7 Color Vector Graphics (HP-GL/2)

Introduction

The process involved in using HP-GL/2 with the HP Color LaserJet family or DeskJet 1200C and 1600C color printers is nearly identical with using HP-GL/2 on other color printers or plotters. However, these two color printers add a few HP-GL/2 commands and expand the functionality of some existing commands. This chapter describes these commands and other pertinent points to keep in mind when using HP-GL/2 with these color printers.

The HP-GL/2 commands explained in this chapter include the following: The Merge Control (MC) command, which functions in a similar way to the PCL logical operation command. The Pen Color (PC) command, which modifies palette colors, the Number of Pens (NP) command, which changes the palette size, the Pixel Placement (PP) command, which determines how pixels are rendered in HP-GL/2 polygons, and the Color Range (CR) command, which sets the range for specifying relative color data (the CR command is not supported by the HP Color LaserJet 4500 or 8500 printers).

In general, when using HP-GL/2 on the HP Color LaserJet family and DeskJet 1200C and 1600C color printers, keep in mind that:

- Palette information stays the same when switching between PCL 5 and HP-GL/2.
- The HP-GL/2 Initialize (IN) command sets the palette to the default eight-pen palette, and also resets the ROP code (see the MC command section later in this chapter) and the pixel placement command.
- As with color plotters, to specify a particular color, you use the SP (Select Pen) command.

If you are not familiar with using HP-GL/2, see the *PCL 5 Printer Language Technical Reference Manual*.

Enter HP-GL/2 Mode

This command causes the printer to interpret subsequent commands as HP-GL/2 commands, instead of PCL printer language commands.

^{E}C**%#B**

= −1 - Stand-alone plotter mode (single context)

0 - Position pen at previous HP-GL/2 pen position

1 - Position pen at current PCL cursor position

2 - Use current PCL coordinate system and previous HP-GL/2 pen position

3 - Use PCL dot coordinate system and the current PCL CAP

Default = 0

Range = 1 to 3 (unsupported negative values default to −1; all other unsupported values are ignored)

As soon as the printer receives this command, it switches to HP-GL/2 mode, interpreting commands as HP-GL/2 commands until it receives an Enter PCL Mode, ^{E}CE, or UEL command, or until the printer power is switched off and on.

The value field (#) determines the cursor position once HP-GL/2 mode is entered.

Note HP Color LaserJet printers do not support ^{E}C**%−**1B, ^{E}C**%**2B, or ^{E}C**%**3B

- **−1** — A value field of −1 creates a "single context" or "stand-alone plotter" mode which has the following effects:
  - The current page is closed and printed and the HP-GL/2 environment is initialized (IN command).
  - HP-GL/2 output begins on a new page.
  - HP-GL/2 and PCL output cannot be combined on the same page.
  - No PCL commands except ^{E}CE, ^{E}C%#A, and the PJL command ^{E}C%-12345X are recognized by the printer.
  - The PCL picture presentation directives are ignored.

- The ^{E}c%#A command closes HP-GL/2, prints the current page, and performs an ^{E}cE before entering PCL.
- The default HP-GL/2 orientation is reverse landscape.
- Hard-clip limits are equal to the printable area.
- The ^{E}cE command functions as usual.

When the single-context mode is used (^{E}c%–1B), the following steps should be followed:

1 Enter HP-GL/2 mode using the ^{E}c%–1B command.

2 Transmit one or more HP-GL/2 drawings.

3 Exit HP-GL/2 mode (^{E}c%#A).

- **0** — This parameter option (^{E}c%0B) sets the pen position to the previous HP-GL/2 position; if this is the first time HP-GL/2 mode is entered in the present print job (assuming an ^{E}cE has been sent), the pen position is at the lower left corner of the PCL Picture Frame (0,0).
- **1** — This parameter option (^{E}c%1B) specifies that the pen position and the label carriage return point become the same as the current PCL cursor position.
- **2** — ^{E}c%2B transfers the current PCL dot coordinate system to HP-GL/2, including the PCL origin and axes, but uses the previous HP-GL/2 pen position as the new pen position. Once the PCL coordinate system is established with this command, it is independent of the P1 and P2 positions.
- **3** — This parameter option (^{E}c%3B) specifies that the pen position and the label carriage return point become the same as the current PCL cursor position. The current PCL dot coordinate system and axes are also transferred to HP-GL/2; once the PCL coordinate system is established with this command, it is independent of the P1 and P2 positions.

When HP-GL/2 is entered using any dual-context mode (any variation of the command except ^{E}c%-1B), the HP-GL/2 and PCL contexts can be merged, resulting in the following:

- HP-GL/2 and PCL data can be combined on the same page.
- HP-GL/2 graphics can be integrated directly with text.
- The size and location of the PCL picture frame can be specified.
- HP-GL/2 graphics can be scaled to fit within the picture frame.

- The PCL palette and color configuration are transferred between contexts.
- The current logical operation and pixel placement settings are transferred between contexts.
- The current active position (CAP) is transferred between HP-GL/2 and PCL (for E_C%1B and E_C%3B only).
- The PCL orientation determines the HP-GL/2 orientation.

In PCL mode, the Enter HP-GL/2 Mode command must be executed, except when in display functions mode or within a binary data transfer. HP-GL/2 ignores this command.

Default Settings when Entering HP-GL/2

When you enter HP-GL/2 mode, most vector graphics variables retain their previous HP-GL/2 value. However, the following changes in the PCL environment can affect the HP-GL/2 environment:

- Resetting the printer (E_CE or control panel reset):
  - Executes an IN (Initialize) command
  - Defaults the PCL Picture Frame size
  - Defaults the PCL Picture Frame anchor point
  - Defaults the HP-GL/2 plot size
  - Defaults the PCL logical page orientation
- A page size, page length, or orientation command:
  - Defaults the PCL Picture Frame anchor point
  - Defaults the PCL Picture Frame
  - Defaults the HP-GL/2 plot size
  - Defaults P1 and P2 (IP, IR commands)
  - Resets the soft-clip window to the PCL Picture Frame boundaries (IW command)
  - Clears the polygon buffer (PM0, PM2)
  - Updates the cursor to the lower-left corner of the picture frame (P1).

- Redefining the PCL Picture Frame size or setting the anchor point:
  - Defaults P1 and P2 (IP, IR commands)
  - Resets the soft-clip window (IW) to the PCL Picture Frame boundaries.
  - Clears the polygon buffer (PM0, PM2)
  - Updates the current pen position to the lower-left corner of the picture frame (P1).
- Setting an HP-GL/2 plot size:
  - Changes the picture frame scaling factor.
- Redefining the palette:
  - Changes colors selected by the Select Pen (SP) command and used in patterns defined by the Raster Fill Definition (RF) command and/or used by the Fill Type (FT) command.

MC (Merge Control)

The MC command controls the color of pixels where two or more page marking primitives intersect on the page. This command supports all 256 Microsoft Windows ternary (ROP3) raster operation codes. A common application of the MC command is the rendering of complex polygon fill patterns. Raster Operations specify how source, destination, and patterns are combined to produce final images.

MC *mode, [opcode][;]*

Parameter	Format	Functional Range	Parameter Default
mode	clamped integer	0 or 1	0 (off)
opcode	clamped integer	0 to 255	252 (mode=0), 168 (mode=1)

- **Mode** — defines the merge control mode as follows:

  0 (off, default) Pixels in a primitive replace corresponding destination pixels. If no opcode is specified, 252 is used.

  1 (on) Pixels in a primitive merge with corresponding destination pixels, creating a new color based on the colors of the source data and the contents of the destination (frame buffer). If no opcode is specified, 168 is used.

Note This command is the HP-GL/2 version of the PCL Logical Operation command.

This command sets a ROP value which affects not only HP-GL/2 operation but also the PCL ROP value.

The MC command is defaulted by an IN command.

- **Opcode** — Specifies the logical operations performed on a source, destination, and pattern prior to drawing the final image. These raster opcodes (ROPs) are listed on the following pages in reverse polish notation (RPN) using the following abbreviations:

  D — Destination
  S — Source
  T — Texture
  a — and
  n — not
  o — or
  x — exclusive or

For example, when mode = 0, the opcode default is 252, which is the logical function TSo (Texture OR Source).

The operation code (opcode) specifies the logical operations that are performed on a source, destination, and patterned image prior to drawing the final image. The opcodes are created by listing all possible combinations of a single pattern, source and destination pixel, and constructing the desired final pixel values. The following table shows three common opcodes constructed by reading the output values bottom up.

Pixel Combinations			Desired Destination Values		
Patter Pixel	Source Pixel	Destination Pixel	Source Overwrite	Transparency (TR command)	Source Destination
0	0	0	0	0	0
0	0	1	0	1	1
0	1	0	1	1	1
0	1	1	1	1	0
1	0	0	0	0	0
1	0	1	0	1	1
1	1	0	1	1	1
1	1	1	1	1	0
Resulting Opcode			204 (0xCC)	238 (0xEE)	102 (0x66)

Note   When using the MC command, some pattern types will not produce the expected ROP result. This only occurs when using the FT (Fill Type) command pattern types 1, 2, 3, and 4, and when the ROP includes an XOR operation. (This problem is due to the fact that these patterns are the result of a vector operation and do not produce raster data for use by a ROP operation.) All other Fill Type command patterns (types, 10, 11, 21, or 22) operate as expected.

The MC command supports all 255 Microsoft Windows ROPS, which are listed on the following page in reverse polish notation (RPN) using the abbreviation listed above (D for Destination, S for Source, etc.).

Note   See "Logical Operation Command" in Chapter 5 for usage and ROP selection information.

Table 7-1. Logical Operations (ROP3)

Input Value	Boolean Function	Input Value	Boolean Function
0	0	27	SDTSxaxn
1	DTSoon	28	TSDTaox
2	DTSona	29	DSTDxaxn
3	TSon	30	TDSox
4	SDTona	31	TDSoan
5	DTon	32	DTSnaa
6	TDSxnon	33	SDTxon
7	TDSaon	34	DSna
8	SDTnaa	35	STDnaon
9	TDSxon	36	STxDSxa
10	DTna	37	TDSTanaxn
11	TSDnaon	38	SDTSaox
12	STna	39	SDTSxnox
13	TDSnaon	40	DTSxa
14	TDSonon	41	TSDTSaoxxn
15	Tn	42	DTSana
16	TDSona	43	SSTxTDxaxn
17	DSon	44	STDSoax
18	SDTxnon	45	TSDnox
19	SDTaon	46	TSDTxox
20	DTSxnon	47	TSDnoan
21	DTSaon	48	TSna
22	TSDTSanaxx	49	SDTnaon
23	SSTxDSxaxn	50	SDTSoox
24	STxTDxa	51	Sn
25	SDTSanaxn	52	STDSaox
26	TDSTaox	53	STDSxnox

Table 7-1. Logical Operations (ROP3) (continued)

Input Value	Boolean Function	Input Value	Boolean Function
54	SDTox	81	DSTnaon
55	SDToan	82	DTSDaox
56	TSDToax	83	STDSxaxn
57	STDnox	84	DTSonon
58	STDSxox	85	Dn
59	STDnoan	86	DTSox
60	TSx	87	DTSoan
61	STDSonox	88	TDSToax
62	STDSnaox	89	DTSnox
63	TSan	90	DTx
64	TSDnaa	91	DTSDonox
65	DTSxon	92	DTSDxox
66	SDxTDxa	93	DTSnoan
67	STDSanaxn	94	DTSDnaox
68	SDna	95	DTan
69	DTSnaon	96	TDSxa
70	DSTDaox	97	DSTDSaoxxn
71	TSDTxaxn	98	DSTDoax
72	SDTxa	99	SDTnox
73	TDSTDaoxxn	100	SDTSoax
74	DTSDoax	101	DSTnox
75	TDSnox	102	DSx
76	SDTana	103	SDTSonox
77	SSTxDSxoxn	104	DSTDSonoxxn
78	TDSTxox	105	TDSxxn
79	TDSnoan	106	DTSax
80	TDna	107	TSDTSoaxxn

Table 7-1. Logical Operations (ROP3) (continued)

Input Value	Boolean Function	Input Value	Boolean Function
108	SDTax	135	TDSaxn
109	TDSTDoaxxn	136	DSa
110	SDTSnoax	137	SDTSnaoxn
111	TDSxnan	138	DSTnoa
112	TDSana	139	DSTDxoxn
113	SSDxTDxaxn	140	SDTnoa
114	SDTSxox	141	SDTSxoxn
115	SDTnoan	142	SSDxTDxax
116	DSTDxox	143	TDSanan
117	DSTnoan	144	TDSxna
118	SDTSnaox	145	SDTSnoaxn
119	DSan	146	DTSDToaxx
120	TDSax	147	STDaxn
121	DSTDSoaxxn	148	TSDTSoaxx
122	DTSDnoax	149	DTSaxn
123	SDTxnan	150	DTSxx
124	STDSnoax	151	TSDTSonoxx
125	DTSxnan	152	SDTSonoxn
126	STxDSxo	153	DSxn
127	DTSaan	154	DTSnax
128	DTSaa	155	SDTSoaxn
129	STxDSxon	156	STDnax
130	DTSxna	157	DSTDoaxn
131	STDSnoaxn	158	DSTDSaoxx
132	SDTxna	159	TDSxan
133	TDSTnoaxn	160	DTa
134	DSTDSoaxx	161	TDSTnaoxn

Table 7-1. Logical Operations (ROP3) (continued)

Input Value	Boolean Function	Input Value	Boolean Function
162	DTSnoa	189	SDxTDxan
163	DTSDxoxn	190	DTSxo
164	TDSTonoxn	191	DTSano
165	TDxn	192	TSa
166	DSTnax	193	STDSnaoxn
167	TDSToaxn	194	STDSonoxn
168	DTSoa	195	TSxn
169	DTSoxn	196	STDnoa
170	D	197	STDSxoxn
171	DTSono	198	SDTnax
172	STDSxax	199	TSDToaxn
173	DTSDaoxn	200	SDToa
174	DSTnao	201	STDoxn
175	DTno	202	DTSDxax
176	TDSnoa	203	STDSaoxn
177	TDSTxoxn	204	S
178	SSTxDSxox	205	SDTono
179	SDTanan	206	SDTnao
180	TSDnax	207	STno
181	DTSDoaxn	208	TSDnoa
182	DTSDTaoxx	209	TSDTxoxn
183	SDTxan	210	TDSnax
184	TSDTxax	211	STDSoaxn
185	DSTDaoxn	212	SSTxTDxax
186	DTSnao	213	DTSanan
187	DSno	214	TSDTSaoxx
188	STDSanax	215	DTSxan

Table 7-1. Logical Operations (ROP3) (continued)

Input Value	Boolean Function	Input Value	Boolean Function
216	TDSTxax	236	SDTao
217	SDTSaoxn	237	SDTxno
218	DTSDanax	238	DSo
219	STxDSxan	239	SDTnoo
220	STDnao	240	T
221	SDno	241	TDSono
222	SDTxo	242	TDSnao
223	SDTano	243	TSno
224	TDSoa	244	TSDnao
225	TDSoxn	245	TDno
226	DSTDxax	246	TDSxo
227	TSDTaoxn	247	TDSano
228	SDTSxax	248	TDSao
229	TDSTaoxn	249	TDSxno
230	SDTSanax	250	DTo
231	STxTDxan	251	DTSnoo
232	SSTxDSxax	252	TSo
233	DSTDSanaxxn	253	TSDnoo
234	DTSao	254	DTSoo
235	DTSxno	255	1

PC (Pen Color)

This command changes the pen color in a palette created by the IN or CID command (E_C*v#W). The PC command defaults the colors of all pens as indicated in the table below.

PC *[pen [,primary1, primary2, primary3;]]*

or

PC *[pen;]*

or

PC*[;]*

Parameter	Format	Functional Range	Parameter Default
pen	integer	determined by NP	see table
primary1, primary2, primary3	clamped real	0 to 255 (for those printers supporting the CR command, the CR command determines the range)	see table

- **pen** — specifies the number of the pen whose color is being defined. An out-of-range pen parameter sets error 3 and the command is ignored. (The range for the pen parameter is determined by the size of the current color palette.)

- **primary1, primary2, primary3** — specifies the primary component values which are to be associated with that pen. See the CR command description for the range associated with the values. If a primary color is outside of the color range defined in the CR command, the value is clamped to the color range limits (the CR command is not supported by the HP Color LaserJet 4500 or 8500 printers).

The "PC;" command defaults the colors of all pens as shown in the table below. The "PC pen;" command defaults the number of pens as shown in the table on the following page for an HP-GL/2 palette. When color device palettes larger than 8 pens default, the first 8 pen colors are as defined for a palette of 8; all remaining pen colors are device- dependent. If the palette is a non-default palette, it defaults in accordance with the default palettes in Chapter 4.

No. of Pens in Palette	Pen Number	Color
2 ("NP 2;")	0	White
	1	Black
4 ("NP 4;")	0	White
	1	Black
	2	Red
	3	Green
8 ("NP 8;")	0	White
	1	Black
	2	Red
	3	Green
	4	Yellow
	5	Blue
	6	Magenta
	7	Cyan

For black and white printers that accept color descriptions and palettes, pen 0 defaults to white; all remaining pen colors default to "equivalent gray levels." An equivalent gray level means that lighter colors (for example, yellow) are converted to light gray shades, and darker colors (for example, purple) are converted to dark gray shades. The mapping algorithm is device-dependent. However, equivalent gray levels represent solid colors, and any white pixels within them are not subject to transparency mode (TR).

Note In the "shading" Fill Type command (FT10;), the shading levels are mapped between white (0% shading) and the equivalent gray level for the currently selected pen (100% shading). In the "HP-GL/2 user-defined" Fill Type command (FT11;), each pixel in the RF pattern is rounded to white or black based on the equivalent gray level of the pen number for that pixel. This rounding should use a low enough white/black threshold so that yellow will round to black.

For a black and white device, pen 0 defaults to white; all remaining pen colors default to black.

This command is ignored if the current palette was created by the Simple Color command (^{E}c*r#U). An IN command defaults pen colors as indicated in the previous table.

NP (Number of Pens)

The NP command resizes the palette after the IN or ^{E}C*v#W commands.

NP *[n;]*

or

NP*[;]*

Parameter	Format	Functional Range	Parameter Default
n	clamped integer	2 to 32768	device-dependent*

 * The default palette size for the HP color printers is 8.

- **n** — the parameter n denotes the size of the HP-GL/2 palette, where n is a power of two. If n is not a power of two, the next larger power of two is used. The palette is an array of virtual pens, each having an associated color value and an associated width. Pen colors are defined in terms of RGB components using the PC command. Widths are established using the PW and WU commands. A pen is selected with the SP command.

The maximum value for n is device-dependent, but is greater than or equal to the number of distinct colors the printer is able to produce. If n is larger than that maximum, the maximum-sized palette is allocated. If n < 2, error 3 is set and the command is ignored.

The "NP;" command defaults the palette size. Receipt of this command does not default pen colors and/or widths for existing pen values. For example, if the palette size is initially 8 and is decreased to 4, pen colors and widths for the new palette are retained from the colors and widths of the first 4 pens of the old palette. If the palette size is increased from 8 to 16, the colors and widths for the first 8 pens remain the same, and the colors and widths of the remaining pens are defaulted. The pens are defaulted in accordance to how the palette was created (either CID or Simple Color palettes).

If the currently selected pen is outside the range of the new palette size, the SP command modulo function is applied to obtain a pen number which will index into the new palette; this clears the current residue (the unused portion of a pattern) and terminates any sequence of continuous vectors. For more information, see the descriptions of the Line Attribute (LA) and Line Type (LT) commands in the *PCL 5 Printer Language Technical Reference Manual*.

The number of pens is defaulted by an IN command.

This command is ignored if the current palette was created by the Simple Color command (^{E}C*r#U) or ^{E}CE.

CR (Color Range)

The CR command sets the range for specifying relative color data.

This command is only supported by the HP Color LaserJet, Color LaserJet 5, 5M, and DeskJet printers. It is not supported by the HP Color LaserJet 4500 or 8500 printers.

CR *[b_ref_red, w_ref_red, b_ref_grn, w_ref_grn, b_ref_blue, w_ref_blue;]*

Parameter	Format	Functional Range	Parameter Default
b_ref (red, green, blue)	clamped real	-32768 to 32768	0
w_ref (red, green, blue)	clamped real	-32768 to 32768	255

Relative color is in reference to a range defined by a black and white reference value for each primary (red, green, and blue). For example, if the white reference is set as red=63, green=63, blue=63, and the black references are set as red = 0, green = 0, and blue = 0, then white = 63, 63, 63; black = 0, 0, 0; and medium blue = 0, 0, 31. However, if the white reference is set as red = 63, green = 127, blue = 31 and the black reference is set as red = 4, green = 0, and blue = 0, then white = 63, 127, 31; black = 4, 0, 0; and medium blue = 4, 0, 15.

The first two parameters set the black and white references (respectively) for red; the second pair sets the green references, and the final pair the blue reference values. If the black reference value for any primary is equal to the white reference value for the same primary, the command is ignored.

The default for red, green, and blue "black references" is 0; the default for red, green and blue "white references" is 255.

This command is defaulted by the "CR;" and IN commands.

Execution of this command causes current pen colors to be remapped to the new range, so that current palette colors remain unchanged.
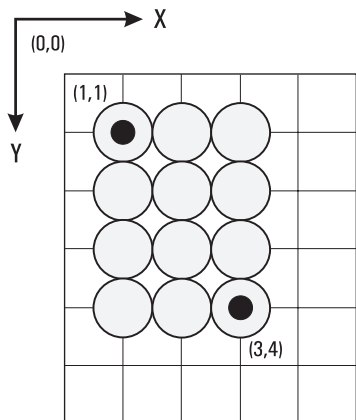
PP (Pixel Placement)

When printing, the printer places pixels at the intersection of the squares of a theoretical, device-dependent grid covering the printable area on a page. When the sides of two HP-GL/2 polygons touch each other, the pixels along the border may be printed twice or not at all—depending on the logical operation in effect. For example, if a source rectangle consisting of all 1's is XORed with a destination consisting of all 1's, a white rectangle is printed. If another source rectangle is placed on the page touching the first rectangle, the two rectangles are white-filled except at their common border: that is, $(1\wedge1)\wedge1 = 1$.

To correct this situation, two models of pixel placement are used: grid intersection and grid centered. The grid intersection model is the default: pixels are rendered on the intersections of the device-dependent grid covering the page. In the grid-centered model, the number of rows and columns are each reduced by one, and pixels are placed in the center of the squares, rather than at the intersections.

The following example illustrates the concepts of the two models. Assume a rectangle extends from coordinate position (1,1) to position (3,4). As shown below, for the same coordinates, the grid-centered model produces a rectangle that is one dot row thinner and one dot row shorter than the grid intersection model. Thus, when two or more polygons on a page share a common border, grid centering (value=1) can be turned on.
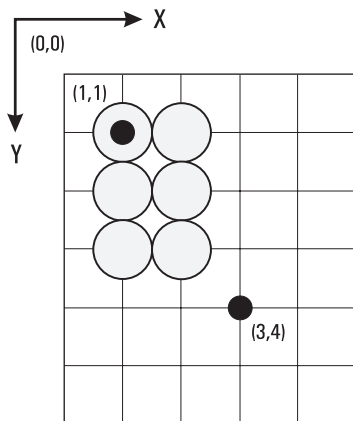
Since PCL printers print only at the intersections of the grid, the actual implementation of the grid-centered model is also shown in the following illustration.

Grid Intersection
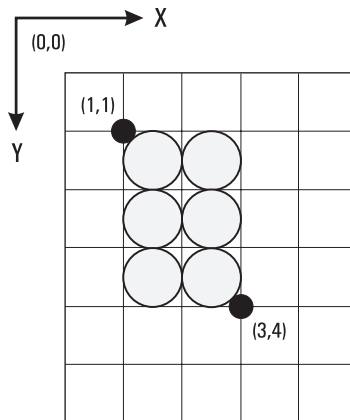
Grid Centered

Actual Grid Centered Implementation

Figure 7-1   Pixel Placement

PP, Pixel Placement Command

The Pixel Placement (PP) command controls how pixels are placed on the layout grid during polygon fills. The two pixel placement modes are grid intersection or grid centered.

PP *[mode;]*

Parameter	Format	Functional Range	Parameter Default
mode	clamped integer	0 or 1	0 (grid intersection)

- **mode**

    0   grid intersection; device draws pixels centered at grid intersections (see Figure 7-1).

    1   grid centered; device draws pixels centered inside the boxes created by the grid (see Figure 7-1).

When the printer is set to grid-centered mode (mode 1), portions of a polygon that are zero height or zero width are not rendered. When the printer is set to grid intersection mode (mode 0), portions that are zero height or width are rendered as lines. Portions that are both zero height and width are rendered as dots.

This command affects only HP-GL/2 polygons; it has no effect on characters, rules, or raster graphics. This command can be invoked multiple times during a page; it has no effect except to switch the model used for imaging.

This command is the HP-GL/2 version of the PCL Pixel Placement command. Whatever mode is selected, using the HP-GL/2 PP command also applies to PCL operation. Likewise the PCL Pixel Placement command also affects HP-GL/2 pixel placement.

Note   Microsoft Windows fills polygons based on the grid- centered method.

This command determines how pixels will be placed for both HP-GL/2 and PCL operation.

The PP command is not defaulted by an IN command.