PRESS PERFORMANCE COMPARISON BETWEEN AM AND FM SCREENING

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Keywords Screening, dot gain, colorimetry, color management system

Abstract FM screening has been praised for its apparent resolution advantage over conventional AM screening. FM screening is also known for its criticalness of film output and difficulties in the proofing stage because of the microdot formation. However, FM screening is not a well understood process from press performance point of view. This paper set out to explore (1) dot gain differences between AM and FM screening, (2) whether transfer curves, derived from AM and FM plate/press curves, can modify color-managed AM images for FM reproduction, and (3) how well does the dot gain compensation technique work in all parts of the color gamut. The IT8.7/3 basic color block, including 182 color patches, was used to test two FM screening methods, Agfa's CristalRaster and Ugra's Velvet. We learned that FM images can be successfully rendered to match closely to its color-managed AM reproduction when transfer curves are applied. This was verified by colorimetric analysis with the use of the IT8.7/3 target.

Introduction

FM screening, also referred to as stochatic screening, can be regarded as an electronic implementation of screenless printing. From literature review, advantages of FM Screening include, but not limited to, continuous-tone like, sharper image details, no screen angle, etc. Disadvantages of FM Screening, however, include higher dot gain, greater visual noise in highlight and midtone—not suitable for rendering flat tints, difficulties in color rendering by many off-press proofing systems, etc.

FM Screening Characteristics

The key to tonal rendering with FM screening is the formation of micro-dot. With today's electronic screening approach, a 2400 dpi imagesetter has a laser spot size of 10.6 µm. And the size of a dispersed micro-dot is 21 µm. This means that each micro-dot is made up of a 2 x 2 "clustered" laser spots. The clustered 21 µm dot is equivalent to a 1% dot at the screen ruling

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of 150 lines/in. To put everything in perspective, the size of a micro-dot in comparison to other small particle sizes is shown below:

Table 1. Comparison of small particle sizes.

Example	Particle Sizes
Tobacco smoke	0.01 - 1.0 μm
Dusts	0.01 - 10 μm
Laser spot of a 2400 dpi imagesetter	10 μm
Laser spot of a 300 dpi printer	80 μm
Thickness of human hair	100 μm

In contrast to amplitude-modulated (AM) or conventional screening, FM screening uses micro-dots of the same size and variable spacing between them (also known as the first order FM screening) or variable size and variable spacing (also known as the secondary order FM screening) to render tonality and color. Resolution of light sensitive materials, including films, proofs, and plates, for FM screening applications and their exposure conditions are critical.

FM screening possesses a higher level of dot gain. When comparing FM and AM images printed with a sheet-fed offset press on coated paper, 21 μm micro-dot has 20% more dot gain over conventional 150 lpi halftone at the 50% dot area level as computed by the Murray-Davies dot gain formula (Figure 1). Although only the plate/press curve and the dot gain of the cyan printer are shown in Figure 1, the 20% more dot gain is typical for the other three printers as well.

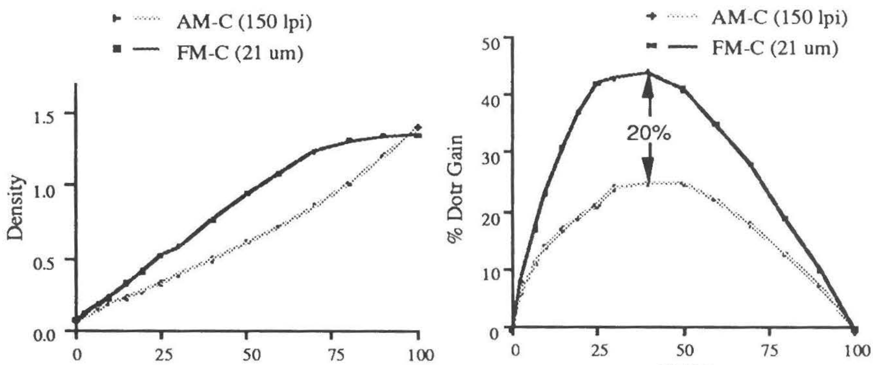

Figure 1. Plate/press & dot gain curves of AM vs. FM screening.

Dot Gain Compensation

For a common film input, differences in dot gain during presswork will result in different tone reproduction. Fortunately, differences in dot gain can be compensated between two different printing conditions by means of transfer curves in prepress. This was done in an analog fashion with contact screens and the three-point exposure control method in the past. Today, this can be done digitally with the use of desktop prepress technologies such as Adobe's Photoshop and imagesetters.

In Figure 2, plate/press curves (left) are used to find an input/output relationship in % film dot area whereby the same density is achieved. For example, a 50% AM dot, when printed, yields the same density as a 32% FM dot. If we derive sufficient number of input/output relationships between AM and FM dot areas from the plate/press curves, we can construct a transfer curve as shown on the right-hand-side of Figure 2.

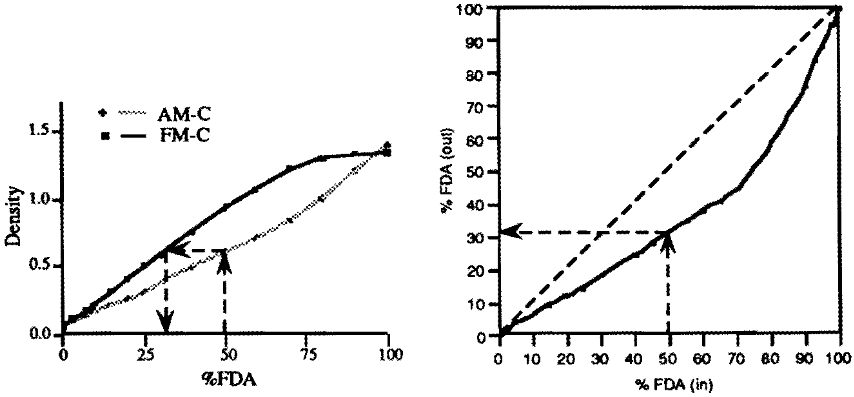

Figure 2. Deriving transfer curve from plate/press curves.

As mentioned earlier, a transfer curve may be implemented within the Photoshop and then converted to FM screening with software like Ugra's Velvet. However, some FM screening technologies, e.g., Agfa's CristalRaster, will perform dot gain compensation at the raster image processing stage without human intervention. In this case, CristalRaster uses the screen ruling of 102 as a flag to implement its FM screening with an average dot gain compensation.

Research Question and Methodology

Color management systems are developed primarily for AM screening. In this research, transforming or morphing a color managed AM separation into its FM equivalent to achieve the same tone reproduction is the essence of dot gain compensation. The question we wish to answer is, "How well does this morphing technique work in all parts of the reproducible color gamut?" The following experimental procedures were carried out:

Step 1. Calibrating the printing conditions: (a) Obtain the IT8.7/3 basic color block in EPS format. The IT8.7/3 basic color block contains 182 patches of known CMYK values. They represent a collection of single-color, two-, three-, and four-color overprint patches. (b) Output the target to film in AM (150 lpi) and FM (CristalRaster 112) without dot gain compensation. (c) Make plates and print under specified ink-paper-press conditions. (d) Measure and derive C, M, Y, K transfer curves from their plate/press curves.

Step 2. Preparing and printing test images: (a) Prepare AM color separations with the use of a KEPS PCS100 color management system in Photoshop environment. (b) Derive FM color separations from the above AM images without dot gain compensation by CristalRaster 112. (c) Derive FM color separations from the above AM images with dot gain compensation by two different methods: (i) converting the same EPS file used for AM screening with Agfa/CristalRaster FM screening program (CR 102); and (ii) applying transfer curves to the AM images in Photoshop for each of the C, M, Y, K separations, and then converting them with an Ugra/Velvet FM screening program. (d) Build a test form consisting IT8.7/3 basic color block and color separations in AM (150 lpi), FM (CR 112), FM (CR 102), and FM (Ugra/Velvet) in QuarkXPress. (e) Output films, platemaking, and print the test form under the same plate/press conditions as in step (1).

Step 3. Visual and colorimetric assessment of printed results. For colorimetric assessment, measurements are made from the IT8.7/3 basic color block in accordance to CGATS.5 specifications.

Result and Discussion

When making visual comparison of pictorial images, the color-managed AM reproduction was judged to be pleasing, and was used as the reference. Due to high dot gain in FM screening, the unmodified FM (CR 112) reproduction appeared to be too dark. When the higher dot gain in FM screening is compensated, both FM reproduction (CR 102 and Ugra/Velvet) resemble the AM reference closely.

When performing colorimetric comparison, CIELAB values (D50, 2-degree, 0/45 geometry) of the IT8.7/3 basic color block were measured from AM, FM (CR 112), and FM (CR 102) reproduction. We were unable to render the IT8.7/3 basic color block with the Velvet FM screening program because the Velvet program could not recognize the IT8 target in its EPS/ASCII format.

As a check point, all three screening methods share the same printing conditions, therefore, they should exhibit the same color gamut. By plotting C, M, Y, R, G, B solids between AM and FM test patches (Figure 3), we can clearly see the similar shape and size of their color gamuts. The magnitude of the experimental error between AM and FM test page at their solids is 2.2 ΔE in average.

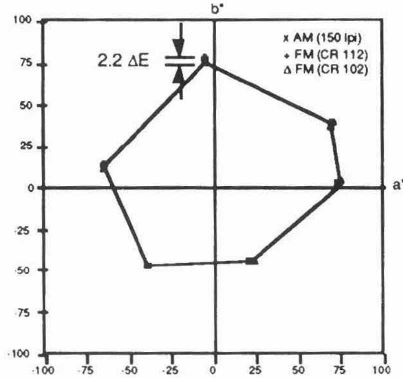

Figure 3. Color gamut is common for AM and FM screening.

Using colorimetric values of the AM version of the IT8.7/3 basic color block as the reference, ΔE between AM and unmodified FM (CR112), and ΔE between AM and dot gain compensated FM (CR102) were calculated. A graphical representation of ΔE with respect to the orientation of the IT8.7/3 target is shown below:

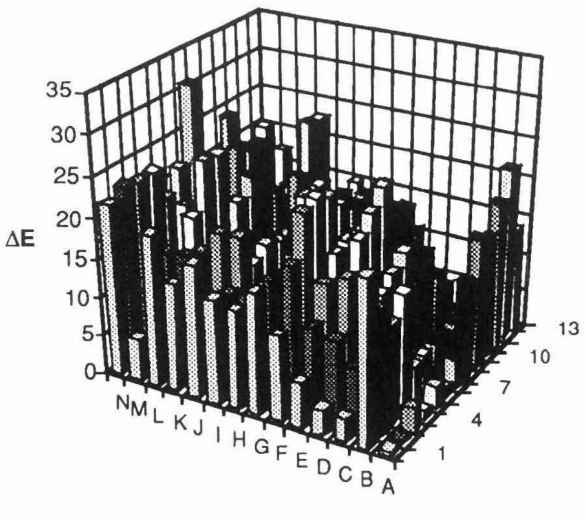

Figure 4. ΔE between AM and FM (112) without dot gain compensation.

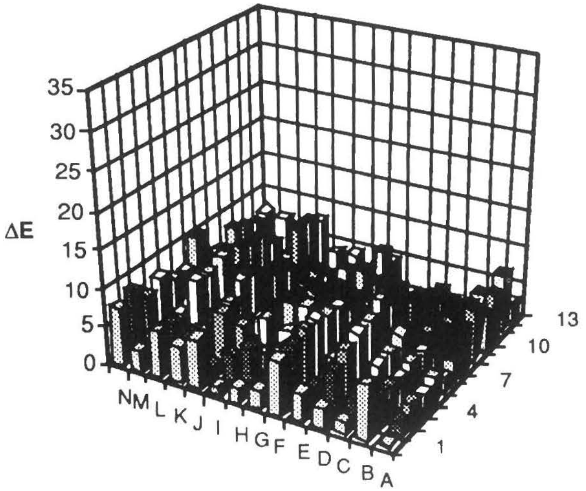

Figure 5. ΔE between AM and FM (102) with dot gain compensation.

Furthermore, the effect of dot gain compensation can be assessed from the histogram of ΔE between AM and FM rendered IT8.7/3 basic color block (Figure 6). Notice that there is a three-fold reduction in ΔE values when dot gain was compensated. Specifically, the average ΔE of all 182 patches between AM and FM screening was reduced from 12.96 to 4.34. By means of data examination, the minimum ΔE occurred, as expected, in the paper patch. The maximum ΔE, however, occurred in patch N7 containing 100Y and 70K, a 2-color overprint patch.

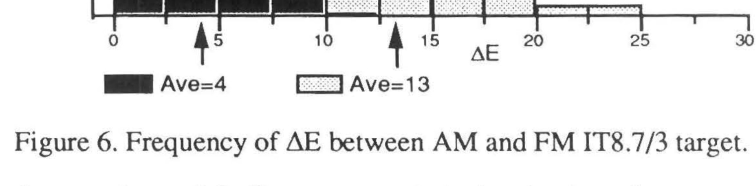

Figure 6. Frequency of ΔE between AM and FM IT8.7/3 target.

From the experimental findings, we conclude that the dot gain compensation technique works well to morph AM images into its FM version in all parts of the reproducible color gamut. If transfer curves, derived from actual plate/press curves, were used, we would expect smaller ΔE than that of general dot gain compensation conditions.

We also want to point out that contrary to conventional belief that dot gain curves are symmetrical and peaked at the midtone, the peak dot gain for FM screening occurs more closer to quarter-tone. If we take a closer look at the Murray-Davies dot gain formula, we can see that there is a theoretical limit as to how much the dot gain can be for a given % film dot. In all cases, the maximum dot gain equals to (100% - % film dot). This is shown as the diagonal line in the right-hand-side of Figure 7. Causes of higher dot gain are (a) light undercutting during platemaking, (b) ink film spread at presswork (physical dot gain), and (c) light penetration into paper (optical dot gain).

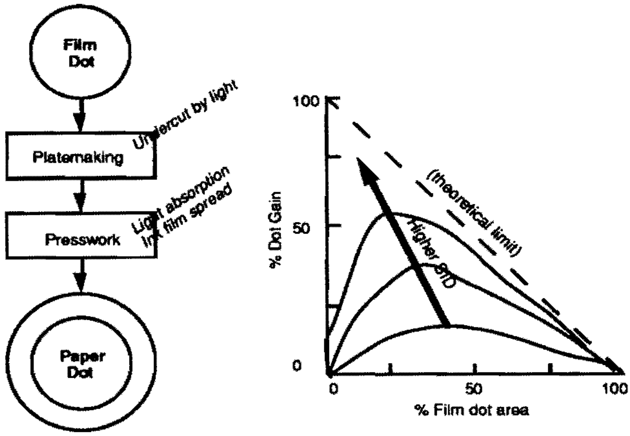

Figure 7. Causes of dot gain and peak dot gain trend.

Conclusion and Further Study

Using standardized targets like IT8.7/3 and printing to known screening, ink, paper conditions is a meaningful device calibration endeavor. Plate/press differences can be assessed between two screening conditions with the use of this target. The dot gain compensation technique works well to morph AM images into its FM version in all parts of the color gamut. This makes color management systems more viable.

The dot gain compensation technique, described in this paper, does not limit itself to just reconcile dot gain difference between AM and FM reproduction. We have taken the approach further by applying the technique to morph a printing profile with larger color gamut, e.g., gravure Group VI, into another printing profile with a smaller color gamut, e.g., web offset (SWOP).

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Reference

Graphic Technology - Input Data for Characterization of 4-Color Process Printing, ANSI IT8.7/3, 1993.

Graphic Technology - Spectral Measurement and Colorimetric Computation for Graphic Arts Images, ANSI CGATS.5, 1993.

CristalRaster User Guide, Part No. 209498-001, Agfa, 1993.

"Merging Technologies...," by Mike Bruno, TAGA Newsletter, No. 111, Spring 1994, pp. 2, 4.

UGRA/FOGRA Velvet Screen, Instructions for Use, Version 1.0, EMPA/UGRA, 1994.