TECHNICAL NOTE:

OBTAINING THE LOWEST LATENCY FROM YOUR HARRIER AF-ZOOM IP CAMERA

Summary

This Technical Note introduces IP cameras and the latency associated with IP video transmission; it also explains how to achieve the lowest latency from a Harrier AF-Zoom IP camera or Harrier IP Camera Interface Board, and what rates can be expected. With some Harrier cameras, latency can be as low as 140ms, however many factors will affect this, including the network configuration and type of PC used.

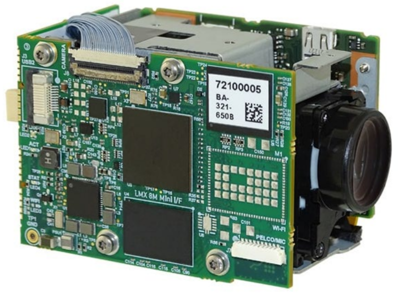

Figure 1 – Harrier 10x AF-Zoom IP/HDMI Camera (Tamron MP3010M-EV)

Background

An IP (Internet Protocol) camera is a digital camera that transmits and receives data over a network or the internet. An IP camera uses its own IP address to connect to a network and doesn't rely on a connection to a PC or alternative host device. IP cameras capture images, compress them (usually using H.264 or H.265 encoders) and then transmit them over an Ethernet network, commonly in the form of streaming real-time video. They may be used with a wired network (connected via an Ethernet cable to a switch/router/PC), or wirelessly (via a WiFi router/access point).

Controlling Harrier AF-Zoom IP cameras is straightforward. As they are ONVIF Profile S compatible, user developed applications, or any Profile S-based third-party software, can easily control the camera. Harrier AF-Zoom IP cameras also offer a wide range of other advanced camera features (e.g. day/night functionality, optical zoom, WDR, etc.) that can all be controlled remotely. In addition, the IP video stream is available in three different profiles, each with different video compression settings.

Understanding latency

For the purpose of this Technical Note, latency is defined as the delay from when an image is captured by the camera lens to when it is observable on a video display (glass to glass). Variability in latency is referred to as jitter, so a system with high variation in latency will have high jitter.

Image capture and video data transmission will always be subject to latency because of the unavoidable acquisition, transport and processing delays between various system components. Latency in vision systems is typically recorded in milliseconds (ms).

The level of acceptable latency within a vision system depends on the application. For example, an ANPR parking system can tolerate high latency as there is no short critical time requirement in the application. However, a moving remote-operated robot or vehicle requires the lowest latency possible so that the operator can respond quickly to the changes in the environment with minimal delay; a slow response time can result in inefficient operation and even damage to the vehicle or other nearby objects.

Human perception also plays a part in determining if latency levels are acceptable – anything taking longer than 200-300ms tends to feel sluggish and awkward to control, so ideally a real-time user-controlled system will aim for less than this.

Sources of latency and optimizations

Many different elements of the vision system add latency to the overall data transmission. The diagram below (Figure 2) shows where latency may be introduced.

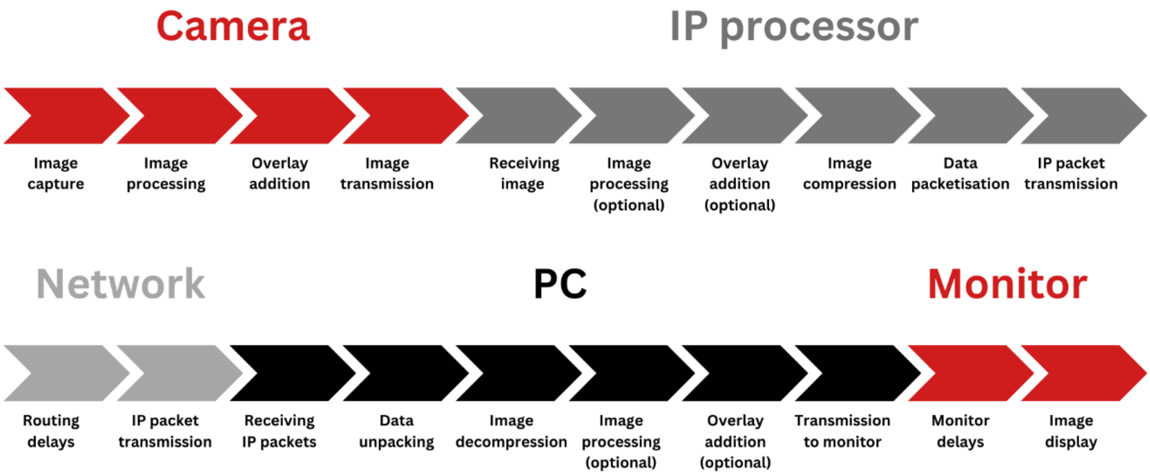

Figure 2 - Elements that may add latency to vision systems

Most Harrier IP cameras consist of an AF-Zoom block camera module (with LVDS output) connected to a Harrier IP Camera Interface Board that converts the LVDS video to IP format (see Figure 1).

AF-Zoom block cameras are sophisticated imaging instruments and they have many image processing features (e.g. auto white balance, auto exposure, lens distortion compensation, noise reduction, image stabilization, text and color overlays, privacy screens, motion alerts, and more).

However, the processing required for these features takes time, increasing the latency of the camera video. A typical AF-Zoom camera will have latency of 2-6 frames depending on the camera and the processing operations performed. The latency is also usually related to the video frame rate; e.g. features that require the processing of two image frames can only be applied after two frames have been captured, giving a minimum latency of at least a two frame time period. If the frame rate is faster, this time limitation is smaller - hence there is a direct relationship between frame rate and video output latency. To minimize latency in the block camera you should set a fast frame rate and not use complex image processing features; your camera may have low latency modes that can be enabled using a VISCA command (note: e.g. Tamron MP3010M-EV, however setting these modes usually limits the processing features of the camera, for example it may disable lens distortion correction).

The Harrier IP Camera Interface Board receives the image data from the camera module and can perform additional image processing such as the addition of overlays or image scaling. The images are then H.264 compressed and converted to a data packet format (IP/UDP) that can be sent to the network. Latency is reduced by using hardware to encode the video, and by optimizing/minimizing the video processing required. The latency of the Harrier IP Camera Interface Board is ~80ms.

The network receives the IP packets and routes them to the host computer. Receiving and transmitting the data is usually relatively fast and free of jitter. However, a complex and busy network will incur longer delays and more jitter as the packets may get held up and/or routed over different network paths. For low latency the network should be as simple as possible and not carry high amounts of unrelated data. A point-to-point (camera to host PC) connection will deliver the lowest latency and jitter.

As shown in Figure 2, the receiving computer/PC will add further latencies; data decompression and (optional) image processing contributing the greatest delays within the PC. Selecting a high-performance computer that can receive, decode, process and display the images quickly and without interruption will help deliver low latency, low jitter video transmission.

The video rendering software used to capture and display the video can also make a significant difference to the latency. Some software buffers several frames of data so that it can perform additional image processing to improve the image quality and deliver a smooth video stream. To reduce latency, ensure that the software can be, and is, set up to do minimal buffering and processing of the video stream before it sends the images to the screen. If a TCP/IP packet is lost the networking system will request that the packet be resent – this can cause the software to pause the video while it is waiting for the missing packet, other video data that is arriving is buffered, delaying the video stream. Some video renderers preserve this buffer/delay resulting in a longer latency, so you should check the properties of your video renderer and potentially use UDP packets instead of TCP. Missing UDP packets are not tracked/recovered and are simply lost.

Finally comes the latency of the display itself (often called input/display lag by gamers). This delay is caused by the time taken for the monitor electronics to receive and display the image on the LCD screen and can vary between 5ms and 68ms. Note that this is not the same as the pixel response time, which is the time taken for a pixel to change from one color to another. Some televisions and monitors/displays buffer a whole frame before displaying the image, adding a minimum latency of one frame period (~16.7ms @60fps). Others may also perform image processing to scale the image (to match the native display resolution) and/or reduce image artefacts (e.g. HDR, dynamic brightness/contrast, edge sharpening, comb filtering, etc.). These all add latency to the display of the image. For this reason, many modern televisions and displays offer a "game mode" setting that turns off the additional processing and minimizes the latency. Some gaming monitors can run at higher fame rates (e.g.120Hz); this reduces the monitor latency in the same way that setting your camera to the highest frame rate does.

For minimum latency, carefully check the features of your display, turn off all processing options that add latency and set the video resolution to be the same as the native monitor resolution (so that no image scaling is required and hence the latency is optimized). Some monitors may even have some input ports that are lower latency than others!

TN015: Obtaining the lowest latency from your Harrier AF-Zoom IP camera

For low latency video, keep the system as simple as possible and select your hardware and software carefully and with configuration for low latency in mind. Design the system to perform fewer, more specific tasks and eliminate unnecessary additional image processing where possible. Implement a latency optimized system and use hardware acceleration to minimize/eliminate delays and reduce jitter.

IP Ethernet latency measurement

This is how the latency of the Harrier IP camera module was measured:

- An application that shows the view of the camera on the PC monitor/display/screen is required e.g. ONVIF Device Manager (ODM), GStreamer.
- The camera was pointed at the PC screen.
- A timer with a fast screen refresh should be placed in the view of the camera.
  In this case the Windows Clock application was run in stopwatch mode and displayed on the screen so that it was in the view of the camera.
- The IP video display application was opened and the camera video displayed on the screen. The camera view was positioned so that the image of the timer on the screen was also in the view of the camera. Screen shots were made and glass-to-glass latency calculated from the difference in the two timer images shown on the display. Multiple measurements were made. It is also possible to record a video of the screen and then playback/pause the video to review individual frames so that multiple measurements can be easily made.

  When using GStreamer to display the video the command line used was:

  ```
  gst-launch-1.0.exe rtspsrc location=rtspu://192.168.189.99:8554/quality_h264
  latency=0 !  decodebin !  autovideosink sync=false
  ```

- As the timer display, camera and output monitor each have their own asynchronous refresh rates the calculated latency varies as these timings go in and out of phase resulting in jitter of approximately 40-50ms.

Example System Setup:

Harrier IP Camera:

- Profile: balanced_h264 (bitrate=0)
- Firmware version: v3.2 / v4.3
- Connection: 1000BASE-T (wired)
- Type: TCP / UDP

PC/software:

- ThinkPad X1 carbon 6th
  Intel(R) Core(TM) i7-8550U CPU @ 1.80GHz / 1.99 GHz
- Thinkpad USB-C dock, DK1633
- Windows 10 Pro 22H2
- ODM v2.2.250 / Gstreamer msvc_x86_64 v 1.0
- Microsoft Windows Clock application
- Dell monitor U2412M

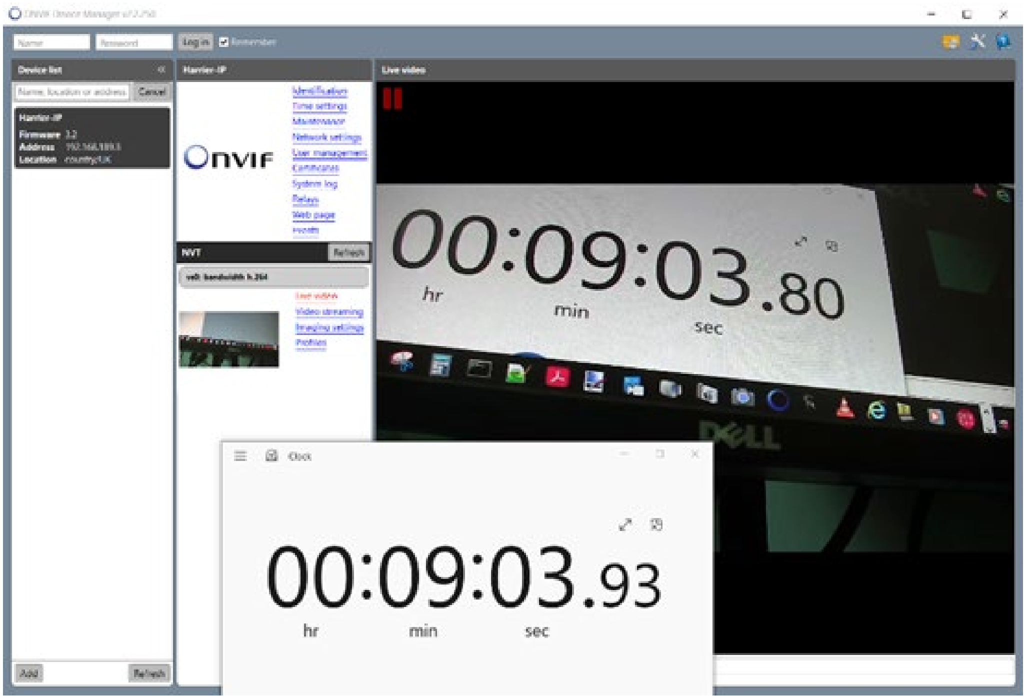

Figure 3: Example screen set up for recording latency measurements

Latency measurements

Camera Model	Resolution & FPS	Encoding Interval*	Latency (ms)
Cameras with Harrier IP Camera Interface Board technology			
Harrier 10x AF-Zoom IP Camera AS-CIB-IP-001-10LHD-A	1080p60	1	~140
	1080p60*	2	~140
	1080p30	1	~210
Harrier 10x AF-Zoom IP/HDMI Camera (Tamron MP3010M-EV) AS-CIB-IP-001-3010-A LL= camera Low Latency mode enabled	1080p60 LL**	1	~140
	1080p60	1	~175
	1080p60*	2	~180
	1080p30	1	~280
Harrier 36x AF-Zoom IP Camera AS-CIB-IP-001-36LGHD-A	1080p30	1	~230
Harrier 40x AF-Zoom IP Camera AS-CIB-IP-001-40LHD-A	1080p60	1	~140
	1080p60*	2	~140
	1080p30	1	~200
Harrier 55x AF-Zoom IP Camera AS-CIB-IP-001-55LHD-A	1080p30	1	~180
	1080p25	1	~210
Harrier 30x AF-Zoom IP Camera (Sony FCB-EV9520L) AS-CIB-IP-001-9520L-A	1080p60 LL**	1	~145
	1080p60	1	~185
	1080p60*	2	~170
	1080p30	1	~230
Harrier 30x AF-Zoom IP Camera (Sony FCB-EV7520A) AS-CIB-IP-001-7520A-A	1080p60	1	~210
	1080p60*	2	~220
	1080p30	1	~310
Cameras with native Ethernet IP video output			
Harrier 23x AF-Zoom IP 4K Camera AS-CAM-23IP4K-A	2160p25	1	~210
	1080p25	1	~150
Harrier 52x AF-Zoom IP Camera AS-CAM-52IPHD-A	1080p25	1	~180

NOTE: The Harrier IP Camera Interface Board introduces a latency of approximately 80ms depending on the mode used. Most of the remaining latency comes from the AF-Zoom block camera and other parts of the system. The Harrier 23x AF-Zoom IP 4K camera and the Harrier 52x AF-Zoom

IP camera do not require a camera interface board as processing is carried out directly on the camera.

*** Harrier 1080p30 special low latency mode**

The Harrier IP Camera Interface Board has a special 1080p30 low latency configuration. This mode delivers 1080p30 video with the same camera latency as 1080p60 video by configuring the camera to 1080p60 output but setting the IP video encoder to only process every other frame (Encoding Interval (E.I) = 2) resulting in a 1080p30 video stream.

The value of the Encoding Interval can be set in ONVIF Device Manager or in the ONVIF element: `VideoEncoderConfiguration:: RateControl.`

**** Camera low latency mode**

Some AF-Zoom block cameras have low latency modes that can be turned on – however these reduce the amount of image processing and can affect the quality of the image (e.g. disabling lens/distortion correction functions) and restrict the ability of the camera to process the video data. The Tamron MP3010M-EV low latency mode reduces the latency by the time for two video frames and a measurement is listed/shown as 1080p60 LL (Low Latency) in the table/graph.

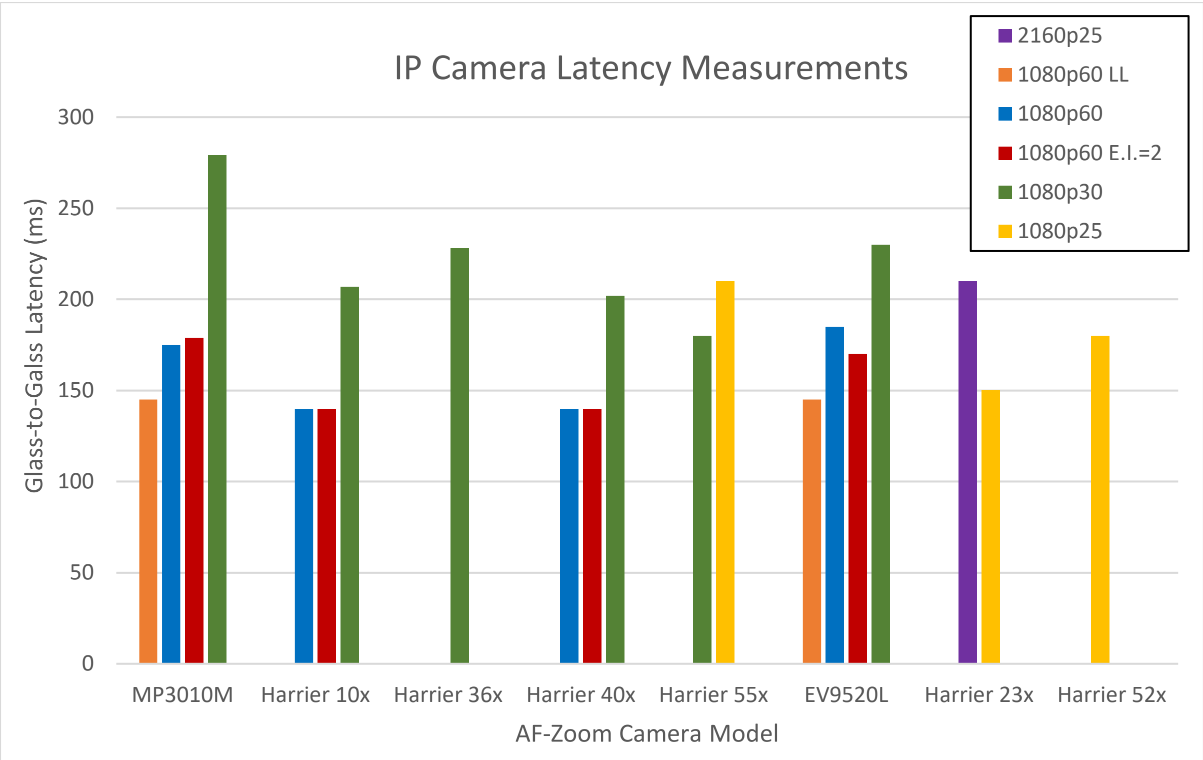

Figure 4: Latency measurements in milliseconds

TECHNICAL NOTE

TN015: Obtaining the lowest latency from your Harrier AF-Zoom IP camera

Summary

Harrier IP cameras bring extremely low latency to the video system. While each element of a vision system will add to the overall latency, developers can address aspects of each component to reduce this as much as possible. In this note, we have made these recommendations to minimize latency:

- Set the highest frame rate on the AF-Zoom camera (e.g. 60Hz).
- Do not use processing-intense AF-Zoom camera features.
- Enable low latency mode if the AF-Zoom camera has one.
- If the volume of the data at the high frame rate is too high set the Harrier IP Camera Interface board Encoding Interval to 2 to deliver 1080p30 with ~1080p60 latency.
- Use a hardware accelerated IP processing interface board such as the Harrier IP Camera Interface Board.
- Operate a simple network that doesn't carry high amounts of unrelated data.
- Use a point-to-point network connection for the lowest latency and jitter.
- Select a high-performance computer that can receive, decode, process and display images quickly without interruption.
- Select software which can be set to perform minimal buffering and video processing.
- Ensure that the display screen has minimal latency.

Depending on the model and mode/image processing features used, the AF-Zoom camera will add between 50-200ms of latency to the video. The Harrier IP Camera Interface Board will add approximately 80ms of additional latency. By configuring the various components of the system, you can obtain the lowest latency results for your vision system without additional complexity or cost.

FAQs

How do I set up my Harrier IP camera and interface board?

All our Harrier cameras and interface boards come with a Quick Start guide which can be downloaded from the product page on our website:
https://www.activesilicon.com/products/cameras/

This includes instructions on discovering the camera's IP address, assigning a fixed IP address, viewing video streams and controlling the camera. You can also view the tutorial video on our website, "How to set up a Harrier IP camera".

Examples of how to implement the text/graphical overlays and VISCA camera control can be found in the Harrier IP Example Software which is also available to download from our website.

What are the optimal camera settings?

Camera latency is usually related to the frame rate so higher frame rates are usually better. For example the camera latency may be specified as 3 frames, so at 30Hz this is 100ms, at 60Hz this is 50ms.

If 60Hz generates too much data for your network or your recordings, the Harrier IP Camera Interface Board can be set into a special low latency mode; the camera is configured as 1080p60 and the

Encoding Interval set to 2. In this mode, the camera is set to 60Hz to obtain the lowest latency, but every other frame is discarded to give a 30Hz IP video output. This reduces the transmission bandwidth and storage requirement but retains the lowest camera latency.

Can this be optimized further with less compression?

The H.264 compression is done in hardware so changing the compression settings is unlikely to noticeably reduce the latency.

What's available in the Harrier range?

The Harrier range of IP video products consists of:

- Harrier IP Camera Interface Board – supports Harrier, Tamron, Sony and other LVDS block cameras (converts LVDS video data to Ethernet IP [H.264 RTP streaming] video). The IP board has an option to support both wired and wireless IP connectivity.
- Harrier 10x AF-Zoom IP Camera
- Harrier 10x AF-Zoom IP/HDMI Camera (Tamron MP3010M-EV)
- Harrier 23x AF-Zoom IP 4K Camera
- Harrier 30x AF-Zoom IP Camera (Sony FCB-EV9520L)
- Harrier 30x AF-Zoom IP Camera (Sony FCB-EV9500L)
- Harrier 36x AF-Zoom IP Camera with Global Shutter
- Harrier 40x AF-Zoom IP Camera
- Harrier 52x AF-Zoom IP Camera
- Harrier 55x AF-Zoom IP Camera

Active Silicon
COMPUTER IMAGING PRODUCTS
A SOLID STATE PLC GROUP COMPANY

Headquarters:

Active Silicon Ltd
Pinewood Mews, Bond Close, Iver,
Bucks, SL0 0NA, UK.

Tel: +44 (0)1753 650600
Fax: +44 (0)1753 651661
Email info@activesilicon.com
Website: www.activesilicon.com

North America:

Active Silicon, Inc.
479 Jumpers Hole Road, Suite 301,
Severna Park, MD 21146, USA.

Tel: +1 410-696-7642
Fax: +1 410-696-7643
Email: info@activesilicon.com
Website: www.activesilicon.com