Technical white paper

HP PageWide Technology

Features and user benefits

Based on reliable HP Thermal Inkjet Technology and HP pigment inks, HP PageWide Technology offers high quality at high printing speeds. It is scalable to meet a wide range of application and performance requirements, and offers robust operation with economical print production.

Introduction

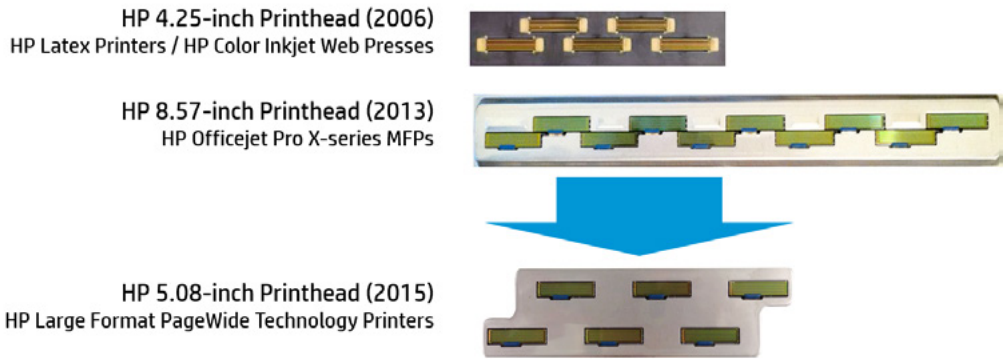
In 2006, HP introduced a versatile 4.25-inch Thermal Inkjet printhead platform that has been used in wide writing systems in HP's large format Latex Printers and in HP Color Inkjet Web Presses.[1] HP Scalable Printing Technology allows this printhead to be customized to a wide range of applications including different drop weights and inks. In 2013, HP introduced HP PageWide Technology in a high-performance family of desktop multifunction printers: the HP Officejet Pro X-Series. Using an 8.57-inch, 4-color printhead these MFPs are capable printing up to 42 US Letter A/A4 pages per minute.[2]

HP Large Format PageWide Technology Printers—a family of high-productivity 40-inch (1,016 mm) color printers for technical graphics and reproduction services—have unique operating and performance requirements that are not optimally provided by HP's 4.25- and 8.57-inch printhead platforms. For example, the 4.25-inch printhead delivers 1 or 2 colors of ink, and making a wide 4-color printer by stacking these printheads along and across the web (of printing material) requires a print zone larger than desirable for a technical graphics printer. The four-color 8.57-inch printhead module was not designed to be stackable or user-replaceable.

Both the strengths and limitations of these earlier generations of wide printheads provided an opportunity to develop a new HP printhead platform: the HP PageWide Printhead with a 5.08-inch (127.5 mm) print swath.

Three generations of HP wide Thermal Inkjet printheads are shown to scale in Figure 1. Note that each uses multiple, staggered HP Thermal Inkjet chips—called "dies." Dies are precision-aligned and placed on a dimensionally-stable substrate providing mechanical alignment, ink supply channels, and electrical interconnection. Both the 8.57-inch and 5.08-inch printheads have a stainless steel shroud surrounding the dies. This component facilitates capping and servicing the printhead and protects the dies from media strikes during cut-sheet loading/unloading and printing.

Figure 1 - Three generations of wide HP Thermal Inkjet printheads



[1] For example, this is the HP A51 Printhead for HP Color Inkjet Web Presses and the HP 881 Printhead in the HP Latex 3000 Printer.
[2] Based on ISO print speed for the HP Officejet Pro X576dw MFP. Maximum print speed is up to 70 ppm color and black.

From initial conception, HP's 5.08-inch printhead was designed to be an element of a scalable and versatile writing system that could power a wide range of high-performance HP PageWide printing solutions. Scalable describes a design philosophy where modules are repeated along and across the print zone to support a range of formats and features such as additional inks and higher print speeds. Modularity includes the printhead, ink delivery system, printhead drive electronics, and the image-processing pipeline. Versatility comes from the capability to customize drop generators to deliver the drop weights required by the application, media, and inks as well as the ability to use a range of water-based HP pigment inks.

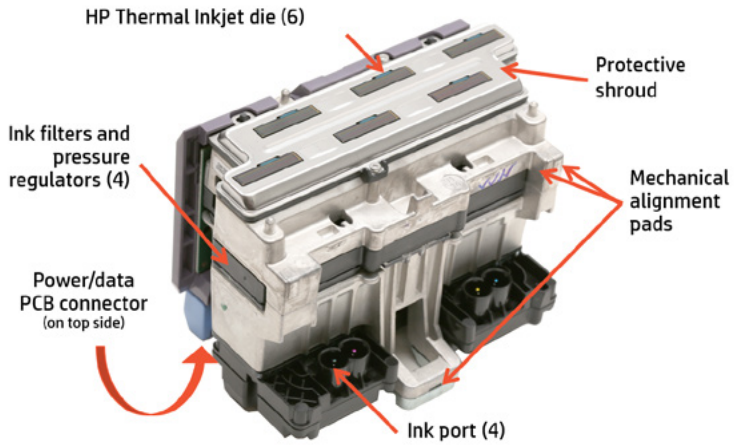
A new printhead platform for HP PageWide printing

Performance objectives and features for HP PageWide Printheads were driven both by the needs of HP PageWide Technology Printers and extensibility to future HP PageWide printing solutions:

- High sustained drop rates for reliable print quality in high productivity applications;
- Reliable drop ejection to reduce print quality defects from "nozzle outs";
- Extended time between service station cycles for sustained productivity;
- High print density in high-speed, one-pass printing for high black/color saturation at high productivity;
- Long life to reduce intervention rates and provide lower total cost of operation in high duty-cycle applications;
- Improved dot placement accuracy to meet the requirements of technical graphics;
- Stackability for a more compact 4-color print zone with the versatility to support a range of print widths;
- Compact print zone for better media control, precise color-to-color alignment, and to reduce printer size.

Printhead designs, ink delivery systems, ink technologies, service station functions, and materials proven in service by HP's 4.25-inch and 8.57-inch printheads were leveraged into the HP PageWide Printhead Module, shown in Figure 2.

Figure 2 – HP PageWide Printhead Module



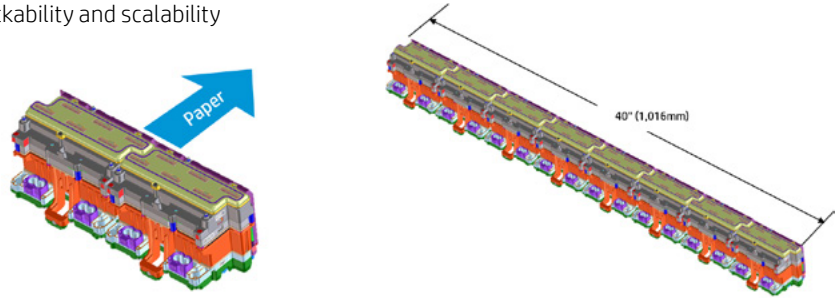
The following are key specifications and features of the HP PageWide Printhead:

- HP Thermal Inkjet technology
- 4-colors (CMYK), HP PageWide Pigment Inks [3]
- 25,344 nozzles per printhead
- Modular, stackable design for scalable printing solutions
- Built-in ink filtration and pressure regulation
- 5.08-inch (129mm) print swath
- 1,200 nozzles per inch native resolution
- 6,336 nozzles per color
- User replaceable without tools or mechanical adjustments
- Designed for sustained, high-speed printing

Improved stackability is obtained by the "S-shape" design of the modules. This shape allows them to fit together in a compact, linear printbar shown in Figure 3. Printing configurations of different widths are available in 5-inch increments. For instance, eight HP PageWide Printheads are stacked together to make a 40-inch printbar, but scalability supports narrower or wider formats.

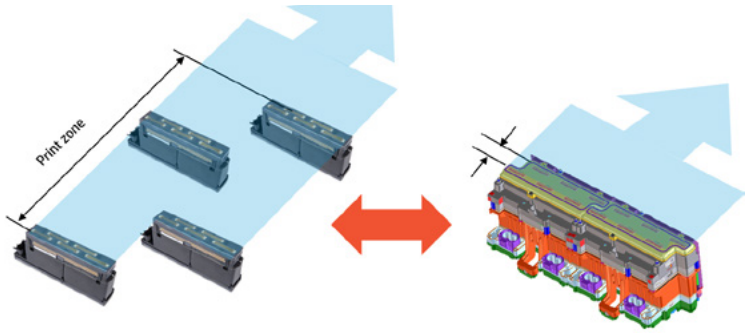
[3] HP PageWide Pigment Inks are described in the companion White Paper: Inks for HP PageWide Technology, June 2014

Figure 3 - Stackability and scalability



Two schemes for 4-color printing are shown schematically in Figure 4. Four HP 4.25-inch printheads produce an 8-inch print swath and two HP PageWide Printheads produce a 10-inch swath. The arrangement of printheads is shown to relative scale.

Figure 4 - Compact print zone



When the 4.25-inch printheads are configured to print two colors of ink, two printheads are required along the paper feed direction in a 4-color printing system. In HP's Color Inkjet Web Presses, this is implemented with two tandem printbars. Unlike HP PageWide Printheads, HP's 4.25-inch printheads were not designed to directly stack together and so they must be staggered and offset as shown in Figure 4.

HP PageWide Printheads stack together on a single printbar to provide a more compact print zone. A compact print zone gives better control of the media during printing. For example, maintaining precise spacing between the printheads and the media—on the order of 1 mm—is important both to dot placement accuracy and to prevent the media from striking (and damaging) the printhead. When the nozzle arrays for each ink are placed close together, and especially when all are on the same die, color-to-color alignment is easier to maintain because dot placement errors from media deformation and skew are reduced. This is important when using water-based inks on plain papers, because these papers can swell—"wet cockle"—and stretch when water is applied.

One-pass printing

While one-pass printing offers high throughput, it faces many challenges compared to the scanning printhead designs used in HP's large-format Designjet printers. Table 1 outlines some of the differences between scanning and PageWide printhead configurations.

Table 1 – Comparison of scanning and PageWide writing systems

	Scanning printheads	**HP PageWide Technology**
Printhead motion	Bi-directional scanning across the print zone	Fixed, spans the print zone
Media motion	Intermittent, precision position advance	Continuous, precision velocity control
Print modes	Typically 1-16 passes	1-pass, different media feed rates
Printhead servicing and decap management	May spit in spittoon after each scan (~2 sec)	Spit-on-page, decap up to 10 minutes
Error hiding	Multiple passes, nozzle substitution	Good nozzles substitute for out-of-spec nozzles
Maximum drops/sec	0.2 billion (HP T7200)	3.7 billion (40-inch printbar)

These characteristics of PageWide writing systems will be discussed in more detail in the following sections.

Inks for HP PageWide printing

HP developed a new generation of water-based pigment inks to meet the unique requirements of pagewide, technical graphics printing. In particular, high black and color densities must be produced in a single pass with lower ink loadings compared to scanning printhead printers.

Multi-pass print modes in scanning printhead systems limit wet dot-to-dot interactions by allowing ink to penetrate and spread between printhead passes. Several seconds can elapse between scans before a dot is printed next to its neighbor. This can allow higher ink loading than possible in a single pass because the ink is partially-absorbed between passes. Typically, it takes about 100 milliseconds for a drop of water-based ink to wet and begin to spread and absorb on the media surface.

In HP PageWide Technology, all the drops from each die are printed in a single-pass and within about 5 milliseconds at typical media feed rates. So, all ink interactions are wet-on-wet, and this is a challenge for ink design to control color bleed, feathering, and mottling in area-fills and images.

“Decap” performance—where the printhead is uncapped and does not have access to a service station for a clean and wipe cycle—is critical to PageWide printhead reliability and image quality. Without properly managing the effects of decap, print quality defects from slow, weak, or misdirected drops may quickly become visible. Scanning printhead printers typically spit a few drops from each nozzle into a service station spittoon every few seconds. In high-productivity applications, a PageWide printhead must operate reliably for several minutes without a visiting the printhead service station. Ink design plays an important role in this capability.

New HP PageWide Pigment Inks were formulated to meet these requirements. A companion Technical White Paper, Inks for HP PageWide Technology, discusses ink performance requirements and innovations in design of inks for HP Large Format PageWide Printers.

Media

A technical graphics printer must support a range of media commonly found in practical applications. These media include bond paper, vellum, thick bond paper, low-cost photo papers, poster papers, natural tracing papers, and polypropylene. HP PageWide Pigment Inks were designed to provide high line, text, and graphics quality on these materials.

Ink delivery system

HP PageWide Pigment Inks will be supplied in 400ml and 775ml cartridges. For unattended, high-productivity printing, some models of HP Large Format PageWide Technology Printers feature two sets of C, M, Y, and K cartridges. In dual-cartridge systems, the printer detects when a cartridge is out-of-ink and this triggers an automatic ink cartridge switchover. The operator can replace used cartridges while the printer is running.

When an ink cartridge is pressurized with air, ink is forced through tubes to the printbar and into an ink distribution system along the printbar. Flexible supply tubes allow the printbar to move vertically during servicing and capping.

Each printhead interfaces with an ink supply module. Ink supply modules are stackable and interconnect with each other to make a PageWide ink manifold. This scalable design allows printbars of different widths to be built by stacking together printhead and ink supply modules.

Each printhead is connected to its ink supply module with a needle and septum for each color. The four (4) ink ports on the printhead module are shown in Figure 2. A sheathed needle on the printhead module engages a septum on the ink supply module as the printhead is pushed and latched into place. Manual handling of ink tubes is eliminated.

Printhead servicing

In a PageWide printhead, nozzles are subjected to extended decap time and can be fully-serviced only by interrupting printing. When servicing is required, the printbar is automatically retracted from its printing position so that the service station module can operate in the space between the printhead and the media. The printheads are also capped in this retracted position.

The time required for servicing may reduce productivity under high use conditions, and so it should be performed as infrequently as possible. Usually, servicing can be performed while the printer is idle. HP PageWide Printheads and HP PageWide Pigment Inks are designed for continuous printing for up to 10 minutes.

An element of the solution to issues presented by extended decap time and infrequent access to the service station involves spitting ink onto the media while printing. So-called "spit-on-page" (SoP) servicing refreshes the ink in the nozzles. If drops from every nozzle are placed randomly, and not too many are required, then SoP effects are practically invisible to the user.

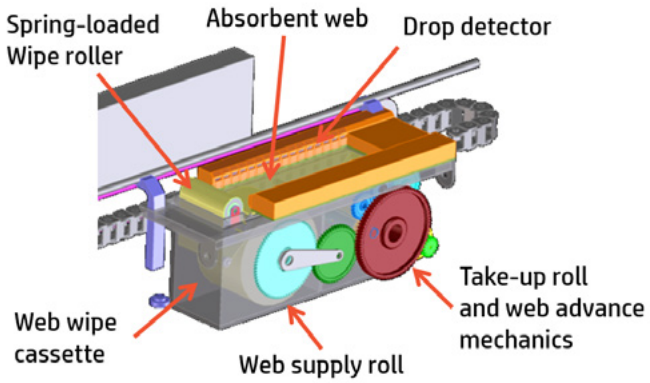
HP PageWide Technology achieves robust operation by combining a low rate of SoP with the properties of HP PageWide Pigment Inks designed for sustained printing and longer decap times.[3]

Wiping the nozzles

The service station components are shown schematically in Figure 5. Printhead nozzles and the protective shroud are wiped by scanning across the printbar during a service cycle. The service station has a user-replaceable cassette containing a web of absorbent material. This wipes the printheads and absorbs ink ejected from spitting and drop detection.

The web is pulled over a spring-loaded wipe roller that presses the web against the printheads. The web advances from a supply roll to a take-up roll providing fresh material while in contact with the nozzles. The cartridge is designed for hundreds of wipe cycles, and the printer's user interface notifies the operator when the web has been consumed.

Figure 5 – Scanning service station with web wipe cassette and optical drop detector



Testing the nozzles

The nozzles fire drops onto the absorbent web through an optical drop detector module. The optical drop detector is mounted above the web wipe cassette. The module contains twelve (12) pairs of LEDs and photodetectors allowing measurement of multiple nozzles at the same time. On-board signal processing electronics digitize and process the measurement data to determine the health of each nozzle as the service station scans across the printbar. The error rate for failing to detect a missing drop is 1 part per billion. All printhead nozzles—202,752—can be tested in a minute. Non-functioning nozzles are flagged in a "nozzle-out" lookup table used by the image processing pipeline for active nozzle substitution.

Capping the nozzles

A cap on the printbar rotates into place to cap the printheads when the printbar is retracted from the print zone. Features on the protective shroud allow the cap to self-align and seal around the dies. The cap provides a humid environment to keep nozzles healthy and ready to print.

Printer and printhead calibration

A three-channel densitometer developed by HP is mounted on the bottom of the scanning service station. This sensor is used in HP Designjet, Officejet, and Photosmart printers. It performs three important functions.

Edge detection during media loading

For proper image placement, the sensor locates the edges of the media as it is loaded into the print zone. (A separate top-of-form sensor measures the position of the leading edge).

Printhead alignment along and across the sheet

Adjacent dies overlap by 48 nozzles. A dot interference pattern is printed and scanned. The lightest patch corresponding to a particular selection of nozzles indicates the best alignment of nozzles in the overlap zone.

Closed-loop color calibration

This is a die-to-die color density calibration relating input levels to output print densities. Each die prints multiple levels of each primary color in a test pattern. Using illumination that gives the highest signal-to-noise ratio for each color (e.g., a blue LED is used to illuminate yellow patches), the reflection density is measured. Compensation is applied in the image processing pipeline to each die to produce the most uniform color across the printbar.

Error hiding in one-pass printing

Essential to achieving high quality in one-pass printing is reliable drop ejection and nozzle substitution. HP PageWide Printheads and HP PageWide Pigment Inks were designed together for reliable drop ejection. HP Thermal Inkjet's capability to produce high drop rates and its high nozzle density of 1,200 nozzles per inch provide both active and passive nozzle substitution to suppress the effects of failed nozzles. A failed nozzle could leave an unprinted dot row along the media feed direction. For example, this could be seen as a white streak in a black area fill.

The choice of where to place ink drops to produce smooth text and lines and area-fills of a specified density—as well as the selection of nozzles to substitute for a failed nozzle—involves sophisticated algorithms to control ink load and to minimize image artifacts (such as edge roughness in text and lines, image grain, and banding).

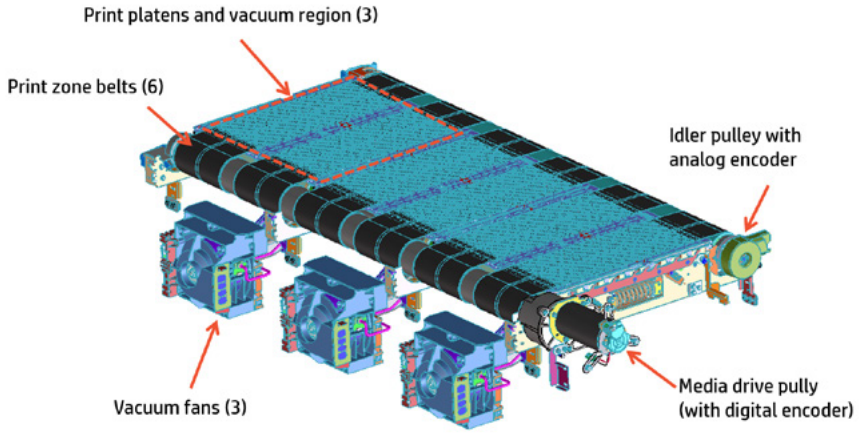
Passive nozzle substitution makes direct use of HP Thermal Inkjet's high nozzle density: if a nozzle fails, the surrounding nozzles compensate for the missing dot row. Two neighbor nozzles are only 1/1,200th of an inch (21 um) from the center of the missing dot row. The dot size from HP PageWide Printheads allows ink to spread from adjacent dot rows to make a nozzle failure practically invisible. Passive nozzle substitution suppresses print defects between service station cycles, where bad nozzles can either be recovered or a persistent failure identified and flagged by the drop detector. In the latter case, active nozzle substitution is employed.

Active nozzle substitution uses a "nozzle-out" lookup table compiled from drop detection measurements. Some nozzles may remain out while others recover after printhead servicing. The lookup table is processed to select neighbor nozzles to eject drops at appropriate locations to compensate for a missing nozzle.

Media drive

More than 20 years of HP Designjet product development provided assets for building a high-precision media transport for HP Large Format PageWide Technology Printers. The media drive consists of six (6) perforated belts backed up by three (3) print platens. Under each platen is a plenum that is partially-evacuated by a vacuum fan. This provides precise media hold-down and control of printhead-to-media spacing. The vacuum in each plenum is controlled by a pressure sensor. The media drive system is shown schematically in Figure 6.

Figure 6 –Media



The belts are driven by a fixed drive pulley on the output side of the print zone using a DC servo motor with a digital encoder and transmission. The idler pulley on the input side is encoded by an analog encoder, and is pushed away from the drive pulley by four (4) tensioner springs. The pulleys have guiding grooves for the belts to suppress lateral motion.

The analog encoder, signal-processing electronics, and sophisticated algorithms predict when the belt (and media) will be at the next dot position, and this information is used to synchronize drop ejection from the printheads.

The media path outside the print zone includes mechanics to transport media from rolls in the media drawers, cut the media to length, feed the media into the print zone, feed the media through an optional dryer after printing, and eject the printed sheet into the proper output device (i.e., basket, stacker, or folder).

While media is being fed into the print zone, a slack loop—called a "media bubble"—is created to decouple forces in the media supply system from the media drive. This isolation is important to suppress banding from media velocity variations in the print zone. The media bubble also allows the trailing edge of the media to halt momentarily as it is cut exiting the media drawer.

Image processing pipeline

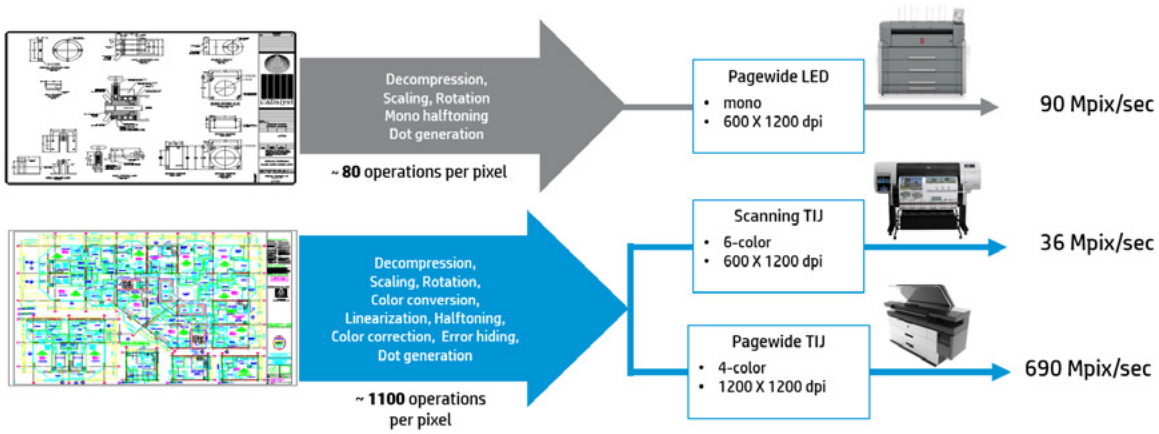
HP leveraged assets originally developed for high-bandwidth image processing in HP's family of Color Inkjet Web Presses. These 4-color presses print on webs as wide as 42 inches (1,067 mm) at speeds up to 600 feet (244 m) per minute.

Requirements for a 40-inch technical color graphics printer—such as low hardware cost, high integrated functionality, high sustained drop rates, and extensibility to wider (and more) printbars—drove key advances in electronics hardware, imaging algorithms, and data processing architectures. The result is a new generation of scalable and extendable image processing solutions with capabilities to support a wide range of HP PageWide Technology Printers.

Image data processing is illustrated in Figure 7. To give a sense of the amount of data processing required to print an image, HP PageWide Technology in an HP Large Format PageWide Technology Printer is compared to a monochrome PageWide LED printer and a scanning TIJ—HP Thermal Inkjet—printer, for example the HP T7200 Designjet printer.

In a monochrome LED printer, only about 80 operations are performed on each pixel compared to 1,100 operations on each pixel in a color inkjet printer. HP Large Format PageWide Technology Printers process about 7.5-times as many pixels per second as a PageWide mono LED printer and 19-times as many pixels per second as the HP Designjet T7200 printer.

Figure 7 - Comparison of image processing performance

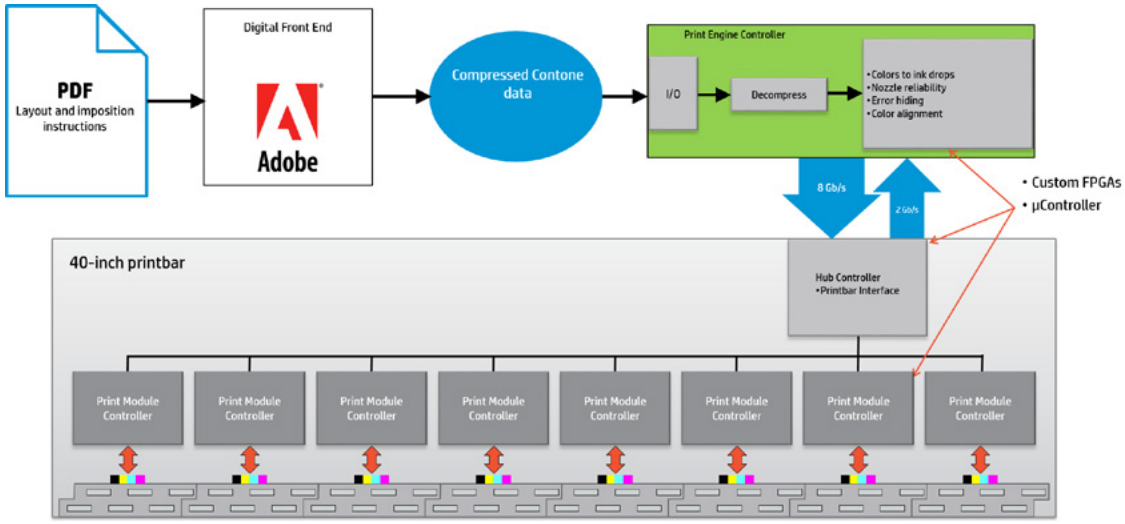


The modular architecture of the image processing pipeline for HP Large Format Pagewide Printers is shown schematically in Figure 8. Wider (or narrower) printbars can be built by adding (or removing) print module controllers. As with the printhead and ink supply modules, the image processing pipeline is modular and scalable along the printbar. By adding hub controllers for each printbar, multiple printbars can be supported in future product platforms.

The digital front end (DFE) of HP PageWide Technology Printers employs the latest version of the Adobe® rendering engine—the raster image processor (RIP). This ensures that the rendered output to the print engine controller is completely compliant with PDF specifications. The Linux-based DFE uses Intel® Core™ i3 or i7 processors.

The printer receives PDF files along with layout and imposition instructions from the HP Designjet SmartStream job preview and submittal application. Processing PDF files in the printer—compared to using an external RIP—significantly reduces the amount of data to be sent to the printer and ensures that the printer does not "run out of data" while printing under high network loading conditions.

Figure 8 - Scalable image processing architecture



Throughout the image processing pipeline, microcontrollers and custom FPGAs—Field-Programmable Gate Arrays—perform image processing and data management tasks. FPGAs run HP algorithms at speeds up to 190 billion operations/sec.

To control the printheads and other functions, the print engine controller delivers up to 8 gigabits/sec of data to the hub controller on the printbar. Up to 2 Gb/sec can be returned to the print engine controller. This information is produced by the drop detector, the printheads, and other writing system sensors including the analog and digital encoders on the media drive.

Summary

HP's vertical integration in the R&D and manufacture of inkjet printheads, inks, writing systems, and image processing underlies the design and development of advanced, integrated printing solutions.

HP PageWide Technology achieves productivity significantly higher than can be obtained with scanning printhead systems. The reliable operation of more than 200,000 nozzles arranged over a 40-inch printbar involves many challenges in the design, development, and integration of printheads, inks, printhead servicing, nozzle testing, writing systems, and the image processing pipeline.

HP PageWide Pigment Inks are a new generation of HP pigment inks designed for single-pass, PageWide printing. They produce high black optical density and high color saturation and allow HP PageWide Printheads to operate reliably with infrequent service cycles to deliver sustained, high-quality productivity.

HP PageWide Technology in the new family of HP Large Format PageWide Technology Printers is the first implementation of a third-generation HP Thermal Inkjet printing platform that will form the foundation for HP solutions—now and in the future—offering high-speed, reliable, robust, and economical printing on a wide range of media. HP PageWide Technology solutions are scalable and versatile in design and performance to meet the needs of a broad range of applications in office, commercial, and industrial printing.

Learn more at

hp.com/go/LargeFormatPageWide

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