white paper

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Harlequin Dispersed Screening™

Harlequin Dispersed Screening: Global Graphics' solution for high quality stochastic screening

This white paper is a detailed description of Global Graphics' patented second generation stochastic screening technology.

Introduction

For over a hundred years the printing and publishing industry has attempted to capture the quality of continuous tone images, such as photographs, in print. This has been achieved through the use of screening methods that convert images into dots for subsequent reproduction by a printing process. As prepress and printing technologies have changed, screening techniques have been refined to make better use of these new technologies. This white paper provides information on one of these refined techniques: Global Graphics' patented solution for high quality stochastic screening – Harlequin Dispersed Screening.

Robust, high-quality screening for a variety of printing situations.

Conventional Screening

Conventional halftone screening technology (AM screening) was developed long before the advent of digital imaging technologies and was achieved with the tools available to the prepress trade at that time - cameras, glass & contact screens, rulers, and color filters. Automation began with the introduction of electronic scanners that generated screened halftones direct to film. With the development of page description languages such as PostScript®, conventional screening methods were transitioned from proprietary electronic systems to more open digital processes. However, while making the computerization of the prepress process more palatable by applying a proven screening technique, problems inherent in the traditional method remained and were joined by new problems resulting from limitations and characteristics of digital output devices.

The conventional halftone screening process breaks a continuous tone black and white image into a series of dots of varying sizes and places these dots in a rigid grid pattern. For a continuous tone color image it is necessary to break the colors down into the four process color inks - cyan, magenta, yellow, and black (a process known as separation). Each color is screened to a different piece of film or plate to create a color separation. To avoid image distortion, the rows and columns of dots for each separation are rotated to print at different angles. Gradations of color and intensity are reproduced by increasing or decreasing the actual size of the dots in a particular area of the image while the distance between dots remains constant. Sharpness is controlled by changing the screen ruling, or the constant distance between the dot centers, measured in lines per inch. The closer the dots in a particular screen (the higher the screen ruling), the better the representation of image detail, but the more difficult it may be to print or reproduce.

Moiré

Probably the most serious quality issue with halftone screening is the unavoidable creation of interference patterns known as 'moiré'. These patterns result from the necessary angle offset of the screens for each separation. Moiré patterns can destroy the illusion of a continuous tone image by superimposing interference artefacts over the intended image.

Careful selection of the angles between separations can help to reduce the appearance of moiré and the screen angles typical of conventional screening methods create a pattern known as a rosette. Better screens have tighter, more perfectly formed and consistent rosette patterns.

As well as occurring between screens, moiré can result from interference between a single screen and structures within the image objects being reproduced. Like inter-screen moiré and rosettes, object moirés are inherent to the technique used to create the fixed dot screens. These are irregular patterns caused by interference between halftone dots and lines in the original image. Object moiré can be especially problematic in images incorporating patterns such as Venetian blinds, picket fences, tweeds and other fabrics.

Much work has been done to eliminate the problem of moiré in conventional halftone screening by altering screen angles, dot size and shape. Vendors have developed screening techniques with everything from angle calculations based on the triangle (Rational Tangent Screening), to methods based upon cross patented screen angles (Irrational Screening), and finally the grouping of halftone spots into larger dots in what is called Supercell Screening. Different methods produced varying results that often minimized but could not eradicate the moiré problem.

Problems with Tone Gradation: Mid-tone Jump and Banding

Another way to minimize moiré is to increase the screen ruling, or frequency, by increasing the number of screen lines per inch. As the screen ruling increases, image detail becomes better defined and moiré is less noticeable to the eye. Unfortunately though, all other conditions being equal, the higher the screen ruling, the more likely the appearance of mid-tone jump or banding in vignettes. As a color's intensity increases from darker to lighter shades (or vice versa), the progressive tones known as gray levels are represented by altering the size of the screening dots, Mid-tone jump occurs in the 50 percent range, particularly with round or square shaped dots, where the area of white is roughly equivalent to the black area resulting in a checkerboard effect on the screen. A dark band of color occurs where a smooth transition should be.

Registration and Dot Gain

One additional complication added by computerization of the halftone screening process is the interaction between the screening implementation and the output device. Using a higher line frequency to minimize moiré patterns places greater demands on the system's ability to preserve the fidelity of the output halftone image. If not handled correctly, both dot gain and registration errors can contribute to distortions in the output and a degradation in perceived image quality.

Loss of Highlight Detail

Highlight detail often suffers because the small dot sizes used to reproduce high light information are lost in the transfer to film or plate and then to press. This effect is especially pronounced where high line screens are used, for example to reduce moiré.

The Harlequin Screening Library

Global Graphics has developed a series of screening techniques, provided as the Harlequin Screening Library. These techniques have been designed to resolve the quality issues faced by the prepress and printing industries. Screening techniques provided include:

Conventional screening, with a wide range of configurable dot shapes, screen rulings and angles

- **Harlequin Precision Screening™ (HPS):** an enhancement to conventional screening that uses a proprietary algorithm to calculate the screen angles and frequencies for a particular image that most effectively reduce moiré while minimizing memory requirements. HPS can make minor adjustments to the selected angles and frequency within a specified range to achieve extremely high quality results. The resulting efficiencies in memory usage and decrease in processing times are dramatic.
- **Harlequin Chain Screening™ (HCS):** Harlequin Chain Screening uses an elongated dot shape to create better reproductions of certain images such as computer-generated graphics. Instead of the conventional symmetrical dot shape, HCS uses a long elliptical dot to produce a chain-like structure. The elliptical dot creates particularly smooth flat tints and vignettes even when working at relatively low screen rulings. This makes HCS particularly well-suited to printing charts, weather maps, and other computer-generated graphics and also for printing processes such as those used for news print.
- **Harlequin Dispersed Screening™ (HDS):** a patented second- generation stochastic screening algorithm that eliminates many of the problems with other stochastic techniques as well as providing a high quality alternative to conventional screening.
- **Harlequin Error Diffusion Screening™:** an EDS screening is a frequency modulated (FM) screening method that can be used to avoid image artifacts in color proofs. EDS screening is particularly good at low resolutions because it does not use dot patterns and therefore produces prints that are free from moiré. EDS screening typically produces smoother vignettes than amplitude modulated (AM) screening and is good at reproducing fine detail. It is for these reasons that EDS screening is particularly suited to the production of proofs on inkjet printers.

The rest of this white paper discusses stochastic screening and the specific benefits of Harlequin Dispersed Screening. For information on other Global Graphics screening technologies contact a Global Graphics commercial representative [see contacts section].

Stochastic Screening - an alternative to conventional screens

Early stochastic screening (also known as FM screening) was developed in an attempt to solve quality issues such as moiré associated with conventional screens. In stochastic screening, the screened image is created by dots of a fixed size with the number of dots in an area, rather than their size, controlling the perceived intensity of the printed image. Conventional screening fixes the location and number of the dots but varies the size; stochastic approaches use a constant dot size but vary their number and location. A pseudo-random element to the screen controls the scattering and clustering of dots over a small area of the image, this creates different output shades based upon the grey level in a particular area of the original continuous tone image.

The very minute dots used in stochastic screening allow for better rendition of detail and significantly better quality images than conventional screening. Since stochastic dots are not placed in a rigid grid and do not require screens to be angularly displaced, the moiré caused by interfering patterns is entirely eliminated. Also, the use of smaller dispersed dots virtually eliminates the problems of banding and mid-tone jump. With no screen angles to align, the need for extremely accurate press registration is less important and the make-ready time to prepare a press to produce accurate color can be shortened.

Despite these advantages, early stochastic screens had a number of characteristics that made them difficult to use in practice. These problems led to questions raised in the industry press about the quality and practical use of first generation stochastic screening in a prepress or production environment. Some of the issues were due to the characteristics of the output devices and media in use at the time, others were due to factors such as press process control; however the majority of issues were deficiencies in the early screening algorithms. While eliminating many of the problems associated with conventional screening methods, the distribution of stochastic screening dots caused a host of other quality issues due mainly to the random manner in which dots were clustered together.

Some of the issues encountered in practice include:

- **Grainy Effect in Highlight Areas**

  One of the greatest problems experienced with stochastic screening methods is a grainy effect in highlight areas which is often the price of better definition in the other 90 percent of an image. This is caused by the clustering of dots into odd sizes and shapes and is most noticeable in smooth areas of continuous tone pictures, flat tints, and vignettes. Particularly in first-order stochastic screening, where dots are randomly clustered together, an uneven transition can occur between shades of gray. The larger the dots used, the grainier these transitions will appear to be.

- **Loss of Highlight Dots**

  While larger dots can worsen the problem of graininess, ironically the finer the dots, the greater the tendency to lose detail. Highlight dots are difficult to hold when printed in both stochastic and conventional screening as a result of the process of reproduction from film to plate to press.

- **Dot Gain**

  In addition to being difficult to hold in stochastic screening, small dots are also subject to dot gain – the enlargement of dots in the midtone area as a result of ink spread on the plate or the paper. The answer for both dot gain and loss of highlight dots is in the proofing and calibration methods.

- **Harder to control on press**

  Stochastic screens are traditionally harder to control on press – one of the factors that caused problems for early implementers. With recent moves towards improved process control on the press, this is becoming less of an issue (and is considered by some as an advantage).

- **RIP Efficiency and System Speed**

  The complex calculations required by many stochastic screening algorithms can significantly reduce rendering speeds, resulting in lower system productivity.

- **Direct Output on Low Resolution Printers and Plotters**

  Conventional screening methods have never been able to accurately reproduce images at low resolutions without color shifts and loss of clarity. Several deterministic screening technologies have been developed, such as dithering and error diffusion, to reproduce large images at low resolutions while maintaining high quality. However, these screening methods generally use a fixed size dispersed dot with computationally-intensive algorithms as a post process to the interpretation and rendering of an image. While these screening methods produce good quality output, they can greatly slow down printing, especially when processing large images.

- **Limitations in Usage: Some FM Methods Demand Specialised Equipment**

  Aside from actual production issues, one of the greatest problems with many of the FM screening options on the market today is the fact that they were developed for use with specific equipment: from state-of-the-art imagesetters; CtP; specialty proofing equipment to high-end printing systems. Realistically, only those who have been able to afford expenditures on entirely new hardware and software have been able to effectively achieve the quality of FM screening methods.

Subsequent development was designed to address the problems which had arisen with initial stochastic screening. The main innovation was the introduction of sophisticated proprietary algorithms to more accurately position dots as based upon tones in the scanned image. Despite the obvious advantages in image quality and process efficiencies over conventional screening, many of the FM technologies on the market today have not been able to overcome the problems of stochastic screening.

Harlequin Dispersed Screening; FM Screening with a Difference

Harlequin Dispersed Screening (HDS) is Global Graphics' patented second generation stochastic screening system. As part of the Harlequin Screening Library, HDS is one of the screening options available for the Harlequin® RIP. In addition, HDS is the standard screening method included in versions of the Harlequin RIP designed for low-resolution output devices.

HDS creates reproductions with increased sharpness over conventional screening methods and offers complete freedom from both cross screen and object moirés. Also, with HDS Global Graphics has addressed many of the deficiencies in other stochastic screening techniques to provide a robust and high quality screening solution for a variety of printing situations.

Unique Screen Structure

Although the screen structure of HDS contains a random component, there is an underlying ordered, though dispersed, structure as well. Many of the advantages of early stochastic screening techniques are due, not to their random characteristics, but to the fact that they have a dispersed structure and not the clustered structure of traditional periodic screen rulings. The dispersed screens produce structures with a high perimeter to area ratio, and this is what allows reproduction with greater sharpness even at relatively low scanner resolution. HDS is ideal for reproducing subjects for which moiré is a problem and where detailed reproduction is required. HDS offers increased image sharpness and fewer press registration problems over conventional screens and addresses those problems that other FM screening methods have been unable to overcome.

Incredible Speed and Performance

Where most FM and stochastic screening methods on the market slow the RIP down, HDS can be implemented with no performance penalty. When combined with the power and sophistication of the Harlequin RIP; HDS can be implemented with no speed penalty. HDS processing can be integrated into the RIP, an approach that results in speed and performance gains over other FM screening methods. With the ability to produce high-quality output at incredible speeds, HDS leads the industry in performance.

Smart FM Dot Dispersal Means Higher Quality Images

HDS eliminates the grainy highlight effect experienced with some FM screening methods. These artefacts are most apparent in smooth areas of contone pictures, flat tints, and vignettes and are the result of purely random screening methods that cluster dots into odd sized and shaped structures. The HDS approach dramatically improves the printability, stability, quality and predictability of the printing process. HDS uses a dispersed but still clustered technique to produce a screen that has the benefits of both purely stochastic, or random screens, and conventional screens. The clustering improves dot gain characteristics, plate lifetime on the press, and ability to produce a representative proof while the dispersed component eliminates moiré and improves image quality.

Since individual spots do not randomly cluster into structures with odd sizes and shapes, graininess is reduced over other FM screening methods. At the same time, the underlying structures are so fine in scale that all the benefits of increased sharpness are maintained. Though there is no regular and periodic structure, as with a conventional halftone screen, there is a certain regularity of form and scale. If you examine HDS tints closely you will notice that, at any given level of tone, the tints have a certain homogeneous structure that changes smoothly up and down the gray scale. This consistency in structure at a particular gray level or dot value is a hallmark of HDS and eliminates many of the problems of controlling printing conditions associated with purely stochastic screening methods that contain structures of many different sizes at the same dot value.

Calibration Tools and Techniques from the Experts

One of the reasons why conventional screening techniques have remained popular, despite the inherent problems, has been their predictability. Predictable screens implemented in a production process mean that the production process is manageable.

To get the best results from HDS there are a number of factors that need to be tackled. The preceding discussion has highlighted a number of areas, including dot gain and loss of high light dots, that can cause problems in the implementation of stochastic screening. While HDS has characteristics that go a long way to minimising these problems, there is no doubt that the recent renewal of interest in stochastic screening within the industry has been as a result of changes elsewhere in the imaging pipeline that have improved the predictability and fidelity of the printing process. Amongst these changes has been the move to CtP, eliminating a source of image degradation, improvements in output device, in particular the quality and accuracy of the dots produced, and improvements in control of the printing process

● FM Screening for Everyone

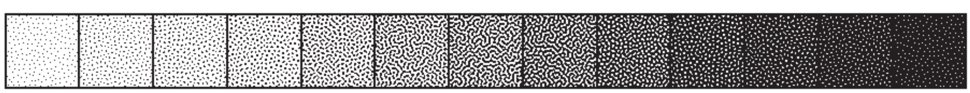
Global Graphics is focused on providing best of breed technology to its partners. It specialises in software technology for the printing and imaging communities and its partners specialise in producing products that incorporate that technology to produce solutions for many different markets.

This business focus means that HDS is not limited to a certain device from a certain manufacturer, or even to a specific software application from one vendor. HDS has been used successfully on all sorts of imaging devices, from image setters to ink-jets, and through its OEM partners Global Graphics continues to make HDS available to the widest possible range of users.

● The HDS Family

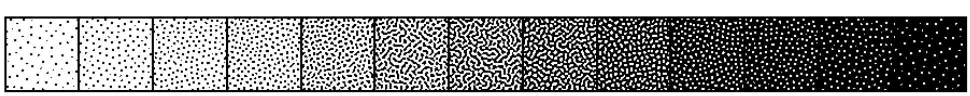
HDS provides a family of screens, tailored for different types of reproduction and different output device capabilities. HDS includes standard four colorant screens for use with the standard CMYK process colors as well as variants developed for hexachrome and photoink devices. HDS is also available in five varieties of dot structures or "settings" making it compatible with many different types of output device.

Please note that each sample below has been enlarged to better display the transitions between different tones or dot percentages.



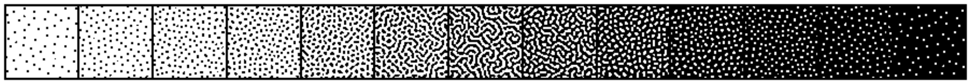
● HDS Fine

HDS Fine produces extremely smooth grain-free results and has the finest structure of any HDS setting. It is intended for use with high quality output devices capable of recording single isolated laser spots on separations. HDS Fine works best for high quality commercial printing environments with tight prepress and printing controls.



● HDS Medium

HDS Medium offers a slightly larger dot structure in the midtone range. It may be used in intermediate commercial and publications printing, either sheetfed or web. HDS Medium is also intended for use with output devices capable of recording single isolated laser spots on separations.



- **HDS Coarse**

HDS Coarse makes use of somewhat larger structures to increase printability and is best selected on presses which cannot hold very fine detail such as in high speed web printing. The larger structures produce results that are somewhat more grainy than those built with HDS Fine or Medium. However, HDS Coarse offers better results for capstan and/or infrared diode imagesetters not capable of holding single laser spots.

- **HDS Super Coarse**

HDS Super Coarse uses a larger structure to increase printability and the ability to hold highlight areas of an image. It is suitable for use on mid- to low-range imagesetters or platesetters with resolutions between 1000 and 1600 dpi. Newspaper production, where printability on low quality paper stock is of paramount importance, is well served by either HDS Coarse or Super Coarse.

- **HDS Super Fine**

In addition to the settings above which are meant for use with various types of imagesetters and CtP devices, Global Graphics has developed a screening solution for low resolution output devices which delivers high quality output without compromising speed. HDS Super Fine supports direct output to low-resolution color and monochrome laser, ink jet, and electrostatic printers. This variation reproduces high quality black and white or color images even at low resolutions. HDS Super Fine is ideal for the reproduction of banners, exhibit graphics, point-of-purchase displays, signs, billboards, and murals as well as for use in standard office printers. The processing of images with HDS is also extremely fast when integrated into the Harlequin RIP, instead of a post process like most of the dithering and error diffusion screening methods currently on the market. With this technology, Global Graphics brings both exceptional quality and speed to the fast-growing low- resolution digital color and large format printing markets.

- **Selecting Appropriate HDS Variants**

Unlike many screening systems that only operate on expensive output systems, with HDS the user can specify a minimum dot size. In general, the higher the quality of the entire printing process, the smaller the HDS dot that can be used. The selection of which type of HDS dot to apply should be based on the physical characteristics of the imagesetter, CtP device, printing and press environment as well as the type of ink and paper in use. The physical size of the HDS dot created with each of these options will vary both with the device laser spot size and the resolution at which it is driven.

As an illustration, below is a table with the theoretical spot sizes in microns for the different HDS models and different output resolutions for 20% HDS screen (although HDS is not limited to output resolutions listed here).

Imagesetter/platesetter resolutions dpi	1016	1200	1800	2400	3600
HDS Super Fine 1x1 pixel	25	21	14	11	7
HDS Fine 2x1 pixels	35	30	20	15	10
HDS Medium 2x2 pixels	50	42	28	21	14
HDS Coarse 2x3 pixels	61	51	34	26	17
HDS Super Coarse 4x4 pixels	100	84	56	42	28

● HDS Availability

Harlequin Dispersed Screening is provided as integrated option for Harlequin RIPs available in many workflow and RIP application products from a range of Global Graphics partners. For details of companies that supply solutions based on the Harlequin RIP see:
http://www.globalgraphics.com/harlequin_oem.html

In addition, HDS is also used as a core component in other workflow solutions from various suppliers. When licensed for use with other RIP technologies HDS is normally re-branded.

Enquiries for licensing HDS should be directed to the email address:
harlequin-sales@globalgraphics.com or via your usual commercial contact

● The future of HDS

HDS remains the focus of continuous development and Global Graphics has undertaken consultancy projects to optimise HDS for specific applications.

Conclusion

Stochastic screening addresses many of the quality issues that conventional screening methods have failed to solve due to the inherent nature of problems such as moiré, mid-tone jump and banding. Earlier problems with FM technologies such as graininess, dot gain, dot loss, and system slowness have been solved though a combination of technology such as HDS and recent advances in the predictability and fidelity of the digital output and printing processes.

Rather than accepting second-rate quality, or having to invest in new equipment, users can insist on high quality screening solutions tailored for their particular printing environment and applications, no matter how specialized. Global Graphics makes this technology available to the entire industry: Today.

The technology expert for open document and print solutions

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the smarter alternative™
GLOBAL GRAPHICS®

Global Graphics Software Inc.
5875 Trinity Parkway, Suite 110
Centreville, VA 20120, USA
Tel: +1 703 266 9588
Fax: +1 703 266 9582

Global Graphics Software Ltd
Barrington Hall, Barrington
Cambridge CB2 5RG UK
Tel: +44 (0)1223 873800
Fax: +44 (0)1223 873873

Global Graphics KK
Level 14, Hibiya Central Building
1-2-9 Nishi-Shimbashi, Minato-ku
Tokyo 105-0003. Japan
Tel: +81-3-5532-7340
Fax: +81-3-5532-7373

www.globalgraphics.com