15 Raster Graphics

Introduction

A raster image is an image composed of dots. Pictures in newspapers or on television screens (also, a page printed by this printer) are examples of raster images. The PCL language includes commands for printing raster graphic images. These commands enable the LaserJet printer to receive binary data and print it as a raster image.

The binary data used to create a raster image is divided into dot rows: a row describes a one-dot-high strip of the image. Each dot position within a row is represented by a binary data bit. If a bit in a row is set to one, a dot is printed; if the bit is set to zero, no dot is printed for that position. A dot row of raster image data is transferred to the printer as a string of bytes containing a dot-per-bit representation of the row.

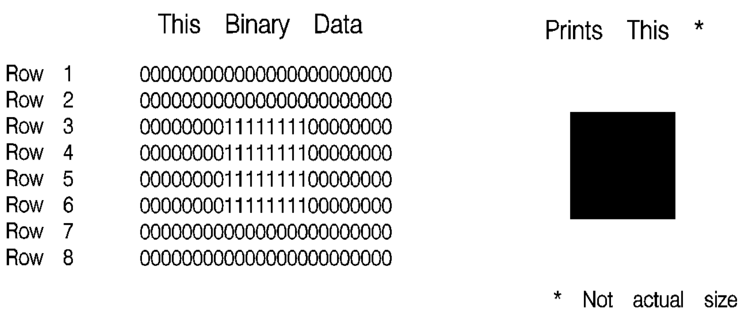

Figure 15-1 Binary Raster Data

Since it takes a considerable amount of data to create even a small raster image, several methods are provided to reduce the amount of data needed to define an image. (Note, that the above illustration creates a rectangle 0.013 by 0.027 inches; a binary “1“ = 1 dot = 1/300 inch.) These reduction techniques include several binary data compression methods, and additional reduction techniques associated with the **raster area** feature (see Figure 15-2).

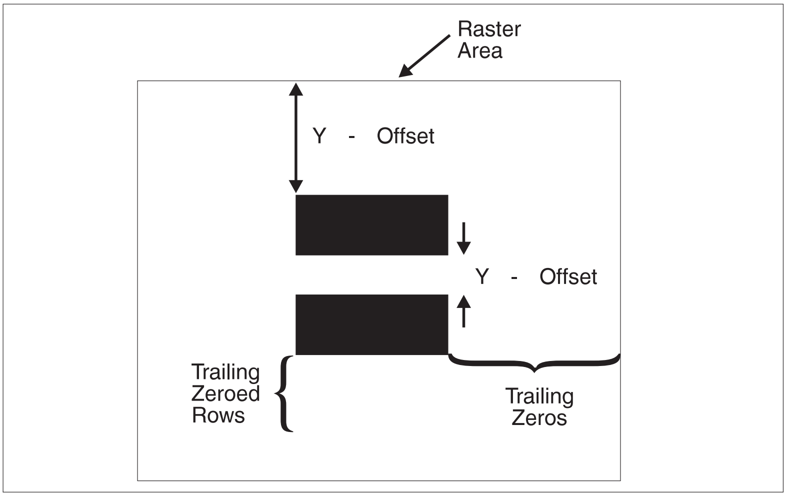

Figure 15-2 Raster Area

Data compression methods include: run-length encoding, tagged image file format (TIFF), delta row, and adaptive compression. These techniques are described in detail later in this section, under the Set Compression Method command.

In addition to the compression methods, the raster area feature provides some other raster reduction techniques which utilize a defined raster area. The raster area is defined by a width and height which are set using the Raster Width and the Raster Height commands.

Zeroed rows at the top and within the raster image can be eliminated by using the Y-offset feature. Y-Offset identifies how many rows to skip (zero fill). The Y-offset command specifies the Y-offset or number of rows for the printer to fill with zeroed rows. This provides a reduction in data for increased efficiency.

Trailing zeroed full rows at the end of the raster image need not be sent. The printer automatically fills in any unsent zeroed rows from the end of the raster image (last raster row with any “1”s) to the bottom of the raster area.

The final data reduction technique provided by the raster area involves the printer's ability to fill in trailing zeros to the edge of the raster area. Any zeros following the last "1" in the raster row to the edge of the picture area need not be sent. The printer automatically fills them. This technique eliminates the need to transmit raster data rows that are all the same length, as required in a raster image which does not use the raster area feature.

The raster area represents a boundary. Within this boundary the printer zero-fills missing rows and fills in short rows to the edge of the raster area. However, in addition to filling to the boundaries of the raster area, the printer also clips any raster line which extends beyond the boundary. Thus, if an image extends beyond the raster area, then that portion of the image is not printed.

When the raster area reduction techniques are used in conjunction with the raster compression techniques, a considerable savings in data can be realized. This results in a saving of host storage and data transmission time. However, these reduction techniques do not reduce the amount of printer memory required for page formatting.

Raster Graphics Command Sequence

PCL raster commands include: Start Raster Graphics and End Raster Graphics commands, Transfer Raster Data by Row, Raster Compression, Raster Presentation, Raster Resolution, Raster Height and Raster Width (which define the raster area), and Raster Y Offset commands. The normal sequence of execution for these commands is shown below:

Table 15-1

Raster Presentation

Raster Resolution

Raster Height

Raster Width

Start Raster Graphics

Y Offset

Raster Compression

Transfer Raster Data

⋮

Transfer Raster Data

Y Offset

Transfer Raster Data

⋮

Y Offset

Raster Compression

Transfer Raster Data

⋮

Raster Compression

Transfer Raster Data

End Raster Graphics

The emphasis in the previous command sequence is that the Raster Presentation Mode, Raster Resolution, Raster Height, and Raster Width are all set outside the *start..data..end* sequence of commands. Also, the entire image is sent during the *start..data..end* sequence, choosing the most effective compression method for each raster row of data.

Raster Presentation, Raster Resolution, Raster Height, Raster Width, and Raster Compression are all true modes. Once specified, the printer remains in that mode unless explicitly changed by issuing the command again, or reset to default values by a soft reset, self test, font printout, or power cycle.

Note

Only raster data appearing within the intersection of the logical page, the printable area, the raster width, and height is printed. If raster width and/or raster height have not been set (are defaulted), then the intersection of the logical page and the printable area determines where raster graphics appear; raster data is clipped to the printable area.

Raster Graphics Resolution Command

Raster graphics can be printed at various resolutions. This command designates the resolution of subsequent raster data transfers in dots-per inch.

$^{E}{}_{C}$ * t # R

\# = 75 - 75 dots-per-inch
100 - 100 dots-per-inch
150 - 150 dots-per-inch
200 - 200 dots-per-inch[1]
300 - 300 dots-per-inch
600 - 600 dots-per-inch

Default **=** 75
Range **=** 75, 100, 150, 200, 300, 600

This command must be sent prior to the start graphics command. The factory default resolution is 75 dots-per-inch.

Note Lower resolution graphics occupy less user memory. For example, the number of bits required to represent a two-inch by three-inch image at 75 dots-per-inch is 33,750. The same image at 300 dots-per-inch requires 540,000 bits.

When configured for 300 dpi resolution, the printer automatically expands raster graphics transferred at resolutions less than 300 dots-per-inch to 300 dots-per-inch during printing. illustrates how a single bit is translated into the corresponding printed dots in various graphics resolutions when the printer is configured for 300 dpi.

1. Only available if the printer is configured for resolution=600 dpi.

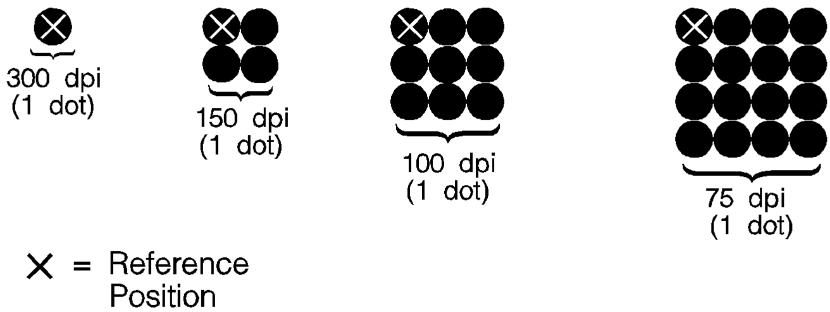

Figure 15-3 Raster Graphics Expansion - at 300 dpi

Note

Rectangular area fills and character data are not affected by changes in resolution. Rectangular Area fills and character data always print at the maximum resolution, regardless of the resolution setting.

When configured for 600 dpi resolution, the printer automatically expands raster graphics transferred at resolutions less than 600 dots-per-inch to 600 dots-per-inch during printing. illustrates how a single bit is translated into the corresponding printed dots in various graphics resolutions when the printer is configured for 600 dpi.

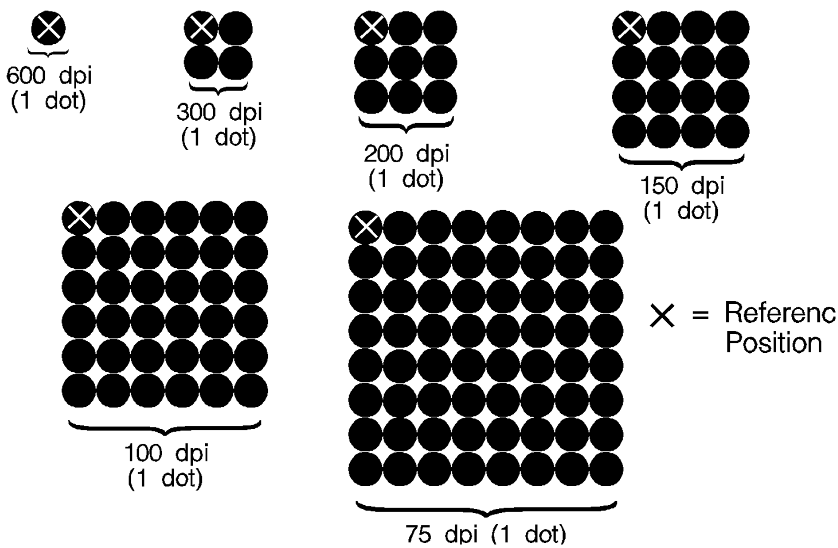

Figure 15-4 Raster Graphics Expansion - at 600 dpi

Raster Graphics Presentation Mode Command

The Raster Graphics Presentation command specifies the orientation of the raster image on the logical page.

$^{E}{}_{C}$ * r # F

\# =0 - Raster image prints in orientation of logical page
3 - Raster image prints along the width of the physical page

Default **=** 3
Range **=** 0, 3

A value of 0 indicates that a raster row 'will be printed in the positive X-direction of the PCL coordinate system. (The print direction translates the PCL coordinate system.)

A value of 3 indicates that the raster graphics will be printed along the width of the physical page, regardless of logical page orientation. In portrait orientation, a raster row is printed in the positive X-direction of the PCL coordinate system and a subsequent raster row is printed beginning at the next dot row position in the positive Y-direction. In landscape orientation, a raster row is printed in the positive Y-direction of the PCL coordinate system and a subsequent raster row is printed beginning at the next dot row position in the negative X-direction. Figure 15-5 illustrates presentation mode 0 and 3.

Table 15-2

Raster Presentation Mode	Orientation	Default Graphics Margin
0	portrait	logical page left bound
0	reverse portrait	logical page left bound
0	landscape	logical page left bound
0	reverse landscape	logical page left bound
3	portrait	logical page left bound
3	reverse portrait	logical page left bound

Table 15-2 (continued)

3	landscape	50 dots in from the logical page *top* bound
3	reverse landscape	50 dots in from the logical page *top* bound

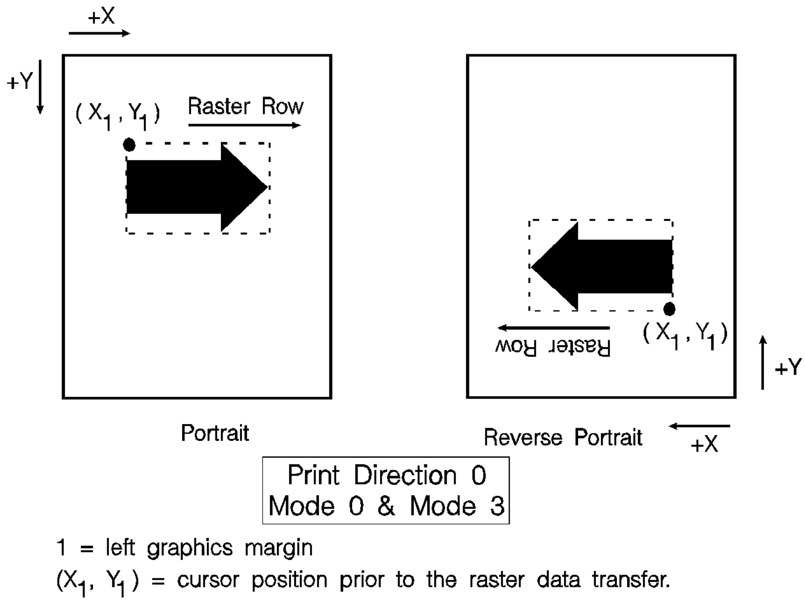

Figure 15-5 Raster Graphics Presentation Mode for Portrait Orientation

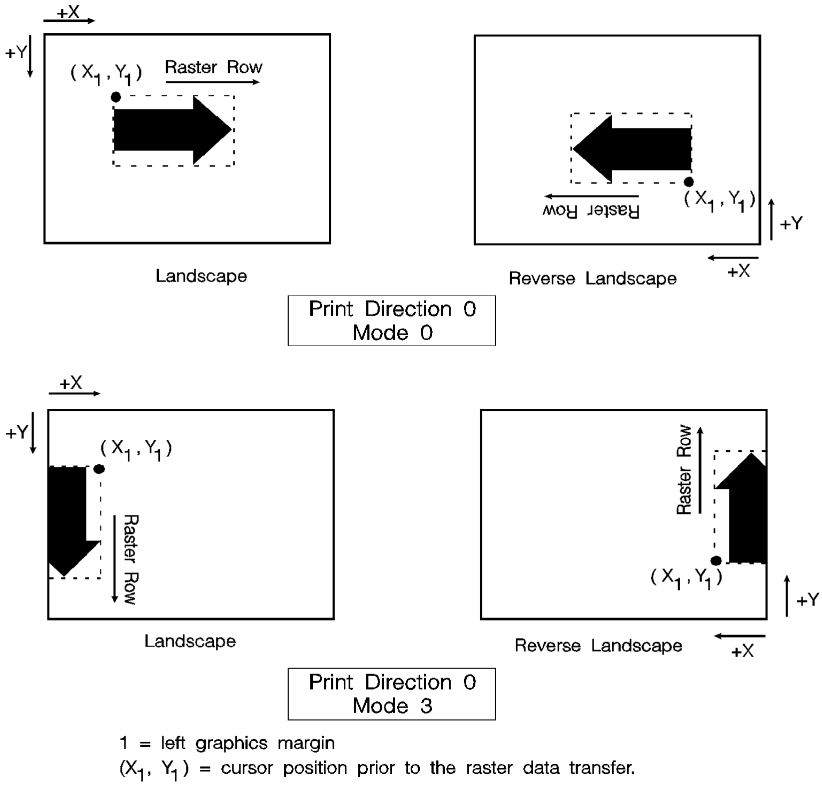

Figure 15-6 Raster Graphics Presentation Mode for Landscape Orientation

Raster Height Command

The Raster Height command specifies the height in raster rows of the raster area. Height is the direction perpendicular to the direction that raster rows are laid down, hence, height is subject to the current raster presentation mode and print direction (see Figure 15-7).

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

\# = Height in raster rows

Default **=** N/A
Range **=** 0 to (logical page length – current Y-position of the 0,cursor)*

* Greater values default to (logical page length – current Y-position of the cursor)

This command fills the raster area to the full raster height with zeroed rows. Unspecified rows map to either white or transparent depending on the source transparency mode.

When a Transfer Raster Data command is received that causes any raster row to extend beyond the row boundary set by the Raster Height command, the row outside the boundary is clipped. This includes the case where the cursor is moved beyond the height boundary with a Raster Y Offset command and the printing of raster data is attempted.

If you have specified either a raster height or a raster width of 0 and a Start Raster Graphics (or Transfer Raster Data) command is received, then the entire raster graphic is clipped. If both a raster height and a raster width are specified (non-zero) and a Start Raster Graphics (or Transfer Raster Data) command is received then the raster area is guaranteed to be logically zeroed-out.

If the raster height is not set, the raster height is ignored so that no padding or clipping of rows takes place.

This command is ignored after the Start Raster Graphics or Transfer Raster Data commands until the next End Raster Graphics command.

Note Only raster data appearing within the intersection of the logical page, the printable area, and if set, the raster width and height is printed. Data outside the intersection is clipped.

Upon receiving an End Raster Graphics (^{E}C***rC**) command, the cursor position is set to the left graphics margin of the next raster row after the raster height boundary.

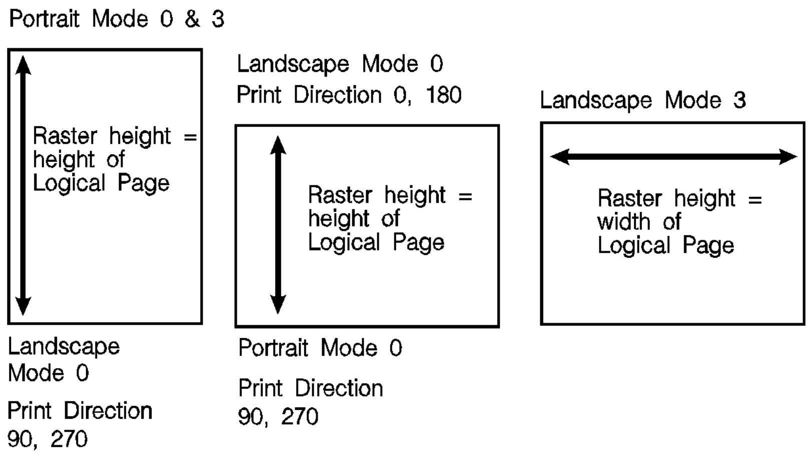

Figure 15-7 Maximum Raster Height

Raster Width Command

The Raster Width command specifies the width in pixels of the raster area. Width is in the direction that the raster rows are laid down, hence, width is subject to the current raster presentation mode and print direction (see Figure 15-8).

$^{E}{}_{C}$* r # S

=Width in pixels of the specified resolution

Default	**=**	depends on raster presentation mode - when presentation mode is 0, width = width of logical page - left graphics margin when presentation mode is 3 then width = dimension of logical page along paper length - left graphics margin
Range	**=**	0 to (logical page width – left graphics margin)*

*Greater values default to the (logical page width – left graphics margin).

This command allows you to implicitly tell the printer to pad raster rows that are not specified for the full raster width with zeros. Unspecified data maps to either white or transparent depending on the source transparency mode.

When a Transfer Raster Data command is received that specifies a row of data that is longer than the raster width, the data that extends past the raster width is clipped.

This command is ignored after the Start Raster Graphics or Transfer Raster Data commands, until the next End Raster Graphics command.

Note Only raster data appearing within the intersection of the logical page, the printable area, and if set, the raster width and height is printed. Data outside the intersection is clipped.

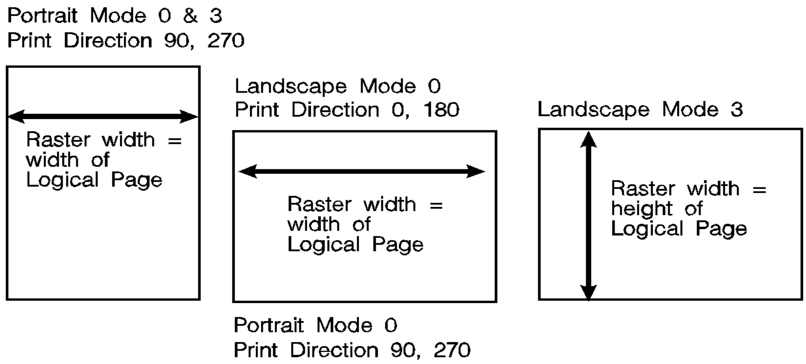

Figure 15-8 Maximum Raster Width

Start Raster Graphics Command

The Start Raster Graphics command identifies the beginning of the raster data and also specifies the left graphics margin.

$^{E}{}_{C}$ * r # A

\# =0- Start graphics at default left graphics margin X-position 0).
1 - Start graphics at current cursor position (current X-position).

Default **=** 0
Range **=** 0, 1 (values outside the range default to 0)

A value of 0 specifies that the left graphics margin is at the default left margin of the page (X-position 0). A value of 1 specifies that the left graphics margin is at the current X-position. In presentation mode 3, the location of the left graphics margin varies depending on the orientation.

Once a Start Raster Graphics command is received by the printer, raster graphics resolution, raster graphics presentation mode, raster height, raster width, and left raster graphics margin are fixed until an end raster graphics command is received.

Once in Raster Graphics Mode, PCL commands and text imply an End Raster Graphics ($^{E}{}_{C}$***rC**) except for the following commands:

- Transfer Raster Data
- Set Raster Compression Method
- Raster Y Offset

In addition, the following commands are ignored (i.e., locked out) while in Raster Graphics Mode and do not imply an End Raster Graphics command:

- Start Raster Graphics
- Set Raster Width
- Set Raster Height
- Set Raster Presentation Mode
- Set Raster Graphics Resolution

Notes

An implied End Raster Graphics resets the Raster Compression Method 3 seed row, but does not reset the Raster Compression Method nor the left raster graphics margin.

If source and/or transparency modes have been set, frequent start/end graphics commands in an image can result in a memory overflow condition.

Raster Y Offset Command

The Raster Y Offset command moves the cursor position vertically the specified number of raster lines from the current raster position in the raster area.

$^{E}{}_{C}$ * b # Y

\# =Number of raster lines of vertical movement

Default **=** N/A
Range **=** 0 - 32767

This command is recognized only while in raster graphics mode and only within the raster area.

Set Compression Method Command

The Set Compression Method command allows you to code raster data in one of four compressed formats: Run-length encoding, tagged imaged file format (TIFF) rev. 4.0, delta row compression, and adaptive compression. The choice of compression methods affects both the amount of code needed to generate a raster graphic image and the efficiency with which the image is printed.

$^{E}{}_{C}$& * b # M

=0- Unencoded
1 - Run-length encoding
2 - Tagged Imaged File Format (TIFF) rev. 4.0
3 - Delta row compression
4 - Reserved
5 - Adaptive compression

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

Unencoded (Method 0)

This is a simple binary transfer of data: no compression. Each bit describes a single dot. Bit 7 of the first byte corresponds to the first dot within the raster row, bit 0 corresponds to the eighth dot, and so on.

Note Compressed data formats allow for efficient transfer of data from the host system to the printer. However, compressed data formats do NOT reduce the amount of printer memory required to produce an image.

Run-length Encoding (Method 1)

Run-length encoding interprets raster data in pairs of bytes. The first byte of each pair is the repetition count for the data in the second byte. The second byte is the raster data to be printed.
A repetition count of 0 signifies the pattern in the data byte is not repeated (it occurs only once). A repetition count of 1 signifies the pattern occurs twice. The repetition count can range from 0 to 255 for a repetition of 1 to 256 times.

[(Repetition count byte 0-255)(pattern byte)] . [.] [ ]

Tagged Image File Format Encoding (Method 2)

Tagged image file format encoding interprets raster data as TIFF "Packbits." This format combines features of methods 0 and 1. A **control byte** precedes the raster data (pattern bytes). The control byte identifies whether the pattern byte(s) represent a byte that is to be repeated some number of times (up to 127), or represent some number of bytes (up to 127) which are to be printed as is (literal).

The sign of the number in the control byte identifies whether the byte or bytes that follow represent a literal pattern or byte to be repeated. A positive number (1 to 127) indicates that the bytes are literal. A negative number (-1 to -127), represented by the twos complement, indicates a repeated byte. The value of the number, if positive (literal), identifies the number of pattern bytes which follow the control byte; if negative (repeated), identifies the number of times to repeat the following byte. A pattern byte may be repeated up to 127 times; or up to 127 literal bytes may follow the control byte.

As mentioned, for a byte to be repeated, the control byte must be a negative value as represented by the twos complement. For example, to repeat a pattern three times would require the twos complement of the number 3. The twos complement is computed as follows. The binary of 3 is 00000011. Complement each bit to get 11111100, then add one to this value to produce 11111101, the twos complement. The decimal value of this number, 253, used in the control byte, produces a repetition of 3 bytes for a total of 4 occurrences of the pattern.

The range of numbers for the control byte is shown below.

Table 15-3 Literal Pattern Values

# of Bytes	Binary value	Decimal value
1	0000 0000	1
to	to	to
127	0111 1111	127

Table 15-4 No Operation Value

NOP value	Binary value	Decimal value
128 (-128)	1000 000	128

Table 15-5 Repeated Pattern Values

# of Repetitions	Binary value[1]	Decimal value
1 (-1)	1111 1111	255
to	to	to
127 (-127)	1000 0001	129

1. These negative values are represented by taking the twos complement of the value of the number.

Note Another method to calculate the number needed in the control byte for some number of repetitions is to subtract the number of desired repetitions from 256. For example, the control value for 3 repetitions (4 occurrences) of a byte is 256 minus 3 = 253.

A zero or positive value in the control byte means that the subsequent byte or bytes are non-replicated bytes of data. The value of the control byte *plus one* indicates the number of data bytes that follow. For example, a control byte of 0 means the following 1 byte is literal raster data. A control byte of 6 indicates that the following 7 bytes are literal raster data bytes.

TIFF encoding also allows you to include a non-operative (NOP) control byte, represented by the value –128. This byte is ignored, and the subsequent byte is treated as the new control byte.

Note It is more efficient to code two consecutive identical bytes as a repeated byte. If these bytes are preceded and followed by literal bytes, however, it is more efficient to code the entire group as literal bytes.

Examples: Run-length and TIFF Compression

The following examples show how a raster row can be coded using run-length and TIFF compression methods. Note that the compression examples use characters to represent the binary data stream.

Table 15-6

Byte Number	#1	#2	#3	#4	#5	#6	#7
Bits	01010101	01010101	01010101	01010101	01000001	01010100	01010100
ASCII	U	U	U	U	A	T	T

Unencoded

$^{E}{}_{C}$*r1A

$^{E}{}_{C}$*b0m7WUUUUATT

$^{E}{}_{C}$*rC

Run-length Encoding

$^{E}{}_{C}$*r1A

$^{E}{}_{C}$*b1m6W(3)U(0)A(1)T

$^{E}{}_{C}$*rC

TIFF Encoding

$^{E}{}_{C}$*r1A

$^{E}{}_{C}$*b2m6W(-3)U(0)A(-1)T or $^{E}{}_{C}$*b2m6W(-3)U(2)ATT

$^{E}{}_{C}$*rC

In the TIFF encoding example above, parenthetical expressions are used to identify control bytes. For example, the byte (-3) is shown to represent the control byte for a repetition (minus value) of 3. The actual value for this position is the decimal value 253. Additional "encoded" control bytes in this sequence include: (0) for decimal 0, (-1) for decimal 255, and (2) for decimal 2. The raster data (pattern) bytes are represented as by the ASCII character.

Delta Row Compression (Method 3)

Delta row compression identifies a section of bytes in a row that is different from the preceding row, and then transmits only that data that is different (the delta data). If a row is completely different from its preceding row, then the entire row must be sent as the delta (not very efficient); if only one bit is different, then only one byte is identified and sent. To reassemble the raster data rows, the printer takes the current row (referred to as the seed row) and makes the changes indicated by the delta data, to create the new row. The new row (which becomes the new seed row) is used by the next delta compression data to create another row.

A delta compression row consists of two parts, a command byte and the replacement bytes, as shown below:

[(Command byte)(1 to 8 Replacement bytes)]

The command byte identifies two things: 1) the number of replacement (delta) bytes that follow; and, 2) where to position the replacement byte string (the left offset). The replacement bytes are some number (up to eight bytes) of consecutive bytes that are used to create the new row from the seed row.

Table 15-7

Command Byte

7 5	4 0
Number of bytes to replace (1-8)	Relative offset from last untreated byte

If more than eight replacement (delta) bytes are needed, additional command byte/replacement bytes may be added, as shown below:

> $^{E}{}_{C}$*3m#W [(Command Byte)(1 to 8 Replacement Bytes)][(Command Byte)(1 to 8 Replacement Bytes)]. . .

In the command byte, the upper three bits identify the number of replacement (delta) bytes (which can be 1 to 8 bytes). The lower five bits identify the location the replacement bytes are to be positioned. This position is identified as some number of bytes in, from the first untreated byte, referred to as the **offset**. For example, if there are 5 replacement bytes and the offset is 7, then the replacement bytes replace byte 7, 8, 9, 10, and 11 (the five bytes beginning at byte 7 from the seed row).

If there is more than one replacement in a row, the second offset is counted from the next untreated byte in the row: the first byte following the last replacement byte.

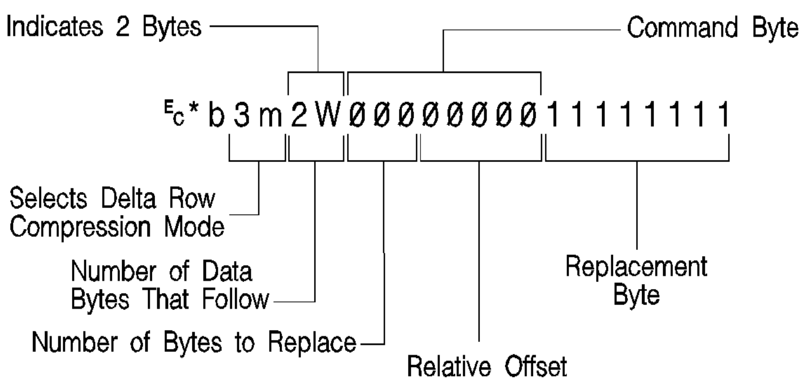

Figure 15-9

As mentioned, the offset is contained in the lower five bits of the command byte allows for offset values from 0 to 31. Compression mode allows offsets larger than 31 bytes as follows:

- An offset value of 0-30 indicates that the replacement bytes are offset from the 1st byte to the 31st byte.
- A value of 31 indicates that the next byte following the command byte is an additional offset byte which adds to the first (32) offset value. This allows offset values larger than 31. Also, if this second offset byte is set to 255 (all ones), additional offset bytes follow until the required offset value is obtained. When the formatter detects an offset byte less than 255, it is assumed to be the last offset value and the offset bytes are then totaled (added). The following example shows an offset larger than 31:

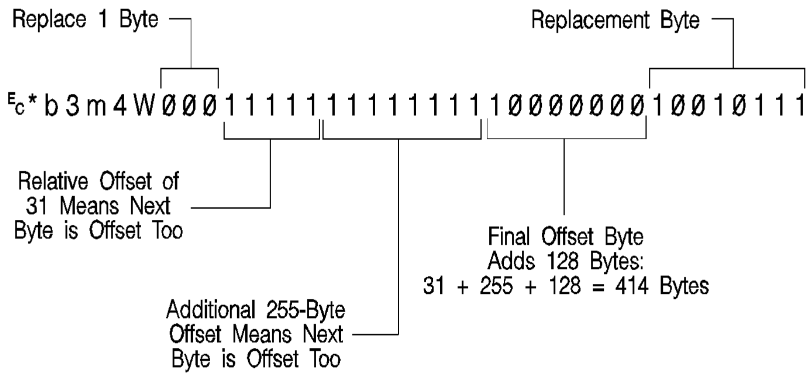

Figure 15-10

The total offset 414, which is the sum of the three offset values: 31 + 255 + 128.

Seed Row

The seed row is basically the current raster data row; the row being printed. It is maintained by the printer for use by delta row compression. The delta compression replacement bytes are applied to the seed row to create the new row. This new data row is printed and becomes the new seed row.

The seed row is updated by every raster graphic transfer, regardless of the compression method. This allows delta compression method to be mixed with other methods to achieve better compression performance.

Repeating a Row

$^{E}{}_{C}$*b0W

When using the delta compression method, it is possible to repeat or copy the previous raster row using the Raster Data Transfer command. This is accomplished by setting the Raster Data Transfer command, value field, to zero.

Printing A Zeroed Row (Setting the Seed Row to Zero)

$^{E}{}_{C}$*b1Y

It is possible to print a row of all zeros using the Raster Y-Offset command. Sending a Raster Y Offset command, with a value field of 1, sets the seed row to zero and prints the zeroed row. Note, that the next delta row is applied to a zeroed seed row.

Other cursor position moves set the seed row to zeros. (Remember, non-graphic cursor moves have the same effect as an end graphics command.)

Note

If the byte count of the Transfer Raster Data command value field is less than the number of bytes that can be replaced, the byte count has precedence. Also, if the last byte is a control byte, it is ignored. Therefore, **&esc*b1W** does not affect the seed row, but causes the previous row to be replicated.

Example: Delta Row Compression

The following example demonstrates how to compress the following data using the delta row compression. (The bytes highlighted in italic type indicate those bytes needing replacement — those bytes that are different from the previous row, the seed row.)

Table 15-8

Byte No.	**0**	**1**	**2**	**3**	**4**
Row 1	00000000	**11111111**	00000000	00000000	00000000
Row 2	00000000	11111111	**11110000**	00000000	00000000
Row 3	00001111	11111111	11110000	**10101010**	**10101010**

$^{E}{}_{C}$***r1A** – The *start raster graphics* command initializes the seed row to all zeros.

Row 1 — $^{E}{}_{C}$***b3m2W**(00000001)(11111111)

The **3m** selects the delta row compression method and the **2W** indicates that 2 bytes of data to follow. The first three bits of the first data byte, the command byte, signify a single byte replacement (all three bits are 0). The next five bits indicate an offset of 1 byte from the current position. The replacement byte follows and contains **11111111**.

Row 2 — $^{E}{}_{C}$***b2W**(00000010)(11110000)

The first three bits of the command byte indicate that one byte will be replaced, and the next five bits indicate a relative offset of 2, so the replacement will occur 2 bytes from the current position. The replacement byte follows and contains **11110000**.

Row 3 — $^{E}{}_{C}$***b5W**(00000000)(00001111)(00100010)(10101010)(10101010)

As in the other rows, the first three bits of the command byte are zero, indicating a single byte replacement. The five offset bytes indicate a relative offset of zero bytes. The replacement byte follows and is 00001111. The third byte is another command byte and the first three bits signify the replacement of two bytes (the top three bits are 001). The offset bits indicate an offset of two bytes from the current position. The fourth and fifth bytes are the two replacement bytes.

Adaptive Compression (Method 5)

Adaptive compression enables the combined use of any of the four previous compression methods (0 through 3), and it includes the ability to print empty (all zeros) rows or to duplicate rows.

Adaptive compression interprets a raster image as a block of raster data rather than as individual rows. The result of this interpretation is that the Transfer Raster Data ($^{E}{}_{C}$***b#W**) command is sent only once at the beginning of a raster data transfer, and the value field (**#**) identifies the number of bytes in the block (all rows). For the other compression methods, the Transfer Raster Data command is sent at the beginning of each row and the value field (**#**) identifies the number of bytes for that row only.

The size of a block is limited to 32,767 bytes. (32,767 bytes is the number of compressed bytes and not the size of the uncompressed data). To transfer greater than 32,767 bytes, send multiple blocks.

Adaptive compression uses three control bytes at the beginning of each row within the block. The first of these bytes, the command byte, identifies the type of compression for the row. The two following bytes identify the number of bytes or rows involved. The format for adaptive compression raster rows is shown below:

<command byte><# of bytes/rows - upper byte><# of bytes/rows - lower byte> ...
...<first raster row byte>...<last raster row byte>

The command byte designates the compression method, empty row, or row duplication. Command byte values are shown below.

Table 15-9

Value	Compression Operation
0 -	Unencoded
1 -	Run-Length Encoding
2 -	Tagged Image File Format (TIFF) rev 4.0
3 -	Delta row
4 -	Empty row
5 -	Duplicate row

For command byte values 0 - 3, the two **<# of bytes/rows>** bytes specify the number of bytes (row length) for the row. For command byte values 4 and 5, these bytes identify the number of empty or duplicate rows to print. The maximum value for these two bytes is 65,535; however, the image is clipped to the logical page. Thus, the value of these bytes should not exceed the maximum number of bytes/rows that can be printed on the current logical page size.

If an out of range command byte is encountered, the remainder of the block is skipped, the cursor is not updated, and the seed row is cleared.

Compression methods 0 - 3 are the compression methods used by the Set Compression Method command. Value fields 4 and 5 are features for the adaptive compression method and are explained below.

Empty Row

A command byte of 4, empty row, causes a row of zero's to be printed. The number of rows printed depends on the value contained in the two **<# of bytes/rows>** bytes following the command byte. The empty row operation resets the seed row to zero and updates the cursor position.

Duplicate Row

A command byte of 5, duplicate row, causes the previous row to be printed again. The row can be duplicated the number of times indicated by the value contained in the **<# of bytes/row>** byte. Duplicate Row updates the cursor position but does not change the seed row.

Adaptive Compression Operation Hints

Note Some HP LaserJet printers perform internal compression techniques to support full-page graphics. Refer to Chapter 1 of the *PCL 5 Comparison Guide* for specifics.

- The compression methods cannot be mixed within one raster row. A raster row must be compressed using only one method.
- The cursor position is updated with each row of the raster block. The cursor position is also incremented when a block count of less than 3 is sent.
- A Raster Y-Offset command moves the entire block of raster data and initializes the seed row to zeros. The seed row is set to zero even if the y-offset is zero.
- Block size takes precedence over row length. If the row length of any line exceeds the block size, the row length is truncated to the block size.
- For duplicate and empty rows a row length value of zero does not update the cursor, however, the seed row is initialized to zero.
- If an unsupported command byte for a raster row is encountered, the remaining bytes for the block are skipped, the seed row is cleared, and the cursor is not incremented.
- For method 1, run length encoded, if the row length is odd, the cursor is incremented and the row data is skipped (thrown away), and the seed row is left unchanged.
- For method 1, a row length value of zero increments the cursor and zero fills the seed row.
- For method 2, TIFF, if row length terminates the data before the control byte value is satisfied (literal byte count greater than row length), the data following the control byte (if any) is printed as text. The cursor is incremented.
- For method 2 - If row length is equal to one, the one byte is consumed from the I/O and the cursor is incremented. The data is ignored and the seed row is zeroed.
- For method 3 - delta row compression, within an adaptive compression block, the seed row is updated by every raster compression method or type of row. For example, a row compressed with method 2, TIFF, updates the seed row, while the effect of an empty row initializes the seed row to zeros. Maintaining the seed row allows method 3 to be mixed with other methods to achieve optimal compression performance.

- For method 3 - Since delta row compression requires that the seed row be available whenever raster graphics mode is entered, the seed row is initialized to zeros upon raster graphics mode entry ($^{E}{}_{C}$*r#A). The seed row is also initialized upon receipt and completion of each raster block.
- For method 3 - If the row length terminates the data before the control byte value is satisfied (literal byte count greater than row length), the data following the control byte (if any) is printed as text. The cursor is incremented.
- For method 3 - if the row length is equal to one, the current row is duplicated, and the cursor is incremented.

Transfer Raster Data Command

The Transfer Raster Data command is used to transfer a row of raster data to the printer.

$^{E}_{C}$ * b # W   [*raster data*]

Default **=** N/A
Range **=** 0 - 32767

The value field (#) identifies the number of bytes in the raster row. These bytes are interpreted as one row of raster graphics data that is printed at the current Y position at the left raster graphics margin. Upon completion of this command, the cursor position is at the beginning of the next raster row at the left raster graphics margin.

Within the raster data, each bit describes a single dot. The most significant bit (bit 7 is the most significant, bit 0 is the least significant) of the first byte of data corresponds to the first dot within the row. If a bit is set to 1, the corresponding dot is printed. Each dot of the raster data is expanded according to the specified raster resolution.

Raster graphics is independent of the text area and perforation skip mode – these boundaries are ignored.

Raster graphic images, raster height, and raster width are limited to the printable area; images that extend beyond the printable area are clipped.

Note The byte count of the value field in the Transfer Raster Data command has precedence over the literal or the command byte, byte count. For example, the command,

$^{E}_{C}$*b2m3W [*binary data*]

sets compression method=2 and sends 3 bytes of raster data for the row. Suppose the binary data appears as follows:

00000010 00000001 00000001 00000001

The control (first) byte value of +2 indicates that 3 bytes of literal (unencoded) raster data will follow. The Transfer Raster Data command, however, specified only three bytes total (including the control byte) in the raster row. The control byte and the following two data bytes are read, and the remaining data byte is ignored.

Notes If the last byte indicated by the value field in the Transfer Raster Data command is a control byte, that byte is ignored.

If a Transfer Raster Data command is received without an accompanying Start Raster Graphics command, any preceding start raster values are used (such as left graphics margin, raster height and width, etc.).

End Raster Graphics Command

The **End Raster Graphics** command signifies the end of a raster graphic data transfer.

$^{E}{}_{C}$ * r C

- Receipt of this command causes 5 operations:
- Resets the raster compression seed row to zeros.
- Moves the cursor to the raster row immediately following the end of the raster area (if a source raster height was specified).
- Allows raster commands which were previously locked out to be processed.
- Sets compression mode to 0 (no compression)
- Defaults the left graphics margin to X-position 0.

Notes This command is a modified version of the $^{E}{}_{C}$***rB End Raster Graphics** command. This new version ($^{E}{}_{C}$*rC) performs two additional operations: 1) it resets the compression mode to 0, and 2), it defaults the left graphics margin to 0.

This command ($^{E}{}_{C}$*rC) is not supported by the HP LaserJet III or the HP LaserJet IIID printers. Use the $^{E}{}_{C}$***rB End Raster Graphics** command to terminate raster graphic data transfers for these printers.

Refer to the “PCL Feature Support Matrix” in Chapter 1 of the *PCL 5 Comparison Guide* for specific printers which support these commands.

Raster Graphics Example

To transfer an unencoded raster graphic image (see Figure 15-11) in the shape of an arrow, perform the following steps:

Table 15-10

1. Position the cursor:

$^{E}{}_{C}$*p300x400Y	This moves the cursor to PCL Unit position (300, 400) within the PCL coordinate system.

2. Specify the raster graphics resolution:

$^{E}{}_{C}$*t75R	This sets the raster graphics resolution to 75 dots-per-inch.

3. Specify the raster graphics presentation method:

$^{E}{}_{C}$*r0F	This specifies that the raster graphics is printed in the orientation of the logical page.

4. Specify the left raster graphics margin:

$^{E}{}_{C}$*r1A	This sets the left graphics margin to the current X position (300).

5. Transfer the raster data to the printer:

Divide the image into dot rows and transfer each dot row to the printer as a string of bytes, as illustrated on the following page.

6. Signify the end of the raster graphic image transfer:

$^{E}{}_{C}$***rC**	This example prints the arrow as shown in Figure 15-11.

Table 15-11 Example of Raster Graphic Image Data

	Raster Image Data				Command Data
Dot Row	**byte 1**	**byte 2**	**byte 3**	**byte 4**	**Decimal Equivalent**
1	00000000	00000000	10000000	00000000	$^{E}{}_{C}$*b4W[0, 0,128, 0]
2	00000000	00000000	11000000	00000000	$^{E}{}_{C}$*b4W[0, 0,192, 0]
3	00000000	00000000	11100000	00000000	$^{E}{}_{C}$*b4W[0, 0,224, 0]
4	00000000	00000000	11110000	00000000	$^{E}{}_{C}$*b4W[0, 0,240, 0]
5	00000000	00000000	11111000	00000000	$^{E}{}_{C}$*b4W[0, 0,248, 0]

Table 15-11 Example of Raster Graphic Image Data (continued)

6	00000000	00000000	11111100	00000000	EC*b4W[0, 0,252, 0]
7	00000000	00000000	11111110	00000000	EC*b4W[0, 0,254, 0]
8	00000000	00000000	11111111	00000000	EC*b4W[0, 0,255, 0]
9	00000000	00000000	11111111	10000000	EC*b4W[0, 0,255,128]
10	11111111	11111111	11111111	11000000	EC*b4W[255,255,255,192]
11	11111111	11111111	11111111	11100000	EC*b4W[255,255,255,224]
12	11111111	11111111	11111111	11110000	EC*b4W[255,255,255,240]
13	11111111	11111111	11111111	11111000	EC*b4W[255,255,255,248]
14	11111111	11111111	11111111	11111100	EC*b4W[255,255,255,252]
15	11111111	11111111	11111111	11111110	EC*b4W[255,255,255,254]
16	11111111	11111111	11111111	11111111	EC*b4W[255,255,255,255]
17	11111111	11111111	11111111	11111111	EC*b4W[255,255,255,255]
18	11111111	11111111	11111111	11111110	EC*b4W[255,255,255,254]
19	11111111	11111111	11111111	11111100	EC*b4W[255,255,255,252]
20	11111111	11111111	11111111	11111000	EC*b4W[255,255,255,248]
21	11111111	11111111	11111111	11110000	EC*b4W[255,255,255,240]
22	11111111	11111111	11111111	11100000	EC*b4W[255,255,255,224]
23	11111111	11111111	11111111	11000000	EC*b4W[255,255,255,192]
24	00000000	00000000	11111111	10000000	EC*b4W[0, 0,255,128]
25	00000000	00000000	11111111	00000000	EC*b4W[0, 0,255, 0]
26	00000000	00000000	11111110	00000000	EC*b4W[0, 0,254, 0]
27	00000000	00000000	11111100	00000000	EC*b4W[0, 0,252, 0]
28	00000000	00000000	11111000	00000000	EC*b4W[0, 0,248, 0]
29	00000000	00000000	11110000	00000000	EC*b4W[0, 0,240, 0]
30	00000000	00000000	11100000	00000000	EC*b4W[0, 0,224, 0]
31	00000000	00000000	11000000	00000000	EC*b4W[0, 0,192, 0]
32	00000000	00000000	10000000	00000000	EC*b4W[0, 0,128, 0]

The brackets and commas are not part of the raster data command; they are used only to delineate the data.

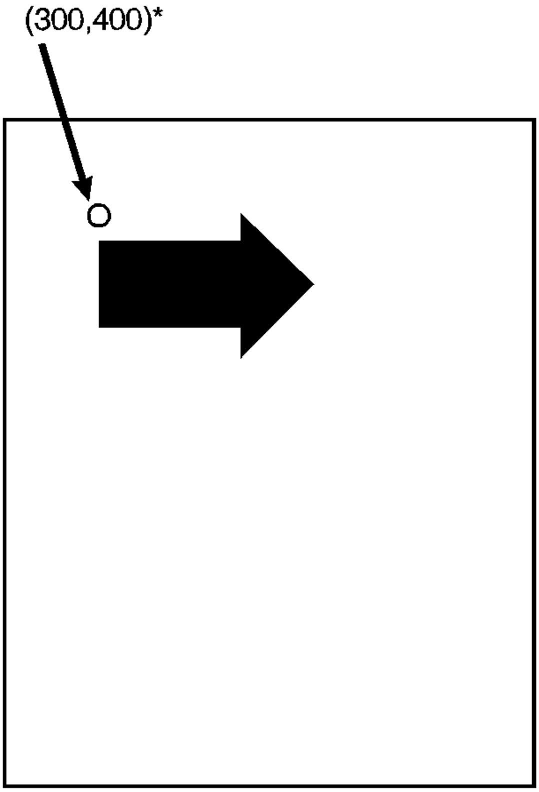

Figure 15-11 Example of Raster Graphic Image Data