# Using Personal Computers as Host Graphics Devices

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## ABSTRACT

This paper discusses numerous alternatives for using personal computers to display, save, and produce hardcopy of graphs created on remote hosts. Topics discussed include terminal emulation, cooperative processing, and transferring graphics catalogs and files.

## INTRODUCTION

The personal computer has become a standard piece of equipment in most offices and many homes. In addition to serving as a stand-alone platform for running applications, the personal computer is used extensively as a method of remote access to mainframes, minicomputers, and workstations. As a result, SAS® software users find it increasingly necessary to run SAS applications on remote computers and display the output on a personal computer or on a hardcopy device attached to a personal computer.

This paper will discuss different methods for using an IBM® Personal Computer, IBM PS/2®, or Apple Macintosh to display, save, and produce hardcopy of graphs produced by SAS/GRAPH® software running on remote computers. Alternatives to be discussed include SAS/CONNECT™ software, terminal emulators (including SAS/RTERM® software), and downloading of graphics stream files.

## WHY USE PERSONAL COMPUTERS AS HOST GRAPHICS DEVICES?

Using personal computers to display and process host graphics can save computing resources and provide capabilities that might not be available through the use of terminals and hardcopy devices attached to the remote host. Some of the advantages are described below:

- Using personal computers can eliminate the need to purchase terminals that can only be used with the host system. Using a personal computer with terminal emulation software provides the resources of both a personal computer and a terminal, at a much lower cost than two separate pieces of equipment.

- PCs can be more versatile than terminals. With some terminal emulators, you can run other PC applications while communicating with a host. Using a multi-tasking environment such as OS/2® or Windows provides even more power and flexibility.

- Users have more options with which to allocate computing resources. Depending on your application and hardware, you may find it advantageous to move much of the processing from a remote computer to your PC. Alternatively, you have the option of using the remote computer to process large applications that would take a great deal of time on the PC, and then displaying the results on your PC.

- In many instances, devices that can produce hardcopy graphics are connected to a personal computer or a network and cannot be accessed directly from the host. In these cases, you can transfer graphics from the host to your PC and send them to the hardcopy device.

- You can use software that is not available on the host computer. For example, you can create a graph on a host and transfer the output to a word processing, graphics, or desktop publishing package on your PC.

These are only a few of the reasons for using your PC as a host graphics tool. Whatever the reason for doing so, it is clear that virtually any SAS software user can benefit from a PC-host connection.

## STRATEGIES FOR DISPLAY OR HARDCOPY OF HOST GRAPHICS

There are several different methods by which you can generate SAS/GRAPH output on a host computer and then display, save, and produce hardcopy using your PC. The following methods will be addressed in this paper:

- using SAS/CONNECT software

- using IBM 3270 terminal emulation software and hardware (IBM mainframes only)

- using Asynchronous (ASCII) terminal emulation software

- using X Windows emulation software (UNIX and VMS hosts)

- downloading and transferring files to PC applications

- downloading and transferring files to a hardcopy device attached to a PC.

## USING SAS/CONNECT SOFTWARE

SAS/CONNECT software gives you the capability of using either your PC or host, or a combination of both, to produce graphics output. To use SAS/CONNECT software to display host graphics, you must have SAS/GRAPH software available both on your host and your PC. With SAS/CONNECT software, you can start a SAS session on your personal computer, and from that session access a remote host and start up a SAS session there. You can then use the SUBMIT command to submit SAS statments to the SAS session running on your PC, or use the RSUBMIT command to submit SAS statements to the session running on your host. Output from the session running on your host can be displayed on your PC monitor. You can also use SAS/CONNECT software to transfer SAS data sets, raw files, and catalogs between your host and PC.

### Graphics Capabilities of SAS/CONNECT Software

For displaying and producing hardcopy graphics, SAS/CONNECT software gives you the following options:

- Submit statements to a SAS session running on your PC to have the local session generate graphics display or hardcopy.

- Submit statements to a SAS session running on your host, and have output sent directly to a device attached to your host.

- Submit statements to a SAS session running on the host, and have the graph displayed on your PC monitor or hardcopy device. with the option of saving the graph on your PC.

- Download a graphics catalog from the host to your PC. You can then display the graphs on your PC monitor or send them to an attached hardcopy device.

Which of the above options you choose depends on such factors as where the data used for the graph reside, where your hardcopy device is located, and the availability of other resources such as

time and processing power. The last two options provide the most flexibility and take best advantage of the capabilities of your host and PC. They are discussed in more detail in the following sections.

## Displaying Host Graphics and Producing Hardcopy

Transfer and display of hardcopy graphics with SAS/CONNECT software are done through the use of the GRLINK device driver. The GRLINK driver is a special driver that is supplied with SAS/GRAPH software on all host systems. Unlike other drivers which display and produce hardcopy graphics automatically, the GRLINK driver sends a stream of data from the host to your personal computer, where routines and drivers on the PC use the data to create a catalog entry on the PC and either display the graph or send it to a hardcopy device. SAS/CONNECT software can be used through an asynchronous connection to your host, or with a variety of 3270 emulators. The following sections explain how to use the GRLINK driver.

## Using the GRLINK driver to display graphs

With SAS/CONNECT software, you can use the following steps to run a SAS/GRAPH procedure on a remote host and display the graph on your PC monitor:

* Log on to your host computer using communications software and/or hardware available on your PC.

* Exit or hot key to DOS (in the OS/2 or Windows environment, open another window).

* Invoke the SAS System on your PC.

* From the SAS session running on your PC, use a script file to issue the SIGNON command to establish the link between your PC and host and to start a SAS session on the remote host. Refer to *SAS/CONNECT Software: Usage and Reference, Version 6, First Edition* for details on establishing the connection between a local and remote host.

* Use the RSUBMIT command to submit the following statement to the SAS session running on the host:

    goptions device=grlink;

* From the SAS session running on your PC, submit the following statements where *drivername* is the SAS/GRAPH driver for your monitor or attached hardcopy device:

    goptions device=*drivername*;

    For example, if your PC has a VGA adapter and you want to display the host graph on your monitor, under PC DOS you can specify:

    goptions device=vga;

    while under OS/2 you can specify:

    goptions device=pmvga;

* Use the RSUBMIT command to submit your SAS statements to the host to create the graph. When the SAS/GRAPH procedure runs on the host, the output is displayed on your PC monitor.

## Using the GRLINK driver to produce hardcopy

To use the GRLINK driver to send host graphics output directly to a hardcopy device attached to your PC, follow the steps listed in the previous section. However, instead of specifying the device driver for your display adapter in the SAS session running on your PC, specify the driver for your hardcopy device. For example, if you want output from a graphics procedure running on your host to be sent directly to a Hewlett-Packard Laserjet Series II printer attached to your PC, submit the following statement to the SAS session running on your PC:

    goptions device=hplj300;

In this case the graph is sent directly to the printer and is not displayed on your screen.

## Saving and Redisplaying Graphs on Your PC

The process by which the GRLINK driver generates a graph on your PC screen or hardcopy device actually has two stages. First, graphics data are sent from the host to the PC and stored on the PC as a graph in the catalog WORK.GSEG. Then the driver you specify in the SAS session running on the PC reads the graph from the catalog and either displays it on your screen or sends it to a hardcopy device, depending on the driver specified. The graph that is stored in the WORK.GSEG catalog is just like any other graph you create with SAS/GRAPH software. This means that you can use the GREPLAY procedure on your PC to save it to a permanent catalog, redisplay it on your screen, send it to a hardcopy device, or send it to a graphics stream file.

Suppose you have used the GRLINK driver on the host and the VGA driver on your PC to run the GPLOT procedure on your host, displaying the output on your VGA monitor. You can then use the following statements in the SAS session running on your PC to save the graph to a permanent catalog (PERM.GRAPHS) and then replay the graph to a PostScript printer attached to your PC:

    libname perm ' ';
    proc greplay nofs igout=work.gseg gout=perm.graphs;
    copy gplot;
    device ps;
    replay gplot;

You can specify the name of the graph to be placed initially in the WORK.GSEG catalog by using the NAME= option when you run PROC GPLOT on your host. If you do not specify a name, the SAS System uses the name of the procedure (GPLOT in this case), and appends a number to the name for subsequent graphs generated by the same procedure (GPLOT1, GPLOT2, and so on).

Note that you can use PROC GREPLAY in your PC session to replay graphs even if you are no longer connected to the host. However, because the WORK.GSEG catalog is deleted when you end the SAS session on your PC, you should move the graph to a permanent catalog if you want to replay it in a later SAS session.

## Transferring Graphics Catalog Entries with SAS/CONNECT Software

You can also transfer graphics catalog entries from the host to your PC without displaying the graph or sending it to a device. The method you use depends on what releases of the SAS System you are running on the host and your PC.

If you are running Release 6.06 or a later release on both your PC and host computer, you can use the DOWNLOAD procedure to transfer catalogs. Suppose you want to transfer the graphs from the catalog HCAT.GRAPHS on your host to the catalog PCAT.GRAPHS on your PC. First, use the SUBMIT command to submit the following statement to the SAS session running on your PC:

    libname PCAT 'PC-SAS-data-library'

Then submit the following statements to your host session to specify the host catalog and download the catalog members:

    libname HCAT 'host-SAS-data-library'
    proc download incat=hcat.graphs outcat=pcat.graphs;

If you are running Release 6.06 of the SAS System on your host, you must download the entire catalog; you cannot download individual graphs. If you are running Release 6.07 of the SAS System on the host, you can use the SELECT statement with PROC DOWNLOAD to download individual graphs from a catalog.

If you are running a release prior to 6.06 on either your PC or host, you cannot use PROC DOWNLOAD to transfer graphics catalogs.

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Instead you must use the GRLINK driver in conjunction with PROC GREPLAY. Suppose you want to transfer all of the graphs from the catalog HCAT.GRAPHS on your host to the catalog PCAT.GRAPHS on your PC, and you want to view them as they are downloaded. First, use the RSUBMIT command to submit the following statements to your host:

    libname HCAT 'host-SAS-data-library'
    goptions device=grlink;

Then submit the following statements to the SAS session running on your PC:

    libname PCAT 'PC-SAS-data-library'
    goptions device=drivername nodisplay;

where *drivername* is the driver for the device you ultimately intend to display the graphs on after they are downloaded. Then use the RSUBMIT command to submit the following statements to the host:

    proc greplay igout=hcat.graphs;
    replay _all_;

The graphs will be transferred from the catalog HCAT.GRAPHS on the host to the temporary catalog WORK.GSEG on your PC. You can move them to a permanent catalog (PCAT.GRAPHS) by submitting the following statements to the SAS session running on your PC:

    libname pcat ' ';
    proc greplay nofs igout=work.gseg gout=pcat.graphs;
    copy _all_;

Once you have transferred graphics catalog entries to your PC, you can use PROC GREPLAY to replay them on any device supported by SAS/GRAPH software.

## IBM 3270 TERMINAL EMULATION

IBM 3270 emulation packages enable you to use your personal computer or Macintosh as an IBM 3270-type terminal when connected to an IBM mainframe computer. The most commonly emulated terminals are IBM 3278, 3279, and 3179 models.

### Hardware and Software Requirements for 3270 Emulators

Emulation of a 3270 graphics terminal requires the following components:

* hardware to provide a physical connection between the PC and host

* emulation software on the PC to process 3270 text screens

* graphics emulation software to interpret and display 3270 graphics streams

* correct configuration of communications software and hardware on the host to support graphics streams.

Some emulation packages provide the first 3 components in a single package. Others consist of software designed to be used with already-present 3270 hardware. Still others provide only the graphics emulation, designed to be used with hardware and 3270 text emulation software already residing on the PC or network.

### Physical connection to the host

With 3270 emulation, your PC can be either directly connected to a 3174 or 3274 control unit or connected to a network gateway, which in turn is connected to the host. Direct connection requires the installation of a 3270 communications board in your PC; a coaxial cable connects the PC with the control unit. In a network environment, the PCs in the network are connected to a PC serving as a network gateway. The gateway is in turn connected to the host computer.

### Software requirements

The emulation software processes the 3270 data stream sent from the host and formats it to display on your PC monitor. In order to display host graphics on a PC with a 3270 emulation package, the package must emulate a **graphics** terminal. Many packages provide emulation only of a 3278 or 3279 text terminal, and thus do not provide host graphics capabilities. If a 3270 emulation package provides graphics support, it is typically through emulation of an IBM 3179G or 3279G terminal. Packages that provide IBM 3279 emulation use Programmed Symbols (a bit-mapped based technology) to produce graphics, while those that provide IBM 3179 emulation use All-Points-Addressable (vector) graphics. The following packages for IBM personal computers emulate an IBM 3179 terminal, using vector graphics:

* IBM GDDM-PCLK

* IBM GDDM OS/2-Link

* Attachmate EXTRA!, with Host Graphics Option (HGO)

* IRMAX, IRMAlan, or IRMAremote with DCA 3270 APA Graphics

* IRMAcom APA Graphics Package

* Novell-CXI PCOX APA package

* Novell Netware 3270

* Zephyr Development Passport APA or GRAPH-TEK APA

* Wall Data RUMBA Graphics.

The following are among the Macintosh packages that emulate an IBM 3179 terminal:

* MacIrma Graphics

* TN3270.

The following packages for the IBM PC provide IBM 3279 emulation, using programmed symbols:

* IRMAX PS Graphics Package

* IRMA 3279 Graphics Package

* FORTE/GRAPH PC

* Attachmate EXTRA! with Host Graphics Option (HGO).

The above lists represent some of the more popular emulation packages. For a complete list of 3270 emulation packages, along with details on their hardware requirements and capabilities, contact the Technical Support Division at SAS Institute.

### Host requirements

Once you have installed the appropriate hardware and software on your PC, you must make sure that the PC is properly defined to ACF/VTAM® or VM as a graphics terminal. The IBM 3274 or 3174 control unit to which the PC or gateway is connected must also be configured to support graphics. Refer to the SAS/GRAPH installation instructions for details on host communications software definitions and control unit configuration.

Some of the packages listed above, such as GDDM-PCLK, GDDM OS/2-Link, and GRAPH-TEK APA, require that IBM's GDDM product be installed on the host computer for display and hardcopy support. In addition, these packages may require special definitions in the GDDM ADMDEFS file. Refer to the documentation for your emulation package for specific instructions.

### Using 3270 Emulation Packages

In addition to displaying host graphics on your PC monitor, many 3270 emulation packages provide the ability to print or plot the graph on a hardcopy device attached to your PC, save the graph on disk, and either redisplay the graph or send it to a hardcopy device after you have disconnected from the host.

To display SAS/GRAPH output on your PC monitor using a 3270 emulation package, specify the driver for the terminal that the package emulates, usually IBM3179 or IBM3279. For packages that require an interface with GDDM, use the GDDMPCG driver for 3179 emulation and the GDDM79 driver for 3279 emulation. If you do not specify a driver and the GWINDOW option is in effect, SAS/GRAPH software will select the appropriate driver and use it to display the graph in a GRAPH window. If you encounter problems displaying SAS/GRAPH output using the IBM3179 or IBM3279 drivers with an emulator, an alternative is to use the GDDM79 driver (for IBM 3279 emulation) or the GDDMPCG driver (for IBM 3179 emulation). Note that these GDDM drivers do not support GRAPH windows or the SAS/GRAPH Graphics Editor.

Many 3270 emulation packages provide hardcopy support, enabling you to send the output to a printer or plotter attached to the PC after it is displayed on the screen. For most packages you produce hardcopy by pressing a function key while the graph is displayed. Pressing the function key will either cause the graph to be immediately plotted or printed, or will bring up a menu where you can specify where the output is to go.

Many packages also provide the ability to save a graph on disk, often as a Picture Interchange Format (PIF) file. The file can then be either redisplayed or sent to a hardcopy device, even after you disconnect from the host.

### Using SAS/RTERM Software with IBM 3270 Emulation Packages

SAS/RTERM software is a multi-purpose graphics emulation package that runs under DOS and can be either used to provide asynchronous terminal emulation (to be discussed in a later section) or used with with non-graphics 3270 emulation packages to display host graphics on your PC monitor and send graphs to a plotter or printer attached to your PC. Note that use of SAS/RTERM software does not require that you have SAS software on your PC. Like most of the 3270 graphics emulation packages described above, SAS/RTERM software gives you the capability to save graphs to disk, redisplay them, and send output to a hardcopy device, without being connected to the host. 3270 text emulation packages supported by SAS/RTERM software include

- IRMA E78
- Attachmate EXTRA!
- IBM 3270 Workstation Program
- RabbitSTATION Coax
- IBM PC3270 Emulation Program, Entry Level.

To use SAS/RTERM software with a 3270 emulator, first invoke the control program for your emulator. Then invoke SAS/RTERM software and (optionally) progress through a series of menus that configure SAS/RTERM software for the hardware and software you are using. Then use your 3270 emulation package to log on to your mainframe and invoke a SAS session there. In your SAS session, specify the appropriate device driver and run a SAS/GRAPH procedure. When the procedure produces a graph, you will be prompted to hot key to your DOS session, where the graph is displayed. From here, you can press function keys to send the graph to an attached printer or plotter, or save the graph on disk. After you have finished viewing (or printing or saving) the graph, you can hot key back to your host session.

A special set of drivers is supplied with SAS/GRAPH software for use with SAS/RTERM software. For details on using SAS/RTERM software, refer to the *SAS/RTERM User's Guide, Version 2.*

## ASYNCHRONOUS TERMINAL EMULATION

Asynchronous terminal emulation packages can be used to make your PC emulate an asynchronous terminal. Most packages provide emulation of either a Digital VT-series, Tektronix, or Hewlett-Packard terminal. Asynchronous emulators can be used to access ASCII-based systems, such as a VMS or UNIX system. They can also be used to access IBM mainframes, either in line mode or through a protocol converter. Typically, connection to the host is through a modem (either internal or connected to a serial port) or a network gateway. The following sections discuss use of asynchronous emulators from other companies and the use of SAS/RTERM software.

### Emulation Software from Other Vendors

In order to display host graphics, terminal emulation software must emulate a **graphics** terminal. Packages which emulate text-only terminals, such as a Digital VT100 or VT220, cannot display host graphics. Graphics terminal emulators typically emulate either a Digital VT240 or VT340; Tektronix 401x, 41xx, or 42xx; or Hewlett-Packard 2397 terminal. Some of the popular eumlation packages for IBM PCs that can be used with SAS/GRAPH software are

- Kermit
- REFLECTION
- SmartTerm
- ZSTEM
- EM4010 and EM4105
- EmuTEK
- TGRAF.

Terminal emulation products for Macintosh computers that can be used with SAS/GRAPH software include

- REFLECTION
- TGRAF
- Versaterm Pro
- MAC241.

When using SAS/GRAPH software with an asynchronous terminal emulator, you use the same device driver that you would if you were using the terminal that the package emulates (such as VT340 for VT340 emulation). In some cases (usually with Tektronix 401x emulation) you may need to specify values for the GPROLOG or GEPILOG option to place the emulator in and out of graphics mode. If you are accessing an IBM mainframe through a protocol converter, you will also need to specify the GPROTOCOL= option. Refer to the SAS help facility, or *SAS/GRAPH Software: Using Graphics Devices* for more details on using the GPROTOCOL option.

As with 3270 emulators, you may encounter problems using SAS/GRAPH software with products whose emulation is not totally complete. Some typical problems include incorrect colors or sizing on the graph, problems switching to and from graphics mode, or incorrect colors or stray characters on the screen when returning to text mode. Many of these problems can be corrected by modifying such parameters as HSIZE, VSIZE, GPROLOG, GEPILOG, HANDSHAKE or the color list in the device catalog entry for the driver being used. Contact the Technical Support Division at SAS Institute for information on correcting problems with specific emulators.

Many asynchronous emulators provide the ability to produce hardcopy graphics on a printer or plotter attached to your PC. The specific hardcopy devices supported, hardcopy resolution, and method of producing hardcopy vary from product to product.

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Typically you generate hardcopy by pressing one or more function keys after the graph is displayed. Pressing a key will either immediately send a copy of the graph to the hardcopy device, or bring up a menu where you can set parameters and then send output to the device.

With many packages, you can also save a copy of the graph on disk and later replay the graph or send it to a hardcopy device. Some packages can save the file in a format that can be exported to PC graphics packages, where you can edit the graph or include it in a document.

### Using SAS/RTERM Software for Asynchronous Terminal Emulation

Like the packages mentioned in the previous section, SAS/RTERM software can be used to make your PC emulate a host graphics terminal. In addition to providing Tektronix 4105 graphics emulation and VT100 text emulation, SAS/RTERM software can be used to transfer files, produce hardcopy graphs on plotters or printers attached to your PC, and save graphs on disk for later redisplay or hardcopy. Use of SAS/RTERM software does not require that you have SAS software installed on your PC.

You use SAS/RTERM software to display host graphs as you would any other terminal emulation package. After invoking SAS/RTERM software, you (optionally) progress through a series of configuration screens, and then establish a connection to the host. You can then invoke the SAS system on your host and display graphics on your PC monitor by running a SAS/GRAPH procedure and specifying the appropriate driver. A special set of SAS/GRAPH drivers is available for use with SAS/RTERM. The driver you use depends on the type of graphics adapter you have on your PC and what (if any) type of hardcopy device you are using. If you are accessing an IBM mainframe through a protocol converter you may also need to specify the GPROTOCOL= option. Refer to the SAS help facility or *SAS/GRAPH Software: Using Graphics Devices* for more details on using the GPROTOCOL option.

After displaying a graph on your PC monitor, you can send the graph to a printer or plotter attached to your PC by pressing a function key. You can also save the graph on disk and either redisplay the graph on your screen or send it to a hardcopy device. You can also use SAS/RTERM software to transfer files to and from the host using Kermit, XMODEM, or simple ASCII file transfer. For details on using SAS/RTERM software, refer to the *SAS/RTERM User's Guide*.

## X WINDOWS EMULATION

Several packages are now available that provide X Windows emulation on IBM Personal Computers, IBM PS/2 systems, and Macintosh computers. These emulators are normally used in a network environment, where Ethernet connections provide the speed necessary to transfer the large amounts of data required by X Windows displays. You can use X Window emulators to display SAS/GRAPH output produced on VMS and on UNIX systems and their derivatives.

When using an X Windows emulator, you display graphs just as you would with an X Windows display attached to the host. In most cases, you do not have to specify a device driver in your SAS/GRAPH programs; the XCOLOR or XBW driver (depending on whether you have a color or monochrome display) is used automatically.

## DOWNLOADING AND TRANSFERRING FILES TO PC APPLICATIONS

In some cases you may find it useful to create a graph on a host computer, download the graph, and process it on your PC with a graphics, desktop publishing, or word processing package. This approach can be useful if

- you want to send output to a device that is not supported by SAS/GRAPH software

- you want to edit the graph, but are running a release of SAS/GRAPH software prior to Release 6.07 or do not have a terminal that is supported by the Graphics Editor

- you want to include the graph in a document being prepared with another package.

### Producing Standard File Formats

Most graphics, word processing, and desktop publishing packages can import graphs in one or more common formats. SAS/GRAPH software can produce three commonly used file formats: Computer Graphics Metafile (CGM), Hewlett-Packard Graphics Language (HP-GL), and Tagged Image File Format (TIFF). TIFF files can be generated in Release 6.07 of SAS/GRAPH software, CGM files can be generated in Release 6.03 and later, and HP-GL files can be generated in all releases. In addition to creating standard CGM files that use default attributes, special CGM drivers are available that are tailored for use with specific packages. The following packages are among those for which specific CGM drivers are available:

- Harvard Graphics
- Lotus Freelance
- Ventura Publisher
- WordPerfect
- DrawPerfect
- Draw Applause
- Hewlett-Packard Graphics Gallery
- Microsoft Word.

In addition to drivers for these products (which are supplied with SAS/GRAPH software), new drivers for packages such as Microsoft Word for Windows, Borland Quattro, and Lotus Ami Pro 2.0 can be obtained from the Technical Support Division at SAS Institute.

To export SAS/GRAPH output to another package, first determine what graphics formats the target package can accept as input. Then select a SAS/GRAPH driver that can produce a file in that format (you can obtain a list of SAS/GRAPH drivers by using the GDEVICE procedure) and use the driver to create a graphics stream file. Finally, download the graphics stream file to your PC and include the file in the target application. When downloading the file, you should use a binary file transfer. As an example, the following statements can be used to create a CGM file that can be imported into a WordPerfect document on your PC:

```
filename gsasfile 'your_output_file';
goptions device=cgmwp gaccess=gsasfile
    gprotocol=sasgpasc gsfmode=replace
    gsflen=80;
```

For more information on creating and transferring CGM and HP-GL files, refer to the SAS help facility, or *SAS/GRAPH Software: Using Graphics Devices*, or contact the Technical Support Division at SAS Institute.

Note that one limitation of using this approach is the inability to see the graph as it is being created on the host computer. You can overcome this limitation by first specifying the CGMxxx or HPGL driver as a target device (using the TARGETDEVICE= option) and displaying the graph on your screen using the driver for the terminal you are using (or which is being emulated). The graph that is displayed on your screen will be a close approximation of the graph as it will appear when it is exported to the target package. You can rerun the graph specifying the CGMxxx or HPGL driver to create the graphics stream file to be exported. If you are using a terminal

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or emulator that supports the GRAPH window, you can create the graphics stream file by issuing the PRINT command from the command line of the GRAPH window when the graph is displayed.

### The Meta Application for Macintosh Computers

The Meta Application is software, available from SAS Institute, which enables you to take graphs produced by SAS/GRAPH software on any host and display them on an Apple Macintosh computer. You can subsequently save the graph in PICT format and either print the graph or transfer it to another application running on the Macintosh. The Meta application consists of two parts:

- a special host driver that creates a metafile of graphics commands that you can transfer to your Macintosh

- an application (Meta) that runs on the Macintosh and enables you to display the graph, copy the graph to another application, save the graph in PICT format, or print the graph.

For details on the Meta application, contact the Technical Support Division at SAS Institute.

## DOWNLOADING AND TRANSFERRING FILES TO A HARDCOPY DEVICE

If you want to send output to a hardcopy device attached to your PC, an alternative to the strategies discussed so far is to use the SAS/GRAPH driver for the hardcopy device to create a graphics stream file on the host. You can then download the file to your PC and send it to the hardcopy device. As an example, the following statements can be used to create a file that can be downloaded and sent to a Hewlett-Packard Laserjet Series II printer attached to a PC:

```
filename gsasfile 'your_output_file';
goptions device=hplj300 gaccess=gsasfile
gprotocol=sasgpasc gsfmode=replace;
```

After the file is created on your host, download the file to your PC using a binary file transfer. Once the file has been downloaded, you should copy the file to the hardcopy device using a utility or command that does not add line feed or page eject characters. Under PC/DOS use

```
copy/b filename.ext port
```

where filename.ext is the name of the downloaded file, and port is the name of the port to which the file is copied (usually LPT1: or COM1:).

As with the export of CGM and HP-GL files discussed in the previous section, a limitation of this approach is the inability to see what the graph will look like as it is being created. You can use the method described in that section to use the TARGETDEVICE= option to preview the graph and then create a graphics stream file.

## WHICH METHOD SHOULD YOU USE?

This article has discussed several different approaches for displaying and producing hardcopy of host graphics output. No single method is ideal for all applications. In deciding which method to use, you should consider the following:

- Where do you want most of the computing work done?

- Do you need hardcopy?

- What types of hardcopy devices do you have?

- What type of connection do you have between the PC and host?

- Do you want to redisplay graphs on your PC after you have disconnected from the host?

- Do you want to modify graphs on your PC?

All of the methods are useful if you want to minimize the use of processing resources on your host computer. An advantage of using SAS/CONNECT software, SAS/RTERM software, and some emulators is that the display and transfer of graphics data take place in the same step, whereas the methods involving downloading a graphics stream file require separate steps to generate the graphs and download them. On the other hand, use of SAS/CONNECT software, SAS/RTERM software, and other emulators requires that you run your SAS/GRAPH programs interactively, while the downloading methods give you the option of creating a graphics stream file with a batch job and later downloading the file. This approach may be more efficient if connection time to the host is expensive.

Except for some emulators, all of the methods discussed can be used to produce hardcopy on a device attached to your PC, even after you have ended your host session. With SAS/CONNECT software, you can send output directly to the hardcopy device with the GRLINK driver, or you can save the graph in a SAS catalog on your PC and use PROC GREPLAY to replay it to your hardcopy device. SAS/CONNECT software gives you the ability to send output to any device supported by the version of SAS/GRAPH software running on your PC, including cameras and many printers and plotters not directly supported by terminal emulators. SAS/RTERM software offers a more limited choice of hardcopy devices, GDDM PCLK supports only IBM hardcopy devices, and GDDM OS/2-Link supports any hardcopy device for which there is an OS/2 Print Manager driver. Creating a CGM file and exporting the file to another package gives you access to hardcopy devices (but only to those devices) supported by the package to which the CGM file is exported.

The type of connection between your PC and host dictates which types of terminal emulators you can use—3270 emulators for a coaxial connection to an IBM mainframe, and asynchronous terminal emulators for asynchronous (RS-232) connections. An advantage of both SAS/CONNECT software and SAS/RTERM software is that they can be used with either type of connection, so you may find these products useful if you are accessing hosts through both types of connections. Downloading and transferring graphics stream files to other applications or hardcopy devices is another approach that can be used with both types of connections.

SAS/CONNECT and SAS/RTERM software both provide the ability to save a graph on disk and redisplay it after you have ended your SAS session. The redisplay is somewhat faster with SAS/RTERM software; with SAS/CONNECT software, the graph is stored as a member of a SAS catalog on the PC and you use PROC GREPLAY to redisplay it, while with SAS/RTERM, the graph is stored in a format that requires somewhat less processing to redisplay. Redisplay of graphs is also possible with most emulators, as well as with PC graphics and word processing packages.

Currently the only way to effectively modify or edit graphs once they have been transferred to the PC is to export the graph to another graphics package. However, with Release 6.07 of SAS/GRAPH software under the OS/2 and Windows environments, you will be able to use the SAS/GRAPH graphics editor to modify graphs transferred to the PC with SAS/CONNECT software.

## CONCLUSION

As we have seen, several different methods are available to use the power of a personal computer to display, print, and replay graphs generated on a host computer. The method that is best for you depends on the type of output you want to generate, as well as the software and hardware available to you. In the future, we can expect new features of the SAS System, as well as advances in hardware and other software, to offer even more choices to those who want to offload graphics processing from host computers to personal computers.