LW Pro 810 & LW Select 360: Gray Levels (3/94)

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TOPIC -----

How many gray levels are supported at the various printer resolutions by the LaserWriter printers?

DISCUSSION -----

Current laser printers are single-bit devices that can only print black dots or no dots. To print multi-bit (grayscale) objects, printers must convert multiple-bit data into single-bit data for printing using a process called halftoning.

The most popular halftoning technique used to perform this conversion is called screening. Screening uses a matrix of black or white pixels to simulate shades of gray.

There are two key concepts when discussing screening.

1) A Screen is composed of a group of pixels called a halftone cell. The number of shades of grays possible increases as the number of pixels in the halftone cell increases. The halftone made up of a single pixel offers two shades of gray, black or white. The four pixel halftone offers five shades of gray including white and the progressive filling of the pixels. The chart below depicts a 2x2 halftone cell with each asterisk representing one pixel of toner.

White	One	Two	Three	Four
	*	* *	* * *	* * * *

2) The size of the halftone cell helps to determine the screen frequency. The screen frequency is the maximum effective image resolution of the printer for a given size halftone cell. Because multiple pixels are used to simulate gray, the effective resolution (the size of the smallest object that can be resolved) of the printer decreases as the size of the

cell increases. The screen frequency is calculated by dividing the nominal resolution of the printer by the number of horizontal pixels in the halftone cell.

If a 300 dpi printer uses a 1x1 halftone cell, a 300-line screen (lines per inch) results which can offer 2 shades of gray. With a 2x2 halftone cell on the same 300 dpi printer a 150-line screen is the result offering 5 shades of gray. Screening is a trade-off between effective resolution and number of gray shades achievable. Five shades of gray is not sufficient for most images so 300 dpi printers must use very large halftone cells which result in a very low effective resolution. The effect is that individual halftone cells are plainly visible.

The default halftone cell on the LaserWriter IIg has 8 elements as shown below. This results in a 106 line screen with 67 levels of gray which means that the LaserWriter IIg provides twice the gray levels and twice the screen frequency compared to other 300 dpi printers.

Calculating gray levels for any device that implements halftoning is very difficult as there are both mathematical calculations, as well as actual measured results that determine the number. We are providing you with the "calculated" gray levels for the LaserWriter Pro 810 at the 300 and 400 dpi settings, however, there are some considerations that need to be taken into account with the numbers:

- The LaserWriter Pro 810 has native resolutions of 300 and 400dpi. Thus, the calculation for number of grays is accurate for these resolutions. For 600 and 800dpi, resolution enhancement technology (RET) is utilized to provide the higher dpi, so the calculations would be much less accurate. The best way to determine the number of grays for 600 and 800dpi would be through physically measuring results via specific print tests. Engineering has performed some of these tests and have come up with gray level values close to that of 300 and 400dpi.

- The calculations are based on line frequency and screen angle default values that the printer has been calibrated to. These default values are also used with most of Apple's non-Photograde printers.

- Level of grays is always a tradeoff to resolution, so the higher the number of grays, the lower the resolution. The line frequency and screen angle default values are optimized for a balance between grays and resolution.

- There are some applications, such as Photoshop, that enable you to easily modify the line frequency and screen angle to increase or decrease the number of grays. These values are sent to the printer when documents are printed. This allows for flexibility in meeting specific grayscale needs. At the most simplistic level, here is a formula that determines the number of gray levels:

  (resolution/line frequency)**2 + 1

Thus, for a 300dpi LaserWriter with line frequency set 60 lpi, the calculation is:

(300/60)**2 + 1 =   26 levels of gray

- There is a threshold where the human eye is unable to differentiate between gray levels, so there will be a "reasonable" range of line frequency and screen angle values implicitly defined for each resolution.

Here are the number of gray levels for the LaserWriter Pro 810, based on the default Line Frequency of 60 lpi, and Screen Angle of 45°.

300dpi	400dpi	
26	45	levels of gray

Again, the number of grays for 600 and 800dpi are going to be very close to these listed for 300 and 400dpi.

The line frequencies and gray levels for all of our other printers, the default line frequencies can be found in the respective PPDs for the printer in the "Halftone" information section. With the line frequency, you can use the formula outlined above to determine the number of gray levels.

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7 March 1994 - Added additional information on determining gray levels.

Support Information Services

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