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http://www.teledynedalsa.com/Genie-Nano

G3-AN0004-v1: TurboDrive v2.0 Application Note

Genie Nano: Comparing TurboDrive v2.0 with TurboDrive v1.0

For Nano models with P/N: G3-Gxxx-xxxxx

Overview

Teledyne DALSA TurboDrive v2.0 is an evolution from the original TurboDrive v1.0, allowing greater user-control and minimum guaranteed image compression that provides dependable bandwidth. This application note details the TurboDrive v2.0 features , highlights the improvements from TurboDrive v1.0, and provides general information on using TurboDrive.

The following table lists the Genie Nano firmware and software to support TurboDrive v2.0 and TurboDrive v1.0.

TurboDrive Version	Genie Nano Firmware	Software SDK
TurboDrive v2.0	version 2.x	Sapera LT 8.40 Sapera LT 8.02 to 8.30 (with installation of Sapera GigE Vision & Generic GigE Vision Acquisition modules v5.10)
TurboDrive v1.0	version 1.x	Sapera LT 8.02 to 8.30
		Teledyne DALSA's GigE-V Framework for Linux 32/64-bit Version 2.02 and greater
		Stemmer Common Vision Blox 2016 (and greater)

Sapera LT SDK (full version), the image acquisition and control SDK for Teledyne DALSA cameras and frame grabbers, as well as the **GigE-V Framework for Linux**, is available for download from the Teledyne DALSA website:

http://teledynedalsa.com/imaging/support/downloads/sdks/

TurboDrive Overview

TurboDrive is an image encoding/decoding technology. Image encoding is performed on cameras equipped with TurboDrive firmware; the sensor outputs images that are encoded (compressed), packetized according to the GigE-Vision standard and transmitted via the camera's Ethernet port to the host computer. Image decoding is performed by the host computer, running the Sapera Network Imaging Package. GigE-Vision packets are received on the host computer's Ethernet network interface, decoded and complete images placed in memory buffers for the application to access.

This process is transparent to the user; image buffers are transferred from the camera to the host and retrieved in the same manner as any normal acquisition, without regard to the transmission mechanism or any TurboDrive encoding/decoding which is performed below the application level.

TurboDrive v2.0 vs. v1.0

The primary enhancements in TurboDrive v2.0 from v1.0 are encoding can be both lossless/lossy and minimum image compression rates guaranteed, regardless of image contents. In contrast, TurboDrive v1.0 supports lossless encoding only and compression levels are image content dependent.

While TurboDrive v1.0 provides lossless compression only (enabled/disabled (On/Off), without any possible configuration), TurboDrive v2.0 allows the user to select a "Quality Level" from lossless (Quality Level 0) to varying degrees of lossy compression (Quality Level 6 being the highest compression level).

Currently TurboDrive v2.0 is implemented for 8-bit pixels, monochrome or Bayer; TurboDrive v1.0 supports 8, 10, 12-bit monochrome pixels, as well as Bayer encoding.

Metadata is supported by TurboDrive v1.0 (Genie Nano firmware 1.07 and greater); TurboDrive v2.0 support for metadata is planned for future releases.

The following table compares the available features for TurboDrive v1.0 and v2.0:

Feature	TurboDrive v2.0	TurboDrive v1.0
8-bit images	✔	✔
10-bit images		✔
12-bit images		✔
Lossless Compression	✔	✔
Lossy Compression	✔	
User-configurable Quality Levels	✔	
Metadata Enable		✔ * (*release 1.07 and higher only)

Quality Level

The "Quality Level" determines the compression to use to encode pixel values. The Quality Level ranges from 0 (lossless) and 1 to 6 (lossy).

Using the maximum lossy quality level (Quality Level 6), TurboDrive v2.0 can typically encode images with exceptional preservation of image data and few noticeable artifacts (depending on the image contents), compressing images to about a 1/3 of the original size.

As shown below in these sample images, a high level of image detail can be maintained even when Quality Level 6 is used. The high contrast regions contain the most noticeable artifacts, which are still minimally noticeable to the naked eye.

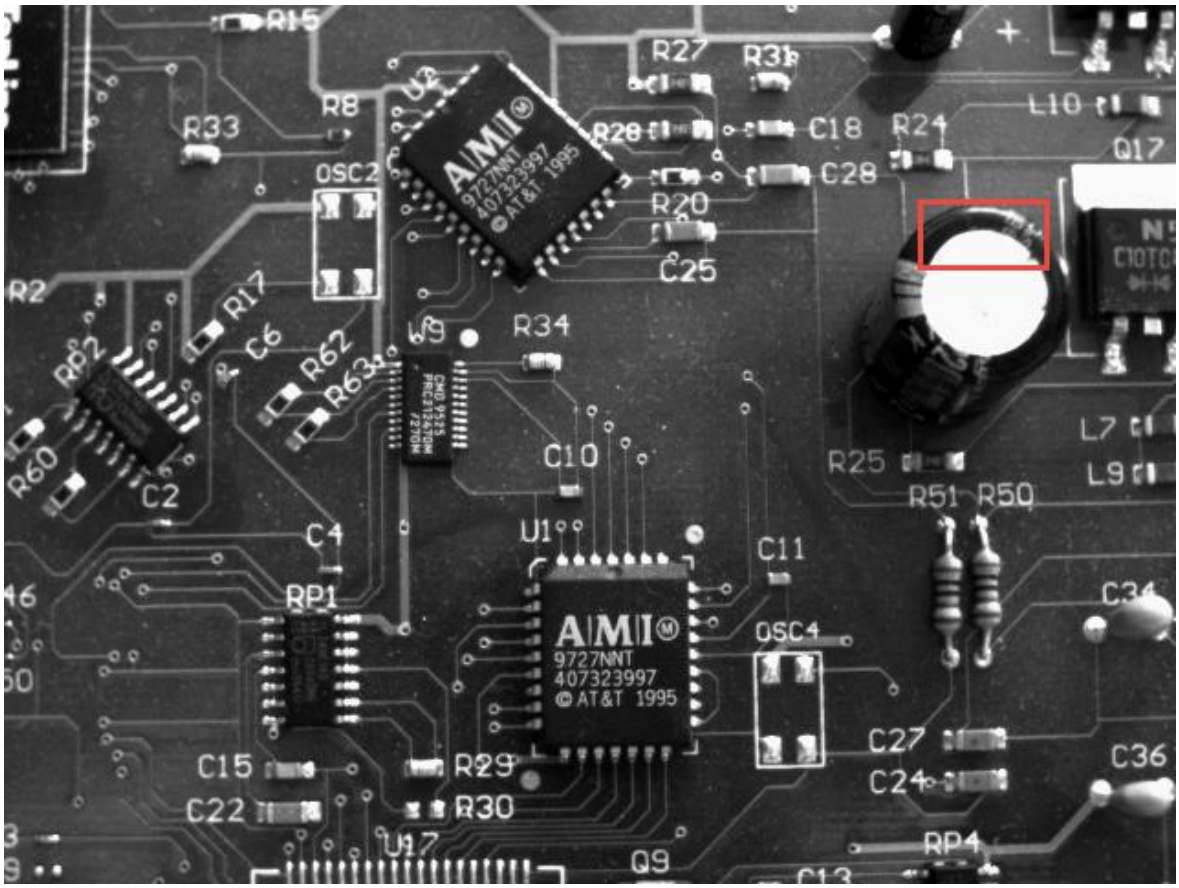


Figure 1: Raw image

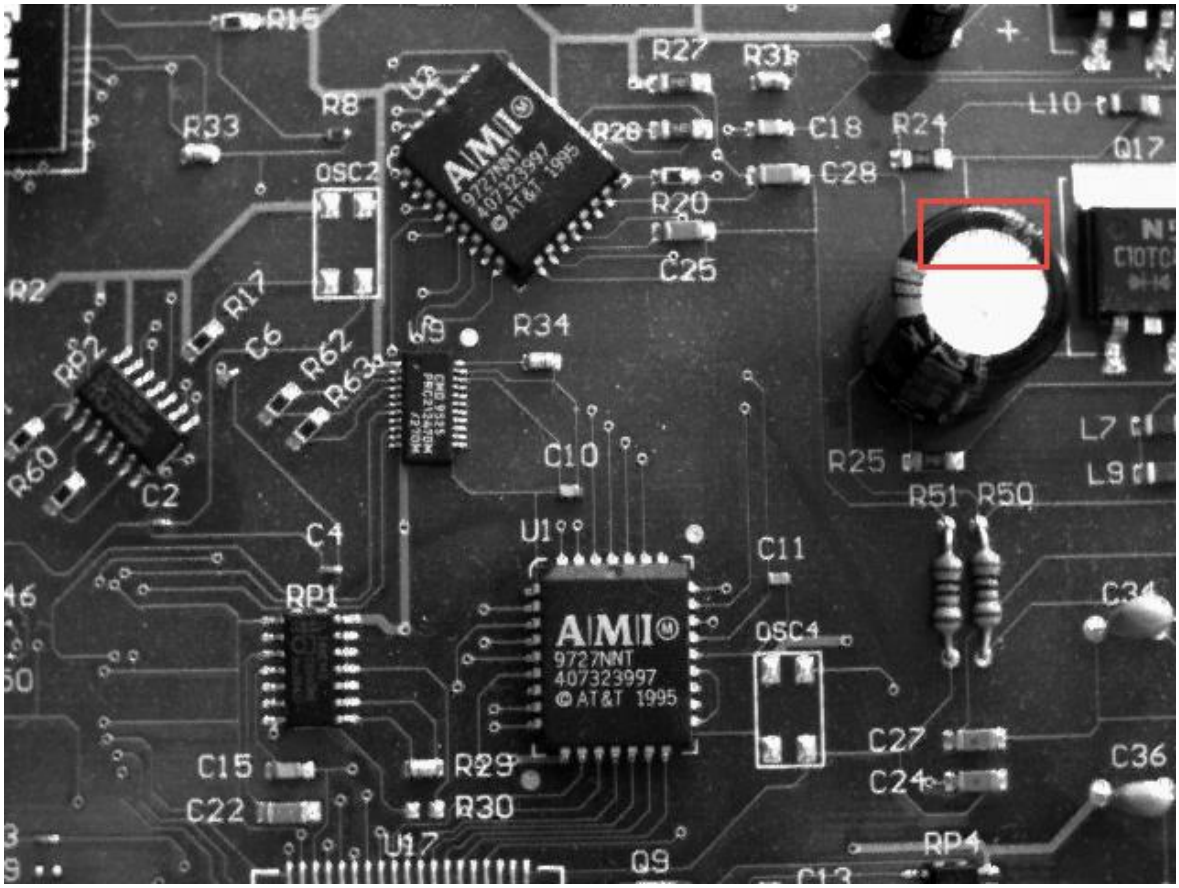


Figure 2: Image at Quality Level 6

Quality Level 0	Quality Level 1	Quality Level 2	Quality Level 3
			
Quality Level 4	Quality Level 5	Quality Level 6	
			

Figure 3: Quality Level Comparisons

The lossy technique has a new advantage of being able to guarantee a minimum level of compression for each Quality Level. The following table provides the **guaranteed** minimum compression enabled by each Quality Level (with pixel size of 8-bit), for the absolute worst case scenario (no use of higher compression due to image contents):

Quality Level	**Image Compression Ratio** (absolute worst case scenario)	**Effective Bandwidth Gain**
0 (Lossless)	1.00	No gain
1	0 .96875	1.03X
2	0.84375	1.18X
3	0.71875	1.39X
4	0.59375	1.68X
5	0.46875	2.13X
6	0.34375	2.90X

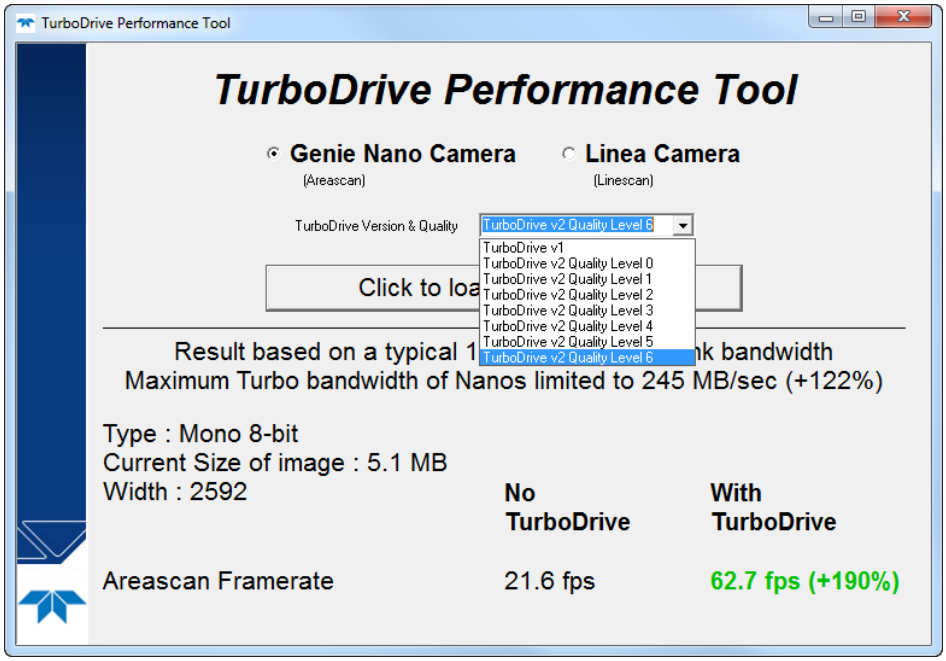
For example, TurboDrive 2.0 provides the following results with a standard HD image (1920 x 1080) using the absolute worst case scenario:

Quality Level	**Image Size** (in megapixels)
0 (Lossless)	2.07 MP (2073600 pixels)
1	2.01 MP (2006934 pixels)
2	1.75 MP (1749600 pixels)
3	1.49 MP (1490400 pixels)
4	1.23 MP (1231200 pixels)
5	0.97 MP (972000 pixels)
6	0.71 MP (712800 pixels)

Higher compression levels than the miniumum provided by the selected Quality Level are possible, depending on the image contents.

TurboDrive Performance Tool

The TurboDrive Performance Tool allows you to evaluate the actual performance of either TurboDrive v2.0 or v1.0 for an application's expected typical image, using any supported image type. For TurboDrive v2.0, all Quality Levels are available.

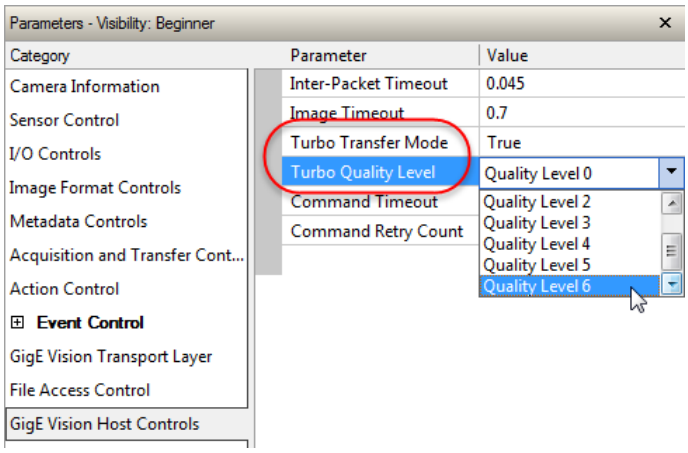


The TurboDrive Performance Tool is available for download from the Teledyne DALSA website's Turbo Drive page:

www.teledynedalsa.com/meet-turbodrive

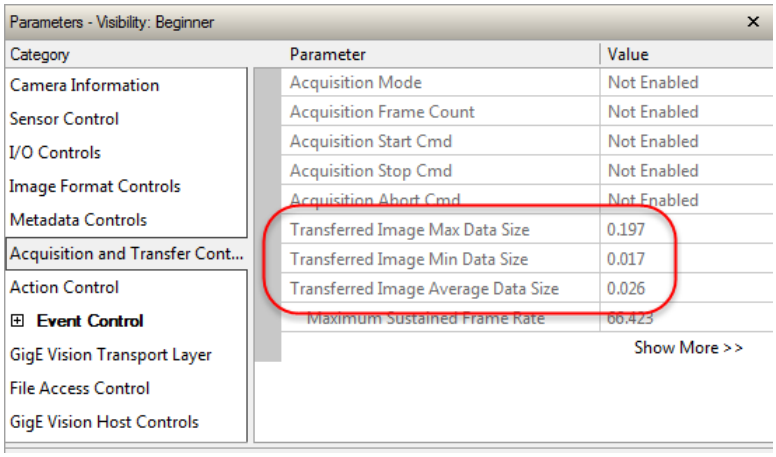
Enabling TurboDrive and Setting Quality Level

To enable TurboDrive, set the Turbo Transfer Mode feature to True (*turboTransferMode = True*) and set the Turbo Quality Level feature to the required level (*turboTransferQualityLevel = Quality_Level_x_x*). These features are available in the GigE Vision Host Controls category.



Transfer Performance Statistics

The features available in the Acquisition and Transfer Control category can be used to monitor the transfer performance. These statisitics are available for any acquisition, whether using TurboDrive or not.



Available statistics include:

- Maximum image data size, in MB, transferred since the start of acquisition. (*transferMaxBlockSize* feature)
- Minimum image data size, in MB, transferred since the start of acquisition. (*transferMinBlockSize* feature)
- Average image data size, in MB, for the last 16 images. (*transferAverageBlockSize* feature)

These statisitics can be used to calculate mininum, maximum, and average framerates transferred on the GigE cable. Generally, it is recommended to perform calculations using the GigE link speed as ~115 MB/s to allow for network overhead.

For example, to calculate the average framerate in MB/s:

$$\frac{115}{transferAverageBlockSize}$$

Avoiding Lost Frames: Monitoring the Transfer Queue

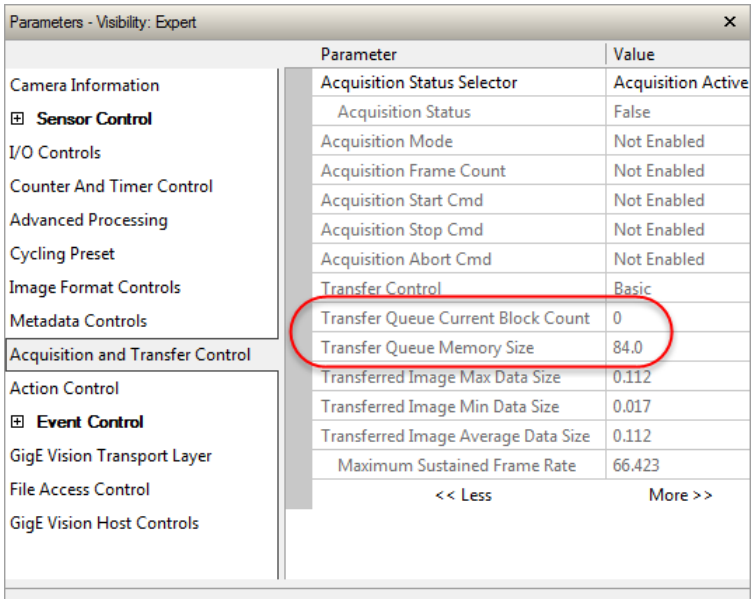
Genie Nano cameras use on-board memory, known as the transfer queue, to store images before transferring them to the host computer. In general, for reliable transmission, the transfer queue block count should be 0 or 1 (depending on the actual time when the feature is read); higher transfer queue block counts indicate that the network limits are being reached and frame losses can occur if the transfer queue memory is filled.

However, the transfer queue memory can be used in a controlled manner for applications where a burst of images at a higher than sustainable frame rate is required.

The Transfer Queue Current Block Count feature (*transferQueueCurrentBlockCount*), available in the Acquisition and Transfer Control category, returns the current number of memory blocks used by the camera's on-board transfer queue. This feature can be polled regularly to implement corrective actions to avoid lost frames.

The size of the transfer queue, in MB, is provided by the Transfer Queue Memory Size feature (*transferQueueMemorySize*). The number of images that can be saved in the transfer queue depends on the current image size.

The transfer queue features are available for any acquisition, whether using TurboDrive or not.



Turbo Drive Packet Size Considerations

The ethernet packet size (*GevSCPSPacketSize* feature) can affect the TurboDrive performance. In general, a larger packet size is beneficial since less overhead is required (for example, packet headers and trailers) to encapsulate larger data payloads, resulting in less packets per image than when using smaller packet sizes.

However, with small images (less than 1 megapixel), smaller packet sizes may have better performance. With small images, the last packet of image data may not be entirely filled and require padding; when using large packet sizes, the number of packets needed to transmit the image is reduced, therefore the padded packet represents a larger percentage of the total number of packets, resulting in wasted bandwidth. That is, since all packets are the same size, regardless of data content, the last packet may use bandwidth to transfer a large number of padded bits that consume network resources uselessly, resulting in a lower effective image transfer rates.

For example, when using jumbo packets, a small 30 KB image without TurboDrive has a packet utilization of ~83% (30 KB / 36 KB (4 packets)) resulting in a loss due to padding of ~17%.

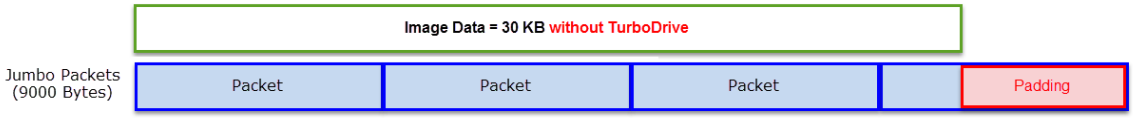


Figure 4:Small Image Jumbo Packet Padding

However, this effect is further amplified with the compression provided by TurboDrive; a well compressed small image may need only a third of the normal number of packets. To avoid this, it is recommended that smaller packet sizes be used with small images when using TurboDrive; padding of the last image packet will then represent a smaller overall percentage of the utilized bandwidth. This gain outweighs the increase in overhead introduced by the greater number of packet headers/footers.

For example, a small 30 KB image compressed with TurboDrive may be only 10 KB. Using jumbo packets, this represents a relatively large loss due to padding of ~44%. Using smaller 1500 byte packets, the loss due to padding can be reduced to ~5%.

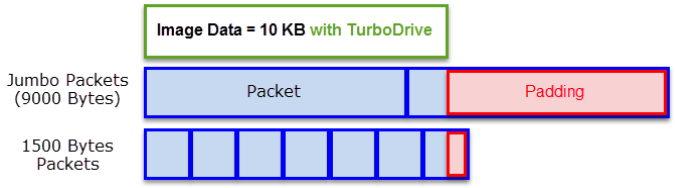


Figure 5:Large Packet vs. Small Packet Payload Padding

The use of smaller packets is recommended for images of less than 1 MB. To illustrate using another example, consider a 2400 x 128 partial scan image with 307200 pixels. Using jumbo packets (payload ~9KB) requires 35 packets. With considerable padding of the last packet, this can represent approximately 1/35 (~3%) of lost bandwidth. If compression reduces the number of packets required to 10, the padding of the last packet can represent a loss of up to 10% of the available bandwidth.

Interpacket Delay

When using smaller packets the interpacket delay (*GevSPCD* feature) has a correspondingly larger effect since more packets introduce more interpacket delays. Depending on the size of the interpacket delay this effect may have an impact on available bandwidth.

For more information, refer to the Network Imaging Package for Sapera LT Optimization Guide, available through the Windows Start menu.