

Enhanced frame delay reduction on image processors for LED displays

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1. Introduction

Video always has a certain refresh rate – the speed with which one image follows the other. Everyone probably remembers the old trick of a sketchbook with consecutive images. If you flipped through it very quickly, the image started ‘moving’. Video, whether analog or digital, uses the same principle, but its images follow one another so fast that the human eye perceives it as fluid motion, just like everyday reality.

However, challenges arise when the original content has to be transmitted, processed or manipulated in real time to get it from one device to another – e.g. feeding a camera image directly to a large screen on stage during a live show. Challenges could include a subpar synchronization of audio and video, that the image on screen appears later than what’s happening in real time, or that the image’s refresh rate looks choppy when compared to the actual live event.

Image processing equipment in particular deals with these challenges all the time, in various forms. Image processing on multi-tiered LED walls in particular have gone through subsequent evolutions that allows it to reduce so-called “frame delays” to a minimum.

2. Frame delay on LED walls

In rendering video content on LED display walls, frame delay is an important aspect. Generally, frame delay becomes slightly noticeable, depending on the individual viewer, once audio and video are out of sync for four frames or more. As such, a delay of three frames or less is ideal.

Barco’s DX-700 can overcome the synchronization challenges typically associated with very large LED walls and their extremely high video quality. For example, displaying live camera feeds at a close distance to the source requires an extremely low delay time.

To provide this very low video delay for delay-critical applications, three new and one enhanced video processing mode that provide significantly reduced video delay, have been added in the DX-700. With these modes, video delay as low as 2ms can be achieved for interlaced cameras, while still providing good image quality and full scaling capability.

The next sections detail the frame delay modes for the DX-700.

2.1. Standard mode for interlaced sources (existing mode):

The DX-700’s standard processing mode provides the highest image quality and video processing flexibility. This mode is ideal for applications that require live camera video or playback of recorded or prepared content. Applications may include:

- Applications requiring genlock to a house sync
- Multi-bank stacking applications for large LED walls
- Applications requiring vertical stacking of outputs
- Applications where the LED video refresh rates differ from the source

Delay in the DX-700 standard processing mode for interlaced sources is two frames (four fields) of video (80ms for 50Hz or 66.7ms for 59.94Hz). This delay is comprised of two fields in the de-interlacer, one field in the scaling engine and one field in the LED output channel frame buffers. All numerical references to delay are based on the DX-700 operating at 50Hz. The details are as follows:

- **De-interlacer delay** – Full motion adaptive de-interlacer processing delay in the DX-700 is one field + 100 lines. In a genlocked scenario, the output vertical timing must be synchronous and in-phase with the genlock source, to keep the LED image update synchronous with any cameras that may be used to record or broadcast the event. For the output to maintain vertical alignment with the genlock source, the “one field + 100 lines” must be re-aligned to two fields.
- **Scaler delay** - The scaler circuits add one field of processing delay.
- **Output buffer delay** - There is an additional field of delay (20ms for 50Hz, 16.7ms for 59.94Hz) in the DX-700 that applies to both interlaced and progressive input signals. The DX-700 creates one large image on a 2048x1080 canvas, similar to Barco’s Encore presentation system. Each LED output circuit crops out an output window from this canvas and outputs it to the LED wall. In each LED output channel, there is an output frame buffer that ensures that all pixels sent to all LED outputs are from the same image frame of the canvas image. Without this buffering, there could be frame tearing within the LED images as well as tearing between outputs that are vertically stacked. For example, consider a wall that is made up of two vertically stacked outputs. Without this frame buffer, the top output could be outputting the current frame of video while the bottom output would be outputting the previous frame.

2.2. Reduced Delay mode for interlaced sources (new mode)

The new Reduced Delay mode provides the same high image quality as the Standard processing mode, but at a much lower video processing delay. This mode is ideal for applications that need the highest possible image quality at lower video processing delay. It depends on the following conditions, all of which can easily be met:

- Single-bank LED walls, limited to 2048x1080 in size
- Applications requiring genlock to a house sync (no multi-banking)
- No vertical stacking of outputs
- LED wall refresh rate must be locked to that of the input source

In Reduced Delay mode for interlaced sources, total video processing delay in the DX-700 for 1080i sources is less than 25ms for 50Hz, or approximately 20ms for 59.94Hz (one interlaced field + n lines). This low processing delay is achieved with the full processing and image quality of the standard processing mode, but restricted to applications that do not require multi-bank stacking or vertical output stacking within a bank. However, these are conditions which do not occur in trade show setups where camera delay is an issue.

Delay improvement was achieved by:

- **De-interlacer delay** - Using low-latency field-frame processing in the Athena scaler, each field of interlaced input is scaled directly to the desired LED wall size. The motion-adaptive de-interlacer processing is bypassed since the progressive output is not created by combining interlaced fields. Please note that all input fields of data are used.
- **Scaling delay** - Video processing delay in the resizing engine has been optimized to be a number of lines, rather than a full field.
- **Output buffer delay** - Output buffer delay has been virtually eliminated, since multi-bank stacking and vertical stacking are not allowed in this mode.

2.3. Reduced Delay mode for progressive sources (new mode)

In this new mode, total video processing delay in the DX-700 is less than 2ms. It is ideal for applications where low video delay is critical and progressive 720p video cameras are used. For example, press events in a trade show booth, where the audience views the camera video up close on the LED wall and lip sync is possible.

In this mode, output timing must be locked to the input source. Please note that while this mode is not available in stacked multiple banks or vertical stacking of outputs, these are conditions which do not occur in trade show setups where camera delay is an issue.

Delay improvement was achieved by:

- **Video processing delay** in the resizing engine has been optimized.
- **Output buffer delay** has been virtually eliminated, since multi-bank stacking and vertical stacking are not allowed in this mode.

2.4. Minimum Delay mode for interlaced sources (new mode)

In this mode, total video processing delay in the DX-700 is less than 2ms. This extremely low processing delay is achieved for both SD and HD interlaced sources at both 50 and 59.94Hz. Output timing must be locked to the input source. Please note that while this mode is not available when stacking of multiple banks or vertical stacking of outputs, as these are conditions which do not occur in trade show setups where camera delay is an issue.

- **Low-latency field-frame de-interlacing** - Each field of interlaced input is scaled directly to the desired LED wall size. The motion-adaptive de-interlacer processing is bypassed since the progressive output is not created by combining interlaced fields. Please note that all input fields of data are used
- **Video processing delay** in the resizing engine has been optimized.
- **Output buffer delay** has been virtually eliminated, since multi-bank stacking and vertical stacking are not allowed in this mode.

2.5. Minimum Delay mode for progressive sources (improved mode)

In this mode, total video processing delay in the DX-700 is less than 2ms. This is slightly more than previously available in the Minimum Delay mode for progressive

inputs. However, the capability to scale the source to the LED wall size has been added to this mode. This capability was not available previously, except in the Standard Delay mode. In this mode, output timing must be locked to the input source. Please note that while this mode is not available when stacking of multiple banks or vertical stacking of outputs, these are conditions which do not occur in trade show setups where camera delay is an issue.

Delay improvement was achieved by:

- **Video processing delay** in the resizing engine has been optimized.
- **Output buffer delay** has been virtually eliminated, since multi-bank stacking and vertical stacking are not allowed in this mode.

3. Summary - DX-700 Video Processing Delay at 50Hz

Processing Mode	Selected Genlock Mode	Delay for 1080i@50 Sources	Delay for 575i@50 Sources	Delay for 720p@50 Sources
Standard Processing Mode	Free-run	80ms	80ms	60ms
	External	80ms *	80ms *	40ms *
	Input	80ms **	80ms **	40ms ***
Reduced Delay Mode	Input	25ms **	27ms **	2ms ***
Minimum Delay Mode	Input	2ms **	2ms **	2ms ***

* Value applies to all sources that are also genlocked to the same composite or black burst reference signal as the DX-700.

** For the genlock-selected interlaced source only.

*** For the genlock-selected progressive source only (60ms for other progressive sources)