# 13 The PCL Print Model

## Introduction

The Print Model feature allows images and characters to be filled with any of the printer's predefined shading or cross-hatch patterns, or with a user-defined pattern. Images include any raster graphic, such as one created with PCL raster graphics commands (as described in Chapter 15, *Raster Graphics*); a rectangular fill area (as described in Chapter 14, *PCL Rectangular Area Fill Graphics*); or a character or characters selected from any font.

Print model operation defines a **pattern, source image,** and **destination image**. These images are applied to each other using the print model's transparent and opaque modes to produce a resulting image that is a combination of the others. The print model features, listed below, are illustrated in Figure 13-1 and Figure 13-2, and described on the following pages.

- Pattern
- Source Image
- Destination Image
- Source Transparency Mode
- Pattern Transparency Mode

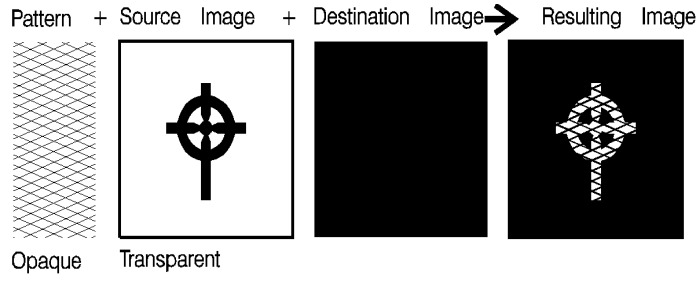


**Figure 13-1 Print Model Imaging**

## Pattern

The design which is “painted” through the black (“1” bits) area of the source image onto the destination image. For patterns, the Print Model uses one of the printer’s internal predefined eight shading patterns (see Figure 13-4) or one of the six cross-hatch patterns (see Figure 13-5), or a user-defined pattern.

**Notes**

When printing a page, text and raster images are printed using the **current pattern**. The default current pattern is 100% black. The print model allows the current pattern to be changed to white, to one of the six predefined cross-hatch patterns, to one of the eight shading patterns, or to a user-defined pattern. Once the current pattern is changed, it stays in effect until another is selected or the printer is reset. A reset returns the current pattern to its default value (100% black).

The current pattern does not always apply to rectangular area fill, which uses patterns defined by the rectangular area fill pattern commands. Refer to “Transparency Mode and Rectangular Area Fills” at the end of this chapter for additional information.

## Source Image

An image in which the black (“1” bits) are replaced by the specified pattern. This is like a stencil through which the pattern is applied to the destination image. The source image may be defined as a rectangular fill area, a raster graphics image, or characters.

## Destination Image

The image onto which the source image/pattern combination is placed. The destination image is the result of any previous operations.

## Source Transparency Mode

The transparency or opaqueness of the source image’s white pixels (the “0” bits) as they are applied to the destination image. Setting the source transparency mode to 1 (opaque) applies the source image’s white pixels to the destination image; with a setting of 0 (transparent), these pixels have no effect on the destination.

## Pattern Transparency Mode

The transparency or opaqueness of the white pixels in the pattern. When set to 0 (transparent), these pixels have no effect on the destination; when set to 1 (opaque), they are applied through the black pixels of the source pattern to the destination.


**Figure 13-2 Opaque and Transparency Modes**

Figure 13-3 illustrates the effects of the source and pattern transparency modes on the final image.

In the first example (1a), the transparency mode for both the source image and the pattern is transparent. Since the source mode is “transparent,” only the black-pixeled region (the circle) of the source image is overlaid on the destination. Since the pattern mode is also transparent, the patterned source image is applied only to the white areas of the destination image.

In the second example (1b), the source mode is still “transparent,” but the pattern mode is “opaque” — so the pattern’s white pixels are applied to the destination. The resulting image shows the entire circle region visible and patterned.

In the third example (1c), the source mode is “opaque” and the pattern mode is transparent. Since the source mode is opaque, the entire source image (the circle and the surrounding square) appears overlaid onto the destination. The pattern, however, is allowed to pour through only onto the white-pixeled area of the destination. The circle is visible in the result, but only two opposing quarters appeared patterned.

In the fourth example (1d), both source and pattern modes are “opaque.” The entire source image is overlaid onto the destination, and the entire circle is patterned.

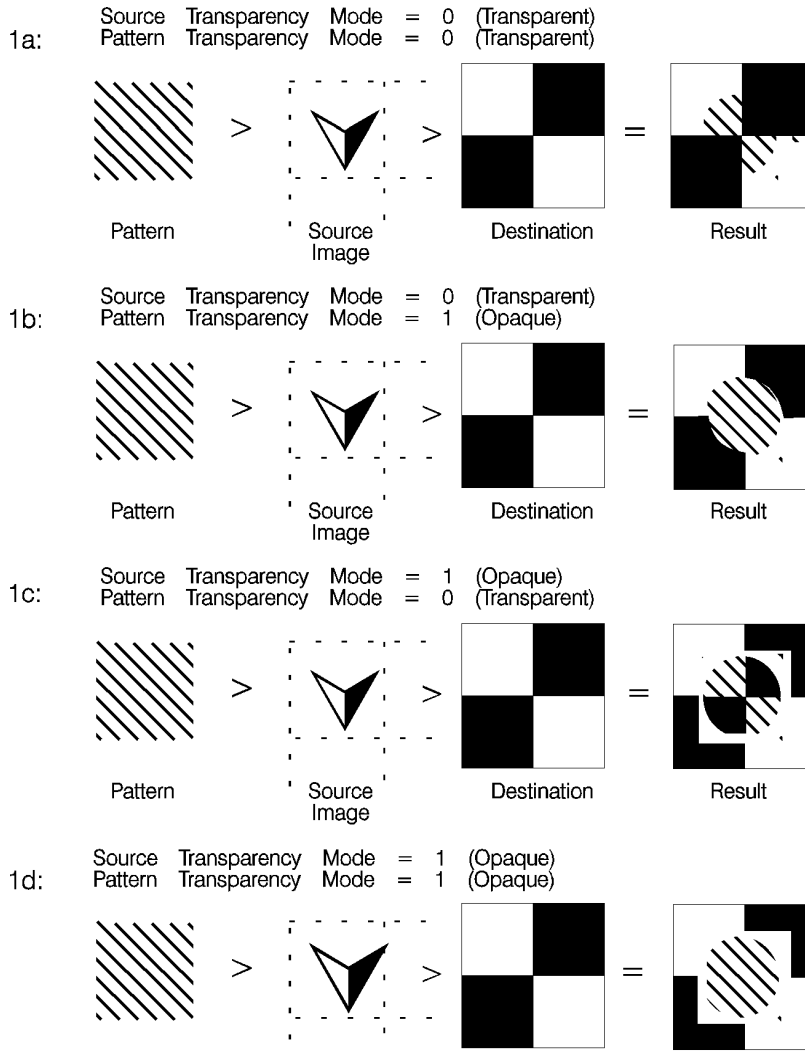


**Figure 13-3 Effect of Transparency Modes on Images**

# Command Sequence

The following illustration shows the Print Model Command Sequence for selecting a current pattern and using it to fill a destination image.

**Table 13-1**

| Operation | Comments |
|---|---|
| • | |
| • | |
| Download Page Data | Prior raster and character data downloaded to the page is considered destination image. |
| • | |
| • | |
| Select Transparency Modes | $^{E}_{C}$*v#N and/or $^{E}_{C}$*v#O |
| | |
| Select Specific Pattern ID | Pattern ID $^{E}_{C}$*c#G |
| and | |
| Select Pattern | $^{E}_{C}$*v#T (redefines current pattern) |
| Download Page Data (Source Image data) | Raster image/characters |
| Return to regular print mode | Default *current* pattern and |
| | transparency modes: $^{E}_{C}$*v0T (100% black pattern selected) and $^{E}_{C}$*v0N $^{E}_{C}$*v0O (transparency modes selected). |
| • | |
| • | |
| Download remaining page data | Transfer data for regular printing, or the above process may be repeated to produce another print model effect. |

Table 13-1 (continued)

| | |
|---|---|
| • | |
| • | |
| End of Page Data | |

# Source Transparency Mode Command

The Select Source Transparency Mode command sets the source image's transparency mode to transparent or opaque.

$E_C$ * v # N

# =0 - Transparent
1 - Opaque

**Default** = 0
**Range** = 0, 1 (other values cause the command to be ignored)

With a transparency mode of "0" (transparent), the white regions of the source image are not be copied onto the destination. With a transparency mode of "1" (opaque), the white pixels in the source are applied directly onto the destination.

Refer to the preceding definitions and the discussion of Figure 13-3 for an explanation of the effects of transparency.

# Pattern Transparency Mode Command

The Pattern Transparency Mode command sets the pattern's transparency mode to transparent or opaque.

$^{E}_{C}$ * v # O

# =0 - Transparent
1 - Opaque

**Default** = 0
**Range** = 0, 1 (other values cause the command to be ignored)

A transparency mode of "0" (transparent) means that the white regions of the pattern image are not copied onto the destination. A transparency mode of "1" (opaque) means that the white pixels in the pattern are applied directly onto the destination.

**Note**

When printing white rules, the pattern transparency is treated as if it were "opaque"; white rules erase black rules regardless of the transparency mode.

Refer to the preceding definitions and the discussion of Figure 13-3 and Figure 14-3 for an explanation of the effects of transparency.

# Pattern ID (Area Fill ID) Command

The Pattern ID command (formerly called Area Fill ID) identifies the specific shading, cross-hatch, or user-defined pattern. (This command is also used for rectangular area fill. Refer to Chapter 14, *PCL Rectangular Area Fill Graphics.*)

$$E_C * c \# G$$

**Table 13-2**

| **Selecting Shaded patterns** | | **Selecting Cross-Hatch patterns:** | |
|---|---|---|---|
| # = | 1 thru 2 = 1-2% shade | # = | 1 - Pattern #1 |
| | 3 thru 10 = 3-10% shade | | 2 - Pattern #2 |
| | 11 thru 20 = 11-20% shade | | 3 - Pattern #3 |
| | 21 thru 35 = 21-35% shade | | 4 - Pattern #4 |
| | 36 thru 55 = 36-55% shade | | 5 - Pattern #5 |
| | 56 thru 80 = 56-80% shade | | 6 - Pattern #6 |
| | 81 thru 99 = 81-99% shade | | |
| | 100 = 100% shade | | |
| **Selecting User-Defined patterns:**[1] | | | |
| # = ID number of user-defined pattern | | | |

1. Not supported on all LaserJet family printers. Refer to the “PCL Feature Support Matrix” in Chapter 1 of the *PCL 5 Comparison Guide* for specifics.

# =ID number of user-defined pattern

**Default** = 0 (no pattern)
**Range** = 0 - 32767 (values outside the range are ignored)

For rectangular areas, the pattern material is determined by both the pattern ID and the value of the Fill Rectangular Area command. For other images, the pattern material is determined by the pattern ID and the value of the Select Pattern command.

Figure 13-4 and Figure 13-5 illustrate the HP-defined shading patterns and cross-hatched patterns, respectively.

**Notes**

This command is used for both the Select Pattern and Area Fill graphics (it is also described in Chapter 14, *PCL Rectangular Area Fill Graphics*). It is duplicated here for convenience.

For user-defined patterns, this command, sent prior to downloading a user-defined pattern, assigns an ID pattern number to the downloaded pattern. (For more information, see “User- Defined Graphics,” later in this chapter.)

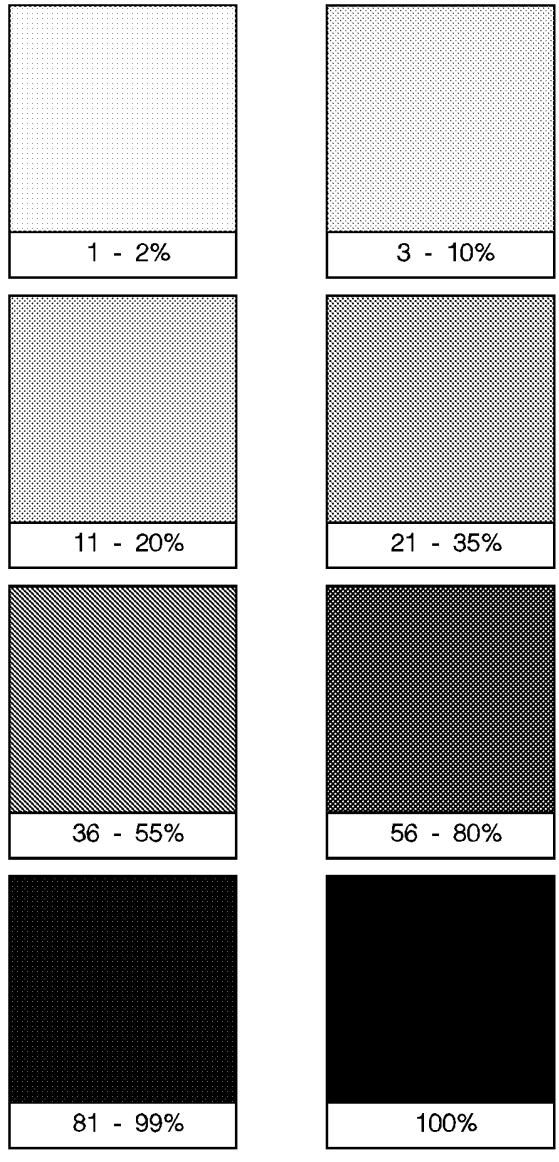


**Figure 13-4 Shading Patterns**

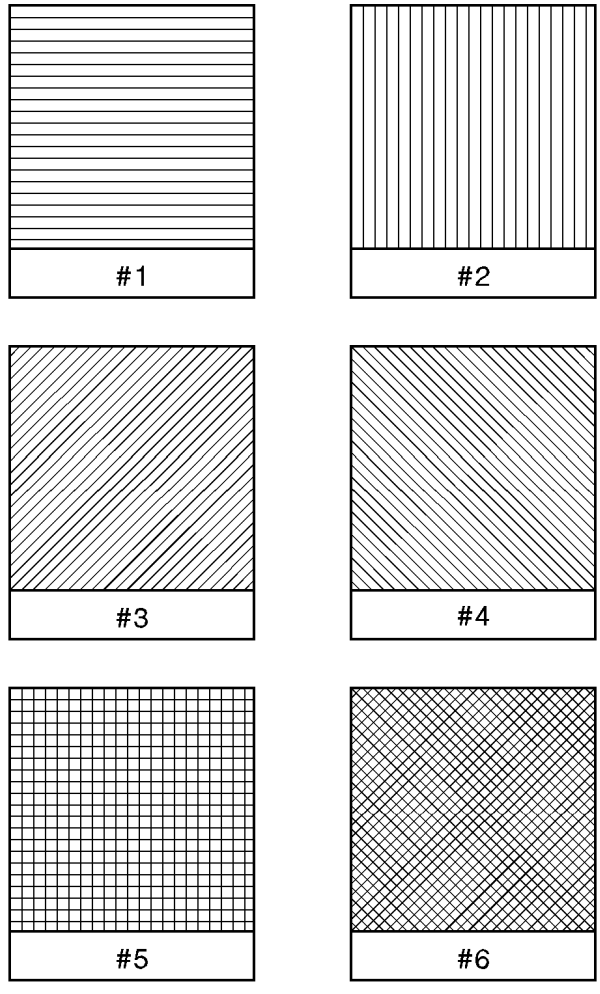


**Figure 13-5 Cross-Hatch Patterns**

# Select Current Pattern Command

The Select Current Pattern command identifies the type of pattern to be applied onto the destination.

$^{E}_{C}$ * v # T

# =0 - Solid black (default)
1 - Solid white
2 - Shading pattern
3 - Cross-hatch pattern
4 - User-defined pattern

**Default** = 0
**Range** = 0 - 4 (values outside of range are ignored)

This command selects which *type* of pattern is applied. For values 2, 3, and 4, the shading level (Figure 13-4), cross-hatch pattern (Figure 13-5), or user-defined pattern number is identified by the Pattern ID command described earlier in this chapter.

**Notes**

For selecting or changing the current pattern, the Select Current Pattern ($^{E}_{C}$*v#T) and the Pattern ID ($^{E}_{C}$*c#G) commands work together. **Sending the current pattern** (Select Current Pattern command) **alone does not change the current pattern; the Pattern ID must be sent first.** However, when selecting solid white (white rule) or solid black (black rule), only the Select Current Pattern command is required.

Once a current pattern is selected, that pattern applies to all images placed on the page until a new pattern is selected.

# User-Defined Pattern Graphics

In addition to the eight shading patterns and six cross-hatch patterns, users can design their own patterns (area fill). These **user-defined patterns** are downloaded to the printer and controlled using three new commands:

- User-Defined Pattern $^{E}_{C}$*c#W [data]
- Set Pattern Reference Point $^{E}_{C}$*p#R
- Pattern Control $^{E}_{C}$*p#Q <Unknown> <list> >

## User-Defined Pattern Implementation

To create a user pattern, a user defines a binary raster data image as a base pattern. This base pattern is downloaded to the printer using the User-Defined Pattern command. Prior to downloading the pattern, a Pattern ID command is sent to assign the user pattern an ID number. This ID number is used to select the pattern for printing and for pattern management.

To apply the pattern to an image, the printer duplicates or tiles (like placing ceramic tiles) the pattern across and down the page. This pattern can be applied to any image, or used as rectangular area fill.

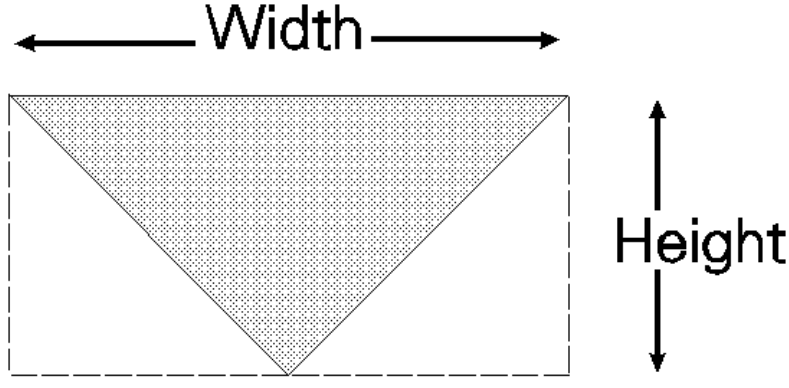


**Figure 13-6 User-Defined Base Pattern Example**

A user-defined pattern may be applied to any image in the same manner as the internal (cross-hatch or shade) patterns.

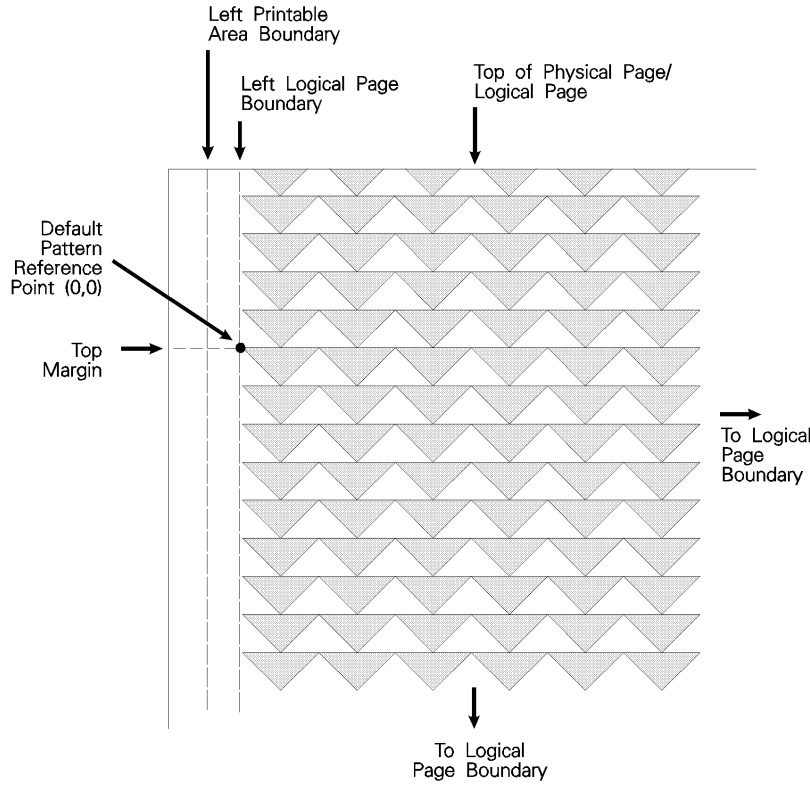


**Figure 13-7 Pattern Layout Across the Printable Area**

## Pattern Reference Point

The pattern reference point is a position on the logical page at which the base pattern is positioned for tiling. The upper left corner of the base pattern is positioned at this point (see ). The default pattern reference point is position 0,0. However, it is possible to set the pattern reference point to the current cursor position. This allows the pattern to be positioned or adjusted for fill areas. The pattern reference point may be shifted more than once for as many fill areas as there are on a page (the area must be filled before the tile point is moved for the next fill area).

Figure 13-8 shows two areas filled with the pattern reference point fixed at the default (0,0) position. The lower portion of the illustration shows two areas in which the pattern reference point was moved to the upper left corner of each area and the area filled separately.

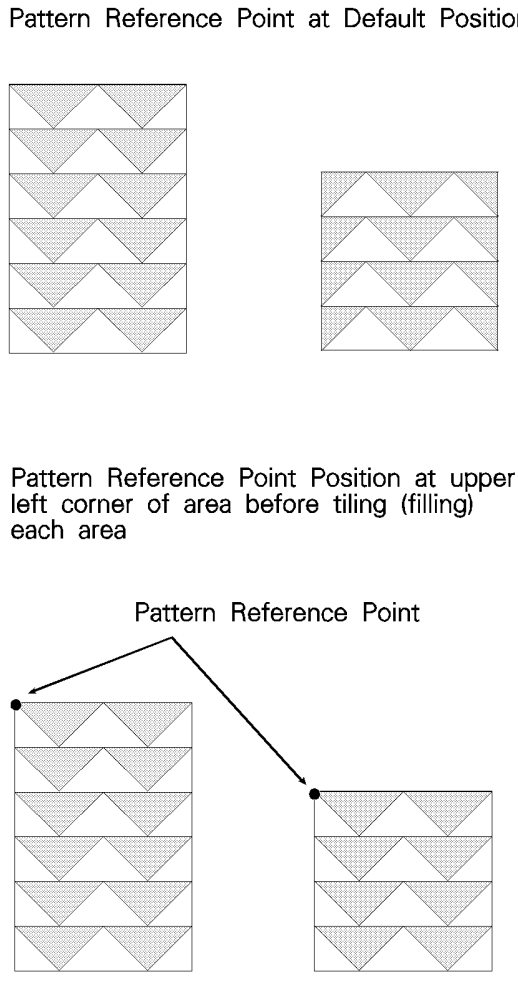


**Figure 13-8 Moving Pattern Reference Point for Pattern Filling**

# User-Defined Pattern Command

The User-Defined Pattern command provides the means for downloading the binary pattern data that defines the user pattern.

$^{E}_{C}$ * c # W [pattern data]

# =Number of pattern data bytes

**Default** = 0
**Range** = 0 - 32767 (values outside the range are ignored)

The value field (#) identifies the number of pattern data bytes that follow the User-Defined Pattern command. In addition to the binary pattern data, there are eight bytes of pattern descriptor (header) information included in this pattern data. The format for a 300 dpi resolution header is shown in Table 13-3, below.

**Table 13-3 User-Defined Pattern Header (300 dpi resolution)**

| Byte | 15 - MSB 8 | 7 LSB-0 |
|---|---|---|
| 0 | Format (0) | Continuation (0) |
| 2 | Pixel Encoding (1) | Reserved (0) |
| 4 | Height in Pixels | |
| 6 | Width in Pixels | |
| 8 | Pattern image<br>⋮ | |

With the introduction of the LaserJet 4 printer, user-defined patterns can be printed either 300 or 600 dpi resolution. X Resolution and Y Resolution fields have been added to the header information included in the previous header. The format for the new header is shown in Table 13-4, below.

**Table 13-4 Resolution-Specified User-Defined Pattern Header**

| Byte | 15 - MSB 8 | 7 LSB-0 |
|---|---|---|
| 0 | Format (0) | Continuation (0) |
| 2 | Pixel Encoding (1) | Reserved (0) |

**Table 13-4 Resolution-Specified User-Defined Pattern Header**

| | | |
|---|---|---|
| 4 | Height in Pixels | |
| 6 | Width in Pixels | |
| 8 | X Resolution | |
| 10 | Y Resolution | |
| 12 | Pattern image<br>⋮ | |

**Notes**

The Master X and Master Y Resolution fields can be used to specify 600 dpi resolution for a pattern originally designed at 300 dpi. However, a pattern which was designed at 600 dpi is not available for selection at 300 dpi resolution.

Patterns are identified by some value (ID number). This is the current pattern ID number.

If the Pattern ID command is not used to assign an ID number to the user pattern, the existing (current) pattern ID value is used. If a pattern is already associated with the ID, that pattern is replaced with the new pattern.

## Format (Byte 0)

This field, byte 0, must be set to “0.”

## Continuation (Byte 1)

This field, byte 1, must be set to “0.” (This byte is for future printer support and does not currently provide any continuation operation.)

## Pixel Encoding (Byte 2)

This field, byte 2, should be set to “1.” (This byte is reserved for future printer operation.)

## Reserved (Byte 3)

This field, byte 3, is not currently used and must be set to 0.

## Height in Pixels (Bytes 4 and 5)

This field, bytes 4 and 5, identifies the number of rows (height) of the pattern.

## Width in Pixels (Bytes 6 and 7)

This field, bytes 6 and 7, identifies the number of pixels (width) of the pattern.

## Pattern Image

This field contains the raster data for the pattern.

## Master X Resolution (UI)

The Master X Resolution field is the pixel resolution in the X scan direction at which the pattern was designed.

## Master Y Resolution (UI)

The Master Y Resolution field is the pixel resolution in the Y scan direction at which the pattern was designed.

## User-defined Pattern Example

This example shows how the user-defined pattern command is used to create a user-defined patterns. For this example, a pattern of triangles is used. The first step is to design the base pattern triangle (in this case, using 64 bytes of data). The base pattern binary data is shown below:

```
11111111111111111111111111111111
01111111111111111111111111111110
00111111111111111111111111111100
00011111111111111111111111111000
00001111111111111111111111110000
00000111111111111111111111100000
00000011111111111111111111000000
00000001111111111111111110000000
00000000111111111111111100000000
00000000011111111111111000000000
00000000001111111111110000000000
00000000000111111111100000000000
00000000000011111111000000000000
00000000000001111110000000000000
00000000000000111100000000000000
00000000000000011000000000000000
```

This translates into the following 64 bytes in hexadecimal values:

**Table 13-5**

| | | | |
|---|---|---|---|
| FF | FF | FF | FF |
| 7F | FF | FF | FE |
| 3F | FF | FF | FC |
| 1F | FF | FF | F8 |
| 0F | FF | FF | F0 |
| 07 | FF | FF | E0 |
| 03 | FF | FF | C0 |
| 01 | FF | FF | 80 |
| 00 | FF | FF | 00 |
| 00 | 7F | FE | 00 |
| 00 | 3F | FC | 00 |
| 00 | 1F | F8 | 00 |
| 00 | 0F | F0 | 00 |
| 00 | 07 | E0 | 00 |
| 00 | 03 | C0 | 00 |
| 00 | 01 | 80 | 00 |

When using the 300 dpi User-Defined Pattern header (see Table 13-3). Set the eight bytes of header information to the following values:

Byte 0 - Format = 0 (00 hex)

Byte 1 - Continuation = 0 (00 hex)

Byte 2 - Pixel Encoding = 1 (01 hex)

Byte 3 - Reserved = 0 (00 hex)

Byte 4/5 - Height in Pixels = 0 / 16 (00 / 10 hex)

Byte 6/7 - Width in Pixels = 0 / 32 (00 / 20 hex)

Byte eight begins the first bytes of binary data.

The PCL code below downloads the user-defined pattern and assigns it an ID number of 3.

**1** Specify the pattern ID number:

$E_C$*c3G

Assigns an ID number of 3 to the pattern data which follows.

**2** Send the User-defined Pattern command:

$E_C$*c72W

Specifies that 72 bytes are to follow (8 bytes for header plus 64 bytes of pattern data).

**3** Send the pattern header and binary data:

**Table 13-6**

```
00 00 01 00 00 10 00 20
FF FF FF FF
7F FF FF FE
3F FF FF FC
1F FF FF F8
0F FF FF F0
07 FF FF E0
03 FF FF C0
01 FF FF 80
00 FF FF 00
00 7F FE 00
00 3F FC 00
00 1F F8 00
00 0F F0 00
00 07 E0 00
00 03 C0 00
00 01 80 00
```

**Notes**

There must be an even number of bytes in user-defined pattern data, hence the trailing zeros (“padding”) in the last eight data rows above.

The user-defined pattern downloaded in the previous example is printed within a rectangular area in Chapter 14 under “Rectangular Area Fill Examples.”

In the previous example, the raster data code is presented in hexadecimal, however, the numbers in the escape sequences are decimal.

# Set Pattern Reference Point Command

The Set Pattern Reference Point command causes the printer to tile patterns with respect to the current cursor position. This command also specifies whether the pattern rotates with the print direction or remains fixed.

$E_C$ * p # R

# =0 - Rotate patterns with print direction
1 - Keep patterns fixed

**Default** = 0
**Range** = 0,1 (values outside the range are ignored)

A value field of 0 rotates the patterns with changes in the print direction (see Print Direction command). For a value field of 1, patterns remain fixed for changes in print direction.

The default pattern reference point is the upper left corner of the logical page at the top margin (position 0,0). If the Set Pattern Reference Point command is not set, the pattern is tiled with respect to the default reference point.

**Notes**

All patterns are rotated for changes in orientation (refer to “Logical Page Orientation Command” in Chapter 5 of this manual).

This command applies to user-defined, shading, and cross-hatch patterns.

# Pattern Control Command

The Pattern Control command provides a means for manipulating user-defined patterns.

$^{E}_{C}$ * c # Q

# =0 - Delete all patterns (temporary & permanent)
1 - Delete all temporary patterns
2 - Delete pattern (last ID # specified)
3 - Reserved
4 - Make pattern temporary (last ID # specified)
5 - Make pattern permanent (last ID # specified)

**Default = 0**
**Range = 0 - 5 (values outside the range are ignored)**

For value fields 2, 4, and 5, the Pattern ID ($^{E}_{C}$***c#G**) command is sent prior to the Pattern Control command to identify the specific pattern for the Pattern Control command action.