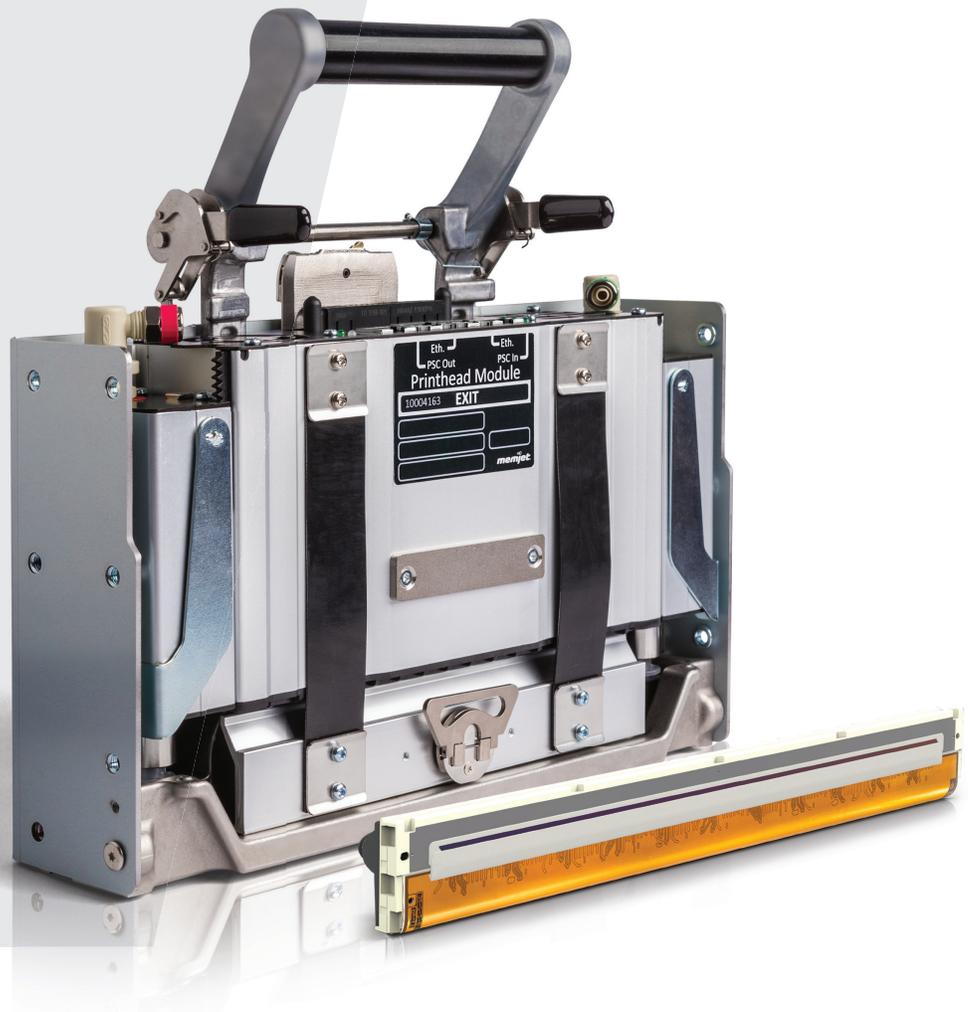


A DuraLink® Technology White Paper



memjet®

Beautiful Precision, Simplicity, and Affordability.

We Are R&D

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Part 1

DURALINK®

The affordable, flexible, all-new DuraLink platform from Memjet®. Memjet’s DuraLink digital press platform is a game changer that will allow Memjet customers to dominate their print markets.

DuraLink, Memjet’s modular, high-volume, production-focused technology platform, features a new long-life printhead, durable pigment inks, and a range of versatile modules - enabling fast and cost-efficient product development of commercial, packaging, and industrial printing solutions.

Memjet DuraLink Technology

Building on the success of its original technology platform, Memjet now introduces DuraLink, a single-pass digital printing platform that features a long-life printhead, durable pigment inks, over 2.5 meters (over 100 in) maximum print width and a range of versatile modules.

The DuraLink system includes printheads, inks, printhead support modules, ink delivery and management components, printhead maintenance components, custom support electronics and software, control and interface software. Memjet also offers reference designs to facilitate integration with an OEM’s media handling and IT systems, as well as software to interface with a raster image processor and a vision system for automating image capture of alignment data.

OEMs add the media handling system, RIP, output imaging system, software and hardware control interfaces, computers, wiring and cables, fluidic tubing, print bars, press chassis, and power.

Industry-Leading Speed and Quality

Together, these features provide industry-leading quality and speed to a range of commercial, packaging and industrial printing markets. This robust technology enables fast and cost-efficient product development, industry-leading native resolution, and small drop sizes for offset-like print quality up to 1600 x 1585 dpi, with 5x nozzle redundancy, and print speeds of up to 203.6 meters per minute (668.1 fpm).

Resolution	Meters per Minute	Feet per Minute	Inches per Second
1600 x 1585	74.5 m/min	244.5 ft/min	48.9 in/sec
1600 x 1260	93.7 m/min	307.5 ft/min	61.5 in/sec
1600 x 790	149.5 m/min	490.5 ft/min	98.1 in/sec
1600 x 580	203.6 m/min	668.1 ft/min	133.6 in/sec

Figure 1- DuraLink Print Speeds, by Resolution

Print Modules for Stability and Flexibility

The DuraLink print data pipeline provides for both uncompressed, dot-level control of print data streams from an external RIP, or a fast, embedded RIP for processing PDF images.

Print Data Pipeline with Custom Controller Chip

The DuraLink print data pipeline provides high-speed, uncompressed, dot-level control of print data streams, from the RIP to the printheads for each color.

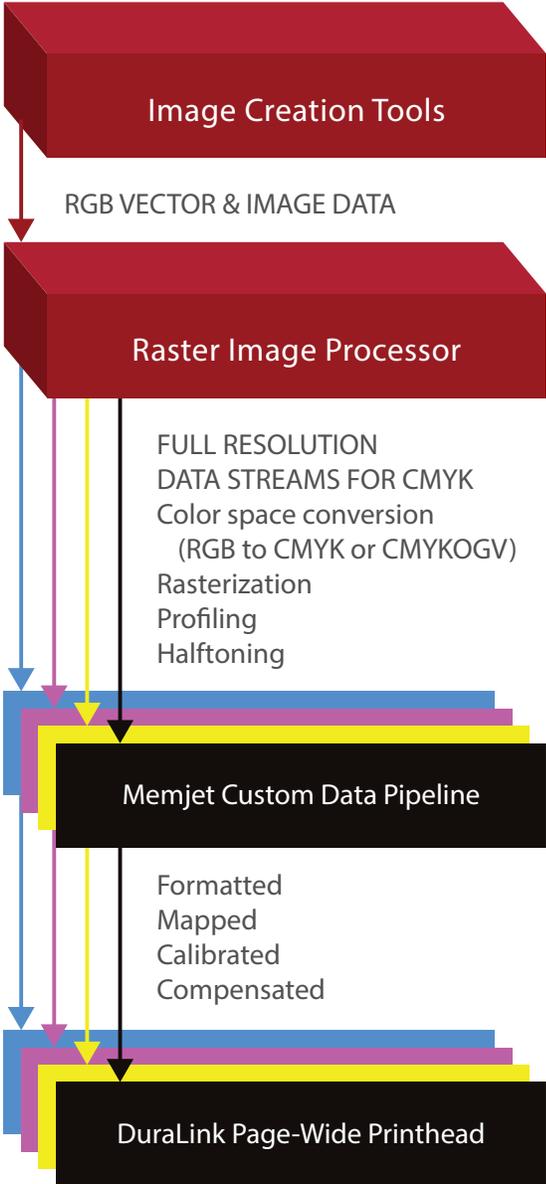


Figure 2 - DuraLink Data Pipeline with Dot-Level Control

The DuraLink Printhead

The essential component of DuraLink printing is the 70,400-nozzle inkjet printhead.



Figure 3 - The Memjet DuraLink Printhead

Remarkable Reliability and ROI

The DuraLink printhead is a 1600 dpi, 222.8 mm wide, single-color printhead, with 70,400 nozzles and 5x nozzle redundancy, which is enhanced by DuraLink aqueous pigment inks for long life and reliability. Five nozzles addressing each pixel column on the page allows for a single missing nozzle to go virtually unnoticed in the printed image.

Excellent print quality is sustainable for 4 billion ejections per nozzle for each color. Figure 4 shows magnified images of lines that are 1 dot wide, with rectangles 1/100 inch (16 dot pitches) wide, comparing a print at the start of printhead life (left) compared to a print after 4 billion ejections (right). Even after 4 billion ejections, the print quality is exceptional.

Designed for Quality and Durability

The new DuraLink printhead design replaces the suspended heater with a bonded heater, which has a durable coating. With pigment inks, the new design contributes to longer life, ejection stability, and excellent print quality.

The new printhead produces 2.1pL drops up to the recommended maximum nozzle firing frequency of 15.5 kHz. It has improved bubble tolerance and priming robustness via “open” fluidic architecture. A new MEMS structure improves the consistency of chamber depth and hence the droplet size, and a symmetric chamber design (patented) improves drop trajectory consistency, reducing drop misplacement.



Figure 4 – Construction details of Memjet DuraLink Printhead

The DuraLink Pigment Inks

DuraLink aqueous pigment inks provide excellent printhead reliability and long-life while delivering first rate print quality and outstanding durability.

Years of Research and Development

In co-development over five years, Memjet and a leading pigment dispersion manufacturer have developed DuraLink aqueous pigment inks for excellent ink-on-media performance with DuraLink printheads in high-speed inkjet presses.

The challenges were steep: achieve water fastness, resistance to light fade, compatibility with a broad range of media, competitive gamut and image quality, high reliability, and long life—all within the low-cost, short dry time, small drop-volume, Memjet thermal inkjet printhead.

Custom polymers (dispersants), designed for long printhead life and broad media compatibility, are combined with base colors to produce the pigment dispersion. The particle size is controlled during dispersion to optimize color properties, fade resistance, and good jet-ability from the printhead. Advanced purification is used to support Memjet's small drop size and fluidic structure. The pigment dispersion is combined with the ink vehicle, including co-solvent and surfactant packages, additives, and water to provide the optimum balance of printhead life, speed, and print quality.

High Print Quality with Image Durability and Printhead Reliability

DuraLink aqueous pigment inks provide excellent image quality on a range of media, while ensuring resistance to damage from rubbing, moisture, and light. They also support the objectives of the DuraLink printhead for ejection and installed life.

The standard DuraLink ink set provides competitive gamut and image quality on a range of inkjet commercial print and packaging substrates. Custom colors can be developed by special arrangement.

Water Fastness and Fade Resistance

Prints with DuraLink inks are water fast, with excellent fade resistance—one of the key reasons for choosing pigment inks for applications where that matters most.

Memjet conducted tests with DuraLink inks to evaluate indoor light fade. Using the Wilhelm Imaging Research (WIR) method of accelerated testing, colors are still vibrant after 40 years, compared to an un-exposed, original print as illustrated in Figure 5.

Accelerated testing for ozone fade showed 25+ years.

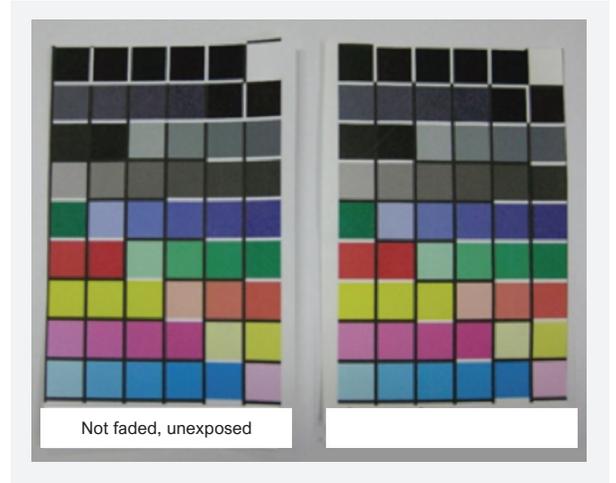


Figure 5 - Simulated 40-Year Indoor Light Fade Test: Just Printed (left) vs. Print Subjected to Fade Conditions

Media Compatibility

DuraLink pigment inks are compatible with media commonly used in inkjet presses, including:

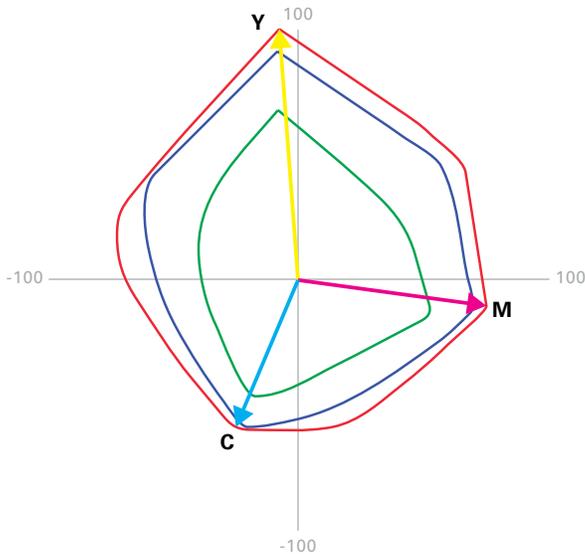
- Plain papers (bond, uncoated offset)
- Inkjet treated uncoated papers
- Inkjet coated media

At the time of publication, Memjet has already tested over 40 media from more than 10 manufacturers for DuraLink pigment inks, and the compatibility testing continues. Compatibility with media is expected to extend to media used in a variety of packaging applications, as well as on some special media, such as coated films and label stock.

Gamuts

Memjet DuraLink pigment inks provide competitive gamut—among the widest in the market, competitive with leading inkjet solutions—especially when printed on inkjet coated media.

The graph in Figure 6 shows Memjet’s gamut on three different paper types.



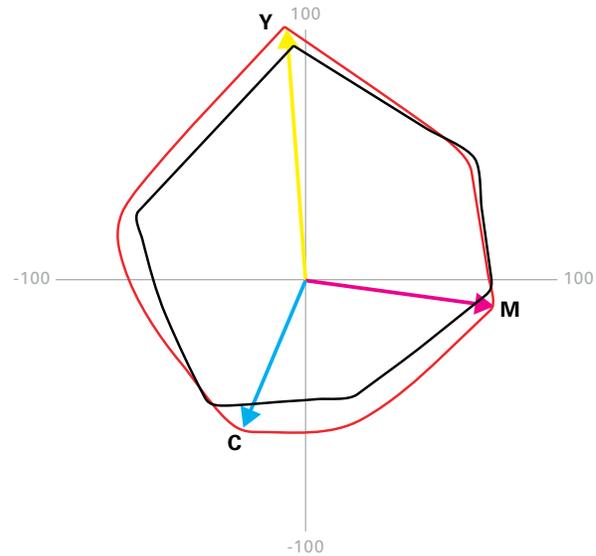
Key (from inner to outer on diagram):

- Plain
- Inkjet Coated Matte
- Inkjet Coated Gloss

Figure 6 - DuraLink Pigment Inks Gamut - by Media

GRACoL is a standard in pressrooms in America. GRACoL is not just a set of colors, but a set of methods on how to calibrate a press to achieve consistent color. This repeatability led to reduced costs in time and waste when reproducing work.

DuraLink inks on inkjet coated media compares favorably with GRACoL coated, as shown in Figure 7.



Key: (from inner to outer in diagram):

- GRACoL Coated Gamut
- DuraLink Pigment Inks Gamut

Figure 7 - DuraLink Inks Gamut on Coated Media, Compared to GRACoL Coated Gamut

DuraLink can be configured with OGV expanded gamut inks (orange, green, and violet), helping printers achieve wider gamut and brand-color matching, critically important to packaging applications.

Ink Safety and Environmental Friendliness

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

The DuraLink Modules Set

DuraLink Modules are the building blocks of a DuraLink printer (Powered by Memjet).

A Print Bar is a single-color set of printheads that make up a single stitched swath of printing and all the associated equipment including Printhead Modules, Maintenance Modules, plus chassis for maintenance and the Print Zone.



Figure 8 - DuraLink Modules

Printhead Module (PHM)

Each Printhead Module contains one printhead, furnishing interfaces to the rest of the press components. Accurate printhead placement and movement is provided by the Printhead Module Nest. The Printhead Module contains the Memjet custom data pipeline electronics, which receives raster data directly from the RIP and controls exact placement on the media. The Printhead Module also controls the pressure point of the ink in each individual printhead to achieve consistent ink pressure and drop size across a print bar.

Waste Ink Management Module (WIMM)

The WIMM provides the vacuum required to support the action of the Maintenance Module in wiping the printhead to maintain optimum print quality. It manages the small quantities of waste ink generated during maintenance operations.

Print Bar Interface Module (PBIM)

The Print Bar Interface Module distributes timing signals to synchronize printing across print bars.

Maintenance Module (MM)

The Maintenance Module prepares a printhead for printing and caps it when not in use. It contains a cap, a wiper, and the movement mechanisms for printhead maintenance.

Ink Supply Module (ISM)

The Ink Supply Module draws ink from the bulk ink supply and feeds the ink to the Printhead Modules at controlled pressures. It also filters and degasses the ink, and provides sufficient storage to support replacing depleted bulk ink containers while printing.

Dongle Dock Module (DDM)

The Dongle Dock Module provides ink dongle ports for each color. Hot swapping is supported for continuous printing during ink supply changes.

Aerosol Management Module (AMM)

The Aerosol Management Module provides a controlled vacuum to extract aerosol from the print zone through the aerosol nozzles, and it separates the ink from the airflow for disposal. The Aerosol Management Module is connected to aerosol nozzles by the aerosol manifold and a flexible hose.

Print Engine Supervisor Module (PESM)

One Print Engine Supervisor Module controls all modules across all print bars within a printing system, including the ink quality assurance (QAI) authentication. The PESM allows a single point of control interface for the OEM printer controller through an Ethernet port to simplify control of the array of printheads.

Modules are Ready to Use

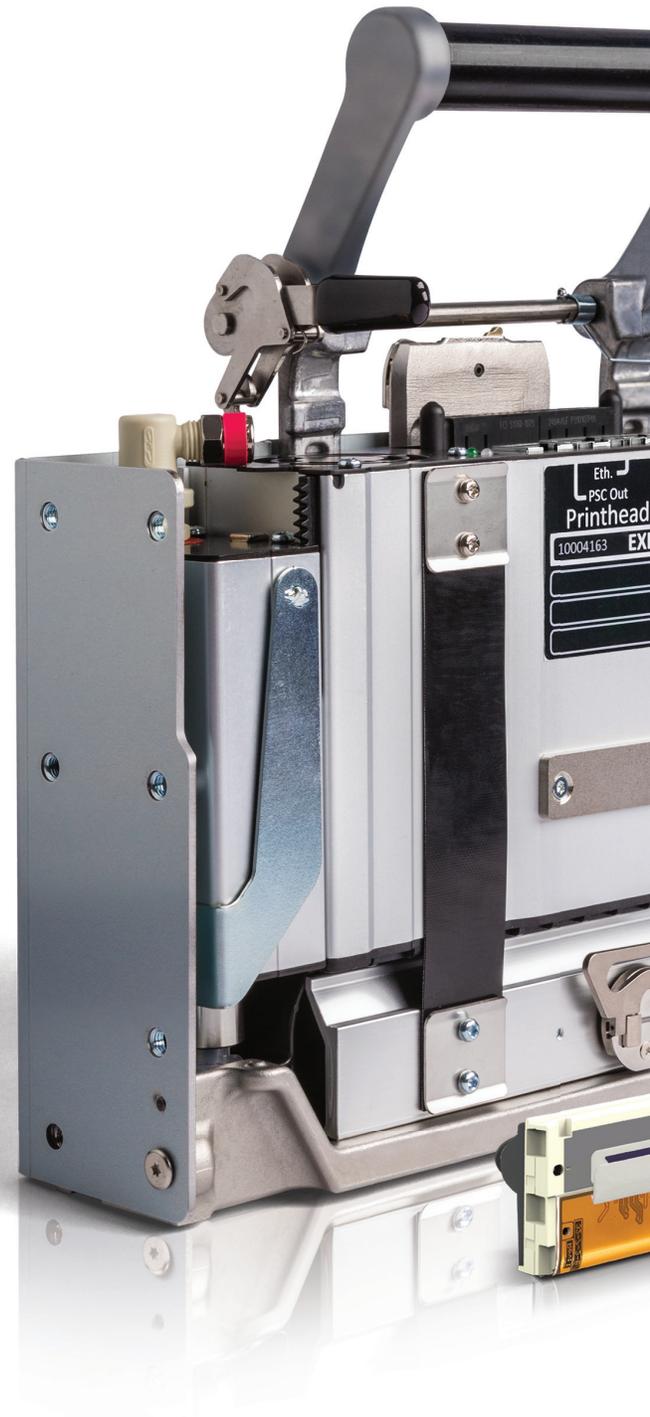
Modules come ready to use, without special commissioning by the OEM during installation. All modules are configured by a unified controller, the Print Engine Supervisor Module (PESM). Modules are designed to last the life time of the DuraLink-based printer (estimated install life is > 5yrs), except for user-replaceable parts, like filters.

Controlling the Modules

A System-On-Chip (SOC) runs embedded firmware in the Printhead, Ink Supply, and the Waste Ink Management Modules to control local functions. This distributed network of SOCs allows the Print Engine Supervisor Module (PESM) to manage the array of modules efficiently by distributing real-time control to local SOCs.

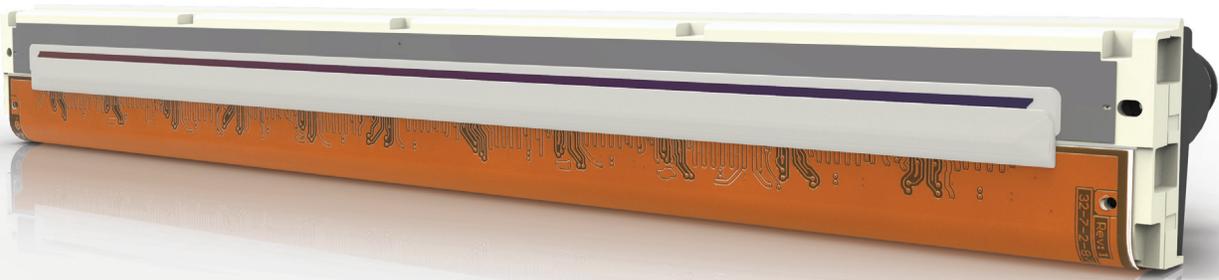
The Maintenance and Aerosol Management Modules do not have embedded controllers. Instead, they are partnered with connected modules to receive their controlling commands:

- The Printhead Module controls the Maintenance Module.
- The Waste Ink Management Module controls the Aerosol Management Module.



Calculating the Number of Printheads Required

The number of printheads required in a DuraLink-based printer is determined by the requirements for width of printing, number of colors, and whether for simplex or duplex printing.



Maximum Print Width (mm)	No. of PHs per Color	For Duplex	Example
222.80	1 per color	x 2	<p>Example calculation for a DuraLink-based printer:</p> <ul style="list-style-type: none"> • Requiring a printing width of 1000 mm • 4 colors • Duplex printing <p>5 printheads wide (1074 mm) x 4 colors x 2 for duplex = 40 printheads</p>
444.60	2 per color	x 2	
666.40	3 per color	x 2	
888.20	4 per color	x 2	
1110.00	5 per color	x 2	
1331.80	6 per color	x 2	
1553.60	7 per color	x 2	
1775.40	8 per color	x 2	
1997.20	9 per color	x 2	
2219.00	10 per color	x 2	
2440.80	11 per color	x 2	
2662.60	12 per color	x 2	

Figure 9 - Calculating the Number of Printheads Required

Calculating the Number of DuraLink Modules Required

The modular architecture of the DuraLink print components enables an OEM to construct a printer that is up to 12 printheads wide and up to 8 print bars deep for a maximum of 96 printheads in total for simplex printing, 192 printheads for duplex printing. A Print Bar (supplied by the OEM) is a single-color set of printheads that make up a single stitched swath of printing and all the associated equipment.



DuraLink Components	Number of Components
Print Engine Supervisor Module	1 per System (up to 192 printheads (12x8x2))
Print Bar Interface Module	1 per print zone
Printhead Module	1 per Printhead
Printhead Module Nest	1 per Printhead
Maintenance Module	1 per Printhead
Ink Supply Module	Within a single Print Bar: 1 – 6 Printheads of a single color Across two Print Bars for duplex: 6x2 Printheads of a single color
Waste Ink Management Module	1 per 12 Printheads (Multi-Color)
Aerosol Management Module	1 per 12 Printheads (Multi-Color)
Dongle Dock Module	1 per 4 Ink Colors
Aerosol Nozzle Assembly	1 per Printhead, plus 1 extra per Print Bar

Figure 10 - Table of Modules Required

The following sections provide details about each module and selected components.

Printhead Module (PHM)

The Printhead Module (PHM) provides the fluidic (ink), mechanical, and electrical connections to the printhead. It contains the electronics necessary to distribute the print data, fire the print nozzles, and control the Maintenance Module associated with it.

The Printhead Module mounts a single DuraLink Printhead inside a Printhead Module Nest to provide a repeatable and stable position for printing. When mounted in a suitable chassis, an array of Printhead Modules can be accurately positioned at the correct spacing from the media to ensure the best print quality for any configuration.

The Printhead Module also contains the control systems that communicate with the Print Engine Supervisor Module, allowing the operator control over print and maintenance functions, including the DuraLink Maintenance Module.

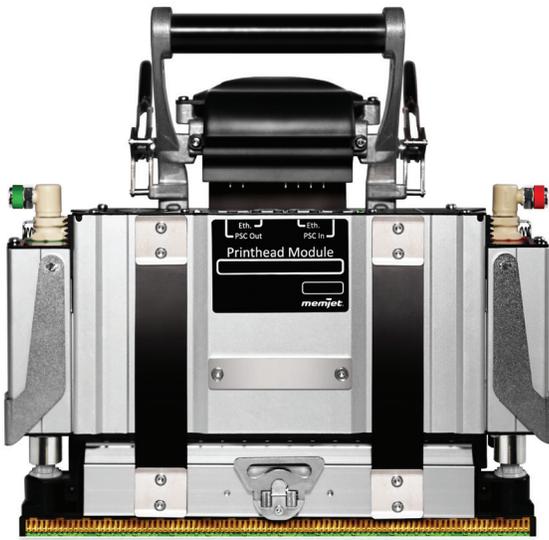


Figure 11 - Printhead Module with Local Pressure Regulators

The Printhead Modules, in conjunction with the Printhead Module Nests, are mounted to a Print Zone chassis, which moves vertically from Print - Maintenance - Maintenance Clear - Service (pre determined positions). The Print Zone Chassis is an OEM-supplied component that allows each OEM to quickly develop a printer to the width needed for their custom use.

Printhead Module Nest

The Printhead Module Nest assures proper printhead module positioning. The Printhead Module Nest, in conjunction with the Print Zone Chassis, secures the printheads in the printing position reliably and within known tolerances.



Figure 12 - Printhead Module Nest

Maintenance Module

Regardless of the final layout, or total number of printheads, there must be one Maintenance Module for every Printhead Module within the printing system. The DuraLink Maintenance Module is a multi-function component that prepares the printhead for printing and protects the printhead when it is not in use. Wiper and Cap Assembly are user-replaceable components.

The Maintenance Modules are arrayed adjacent to the printheads to allow close-packing and minimum overlap. When the printheads are in use, the cap and wiper are stowed to allow the printhead access to the media path.

The Maintenance Modules are attached to the Maintenance Chassis, a fixed component that is supplied by the OEM and designed to mount the Maintenance Modules in position above the media path.



Figure 13 - Maintenance Module

Wiper Cartridge (User-Replaceable)

The Wiper Cartridge uses microfiber material to wipe the printing surface of the printhead. The microfiber wiper material is housed within a user-replaceable cassette. The Wiper Cartridge indexes to a new section of microfiber material after a predetermined number of wipes to assure consistent printhead cleanliness. The cartridge is replaced after 15,000 wipes.



Figure 14 - Wiper Cartridge

Cap Assembly (User-Replaceable)

The printhead Cap is a multi-function unit that seals the printhead when not printing or maintenance operations are in progress. It also wicks away and collects residual waste ink produced during maintenance.



Figure 15 - Cap Assembly

Ink Supply Module (ISM)

One Ink Supply Module (ISM) is required per color, supporting up to 6 PHM's reliably in a duplex application and 7-12 dependent on density and fluidic design. The Ink Supply Module, along with the Local Pressure Regulators (LPR) in the Printhead Module and the common rails (provided by the OEM), comprise the Ink Delivery System (IDS). The Ink Delivery System is designed to cleanly and reliably deliver ink to the printhead while minimizing color mixing, drop weight variation, and dehydration. A user-replaceable filter ensures clean ink.

The Ink Supply Module pulls ink from a bulk ink supply and distributes it to the Printhead Modules (up to 12) at controlled pressures. It filters and degasses the ink. It contains an intermediate reservoir to allow printing to continue uninterrupted while the replaceable ink tank is replaced.



Figure 16 - Ink Supply Module

Waste Ink Management Module (WIMM)

The Waste Ink Management Module (WIMM) provides controlled vacuum to facilitate maintenance operations and manages the ink drawn from the printhead during those maintenance operations. This is collected into an OEM-supplied waste ink container.

A single Waste Ink Management Module handles up to a maximum of 12 Maintenance Modules.



Figure 14 - Waste Ink Management Module

Aerosol Management Module

The Aerosol Management Module applies vacuum to the aerosol manifold on each Print Bar to provide the required negative pressure to each aerosol nozzle. The Aerosol Management Module separates the waste ink aerosol from the airflow and exhausts the extracted air.

Aerosol Nozzle components attach to the front of the print bar to provide uniform removal of aerosol across a Print Bar, while providing clear access to printheads across the top of the array.

Aerosol Management Module (Continued)

The Aerosol Management Module is connected to the Aerosol Nozzles, which are mounted next to the printheads. The module is designed to handle the maximum amount of aerosol expected from up to 12 printheads. A print engine with more than 12 printheads must have multiple Aerosol Management Modules, each servicing no more than 12 printheads.

The Aerosol Management Module has a user-replaceable filter.



Figure 18 - Aerosol Management Module



Figure 19 - Aerosol Filter (top) and Aerosol Nozzle (bottom)



Print Engine Supervisor (PES) Module

The Print Engine Supervisor Module runs the Print Engine Supervisor software which is provided by Memjet to coordinate all activities of the various modules that comprise a DuraLink print system. It also maintains the Quality Assurance Infrastructure (QAI) which ensures that only the correct DuraLink and OEM-branded equipment and supplies can be used in a DuraLink print system.

There is only one Print Engine Supervisor Module per DuraLink print system.

Print Engine Supervisor (PES) Module (Continued)

The Print Engine Supervisor Module communicates with and supervises all other connected modules in a DuraLink print system via a local area network. The modularity of a DuraLink-based printer system requires an abundance of connections among modules, particularly in multi-printhead and multi-color systems, requiring several Ethernet/LAN switches to facilitate connectivity. These switches are referred to collectively as the Print Engine (PE) Ethernet Switch Infrastructure.

At print system boot up, the Print Engine Supervisor Module initializes first, then oversees the booting of the remainder of the print system, providing firmware images to the remainder of the modules via the PE Ethernet Switch Infrastructure. This means that all upgrades to software, firmware, and other configuration information are managed through a single unified software upgrade to the Print Engine Supervisor Module.

The ink dongles store virtual consumables, license, security, and other information used by the print system.



Figure 20 - Print Engine Supervisor Module

Print Bar Interface Module

The Print Bar Interface Module:

- Connects to the Print Engine Supervisor Module over Ethernet for status information and control.
- Receives media timing information (encoder pulses and Top of Form (TOF) signals) from the media handling system and passes this on in an appropriate format both to the Print Bar it controls and other Print Bar Interface Modules via the PSC Interface.
- Drives the Flush Valve for the Print Bar(s) it controls - 4 flush valves maximum.



Figure 21- Print Bar Interface Module

Dongle Dock Module

The Dongle Dock Module connects to a Virtual Ink (VI) management framework that is used when several printheads are plumbed for a single color and draw from the same bulk ink barrel.

Two VI dongles per color on the Dongle Dock enables hot swapping for continuous printing.



Figure 22 - Dongle Dock Module

Part 5

DuraLink Software

Besides modules and components, Memjet provides supporting software to control printing functions.

- Print Engine Supervisor (PES) Software, which is required for operation of the system. The DuraLink Definition XML file resides on the PES hard disc and contains all the OEM-specific configuration data. The PES software references the data to configure the DuraLink modules into an OEM's DuraLink-based printer.
- Print Engine Supervisor (PES) Interface is the command set that an OEM can use to control the print engine. The OEM controller directs all the DuraLink print engine functions, and receives status and diagnostics information through this interface.
- A reference design Printer Control System, including a graphical user interface (GUI). This allows OEMs a fast start to building their own printer controller to communicate with the PES software. A fully-functional GUI is provided standard.
- OEMs select the RIP of their choice. They use the Job Submission Library (JSL) as both an interface and a plug-in to enable RIPs to connect easily to the DuraLink printheads. The JSL is embedded into the RIP software as a plug-in to manage the transfer of data.
- OEM Component Controller (OCC) Interface, connecting the Print Engine Supervisor to the OEM Component Controller software.
- OEM Controller Interface (OCI), connecting the Printer Control System to the OEM Equipment Controller software.
- OEM Control Interface (OCI), connecting the Printer Control System to the OEM Equipment Controller software.
- Software is also available for the reference Memjet Vision System for inline alignment and live viewing.



Figure 23 - Memjet Reference DuraLink Printer and OEM System Architecture

Part 6

Building the Future of Print

The DuraLink digital printing platform expands Memjet's industry-leading speed, simplicity, and affordability to a broader range of commercial, packaging, and industrial printing markets.

With flexible printer development, outstanding print quality and durability, and remarkably long-lasting printheads, affordability takes on a new name.

DuraLink from Memjet. Brand new platform. All new potential.

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