Tekniques

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4054 Graphs Flight in Real Time

Tekniques

In This Issue

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CBS Television carried the 10th World Aerobatic Championships on Sports Spectacular November 29, 1980. Wally Potter, Tektronix Sales Engineer, and Andy Glick, Tektronix Systems Analyst, were instrumental in the state-of-the-art configuration of a TEKTRONIX 4054 and Enterprise commercial radar which tracked contestants' aircraft. Their article details the role of the 4054 in the 10th World Aerobatic Championships.

World Aerobatic Championships: 4054 Teams with Radar for Automated Boundary Judging

by Wally Potter and Andy Glick
Tektronix, Inc.
Los Angeles, CA

August 1980 saw a gathering of some of the most highly skilled aircraft pilots in the world. Coming from Australia, France, West Germany, Canada, Switzerland, United Kingdom, South Africa, and Italy, as well as the United States, nine teams with 50 pilots plus crew members touched down in Oshkosh, Wis., for the 10th World Aerobatic Championships. Held biennially, the event can be considered the Olympics of the air.

Men and women with the talent and endurance for precision flight execute intricate maneuvers. Their feats might be compared to those executed in competition ice skating — spins, spirals and other gyroscopic movements. But in this case, the "rink" is three-dimensional and invisible.

Unseeable boundaries define a cube 1000 meters each way, with the lower surface 100 meters above ground. The contestants fly their plane into the cube, execute the pattern and leave. They must keep the unseen boundaries of their aerial arena firmly in mind, for they are penalized if their aircraft cuts through them.

The aircraft are small, averaging perhaps 14 feet in length, "one engine with a lot of fabric," one observer commented.

So how can the judges be absolutely sure when a wingtip of such a small object slips over an imaginary line, or when the aircraft drops below the invisible lower boundary? In the past, all admit, this has been a problem.

In the previous championships, boundary judges were aided by theodolites[1] placed at the four corners and a mental picture of an aircraft that had flown the lower boundary of the cube. From these guides, the boundary judges determined if an aircraft had gone outside the cube. While this worked well, it was not absolutely accurate. And, penalties assessed for violating the boundaries could certainly impact ratings, especially when the scores were close.

Coordinated Effort Configures Equipment

To overcome the dilemma, a couple of years ago Dr. Jim Young and Gene Baskevitch, engineer at Hughes Aircraft in El Segundo, CA, started investigating what could be done. They examined any number of electronic means, including

[1] A surveyor's instrument for measuring horizontal and also vertical angles.

The Three-Dimension Arena

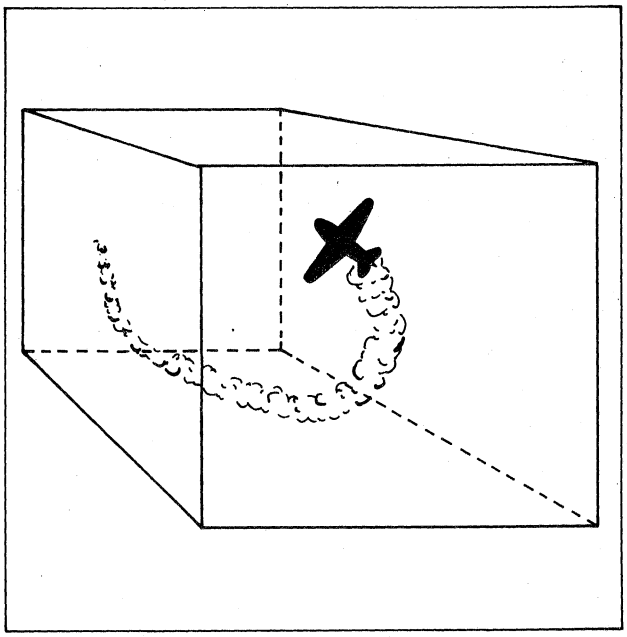
What Happens?
It's like competition ice skating. But with aerobatics, the rink is three dimensional. As in ice skating, there are a series of compulsory and free style programs:

Program 1
is a sequence of maneuvers designed and approved by the Aerobatic Committee of the Federation Aeronautique Internationale. This compulsory sequence is flown by all men and women competitors.

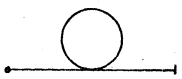
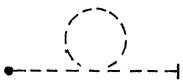
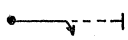
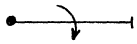
Program 2
the UNKNOWN Compulsory, is composed of one maneuver selected by each country from an approved list and is again composed into a flyable sequence by representatives of the F.A.I.'s Aerobatic Committee. This sequence is flown by each male and female competitor with **NO** practice.

Program 3
is a Free Style composed by each individual male and female competitor not to exceed 25 maneuvers and a maximum of 700 points coefficient of difficulty. Each of these flights require about 10 minutes.

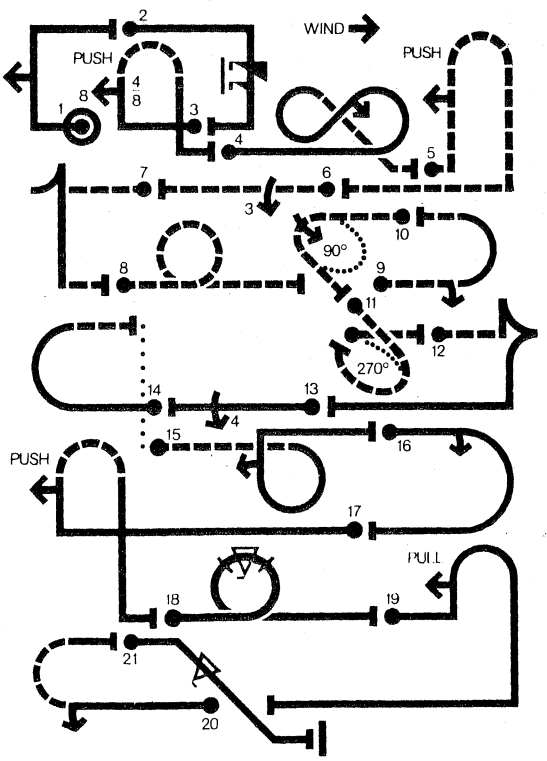
Program 4
is flown by the upper 1/3 of the male pilots and the upper 1/2 of the female pilots to determine the men's and women's INDIVIDUAL CHAMPIONS. This fourth flight is limited to **exactly** four minutes and is not restricted to catalog maneuvers. It's a true Free Style, and sometimes referred to as the "Air Show" sequence.



Aerobatic Shorthand

	This may look like a doodle on a scratch pad to the uninitiated, but to an Aerobatic Pilot or a Judge it is an "ARESTI SYMBOL". An international language devised by a Spanish Count to diagram Aerobatic Maneuvers — this particular one an ordinary loop done from left to right before the Judge (the dot representing the beginning; and the bar the termination of the maneuver).
	The same maneuver done upside down or in inverted flight. The pilot is hanging from his seat belt all the way around with gravity and inertial forces trying to hurl him from the cockpit.
	One half of a roll from upright to inverted horizontal flight.
	A full roll in horizontal flight.
	A full roll in vertical flight finishing inverted, going the opposite direction.
	Each Aresti figure (and there are thousands of combinations) is assigned a coefficient of difficulty and a panel of 10 Judges from 10 different countries grade each maneuver on a scale of 0 to 10, with 10 a perfect score. Scores are then computed on a system of weighted averages with discarding of anomalies to determine total points for each contestant.

Known Compulsory Sequence



Reprinted from "WORLD AEROBATICS '80" brochure.

laser. Radar looked the most promising, but many types with the desired attributes were classified. After Dr. Young's untimely death, Don Taylor, W.A.C Contest Director and Captain with United Air Lines stepped in as chairman and continued the search with Gene. They decided the best thing available was a commercial radar used by the National Oceanic & Atmospheric Administration (NOAA), the WF-100-4 built by Enterprise Electronics of Enterprise, Ala.

Ken Clark at NOAA's Springfield, Md., office and two engineers from Enterprise, Buddy Rogers and Ron McDougald, cooperated to modify one of the NOAA radars. The modifications included innovative technology which improved the tracking capabilities to follow the small, fast moving aircraft.[2]

With this in place, they had to figure out the rest of the system. Gene wanted Tektronix equipment for the graphics. "The calculations could be done on any computer," he said, "but it would be very hard to convince a pilot, judge, or others not familiar with computers of the computer's accuracy without graphics. Graphics are worth a thousand words." Gene contacted the Tektronix Field Office in Los Angeles for help.

The original plan had been to interface the radar with a TEKTRONIX 4014 terminal and a minicomputer.[3] As things developed, the minicomputer didn't work out. Consequently, the TEKTRONIX 4054 replaced both the mini and the 4014. Buddy Rodgers from Enterprise, developed the special interface which allowed the 4054 to communicate with Enterprise radar through the RS-232 port of the 4054. Dylon Corp. in San Diego loaned a Dylon 9-track tape system which interfaced directly with the 4054 through the General Purpose Interface Bus.

At this point, a BASIC program was required. Bob Davis, a recent high school graduate headed for engineering school at UCLA, was working part-time for Hughes Aircraft and heard about the project. Bob worked with Don Taylor, Gene, Don Tollefson and others to design the program. Paul Montag, a Hughes engineer, helped Bob develop the algorithms. Although Bob had never programmed a 4054, he produced a 600+ statement program which identified the invisible aerial arena in relation to the radar, read the aircraft's positions from the radar, analyzed them in relation to the boundaries, graphed the aircraft's flight in real time, and transferred the readings to a 4924 Tape Drive.

Hughes donated a surplus truck trailer which had been modified for radar testing. Dan Rihn, an engineer at Northrop arranged for a group of volunteers from his aerobatics team to provide manual clean up, painting and other modifications to the trailer to accommodate the required gear.

Dan also used his personal airplane, a Pitts Special,[4] for testing the system. At the Hughes test facilities in Culver City, CA, the coordinators set up the system and ran it. Everything worked. Once lock-on was achieved and autotrack initiated, the radar would be capable of tracking a baseball-sized target out to a distance of 185 kilometers.

At this point the configured equipment and trailer were shipped to Oshkosh. The radar consoles and computer equipment were housed inside an air conditioned, paneled trailer which was the office for radar tracking personnel. The radar dish on its pedestal was mounted on the roof of the modified trailer.

The radar/4054 was calibrated several times during the competition. Don Taylor flew his twin engine Baron along the

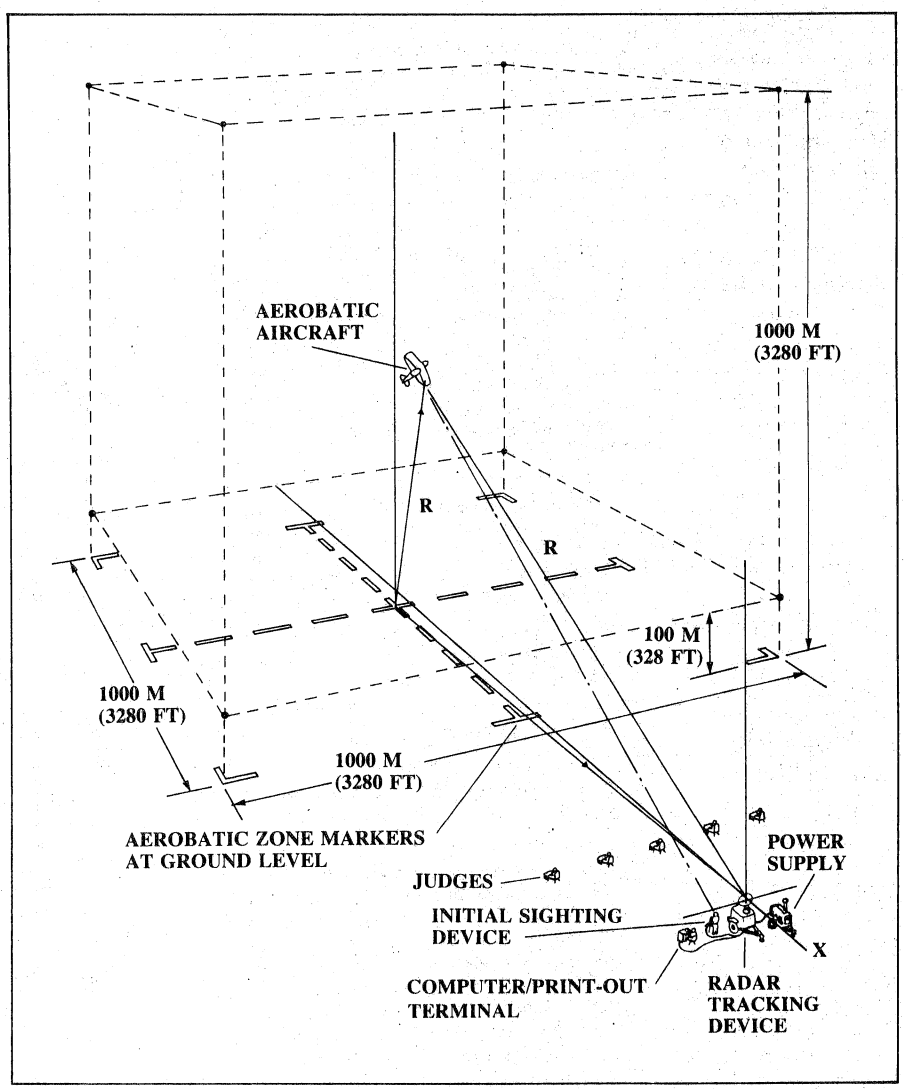


Fig. 1. The intricate maneuvers of the aircraft were tracked by the radar which relayed the target range, azimuth, and elevation data to the 4054.

[2]These modifications are now standard on all Enterprise WF-100-4 radar systems.

[3]Both an Eclipse and Hewlett Packard 1000 were tried.

[4]The Pitts Special is widely used for aerobatic competition.

upper and lower boundary lines in all directions and the system was adjusted to align the display of aircraft position. A second check was performed by flying the Aerobatic Association's helicopter at exactly 50 meters above the center of the bottom plane of the cube.

```
WHAT DATA WILL BE ENTERED?
1-VECTOR R SUB R
2-VECTORS R1,R2
3-VECTORS R1,R2,R3,R4
TYPE 1,2,OR 3
1
EQ IS THE Y AXIS ROTATION OF RADAR
MQ IS THE Z AXIS ROTATION OF RADAR
WHAT ARE CORRECTION FACTORS EQ,MQ?
0,0
IS CUBE INITIALIZATION DATA FROM RADAR OR SURVEYOR?
1-CUBE INITIALIZATION DATA IS FROM RADAR
2-CUBE INITIALIZATION DATA IS FROM SURVEYOR (SPHERICAL)
3-CUBE INITIALIZATION DATA IS FROM SURVEYOR (CARTESIAN)
TYPE 1,2,OR,3
3
X IS THE X COORDINATE OF THE RADAR OR THE CENTER POINT
Y IS THE Y COORDINATE OF THE RADAR OR THE CENTER POINT
Z IS THE Z COORDINATE OF THE RADAR OR THE CENTER POINT
ENTER X,Y,Z
1000 0,0
```

Fig. 2. The initialization of the cube boundaries were achieved with data from the radar or from a surveyor. In this example, initialization was from the surveyor in cartesian coordinates.

System Tracks Aircraft's Flight Path

During competition, as the contestant approached the aerobatic box, Ken Clark (NOAA) followed the aircraft with a manual optical tracker. At a wing waggle that signaled the pilot was ready, Ken keyed a switch that automatically locked on the autotrack function of the radar dish and initiated the digital timer. From this point on, the radar tracked and sensed the aircraft's position automatically, relaying the target range, azimuth, and elevation data to the 4054.

The BASIC program running on the 4054 contained the coordinates comprising all six surfaces of the aerobatic box. If at any time the aircraft location coordinates sensed by the radar exceeded the extent of the aerobatic box, the 4054 noted the penetrated surface, the penetration coordinates, and the time of penetration, plus assessed penalty points.

At the second flight wing waggle, Ken disengaged the autotrack. This advised the 4054 to total the out penalties and to note the flight sequence time in minutes and seconds. Additionally, the 4054 analyzed the hundreds of thousands of aircraft position inputs for that flight, and yielded the mean position of the aircraft's entire sequence relative to the center of the box. Finally, it awarded the proper framing score in full points and tenths of a point, and displayed it all on the 4054 screen.

```
RUN
 999.99953375      0              577.35          0
 1212.22460421     -21.1551794094 699.984769516   0.1
 1211.5927324      -42.2753979793 699.939082702   0.2
 1210.54297785     -63.3258218519 699.862953475   0.3
 1209.08036583     -84.2718700276 699.756405026   0.4
 1207.21188709     -105.079338044 699.619469809   0.5
 1204.94645367     -125.714518398 699.452189537   0.6
 1202.29484287     -146.144316679 699.254615164   0.7
 1199.2696297      -166.336362461 699.026806874   0.8
 1195.88510853     -186.259114041 698.76883406    0.9
 1192.15720461     -205.881956196 698.480775301   1
 1188.1033762      -225.175290237 698.162718345   1.1
 1183.74250808     -244.110615701 697.814760073   1.2
 1179.09479753     -262.660603143 697.437006479   1.3
 1174.1816335      -280.799157604 697.029572628   1.4
 1169.02546999     -298.501472417 696.592582629   1.5
 1163.64969482     -315.744073149 696.126169594   1.6
 1158.07849449     -332.504851581 695.630475596   1.7
 1152.33671642     -348.763089735 695.10565163    1.8
 1146.44972934     -364.499474083 694.55185756    1.9
 140.44328296      -379.696100154 693.969262079   2
 1134.34336778     -394.336467878 693.35804265    2.1
 1128.17607592     -408.405468092 692.718385457   2.2
 1121.96746393     -421.889360714 692.050485345   2.3
 1115.7434182      -434.775745172 691.354545764   2.4
 1109.52952389      447.053523752 690.630778704   2.5
 1103.3509379      -458.712858575 689.87940463    2.6
 1097.23226663      469.745122969 689.100652419   2.7
 1091.19744888     -480.142848046 688.294759286   2.8
 158.684536103     -265.998620624 191.769069391   0
 2.9               0              2.9             5.93333333333
```

Fig. 3. The 4054 recorded the hundreds of thousands of aircraft position inputs for the flight.

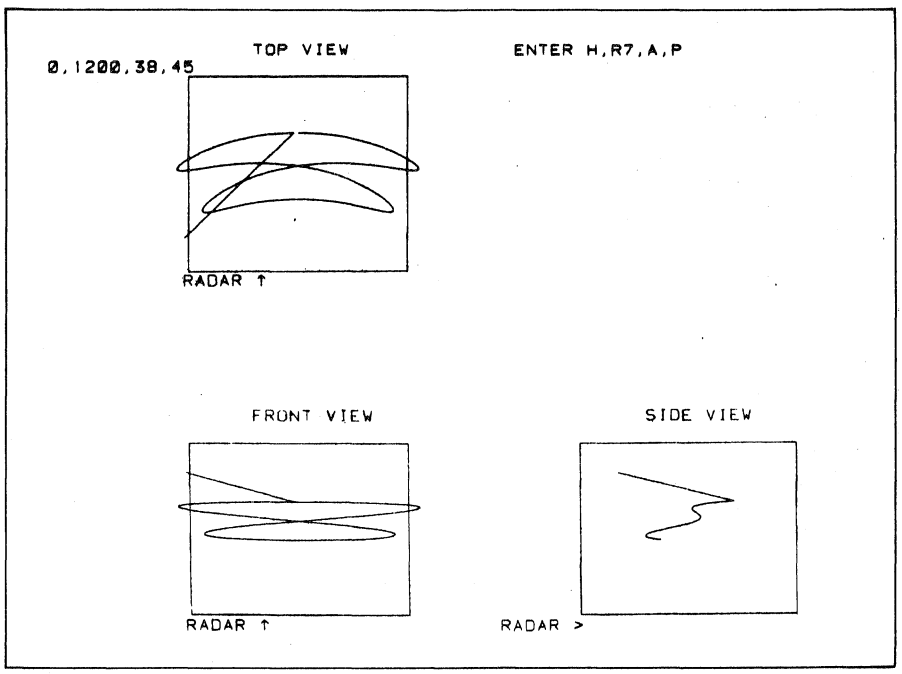


Fig. 4. The aircraft's flight positions were graphed in real time on the 4054.

```
THE COORDINATE AVERAGES ARE
X= +129.96          Y= -392.91          Z= +102.65
TOTAL PENALTY POINTS= 0
TOTAL TIME INSIDE CUBE=   3.80 SECONDS
TOTAL TIME OUTSIDE CUBE=   0.90 SECONDS
TOTAL TIME OF FLIGHT=   4.70 SECONDS
THE FINAL SCORE IS 5.3
```

Fig. 5. At the end of the aircraft's maneuvers, the 4054 yielded the mean position of the aircraft's entire sequence relative to the center of the cube, assessed total penalty points, timed the flight, and awarded the proper framing score.

A hard copy of the 4054 screen was forwarded to the master scoring room. The 4924 tape copy of the flight was retained. This enabled the judges to recall and review the flight on the screen in case of a protest. Later, the software copy was transferred to the Dylon 9-track tape drive for archiving.

As a backup, the old-fashioned corner theodolites were in place and a radio hotline maintained to alert the boundary judges to step in for the radar/4054 system. However, in the two weeks of the contest, no down time was experienced. The system worked beautifully and accurately; judges and contestants were equally pleased.

Epilogue

The 4054/radar team proved it was possible to automatically and accurately track small fast moving objects within defined boundaries using commercial equipment. In this case, of course, it helped replace subjective judgement with objective hard copy results. The consistent boundary judging of contestants, over long periods of time, eliminated a good deal of friction.

Furthermore, the state-of-the-art configuration of the TEKTRONIX 4054 Graphic Computer with the other special purpose devices produced understandable results for everyone in a common language.

After all, if you were the best pilot in Italy, would you believe five guys sitting at a fold-up card table in the middle of an Oshkosh, Wis. cornfield who, admittedly, did not have enough sense to "come in out of the rain"?

10th World Aerobatic Championships—Results

Both in the men's and women's individual divisions, the first three places were captured by entrants from the United States. The team ratings were 1 — USA, 2 — Switzerland, 3 — Australia, 4 — France, 5 — West Germany, 6 — United Kingdom, 7 — Canada, 8 — South Africa, and 9 — Italy.

World Aerobatic Championships—Future

John Firth's comment in FLIGHT International[5] perhaps sums up the value of the aerobatic competition:

"National aerobatic teams represent the ultimate in aircraft handling. With the dogfighter firmly re-established in the skies of Europe and in a country covered with airfields and now reawakening to the prudence of self-defence . . . . If the present resurgence in UK aerobatics can be maintained, this bodes well for the future."

Don Taylor, Gene Baskevitch and others of the United States coordinating team are at work to support the aerobatics effort. They are raising funds to acquire a permanent radar/computer boundary detecting system for future World Aerobatic Championship contests. It's a hard battle. The World Aerobatics Foundation is totally supported by the individuals within it and by donations.

[5] "U.S. Win World Aerobatics," FLIGHT International, 20 September 1980, IPC Transport Press Ltd., Dorset House, Stamford Street, London FE19LU.

Fast Popular Do It Yourself Graphics at HUD

At the Department of Housing and Urban Development headquarters, John Piper (right) and Mallory Green are using 4050 Systems and "smart" graphics programs to help their users depict how $4 billion is spent.

by Patricia Kelley
TEKniques Staff

The few days prior to March 31 this last spring saw a beehive of activity on the third floor of the Department of Housing and Urban Development (HUD) headquarters located just off the Capitol Mall. As anyone who has worked in Washington knows, such frenzied activity at this time of year is not uncommon; March 31 is the deadline for all those reports required by Congress. What was unusual was the diverse array of individuals totally involved in designing and generating their own graphs on a desktop computer. Not graphic designers or computer experts, but economists, accountants, secretaries, statisticians and others were producing legible, intelligible, appealing graphics which rendered suffocating data into fathomable reports.

At the center of this activity were a 4051 Desktop Computer, 4907 File Manager, 4662 Plotter, 4631 Hard Copy Unit and three very interactive, flexible, forgiving programs. John Piper and Mallory Green related the approach they took in designing the programs to achieve widespread acceptance of the "do it yourself" graphics.

But first, let's look briefly at who is generating the data and where Mallory and John fit into the picture.

Interpreting Dollars Spent

The Community Planning and Development Group of HUD pours many dollars into preserving the economic vitality of our communities. One primary program, known as Community Development Block Grants, distributes approximately $4 billion a year. Using Census Bureau data and a formula-based approach, the individual needs are measured the $4 billion pie sliced accordingly. The results must be recorded and interpreted to Congress, to the many agencies involved, and to the taxpayers.

Supporting this group's tremendous data processing requirements is John Piper and his staff of seven. One of the seven is Mallory Green. Because of the small staff, quite a bit of the data processing work is done by contractors, which means the staff primarily function as project managers. However, to avoid more contracting, but not increase the programming burden on the staff, Mallory designed and implemented several interactive graphic design programs. These programs are mostly tutorial and with rudimentary instruction, users become proficient in a short time. In fact, Mallory says they now have over 20 regular users who

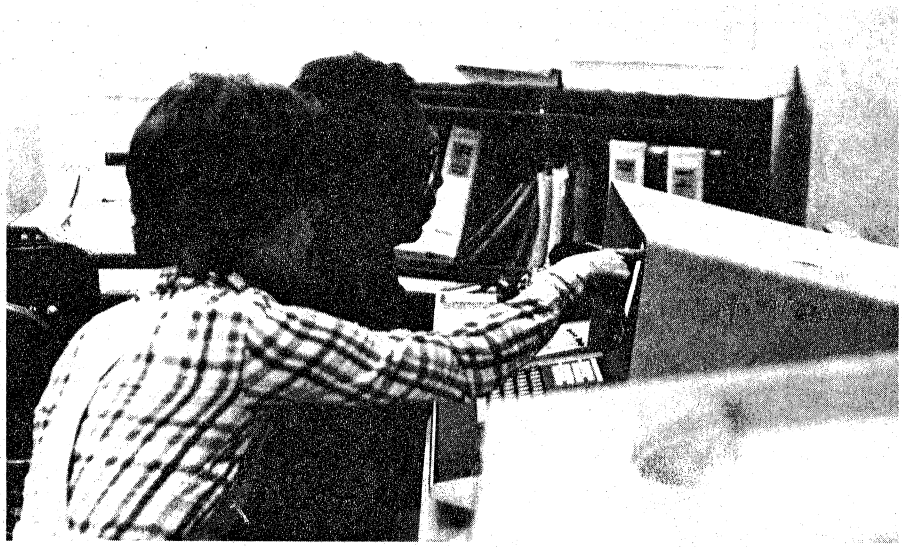


Fig. 1. Experienced users teach newer users how to run the programs on the 4050 desktop computer. Laurie Coplin points out a feature to a new user, Virginia Battle.

Fig. 2. Laurie and Virginia are program analysts with Department of Housing and Urban Development, Community Planning and Development, Office of Evaluation.

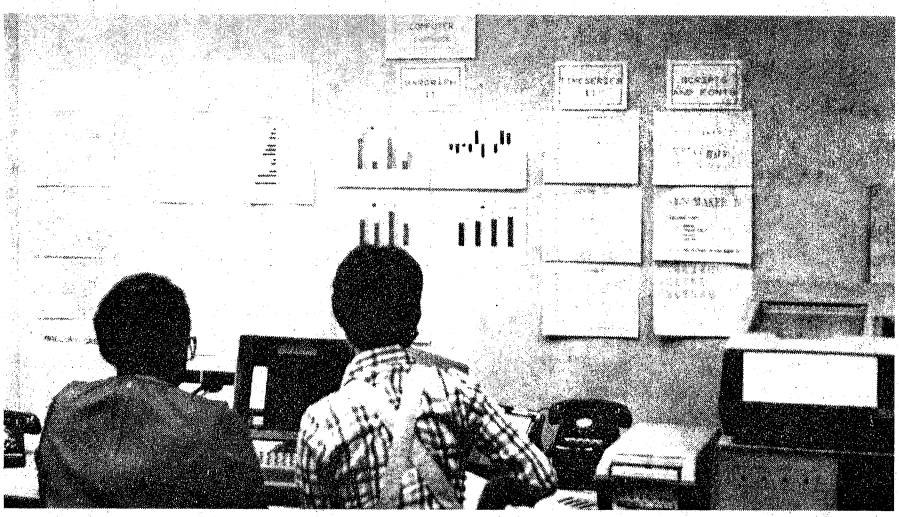


Fig. 3. Do it yourself graphics begin with samples of output from each program posted in a highly visible location – the wall.

are teaching newer users (Figs. 1 and 2), which further alleviates the small staff's load.

A Step-by-Step Approach

Returning to the reasons for the programs' success, Mallory attributes the ease of interaction with the 4050 system along with user-oriented programs requiring brief instructions—no one has time to read manuals. Graphic aids adorn the walls to help the users (Fig. 3); convenient hand-sized reference guides are printed for each program,(Fig. 4); and User-definable Keys drive the program subroutines. Mallory has made everything as easy as possible for his "customers."

In addition to the samples of available output from each program (Fig. 3), the procedure for powering up the equipment is also posted on the wall. An autoload tape begins each program which initializes the 4050 and 4907, with prompted input from the user.

Since each user requires something a little different for his graph, Mallory has segmented each program into overlays driven by the User-Definable Keys. This overcomes memory limitations while allowing a lot more design choices.

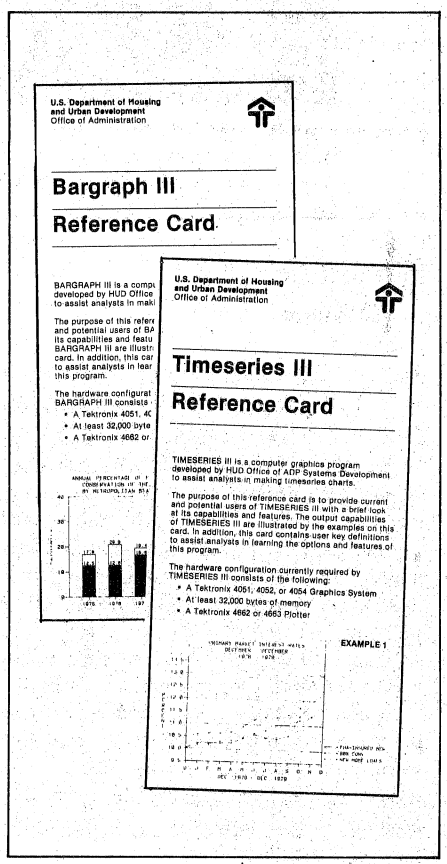


Fig. 4. Reference cards quickly introduce users to Mallory's graphing programs.

Thus, all the user has to do is input the data for his graph, specify the graph parameters as prompted by the 4050, and carry away the output to incorporate into his report (Fig. 5). It's fast, simple and versatile graphics.

As the demands on their group grow, John and Mallory are seeking even better ways to represent the huge volume of numbers. Mallory listens to his users and converts their feedback into new routines; his programs are continually evolving to meet his user's needs.

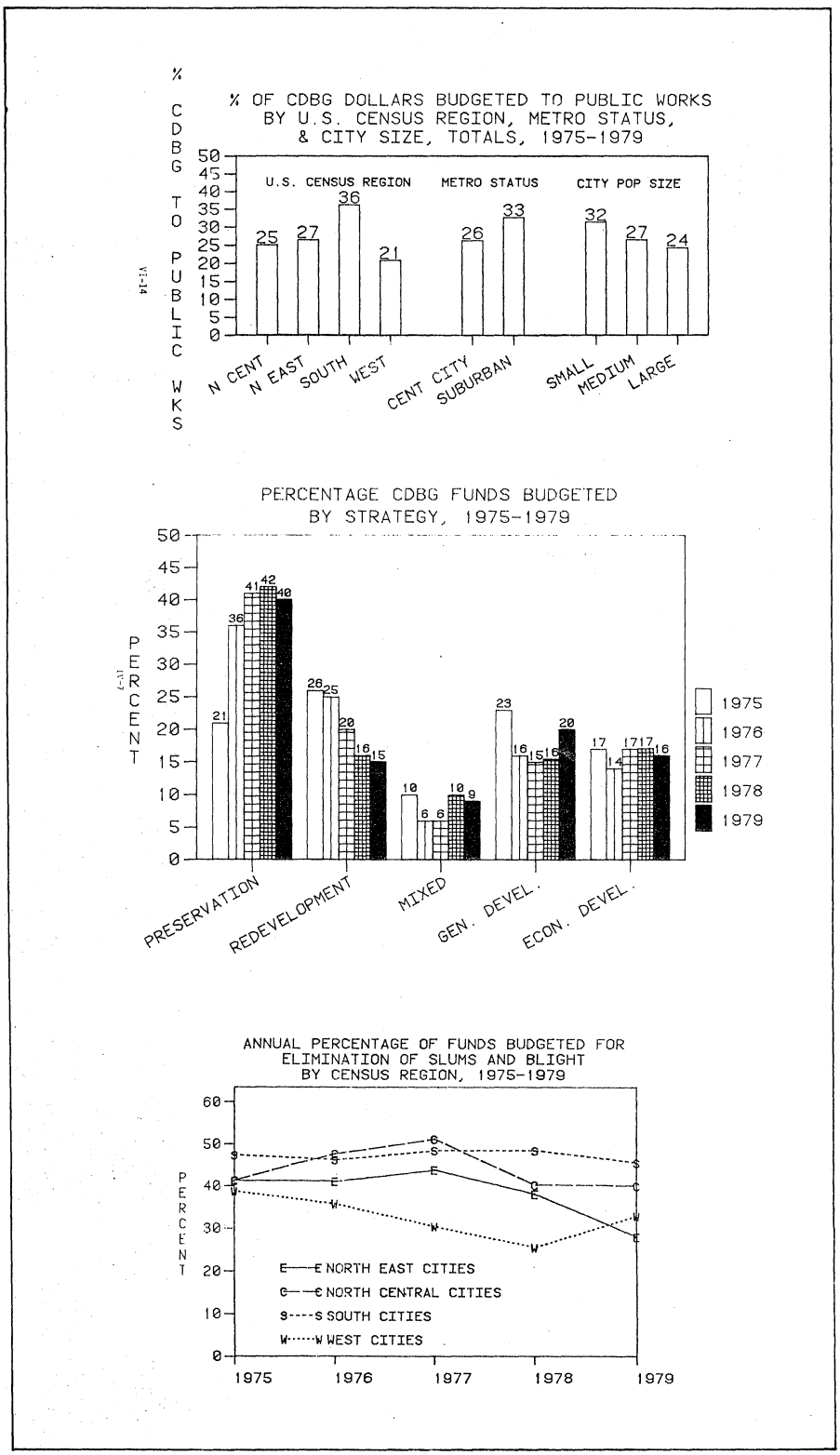


Fig. 5. Examples which were contained in Community Development Block Grant Program, Fifth Annual Report to Congress (1980).

(Note the new abstracts in this issue for new versions of Bargraph and Timeseries.)

Sharing the Results

Because it's taxpayers' money, John Piper said, "We felt, 'Why should other agencies spend that money all over again doing comparable things.' That prompted us to look around to see if others could benefit from the results of our work — and conversely, if we could benefit from theirs. And this is what's happening."

Mallory and a group of area 4050 users meet periodically to exchange information and help one another. (Their 10th meeting will be January 22, 1981.) The group has become an ongoing dissemination of ideas, information and programs. Mallory has also contributed his tutorial business programs to the 4050 Series Applications Library:

51/07-0906/1	Bargraph II
51/07-0907/1	Timeseries II
51/07-0910/0	Bargraph III
51/07-0909/0	Timeseries III
51/07-9545/0	Sign Maker III
51/07-9546/0	Sign Maker IV

Mallory's background is a BBA in Operations and Research (72) and an MBA (73), plus computer experience with Computer Services Corp. During his three years with the Department of H.U.D., he has used his talents to advance business graphics within his agency, department, and the D.C. area. Mallory's success in graphics might be partly attributed to the following two mottos on his wall:

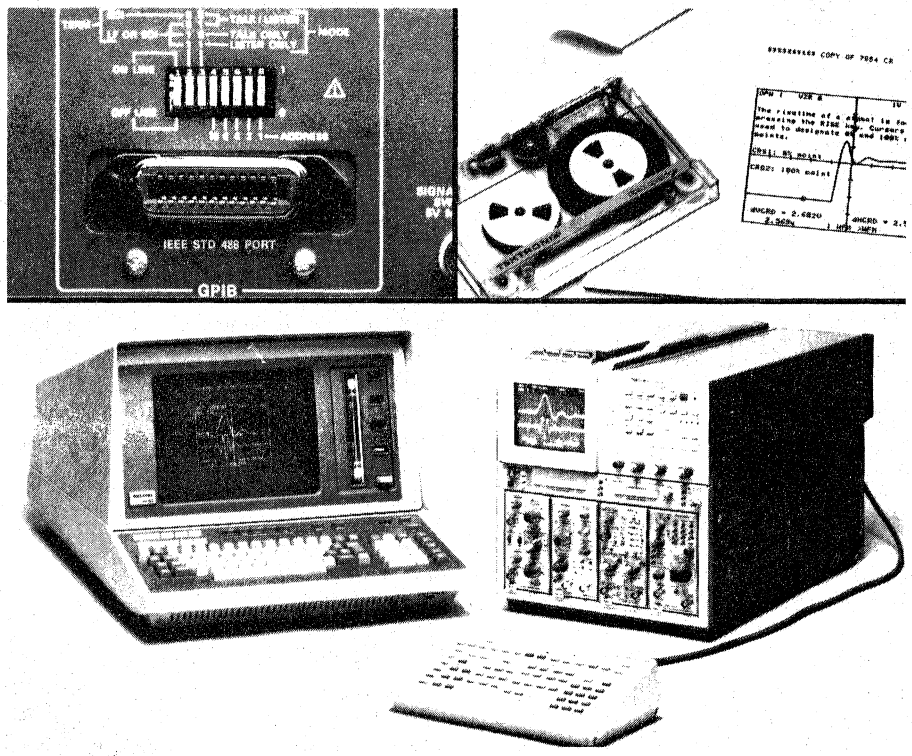
WORK SMARTER NOT HARDER

and

PEOPLE ARE WHAT COUNT

Editor's Note: Mallory's contributions and suggestions to the 4050 Series Applications Library led us to believe he had a ship-shape operation that would be interesting to other 4050 users. Steve Swindell, Tektronix Sales Engineer at Rockville, MD, confirmed our belief and arranged for the interview with Mallory and John. Our thanks to all for their time and help in bringing this application to TEKniques readers.

4052 and 7854 Oscilloscope Combine for Extended Waveform Processing and Documentation



by Clark Foley
Tektronix, Inc.
Beaverton, OR

The recently introduced TEKTRONIX 7854 Oscilloscope expands the unique family of instrumentation components for the laboratory. The newest addition provides extensive waveform processing. Press a few buttons and complete pulse parameters appear on the oscilloscope screen. Two more buttons and waveform mean and RMS values are computed. All of these functions can be combined into programs through an attached Waveform Calculator keyboard. The result is a single instrument with self-contained waveform processing for the laboratory bench.

However, for even more extensive waveform analyses (analyses requiring fast Fourier transform or convolution or correlation), or control, the 7854 may be interfaced to the 4052 Desktop Computer through the General Purpose Interface Bus (GPIB). For example, in a manufacturing test environment, several 7854 Oscilloscopes might be interfaced to one 4052. Multiple users could sample and process waveforms independent of the 4052. When they wanted to log test data to a tape file, or download a new 7854 program, they would assert a service request (SRQ). After the 4052 responded to the SRQ, it would be free to process other requests. In addition to acting as a controller or performing extended waveform processing, the 4052 offers long term program and data storage on magnetic tape, as well as graphic routines for completely documenting measurement results.

The 4052 has complete access to 7854 memory and its display screen. Messages can be sent from the 4052 keyboard for display on the 7854 Oscilloscope screen (Fig. 1). Easy-to-understand mnemonic input/output commands conduct entire data transfers over the bus. For example, the >TEXT command allows you to type messages on the 7854's screen from the 4052 keyboard. Or the >TEXT command can be used in a 4052 program to generate message displays under program control. Not only can you label waveform displays, but it's an excellent way to communicate prompts or instructions to an operator during programmed test sequences.

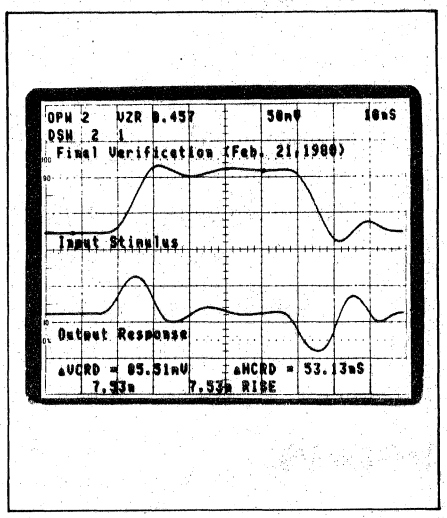


Fig. 1. Photo of a 7854 CRT display with 7854-generated as well as 4052-generated labeling.

All of the stored information for display on the 7854 screen can be accessed by the 4052 for display on its screen. Of course, once the waveform information is displayed on the 4052's screen, it can be hard copied (Fig. 2). No more scratching emulsions to label waveform photos. No more waveform photos. You get instead clear, crisp paper copies of what is displayed on the screen — annotated waveform pictures that can be quickly and inexpensively duplicated with a standard photocopier. And you get them the first try. Every time. In less than a minute.

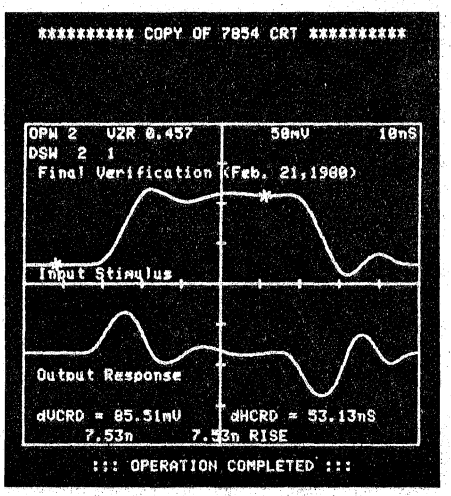


Fig. 2. Hardcopy of the 7854 display reconstructed on the 4052.

A partial list of 7854 input/output commands is given in Table 1. These commands, along with all of the 7854 function key commands, can be issued over the GPIB from the 4052 keyboard or from a 4052-executed program.

TABLE 1

Part of the 7854 GPIB Command Set

SENDX	Outputs the contents of the X-register (7854) to the GPIB. If the register contents is a numeric, that number is sent. If it is a waveform, the entire waveform record is sent.
READX	Inputs a number or waveform from the GPIB and places it in the 7854 X-register. Waveform data is stored as 0 WFM.
>TEXT	Inputs up to 12 lines of alphanumeric text (40 characters maximum in each line) from the GPIB for display on the 7854 CRT (in STORED, BOTH, or SCOPE modes).
TEXT	Outputs a copy of all 16 lines of currently displayed text to the GPIB.
SAVE	Outputs user programs stored in the 7854 to the GPIB.

By combining these commands into a program, you can achieve complete waveform analysis along with full documentation of results. The desk-top combination of a 7854 Oscilloscope with a 4052 comprises a total measurement system that embodies the full measurement cycle from signal acquisition, through processing for results, to putting those results on paper.

For more information on how you can put this system to work for you, contact your local Tektronix Measurement Products Sales Engineer and ask about the 7854. Outside the United States, the Tektronix subsidiary or representative can provide data sheets and applications information.

Editor's Note: A program to document 7854 CRT display by the 4052 for hard copying is included in the Programming Tips section.

Editor's Note

December Shutdown Coming

As mentioned in the previous issue of TEKniques, the 4050 Series Applications Library has a planned closure during the Christmas-New Years holiday season. During the two weeks from Dec. 20, 1980 through Jan. 4, 1981, the Applications Library and the TEKniques office will be closed. We want you to know ahead of time, so you can plan your contact with the library during available periods.

Catalogs Still Available

This is just a note to remind you that 4050 Series Applications Library Catalogs are still available, and free for the asking. You should have received yours by now, but if you haven't, or if you need additional copies, just drop a line to the Applications Library office serving you. The addresses are listed at the back of each TEKniques issue.

Looking For Good Tips

Like everyone, we're always looking for a good tip. Especially a good Programming Tip. So if you have a helpful hint about programming, let us know. We'd love to publish it, as a Programming Tip or a BASIC Bit. And you get any one of 12 programs from the library for each of your published Tips or Bits. Details are listed at the end of the BASIC Bits column.

Contest Reminder

Don't forget about the latest Applications Library Contest, announced in TEKniques, Vol. 4, No. 7. The contest subject is In-Depth Graphing, with two categories to stir your imagination. The categories are 2-D Graphing with shading, in which graphs are enhanced to simulate a third dimension, and 3-D Graphing, where three variables are acutally plotted on the X, Y, and Z axes.

You can submit as many programs as you like, but a program can be entered in only one category. Programs must run on a 4050 Series Graphic Computing System. Entries must include the program (on tape or disk), the documentation, and a completed and signed submittal form. And for each program you enter, you'll receive your choice of three programs from the Applications Library, so you really can't lose.

There will be first, second, and third place winners in each category. First place winners will get five boxes of tapes or disks, second place — three boxes, and third place — two boxes. And all winners will have the choice of tapes, disks, or a mix of the two. The entry deadline is March 31, 1981, so don't delay. More information about the contest can be found in TEKniques Vol. 4, No. 7.

More Workshop Dates

TEKniques Vol. 4, No. 6 carried a reminder of the 4050 Series Graphic Systems Workshops that are available. These workshops can be a real benefit in helping everyone get the most out of their 4050 System. Here's an extended schedule for the first part of 1981, showing dates and locations of schedule classes through April. For details on the classes, see the article in TEKniques Vol. 4, No. 6.

Graphic System Workshop Schedule

Dates	Locations
January 12-16, 1981	Rockville, MD and Santa Clara, CA
February 9-13, 1981	Rockville, MD and Santa Clara, CA
March 9-13, 1981	Santa Clara, CA
March 30-April 3, 1981	Rockville, MD
April 20-24, 1981	Rockville, MD
April 27-May 1, 1981	Santa Clara, CA

Don't Miss Out on Applications and Tips

Are you missing any TEKniques issues? Any of the issues from Vol. 4 are available by calling or writing the Applications Library office serving your area. Issues from Vol. 1-3 are no longer available, but the information has been combined into Application Reprints and a collection of Programming Tips. The following five categories of Application Reprints are currently available:

Engineering and Design AX-4449
Mapping AX-4460
Data Acquisition and Analysis ..AX-4450
Business Graphing and Reporting AX-4451
Peripherals and ROM Packs AX-4452

If you need an article from one of the issues in Volumes 1-3, one of these reprint sets will likely fill your needs. Just contact your local Tektronix office, or the Applications Library serving you, to get your set.

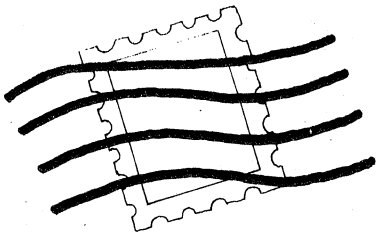
The Programming Tips collection combines 148 tips from the three volumes into one handbook, with a keyword index to help you find what you need. The handbook is available through the Applications Library. U.S. domestic prices is $10.

New Year Bringing New Prices

Applications Library prices were last changed 18 months ago. However, as mentioned in TEKniques Vol. 4, No. 7, the following new prices will take effect Jan. 1, 1981:

Documentation and Listing only $25
Documentation, Listing and Recording Fee $30
Cartridge Tape $36
Flexible Disk $15

INPUT / OUTPUT



TEKniques Vol. 4 No. 5 discussed questions users had regarding their 4050 System and the Option 1 RS-232 Interface. **Howard Sanders, Technical Support Specialist, and Frank Lees, Communications Support Specialist, at Tektronix, Wilsonville,** continue with their clarification.

Would you explain in hardware terms how Half Duplex Supervisor data communication works?

Half Duplex Supervisor uses a reverse channel which is directed opposite the principal data path. The host uses the reverse channel to control line turn-around; the terminal can use it to tell the host to stop transmitting data.

Typical Operation

Let us assume for this description that as soon as the telephone line connection is made, communication will begin from the host computer to the terminal.

As the first step, the HOST sets Request to Send[1] high to the HOST MODEM. In response, the HOST MODEM generates a carrier to the TERMINAL MODEM and sets Clear to Send high to the HOST.

The TERMINAL MODEM detects the carrier and sets Received Line Signal Detector high to the TERMINAL. As a result the TERMINAL sets Secondary Request to Send high to the TERMINAL MODEM which causes it to generate a secondary carrier to the HOST MODEM.

The HOST MODEM detects the secondary carrier and sets the Secondary Received Line Signal Detector high to the HOST.

The TERMINAL now receives data over the Received Data line.

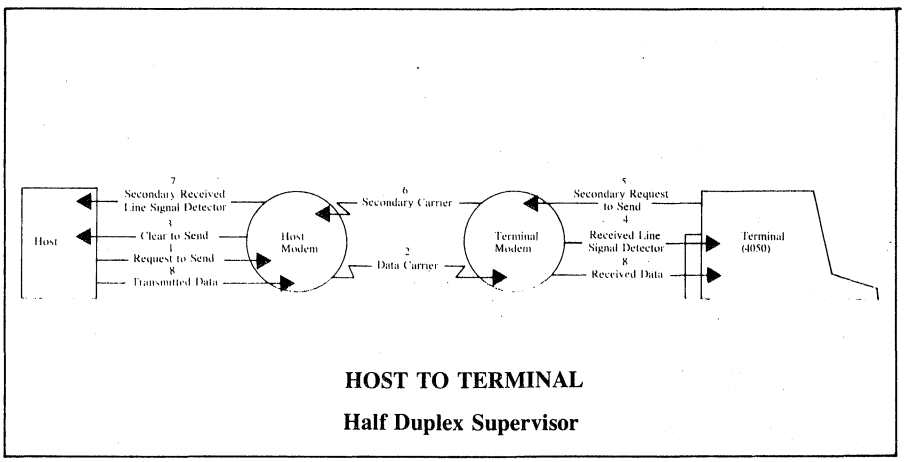


Fig. 1. Sequence of signal line events in Half Duplex Supervisor data communications, host to terminal.

Turn-Around to Host

When the HOST has finished sending data to the TERMINAL, it will initiate line turn-around by bringing its Request to Send low which will cause the HOST MODEM to turn off its carrier and lower Clear to Send to the HOST.

The TERMINAL will see Received Line Signal Detector go low from the TERMINAL MODEM when the HOST MODEM removes its carrier. The TERMINAL will then lower its Secondary Request to Send which tells the TERMINAL MODEM to lower the secondary carrier. This causes the HOST MODEM to lower Secondary Received Line Signal Detector.

The TERMINAL then raises Request to Send to tell the TERMINAL MODEM to raise its carrier. The TERMINAL MODEM complies and raises Clear to Send to the TERMINAL.

When the HOST sees the TERMINAL MODEM's primary carrier via Received Line Signal Detector from the HOST MODEM, it will raise its Secondary Request to Send which enables the HOST MODEM's secondary carrier.

The TERMINAL MODEM's Secondary Received Line Signal Detector will go high on receipt of the HOST MODEM's secondary carrier.

All the lines have now been turned around and the TERMINAL transmits data over Transmit Data line, through the primary carrier to the HOST's Received Data line.

Turn-Around to Terminal

When the TERMINAL has finished transmitting, it sends a turnaround character to the HOST.

On receipt of this character, the HOST drops its Secondary Request to Send which causes the HOST MODEM to drop the secondary carrier.

When the TERMINAL MODEM sees the loss of the secondary carrier, it lowers the Secondary Received Line Signal Detect or to the TERMINAL. This causes the TERMINAL to lower its Request to Send.

The TERMINAL MODEM drops the primary carrier and lowers Clear to Send to the TERMINAL. When the HOST MODEM sees the loss of the primary carrier, it lowers Received Line Signal Detector to the Host, and repeats the procedure beginning with Step 1.

[1]For RS-232 signal definitions refer to TEKniques Vol. 4, No. 5 (Input/Output), the Option 1 Operator's Manual, or other RS-232 literature.

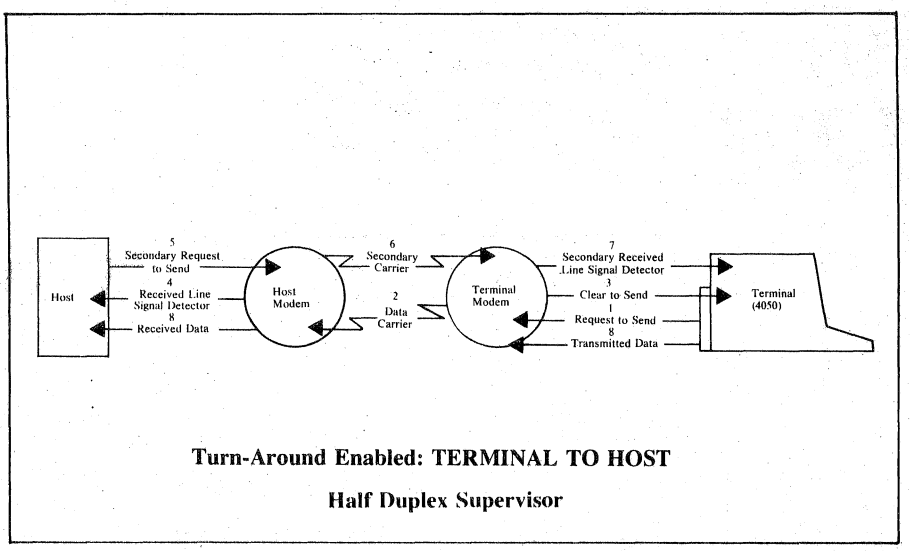


Fig. 2. Sequence of signal line events in Half Duplex Supervisor data communications, terminal to host.

Notice how the HOST controls the lines of communication. Although the TERMINAL was through, all the signal lines remained in their existing state until the HOST initiated turnaround by bringing its Secondary Request to Send low.

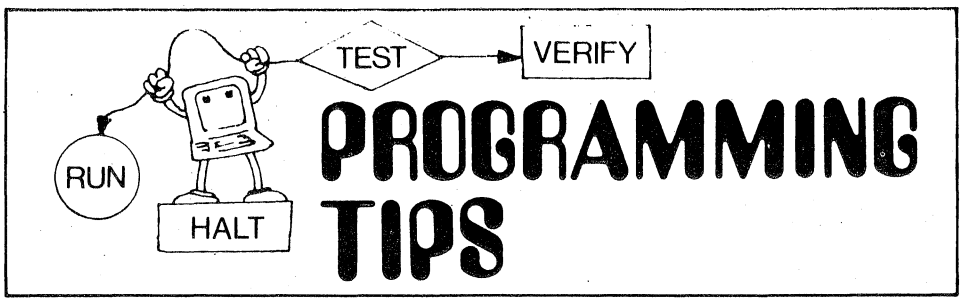
Interrupt by Terminal

A feature of the Half Duplex Supervisor is being able to interrupt the HOST when the HOST is transmitting data by pressing the BREAK key or when the 4050 System's screen is full.

Should the TERMINAL OPERATOR press the break key, it will cause the Secondary Request to Send to the TERMINAL MODEM to drop momentarily. This causes the HOST to initiate the turn-around as described above.

Host Determines Operation

This describes a "typical" operation and gives you an understanding of how hardware signals function. However, the actual operation depends on your host computer.



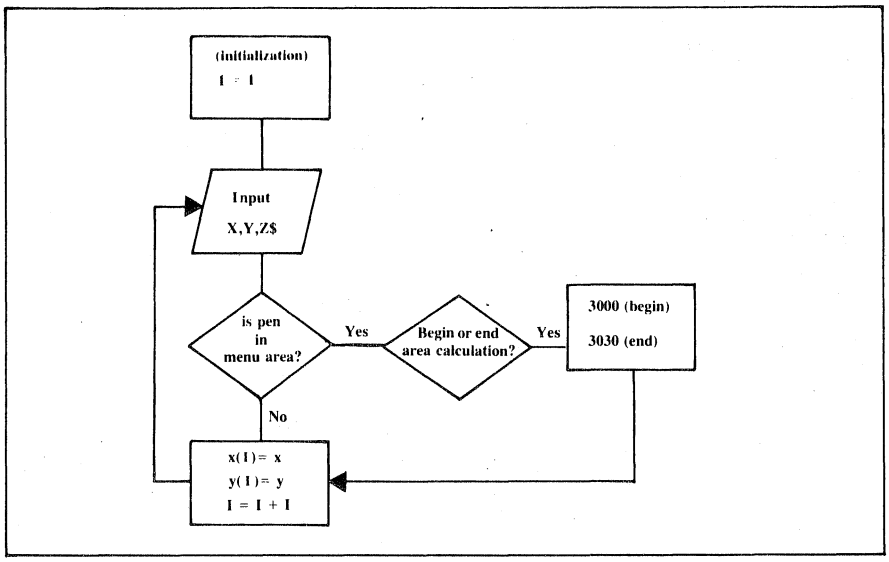
Area Calculation

by Bernie Gunn
W. & K. McLean, Ltd.
Glenn Innes, Auckland,
New Zealand

When digitizing a plan, the area of part or all of the plan is often required. The main problem is how, at any point while digitizing, to begin the area calculation loop. The simplest way is to define two items on the on-board menu. When one of these menu items is touched with the digitizing pen, the loop counter is initialized to the current X,Y coordinate counter, I; when the second is touched the loop is closed. The area must be digitized in a clockwise direction.

Obviously A3 can be modified by a scale factor to give a real area in terms of square feet, roods, perches, ha, or whatever.

```
3000 REM BEGIN AREA CALCULATION
3010 A1=I
3020 RETURN
3030 REM END AREA CALCULATION
3040 A2=I-1
3050 REM A3=TOTAL AREA
3060 A3=0
3070 X(A2+1)=X(A1)
3080 Y(A2+1)=Y(A1)
3090 FOR J=A1+1 TO A2+1
3100 A4=0.5*(ABS(Y(J)-Y(J-1))*(X(J)+X(J-1)))
3110 IF Y(J)>Y(J-1) THEN 3140
3120 A3=A3+A4
3130 NEXT J
3140 A3=A3-A4
3150 NEXT J
3160 PRINT "AREA =";A3
3170 RETURN
```



Initializing Random ASCII data files on the 4907

by S. Lawrence
C. E. B. S.
Sydney, Australia

The following method quickly initializes random ASCII data files on the 4907 disk. A string is created containing spaces plus a carriage return for each record. The string is then printed to the disk.

R0 in statement 120 contains the number of records; D0 in statement 140 contains the number of bytes in each *logical* record. Statement 170 allocates the storage space for each *physical* record; consequently, it adds one additional byte to each logical record to accommodate the carriage return (logical record separator).

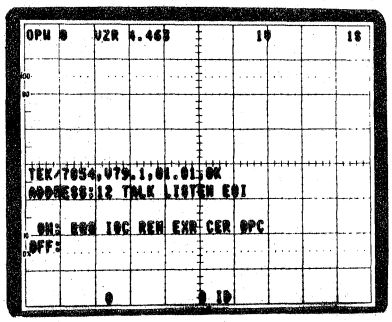
```
100 INIT
110 PAGE
120 R0=1000
130 F$="TEST"
140 D0=4
150 DIM S$(300),D$(R0*(D0+1))
160 KILL F$
170 CREATE F$,"A";R0+0,D0+1
180 OPEN F$;2,"F",S$
190 I$=""
200 FOR J0=1 TO D0
210 I$=I$&" "
220 NEXT J0
230 J$=CHR(13)
240 I$=I$&J$
250 REM INITIALIZE FILE
260 D$=""
270 FOR J0=1 TO R0
280 D$=REP(I$,1+LEN(D$),0)
290 NEXT J0
300 PRINT #2,1:D$;
310 END
```

Reproducing 7854 Displays on the 4052 Screen

by Clark Foley
Tektronix, Inc.
Beaverton, OR

This program duplicates Tektronix 7854 Oscilloscope displays on the 4052 graphic screen.

With the program in 4052 memory, type RUN. The 4052 will display a list of the User-Definable Key assignments and ask for the GPIB address of the 7854. Power on the 7854 and press the ID button on the 7854's front panel; an ID message will be displayed on the 7854 screen, as shown below. The message contains the 7854's GPIB address and the selected communication mode.



ID message display on the 7854 CRT.

In this example, the address is 12 and the mode is TALK LISTEN with EOI as the GPIB message terminator. The address, communication mode, and message terminator are all rear-panel selectable on the 7854. For the program listed above, you must select TALK LISTEN with EOI.

Enter the 7854 address from the 4052 keyboard and press the RETURN key. Press the RQS button on the 7854 front panel to continue. From this point, you may select User-Definable Key 1 or 2 as often as you like. To send a message for display on the 7854 screen, press UDK 2. A simulated graticule will be drawn on the 4052 for use in positioning your message as you wish to see it on the 7854. Up to 12 message lines of 40 characters each can be sent. Type XMT on the first available new line to send your message. (If you exceed the 12-line message, all 12 lines will be automatically sent.)

To get a duplicate of the entire 7854 display — including messages, waveforms, and computer waveform data — on the 4052 screen, simply press UDK 1. The program will transfer and reconstruct the display for you. Now all you have to do is press the copy button for a paper copy of the display. You could add another routine to cause the display to be stored on the 4052's magnetic tape for further reference.

```
1 PRINT "GGGGGG"
2 T9=3
3 GO TO 40
4 A=A1
5 T9=0
6 WBYTE 017,32+A,63;
7 GO TO 300
8 A=A1
9 T9=0
10 WBYTE 017,32+A,63;
11 GO TO 500
12 PAGE
13 WBYTE 032+A,1,63;
14 PRINT "JJJ******** RETURN TO LOCAL ********"
15 END
40 PAGE
45 PRINT "JJ                ********** USER KEY ASSIGNMENTS **********"
55 PRINT "JJJJ1        @1:....COPY 7854 CRT."
60 PRINT "JJ           @2:....SEND TEXT TO 7854."
65 PRINT "JJ           @5:....RETURN TO LOCAL."
70 PRINT "JJ           @10:...MENU."
75 IF T9=3 THEN 85
80 END
85 PRINT "JJJGIIUUUENTER THE DESIRED GPIB DEVICE ADDRESS."1
90 INPUT A
91 IF A<1 OR A>30 THEN 85
95 A1=A
100 PRINT "JJ                IF 7854 POWER IS ON, PRESS 'RQS' ON THE 7854."
105 PRINT "JJUUUUUUUUUUIF 7854 IS OFF, TURN IT ON AND WAIT UNTIL READY.GGG"
110 L=0
115 ON SRQ THEN 900
120 IF K2<1 THEN 120
125 PRINT @A:"RQSON ICON REMON EXROFF CEROFF OPCON ID"
130 PWINT "JJ:::    READY    :::GGGG"

135 T9=0
140 END
200 REM ********************* COPY OF 7854 CRT ****************************
205 ON SRQ THEN 900
210 PAGE
215 PRINT "JJ********** COPY OF 7854 CRT **********"
220 DELETE T$,L$,M$,J$,K$,U$,V$,Q$,W$,W,U
225 GOSUB 600
230 GOSUB 1300
235 GOSUB 1400
236 Q$=SEG(J$,1,3)
237 IF Q$<>"OPW" THEN 395
240 Q$=SEG(J$,5,2)
245 W$=Q$
250 GOSUB 1700
255 GOSUB 1800
260 A9=0
265 M$=SEG(K$,35,2)
270 B9=1
275 U=0
280 IF M$<>"US" THEN 300
285 GOSUB 1100
290 A9=1
295 B9=0
300 GOSUB 700
305 GOSUB 800
310 IF H=0 THEN 320
315 GOSUB 1000
320 M$=SEG(K$,1,3)
325 IF M$<>"DSW" THEN 370
330 H=0
335 GOSUB 1155
340 IF O$<" " THEN 370
345 IF VAL(N$)=VAL(O$) THEN 335
350 GOSUB 1700

355 GOSUB 1000
360 GOSUB 700
365 GO TO 335
370 E2=0
375 PRINT @A:"READX"
380 IF E2<1 THEN 380
385 PRINT @A:M$
390 PRINT @A:"WFM"
395 MOVE 5,3
400 PRINT "J     ::: OPERATION COMPLETED :::GGG"
405 WBYTE 032+A,1,63;
410 HOME
415 DELETE T$,U$,V$,Q$,U$,U,W
420 END
500 REM ******************* SEND TEXT TO 7854 ********************
505 PAGE
510 PRINT "JJ********** SEND TEXT TO 7854 **********"
515 PRINT "JJINPUT TEXT AS DESIRED(12 LINES OF 40 CHRS MAX)."
520 PRINT "TO SEND TYPE 'XMT' ON THE NEXT LINE OR EXCEED 12 LINES."
525 GOSUB 600
530 GOSUB 1900
535 MOVE 10,10
540 PRINT "J     ::: TRANSFER COMPLETED :::GGG"
545 WBYTE 032+A,1,63;
550 END
600 REM ************ GENERATE GRATICULE ***************
605 VIEWPORT 30,103,28.5,81.5
610 WINDOW 2.5,127.5,0,100
615 AXIS 12.5,12.5,65,50
620 MOVE 2.5,0
625 RDRAW 0,100
630 RDRAW 125,0
635 RDRAW 0,-100
640 RDRAW -125,0
645 RETURN

700 REM ******************** WAVEFORM PLOT ********************
705 ON SRQ THEN 900
710 VIEWPORT 19,114,12.5,88.7
715 WINDOW 0,130,-5,100.5
720 MOVE 15+B9+(V(1)*10+65)*A9,W(1)*10+50
725 F=100/P
730 X=0
735 FOR I=1 TO P
740 DRAW (X+15*B9+(V(I)*10+65)*A9,W(I)*10+50
745 X=X+F
750 NEXT I
755 RETURN
800 REM ***************** FIND CURSOR LOCATIONS ****************
805 H1=0
810 H2=0
815 IF H=0 THEN 875
820 E2=0
825 PRINT @A:"CRS1 HCRD HSCL / P/W * 1 0 / SENDX"
830 IF E2<1 THEN 830
835 INPUT @A:H1
840 H1=INT(H1)
845 IF H=1 THEN 875
850 E2=0
855 PRINT @A:"CRS2-1 HCRD HSCL / P/W * 1 0 / SENDX"
860 IF E2<1 THEN 860
865 INPUT @A:H2
870 H2=INT(H2)
875 RETURN
900 REM ****************** SERIAL POLL *****************
905 POLL E1,E2,A
910 RETURN
1000 REM ***************** CURSOR PLOT ***************************
1005 FOR J=1 TO H
1010 X=H1#100/P
1015 I=H1+1

1020 MOVE (X+15)*B9+(V(I)*10+65)*A9,W(I)*10+50
1025 FOR X=1 TO 6
1030 RDRAW 1,1
1035 RMOVE -1,-1
1040 SET DEGREES
1045 ROTATE 60#K
1050 NEXT K
1055 H1=H1+H2
1060 H2=0
1065 NEXT J
1070 HOME
1075 RETURN
1100 REM ***************** X VERSUS Y PLOT ***********************
1105 M$=SEG(K$,30,2)
1110 E2=0
1115 PRINT @A:"READX"
1120 IF E2<1 THEN 1120
1125 PRINT @A:M$
1130 E2=0
1135 PRINT @A:"WFM SENDX"
1140 IF E2<1 THEN 1140
1145 INPUT @A:U$,U
1150 RETURN
1155 REM ********************* IDENTIFY DSW WAVEFORMS ********************
1160 IF LEN(K$)<>3 THEN 1215
1165 O$=" "
1170 FOR I=1 TO 12^3
1175 M$=SEG(K$,30,2)
1180 E2=0
1185 PRINT @A:"READX"
1190 IF E2<1 THEN 1190
1195 PRINT @A:M$
1200 E2=0
1205 PRINT @A:"WFM SENDX"
1210 IF E2<1 THEN 1210
1215 INPUT @A:U$,U
1220 I=I+1
1225 NEXT I
1300 REM ********** INITIATE TEXT AND SRQ? ************
1305 ON SRQ THEN 900
1310 PRINT @A:"SRQ?"
1315 INPUT @A:X$
1320 X$=SEG(X$,5,50)
```

```
1325 E2=0
1330 PRINT @A:"TEXT"
1335 IF E2<1 THEN 1335
1340 RETURN
1400 REM ***************** INPUT TEXT ********************
1405 B$=CHR(27)
1410 E$=CHR(127)
1415 D$="bg e  D g    dPostuv ow  >< ?"LE?
1420 VIEWPORT 0,130,0,100
1425 WINDOW 0,130.0,100
1430 MOVE 31,78.5
1435 H=0
1440 FOR I=1 TO 16
1445 INPUT @A:Y$
1450 IF I>1 THEN 1460
1455 J$=Y$
1460 IF I>2 THEN 1470
1465 K$=Y$
1470 IF I<>15 THEN 1500
1475 IF LEN(Y$)<3 THEN 1500
1480 H=1
1485 R$=SEG(Y$,2,1)
1490 IF R$=" " THEN 1500
1495 H=2
1500 IF I<16 THEN 1525
1510 Y$=X$
1515 REM SEARCH Y$ FOR 'ESC'(DECIMAL 27) FOLLOWED BY SPECIAL CHAR.
1525 FOR J=1 TO LEN(Y$)
1530 J=POS(Y$,B$,J)
1535 IF J=0 THEN 1570
1540 Z#=SEG(Y$,J+1,1)
1545 Z=ASC(Z#)
1550 C#=SEG(D$,Z,1)
1555 Y$=REPC(C$,J,1)
1560 NEXT J

1565 Y$=X$
1570 PRINT Y$
1575 RMOVE 0,-3.82
1595 NEXT I
1600 RETURN
1700 REM ************** READ DISPLAYED WFMS FROM 7854 ***************
1705 ON SRQ THEN 900
1710 E2=0
1715 PRINT @A:"READX"
1720 IF E2<1 THEN 1720
1725 PRINT @A:O$
1730 E2=0
1735 PRINT @A:"WFM SENDX"
1740 IF E2<1 THEN 1740
1745 RETURN
1800 REM ************** ARRAY INPUT OF WFMS ***************
1805 INPUT @A:P,X$,X1,Y$,Y1
1810 DELETE W,L$,Q$,U$,T$
1815 DIM W(P),U(P)
1820 INPUT @A:W
1825 RETURN
1900 REM ********************** SEND TEXT **********************
1905 DIM T$(300)
1910 T$=""
1915 B$=CHR(3)
1920 VIEWPORT 0,130,0,100
1925 WINDOW 0,130,0,100
1930 MOVE 31,74.5
1935 FOR I=1 TO 12
1940 RMOVE 0,-3.82
1945 INPUT A$
1950 IF A$="XMT" THEN 1975
1955 IF I=12 THEN 1965
1960 A$=A$LB$
1965 T$=T$+A$

1970 NEXT I
1975 ON SRQ THEN 900
1980 E2=0
1985 PRINT @A:">TEXT"
1990 IF E2<1 THEN 1990
1995 PRINT @A:T$
2000 HOME
2005 RETURN
```

1-3, 40-95	**Initialize program and prompt user to input 7854's GPIB address.**
6, 9	**Implement a "local lock out" so the 7854 front-panel keys are inactive while the 4052 is executing. Lock out is removed automatically when the 4052 finishes or becomes idle.**
100-285	**Main line of the copy program. Includes tests for X-Y and multiple waveform displays.**
600, 645	**Subroutine for simulated graticule.**
1300, 1600	**Subroutine to retrieve all alphanumerics displayed on the 7854. D$ contains substitute characters.**
1700, 1825	**Subroutine to transfer a single waveform to an array.**
1100-1150	**Subroutine to transfer a second waveform to an array for an X-Y display.**
700, 755	**Waveform plot subroutine. For X-Y plot, the second waveform is horizontal values.**
800, 875	**Subroutine to get cursor locations as array element indices.**

This program duplicates 7854 displays on the 4052 Graphic Computing System screen.

Repetitious Data Entry

by Michael Anderson
Owens-Illinois, Inc.
Valdosta, GA

When entering a large number of data observations, many are often repeated. The following statements allow a user to merely press the RETURN key to automatically input the I-1 data item into the Ith data item.

```
100 INIT
110 DIM X(5)
120 FOR I=1 TO 5
130 PRINT "INPUT VALUE NUMBER ";I;"  FOR X: ";
140 INPUT X$
150 IF X$="" THEN 180
160 X(I)=VAL(X$)
170 NEXT I
180 IF I=1 THEN 130
190 X(I)=X(I-1)
200 PRINT "X";I,"          ";X(I)
210 NEXT I
220 END
```

Shellsort When 4051R07 or 4052R07 Not Available

by Dr. Bernard Gunn
W. & K. McLean Ltd.
Glenn Innes, Auckland,
New Zealand

TEKniques Vol. 3 No. 4 compared the use of a Bubblesort routine, with and without the use of the 4052R07 ROM, to a Quicksort routine.

It should be pointed out that Bubblesort is extremely primitive and is not widely used. To bubble a single zero up through a hundred numbers requires 200 exchanges. The original Quicksort is rather complex and usually only used on mainframes; a more convenient alternative is Shellsort which requires only 15 lines.

The times to order 80 and 500 numbers on a 4052 are:

No.	Bubblesort	Shellsort
80	36 seconds	4.5 seconds
500	25 minutes	50 seconds

As Shellsort is no more complicated to write and is enormously more efficient, it should be used in any case when a 4051R07 or 4052R07 ROM is not available.

```
100 INIT
110 REM
120 SET KEY
130 PRINT "HOW MANY RANDOM NUMBERS DO YOU WANT "
140 PRINT "TO SEE SORTED?GG "
150 INPUT N
160 DIM A(N)
170 IMAGE N(2D.7D,2X)
180 A=1
190 A=RND(A)
200 A=1000*A
210 A=INT(A)
220 PRINT A
230 REM *** BEGIN SORT ***
240 PRINT "L ** SHELLSORT STARTED **GG"
250 D=1
260 D=INT(2*D)
270 IF D<=N THEN 260
280 D=INT((D-1)/2)
290 IF D=0 THEN 420
300 I1=INT(N-D)
310 FOR I=1 TO I1
320 J=I
330 L=J+D
340 IF A(L)=>A(J) THEN 400
350 T1=A(J)
360 A(J)=A(L)
370 A(L)=T1
380 J=J-D
390 IF J>0 THEN 330
400 NEXT I
410 GO TO 200
420 PRINT "** SORT FINISHED GGG"
430 PRINT A
440 END
```

Update to Quicker Sort

by W. B. Reid, Ph.D. F.C.C.P.M.
Saskatoon Cancer Clinic
Saskatchewan Cancer Foundation
University Hospital
Saskatoon, Canada

The quicker sort algorithm on page 104 of the Programming Tips (handbook) has some extra statements and a little bit of superfluous logic. The following listing shows the version on page 104 with the modifications I made. It also uses several less variables.

In sorts as short as 20 seconds, these modifications didn't seem to make any significant time different; it is, however, somewhat easier to draw the flow diagram.

```
100  INIT
110  B1=10
120  R=26
130  DIM B$(B1),G$(B1),F$(B1)
140  OPEN "SUB/SORT/STRING/TESTFILE";1,"F",G$
150  PRINT "STRINGSORT"
160  PRINT "PLEASE WAIT"

170  REM
180  REM

190  DELETE B3
200  DIM B3(24)
210  IF R<=1 THEN 810
220  B4=0
230  B1=1
240  B2=R
250  IF B2<=B1 THEN 760
280  IF B2-B1>1 THEN 370
290  READ #1,B1:F$
300  READ #1,B2:G$
310  IF F$<=G$ THEN 760
330  WRITE #1,B1:G$
340  WRITE #1,B2:F$
350  GO TO 760
370  B5=INT(0.5*(B1+B2))
380  READ #1,B5:B$
400  READ #1,B1:F$
410  WRITE #1,B5:F$
420  B6=B2
430  A4=B1
440  A4=A4+1
450  IF A4>B6 THEN 600
460  READ #1,A4:G$
470  IF G$<=B$ THEN 440
480  IF B6<A4 THEN 600
490  READ #1,B6:F$
500  IF F$<B$ THEN 560
510  B6=B6-1
520  GO TO 480
560  WRITE #1,A4:F$
570  WRITE #1,B6:G$
580  B6=B6-1
590  GO TO 440
600  READ #1,B6:F$
610  WRITE #1,B1:F$
620  WRITE #1,B6:B$
622  B4=B4+2
630  IF B6+B6<=B1+B2 THEN 680
640  B3(B4-1)=B1
650  B3(B4)=B6-1
660  B1=B6+1

670  GO TO 250
680  B3(B4-1)=B6+1
690  B3(B4)=B2
700  B2=B6-1
710  GO TO 250
760  IF B4<=0 THEN 810
770  B1=B3(B4-1)
780  B2=B3(B4)
790  B4=B4-2
800  GO TO 250

                    SPACE=1021 LINES=60
```

Alpha List from 4907

by Michael W. Moore
Bendix Forest Products Corporation
San Francisco, CA

Use the 4051R06 Text Editor ROM Pack to produce a complete alphabetized listing of all the scratch library files on your disk. Simply take the following steps:

1. Put a tape into the internal tape drive and FIND the file you wish to use as temporary storage.
2. MOUNT the disk.
3. Print the Directory at the internal tape drive.
   a. FIND n where n = tape file number
   b. DIRECTORY @33:
   c. CLOSE
4. CALL the Editor:
   a. Edit out "Scratch lib/"
   b. Sort the file listing
   c. Print the file listing. (It's best to save with the EDITOR-assigned numbers.)

For example, using file 2 of the internal tape drive and Unit 0 of the 4907, try the first code:

For an alphabetized listing of all your disk files, use the second code:

```
FIND 2
CALL "MOUNT",0,A$
DIR @33:
CLOSE
CALL "EDITOR"
FIND 2
OLD
S "SCRATCHLIB/"; ""
     :TEK4516
     :SEGMENT
     :BUG
     :TEST
     :PIE
     :UTILITY
     :PIECHART
     :GROUPOPEN
     :PIEFINAL
     :NATHAN
SORT ,, 1,2,3,4
REN
SWN@41:
```

The 'SCRATCHLIB' directory on disk is printed to tape, then using the Editor ROM is olded, 'SCRATCHLIB' edited out, sorted, renumbered and listed on the printer with the numbers assigned by the Editor ROM.

```
 1 BUG
 2 GROUPOPEN
 3 NATHAN
 4 PIE
 5 PIECHART
 6 PIEFINAL
 7 SEGMENT
 8 TEK4516
 9 TEST
10 UTILITY
```

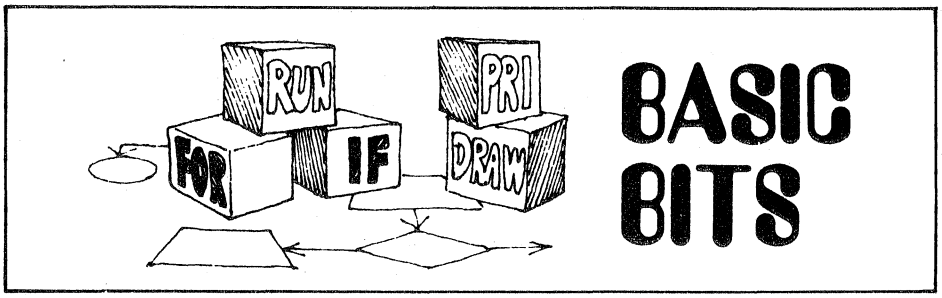
Listing of alphabetized SCRATCHLIB.

```
FIND 2
CALL "MOUNT",0,A$
DIR @33:0,"@"
CLOSE
CALL "EDITOR"
FIND 2
OLD
SORT ,, 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24
```

Directory of all disk libraries is printed to tape, then sorted by the Editor ROM.

```
:DATABASE/ZAP/MASTER/DATA
:DATABASE/ZAP/MASTER/INIT
:SCRATCHLIB/BUG
:SCRATCHLIB/GROUPOPEN
:SCRATCHLIB/NATHAN
:SCRATCHLIB/PIE
:SCRATCHLIB/PIECHART
:SCRATCHLIB/PIEFINAL
:SCRATCHLIB/SEGMENT
:SCRATCHLIB/TEK4516
:SCRATCHLIB/TEST
:SCRATCHLIB/UTILITY
:UTILITY/ASCII
:UTILITY/BINARY
:UTILITY/COPY
:UTILITY/DUP
:UTILITY/FORMAT
:UTILITY/HELP
:UTILITY/HELPLIB/APPEND
:UTILITY/HELPLIB/ASSIGN
:UTILITY/HELPLIB/CLOSE
:UTILITY/HELPLIB/COMPRS
:UTILITY/HELPLIB/COPY
:UTILITY/HELPLIB/CREATE
:UTILITY/HELPLIB/CUSTAT
:UTILITY/HELPLIB/DIRECTORY
:UTILITY/HELPLIB/DISMOUNT
:UTILITY/HELPLIB/DREL
:UTILITY/HELPLIB/DRES
:UTILITY/HELPLIB/DSTAT
:UTILITY/HELPLIB/DUP
:UTILITY/HELPLIB/EOF
:UTILITY/HELPLIB/FFRMT
:UTILITY/HELPLIB/FILE
:UTILITY/HELPLIB/FMVALS
:UTILITY/HELPLIB/FORMAT
:UTILITY/HELPLIB/HERRS
:UTILITY/HELPLIB/INPUT
:UTILITY/HELPLIB/KILL
:UTILITY/HELPLIB/MOUNT
:UTILITY/HELPLIB/MRKBBG
:UTILITY/HELPLIB/NEXT
:UTILITY/HELPLIB/OLD
:UTILITY/HELPLIB/ON
:UTILITY/HELPLIB/OPEN
:UTILITY/HELPLIB/PRINT
:UTILITY/HELPLIB/READ
:UTILITY/HELPLIB/RENAME
:UTILITY/HELPLIB/REWIND
:UTILITY/HELPLIB/SAVE
:UTILITY/HELPLIB/SECRET
:UTILITY/HELPLIB/SETTIM
:UTILITY/HELPLIB/SPACE
:UTILITY/HELPLIB/TIME
:UTILITY/HELPLIB/TYP
:UTILITY/HELPLIB/UNIT
:UTILITY/HELPLIB/USERLIB
:UTILITY/HELPLIB/WRITE
:UTILITY/LIST
:UTILITY/LIST.LIST
:UTILITY/MENU
:UTILITY/RASCII
:UTILITY/RBINARY
```

An alphabetized listing of all files on the disk.



Update to Byte Counter

by A. C. Visser
Institute for Land and Water Management
Wageningen, The Netherlands

First, the routine "Byte Counter" in TEKniques Vol. 3 No. 2[1] needs a small correction:

Change line

```
120 DIM A$(MEMORY-300)
```

to

```
120 DIM A$(MEMORY-300),R$(73)
```

because R$ contains a program line (maximum 72 characters) and CR.

The following program is based on the Byte Counter tip. Start a new tape with this program. When you have developed your program and are ready to store it, the following routine will compute the length of the program, mark a file (LAST minus 2), store the program in that file, and will then mark a file to store this utility routine.

```
300 PAGE
310 INIT
320 C$=CHR(13)
330 DIM A$(MEMORY-300),R$(73)
340 ON EOF (0) THEN 460
350 PRINT "Which file has to be recomputed? ";
360 INPUT F2
370 PRINT "JJGGGWARNING, FILE ";F2-1;" WILL BE REMARKED"
380 PRINT "To continue press <RETURN>"
390 INPUT A$
400 A$=""
410 FIND F2
420 INPUT @33:R$
430 R$=R$&C$
440 A$=REP(R$,1+LEN(A$),0)
450 GO TO 420
460 T=LEN(A$)+1
470 F1=F2-1
480 FIND F1
490 MARK 1,T
500 MARK 1,1280
510 FIND F1
520 PRINT @33:A$;
530 FIND F2
540 SAVE
550 END
```

Editor's Note: If you are going to use this program to calculate the length of ASCII data files, add the following statement and change statement 340 to read:

```
340 ON EOF (0) THEN 455
```

This will ensure that data saved with CR suppressed (PRI @:"TEST";) will be included in A$ (statement 455).

```
455 A$=REP(R$,1+LEN(A$),0)
```

[1]Programming Tip handbook, p. 74.

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 disk for a small recording fee per program plus the charge for the tape cartridge or flexible disk. One tape/disk will hold several programs. Programs will be recorded on like media only, i.e., programs on tape cannot be sent on disk and vice versa unless so noted in the abstract.

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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# : 51/07-0909/0

Title: Timeseries III
Author: Mallroy M. Green
Dept. of HUD
Washington, D.C.
Memory Requirement: 32K
Peripherals: 4662/4663 Plotter
Optional-4051R05 Binary ROM
-4907 File Manager

Timeseries III is an easy-to-use interactive program which prompts the user for graph parameters.

Maximum parameters:

4 data lines or bar shading types
20 time periods
3 title lines
72 characters per title line
30 characters per data line label
60 characters for X-axis label
60 characters for Y-axis label
3 extra text strings
72 characters per extra text string
choice of symbols

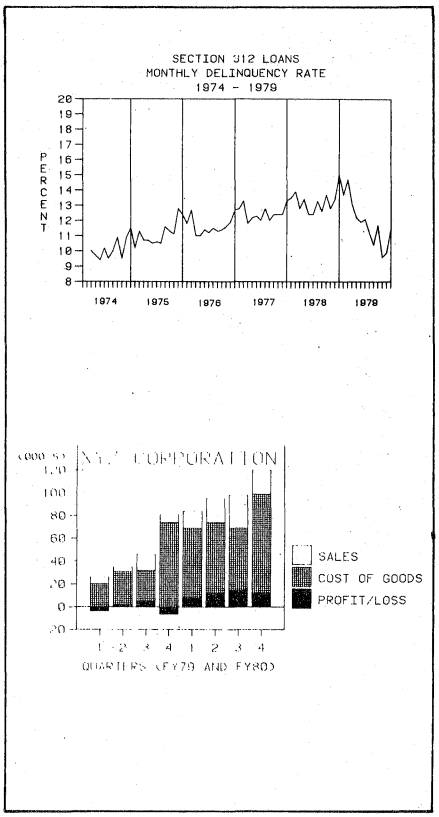
Parameters may be adjusted within memory limits, by decreasing some and increasing others.

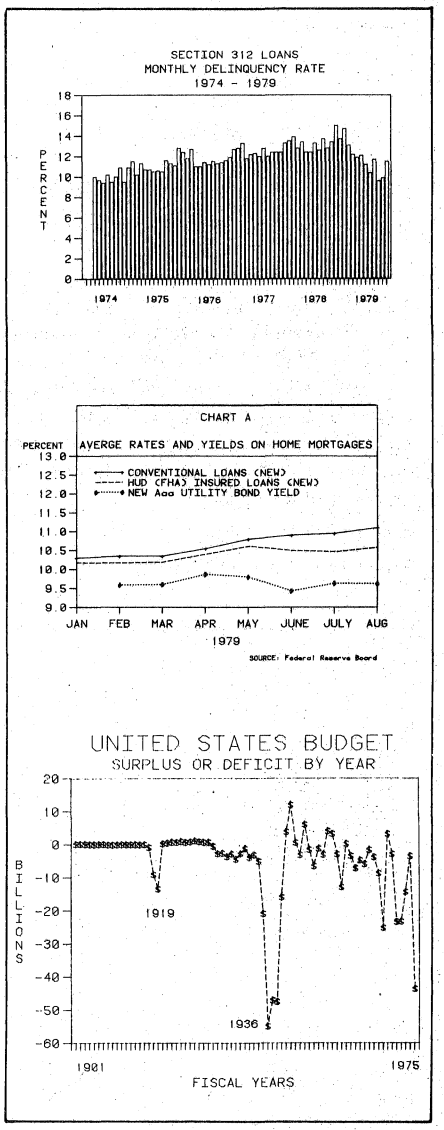
Graphs are easily modified through the User-Definable Keys.

Time periods may be added to or deleted from either end of the X-axis. Lines/bars may be added or deleted, their legends/labels changed or moved. Individual data items may be changed or a series may be changed.

Chart descriptions can be saved to tape or disk.

Output to the plotter in one color or multiple colors. Plot may be rotated 90 degrees. Tabular and graphic display also on the screen.





ABSTRACT#: 51/07-0910/0

Title: Bargraph III
Author: Mallory M. Green
Dept. of HUD
Washington, D.C.
Memory Requirement: 32K
Peripherals: 4662/4663 Plotter
Optional-4051R05 Binary ROM
-4907 File Manager

Bargraph III is an easy-to-use interactive bar chart program. The user defines a bar graph by responding to Bargraph III prompts.

A group of bars consists of one or more bars with different shading patterns. The bars may be horizontal or vertical; and they may be stacked, overlayed or comparative.

Maximum parameters:

12 groups of bars
4 bar types
3 title lines
72 characters per title line
30 characters per data set legend
20 characters per group label
3 extra text strings
72 characters per extra text string

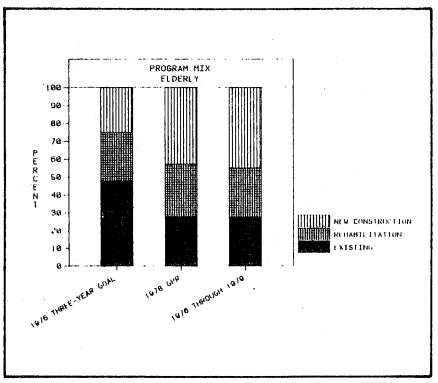
Parameters may be adjusted within memory limits, by decreasing some and increasing others.

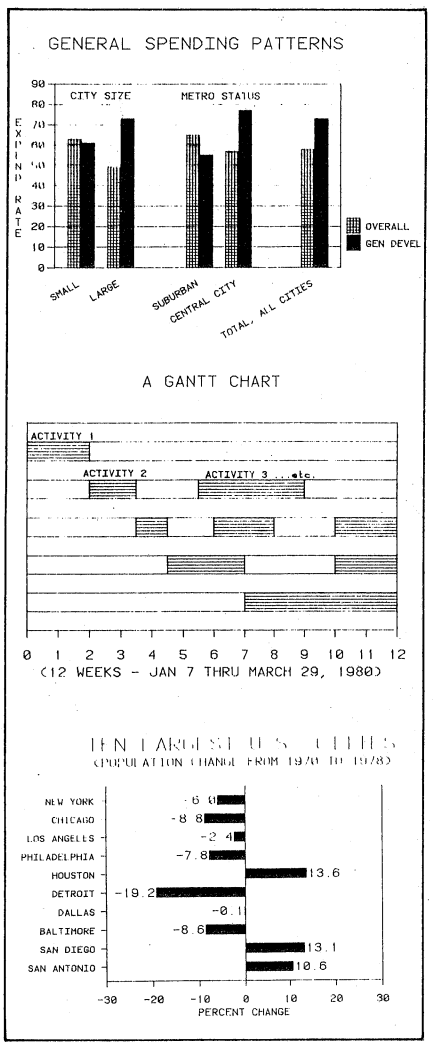
All titles, labels and text are drawn at user-specified scales. Various lines modes and data symbols are user selectable.

Chart modification, including adding/deleting bars or groups of bars, can be done easily through the User-Definable Keys.

Chart descriptions can be saved to tape or disk.

Output to the plotter in one color or multiple colors. Plot may be rotated 90 degrees. Tabular and graphic display also on the screen.





ABSTRACT# 51/07-9545/0

Title: Sign Maker III
Author: Mallory M. Green
Dept. of HUD
Washington, D.C.
Memory Requirement: 32K
Peripherals: 4662/4663 Plotter
Optional-4907 File Manager

Sign Maker III is an interactive easy-to-use sign making program. The user may create, modify, plot, display, or save and recall signs from tape or disk.

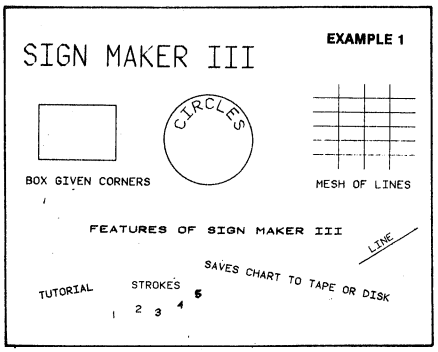
Through the User-Definable Keys the user can add, delete, or modify individual text lines. Text may be centered, positioned, scaled and rotated. It may be made bold through multiple strokes.

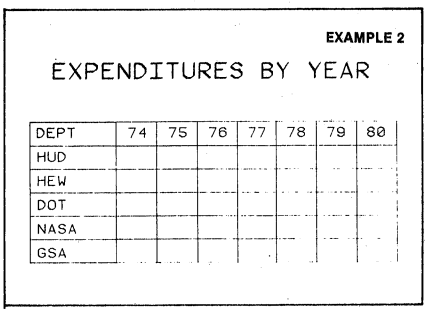
The signs can include boxes, circles, lines, and page boundaries.

The signs may be plotted in one or multiple colors.

Program limits:

72 characters per text line
20 text lines and/or shapes per sign with 32K system
200 text lines and/or shapes per sign with 64K system





ABSTRACT#: 52/07-9546/0

Title: Sign Maker IV
Author: Mallory M. Green
Dept. of HUD
Washington, D.C.
Memory Requirement: 64K
Peripherals: 4662/4663 Plotter
Optional-4907 File Manager

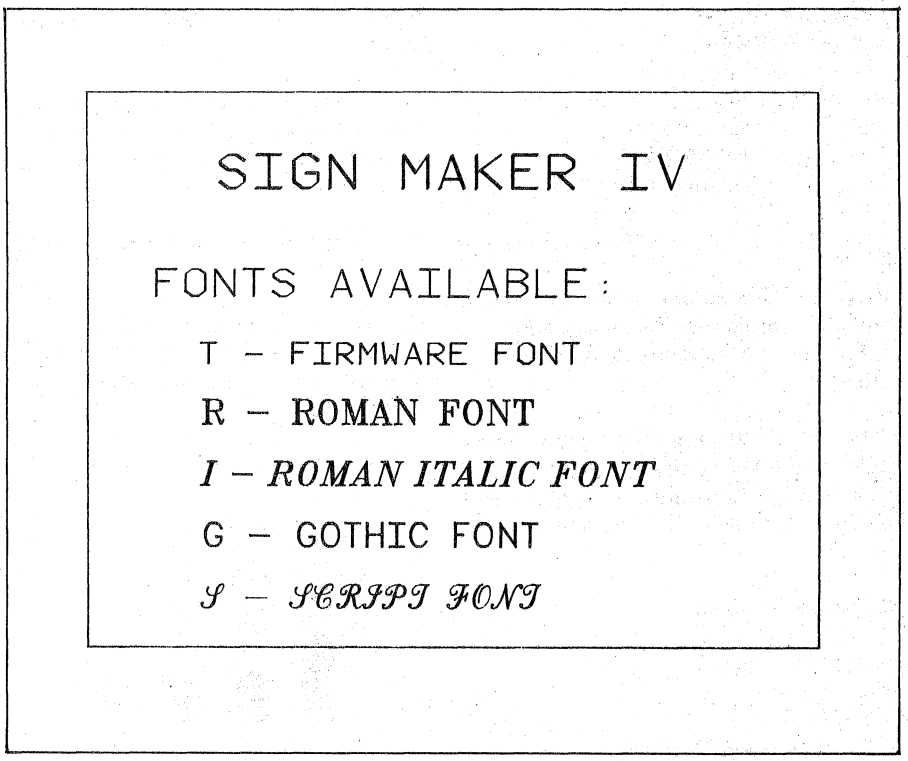
Sign Maker IV is the Sign Maker III program with the following four fonts added:

Roman
Roman Italic
Gothic
Script

Like Sign Maker III, it's interactive and easy to use. The user may create, modify, plot, display, save and recall signs. Individual text lines may be added, deleted or modified through the User-Definable Keys.

Signs can be drawn in one or multiple colors and can include shapes such as boxes, circle and lines.

Text may be centered or position, scaled and rotated.



ABSTRACT#: 52/07-9547/0

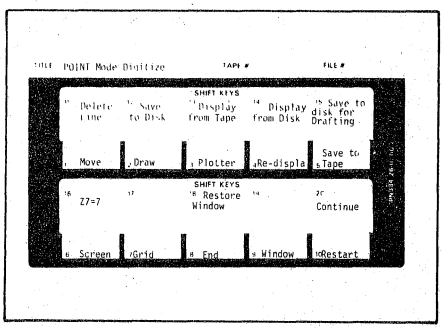
Title: POINT Mode Digitize
Author: Craig Bulmer
Tektronix, Inc.
Chicago, IL

Memory Requirement: 32K (64K Optimum)
Peripherals: 4956 Tablet
Optional-4662/4663 Plotter
-4907 File Manager
Statements 336
Files: 1 Binary
Requires pre-marked data files

This program allows you to digitize a drawing on the 4956 Tablet in POINT mode using the Writing Pen. The data format on disk is compatible for use with "4052/4 Drafting Program" in the Applications Library.

User-Definable Keys invoke the routines. As you are digitizing, the drawing is reproduced on the 4050 Screen. Lines may be deleted from your drawing. The completed drawing may be re-displayed, or continued. The drawing may be saved to tape or disk and recalled from either.

A grid structure coupled with a ZOOM windowing routine helps you choose your window.



Routine Maintenance Enhances Appearance, Performance

by Terry Davis
TEKniques Staff

As 4050 System Users, we're all aware of their ease of use and their minimal need for attention. The systems are ready to run in most all situations. But like all technical equipment, the 4050 system will look better and last longer with a few minutes of attention, on a planned maintenance schedule. Keeping the screen and exterior clean will enhance the appearance of the system, while routine tape head cleaning will prevent data errors during tape reads and writes.

This article will describe a few routine cleaning operations that can be done by any system user. In addition, we'll discuss the suggested schedule for these maintenance operations, as well as reasons why a user might wish to accelerate the schedule. Another article will follow in the next issue of TEKniques to describe similar maintenance procedures for peripheral equipment.

Table 1 establishes the maintenance steps and schedule; it's followed by specific instructions on the required maintenance items. Keep in mind that the 4050 Series Graphic Computing Systems are designed with a wide range of environmental conditions in mind; the environmental specifications are listed in the Specifications Section of the Graphic System Operators Manual. Operating systems in more extreme environments may require more frequent maintenance steps.

Table 1
Routine Maintenance Schedule*

Maintenance Item	Interval
Clean Exterior Surfaces	30-60 days or as needed
Clean Display Screen	30 days or as needed
Clean Dust Filter (4051/4054 Fan)	90-120 days, or as needed
Clean Tape Head	90 days
Packing Mag Tapes	10-12 uses

*The maintenance schedule shown here is based on the experience of 4050 System users. However, cleaning is dictated by system use and environment. Some systems environments may require more frequent cleaning of the filter and exterior. Other systems may require more frequent cleaning of the screen to remove fingerprints from everyday system use. Use this schedule as a guideline; customize it to your own application and environment.

Cleaning the Exterior Surfaces

CAUTION

Avoid chemical cleaning agents that might damage the plastics, paint, or metal in the 4050 system. Avoid chemicals that contain benzene, toluene, xylene, acetone, or similar solvents.

WARNING

Don't clean the unit with power applied.

You can clean the keyboard and other exterior surfaces of the system with a mild detergent and water solution. Dampen a soft cloth with the solution, and wring it out thoroughly before wiping the surface (see Fig. 1). Don't use too much detergent and water, as it may run into the internal parts of the system. If extensive scratches or finish damage are present, you can obtain touch-up paint through your local Tektronix representative.

You can remove fingerprints, dust, etc., from the display screen by cleaning with a commercial glass cleaner. Just spray the cleaner onto a cloth, wring the cloth thoroughly, then wipe and polish the display. The display cleans more easily if it is cool when cleaned.

Cleaning the Dust Filter

The dust filter is located on the rear panel of the 4051 and 4054 only; the 4052 requires no filter. The filter is shown in Fig. 2. Check the filter periodically, and clean it as needed, in order to ensure op-

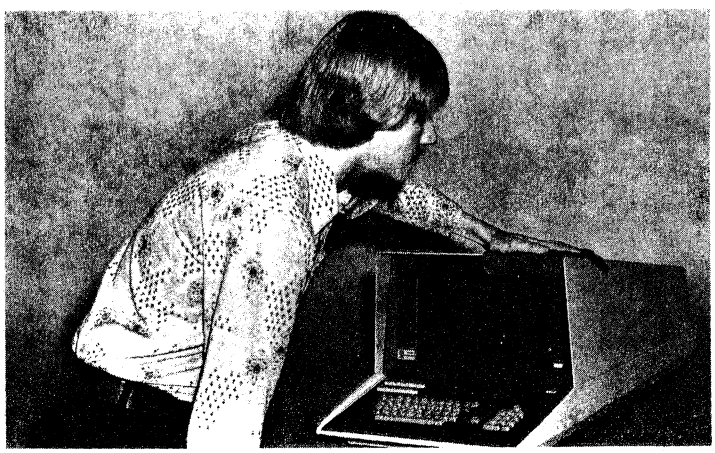


Fig. 1. Cleaning the 4050 Series Graphic Computing System.

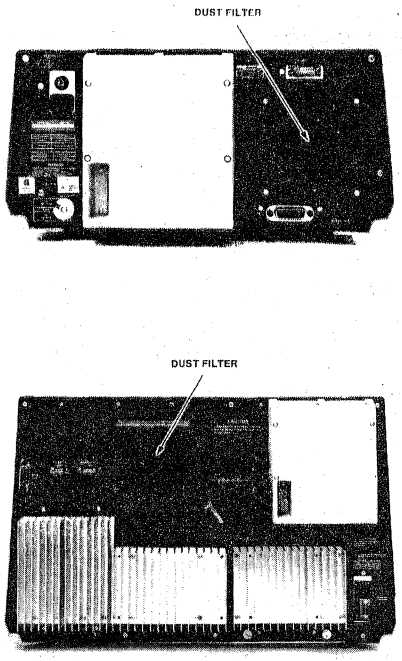


Fig. 2. 4051 and 4054 Dust Filters are located on the back panel.

timum air flow for cooling. The cleaning procedure is as follows:

1. Turn OFF the Graphic System power switch, and unplug the power cord from your power outlet.
2. Remove the dust filter by pulling it through the opening in the filter bracket.
3. Shake loose (or vacuum) as much dust as possible.
4. Clean the filter in a mild detergent and water solution, then rinse it and dry it thoroughly.

CAUTION

Do not clean the filter with any other spray or solution. Be sure the filter is thoroughly dry before placing it back into the Graphic System.

5. Replace the filter.
6. Plug the system power cord back into your power source, and turn ON the System power switch.

Cleaning the Magnetic Tape Head

It's important that your system's tape head be kept clean, both to prevent data errors and to preserve the life of the head. Oxide deposits, dust, and other foreign particles may be left on the head during tape operation, and can act as abrasives. The frequency of cleaning depends on the amount of tape drive use and the cleanliness of the system environment. Use the following procedure to inspect and clean the tape head.

CAUTION

Do not use magnetic devices near the tape head. Do not touch the tape head with metal or other hard objects. Doing so may damage the head, resulting in tape cartridge damage and causing loss of data.

1. Turn OFF the Graphic System power switch, and unplug the System power cord from your power source.
2. Inspect the tape head by shining a small light, such as a penlight, at an angle across the head surface. Look for accumulated foreign matter or damage to the head (Fig. 3).

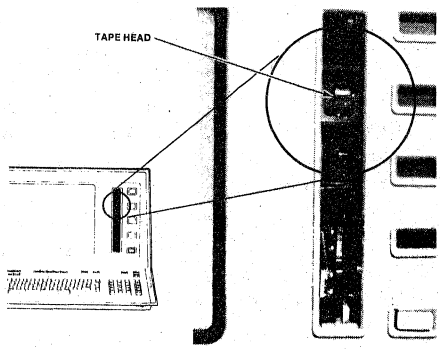


Fig. 3. Check for head wear or damage when you clean the head.

3. If the head is dirty, continue with this procedure. However, if the head is damaged or worn, it should be replaced by a Tektronix Field Service Specialist. (Refer to Fig. 4.)

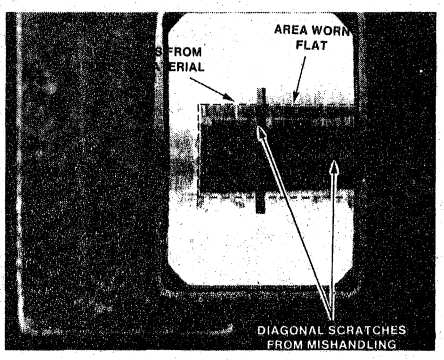


Fig. 4. Tape head damage to look for.

4. To clean oxide and accumulated foreign matter off of the head surface, use a cotton swab moistened with isopropyl alcohol or a special cleaning pad (available through a Tektronix representative). Light oxide accumulations are readily removable. Heavy, or long-term, accumulations may require more cleaning, with more alcohol and clean swabs. Use extreme care when cleaning the head to prevent scratching or damaging the head surface.
5. After removing all accumulated material, use a clean, dry cotton swab to remove alcohol residue and polish the head.
6. Plug the System power cord back into the power source, and turn ON the Graphic System power switch.

Packing Tapes

It is wise to cycle (wind and rewind) tapes periodically. This "packs" the tape, to keep the tape tension evenly adjusted and to prevent irregular stacking. This is especially important if only a portion of the tape is used repeatedly. It is also valuable if the tape has been dropped or has undergone a significant temperature change.

4052 and 4054 Systems. This operation is built into the 4052 and 4054. To cycle a tape, just insert it into the system and enter CALL "MTPACK" and press return. The tape will run out to the end and return.

4051 Systems. To cycle a tape on a 4051 Graphic System, remove the write protection and proceed as follows. This procedure is safe for data already on the tape.

```
FIND n
(n is the LAST file on tape)

    MARK 1,400000
      (large enough to
      reach the end of
      the tape without
      room for a LAST
      file)
```

The maintenance operations are simple to perform, and can help to keep your system looking its best, and operating its best as well.

4050 Series Graphic Computing System Publications

The following is a summary of all current manuals related to 4050 Series Graphic Computing Systems. The correct nomenclature and Tektronix part number are included.

Contact your local Tektronix office for prices, availability, and to order any of these publications.

Key to Titles

Operator's = operation instructions for hardware product.
Service = maintenance information.
Instruction = operation and maintenance combined.
User's = operation instructions for software product.
Reference = programmable features.

Standard

4050 Series Graphic Computing System Operator's	070-1940-01
4050 Series Graphic Computing System Reference	070-2056-01
Reference Guide to 4050 Series BASIC	070-2142-01
PLOT 50: Introduction Programming BASIC	070-2058-01
Introduction to Graphic Programming BASIC	070-2059-01

Options

4054 Option 30 Dynamic Graphics Operator's	070-2289-00
4054 Option 30 Dynamic Graphics Reference Guide	070-2586-00
4052 FO2 Four Slot ROM Backpack Instruction Sheet	070-2987-00

Service

4051 Graphic System Service Vol. 1	070-2065-00
4051 Graphic System Service Vol. 2	070-2286-01
067-0962-00 4051 Service ROM Pack Instruction	070-2988-00
067-0746-00 4051 System Test Fixture Instruction	070-2304-00
4052 Graphic System Parts and Schematics Service	070-2829-00
4054 Graphic System Parts and Schematics Service	070-2839-00
4052/4054 Graphic System Technical Data Service	070-2840-00
4054 Option 30 Dynamic Graphic Service	070-2601-00
067-0900-00 Diagnostic ROM Pack for 4052/4054 Instruction	061-1990-00
067-0902-00 4052/54 System Test Fixture Instruction	061-2224-00
067-0942-00 Personality Board for 4052/54 Instruction	061-2223-00
067-0943-00 Personality Board for 4054 Option 30 Instruction	061-2222-00
067-0969-00 Tape Head Alignment Module Instruction	070-3385-00

ROM Pack

4051R01 Matrix Function Operator's	070-2127-00
4051R05 Binary Program Loader Operator's	070-2171-00
4051E01 ROM Expander Instruction	070-2215-00
4050 Series RO6 Editor Operator's	070-2170-01
4050 Series RO7 Signal Processing ROM Pack No. 1 Instruction	070-2557-00
4050 Series R08 Signal Processing ROM Pack No. 2 (FFT) Instruction	070-2841-00
4052R09 Real Time Clock ROM Pack Instruction	070-3415-00
020-0614-00 4052 TAPE SEND Enhancement (ROM Pack)	070-3544-00

Interface

4051 Option 1 Data Communications	070-2066-01
4050 Series Option 10 RS-232 Printer Interface (4051F10/4052F10) replaces 070-2119-00	070-2908-00
4051 GPIB Hardware Support	070-2270-00
4051 GPIB Application Support	070-2307-00

Software

4050A01 PLOT 50 Statistics Vol. 1 User's	070-2809-00
4050A02 PLOT 50 Statistics Vol. 2 User's	070-2810-00
4050A03 PLOT 50 Statistics Vol. 3 User's	062-1856-00
4050A04 PLOT 50 Mathematics Vol. 1 User's	070-2776-00
4050A05 PLOT 50 Mathematics Vol. 2 User's	070-2777-00
4050A06 PLOT 50 Electrical Engineering Vol. 1 User's	062-2280-00
4050A07 PLOT 50 Graph Plot User's	070-2288-01
4050A08 PLOT 50 General Utilities Vol. 1 User's	070-2287-01
4050A09 PLOT 50 Business Planning and Analysis Vol. 1 User's	070-2226-01
4050A10 PLOT 50 Statistics Vol. 4 User's	070-2214-00
4050A11 PLOT 50 Business Planning and Analysis Vol 2. User's	070-2290-00
4050A12 PLOT 50 Business Planning and Analysis (Disc Version) User's	070-2888-00

4050B01 Modeling and Reporting System Option 05 Flexible Disc Version User's		070-2673-01
4050B01 Modeling and Reporting System (Tape Version) User's		070-2544-00
4050D01 PLOT 50 Easy Graphing Vol. 1 User's		070-2936-00
4050D01 PLOT 50 Easy Graphing Vol. 1 Reference Guide		070-2935-00
4050D02 PLOT 50 Statistics, Test and Distributions User's		070-3431-00
Peripheral		
4631	4631 Hard Copy Unit User's	070-1830-01
	4631 Hard Copy Unit Service	070-1831-02
4641	4641/4641-1 Character Printer Operator's	070-2110-00
	4641/4641-1 Printer Service	070-2111-00
4642-1	4642/4642-1 Printer Operator's	070-2486-01
	4642/4642-1 Printer Service	070-2489-00
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	4662 Interactive Digital Plotter User's	070-1932-01
	4662 Interactive Digital Plotter Service	070-1933-00
	067-0829-00 4662 Test Tape Operator's	070-2366-00
	Diagnostic Test Fixture Instruction	070-2564-00
4663	4663 Interactive Digital Plotter Reference Guide	070-2828-00
	4663 Interactive Digital Plotter User's	070-2670-00
	4663 Interactive Digital Plotter Service	061-1910-00
4907	4907 File Manager Operator's	070-2380-01
	4907 File Manager Operator's Pocket Reference	070-2381-01
	4907 Installation Guide	070-2493-00
	4907 File Manager Service	070-2405-00
	119-0977-00 Flexible Disc Drive Installation	070-2504-00
4923	4923 Service Manual	070-1909-00
	4923 Operator's Manual	070-1908-01
4924	4924 Digital Cartridge Tape Drive Operator's	070-2128-00
	4924 Digital Cartridge Tape Drive Service	070-2131-00
	4924 Reference Guide	070-2302-00
4952	4952 Joystick Option 2	070-2098-00
4956	4956 Graphics Tablet Operator's	070-2210-00
	4956 Graphics Tablet Service	070-2211-00

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