# Image Quality and Productivity of the New Xeikon Digital Presses using "true 1200 dpi" Multilevel Print Head Technology

***Frank Deschuytere, Stefaan Lippens** and Dirk Broddin;     Xeikon productline, Punch Graphix, Lier, Belgium***

## Abstract

*Xeikon has recently introduced the new Xeikon 8000 digital press, the new Xeikon 33000 label press and a new "1200 dpi" enabled version of the Xeikon 6000 digital press*

*The integration of "true 1200 dpi" print head technology, new accelerator boards in the X800 digital front end and a powerful range of halftone screens in a novel screen library which is called "the Pericles" have enabled a significant increase in the perceived image quality with higher image detail, reduced image noise and improved smoothness of tonal scales with screen frequencies up to 240 lpi.*

*The "one pass duplex " architecture of the Xeikon8000 and Xeikon6000 allows a high productivity with up to ten printing stations printing in parallel, realizing 230 ppm on the Xeikon 8000 while keeping the printing speed at a moderate level that does not compromise the achievable image quality.*

## Xeikon @ 1200 dpi

The Xeikon 8000, the Xeikon 3300 and the "new" Xeikon 6000 build on the 1200 dpi LED print head technology that was addressed at the IS&T's NIP21: International Conference on Digital Printing Technologies, Baltimore, MD; September 18, 2005; p. 667-670.


*Figure 1*

The Xeikon 8000, as a flagship product, sets a new reference in digital color printing with

- a productivity of 230 A4/244 letter-size pages per minute
- a monthly duty cycle of 8.5 million pages per month
- a resolution of 1200 dpi at 4 bit per spot
- a new library of halftone screens with screens up to 240 lpi
- an expanded imaging width of 504 mm
- One-Pass-Duplex TM Printing
- a substrate range: 40 gsm (27 lb text) to 350 gsm (16 pt board )

## "True" 1200 dpi resolution implies a match of the illumination spotsize to the addressability of the device

Desktop printers and other consumer devices have a long tradition of claiming ever increasing resolution or addressing capabilities in a specification war that has been covering a range of digital technologies including electrophotographic, thermal and ink jet printers as well as scanning devices as in CCD based flatbed scanners or multifunctional devices. For higher apparent resolution, CCD's are over sampled using interpolations schemes and along the same lines, various resolution enhancement approaches have been improving printed text acuity to levels exceeding that of the isolated marking spot that can be generated from electro-optics in the device itself.

LaserJet printers manufactured by Hewlett Packard have been pioneering the technology of resolution enhancement, taking text quality well above the 300 dpi level that was a standard in those early days of toner based printing.

Modern digital production printers come with a digital front-end that does the raster image processing of the print jobs that were originally supplied as PDF document or as a document in some other page description language. Depending on the options available and chosen in the front end, apparent resolutions can be selected that do not necessarily correspond to "intrinsic" resolution of the imaging system.

HP Indigo systems as a example emulate 800 by 1200 dpi and even 2400 by 2400 dpi based on a laser polygon scanning system that operates at a bas resolution of 800lpi (812 lpi).

The LED exposure system of the recent Xeikon presses has an optics system tuned for 1200 dpi. The Pitch of 21.16 microns along the length of the print head is fixed as the pitch of the emitting regions of the led diode chips. The number of LED's on a diode array being fixed, resolution, as it is defined here, is a hardware specification. Another characteristic of the imaging device, in addition to resolution, is addressability. The addressability of a device determines the number of dots that can be printed within a specific grid. These dots can overlap. Addressability is defined in two directions, e.g. 600 x 600 dpi (symmetrical) or 1200 x 3600 dpi (asymmetrical).

Over sampling modes are available from our current print head that allows an addressability increase in print direction of e.g. a factor 3 leading to an addressability mode op 1200 x 3600 dpi.

The figure below shows a enlarged scan of a print made with the electrophotographic printing as in the 600 dpi equipped Xeikon 6000 (2006 model) compared to the 1200 dpi equipped Xeikon 8000 (2008 model)

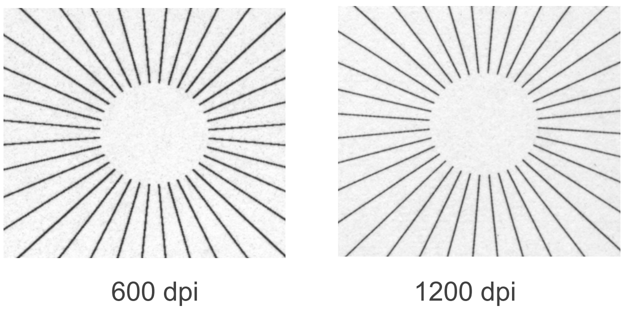



*Figure 2*

The rendition of fine text and fine lines with this tuned system sets a standard in digital printing technologies. The figure below shows a comparison of the rendition of fine text by a number of state of the art digital print technologies as taken from print samples of the same file containing 2 point fine text.

The print samples above were provided by the participants as a part of a comparative print quality analysis organized by the Association of Graphical Arts Solution Providers at the occasion of the Digital Print Forum , held in Chicago, April 22-28th 2008. (www.ipa.org) In this test the Xeikon 6000 is based on 600 dpi illumination.


*Figure 3*

## Image quality of screened images

Most digital printing systems cannot print continuous tone images as they can only deposit dots with a limited number of bits per process color, which is why for printing purposes continuous tone images need to be converted to a pattern of dots containing the right number of bits per process color.

The process used to do this is halftoning and relies on the limitations of the human eye: the human eye cannot easily distinguish small dots that are closely spaced. The conventional halftoning process converts a continuous tone black and white image into a series of equidistant dots of varying sizes (halftone dots) placed in a grid pattern (the 'screen', i.e. lines of equidistant dots). Halftone screens are measured in lines per inch (lpi). The higher the number of lines, i.e. the higher the 'screen ruling' or 'line frequency', the better the representation of detail, but the more difficult the image may be to reproduce (it means that the halftone dots are smaller and closer together, so less discernable).

To avoid image distortion, the screens of the process colors are rotated over a certain angle relative to each other to create the well-known 'rosette' pattern.

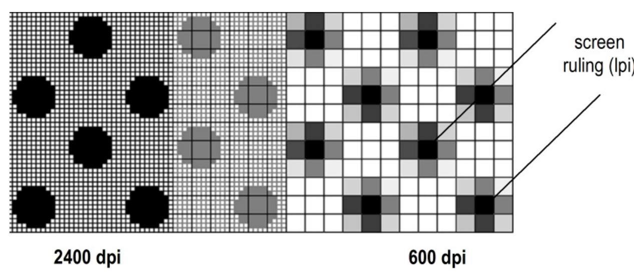



*Figure 4*

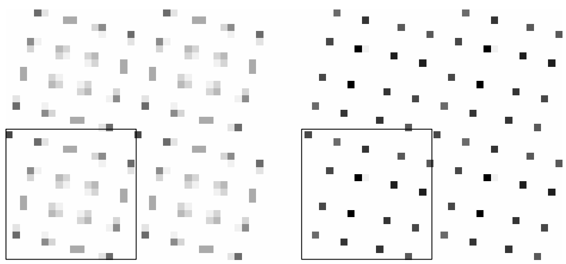
The figure above shows a simplified "box model" approach to converting a high resolution binary screen to a lower resolution screen for a printing device capable of rendering multiple densities at the pixel level.

## High contrast multilevel approach to conventional rotated square clustered dot screens

Approaches to fit a conventional set of rotated clustered dot screens on a multilevel digital printer with a limited addressability have recently been discussed in "Suppression of Automoiré in Multilevel Supercell Halftone Screen designs" " in NIP23 and Digital Fabrication 2007. pages 201-204 – 493 published in 2007 by IS&T (ISBN 0-89208-273-9). The solutions obtained in the analysis above are of limited use as they are generate dot configurations that are even more soft than the straightforward "box filter " approach.

Most electrophotographic technologies give most stable results however when the contrast in the halftone images is maximized. The claim in " Advances in Technology of KODAK NEXPRESS Digital Production Presses" in NIP23 and Digital Fabrication 2007. pages 489 – 493 that the rotating magnet development of this device has a limited capability to render "continuous tone images" without any screening is more academic than practical and an exception. Most electrophotographic systems use alternating current assisted development with a steep development response that heavily relies on dot area modulation of screened patterns with high contrast and the intrinsic grayscale response of such systems is limited and very sensitive to process fluctuations. Experiments have shown that "high contrast" screens as depicted below are more stable and have less sensitivity to development artifacts than the "box filter" approach or screen patterns that are even softer than that.

A framework for generating screens with a desired level of contrast is discussed in a separate NIP24 contribution by S. Lippens et. al. High contrast screens using that approach were further optimized to minimize perceived patterns using a perception based approach.

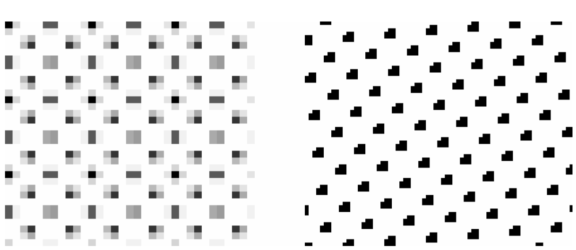


box filter high contrast

*Figure 5*

Even after optimization, there is a level of visibility of the static dot distortion patterns and these patterns are most easily picked up for separations printed with inks or toners that have a high absorption over the visually weighted spectrum such as black toner or ink. Dot distortion patterns are far less perceivable for higher chrominance inks such as Cyan, Yellow, Magenta and bright spot colors.

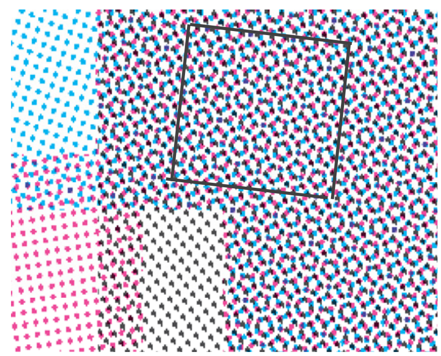
The screens in the Pericles library that ships with the 1200 dpi enabled Xeikon 5000+, Xeikon 6000, Xeikon 8000 and Xeikon 3300 are based on screen sets where the black toner is typically a simple rational screen where each screen dot cluster has the same relation with respect to the grid of 1200 dpi addressable dots. The screens for the other colorants are the appropriately rotated high contrast screens that form the conventional "stable" rosette.



155 lpi 600 dpi 45 degrees 154 lpi 1200 dpi 50,2 degrees

*Figure 6*

Currently screens are shipped in the Pericles library with screen rulings at 95 lpi, 105 lpi, 141 lpi, 154 lpi, 170 lpi, 187 lpi, 212 lpi and 240 lpi. To achieve a rational screen for one of the separations, some of the sets of screens are rotated over a small angle compared to the conventional set with one screen at an angle of 45 degrees. The screen operation is a real time operation supported in hardware based on a "brick"-wall tessellation and tile sizes up to one million pixels are supported. The larger tile sizes allow an arbitrary close approximation of the ideal screen angles. ( rational approximants with atan(A/B) approaching 15 degrees range from angle errors of a full degree with A=1 B=4 and improve as the approximants get better with an error of less than .07 degrees for A=4, B = 15 and less than .005 for A=15 B = 56 ). The framework supports multiple screens on a single image frame, with as a readily available option in the Digital Front End user interface to select one screen for images and another screen for line work based backgrounds and annotations.



187 lpi K at 39 degrees A = 4 B = 15

*Figure 7*

## Better image detail, reduced image noise and photo-quality

Whereas screens of 170 lpi are widely used in graphics arts applications, expectations for the reproduction of photographs as in photo books or as a substitute for silver halide photo prints imply the absence of any perceivable screen effects or rosette pattern.

For quantization of the level of perceivable patterns and for characterization of more random image grain, our image quality labs routinely apply the technique of visual noise estimation. The visual noise estimation method is based on high resolution scans that are processed according to a visual perception model to quantify the image grain in monochrome uniform patches to asses the total effect of the addition of various sources of noise such as mottle in transfer, graininess of the toner development process associated with the coarseness of the magnetic brush and effect of patterns due to the screening algorithm. The standard approach is to analyze black only uniform patches of a range of density steps but the method can be applied to neutral density aspects of CMYK images by converting to the luminance channel. The bar charts below show the image noise analysis for a viewing distance of 375 mm (normal viewing) and 250 mm (close viewing ) of a uniform midtone K (C,M,Y,K=0.0.0.50 ) and a CMY composite

(C,M,Y,K=50,40,40,0) patch of the "variation of a tint " sample as submitted by the same set of participants to the Digital Print Forum Print Quality analysis exercise.

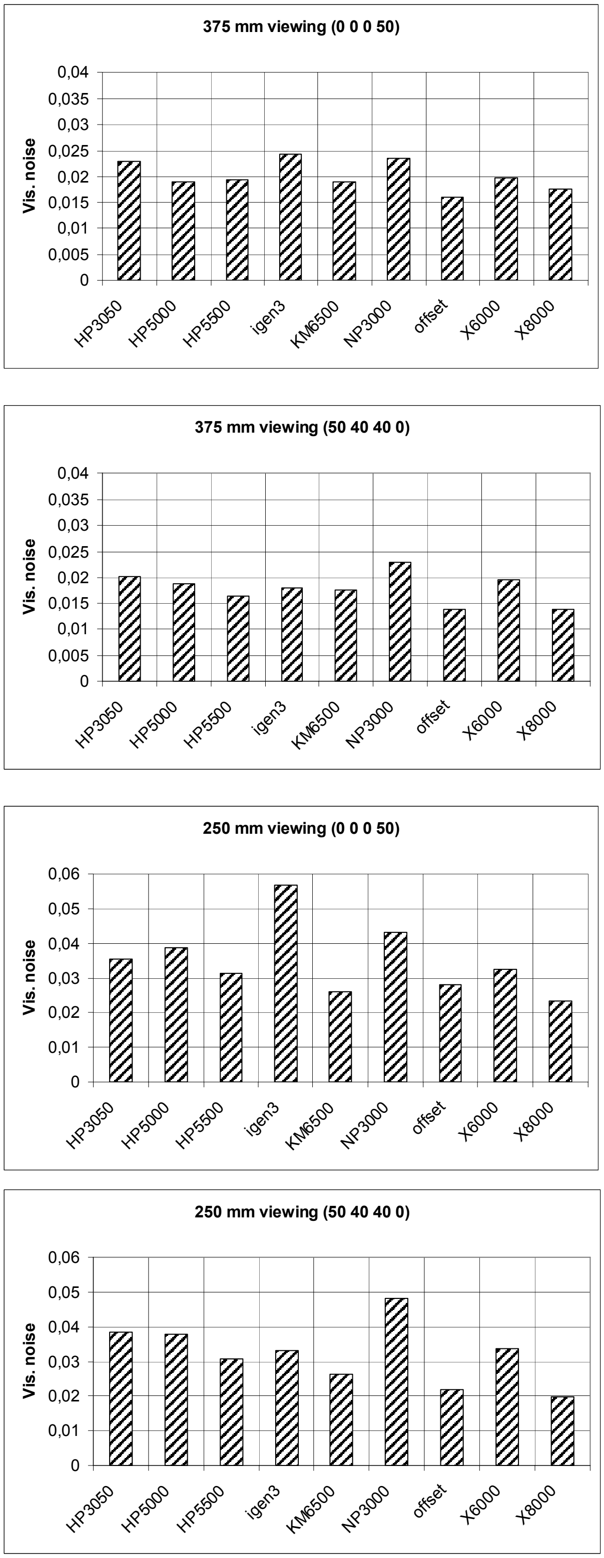



*Figure 8*

The Xeikon 8000 (X8000) prints in the comparison were made with the new Pericles screens at 240 lpi. The very low noise values persist even if the prints are viewed from 250 mm viewing distance. At screen rulings of 212lpi or higher, the rosette pattern of the CMY(K) overlay is much finer and generally not perceivable in the prints even at 250 mm viewing. The very low image noise value at smaller viewing distance is a result of the much finer rosette structure and opens up the applications such as photo books and alike.

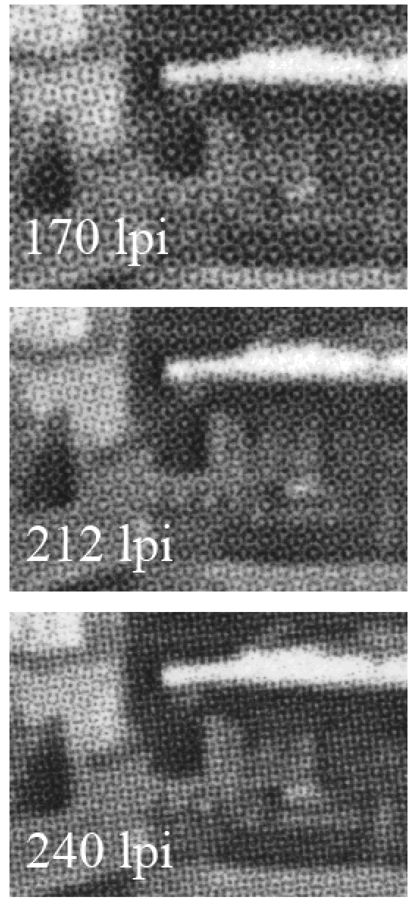



*Figure 9*

## Acknowledgement
*Results reported are partly based on research funded by the Institute for the promotion of Innovation through Science and Technology (IWT-Vlaanderen)*
*** S. Lippens is affiliated with TELIN-Ghent,University /IBBT, Ghent, Belgium*

## Author Biography
*Frank Deschuytere is the Chief Technology officer of Punch Graphix in Lier, Belgium managing product development for the Xeikon, Basysprint and Newspaper OEM product lines.*
*He received his masters degree in electrical engineering at the University of Ghent in 1987 and received an MBA at the university of Louvain in 1999.*
*He began his technical career at Agfa in 1989 where he ran several projects in image processing at the central department of equipment development (ROAM).*
*He joined Xeikon in 1999. He holds over 20 patents worldwide.*