S990 Quick Start Guide

Image Calibration

The Phantom S990 has 3 possible shutter modes: Rolling, Global, and Bright Field mode. Each S990 is factory calibrated and allows the user to download a gain and offset value, per pixel, to perform a first-order calibration of the image if desired.

Calibration Data Format

The S990 calibration data contains 4096 x 2304 16-bit unsigned integers (1 per pixel), indexed in order from top left to the bottom right of the image. For the gains table, the gain multiplier is scaled by 16384, so it is necessary to bring the uint16 value back to a float prior to the calibration. The offset table is not scaled but is saved as a 12 bit value. Bit shift to match the image bit depth, then simply subtract these values from the raw image.

$$[Image_{cal}] = ([Image_{raw}] - [Offset]/2^{12-bitdepth})\left(\frac{[Gains]}{16384}\right)$$

Please note that the offset image is simply a black reference image measured at the factory at 30 fps and a long exposure time. It is suggested to always take a new black reference image using your specific setup (lighting, rate, exposure settings, etc.) for a more accurate image calibration.

Windowing

The Phantom S990 supports resolutions smaller than 4096 x 2304 and will window around the center of the frame. It is especially important to consider frame windowing when applying calibration to a raw, live image. The calibration arrays are of full frame size so be sure to window these arrays to the same resolution as the raw, live image.

How to Download

Each calibration file is saved to camera flash and can be accessed by changing the 'ImageSource' register, located under 'ImageFormatControl', to one of the following options:

Display Name	Name
Live Image	Imgsrc0
Offset Table @ Rolling	imgsrc1
Gain Table @ Rolling	imgsrc2
Offset Table @ Global	imgsrc3
Gain Table @ Global	imgsrc4
Offset Table @ Bright Field	imgsrc5
Gain Table @ Bright Field	imgsrc6

Table 1: Shutter Modes

To download, select one of these options from the ImageSource register and grab a single image. Since this calibration data is factory set and will not change, it is suggested to save this to file locally and access it from the PC instead of the camera every time it is needed. Please note that this image is saved in camera flash, in which data reads are quite slow. Streaming one frame of a full 4K, 16bpp image can take approximately 2 minutes.

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General Purpose Input/Output (GPIO)

The S990 provides some general purpose features that give flexibility to the user to adjust or read stream parameters in real time, accessible electrically via the S990's GPIO port.

Types of GPIO

Type	I/O	Description
Trigger In	Input	On falling edge, exposure will start. If in ExposureActive mode, exposure will stop at next rising edge. This is selectable only through the TriggerSource register.
Trigger Out	Output	Outputs a falling edge at the start of every exposure. Active only in 'TriggerModeOff'
Software Trigger Out	Output	Outputs a rising edge when a software trigger is received from the frame grabber.
Strobe	Output	Waveform that represents the frame rate and exposure time of each frame. Exposure start happens on the falling edge, exposure end happens on the rising edge. Falling edge to falling edge represents the frame rate.
Event	Input	If 0V, the event flag in the timestamp metadata will be TRUE.
Ready	Output	If 3.3V, stream is inactive. If 0V, stream is active.s
Memgate	Input	If 3.3V, allow streaming (using either external or internal triggering depending on the 'SyncImg' register). If 0V, pause streaming.
Timecode In	Input	IRIG-B (modulated or unmodulated) input
Timecode out	Output	IRIG-B unmodulated output

Table 2: Available GPIO Types

How to Configure

To configure the GPIO lines, access the registers 'GPIO0', 'GPIO1', 'GPIO2', 'GPIO3', 'GPIO4', and 'GPIO5' under the 'DigitalIOControl' section.

Trigger In can be enabled and configured using the TriggerMode, TriggerSource and TriggerSelector registers under the 'AcquisitionControl' section.

Electrical

The GPIO ports available in the S990 and can be configured in 3 different ways: bi-directional, isolated input and isolated output.

Type	Count	GenICam Label	Available Features
Bidirectional	4	GPIO0, GPIO1, GPIO2, GPIO3	Trigger In, Trigger Out, SW Trigger Out, Strobe, Event, Ready, Timecode Out, Memgate.
Isolated Input	1	GPIO4	Event, Memgate
Isolated Output	1	GPIO5	Strobe, Ready, Timecode Out
Timecode In	1	N/A	Timecode In

Table 3: GPIO Electrical Configurations

The S990 GPIO uses a Hirose HR10A-10R-12PB connector and all GPIO signals are 3.3V LVTLL tolerant. The mating cable mount connector is a Hirose HR10A-10P-12SC(73). Also, for the bi-directional inputs (memgate, event), an internal pullup resistor allows for the shorting of the GPIO line to ground to toggle the line.

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GPIO Connector Pinout

Hirose Pin	Signal
1	Isolated Out
2	Isolated Ground
3	IRIG In
4	GPIO2
5	GPIO1
6	GPIO0
7	Signal Ground
8	Signal Ground
9	Signal Ground
10	Isolated Ground
11	GPIO3
12	Isolated In

Table 4: GPIO Pinout

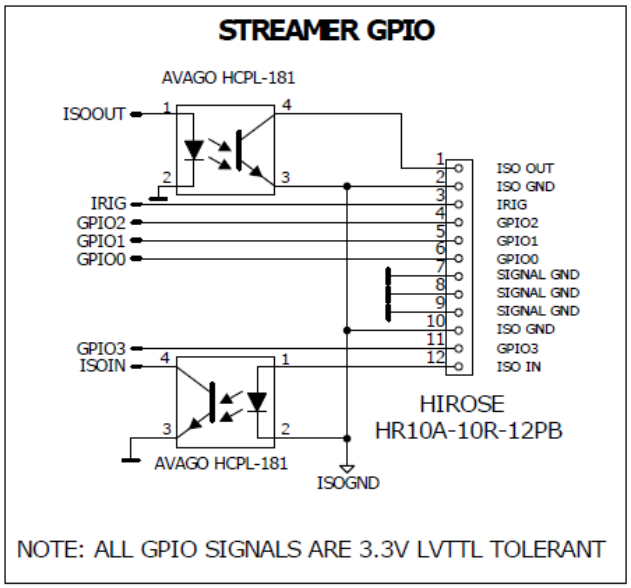

Figure 1: Internal GPIO Wiring

Trigger Types

There are 2 triggering types that the S990 implements: ExposureStart and ExposureActive.

ExposureStart

ExposureStart is available in all 3 shutter modes: Rolling, Global and Bright Field. On falling edge, the sensor will expose the sensor for the duration of time in the exposure register. Note: be sure that the exposure time in the register is less than the input clock period. Also, be sure that the input clock rate is supported by the camera at your specific set resolution.

ExposureActive

ExposureActive is available in Global and Bright Field mode. This allows the low time of the input pulse (falling edge to rising edge time) to control the exposure time of the sensor. Note: there is a frame

overhead time of ~2.5us that will occur at the end of each exposure. If this level of precision is required, be sure to measure and take into account this frame overhead time.

Timestamp Data

There is frame metadata that the S990 can output to the user: frame timestamp, event flag, lock to timecode flag, frame count, and core ID. Unfortunately, this metadata does not fit into the standard CXP header buffer. Due to this limitation, the S990 can output this information as an additional line in the image at row 0.

How to Access

To enable this metadata output change the 'TimeStamp' register under 'Acquisition Control' to 'TSOn'. This will increase the resolution by 1 row. For each image, remove the top row and parse to decode this metadata. Note: since this is embedded in the image, it is subject to padding if in a bit depth greater than 8 (ie. mono12, BayerRGB12). The following format is for a 8 bit depth image stream.

The 'TimeStampSet' register is the Unix time offset value. By default it is set to 0 at startup. Enter in the Unix time offset if necessary.

Timestamp Format

```
struct timestamp{
// time from beginning of the year in 1/100 sec units
unsigned int csecs;
// exposure time in us
unsigned short exptime;
// bits[15..2]: fractions (us to 10000); bit[1]:event; bit[0]:lock
unsigned short frac;
// exposure time extension (1/65536 of a us)
unsigned short exptime32;
// time stamp extension (1/65536 of a us)
unsigned short frac32;
//17 bytes of 0 padding
0x0000 0000 0000 0000 0000 0000 0000 0000 00;
// bank stream identifier
unsigned byte core_id;
// frame count
unsigned short count;
};
```

Image Stitching

Typically, CXP framegrabbers can only stitch lines for area scan cameras consisting of 1 to 4 CXP ports. However, the S990 can be set into 3 possible configurations to increase bandwidth as needed by your application: 1 bank of 4 CXP ports, 2 banks of 4 CXP ports, or 4 banks of 4 CXP ports.

Since the S990's 8 and 16 port configurations are not currently being supported by any framegrabber manufacturer, it is required by the application to stitch the image together, post-acquisition, to get a full frame image at these bandwidths.

In these multi-bank modes, the S990 will be discovered as 2 or 4 separate cameras, but any action done over one bank applies to all connected banks.

Connection Configurations

'Banks_A' – 1 Bank mode

This configuration allows for a full frame (4096x2304) to be streamed over a single bank of 4 CXP ports.

If a maximum bandwidth of ~2Gbps is acceptable, simply connect all 4 ports from Bank A to a 4 port framegrabber card. Change the 'Banks' register under 'CXP' to 'Banks_A' and begin streaming.

'Banks_AB' – 2 Bank Mode

This configuration allows for a full frame to be split in half with one section being streamed over Bank A and the other over Bank B. It is important to remember that the 'Height' register details the number of lines to be streamed *across one of the banks.* For example, if a 4096x2304 image is required, the 'Width' and 'Height' registers should be set to '4096' and '1152' respectively.

If a maximum bandwidth of ~4Gbps is acceptable, simply connect 4 ports from Bank A to a 4 port framegrabber card and connect 4 ports from Bank B to another 4 port framegrabber card. Change the 'Banks' register under 'CXP' to 'Banks_AB' and begin streaming.

'Banks_ABCD' – 4 Bank Mode

This configuration allows for a full frame to be split into quarters with each separate sections being streamed over Banks A, B, C and D. It is important to remember that the 'Height' register details the number of lines to be streamed *across one of the banks.* For example, if a 4096x2304 image is required, the 'Width' and 'Height' registers should be set to '4096' and '576' respectively.

For a maximum bandwidth of ~8Gbps, simply connect each of the S990 4 port banks to separate 4 port framegrabber cards. Change the 'Banks' register under 'CXP' to 'Banks_ABCD' and begin streaming.

Image Ordering

For the 2 and 4 bank configurations, only a portion of the image is streamed over each bank and it is necessary for the application to stitch these sections together in order to rebuild the full frame.

Core ID and Frame Count

There are 2 identifiers that are saved in each frame data to correlate which stream is related to a bank and frame. These are core ID and frame count and can both be found in the timestamp data. Additionally, the core ID value can be found in the 'StreamID' register.

'Banks_ABCD'

In the 'Banks_ABCD' mode, a quarter of the image is streamed over each of the 4 banks. Each bank streams 2 lines, in a round-robin order from bank A to D, starting from the top of the image.

Line	Bank	CoreID/StreamID
0, 1, 8, 9, …	A	1
2, 3, 10, 11, …	B	2
4, 5, 12, 13, …	C	3
6, 7, 14, 15, …	D	4

Table 5: Line Ordering for 'Banks_ABCD' Mode

To determine which image stream is related to a bank, either parse the Core ID from the timestamp data or read the 'StreamID' register.

'Banks_AB'

In the 'Banks_AB' mode, half of the image is streamed over bank A and bank B. Each bank streams 2 lines, in a round-robin order from bank A to D, starting from the top of the image.

Line	Bank	CoreID/StreamID
0, 1, 4, 5, 8, 9…	A	1
2, 3, 6, 7, 10, 11…	B	2

Table 6: Line Ordering for 'Banks_AB' Mode

Bank Control

Depending on the application, it might be simpler to have one of the S990 banks be enabled to respond to register writes while the other banks are blocked from responding to write commands. Enabling a 'master' bank can be done by utilizing the 'UsermemWriteMask' register.

The UsermemWriteMask register is a bitmask integer where each bit enables the associated bank to respond to register writes, where 1 is disabled and 0 is enabled. The associated bit values are as follows:

Bit 0 = Bank A
Bit 1 = Bank B
Bit 2 = Bank C
Bit 3 = Bank D

For example, to enable Bank A as the master bank and disabling all other banks, the UsermemWriteMask register should be set to 14 (binary 1110).

PC Setup

In order to take full advantage of the S990 throughput, ensure that the PC you are running matches or exceeds the framegrabber requirements that you choose. Common things to check are:

- PCIe generation (typically gen 3)
- PCIe lanes (use maximum or greater that required by the framegrabber)
- CPU clock speeds
- RAM size
- ROM write speeds (HDD vs SSD)
- GPU

Most commonly, the camera throughput will be throttled when the framegrabber is installed into an older generation of PCIe slot, or a PCIe slot with less lanes than required. Most framegrabbers will be able to function properly in a lower throughput or older generation PCIe slot, but the camera throughput will be affected. Check the PCIe slot map of the PC's motherboard to verify the framegrabber is installed in an appropriately sized slot.