Technical white paper

HP PageWide Technology

Breakthrough speed, professional quality

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Business moves fast. Professional impressions are paramount. Exceptional office printing helps set the pace, pushes projects forward, makes workteams more efficient, and improves the bottom line.

Breakthrough speed, professional quality

Using breakthrough HP PageWide Technology, HP Officejet Pro X Series desktop printers and MFPs deliver up to twice the speed[1] at up to half the printing cost compared with color laser printers.[2] This new class of devices offer the best of both ink and toner technologies, including:

- Fast printing speed, up to 70 pages per minute in General Office quality mode
- Powerful savings—up to 50% lower cost per page than color laser printers[2]
- No-compromise print quality, reliability, and energy savings
- Compatibility with corporate enterprise networks for management and workflow solutions[3]

Original HP pigment inks deliver superb output quality and resist smearing on a broad range of papers. Plus, offices save money through low acquisition and operating costs and can save additional money and resources with an ENERGY STAR® qualified device.

1 Comparison based on manufacturers' published specifications of fastest available color mode (as of March 2012) and includes color laser MFPs <$1000 USD MSRP and color laser printers <$800 USD MSRP available March 2012 based on market share as reported by IDC as of Q1 2012 and HP internal testing of printer in fastest available color mode (sample 4-page category documents tested from ISO 24734). For more information, see www.hp.com/go/printerclaims.

2 Cost per page (CPP) claim is based on the majority of color laser MFPs <$1000 USD MSRP and color laser printers <$800 USD MSRP as of March 2012, ISO yield based on continuous printing in default mode based on market share as reported by IDC as of Q1 2012. CPP comparisons for laser supplies are based on published specifications of the manufacturers' highest capacity cartridges. CPP based on HP 970XL/971XL ink cartridges estimated street price. For more information, see www.hp.com/go/learnaboutsupplies.

3 Supports HP PCL 6, HP PCL 5c, HP postscript level 3 emulation, native PDF printing (v 1.7), HP Universal Print Driver, HP Web Jetadmin, HP Imaging and Printing Security Center. Additional workflow solutions available through HP's certified software and third-party partner program. For solution details, go to www.hp.com/go/ideabook.

How HP PageWide Technology achieves breakthrough speed

HP PageWide Technology takes proven, advanced commercial printing technologies and scales them to a new class of multifunction printers designed to serve small workteams. More than 40 thousand tiny nozzles on a stationary printhead that spans the width of a page deliver four colors of Original HP pigment ink onto a moving sheet of paper. Because the paper moves and the printhead doesn't, HP Officejet Pro X Series printers are quiet and dependable offering laser-fast print speeds and a rapid first page out.

The HP Officejet Pro X Series comes standard with built-in duplex printing capability, two input trays, and copy, scan, and fax functionality on multifunction models.

The key elements of the HP PageWide Technology platform producing high print quality, speed, and reliability include:

- A pagewide array of 42,240 nozzles that produce ink drops with uniform drop weight, speed, and trajectory
- 1,200 nozzles-per-inch native resolution for consistently high print quality
- HP Pigment Inks that provide controlled ink-paper interactions, high color saturation, dark, sharp, and crisp text, and rapid drying
- Precise control of paper motion for dependable print quality and reliable operation
- Automatic nozzle health sensing, active and passive nozzle substitution, and automatic printhead servicing for dependable print quality

How ink printing works

The basic elements of ink-based digital printing are colorants, the process for transferring colorant to the paper, and office papers.

HP inks—a recipe for quality

Colorants form the image on paper by reflecting light at specific wavelengths to produce distinct colors. Colorants can be made of dyes, pigments, or a mixture of both.

Dyes are composed of individual molecules, whereas pigments are tiny colored particles whose diameter is about a wavelength of visible light. Both can produce bright, colorful images. However, pigments offer superior color saturation, black density, fade resistance, and smear resistance (for example, from water and highlighters) on office papers and coated brochure papers. These attributes make pigments the colorant of choice for HP LaserJet toners and for the HP inks used in HP Officejet Pro X Series printers.

In order to produce colorful graphics and images along with sharp, crisp lines and text, the colorant must remain at or very near the paper surface. If colorant moves across the surface or penetrates too deeply into the sheet, then lines and text won't be sharp, blacks won't be dark, and colors won't be vivid. To achieve high print quality, colorants must rapidly immobilize in a thin surface layer immediately after they reach the paper—a primary factor in the high quality produced by HP LaserJet printers and HP Officejet Pro X Series printers.

Moving the ink from printhead to paper

Unlike HP LaserJet toners, which are dry powders, inks are liquids during storage and delivery to the paper, and they behave like liquids for a short time on the paper surface.

Inks are composed of colorants and a clear liquid, called the "ink vehicle", that carries the colorants to the paper. The ink vehicle in HP pigment inks is primarily water, but it also contains ingredients required for consistent, reliable drop ejection and for controlling interactions between the ink and paper.

Ink travels to the paper surface in tiny, 6 picoliter drops. There are one trillion (1,000,000,000,000) picoliters in a liter, and a gram of ink yields about 170 million 6 picoliter drops. The printhead ejects drops one at a time through individual nozzles, and each drop must emerge at a consistent weight, speed, and direction to place a correct-sized ink dot in the correct location.

An HP Thermal Inkjet printhead has no moving parts. Nothing moves except the ink itself. Inside the printhead, shown by the cutaway diagram in Figure 1, an electrical pulse lasting about a microsecond heats a tiny resistor in the drop generator—a three-sided chamber with a refill channel and nozzle—that is filled with ink. A thin layer of ink vaporizes to form a bubble that expands to propel a drop out of the nozzle at around 10 meters (33 feet) per second. The bubble acts like a tiny piston, rising out of the floor of the chamber to push ink through the nozzle overhead. As the bubble collapses, after about 10 microseconds, it breaks the ink stream into a droplet and draws fresh ink into the chamber refilling it for another cycle (shown by the black arrow in Figure 1).

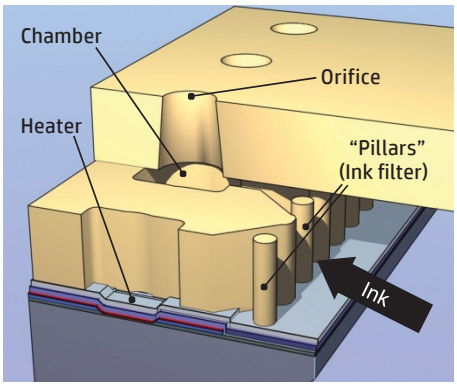

Figure 1: Cutaway view of an SPT-based drop generator

After leaving the printhead, the ink drop flies about 1 mm to produce a dot in a precise location on the paper. This process can repeat tens of thousands of times per second in each drop generator.

Once on the paper, pigments must quickly immobilize to produce sharp text and lines and to achieve high color saturation and black optical density. HP pigment inks quickly separate the pigments from the ink vehicle to prevent color and black inks from mixing at the boundaries of lines and characters.

The printed image dries as volatile components of the ink vehicle (primarily water) evaporate and leave the pigments behind.

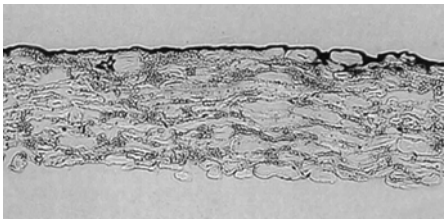

Figure 2: HP pigment ink on HP Multipurpose Paper with ColorLok® Technology
(Image source: HP)

Figure 2 shows a cross-section view of HP pigment ink on HP Multipurpose Paper with ColorLok® Technology. A thin, conformal film of pigments is seen on the paper surface along with the internal structure of the paper. The chemistry of ColorLok® Technology holds the pigments at the paper surface, enabling HP pigment inks to deliver color and black imaging performance comparable to HP LaserJet toners.

Building a pagewide printhead

HP Scalable Printing Technology

The dependable print quality, speed, and reliability of HP Officejet Pro X Series printers is made possible by HP Scalable Printing Technology (SPT)—the latest generation of HP Thermal Inkjet technology that employs ultra-precise and proven materials, design rules, and manufacturing processes.

SPT brings to printhead manufacturing the benefits of large-scale, precision processes developed for the production of integrated circuits. With SPT, all parts of the printhead, from thin-film integrated circuits to thick-film fluidic structures, are defined using a process known as photolithography, which can define very small structures. The ink passages, chambers, and nozzles in SPT printheads are produced with sub-micron precision to deliver every drop with uniform volume, speed, and trajectory for consistent image quality.

Figure 1 presents a schematic, cutaway view of an SPT-based Thermal Inkjet drop generator. On a silicon substrate, thin-film layers produce integrated electronic circuits and the resistors (or heaters) used to eject drops. A feed slot fabricated through the silicon (seen at the lower right) provides the ink supply to arrays of drop generator chambers placed on either side of the feed slot.

The pagewide printhead is designed to last the lifetime of an HP Officejet Pro X Series printer, and its reliable operation depends on robust contamination resistance. SPT enables the placement of tiny pillars (shown in Figure 1) that act as an ink filter, forming a barrier to particles that could enter and clog the drop generators.

The drop generator chamber and the orifice (nozzle) plate are made of the same photoimageable polymer (shown in a tan color). To give a sense of scale, the thickness of the chamber and orifice plate is less than a human hair (~50 microns). This integrated structure is built up from the silicon through several steps involving polymer deposition, exposure, and development. To help ensure a long service life, the thin-film layers on the silicon substrate, ink feed slot, chamber, and orifice material all have high resistance to chemical interaction with the inks.

A pagewide printhead

Figure 3: Pagewide writing engine assembly

HP's pagewide, 4-color writing engine assembly is shown in Figure 3. Ink cartridges for black, magenta, cyan, and yellow inks plug into ink fittings at the top of this assembly that provides pressure regulation and filtration for each ink. It also senses when the cartridge is running low or out of ink. Cartridges can be changed easily: an informational animation on the printer control panel describes this process.

The printhead has 10 HP Thermal Inkjet chips, called dies,[4] placed upon rigid, dimensionally stable, injection-molded plastic carriers. The carriers precisely align each die in the array and provide interfaces for the ink. Figure 4 shows a bottom view of the writing engine assembly with the printhead visible.

Figure 5 shows a close-up view of a die and its neighbor. Each die has 1,056 nozzles for each of four ink colors, totaling 4,224 nozzles per die and 42,240 nozzles on the printhead.

The nozzle array for each ink is formed from two columns of drop generators on either side of an ink feed slot fabricated through the die (see Figure 5). The polymer material that forms the orifice plate and drop generator chambers is transparent, so the drop generator chambers and the surface of the die with its four-ink feed slots are visible in Figure 5.

The printing order, seen top-to-bottom in Figures 4 and 5, is black, magenta, cyan, yellow (KMCY).

4 The term "die" comes from integrated circuit manufacturing and means a silicon chip. HP Thermal Inkjet printheads start out as silicon wafers with integrated electronics and heaters.

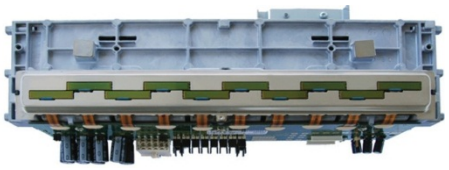

Figure 4: Pagewide writing engine assembly, bottom view

Figure 5: Detail of an HP Thermal Inkjet die

Figures 4 and 5 show the stainless steel shroud that seals around the dies. The shroud provides a flat surface for the service station to cap and wipe the printhead.

Electrical connections are made by bonding a flexible circuit to interconnect pads on the sides of each die. These bonds are protected by the (blue) bead of epoxy seen in Figure 5. The flexible circuit carries signals and power between each die and a printed circuit board on the writing engine assembly (seen in Figures 3 and 4).

In addition to the drop generators, each die has integrated electronics for signal-processing and power-control. Only 10 electrical interconnections[5] to each die are needed to operate 4,224 nozzles. Data rates into each die can exceed 100 megabits per second.

As seen in Figures 4 and 5, dies are staggered and overlap by 30 nozzles at each end. For the dot rows in the overlap zones, the printhead uses nozzles on both dies to suppress any print artifacts at the die boundaries.
The print swath spans 8.575 inches (217.8 mm), allowing HP LaserJet margins[6] on US Letter A and US Legal (8.5 inches) and ISO A4 (8.27 inches) formats. For each of the four colors, the print swath is 10,290 dot rows spaced at 1,200 dots per inch across the printhead.

Managing 42,240 nozzles

HP PageWide Technology periodically tests the performance of all 42,240 nozzles on the printhead to help maintain dependable print quality. This automatic process finds nozzles that are not performing within specifications, and also checks each nozzle frequently so that it catches and corrects any failures that could affect print quality.

HP Officejet Pro X Series printers use optical sensors to calibrate the printhead, measure nozzle performance, and monitor paper motion. These sensors are placed on a small carriage that scans across the paper and printhead. A paper sensor scans printed diagnostic test patterns, and the writing system controller uses this information to electronically compensate for die-to-die alignment tolerances and variations in drop volume that could produce visible print artifacts. This sensor also detects the edge of the sheet as it moves into the print zone. A printhead sensor, developed specifically for HP Officejet Pro X Series printers, measures individual drops in flight as part of a system that provides robust print quality by substituting good nozzles for those that do not meet operating specifications.

Pagewide printing arrays, whether in a toner- or ink-based printer, can produce streaks along the paper axis when dots are missing or misplaced. With ink, a bad nozzle typically produces a light streak that is visible in the dark and mid-tone areas of monochrome images; a light or colored streak may appear in color graphics and images.

With 1,200 nozzles per inch across the page, missing or misplaced black dots from one or more isolated bad nozzles will generally have little or no visible effect on black text. Because text is printed at high density, the spread of ink into the missing dot row from neighboring dots will suppress a streak.

The problems with bad nozzles can be suppressed by nozzle substitution, by which the immediate neighbors of a bad nozzle take over printing its dots. For the printing system to perform automatic nozzle substitution, it must determine precisely which nozzles are good and which are bad.

5 With redundant power and ground connections, there are 16 physical conductors.

6 LaserJet margins are 1/6 inch.

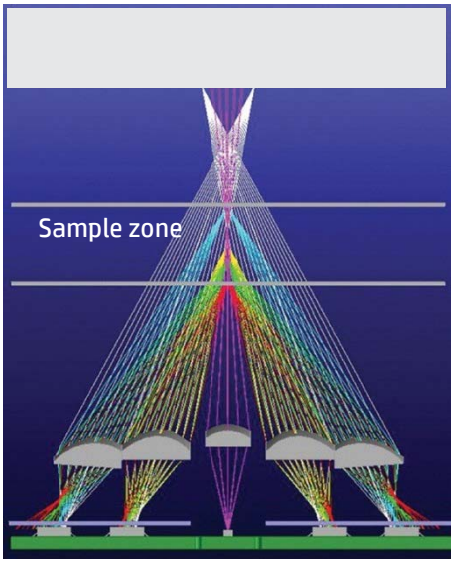

Figure 6: Schematic of Backscatter Drop Detection

There are many challenges to measuring individual ink drops in-flight from a pagewide printhead:

- Each drop is less than 25 microns (0.001 inch) wide, and drops move at about 10 meters (33 feet) per second.
- There are four nozzle arrays on each die. Since the dies are staggered on the printhead, the arrays of nozzles are positioned at different distances from the sensor.
- The measurement system must fit into a confined space close enough to the printhead to measure individual drops.
- The sensor must be highly immune to stray reflected light and electrical noise.
- Drop detection must have little impact on printer productivity.[7]

For HP Officejet Pro X Series printers, HP developed a new technology called Backscatter Drop Detection (BDD). BDD employs innovative optics and multiple photodetectors along with advanced analog and digital signal processing. Unlike other optical methods, where a drop passes between a light source and a detector, BDD works by detecting the light that is backscattered (reflected) by a drop passing through a focused light beam. The Backscatter Drop Detector can test several hundred nozzles per second.

BDD is shown schematically (with light rays traced) in Figure 6. The BDD module consists of a housing (not shown), five lenses, a surface-emitting diode (SED) light source indicated by the magenta rays in Figure 6, and four photodetectors—two on each side of the SED—behind aperture plates.

The SED emits a beam of light through a projection lens, and four imaging lenses focus backscattered light from the drops onto the photodetectors. With staggered dies on the printhead and multiple columns of nozzles per die, drops are emitted at different distances from the detectors in a sample zone that is about 0.4 inches (10 mm) deep. A backplane behind the printhead reduces unwanted reflections of light, which improves its ability to detect the very weak signal produced by backscattered light. After a backscattered signal is processed by analog and digital circuits, algorithms assess each nozzle's fitness to print.

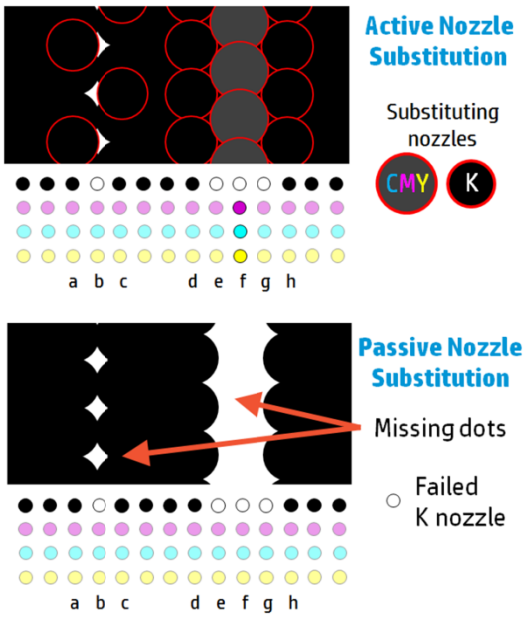

Figure 7: Schematic: nozzle substitution

Nozzle substitution

HP Thermal Inkjet's high drop rates and high nozzle density provide both active and passive nozzle substitution to suppress the effects of failed nozzles. This is one of the keys to the excellent print quality achieved by HP Officejet Pro X Series printers.

Figure 7 shows examples of nozzle substitution in a 1,200 x 1,200 grid for a passive case and two active cases. For orientation, dot rows run down this page, designated by the letters "a" through "h" in this figure. The nozzles out in this example are "b" and "e", "f", and "g", shown by the empty small black dots representing drop generators. Good black and color drop generators are shown by the small colored dots. Dot columns run across this page, and are associated with nozzle locations on the printhead. The paper moves down the page in this figure.

The choice of grid points that receive ink drops to produce a solid black area fill, as well as the selection of nozzles to substitute for a failed nozzle, use sophisticated algorithms to control ink load, minimize image artifacts (such as grain and banding), and implement active nozzle substitution. Figure 7 is highly schematic and doesn't take into account the full extent of dot spread, which will substantially fill in the white spaces as shown to further improve the results of error hiding. But, to illustrate basic principles, Figure 7 is faithful to the actual processes used for nozzle substitution.

7 Drop detection is typically done while the printer is idle, and the process can be interrupted by a print job.

Passive nozzle substitution makes direct use of HP Thermal Inkjet's high nozzle density: if one nozzle fails, the surrounding nozzles compensate. With 1,200 nozzles per inch, there are two nozzles for each ink color that can print within a 600 x 600 grid,[8] and neighbor nozzles are at most 1/1,200th of an inch (21 um) from the affected dot row.

Passive substitution is shown schematically for the nozzle printing column "b" in Figure 7. Nozzle failure could potentially produce the white streak shown in the lower half of the figure. But, with ink spread from the neighboring dots, the white streak is substantially smaller than a full 1,200 x 1,200 square. In fact, dot spread may completely close up the white space, making a single nozzle failure practically invisible. In any case, this defect will usually be difficult to see in normal-size text. After this nozzle failure is detected, active nozzle substitution is employed for row "b" in the upper half of the figure.

Active nozzle substitution uses a nozzle-out lookup table compiled from the results of several BDD measurements over time. Some nozzles may remain out while others recover after printhead servicing. The lookup table is processed to select nozzles that can take over printing from a failed nozzle. This may require double the drop rate from the substituting nozzles. In some cases, drops of other ink colors can be substituted in the same and neighboring dot rows. In this way, active nozzle substitution can effectively handle situations where two or more adjacent nozzles have failed.

Figure 7 shows two cases of active nozzle substitution: one black nozzle out (row "b") and three adjacent black nozzles out (rows "e", "f", and "g").

For a single black nozzle out in row "b", active substitution prints dots using neighboring black nozzles from rows "a" and "c". The upper half of Figure 7 shows this schematically with black dots highlighted here by a red outline. Alternating dots between rows "a" and "c" reduces the visibility of the white space and breaks up a dark line that might otherwise be visible if dots were substituted only on one side of row "b".

If three or more adjacent nozzles are out, active nozzle substitution uses both black and color inks. For example, consider black nozzles out in rows "e", "f", and "g" in Figure 7.

In the lower half of Figure 7, having three adjacent empty dot rows could produce a visible white streak as shown. Three adjacent dot rows are too large a gap to be effectively handled by passive nozzle substitution. After the failures are detected and processed into the nozzle-out lookup table, active nozzle substitution is applied as shown in the upper half of the figure. Good neighboring black dots (shown highlighted by a red outline) are substituted in rows "d" and "h". Row "f" is printed with composite black dots, indicated schematically by dots with a red outline and dark gray fill, from the printhead's cyan, magenta, and yellow nozzles that print in row "f". (The printed dots are not actually gray – gray is shown only for the purpose of illustration.)

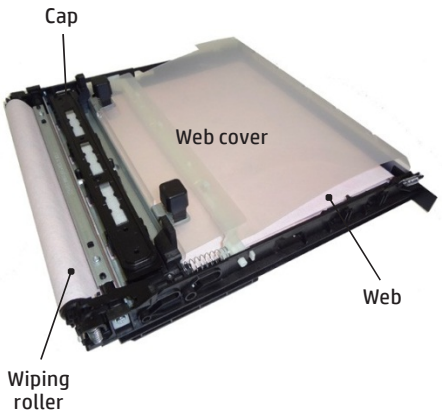

Figure 8: Printhead service station cassette

Printhead servicing

Periodic printhead servicing is an essential part of reliable print quality. It keeps good nozzles working and may be able to recover bad ones. HP Officejet Pro X Series printers feature a built-in service station cassette[9] that performs four key functions: printhead capping, nozzle conditioning, nozzle plate wiping, and ink containment used for servicing. While printhead servicing is automatic, a user may initiate a printhead cleaning cycle, if required. Figure 8 shows the cassette and calls out the key components.

When the printhead is not in use, it is capped to prevent ink from drying and clogging the nozzles. Capping provides a humid storage environment that keeps the inks liquid in the nozzles at a viscosity that allows drops to be ejected. The cap presses against the printhead's stainless steel shroud and seals around the dies without touching them.

8 For example, a 600 x 600 dpi print mode.

9 The service station cassette is designed for the life of the printer and is not user replaceable.

Nozzle conditioning refreshes the ink in each nozzle. This allows the printhead to eject drops within mass, speed, and trajectory specifications. Due to the loss of volatile ink components (mainly water), each nozzle periodically ejects a few drops through the print platen to purge ink that has become too viscous to meet print quality specifications and could clog the nozzle. Drops used for nozzle conditioning are captured below the print platen on a spit roller that indexes slowly with paper motion. Ink is removed from this roller and stored in a chamber inside the duplexing unit. Since a small amount of ink is used for nozzle conditioning, and it evaporates over time, the chamber capacity is designed to last the lifetime of the printer with no servicing required.

In the service station cassette, a circulating web of absorbent material stores used ink and provides a means of wiping the printhead nozzle plate. Because most of this ink eventually evaporates, the web dries between wiping and servicing events and is reused.

The web advances automatically during service functions. During servicing, the writing engine assembly automatically lifts away from the platen, allowing the service station to move under the printhead. For wiping, the web advances over a spring-loaded roller (see Figure 8) that gently presses it against the nozzles. This removes paper dust and any ink accumulation. The cassette then advances further under the printhead to engage the cap.

Ink and paper, working together

Pagewide printing requires special ink formulations and highly controlled interactions between ink and paper to achieve high print quality in a single pass. HP pigment inks produce superb results on ColorLok® papers.

HP pigment inks

HP ink chemists formulated HP pigment inks for HP Officejet Pro X Series printers to meet the demanding requirements of dependable, high-quality, fast, single-pass printing:

- Nozzle arrays for each color are placed close together on each printhead die, so inks must resist mixing and cross-contamination during operation, storage, and wiping.
- Black inks must produce high black optical density in a single pass.
- Single-pass, high-speed printing requires that the inks resist mixing at color-to-color boundaries in the image while still liquid. However, inks must be able to produce smooth and saturated secondary colors (such as reds, greens, and blues) in a single pass when different inks are printed dot on dot and wet on wet.
- The printer must quickly control paper curl and cockle (puckering) to prevent paper jams, and must quickly immobilize pigments to prevent ink from smearing during paper transport and to prevent ink transfer (sheet to sheet) in the output tray.

Papers with ColorLok® Technology

Liquid inks undergo complex physical processes and chemical reactions on the paper surface. Therefore, ink and paper must work together as a system to deliver the best results.

Substantial advances in both ink- and toner-based printing technologies have driven high demand for office papers that offer enhanced print quality with reliable and consistent results for both ink and toner. ColorLok® Technology delivers these benefits on plain papers used for office printing.

ColorLok® papers have special additives to rapidly separate pigments from the ink and immobilize them on the paper surface. For ink-based printing, ColorLok® papers deliver higher print quality with bolder, darker blacks, and richer, more vibrant colors. Ink dries faster, which means pages can be handled without smearing right from the output tray. All these benefits also apply for recycled papers with ColorLok® Technology. ColorLok® papers are available worldwide from leading paper suppliers.

HP recommends ColorLok® papers for best printing results. To learn more about the benefits of ColorLok® Technology, visit http://www.colorlok.com.

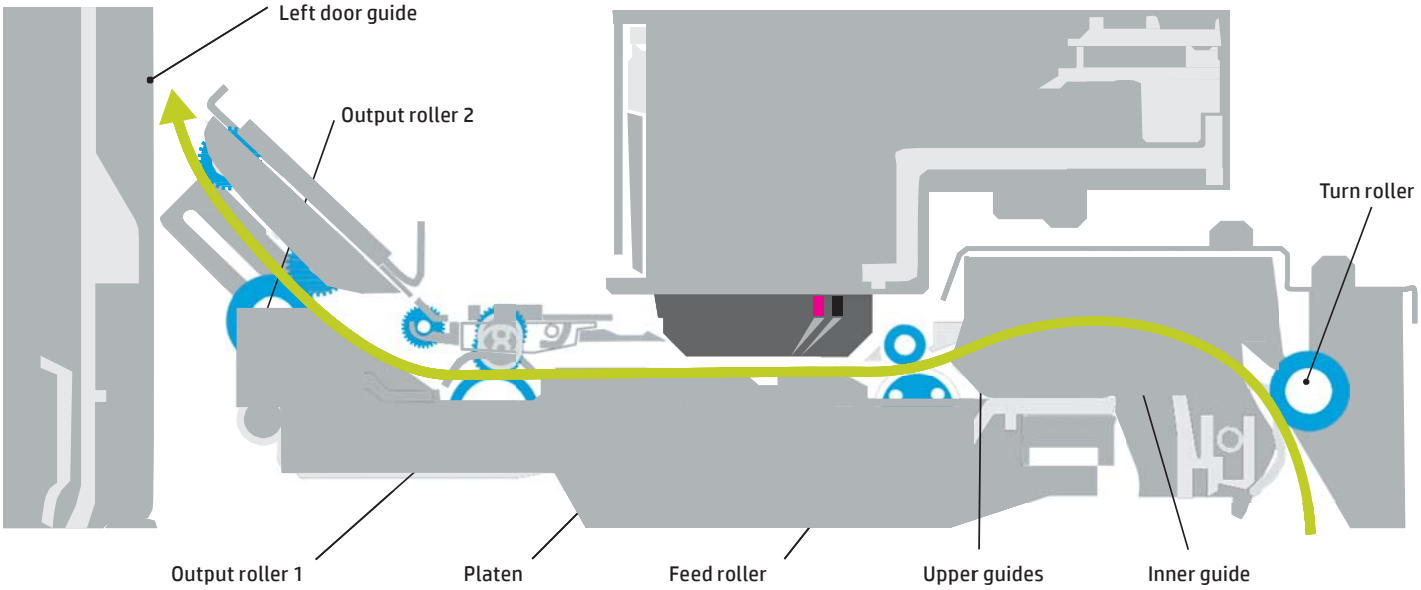

Figure 9: Cross-section of the paper transport system

Moving the paper

To compete with color laser printers in small workteam environments, HP Officejet Pro X Series printers need a compact, reliable paper transport that produces fast, face-down, correct-order output with built-in duplexing. HP designed a new paper transport to meet the needs of pagewide array printing. Figure 9 shows a cross-sectional view of the key components. A single sheet of paper, shown by the green arrow, moves from right to left in this view.

A sheet printed on one side (simplex) moves up against the left door guide, crosses the writing system assembly (Figure 3), and exits face down to the output bin. A duplex-printed sheet moves up against the left door guide, then reverses and passes under the duplexing unit (not shown), following the same path taken by sheets coming from the multipurpose tray (tray 1). This design efficiently integrates duplexing and multipurpose tray functionality into the paper path.

The HP Officejet Pro X Series paper transport effectively stabilizes and constrains the sheet through the printer from pick to drop. It delivers reliable paper pick, low jam rates, and continuous and accurate movement of the paper in the print zone. Sheets are printed, duplexed, and delivered to the output tray without smearing ink.

The HP Officejet Pro X Series paper transport incorporates a number of innovations that enable cost-effective, precise paper motion control. These include:

- A gear train with precision-matched pitch diameters
- Precision, low-cost bearings
- Servo-controlled overdrive of specific rollers
- Precision roller diameters
- Star wheels
- Drive shaft biasing to prevent backlash

Users have come to expect low rates of pick and jam failures from HP LaserJet solutions. HP adapted paper pick mechanics and paper supply tray spring-plate designs from high-end HP LaserJets to give HP Officejet Pro X Series printers pick and jam failure rates measured in single events over several thousand pages—similar to HP LaserJets.

Under steady-state conditions, constant paper velocity in the print zone is relatively easy to produce. In cut-sheet paper handling, however, a sheet's leading or trailing edge is almost always moving into or out of a set of elastic rollers, and this can disrupt smooth paper motion. If not properly controlled, edge transitions produce paper velocity variations in the print zone that can appear as dark or light bands and irregular lines. The paper transport in HP Officejet Pro X Series printers is designed to effectively handle edge transitions and maintain controlled paper motion through the print zone.

Uncontrolled movement of paper along any axis of motion or rotation translates into dot placement errors on the sheet. Motion in the paper feed direction and movements that affect printhead-to-paper spacing are of particular concern. Multiple hold-down features are incorporated into the paper transport design to stabilize and constrain the paper.

A dual reverse-bow is introduced in the paper on the input and output sides of the paper transport, as seen in Figure 9. This effectively holds paper against the platen and prevents the paper's leading and trailing edges from lifting while entering and exiting the print zone.

The high rate of ink application on paper from a pagewide array means that the ink is still wet when it leaves the print zone. Damp paper loses stiffness, so it must be handled carefully to avoid smearing ink. The paper path design addresses issues associated with handling a damp sheet by guiding the paper with star wheels—thin, metal gears that only touch the paper with sharp points, so they can roll over wet areas without leaving ink tracks. Although HP has used star wheels in printers for many years, they have not been used extensively to drive damp paper around tight corners inside a printer. The paper path for HP Officejet Pro X Series printers uses more than 300 star wheels to precisely control paper motion.

HP Officejet Pro X Series printers have an active flap near the output tray that controls curl as the printer ejects paper. The flap is closed when the printer is not printing. It opens partially when printing with high ink densities in dry environments—when more curl might occur—and opens fully under other conditions to control moderate curl.

Achieving high print speeds and fast first page out

Quality Mode	Simplex Pages/min.[11]	Duplex Pages/min.[11]
General Office	Up to 70	Up to 33
Professional—ISO (default)	Up to 42	Up to 22

The data processing architecture for HP Officejet Pro X Series printers was designed to support the high printing speeds from the pagewide printhead as well as provide fast first page out. Throughput of HP Officejet Pro X Series printers in General Office and Professional (default) modes are shown in the table at left.

First-page-out time—measured from the moment of selecting "Print" to the drop of the first page into the output tray—depends on a number of factors including host processor speed, interface type, network speed and network traffic, document complexity, and printer status (active, standby, sleep). From standby, HP Officejet Pro X Series printers take less than 10 seconds to put out an ISO standard page.[12]

Conserve resources—save energy and money

Mode	Officejet Pro X551dw Series
Off	0.14 W
Sleep	0.95 W
Standby	9 W
Operating	48 W

HP Officejet Pro X Series printers meet ENERGY STAR® guidelines and offer users low operating and standby power requirements and a low Typical Energy Consumption (TEC)[13] of only 0.6 kilowatt hours (kWh) per week.[14]

HP PageWide Technology saves significant power by eliminating the fuser required for toner-based printing technologies.

The table at left lists average power requirements for the HP Officejet Pro X551dw printer for different modes.[15]

Summary

HP Officejet Pro X Series printers bring the best of toner- and ink-based printing to small workteams by delivering high levels of reliability, color and black print quality, and productivity. These printers offer low product acquisition costs, have low total energy consumption, and produce color pages at up to twice the speed[1] and up to half the printing cost[2] compared with color laser printers.

HP PageWide Technology breakthroughs enable the high performance and robust print quality of HP Officejet Pro X Series printers. Exceptional features include a pagewide printhead with a nozzle density of 1,200 per inch for each of four colors, controlled ink-paper interactions using HP pigment inks, precision paper motion control, automatic nozzle performance measurement, active and passive nozzle substitution, and automated printhead service routines that can restore nozzle operation.

For more information about HP Officejet Pro X Series printers, visit hp.com/go/officejetprox.

11 Measured after the first set of ISO test pages. For more information, see www.hp.com/go/printerclaims.

12 For details, see www.hp.com/go/printerclaims.

13 TEC is based on ENERGY STAR measurement protocols. For more information, visit www.energystar.gov.

14 Preliminary result subject to change based on simplex printing in Professional mode, 32 jobs per day, 25 pages per job.

15 Power requirements depend on printer configuration and installed accessories. See product data sheets for specific values.

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