Tekniques

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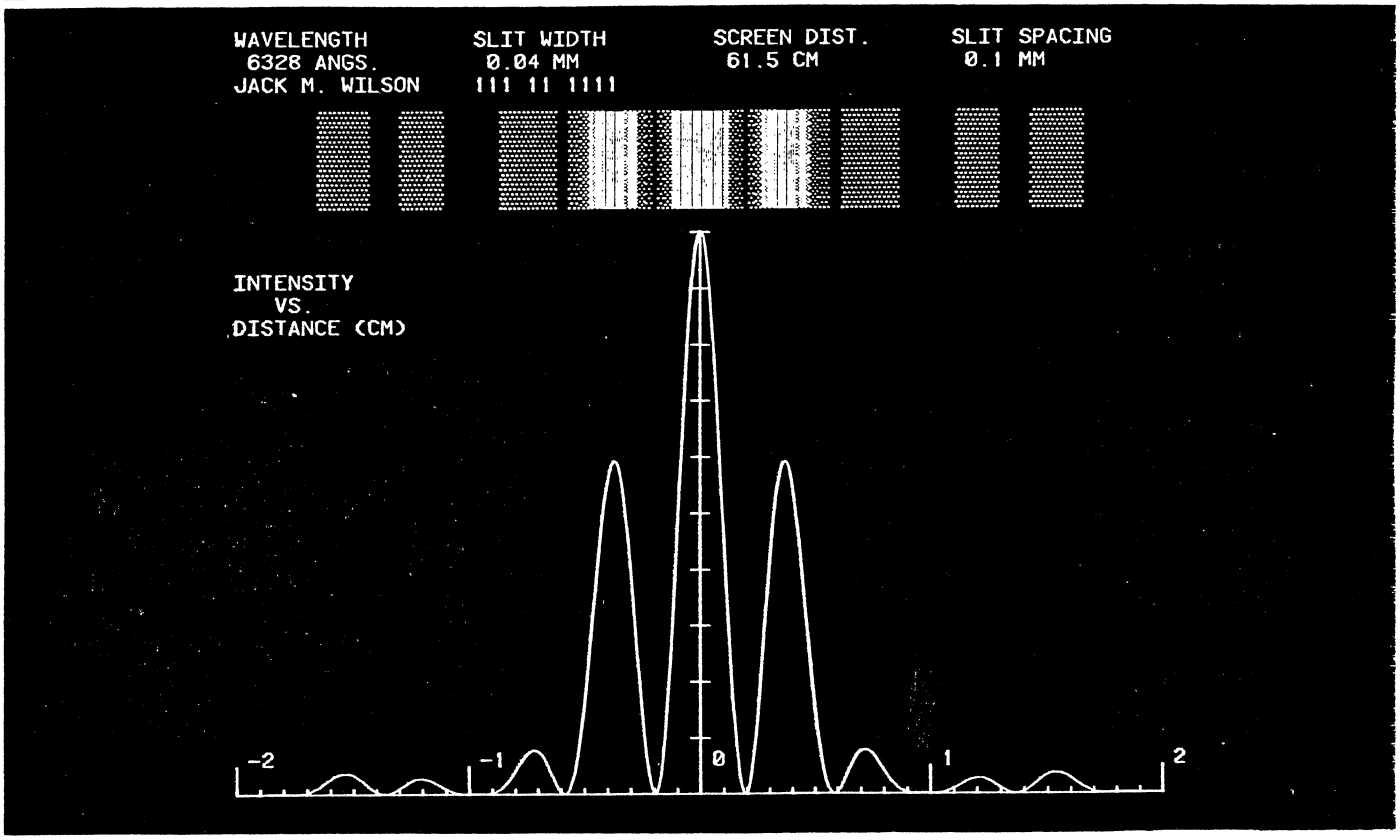

At Sam Houston State University, Huntsville, TX, the 4051 Graphic System and 4662 Plotter introduces physics students to laboratory equipment and methods. A double slit diffraction pattern and intensity plot results from the diffraction simulation.

Simulating Physics Experiments With The 4051

by Dr. Jack M. Wilson

Department of Physics
Sam Houston State University
Huntsville, TX

The Question: How does the modern university ease the student into the complex world of the advanced physics laboratory? This laboratory is an important turning point for two reasons: it's a significant advance in sophistication of both the experimental design *and* the equipment required to perform the experiment. Couple this increased sophistication with the introduction of concepts like relativity and quantum physics, and the potential looms for student confusion and difficulty in the lab.

The Answer: The modern university relies on the computing power and graphics capability of the Graphic Computing System. At Sam Houston State University, the physics lab begins at the keyboard of the 4051.

Some Background on the Physics Laboratory

Beyond the high degree of sophistication (and potential confusion) that is part of the nature of the laboratory, two other familiar difficulties arise: time and money. Equipment for many physics experiments is, quite simply, very expensive, and most universities operate on a limited budget. That means that most laboratories have only enough gear for one experimental station, adding another complicating factor. Universities have previously tried a number of methods for dealing with the limited equipment and experimental complexity.

An individualized lab system is one approach, providing each student (or team of students) with their own lab time, where they will have individual, exclusive access to the experimental station. While this solves the equipment limitation and uses student time efficiently, it is highly inefficient in its use of instructor time. The students in the lab are usually unfamiliar with the equipment and the methods, making it necessary that an instructor be available for occasional student assistance. Previous attempts at an open but unsupervised lab system produced excellent results in some students (the most motivated), and complete failure in others. The instructor's pre-lab briefings don't seem to help the student once they enter the lab.

Video tapes have also been tried. Generally, a video tape contains an instructor's ex-

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In This Issue

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Publishing Manager	Mark Mehall
Managing Editor	Patricia Kelley
Editor	Terence Davis
Technical Editor	Dan Taylor
Graphic Design	John Ellis
Circulation	Rory Gugliotta

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planation of the physical concept under investigation, an explanation of the equipment used in the experiment, and instructions for setting up the laboratory experiment. There are several deficiencies in this approach: The student's inability to interact with the instructor is a major drawback. In addition, there is little opportunity for the student to contribute to the experimental design. A videotaped "how to" pre-lab can lead to a "cookbook" approach to the lab, where rote steps are performed, but little learning occurs.

A more desirable approach, especially in the advanced laboratory, would allow the student to contribute to the experimental design. Several approaches might even be tried, in a trial and error method. But even this has drawbacks. Experimentation with unfamiliar equipment could lead to damage to the equipment, perhaps even injury to the student. At the least there could be a lot of time wasted, and a lot of useless data gathered.

Enter the 4051 Graphic System

Using the 4051 Graphic System in an interactive manner prepares the student for the laboratory in a way that surmounts many of the problems that were just described. Combining simulation on the Graphic System with actual data taking in the laboratory seems a particularly effective technique. The first step was to develop a set of graphic laboratory simulations that let the student help quide the experimental design, enhancing student understanding of the experiment at the same time.

One technique for experimental simulation was developed by Dana Main and a group at Michigan State University, for laboratories in psychology. Refined versions of this package, known as EXPER SIM, have been made widely avaliable and even adapted to other fields with the support of the Exxon Educational Foundation. The EXPER SIM approach was used as the basis for physics experiment simulation. The approach was extended to include actual laboratory experience with the simulation.

Before the student begins the actual laboratory experiment, the experiment simulation is performed on the 4051 Graphic System. During the simulation, the student makes some of the choices (selecting independent variables and their values, for instance) which will be encountered in the laboratory, and observes the effects of changing variables. The student can proceed to the actual laboratory at any time after completing the simulation.

The Physics Simulation Package

The experiment simulation package for the physics laboratory consists of a directory program (supervisor), and eleven programs for individual laboratory simulations. The eleven simulations include the following.

- The Speed of Light
- The Interferometer*
- Positron Annihilation
- Electron Diffraction
- Relativity—Mossbauer Effect
- Diffraction and Young's Double Slit Experiment
- The Photoelectric Effect*

Dr. Jack M. Wilson works with a student on diffraction simulation on the 4051. (Photo courtesy of David Berryman, Department of Physics, Sam Houston State University, Huntsville, TX)

- Charge/Mass of the Electron
- Properties of X-rays*
- Franck-Hertz Experiment
- Spectra and Spectrometers

The entire package was written in extended graphic BASIC, to run on a 4051 Graphic System with 32K bytes of memory. (Eight of the simulations could be run on a 16K system, but the remaining three—marked with an asterisk—require the 32K system.) And, of course, the whole package will run on a 4052 or 4054 with a speed increase of up to 40 times. Also included in the system is a hard copy unit, a 4662 Digital Plotter, and a printer. The system is also interfaced to several multi-channel analyzers, a floppy disc, and a microprocessor controller. This configuration allows the data output that is as close as possible to observations that would be made while performing the experiment. The capability of high-resolution graphic display is indispensible.

The package requires no previous computer experience on the part of the student. To perform a simulation, the student obtains a magnetic tape cartridge, which contains the entire package, from the instructor. After the cartridge is inserted into the 4051, the student presses the "AUTOLOAD" button and the first program on the tape, the supervisory program, is loaded into memory and executed. The student is asked to enter his or her name, social security number and the date and time of usage; this information is logged onto another portion of the magentic tape. A menu of simulations is then displayed from which the student selects the appropriate laboratory simulation. The simulation program selected by the student is automatically appended to the supervisory program and executed.

The specific sequence of events is determined by the particular simulation but, in general, the simulation proceeds as follows: First the laboratory is described in general. Then the student selects the independent variables and assigns values to them. The simulation responds by providing data on the dependent variables, just as would occur in the laboratory. Oscilloscope traces, diffraction patterns, multi-channel analyzer displays, X-Y plots, light patterns, and numerical readings are some of the experiment displays.

Many of the simulations include a data analysis section, in which the student may be asked to decide what type of graph would be most appropriate for the presentation and analysis of the data, to select appropriate variables for the axes, and to draw conclusions from the resulting graph provided by the 4051.

Using the Package in the Open Laboratory

The open laboratory system has been used for the Modern Physics course at Sam Houston State University for the last three years, with certain aspects in common with other open laboratory approaches. However, the integration oof the open laboratory, the use of "student leaders", and the use of the 4051-based graphic experimental simulation represents a unique and practical approach to the advanced laboratory. Each week the equipment for a particular experiment is made available in the laboratory, which is kept open during normal working hours daily. The students are divided into groups of three, with each group responsible for reserving an appropriate time period to perform the experiment. Arrangements can be made, at the mutual convenience of the laboratory assistant and student groups, to perform the laboratory during the evening. The assistant is not expected to be present at all times, but rather to post office hours and be available as a resource person.

Use of 4051-based graphic experimental simulation in the open laboratory has markedly improved the student's attitude toward and understanding of the laboratory experiences. Although the students work in groups of three in the laboratory, each student is required to perform the simulation individually prior to performing the experiment. The brief report must include the hard copies produced by the simulation (such as those in Figures 1 through 3). This design is intended to ensure that no student will be able to rely on others to do the work.

An Example: Diffraction and Young's Double Slit Experiment

As an example of a simulation, consider an experiment involving the interference of light in which the student observes diffraction of light from a single slit and from two closely spaced slits. The independent

Simulation of the Photoelectric Effect Experiment

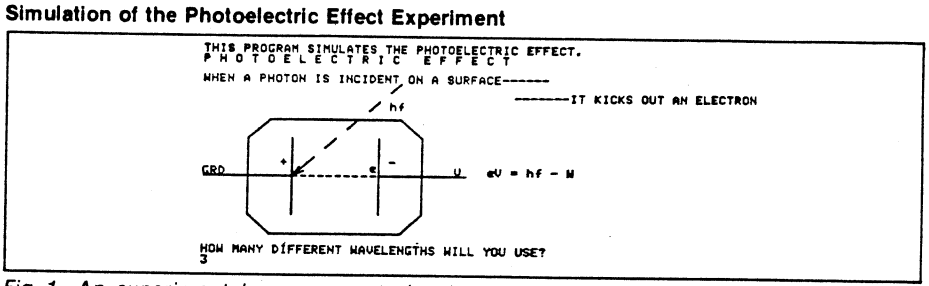


Fig. 1. An experimental arrangement showing the incoming visible light photon (hf), the ejected electron (e) and the famous equation for the stopping potential (e $\mathcal{V}$).

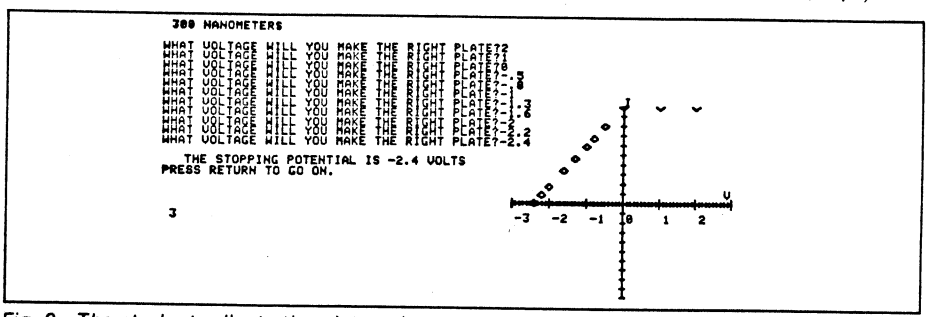


Fig. 2. The student adjusts the plate voltage to find the stopping potential.

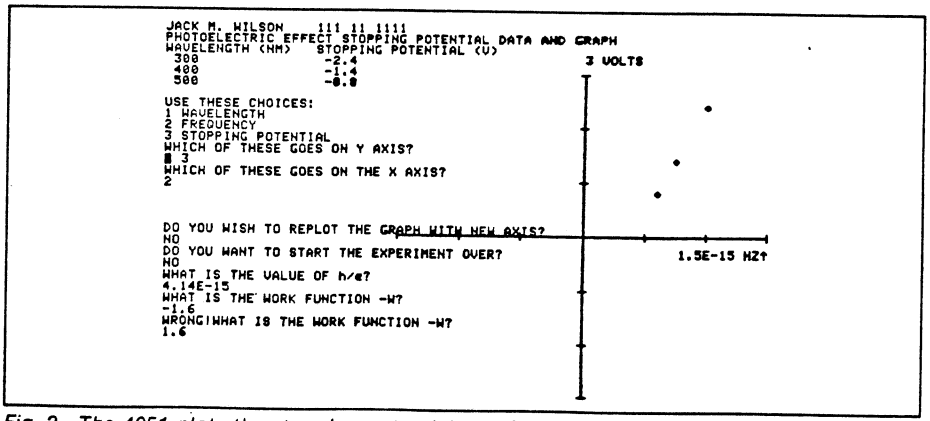


Fig. 3. The 4051 plots the stopping potential as a function of frequency.

variables for this model would be the light wavelength, the number of slits, the size of the slits, the spacing of the slits, and the slit-to-screen distance. The dependent variables are displayed as a light pattern and as a plot of intensity versus screen position; these are the two ways in which data are obtained in the laboratory. The student may then obtain the position and intensities of the interference maxima from these patterns. By repeating the experiment with various combinations of independent variables, the student may discover the relationship between the dependent and independent variables.

While performing the simulation, the student is expected to discover the answers to a series of questions from the laboratory manual: How does the width of the single slit affect the interference pattern? How does the wavelength of the light affect the interference pattern? How is the single slit pattern related to the double slit pattern? Calculate the positions at which you would expect to see maxima for a given double slit arrangement. Do all of the maxima appear? Explain. How does the slit spacing affect the double slit pattern? How does the slit width affect the double slit pattern? How does the wavelength affect the double slit pattern?

The simulation begins with the assignment of values to the independent variables for the single slit. Figure 4 shows the display after the student has selected the values for the light wavelength and the slit width. Any wavelength in the visible region may be used; choosing any other wavelength will result in the student being asked to reconsider the selection. The slit-to-screen distance is fixed at 61.5 cm, corresponding to the fixed spacing on the actual laboratory equipment. Figure 5 shows the diffraction pattern as it would appear to the student (above), and the plot of intensity versus position as it would be obtained using a photometer (below). The gradations in intensity of the light pattern are produced by varying the density of the points. This is very effective when plotted on the CRT display, but less so when reproduced on a plotter.

The single slit may be repeated with different values for wavelength or slit width, or the student may elect to go on to the simulation of the double slit pattern. When the double slit pattern is selected and the values of wavelength, slit spacing, and slit position are selected, the 4051 will generate the display exhibited in Figure 6. From the comparison of the patterns of the single slit and the double slit, the student usually discovers that the addition of another slit will result in the interference pattern from the two separate light paths being superimposed upon the diffraction pattern of the single slit. The student may repeat the single or double slits as often as necessary.

Experimental error is one characteristic of many of the programs which is not shown here. Data from many experiments is subject to statistical fluctuation; the mean and standard deviation of the data distribution may be related to the choice of independent variable values. In the example of the diffraction pattern, the signal-to-noise ratio is so large that it makes noise (statistical fluctuation) negligible. However, in experiments such as Positron Annihilation, X-ray Spectroscopy, and the Mossbauer Effect, radiation from a radioactive source is detected and displayed on a multichannel analyzer. The number of counts detected in any given time period is subject to a very large statistical fluctuation; these statistical fluctuations are simulated by generating a normally-distributed set of random numbers with the proper mean and standard deviation as determined by the choice of independent variables. The introduction of "noise" and experimental error in these and other simulations is an important factor in maintaining realism in the simulations.

Results, and the Future

Graphic experimental simulation in the physics laboratory has quickly become a valuable supplement to traditional experimental data taking. Designed to familiarize the student with the experiment, to allow students to try broader experimental combinations, to encourage student participation in experiment design, and to build student confidence before laboratory experiments, the 4051-based simulations have been successful on every count. Student response has been positive, even though total lab time (through the simulation and the laboratory experiment) is increased. Laboratory reports have improved markedly over earlier reports, and student dissatisfaction with the open laboratory system has vanished.

A tremendous potential exists for further Graphic Experimental Simulation, based on the positive results achieved so far. There is already support for extending the simulations into other physics labs (Electronics and Optics) and to two chemistry labs (Physical Chemistry and Advanced Inorganic Chemistry). Success in these areas will undoubtedly lead to other Experiment Simulation packages, all enhancing learning and easing the experience at the same time. And the successful physics lab simulation on the 4051 Graphic System has made it possible.

Simulation of Diffraction through Single and Double Slits

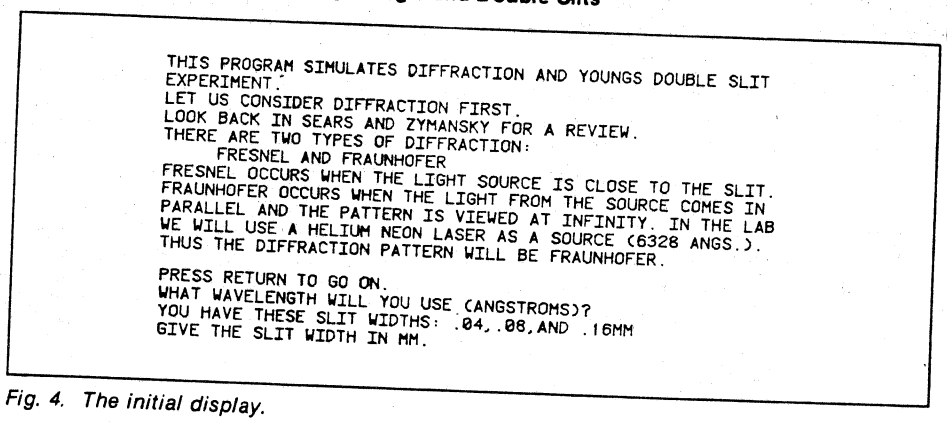


Fig. 4. The initial display.

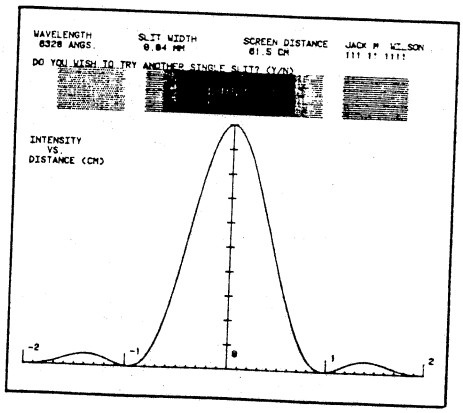


Fig. 5. The single slit diffraction pattern and intensity plot.

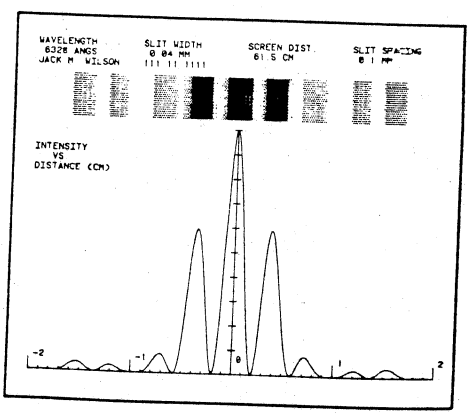
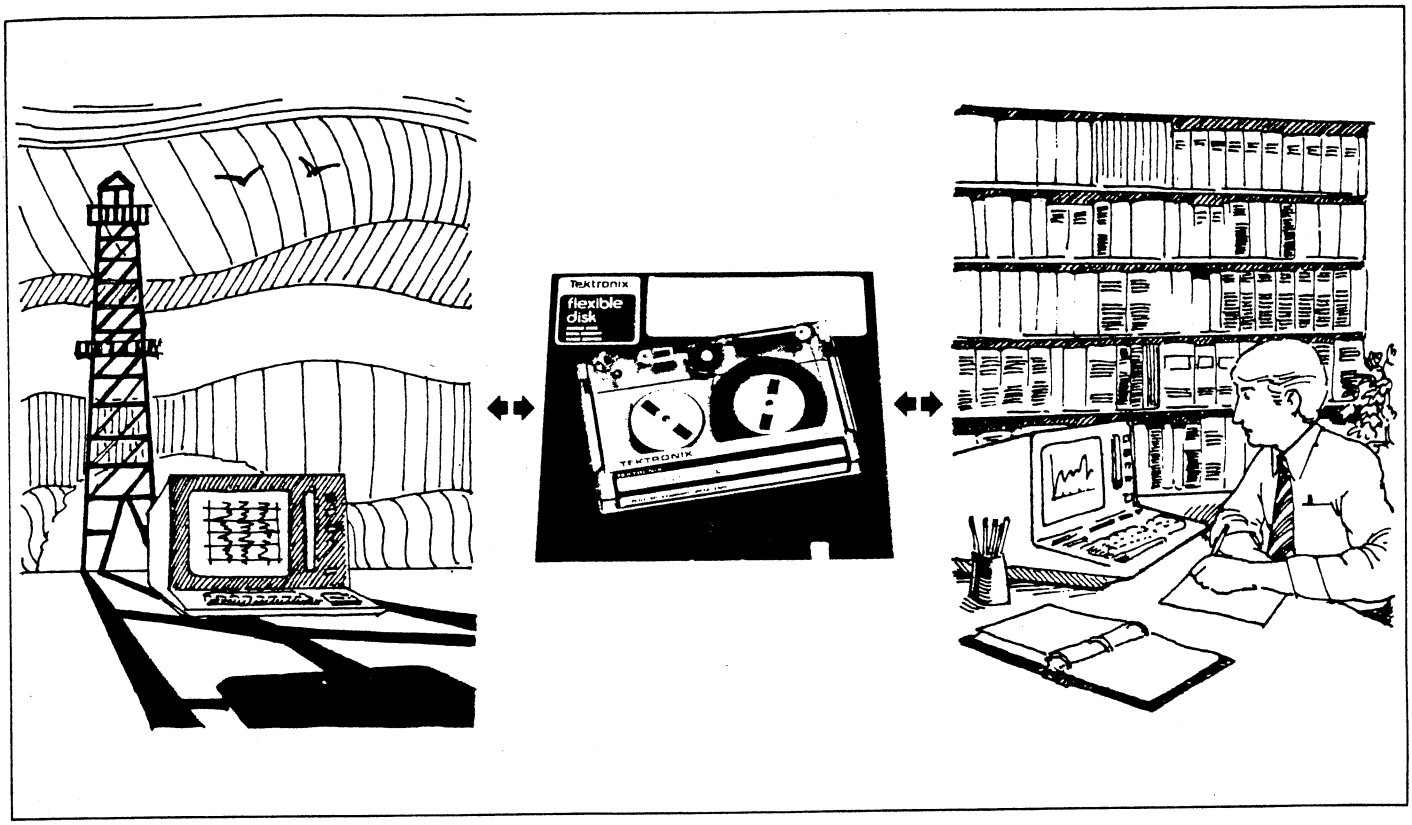


Fig. 6. The double slit diffraction pattern and intensity plot.



PLOT 50 Standard File communicates data between programs

by Dennis Heckman
Tektronix, Inc.
with Patricia Kelley
TEKniques Staff

4050 System users have expressed the desire to use the same data for different applications. After talking to many of these users, Graphic Computing Systems at Tektronix sat down to figure out how data could best be communicated among the varied, often disparate, applications. What developed is the PLOT 50 Standard File. This is a specially formatted source data file which any PLOT 50 *Standard File Compatible* software package can access.

Every PLOT 50 Standard File Compatible package will contain utility programs that output PLOT 50 Standard Files from the data files produced by that particular package, and input PLOT 50 Standard Files for use in that package.

The first PLOT 50 package which implements the PLOT 50 Standard File is the **disc** version of Business Planning and Analysis, Volume 2, 4050A12.[1] (TEKniques Vol. 3 No. 5 carried the highlights of this time-series analysis and forecasting package.) As other PLOT 50 Standard File Compatible software packages become available, they will be announced in TEKniques.

So 4050 Graphic System users may use PLOT 50 Standard Files with their own data analysis packages, or communicate their data to PLOT 50 Standard File Compatible packages, the file format is explained in the following paragraphs.

A Standard File Overview

A Standard File is actually composed of two files: a HEADER file and a DATA file. In addition, SPECIAL files may be associated with a Standard File, and FREE files unique to a package may be included. The files reside on the 4907 File Manager program disc or a 4050 System cartridge tape.

The DATA file consists of observations of one or more variables. The number of variables may run from 0 to 100. The number of observations is limited only by the space available on the tape or disc.

The HEADER file contains information about the DATA file including variable labels and observation labels, if desired.

SPECIAL files and FREE files are software package dependent. Thus, a different PLOT 50 Standard File Compatible software package will not necessarily access SPECIAL files or FREE files generated by BPA-1. These files are for use only by the package which produced them.

As one example, the scaled min/max and the tic interval might be stored in a SPECIAL file for use when graphing the data from the PLOT 50 Standard File with which it is associated. A FREE file might contain special commands or parameters for use with any PLOT 50 Standard File generated by that package.

Two symbols will be used to denote the data discussed in the Standard File:

M = number of variables
N = number of observations

[1]PLOT 50 Standard Files are not supported by the 4924 Tape version of BPA-2—4050A11.

Plot 50 Standard, Special, and Free File Structures on the 4907 Disc

Both the HEADER file and the DATA file are random access files. The SPECIAL and FREE files may be random or sequential. A username identifies each Standard File and Special File(s) associated with it, which means a HEADER file, a DATA file and any associated SPECIAL files must carry the same username.

The HEADER File on Disc

The HEADER file always resides in the Scratch Library.[2] The extension is .HEAD. Thus, the file identifier format: SCRATCHLIB/username.HEAD.

The number of records within the HEADER file can range from 3, to 3 plus the number of variable labels plus the number of observation labels (3+M+N).

Each record is 41 bytes long.

The *first record* contains four numeric values:

1. the number of variables ($0 \leq M \leq 100$)
2. the number of observations ($0 \leq N$)
3. the missing data value
4. logic denoting label types

Items 1 and 2 are self explanatory.

Item 3, the missing data value, is package dependent. The default is -1.0E301. A data set should have this value inserted in the missing data slots to signal programs that data is missing. If a program accommodates missing data, it will recognize this figure as a place holder for missing data and handle it accordingly. (BPA-2 does not accommodate missing data. Should it encounter the default value in a data set, the program will halt and display an error message.)

Item 4 is a flag for the possible observation and variable labels:

0 = no labels
1 = variable labels only
2 = observation labels only
3 = variable and observation labels

DISC HEADER FILE
SCRATCHLIB/username.HEAD

Record 1	0—100	0—N	-1.0E300	0—3	
Record 2	1—36 characters				file title
Record 3	1—36 characters				
Record 4[3]	1—36 characters				variable/observation labels[4]
Record[3] (3+M)or (3+N)or(3+M+N)	1—36 characters				

[3]Optional.
[4]Please note that label records (if any) can never be null; they must at least contain a single blank character.

The *second record* contains the first 36 characters of the file title. The *third record* contains the last 36 characters of the file title. Neither of these records are null; they at least have an ASCII space character written into them.

The *fourth record* depends on the labeling; it is directly related to the logic variable in the first record.

- If there are no labels, logic = 0, there will be no fourth record.
- If there are variable labels only, logic = 1, the fourth record will contain the label (36 characters max) of the first variable. Succeeding records will contain the labels of the subsequent variables (to a maximum of 100 variables) for a maximum of 103 records (3+M).
- If there are observation labels only, logic = 2, the fourth record will contain the label (36 characters max) of the first observation. Succeeding records will contain the labels of the subsequent observations for a total of 3+N records.
- If there are both variable and observation labels, logic = 3, the fourth record through record 3+M will contain the variable labels. The subsequent records will contain the observation labels, for a total of 3+M+N records.

[2]Refer to the 4907 File Manager Operator's Manual for a review of the different library types and file identifier construction.

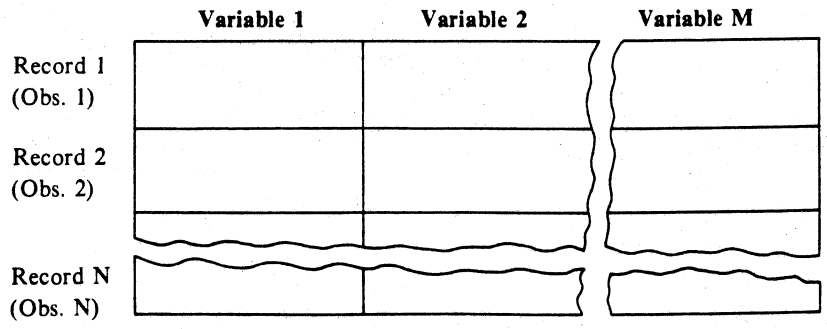
The DATA FILE on Disc

The DATA file always resides in the Scratch Library. The extension is .DATA. Thus, the file identifier format: SCRATCHLIB/username.DATA. *NOTE: The username of .DATA must match that of .HEAD.*

The number of records within the DATA file range from 0 to N. Each observation may be thought of as a row in an N by M matrix; therefore, each record contains one observation for each variable.

Each record is (9*M+1) bytes long, for a maximum of 901 bytes.

DISC DATA FILE
SCRATCHLIB/username.DATA



SPECIAL and FREE Format Files on Disc

By letting them share the username, one or more SPECIAL files may be associated with a HEADER and DATA file. The SPECIAL file always resides in the Scratch Library. Thus, the file identifier format: SCRATCHLIB/username.XXXX. *NOTE: The username of .XXXX must match that of .HEAD and .DATA with which it is associated.*

The username of a FREE file **must not be shared** with any HEADER, DATA or SPECIAL files. The FREE file always resides in the Scratch Library. Thus, the file identifier format: SCRATCHLIB/username.XXXX. *NOTE: the extension is not .HEAD or .DATA.*

The format for SPECIAL files and FREE files is completely open, i.e., package- or user-defined.

Plot 50 Standard, Special, and Free File Structures on the Cartridge Tape

A *dedicated PLOT50 Standard Data Tape* is always used for PLOT 50 Standard and Special files. A file in a format other than the PLOT 50 Standard Files, Special Files or Free Files will cause an error when the PLOT 50 Standard File Compatible software attempts to read the Standard Data Tape.

File Format

The *first file* on the PLOT 50 Standard Data Tape is an ASCII program. When the tape is autoloaded, this file identifies the tape to the user as a PLOT 50 Standard Data Tape. The *second file* is a binary data file. As its first item it contains the string: P50STND. This string identifies the tape to any PLOT 50 Standard File Compatible program attempting to read PLOT 50 Standard Files from the tape. Without this file, the tape cannot be read by a PLOT 50 Standard File Compatible program. This file may also contain additional information identifying the tape.

All other files on the PLOT 50 Standard Data Tape are in binary data format. Each PLOT 50 Standard File contains first the HEADER file, then the DATA file. These may be followed by SPECIAL files, and FREE files.

The HEADER File on Tape

The HEADER file is a binary data file. The minimum length is 768 bytes. (For more information on binary data file length, refer to the MARK, READ and WRITE operations discussed in the 4050 Graphic System Reference Manual.)

Items 1 and 2 are self explanatory.

Items 3, 4, 5 and 6 correspond to Record 1 of the disc HEADER file. Item 7 corresponds to Records 2 and 3 of the disc HEADER file. And Items 8 through 7+M+N correspond to Records 4 through 3+M+N on the disc HEADER file.

TAPE HEADER FILE DESCRIPTION

Item	Contents	Type
1	P50HEAD	String (7 characters)
2	username.HEAD	String (6 to 15 characters)
3	Number of Variables(M)	Numeric
4	Number of Observations(N)	Numeric
5	Missing Value	Numeric
6	Label Flag	Numeric
7	Title	String (1 to 72 characters)
8	Label for Variable 1	String (1 to 36 characters)
9	Label for Variable 2	String (1 to 36 characters)
|	|	|
|	|	|
7+M	Label for Variable M	String (1 to 36 characters)
8+M	Label for observation 1	String (1 to 36 characters)
|	|	|
|	|	|
7+N+M	Label for observation N	String (1 to 36 characters)

The DATA File on Tape

The DATA file is a binary data file. The minimum length is 768 bytes.

Beginning with Item 3, data is recorded in the format:

observation 1 for variable 1
observation 1 for variable 2
|
|
observation 1 for variable M
observation 2 for variable 1
observation 2 for variable 2
|
|
observation N for variable M

TAPE DATA FILE DESCRIPTION

Item	Contents	Type
1	P50DATA	String (7 characters)
2	username.DATA (the username matches that of .HEAD)	String (6 to 15 characters)
3	Data Value(1,1)	Numeric
4	Data Value(1,2)	Numeric
| |		
2+M	Data Value(1,M)	Numeric
3+M	Data Value(2,1)	Numeric
| |		
2+MxN	Data Value(N,M)	Numeric

SPECIAL Files on Tape

SPECIAL files are free-form binary data files. The minimum length is 768 bytes.

TAPE SPECIAL FILE DESCRIPTION

Item	Contents	Type
1	P50SPEC	String (7 characters)
2	username.XXXX	String (6 to 15 characters)
	(the username matches that of the .HEAD and .DATA files with which it's associated. The extension may be anything *except* .HEAD or .DATA.)	
3	anything	

FREE Format Files on Tape

FREE files are free-form binary data files. The username is *not* shared with HEADER, DATA or SPECIAL files.

A FREE file might contain special commands or parameters for use with any PLOT 50 Standard File. Again, this is strictly germane to the package that generated it.

TAPE FREE FILE DESCRIPTION

Item	Contents	Type
1	P50XXXX (X represents any character)	String (7 characters)
2	username.XXXX (username is not shared with HEADER, DATA or SPECIAL files. The extension is *not* .HEAD, or .DATA)	String (6 to 15 characters)
3	anything	

While the same data is not always appropriate for different analytical methods, in those cases where you can gain greater insight by subjecting your data to several programs, a compatible data base will certainly save time. Defining and implementing PLOT 50 Standard Files is a step toward helping 4050 Series System users communicate data between programs quickly and easily. As more PLOT 50 Standard File Compatible programs become available, the significance of Standard Files will increase.

Editor's Note

New Contest Still Rolling

Our new Applications Library contest is rolling along; entries will be accepted until the contest deadline of March 31, 1980. The theme is interfacing for data acquisition or instrument control, with awards to be made in three categories.

The categories are divided by interface.

Category I—Application using the General Purpose Interface Bus (GPIB)

Category II—Application using the Option 1 Data Communications Interface (RS-232)

Category III—Application using any other type of interface—commercially constructed or "home built".

Awards

Awards will be given to three places in each category. Each winner will have his/her choice of 4050 Series ROM Packs, PLOT 50 software, or Applications Library software, at catalog price, up to the award amount for his/her placing.

	Category I	Category II	Category III
1st Place*	$750	$750	$750
2nd Place*	500	500	500
3rd Place*	375	375	375

***equivalent value in ROM packs or software**

All entrants will receive three programs in exchange for theirs. This exchange, of course, is in addition to any award that might be received.

Complete rules can be found in TEKniques (Vol. 3 No. 7). Entry deadline is March 31, 1980.

So, clean-up those programs, complete the documentation, and send it in. If you need documentation guidelines or any of the forms, send us a note; our address is shown under UNITED STATES on page 16.

INPUT/OUTPUT: TEKniques will Feature a Question and Answer Column

Beginning with TEKniques Vol. 4 No. 2 a regular feature will be INPUT/OUTPUT: a question and answer column. If any reader has a question, drop TEKniques a note. We'll print the question along with the answer in this column.

Also included in this column will be questions asked most often of Tektronix Systems Analysts, with their answers. In familiarizing customers with their Tektronix systems, the Systems Analysts have first-hand knowledge of customers' problems, and solutions. By publishing the frequently asked questions concerning the 4050 System hardware and software and the answers, we may save you a telephone call.

We encourage you to send in your questions. Write to the United States 4050 Series Applications Library address shown on the back page.

Back Issues Available

We still have copies available of previous TEKniques issues. While we make it a practice to keep these back issues available, in some cases they are not original stock. As our stock of initial printings runs out, we are turning to our local reproduction press to replenish our back issue inventory. This allows us to keep the content of back issues available to all.

New Catalog Available

All of the Application programs in the library (through Vol. 3 No. 4) are listed in the 4050 Series Applications Library Cataolog, available for the asking. If you haven't received your copy, drop us a note at the appropriate applications library address on the back of this issue. The new catalog contains 126 programs, with hard copy examples of most programs. The new catalog also contains a photo section of peripheral devices that can be used to extend system capabilities. Your own library isn't complete without one.

4052 and 4054 Users Take Note

One of the things we'd like the new year to bring is a series of feature articles on 4052 and 4054 applications. But we can only do that with your help.

If you're using one of these new systems, we'd like to hear from you. We'll edit your article for you, or help you write it if you wish. Just drop us a note or give us a call; addresses are found on the back of each issue.

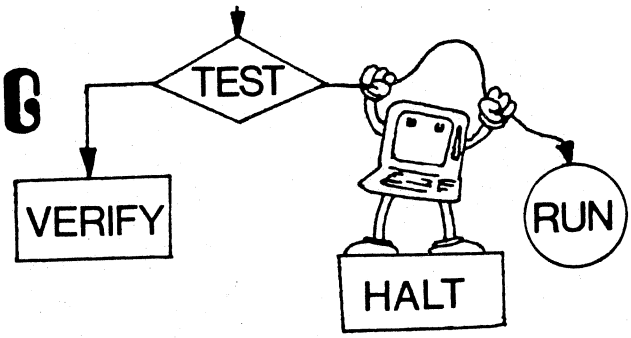
Programming Tip Exchange

Send in your programming tip. Any one of the following 4050 Series Applications Library programs will be yours when it's published. Simply jot down a brief description of the function, the code, and your choice of program. Mail it to the 4050 Series Applications Library serving you; Library addresses are listed at the back of each TEKniques issue.*

51/00-0501/0	51/00-6002/0
51/00-0901/0	51/00-8004/0
51/00-1403/0	51/00-8017/0
51/00-1603/0	51/00-8022/0
51/00-4002/0	51/00-9507/0
51/00-5204/0	51/00-9533/0

***Documentation and listing only.**

PROGRAMMING TIPS



Paging Using The 4907

by Jim Gish
Tektronix, Inc.
Irvine, CA

The time it takes to read or write large amounts of data to the 4907 File Manager can be dramatically reduced by using "Paging" techniques. This note gives a brief explanation of what is meant by the term "Paging", and how it can be used.

Consider an application program that draws the outline of a land mass in great detail. To do this requires a data base on the 4907 File Manager that contains 6000 X, Y coordinates. What would be the fastest way to draw the land mass? The fastest method would be to read all 6000 coordinates into the 405X memory, then plot them, but there isn't sufficient memory to do this. Another logical solution is to read and plot the data one coordinate pair at a time in a FOR/NEXT loop. This way you can plot all 6000 points, but it is very slow. Paging is a compromise between these two methods. As a rule, the fewer disc reads and writes used to pass a constant amount of data, the less time it will take. Paging minimizes the number of reads and writes and therefor, minimizes the time to transfer the data.

In theory it works this way: Data is organized into blocks called pages. The size of the page should be as large as possible, given that the application program and one page of data must fit into the 405X memory. In the example above, coordinates would no longer be read individually from the 4907, instead a page of coordinates would be read, then plotted. After this the next page can be read and plotted. The cycle of paging in new coordinates and plotting the coordinates can continue indefinitely, until all pages have been read. Using this method, any data value is retrieved by the program in two steps. First the page that contains the values is read into memory, usually as a large array, then the value is pulled from the array. Applications that handle data sequentially can easily be modified to use paging techniques, but programs that need to access data values in a random nature may be impossible to change. In either situation the general rule applies. The fewer disc reads or writes it takes to pass a given number of data values, the less time it will take.

TIMING EXAMPLE USING 4052/4907

Example A

No Paging

```
FOR I=1 TO 3000
READ #1,I:X


NEXT I
```

Example B

Page size of 1000 values

```
DIM X(1000)
FOR I=1 TO 3
READ #1,I:X


NEXT I
```

Example A takes 521 seconds to transfer 3000 values, while example B will take 22 seconds. This is a twenty fold savings of time when paging is used. Such dramatic savings are not always achievable, but the possible savings may be worth the effort to see how much faster your application will run if you use paging.

Using CALL GIN with the 4050 Graphic System and 4662 Plotter

The CALL switch on the front panel of the 4662 Digital Plotter has three functions: to provide coordinates of the present pen location, to transmit a system status block, or to initiate a self-test. When the CALL switch is depressed momentarily, the pen coordinates are placed in the output queue; if the switch is held down until the bell rings (about one second), a system status block is transmitted; if the switch is depressed until the bell rings twice, the Self-Test sequence is activated.

Often a program inputs the pen coordinates after it has asked the operator to position the pen and notify the 4050 System he has done so by depressing the CALL button. For example:

```
5000 REM  Following is Call GIN
5010 INPUT @1,27:X1,Y1
```

Everything works fine as long as the CALL switch on the 4662 Plotter is pushed and released quickly. However, if the operator depresses the CALL button and holds it down until the bell rings, the Plotter outputs the system status block which is one number, such as 2043. Consequently, the 4050 System will wait for another input which is never forthcoming. To avoid this, use the following code:

```
5000 REM  Following is Call GIN
5010 INPUT @1,27:A$
5015 INPUT @1,24:X1,Y1
```

Here the response to the CALL GIN statement (secondary address 27) indicates the user has positioned the pen. The GIN statement (secondary address 24) then retrieves the pen coordinates in Graphic Disp Units (the GIN @1:X1,Y1 would retrieve the pen coordinates in user definable units).

RND (0) Identifies 4050 System

by Mark Mehall
Tektronix, Inc.
Wilsonville, OR

A program can use the random number function to determine on which 4050 Series Graphic System it's running. When the parameter of the RND function is 0, the following numbers are always returned.

System	RND (0)
4051	0.196324846518
4052	0.706280095237
4054	0.88093139039
4054 Opt. 30	0.505007490939

Therefore, the following line of code would return a value in F indicating whether a 4051 or one of the new systems was being used:

```
F = RND(0) AND 1
```

F = 0 would represent a 4051 whereas F = 1 would represent a 4052, 4054, or 4054 Opt. 30.

Uses

The duration of waiting loops could be set according to the system being used, or a program could be directed to take advantage of the features of the 4052 and 4054 such as additional memory or the refresh option of the 4054. Note the programming tip in this issue "Buffering Data Received Over the RS-232" which uses the RND (0) function to determine the waiting loop in statement 180.

Buffering Data Received Over the RS-232

by Ray DeMers
Tektronix, Inc.
Rochester, NY

In addition to connecting your 4050 Series System to a modem for use in **TERMINAL mode**, the Option 1 Data Communications Interface will connect your system to a variety of RS-232 compatible devices for use in **BASIC I/O mode**, such as programmable instruments, plotters, card readers, and so on.

In a simple configuration, the 4050 System might issue a PRINT @40:A$ to instruct the external device to execute a sequence. This would usually be followed by INPUT @40:B$ to request the results of the sequence for use in the 4050 BASIC program. However, once the INPUT command is executed, the 4050 System will wait until the data, or at least a CR, is returned. In another configuration the external device might operate independently and call the 4050 periodically to send it data. In both of these cases you may continue running a program on your 4050 System, instead of having it sit idle while waiting for data. This is accomplished by taking advantage of the 4050 System's input buffer.

The input buffer is enabled through a PRINT @40,30: command; it will store up to 255 characters received over the RS-232 Data Communications Interface. Then, by executing INPUT @40,0:A, the 4050 System may determine the number of CR characters in the buffer, indicating data have been received. If it finds data in the buffer, it can branch to a service routine to bring it in.

The buffer may be used in two ways. The first, and most desirable, approach is to have the external device send a CR (or message of *no more* than 255 characters including several CRs) and wait for a reply from the 4050 System. This permits the 4050 System to test for a request when it has come to a convenient interrupt point in the BASIC program.

```
1 REM RS-232 INTERRUPT SIMULATOR
3 REM
4 RUN 100
20 PRINT @32,26:0
21 END
24 PRINT @40:"I    *****INTERRUPT*****"
25 RETURN
100 INIT
110 SET KEY
120 DIM A$(300)
130 PRINT @32,26:2
140 PAGE
150 CALL "RATE",2400,0,0
155 REM ENABLE BUFFER
160 PRINT @40,30:
170 PRINT "NORMAL PROCESSING"
175 REM SET TIMING LOOP FOR GRAPHIC SYSTEM
180 FOR K=1 TO 215*1725*(RND(0)>0.2)
190 NEXT K
200 GOSUB 1000
210 GO TO 170
970 REM
980 REM POLLING SUBROUTINE
990 REM
1000 INPUT @40,0:A
1010 IF A=0 THEN 1070
1020 INPUT @40:A$
1030 IF LEN(A$)>1 THEN 1050
1040 A$="[CR] ONLY RECEIVED."
1050 PRINT " "|A$|" [CR] REMAINING IN BUFFER = "|A-1
1060 GO TO 1000
1070 RETURN
```

The second approach is used when the device sends data at odd intervals and cannot wait to be acknowledged. In this case, the programmer must GOSUB to test and unload the buffer often enough[1] to prevent overflow[2]. The data stream should have a minimum of two CRs: one at the beginning to get the attention of your program promptly, and one at the end to complete buffer transfer.

A Sample Program

The following short program uses the second approach to show the general capabilities of the buffer. Run the routine using an external RS-232 compatible device (e.g., a terminal or another 4050 System), or only the 4050 System.

UDK 1 starts the program doing "NORMAL PROCESSING," with a test of the buffer at the appropriate interval for the baud rate and Graphic System. If one or more interrupts (CR) have been received, they will be serviced in sequence, with an

[1]Divide the buffer size by the baud rate (in characters per second) and you'll have some idea how often to test the buffer, e.g., 255/(2400/10) = 1.0625 seconds between tests.

[2]If more than 255 characters are received by the buffer at any one time, an overflow condition occurs. Data in the buffer and all data received after an overflow condition are lost. Once an overflow condition occurs, the buffer must be reset with a PRINT @40,30: command. See "BASIC I/O MODE" in the Option 1 Data Communications manual for a full discussion of overflow consequences.

indication of the number remaining, followed by a RETURN to the main program. The program will end if you press UDK 5 or the BREAK key, or if you overflow the buffer.

Using an External Device

Plug the RS-232 compatible device into the Option 1 Interface, select the same baud rate on both units, and RUN the program. Key in combinations of characters and CRs from the external device to see buffer operation. Keying in CRs quickly will show how they are stacked in the buffer. Key in a long string of characters and note that nothing happens until a CR is issued. Also note that the buffer may be overflowed by keying in more than 255 characters without issuing a CR.

Using the 4050 System Alone

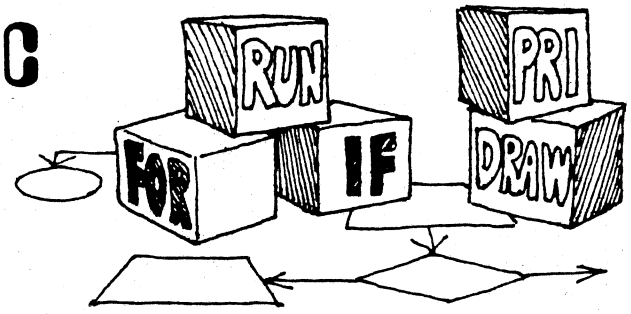
Plug the modem cable with a self-test adapter into the Option 1 Interface and RUN the program. Pressing UDK 6 will send a message out the interface which will loop back into the buffer. Quick, successive operation of UDK 6 will show how the messages are stacked in the buffer, with the possibility of overflow and loss of data.

Running this short routine will help you see how data stacks up in the input buffer and how a service routine allows the 4050 System to treat the CR delimiter[3] as an interrupt.

---

[3]Although input may be terminated by delimiters other than CR by using %40 form (see "INPUT" section in the Graphic System Reference Manual), INP %40,0:A still only counts CRs.

BASIC BITS



Use VAL Function to Avoid Errors

by Steve Franck
Tektronix, Inc.
Phoenix Field Office

When a program requests a numeric response from a user (number of months, number of curves), often there is a reasonable default value (12, 1). Thus, it is convenient to assign input to a string variable and let a RETURN trigger the default:

```
1410 PRINT "Enter file # (RETURN=end): ";
1420 INPUT F$
1430 IF F$>"" THEN 1450
1440 END
1450 F=VAL(F$)
1460 FIND F
```

But sometimes the operator keys in a character that can't be interpreted as a numeric, and the program is stopped with an error (in line 1450 in this example).

However, almost all numeric inputs have at least one meaningless value. (In the above example, 0 would be such a value.) This value can be used to construct a numeric validity check:

```
1410 PRINT "Enter file # (RETURN=end): ";
1420 INPUT F$
1430 IF F$>"" THEN 1450
1440 END
1450 F$=F$&"#0"
1460 F=VAL(F$)
1470 IF F=0 THEN 1420
1480 FIND F
```

There is no way the VAL function in line 1460 can fail.

A more general technique, of course is to program the input and check as a subroutine:

```
64000 REM --- SUBROUTINE TO INPUT A NUMERIC X,X$
64010 INPUT X$
64020 IF X$="" THEN 64060
64030 X$=X$&"#0"
64040 X=VAL(X$)
64050 IF X=0 AND POS(X$,"0",1)=LEN(X$) THEN 64010
64060 RETURN
```

The program accessing the subroutine might read:

```
1410 PRINT "Enter file # (RETURN=end): ";
1420 GOSUB 64000
1430 IF X$>"" THEN 1450
1440 END
1450 FIND X
```

New Programmers Note

Are you new at programming on the 4050 Graphic System? Take a look at the LANGUAGE SYNTAX section of your 4050 Series Graphic System manual.

Graphic System BASIC syntax rules, device numbering, keywords and their required and optional parameters, are all explained. It's easy to read and sheds a lot of light on your 4050 Graphic System's logic.

Survey Results In: Question and Answer Column Wanted

by Patricia Kelley
TEKniques Staff

You told us and we listened.

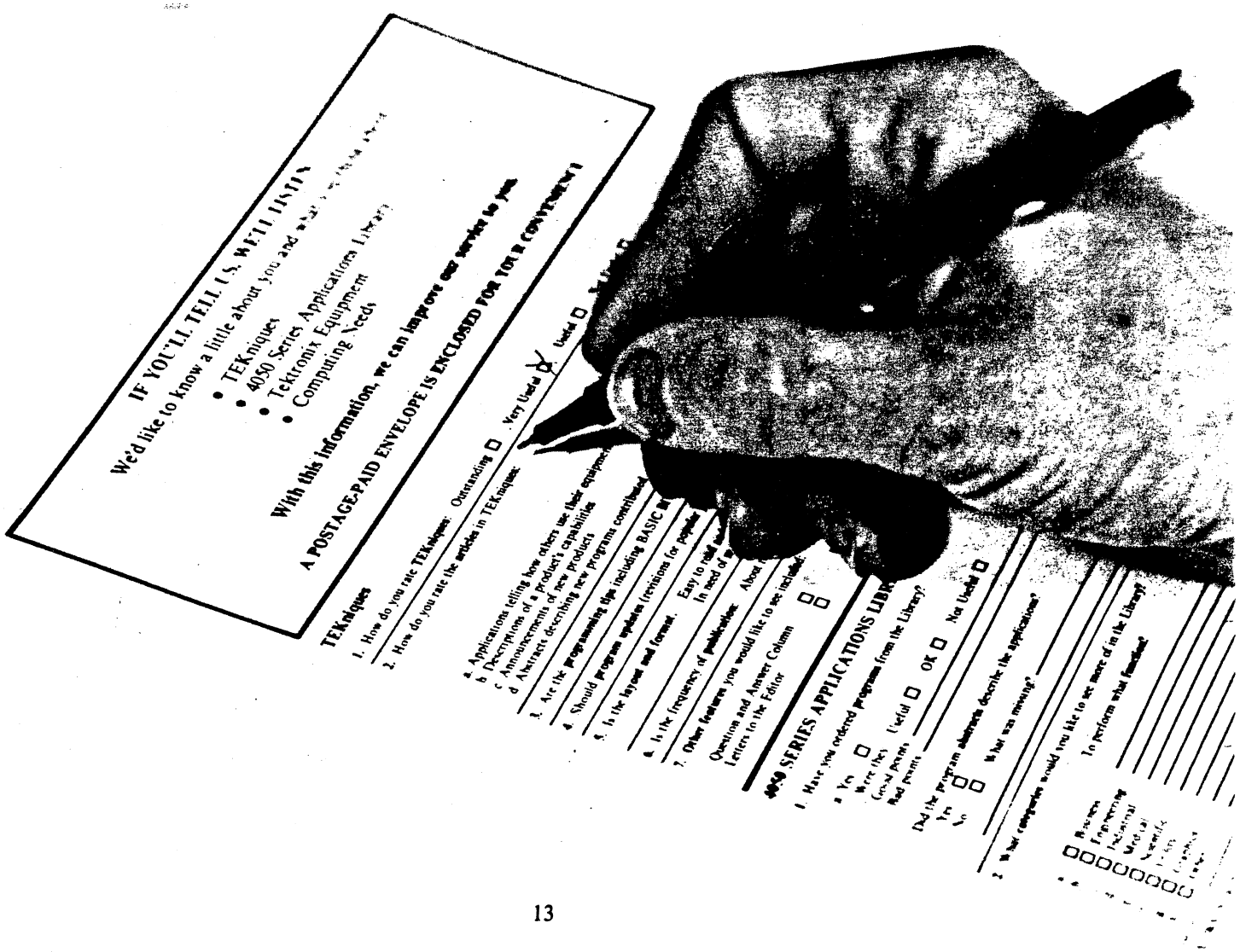
The majority of those who responded to the questionnaire sent along with TEKniques Vol. 3 No. 5 want a Question and Answer column. This feature will begin with the March 15 issue of TEKniques. Guidelines are noted elsewhere in this issue.

Most everyone found TEKniques *very useful.* Some thought it *outstanding.* However, one disgruntled reader couldn't find any use for it whatsoever. The articles received a 75% rating for the *right amount of information* with *not enough details* receiving the majority of the remaining 25%, especially on program abstracts. The programming tips seem to please 92% of the readers and all but 3% want the program updates continued. Most everyone found TEKniques easy to read and follow but 26% did want more illustrations, photos, and graphs. The majority liked the frequency of publication, although several would like to receive TEKniques more often.

The 4050 Series Applications Library took its lumps and we're working on the problems. Documentation is the hindrance restricting program contribution, although the proprietary nature of programs was also a stumbling block. All but 4% thought the 3-for-1 exchange was adequate.

The new 4052 and 4054 Graphic Systems have already provided a response to the two major gripes concerning the 4051—speed and memory. Other shortcomings mentioned and suggestions for improving the 4050 Systems and their peripherals have been passed to the engineering groups.

Your cooperation in taking your time to respond to the questionnaire is really appreciated. We will try hard to improve the suggested areas in the 4050 Series Applications Library. Your answers and suggestions will also play an important part in future Graphic Computing Systems products and policies. Thank you!



4050 Series Applications Library Program Abstracts

Order

Documentation and program listings of each program are available for a nominal charge. Programs will be put on tape or disc for a small recording fee per program plus the charge for the tape cartridge or flexible disc. One tape/disc will hold several programs. Programs will be recorded on like media only, i.e., programs on tape cannot be sent on disc and vice versa unless os noted in the abstract.

(The program material contained herein is supplied without warranty or representation of any kind. Tektronix, Inc. assumes no responsibility and shall have no liability, consequential or otherwise, of any kind arising from the use of this program material or any part thereof.)

Domestic U.S. Prices

Documentation and listings	*$20 per program*
Recording Fee	*5 per program*
Tape Cartridge	*30 per tape*
Flexible Disc	*15 per disc*

Contribute

Contribute one program to the Library and receive three in exchange. Send in the membership card from your 4050 Series Graphic System Reference Manual to get the details. Or call us (503) 682-3411, ext. 3618.

Forms

Please use the Applications Library Order Form. Order forms are included in the Membership Packet and are available from your local Tektronix Sales Engineer.

Outside U.S.

Program contributions or orders outside the U.S. must be processed through the local Tektronix sales office or sent to one of the Libraries serving your area. See Library Addresses section.

ABSTRACT #: 51/00-8032/0

Title: **Device Address Adding Program**
Author: Jan Broenink
Tektronix International Inc.
European Marketing Centre
Amstelveen, Holland
Memory Requirement: 16K
Peripherals: 4924 Digital Cartridge Tape Drive
Optional—4631 Hard Copy Unit
4641/4642 Printer
Statements: 402
Files: 1 ASCII Program

The program reads a tape file containing a 4050 BASIC program in ASCII format and updates the program by adding a device address (for graphics and alpha-numerics) to output statements without a device address or with address 32 (without a secondary address).

The program searches for the following output statements without a device address or with address 32:

PRINT	MOVE
LIST	DRAW
RMOVE	AXIS
RDRAW	GIN

and will automatically or with user interaction add a device address. Interaction allows the user to define more than one output address within a program. For instance, user instructions may be directed to the screen while graphs may be directed to the plotter.

A routine is added to the original program to define a device address for graphical and alpha-numerical output. An unused User Definable Key in the original program may be used to call this routine.

The original program may be stored on several sequential tape files.

```
*** ADD OUTPUT-DEVICE ADDRESSES (incl. selection) ***

          GRAPHICS TO PLOTTER
          ALPHA-NUMERICS TO PRINTER

SET ORIGINAL TAPE ON SAFE AND INSERT IT IN THE 4924
TYPE [DONE] AND PRESS [RETURN] WHEN READY :DONE
WHAT IS THE GPIB-ADDRESS OF THE 4924 : 4

SET NEW TAPE ON UNSAFE AND INSERT IT IN THE 4051
TYPE [DONE] AND PRESS [RETURN] WHEN READY :DONE

FIRST FILE OF ORIGINAL : 1
LAST FILE OF ORIGINAL  : 4

FILE #1 OF ORIGINAL TO BE COPIED TO
FILE #1   OF NEW TAPE.

AUTOMATIC MARKING (YES/NO) : YES

INTERACTION PRINT & LIST-STATEMENTS (YES/NO) :YES

ADDRESS OF OUTPUT-DEVICE FOR THIS PROGRAM : 32
```

ABSTRACT #: 51/00-0718/0

Title: **Business Simulation**
Author: Gene Lynch
Tektronix, Inc.
Memory Requirement: 32K
Peripherals: Optional—4051R05 Binary ROM Pack
Files: 5 ASCII Program
1 Binary Program
Statements: 1821

The program simulates a manufacturing firm. The affects of employee attrition, equipment failure, age of product, schedul-

```
FOR NO CHANGE FROM LAST MONTH'S VALUE, JUST PRESS RETURN.

THE NUMBER OF EMPLOYEES              MARCH        50        APRIL 52
THE NUMBER OF SALES PEOPLE           MARCH        20        APRIL 20
THE RESEARCH & DEVELOPMENT ($)       MARCH     30000        APRIL 30500
PRODUCT INVENTORY FOR HOPE             335
UNFILLED ORDERS FOR HOPE               0
PARTS INVENTORY FOR HOPE               225
ORDERS LAST MONTH FOR HOPE             440
PRODUCTION LAST MONTH FOR HOPE         425
PARTS ORDERED FOR HOPE          400 IN LAST MONTH        400 EXPECTED NOW
                                     MARCH       400        APRIL 500
BUILD SCHEDULED FOR HOPE             MARCH       425        APRIL 475
ADVERTISING FOR HOPE          ($)    MARCH      6000        APRIL 4500
THE PRICE FOR HOPE            ($)    MARCH       600        APRIL 600
NUMBER OF MACHINES RUNNING LAST MONTH 10
NUMBER OF MACHINES ON ORDER NONE
ORDER MACHINES 0
DO YOU WANT TO MAKE ANY CHANGES IN YOUR ANSWERS? (YES,NO)NO
SHOULD WE BREAK GROUND FOR A NEW PLANT?(YES,NO)
(ABOUT 12 MONTHS CONSTRUCTION TIME)NO
```

ing, finance, inventory, advertising, pricing, planned growth, research and development, inflation, overhead, hiring, firing, and training are included in the simulation.

The user has complete control of the operation of the company. The program supplies operational information and status reports from which the user must decide to: hire or fire people, increase or decrease advertising and R&D budgets, order parts and equipment, set production schedules and prices, and pay off outstanding notes.

Operation begins in March of manufacturing year 1 with no outstanding debts, $600,000 in liquid investments, 1 plant (20-machine capacity), 10 machines, 50 general employees, and 20 sales people. The current price for parts-per-unit is $100.

```
BUSINESS TEST                    APRIL, YEAR  1

                          HOPE
                                                  TOTALS ($)

UNITS SOLD                 477                       286,200
INVESTMENT INCOME                                      4,313

TOTAL INCOME                                         290,513

DIRECT MATERIAL COSTS    40000                        40,000
DIRECT LABOR COST        78520                        78,520
PARTS INVENTORY            150                           366
PRODUCT INVENTORY          333                         2,831
ADVERTISING               4500                         4,500
CREDIT PAYMENTS                                            0
OVERTIME                                                   0
OVERHEAD                                                33,602
RESEARCH AND DEVELOPMENT                                30,500
SALES COST                                              45,300
EQUIPMENT                                                  0

TOTAL COSTS                                          235,619
BALANCE                                               54,894

M=MANUFACTURING
O=ORDERS
P= PARTS INVENTORY
I= PRODUCT INVENTORY

                                  M O P I
                                  HOPE

FOR ADDITIONAL
REPORTS PRESS RETURN
```

```
WHEN YOU TOOK OVER BUSINESS TEST       IT HAD:
      LIQUID ASSETS OF 600,000
      NO OUTSTANDING DEBTS
      10 MACHINES
      50 GENERAL EMPLOYEES
      20 SALES PEOPLE
       1 PRODUCT(S)
       1 PLANT(S)
      NET ASSETS OF 2,200,000
      MONTHLY SALES OF ABOUT 450 UNITS
      MONTHLY INCOME OF ABOUT 275,000
      MONTHLY COSTS OF ABOUT 230,000
      MONTHLY GROSS PROFITS (BEFORE TAXES) OF  45,000

AFTER OPERATING BUSINESS TEST       FOR 2 MONTHS IT NOW HAS:
      LIQUID ASSETS OF     689,194
      AN OUTSTANDING DEBT OF          0
       10 MACHINES
       50 GENERAL EMPLOYEES
       20 SALES PEOPLE
       1 PRODUCT(S)
       1 PLANT(S)
       NET ASSETS OF  2,332,343
     AVERAGE MONTHLY INCOME LAST QUARTER WAS    276,055
     AVERAGE MONTHLY COSTS LAST QUARTER WERE    229,657
     AVERAGE MONTHLY PROFIT (BEFORE TAXES) WAS     46,398

YOU HAVE MANAGED TO INCREASE THE MONTHLY PROFIT
(ADJUSTED FOR INFLATION FACTORS) BY 1.99 PER CENT

WOULD YOU LIKE TO RETIRE OR ACCEPT A BETTER POSITION AT THIS TIME
(YES,NO)
```

TEKniques

The 4050 Series Applications Library Newsletter
Vol. 3 Index (8 Issues)

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ARTICLES—BY EQUIPMENT

PROGRAMMING TIPS—BY ISSUE

PROGRAMMING TIPS—BY PROCEDURE

PROGRAMMING TIPS—BY EQUIPMENT

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Applications Library
Group 451
P.O. Box 500
Beaverton, Oregon 97005

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4050 Series Applications Libraries

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Contact local sales office

Australia

4050 Series Applications Library
Tektronix Australia Pty. Limited
Sydney
80 Waterloo Road
North Ryde, N.S.W. 2113

Canada

4050 Series Applications Library
Tektronix Canada Ltd.
P.O. Box 6500
Barrie, Ontario
Canada L4M 4V3

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IDD Group
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Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon 97077
U.S.A.

Japan

4050 Series Applications Library
Sony/Tektronix Corporation
9-31 Kitashinagawa-5
Tokyo 141 Japan

United States

4050 Series Applications Library
Tektronix, Inc.
Group 451
P.O. Box 500
Beaverton, Oregon 97077