Tekniques

The 4051 Applications Library Newsletter Vol. 2 No. 5

The Gould Flight Test Aircraft logs many air miles testing advanced navigation systems developed by Gould NavCom Systems Division of El Monte, CA.

Testing Advanced Navigation Systems With The 4051

by Robert B. Denny
Gould NavCom Systems Division
El Monte, CA

The NavCom Systems Division uses the 4051 to control and monitor tests of an advanced long-range flight navigation system (see Fig. 1). Testing is now accomplished in real time during flights as well as in the lab, replacing the previously used blind data collection and subsequent laboratory reduction. The immediate graphic feedback provided by the 4051 has greatly enhanced flight testing of developmental navigation systems.

The NavCom System provides highly accurate in-flight position data for instrument navigation. It relies on the signals from at least four of the eight VLF (Very Low Frequency) OMEGA navigation stations, and uses triangulation to achieve a position reading within a few miles. The system compares the phase differences from the stations to obtain an accurate indication of position. Of course, the accuracy of the system depends on the "noise" contained in the received signal.

The nav system can be reconfigured to accept more accurate signals from VORTAC, a sensor beacon network which is the primary navigation aid used in the United States. Relying on these signals the NavCom System can pinpoint in-flight location within a few thousand feet.

In This Issue

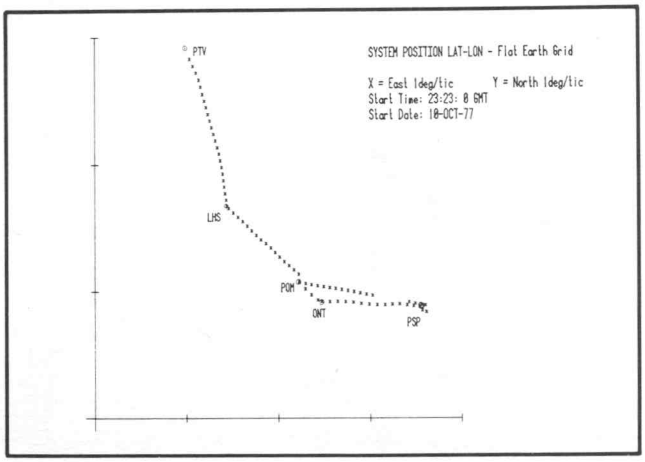

Fig. 1.

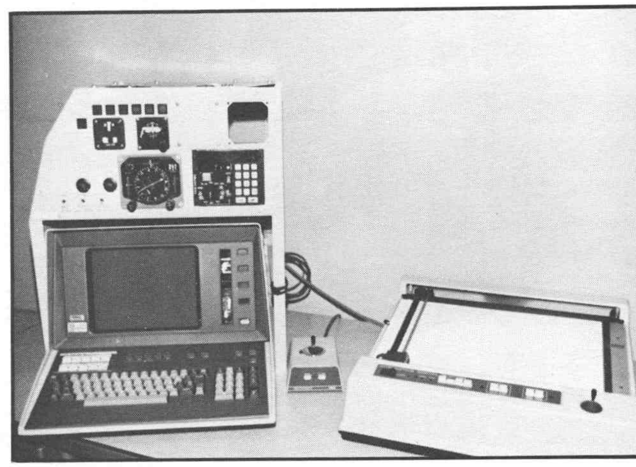
Fig. 2.

The developmental nav system is built around a 4051 connected to a 4662 Interactive Digital Plotter and a line printer (Fig. 2). Also, connected to the GPIB is an in-house designed GPIB-to-navigation system interface, allowing control and communication between the 4051 and the navigation system's processor (an in-house bit-slice design). The 4051 remains on-line to this processor, operating as a controller rather than as a terminal or peripheral. A block diagram of the system is shown in Fig. 3.

The 4051 uses secondary addresses transferred over the GPIB to load and read the interface control, communication and breakpoint registers. This technique is used to control the nav system processor's run-halt, master clear and direct-execute interrupt lines. A direct execute interrupt causes the system processor to fetch an instruction from one of its I/O channels, which in this case is assigned to the GPIB interface. This gives the 4051 the ability to force the nav system processor to execute any single instruction. Instruction, address and data information is supplied to the nav system processor via registers in the GPIB interface. Forcing an input instruction allows the 4051 to load a memory location in the nav system; forcing an output instruction allows reading a memory location. The 4051 converts the system processor's binary

* Editor's Note

New Contest Coming

Another contest is in the offing. TEKniques Vol. 2 No. 6 seems like the time to announce it. Vacations will be rolling to an end; school will be starting. And, with all the physical exercise of summer, the brain will need triggering. Watch for the announcement of categories and prizes.

Catalog Reminder

A new catalog of 4051 Applications Library Programs is now available, and should have reached most of you by now. The catalog contains several new program categories and lots of new programs. If you haven't received a copy, or if you'd like additional copies, drop us a line. They're free for the asking.

TEKniques Back Issues Available

You may have back issues of TEKniques by simply letting us know you want them. Send us a note; give us a call.

How About Your Application

Are you using your 4051 in a way that you think might interest others? If you are, we'd like to hear about it; your application could be the subject of another TEKniques article. You can draft an article and send it to us for editing and publication. Or, you can give us a call or drop us a line to tell us what you have. We will then contact you and send you a questionnaire from which we can compose the article. Let us know; we'd like to hear from you.

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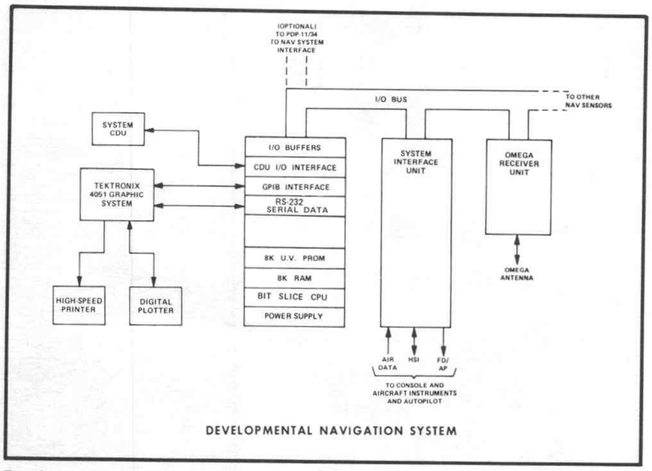


Fig. 3.

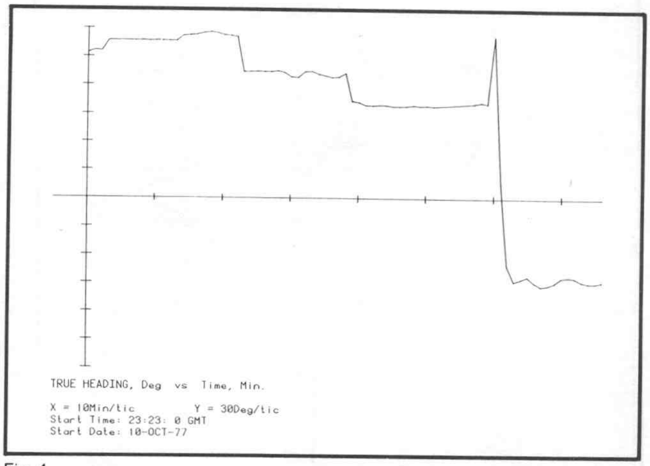


Fig. 4.

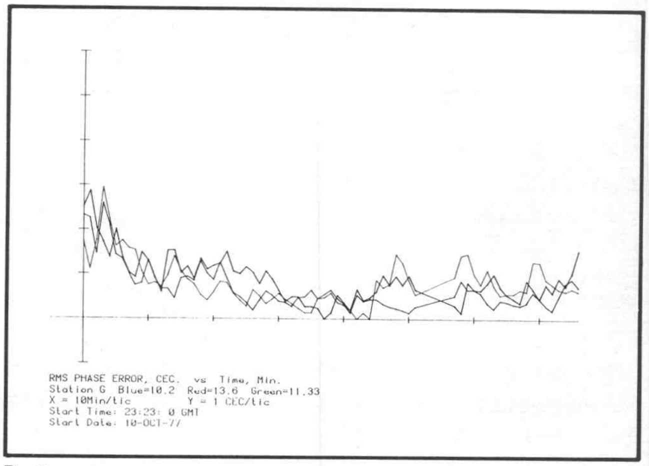


Fig. 5.

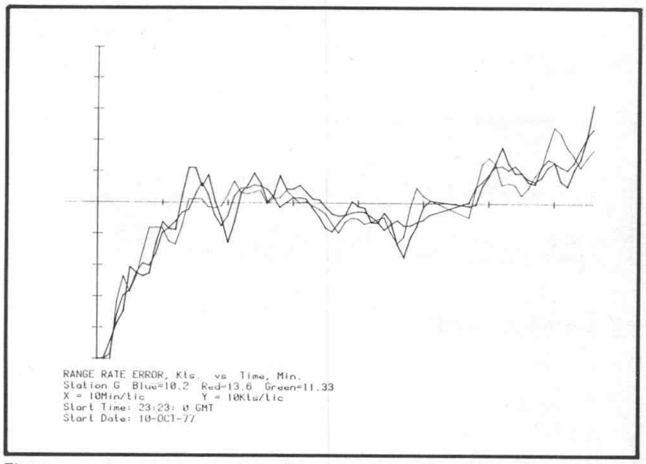


Fig. 6.

data representation into meaningful engineering data values and vice versa. Various types of graphic data display are available. In addition, this feature is used to patch the nav system program by loading new instructions into its memory.

The interface provides for setting a memory access breakpoint which, when reached, generates a GPIB service request (SRQ) interrupt and, if desired, halts the nav system processor. In this way, data collection can be synchronized to the nav system program. The instant-halt feature allows detection of program faults by freezing the nav system processor upon read and/or write accesses to a memory location specified by the 4051.

Before this development, flight tests were conducted "blindly" with data collected on paper tape or magnetic tape. After the test flight, data from tape was fed to a computer for data reduction and analysis. The 4051-based system makes the data gathered more immediately useful through real-time analysis and reduction. Monitoring and displaying the key variables in the navigation system graphically in real time allows the test procedure to be modified on the spot, depending on the results observed. The data is also recorded on mag tape for further analysis back in the lab.

Operation is controlled by a fairly large software package developed by NavCom Systems Division for the 4051. The software allows the operator to control navigation system mode, data gathering, memory inspection and change, and other system functions, all through the User-Definable Keys (Fig. 7). This makes for a complex, advanced test system that is simple and easy to use.

When the 4051 is not testing navigation systems, there are other functions in the NavCom lab to keep it busy. Some of these duties include algorithm development, closed-loop system behavior simulation, and other design-related problem solving. A plug-in PROM Programmer built for the navigation system is also connected to the GPIB. The 4051 controls the programming cycle of the

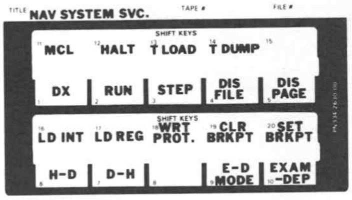
Fig. 1. Actual in-flight data gathered from the system on a flight from Porterville, CA, to Pomona, CA, via Lake Hughes (LHS), Pomona (POM), Ontario (ONT) and Palm Springs (PSP). A temporary loss of electric power occurred on the final leg from Palm Springs to Pomona.

Fig. 2. Developmental nav system configured for the Gould NavCom Systems laboratory includes the 4051, 4662 Plotter and a line printer (not shown).

Fig. 4. Direction (heading) as a function of time.

Fig. 5. Receiver tracking filter phase RMS jitter.

Fig. 6. Receiver tracking filter velocity error for all 3 frequencies from one station (Station G, which is currently in Trinidad).



Legend

1 Direct Execute
2 Run
3 Single Step
4 Display Register File
5 Display Memory Page
6 Hex to Scaled Decimal
7 Scaled Decimal to Hex
8
9 Examine/Deposit Mode
Modes: Hex
Single Precision Scaled Decimal
Double Precision Scaled Decimal
10 Examine/Deposit
11 Master Clear
12 Halt
13 Tape Load
14 Tape Dump
15
16 Load Interface
17 Load Register
18 Write Protect Memory
19 Clear Breakpoint
20 Set Breakpoint

Fig. 7

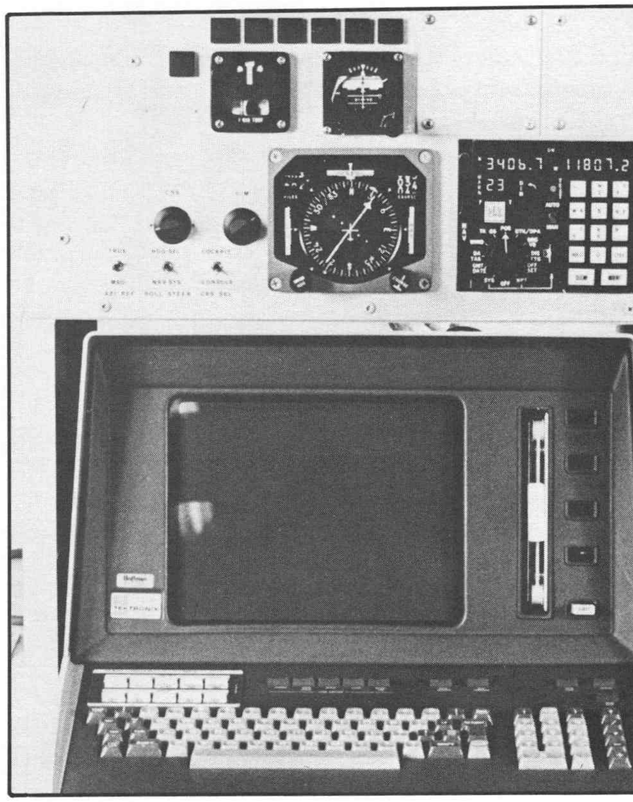


Fig. 8.

PROM program so that the 4051 can transfer data from the navigation system working memory into the PROM being programmed.

The NavCom System Division of Gould is continually designing and developing state-of-the-art navigation systems. These systems will eventually be produced for military and commercial aircraft world-wide. The 4051 is playing an important part in this innovative engineering.

Teknıques

Fig. 7. User-Definable Keys make this complex, advanced test system simple and easy to use.

Fig. 8. The nav system which goes along on the flight is designed to fit into the curvature of the left side of the Gould Flight Test Aircraft.

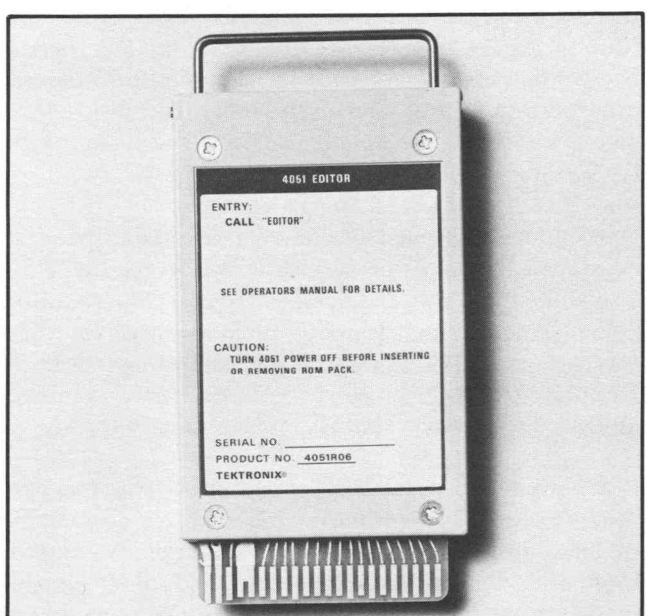
The 4051R06 EDITOR: A Text Editor for the 4051

by Cathy Cramer

This is the first in a series of articles on the Tektronix 4051R06 EDITOR.

One of the most impressive accessories for the 4051 is the 4051R06 EDITOR. The 4051R06 EDITOR is a ROM Pack, a small Read-Only Memory device that fits into one of the 4051 backpack slots, or into a ROM Expander slot. Inside the ROM Pack is a complete line-oriented and string-oriented text editor that allows you to use the 4051 to create, edit, and store ASCII text of any kind.

The EDITOR'S text editing language consists of 29 commands, including special purpose editing commands, I/O commands, and "environmental" or system status commands. All of the commands become available when you execute the statement CALL "EDITOR" from the



TEKTRONIX 4051R06 EDITOR ROM Pack allows you to use the 4051 to create, edit and store ASCII text of any kind.

4051 keyboard. And because it's a ROM Pack, the EDITOR takes up only 592 bytes of read/write memory. The remainder of read/write memory can be used to hold text for editing.

You can use the EDITOR to create new files, or to edit already existing files. The commands let you bring lines of text into memory from tape, modify them quickly and easily, and send the edited lines to an internal or external tape storage or printing device. The "text" you work with may be any set of ASCII characters—programs, data, or free text like than in a letter or textbook. If your text is a program, it need not be a BASIC program: you can use the EDITOR to write or edit programs in FORTRAN, COBOL, or any other programming language based on the ASCII character set.

This opens up a whole new world for the 4051. For the first time, you can use the 4051 to write programs in other programming languages without getting syntax errors. You can write and store your programs off-line using the EDITOR, then use the Option 1 Data Communications Interface to send them to a host computer for processing. Or, you can use the same interface to pull files from the host into the 4051 internal magnetic tape, then edit them off-line with the EDITOR. Writing, updating, and documenting programs or data off-line using the EDITOR can save you costly connect time, and spares you from the irritating response delays you can experience while using a text editor that resides on the host.

There are many uses for the EDITOR beside writing programs in other languages. The EDITOR provides fast methods for editing BASIC programs. For example, with one command you can modify an entire program so that it sends all output to a different peripheral device. With another command, you can obtain a listing of every line in the program that contains a particular variable name or keyword. This also means you can easily use the EDITOR to translate programs from other versions of BASIC into 4051 BASIC.

You can use the EDITOR's SORT command to alphabetize long lists of names or to put lists of numbers in increasing or decreasing order. The EDITOR can also play an important role in mass producing high-quality letters. You create and edit the letter at the 4051 keyboard, under EDITOR control, and save it on tape. Then you use a simple BASIC program to read the letter into memory as a string, add the name and address of the recipient of the letter, and send a final copy to a typewriter terminal.

Using the EDITOR

To use the EDITOR, all you have to do is type CALL "EDITOR" and press RETURN. The EDITOR immediately takes control of the Graphic System. Now you enter EDITOR commands, not BASIC commands. During a typical session, you might create and store several new files of text; or bring previously stored files into memory, edit them, and save the corrected versions on tape.

The EDITOR allows you to enter lines up to 396 characters long. (Without the EDITOR, the 4051 accepts lines up to 72 characters long.) The total amount of text you can enter is limited only by the amount of read/write

Fig. 1. The EDITOR displays FORTRAN text in two columns on the 4051 screen.

memory available in your 4051 when you call the EDITOR. You can still use the LINE EDITOR keys on the keyboard, to correct one line at a time. And three of the user-definable keys allow you to control how the text appears on the display, and what happens when a PAGE FULL condition occurs. For example, pressing the key labeled MARGIN 2 on the overlay causes text entered from the keyboard or listed on the display to appear in two columns, as shown in Fig. 1. When the screen is full, a blinking F appears, prompting you to press HOME/PAGE.

When you are finished using the EDITOR, just press the RETURN TO BASIC overlay key. Control is immediately returned to BASIC. BASIC commands are available again, as well as any program or variables that were in memory when you called the EDITOR.

EDITOR Commands

The EDITOR is a natural extension to BASIC. If you know BASIC, you won't have any problems learning the EDITOR. In fact, you may find the EDITOR even quicker and easier to use than BASIC. Most EDITOR keywords can be abbreviated to one character: O for OLD and L for LIST, for example. And like BASIC, the EDITOR allows you to omit parameters and rely on default values. For example, you just enter L to list the entire text.

Some of the EDITOR commands are already familiar to you. APPEND, DELETE, FIND, INPUT, MARK, OLD, PRINT, RENUMBER, SAVE, and WRITE are similar to their BASIC counterparts. In addition, the EDITOR offers many commands you haven't seen before: commands like COPY, INSERT, MOVE, SEARCH, SKIP, SORT, and others. These new commands are specially designed to allow you to swiftly rearrange and modify text.

For example, the COPY command allows you to copy one or more lines, and place the copy anywhere you want. The MOVE command allows you to move specified lines around in the text. The INSERT command lets you insert new lines anywhere in the text (and is the command you use to create new next).

Some examples are shown in Figs. 2 through 4. You'll notice in the examples that EDITOR commands allow you to specify line numbers. The line numbers are called "edit line numbers," and are assigned to the text by the EDITOR command RENUMBER. In the examples, you'll see the edit line numbers to the left of the lines, and separated from the text by a colon.[1]

In Fig. 2, the COPY command is used to duplicate two lines of text. First, a complete listing is obtained by entering L for LIST. Next the command C 2,3,8 is executed to duplicate lines 2 through 3, and place the copy immediately before line 8. A new listing obtained by entering L again shows the results.

```
L
    1:        REAL FUNCTION RSCALE(M)
    2:        COMMON /BTEST/ A, B, C, D
    3:        INTEGER A, B, C, D
    4:        RSCALE = FLOAT(M)/256.0
    5:        RETURN
    6:        END
    7:C
    8:        REAL FUNCTION RANGLE(N)
    9:        RANGLE = FLOAT(N)*180.0/32767.0
   10:        RETURN
   11:        END

C 2,3,9
L
    1:        REAL FUNCTION RSCALE(M)
    2:        COMMON /BTEST/ A, B, C, D
    3:        INTEGER A, B, C, D
    4:        RSCALE = FLOAT(M)/256.0
    5:        RETURN
    6:        END
    7:C
    8:        REAL FUNCTION RANGLE(N)
     :        COMMON /BTEST/ A, B, C, D
     :        INTEGER A, B, C, D
    9:        RANGLE = FLOAT(N)*180.0/32767.0
   10:        RETURN
   11:        END
```

Fig. 2.

In Fig. 3, the MOVE command is used to rearrange a portion of a FORTRAN program. An initial listing is obtained by entering L. Then the command M 6,10,1 is executed to move lines 6 through 10, and place them immediately before line 1. A new listing shows how the lines have been rearranged.

```
L
    1:C  DEFINE FORTRAN FUNCTION F(X)
    2:        FUNCTION F(X)
    3:        F = X**2-5
    4:        END
    5:        RETURN
    6:C  DEFINE FORTRAN FUNCTION DF(X)
    7:        FUNCTION DF(X)
    8:        DF = 4*X**2-8
    9:        END
   10:        RETURN

M 6,10,1
L
     :C  DEFINE FORTRAN FUNCTION DF(X)
     :        FUNCTION DF(X)
     :        DF = 4*X**2-8
     :        END
     :        RETURN
    1:C  DEFINE FORTRAN FUNCTION F(X)
    2:        FUNCTION F(X)
    3:        F = X**2-5
    4:        END
    5:        RETURN
```

Fig. 3.

Fig. 4 shows the INSERT command being used to add a new line of text. After the initial listing, the command I 3 is given. This tells the EDITOR that new text is about to be entered, and should be placed immediately before line 3. The EDITOR returns the colon (:) as a prompt, and waits. The new line Apt. 5 is entered from the keyboard and the BREAK key is pressed. (To insert more than one line, you'd press RETURN here instead of BREAK.) The final listing shows the newly created line immediately before line 3.

```
L
    1:Anne L. Brunner
    2:11635 Nobel Ave.
    3:Los Angeles, Calif.  97685

I 3
     :Apt. 5

L
    1:Anne L. Brunner
    2:11635 Nobel Ave.
     :Apt. 5
    3:Los Angeles, Calif.  97685
```

Fig. 4.

These were very simple examples. In upcoming months, you'll see more articles on the EDITOR, including using the EDITOR to perform searching and sorting operations.

[1] **You'll also notice that lines moved by the MOVE command, or newly created by the COPY or INSERT command, do not have edit line numbers. You can assign a complete set of line numbers at any time, by executing a RENUMBER command.**

CAD Contest Winners from Canada, Virginia, and Kansas.

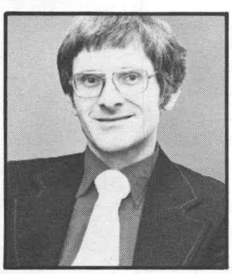
Circuitboard Patterns, Interactive Beam Analysis, and Belt Length Calculation take the prizes in the Computer Aided Design contest sponsored by TEKniques. Extensive programs and unique concepts caused the judges to deliberate long hours before picking these winners. All of the programs are excellent, and are useful additions to the 4051 Applications Library. Take a look in the Abstracts section for a description of these programs.

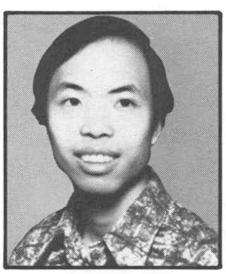
Jan Beckman, First Place

Jan Beckman was born and educated in Holland. He came to Canada and joined Imperial Oil Limited in 1968, initially in the Production Engineering department. In 1974 he transferred to the Off Shore Construction department, where he was involved in building drilling islands off Canada's Arctic Coast. During the past two years Jan has developed several computer programs that assist in quickly and accurately positioning off shore equipment and in calculating island material volumes.

TEKniques was unable to contact Mr. Beckman; the above information was provided by the Canadian Office of Imperial Oil. Jan is still with Imperial Oil, now in the London Office.

Larry Mitchell and Yiu Wah Luk, Second Place

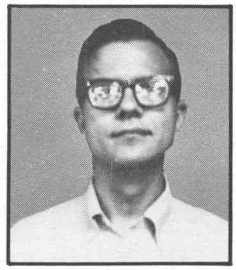




Professor Mitchell received his B.S., M.S., and Ph.D. degrees in Mechanical Engineering from the University of Michigan. He joined Virginia Polytechnic Institute and State University in 1971 after six years of industrial experience with duPont in Wilmington, Delaware. His major technical interests involve machine design, mechanical system dynamics, signature analysis of mechanical equipment, acoustics, and computer aided design. He has directed 12 graduate students in these areas of investigation. His hobbies include woodworking, cooking, and weight lifting.

Mr. Luk was born in Hong Kong and received his B.S. in Mechanical Engineering from the University of California, Berkeley, and his M.S. in Mechanical Engineering from Virgina Polytechnic Institute and State University. He is returning to VPI&SU to pursue his doctorate. He helped found the Hong Kong Club at VPI&SU; and was the first president of this club. He is a student member of the American Society of Mechanical Engineers.

Allen Hahn, Third Place



Allen Hahn is a graduate engineer with a B.S. in Mechanical Engineering from Kansas State University in 1970. He is presently Design Analysis Engineer with Hesston Corporation, Hesston, Kansas, a manufacturer of specialized farm equipment, where he performs theoretical structural analysis on the equipment. He is a registered Professional Engineer in Kansas and a member of the American Society of Mechanical Engineers and the American Society of Agricultural Engineers. Allen's hobbies include square dancing and square dance calling.

P.C. Holman, Honorable Mention

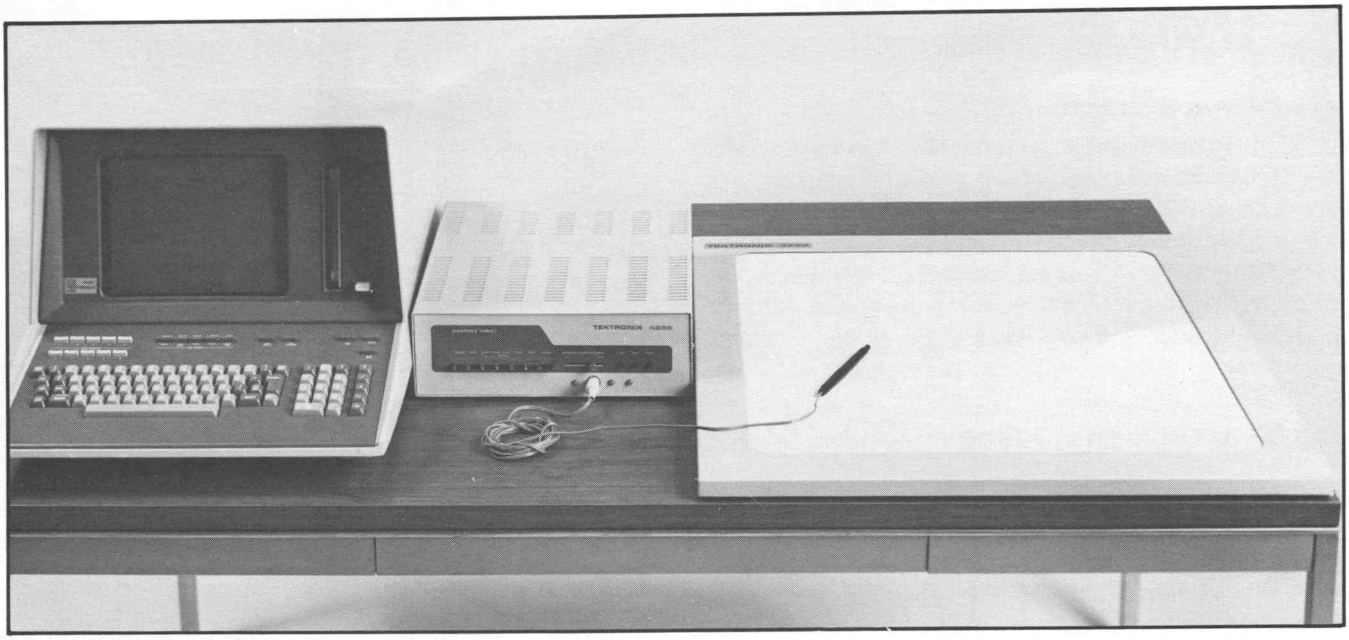
Dr. P.C. Holman received his B.S. and M.S. degrees from Illinois State, his M.N.S. (Master of Natural Science) from Arizona State, and his Ph.D. from Michigan State. In addition, Dr. Holman has done advanced work at 13 other universities. He has directed research programs at the State Univiersity of New York, State University of Wisconsin, and the University of Wisconsin, where he is currently director of research.

Ralph Deutsch, Honorable Mention

Mr. Deutsch was born in Boston, Massachusetts and received a B.S. degree in physics (1941) and an M.A. degree in mathematics (1950) from the University of Michigan, and an M.S. degree in physics (1947) from George Washington University. He has 37 years of technical experience in physics, applied mathematics, radar systems, noise and information theory, communication systems, countermeasures, space vehicles, and the application of digital techniques to the synthesis of musical sounds.

Glenn Hottel, Honorable Mention

Glenn Hottel is a student at Purdue University, School of Nuclear Engineering. TEKniques was unable to contact him due to the school's summer vacation period.



The TEKTRONIX 4956 Graphic Tablet coupled with the 4051 converts tedious, error-prone tasks into efficient and accurate ones.

4956 Graphic Tablet Provides Fast and Accurate Graphic Input

by Miki Tokola

For fast, accurate and convenient graphic data entry into the 4051, consider the TEKTRONIX 4956 Graphic Tablet. It calculates the coordinates of any point you specify on its special work surface, and transfers the coordinates directly to the 4051 through the GPIB. Coordinates can be stored, displayed, or used in calculations. The 4051/4956 system brings exceptional speed and accuracy to any application requiring identification and processing of coordinate information on a two-dimensional surface.

You can use the Graphic Tablet to create a graphic display on the 4051 screen without calculating all of the points and using the necessary MOVE and DRAW commands.

You can generate data files from graphic media, such as strip charts, without tedious data measurement and time-consuming keyboard entry. You can then store these data files on the internal magnetic tape unit, peripheral disc, or other peripheral recording device.

Another way to use the Graphic Tablet is for task and program control, by using the Tablet in a "menu selection" application. When the Tablet is used in this way, coordinate data transferred to the 4051 represents a choice from a "menu" of items. Or it may indicate the location for a desired action, such as the placement on a schematic of a component stored in memory and recalled through "menu selection."

System Parts Work Together

The 4956 consists of a standard 20″ by 20″ Tablet, a Tablet Controller, GPIB cable, a standard Tablet Writing Pen, and a PLOT 50 Graphic Tablet Support Tape. Options include a 36″ by 48″ Tablet and a Four-Button Cursor.

The Tablet serves as the working surface on which you place the graphic material to be digitized. This surface is constructed on an extremely flat and stable metal wood sandwich. Special wires which change dimensions depending on their state of magnetization (magnetostrictive wires) are laid under the writing surface in both the X and Y directions. They form a two-layer mesh measuring 4,000 units by 4,000 units and provide identifiable points that are only .005″ apart.

A current pulse generates a strain wave which propagates down all the wires in one direction simultaneously. A receive coil in the Writing Pen provides an electrical signal from the flux change. The 4956 microprocessor converts time delay distance between the "send" and "receive" coils to digital information by gating clock pulses into a binary counter. The number stored between the start and stop times represents the coordinate value.

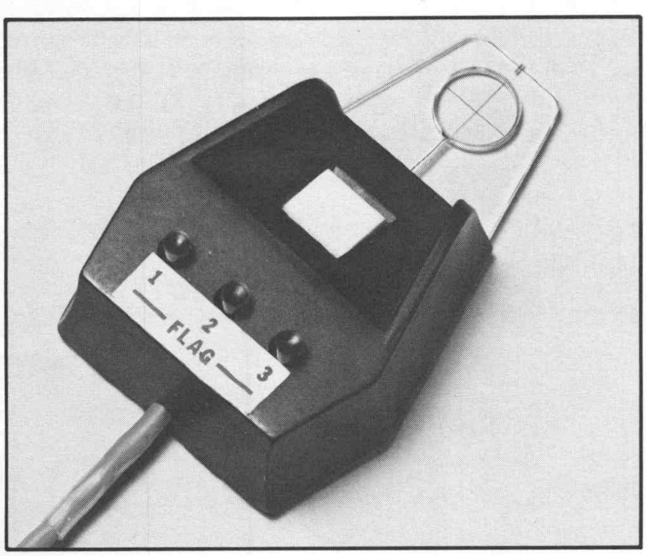
By pulsing from both ends simultaneoulsy, two sets of values are produced which are calculated by the on-board processor resulting in a highly accurate digital coordinate.

The same process is repeated for the Y axis and this data is placed on the GPIB port ready for direct interfacing.

A free-hand Writing Pen is a part of the system, used like an ordinary pen or pencil. It has a built-in switch that is activated by pressing the ball point against the Tablet to start and stop the X and Y count during the digitizing process. The Writing Pen is supplied with an inking ball-point filler. A dry refill is also included, for applications where the digitizing surface must be kept clean (such as digitizing points from a graph in a book).

An alternative to the Writing Pen is a four-button Cursor. This cursor has crosshairs for exacting accuracy and a button to activate the digitizing process. In addition to the main button, the Cursor has three user-definable buttons that can be used for program control. For example, when an appropriate INPUT instruction occurs in a 4051 BASIC program, the Tablet returns ASCII coordinates and an ASCII character status byte through the GPIB. The status byte indicates which combination of Cursor buttons have been depressed. The status byte can be tested to decode the button combination for branching to different parts of the program. Some functions commonly assigned to the Cursor buttons are DRAW, MOVE, delete the last point entered, halt the input process, and rotate the component to be drawn.

The Tablet Controller supplies all operating voltages and currents, provides the controls for choice of operating modes and choice of rate of coordinate pair production, a counter and a microprocessor for system control and self-calibration. The controller output will transfer X and Y data, status, and required operating pulses at TTL levels for control and interface purposes through the GPIB. Buttons on the Tablet Controller control the manner in which points are digitized, along with appropriate indicator lights.



A Four-Button Cursor is an alternative to the Tablet Writing Pen.

Several Operating Modes

The simplest mode of operation is the POINT mode. You digitize a single point each time you activate the Writing Pen or Cursor. This mode is useful for specifying individual points on the Tablet surface, such as the endpoint of a straight line, or for indicating the location for an object to be drawn.

A **STREAM** mode is also available; it is particularly useful when tracing or drawing freehand. In this mode you continuously generate coordinates and status while the Pen or Cursor is on the Tablet and activated. **STREAM** mode generates a series of points.

The Tablet Controller contains time and distance filters to regulate the number of point coordinates generated in **STREAM** mode. Filters reduce the amount of data stored to manageable proportions, and reduce the effects of random pen or cursor movements.

The time filter adjusts the digitization rate on the basis of elapsed time; it is implemented by moving a slide control on the Tablet Controller front panel. You can use a slow rate when storage capacity is a consideration, such as when digitizing an extensively detailed map. Or you can use a faster rate in making curves or drawing quickly, such as when tracing a signature.

When you press the **INCRE** button on the Tablet Controller front panel, you activate a distance filter. The distance filter adjusts the digitization rate on the basis of distance. Now you must move the Writing Pen or Cursor at least .01 inch before you can digitize the next acceptable point. This reduces the effect of pen tremors or random movements.

A PLOT 50: Graphic Tablet Support Tape is provided with the 4956. It contains programs to display and/or store the graphic data in memory or on magnetic tape, to edit and to merge graphic data.

An Example

As a simple example of 4956 use, suppose you wish to generate a display of a given triangle, along with the coordinates for calculations. You would first place the drawing of the triangle on the Tablet surface. Then you would load a simple BASIC program into the 4051 and begin the data entry. You would identify each point of the figure by either touching it with the Writing Pen, or by placing the crosshairs of the Cursor over the point and depressing a Cursor button. A portion of your program calculates the length of one leg of the triangle as follows:

```
300 REM--TRANSFER THE COORDINATES AND STATUS OF A POINT
310 INPUT @8:X1,Y1,A$
320 PRINT USING 330:"X1= ",X1,"Y1= ",Y1,"A$= ",A$
330 IMAGE 4A,4D,5X,4A,4D,5X,4A,2A
340 REM--TRANSFER THE COORDINATES AND STATUS OF ANOTHER POINT
350 INPUT @8:X2,Y2,A$
360 PRINT USING 330:"X2= ",X2,"Y2= ",Y2,"A$= ",A$
370 REM--CALCULATE THE DISTANCE BETWEEN THE POINTS
380 Z=SQR((X2-X1)↑2+(Y2-Y1)↑2)
390 PRINT USING 400:"Z= ",Z
400 IMAGE 4A,4D
410 REM--CONVERT THE DISTANCE FROM TABLET UNITS TO INCHES
420 I=Z/200
430 PRINT USING 440:"I= ",I
440 IMAGE 4A,2D.2D
```

Variable Z is the distance between the two specified points in Tablet units. A conversion to inches is easily performed in statement 420 with a division by 200 (=4000 units/20 inches).

An example of the output generated by this portion of the code is as follows:

```
X1=  772     Y1= 1276     A$= 1
X2= 2271     Y2= 1848     A$= 1
Z=  1604
I=    8.02
```

By merely touching the three corners of a triangle, you can display the triangle and have the coordinates available in storage for calculations such as perimeter, distance and area.

Using the 4956 Graphic Tablet to identify a series of specified points by coordinate pairs has broad applications in many areas. These areas include:

curve integration	cartography
structural analysis	computer and design
system design (traffic, electrical, etc.)	interactive graphics
schematics	space planning
land analysis	medicine
architecture	freehand design

If you are entering data into the 4051 in an application that is inherently graphic, the 4956 Graphic Tablet is a most convenient tool. Using the Tablet can save you time, by allowing data entry without the keyboard. It increases accuracy over hand measurements, and it saves effort because points are merely touched, not measured and interpreted. It converts tedious, error-prone tasks into efficient and accurate ones. There's no POINT in doing it any other way. Teknıques

Flowchart Program 51/00- 8005/1 Updated

By Leland C. Sheppard
Sunnyvale, CA

The following is an update to Flowchart Program 51/00-8005/1. Within that program, the VAL function in statement 1500 objects to PRINT statements with an sign and no numeric fields, such as PRI@P: X. To overcome this problem, insert the following two lines of code which add a 0 in front of the string being checked and delete it afterwards:

```
1495 C$=REP("0",1,0)
1505 C$=REP("",1,1)
```

Another program enhancement speeds up the control character scan routine with half the code. Delete lines 5130 through 5200 and the "DIM R(7)" in statement 190. Next, add the following code:

```
5010 FOR I=1 TO 9                    loop thru ctrl char
5020 Q=1                             search start for each one
5030 B$=SEG("HGIJKL↑_[",I,1)         get a ctrl char
5040 D=POS(C$,B$,Q)                  is it in statement?
5050 IF D=0 THEN 5120                br if no
5060 A=ASC(B$)                       convert to decimal
5070 B$=CHR(A+64)                    get alpha equivalent
5080 B$=B$&"H_"                      alpha+backspace+underline
5090 C$=REP(B$,D,1)                  replace it in statement
5100 Q=D+3                           bump search start
5110 GO TO 5030                      look for more of this one
5120 NEXT I                          and do the rest of them
```

Each control character added increases search time, therefore, only those normally used in 4051 BASIC programs have been included in line 5030. However, if you are flowcharting a program with other control characters, add those to the string in line 5030 and change line 5010 to the new total. For example, to include "@" change line 5010 to `5010 FOR I=1 TO 10` and line 5030 to `5030 B$=SEG("HGIJKL↑_[@",I,1)`

If you wish to search for all possible control characters, substitute the following code:

```
5010 FOR I=LEN(C$) TO 1 STEP -1
5020 B$=SEG(C$,I,1)
5030 IF B$>=" " THEN 5070
5040 B$=CHR(ASC(B$)+64)
5050 B$=B$&"H_"
5060 C$=REP(B$,I,1)
5070 NEXT I
```

Verifying Ensures High Quality Tape Recording Surface

A note from David Bruning of Lockheed Electronics, Las Cruces, NM, discussed verifying a tape prior to collecting critical data. His suggestions prompted the following article.

Even though most vendors certify their tapes, it might be a good idea to verify them again if the data to be recorded is critical. Also, if you are going to resurrect a used tape you can verify it to determine its condition.

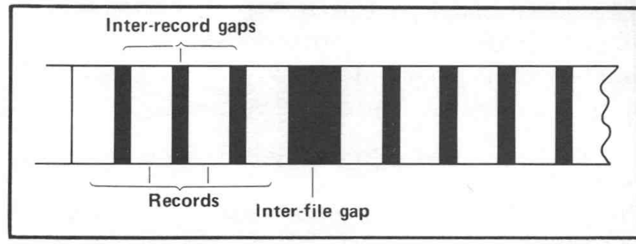
Understanding a tape verification means understanding how the 4051 MARks a tape. A marked file consists of several 256-byte[1] physcial records with small gaps separating each bit, each character and each record. Between the files are larger gaps of about 3½ inches.

MARking a tape its full length, printing and reading (INPut) a test pattern verifies only 57% of the tape. To check the gaps, the tape must be re-MARked into files of varying sizes and the test pattern again printed and read. Also, simply printing to the tape won't verify it. It must be read to take advantage of the 4051's checksum feature.[2]

The 4051 checksum adds all of the data bits in each record and prints the total as the last byte on that physcial **record**. When the data is read, the 4051 again sums the bits in each record then compares that total to the last byte on each record. If these totals are not the same, it tries 9 more times to read that record and come up with the same total. If the totals still don't agree after the 10 reads a read error is generated.

However, as Mr. Bruning points out, before throwing out the tape (or returning it to the vendor if new), clean your tape head and run the program again. Often a tape will verify on the second try.

It is important to realize that all data and program files existing on a tape are destroyed during the verification process.



During the verification process, the tape may run off the spool. This could mean a bad tape window or no BOT-EOT tape signals. Repeated occurrences with different tapes may indicate a hardware problem in the tape unit and you should contact your local Tektronix Service Specialist.

If writing a tape verification program sounds like a lot of work, don't despair. Tektronix PLOT 50: General Utility Programs, Volume 1 has such a program. It verifies a tape in about 25 minutes. If you want more information on this and the many other programs in this package, call your local Sales Engineer.

Mr. Bruning sent in the handy Error Message and Recommended Action table which he had compiled for their program. It applies to the PLOT 50 Verification program as well and should prove useful for many users.

ERROR MESSAGE	WHAT TO DO
53	Read/write error. Clean recording head of the magnetic tape unit; try again. If second attempt results in same message, don't use the tape.
54	EOT has been reached. This is a short tape; return it to the vendor.
56	Tape is SAFE. Rotate the lockout plug and try again.
57	No tape. Insert a tape and try again.
63	Header error. Try cleaning the tape head and run the program again. If it aborts a second time with this same error, there may be a machine malfunction. Contact the key operator.
Tape winds one end off of spool (no error message).	Bad tape window, or no BOT-EOT tape signals. Return tape to vendor. Repeated occurrences may indicate a hardware problem in the tape unit. Contact your local Tektronix Service Specialist.

For more information see pages 7-89 to 7-93 in your 4051 Graphic System Reference Manual. Page 2-15 in the 4051 Graphic System Service Manual Vol. 1 (part number 070-2065-00) graphically illustrates tape marking.

[1]128 byte records may be marked for compatibility with the TEKTRONIX 4923.

[2]The checksum error checking technique may be changed to allow reading of tapes which were recorded without using this feature.

Memory Full

by Ed Mitchell

During program operation or debugging, you may have encountered a MEMORY FULL error. This error is generated when the 4051 sees it is out, or nearly out, of user memory. The system was designed to give the operator a warning prior to using all of memory so that corrective action could be taken. The amount of memory left when the error message occurs may vary, and depends on how the error was generated. If a MEMORY FULL error message is generated and the correct action is not taken, the only recourse may be to cycle the power with loss of the program and variables. The actions which should be taken when a MEMORY FULL occurs are as follows:

1. If possible, delete a variable.
2. Type "END", which recovers all memory which was allocated by "FOR NEXT Loops", etc.
3. Save the program on tape or disc.
4. Save the variables if necessary.
5. Enter MEM (which will compress memory and return the amount of free space).

If the MEM command returns a significant number of bytes, check your program for "FOR NEXT" loops which may have been branched out of and never completed, or function key and GOSUB operations not terminated with RETURN.

If your program is just too large, you might consider appending or linking sections of the program. TEKniques

Cycling

By Jack Gilmore

Often only a portion of a tape is recorded with files and used. With time this will cause irregular stacking of the tape because of temperature variations and physical shock. A simple technique will cycle the tape resulting in an evenly stacked tape once more.

FINd n	(n is the last file on the tape)
MARk 1, 400000	(large enough to reach end of tape)

The 4051 will reach the end of the tape, rewind it and print error message 54 to the screen. At this point, you may want to restore the last file.

FINd n	(find last file again)
MARk 1,1	(this will put a LAST file back on the tape)

The tape is now ready for continued use.

Take Care of Your Tapes

Before growling at your 4051 when read/write errors occur, take a look at how you treat your tape. Is it packed around in the rear window of your car, frying in the summer heat, and then expected to perform? Or is it locked in the trunk at −10°, numb clear to its last byte? In any case, a tape should be acclimated to the operating temperature for several hours if it's been stored in an environment that's colder or warmer. Like most inert objects, its parts expand and contract with temperature swings. Wide temperature variations can also cause creases on a tape. And, at higher temperatures (but below 113° F), the number of passes a tape can handle goes down significantly. After conditioning the tape to the operating temperature, cycle it (wind and rewind) to correct any tension problems and minimize creases.

Cycling a tape also takes care of any stacking problems. Shocking (dropping or hard jostling) sometimes happens when shipping tapes, causing uneven stacking of the tape. Consequently, the tape does not pass over the read head at the proper angle, resulting in errors. When writing on an improperly stacked tape or poorly tensioned tape, data may be recorded but it may not be readable after the tape is cycled. Note the program tip **Cycling** for an easy check on used tapes. As described in TEKniques Vol. 1 No. 7, cycle *new* tapes with FINd 2. When the error message is printed on the 4051 screen, press the rewind key and the tape will be ready for use.

Also, remember that tapes leave an oxide deposit on your machine's read/write head. Clean the head every couple of months with a cotton swab moistened with isopropyl alcohol.

A final caution—don't store the tape cartridge in the tape drive. Flat spots can occur on the rubber drive roller, which will generate noise and may cause occasional tape slippage.

Tektronix uses and sells only tapes certified by the vendor. However, if they are mistreated, their ability to properly function drops.

Specifications on Tektronix Data Cartridges:

5° to 45°C	Operating temperature with data on the tape. (41° to 113°F)
-40° to 45°C	Non-operating temperature range with no data on the tape.
20% to 80%	Non-condensing humidity range.

In short: Cycle new and old tapes, store and use them in an office environment, clean the tape heads frequently, and use certified tapes. Teknıques

4051 Applications Library Program Abstracts

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Documentation and program listings of each program are available for a nominal charge. Programs will be put on tape for a small recording fee per program plus the charge for the tape cartridge. One tape will hold several programs. (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.)

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Documentation and listings	*$15 per program*
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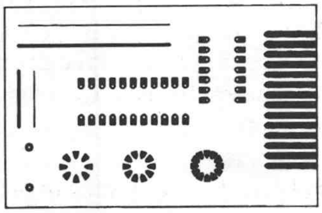
1

ABSTRACT NUMBER: 51/00-1404/0

Title: **Circuitboard Patterns**
Author: Jan Beckman
Imperial Oil Ltd.
Edmonton, Alberta, Canada
Memory Requirement: 16K
Peripherals: 4951 Joystick
4662 Plotter
Statements: 496
Files: 4

You can draw circuitboard patterns on the 4051 screen with this program. Once you are satisfied with the pattern, draw it on the 4662 Plotter. Use a Mylar pen in the Plotter and draw your foil pattern on a copper board right on the Plotter. The Mylar pen works as an etch-resist pencil would.



Functions:

- Board size (can be changed during design)
- Scaling
- Optional Grid at 0.1 inches (standard DIP size)
- Generate data and store
- Retrieve existing data
- Update data
- Components
  - Conductor
  - Ground Conductor (full width conductor)
  - IC—8, 10 or 12 Pin Round or DIP's (horizontal or vertical) or other pin numbers specifying your own width
  - Solderpad
  - Resistor Pads
  - Edge Connector Strip
  - Transistor Pads
  - Move without drawing
  - End (closes all files)

Test data is included to familiarize yourself with the program.

ABSTRACT NUMBER: 51/00-1602/0

Title: **Interactive Beam Analysis**
Authors: Professor Larry D. Mitchell, Yiu Wah Luk
Virginia Polytechnic Inst.
Blacksburg, VA
Memory Requirement: 32K
Peripherals: Optional-4631 Hard Copy Unit
Statements: 1070
Files: 2

This is a beam analysis program which solves static or dynamic (forced, undamped vibration) response.

One of the most frequently encountered engineering designs is beam because it can be used for modeling many structures. This program, using transfer matrix method, computes and plots the curves of deflection, slope, moment, and shear along the beam. Static and forced, undamped dynamic analysis can be performed for beams of uniform or variable cross section. Uniformly or linearly-varied distributed loads, concentrated point loads, applied moments, or combinations of all three may be applied.

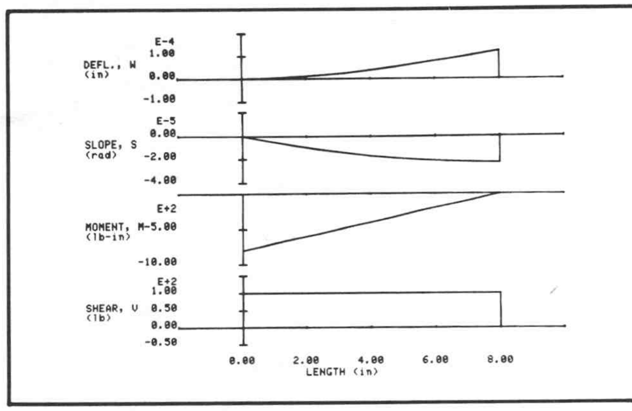
This program allows any combination of pinned, fixed, free, or guided flexural boundary conditions. Even normally kinematically unstable conditions can be handled if sufficient internal supports are provided. Inspan support can be elastic springs and/or elastic moment spring. Modeling for dynamic response uses lumped mass.

It does not handle rigid in-span indeterminants.

Units can be either in English or the S.I. system. The beam is first divided into several sections, such that each section has the same distributed stiffness and a point element at the end, if any. For each section, inputs required are:

1. Length of section
2. Modulus of elasticity
3. Area moment of inertia
4. Magnitude of uniformly distributed load
5. Magnitude of linearly varied distributed load
6. Magnitude of concentrated load
7. Magnitude of moment
8. Stiffness of the support
9. Support moment stiffness
10. Magnitude of concentrated weight
11. Weight moment of inertia
12. Frequency
13. Type of vibration of the beam or rotor

Several examples are included in the documentation.



LENGTH (in)	DEFLECTION (in)	SLOPE (Radian)	MOMENT (lb-in)	SHEAR (lb)
0.00E+000	0.00E+000	0.00E+000	-8.00E+002	1.00E+002
8.00E-001	1.76E-006	-4.31E-006	-7.20E+002	1.00E+002
1.60E+000	6.78E-006	-8.17E-006	-6.40E+002	1.00E+002
2.40E+000	1.47E-005	-1.16E-005	-5.60E+002	1.00E+002
3.20E+000	2.52E-005	-1.45E-005	-4.80E+002	1.00E+002
4.00E+000	3.78E-005	-1.70E-005	-4.00E+002	1.00E+002
4.80E+000	5.23E-005	-1.91E-005	-3.20E+002	1.00E+002
5.60E+000	6.82E-005	-2.07E-005	-2.40E+002	1.00E+002
6.40E+000	8.52E-005	-2.18E-005	-1.60E+002	1.00E+002
7.20E+000	1.03E-004	-2.25E-005	-8.00E+001	1.00E+002
8.00E+000	1.21E-004	-2.27E-005	-1.09E-011	1.00E+002
8.00E+000	1.21E-004	-2.27E-005	-1.09E-011	0.00E+000

Do you wish to see the graphs for deflection, slope, moment and shear? (Y or N)Y

ABSTRACT NUMBER: 51/00-1603/0

Title: **Belt Length Calculation**
Author: Allen G. Hahn
Hesston Corporation
Hesston, KS
Memory Requirement: 16K
Peripherals: Optional-4631 Hard Copy Unit
Statements: 281

With this program, you enter the location of any number of pulleys, the pulley diameters and which side of the enclosed area the pulleys are on. The User Definable Keys are then used for the following options:

Calculate the belt length required to go around the pulleys in the defined manner.

Enter a desired belt length and the number of a moveable pulley. Select one of three types of movement: 1) pivoted arm, 2) straight slot, 3) neither. In the first two choices the program will iteratively move the pulley, calculate length, compare to desired length and move again. When the desired belt length has been reached within ±0.1 unit or 20 iterations have been performed, the results will be tabulated. If the desired length is shorter than is possible, when the pulley leaves the belt a warning will be printed. If the final length is not within ±0.1 unit of the desired length, and the pulley has not left the belt, calculations may begin again at this point.

In the third choice, the program will print the amount the present belt length is shorter or longer than the desired length and will request new coordinates for the moveable pulley.

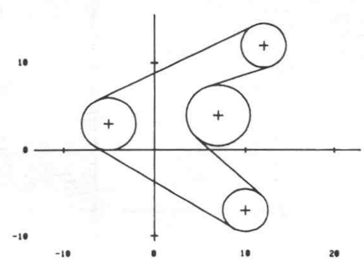
Change data on any pulley in the drive.

Draw a picture of the drive.

Configure a completely new drive.

End the session and return to the menu.

Note: This program also gives approximate results for roller chain.



PULLEY NO.	CENTER COORDINATES	PITCH DIAMETER	SIDE	WRAP (DEG)	CENTER DISTANCE
1	(-5.000, 3.000)	6.000	IN	121.5	10.028
2	(10.000, -7.000)	5.000	IN	169.1	11.402
3	(7.000, 4.000)	7.000	OUT	118.5	9.434
4	(12.000, 12.000)	5.000	IN	187.9	19.235

The belt pitch length is 83.40

ABSTRACT NUMBER: 51/00-1405/0

Title: **Digital Filter Design and Implementation**
Author: Ralph Deutsch
Deutsch Research Laboratories
Sherman Oaks, CA
Memory Requirement: 32K
Peripherals: Optional-4662 Plotter
Statements: 724
Files: 2 Program, 3 Data

From user design specifications, the program computes the digital filter coefficients for a low-pass, high-pass, band-pass, or band-reject filter. Steady state and transient responses are plotted. The output results can be used to software or hardware implement the filter.

The program's interactive technique allows near-optimal design for a digital filter to be rapidly approached using trial data. The user can specify the order of the filter, critical edge frequencies, sampling frequency, and attenuation in the reject bands. Inconsistent input data is detected and error messages displayed.

The program displays the zeroes and poles for each case in a form suitable for a hardware implementation of the digital filter. A second program can be called which will execute the digital filter on user-supplied data.

Functions proided by the User Definable Keys:

Run the program, (the design process).

Run and plot transient response.

Compute and plot amplitude/frequency response for 50 points.

Compute and plot amplitude/frequency response for 200 points.

Load the Digital Filter Implementation program.

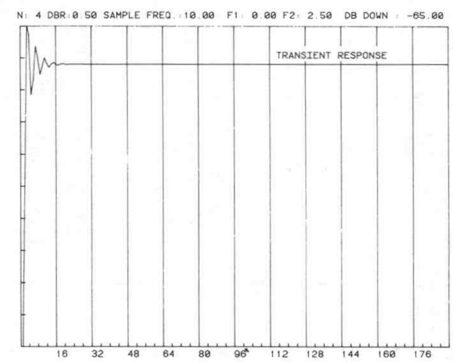


FIGURE 4

ABSTRACT NUMBER: 51/00-6105/0

Title: **Transposition-Music**
Authors: Dr. P.C. Holman, Mrs. Janet Bruegl,
Michael Voica, James Wood
University of Wisconsin-Stevens Point
Stevens Point, WI
Memory Requirement: 32K
Peripherals: 4631 Hard Copy Unit
Statements: 416

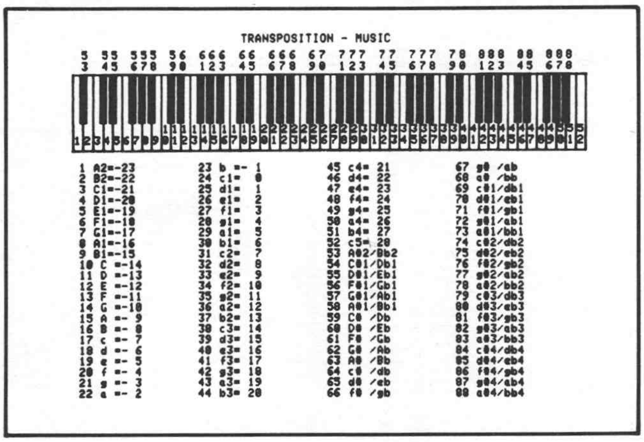
With this program a piece of music written in the key of 'c' may be transposed into four voices (soprano, alto, tenor and bass) and into the chord at the same time. The invention of a universal keyboard numbering system makes it possible to communicate music to the computer. This technique is non-language dependent meaning that non-English speaking persons are able to transpose music with this program with a minimum of problems.

Begin with the first note of the melody and enter each note using the universal keyboard numbering system. A "clinker" preventer is built in. If a user enters an out-of-range or illogical note, the computer adjusts the note. Alternative possibilities for a note are printed on the screen with the best choice at the end.

Function Keys include:

- Call Menu
- Run Program
- Change Data
- List Data
- Append Data
- Insert Data
- Printout

The program is tutorial.



ABSTRACT NUMBER: 51/00-9524/0

Title: **General Graphing**
Author: Glenn Roy Hottel
Purdue University
Memory Requirement: 32K
Peripherals: 4051R05 Binary ROM
4662 Plotter
Statements: 2433
Files: 9

29 routines generate quality graphs.

To input data the user may bring it in from tape, write a function from which to generate data points or enter it from the keyboard. This data may be added to, changed or deleted, and stored on tape.

Parameters of the graph are quickly and easily set from a variety of choices. The parameters include X and Y axes range, X and Y axes tic intervals, regular, semi-log and log-log axes, graph symbol type and placement, points or histogram, types of connecting lines, and labels.

Output may be to the Plotter or screen with different paper size taken into consideration.

Routines allow least squares curve fitting, smooth line drawing and graph digitizing.

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