

Vision Research S990 & S710 Revision 2.0 2022-02-28

Purpose

This document explains how to interface the Vision Research S990 and S710 cameras to the BitFlow's Cyton and Claxon CXP frame grabbers. The S990 is very high speed camera running 4K x 2k at 1000 FPS. The S710 has an even higher frame rate of 7200 FPS, but at a resolution of 1920 x 800. These data rates exceed the speed of a single frame grabber so the cameras have 16 outputs and requires four Cyton or Claxon frame grabbers. These cameras will, however run with two or even one frame grabber, with a proportional reduction in the maximum frame rate.

When these cameras are running in two or four frame grabber mode, the camera outputs interleaved "chunks" lines simultaneously to each connected frame grabber. These lines must be re-interleaved in the host PC. The frame grabber's DMA engine is powerful and flexible enough to perform this re-interleaving task on the fly, with no CPU usage. This re-interleaving works in both two and four frame grabber modes. Then end result is fully raster-scan images ready for processing.

Requirements

- One Vision Research S990 or S710
- Four Cyton-CXP4 or Claxon-CXP4 frame grabbers
- Sixteen coax cables (DIN to DIN for Cyton, DIN to HD BNC for Claxon)
- One PC with at least four PCIe x8 or x16 Gen 2 or Gen 3 slots
- BitFlow SDK 6.6 or later
- BitFlow's Ximilon GenTL Consumer Camera Control application

System Setup

Install the BitFlow SDK

Follow the instructions in the "Getting Started with SDK X.XX.pdf" document

Install Ximilon

Simply run the installer

Test the System with One Cyton or Claxon

Install one Cyton in to the PC

Install one Cyton into one PCIe x8 or x16 Gen 2 or Gen 3 slot

Connect Four CXP Cables

Connect the cables as shown in the following table:

Cyton/ Claxon Connector	Camera Connector Bank A
1	1
2	2
3	3
4	4

It is recommended that cables are connected when the camera is off.

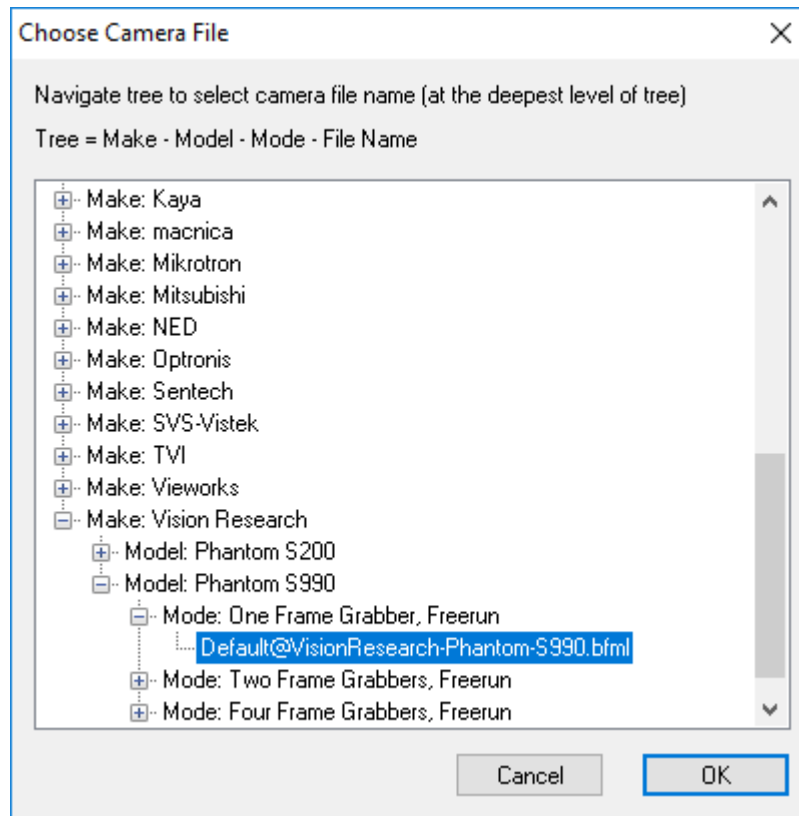
Configure the system for Single Frame Grabber Mode

Run SysReg, click on Bd(0), hit the "Configure" button. The "Board Details" dialog will show up. Click the "Add" button to attach a configuration file.

For the S990: select the following file: Make: Vision Research > Model: Phantom S990 > Mode: One Frame Grabber, Freerun

For the S710: select the following file: Make: Vision Research > Model: Phantom S710 > Mode: One Frame Grabber, Freerun

Finally, click on the mode name and hit "OK", then click "OK" two more times to close SysReg.



Test the System

Next run "BitFlow Preview" to see live video from the camera in single frame grabber mode. The maximum frame rate in this mode will be about one fourth of the camera's maximum in four frame grabber mode.

It's helpful to use this mode to get the camera set up and focused.

Test the System with Four Frame Grabbers

Install Four Cytons or Claxons in the PC.

Install the four boards in four PCIe x8 or x16 slots.

Each physical frame grabber is seen by the operation system as four Virtual Frame Grabbers (VFGs). Each board will exposure VFG0, VFG1, VFG2 and VFG3. When using a quad link CXP camera, only the first VFG (VFG0) is used on the board. All of the VFGs in the system are accessed by selecting their board numbers. Thus the system will look like this:

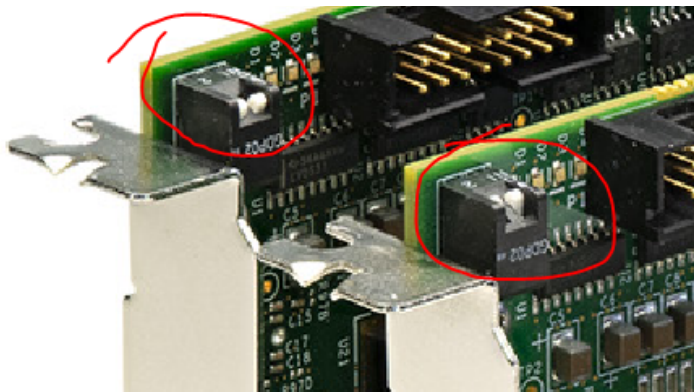
Cyton/ Claxon	Board Number	VFG	Connector	Board
0	0	VFG0*	1	0
0	1	VFG1	2	1

Cyton/ Claxon	Board Number	VFG	Connector	Board
0	2	VFG2	3	2
0	3	VFG3	4	3
1	4	VFG0*	1	4
1	5	VFG1	2	5
1	6	VFG2	3	6
1	7	VFG3	4	7
2	8	VFG0*	1	8
2	9	VFG1	2	9
2	10	VFG2	3	10
2	11	VFG3	4	11
3	12	VFG0*	1	12
3	13	VFG1	2	13
3	14	VFG2	3	14
3	15	VFG3	4	15

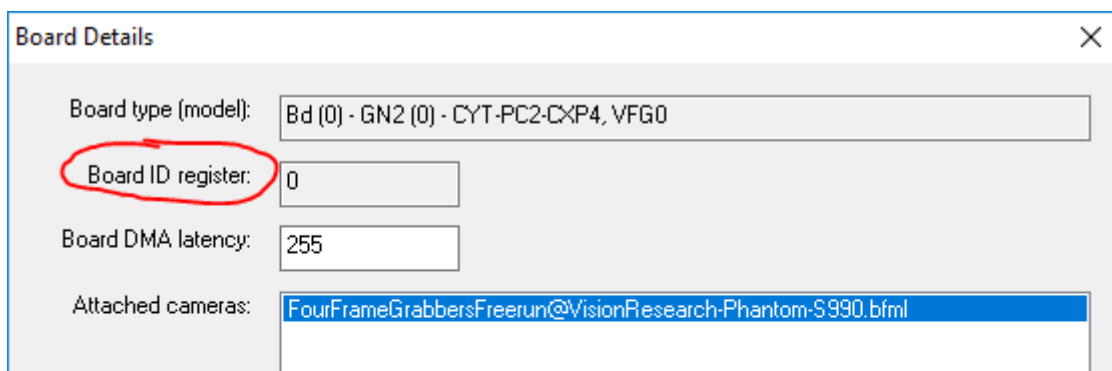
* These are the VFGs which must be configured and which are used to acquire images.

Because these cameras require four Cytons or Claxons, the operating system will see 16 VFGs. You will only be using the first VFG0 on each frame grabber. This means that you will be working with VFG0 on each board.

It is important to establish which physical board corresponds to which VFG. To help with this each boards has a small switch on the top of the board near the CXP connectors. You can set this switch to a different value on each physical board.



You can then use SysReg to determine the switch value of each VFG.



Discover order of the Cytons in the PC

We recommend setting the switches on the four Cytons or Claxons so that the switch setting are in the same order as the VFGs. This will make connecting cables less confusing.

Board Number	Switch
0, 1, 2, 3	0
4, 5, 6, 7	1
8, 9, 10, 11	2
12, 13, 14, 15	3

The procedure goes something like this:

- Set the switch on each board to a unique value
- Run SysReg, click on VFG0, Click on "Configure", then look at the "Board ID register".
- If VFG0 does not have ID = 0, swap the board's switch settings around so that VFG0 has ID = 0
- Repeat this process with VFG4, VFG8 and VFG12

Connect the 16 CXP cables from the camera to the Cytons in the correct order

Now that you know the order of the frame grabbers, connected this 16 cables between the camera and the board as shown in the table below:

Cyton/ Claxon	Connector	Camera Bank	Camera Connector
0	1	A	1
0	2	A	2
0	3	A	3
0	4	A	4
1	1	B	5
1	2	B	6
1	3	B	7
1	4	B	8
2	1	C	9
2	2	C	10
2	3	C	11
2	4	C	12

Cyton/ Claxon	Connector	Camera Bank	Camera Connector
3	1	D	13
3	2	D	14
3	3	D	15
3	4	D	16

Configure the system for Four Frame Grabber Mode

Run SysReg, click on Bd(0), hit the "Configure" button. The "Board Details" dialog will show up. Click the "Change" button to attach a configuration file. Select the following file:

Make: Vision Research > Model: Phantom Sxxx > Mode: Four Frame Grabbers, Freerun. Click on the mode name and hit "OK". Repeat this process for Bd(4), Bd(8) and Bd(12). You do not need to attach a configuration file to any of the other VFGs.

Test the system in four frame grabber mode

You can now run "BitFlow Preview" four times. Each time it will ask you which board to open. Select Bd(0), Bd(4), Bd(8) then Bd(12) in that order. When the system is in four board mode, each frame grabbers gets 1/4 of the lines. The result of this is that the images in each "BitFlow Preview" window will look squished vertically. The image width will be correct, but the image height will be one fourth of what it should be. If you zoom in you will see that 3/4's of the lines are missing from each copy of "BitFlow Preview".

Test the system using BiFlow2x

BiFlow2x is an application that is designed to acquire images from two or four Cyton frame grabbers simultaneously and re-interleave the image lines from each Cyton so that the images in memory look exactly like they do on the image sensor.

Images are recorded to host memory. After they are captured, they can be played back using the VCR style controls (or menu commands). Images sequences can also be saved to disk for off-line processing.

Run "\BitFlow SDK X.XX\BinXX\BiFlow2x.exe"

Click "NO" to run the application in four board mode

The "Open which board?" dialog will appear four times in a row. Select Bd(0) the first time, Bd(4) second time, Bd(8) then third time then Bd(12) hit "Open Initialized" each time. After the last time it will take a little while to open and configure all four boards.

Next the "Memory Allocation" dialog will pop up. This lets you select the number of frames that can be captured in a sequence, to start with we recommend setting a smaller number of frames, maybe 100 to 1000. Click "OK" to close this dialog and open the application.

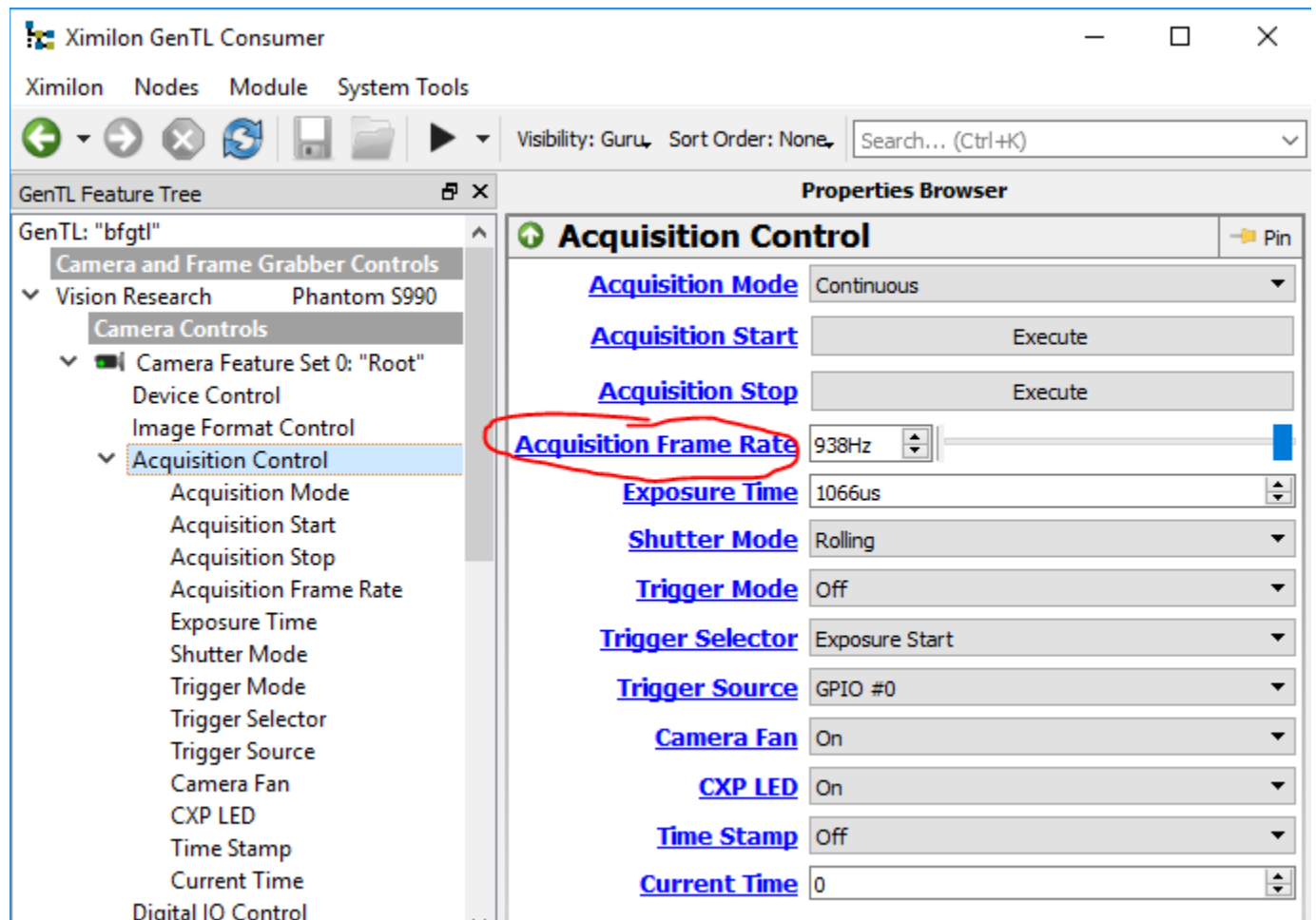
When the main application window opens up, select Acquisition > Setup to set up the boards for acquisition.

To start acquisition, select Process > Start Acquisition, click "OK" to the frame selector, the "OK" to the acquisition start dialog. After the last "OK" acquisition will start and quickly end when all frames are acquired.

Once acquisition is complete, a dialog will popup indicating it is done. Click "OK" to this dialog.

You can now look at the frames in the display window. You can step through them or play them back using the VCR style controls. Frames can be saved using the File > Save menu command.

Note that the camera's default power up frame rate is 100 FPS. You can modify this rate by running our Ximilon application and navigating to the Acquisition settings where you can set the frame rate. Ximilon also provides controls for all of the other camera settings.



Synchronizing Multiple Frame Grabbers

All 16 camera outputs are always outputting the same frame at the same time. Each frame grabber attached to each bank of outputs will, of course, be acquiring the same frame and DMA it to memory at the same time. However, these camera are usually used to acquire sequences of frames to host memory. Since each frame grabber is DMAing lines to the same buffer, it's imperative that each frame grabber starts acquiring at the exact same point in time. It's impossible to achieve this level of synchronization using software commands alone. Some hardware means of synchronization is required to start the multiple frame grabbers at exact same time.

Note: the only the acquisition start needs to be synchronize, once all frame grabbers are started in sync, then they will remain synchronized for the duration of the sequence capture.

Some solutions are described below.

Triggering the Camera (where the trigger signal can be stopped)

A hardware trigger can be connected to the camera. Each pulse on this trigger causes one frame to be exposed and output to the frame grabber. If the user can stop and start these pulses, then it is possible to have full control of when acquisition is started. For this method to work, acquisition must be started on all four frame grabbers before the hardware trigger signal starts sending pulses to the camera. For example, assume the trigger starts off not running, the application BiFlow2x can be run, acquisition setup, the sequence started (which starts acquisition on all four boards), then the trigger signal can start sending pulses to the camera. The resulting sequence will be perfectly in sync.

Note: this method requires a pulse for each frame, so if the user wants the camera to run at 2000 FPS, the user must supply a 2000 Hz square wave signal.

Note: the camera must be put in a triggered mode in order for this to work.

Sending a Trigger Signal Through the First Cyton/Claxon

Similar to the method above, a trigger signal can be connected to the first Cyton or Claxon. The frame grabber then forwards the trigger signal to the camera. As long as acquisition is started on each frame grabber before any pulses are sent to the camera, all boards will remain synced for the duration of the sequence capture. The advantage of this method is that the trigger signal can be enabled and disabled from software. This way the application can control when pulses are sent to the camera, which means this method will work even in the case where the trigger source can not be turned off.

Using the Timing Sequencer On the First Cyton/Claxon

If there is no need to synchronize image capture with an external event, the Cyton and Claxon have a built-in timing generator called the Timing Sequencer (TS). This can be programmed to produce a square wave over a huge range of frequencies. The TS can be started and stopped easily from software. So the method here would be to program the TS to the desired frame rate, start acquisition on all frame grabbers, then start the TS on the first Cyton/Claxon. All boards will remain in sync.

Triggering Acquisition Start on all Frame Grabbers

It may not be desirable to have the camera in triggered mode, in other words, in some applications the user may want the camera to run on its own internal timing. The situation can be supported by putting all frame grabbers in triggered acquisition mode. The trigger in this case must come from an external source and be connected to all four frame grabbers' trigger input pin. This trigger just needs one pulse to start acquisition on all boards. Once acquisition is started, it will run based on the camera's timing. This method can also be used to synchronize the start of acquisition with some event in the real world. As long as the event can produce a trigger signal, it can start acquisition.

Note: triggered acquisition requires that the bit Z_OPEN be set to 1. This can be done by software or from the configuration file (BFML file). The S710 and S990 BFML files include a "Synced" mode for both two and four frame grabbers.

Note: this method does not require the camera to be in a triggered mode.

If an external signal is not available, the frame grabber can be used to produce the signal. For example, the CC3 general purpose output can be used to drive the trigger input on all four frame grabbers.

Acquisition can be started on all frame grabbers, then the software can write SEL_CC3 from 0 to 1, which will produce the necessary trigger pulse on the board's CC3 output.

Using GenICam Commands to Start Acquisition on the Camera

This method is actually one of the easiest. Normally when a BitFlow CXP frame grabber is opened, it automatically starts acquisition on the camera. This can be disabled by modifications to the configuration file (BFML). Then acquisition can be started on all frame grabbers. They won't acquiring anything as the camera is not running. Next, the GenICam command to start acquisition can be sent to the camera. Now all frame grabbers will start on the exact same first frame out of the camera, and will stay synchronized for the duration of the sequence.

Once the sequence has been acquiring, it the camera's acquisition should be stopped, to get ready for the next sequence, which will require another start command.

Note: The BitFlow SDK supports three different methods for sending commands to CXP camera:

1. Low level register commands
2. The GenICam API can be used to send commands
3. BitFlow's BFGTL API greatly simplifies using GenICam

Writing Applications for the S990 and S710

Even though the process of programming DMA engines for two or four frame grabbers DMAing these interleaved images is quite complicated, BitFlow makes writing application for these cameras just as easy a "normal" camera. The BitFlow SDK has a dedicated API for sequence acquisition. This same API can be used for the S990 and S710. There are many examples included with the SDK that illustrate how this API works. And the source code for BiFlow2x is also included. The only changes need between a single frame grabber camera and these multi-frame grabber cameras are listed below.

1. Open two or four frame grabbers normally. Make sure to open the correct VFGs (board numbers): 0 and 4 for two frame grabber mode, and 0, 4, 8 and 12 for the four frame grabber mode.
2. Allocate a sequence of buffers for the first frame grabber only. The buffers should be two times the default size for two frame grabber mode, and four times the default size for four frame grabber mode.
3. Set up sequence acquisition for all frame grabbers. All grabbers are program to use the same host memory buffers allocated above. Depending on the mode, pass in the following flags in the *Options* parameter

Two frame grabber mode:

Board	Options
1	OnlyEvenLines
2	OnlyOddLines

Four frame grabber mode:

Board	Options
1	FourHorizInterleavedChunks0
2	FourHorizInterleavedChunks1
3	FourHorizInterleavedChunks2
4	FourHorizInterleavedChunks3

4. Start acquisition on all boards using the normal commands, use one of the synchronization methods discussed in the previous section to make sure that all boards start acquisition on the exact same frame.

5. Wait for acquisition to complete on all four boards using the normal commands.

6. Process the buffers allocated in step 2.