

# Understanding and Optimizing the Latency on the VIO 4K

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## Introduction

Latency is a keyword when managing large video systems with a lot of chained devices, especially cameras whose content is delivered in real time close to the filmed subject. Each element in the chain adds its own latency to the system. If the latency induced by devices is not optimized, the delay between the video source and the display may become noticeable, not to say unbearable: delivered video is late causing desynchronization with the real scene.

## 1 Understanding the origins of the latency in the VIO 4K

Even if it seems natural that any device processing video adds latency (at least the time for the electric signal to go from the input plug to the output), it is often difficult to understand and control the latency of a device. Therefore, it is important to understand how video processing works and why it generates some delay.

The VIO 4K is a multi-format converter that can support any kind of input signal and convert it to another type. So it must be able to achieve, amongst other treatments, the following processing:

- **Data acquiring:** convert the data from the source to a processable format
- **De-interlacing:** transform an interlaced input signal into a progressive signal
- **Framerate Conversion:** change the input rate to another one
- **Scaling/Resize:** change the input resolution to another one
- **Rotation:** rotate the output content by 90° increments
- **Data delivery:** convert the data from the internal format to the output format

Analog Way's engineers optimized the VIO 4K video pipeline so that most of the image processing algorithms generate a latency limited to few lines only, even for rotation. The 3 main origins of the latency in the VIO 4K:

- **De-interlacing**
- **Framerate conversion**
- **Scaling**

Please note that processing analog or digital signal doesn't significantly change the latency.

### 1.1 De-interlacing

The de-interlacing process is used for interlaced input formats. In these formats, each image/frame is also called a field. The fields alternatively contain either the even lines or the odd lines of the video.

When simply combining two consecutive fields to create a progressive scan, a horizontal movement in the picture will cause a comb effect as the two fields were not captured at the same time.

- ⇒ To improve the quality of the recombined image, the algorithm also has to take care of the movement of each pixels

Depending on the used algorithm, the latency added by the de-interlacing process may vary from 0 to several frames.

The VIO 4K integrates Analog Way's latest generation of de-interlacing algorithm. This algorithm can work according to two modes:

- **Low latency mode:** this mode doesn't add any extra latency, still providing results better than most of algorithm found on the market.
- **Better quality:** this mode must be used for the most demanding applications. It adds a latency of one extra input frame.

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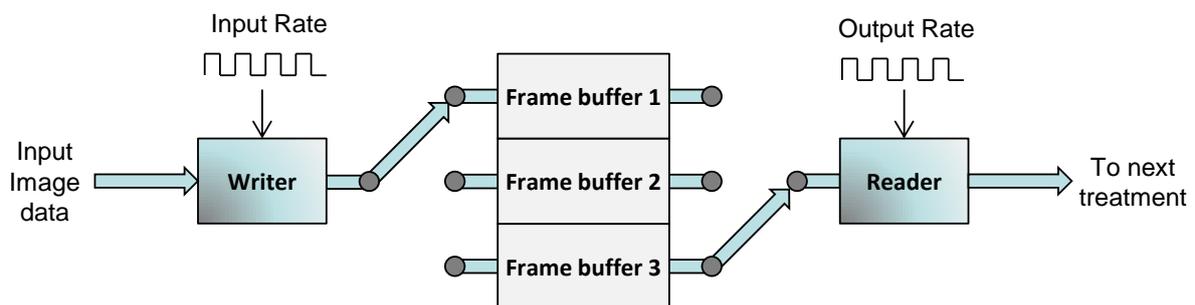
## 1.2 Framerate Conversion

To make things easier, the framerate conversion can be divided into two parts:

- The input part (Writer)
- The output part (Reader)

The input and output parts respectively writes and reads in 3 buffers according the following rules.

- The Writer writes the buffers at the input rate
- The Reader reads the buffer at the output rate
- A buffer can't be accessed simultaneously by the Writer and the Reader
- The Writer can write in a buffer only if it is empty
- The Reader can read a buffer only if it is full



If the writer fills the buffers faster than the reader reads them, it will get stuck as there is no more free buffer. The only solution is to overwrite the written buffer previously: one frame is lost. This is what typically arrives when you convert 60Hz to 50Hz.

If the reader reads the buffers faster than the writer fills them, it will get stuck as there is no more ready buffer. The only solution is to read again the same buffer: one frame is inserted. This is what typically arrives when you convert 50Hz to 60Hz.

In both cases, the image flow is modified to insert or delete images, generating a jerky perturbation.

The resulting latency is also composed of two parts:

- The input part adds a compulsory latency of one input frame for image buffering (used for scaling),
- The output part adds a latency that vary from 0 to one frame according to the phase shift between the Reader and the Writer.

Please note that:

- When using an internal reference for the output rate, the framerate conversion is always running even if both the selected rate and the input rate are the same. This is due to the fact that the input frequency and the internal clock may be slightly different and out of phase.
- The Frame rate conversion can be bypassed using the framelock/genlock features and there is no additional latency.

## 1.3 Scaling/Resize

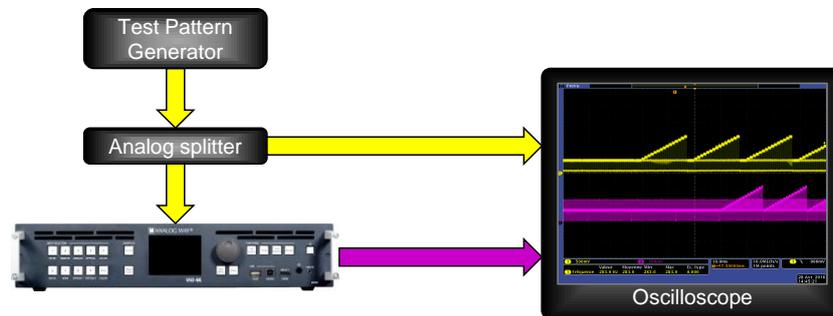
The fast algorithms to scale/resize a picture need several lines (at least two) to generate one output line. Depending on the scaling ratio (especially when downscaling), this number of required lines may dramatically increase for filtering purposes in order to improve the result. The source has to be softened before resizing in order to prevent the resulting image from being too sharp.

Therefore, a full image must be systematically buffered to achieve the scaling process

⇒ This buffering adds one extra output frame.

## 2 Latency measurement

The latency measurements can be achieved using the following setup:



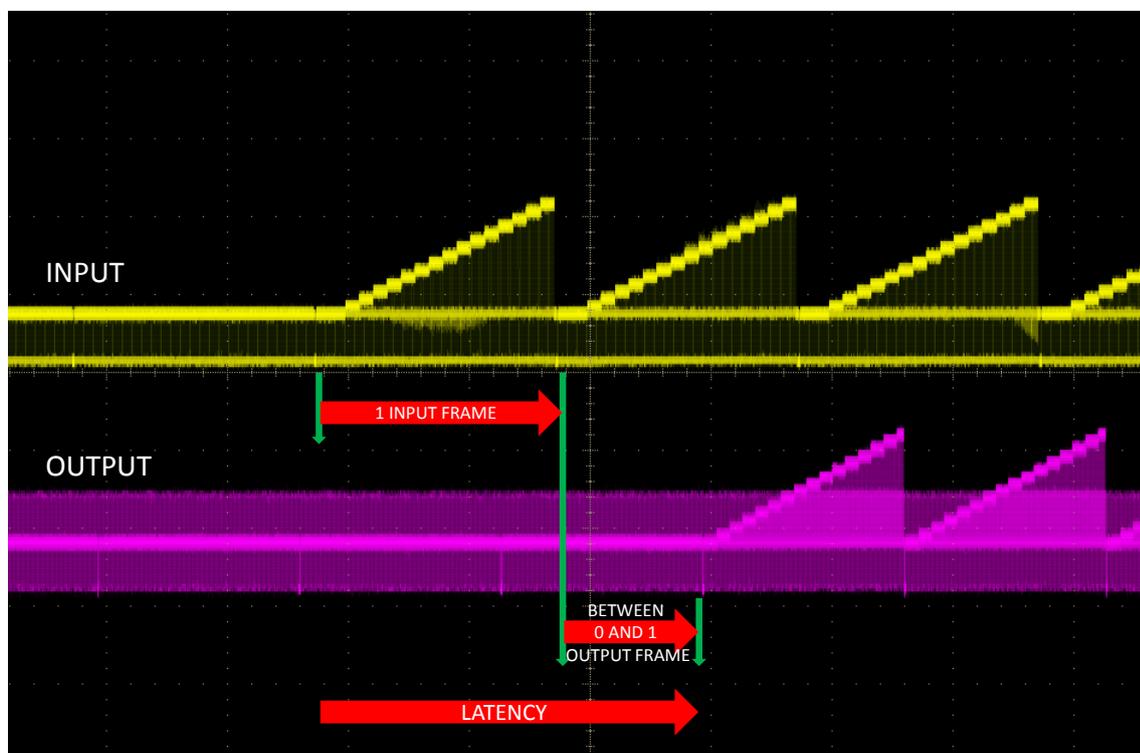
A test pattern generator delivers a color scale pattern. This analog signal is split into two identical signals (Yellow). One of these signals is sent directly to an oscilloscope whereas the second one is sent to the analog input of the VIO 4K. The analog output of the VIO 4K is also sent to the oscilloscope so that they can be compared.

To make sure the latency (phase) between the two signals is properly detected, the measurement is triggered when the input signal is detected by the oscilloscope.

**Please remember that processing analog and digital signals doesn't change the latency significantly.**

In the following sub-chapter, you can find screenshots from the oscilloscope with different input signals (progressive or interlaced) and output clock settings (internal reference or frame-lock)

### 2.1 Progressive input signal (720p 60) and Internal Reference output clock (1080p60)



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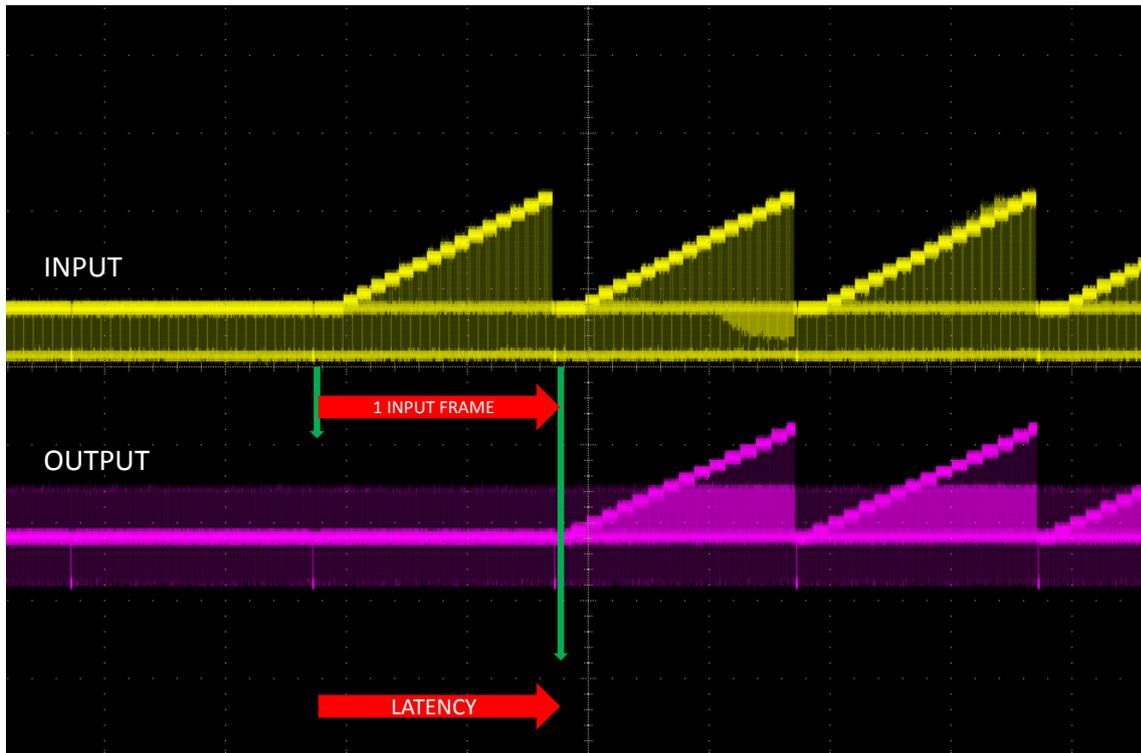
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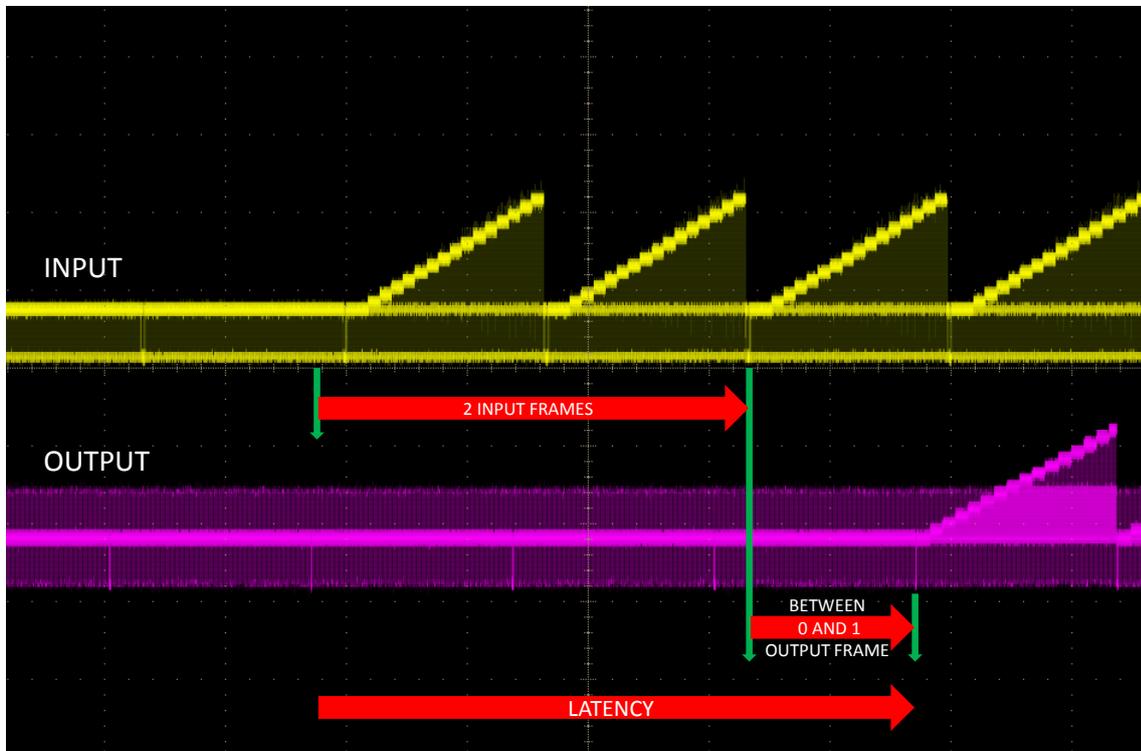
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**2.2 Progressive input signal (720p60) and frame-locked output clock (1080p60)**



**2.3 Interlaced input signal (1080i60), full quality de-interlacing mode and Internal Reference output clock (1080p60)**



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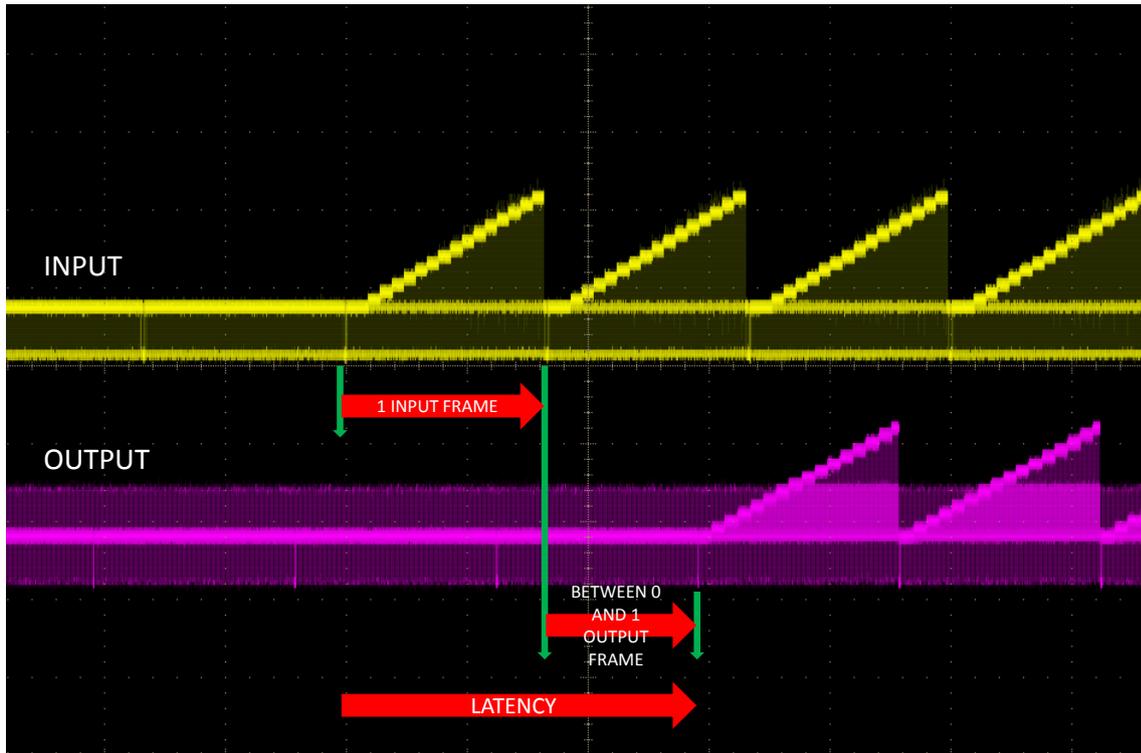
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**2.4 Interlaced input signal (1080i60), Low-latency de-interlacing mode and Internal Reference output clock (1080p60)**



**3 Optimizing the latency of the VIO 4K**

Now that the origins of the latency are better understood, it is much easier to configure the VIO4K to reduce it to the minimum.

**3.1 Rules**

- 1) If you have an interlaced input signal, check that the de-interlacing algorithm is configured to the **low latency mode** (This is the default mode).
- 2) Make sure the output rate is either:
  - a. **frame-locked** to the rate of the displayed input,
  - b. or **genlocked** to a reference signal that is also used to genlock the displayed input.
- 3) On the VIO 4K, rotation doesn't add any extra latency

**3.2 Summary**

	Internal Reference output clock	Frame-locked output clock
Progressive input signal	1 input frame + [0,1] output frame	1 input frame
Interlaced input signal + Low-latency de-interlacing mode	1 input frame + [0,1] output frame	1 input frame
Interlaced input signal + High quality de-interlacing mode	2 input frames + [0,1] output frame	2 input frames