Halftoning by its very nature is a complex subject, and what with all the different technologies for halftoning, it is easy to see why halftoning can be so confusing. The purpose of this article is to give some general background and historical information on digital halftoning. For more detailed information on halftoning technology, refer to the reading list on page 27.

There are three classes of digital halftoning in the Linotype-Hell product line: rational tangent screening, irrational tangent screening, and frequency modulated screening. Within rational tangent screening there are two other divisions, one of which uses a regular halftone cell and one which uses a supercell. (See below.)

Classes of halftoning

- Rational tangent screening
  - Regular halftone cell, example: *RT Screening®*
  - Supercell, example: *HQS Screening®*
- Irrational tangent screening, example: *IS Technology™*
- Frequency modulated screening, example: *Diamond Screening®*

Digital halftoning

In 1972, a company known at the time as Dr. ing. Rudolph Hell GmbH introduced a scanner called the DC300A.[1] The halftoning technology for the DC300A was rational tangent screening which provided good results as long as some rather quirky screen angles were used.[2] Users didn't really like the rosette patterns that this halftoning method produced, but electronic scanners, particularly those with digital halftoning methods, had so many advantages over conventional photographic separation methods that many Hell customers chose to use them. Later, in 1981, Hell introduced another halftoning method,[3] this one based on irrational tangent screening. This halftoning method, now known as IS Technology, turned out to be so good that virtually all of the scanner manufacturers in the industry licensed the underlying technology from Hell. When Linotype and Hell merged in 1990, one of the many benefits of the merger was that the new joint company would own the rights to some very sophisticated halftoning technology.

In the PostScript™ world a similar series of events took place about a decade later. When the PostScript page description language was first introduced by Adobe Systems in 1985, the halftoning method it used was rational tangent screening. (Adobe later licensed RT Screening from Linotype-Hell for use in PostScript.) When users tried to do color work with this halftoning method they found that their images had tremendous moiré problems. This was simply a result of an incorrect application of the rational tangent technology that was being used by PostScript. The simple solution to this problem was to use 18.43° and 71.57° screen angles (along with some well-chosen screen ruling combinations). In 1989 Adobe Systems published some screen angle and ruling recommendations that were based on the Hell color work of the early seventies. These angle and ruling combinations drastically reduced the appearance of moiré, but left people with the same unusual rosette patterns that the original DC 300As produced with a rational

[1] After the introduction of the C399 and DC350, the DC300A was referred to as the DC300ER.

[2] 18.43° instead of 15°, and 71.57° instead of 75°

[3] This coincided with the introduction of the Hell DC 350 scanner.

tangent screening method. And so, the search was on for the fabled Hell angles that would produce a satisfactory rosette. Few people realized at the time was that it wasn't just a question of selecting the right angles, it was a question of selecting a halftoning method that could achieve those angles.[4]

[4]People knew what angles they wanted to get: 0°, 15°, 45° and 75°. The problem was in finding a halftoning method that could produce those angles extremely accurately. (See the Linotype-Hell technical information article entitled Rational and Irrational for more information.)

Since Hell has done so much groundwork in the area of halftoning, there are, in fact, many different Hell angles. Probably what most people thought of as the Hell angles were those produced by Hell's irrational screening method. For those who are familiar with the Hell terminology, that refers to terms like Screen Systems 10, 20, and 30, to name just a few.

Improved PostScript halftoning

The search for better PostScript halftoning methods led a number of companies to develop supercell rational tangent approaches to halftoning. In 1991 Linotype-Hell introduced HQS Screening, Agfa™ introduced Balanced Screening, and Adobe introduced Accurate Screens.™ These supercell methods significantly advanced the status of PostScript color halftoning by providing angles extremely close to those achieved in conventional halftoning. These methods provide excellent quality, but still fall somewhat short of irrational tangent screening methods. The first irrational tangent screening method to be introduced into the PostScript world was IS Technology which was released for use on a Linotype-Hell RIP 60 in 1992.

And halftoning technology continues to move forward, as shown by the recent introduction of Linotype-Hell's Diamond Screening, a frequency modulated screening method. This landmark halftoning method is the first widely available digital halftoning method that doesn't mimic the look of conventional photographic halftones. Gone are the well-known halftone dot, screen angle, and screen ruling. In their place is a random pattern of laser spots. (See the Linotype-Hell technical information article entitled Diamond Screening for more information.)

Screening filters

It should be clear by now that the halftoning method is more important than any magic set of angles. However, once the halftoning method is determined, screen angles and rulings must be chosen to get the best results from that halftoning method. In the PostScript world, the first step towards understanding this problem was the release in 1989 of the angle and ruling recommendations for RT Screening. In addition, Printer Description Files (PDFs) include angle and ruling information for specific output devices. But since it is possible to have more than one halftoning method per raster image processor (RIP), the RIP is actually the best place to assign screen angles and rulings. (See chart on the next page.) Linotype-Hell has done this with screening filters for its RIPs since the introduction of the Linotype-Hell RIP 30 in 1990. The purpose of a screening filter is simple. Once a halftoning method has been chosen, the RIP selects screen angle and ruling values that have been tested and work well with a given halftoning method.

Technology overview

The four primary halftoning methods in the Linotype-Hell product line have the following distinguishing features:

- **RT Screening** – A rational tangent screening method developed by Linotype-Hell Company, and licensed to Adobe Systems for use in PostScript. Distinguishing features: RT Screening is best for black and white work; has some difficulty achieving certain angle and screen ruling combinations (particularly 15° and 75°); best results for color achieved with a somewhat peculiar set of angles and rulings distinguished primarily by the angles 18.43° and 71.57° substituted for the commonly used 15 and 75 degree angles in color separation (0 and 45 are more easily achieved in RT Screening); the resulting rosette pattern is somewhat coarser than the rosette pattern most people are used to seeing, and has been described sometimes as a fish scale pattern.

Linotype-Hell RIPs and Halftoning Methods

RIP name	Date of introduction	Halftoning methods	Remarks
RIP 1	April 1985	RT Screening	First high resolution PostScript RIP
RIP 2	October 1987	RT Screening	
RIP 3	March 1989	RT Screening	
RIP 4	January 1990	RT Screening	
RIP 30	May 1990	RT Screening & HQS Screening	First to include a screening filter
RIP 40	June 1991	RT Screening & HQS Screening	
RIP 20	February 1992	RT Screening & HQS Screening	
RIP 60	February 1992	RT Screening & IS Technology	Diamond Screening optional (Fall '93)
RIP 50	September 1992	RT Screening & HQS Screening	Diamond Screening optional (Fall '93)

- **HQS Screening** – A supercell rational tangent screening method developed by Linotype-Hell Company. Distinguishing features: Angle and ruling may be achieved extremely accurately; moiré length is greatly increased over RT Screening, but is not infinite as in the case of IS Technology. It is very easy to tell HQS Screening from RT Screening, but much more difficult to tell HQS Screening from IS Technology.
- **IS Technology** – An irrational tangent method developed by Linotype-Hell. IS Technology is Linotype-Hell's highest quality method of amplitude modulated digital halftoning. It has been licensed by Linotype-Hell to many other companies in the industry. Distinguishing features: The moiré length is infinite, also, IS Technology is capable of producing extremely high screen rulings in conjunction with Hi-Dot in ChromaCom® mode.
- **Diamond Screening** – A frequency modulated screening method and Linotype-Hell's newest method of halftoning. Distinguishing features: Moiré length is no longer an issue; screen angle, screen ruling and halftone dot shape are eliminated; produces images with extraordinary detail and color; however special production requirements must be observed in platemaking and printing. Linotype-Hell has held patents on this technology for over a decade, but it is only recently that RIPs, presses and plates have been developed that can handle the complexity of frequency modulated screens.

Conclusion

Digital halftoning technology has evolved dramatically over the past twenty years, and undoubtedly the technology will continue to change. If you are interested in more information on halftoning technology, the following documents are all part of the Linotype-Hell technical information series:

- Blends and Shadestepping
- Diamond Screening
- Digital Halftone Dots
- Halftone Dot Shape
- Measuring Screen Angle and Ruling[5]
- Moiré
- What factors play a role in Moiré?
- Rational and Irrational
- Rosettes, Moiré, and Color Shifts
- Screen Angle and Ruling Recommendations
- Part II: Screen Angle and Ruling Recommendations

[5]For those interested in measuring screen angle and ruling, Linotype-Hell supplies two tools for that purpose. One measures angles and rulings between 80 and 200 lines per inch, and the other measures angles and rulings between 30 and 100 lines per inch. To obtain a complimentary copy of either of these tools, send a 9" by 13" self-addressed manila envelope with four first class stamps to the following address:

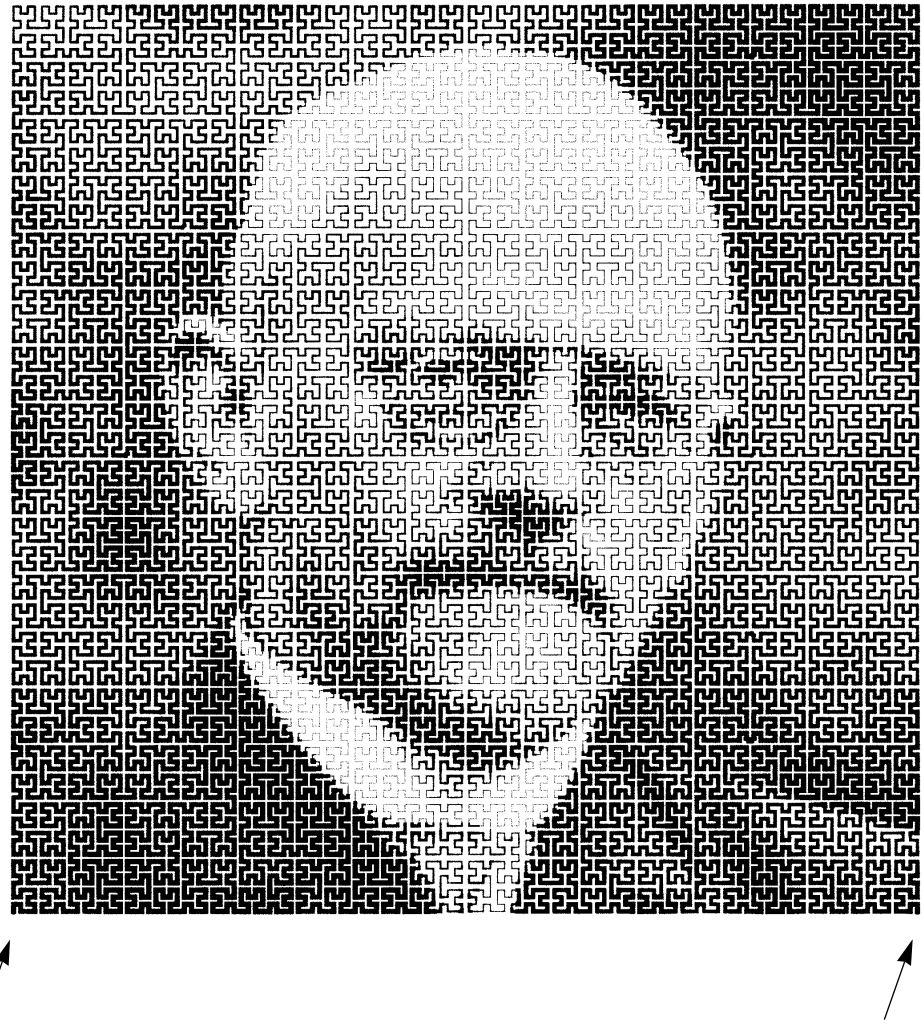
Jim Hamilton, Marketing Department, Linotype-Hell Company
425 Oser Avenue, Hauppauge, NY 11788

Appendix

Finally, for your enjoyment, here is an example of a very creative method for halftoning an image. This illustration was produced by PostScript programmer Fritz Lott, who has used an underlying line art image as the actual halftone dot pattern. This allows him to reproduce a grayscale image that looks fine when viewed from 10 or 15 feet away, but that reveals an intricate line art image when viewed up close.

The photograph is of David Hilbert, the mathematician who developed the space-filling curve that is used as the background pattern in this image. (The photograph was supplied to us by the David Eugene Smith Collection of the Rare Book and Manuscript Library at Columbia University.) Notice that the image consists of a single line that starts at the left arrow, continues throughout the image, and exits at the right arrow.

Mr. Lott may be contacted care of: W.R. Beamish Company, 220 Sunnyridge Lane North., Golden Valley, MN, 55422-5300. He may also be reached by phone at 1-612-377-3032.



Please direct any questions or comments to: Jim Hamilton, Marketing Department, Linotype-Hell Company, 425 Oser Avenue, Hauppauge, NY 11788
(For subscription information on the Linotype-Hell technical information series, please call 1-800-842-9721.)

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