



Grayscale and Beyond

Combining superior print quality with unprecedented speed is the driving force behind high performance industrial inkjet imaging. Until recently, systems developers had to trade-off image quality for production speed. Now Dimatix printheads, in particular its Q-Class when combined with its VersaDrop™ jetting technology, delivers high-accuracy, variable-drop jetting without affecting device productivity.

Q-Class is a family of drop-on-demand printheads with drop sizes ranging from 10 to 200 picoliters that combines precise, high-speed, multi-pulse binary jetting and versatile grayscale operation. Q-Class printheads offer the developer a choice of nozzle plates from metal to silicon. The choice of nozzle plate material determines the degree of drop placement accuracy, durability, corrosion resistance, ink formulation latitude, range of fluids accommodated and stand-off distance.

VersaDrop jetting technology leverages the inherent high frequency response of Q-Class printheads. It does this by activating the piezoelectric element with waveform pulses of varying amplitude to produce metered amounts of ink which are pumped into a single drop before the droplet detaches from the nozzle. This capability is used to form variable size drops with no compromise in jetting productivity. It offers a more robust solution compared to other grayscale implementations for modulating drop size by producing a single drop at high speed, rather than a burst of drops at significantly slower speeds.

Variable spot size, image quality and productivity

The highest image quality in fine text and color gradients is accomplished using a small spot size. For any given spot size, to achieve full ink coverage and optimal color density, the printing device must match resolution with spot size. For example, a 10-picoliter drop may require more than 1000-dpi resolution while a 50-picoliter drop has ample ink coverage on the same substrate at 400-dpi.

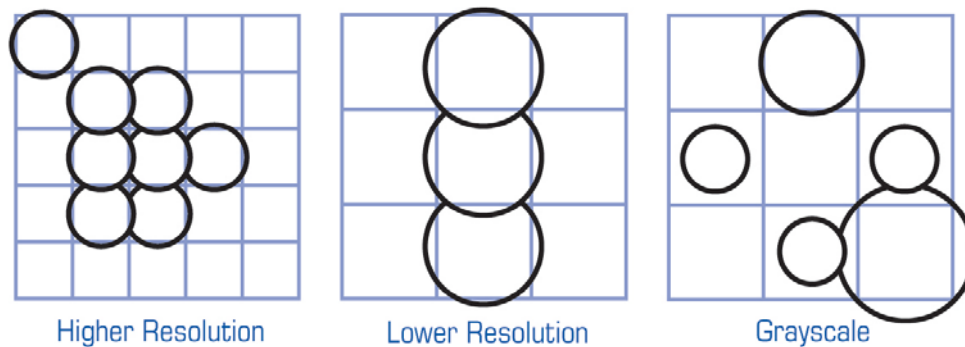
Once the resolution and drop size are established, the resolution and carriage speed determine printhead (printing) frequency. Dimatix printheads have a wide range of frequency choices but have a maximum frequency upper limit which is not typically exceeded. To summarize the key relationship – improving image quality drives toward the use of small drop sizes, but small drops/high resolution need higher frequency which limits overall printer productivity. Unlike other variable drop implementations,

VersaDrop decouples these two fundamental constraints to achieve high image quality and productivity within a single printing system.

Uniquely, VersaDrop produces variable drop sizes from a single printhead in two ways. First, variable binary mode can be used to create all drops within a single image with one drop size, but it allows the drop size to be changed for different print jobs based on desired image quality or substrate attributes. This allows the printing system to run in *high-quality* mode using small drop sizes, and then switch to *high-productivity* mode with a higher speed and lower resolution using larger drop sizes. This capability makes a more versatile printing system and does so without altering the linkage between image quality and productivity.

Second, in grayscale operating mode, VersaDrop can produce drops of varying sizes within a single image file to derive image quality consistent with small drop high resolution imaging combined with the productivity associated with large drop printing. Figure A shows typical spot patterns for two binary modes and grayscale.

Figure A



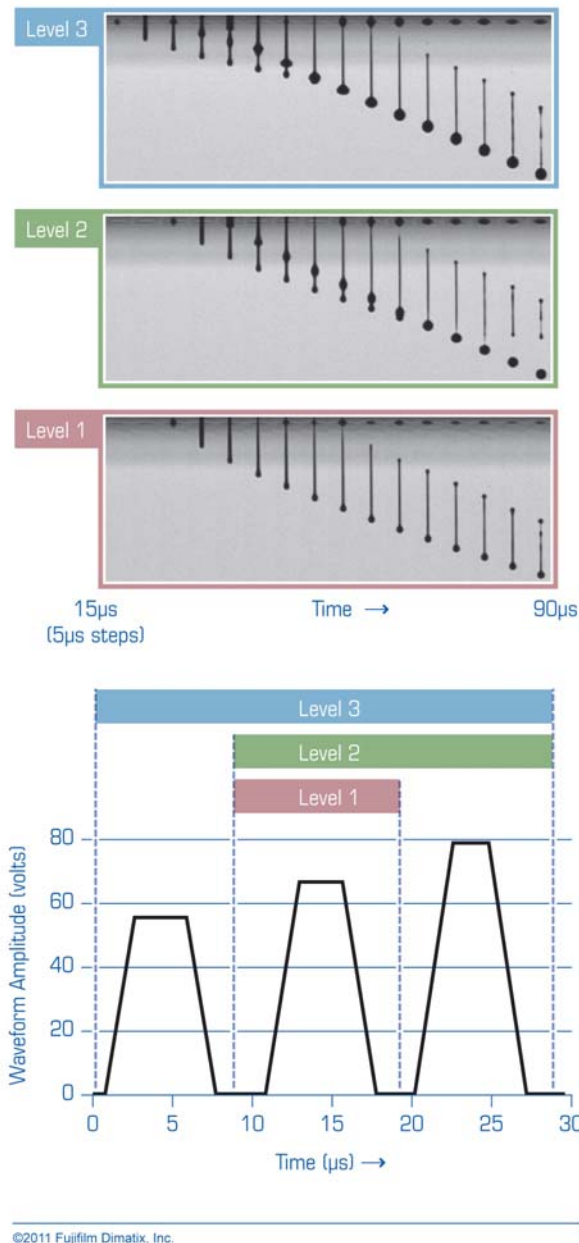
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VersaDrop variable drop size jetting combined with common interface Q-Class printheads enables the creation of very versatile and flexible printing systems.

Basic VersaDrop functionality

In a typical VersaDrop implementation a single complex waveform of multiple, varying height and width pulses is divided into segments. The RIP and data-path match combinations of waveform segments to gray levels to print the desire dot pattern. Any combination of waveform segments can be mapped to a given gray level, providing unprecedented versatility.

Figure B



Unique capabilities of VersaDrop

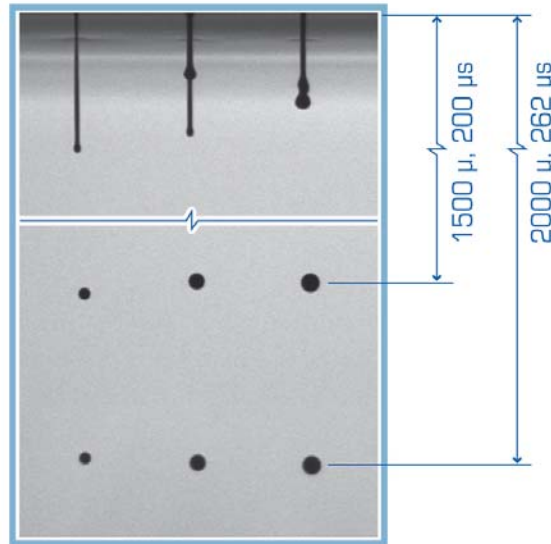
- **Tuned velocity for accurate spot placement**

Independent timing of each pulse and matching of any segments to a particular drop size allows greater control over simple multi-pulse operation. High velocity jetting is achievable with all drop sizes, including small drop resulting in accurate drop placement. By independently adjusting the velocity of the different drop sizes, application specific

tuning is possible. For example, system developers can tune all drop sizes to arrive at the substrate at the same location for a given stand-off distance.

Figure C

3 Drop Sizes Reaching Substrate at Same Time with Stand-off Distances

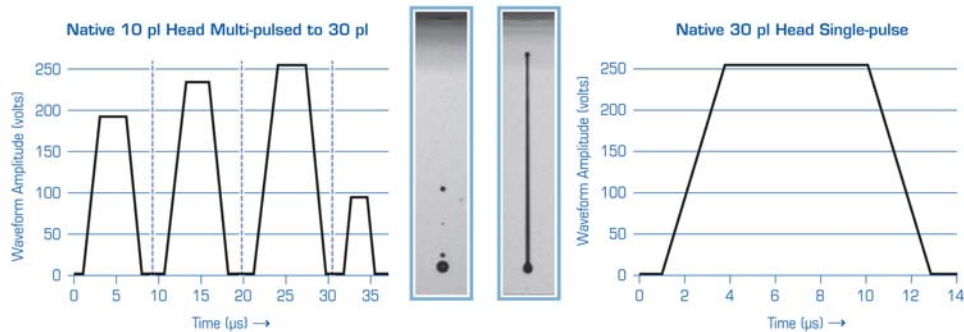


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- **Improve drop formation**

Waveforms can be tuned for optimum drop formation. Unlike other grayscale implementations, VersaDrop waveforms have the unique capability of forming the drop at the nozzle, for every drop size. This produces more defined spots on the substrate resulting in enhanced print quality. Figure D shows the improved drop formation possible on a 30ng drop using a multi-pulse compared to a single pulse waveform.

Figure D



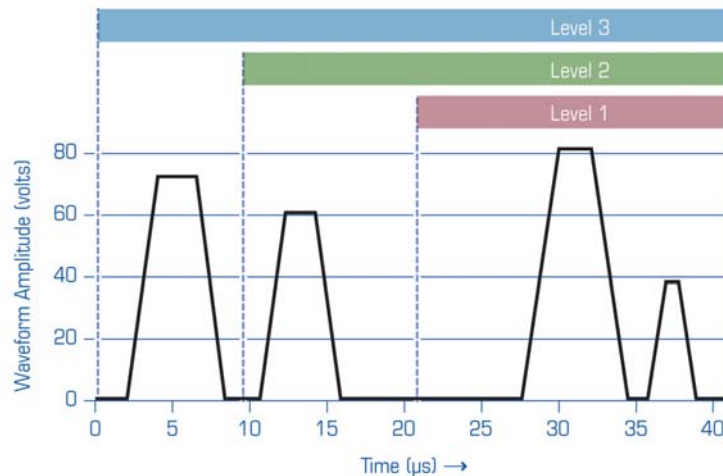
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- **Increased ink latitude**

Even within conventional applications such as wide format graphic printing there can be significant differences in ink properties such as speed of sound and ink rheology. As inkjet technology moves beyond wide format graphics into more demanding applications such as ceramics, textile and package printing, VersaDrop enables the accommodation of a wider range of formulations and properties-- critical to success.

VersaDrop technology is being used to enable more sustained jetting of volatile inks using a pulse too small to eject a drop, but large enough to refresh the ink near the nozzle. It is common to use VersaDrop to tune waveforms to match the ink speed of sound for most efficient jetting and to adjust drop break-off phenomena for complex ink rheology. In another example, the waveform in Figure E was developed for optimum sustainability for a particular UV ink.

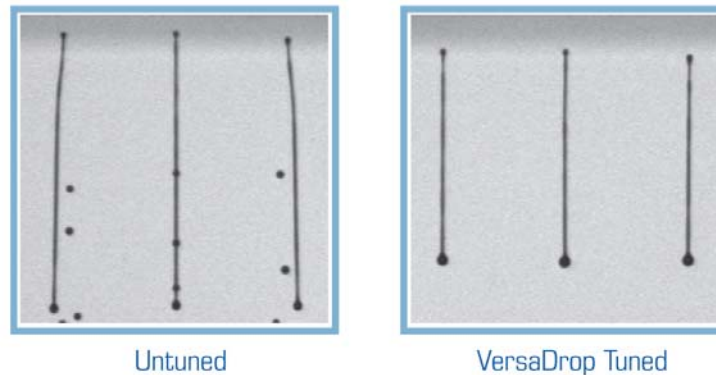
Figure E



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Nozzle plate wetting conditions are critical to maintaining straight and reliable jetting of ink. Jet break-off phenomena and meniscus behavior combine to deposit or consume ink on the nozzle plate, affecting steady state and transient wetting conditions. VersaDrop tools enable waveforms that maintain the nozzle plate in an optimum condition-- wetted but without ink pooling. Figure F shows the results of waveform tuning on this variable.

Figure F



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System requirements and support tools

To derive the full benefit of VersaDrop, system developers provide the necessary electronic interface and work closely with their ink developers to achieve high levels of sophistication in jet visualization and ink development. Dimatix provides the support hardware, software and training.

Tight linkage between data path and power electronics

The electrical interface to Dimatix printheads delivers straightforward access to basic VersaDrop functionality. To maximize performance and utilize the resident high printhead frequencies, timing of electronics is critical. Dimatix provides detailed application notes, packaged power and data electronics and design guidelines allowing developers to quickly advance their electrical system designs.

Drop visualization and waveform creation

Dimatix provides software enabling easy manipulation of all characteristics of complex waveforms and to facilitate interaction with jet visualization tools. These tools greatly speed the development of new waveforms and the tuning of existing ones. This can be done either by the developer's site or as a service by Dimatix.

Understanding how ink properties and waveforms interact

VersaDrop waveforms can quickly be modified to accommodate a speed of sound variation in an ink or optimized for the velocities of the different drop sizes. As the range of applications expand so do the need for new ink properties. Dimatix assist developers in the use VersaDrop by correlating ink properties with optimum waveforms and printer settings.

VersaDrop technology creates unrivaled flexibility to design waveforms and imaging strategy combinations specifically tuned for inks and desired jetting parameters stretching inkjet into new applications and new extremes of performance. Variable drop size jetting is a powerful method to achieve high productivity with superior print quality, simultaneously and without compromise.