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Using Color Modes

Introduction

The PCL printer language has four color modes:

- Black-and-White
- Simple Color
- PCL Imaging
- HP-GL/2 Imaging

PCL allows you to use any mode or combination of modes to accomplish your printing objectives most efficiently.

All four of the color modes create a palette. The palette for each mode is discussed in the section describing that mode, and also in Chapter 3 (“Using Palettes”).

Black-and-White Mode (Default)

Black-and-White Mode is the default color mode. PCL devices power up in this mode and revert back to it whenever the printer receives an ECE reset. Black-and-White mode is also selectable using the Simple Color command (EC*r1U). This mode creates an unmodifiable, default 2-pen palette, with white at index 0 and black at index 1 (compatible with existing monochrome PCL 5 printers).

Simple Color Mode

Simple Color Mode, entered by the Simple Color command (EC*r#U), creates a fixed-size, fixed-color, unmodifiable palette. Depending on the value field, EC*r#U can create a 2-pen Black-and-White palette, an 8-pen RGB palette, or an 8-pen CMY palette. When using the Simple Color mode, the pixel encoding mode is always indexed planar.

PCL Imaging Mode

PCL Imaging Mode, enabled by the Configure Image Data command (EC*v#W), allows a maximum of 24 bits per pixel for color specification. Therefore, more colors may be specified than are obtainable in Simple Color Mode. In the PCL Imaging Mode, pixel encoding mode, bits per pixel, bits per primary, and the color palette are all programmable.

HP-GL/2 Imaging Mode

In HP-GL/2, the Initialize (IN) command starts color imaging and performs the following:

- Sets the pixel encoding mode to index by plane.
- Sets bits per index to 3.
- Creates an 8-pen palette that is reprogrammable in either PCL or HP-GL/2 contexts (see Chapter 3, “Using Palettes,” for more information).

Although default HP-GL/2 palettes are different than default PCL palettes, an HP-GL/2 palette is modifiable in either PCL or HP-GL/2 (using the Assign Color Index [EC*v#I] or Pen Color [PC] commands, respectively). Likewise, a PCL palette created by the Configure Image Data command (EC*v#W) is modifiable in both PCL and HP-GL/2 using the same commands.

The active palette is always transferred between HP-GL/2 and PCL contexts. Since only one palette at a time can be active, a new palette created in either context overwrites the current palette.

Simple Color Mode

The Simple Color command (EC*r#U) specifies color selection from a fixed palette. RGB or CMY raster data must be sent by plane (EC*b#V) as well as by row (EC*b#W). The last plane in each row is sent using the EC*b#W command; all other planes are sent using the EC*b#V command. In Simple Color mode, the pixel encoding mode is always indexed planar.

Simple Color Command

The Simple Color command creates a fixed-size palette, whose color specification cannot be modified.

EC***r#U**

# = –3 - 3 planes, device CMY palette
1 - Single plane K (Black) palette
3 - 3 planes, device RGB palette

Default = 1
Range = –3, 1, 3

This command destroys the active palette and creates a new palette, which becomes the active palette. When the Simple Color mode is active, PCL and HP-GL/2 commands that modify the palette are locked out (NP, PC, EC*v#A, EC*v#B, EC*v#C, EC*v#I). When a Simple Color palette is popped from the stack (EC*p#P), it cannot be modified, and the pixel encoding mode reverts to indexed planar.

- A value field of **1** creates a 2-entry Black-and-White default palette.
- A value field of **3** creates an 8-entry Device RGB palette (compatible with a PCL Imaging Mode palette, but not an HP-GL/2 default (IN) palette).
- A value field of **–3** creates an 8-entry palette in Device CMY color space.

The Simple Color palettes are structured as follows:

Single Plane (value = 1)

Index	Color
0	White
1	Black

3-Plane RGB (value = 3)

Index	Color
0	Black
1	Red
2	Green
3	Yellow
4	Blue
5	Magenta
6	Cyan
7	White

3-Plane CMY (value = –3)

Index	Color
0	White
1	Cyan
2	Magenta
3	Blue
4	Yellow
5	Green
6	Red
7	Black

PCL Imaging Mode

The PCL Imaging mode, entered using the Configure Image Data (CID) command ($^{E}{}_{C}$*v#W), creates a variable-sized programmable palette. It provides multiple color spaces, pixel encoding modes, and reprogrammable palettes.

Configure Image Data (CID) Command

The CID command provides configuration information for creating palettes and transmitting raster data. The CID command performs the following:

- Designates the color space for the newly created palette
- Designates the size of the palette
- Designates the Pixel Encoding Mode, the format of the raster data
- Designates, in certain circumstances, the size, in bits, of the three components of the color specifications. However, this information is rarely useful since it applies only to the direct-by-pixel PEM, where the format must be eight bits per component for 24-bit direct color, and the direct-by-plane, where there is one bit per component.

$^{E}{}_{C}$***v6W b0 b1 b2 b3 b4 b5**

Where:

6 =	The number of bytes following the “W”	
b0 =	byte 0	The color space
b1 =	byte 1	The Pixel Encoding Mode
b2 =	byte 2	The number of bits per index which implies the size of the palette
b3 =	byte 3	The number of bits in color component (primary) #1
b4 =	byte 4	The number of bits in color component (primary) #2
b5 =	byte 5	The number of bits in color component (primary) #3

The bytes are ordered as follows and are unsigned bytes:

Byte	**15 (MSB) 8**	**7 0 (LSB)**	**Byte**
0	Color space	Pixel encoding mode	**1**
2	Bits/index	Bits/primary #1	**3**
4	Bits/primary #2	Bits/primary #3	**5**

Invalid configurations of the CID command are ignored and the data discarded. A minus or a plus sign in the value field (-6 or 6) is ignored

The data fields in the command, bytes zero to five, must contain byte-aligned binary data, not ASCII data.

Byte 0 (Color Space)

This byte specifies the color space. The range of values is 0 through 2. All other values are ignored.

Byte Value	**Color Space**
0	Device Dependent RGB (default)
1	Device Dependent CMY
2	Standard RGB (sRGB)

Color space 2, sRGB, was the designation for Colorimetric RGB in the Color LaserJet and Color LaserJet 5 printers. The value 2 is used to represent sRGB since it is analogous to a standardized Colorimetric RGB and the intent of the two color spaces is the same.

Byte 1 (Pixel Encoding Mode)

This byte designates the format of any subsequent raster images. The range of the value is zero to three. All other values for this field are ignored.

Value	Pixel Encoding Mode	Restrictions
0	Indexed by Plane	Bits/Index can only be 1, 2, 3, 4, 5, 6, 7, or 8. Bit/Components 1, 2, and 3 are ignored
1	Indexed by Pixel	Bits/Index can only be 1, 2, 4, or 8. Bit/Components 1, 2, and 3 are ignored
2	Direct by Plane	Bits/Components 1, 2, and 3 must be 1
3	Direct by Pixel	Bits/Components 1, 2, and 3 must be 8

The number of bits per index determines the size of the palette created by this command. In the case of the Indexed by Plane mode the number of planes needed to represent the index is also determined by the number of bits per index. Therefore, if a 256 entry palette is needed, then the bits per index is set to eight since $2^8 = 256$. If the Indexed by Plane mode is chosen, at most eight planes are needed to represent each row of data.

The recommended pixel encoding mode is Direct by Pixel, since this gives the most efficient raster processing. However, using this mode means that delta row compression should be used since it exploits redundancy between rows. Other PCL compression modes exploit redundancy within a row. With Direct by Pixel the redundancy from pixel to pixel in a row is masked by the differences at the byte level within the pixel, that is, the differences between the red, green, and blue bytes within the pixel.

Note

Raster data in Index by Plane or Direct by Plane modes cannot be compressed using raster compression mode 5.

You need one plane or one bit/pixel for each power of two colors in the palette. For example, a 256-color palette requires 8 planes or 8 bits/pixel ($2^8 = 256$).

PEM 0: INDEXED BY PLANE

In Pixel Encoding Mode 0, successive planes of data are sent for each raster row. A plane contains one bit for each pixel in a row. A pixel is not fully defined until all the planes for that row have been received, which is signaled by a transfer raster row command. The planes in a row form index numbers into the current palette. For example, assuming three bits per index, the underlined column of bits in the figure below is the palette index for pixel three of the first row (i1 is the least significant bit, i3 is the most significant bit). Note that the Transfer Raster Data by Plane command (^{E}C*b#V) is used for all planes except the last plane of each row, which is sent using the Transfer Raster Data by Row command (^{E}C*b#W).

^{E}C*b#V	row 1	plane 1	i1	i1	i1	**i1**	i1	i1
^{E}C*b#V		plane 2	i2	i2	i2	**i2**	i2	i2
^{E}C*b#W		plane 3	i3	i3	i3	**i3**	i3	i3
^{E}C*b#V	row 2	plane 1	i1	i1	i1	i1	i1	i1

Example:

In the example below, the row transfer commands are shown in binary for clarity, even though the actual data would be byte-aligned binary data. The example is for an eight-pixel-wide image.

^{E}C*v6W 00 00 03 08 08 08	Binary data for CID represented in hex. This command sets the color space to RGB, the PEM to Indexed by Plane, the palette size to 8 (2^3). The last 3 bytes are ignored.
^{E}C*r1A	Start raster.
^{E}C*b1V10110000	Transfer plane 1 (the first bit for each pixel in the first row).
^{E}C*b1V01110000	Transfer plane 2 (the second bit for each pixel in the row).
^{E}C*b1W10101000	Transfer plane 3 (the third and final bit for each pixel in the row) and move to the next row. Note that the ^{E}C*b#W command is used to send the last plane of each row.

PEM 1: INDEXED BY PIXEL

In this mode, each pixel in a row is fully specified before any bits are sent for the next pixel. The bits for each pixel form a palette index number. Assuming four bits per index, the underlined block below is the palette index for pixel two of row one (i1 is the least significant bit).

EC*b#W row 1 i4 i3 i2 i1 **i4 i3 i2 i1** . . .

EC*b#W row 2 i4 i3 i2 i1 i4 i3 i2 i1 . . .

EC*b#W row 3 i4 i3 i2 i1 i4 i3 i2 i1 . . .

Example:

In the example below the data in the row transfer commands are shown as two-digit hexadecimal numbers for clarity, even though the actual data would be byte-aligned binary data. The example is for a two-pixel-wide image.

EC*v6W 00 01 04 08 08 08	Binary Data for the CID command represented in hexadecimal. This command sets the color space to RGB, the PEM to Indexed by Pixel, the palette size to 16 (2^4). The last three bytes are ignored.
EC*r1A	Start raster
EC*b1W45	The most significant nibble selects palette entry 4 for the first pixel. The second pixel is set to index 5. Move to next row.
EC*b1W6A	The first pixel is index 6, the second pixel is index 10. Move to the next row.
EC*b1W03	The first pixel is index 0, the second pixel is index 3.

MODE 2: DIRECT BY PLANE

In this mode, a pixel is composed of three, one-bit components. The data is transferred a plane at a time, one plane for each component. Therefore, each bit in a plane represents one component of a pixel. The underlined bits below show the components for a pixel.

EC*b#V	row 1	plane 1 (red)	b1	b1	b1	**b1**	b1	b1
EC*b#V		plane 2 (green)	b2	b2	b2	**b2**	b2	b2
EC*b#W		plane 3 (blue)	b3	b3	b3	**b3**	b3	b3
EC*b#V	row 2	plane 1 (red)	b1	b1	b1	b1	b1	b1

Example:

In the example below the data in the row transfer commands are shown in binary for clarity, even though the actual data would be byte-aligned binary data. The example is for an eight-pixel-wide image.

EC*v6W 00 02 01 01 01 01	Binary Data for the CID command represented in hexadecimal. This command sets the color space to RGB, the PEM to Direct by Plane. The palette size is ignored. The last three bytes are always one for this mode.
EC*r1A	Start raster
EC*b1V10110000	Transfer plane 1 (the first bit for each pixel in the first row). Each bit controls the red primary.
EC*b1V01110000	Transfer plane 2 (the second bit for each pixel in the row). Each bit controls the green primary.
EC*b1W10101000	Transfer plane 3 (the third and final bit for each pixel in the row) and move to the next row. Each bit controls the blue primary. Note that the EC*b#W command is used to send the last plane of each row.

MODE 3: DIRECT BY PIXEL

This mode specifies a pixel as three, eight-bit components, thus the name 24-bit direct color. Assuming the RGB color space with the mandatory eight bits per component, the underlined bytes below define the first pixel of row two.

EC*b#W	row 1	r7–r0	g7–g0	b7–b0 . . .
EC*b#W	row 2	**r7–r0**	**g7–g0**	**b7–b0** . . .
EC*b#W	row 3	r7–r0	g7–g0	b7–b0 . . .

Example:

In the example below the data in the row transfer commands are shown as two-digit hexadecimal numbers for clarity, even though the actual data would be byte-aligned binary data. The example is for a one-pixel-wide image.

EC*v6W 00 03 00 08 08 08	Binary Data for CID command represented in hexadecimal. This command sets the color space to RGB, the PEM to Direct by Pixel. The palette size is ignored. The last three bytes must be 8.
EC*r1A	Start raster
EC*b3W 45 06 30	The three bytes specify a single pixel. The first sets 45 as the red component’s value, the second sets the green value to 06, and the third sets the blue value to 30.

Byte 2 (Number of Bits per Index)

This command creates a palette regardless of the PEM chosen. This byte determines the size of the created palette. The palette size is two raised to the power of n (2^n), where n is the bits per index.

- In the Indexed-by-Plane PEM, where the raster data is interpreted as palette indices, this value determines the number of planes required per row.

- In the Indexed-by-Pixel PEM, where the raster data is interpreted as palette indices, this value determines how to interpret the byte-ordered row transfers. The following list shows how each byte is translated into indices:

Bits/Index	**Indices/Byte**
1	8
2	4
4	2
8	1

- In the Direct-by-Plane and Direct-by-Pixel PEMs, byte 2 does not apply to the raster format.

Bytes 3, 4, and 5 (No. of Bits for Components 1, 2, and 3)

These bytes are ignored for the Indexed by Plane and Indexed Direct PEMs. For the Direct by Plane PEM they must be set to one bit per component. For the Direct by Pixel PEM, they must be set to eight bits per component.

HP-GL/2 Imaging Mode

The HP-GL/2 Imaging Mode provides a way of using vector commands in printing documents. Although the default PCL and HP-GL/2 palettes are not the same, when transferring from PCL to HP-GL/2, active palette information does stay the same. You can switch between PCL and HP-GL/2 and use the same palette, and you can also modify palettes using either PCL or HP-GL/2.

Compared to monochrome printers, the HP Color LaserJet printer family, DeskJet 1200C and 1600C color printers have some commands that are new and/or modified for use with color printers. Chapter 7 describes the new or modified HP-GL/2 commands.

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