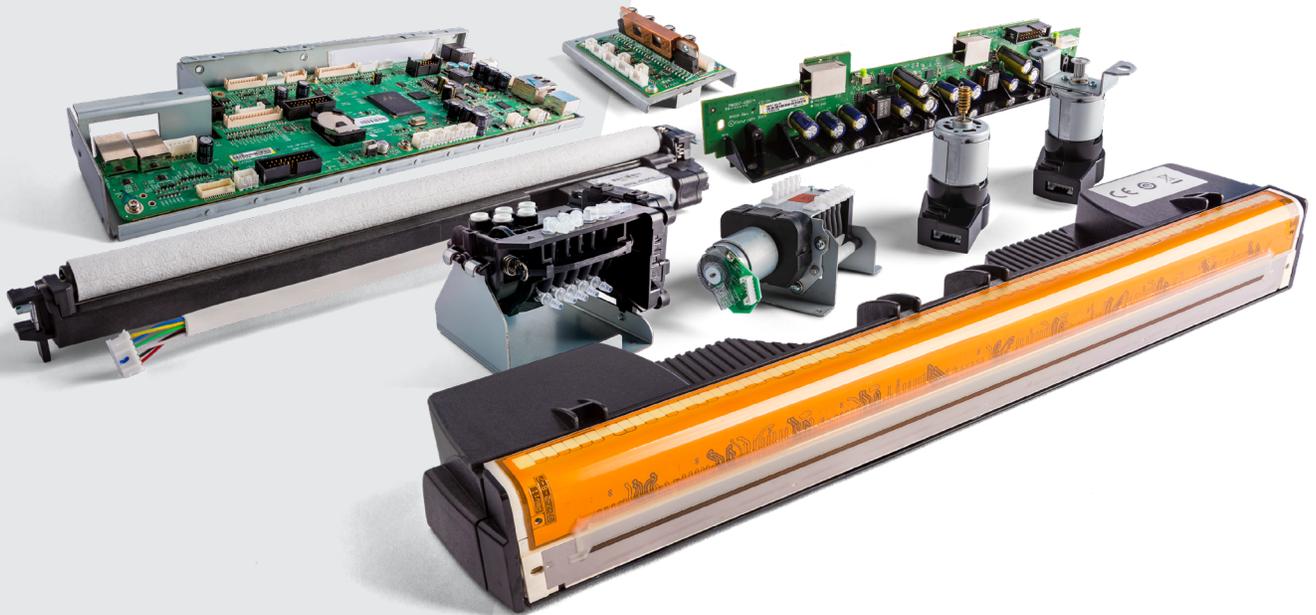


A VersaPass® Technology White Paper



memjet®

Beautiful Precision, Simplicity, and Affordability.

We Are R&D

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Memjet® Technology Drives Fast And Affordable Color Printing

Since the introduction of the first Memjet-powered printing devices in 2010, Memjet technology has been disrupting the world of digital inkjet printing. Memjet's unique page-wide printhead, custom inks, electronics and components continue to empower Original Equipment Manufacturers (OEMs) to create fast, affordable, color printing solutions for a range of applications, from desktop to wide format and production printers.

OEMs use Memjet print engines and print components—supplemented by reference design software and infrastructure, and supported by application engineering—to jumpstart their own design and development of unique printing solutions. This white paper provides a look at the science behind Memjet's VersaPass technology and a peek at the products that continue to make Memjet one of the world leaders in digital printing.

Memjet VersaPass Printing Systems—The technology that started it all

Memjet VersaPass Technology printing systems bring blazing fast speed, simple integration, and superb profitability to page-wide, dye-based inkjet printing, with printing ranges from [Letter/A4 \(and below, based on hardware configuration\)](#) and [double-wide \(up to 17 in / 432 mm\)](#) to [wide format \(42 in / 1067 mm\)](#).

VersaPass technology includes printheads, printhead drive ASICs, FPGAs, and firmware, dye-based aqueous inks, quality assurance infrastructure (QAI), and printer components. The technology is highly flexible, as well as adaptable to a wide range of printing markets—from desktop labels to commercial and industrial applications.

Memjet VersaPass Technology

The “MEM” in Memjet refers to Microelectromechanical Systems (MEMS). The “jet” refers to “inkjet.” Memjet VersaPass printheads are fabricated using MEMS processes: modified semiconductor fabrication that enables creation of the tiny nozzles and drop-ejection system.

From the outset, Memjet has focused on delivering single-pass, page-wide technology that meets these objectives:

- [Print quality as good as human vision](#)
- [Low cost hardware](#)
- [Low running cost](#)
- [High Speed](#)
- [Scalability](#)
- [Compact Size](#)

Part 2

The *Versapass* Thermal Inkjet Printhead

The foundation of the VersaPass Memjet printing system is the 70,400-nozzle thermal inkjet printhead.



Figure 1: The Memjet VersaPass Printhead

The VersaPass printhead has five independent ink channels, each 1600 npi (nozzles per inch), with a printing width of 8.77 in (222.8 mm). Each channel is made up of two linear nozzle arrays, spaced at 800 npi and offset from one another by 1/1600 inch. Ten nozzle rows achieve the five-channel 1600 npi architecture.

The nozzle array has an efficient layout with a total print zone width of 0.72 mm. This narrow print zone simplifies the media path in printer designs.

Ink can recirculate through the printhead, into one end of the manifold structure and out the other. This recirculating functionality improves priming efficiency at start-up, as well as bubble removal for better image quality.

Besides improving performance, the printhead's fixed-head architecture also reduces the noise, vibration, and mechanical complexity associated with other traditional swathing inkjet architectures that shuttle the printhead back and forth across the width of the media

Multi-Pass (Scanning) vs. Single-Pass Printing

A key feature of Memjet's VersaPass printhead is its ability to print up to 8.77 in (222.8 mm) wide with a single printhead on Letter and A4 sized papers. In addition, multiple VersaPass printheads can be configured in an array to support single-pass printing on wider media.

Many desktop inkjet printers use the scanning printhead model with a printhead that is considerably smaller than the width of the media being printed.

As illustrated in [Figure 2](#), a scanning printhead (on the left) scans the surface of the media in multiple passes to cover the entire page and requires both the printhead and the media to move.

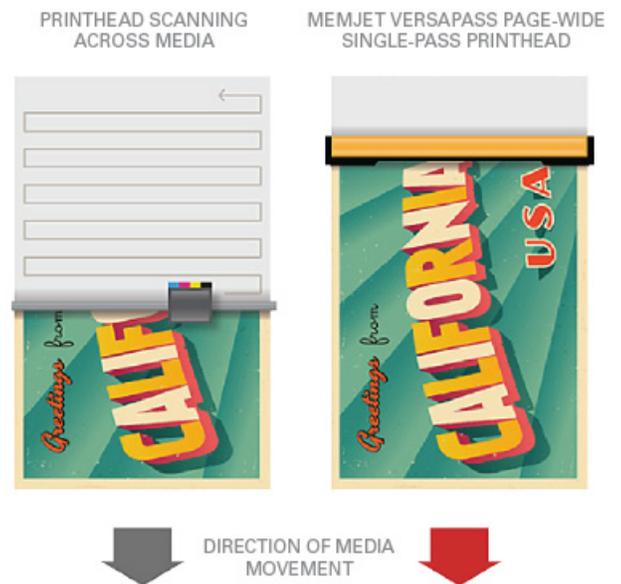


Figure 2:
Scanning Printhead vs. Stationary Memjet VersaPass Printhead

Designed for Quality and Durability

In contrast, Memjet technology enables page-wide printing for both desktop and commercial printing. The printhead extends across the entire width of Letter/A4 media. The printhead remains stationary while the media passes underneath at high speed during printing. The image is printed in a single pass.

The VersaPass Wide Format Engine uses five printheads to print up to **42 in (1067 mm) wide** (see [VersaPass Wide Format Engine on page 13](#)). For commercial printing, two printhead arrays can be configured side-by-side to print a stitched image up to 17 in (432 mm) wide (see [Press Engine Configurations on page 15](#)).

Silicon MEMS Fabrication

The core of VersaPass technology is the printhead Integrated Circuit (IC). The use of silicon MEMS fabrication techniques to build the VersaPass IC not only enables high-density, low-cost, and scalability, it also provides extremely precise geometries within the chip. In the Memjet printhead, the within-chip nozzle alignment tolerance is less than 0.1 μm .

Continued

Feature size and placement tolerance in all three dimensions is designed for precision. The fluidic structure is completely uniform from nozzle-to-nozzle, leading to highly uniform drop size, trajectory, and velocity. Uniform, high-precision drops lead to high-quality printed images at a maximum nozzle firing frequency of 15.5 kHz – providing an effective frequency of ejection at the printhead level of 31 kHz per color. It has improved bubble tolerance and priming robustness via its “open” fluidic architecture. A new MEMS structure within the Printer IC improves the consistency of chamber depth and hence the droplet size, and the patented symmetric chamber design improves drop trajectory consistency thereby reducing drop misplacement.

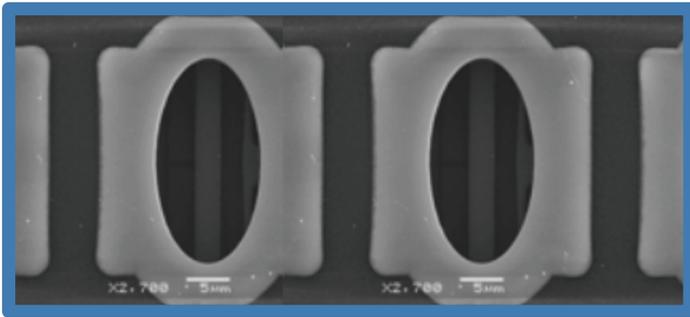


Figure 3: SEM Image Close-Up of a Nozzle

Memjet creates the printhead cartridge by placing eleven VersaPass ICs tightly and precisely next to one another on a common substrate—with a chip-to-chip initial placement tolerance of $\pm 4\mu\text{m}$. Specifically, each IC carries 1,280 nozzles per channel, for a total of 6,400 nozzles per IC. With eleven ICs, the total number of nozzles in the VersaPass printhead cartridge is 70,400.

Manufacturing the VersaPass Printhead

VersaPass printheads leverage high-tech, yet mature, cost-efficient manufacturing processes, utilizing silicon very efficiently.

Memjet uses significantly less silicon than other thermal inkjet printheads. From a fabrication standpoint, each wafer carries almost four million nozzles. The key to its commercial success owes much to its compact nozzle architecture and low-cost manufacturing processes.

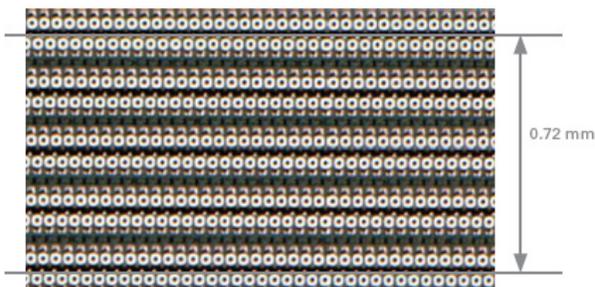


Figure 4: Ten Rows of Nozzles for Five Colors at 1600 dpi

Designed for Print Quality Success

Between each segment of the primary linear array, there is a small wedge of nozzles, known as the “dropped triangle” (see Figure 5). With an offset in the process direction equivalent to the channel-to-channel spacing and a corresponding shift in drop firing, this section compensates for the physical gap between the chips. The combined effect of aligning of the ICs linearly adjacent to one another, coupled precisely with the dropped triangle, produces excellent print quality.

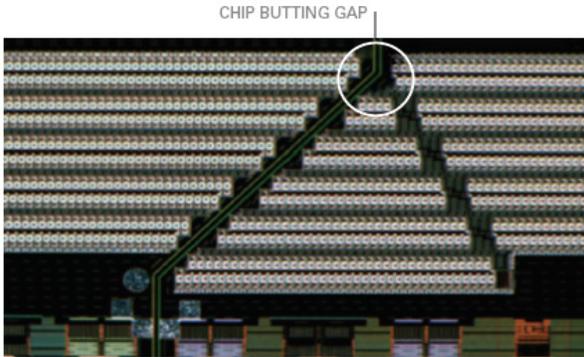


Figure 5: Dropped Triangle Close-Up Showing the Join Between Two Memjet™ Chips

Impact of Memjet Architecture

The impact of how the ICs are placed and aligned relatively to one another is significant. By butting the ICs directly against one another, there are no overlapping nozzles.

Memjet’s linear placement of the ICs creates the most compact array possible, [minimizing the overall array height, which supports a lower cost architecture as well as improved print quality](#). The enablers for this technique are the extremely uniform nozzle-to-nozzle behavior across the entire chip and Memjet’s own state-of-the-art die-bonding process.

Key Printhead Specifications

Type	Thermal Inkjet
Native	Resolution 1600 dpi
Number of Color Channels	5
Ink Type	Aqueous Dye
Drop Size	1.2 pL

Electronics, Software, And Support

From the outset, Memjet has recognized the importance of taking a holistic approach to the complete printing system.

The printhead, printhead controller and other electronics, ink, print components, and printing media all play critical roles in the final quality of printed output. Within this system, the relationship between the printhead and ink is of utmost importance since their compatibility is required for proper drop ejection and printhead reliability. Throughout development, Memjet provides reference software, training and documentation, and support.

Printhead Controller

The printhead controller electronics and the print engine work to ensure optimal interactions between printhead and ink. Running 70,400 jets between 9.6 kHz and 15.5 kHz operating frequency requires calculation of up to one billion pixels per second, calling for printhead electronic performance well above the norm. Memjet has developed two approaches for [high-speed electronic control](#) to match customer requirements, balancing affordability with performance:

- | An ASIC for multi-color printheads and a lower cost approach. This is used in the VersaPass Desktop and Wide Format engines, as well as the Components Set.
- | An FPGA, for high-performance, single-color printheads. This is used in the VersaPass Press Engine.

Ink Quality Assurance

[The quality and authenticity of Memjet VersaPass ink is protected electronically.](#) Two systems are available, based on the size of the ink containers used by the printer system.

- | Quality Assurance Infrastructure chips (QACs) are used on smaller replaceable ink tanks (250 mL, 2 L, and 10 L).
- | QA Manager Kit (QAMK) is used on bulk ink barrels (55 L). This is a Virtual Ink (VI) management framework that can be used when several printheads are plumbed for a single color and draw from the same bulk ink barrel. The QAMK also enables hot swapping of ink supplies.

Reference Design Software and Support

Besides creating print engines and components, Memjet has also developed reference design software for control, user interface, printer drivers, and alignment. [Software Development Kits \(SDKs\)](#) provide customers the tools for customizing and branding their own systems.

Application Engineering and Customer Service provide OEMs with documentation, training, and on-going support, from initial design through production.

Part 4

Versapass Dye Inks For Quality Printing

VersaPass dye inks provide excellent printhead reliability and long-life while delivering first-rate print quality. This high reliability and quality enables affordable printing through reduced downtime and waste, as well as competitive cost per page.

Ink Design, Tuning, and Testing

[Memjet's VersaPass inks are designed by Memjet's team of R&D ink chemists, who work in close cooperation with printhead designers, color scientists, system engineers, and media specialists.](#)

Through close collaboration with these experts, the inks are finely tuned to jet with extremely high reliability throughout the life of the printhead, while also providing consistently high quality output on a range of media. Memjet has invested in custom-designed test equipment that enables in-depth characterization of jetting performance over the life of the printhead, which helps ensure that the long-term performance of Memjet-designed inks provide the best print quality with every print job.

By using Memjet-designed inks, waste and cost are minimized for the end user. Once the ink is designed and released, Memjet's quality assurance specialists make sure that every batch of ink meets Memjet's strict quality and cleanliness standards. Memjet also works closely with ink manufacturers to ensure that their ink manufacturing processes and quality system meet Memjet's stringent requirements for manufacturing consistency and quality.

Dye-Based Aqueous Inks

[VersaPass inks are water-based and use dyes as colorants.](#) The dyes are water-soluble and impart high color strength, allowing for reliable and efficient printing of color. While water makes up more than 70% of the ink formula, other ingredients include humectants, surfactants, and specialty additives.

Continued

These customized formulas, along with the high purity dyes, enable the 70,400 tightly packed nozzles on the Memjet printhead to remain unclogged and jet reliably, even after long periods of non-activity. The formulation also contributes to excellent drop formation within the printhead and controlled drop spread and fast dry-time on media. Combined with Memjet’s native 1600 dpi printhead, VersaPass inks provide crisp lines and text, as well as uniform color performance in area fills.

Compatible Media

Memjet VersaPass inks perform well on a variety of plain papers, as well as uncoated and coated media that are designed for aqueous inkjet printing.

Currently, over 640 medias from 70 suppliers have been qualified for various applications, with qualifying testing ongoing by Memjet, OEMs, and media suppliers.

Lightfastness

Memjet’s VersaPass inks have exceptional lightfastness under various conditions, particularly when paired with appropriate media. The table on the following page shows the estimated lightfastness based on industry-standard tests ran internally by Memjet. Actual results may vary depending on several factors, such as media, image content, light intensity, temperature, and humidity.

Waterfastness

Since dyes are soluble in water, waterfastness can be an issue with dye-based inks. However, if printed on specially designed media, Memjet’s VersaPass inks are waterfast. In recent tests, Memjet has demonstrated that prints generated with VersaPass inks on a range of waterfast media do not bleed or migrate when submerged in water for 24 hours.

Optical Density

The black optical density of VersaPass inks varies depending on media and profile. With Memjet’s unique 5-channel printhead, users can maximize optical density by increasing print resolution (up to 1600 dpi) or by choosing to use two channels of black ink for increased black ink coverage and higher density prints. Alternatively, if the user prefers speed and lower ink usage, a lower resolution/ink profile can be chosen. The table provides representative black optical density on a range of media.

Paper Type	Black Optical Density
Plain Paper	1.0 - 1.5
Matte Coated	1.2 - 1.4
Glossy Coated	1.5 - 1.9

Optical Density

Lightfastness Conditions	Coated Media	Plain Paper
Office with only fluorescent lighting (~250 lux for 12 hrs/day)	4 - 5 years	6 - 7 years
Office with bright or mixed lighting (~450 lux for 12 hrs/day)	2 - 2.5 years	3 - 3.5 years
Office with mostly natural lighting (>900 lux for 12 hrs/day)	12-15 months	18 - 20 months

Gamut

Memjet VersaPass inks provide competitive gamut, especially when printed on coated and glossy media. The graph in [Figure 6](#) shows Memjet's gamut compared to competitive pigment and toner-based products.

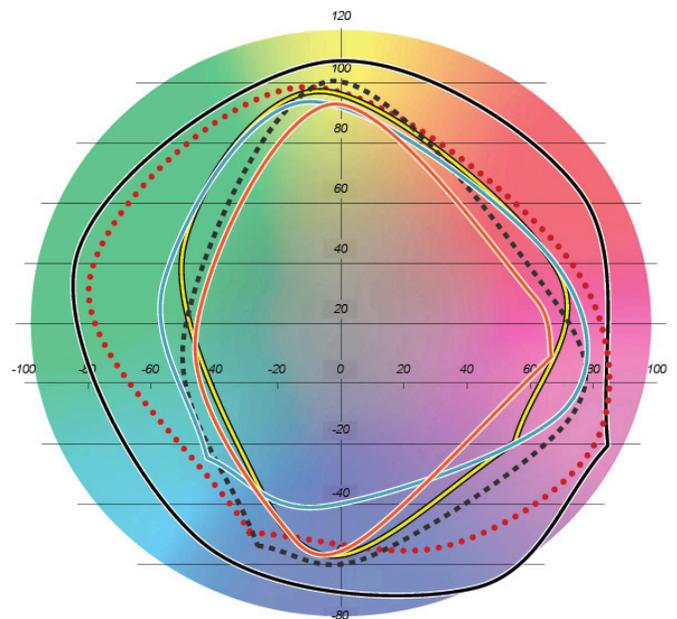


Figure 6 - VersaPass Competitive Ink Gamut

Ink Safety and Environmental Friendliness

With a formulation comprised of ~70% water, Memjet VersaPass Inks are safe to use and are friendlier to the environment than UV, solvent, or liquid toner inks. The formulations do not contain any HAPs (hazardous air pollutants), SVHCs (Substances of Very High Concern per REACH), or toxic metals as regulated by RoHS.

The following table shows a comparison of Memjet VersaPass inks versus competitive technologies for safety and environmental factors. Assessments are based on commercially available inks in each category. Rating does not represent every ink in that class, but is expected to be typical for the class.

	Memjet VersaPass Inks	Typical UV Ink	Typical Solvent Ink	HP Indigo	Typical Eco-Solvent Ink
Odor					
HAPs					
VOCs					
Special Ventilation Required					
Ink Health Hazard—Desktop Inks					
Ink Health Hazard—Press Inks					
Peripheral/Cleaning Fluids Hazard	N/A				
Transportation/Flammability					
Waste/Environmental Risk					

Versapass Engines And Components Set

Memjet produces hardware and electronics, along with specialized ink delivery systems, for faster OEM printer system design and development.

VersaPass Desktop Engine

The VersaPass Desktop Engine is the core component in several [OEM-developed printing systems for mailing and addressing, as well as labeling](#). Using a single printhead for full color printing, the Desktop Engine offers a compact solution for a range of applications, including envelopes, mailing inserts, forms, primary and secondary labels.

The Desktop Engine includes a chassis/paper path, ink cartridges interface, ink delivery system, printhead interface with maintenance system, and electronics. OEMs design and provide the media handling through the print engine's paper path. Ink cartridges and printheads are bought separately from the print engine.



Figure 8 - VersaPass Desktop Engine

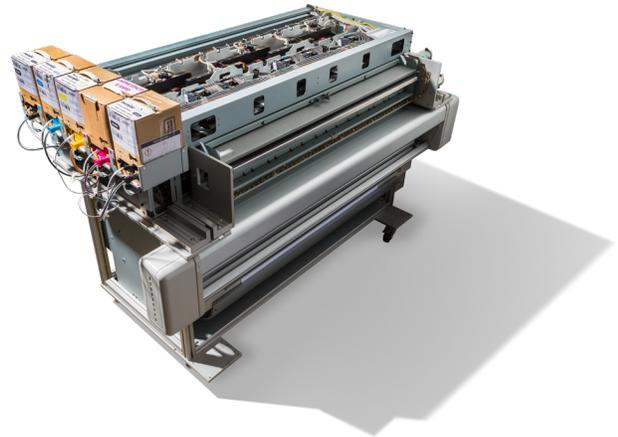


Figure 9 - VersaPass Wide Format Engine

VersaPass Wide Format Engine

The VersaPass Wide Format Engine is the core of fast and affordable printing systems that deliver vivid color images up to [42 in \(1067 mm\) wide](#).

The Wide Format Engine gives composite color (CMYK) to full-sized architectural, engineering, and geographical information systems documents. [It is also used for printing indoor signage, corrugated boxes, folded cartons, and other large-scale documents](#). The Wide Format Engine includes five printheads, an ink delivery system (IDS), printhead maintenance components, and electronics with firmware.

OEMs design and provide the media handling system. Ink cartridges and printheads are bought separately from the print engine.

VersaPass Components Set

The VersaPass Components Set provides OEMs full flexibility to create custom designs of desktop printers and free-standing minipresses. The set simplifies engine development by providing qualified sub-systems and component parts. With above-web maintenance, the components support longer roll-to-roll applications than other desktop printers. They also support printing on thicker substrates, based on the OEM-designed media handling system.

With two options for the ink delivery system (IDS)—either active or passive, the components set includes a single printhead (bought separately) for full-color printing, plus components for printhead maintenance and electronics. Replaceable ink tanks (bought separately) come in four standard process colors (cyan, magenta, yellow, and black), packaged in either 250 mL cartridges (for the passive IDS) or 2 L boxes (for the active IDS).

OEMs can use [Memjet reference design software to customize interfaces to media handling systems, Windows print drivers and RIP, and a graphical user interfaces for printer control and status reporting. Standard printhead maintenance algorithms can also be customized.](#)

An evaluation kit is available from Memjet for use in the preliminary design, development, and testing.

The design flexibility of the VersaPass Components Set makes it an ideal starting point for affordable printing of small format packaging and cartons, unfolded boxes, labels, envelopes, pre-treated materials for aqueous inkjet printing, thick objects like padded envelopes and wooden planks, and even ready-for-shipment folded boxes. The VersaPass Components Set can also be used for designing desktop printers for business and industrial applications.

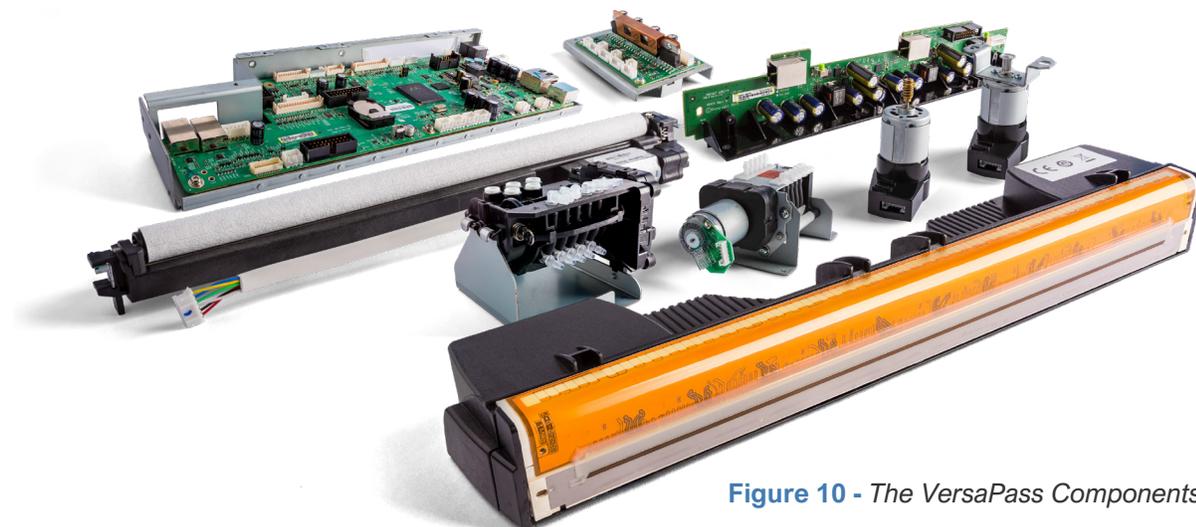


Figure 10 - *The VersaPass Components Set*

VersaPass Press Engine

Memjet's VersaPass Press Engine is an inkjet print engine with related components, designed to be:

- | Either, the major component(s) in a production press printing system that is newly designed and manufactured by an Original Equipment Manufacturer (OEM).
- | Or, major components that are retrofitted to an existing digital or analog production configuration, bringing additional functionality to a current production press.

The VersaPass Press Engine is comprised of hardware, ink and ink delivery systems (IDSs), up to five single-color printheads, electrical components with firmware, connected via a network to computer systems with software for system control, print data delivery, and raster image processing (RIP). A separate flatbed scanner or an inline camera vision system is used for printhead alignment.

Ink cartridges and printheads are bought separately from the print engine.

The VersaPass Press Engine is a fully integrated printhead support device with functionality for supporting VersaPass printheads: [capping](#), [cleaning](#), [vertical motion control](#), [ink management](#), and [dot-level control of data streams for up to five colors](#). The print engine connects to a media handling system, as provided by the OEM, along with any other equipment required for pre-treatment, finishing, packaging, and other production operations.

PART 6

Memjet Reference Design Software

Memjet has developed reference design software for various products, including control software and printer drivers, graphical user interfaces (GUIs), software developer's kits (SDKs), and color plane and stitch alignment. These reference designs, tailored for specific Memjet products, provide an excellent foundation to OEMs for designing, developing, and testing their own customized and branded systems.

Control Software, User Interfaces, and Printer Drivers

Control software runs on a host computer, providing interfaces to the print engine data pipeline (PEP) and other related components.

A Graphical User Interface (GUI) provides users with system control, plus job and system status, and error messaging. Some GUIs can include help text and messages for error recovery.

Printer drivers, depending on the product, may be based on a standard Windows driver or a specific interface to a raster image processor (RIP). This software can be customized by the OEM.

Software Development Kits (SDKs)

Software Development Kits (SDKs) are tools for customizing drivers, control software, and GUIs.

Memjet's ImageAPI provides OEMs with the application programming interface (API) details for understanding and developing a raster image processing (RIP) application for sending image data to *Powered by Memjet* printing systems.

Vision System for Inline Printhead Alignment and Stitched Images

With multi-printhead systems, such as the VersaPass Press Engine, printhead alignment is critical for print quality and printing stitched images with side-by-side engines.

The reference design Memjet Vision System (MVS) provides an inline camera with live viewing and fine adjustment of color plane alignment, without having to stop and cut a roll-to-roll media web.

Side-by-side configurations of the Press Engine can print stitched images up to **17 in (432 mm) wide**, either as butt or feathered stitches. Pre-packaged seed dithers are available by type of media for use by the RIP in mitigating stitch artifacts. A reference design Stitch Dither Generator application is available for creating custom seed dithers for specific media.

PART 7

Product Summary Comparison Table

Feature	VersaPass Desktop Engine	VersaPass Wide Format Engine	VersaPass Components Set	VersaPass Press Engine
Print Speed Inches/second (ips) & millimeters/second (mm/s) or meters/minute (m/min) @Resolution (dpi)	6 in/sec (152 mm/sec): @1600x1600 dpi 12 in/sec (304 mm/sec): @1600x800 dpi	6 in/sec (152 mm/sec): @1600x1600dpi 12 in/sec (304 mm/sec): @1600x800 dpi	6 in/sec (152 mm/sec): @1600x1600 dpi 12 in/sec (304 mm/sec): @1600x800 dpi	55.0 in/sec (84 m/min): @1600x1375 dpi 66.6 in/sec (101.5 m/min): @1600x1135 dpi 104.3 in/sec (159 m/min): @1600x725 dpi 136.2 in/sec (207.6 m/min) @1600x555 dpi
Replaceable Ink Tanks (RITs) Sizes	250 mL (0.26 qt)	2 L (2.1 qt) or 10 L (2.7 gal)	250 mL (0.26 qt) for passive IDS or 2L (2.1 qt) for active IDS	10 L (2.7 gal) or 55 L (14.5 gal)
Ink Tank Configuration and Number of Printheads	CMYKK - 4 tanks for a single 5-color printhead	CMYKK - 4 tanks for a single 5-color printhead	CMYKK (passive IDS) or CMYK (active IDS) - 4 tanks for a single-color	YSCMK (S is custom spot) in 5 mono-color printheads
Print File Format	Zj - Proprietary compressed vector format	Zj - Proprietary compressed vector format	Zj - Proprietary compressed vector format	Halftone – 1 bit/pixel/channel
Engine Configuration	Single Engine	Single Engine	Single Engine	Single-Engine, 2-Engine, or 4-Engine Configurations
Maximum Print Width	8.77 in (222.8 mm)	42 in (1067 mm)	8.77 in (222.8 mm)	Single engine: 8.77 in (222.8 mm) Side-by-side engines stitched: up to 17 in (432 mm)
Media Path	Custom Designed by OEM, e.g. Roll to Roll, Roll to Cut, etc.	Custom Designed by OEM, e.g. Roll to Roll, Roll to Cut, etc.	Custom Designed by OEM, e.g. Roll to Roll, Roll to Cut, etc.	Custom Designed by OEM, e.g. Roll to Roll, Roll
Computers/OS	Host Controller PC – Win7 or Win10	Host Controller PC – Win7 or Win10	Host Controller PC – Win7 or Win10	Control PC (1/engine) – Win7 or Win10 Print Data PC (1/engine) – CentOS 6 Vision PC (only for vision system) (1 per 2 engines) – Win7 or Win10
Example Applications	Desktop Solutions, Labels, Mailing and Addressing, Business Documents and Forms	Posters, CAD, GIS and Maps, Point of Sale (POS) Signage, and other large-scale documents	Boxes and Labels, Small Format Packaging, Padded Envelopes, Transpromo	High-Speed Commercial Printing, Labels, Newsletters, Transactional Statements, Direct Mail, Transpromo

PART 8

Setting The Standard

Memjet VersaPass Technology sets the standard for full-color, single-pass, page-wide printing with excellent image quality.

Scalable to span a broad market space, printers with VersaPass technology have succeeded in a range of segments in the commercial and industrial printing markets.

Powered by VersaPass printheads, inks, electronics and software, engines and components, OEM printers are market front-runners, delivering unparalleled combinations of speed, simplicity, and profitability.

To learn more visit www.memjet.com/technology/versapass
or email us at info@memjet.com.