HP RTL Reference Guide

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HP RTL Reference Guide

HP Raster Transfer Language (HP RTL) is a raster graphics language based on HP's PCL language. HP RTL supports color plotting with custom-defined palettes, combined vector and raster plotting, plot scaling and clipping, variable plot resolutions, and several data compression methods.

HP RTL is only available on devices that support the second generation of HP's vector graphics language, HP-GL/2. HP RTL interacts with HP-GL/2 as described under "Writing HP RTL Drivers" in chapter 1.

This document describes HP RTL in a generic fashion. *Device notes* identify where the implementation may vary from one device to another. The section "Summary of Device Dependencies" under "Writing HP RTL Drivers" in chapter 1 identifies the kind of differences that may exist between implementations. Each device that supports HP RTL includes information in its documentation on how it implements HP RTL.

In This Book

This document is meant to serve as a reference handbook for HP RTL programmers.

Chapter 1, "Programming in HP RTL," describes HP RTL concepts. The concepts are grouped into topics, for example, resolution, scaling, setting colors, and so on. There is a special topic on writing HP RTL drivers, including a detailed information on device dependencies.

Chapter 2, "HP RTL Command Reference" describes each HP RTL command in detail, listing possible parameter values and command functionality. Commands are grouped according to their function: switching language contexts, setting colors, setting boundaries and resolution, and sending raster data.

Related Manuals

HP RTL is a companion product to HP-GL/2. Refer to the *HP-GL/2 Reference Guide*, HP part number 5959-9733, for more information on HP-GL/2. For information on how HP RTL is implemented on a specific device, refer to the documentation for that device.

Documentation Conventions

This manual uses the following symbolic conventions:

`program code`	Examples of program code appear in this typeface.
|	A vertical bar separates characters in commands that can end with either uppercase or lowercase letters. See "Using HP RTL" in chapter 1.
ESC	Represents the ASCII escape character, decimal 27.
[data]	Shows where binary data is to be inserted in a command.

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Programming in HP RTL

Programming in HP RTL

This chapter describes the concepts you will need to create raster programs using HP RTL. It covers the following topics:

- Writing HP RTL Drivers (including device dependencies and interactions with HP-GL/2).
- Using HP RTL (syntax, combining commands).
- Changing Language Contexts and Modes.
- Setting Raster Boundaries (using HP-GL/2 and HP RTL).
- Coordinate Systems and the Current Active Position (CAP).
- Controlling Image Resolution.
- Setting Colors.
- Understanding Indexes.
- Transferring Raster Data.
- Merging Vector and Raster Data.
- Scaling Raster Images.
- Compressing Data.

Writing HP RTL Drivers

Writing a raster driver is somewhat simpler than writing a vector driver, since raster drivers assume that the data is already in some raster format. HP RTL is made up of 21 commands, considerably fewer than its companion vector graphics language, HP-GL/2. On the other hand, since a raster-format image is closer to a raster device's native mode of operation than vector output, a raster language is by nature more device dependent than a vector language.

Some users may choose to write a driver to support only one specific device. However, it is assumed that most driver authors will want to write their drivers in such a way that they can be easily adapted to different HP RTL devices, both present and future. This manual therefore attempts to clearly identify areas of the language that are device dependent so that the programmer can define program variables and organize program procedures accordingly.

Device Note

Device dependencies are identified throughout this manual by *device notes* like this one.

Summary of Device Dependencies

The table beginning on the next page lists the HP RTL characteristics that can vary among devices.

Device Note

Differences in plot technologies, media, imaging agent (ink or toner, for example), and the plotting environment lead to color differences among devices. Since these differences are generally not subject to programmatic control, they receive no further coverage here.

Summary of Device Dependencies

Dependency	Description
Resolution	See "Controlling Image Resolution" in this chapter.
Physical device resolution	The actual number of dots per inch (dpi) a device can plot. "Native" resolutions are usually a multiple of physical device resolution.
Resolution type	Options are continuous or incremental resolution. Only devices that support continuous resolution can accurately plot a specific resolution.
Resolution Range and Default	Allowable range and default for the Set Graphics Resolution command. The resolution setting is independent of the physical device resolution. Images are scaled to the requested resolution. If explicit scaling is requested in the Start Raster Graphics command, the resolution setting is ignored.
Draft Resolution Support	Some devices support "draft" resolutions which allow faster plotting than "final" resolutions. Draft resolutions are usually native resolutions. On these devices the HP-GL/2 instruction Quality Level (QL) is used to choose draft or final resolution.
Scaled-Down Rendering	When scaling an image down, loss of detail always results. The algorithm used for scaling down is device dependent.
Source Raster Height and Source Raster Width Ranges	These ranges are determined by a device's physical limits. See "Setting the HP RTL Width and Height" in this chapter.
Color Support	Options are full color, grayscale monochrome (color maps to gray), and two-tone monochrome (no color support). Two-tone monochrome devices may not support certain HP RTL commands. See "Setting Colors" in this chapter.

Summary of Device Dependencies, continued

Dependency	Description
Color Palette Management	See "Setting Colors" in this chapter.
Maximum Palette Size	The larger the palette, the more colors can be explicitly defined. Palette size is set via the Number of Bits per Index byte of the Configure Image Data command. The maximum value corresponds to the number of data planes the device supports.
Number of Bits per Primary	This byte of the Configure Image Data command determines the ranges for defining custom palette colors.
Palette Transferability	Some devices allow you to transfer the color palette between HP RTL and HP-GL/2. See the descriptions of the Enter HP-GL/2 Mode and Enter PCL Mode commands in chapter 2.
Pixel Encoding Mode	Some devices support a special pixel encoding mode called plane-by-plane raster. Pixel encoding mode is set in the Configure Image Data command. Future devices may support other pixel encoding modes. See the description of the Configure Image Data command in chapter 2.
Rendering of Incomplete Rows	When CAP is moved with a Y Offset command, or when raster graphics mode ends, some devices plot rows that are incomplete; other devices discard data received so far for that row. See the descriptions of the Y Offset and End Raster Graphics commands in chapter 2.
Media Reversibility	Under certain conditions, some devices allow the media to move backwards after plotting, thus allowing multiple plotting passes. Other devices do not support reverse media movement. See the description of the Y Offset command in chapter 2.

Summary of Device Dependencies, continued

Dependency	Description
Negative Motion Command Implementation	Some devices cannot simultaneously receive and plot raster images. On these devices, the Negative Motion command has no effect. When the command promises no negative motion and the image nonetheless contains negative motion, the effect is device dependent.
Effect of MC and TR on Raster	There are two options for the effect of the HP-GL/2 instructions Merge Control (MC) and Transparency (TR) on raster: MC and TR can affect raster; in this case, vectors and raster mix as defined in HP-GL/2. Or MC and TR can be ineffective when raster is rendered after other data; in this case, raster, including index 0, is always opaque and overwrites what was previously rendered. That is, raster on raster and raster on vector are opaque. Vector on raster and vector on vector is still dependent on MC and TR.
Language Contexts Supported	Some devices support language contexts other than HP-GL/2 and HP RTL via the Universal Exit Language/Start of PJL command. This command may or may not be recognized from within the additional contexts. See "Changing Language Contexts and Modes" in this chapter, and the command description in chapter 2.

Summary of HP-GL/2 Interactions

HP RTL interacts with HP-GL/2 in several ways. This following table summarizes those interactions and tells you where to turn for more information. Section names, in quotation marks, refer to section titles in this chapter; command names refer to command descriptions in chapter 2.

Summary of HP-GL/2 Interactions

Interaction	Section or Command
Transferring the HP-GL/2 pen position to the HP RTL CAP	"Changing Language Contexts and Modes" Enter PCL Mode
Transferring the HP-GL/2 palette to the HP RTL palette	"Changing Language Contexts and Modes" Enter PCL Mode
Transferring the HP RTL CAP to the HP-GL/2 pen position	"Changing Language Contexts and Modes" Enter HP-GL/2 Mode
Transferring the HP RTL palette to the HP-GL/2 palette	"Changing Language Contexts and Modes" Enter HP-GL/2 Mode
Setting boundaries (hard-clip and soft-clip limits) via the Page size (PS) and Input Window (IW) commands	"Setting Raster Boundaries"
Resetting the HP RTL CAP to its origin with HP-GL/2 instructions that cause a page advance	"Coordinate Systems and the Current Active Position (CAP)"
Affecting resolution with the HP-GL/2 instruction Quality Level (QL)	"Controlling Image Resolution" Set Graphics Resolution
Exiting the HP-GL/2 picture header state due to raster transfer commands	"Changing Language Contexts and Modes"

Raster Program Examples

HP RTL supports two basic methods for sending raster data to devices: row-by-row and plane-by-plane. These correspond to pixel encoding modes 0 and 4, respectively. You set the pixel encoding mode with the Configure Image Data command.

Device Note

Some devices do not support plane-by-plane mode. All devices support row-by-row mode within the limits of memory and/or disk space.

This section shows three examples of raster programs:

- Row-by-row (includes commands for optional scaling).
- Plane-by-plane without scaling.
- Plane-by-plane with scaling.

The program examples show you the commands required for general raster programs, and the order in which they must be sent to the raster device. You may need to adapt these examples to your specific application.

Spaces and brackets [ ] are only included in the commands for clarity; do not include them in your programs.

Row-by-Row Example

ESC E	Resets HP RTL and HP-GL/2 defaults.
ESC %0B	Enter HP-GL/2 mode. (Note the 0 value as opposed to the –1 recommended for HP-GL/2 hyperdrivers.)
BP 5,1	Turn off autorotation.
PS length,width	Set logical page size for HP-GL/2 and HP RTL.
[vector data]	Send any vector data that is to be rendered *before* the raster image.
PU	Pen Up so next instruction does not draw a line.
PA x,y	Move the HP-GL/2 pen position to an absolute location. Location will be copied into HP RTL.
ESC %1A	Enter HP RTL mode using HP-GL/2 pen position as CAP.
ESC &a#N	Tell the device whether to expect negative motion for the rest of the page: # = 0 negative motion allowed. # = 1 no negative motion. Allows some devices to begin plotting as soon as data is received.
ESC *v6W 0 0 # 8 8 8	Configure Image Data (data shown in decimal): Color Model = relative (0). Pixel Encoding Mode = row-by-row raster (0). Number of Bits per Index = variable (#). Number of Bits per Primary R/G/B = 8.
ESC *r#S	Set Source Raster Width.
ESC *r#T	Set Source Raster Height. You must set Source Raster Width and Height when scaling. You can also use them to cause zero filling: see “Setting Raster Boundaries” in this chapter.
ESC *t#H	Set Destination Raster Width.
ESC *t#V	Set Destination Raster Height. You usually set Destination Raster Width and/or Height when scaling. If not scaling, these two commands are ignored.
ESC *b#M	Set Compression Method, if any.This is highly recommended to save on data transmission time.
ESC *t#R	Set Graphics Resolution. This command is ignored if you use scaling.

ESC *r#A	Start Raster Graphics at the CAP. # = 1 scaling off. # = 3 scaling on.
ESC *b#V[data]	Transfer plane (only if 3 planes are being sent). Not required for block-based compression methods.
ESC *b#V[data]	Transfer plane (only if 2 or 3 planes are being sent). Not required for block-based compression methods.
ESC *b#W[data]	Transfer the last plane and increment the row.
. .	(repeat for total number of rows)
ESC *rC	End Raster Graphics.
ESC %0B	Re-enter HP-GL/2 mode.
[vector data]	Send any vector data that is to be rendered *after* the raster image.*
PG;	End and plot the current page.
RP n;	Replot n times if desired.

*Some devices handle memory overflow with a technique called on-the-fly plotting. When memory becomes full, the device starts plotting the image immediately. As the top rows of the image are plotted, memory is freed up to accept data for the bottom rows. Since this method discards any vector data received after it enters on-the-fly mode, it is recommended that whenever possible you avoid sending vectors after raster images.

Vectors also cannot be sent after raster if you issue the Negative Motion command with a value of 1, no negative motion allowed (ESC &a1N), since HP-GL/2 drawing operations may contain negative motion. For more information, see the Negative Motion command description in chapter 2.

Plane-by-Plane Example without Scaling

ESC E	Resets HP RTL and HP-GL/2 defaults.
ESC %0B	Enter HP-GL/2 mode. (Note the 0 value as opposed to the -1 recommended for HP-GL/2 hyperdrivers.)
BP 5,1	Turn off autorotation. (Prevents possible crossing of raster and autorotated vector data due to nesting. Raster data does not rotate.)
PS length,width [vector data]	Set logical page size for HP-GL/2 and HP RTL. This must be sent *before* the raster data, but will be rendered *after* the raster image. See "Merging Vector and Raster Data" in chapter 2.
PU	Pen Up so next instruction does not draw a line.
PA x,y	Move the HP-GL/2 pen position to an absolute location. Location will be copied into HP RTL.
ESC %1A	Enter HP RTL mode using HP-GL/2 pen position as CAP.
ESC *v6W 0 4 1 8 8 8	Configure Image Data (data shown in decimal): Color Model = relative (0). Pixel Encoding Mode = plane-by-plane raster (4). Number of Bits per Index = 1. Number of Bits per Primary R/G/B = 8.
ESC *r#S	Set Source Raster Width. Source Raster Height is not required; the height of the image is defined by number of rows transmitted. (Source Raster Height is only required when you want scaling or vertical zero-filling.)
ESC *t#R	Set Graphics Resolution.
ESC *b#M	Set Compression Method, if any.
ESC *r1A	Start Raster Graphics at the CAP.
ESC *v0a0b0c1I	Set index 1 to black.
ESC *b#W[data] . .	Transfer black row. (repeat for total number of rows)
ESC *b#Y	Y Offset back (-1 * number of rows in image).
ESC *v0a255b255c1I	Set index 1 to cyan.

ESC *b#W[data]	Transfer cyan row.
.	
.	
	(repeat for total number of rows)
ESC *b#Y	Y Offset back (–1 * number of rows in image).
ESC *v255a0b255c1I	Set index 1 to magenta.
ESC *b#W[data]	Transfer magenta row.
.	
.	
	(repeat for total number of rows)
ESC *b#Y	Y Offset back (–1 * number of rows in image).
ESC *v255a255b0c1I	Set index 1 to yellow.
ESC *b#W[data]	Transfer yellow row.
.	
.	
	(repeat for total number of rows)
ESC *rC	End Raster Graphics.
ESC %0B	Re-enter HP-GL/2 mode. Causes the last plane to plot. No replot is possible.

Plane-by-Plane Example with Scaling

ESC E	Resets HP RTL and HP-GL/2 defaults.
ESC %0B	Enter HP-GL/2 mode. (Note the 0 value as opposed to the –1 recommended for HP-GL/2 hyperdrivers.)
BP 5,1	Turn off autorotation.
PS length,width	Set logical page size for HP-GL/2 and HP RTL.
[vector data]	Will be rendered after the raster image on a plane-by-plane basis.
PU	Pen Up so next instruction does not draw a line.
PA x,y	Move the HP-GL/2 pen position to an absolute location. Location will be copied into HP RTL.
ESC %1A	Enter HP RTL mode using HP-GL/2 pen position as CAP.
ESC *v6W 0 4 1 8 8 8	Configure Image Data (data shown in decimal): Color Model = relative (0). Pixel Encoding Mode = plane-by-plane raster (4). Number of Bits per Index = 1. Number of Bits per Primary R/G/B = 8.
ESC *r#S	Set Source Raster Width.
ESC *r#T	Set Source Raster Height. Scaling requires that both source width and height be specified.
ESC *t#H	Set Destination Raster Width.
ESC *t#V	Set Destination Raster Height. Setting both height and width means anisotropic scaling.
ESC *v0a0b0c1I	Set index 1 to black.
ESC *b#M	Set Compression Method, if any.
ESC *r3A	Start Raster Graphics at the CAP, with scaling on.
ESC *b#W[data]	Transfer black row.
.	
.	(repeat for total number of rows)
ESC *rC	End Raster Graphics.

ESC *b#Y	Y Offset back (see the formula in the next section for calculating the offset value).
ESC *v0a255b255c1I	Set index 1 to cyan.
ESC *b#M	Set Compression Method, if any.
ESC *r3A	Start Raster Graphics at the CAP, with scaling on.
ESC *b#W[data]	Transfer cyan row.
.	
.	
	(repeat for total number of rows)
ESC *rC	End Raster Graphics.
ESC *b#Y	Y Offset back (see the formula in the next section for calculating the offset value).
ESC *v255a0b255c1I	Set index 1 to magenta.
ESC *b#M	Set Compression Method, if any.
ESC *r3A	Start Raster Graphics at the CAP, with scaling on.
ESC *b#W[data]	Transfer magenta row.
.	
.	
	(repeat for total number of rows)
ESC *rC	End Raster Graphics.
ESC *b#Y	Y Offset back (see the formula in the next section for calculating the offset value).
ESC *v255a255b0c1I	Set index 1 to yellow.
ESC *b#M	Set Compression Method, if any.
ESC *r3A	Start Raster Graphics at the CAP, with scaling on.
ESC *b#W[data]	Transfer yellow row.
.	
.	
	(repeat for total number of rows)
ESC *rC	End Raster Graphics.
ESC %0B	Re-enter HP-GL/2 mode. Causes the last plane to plot. No replot is possible.

Plane-by-Plane Plotting, Scaling, and the Y Offset Command

Note that when scaling is on, you cannot use the Y Offset command to move the CAP. For this reason, it is necessary to exit raster graphics mode before moving the Y offset back to the top of the plot between planes. And since exiting raster graphics also resets the compression method to the default (0), you must set the compression method again before going back into raster graphics mode.

Calculating the Y Offset value is more complicated for scaled plotting than for unscaled plotting. During unscaled plotting, the plotter moves one physical row per row of data sent, so the Y Offset value is simply equal to the number of data rows sent. However, during scaled plotting, the plotter generally plots more (or fewer) physical rows than the actual number of data rows sent, so the number of physical rows no longer equals the number of data rows. Since you must tell the Y Offset command the number of *physical* rows to move back the CAP, you must calculate the Y Offset based on how much the image was scaled.

The formula for calculating the Y Offset for scaled raster graphics is as follows:

$$\texttt{offset} = \texttt{round}\left(\frac{\texttt{destination\_height}}{\texttt{720.0}} * \texttt{resolution}\right)$$

where

`round`	=	a function that returns an integer after 5/4 rounding.
`destination_height`	=	the value from the Destination Raster Height command, that is, the height of the destination image in decipoints.
`720.0`	=	the number of decipoints per inch.
`resolution`	=	the resolution in dots per inch (dpi) as specified in the Set Graphics Resolution command. If no resolution is set, use the device's default resolution.*

*Note that although any resolution setting is ignored during scaled raster graphics, the Y Offset command is nonetheless sensitive to the current resolution setting. This is why the formula requires the resolution parameter.

In essence, the formula converts the destination raster height to inches, and multiplies it by the current dots-per-inch setting to get the number of dots to move. Multiply this offset value by -1 (to cause the plot to move backwards), and use this as the value (#) in the Y Offset command in the "Plane-by-Plane Example with Scaling."

If you specified destination raster width and not destination raster height, you can calculate the destination height as follows:

$$\texttt{destination\_height} = \texttt{trunc}\left(\frac{\texttt{destination\_width}}{\texttt{source\_width}} * \texttt{source\_height}\right)$$

where

`trunc` = a function that returns an integer after truncation.

Due to the potential for rounding error, is it more accurate to explicitly specify destination height in HP RTL than to calculate it using this formula.

Programming Tips

Implement these suggestions wherever possible to create efficient HP RTL programs:

- Use combined commands. Combined commands are shorter than commands spelled out separately; the shorter commands require less data transmission time. See "Combining Commands" under "Using HP RTL" in this chapter.
- Take advantage of zero filling. By using source raster width and height, you can avoid sending unnecessary "blank" data for borders. And you can use the Y Offset command to skip over rows that should be left zero, thus creating a background. See "Using Index 0" under "Understanding Indexes" in this chapter.
- If draft resolutions are supported by the device, use a draft resolution for unscaled plotting. This significantly reduces calculation time. See "Controlling Image Resolution" in this chapter.
- Consider scaling images at the host computer instead of in the device. Which method is best depends on available host resources, plot size, plot complexity, and the scale factor. Comparative testing should look at host processing time, data transmission time, and device processing time.
- Use data compression. Mix compression methods to get the most efficient transmission. See "Compressing Data" earlier in this chapter. If you are using TIFF Packbits encoding, see the note in that section on when to encode data and when to send literal data.

Using HP RTL

HP RTL is based on HP's PCL language, and uses the PCL language syntax. This section describes HP RTL syntax and explains how you can combine HP RTL commands.

Note that although HP RTL is based on PCL and follows the PCL language syntax, HP RTL does not support the fonts and character commands that are part of PCL. HP RTL can be used only to describe raster data.

HP RTL language commands are compact escape sequence codes that are embedded in the job data stream. This approach minimizes both data transmission and command decoding overhead.

Escape Sequences

HP RTL commands are also referred to as *escape sequences*. Some escape sequences in this document contain spaces for clarity. Do not include these spaces when using escape sequences. Note that raster commands are case sensitive: an **ESC** e, for example, cannot be substituted for an **ESC** E.

Escape sequence commands consist of two or more characters. The first character is always the ASCII escape character, identified by the **ESC** symbol. As the device monitors incoming data from a computer, it is "looking" for the **ESC** character. When the **ESC** character appears, the device reads it and its associated characters as a command to be performed and not as data to be plotted. (Exception: When the **ESC** character appears in the middle of binary data of a specified length, it is interpreted as data, not as a command.)

Serial Communications and Raster Data

Parallel and network communications interfaces provide the fastest data transmission times. This is particularly important when transmitting raster data. However, if you must use the RS-232-C serial interface, turn parity checking off at the device. If parity checking is on, the eighth bit of each byte is used as a check bit, which will corrupt raster data.

HP RTL Escape Sequences

There are two forms of HP RTL escape sequences: *two-character* escape sequences and *parameterized* escape sequences.

The only two-character escape sequence used in HP RTL is **ESC** E for Reset.

Parameterized escape sequences have the following form:

ESC X y # Z[Data]

where y, #, and [Data] may be optional, depending on the command. The following table summarizes the parameterized escape sequences.

HP RTL Syntax: ESC X y # Z[Data]

Parameter	Parameter Type	Description
X	Parameterized Character	A character from the ASCII table within the range 33-47 decimal (! through /) indicating that the escape sequence is parameterized. Parameterized characters used in HP RTL are %, &, and *.
y	Group Character	A character from the ASCII table within the range 96-126 decimal (' through ~) which specifies the group type of control being performed. Group characters used in HP RTL are a, b, r, t, and v.
#	Value Field	A group of characters specifying a numeric value. The numeric value is represented as an ASCII string of characters within the range 48-57 decimal (0 through 9) which may be preceded by a + or - sign and may contain a fractional portion indicated by the digits after a decimal point (.). The specific numeric ranges and defaults for each command are given in chapter 2, "HP RTL Commands."
Z	Termination Parameter Character	Any character from the ASCII table within the range 64-94 decimal (@ through ^, which includes the capital letters, but not the lowercase letters). This character terminates the escape sequence.
[Data]	Data	Eight-bit binary data. The number of bytes of binary data is specified by the value field of the escape sequence. Binary data immediately follows the terminating character of the escape sequence. (Do not enclose the data in square brackets [ ]; these are included for clarity only.)

Combining Commands

Following is an example of four HP RTL commands:

ESC * v 0 A	Set Red Parameter
ESC * v 255 B	Set Green Parameter
ESC * v 255 C	Set Blue Parameter
ESC * v 1 I	Assign Color Index Number

This series of commands has the effect of setting index number 1 to be cyan (0% red, 100% green and blue, based on the default parameter range of 0 to 255).

Note in the above example that all the commands begin with the same parameterized character and group character (* and v). The commands belong to the same group. When this is the case, the commands can be combined by making all termination parameter characters except the last one lowercase. The combined command series is:

ESC * v 0 a 255 b 255 c 1 I

The lowercase letters (a, b, and c) are **parameter characters,** and can be any character from the ASCII table within the range 96–126 decimal (' through ~). The termination (final) parameter character must remain in uppercase.

Note the following about combining escape sequences:

- Parameter characters always apply to the value *preceding* the parameter character.
- Commands can only be combined when the first two characters after the **ESC**, the parameterized character and the group character, are identical.
- Combined commands are performed in the order that they are combined, from left to right. Each command is performed immediately; the device does not wait for the termination parameter character to begin executing the commands.
- Some commands do not allow a lowercase parameter character. These commands can only be used to *terminate* a combined command. Chapter 2, "HP RTL Commands," shows which commands do and do not allow lowercase parameter characters. Commands which allow lowercase parameter characters are shown with both lowercase and uppercase letters separated by a vertical bar (|) (for example, **ESC** * v # a | A). Commands which require an uppercase parameter character are shown without the lowercase letter (for example, **ESC** * r C).

Changing Language Contexts and Modes

In order to process HP RTL commands, the device must first be put into HP RTL context or "mode." If the device is in the HP-GL/2 context, you use the context-switching command Enter PCL Mode to tell the device to begin processing HP RTL commands. (As reflected in its name, Enter PCL Mode is the same command used to enter PCL context on PCL devices.) If the device is in a language context other than HP-GL/2, you may have to return to HP-GL/2 mode before changing to HP RTL mode.

Note

Sending raster data exits the HP-GL/2 "picture header state," so HP-GL/2 instructions like Page Size (PS) must be sent *before* sending raster data.

When you first enter the HP RTL context, you are in HP RTL "command mode." You can set boundaries, colors, resolution, and other parameters in this mode.

From HP RTL command mode, you must enter HP RTL "raster mode" in order to transfer raster data to the device. You can think of raster mode as a subset of the command mode. Some parameter-setting commands are ignored during raster mode. You use the HP RTL commands Start Raster Graphics and End Raster Graphics to enter and leave raster mode.

A further distinction is made as to whether the device is in *scaled* or *unscaled* raster mode. The parameter in the Start Raster Graphics command tells the device whether to enter scaled or unscaled raster mode.

When you are finished with an HP RTL command set, you use the HP RTL command Enter HP-GL/2 Mode to return to processing HP-GL/2 vectors.

Transferring Pen Position and Palettes

The Enter PCL Mode and Enter HP-GL/2 Mode commands both have parameters that allow you to transfer the pen position and palettes between the two contexts.

When a palette is transferred, the device remaps the colors as necessary to achieve visibly identical colors in the target context. That is, the color of the HP-GL/2 pen 0 matches the color of the HP RTL palette at index 0, pen 1 matches index 1, and so on. The default palette in the target context is not affected.

Device Note

Some devices do not support transferring palettes between the HP-GL/2 and HP RTL contexts.

See also the command descriptions in chapter 2 for further details on how to change language contexts and modes.

Other Languages

Access to plotter languages other than HP-GL/2 and HP RTL is supported through the Printer Job Language (PJL). PJL is available from the HP RTL or HP-GL/2 context via the Universal Exit Language/Start of PJL command.

Device Note

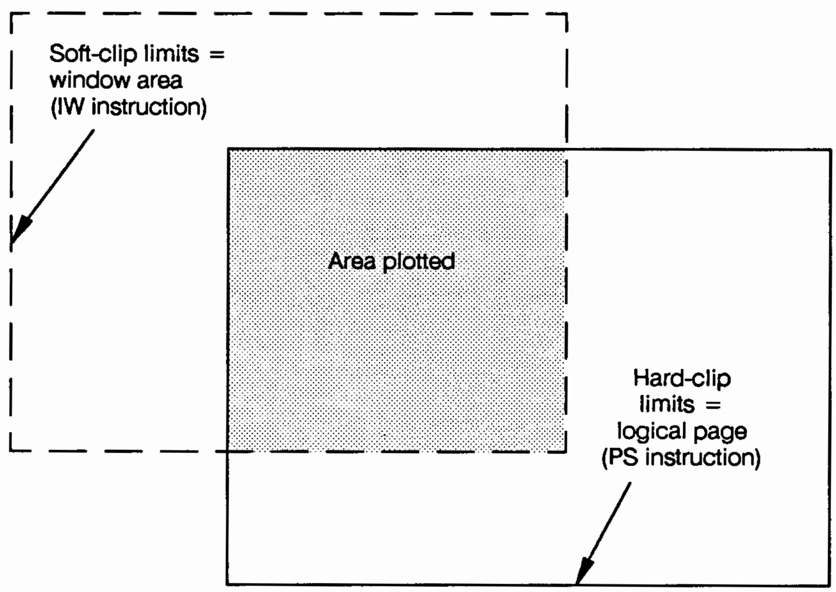
Which languages a device supports is device dependent.

Setting Raster Boundaries

You can use HP-GL/2 instructions to define the logical page and window in which your HP RTL plot should appear. In addition, HP RTL supports its own height and width parameters, which are used for saving on data transmission time and for scaling.

Setting the Logical Page and Input Window

Before entering HP RTL mode, you can define plot boundaries in HP-GL/2 using the PS (Plot Size) and IW (Input Window) instructions. HP RTL respects these boundaries; no raster data will be plotted outside them.



Hard-Clip and Soft-Clip Limits

The area defined by the PS instruction is referred to as the *logical page*. Its borders are called the *hard-clip limits*.

The area defined by the IW instruction is called a *window*; its borders form the *soft-clip limits*.

For more information on the PS and IW instructions, refer to *The HP-GL/2 Reference Guide*, HP part number 5959-9733.

Note that HP-GL/2 scaling as defined using the SC (Scale) instruction is *not* carried over to HP RTL. HP RTL has its own scaling: see "Scaling Raster Images" later in this chapter.

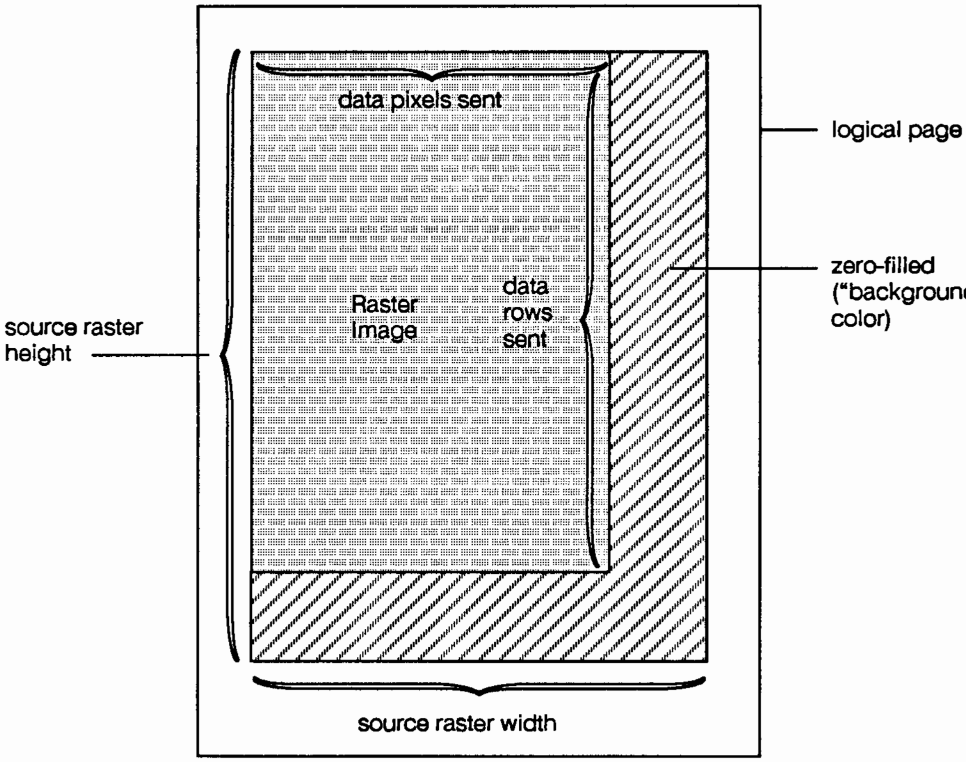
Setting the HP RTL Width and Height

Besides setting boundaries in HP-GL/2, after entering HP RTL mode, you can optionally set raster boundaries using the HP RTL commands Source Raster Width and Source Raster Height. These commands define the boundaries of a plot in terms of *pixel width* and *pixel height* respectively. (Pixel height is sometimes referred to as a number of *pixel rows*.)

The main advantage to setting source width and height is that you can avoid sending unnecessary data. When source width is specified and you send a row of data containing fewer pixels than the source width, the remaining pixels are zero-filled by the device. (Zero-filled area is plotted with the color defined for index zero. See "Understanding Indexes" later in this chapter.)

Likewise, when you send fewer rows of data than specified by source height, the empty rows are zero-filled by the device.

The illustration on the following page shows an example of zero filling using source height and width.



Zero Filling Using Source Width and Height

When you send a row of pixels that is longer than the source width, the excess pixels are discarded; the data is clipped. When you send more rows than specified by source height, the excess rows are discarded (clipped).

It is also possible to set Destination Raster Width and Destination Raster Height. When this is done, source width and height are still used to determine zero filling and clipping. *After* zero filling and clipping, if scale mode is on, the image is scaled to the destination width and height. (Note that source width and height *must* be specified for scaling to work. See "Scaling Raster Images" later in this chapter.) Finally, the image is clipped to the soft-clip and hard-clip limits defined by the HP-GL/2 instructions IW and PS.

Maximum Width and Height

Two factors govern maximum raster plot size:

- The device's physical limits: See the device documentation for information on how many pixels the device can handle, and how much memory and/or disk space is available for raster images.
- The HP RTL language limits: For all models, maximum source width is 65535 pixels, and maximum source height is 65535 raster rows. Each limit applies only if the corresponding command (Source Raster Width or Source Raster Height) is issued.

  Source raster width and height refer to bits of "source" data. One bit of data may plot as several physical pixels if resolution is set to less then the maximum device resolution. See "Controlling Image Resolution" later in this chapter.

Device Note

Devices' physical limits affect maximum plot size. Physical limits include the maximum plot size (maximum number of pixels for height and width), and the amount of data that a device can store in its memory or on its disk.

CAP. Likewise, when switching from HP RTL mode to HP-GL/2 mode, you can choose to transfer the HP RTL CAP so that it becomes the HP-GL/2 pen location.

You can use the Move Cap Horizontal (Decipoints) and Y Offset commands to move the HP RTL CAP. Both commands support *relative* positioning; Move Cap Horizontal (Decipoints) also allows you to position an *absolute* distance from the logical page left bound.

The Reset command resets the CAP to the HP RTL origin (0,0). An HP-GL/2 Advance Full Page (PG) or Begin Plot (BP) instruction, or any instruction which results in a page advance, also resets the CAP to the HP RTL origin (0,0).

Controlling Image Resolution

How you set resolution determines how many physical dots are plotted for each pixel of data you transfer.

Device Note

Maximum physical resolution varies from one device to another.

When you set the HP RTL resolution to the device's maximum physical resolution, one dot is plotted for each pixel of data you send. For instance, if the maximum physical resolution is 300 dots per inch (dpi) and you set HP RTL resolution to 300 dpi, each pixel of data you send causes one dot to plot on the media.

However, if you set HP RTL resolution to 150 dpi, each pixel of data you send is plotted as four dots on the media.

300 dpi	150 dpi
●	● ●
	● ●

Note that this means the same amount of data plotted at a lower resolution creates a larger image than the original. That is, the image is scaled up isotropically. For instance, if you set the resolution to half the original resolution, the same data produces an image that is twice as wide and twice as high as the original:

300 dpi	150 dpi
● ●	● ● ● ●
● ●	● ● ● ●
	● ● ● ●
	● ● ● ●

Requesting a lower resolution does not cause less detail to be printed. The device still plots at its maximum physical resolution, but it plots the image larger.

If you set HP RTL resolution to be *greater* than the device's maximum physical resolution, more than one pixel of data is required to produce one physical dot on the device. This means that some detail is lost, and the image appears smaller than the original; it is scaled down isotropically. The device, as always, still plots at its maximum physical resolution, but it plots a smaller image.

300 dpi 600 dpi

Device Note

The algorithm used for scaling down is device dependent.

You use the HP RTL command Set Graphics Resolution to specify the HP RTL resolution.

Note that the Set Graphics Resolution command does not affect the resolutions of fill patterns defined in HP-GL/2 using the Raster Fill Definition (RF) instruction.

Continuous vs. Incremental Resolution

Device Note

Some devices support continuous resolutions within a certain range. Other devices only support incremental resolutions.

"Continuous" resolution means that you can specify any resolution within the allowable range; you are not restricted to specific values.

However, on devices that support only incremental resolutions, the device can only create plots at certain resolutions. For instance, a device with a maximum physical resolution of 300 dpi may support only 75, 150, and 300 dpi. On these devices, if you request an unsupported resolution through HP RTL, the resolution value is mapped to the next higher supported resolution to assure that the plot is created without data loss. On the device just mentioned, if a you request a resolution of 200 dpi, it is plotted at 300 dpi. If you request a resolution of 140 dpi, it is plotted at 150 dpi.

Draft vs. Final Resolution

Device Note

Some devices support specific "draft" resolutions.

Draft resolutions are usually derived from the device's maximum physical resolution, and allow the device to significantly reduce image processing time. For example, a 300 dpi device may support draft resolutions of 75, 150, and 300 dpi.

When the HP-GL/2 instruction QL (Quality Level) is used to set the device to *draft mode* (QL 0), the device rounds up the specified HP RTL resolution to the next highest draft resolution for the most efficient plotting. Resolutions above the highest supported draft resolution are set to the highest supported draft resolution. This happens whether or not the device supports continuous resolution.

On the other hand, when the HP-GL/2 instruction QL 100 is used to set the device to *final mode* (also its default mode), and the device supports continuous resolution, the device scales the image to the exact HP RTL resolution specified. Plotting in final mode takes significantly longer than plotting in draft mode (unless you explicitly set the resolution to a draft resolution). Use final mode when you must control the exact size of your image. If the device does not support continuous resolution, even in final mode, the resolution is rounded up to the next supported incremental resolution.

Note

Converting images to a specific resolution is a type of scaling. In order not to conflict with user-defined scaling, variable resolutions are only supported when scale mode is off. When scale mode is on, the resolution setting is ignored. See "Scaling Raster Images" later in this chapter for information on user-defined scaling.

Setting Colors

This section explains how to set up the device to receive raster data. It explains data planes, the HP RTL palette, and indexes.

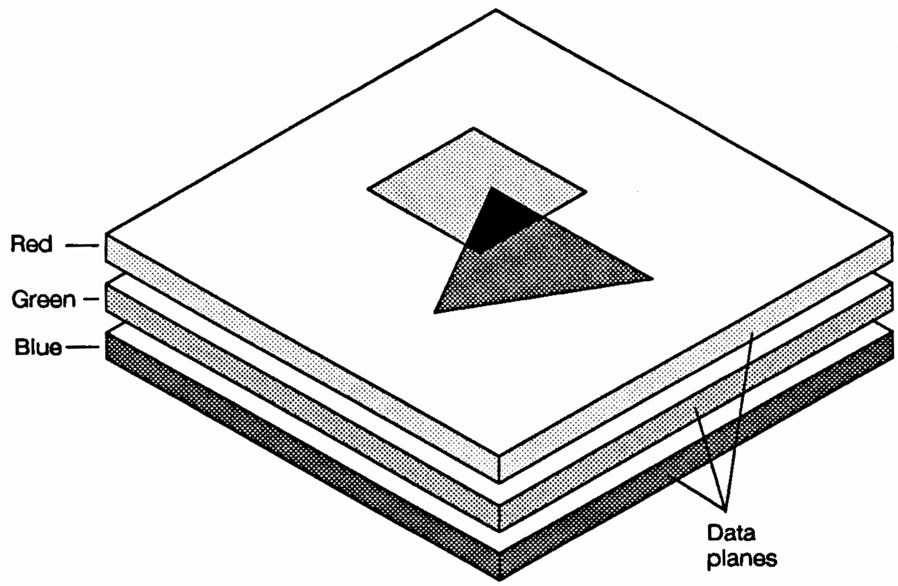
Understanding Data Planes

HP RTL is based on a "plane model" for defining images. You can think of one plane of data as a monochrome image, where "monochrome" doesn't necessarily mean black, but could be any single color. For devices that support multiple planes, by stacking planes on top of each other, different color combination can be achieved. The more planes, the more color combinations are possible.

Device Note

Two-tone monochrome devices support only one plane of data, which yields a two-tone image (normally black and white). Grayscale monochrome devices support multiple data planes but covert the planes to shades of gray for plotting. Color devices support multiple data planes and actually plot these multiple data planes in color.

Assume, for instance, that you define one plane of data to be red, another green, and another blue. (These are, in fact, the recommended definitions for 3-plane devices.) By laying these images on top of each other, up to eight colors can be achieved in any given pixel. All three together in one pixel gives white. Solid red and green together give yellow. Green and blue together give cyan. And so on, following the standard red-green-blue (RGB) color model.



Suggested Use of Three-Plane Data

You use the Set Number of Bits per Index byte of the HP RTL command Configure Image Data to tell the device how many data planes to expect. This command also resets the HP RTL palette to its default—see the next section, "Defining the HP RTL Palette."

You can combine different images with different numbers of planes on the same page. For instance, you could have a 3-plane color image and 1-plane monochrome image on the same page.

Defining the HP RTL Palette

HP RTL maintains an internal palette from which you can choose colors for each pixel of data. The size of the color palette depends on the number of planes being used. For one plane, there are two possible colors. For two planes, there are four possible colors. For three planes, there are eight possible colors. And so on. HP RTL allows for up to 255 data planes.

Device Note

The maximum number of planes, and thus the maximum palette size, is device dependent.

Note that the HP RTL palette is independent of the HP-GL/2 palette. Palettes do not automatically transfer between HP-GL/2 and HP RTL.

Device Note

Some devices support transferring the HP-GL/2 palette to the HP RTL palette via the HP RTL command Enter PCL Mode, and transferring the HP RTL palette to the HP-GL/2 palette via the HP RTL command Enter HP-GL/2 Mode. See the descriptions of these commands in chapter 2 for more information on transferring palette.

The default HP RTL palette is defined as follows:

Number of Planes	Index Number	Color
1	0	White
	1	Black
2	0	Black
	1	Red
	2	Green
	3	White
3-255	0	Black
	1	Red
	2	Green
	3	Yellow
	4	Blue
	5	Magenta
	6	Cyan
	7	White
	> 7	Black

Data sent to the device uses the *index number* to choose a color for each pixel. See “Understanding Indexes” later in this chapter.

Changing the Default Palette

You can use a combination of commands to change the HP RTL palette defaults to any color. For instance, to set index 5 to a 50% blue, you use the following combined HP RTL command:

```
ESC * v 0 a 0 b 127 c 5 I
```

The commands combined here are Set Red Parameter, Set Green Parameter, Set Blue Parameter, and Assign Color Index Number. Note that 127 is halfway (50%) between 0 and 255, the default range for the Set Red/Green/Blue Parameter commands.

Device Note

A "50%" blue may not appear the same on all devices. Differences in imaging technology, media, and environmental conditions can cause differences in the colors created.

You can assign any color supported by a device to an index. On some devices, non-primary colors are plotted using a dithering techniques, as in HP-GL/2 mode. (Primary colors are those colors which a device can create by plotting zero, one, or two ink/toner colors together, usually red, green, blue, magenta, cyan, yellow, black, and white.)

Changing the White and Black References

By default, the RGB value for black is 0,0,0, and the value for white is 255,255,255. You can change these white and black references using the HP RTL command Configure Image Data. For instance, if you work in percentages, you could use the following command to set the ranges to 0 to 100:

```
ESC * v 18 W 0 0 3 8 8 8 0 100 100 100 0 0 0
```

The last six numbers set the white references for red, green, and blue, and then the corresponding black references. (For clarity, numbers in the data string are shown in decimal, separated by spaces. In practise, they must be transmitted as binary numbers, without spaces. See chapter 2 for more information on the Configure Image Data command.)

Now, to set index 5 to 50% blue using the white and black references just defined, use the following combined command:

```
ESC * v 0 a 0 b 50 c 5 I
```

Understanding Indexes

When you send data to the device, you send it one row at a time. Assuming you are sending single-plane data, you send all the data for the first row, then all the data for the second row, and so on.

For example, the loop in a sample program might look like this:

```
for n := 1 to number_of_rows do
  for m := 1 to width_in_pixels do
      send one pixel (one bit) of data;
```

You can think of the color palette as an array in a programming language. The color of each pixel is determined by "indexing into" the color palette using the bit value (0 or 1) as the subscript. A "0" pixel accesses the color assigned to index 0 (by default, white); a "1" pixel accesses the color assigned to index 1 (by default, black).

For instance, assume you sent the following data to the device:

0 1 0 1 1 1 1 1 0 0 0 0 1 1 1 1

Based on the HP RTL default palette, the first pixel would be white, the second black, the third white, and so on.

Multi-Plane Data

As with single-plane data, you send multi-plane data one row at a time. Except with multi-plane data, you send all the planes for each row together: all the planes for the first row, then all the planes for the second row, and so on. (Even in block transfers, the *order* of the data remains the same. Block transfers are explained under "Compressing Data" later in this chapter.)

For example, if you have three planes of data, the loop in a sample program might look like this:

```
for n := 1 to number_of_rows do
    begin
        send one row of data for first plane;
        send one row of data for second plane;
        send one row of data for third plane;
    end;
```

("Send one row of data" implies a loop to send each row a pixel at a time, as shown in the single-plane example above.)

Once the data for all planes in a row has been received, the bits that make up each pixel are combined to arrive at the index number. As with single-plane plotting, this index number is used to index into the palette to determine which color to plot each pixel.

For instance, assume you sent the following data to the device:

Plane 1:	0 1 0 1 1 1 1 1 0 0 0 0 1 1 1 1
Plane 2:	0 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0
Plane 3:	1 0 1 0 0 1 1 0 1 0 0 1 0 0 1 1

The color for each pixel is now defined by a three-digit binary number*, which is the index number. Plane 1 is the *least* significant bit of the number; plane 3 is the *most* significant. To get the index number, turn this page clockwise so that the right edge is at the bottom. Read the binary numbers from left to right, top to bottom. The first pixel is 1 0 0, or decimal 4. The second is 0 1 1, or 3.

The index numbers for this row of pixels are:

Row:	4 3 6 3 3 7 7 3 4 0 0 4 1 1 5 5

If you are using the HP RTL default palette, the first pixel of this row would map to index 4, which is blue. The second pixel maps to index 3, which is yellow. The third maps to index 6, which is cyan. And so on.

Note that when you are using three planes per row and the HP RTL default palette, you are effectively sending planes of red, green, and blue: plane 1 is red; plane 2 is green; and plane 3 is blue.

The same technique for determining index colors is used when there are only two data planes. In this case, the binary number is only two digits, so there are only four possible index numbers (0 to 3).

* Binary numbers are defined as follows:

0 0 0 = 0	1 0 0 = 4
0 0 1 = 1	1 0 1 = 5
0 1 0 = 2	1 1 0 = 6
0 1 1 = 3	1 1 1 = 7

Using Index 0

Index 0 functions like any other index: you can assign a color to it, and you can send data such that any given pixel plots with that color. The color of index 0 in the *default* palette is white for 1 plane per row and black for 2 or more planes per row.

Device Note

The ability to assign colors to index 0 assumes you are using "row-by-row raster mode," that is, the Set Pixel Encoding Mode byte of the Configure Image Data command is set to 0, Indexed by Plane. Some devices support other pixel encoding modes, and index 0 may behave differently under these other modes. Other pixel encoding modes are described in the documentation of the devices that support them.

When you use the HP RTL commands Source Raster Width and Source Raster Height, zero is also the default value for short or missing rows. This means, for instance, that you can use index 0 as a "background color" to form a border around an image. You must send the zeros for any border at the top and to the left of the image. But the device will automatically fill in the empty space to the right and below the image with zeros. Since there is less data to transmit, transmission time is reduced. See the illustration under "Setting the HP RTL Width and Height" earlier in this chapter.

You can also use index 0 as a background color by using the Y Offset command to skip over parts of the plot that should be set to the color of index 0. Rows that you skip are zero-filled and plotted with the color of index 0. This only works when you are in raster graphics mode (after a Start Raster Graphics command) with scale mode off. The Y Offset command is not allowed in raster graphics mode when scale mode is on.

Another alternative is to create background or borders using HP-GL/2 commands before entering HP RTL mode.

Transferring Raster Data

So far in this chapter, we've looked at several concepts regarding raster data, as well as discussing some commands used for setting up the raster transfer. This section explains the basic commands used to actually transfer the data.

When all the setup is complete, you tell the device to expect raster data by sending the HP RTL command Start Raster Graphics. The parameters in this command tell the device whether to start graphics at the left side of the logical page or at the CAP, and whether to start graphics with or without scaling.

Once the device is in raster graphics mode, you can send it data using two HP RTL commands: Transfer Raster Data by Plane and Transfer Raster Data by Row/Block.The data sent with these commands must be formatted according to the current compression method. See "Compressing Data" later in this chapter.

When you have only one plane of data to plot, you only need the second command, Transfer Raster Data by Row/Block. You preface each row of raster data with this command. After the device renders this data on the hard disk, the row counter is incremented, and the device is ready to receive data for the next row. (When you use a block-based compression method, described in chapter 2, you only issue this command once for each block.)

If you have multiple planes of data to plot, you use the Transfer Raster Data by Plane command for all but the last plane of each row. Transfer Raster Data by Plane does not move the CAP to the next row; it only increments the plane counter, readying the device to receive the next plane of data. You send the final plane for each row with the Transfer Raster Data by Row/Block command to increment the row counter and reset the plane counter. (Block transfers use only the Transfer Raster Data by Row/Block command; plane divisions are implied. See "Compressing Data" later in this chapter for an explanation of block transfers.)

When the device is in raster graphics mode, certain commands are allowed and certain commands are ignored. See the Start Raster Graphics command in chapter 2 for a list of these commands.

When all the data for a plot has been sent, you exit raster graphics mode with the HP RTL command End Raster Graphics.

Merging Vector and Raster Data

HP RTL devices allow you to mix HP-GL/2 vector data and HP RTL raster data on the same plot.

In row-by-row raster mode, you can send HP-GL/2 vector data and HP RTL raster data in any order. You can even send multiple vector and raster images for the same plot. The only limitation is disk or memory space. ("Row-by-row raster mode" means that the Set Pixel Encoding Mode byte of the Configure Image Data command is set to 0, Indexed by Plane.)

Vector and raster images are rendered in the order they are received. ("Rendering" refers to when the image is created in the device's internal bitmap.) The plot is not drawn until the device receives an HP-GL/2 end plot instruction, usually a PG (Advance Full Page).

When vectors are rendered on top of raster, the result is dependent on the HP-GL/2 instructions MC and TR (Merge Control and Transparency Mode).

Device Note

When raster is rendered on top of raster or on top of vectors, the effect of MC and TR is device dependent. There are two options. MC and TR can affect raster; in this case, vectors and raster mix as defined in HP-GL/2. Or MC and TR can be ineffective; in this case, raster, including index 0, is always opaque and overwrites whatever was previously rendered.

Device Note

Some devices may have to start plotting before receiving the entire plot in order to free up memory. When this is the case, subsequent vector instructions in the data stream are ignored; and only the current raster image is completed. For this reason, it is recommended that vectors be sent before raster data whenever possible. This way, no vector data will be lost, and as long as only one raster image follows the vector data, the raster image will plot to completion.

Device Note

Handling of merged vector and raster data in plane-by-plane mode is device dependent.

Scaling Raster Images

HP RTL does not follow HP-GL/2 scaling as defined with the HP-GL/2 SC (Scale) instruction. HP RTL does, however, support its own scaling using the Destination Raster Width, Destination Raster Height, and Start Raster Graphics commands. You can either enlarge or reduce an image using scaling.

Device Note

When scaling an image down, loss of detail always results. The algorithm used for scaling down is device dependent.

In order to use scaling, you must specify a *source* raster width and height. If one or the other is not specified, the device will not enter scale mode; the Start Raster Graphics command will default to scale mode off.

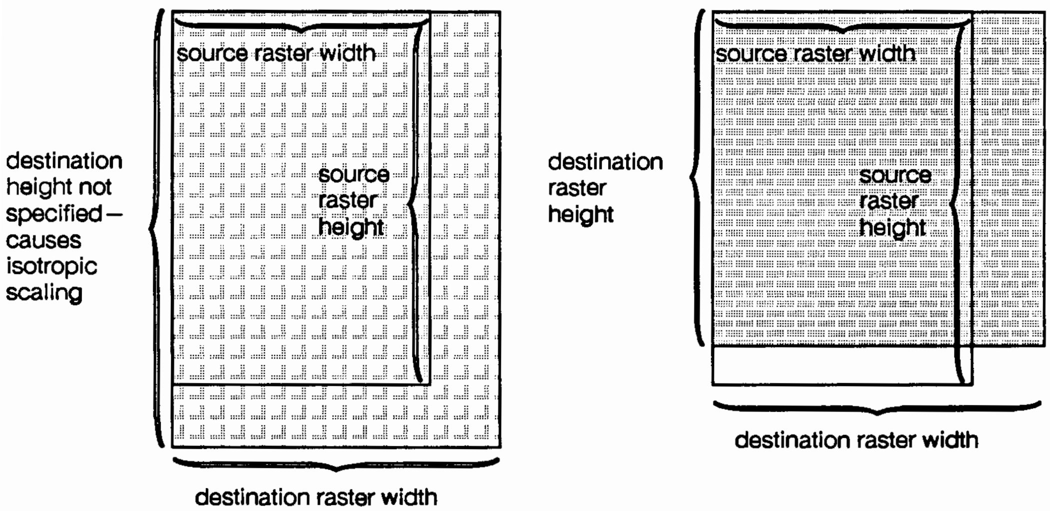
Scaling occurs either *isotropically* or *anisotropically*. See the next page for illustrations of these two types of scaling.

There are three options for scaling:

- You specify either a destination width *or* height, and Start Raster Graphics with scale mode on. In this case, the scale factor is determined by comparing the source and destination sizes for the dimension you specified (either width or height). Isotropic scaling is maintained; the image is not distorted.
- You specify both a destination width *and* height, and Start Raster Graphics with scale mode on. In this case, the scale factors are determined by comparing the source and destination sizes for both dimensions. The plot is scaled anisotropically, that is, the image is "stretched" or "shrunk" to fit the destination dimensions. If the source-to-destination ratio is the same for both width and height, isotropic scaling results.
- You do not specify a destination width or height, and Start Raster Graphics with scale mode on. In this case, the image is scaled isotropically to render the largest image that fits on the part of the logical page that is below the CAP and to the right of the left graphics margin. (The left graphics margin is set either to the CAP's X-location or to the left side of the logical page when you Start Raster Graphics.) Note that since isotropic scaling is used, the image may not actually fill the logical page.

It is possible to set the destination width or height to be larger than the actual page size. In this case, the image is still scaled using the implicitly determined scale factor(s). After scaling, the image is clipped along the window and logical page boundaries set by the HP-GL/2 instructions IW and PS.

The following illustration shows an example of isotropic and anisotropic scaling. It is assumed that no window is specified, and that the logical page is set to the same size as the destination dimensions. If the logical page were a different size, scaling would happen at the same ratio, but the image would be clipped to the logical page.



Isotropic Scaling **Anisotropic Scaling**

Zero filling of pixels and rows based on source width and height is done *before* scaling. See "Setting the HP RTL Width and Height" in this chapter for more information on zero filling.

Scaling takes precedence over any resolution setting (from the HP RTL command Set Graphics Resolution). When scale mode is on, the resolution setting is ignored.

Scaling usually adds significantly to the processing time required to generate a plot. As an alternative, you might consider scaling the image at the host computer before transmission. But if this increases overall image size, the file will take longer to transmit, offsetting gains in plotting speed.

Compressing Data

Raster images normally require that you send a bit (1/8 byte) of data for each pixel; if the image is in color, up to three bits are required per pixel. For this reason, raster image files are generally much larger than vector image files, in which only the endpoints are sent.

In order to cut down on the amount of data that must be sent, HP RTL offer several data compression methods. These methods use different "tricks" to reduce the quantity of data that must be transmitted. Most of the tricks involve having the device replicate identical data instead of sending it explicitly.

Note that data compression applies only to data transmission. As soon as the data is received by the device, it is decompressed. (After scaling, the data may be recompressed by the device, using a low-level internal algorithm, before storage in the device's memory or on its disk.)

Depending on the image and the compression method, a compressed plot can be up to 30 times smaller than an uncompressed plot, with corresponding savings in data transmission time. For this reason, we recommend using data compression whenever possible.

HP RTL supports six data compression methods:

- Run-length encoding (row-based).
- Tagged Image File Format (TIFF) revision 4.0 "Packbits" encoding (row-based).
- Seed-row encoding (row-based).
- CCITT Group 3 one-dimensional encoding (block-based).
- CCITT Group 3 two-dimensional encoding (block-based).
- CCITT Group 4 encoding (block-based).

In addition, there are two unencoded (uncompressed) methods:

- Unencoded (row-based).
- Unencoded (block-based).

It is possible to mix compression methods in the same plot. This allows you to use the most efficient method for each row, or, for block-based methods, for each block. You can also mix row-based and block-based methods in one plot.

You use the HP RTL command Set Compression Method to set select a compression method.

The following sections explain each data compression method. The method numbers refer to the respective values of Set Compression Method parameter (#).

Row-Based Unencoded (Method 0)

This is the default method, and refers to sending one bit for each pixel of each plane. The most significant bit (bit 7) of the first byte corresponds to the first pixel in the row; the least significant bit (bit 0) corresponds to the eighth pixel in the row. The most significant bit of the second byte corresponds to the ninth bit in the row, and so on.

Data for each row must end on a byte boundary. If the number of pixels per row is not evenly divisible by 8, remember that you must send a complete byte anyway. For instance, if you have 2500 pixels per row, you must send 313 bytes. The last four bits of the last byte will contain garbage. You can use the Source Raster Width command to clip off the unwanted data. (You could also fill the trailing bits with data that will index to a non-plotting color, usually white.)

Block-Based Unencoded (Method 4)

This is basically the same as row-based unencoded, except that only one command is needed to transfer data for an entire block of data (Transfer Raster Data by Row/Block).

The first four bytes of the block make up a 32-bit number specifying the number of pixels of data to expect for each row. The device uses this value to determine when to increment the plane and row pointers. Note that this number is sent only at the beginning of the block, not at the beginning of each row. Also, this number is a true 32-bit unsigned binary integer, not a string of ASCII digits that make up a number as is the case with other HP RTL parameters.

As with the row-based unencoded method, each row must start and end on a byte boundary. If the number of pixels per row specified in the first four bytes of the block is not evenly divisible by 8, it is rounded up to the next multiple of 8. For instance, if the first four bytes contain the number 2500, it is rounded up to 2504. Data is not clipped based on this four-byte number. Use Source Raster Width for clipping if desired.

With block-based transfers, data is still sent by row and by plane. For instance, with three planes per row, data for a block is transmitted as follows:

ESC *b#W	Transfer Raster Data by Row/Block
[number of pixels per row]	32-bit integer value
row 1 plane 1	Data organized by row and plane
row 1 plane 2	.
row 1 plane 3	.
row 2 plane 1	.
row 2 plane 2	
row 2 plane 3	
.	
.	
row n plane 1	
row n plane 2	
row n plane 3	

If there is only one plane per row, the data for each plane is transmitted as follows:

ESC *b#W	Transfer Raster Data by Row/Block
[number of pixels per row]	32-bit integer value
row 1	Data organized by row
row 2	.
.	.
.	.
row n	

Note

The parameter value (#) in the Transfer Raster Data by Row/Block command (**ESC** * b # W) refers to the size of the entire block, including the four-byte prefix. Mathematically, the value (#) is equal to

$$4 + \left(\left\lceil \frac{\texttt{number of pixels per row}}{8} \right\rceil * \texttt{number of rows} * \texttt{number of planes} \right)$$

The "number of pixels per row/8" expression, rounded up to the next integer, yields the number of bytes per row. (The angular brackets in the equation represent the "ceiling function," indicating that the result should be rounded up.)

Run-Length Encoding (Method 1)

With run-length encoding, the raster data consists of byte pairs: the first byte is a repetition count, and the second byte is a pattern byte. The repetition count can range from 0 to 255, and tells how often the following pattern byte is to be repeated. A count of 0 means the pattern occurs only once and is not repeated. A count of 255 means the pattern is repeated 255 times for a total of 256 occurrences.

Run-length encoding is a row-based encoding method. A separate Transfer Raster Data command is required for each plane and row.

Note

Run-length encoding relies on byte pairs. If the parameter value (#) in the Transfer Raster Data command is odd, the entire transfer sequence is ignored.

Assume you want to send the following data to the device. The data is shown as binary and as ASCII:

01010101	01010101	01010101	01010101	01000001	01010100	01010100
U	U	U	U	A	T	T

Using run-length encoding, you would use the following combined command to send the row. The numbers in parentheses must be sent as binary bytes. For instance, (3) is binary 00000011, ASCII Control-C or **ETX**. Spaces are added for clarity.

```
ESC * b 1m 6W (3)U (0)A (1)T
```

where

1m means compression method 1 (run-length encoding).

6W means there are six bytes of data following. Note that this is the length of the *compressed* data, not the uncompressed data.

(3)U means repeat the "U" pattern 3 times for a total of four bytes.

(0)A means do not repeat the "A" pattern.

(1)T means repeat the "T" pattern once for a total of two bytes.

TIFF Packbits Encoding (Method 2)

Tagged Image File Format (TIFF) "Packbits" encoding is a combination of row-based unencoded and run-length encoding. You can mix unencoded, or *literal*, bytes with repeated byte patterns.

TIFF Packbits encoding is a row-based encoding method. A separate Transfer Raster Data command is required for each plane and row.

With TIFF Packbits encoding, raster data is always preceded by a *control byte*. The control byte can fall into three ranges:

-1 to -127 The data byte following the control byte is repeated this many times. (Negative numbers are represented by their two's complement, that is, the number of identical bytes is equal to -(control byte) + 1.)

0 to 127 There are from 1 to 128 literal data bytes following the control byte. 0 means 1 literal byte; 127 means 128 literal bytes.

-128 This control byte is a NOP (no operation). This control byte is ignored, and the next byte is treated as a control byte.

Assume you want to send the same data as shown with run-length encoding to the device:

01010101	01010101	01010101	01010101	01000001	01010100	01010100
U	U	U	U	A	T	T

Using TIFF Packbits encoding, you could use the following combined command to send the row. As with run-length encoding, the numbers in parentheses must be sent as binary bytes. For instance, (-3), the two's complement of (3), is binary 11111101, decimal 253. Spaces are added for clarity.

```
ESC * b 2m 6W (-3)U (0)A (-1)T
```

where

2m means compression method 2 (TIFF Packbits encoding).

6W means there are six bytes of data following. Note that this is the length of the *compressed* data, not the uncompressed data.

(-3)U means repeat the "U" pattern 3 times for a total of four bytes.

(0)A means the "A" pattern is a 1-byte literal.

(-1)T means repeat the "T" pattern once for a total of two bytes.

Another valid way to code this data is with the following combined command:

```
ESC * b 2m 6W (-3)U (2)ATT
```

Here, the last three bytes are sent as a literal ((2)ATT).

Note

When using TIFF Packbits encoding, it is more efficient to code two consecutive identical bytes as a repeated byte than as a literal. However, if the repeated bytes are preceded *and* followed by literal bytes, it is more efficient to code the entire group as literal bytes. It is always most efficient to code three identical bytes as a repeated byte.

Seed-Row Encoding (Method 3)

Seed-row encoding describes a raster row by recording only the changes from the previous row (the "seed row"). Seed-row encoding is sometimes called delta row compression because it identifies the "delta," or change, between one row and the next.

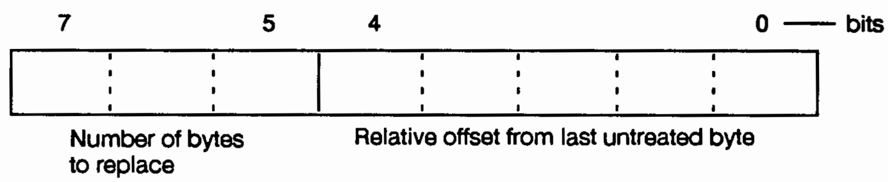
Seed-row encoding is a row-based encoding method. A separate Transfer Raster Data command is required for each plane and row.

With seed-row encoding, the device takes the previous row of data and makes the changes indicated by the delta data to create a new row. The new row is rendered, and becomes the new seed row.

The format of a single "delta" is:

< command byte > [< optional offset bytes >] < 1 to 8 replacement bytes >

The command byte contains both an offset and the number of bytes to replace:



Seed-Row Command Byte

The upper 3 bits contain the number of consecutive bytes to replace (from 1 to 8). The lower 5 bits contain the relative offset to the first byte to be replaced. The values of the offset have the following definitions:

0–30 Relative offset of 0–30 bytes from the first "untreated" byte (either the first byte in a row, or the first byte following the most recent replacement byte). The first offset in a raster row is relative to the left graphics margin. One to eight replacement bytes follow this command byte.

31 Indicates that an additional *offset byte* follows the command byte. The value of the offset byte is added to the command byte offset (31) to get the actual offset. If the offset byte value is 255, yet another offset byte follows.

Consider the following data stream using seed-row encoding. The data is shown as binary numbers:

```
000 11111 11111111 10000000 10010111
```

where

000 means replace one byte.

11111 means add 31 to offset, and that the next byte is an offset byte.

11111111 means add 255 to offset, and that the next byte is an offset byte.

10000000 means add 128 to the offset. Since this is less than 255, the next byte is the data byte.

10010111 replaces the byte at an offset of 31 + 255 + 128 = 414 bytes.

Seed-Row Encoding and Raster Width

The width of the seed row is equal to the source raster width.

The Transfer Raster Data commands both contain a number (#) of bytes of data to expect for the entire command. If this byte count is reached before the literal replacement count is met, the byte count has precedence, and no further bytes are replaced in that row. Data beyond the byte count is parsed as ASCII commands and not as binary data.

Seed-Row Encoding and Multi-Plane Data

When you are using more than one plane of data per row, the device maintains a seed row for each plane. This allows seed-row compression to operate on each plane of graphics independently.

Programming with Seed-Row Encoding

With seed-row encoding, if only one bit in a row is different from the preceding row, then only one replacement byte must be sent (with its location specified in one or more command bytes). Here, seed-row encoding is very efficient. However, if a row is completely different from the preceding row, then the entire row must be transmitted. In this case, another compression method might be more efficient. For this reason, seed-row encoding is often mixed with other compression methods for greatest efficiency.

In order to mix compression methods, it is important to understand how the seed row is affected by various HP RTL commands.

Effect of Other Commands on the Seed Row

The seed row is updated by all row-based graphics transfers. This means that data sent with any row-based compression method is available as a seed row. (In multi-plane images, a separate seed row is updated for each plane.)

The seed row is zeroed by the following commands. If there is more than one plane of data, all seed rows are zeroed:

- Start Raster Graphics command.
- End Raster Graphics command.
- Y Offset command.

In addition, the seed row is zeroed at the completion of any block-based transfer.

Note the effect of the following commands when the device is in raster mode (after a Start Raster Graphics command) and seed-row encoding is active:

ESC `* b 0W` Transfer Raster Data by Row/Block. Repeats the previous row. The seed row is unchanged.

ESC `* b 1Y` Y Offset down one raster row. The seed row is set to zeros.

ESC `* b 0Y` Y Offset down zero raster rows (that is, do not move the CAP). The seed row is set to zeros.

Horizontal CAP moves have no effect on the seed row.

Seed-Row Encoding Example

The following data is to be compressed using seed-row encoding. It is assumed there is only one plane of data. All graphics data is given in binary. The italicized bytes are the ones replaced using seed-row encoding:

Byte #:	1	2	3	4	5
Row 1:	00000000	*11111111*	00000000	00000000	00000000
Row 2:	00000000	11111111	*11110000*	00000000	00000000
Row 3:	*00001111*	11111111	11110000	*10101010*	*10101010*

The following HP RTL commands generate the data shown above:

```
ESC * r 1A
```

Start Raster Graphics initializes the seed row to all zeros.

```
ESC * b 3m 2W  000 00001  11111111
```

Set Compression Method to 3 (seed-row encoding) and Transfer Raster Data by Row/Block for row 1. One byte is replaced. The command byte signifies a single byte replacement (top three bits are zero) and the replacement occurs with an offset of 1 byte from the current position (lower 5 bits contain a relative offset of 1). The replacement byte follows and contains 11111111.

```
ESC * b 2W  000 00010  11110000
```

Transfer Raster Data by Row/Block for row 2. One byte is replaced. The command byte signifies a single byte replacement (top three bits are zero) and the replacement occurs with an offset of 2 bytes from the current position (lower 5 bits contain a relative offset of 2). The replacement byte follows and contains 11110000.

```
ESC * b 5W  000 00000  00001111  001 00010  10101010
    10101010
```

Transfer Raster Data by Row/Block for row 3. Three bytes are replaced using two commands. The first command byte signifies a single byte replacement (top three bits are zero) and the replacement occurs with an offset of 0 bytes from the current position (lower 5 bits contain a relative offset of 0). The replacement byte follows and contains 00001111. The second command calls for the replacement of two bytes (top three bits are 001) and the replacement occurs with an offset of 2 bytes from the current untreated position (lower 5 bits contain a relative offset of 2). The two replacement bytes follow the command byte.

CCITT Group 3 One-Dimensional Encoding (Method 6)

CCITT Group 3 one-dimensional encoding is a block-based compression method that uses a statistical encoding similar to Huffman encoding. The length of alternating white and black (zero- and one-bit) runs are calculated, and then a table lookup is employed to output the corresponding binary codes. Refer to CCITT Fascicle VII.3 Recommendation T.4 for details.*

CCITT Group 3 Two-Dimensional Encoding (Method 7)

CCITT Group 3 two-dimensional encoding is similar to CCITT Group 3 one-dimensional encoding, except that rows 2 through K–1 are sent using two-dimensional encoding, where K is the K-factor used when the data was encoded. Refer to CCITT Fascicle VII.3 Recommendation T.4 for details.*

CCITT Group 4 Encoding (Method 8)

CCITT Group 4 encoding is a block-based compression method similar to the CCITT Group 3 encoding methods, except that all encoding is two-dimensional and does not include end-of-line delimiters. Refer to CCITT Fascicle VII.3 Recommendation T.6 for details.*

---

* Note the following relating to the CCITT encoding methods:

- The first four bytes of the Transfer Raster Data by Row/Block command are a 32-bit unsigned binary integer that specifies the number of pixels in a row. After decoding, any data exceeding the specified Source Raster Width is clipped, and any incompletely specified rows are appended with zeros. If Source Raster Height is specified, undefined rows are zero-filled and excess rows are clipped.
- CCITT Groups 3 and 4 encoding methods are by current definition monochrome compression methods, that is, data is sent for one plane only. The colors defined for indexes 0 and 1 are always used for plotting, regardless of how many planes were defined with the Set Number of Bits per Index byte of the HP RTL command Configure Image Data. When index 0 is set to a color other than white, a two-color plot results: index 0's color appears wherever a "0" bit is sent, and index 1's color appears wherever a "1" bit is sent.

2

HP RTL Command Reference

HP RTL Command Reference

This chapter describes each of the HP RTL commands in detail. Commands are grouped in this chapter as follows:

Switching Language Contexts

Enter HP-GL/2 Mode	ESC % # B
Enter PCL Mode	ESC% # A
Reset	ESC E
Universal Exit Language/Start of PJL	ESC % # x|X

Setting Colors

Configure Image Data	ESC * v # W[data]
Set Red Parameter	ESC * v # a|A
Set Green Parameter	ESC * v # b|B
Set Blue Parameter	ESC * v # c|C
Assign Color Index Number	ESC * v # i|I

Setting Raster Parameters

Source Raster Width	ESC * r # s|S
Source Raster Height	ESC * r # t|T
Move CAP Horizontal (Decipoints)	ESC & a # h|H
Y Offset	ESC * b # y|Y
Destination Raster Width	ESC * t # h|H
Destination Raster Height	ESC * t # v|V
Raster Line Path	ESC * b # l|L
Negative Motion	ESC & a # n|N
Set Graphics Resolution	ESC * t # r|R

Sending Raster Data

Start Raster Graphics	ESC * r # a|A
End Raster Graphics	ESC * r C
Transfer Raster Data by Plane	ESC * b # V[data]
Transfer Raster Data by Row/Block	ESC * b # W[data]
Set Compression Method	ESC * b # m|M

Command Syntax

HP RTL Syntax is described in detail under "Using HP RTL" in chapter 1. However, the following notes are particularly relevant to reading the command descriptions in this chapter:

- Some HP RTL commands can end with either a lower-case or an upper-case parameter character. These commands are shown in this chapter with both options, for instance, **ESC** * v # a | A. See chapter 1 for instructions on combining these commands.
- Some HP RTL commands *must* end with an upper-case parameter character. These commands are shown in this chapter without the lower-case option, for instance, **ESC** * r C.
- In some commands, out-of-range parameter values are "clamped." This means that if the value is *greater* than the maximum value allowed, it is set *to* the maximum value; if the value is *less* than the minimum value allowed, it is set *to* the minimum value.

Switching Language Contexts

You use these commands to switch between HP-GL/2 and HP RTL, and to reset the device.

Since these are the only HP RTL commands with the parameterized character "%", they cannot be combined with any other HP RTL commands. Each must be coded separately.

Enter HP-GL/2 Mode

ESC % # B

Causes the device to begin interpreting incoming data as HP-GL/2 commands.

The following values are allowed:

- **-1** Context switch from HP RTL to "stand-alone plotter."
- **0** (default) The HP-GL/2 pen position and palette are set to the previous HP-GL/2 pen position and palette.
- **1** The HP-GL/2 pen position is set to the current HP RTL CAP; the HP-GL/2 palette is set to the previous HP-GL/2 palette.
- **2** The HP-GL/2 pen position is set to the previous HP-GL/2 pen position; the HP-GL/2 palette is set to the current HP RTL palette.
- **3** The HP-GL/2 pen position is set to the current HP RTL CAP; the HP-GL/2 palette is set to the current HP RTL palette.

Range: –1 to 3. (A missing value is interpreted as 0 and negative values become –1. Positive values set the functions according to the last two bit positions; for instance, a parameter value of 5 (binary 101) is treated as a 1 (001); a value of 7 (111) is treated as 3 (011).)

The capital "B" terminator must be used with this command.

Device Note

Some devices do not support transferring the palette from HP RTL to HP-GL/2 (parameter values 2 and 3).

For parameter values 0 through 3, the usual HP-GL/2 environment is modified. For parameter value –1, the HP-GL/2 context behaves as a "stand-alone plotter," except that the Reset and Enter HP RTL Mode commands are recognized.

Upon entering HP-GL/2 with a –1 parameter, the following actions occur:

1. A conditional page advance is performed. That is, if any data was received for the current page, a page advance is performed. This causes the page to plot.
2. The HP-GL/2 Begin Plot (BP) instruction is executed.

When switching back from stand-alone plotter mode to HP RTL mode (with the Enter PCL Mode command), a conditional page advance is performed.

Stand-alone plotter mode does not allow plotting vector and raster data on the same page.

If HP-GL/2 is entered with a value of 1 or 3, the carriage return point is also updated to the new current position, that is, the current HP RTL CAP.

If the HP RTL palette is transferred to HP-GL/2 (parameter value of 2 or 3), the following occurs:

1 The widths associated with entries in the imported HP RTL palette are defaulted per the current setting of the Pen Width Unit Selection (WU) instruction.
2 The palette becomes the HP-GL/2 default palette for the Begin Plot (BP) and Initialize (IN) instructions until an "IN 1;", Reset or Enter PCL Mode command is executed.
3 If the current pen number is larger than the imported HP RTL palette size, the modulo function (as defined in the Select Pen (SP) instruction) is applied to obtain a pen number which can index into the HP-GL/2 palette.

Except for the CAP and palette, HP-GL/2 state variables are not affected by HP RTL mode and retain their previous HP-GL/2 values upon receipt of this command. However, state variables *are* reset by the Begin Plot (BP) instruction, which is executed for a parameter value of -1 (see above).

This command is ignored if it is received when the device is in HP-GL/2 mode.

Executing an Advance Full Page (PG) instruction in HP-GL/2 mode, directly or indirectly, defaults the HP RTL CAP to HP RTL 0,0.

Enter PCL Mode

ESC % # A

Causes the device to begin interpreting incoming data as HP RTL commands.

The following values are allowed:

- **0** (default) The new HP RTL CAP and palette are set to the previous HP RTL CAP and palette.
- **1** The HP RTL CAP is set to the HP-GL/2 pen position; the HP RTL palette is set the previous HP RTL palette.
- **2** The HP RTL CAP is set to the previous HP RTL CAP. The HP RTL palette is set to the HP-GL/2 palette.
- **3** The HP RTL CAP is set to the HP-GL/2 pen position; the HP RTL palette is set the HP-GL/2 palette.

Range: 0 to 3. (A missing or negative value is interpreted as 0. All values set the functions according to the last two bit positions; for instance, a parameter value of 5 (binary 101) is treated as a 1 (001); a value of 7 (111) is treated as 3 (011).

The capital "A" terminator must be used with this command.

Device Note Some devices do not support transferring the palette from HP-GL/2 to HP RTL (parameter values 2 and 3).

No HP RTL state variables except CAP and palette are explicitly affected by exiting HP-GL/2 mode. The HP RTL *default* palette is unaffected; for a parameter value of 2 or 3, only the *user-defined* palette is updated. Also for a parameter value of 2 or 3, the current setting of the number of bits per index is modified to the smallest value which will accommodate all entries in the new palette. (Number of bits per index is normally set via the Configure Image Data command.)

The Plot Size (PS) and Input Window (IW) currently specified for HP-GL/2 mode are automatically imported into HP RTL mode. The logical page size is set to the hard-clip limits, the HP RTL CAP is updated to retain its logical position, and any subsequent raster image is clipped to the IW window.

If the current HP-GL/2 position is outside the bounds of the HP RTL logical page and the value field is 1 or 3, CAP is allowed to move beyond the logical page boundary.

This command is ignored if it is received when the device is already in HP RTL mode, except that it will implicitly perform an End Raster Graphics if the device is in raster mode.

Reset

ESC E

Reset causes the following actions:

- Prints any partial pages of data which may have been received.
- Executes the HP-GL/2 instruction Initialize (IN).
- Resets all programmable features to their default values. Programmable features whose defaults can be set from the front panel are set to those defaults.
- Returns and fixes the HP RTL CAP to HP RTL (0,0).
- Returns the device to HP RTL parsing mode.
- Implicitly ends raster mode, if necessary.

There is no value parameter.

The capital "E" terminator must be used with this command.

Both the HP-GL/2 and HP RTL contexts recognize the Reset command.

After the Reset command, the device remains online, no subsequent data is lost, and there is no effect on I/O or host-to-peripheral communication.

Reset is a valid HP-GL/2 terminator, and incorporates all the functionality of the Initialize (IN) instruction, as well as defaulting the HP RTL and HP-GL/2 palettes.

Within an HP-GL/2 label, when transparent data mode is on (TD = 1), Reset is interpreted as data and does not reset the device. Transparent data mode is set with the HP-GL/2 instruction Transparent Data (TD).

When the device is expecting HP RTL data, Reset is interpreted as data and does not reset the device. The device expects HP RTL data following the HP RTL commands Configure Image Data, Transfer Raster Data by Plane, and Transfer Raster Data by Row/Block. The length of the data the device expects varies and is specified in each command.

Reset does not cause a page eject if the page does not contain an image (raster graphics or HP-GL/2 graphics).

Universal Exit Language/Start of PJL

ESC % *#* x | X

Causes the current context processor to shut down in an orderly fashion and exit into the Printer Job Language (PJL)

\# **-12345** Exit the current language context and start PJL.

Range: -12345. Only the exact nine-character sequence (**ESC** % -12345 X) is guaranteed to cause exit from the current language context. (Spaces are shown for clarity only.) Note that the value (-12345) is a *string of characters* and not an integer value.

This command performs the following actions:

- Prints all data received before this command.
- Shuts down the current context in an orderly fashion.
- Turns control over to PJL.

The command is always recognized in the following contexts:

- In the HP-GL/2 context, except within an HP-GL/2 label, when transparent data mode is on (TD = 1).
- In the HP RTL context, except when in an HP RTL binary data transfer.

Device Note

Devices that support only HP-GL/2 and HP RTL ignore this command. On devices that support additional language contexts, the command may or may not be recognized in those contexts.

Setting Colors

You use these commands to define how the device handles color data.

All of these commands begin with ESC * v. You can combine these commands using the technique described in "Combining Commands" under "Using HP RTL" in chapter 1. Combining the Configure Image Data command with other commands is not recommended, since the Configure Image Data command resets the values set by the other commands.

Configure Image Data

ESC * v # W[data]

Configures the device for color imaging by performing the following actions:

- Specifies the number of bits per index and defaults the color palette accordingly.
- Sets the color model.
- Sets the pixel encoding mode.
- Sets the number of bits per primary for red, green, and blue.
- Sets the white and black reference values for red, green, and blue.

The following values are allowed:

6 Perform the actions listed above. Set the white and black reference values based on the number of bits per primary red, green, and blue.

18 Perform the actions listed above. Set the white and black reference values to the explicit settings in the last 12 bytes of the data.

There is no default.

Range: 6, 18. (Other values less than 18 cause the command to be ignored. Values greater than 18 are valid, but only the first 18 bytes are used.)

The data field is interpreted as follows:

Byte	Bit Number 15 … 8	Bit Number 7 … 0	Byte
0	Color Model	Pixel Encoding Mode	1
2	Number of Bits per Index	Number of Bits per Primary Red	3
4	Number of Bits per Primary Green	Number of Bits per Primary Blue	5
6	White Reference for Red		7
8	White Reference for Green		9
10	White Reference for Blue		11
12	Black Reference for Red		13
14	Black Reference for Green		15
16	Black Reference for Blue		17

Bytes 0 through 5 are interpreted as 1-byte unsigned binary integers. Bytes 6 through 17 are interpreted as six 2-byte signed binary integers.

The sections "Preparing to Send Raster Data" in chapter 1 describes the concepts behind the Configure Image Data command. Refer to this section for more information on data planes, the color palette, indexes, and raster modes.

The following sections describe each Configure Image Data parameter as a subcommand.

Byte 0: Set Color Model

Sets the color model to relative.

Byte 0 value

(default) 0 (relative model).

Range: 0 (out-of-range values default to 0). Other values are reserved for future color models.

Byte 1: Set Pixel Encoding Mode

Defines how the device is to render planes of raster data.

Byte 1 value

The following values are allowed:

0 (default) Row-by-row raster mode (indexed by plane).

4 Plane-by-plane raster mode (indexed plane-by-plane).

Range: 0, 4 (out-of-range values cause the entire Configure Image Data command to be ignored).

Device Note

Plane-by-plane mode (parameter value 4) is only supported on a limited number of color devices.

In row-by-row raster mode, plots with more than one plane per row are specified by sending all the planes for each raster row before proceeding to the next row. Depending on the compression mode, row-by-row raster mode allows both the Transfer Raster Data by Plane and Transfer Raster Data by Row/Block commands. For more information, see "Transferring Raster Data" in chapter 1.

In plane-by-plane mode, the application or host must separate the color image into four bilevel bitmaps representing the black, cyan, magenta, and yellow planes. The planes are sent in order, one at a time, using the Transfer Raster Data by Row/Block command. In between planes, palette index 1 is redefined to the next color, and the Y Offset command is used to reposition the CAP so that the planes will line up as intended. (While in plane-by-plane mode, if data is sent using the Transfer Raster Data by Plane command, the command and the associated data are parsed and ignored.)

In plane-by-plane mode, index 0 is always treated as "transparent," and setting index 0 to another color has no visible effect until row-by-row raster mode is resumed. In plane-by-plane mode, index 1 is interpreted as the primary nearest to the color assigned to index 1.

Device Note

On devices that support it, plane-by-plane mode may be used to obtain color images at sizes which would otherwise exceed the device's memory limits. Device-specific restrictions may affect temporal ordering and the ability to freely switch between vector and raster data.

See Also

"Merging Vector and Raster Data" in chapter 1 for information on how raster and vector data are overlaid.

Byte 2: Set Number of Bits per Index

Sets the number of bits required for indexing into the relative color palette. Creates a default palette of the size 2^n where “n” is the number of bits per index.

Byte 2 value

Number of bits to access a palette entry (that is, number of planes per row). Default is 1.

Range: 1 to 255 (0 is interpreted as 1).

Device Note

The maximum number of bits per index (and thus the maximum palette size) is device-dependent. Values greater than those supported by a device are clamped to the highest supported value.)

The default HP RTL palettes are described under “Defining the HP RTL Palette” in chapter 1.

If the device is in plane-by-plane raster mode (Pixel Encoding Mode = 4), only the first plane of data is used.

Bytes 3 through 5: Set Number of Bits per Primary

Sets the number of bits per primary for red, green, and blue, respectively.

Bytes 3–5 value

Number of bits of data. There is no default.

Range: 0 to 255 (out-of-range values are clamped).

Device Note

The maximum number of bits per primary is device-dependent. Values greater than those supported by a device are clamped to the highest supported value.

If the Configure Image Data parameter value (#) is 6, these bytes determine the white and black reference values for the color range. In this case, the black reference is always set to 0, and the white reference is set to $2^{\text{number of bits per primary}} - 1$. Use 8 to retain the default color range of 0 to 255 ($2^8 - 1 = 255$).

The following table shows sample values for the number of bits per primary, and the resulting color ranges:

Color	If the Number of Bits per Primary Is...	The Black/White Reference Is...
Red (Byte 3)	8	0 to 255
Green (Byte 4)	6	0 to 65
Blue (Byte 5)	8	0 to 255

When the Configure Image Data value (#) is 18, the number of bits per primary are not used; you can set them to any value.??**generically true?**

Bytes 6 through 17: Set Color Range White/Black Reference

Set the limits for RGB parameters by setting white and black references for each primary color.

Bytes 6-17 values White and black references, as shown in the table at the beginning of the Configure Image Data command. Default: 0 for the black references, 255 for the white references.

Range: -32768 to 32767 for each reference.

Use these bytes to explicitly set the white and black references.

Setting the black reference greater than the white reference for any of the three RGB components produces an inverse mapping for that color component.

You can only include these bytes in the data when the Configure Image Data value (#) is 18.

Set Red Parameter

ESC * v # a | A

This command specifies the red component of any new color entry of the color palette.

Red parameter. Default is 0.

Range: Black reference to white reference for red (as defined in the Configure Image Data command). Out-of-range values are clamped.

This parameter is initialized to 0 after each Assign Color Index Number command.

Set Green Parameter

ESC * v # b | B

This command specifies the green component of any new color entry of the color palette.

Green parameter. Default is 0.

Range: Black reference to white reference for green (as defined in the Configure Image Data command). Out-of-range values are clamped.

This parameter is initialized to 0 after each Assign Color Index Number command.

Set Blue Parameter

ESC * v # c|C

This command specifies the blue component of any new color entry of the color palette.

Blue parameter. Default is 0.

Range: Black reference to white reference for blue (as defined in the Configure Image Data command). Out-of-range values are clamped.

This parameter is initialized to 0 after each Assign Color Index Number command.

Assign Color Index Number

ESC * v # i|I

Assigns the currently specified red, green, and blue (RGB) parameters to the designated index number. RGB parameters are specified by the Set Red Parameter, Set Green Parameter, and Set Blue Parameter commands.

Index number. There is no default.

Range: 0 to (2^n - 1) where "n" is the number of bits per index (planes per row) specified in the Set Number of Bits per Index byte of the Configure Image Data command. (Assign Color Index Number with an out-of-range value sets the RGB parameters to 0, but is otherwise ignored.)

The RGB parameters are set to 0 after executing this command.

Setting Raster Parameters

You use these commands to establish the boundaries of your plot, to move the CAP, to set up for scaling, to tell the device whether to expect negative motion, and to set the resolution.

Some of these commands begin with the same parameter character and group character. Those that do can be combined. For instance, you can combine the Source Raster Width and Source Raster Height commands because they both begin with ESC * r. For instructions on combining commands, see “Combining Commands” under “Using HP RTL” in chapter 1.

Source Raster Width

ESC * r # s|S

Specifies the width in pixels of the source raster image denoted by subsequent Start Raster Graphics commands. Width is in the direction of (parallel to) the raster rows.

Width in pixels. Default: Logical page width for unscaled graphics, undefined for scaled graphics.

Range: 0 to 65535 (out-of-range values are clamped).

Device Note The 65535 limit is the HP RTL limit. Actual limits are device-dependent. Values exceeding the device limits are clamped.

The Source Raster Width and Source Raster Height commands must precede a Start Raster Graphics command where scale mode is set to "on" (parameter value 2 or 3). Without the Source Raster Width and Source Raster Height commands, raster graphics will begin with the scale mode off, that is, as if a parameter value of 0 or 1 were sent.

The default source raster width is also affected by changes in the left graphics margin; that is, if a Start Raster Graphics command is sent with a parameter value of 1 or 3 (which sets the left graphics margin to CAP), the default source raster width is interpreted as extending from the left graphics margin to the right edge of the logical page. This "tracking" behavior terminates when the source raster width is set explicitly, and resumes after a Reset command.

Plane or row data that is not specified for the full source raster width is filled out with zeros; data exceeding the source raster width is clipped. (Zero-filled data plots with the color specified for index 0 in the palette.) If the user specified a source raster width of 0 and a Start Raster Graphics (or Transfer Raster Data) command is received, the entire raster graphic is clipped.

See Also "Setting the HP RTL Width and Height" under "Setting Raster Boundaries" in chapter 1.

Source Raster Height

ESC * r # t|T

Specifies the height in pixel rows of the source raster image denoted by subsequent Start Raster Graphics commands. Height is perpendicular to the pixel rows and is measured in the direction specified by the Raster Line Path command.

Height in pixel rows. There is no default.

Range: 0 to 65535 (out-of-range values are clamped).

Device Note The 65535 limit is the HP RTL limit. Actual limits are device-dependent. Values exceeding the device limits are clamped.

The Source Raster Width and Source Raster Height commands must precede a Start Raster Graphics command where scale mode is set to "on" (parameter value 2 or 3). Without the Source Raster Width and Source Raster Height commands, raster graphics will begin with the scale mode off, that is, as if a parameter value of 0 or 1 were sent.

A Reset command causes an explicitly set source raster height to become undefined.

Row data that is not specified for the full source raster height is filled out with zeros. Zero-filled data plots with the color specified for index 0 in the palette.

When a Transfer Raster Data command is received that causes any pixel row to extend beyond the row boundary set by the Source Raster Height command, the row outside the boundary will be clipped. This includes the case where the CAP is moved beyond the height boundary with a Y Offset command and the printing of raster data is attempted. If the user has specified a source raster height of 0 and a Start Raster Graphics (or Transfer Raster Data) command is received, then the entire raster graphic is clipped.

If the user has not set the source raster height, then raster height is not used; that is, there is no default value.

Upon receiving an explicit or implicit End Raster Graphics command, CAP is set to the left graphics margin of the next pixel row after the raster height boundary. The location of the “next” pixel row depends on the direction specified by the Raster Line Path command.

See Also

“Setting the HP RTL Width and Height” under “Setting Raster Boundaries” in chapter 1.

Move CAP Horizontal (Decipoints)

ESC & a # h|H

Moves CAP horizontally by the specified number of decipoints (1/720 inch). Rendering begins on a byte boundary.

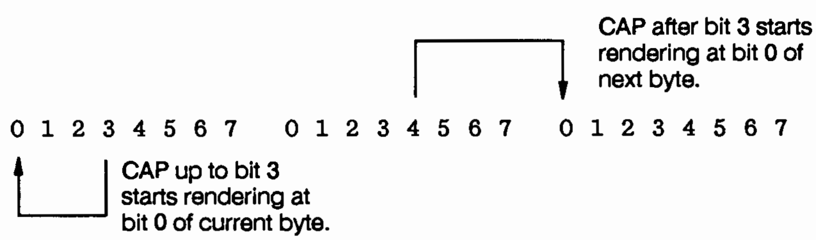
Number of decipoints. There is no default.

Range: -32767 to 32767 (out-of-range values are clamped).

Use a plus sign (+) before the number to move to the right relative to CAP, a minus sign (-) to move to the left relative to CAP, and no sign to move an *absolute* distance from the logical page left bound.

This command can move CAP anywhere along the horizontal axis. Requests for movement outside the logical page are allowed.

Rendering after one or more Move CAP Horizontal commands always begins on a byte boundary. (One byte corresponds to eight dots of the plotter's physical resolution. Bytes are counted from the left edge of the plotter.) After one or more Move Horizontal CAP commands, the effective rendering position is "rounded" to determine which byte to start rendering on. If the series of Move CAP Horizontal commands places the CAP in bit positions 0, 1, 2, or 3, rendering starts at bit 0. If the series of Move CAP Horizontal commands places the CAP in bit positions 4, 5, 6, or 7, rendering begins at bit 0 of the next byte. Note that the CAP itself is not changed; this rounding operation only affects the place where the device starts rendering.



Device Note

The physical distance covered by a byte depends on each device's physical resolution. For instance, at 300 dpi, there are 300/8 = 37.5 bytes per inch, so each byte is 1/37.5 = .027 inches wide.

Y Offset

ESC * b # y | Y

Moves CAP vertically the number of pixel rows specified in the value field. CAP is allowed to move outside the logical page.

Number of pixel rows of vertical movement. There is no default.

Range: -32767 to 32767 (out-of-range values are clamped; a missing value is interpreted as 0).

Use a plus sign (+) before the value, or an unsigned value, to move CAP in the direction specified by the Raster Line Path command. Use a minus sign (–) before the value to move CAP in the direction opposite the raster line path. Unlike the Move CAP Horizontal (Decipoints) command, there is no absolute move possible with this command.

When Y Offset is used in raster mode, skipped rows are zero-filled up to the offset requested, or the current source raster height, whichever comes first. If a negative Y Offset value places CAP outside the position at which raster graphics was started, no zero-filling is done for rows which lie outside the raster area.

The physical distance that this command moves CAP varies according to the current resolution.

Executing this command causes the seed row to be zeroed, even if the command has a zero or missing parameter value (#).

Device Note

When this command is received before a row is completed, it is device dependent whether or not the incomplete row is rendered. If it is rendered, the incomplete row is zero filled, the row pointer is incremented, and the plane pointer is reset to 1. If it is not rendered, the row pointer is not incremented as a result of the incomplete row.

Device Note

Due to memory limitations, some devices may begin plotting an image before it is completely stored in memory. In this mode, a Y Offset command may require that the device "back up" the media. The ability to reverse the media feed direction is device-dependent.

Destination Raster Width

ESC * t # h|H

Defines the width in decipoints (1/720 inch) of the destination raster image denoted by subsequent Start Raster Graphics commands with scale mode on (parameter value 2 or 3).

Width in decipoints. There is no default.

Range: 0 to 65535 (out-of-range values are clamped).

Zero or absent values default destination raster width to a value in which isotropic scaling is maintained.

If the specified destination width exceeds the logical page size, the scale factor is maintained and the image is clipped at the right boundary of the logical page.

See Also "Scaling Raster Images" in chapter 1.

Destination Raster Height

ESC * t # v|V

Defines the height in decipoints (1/720 inch) of the destination raster image denoted by subsequent Start Raster Graphics commands with the scale mode on (parameter value 2 or 3).

Height in decipoints. There is no default.

Range: 0 to 65535 (out-of-range values are clamped).

Zero or absent values default destination raster height to a value in which isotropic scaling is maintained.

If the specified destination height exceeds the logical page size, the scale factor is maintained and the image is clipped at the bottom boundary of the logical page.

See Also "Scaling Raster Images" in chapter 1.

Raster Line Path

ESC * b # l|L

Specifies the following:

- The vertical direction that a Transfer Raster Data by Row/Block command increments the raster row within an image.
- The vertical direction that the Y Offset command moves CAP.
- The vertical direction in which an explicit or implicit End Raster Graphics command moves CAP if a source raster height has been specified.

The handling of line feeds in HP-GL/2 labels is not affected.

#

The following values are allowed:

0 (default) Increment raster row in the +Y direction of the HP RTL coordinate system.

1 Increment raster row in the -Y direction of the HP RTL coordinate system.

Range: 0 to 1 (a missing value is interpreted as 0, and other values cause the command to be ignored).

This command is ignored after the Start Raster Graphics or Transfer Raster Data commands until the next explicit or implicit End Raster Graphics command. Since the raster image will "grow" in the specified direction, it is the user's responsibility to position CAP to avoid unwanted overlaying of the image with vector or other raster graphics.

Device Note

Due to memory limitations, some devices may begin plotting an image before it is completely stored in memory. In this mode, depending on the setting of Raster Line Path, a Y Offset command may require that the device "back up" the media. The ability to reverse the media feed direction is device-dependent.

Negative Motion

ESC & a # n|N

Specifies whether negative motion will be used.

The following values are allowed:

0 (default) Image may contain negative motion.

1 Image contains no negative motion.

Range: 0 to 1 (a missing value is interpreted as 0, and other values cause the command to be ignored).

Negative motion is defined as any command that would potentially require CAP to move in a negative Y direction. In particular, these commands are as follows:

- When raster line path = 0, any negative Y Offset command.
- When raster line path = 1, any positive Y Offset command, or any data transfer command.
- Any HP-GL/2 drawing operation.

Devices normally compose an entire page in memory or on a hard disk before printing. This allows for multiple raster images on a page, or for merged raster and vector images on the page.

However, if there is only one raster image remaining to put on the page, and that image does not use negative motion, it is advantageous on some devices to issue this command with a 1 parameter. These devices can begin plotting immediately, without waiting for the entire image to be stored in memory or on disk.

Device Note

Some devices cannot simultaneously receive and plot raster images. On these devices, this command has no effect.

If negative motion is set to 1 and the image nonetheless contains negative motion (as defined above), the effect is device dependent.

Set Graphics Resolution

ESC * t # r|R

Defines the resolution at which graphics data is to be plotted.

Resolution in dots per inch (dpi). The default is device-dependent.

Range: 0 to 32767 (out-of-range values are clamped).

Device Note

The default resolution is device-dependent.

The 0 to 32767 range represents HP RTL limits. Device limits may be more restrictive.

Actual physical (or native) resolution is device-dependent.

Support of *continuous* or *incremental* resolution is device-dependent.

If scale mode is on, the graphics resolution set with this command does not affect rendering. (You turn scale mode on or off when you Start Raster Graphics.) The following description assumes that scale mode is off.

The HP-GL/2 Quality Level (QL) instruction determines how the requested resolution is interpreted. If "QL 0;" (draft mode) is in effect, the requested resolution is mapped to the next higher "draft copy" resolution regardless of whether the device supports continuous resolution. (Draft copy resolutions are device-dependent values which are usually derived from the device's native resolution, and which are chosen to significantly reduce image processing time.) If the resolution value is greater than the maximum supported draft copy resolution, then the highest supported draft copy resolution is used.

If "QL 100;" (final mode) is in effect and the device supports continuous resolution, the image is rendered using the exact resolution specified, except that a resolution of zero is mapped to the lowest supported resolution of the device.

If "QL 100;" (final mode) is in effect and the device only supports incremental resolution, the resolution value is mapped to the next higher supported resolution to assure that the image is printed without data loss. If the resolution value is greater than the maximum for the device, then that maximum is used.

Device Note

For "QL 100;", when the requested resolution is higher than the device's native resolution, the plot must be scaled down. The algorithm used for scaling down is device dependent.

See Also

"Controlling Image Resolution" in chapter 1.

Sending Raster Data

You use these commands to enter and exit raster mode and to send raster data to the device.

Note that the Set Compression Method command and the two transfer commands both begin with **ESC** * b. You can combine the Set Compression Method command with either of the two transfer commands using the technique described in "Combining Commands" under "Using HP RTL" in chapter 1. You must put the Set Compression Method *first* in the combined command. Transfer commands (which must end in a capital letter, and are followed by data) can only *end* a combined command; they cannot begin one.

Start Raster Graphics

ESC * r # a | A

Places the device in raster mode with scale mode on or off, fixes the starting position of the graphics image, and sets the left graphics margin.

The following values are allowed:

0 (default) Start graphics at logical page left bound.

1 Start graphics at current active position (CAP).

2 Turn on scale mode and start graphics at logical page left bound.

3 Turn on scale mode and start graphics at CAP.

Range: 0 to 3 (out-of-range values default to 0).

Both Source Raster Width and the Source Raster Height must be specified before starting raster graphics in scale mode. If neither is specified, or if only one is specified, a Start Raster Graphics command with a parameter value of 2 or 3 will function as if the parameter value were 0 or 1, respectively. That is, raster graphics will start with scale mode off.

A value of 0 or 2 starts the image at the current vertical position on the left boundary of the logical page; that is, the left graphics margin is set to zero. A value of 1 or 3 starts the image at the current position; that is, the left graphics margin is set to the current horizontal position.

For a Raster Line Path of 0 (the default), the starting corner becomes the upper left corner of the image. For a Raster Line Path of 1, the starting corner becomes the lower left corner of the picture.

Values of 2 or 3 turn scale mode on. Scaled images are rendered in the specified size independent of device resolution.

Device Note

When scaling an image down, loss of detail always results. The algorithm used for scaling down is device dependent

Implicit Start Raster Graphics

A Transfer Raster Data by Plane or Transfer Raster Data by Row/Block command is permitted with no preceding Start Raster Graphics command. Either transfer command implicitly puts the device into (unscaled) raster mode and uses the left edge of the logical page as the left graphics margin, corresponding to a Start Raster Graphics with parameter value 0. It is recommended, however, that you start raster graphics explicitly.

Commands in Raster Mode

After an explicit or implicit Start Raster Graphics command, the device enters a restricted state called *raster mode*. This mode "locks out" (ignores) commands that would affect rendering of the graphics image. These commands remain locked out until raster mode is terminated by an explicit or implicit End Raster Graphics command.

The following commands are ignored in raster mode. Raster mode is in effect after any implicit or explicit Start Raster Graphics command until an implicit or explicit End Raster Graphics command:

Start Raster Graphics
Set Graphics Resolution
Raster Line Path

The following additional commands are ignored in scaled raster mode only. Scaled raster mode is in effect after a Start Raster Graphics command with a value of 2 or 3 is received (and Source Raster Width and Source Raster Height were specified) until an implicit or explicit End Raster Graphics command:

Configure Image Data	Assign Color Index
Y Offset	Source Raster Width
Set Red Parameter	Source Raster Height
Set Green Parameter	Destination Raster Width
Set Blue Parameter	Destination Raster Height

The following commands are always allowed in raster mode:

Set Compression Method
Transfer Raster Data by Plane
Transfer Raster Data by Row/Block

Commands that are neither explicitly ignored or explicitly allowed cause an implicit End Raster Graphics, and are then executed as usual.

End Raster Graphics

ESC * r C

This command ends raster mode. It signifies the end of the transfer of a raster graphics image and ends the current raster row.

There is no value parameter. If a value field is received, it is ignored and the command is still executed.

This command cannot be combined. The capital "C" terminator must be used with this command.

Receipt of this command causes the following operations:

- Resets the seed row used by compression method 3 to zeros.
- If a source raster height was specified, moves CAP vertically, in the direction specified by Raster Line Path, to the raster row immediately following the end of the raster area. If no source raster height was specified, CAP is positioned in the direction of Raster Line Path to the row following the last completed row,.
- Moves CAP horizontally to the left graphics margin. If raster graphics started at the current CAP (Start Raster Graphics 1 or 3), the CAP after the End Raster Graphics is at the same X-coordinate as the starting CAP. If raster graphics started at the left edge of the logical page (Start Raster Graphics 0 or 2), the CAP after the End Raster Graphics is at the left edge of the logical page.
- Defaults the compression method to 0.
- Enables commands that were locked out by Start Raster Graphics.
- Resets the plane pointer to 1.
- Resets the left graphics margin to 0.

Device Note

When this command is received before a row is completed, it is device dependent whether or not the incomplete row is rendered. If rendered, the incomplete row is zero-filled, the row is incremented, and the plane pointer is set to 1. If not rendered, the row is not incremented as the result of the incomplete row.

Implicit End Raster Graphics

Receipt of any ASCII data or any HP RTL command other than those listed under Start Raster Graphics as explicitly allowed or explicitly ignored causes an implicit End Raster Graphics with all of its defined functionality. It is recommended, however, that you end raster graphics explicitly.

Transfer Raster Data by Plane

ESC * b # V[data]

Transfers the number of bytes specified in the value field to the device, but does not move CAP to the next raster row. The plane pointer is incremented, but not the row pointer.

Number of bytes in the data field. If data is compressed, this refers to the length of the *compressed* data. There is no default.

Range: 0 to 32767. Out-of-range values are clamped.

If the number of bytes specified in the value field (#) is greater than 32767, the first 32767 bytes following the command are interpreted as data, and byte 32768 is interpreted as the beginning of the next HP RTL command.

This command is used to send each plane except the last in a multi-plane raster row. It is not used for single-plane rows, or for the last plane in a multi-plane row, since row position is not affected by this command. To transfer raster data and increment the row pointer, the Transfer Raster Data by Row/Block command must be sent.

The number of data bytes is independent of source raster width and can vary from plane to plane. If the image width can accommodate more data than is sent, the undefined data is assumed to be all zeros. For information on how to use this feature, see "Setting the HP RTL Width and Height" under "Setting Raster Boundaries" in chapter 1.

Empty planes can be sent using Transfer Raster Data by Plane with a value of 0 (**ESC** *b0V). A row can be ended "early" with a Transfer Raster Data by Row/Block with a value of 0 (**ESC** *b0W). Absent data is assumed to be zeros: in row-by-row raster mode, when the combined planes yield an index of zero, those pixels are rendered with whatever color has been assigned to index number zero in the color palette. (This command is not used in plane-by-plane raster mode.) This can be used as a method of data compression.

Extra planes are ignored. For example, if three planes have been assigned to each row with the Set Number of Bits per Index byte of the Configure Image Data command, but four planes are sent for a given row, the fourth plane is ignored. If a Transfer Raster Data by Row/Block is used for one of the extra color planes, the data is ignored, but the row is incremented and subsequent planes are again interpreted as valid data (for the next row).

The data in the data field is interpreted according to the current compression method. This command is used only for row-based compression methods. The Transfer Raster Data by Plane command and its associated data are parsed and ignored if sent when a block-based compression method is in effect. See the Set Compression Method command for a listing of row-based and block-based compression methods.

This command is only allowed in row-by-row raster mode. (Plane-by-plane raster mode requires only one plane of data at a time, so this command is not needed.) If this command is received when the device is in plane-by-plane raster mode, the command and its associated data are parsed and ignored.

Device Note

When an explicit or implicit End Raster Graphics command is received before the row is completed with a Transfer Data by Row/Block command, it is device dependent whether or not the incomplete row is rendered. See the device note under the End Raster Graphics command.

If a block of data is transferred using a block-based compression mode before the previous row is completely defined, the plane pointer is set to 1 at the beginning of the block transfer. As with End Raster Graphics, it is device dependent whether or not the incomplete row is rendered.

Transfer Raster Data by Row/Block

ESC * b # W[data]

Transfers the number of bytes specified in the value field to the device in a row-by-row or block format depending on the current compression method.

Number of bytes in the data field. If data is compressed, this refers to the length of the *compressed* data. There is no default.

Range: 0 to 2,147,483,647 (2^{31} - 1) (out-of-range values are clamped).

For row-based formats, this command is used for single-plane rows (including those sent in plane-by-plane mode) or for the last plane in a multi-plane row. After execution, the row pointer is incremented, the plane pointer in a multi-plane row is reset to 1, and CAP is set to the left graphics margin at the start of the next row.

For block-based formats, this command is used for block transfer of single- or multi-plane rows with implied or explicit row and plane divisions. Row and plane divisions depend on the number of planes and the current compression method. At the end of the block transfer, the plane pointer is set to 1 and CAP is set to the left graphics margin.

Set Compression Method

ESC * b # m|M

Determines how raster data is interpreted in the Transfer Raster Data by Plane and Transfer Raster Data by Row/Block commands. The compression method stays in effect until explicitly changed by another Set Compression Method or until defaulted by an explicit or implicit End Raster Graphics or a machine reset.

The following values are allowed:

0 (default) Unencoded (row-based).

1 Run-length encoding (row-based).

2 Tagged Image File Format (TIFF) revision 4.0 "Packbits" encoding (row-based).

3 Seed-row encoding (row-based).

4 Unencoded (block-based).

5 Not implemented.

6 CCITT Group 3 one-dimensional encoding (block-based).

7 CCITT Group 3 two-dimensional encoding (block-based).

8 CCITT Group 4 encoding (block-based).

Range: 0 to 8 (out-of-range or unimplemented values default to 0).

See Also "Compressing Data" in chapter 2 for a description of the data compression methods.

anisotropic scaling See **scaling.**

CAP Current active position, the row and column location of the logical "cursor" in a raster image.

command mode The HP RTL mode for setting boundaries, colors, resolution, and other parameters. See also **raster mode.**

data compression A way to reduce the amount of data that must be transmitted or stored on disk. HP RTL supports several different data compression methods.

device dependency A characteristic of a plotter language that is unique to one or more devices, as opposed to applying universally to all devices.

dpi Dots per inch, the units for measuring resolution of raster images.

driver A special subprogram used by software to control input and output between the software and peripheral devices.

escape sequence A string of characters beginning with the ESC (escape) character, decimal 27 in ASCII. All HP RTL commands are escape sequences.

HP-GL/2 The second generation of HP's vector graphics language.

HP RTL HP Raster Transfer Language, a raster graphics language based on HP's PCL language.

isotropic scaling See **scaling.**

language context The graphics language the device is currently processing, for instance HP-GL/2 or HP RTL.

PCL Printer Control Language, used in HP laser printers and other products.

pixel A point in a raster graphics image. Some devices allow pixels to take on different colors.

render To create the actual graphics image. This may mean printing or plotting directly on output media, or the image may first be created in memory or on a hard disk.

raster graphics Graphic images defined solely by points (pixels). A television is a raster graphics device. See also **vector graphics.**

raster mode The HP RTL mode for transferring the actual raster data. See also **command mode.**

resolution A measure of image sharpness. Raster image resolution is measured in dots per inch (dpi).

scaling Increasing or decreasing the size of an image as compared to the original. Isotropic scaling scales both dimensions in proportion to the original. Anisotropic scaling scales each dimension independently of the original.

vector graphics Graphic images defined by points and lines drawn between them. See also **raster graphics**.

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