : This is to set up the number of data points the user wants to employ to compute the interpolated points. The maximum number is obviously the dimension of X or Y. It should be remembered that interpolation slows the plotting routine considerably; consequently, a number less than 10 is recommended as the input.

USER : Input a number less than 10.

AKPLOT : ENTER THE NUMBER OF POINTS TO BE INTERPOLATED BETWEEN TWO DATA POINTS.

NOTE : This entry tells the plotter routine how many points will be created between two consecutive data points. Here too, a small number from 2 to 5 is recommended so that the program does not slow down.

USER : Input any number between 2 and 5.

AKPLOT : ENTER INDEX VALUES ONE AT A TIME FOR EACH CURVE.

NOTE : Index values pertain to the symbol substituted for the points. There are ten possibilities:

| Index | Symbol |
|---|---|
| 0 | Connect points with lines |
| 1 | . |
| 2 | + |
| 3 | ∴ |
| 4 | □ |
| 5 | x |
| 6 | - |
| 7 | ■ |
| 8 | :: |
| 9 | .. |

USER : Select any number from 0 to 9.

AKPLOT : LEAST-SQUARES FIT MAY BE APPLIED TO ONLY THE ORIGINAL, UNINTERPOLATED POINTS.

DO YOU WANT POLYNOMIAL LEAST-SQUARES FIT?

NOTE : This capability of AKPLOT lets the user perform least-squares fitting of the given data points with a polynomial of any degree less than 100. When using this option, it is advisable to specify the YMIN and YMAX in the XMIN,XMAX,YMIN,YMAX entry described above such that YMIN is less than the minimum of the Y vector by about 10% and YMAX is more than the maximum of the Y vector by 10%. This is desirable because the curve-fitting routine generates new Y coordinates for the same X coordinates and hence the newly generated Y coordinate of the end points of the curve may not fit inside the square specified by the XMIN,XMAX,YMIN,YMAX.

AKPLOT : ENTER THE X-AXIS TITLE :

NOTE : Once the title is keyboarded, the program will compare the length of the axis with that of the title. If the title is too long for the axis, a message appears prompting the user to reenter a shorter title.

USER : Type in the X-axis title for the plot.

AKPLOT : ENTER THE Y-AXIS TITLE :

NOTE : Same as for the X-axis title.

USER : Type in the Y-axis title for the plot.

AKPLOT : PLEASE WAIT, COMPUTATIONS ARE IN PROGRESS :::

This marks the end of user inputs; AKPLOT has all the information necessary to produce the plot. The software now goes through compatibility computations. Where there is an inconsistency, a prompt to reenter a particular input is displayed.

At the end of plotting, the control will wait for the next instruction. If the plot is satisfactory, the screen should be dumped to a printer. Dumping procedures vary, and the user should consult the manual that came with the system.

After dumping, push the RETURN and the program will print out the XMIN,XMAX,YMIN,YMAX, the X-axis graduation distance named DELX, and the Y-axis graduation distance named DELY. Subsequently, the program control will ask the following questions:

AKPLOT : DO YOU WANT TO SAVE THE PLOT IN A FILE?

USER : YES.

AKPLOT : ENTER THE NAME OF FILE TO STORE THE PLOT.

NOTE : Here the user may input any path to a file ("PICTURE") in any directory. AKPLOT will create this file and store the plot in it.

USER : Name.

AKPLOT : DO YOU WISH TO CHANGE ANY PARAMETERS OF THE PLOT?

NOTE : This question is an opportunity to change the plot. If a change is needed, answer YES. If the answer is NO, the plotter session will be terminated.

USER : Answer either YES or NO.

Answering YES prompts another question and answer session. This session is similar to the one we just described, but here the parameter values of the previous run are displayed to facilitate the changes. The only new question in this session is described below.

AKPLOT : DO YOU WANT TO PLOT A PORTION OF THE CURVES?

NOTE : This option lets the user blow up any particular section of the previous plot.

USER : YES.

AKPLOT : THE FOLLOWING CURVES WERE DEPICTED IN THE PREVIOUS RUN.

NOTE : There are M curves given in the X and Y data vectors. A 1 in the first position of the column of M entries means that the first curve was plotted; A 0 in the first position means that the first curve was not plotted. This is done for all the M curves. The numbering of the curve is the same as the position of the data points for that particular curve in the X and Y vectors (this was described in Figure 2).

AKPLOT : ENTER 0 FOR THE CURVE YOU DO NOT WANT FROM THE M CURVES AND ENTER 1 FOR THE CURVES YOU WANT FOR THIS RUN :

NOTE : As explained in the NOTE above, the user can plot selected curves from the M curves present in the supplied X and Y data-point vectors.

USER : Supply the M zeroes and ones.

AKPLOT : LOWER X COORDINATE FOR THE PREVIOUS RUN :
UPPER X COORDINATE FOR THE PREVIOUS RUN :
ENTER THE LOWER X COORDINATE FOR THIS RUN :
ENTER THE UPPER X COORDINATE FOR THIS RUN :

NOTE : Here the section of the curves the user wants enlarged is sought. Note that only the curve tagged with a 1 in the previous question will be plotted for the current run.

USER : Enter the appropriate X coordinates.

When all the questions are completed, AKPLOT will plot the new plot and store it in the file "PICTURE" as before; the question and answer session can be entered again. This simple procedure lets the user manipulate the plots to fit his needs.

The diagnostics associated with AKPLOT check every step to verify that the user input is not inconsistent with other inputs or the AKPLOT. When an inconsistency is found, the user is alerted and given the opportunity to change the input.

NOTE

This program can be obtained from NASA's Computer Software Management and Information Center (COSMIC) at

University of Georgia
Athens, Georgia 30602

or telephoning (404) 542-3205. Ask for AKPLOT NPO 16931.

The documentation and the program are free to NASA employees; for others, there is a charge of $15.00 for the documentation and $200 for the program.

The following pages illustrate the use of AKPLOT.

Run No. 1

```
DO YOU WANT TO WORK WITH PLOT STORED IN A FILE?  :NO

DO YOU WANT TO RUN THE DEMO?
DEFAULT = (RETURN) = NO : NO

ENTER NUMBER OF CURVES TO BE PLOTTED
DEFAULT = (RETURN) = 1 : 3

ENTER °COMPUTE°, °KEYBOARD° OR °FILE° TO SUPPLY THE X AND Y VECTORS : C

ENTER NUMBER OF POINTS PER CURVE : 100

ENTER XMIN,XMAX,YMIN,YMAX FOR THE PLOT : 0,100, -4,4

DO YOU WANT THE 90 DEGREE TILT ACTIVE?  :
DEFAULT = (RETURN) = NO : NO

ENTER THE X AXIS LENGTH (MAX = 250)
DEFAULT = (RETURN) = 250 : 250

ENTER THE Y AXIS LENGTH (MAX = 150)
DEFAULT = (RETURN) = 150 : 150

ENTER THE GRID STYLING SELECTED
DEFAULT = (RETURN) = 0 : 2

ENTER NUMBER OF MAJOR DIVISIONS ON X AXIS (0 IF LOG SCALE) : 4

ENTER NUMBER OF MAJOR DIVISIONS ON Y AXIS (0 IF LOG SCALE) : 4

DO YOU WANT INTERPOLATION?
DEFAULT = (RETURN) = NO : NO

ENTER INDEX VALUES ONE AT A TIME :

?2
?3
?4

LEAST SQUARES FIT MAY ONLY BE APPLIED TO THE ORIGINAL UN-INTERPOLATED POINTS

DO YOU WANT POLYNOMIAL LEAST SQUARES FIT? :NO

ENTER THE X AXIS TITLE : TIME (SECONDS)

ENTER THE Y AXIS TITLE : RESPONSE (VOLTS)
```

(See Figure 5.)

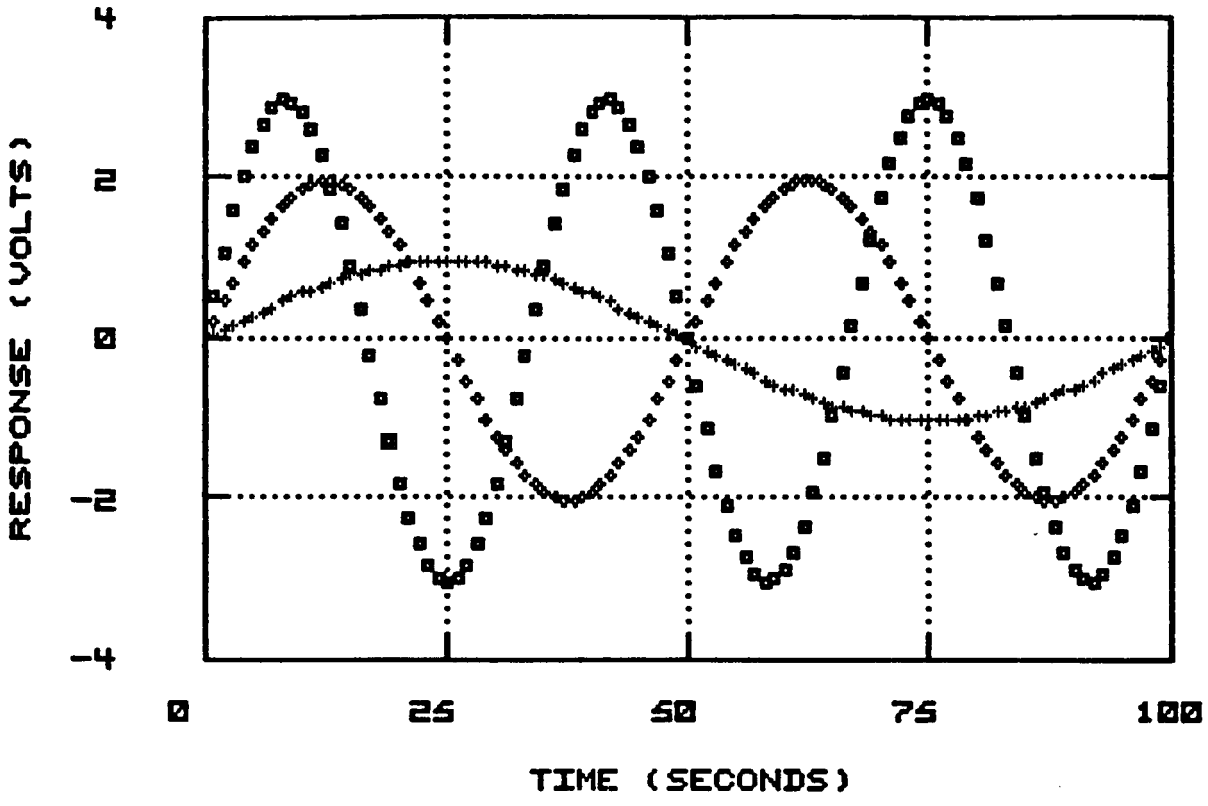


Figure 5. Run No. 1

Iteration No. 1 of Run No. 1

o CONTINUATION OF THE PREVIOUS EXAMPLE.

XMAX = 100 XMIN = 0

YMAX = 4 YMIN = -4

DELX = 25

DELY = 2

DO YOU WANT TO SAVE THE PLOT IN A FILE? :YES

ENTER THE NAME OF FILE TO STORE THE PLOT : XXX.DAT

DO YOU WISH TO CHANGE ANY OF THE PARAMETERS? :YES

DO YOU WANT THE REVERSE AXIS ORIENTATION FOR THIS RUN? : YES

DO YOU WANT TO CHANGE LENGTHS OF AXES? :YES

LENGTH OF THE X AXIS FOR THE PREVIOUS RUN : 150

ENTER THE LENGTH OF X AXIS FOR THIS RUN (MAX = 150) : 150

LENGTH OF THE Y AXIS FOR THE PREVIOUS RUN : 250

ENTER THE LENGTH OF Y AXIS FOR THIS RUN (MAX = 250) : 250

DO YOU WANT TO PLOT A PORTION OF THE CURVES? :

THIS OPTION IS AVAILABLE ONLY FOR MONOTONIC AND SAME X POINTS FOR ALL CURVES : NO

INTERPOLATION MAY ONLY BE USED FOR MONOTONIC X POINTS :

DO YOU WANT TO CHANGE INTERPOLATION STATUS? : NO

LEAST SQUARES FIT MAY ONLY BE APPLIED TO THE ORIGINAL UN-INTERPOLATED POINTS

DO YOU WANT A CHANGE IN POLYNOMIAL LEAST SQUARES FIT STATUS? : NO

DO YOU WANT TO CHANGE SCALE? : NO

DO YOU WANT TO CHANGE X AND Y LIMITS? : NO

DO YOU WANT TO CHANGE THE GRID STYLE? : YES

THE GRID STYLE OF PREVIOUS RUN : 2

ENTER NEW STYLE : 1

```
DO YOU WANT TO CHANGE THE INDEX VECTOR? : YES

THE CURVE INDICES FOR THE PREVIOUS RUN :

2
3
4

INPUT THE INDICES FOR THIS RUN ONE BY ONE :

? 5
? 6
? 7

DO YOU WANT TO PLOT X-Y VECTORS STORED IN ANOTHER FILE ON THE SAME
GRID?:NO
```

(See Figure 6.)

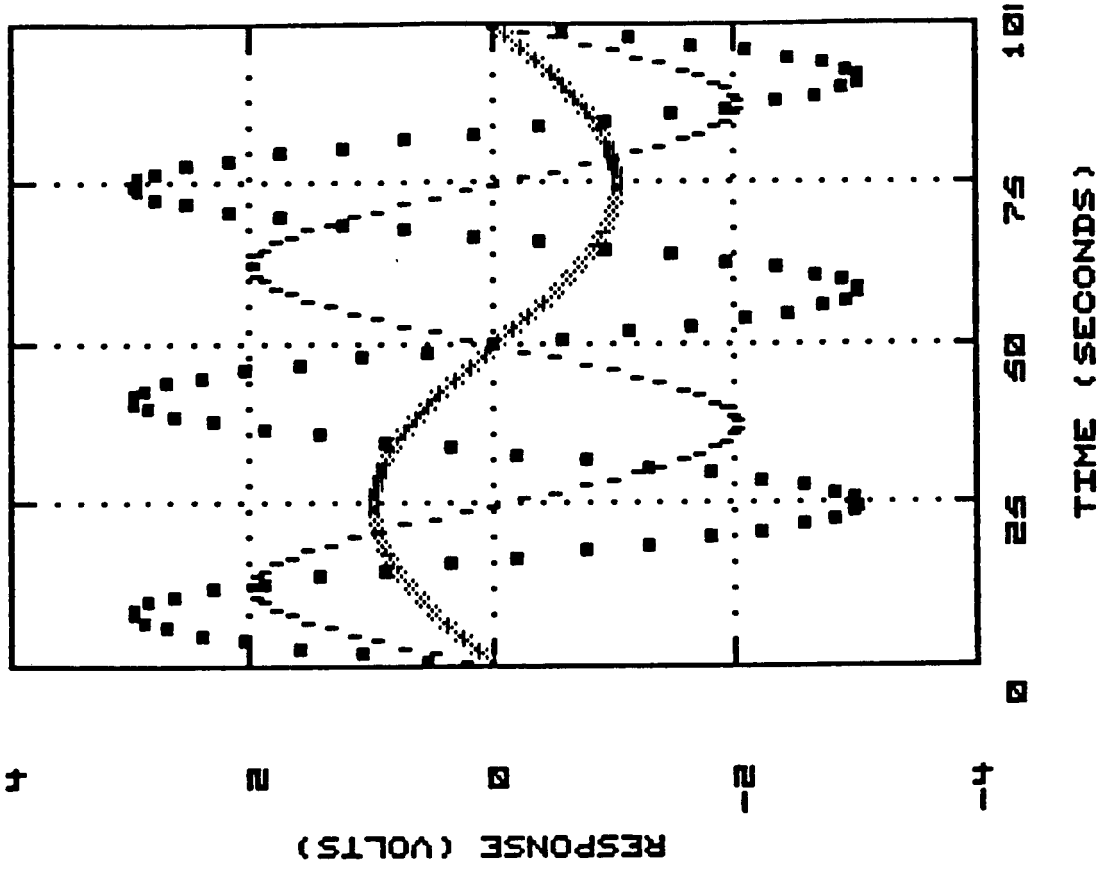


Figure 6. Iteration No. 1 of Run No. 1

Iteration No. 2 of Run No. 1

o CONTINUATION OF THE PREVIOUS EXAMPLE.

XMAX = 100 XMIN = 0

YMAX = 4 YMIN = -4

DELX = 25

DELY = 2

DO YOU WANT TO SAVE THE PLOT IN A FILE? : YES

ENTER THE NAME OF FILE TO STORE THE PLOT : XXX.DAT

DO YOU WISH TO CHANGE ANY OF THE PARAMETERS? : YES

REVERSE AXES ORIENTATION WAS SELECTED FOR THE PREVIOUS RUN :

DO YOU WANT THE REVERSE AXIS ORIENTATION FOR THIS RUN? : NO

DO YOU WANT TO CHANGE LENGTHS OF AXES? : YES

LENGTH OF THE X AXIS FOR THE PREVIOUS RUN : 150

ENTER THE LENGTH OF X AXIS FOR THIS RUN (MAX = 250) : 250

LENGTH OF THE Y AXIS FOR THE PREVIOUS RUN : 250

ENTER THE LENGTH OF Y AXIS FOR THIS RUN (MAX = 150) : 150

DO YOU WANT TO PLOT A PORTION OF THE CURVES? :

THIS OPTION IS AVAILABLE ONLY FOR MONOTONIC AND SAME X POINTS FOR ALL CURVES : YES

FOLLOWING CURVES WERE DEPICTED IN THE PREVIOUS RUN :

1
1
1

ENTER 0 FOR THE CURVE YOU DO NOT WANT OUT OF M CURVES

AND ENTER 1 FOR THE CURVE YOU WANT FOR THIS RUN :

? 1
? 0
? 1

LOWER X CO-ORDINATE FOR THE PREVIOUS RUN : 1

UPPER X CO-ORDINATE FOR THE PREVIOUS RUN : 100

```
ENTER THE LOWER X CO-ORDINATE FOR THIS RUN : 1

ENTER THE UPPER X CO-ORDINATE FOR THIS RUN : 100

INTERPOLATION MAY ONLY BE USED FOR MONOTONIC X POINTS :

DO YOU WANT TO CHANGE INTERPOLATION STATUS? : NO

LEAST SQUARES FIT MAY ONLY BE APPLIED TO THE ORIGINAL UN-INTERPOLATED
POINTS

DO YOU WANT A CHANGE IN POLYNOMIAL LEAST SQUARES FIT STATUS? : NO

DO YOU WANT TO CHANGE SCALE? : YES

ENTER MAJOR DIVISIONS FOR X AXIS (0 FOR LOG) FOR THIS RUN : 0

ENTER MAJOR DIVISIONS FOR Y AXIS (0 FOR LOG) FOR THIS RUN : 4

DO YOU WANT TO CHANGE X AND Y LIMITS? : YES

XMIN AND XMAX OF THE PREVIOUS RUN : 0 , 100

YMIN AND YMAX OF THE PREVIOUS RUN : -4 , 4

ENTER NEW XMIN AND XMAX IN 1EN FORMAT : 1,100

ENTER YMIN AND YMAX FOR THIS RUN : -4,4

DO YOU WANT TO CHANGE THE GRID STYLE? : YES

THE GRID STYLE OF PREVIOUS RUN : 1

ENTER NEW STYLE : 2

DO YOU WANT TO CHANGE THE INDEX VECTOR? : NO

DO YOU WANT TO PLOT X-Y VECTORS STORED IN ANOTHER FILE ON THE SAME GRID? :
NO
```

(See Figure 7.)

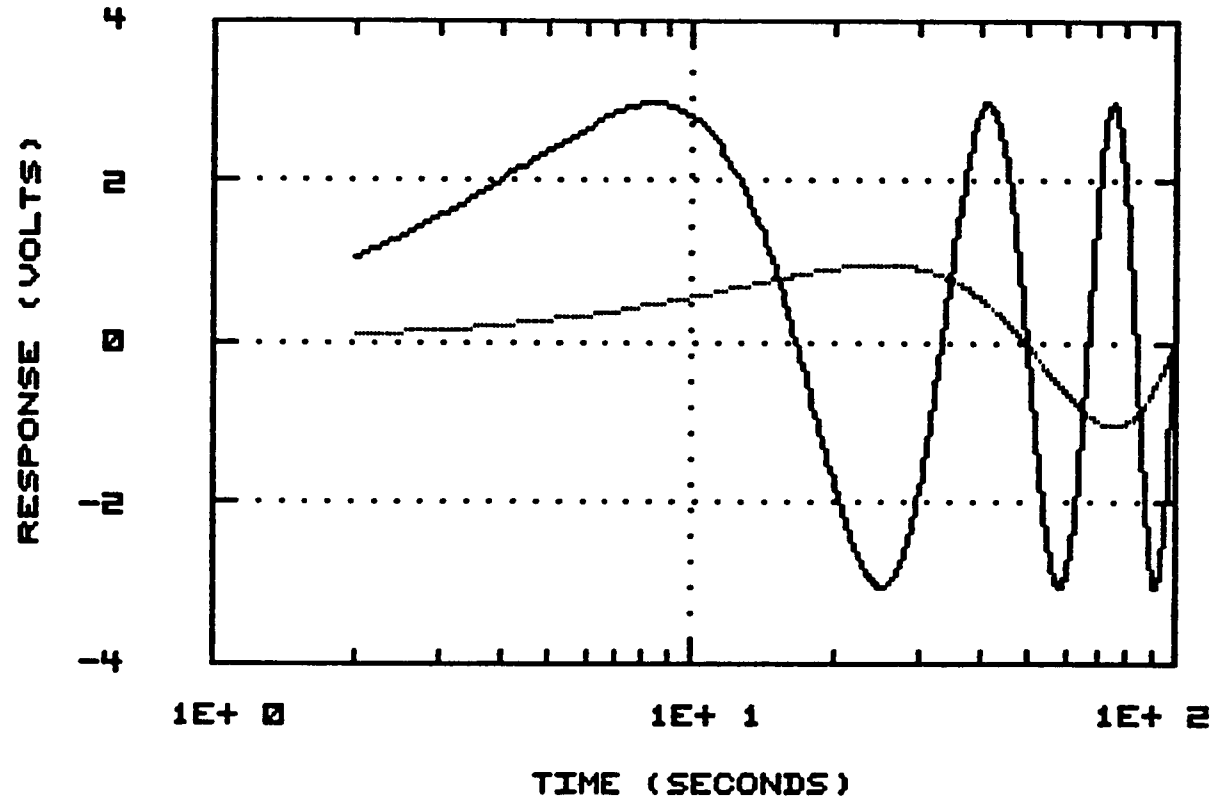


Figure 7. Iteration No. 2 of Run No. 1

Iteration No. 3 of Run No. 1

o CONTINUATION OF THE PREVIOUS EXAMPLE.

XMAX = 100 XMIN = 1

YMAX = 4 YMIN = -4

DELY = 2

DO YOU WANT TO SAVE THE PLOT IN A FILE? : YES

ENTER THE NAME OF FILE TO STORE THE PLOT : XXX.DAT

DO YOU WISH TO CHANGE ANY OF THE PARAMETERS? : YES

DO YOU WANT THE REVERSE AXIS ORIENTATION FOR THIS RUN? : NO

DO YOU WANT TO CHANGE LENGTHS OF AXES? : NO

DO YOU WANT TO PLOT A PORTION OF THE CURVES? :

THIS OPTION IS AVAILABLE ONLY FOR MONOTONIC AND SAME X POINTS FOR ALL CURVES : YES

FOLLOWING CURVES WERE DEPICTED IN THE PREVIOUS RUN :

1
0
1

ENTER 0 FOR THE CURVE YOU DO NOT WANT OUT OF M CURVES

AND ENTER 1 FOR THE CURVE YOU WANT FOR THIS RUN :

? 1
? 1
? 1

LOWER X CO-ORDINATE FOR THE PREVIOUS RUN : 1

UPPER X CO-ORDINATE FOR THE PREVIOUS RUN : 100

ENTER THE LOWER X CO-ORDINATE FOR THIS RUN : 25

ENTER THE UPPER X CO-ORDINATE FOR THIS RUN : 50

DO YOU WANT TO CHANGE INTERPOLATION STATUS : YES

INTERPOLATED CURVES FOR THE PREVIOUS RUN :

0
0
0

```
ENTER 1 FOR THE CURVES YOU WANT TO INTERPOLATE,

OTHERWISE ENTER 0 FOR THIS RUN (ENTER ONE BY ONE) :

? 1
? 1
? 1

NUMBER OF POINTS FOR INTERPOLATION FOR THIS RUN : 10

NUMBER OF INTERPOLATED PTS BETWEEN TWO POINTS FOR THIS RUN : 4

LEAST SQUARES FIT MAY ONLY BE APPLIED TO THE ORIGNAL UN-INTERPOLATED
POINTS
DO YOU WANT A CHANGE IN POLYNOMIAL LEAST SQUARES FIT STATUS? : NO

DO YOU WANT TO CHANGE SCALE? : YES

MAJOR DIVISIONS FOR X AXIS (0 FOR LOG) FOR THE PREVIOUS RUN : 0

MAJOR DIVISIONS FOR Y AXIS (0 FOR LOG) FOR THE PREVIOUS RUN : 4

ENTER MAJOR DIVISIONS FOR X AXIS (0 FOR LOG) FOR THIS RUN : 5

ENTER MAJOR DIVISIONS FOR Y AXIS (0 FOR LOG) FOR THIS RUN : 4

DO YOU WANT TO CHANGE X AND Y LIMITS? : YES

XMIN AND XMAX OF THE PREVIOUS RUN :  1 , 100

YMIN AND YMAX OF THE PREVIOUS RUN : -4 , 4

ENTER XMIN AND XMAX FOR THIS RUN : 25,50

ENTER YMIN AND YMAX FOR THIS RUN : -4,4

DO YOU WANT TO CHANGE THE GRID STYLE? : NO

DO YOU WANT TO CHANGE THE INDEX VECTOR? : NO

DO YOU WANT TO PLOT X-Y VECTORS STORED IN ANOTHER FILE ON THE SAME
GRID? : NO
```

(See Figure 8.)

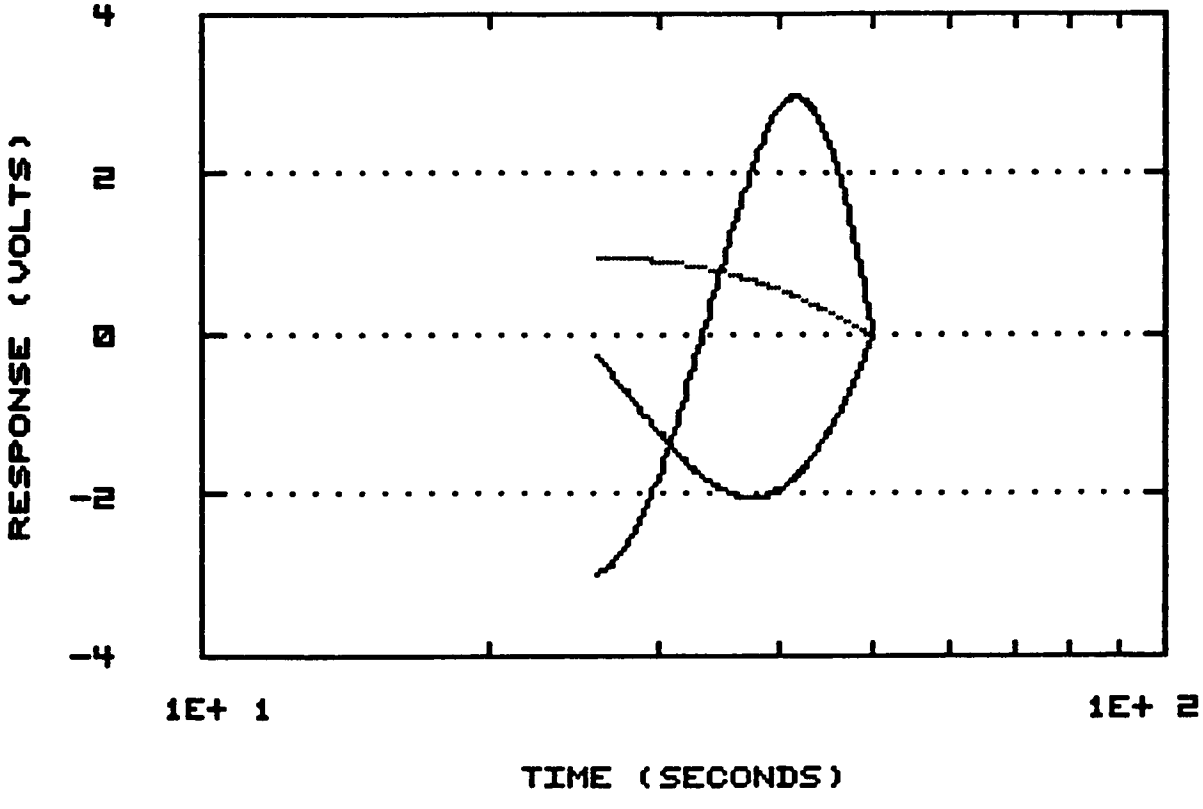


Figure 8. Iteration No. 3 of Run No. 1

Run No. 2

```
DO YOU WANT TO WORK WITH PLOT STORED IN A FILE? : NO

DO YOU WANT TO RUN THE DEMO?
DEFAULT = (RETURN) = NO : NO

ENTER NUMBER OF CURVES TO BE PLOTTED
DEFAULT = (RETURN) = NO : NO

ENTER NUMBER OF CURVES TO BE PLOTTED
DEFAULT = (RETURN) = 1 : 2

ENTER °COMPUTE°, °KEYBOARD° OR °FILE° TO SUPPLY THE X AND Y VECTORS : C

ENTER NUMBER OF POINTS PER CURVE : 100

ENTER XMIN,XMAX,YMIN,YMAX FOR THE PLOT : 0,100,0,2

DO YOU WANT THE 90 DEGREE TILT ACTIVE? :
DEFAULT = (RETURN) = NO : NO

ENTER THE X AXIS LENGTH (MAX = 250)
DEFAULT = (RETURN) = 250 : 250

ENTER THE Y AXIS LENGTH (MAX = 150)
DEFAULT = (RETURN) = 150 : 150

ENTER THE GRID STYLING SELECTED
DEFAULT = (RETURN) = 0 : 0

ENTER NUMBER OF MAJOR DIVISIONS ON X AXIS (0 IF LOG SCALE) : 4

ENTER NUMBER OF MAJOR DIVISIONS ON Y AXIS (0 IF LOG SCALE) : 4

DO YOU WANT INTERPOLATION?
DEFAULT = (RETURN) = NO : NO

ENTER INDEX VALUES ONE AT A TIME :

? 1
? 1

LEAST SQUARES FIT MAY ONLY BE APPLIED TO THE ORIGINAL UN-INTERPOLATED POINTS

DO YOU WANT POLYNOMIAL LEAST SQUARES FIT? : NO

ENTER THE X AXIS TITLE : TIME (SECONDS)

ENTER THE Y AXIS TITLE : OUTPUT (VOLTS)
```

(See Figure 9.)

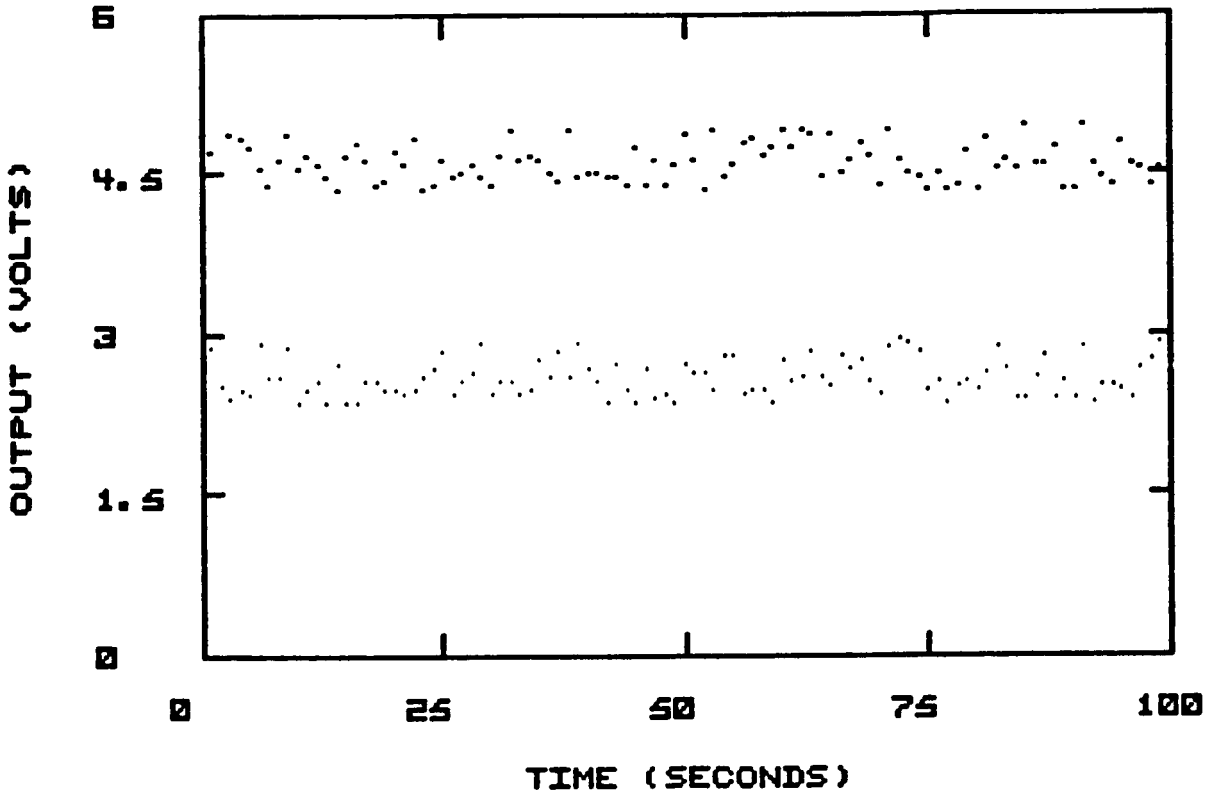


Figure 9. Run No. 2

Iteration No. 1 of Run No. 2

o CONTINUATION OF THE PREVIOUS EXAMPLE

XMAX = 100 XMIN = 0

YMAX = 2 YMIN = 0

DELX = 25

DELY = .5

DO YOU WANT TO SAVE THE PLOT IN A FILE? : NO

DO YOU WISH TO CHANGE ANY OF THE PARAMETERS? : YES

DO YOU WANT THE REVERSE AXIS ORIENTATION FOR THIS RUN? : NO

DO YOU WANT TO CHANGE LENGTHS OF AXES? : NO

DO YOU WANT TO PLOT A PORTION OF THE CURVES? :

THIS OPTION IS AVAILABLE ONLY FOR MONOTONIC AND SAME X POINTS FOR ALL CURVES : NO

INTERPOLATION MAY ONLY BE USED FOR MONOTONIC X POINTS :

DO YOU WANT TO CHANGE INTERPOLATION STATUS? : NO

LEAST SQUARES FIT MAY ONLY BE APPLIED TO THE ORIGINAL UN-INTERPOLATED POINTS

DO YOU WANT A CHANGE IN POLYNOMIAL LEAST SQUARES FIT STATUS? : YES

ENTER THE DEGREE OF POLYNOMIAL FOR THE LEAST SQUARES FIT : 2

ENTER 1 FOR THE CURVE TO BE LEAST SQUARES FITTED OTHERWISE ENTER 0:

? 1
? 1

DO YOU WANT TO CHANGE SCALE? : NO

DO YOU WANT TO CHANGE X AND Y LIMITS? : NO

DO YOU WANT TO CHANGE THE GRID STYLE? : NO

DO YOU WANT TO CHANGE THE INDEX VECTOR? : NO

DO YOU WANT TO PLOT X-Y VECTORS STORED IN ANOTHER FILE ON THE SAME GRID? : NO

(See Figure 10.)

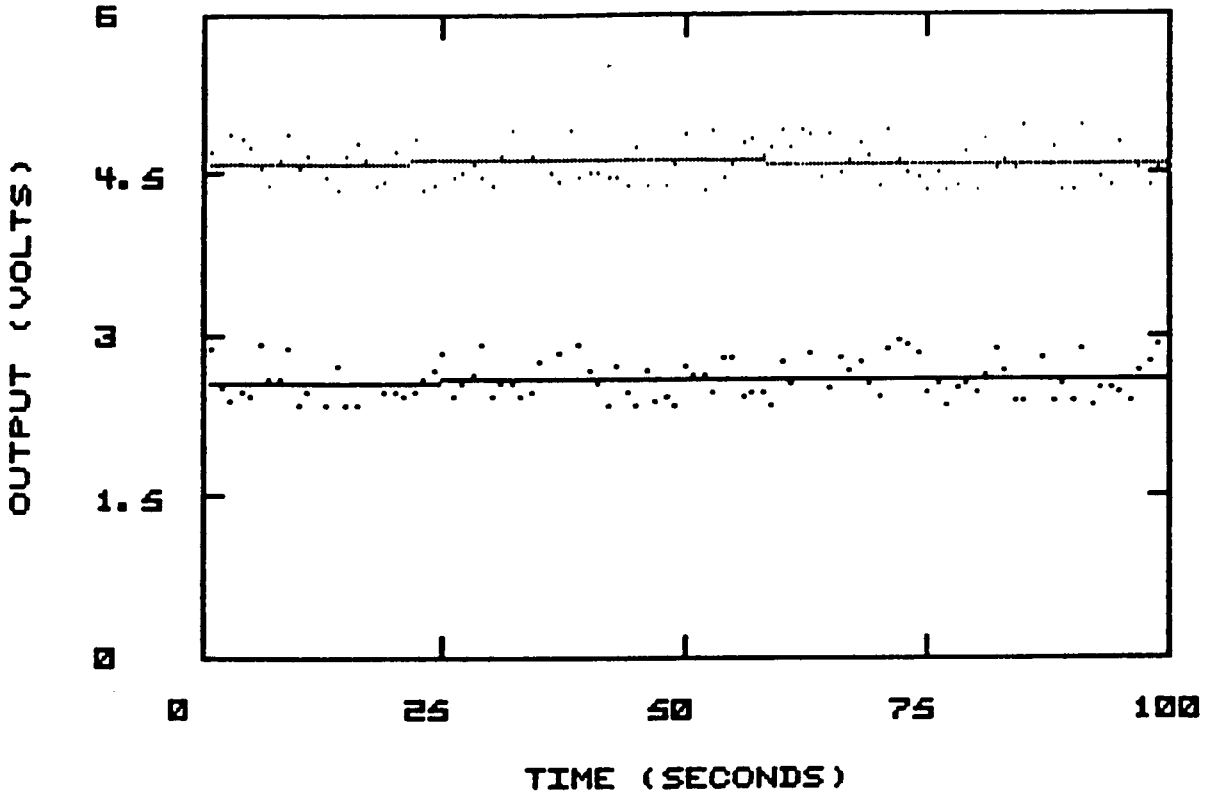


Figure 10. Iteration No. 1 of Run No. 2

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15. Supplementary Notes

16. Abstract

The AKPLOT software for the IBM PC, XT, and AT is an efficient and versatile tool that allows X-Y plotting of quantitative information. Features include IBM four-color graphics, which combined with 10 different symbols allows 40 different curves on the same grid, shrink or expansion of the graph size, any combination of log and linear X and Y axes, selective plotting from multiple curves of a previous run, interpolation and polynomial least-squares fit with any degree polynomial, and a 90-degree tilt of the entire graph. These options are independent, and can be invoked individually.

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