Adobe℠ Customer Services

Understanding Digital Halftones

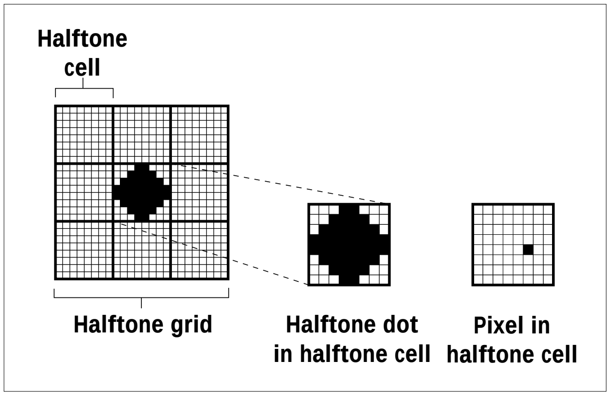
In traditional photographic reproduction, a continuous-tone image (such as a photograph) is prepared for printing by reducing the tonal image to two values, black and white. This process is known as making a *halftone*. This document outlines some of the issues involved in choosing screen sets for digital halftones. For more detailed information, see *PostScript™ Screening: Adobe Accurate Screens™* by Peter Fink, published by Adobe Press.

In conventional graphics printing, a halftone is produced by projecting light onto a photograph through a screen that converts the image into dots. The screen divides the image into a grid of halftone *cells*, with each cell containing one halftone dot. The dots provide room for the ink to spread and indicate the relative darkness of the photograph at any specific point. The relative sizes of the halftone dots produce the shades of black, white, and gray that the human eye perceives. When the halftone cell dots are large, we see black. When the dots are very small (or there is none at all), we see white. Gray shades are made by dots whose sizes increase as the degree of darkness increases.

Digital halftones are produced in much the same way—by breaking the image down into halftone cells, with each cell containing a single halftone dot. With digital halftones, however, the halftone cell is made up of digital picture elements, called *pixels*, which are either turned on (making them black) or turned off (leaving them white) when the laser beam in the imagesetter scans across them. The size and shape of a halftone dot are determined by the pixels that are turned on in that cell.

An imagesetter's resolution, measured in dots per inch (dpi), is the number of pixels per inch the imagesetter can produce. The *screen frequency*, also called *line screen* or *screen ruling*, is the number of halftone cells produced per unit of measurement. A standard laser printer has a resolution of 300 dpi and uses a 53 lines per inch (lpi) screen frequency.

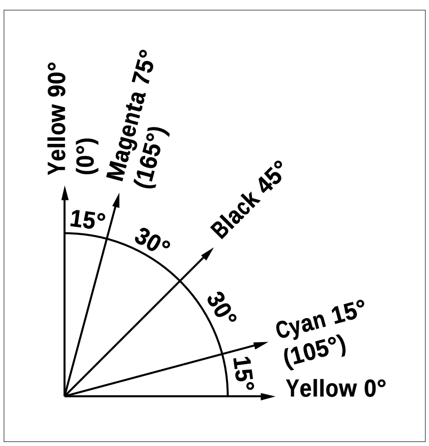
The following illustrations represent an approximation of pixels and halftone cells; in reality pixels are rounded.



THE CHALLENGE OF DIGITAL SEPARATIONS

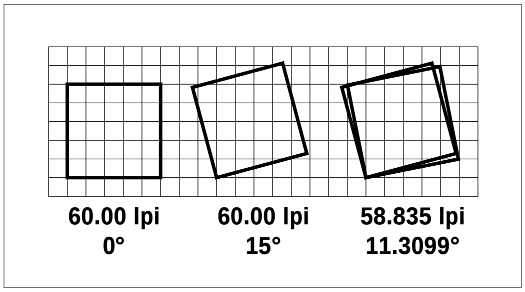
In traditional color separations, a photograph or image is photographed four times using a different color filter for each exposure. The grided halftone screen is rotated to a different angle for each color (cyan, magenta, yellow, and black). If you look at a high-quality printed image under a magnifying glass, you see that the four different-colored dots form a *rosette* pattern. Dots that interfere with one another can produce repeating patterns, called *moiré* patterns. The rosette pattern has been determined to produce the least amount of moiré patterns in images and is generated by a careful balancing of screen angle, screen frequency, and halftone dot shape. In actuality, nearly every four-color prepress process results in some degree of moiré.

In theory, a 30-degree distance between screen angles is ideal for forming a rosette pattern. Keep in mind, however, that the angles 90 and 0 produce exactly the same screen; this means that adjustments must be made to accommodate a fourth screen. Typically, black is assigned an angle of 45 degrees, because 45 degrees is the least visible screen orientation. Magenta and cyan are each rotated 30 degrees from the black screen; the 75-degree and 15-degree angles are considered equally visible and therefore interchangeable. The lightest color, yellow, is assigned the fourth angle (90 degrees) to produce the least noticeable deviation possible in the rosette pattern.



Traditional screen angles. Slight moirés are produced by the 15-degree angle between yellow and magenta and yellow and cyan. Yellow is chosen for this rotation because it is the lightest color and therefore produces the least noticeable pattern.

Digital color separations pose yet another complication for halftone screening, because each halftone screen must line up with the pixels of the device. Specifically, the corners of the halftone cells must align with corners of the device pixels (see the figure below). Similarly, the screen frequency that can be achieved in a digital halftone is constrained by the device pixels, because the number of halftone cells per inch (lpi) is related to both the size of the halftone cell (pixels per cell) and the device resolution (pixels per inch). Most traditional screen frequencies are "ideal" values and cannot be exactly reproduced on electronic output devices.



Screen adjustments necessary for digital halftones on a 300-dpi device. To align with the nearest device pixel, the halftone cell angle must be adjusted. Adjusting the angle alters the number of pixels per cell, changing the actual cells per inch (lpi).

To illustrate the effect that device constraints can have on actual screen angles and frequency in digital separations, suppose that you specify a resolution of 2540 and a screen of 150 in Adobe Photoshop's Auto Screens dialog box (click the Screens button in Page Setup dialog box to open Auto Screens). The screen sets that are actually generated using a typical digital screen method are the following: black at 45 degrees and 149.7 lpi, cyan at 18.4 degrees and 133.9 lpi, magenta at 71.6 degrees and 133.9 lpi, and yellow at 90 degrees and 141.1 lpi.

Remember that adding or subtracting 90 degrees from an angle results in exactly the same screen rotation; therefore, the screen angles 90 and 0 are identical, as are the pairs 105 and 15, 108 and 18, 161 and 71, and so on.

The screen angle and frequency combinations produced by Adobe Photoshop have been tested and shown to produce the least moiré patterns for the output device resolution and frequency specified. Newer technologies, such as Adobe Accurate Screens, are able to calculate screen sets that more closely approach ideal values. These technologies are available on many different output devices. See the technical note "Digital Screening Technologies" for more information on advanced screening technologies.

TERMINOLOGY

The following terms from traditional halftoning are also used in digital halftoning:

Grid Pattern: The shape of the halftone screen dots. Some common shapes are linear, elliptical, and round. Different shapes cause different effects in the final output. Adobe Photoshop 2.5 allows you to specify a diamond dot, which is supported on some of the newer imagesetters. Contact your vendor to find out whether your imagesetter supports the diamond dot function.

Screen Angle: The angle at which a screen is rotated for printing. The angle affects the way the halftone dots are laid down on each separation film. If the dots do not align correctly, moiré patterns appear when the films are placed on top of one another.

Screen Frequency: The number of halftone cells per unit of measurement in a screen; the higher the frequency, the finer the screen. A screen of 30 lines per inch is made up of dots that are one-third the size of the dots in a screen of 10 lines per inch.

Output Resolution: The dots per inch (dpi) of the output device (high-end imagesetters can support various resolutions). The higher the screen frequency, the higher is the output resolution required to maintain 256 shades of gray.

Moiré: An undesirable effect that results when halftone screen patterns become visible. This pattern is often caused by misaligned screens.

Rosette: The pattern created when all four CMYK color halftone screens are printed at traditional angles, shown to produce the best results in printed color output. The rosette pattern is noticeable only under magnification.