RESOLUTION ENHANCEMENT TECHNOLOGIES:

WHAT IS 600X600DPI OPTICAL AND WHAT IS 3600 OR EVEN 4800DPI APPARENT PRINT RESOLUTION? - PART 1

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Overview

In the following article I will try to present the reader with the essentials of modern printing techniques for achieving press-like quality with color laser printing. More specifically I will present you one of these technologies: HP's image RET.

There are many misunderstandings about print resolution nowadays. Many people don't make any difference between such parameters as DPI, SPI, PPI and LPI. To them they are all the same. But the truth is revealed when someone digs deep into the specifications of different manufacturers' brochures and manuals. As part of my current research on parameters and factors affecting the quality of color printing with office equipment I also encountered the question of print resolution. Since the subject is complicated and the reader of this article shouldn't be bothered with science terms too much it is enough to say that for quality printing you need more resolution in term of dots per inch (DPI). If you are interested like me in quality color printing with laser printers, you should probably read the following material and get familiarized with the most common eye deception technology today on the market –since HP is one of the leaders in office color printers today.

Have you wondered why not until long ago the printers stated their real resolution like 600x600 dpi for example and why today you are baffled with figures like 2400, 3600 and even 4800 dpi apparent resolutions? Well, the answer is that the optic-mechanical part of modern printers is almost the same like past models, but the manufacturers don't want to confess that, so they try to develop software ways to compensate for poor optical resolution. That is how the image RET was born too. The normal resolution required for obtaining color separations on an image setter for offset printing is at least 2450dpi optical (real) – beat that laser printers! But the problem is even deeper when the matter of halftones gets involved. A word about halftones – in real world we perceive the world around us like a continuous image. Unlike us – scanners, cameras, monitors and digital printers express the perception of the world in finite elements tightly spaced together. We call these elements samples, pixels, lines and dots, but they are really in relation with each other. So if we want to reproduce an image on a paper for example we must use these elements – dots of colorant to make the print. So we use halftones to reproduce continuous tone images. Here comes the matter of color depth – the higher the numbers of dots we print on paper the more we come close to continuous tone and to unlimited number of shades of color we can reproduce. But this process has its limits – for a good quality print a halftone frequency of 200lpi (lines per inch) is enough. However when we want to print this halftone with 200lpi and we still want to reproduce all 256 shades of color per channel we come to the need to use a printing resolution of at least 2450 real dots per inch!

Remember the laser printers had only 600 real dpi? Here comes the next catch which manufacturers and sales managers use – the definition of the term DOT. When laser printing is concerned the dot means strangely enough two things: 1. A halftone cell and 2. A single laser spot on the imaging drum. So a 200lpi halftone screen with 256 gradations of color means we have 200 halftone dots (cells) with 16 laser spots in each cell. And stated resolution of 600dpi by hp for example means 600 laser spots per inch (not 600 halftone cells (dots) per inch).

The matter becomes even more complicated when other more "honest" manufacturers state their products' resolution in real 256 gradation halftone cells (dots). In my lab I have an old model of high quality digital printer – Konica Minolta CF910 with a resolution of 400dpi. At first I was quite unimpressed with this fact until I made

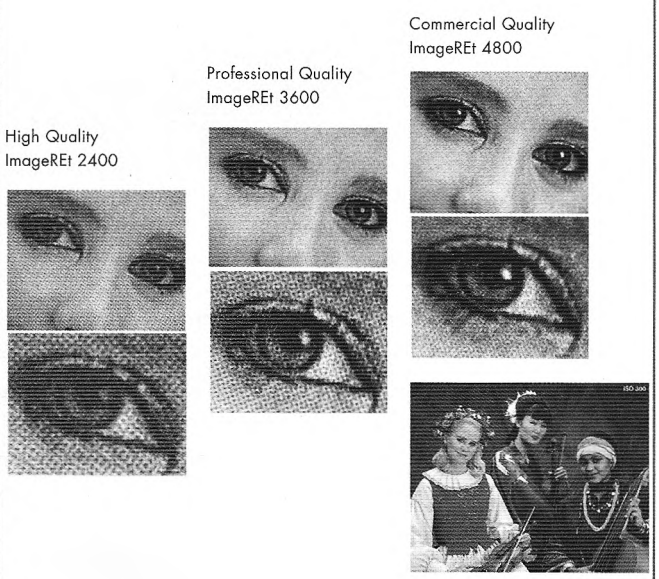
a comparison print of an image with HP CLJ2550 and 3550 models with stated resolutions of 600 dpi. I was surprised to see that the quality of color and detail on the Minolta couldn't be even compared to the "higher" resolution modern HPs. Then I dug into the technical specifications and service manuals and discovered that by 400dpi Minolta meant "real 256 gradations 400 halftone cells per inch", where by 600dpi HP meant "600 laser spots per inch". So as they say "less is more" I guess.

Then I noticed another parameter stated by HP – "apparent resolution 2400 dpi and 3600 dpi with image RET". After a research on the topic and some comprehension I compiled the following pages which explain the mystery of image technologies used in today's inexpensive color printers which mimic (at least theoretically) the quality of print of offset printing presses. Here is the HP's version of the resolution matter so to speak.

HP ImageRET (resolution enhancement technology) is a system of print technologies, developed by HP to deliver press-like print quality. The HP ImageREt system integrates technology advancements and optimizes each element of the print system.

Several categories of HP ImageREt have been developed for a variety of user needs. The system's foundation is comprised of key color laser technologies—including image enhancements, HP Smart supplies and high-resolution imaging—that provide great color automatically, right out of the box. As the level or category of ImageREt increases, these core technologies are refined for more advanced system usage, and additional technologies are integrated.

There are currently three levels of HP ImageREt print technology, developed for different user needs. They are HP ImageREt 2400, HP ImageREt 3600 and HP ImageREt 4800:



The following table details the similarities and differences between each HP ImageREt level:

Printing technology	ImageREt 2400 (High Quality)	ImageREt 3600 (Professional Quality)	ImageREt 4800 (Commercial Quality)
Imaging system	• High resolution dual-beam scanner	• High resolution dual-beam scanner	• High resolution dual-beam scanner
Print mechanism	• Robust	• Accurate	• Precise
Image enhancements	• Great color out of the box • Excellent Edge Control – Color Ret – Trapping – Adaptive halftoning – Halo Reduction Neutral gray treatment	• Great color out of the box • Excellent Edge Control – Color Ret – Trapping – Adaptive halftoning – Halo Reduction • Accurate half toning • Neutral gray treatment	• Outstanding color out of the box • Excellent Edge Control – Adaptive halftoning – Trapping – Halo Reduction • Precision half toning • Neutral gray treatment
Adaptive gloss	• Selective-gloss Instant on fusing	• Selective-gloss Instant on fusing	• High-gloss fuser
Color control	• Intelligent calibration – Automatic closed loop color calibration – Strategic Timing – Environmental compensation • Digital Imaging Enhancements • Multiple Color Themes • HP postscript CMYK emulation	• Intelligent calibration – Automatic closed loop color calibration – Strategic Timing – Environmental compensation • Digital Imaging Enhancements • Multiple Color Themes • HP postscript CMYK emulation	• Intelligent calibration – Automatic closed loop color calibration – Strategic Timing – Environmental compensation • Multiple Color Themes • HP postscript CMYK emulation
Media handling	• HP Glossy paper laser system optimization AT VC	• HP Glossy laser paper system optimization • Automatic Media sensing AT VC	• HP Glossy laser paper system optimization • Superior media handling and Commercial document quality
Supplies	• HP Smart printing supplies • ColorSphere Toner • All in one toner cartridge	• HP Smart printing supplies • ColorSphere Toner • All in one toner cartridge	• HP Smart printing supplies • Chemically-grown spherical dual-component polymer toner
Supported HP Color LaserJet printers	• HP Color LaserJet 2550, 2600, 3000 series printers, 2800aio series	• HP Color LaserJet 3600, 3800, 4700 series printers, 4730mfp series	• HP Color LaserJet 9500 series printer, 9500mfp

HP ImageREt 3600

The dpi specification describes only a small part to the printing system, dpi refers to the laser scanner assembly's addressability—the frequency that the exposure device can be turned on and off. Dpi does not directly relate to an image's resolution because it does not encompass other steps of the imaging process, which may include sophisticated imaging algorithms, toner development, image transfer, and fusing. In modern printing systems with complex imaging algorithms, dpi is a poor estimate of image quality.

1. High-resolution laser imaging system with dual-beam scanner

Benefit: Superior image detail and tone rendition

Technologies: Dual-beam scanner, multi-level positioning laser exposure combined with multi-layering technology

The electrophotographic imaging system consists of an organic photoconductor and a laser diode exposure system. The organic photoconductor changes charge with exposure to light, and is essential to providing the system's excellent image quality. Where the laser writes to the organic photoconductor, positively charged areas are produced, and the negatively charged toner adheres to these areas. The HP Color LaserJet series printers with ImageREt 3600 use a proprietary dual-beam scanning system that uses two laser beams that reflect off the each face of the mirror simultaneously. This provides the ability to print two scan lines for each mirror facet, effectively doubling the scan rate.

The dual beam scanning system has several advantages over conventional methods:

• Achieves higher print speeds without rotating the scanner at excessive speeds. Because the scanner rotates more slowly, simple components can be used that deliver better reliability.

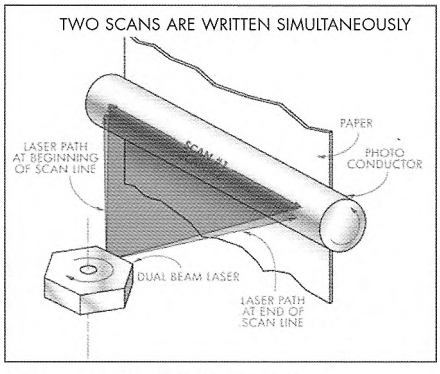


Figure 1. Dual beam scanner

• Since the scanner rotates more slowly, scanner acceleration time is reduced, which decreases first-page-out time.

• With a low number of facets on the rotating mirror, the scanner and optical path are smaller and more compact.

Multi-level/multi-position laser exposure

With HP's sophisticated laser scanning assemblies plus laser modulation control, it is possible to achieve high resolution and vary the size and position of each laser exposure within the 600 dpi addressable engine grid. This ability is what provides HP's multi-level exposure and multi-positioning capabilities. The combination of size and position enable truly spectacular detail and reproduction in printed materials.

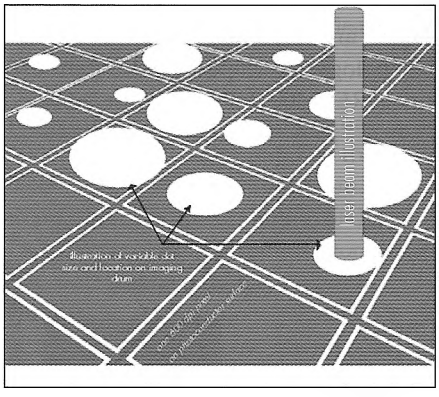
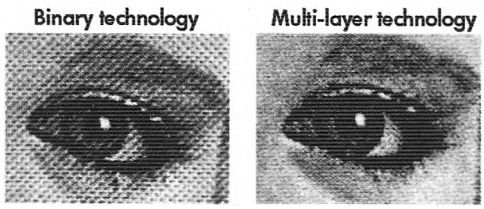


Figure 2. Example of variable dot size and placement.

Multi-level printing

The multi-level printing process precisely controls color by combining up to four colors within a single 600 dpi pixel and by varying the amount of toner in each pixel. As a result, over 100,000 different colors can be created in a single 600 dpi pixel. Combined with high-resolution halftoning, HP ImageREt multi-level technology creates millions of smooth colors, sharp images, and crisp text.



By contrast, the single level (binary) printing process cannot vary the amount of toner in a pixel. Each pixel receives either no toner or a full pixel level of toner for the four toner colors. The primary yellow, cyan, magenta, and black toner colors can only be mixed to create red, green, and blue, meaning that only eight different colors can be created in each 600 dpi pixel. In order create the millions of colors required to print color images, binary printers must use low-resolution halftones with large visible dots.

2. Accurate print mechanism

Benefit: Excellent uniformity and color plane registration

Technologies: Media and environmental sensing, ridged frame, vertical in-line process, helical drive gears, precise motor control, high-quality laser scanners

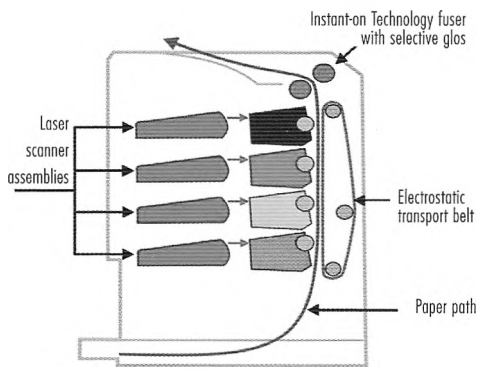
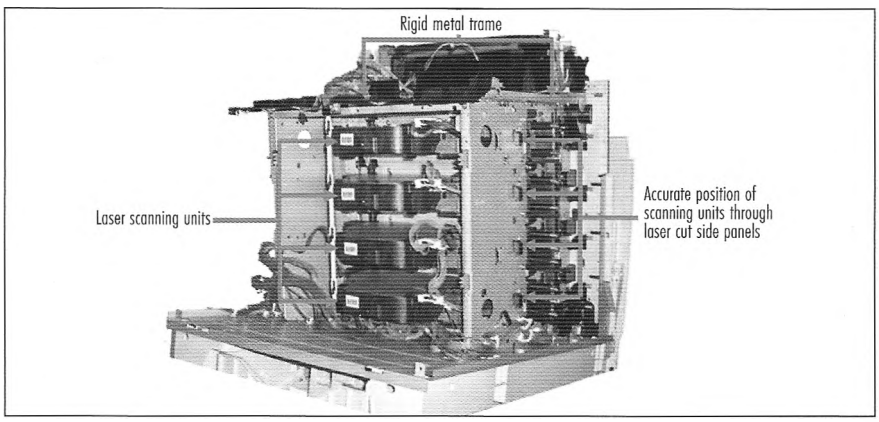


Figure 3. Diagram of print mechanism

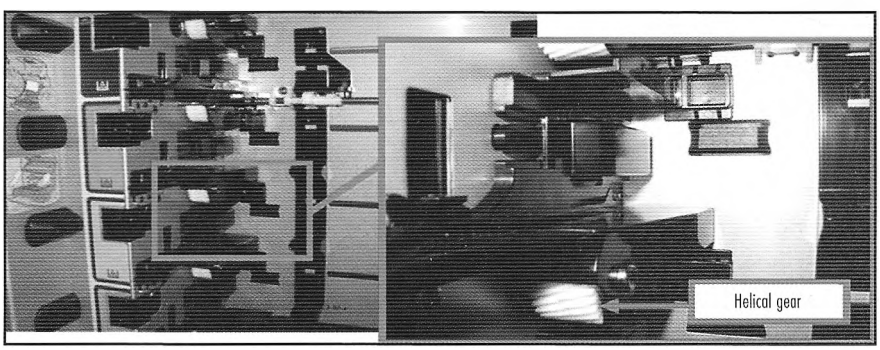
The printer features a direct-to-paper architecture, which means that toner is transferred from the organic photoconductor directly to the media rather than to an intermediate transfer device. While this architecture provides excellent detail with sharp text and line art, it is only possible with sophisticated sensors that signal adjustments to the print system according to the media's electrical properties since the electrophotographic printing process is charge driven. With direct-to-paper architecture, the media is a dynamic element of the print system. An electrical sensor measures the resistivity of each sheet of media that enters the print system while environmental sensors make adjustments to accommodate specific environmental conditions. These measurements, combined with proprietary algorithms, make it possible for the printer to deliver excellent image quality on a variety of media under multiple environmental conditions.

The printer's frame is a crucial component of the printing system. During a typical print cycle, many processes occur simultaneously, and some of these processes generate small shocks and vibrations that can influence the performance of other processes. HP designs and test frames to eliminate these sources of unwanted resonance and vibrations.

The vertical in-line process of the printer is designed with extremely accurate alignment of critical components to aid in precise dot positioning and color plane registration. Close component proximity is accomplished with laser positioning on the frame side panels, and all major components are attached to the frame side panels, which provides independent stability for each component. Helical gears with spiral curved gear surfaces are used in areas where precise rotation is required. These gears not only provide quieter operation, but also help reduce rotational velocity variation by contacting multiple teeth simultaneously, which provides a larger gear contact area and results in smoother printing.



All of the main drive motors are brushless DC motors. Motors that drive critical components such as the photoconductors and fuser use Digital Signal Processing (DSP) technology to precisely control speed. This method uses a mini network within the printer to monitor and adjust the rotation speed of each component individually. Minute speed adjustments are continually made during the printing process to insure that all the major components are rotating at the appropriate speed and are synchronized.



During startup, changing of toner cartridges, or during a CALIBRATE NOW procedure initiated from the control panel, the printer performs an internal, automatic closed loop color plane registration procedure. It does this by writing chevron patterns of toner to each side of the transport belt and then reading those locations. With this data, the printer can dynamically maintain best in class color plane registration which enables the use of other technologies, such as trapping and halo reduction. Trapping and halo reduction are only possible if the original color plane registration is excellent. RCE

To be continued...