Digital halftoning methods, for the most part, have tried to mimic the conventional photographic halftones that were first invented in the late part of the 19th century. These halftones are made up of rows of halftone dots that are built on a grid. (See Figure 1.) Along this grid, the distance from the center of one halftone dot to the next is constant. (See the doubleheaded arrow.). In addition, these halftone dots are usually aligned along a 90° or 180° axis. (A 90° axis is represented by the two dotted lines.) Screen angle is the amount in degrees that this axis is shifted away the horizontal or the vertical. (In this case the axis is shifted 45° from the horizontal dotted line.) Finally, the size of a halftone dot is measured in terms of dot percentage. Each halftone dot in a flat tint is the same size.

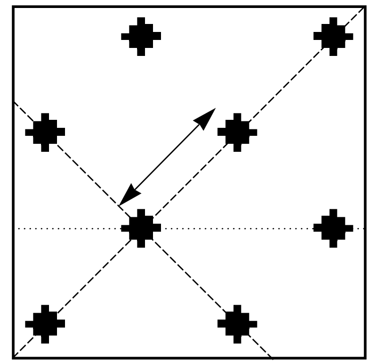

Figure 1 – Artist's conception of a heavily magnified digital halftone.

This method has worked extremely well and is probably still the best method for the widest variety of uses. But mimicking conventional halftones isn't the only way to print images. A newly-introduced method of halftoning turns these conventional rules upside down with results that promise dramatic improvement, particularly in high-fidelity color work.[1] This technique, called Diamond Screening is a frequency modulated method of halftoning.

[1]High fidelity color is the subject of a recent study by consultant Mills Davis which Linotype-Hell co-sponsored.

FM screening

A 100 line per inch screen ruling means that there are 100 halftone dots per linear inch, or if you prefer, there is a halftone dot every 1/100 of an inch. With most conventional and digital halftones this distance from the center of one halftone dot to the center of the next is set and doesn't change. Of course it is possible to have different screen rulings, but not in the same image. And, with digital halftones, each halftone dot is made up of one or more laser spots.

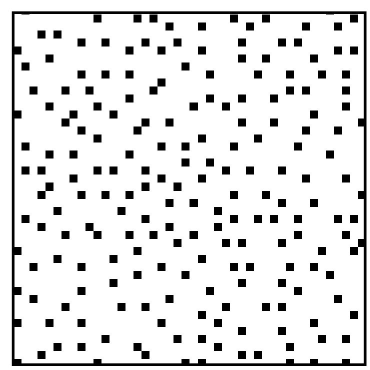

Figure 2 – Artist's conception of frequency modulated screening (heavily magnified).

All of this changes with frequency modulated (FM) screening. Frequency modulated means that the screen frequency (i.e., the screen ruling) actually changes throughout the image. This throws the entire concept of angle and ruling on it's head. Screen angle and ruling are gone, and what is left is a random collection of laser spots built directly on the grid of the imagesetter. (See Figure 2.) Frequency modulated screening may also be called random screening, random dithering, or stochastic screening. (Stochastic is a mathematical term describing randomness.)

Successful FM screening requires that the placement of individual laser spots be truly random. Non-random patterns are likely to be visible if they

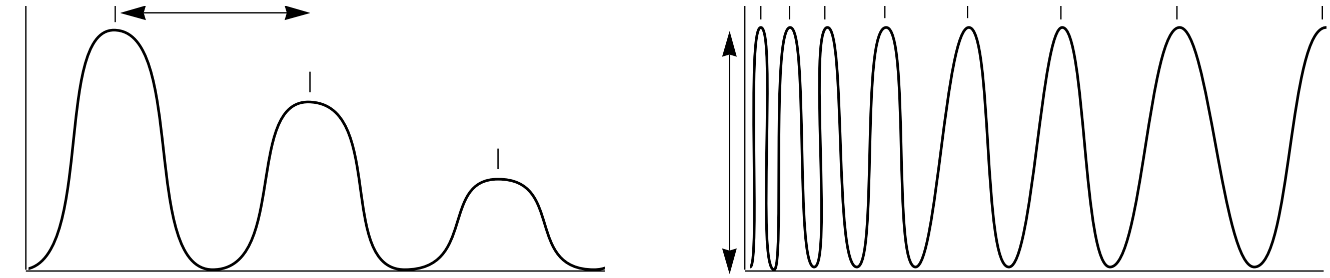

Figure 3 – An amplitude modulated wave form (left), and a frequency modulated wave form (right). The amplitude modulated wave varies in height. With the frequency modulated wave the height (i.e., the amplitude) is constant but the frequency varies.

repeat throughout an image. To achieve this the raster image processor (RIP) must handle very compute-intensive algorithms. FM screening also requires a great amount of precision from an imagesetter.

AM Screening

Conventional screening can be referred to as AM or amplitude modulated screening. And, in the sense of AM and FM radio, there is a parallel here between halftone dots and radio signals. AM radio signals are broadcast via a carrier wave that looks something like the left half of Figure 3. The distance from the peak of one curve to the peak of the next is constant. This distance is called the frequency. However, the height of the waves (the amplitude) does change. You can think of this amplitude change in terms of halftone dot sizes: the higher the wave, the larger the halftone dot size. And the chosen frequency represents the screen ruling. FM radio signals differ from AM signals in that the height of the carrier waves remains constant, but the distance from one peak to the next changes. (See right half of Figure 3.)

Spots and dots

With FM screening, it is important to understand the difference between a laser spot (the smallest mark that an imagesetter can make) and a halftone dot. (For more information, see the Linotype-Hell technical information article entitled Resolution and Screen Ruling.) FM screening replaces the halftone dot with randomly placed laser spots.

To begin with, consider a sequence of tints created with FM screening. At low tint percentage values, single laser spots create a random pattern through the tint area. As the FM screening tint approaches a 50% tint, laser spots begin to form mini-clumps, which are also random in shape. This random clumping continues through the higher percentages.

Because the frequency is modulated, it is impossible to describe the fineness of FM screening in terms of screen ruling. About the only measure of fineness that can be used is that of the smallest laser spot which may be around 15 or 20 microns in diameter.

At higher addressability settings, the laser spot becomes so small as to be totally unreproducible, even with the finest of plate materials. In these cases, clumps of four laser spots are used as the elemental unit instead of individual laser spots. But excellent quality can be achieved with FM screening at lower imagesetter addressabilities.

With color images, different kinds of random distributions are used for each separation. This avoids any problems with color shifts.

Free of angle and ruling

Freeing a digital halftone from the constraints of screen angle and ruling makes a real difference for color applications, particularly those requiring more than the standard cyan, magenta, yellow, and black printing inks. It also eliminates moiré patterns that sometimes appear due to subject matter.

[2]Clothing is not the only source of subject matter moiré. Patterns in fences or screen windows may also cause it. (One common moiré pattern may be seen wherever two chain link fences run parallel to each other, as on highway bridge overpasses.)

Certain repeating patterns that often appear in clothing, particularly thin stripes, fishnets, herringbones, etc., may create moiré patterns when they are reproduced with conventional screening. The reason is simple: the repeating patterns in the clothing form a moiré with the repeating patterns in the halftone. Outside of changing the screen ruling, there is very little that can be done to avoid this. However, with an FM screening method, this type of moiré will not occur because the frequency of the halftone is constantly changing leaving nothing to conflict with the pattern in the clothing.[2]

Another limitation of conventional screening is the requirement that each separation needs to be offset from the next by 30° to avoid moiré. (For more information, see the Linotype-Hell technical information article entitled Moiré). Because most halftones are built on a 90° axis, only three of the four separations may be offset by 30°, the fourth separation (usually yellow) is placed in between two of the others at a mere 15° offset. However for some high-quality applications, printers would like to use five or more screened colors. Within the constraints of conventional screening, this is difficult if not impossible. But FM screening is perfect for high fidelity color.

Advantages and requirements

Besides the above mentioned advantages, FM Screening provides the ability to reproduce finer detail, as well as a larger color gamut (in conjunction with high fidelity color printing methods). Because angles and rulings are no more, rosettes also vanish. Mid-tone jump vanishes too.[3]

[3]Mid-tone jump is caused by the merging of the edges of conventional halftone dots between around 40 to 60%. Mid-tone (or optical) jump can insert a band into the mid-tone areas of otherwise smooth blends.

The advantages of FM screening come hand in hand with some important production requirements:

- The reproduction of FM screening is based on the ability to reproduce extremely small elemental units (something on the order of 15 to 20 microns). This requires high resolution plate materials and stringent production conditions. Reproducing 15 micron laser spots, since they are much smaller than conventional halftone dots, requires extremely high resolution plates which must be able to hold patterns in the area of 6 to 8 microns in width. This means that fine marks like scratches, strip lines, or dust are much more likely to show up on the plate itself. This also makes it more difficult to print and proof.
- Special care has to be taken to assure that the film is properly contacted to the plate so that all of the information is transferred to the plate. (Strict controls must assure that there is no dust or stray light, and that the illumination is uniform. 6 to 8 micron test patterns must copy safely.)
- Because the elemental dots are so small, no manual dot etching (i.e., film retouching) is possible.

For many applications this will mean that users may prefer to work with the higher screen rulings available with HQS Screening® or IS Technology™ rather than using Diamond Screening.

Question and answer

The introduction of a new technology brings up many questions:

- *Can you measure dot percent in the same manner as conventional screens?* Yes. Densitometers, since they measure percent coverage, can still be used to measure dot percentage (even though the halftone dot, so to speak, is gone). This also means that calibration may be handled in the same manner.
- *What do you determine the number of gray steps with FM screening?* The calculation no longer works so simply as before. However, since we have found good results at low addressability settings, the issue of screen ruling and resolution/addressability is something of a moot point.

- *How are USM, UCR, and GCR influenced by the use of FM Screening?* Unsharp masking (USM), under color removal (UCR), and gray component replacement (GCR) are not influenced by FM screening and may all be used in the same manner.
- *How do you determine the proper resolution for scanning images to be reproduced with FM screening?* FM screening benefits from high resolution scans because of the great amount of detail that it can deliver. It is no longer necessary to limit scan resolution based on the screen ruling.

Diamond Screening

Linotype-Hell's FM screening method is called Diamond Screening. FM screening is not exactly a new concept. Linotype-Hell has held patents on this process for nearly twelve years, but recent developments in RIP processing speed as well as in press and plate technology have made it more technically feasible to print images with FM screening.

Diamond Screening will be available this fall as an option to the RIP 50 and RIP 60 XPO. For a printed sample of Diamond Screening, please call the Linotype-Hell Information Center at 1-800-842-9721.

Plate technology

High resolution printing plates are a key factor in the success of frequency modulated screening. These plates can hold a 6 micron line from a UGRA plate control wedge, and have been used with screen rulings as high as 600 lines per inch. They have been commonly available for over a year. One example is DuPont's Primera, a high resolution, positive working plate.

Conclusion

Good communication between a printer and the color separator is an absolute necessity with FM screening. Printing from FM screening films requires such high standards that you cannot assume that any printer will be able to handle them. And so, Diamond Screening will not be for everyone. But for those who are pushing the edge of the envelope of color printing, if will provide a means for producing exceptional detail and amazing color.

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(For subscription information on the Linotype-Hell technical information series, please call 1-800-842-9721.)

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