AN ENHANCEMENT TO THE TEKTRONIX PLOT-10 TERMINAL CONTROL SYSTEM FOR CREATION OF GRAPHICS METAFILES*

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Abstract: Many data handling and analysis codes at the Oak Ridge National Laboratory (ORNL) use the Tektronix PLOT-10 Terminal Control System to graphically display data upon Tektronix or Tektronix-emulating graphics devices. Prior to the development of the software libraries and postprocessors discussed within this report, ORNL users were limited to the type of hardcopy output obtainable from the Tektronix PLOT-10 software library. Only Tektronix graphics devices are supported by the PLOT-10 library. The graphics library presented here eliminates this restriction by implementing a suite of software that optionally creates a graphics metafile within the user's disk area while simultaneously drawing a display image on the screen of a user's Tektronix terminal. This graphics metafile can then be postprocessed onto any of the graphics devices at ORNL via the ORNL PLOT command.

Introduction

There are many complex, elaborate, and user-friendly graphics software libraries available to users of the National Magnetic Fusion Energy Computing Network (NMFECN), such as the DISPLA [1] and NCAR [2] graphics libraries. These well-documented graphics libraries are capable of producing report-quality graphics that can be included within documents with little or no manual intervention.

But there is a high overhead associated with using a graphics library capable of report-quality graphics. This overhead manifests itself in two major areas: (1) increased core requirements and (2) increased execution times. There is a place for report-quality graphics software; however, it does not belong in programs which graphically archive data acquired from some experimental diagnostic. Why should shaded character fonts be used when a simple stick font will suffice?

Such routine graphics tasks should be done by small, efficient graphics libraries. Because of its ease of use, small core requirement, and the availability of numerous Tektronix terminals at Oak Ridge National Laboratory (ORNL), many data handling and analysis computer programs use the Tektronix PLOT-10 Terminal Control System (TCS) [3] to graphically display data upon the screen of a Tektronix 401x series terminal or a Tektronix-emulating graphics device. However, prior to the development of the software library and postprocessors discussed within this report, ORNL users were limited to the type of hardcopy output obtainable from the Tektronix PLOT-10 software library. This restriction was overcome by implementing a suite of software that optionally creates a graphics metafile within the user's disk area while simultaneously drawing a display image on the screen of the user's Tektronix 401x series terminal. The name of this software library is TCSTKF [4]. The first three characters mnemonically represent the Terminal Control System, and the last three represent Tektronix character (K) file. The .TKF-formatted graphics metafile created by the TCSTKF software library is simply an exact duplicate of the ASCII decimal equivalent (ADE) character stream used by TCS to control the electron beam or write out characters on the screen of the terminal.

This concept was collectively conceived circa 1976 and has matured over the intervening years into a most useful and productive system which spans several computer architectures available on the NMFECN. This software library has been fully implemented on DECsystem-10, VAX 11/7xx, and INTERDATA 8-32 computer equipment. Partial implementations exist for PDP-11/xx and the CRAY-1.

The remainder of this report discusses the user interface to the TCSTKF graphics software library. (A user's guide, completely describing the FORTRAN calling sequences for this software, can be found in Ref. [4].)

User-Level TCSTKF Software

The TCSTKF software library can be used without modification to a user's FORTRAN program to automatically produce .TKF-formatted graphics metafiles. However, the following subprograms are available to permit control over the content of the graphics going to either the user's Tektronix terminal or into his .TKF-formatted graphics metafile.

The Tektronix display or the .TKF-formatted graphics metafile output can be selectively turned off or on. Optionally, a mode of execution is available that will allow the user to decide, after a display image has been drawn on a Tektronix screen, whether or not the Tektronix display image should be saved. Of course, transferring the display image to the permanent .TKF-formatted graphics metafile implies that the decision to do so will be made after the display image has been drawn, thus providing an interactive capability. Also available are subroutines to display a previously created .TKF-formatted graphics metafile while executing a FORTRAN program and to merge an ASCII file into a .TKF-formatted graphics metafile so that the resulting metafile will contain both plot and print output.

Graphics Display Device Control

These subroutines can be used to control the graphics display either on the screen of a Tektronix storage tube or in a .TKF-formatted graphics metafile. The first three characters of the subroutine name are either TEK or TKF, depending upon which graphics display the user wishes to control. The last characters are either ON or OFF, depending upon what a user wishes to do with his graphics display. Using this naming convention, the four subroutines are named TEKON, TEKOFF, TKFON, and TKFOFF. None of these four subroutines requires any arguments.

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In all cases, calling one of these subroutines will first cause the internal TCS output buffer to be sent to all graphics devices active before the call was made. After this I/O has been performed, the appropriate switch is set to control the requested graphics display.

Graphics Display Device Status

A facility has been provided to allow the user to examine the status of the TEK and TKF ON/OFF switches. It was determined that interactive programs need to be able to take action depending upon whether a specific graphics display has been turned on or off. For example, if the Tektronix terminal is currently being used as an output device, then a user generally would like to be able to pause to view the display image between drawing the display image and erasing the page in preparation for the next display image. If the Tektronix terminal is not being used as an output device, then a pause is generally unnecessary. The following two subprograms examine the TEK and TKF ON/OFF switches and return the corresponding logical value, depending upon whether or not the display is in use.

Logical function GTSTEK returns the logical value of the Tektronix ON/OFF switch. If the value returned for this function is true, then graphics output can be transmitted to the user's terminal. If the value returned for this function is false, then graphics output to the user's terminal is suppressed.

Logical function GTSTKF returns the logical value of the .TKF-formatted graphics metafile capability. If the value returned for this function is true, then graphics output can be transmitted to the user's .TKF-formatted graphics metafile. If the value returned for this function is false, then graphics output to the user's .TKF-formatted graphics metafile is suppressed.

Software for Selective Saving of Plots

For the interactive user, another option is provided by the TCSTKF software library. Instead of having to place all display images into the .TKF-formatted graphics metafile, control is possible for selectively deciding, after a display image has been drawn, whether or not to transfer the display image to the permanent .TKF-formatted graphics metafile. The three subroutines described in this section implement this control.

The full capabilities of the TCSTKF software library can be used by initializing the subprogram package with a call to logical function INITKF instead of to the TCS subroutine INITT. (Among other functions, subroutine INITKF calls TCS subroutine INITT for the user.) There are two arguments: a .TKF-formatted graphics metafile specification and a logical variable to set the prompt switch. The file specification is the location and name of the .TKF-formatted graphics metafile to be created. The prompt switch argument should be true if the user wishes to activate subprogram FINPAG for an individual .TKF-formatted graphics-metafile-saving option. This facility allows the user to decide after a display image is plotted on the Tektronix storage tube (but during execution of his program) whether or not to place the display image in the permanent .TKF-formatted graphics metafile for subsequent postprocessing. If no interactive individual display image saving is required, then the value of the prompt switch argument should be false.

The TCS software does not provide for a pause between the finish of a display image, the erasure of the screen, and the commencement of a new display image. Logical function FINPAG allows the user time to assimilate the information in a display image by pausing until the user strikes any character on the terminal keyboard (unless he has previously turned the Tektronix terminal off by calling subprogram TEKOFF or unless the program is being executed by the batch controller).

If the logical function INITKF has been called to set up prompting for .TKF-formatted graphics metafile selective display image saving, then a call to logical function FINPAG will query the user with a prompt and wait until a single character is typed from the terminal. A response of N (upper or lower case) will cause the temporary .TKF-formatted graphics metafile to be discarded and reinitialized without transfer to the permanent .TKF-formatted graphics metafile. Any response other than N will be interpreted as positive, causing the temporary .TKF-formatted graphics metafile to be transferred automatically to the permanent .TKF-formatted graphics metafile. After the successful transfer of the display image data, the screen will be erased and program control will be returned to the calling subprogram.

Naturally, if the TKF ON/OFF switch has been turned off, then no transfer will be performed, regardless of a positive response to the prompt. Also, if the TEK ON/OFF switch has been turned off, then no prompt will be made and the temporary .TKF-formatted graphics metafile (if present) will be transferred to the permanent .TKF-formatted graphics metafile.

Logical function TEKPMT may be used to change the statement displayed during execution when the user decides if the display image should be transferred from the temporary .TKF-formatted graphics metafile into the permanent .TKF-formatted graphics metafile. Optionally, subprogram TEKPMT may be used to turn off user interaction completely after processing a display image so that future calls to subroutine FINPAG do not require the user to decide about display image transfers.

FORTRAN-Callable Software for Display of .TKF-Formatted Graphics Metafiles

Certain users have found it convenient to pregenerate .TKF-formatted graphics metafiles containing complex grid labels or other display images that can then be displayed or overlayed onto a new display image. The subprogram TKFTEK provides this capability for the TCSTKF software and is described in the following section.

Logical function TKFTEK can be used to display an existing .TKF-formatted graphics metafile on the user's Tektronix terminal. Optionally, this file can be simultaneously copied into another .TKF-formatted graphics metafile. The subroutines TEKON, TEKOFF, TKFON, and TKFOFF can be used to control the output of the .TKF-formatted graphics metafile in the same manner as they are used to control user-program Tektronix character output.

FORTRAN-Callable Software for Merging Print Output into .TKF-Formatted Graphics Metafiles

The three subprograms presented in this section easily permit inclusion of ASCII print data files directly into a .TKF-formatted graphics metafile.

Essentially, all three subprograms perform the same function. However, they differ with respect to the amount of control the user wishes to have over the ASCII file that is to be merged and the resulting character size for the merged, printed characters. The great advantage to using these subprograms is that the user is free to create the included ASCII files by whatever means available, instead of having to rely solely upon the limited text-string-handling capabilities of the TCS software.

Logical function DATTKF can be used to merge the ASCII print file FOR24.DAT into a previously opened .TKF-formatted graphics metafile. The steps that subprogram DATTKF uses to perform this transfer are described below.

(1) First, FORTRAN logical unit number 24 is closed.

(2) The current TCS and TKF status variables are saved.

(3) Calls to the subroutines TEKOFF and TKFON are made.

(4) The TCS subroutine ANMODE is called to place the .TKF-formatted graphics metafile into the alphanumeric mode.

(5) If a new page has been requested, then calls to the TCS subroutine NEWPAG and HOME are made. If not, these calls are bypassed.

(6) Subprogram TKFTEK is used to transfer the file FOR24.DAT into the currently open .TKF-formatted graphics metafile.

(7) The file FOR24.DAT is deleted. This feature permits FORTRAN logical unit number 24 to be used over and over again without the user having to concern himself about the position of the next write instruction into this file. Because this subprogram deletes FOR24.DAT, FOROTS [5] will always open a new FOR24.DAT file, initialized for sequential output, the next time FORTRAN logical unit number 24 is referenced.

(8) The final step is to restore the TCS and TKF status variables.

This subprogram yields 74 characters per line and 35 lines per page before a TKF postprocessor begins to wrap around the printed characters. These characters are written into the .TKF-formatted graphics metafile, and not drawn. Therefore, the resulting .TKF-formatted graphics metafile size is kept to a minimum.

The only difference between logical functions DATTKF and DASTKF is that the latter's character size for the merged ASCII characters can be specified, thus emulating the capability for variable character sizes of a Tektronix 4014/15 series storage tube terminal.

Logical function DAFTKF differs from DATTKF and DASTKF with regard to specification of the ASCII file to be merged. With the previous two logical functions, it was implicitly assumed that the file FOR24.DAT was to be merged. This logical function determines the file to be merged from the arguments to the subprogram.

Modified TCS Software and Other Subprograms

This section describes several modified TCS subroutines, as well as several miscellaneous subprograms, used by the TCSTKF software library. Modifications required to implement this software into the TCS suite of subroutines involved changing the initialization, termination, output, and timing subroutines of TCSTEK. Other subroutines in this section deal with requesting TCS to send its internal character buffer to a graphics device. Also, a subprogram is presented that initializes the TEK ON/OFF switch to ON, except when the batch controller (BATCON) is controlling the user's job (in which case the TEK ON/OFF switch is turned off).

Modifications to TCS Initialization and Termination Software

Two subroutines of the TCSTEK software library have been augmented to allow automatic creation of .TKF-formatted graphics metafiles without requiring modifications to a user's FORTRAN source code. These are subroutines RESET and FINITT. Subroutine RESET is called by the TCS subroutine INITT to reset several of the important variables in common block /TKTRNX/. Subroutine FINITT is called to terminate a Tektronix graphics display.

The TCS subroutine RESET has been augmented to include a call to logical function OPNTKF. This call is made the first time subroutine RESET is called, usually by subroutine INITT. Subsequent calls to subroutine RESET do not generate calls to logical function OPNTKF. Therefore, a user can interchange the TCSTKF and the TCSTEK software library without changing a single line of FORTRAN code. (The default file name used by subroutine RESET when it calls logical function OPNTKF is FOR24.TKF. This name was chosen for consistency with other graphics packages on the FED DECsystem-10, but this does not imply that FORTRAN logical unit number 24 is used by the TCSTKF software library.)

The TCS subroutine FINITT has been augmented to make a call to logical function CLSTKF to close the .TKF-formatted graphics metafile. Therefore, assuming that the user has included both a call to subroutine INITT and FINITT in his source code, he can switch between the TCSTEK and TCSTKF software libraries without any alterations to his FORTRAN source code. A .TKF-formatted graphics metafile either will or will not be created, depending upon which software library the user loads with his program.

The .TKF-Formatted Graphics Metafile - Opening and Closing Software

So that the TCSTKF software library does not interfere with a user's FORTRAN logical unit number assignments, the FOROTS subroutines ALCHN. and DECHN. [5] are used to obtain and to release a disk I/O channel number, respectively. It is not necessary to preallocate a FORTRAN logical unit number when using the TCSTKF library. This will be done automatically — just as FOROTS does for a user's FORTRAN source code.

The purpose of logical function OPNTKF is to open a .TKF-formatted graphics metafile. If a .TKF-formatted graphics metafile is already open, then a warning message is printed and the error branch is taken.

The purpose of logical function CLSTKF is to close the currently open .TKF-formatted graphics metafile. If there are characters in the internal TCS buffer, they are output before the file is closed.

Rewritten TCS Output and Timing Software

The essence of the TCSTKF software library capability is the augmented functioning of subroutine ADEOUT, an installation-dependent subprogram for writing ADE characters to the user's terminal [6]. This subprogram has been augmented to transmit the same ADE characters to a disk file and to the terminal. Also, subprogram SLP, the TCS subroutine that controls the page-refresh timing delay, has been modified to prevent I/O delays under certain conditions.

The function of subroutine ADEOUT is to optionally send ADE characters to the Tektronix terminal and/or .TKF-formatted graphics metafile, depending upon true values of the TEK and TKF ON/OFF switches, respectively. This subroutine replaces a similarly named subroutine in the TCSTEK software library.

The Tektronix storage tube must have time to refresh after a new page operation so that graphics output will not be lost. This is accomplished by putting the program to sleep. The version of subroutine SLP in the TCSTEK software library unconditionally puts the user's program to sleep. However, the version of subroutine SLP in the TCSTKF library will conditionally put the user's program to sleep only if the TEK ON/OFF switch is on. If the TEK ON/OFF switch is off, then Tektronix terminal display is not available, the timing problem does not exist, and therefore there is no reason to delay the program's execution.

Other Miscellaneous Subroutines

A call to subroutine APNTKF will cause subsequent display images to be appended to an existing .TKF-formatted graphics metafile instead of creating a completely new .TKF-formatted graphics metafile. If the specified .TKF-formatted graphics metafile does not exist, it is not an error. In this case the subroutine call is ignored and a new .TKF-formatted graphics metafile is created.

Subroutine NOTKF will prevent a .TKF-formatted graphics metafile from being opened by any of the file-opening routines. By calling this subroutine before any other graphics subroutines, the TCSTKF software library becomes equivalent in external function to the TCSTEK software library.

Subroutine SNDTKF's function is to force out to disk the current .TKF-formatted graphics metafile character buffer. In general, this routine should never be called by the user.

Subroutine CTSEND's function is to check the presence of ADE characters remaining in the internal TCS character buffer. If there are any ADE characters remaining, then the TCS subroutine TSEND is called to send these characters to the graphics devices and reinitialize the internal TCS character buffer.

Subroutine TEKBAT's function is to determine if BATCON is controlling the user's job. If so, then the TEK ON/OFF switch is turned off. This subroutine effectively prevents the user from inadvertently turning on the TEK ON/OFF switch, even if a call to subroutine TEKON is made while the program is being executed under BATCON.

Postprocessing .TKF-Formatted Graphics Metafiles

Once a .TKF-formatted graphics metafile has been created in the user's disk area, the PLOT command can be used to create display images on several types of graphics devices at ORNL. The following example demonstrates how to postprocess a .TKF-formatted graphics metafile and produce plots on the Versatec printer/plotter connected to the FED DECsystem-10:

```
.PLOT VER:=FOR24.TKF
```

There are other postprocessing alternatives. The following list presents a subset of the currently valid set of PLOT command plotting devices.

ADM	Lear-Siegler ADM-3A with retrographics to emulate a Tektronix 4010 series terminal
TEK	Tektronix 401x series terminal
T4027	Tektronix 4027 series terminal
TV:n	TV is the PLOT command mnemonic representation for a Graphics User's Service Station (GUSS) television monitor. The value of n represents the particular GUSS TV number the user desires his display images plotted on.
VT100	DEC VT100 with retrographics to emulate a Tektronix 4010 series storage tube terminal
V10	Versatec printer/plotter connected to FED DECsystem-10
APL	Applicon color ink jet drum plotter
C1036	CalComp 925/1036 pen and ink drum plotter physically located at the Oak Ridge Gaseous Diffusion Plant (ORGDP)
C1055	CalComp 925/1055 pen and ink drum plotter physically located at ORNL
FR80	Information International, Inc. FR80 precision microfilm recorder
V36	Versatec printer/plotter at ORNL or ORGDP that is 36 in. wide (uses type 500 paper)

For a complete description of the capabilities of the PLOT command, see Ref. [7].

To obtain a copy of the file BEST.TKF on the FR80 at ORGDP using 105-mm microfiche, a special command is available. By typing

```
.FICHE BEST.TKF
```

a request will be generated to a locally written post-processor to spool the .TKF-formatted graphics metafile to a special area. No further action is required by the user. Periodically, the system operator creates a tape that contains all the spooled FR80 requests. Eventually, the requested microfiche is returned to the user's DECsystem-10 output box.

References

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[5] Digital Equipment Corp., DECsystem-10 FORTRAN Programmer's Reference Manual, Maynard, Mass., June 1977, Appendix D.

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