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TECHGUIDE SERIES:

Demystification of In-Line Automated Color Monitoring and Control for Digital Presses – Part 2

Part 2: An Overview of a Closed Loop Continuous Color Control Model

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Manual vs. Automated Color Control

The traditional method of color calibration of a digital press is a manual operation, which falls into two logical categories. The first is a one-time task during the make-ready operation and the second is on going during the press run. Make-ready for a digital press refers to work done to make it ready for printing a particular image, including loading paper, ink, toner, and adjustment of color and registration. The focus here is on color make-ready. Prior to startup, a page or sheet with a color bar printed along the direction of the run is pulled and measured manually. Measured color and density values are compared to target values. The operator uses keyboard entry to adjust density values to correct for deviations. This is an iterative and time-consuming manual process until the target values are achieved. It's also wasteful of paper and colorant. A similar process would have to be undertaken during a run by interrupting the press to make mid course measurements and adjustments to color reproduction. In each case, it's the human operator who closes the loop between manual color measurements and adjustment of colorant densities. Doing this by hand on-press normally will cost more in press time and material waste than the proposed automation. With an automated process, color make-ready and run time press calibration fold into one continuous operation from press startup to print run completion. In this case, a high-speed color measurement instrument (in-line spectrophotometer) mounted on the press computes and commands the corrective density adjustments electronically. This is accomplished by intermediate color correction computations and system feedback fast enough to keep up with press speeds. The key operational benefits of automated color control are:

- Reduction in make-ready time
- Reduction of media and ink or toner waste during make-ready
- Increase in productivity due to avoidance of press interruptions
- Increase in overall throughput due to continuation of press operation even after media and colorant changes have been made

Item #4 refers to on-the-fly color monitoring and control even when colorants and paper stock with measureable and visually noticeable color shifts have been introduced into the same print run. As a catch all, it is important to note that eliminating subjective color judgment frees press operators to perform other important tasks during print production.

An Automated Closed Loop Color Monitoring and Correction System

The main components of an automated color system integrated with a digital press include the following (Figure 1):

- Multi-band in-line spectrophotometer
- On-board high speed computer and operating system
- Integrated feedback electronics which can control colorant laydown
- Software application which monitors and displays real time color correction performance

Controlling laydown implies that it is possible to send corrected colorant values to press control points which will either increase or decrease the density on paper to match a desired color or gamut of colors.

In addition to these on press components, a color bar is printed on the media along the direction of the press run. It consists of shadow, mid tone, and highlight gradations of each colorant as well as overprints with known spectral characteristics. There may also be one or more spot colors included in the color bar to maintain desired densities of special colors such as those used for company logos. The color bar is only an approximation of the actual colors in the page, and some work doesn't leave any room for trim. So, to ensure that important colors within a page are accounted for and not be too dependent on color bars, another admirable degree of freedom for the system is the inclusion of spectrophotometer motion control along the width of the press. This would allow the measurement and correction of specific elements of the printed page such as solid spot colors in a logo or critical solids printed by means of process color.

To round out the system, a useful quality assurance tool is a software application for continuous display of how well colors are controlled for consistency and accuracy throughout a run. Its purpose is to show on going press status as well as trending data showing the direction colors may drift prior to correction.

Spectrophotometer and On-board Computer

The on press spectrophotometer is the heart of the system. To be a key value drive in automated color control, it must be capable of making spectral measurements, color computations, and commanding color corrections at update rates which are consistent with ink jet and toner based press speeds. At a minimum, it should have the following performance characteristics.

- Report 31 spectral bands from 400nm to 700nm
- Compute L* a* b*, LCH, and status T&E densities while press is running at full speed
- Avoid media contact by operating at a range of 3 mm from print material and allowing media variations of up to .5 mm
- Provide a cost effective solution for mid range presses operating 2.5 m/s up to higher speed presses operating at 5 m/s

Integrated Feedback Electronics
The integrated feedback electronics for controlling colorant laydown are already a part of most web and sheet-fed digital presses. Normally, an operator would key in color correction values during press calibration, make-ready, and during an interrupted press run. The automated system avoids manual keyboard entry and provides a correction data path directly from the on-board computer in a hardwired fashion to the print engine. The most likely entry portal would be the printer's RIP.

The simplest form of color control is in one-dimensional look up table transformations for each of the cyan, magenta, yellow, black, or spot color (SC) densities separately to a color corrected value. C to C', M to M', Y to Y', K to K' and SC to SC' A more complex form of color control is required if there are spectral shifts in paper and/or colorants or if overprint values cannot be corrected by one-dimensional mappings. In this case the spectral measurements from the spectrophotometer would be used to generate a CMYK to CMYK' profile to compute new colorant values.

Monitoring Color Correction in Real Time
Any automated system should provide a means for reporting in real time how well it's doing with respect to a set of established performance criteria. It's important for such an automated color control system to employ software designed to monitor and display press color quality performance. It should give the operator the ability to set tolerances for density, delta E, and dot gain. At run time, it compares printed colors to reference colors. The results would be reported to the operator on a display screen to indicate whether or not the automated color control system is doing its job within tolerances established by the customer. At the end of the press run, an important summary response from the monitoring software would be trending and statistical analysis reports both for use by the operator and to present to the customer.

Automated In-Line Closed Loop Color Monitoring and Correction System

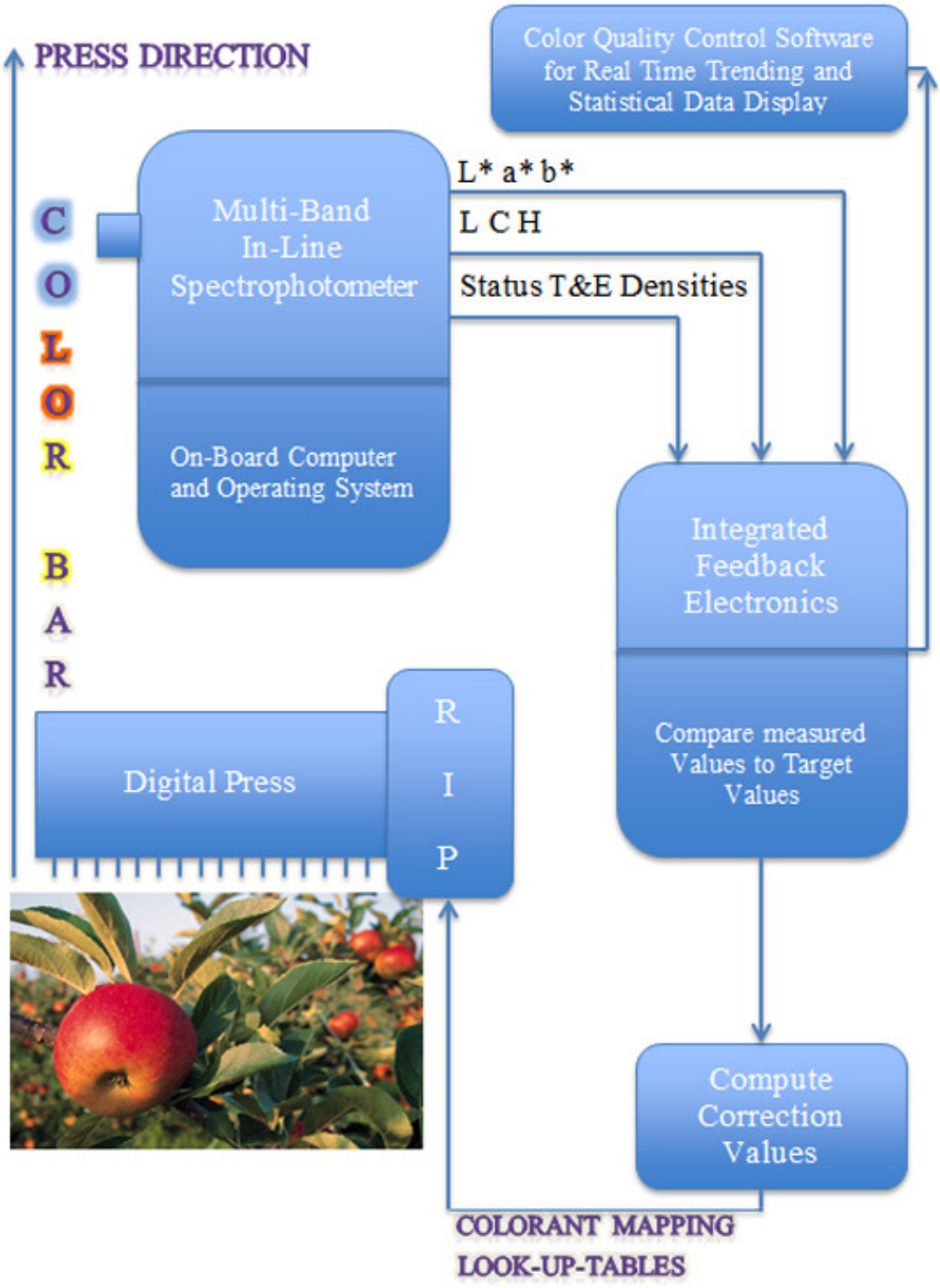

Figure 1