WHITE PAPER

CHOOSING A DIGITAL FRONT END FOR YOUR HIGH-SPEED, SINGLE-PASS, ROLL-TO-ROLL INKJET PRESS

A white paper by Global Graphics Software, the OEM Software business unit of Hybrid Software

GLOBAL GRAPHICS® software

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Abstract

The Digital Front End (DFE) is a crucial component in inkjet printing solutions, acting as the nerve center that controls and coordinates the entire printing process. This white paper explores the role of the DFE in various aspects of inkjet printing, including performance optimization, ensuring print quality, enabling seamless workflows, and establishing secure connections within the production system. It discusses the importance of selecting the right DFE solution and supplier, emphasizing the need for a true partnership that offers expertise and support throughout the process. By carefully considering these factors, Original Equipment Manufacturers (OEMs) can achieve profitability quickly, while also retaining the flexibility to innovate and differentiate their offerings in the competitive inkjet market.

The Digital Front End (DFE) plays a vital role in the inkjet printing process, serving as the central software component that controls and coordinates every aspect of printing. As the print controller, the DFE oversees critical data points and ensures optimal performance throughout the printing workflow. OEMs have the option to build a custom DFE or purchase a turnkey solution, each with its own advantages and trade-offs. The DFE's role is paramount in high-speed, single-pass, roll-to-roll printers, where innovation is crucial for optimizing performance, ensuring consistent print quality, and integrating workflows, all while maintaining an affordable PC hardware cost. Additionally, the DFE must establish secure connections with other components in the production system, aligning with Industry 4.0 principles. This white paper explores the role of the DFE in these areas and highlights the importance of selecting a DFE supplier that acts as a true partner, supporting OEMs throughout their journey to market success. By carefully considering these factors, OEMs can achieve profitability quickly while retaining the flexibility to innovate and differentiate their offerings in the rapidly evolving inkjet market.

The role of the Digital Front End (DFE)

The DFE is the central software component in an inkjet solution, acting as a crucial nerve centre that controls and coordinates every aspect of the printing process. Its primary function is to serve as the print controller, overseeing and configuring critical data points. By fulfilling this role, the DFE plays a pivotal role in ensuring optimal performance throughout the entire printing workflow, from pre-press operations to the printhead drive electronics.

OEMs have various options for implementing the DFE, including the choice between building a custom DFE or purchasing a turnkey solution. Each approach has its own set of advantages and trade-offs, encompassing aspects such as control, speed to market, and the capacity for innovation and differentiation.

Ideally, OEMs strive to strike an optimal balance between building and buying, seeking a ready-made DFE that carries their brand while also providing an open set of components that can be innovated upon and differentiated by their engineering team. This approach enables them to achieve profitability faster while retaining the flexibility to enhance and differentiate their product. In the context of high-speed, single-pass, roll-to-roll printers, there are specific areas within DFEs that necessitate innovation. These areas require the development of advanced capabilities to cater to the unique requirements of such printers.

Performance

As inkjet printing continues to evolve, OEMs face a range of engineering challenges that demand their attention. Among these challenges, performance optimization is of utmost importance, particularly in scenarios involving complex backgrounds, variable data, higher resolutions, increased line speeds, wider print widths, extended gamut inks, and multi-level screening. These factors necessitate the DFE to efficiently process and drive a significant amount of data, ensuring the press operates at its maximum rated speed.

To handle the increasing data rates effectively, the most performant approach is to generate and stream the data inline to the printhead electronics. This eliminates the need to rasterize (RIP) the file ahead and the reliance on ever-increasing amounts of super-fast disk storage for data storage before rasterization.

However, the inline approach presents additional challenges when using PDF as a job format. Given the multitude of PDF creators available, the OEM's customers may not always have control over the software used to create the PDFs. Often, the focus of the creation software and content designers is on the aesthetic aspects of the design rather than the speed at which it can be printed. While PDF documents may appear visually identical in terms of quality, they can exhibit significant variations in rasterization performance due to variations in complexity.

Furthermore, the configuration of the raster image processor (RIP) and the PC hardware used to run it can have a profound impact on the processing speed of a single input document. Factors such as memory speed and CPU performance can produce different effects on different pages within a PDF.

The non-deterministic nature of PDFs and PDF RIPs is not as problematic when offline RIPping to files and then sending them to the press, as only the total rasterization time matters in that case. Similarly, printing inline with sheet-fed presses allows each page to be produced as soon as it's ready. However, in high-speed, roll-to-roll presses driven by an inline RIP, not delivering each page to the press in time can lead to underruns, resulting in waste and production stoppages.

To address these challenges, it is crucial to seek a DFE that RIPs inline directly to the printhead drive electronics. Additionally, the DFE should possess the ability to analyze the PDF and estimate if the RIP can process all pages before the buffer empties. Ideally, the DFE should also have the capability to automatically fine-tune the RIP, enabling more jobs to be run inline. Leveraging the strengths of machine learning and AI, modeling the combination of job complexity, RIP settings, and PC characteristics can lead to smarter DFEs in this area. By selecting a DFE with these capabilities, OEMs can overcome the challenges associated with PDF printing in high-speed, roll-to-roll presses. This ensures efficient production, minimizes waste, and prevents production stoppages, ultimately enhancing the overall performance and productivity of the inkjet printing process.

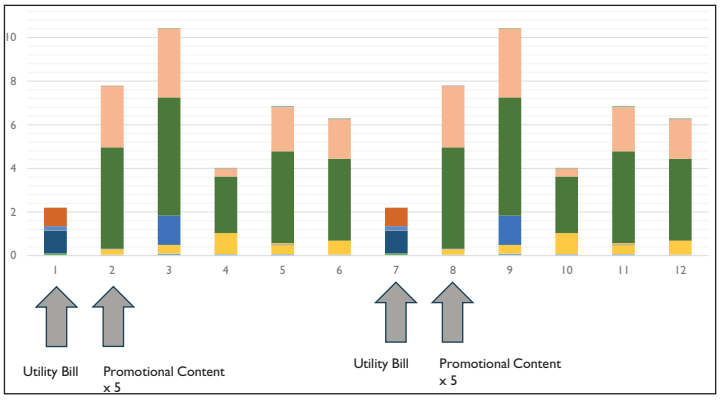

Fig 1: Charting the contribution to overall RIP time offers a visual representation of the work the RIP has to do. The graph shows a typical analysis of a trans-promo job. In this example, the variable (personalized) page comes first followed by promotional material, the pages of which vary in complexity but over the job the same pattern of pages is repeated over and over.

Quality

Ensuring consistent and high-quality print output is a critical objective for OEMs. However, as print becomes integrated into broader production processes, there is a challenge in maintaining the specialized print knowledge possessed by experts among press operators. This poses difficulties in replicating the desired print quality from reference presses to field presses.

To address this challenge, the DFE plays a crucial role. It should enable the packaging and sharing of print-quality expertise specific to media, ink, and press combinations. By capturing and embedding this expertise within the DFE, it becomes possible to ensure consistent and accurate reproduction of print quality across different presses. This empowers operators with the necessary tools and knowledge to achieve the desired output without relying solely on expert judgement.

Furthermore, the DFE should incorporate automation capabilities to handle production artifacts that can affect print quality, such as missing nozzles and banding. By automating the identification and correction of such issues, the DFE helps maintain optimal print quality throughout the production process. This reduces the reliance on manual intervention and minimizes the chances of errors or inconsistencies in the final print output.

Fig 2: The DFE should be able to handle artifacts that affect print quality, such as missing nozzles and banding.

In addition, the DFE should facilitate the collection and analysis of data from presses in the field. This data is invaluable for understanding complex interactions between different variables, such as media, ink, and press conditions. By leveraging this data, OEMs can gain insights into the

performance and behavior of their presses in real-world environments. This understanding enables the implementation of predictive maintenance strategies, ensuring optimal press performance, minimizing downtime, and maximizing overall productivity. By focusing on these aspects, the DFE serves as a critical component in maintaining consistent and high-quality print output. It empowers press operators with the necessary tools, knowledge, and automation capabilities while providing OEMs with valuable data insights for continuous improvement and efficient maintenance strategies

Workflow

To provide customers with significant value, the implementation of an integrated workflow solution is essential. This solution encompasses the design and integration of artwork with raw data, resulting in fully imposed variable data jobs. Pre-flight processes play a vital role in ensuring that these jobs are prepared and optimized for printing. Additionally, seamless connectivity with Management Information Systems (MIS) and Enterprise Resource Planning (ERP) systems streamlines overall operations and enhances efficiency.

For OEMs to meet these requirements, it is crucial to offer a flexible and extensible workflow solution. This solution should have the capability to adapt to different customer workflows, accommodating their unique requirements and preferences. Furthermore, seamless integration with the DFE is paramount, enabling a smooth and efficient transition from the design phase to printing. By integrating the workflow solution with the DFE, automated lights-out printing operations can be achieved, minimizing manual intervention and maximizing productivity.

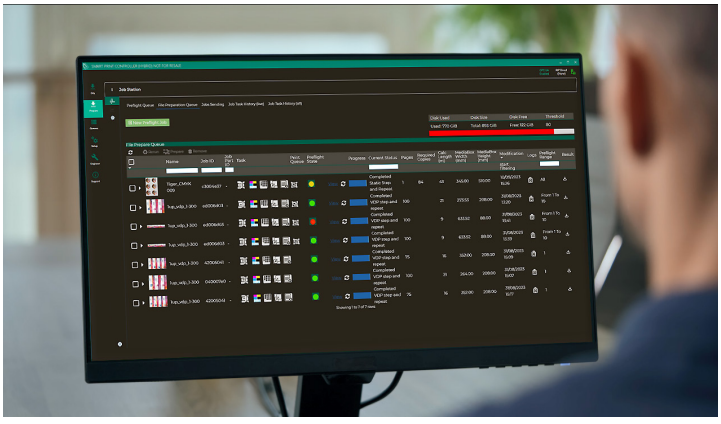

Fig 3: Advanced workflow software integrated into the DFE is essential.

In addition to current needs, OEMs should also consider future scalability and compatibility. By providing a workflow solution that can easily integrate with industry-standard workflows, customers have the flexibility to upgrade and expand their operations as their requirements evolve. This future-proofing approach ensures that the OEM's offering remains relevant and capable of meeting the growing needs of their customers.

The role of secure industry-standard protocols in the DFE for Industry 4.0

It is no longer sufficient for the DFE to solely communicate with press components; it must also establish secure connections with other components in the wider production system, as well as with cloud services. This communication should be facilitated through a secure industry-standard protocol shared by all systems within the production system, for example, OPC UA[1] or MQTT[2], aligning with the principles of Industry 4.0.

One of the primary advantages of Industry 4.0 is the optimization of operational efficiency. By leveraging advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and data analytics, OEMs can collect real-time data from various sensors and devices deployed along the production line. This enables proactive monitoring, predictive maintenance, and streamlined workflows, resulting in reduced downtime and enhanced resource utilization. Furthermore, the integration of cyber-physical systems and automation facilitates seamless communication and collaboration between machines, leading to faster production cycles, improved quality control, and overall increased efficiency. Embracing these capabilities empowers customers to achieve higher levels of productivity, cost reduction, and gain a competitive edge in the market.

[1] *Open Platform Communications Unified Architecture (OPC UA) - is a platform-independent, service-oriented architecture that provides the necessary infrastructure for interoperability across the enterprise, from machine-to-machine, machine-to-enterprise and everything in-between.*
https://opcfoundation.org/about/opc-technologies/opc-ua/

[2] *Message Queuing Telemetry Transport (MQTT) - a lightweight, publish-subscribe, machine-to-machine network protocol for message queuing.*
https://mqtt.org/

Enhancing print quality with camera-based inline inspection: the role of the DFE

The DFE plays a critical role in facilitating automatic quality inspection. An essential component of this inspection system is the camera-based inline inspection system, which serves two primary functions within the press: the first inspection system monitors print quality, detecting potential issues such as missing nozzles and banding. To ensure accurate monitoring, this system requires high-resolution cameras positioned near the print bars. Typically, it works in conjunction with specialized printed targets that enable the system to identify any abnormalities in the print output.

The second function focuses on inspecting the final product. This camera system carefully examines each product to ensure proper printing by reading text and barcodes, and comparing them with a database for accuracy. It also checks print placement, detects missing objects, and evaluates color variations. Importantly, the DFE must generate an output stream that aligns with the print stream going to the press, using RGB format instead of CMYK or Extended Gamut. This enables the camera system to efficiently process large amounts of raster data from the DFE and the camera without requiring the conversion of the CMYK stream to RGB, simplifying the inspection process.

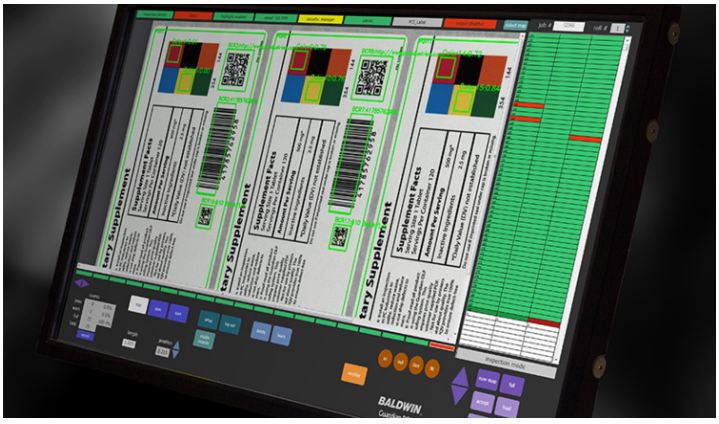

Fig 4: Printing inspection systems, such as those manufactured by Baldwin Vision Systems, make it possible to eliminate all defects, providing perfect quality to brand owners.

When selecting a DFE, it is crucial to choose a solution that can effectively communicate with inline-based camera inspection systems and potentially utilize the inspection results in a fully automated manner. This integration allows for seamless feedback and enables the implementation of a comprehensive, closed-loop quality control system. By incorporating automatic quality inspection capabilities into the DFE, inkjet printing operations can ensure enhanced print accuracy, improve product integrity, and streamline overall production processes.

The power of partnership: choosing a DFE supplier as an extension of your team

Bringing an inkjet press to market requires a specialized skill set and a significant engineering effort. It involves experts in RIP and screening technology, experienced software engineers, and color scientists with decades of real-world experience. Sometimes there may also be a need for additional software resources to overcome specific challenges and ensure a smooth path to market. These challenges can hinder both the press manufacturer and the DFE supplier from realizing steady revenue from ongoing business.

When selecting a DFE, it is important to choose a company that not only possesses extensive knowledge and experience in the industry but also demonstrates a strong commitment to your success in the market. Simplifying your experience can be achieved by selecting a DFE supplier that does not rely heavily on key subcomponents from third parties, such as core RIPs and color management modules. By doing so, your DFE supplier can take prompt action to implement any necessary changes without having to rely on subcontractors who may not prioritize print features as core roadmap items.

Ideally, the DFE supplier should be willing to share their engineering expertise and provide dedicated support to expedite your progress, eliminating any technical barriers along the way. It is crucial that this support is offered free of charge, showcasing a genuine partnership mentality instead of viewing your journey to the market as an opportunity for additional revenue generation.

Given the critical role of the DFE as the nerve centre of your inkjet press, it is vital to choose a DFE supplier that acts as an integral part of your team rather than merely a vendor trying to sell you a product. They should be seen as a true partner, working closely with you to ensure your success and offering the expertise and support needed throughout the entire process. Building

a strong partnership with your DFE supplier will contribute to a successful market launch and ongoing collaboration for long-term success.

Conclusion

The choice of DFE is pivotal for OEMs, as it enables them to achieve profitability quickly while retaining flexibility for innovation and product differentiation. For high-speed, single-pass, roll-to-roll printers, innovative DFE solutions are required to handle complex variables, process data at maximum speeds, and ensure consistent print quality. Moreover, an integrated workflow solution that encompasses artwork integration, pre-flight processes, and connectivity with management systems streamlines operations and provides significant value to customers.

The DFE's role extends beyond print control, as it must establish secure connections with other components in the production system, aligning with Industry 4.0 principles. Additionally, the DFE facilitates camera-based inline inspection for automatic quality control, enhancing print accuracy and product integrity. Selecting a DFE supplier who acts as a true partner, offering expertise and support throughout the process, is crucial for a successful market launch and ongoing collaboration. By carefully considering these aspects, OEMs can raise their chance of reaching sustainable run-rate business quickly and with the ability to innovate and differentiate their offering as the inkjet market matures.

About the author

Eric Worrall, Vice President of Products and Services

Eric Worrall joined Global Graphics Software in 2004 and currently leads the Product Management and Technical Services teams. Eric also leads the product strategy, position and vision within the company.

He has a wide experience of key roles including senior software developer, technical support, sales engineer and product manager, which puts him in an ideal place to understand the complete software business. Prior to joining Global Graphics Eric spent two years' post graduate research at the University of Leicester focusing on speech recognition in adverse noise environments. He worked in engineering and project management roles for both Marconi and Videojet. He has over twenty years of market knowledge in printing, digital documents, and machine vision technologies. Eric has six US Patents and a BEng (Hons) in Electronic and Electrical Engineering.

About Global Graphics Software

Global Graphics Software develops intelligent software components including the Harlequin RIP®, SmartDFE™, ScreenPro™ and Mako™ for print OEMs and Independent Service Vendors. Customers include HP, Canon, Durst, Mimaki, Mutoh, Roland, Kodak and Agfa. The roots of the company go back to 1986 and to the iconic university town of Cambridge, and, today the majority of the R&D team is still based near here. Global Graphics Software is a subsidiary of Hybrid Software Group PLC (Euronext: HYSG).

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Contact us:
info@globalgraphics.com

www.globalgraphics.com

Global Graphics Software Inc.
6601 S Tamiami Trail
Sarasota
FL34231, USA
Tel: +1-941 925 1303

Global Graphics Software Ltd
Building 2030
Cambourne Business Park
Cambourne, Cambridge
CB23 6DW UK
Tel: +44 (0)1954 283100

Global Graphics KK
613 AIOS Nagatacho Bldg.
2-17-17 Nagatacho, Chiyoda-ku,
Tokyo 100-0014
Japan
Tel: +81-3-6273-3198