Color management for digital label presses

A white paper by Global Graphics

GLOBAL GRAPHICS® software

Contents

Digital label presses require front ends that can provide accurate color management that is adapted to the specific characteristics of each model.

This white paper explains the challenges and opportunities presented by the inks and color reproduction of the different common digital label print processes.

It also explains how Global Graphics' Harlequin® Digital Hub offers sophisticated color management tools to press developers and end users.

A Glossary with notes on the concepts is provided at the end.

Introduction

Recent years have seen a rapid growth in the adoption of digital printing processes for commercial production of labels. There has been a proliferation of different digital processes and ink or toner types.

This is leading to new requirements for accurate management of color at the pre-press stage. Global Graphics' Harlequin Digital Hub™ technologies are ideally suited to driving digital label presses of all processes, and incorporate two decades' worth of color management expertise that is available for integration by OEM users.

"Conventional" non-digital processes such as offset lithography, flexography and screen processes are long established. The workflows from original file through color separation, screening, plate/screen and printing are all designed to work within widely used international standards for media, ink and print colors.

Digital printing processes are still being developed and are often improved from year to year, with considerable ongoing potential for further improvement in speed, quality and gamut size. At present this diversity means that there is far less uniformity of results and the international standardization processes have not yet caught up with the potential of digital labelers.

For this reason it is particularly vital for the front end software to control color and screening to obtain not only the optimum quality from a particular printing press, but where necessary to modify the results so they can match existing processes and standards.

Global Graphics has more than two decades' experience in developing industry-leading front end software for conventional pre-press film and plate making systems. For the past decade it has been developing these for digital production printing systems as well as digital proof printers. This includes a lot of knowledge of generating halftone screens and managing color.

This experience with color management knowledge is particularly important as Global Graphics is offering its systems to OEMs in the digital label press market.

Backgrounder: Digital label printing processes

So far three main processes are used in today's digital label presses: liquid toner, dry toner and UV-cured inkjet.

At present the predominant liquid toner label presses on the market are HP Indigo models. These are the most commonly used high productivity digital label printers worldwide.

More traditional electrophotography (i.e. dry toner) is used by Xeikon at the high productivity end of the commercial labels market, and it is fairly common in low volume presses, such as those based on engines from Oki Data. Xeikon claims to be number 2 in terms of worldwide digital label press installations.

Single-pass inkjet, almost always used with UV-cured inks, is used by the majority of label press models available today, even though sales numbers of individual brands are lower than the HP Indigo or Xeikon presses in higher volume sectors.

A further process, called Nanography, is being developed by Landa Corporation. This is in effect an offset inkjet with very small pigment particles that are applied by a heated transfer belt to the substrate. The aim is to achieve higher speeds and lower costs per copy than other digital processes, on a wide range of standard substrates. Landa is planning label presses with this process, but as of late 2013 they are not yet available.

Brand challenges

Accurate reproduction of brand colors is particularly important in the label market. However, it is frequently not possible to achieve an exact match for a particular brand color using the four-color process sets of inks (i.e. cyan, magenta, yellow and black, or CMYK), especially with "conventional" non-digital offset or flexographic ink sets.

With conventional presses and inks the solution is to use extra ink colors that are specially mixed to be exact matches for the brand colors and to use these either as spot colors or in a non-standard process set.

For various technical and practical reasons, it is rarely possible to use special colors on digital presses. One reason is the cost of making a special ink, which is much higher than for conventional offset or flexographic inks. Another problem that particularly applies to inkjets (but not HP Indigos - see below) is the difficulty and expense of cleaning out the ink feed lines and print heads if you need to change between different special colors frequently.

Extended gamut inkjets

Because inkjets are not subject to the same historical limitations (or standards) as offset and flexo presses, it is common for inkjet inks to show greater purity in the CMY process colors. This means that even a UV-cured CMYK inkjet press will often be able to cover a wider color gamut than is possible with CMYK offset or flexo inks. Aqueous inkjets have their own challenges which tend to limit the achievable gamut, but they are not widely used in label printing.

In practical terms an extended gamut means that a greater number of brand colors can be matched satisfactorily. "HiFi color" was coined in the 1990s as a generic term for the concept of achieving extended gamuts in print. Global Graphics uses this term in its color literature.

Inkjet manufacturers also sometimes extend the gamut still further by adding channels for additional process colors for a total of six or seven. Typically these will be CMYK + orange + green (and/or violet), or CMYK + red + green + blue. These are often abbreviated to use just the initial letters of the colorants, such as CMYKOGV. Pantone Inc.'s Hexachrome is a specific variant of a CMYKOG ink set.

These additional process colors are sometimes called extra-trinary, meaning there are more than the standard three (i.e. CMY) colors. Black does not count because it creates neutral tints that do not contribute to the chromaticity of the image.

Each make of inkjet press and ink will tend to have its own gamut, however, so this needs to be assessed when compiling profiles and look-up tables to help match brand colors outside the normal range.

Opaque white colorants are also being increasingly offered with both inkjet and toner label presses. This will normally be used as separate undercoat or overcoat layer on clear or metallic substrates. However, sometimes it can also be integrated as a variable halftone with the main color image, to produce pastel shades. Several label presses now also offer the ability to apply spot varnishes in-line with the inks themselves.

Metallic inks are available with some large format inkjets and for some UV-cured inkjet label presses, but at the time of writing they are not yet widely used.

HP Indigo presses and their special colors

HP Indigo digital label presses with their liquid toner inks can run six or seven colors as standard. Compared with inkjets there is also less of a cleaning issue when switching between colors.

Uniquely among digital print processes, HP offers a facility called the IndiChrome Ink Mixing System for users to mix their own special colored inks in-house from a set of 11 base colors. They can alternatively order small batches of pre-mixed special inks from HP itself.

Even so, most users prefer to run the HP Indigo extended-gamut process sets (called "IndiChrome OnPress"), which are available in CMYK + orange + violet, or CMYK + orange + violet + green.

Global Graphics' color management solutions for digital presses

Global Graphics has developed high quality color management technology that is used with its Harlequin Digital Hub, supplied either as a near turn-key solution or an SDK for integration within a DFE built by a press vendor or integrator.

In both cases the Harlequin ColorPro color management system delivers accurate and optimal use of the printer's gamut. The color and screening is calculated within the RIP and the output raster from the RIP is delivered in the most appropriate format for the press.

Global Graphics provides expertise, documentation and other assistance in the final encoding of the raster delivered so that it can be stored, post-processed and/or forwarded to the printer controller for delivery to the marking engine (laser/drum for EP presses or heads for inkjet presses).

Profiling

Output profiles must be built on sound color science principles to produce color accurate proofs or final print color gamuts.

Color accurate printing is only possible if printing devices can be calibrated, with profiles designed for a given combination of ink, substrate, screening and resolution. Global Graphics supplies a wizard-based color utility called Harlequin SetGold that is designed to prepare a press for profiling by establishing an optimal "Golden State."

Harlequin SetGold™ v5 incorporates many solutions for color profile making by drawing from the latest Graphic Arts community research with the result of more color accuracy. Using Harlequin SetGold profiles along with Harlequin ColorPro in-RIP color management feature set allows easy control of ink/toner limiting requirements and minimizes challenges in representing neutrals accurately.

Gray balance

A gray balanced profile is the first step in building an output profile for a new printing device. This procedure guided by an informative GUI, can determine the correct inking & gray balance and correct the tonal scales values for a new device. This important step improves profile accuracy and avoids over-inking and is often overlooked.

This "Golden State" is then captured and calibration tables can be created for up to four color measurement device types and/or measurement systems, such as density, %dot, Status-T, Status-A etc, so that any non-reference printer can be adjusted to this "Golden State".

What this means is profiles made by the OEM in their color labs on their test presses can be used on a press installed in the field and still be highly color accurate.

Alignment of press color output with measurements of color neutrality also ensures that the output of neutral colors in a print is more robust with variations in media and ink/toner colors, with humidity etc, and remain visually neutral.

Ink limitation

For inkjet presses the separation of ink-limiting from regular ICC profile creation also allows responsibility for the two steps to be split. Over-inking on a UV-cured printer can lead to excess ink standing on the substrate or in extreme cases even running across it, risking contact with rollers and other press components which would then need careful cleaning to avoid marking further work. If aqueous inkjets are used excessive ink lay-down can lead to the substrate being saturated with water, leading to stretch, cockling and other problems.

The OEM, press vendor or integrator can use Harlequin SetGold to place a press in an appropriate golden state, or to develop standardized golden state profiles that are shipped pre-installed in DFEs for all presses. The end user can then use off-the-shelf profiling software, safe in the knowledge that they cannot over-ink the press.

Color gamuts and color matching

The gamut of a color printing device describes the size of the subset of all possible colors that can be printed on that device. The gamut achievable on most digital color printers using toner or UV-cured inks is larger than that of many conventional press technologies, including flexography and offset litho. Equally important, that gamut more or less encapsulates the gamut of conventional printing processes when using CMYK inks, which means that virtually any color that can be printed using those traditional technologies can also be printed on a digital press.

This is important because one requirement for at least some label printing is to match conventionally printed pieces. This may be:

- Because some copies of the same product are produced conventionally and some digitally, and the different print runs must match.
- Because the product is printed in a hybrid fashion, where some or most of the label is printed using a conventional press but additional imagery is added using a digital print head, either in-line with conventional press stations or in a separate converting process.
- Because labels must match other uses of the same imagery, which may be produced using conventional printing technologies, such as collateral and magazine advertising.

Harlequin ColorPro includes the ability to use multiple ICC color profiles to specify the color behavior of the digital press on which the labels are being printed, and that of a conventional press (or standard press characterization) that must be emulated.

To demonstrate this capability, Harlequin has been certified by Fogra against ISO 12647-7 (the contract proofing standard) in matching no fewer than 7 standardized press characterizations.

This certification was performed on an Epson Stylus Pro 7900, which is clearly a more stable device than a high-volume production press, but it is notable that Harlequin is the only Fogra contract proofing certification achieved on an Epson printer to date with off-the-shelf Epson media and inks.

It's unlikely that a production press would be stable enough to achieve contract proofing standard, but the Harlequin certification demonstrates that Harlequin ColorPro can help an output device deliver consistently accurate color; the only limitation is likely to be the stability of the device. Many production presses can probably achieve 12647-8 (validation proof) certification.

So, if CMYK colorants on a digital press can usually enable accurate emulation of a conventional print process, why use gamut expansion using HiFi color spaces? The answer is that brand colors are extremely important in label printing, and many spot colors fall outside of the gamut of CMYK, even on a digital printer.

When using a conventional press brand colors are usually achieved by using specially formulated spot inks, but the use of custom colorants on digital devices is very rare because of their cost, the long development time, and the difficulty of changing colors and cleaning ink/toner feed systems after use without contamination of the next color.

It's been estimated that only around 40% of Pantone colors can be achieved using a standardized CMYK space in conventional print (e.g. G7). The proportion that can be printed using CMYK colorants on most digital presses is likely to be slightly larger than this. But that still leaves a significant proportion of brand colors outside of the achievable gamut, whether they're specified using Pantone or not.

A HiFi space using a larger number of colorants, such as CMYKOGV (i.e. CMYK + orange + green + violet), greatly increases the press gamut, and it's been estimated that around 80% of Pantone colors can be printed accurately in this way. That reduces the proportion of brand colors that can't be printed exactly from 50-60% down to 20%. It also reduces the reproduction error for that remainder, because they are less far outside the achievable gamut of the press. Whether brand owners are willing to accept the remaining discrepancy will vary between companies, but it's worth bearing in mind that most magazine advertisements will be printed in CMYK on offset and will almost certainly vary more from the target color than a label printed using a HiFi colorant set.

Using Harlequin ColorPro with brand colors

ColorPro includes look-up tables for Pantone colors so that a brand color within the PDF or PostScript file submitted for color management and rendering can be transformed accurately. What's more those look-up tables define the color of each Pantone number in a device independent way, so that it's transformed through the appropriate output profile for the press/media/colorant combination in use, meaning that it's not necessary to develop new look-up tables for every different substrate.

Additional tables can be created for colors from other libraries and for custom colors, and entries can be over-ridden if a brand owner wishes to adjust the reproduction of a color away from the formal Pantone definition for any reason.

In order to match the reproduction of a conventional print job using both process colors and brand colors, it's possible to configure ColorPro to emulate that conventional print process for all colors in the job other than the brand colors. The brand colors can then be rendered into the process space of the digital press, but without emulation, so that they use as much of the digital press gamut as they need.

Output to device

Color output from the Harlequin Digital Hub

The Harlequin Digital Hub is capable of outputting rasters in a variety of formats, suitable for delivery to most monochrome and color printers. The output configuration can be split up into a number of dimensions:

- Color space – what colorants are used for physical output. ColorPro can deliver data in:
  - Monochrome
  - Mono plus spots
  - CMYK
  - CMYK plus spots
  - HiFi spaces such as CMYKOG, CMYKOGV
  - HiFi spaces plus spots
  - PhotoInk spaces, which use light variants of process inks in addition to the fully saturated inks such as CcMmYKk to increase smoothness of gentle tonal graduations
  - PhotoInk plus spots

  Spots can include varnish and white colorants, and 'separations' used in the supplied data file for die-lines and other technical (as opposed to color) usage can be explicitly ignored or output separately.

- The interleaving of the supplied colorants can be controlled, both in the lay-down order, and in whether the separations are delivered interleaved by pixel, by line, by band or by frame.

- Raster depth can also be controlled; output can be provided:
  - As 1-bit per pixel halftone screened data
  - Using multi-level screening (e.g. for greyscale inkjet heads) and packed into 2, or 4 bits per pixel
  - As 8-bit unscreened contone data
  - As 10- or 12-bit unscreened run-length compressed data (RLE)

  Screening is dealt with in a separate Global Graphics white paper.

  The RLE options are useful if any post-RIP manipulation of tone levels is required, e.g. for near real-time closed loop calibration. Use of 8-bit contone in such situations can lead to 'stepping' or 'banding' artifacts in tonal graduations because of the loss of grey levels involved in the calibration process. Starting with 1024 or 4096 grey levels instead of only 256 avoids those issues completely, while the delivery of pre-compressed rasters reduces the time required to transfer them within the DFE and reduces storage costs.

The Harlequin Digital Hub can consume PostScript, EPS and PDF (as well as image formats such as TIFF, JPEG etc). The ColorPro color management engine applies equally to all input formats, meaning that only one integration is required to achieve consistent color management across all formats.

Conclusion

Digital printing is changing the economics of label printing. Very short runs, just-in-time ordering, smaller inventories, frequently changed designs and some degree of personalization or localization are all feasible with costs-per-copy that end customers are likely to accept.

However, brand color matching, as well as the requirement to achieve similar overall color appearance to other printed and digital media, remain vital to the acceptance of digital printing within this market.

The technical nature and economics of the primary digital label press processes mitigate against specially mixed inks to achieve brand colors. Extended gamut process ink sets are used instead.

This in turn requires high quality color management to achieve accurate color matches and predictable colors that are consistent on the same press over time, as well as the ability to match colors across different presses and even different print processes.

Global Graphics' color management is proven in the field and is a major benefit to OEMs choosing the Harlequin Digital Hub.

Glossary and notes

Color channel:

In imaging software, a color channel is the data description for a single color component, such as red in an RGB set, or magenta in a CMYK set. Spot colors can be preserved as separate channels. They are interpreted in the RIP and may be incorporated in the process color separations, or preserved and directed to a separate ink channel in the case of special colors such as white, silver, varnish or a specially mixed brand color.

In inkjet printing, a channel is an individual ink path leading to a print head. At the basic level there will be four channels, for CMYK, but there may be more with additional channels given over to white, varnish and/or extra-trinary colors such as orange and green.

Note that some inkjet print heads contain two channels, as separate rows of nozzles. Depending on the press configuration, sometimes they will both print the same color, to build up density, and sometimes it will be different colors.

Color separation:

This is the method of dividing a full-color original image into the four, six or seven ink colors of a process set. The full color original will often be a photograph that normally starts as RGB color values from a digital camera or film scanner. However, separation can also be applied to text, tints and line art that may be defined in RGB, LAB or Pantone® values and needs to be split into process colors for printing.

Separation can be performed at several stages in the workflow from original to printer. If it is performed in the design or imaging software (such as Photoshop®, InDesign®, QuarkXPress or Acrobat® Distiller), it will normally be split into CMYK values, although Pantone's six-color Hexachrome® is an option with some systems. These can be set to either preserve special colors as extra channels, or they may combine them into the CMYK set depending on the user settings.

If the target printer has six or seven color process sets, then a CMYK set should not be used as input. This is because the separation process will compress the original gamut to fit within the CMYK gamut, and the process cannot be reversed.

Instead, the original artwork should be supplied as RGB or CIELAB values for photographs and other artwork elements as appropriate. Where Pantone values are required, these should be left as separate spot color channels. This allows the Digital Hub software to make the best allocation of colors to utilize the maximum gamut of the printer's inks in the separation process.

Color space: This is the technical term for a defined range of colors (or reference colors) within the theoretical whole of a color model such as RGB or CMYK. For instance AdobeRGB or Pro Photo are color spaces for original camera/scanner images, and these are subsets of the theoretical complete RGB color range (most often described as CIE LAB, which itself is a subset based on the color sensitivity of the average human visual system). Fogra 39 is a standardized CMYK subset, primarily intended for offset printing. It is subtly different from gamut, which describes the actual range of color values obtainable from a device in that a color space includes the relationship between the numerical representation of a color and its appearance.

Colorant: An ink or toner actually imaged on press. Individual colors defined in the artwork for the job may be transformed to be printed as a build of colorants representing the process colors (e.g. images separated into CMYKOGV), or may be printed as their own colorants (e.g. a white or varnish).

Extended gamut: In the context of digital label presses, it means the use of inks that can achieve a wider range of colors than the standard CMYK set used by non-digital offset lithography or flexography print processes.

Because non-digital CMYK sets were standardized many years ago with relatively impure shades of cyan, magenta and yellow, then it's possible to achieve wider gamuts with purer, but non-standard CMYK sets.

Many digital inkjet label presses use purer CMYK sets, so they can credibly be claimed to achieve wider gamuts than offset or flexo. Even so, their gamuts are still relatively restricted, so some inkjets are also being offered with additional colors.

There is so far no ISO standard for extended gamut ink sets. Pantone's Hexachrome six-color set is a proprietary standard that can be licensed by ink suppliers; its use is largely confined to packaging applications.

Extra-trinary colors: A name for ink colors that are additional to the three commonly used colors, cyan, magenta and yellow. Extra-trinary means "more than three." Black (K) does not count as a color, because it does not add chromaticity to the image.

HiFi color: A name for the concepts of improved quality printing that emerged in the 1990s as part of a multi-vendor initiative. The main elements were the development of FM screening and related techniques, and work to make six and seven color process sets more practical.

PDF/X: Some workflows for supply of artwork from customer to printer will convert all elements to CMYK in advance. In particular, the PDF/X-1a creation process includes the conversion of artwork to CMYK (and spots). As discussed above, this should not be used for label presses with more than four colors.

Instead, if a PDF/X workflow is required, then a later standard, normally PDF/X-3 or X-4, should be used. These support CMYK and spot colors, as well as calibrated (managed) RGB or CIELAB colors, with ICC profiles.

PDF/X-5n explicitly allows for the creation of files in which graphical elements are specified in the native color space for a press using a HiFi ink set. It is supported in Global Graphics' ColorPro solution, but has not yet been widely implemented in creation tools.

Process color: A standard set of more or less transparent colored inks that can be used together in various combinations to achieve a wide range of colors (the range achieved being called the gamut). The most common process set is cyan, magenta, yellow and black (CMYK), often called the four-color set.

There are many colors that cannot be achieved satisfactorily from these colors alone (for example the popular Reflex Blue, and pure shades of orange, green and purple). Therefore some presses can apply additional transparent colors, usually a choice of green, orange and violet, but sometimes red, green and blue.

The importance of these extra colors being referred to as part of a process set is that they can be part of a modified color separation process and are used in variable amounts as needed to generate particular parts of the consequently expanded color gamut.

Extra ink colors that are called spot or special colors are defined as separate channels or layers within the original digital image. The usual intent is that they are printed as special colors on the press, although if this is not available on a digital press, they can be merged into a process color set by the color separation software. While they can be integrated into photographic images (for example adding a metallic silver behind a car), the process is usually done by manually defined masks and not part of the automated color separation software process. See Spot Color and Color Separation.

The advantage of using an extended gamut process set on a label press is that you never need to worry about changing special inks. You may also be able to achieve multiple different brand color matches side by side or sequentially on the same run.

Spot color:

A common term for a specially mixed ink color that is not part of a process set of inks. Also called Special color. Typically this will be a brand color that cannot be matched satisfactorily by combinations of the standard CMYK four-color process inks.

As noted elsewhere, the only digital label press that currently offers a true spot color facility HP Indigo.

Alternatively, special or decorative effects inks, such as metallics, or white under/overcoating inks, or spot/pattern clear varnishes, are also regarded as spot colors.

The artwork for a label may also include one or more "technical" spot colors, e.g. to specify where a die line should fall.

ColorPro enables the operator to determine whether any individual Spot color should be printed using a build of process colorants, or if it should be printed as a separation in its own right. Also see process color.

1. About Global Graphics Software

Global Graphics Software is a leading developer of software platforms on which OEMs, ISVs and system integrators create solutions for digital printing and electronic document applications.

Customers include leading brands such as HP, Corel, Quark, Kodak and Agfa. The roots of the company go back to 1986 and to Cambridge University in the United Kingdom. Today the majority of the R&D team is still based near this university town. There are also offices near Boston, Massachusetts and in Tokyo.

Software solutions are typically sold under technology agreements with OEMs, ISVs and system integrators. The length of these agreements varies according to the commercial arrangements. Global Graphics is noted for its flexible approach to licensing its software and prides itself on being a trusted commercial and development partner.

2. The Harlequin Digital Hub

The Harlequin Digital Hub is at the centre of Global Graphics' offering to press vendors for developing Digital Front Ends (DFEs). It comprises a range of technologies that can be customized to provide the optimum solution whatever the combination of ink or media.

The Harlequin Digital Hub enables press vendors to create exceptional quality output that is repeatable and reliable while handling data at speed. The combination of technologies available, allow vendors to build DFEs without incurring uneconomically high costs so that they can minimise the cost of the bill of materials for the DFE vs. the cost of the press. These technologies include:

- Fast and compliant rendering:
  - Native PDF and PostScript using Harlequin Host Renderer™
- Color matching and color management:
  - Harlequin ColorPro™
  - Harlequin SetGold™
- Screening engines:
  - One-bit and multi-level AM, FM and hybrid screens using the Harlequin Screening Library™
- Imposition:
  - Fast and high-quality results using automatic tiling, scaling and page rotation options
- Variable data processing:
  - Harlequin VariData
- Font emulation:
  - Patent-pending technology for time-critical applications
- Trapping:
  - Harlequin TrapPro™

Sept 2013

Global Graphics Software Inc.
Somerset Court, Suite 320
281 Winter Street
Waltham, MA 02451, USA
Tel: +1-978-849-0011

Global Graphics Software Ltd.
Building 2030
Cambourne Business Park
Cambourne, Cambridge
CB23 6DW UK
Tel: +44 (0)1954 283100
Fax: +44 (0)1954 283101

Global Graphics KK
704 AIOS Toranomon Bldg.
1-6-12 Nishishimbashi, Minato-ku,
Tokyo 105-0003
Japan
Tel: +81-3-6273-3740
Fax: +81-3-6273-3741

www.globalgraphics.com