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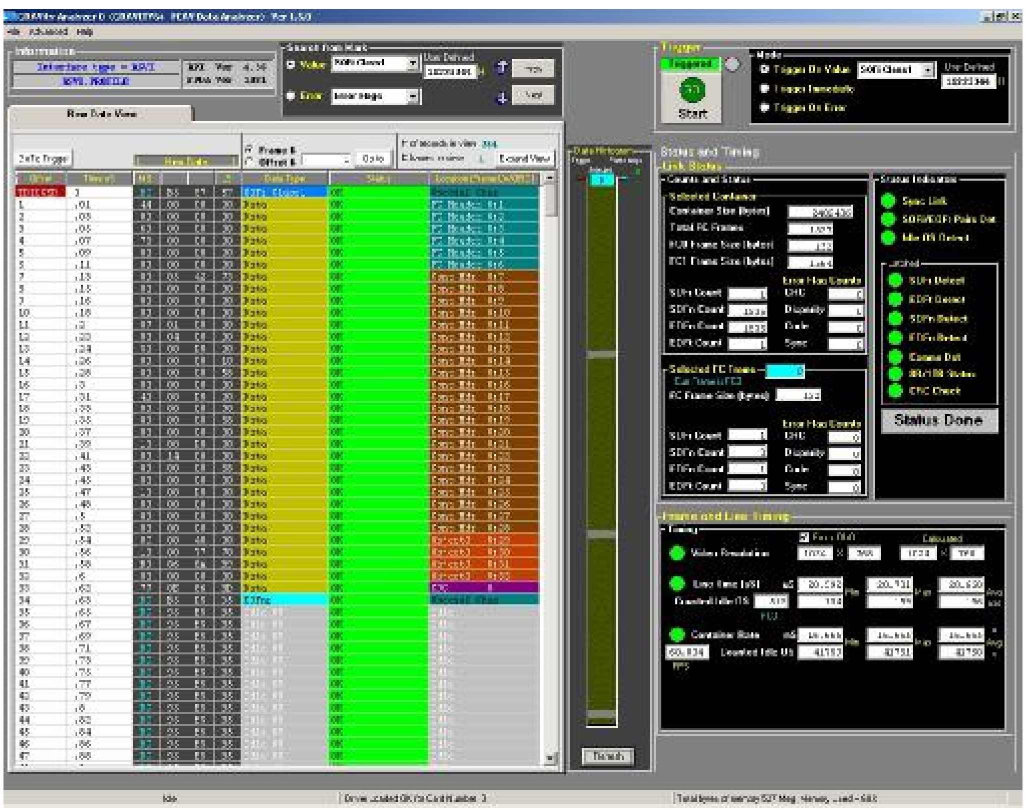
GRAVity FCAV/ARINC818 Analyzer User's Manual

Instruction for using GRAV64_PCI_FCAV_ANA cards & software
Rev E
November 4, 2008



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REVISION HISTORY:

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3/3/2006	REV -	INITIAL RELEASE	INITIAL RELEASE	T. Keller
3/17/2006	REV A	Updates to 4.3.3 and 4.4.4	Updated ed Descriptions for S/W version 1.7	D. Cole
7/25/2006	REV B	Added 4.3.3 and 4.4.6	New sections for Load/Save RAW data and Status Word Error detection.	D. Cole
9/5/06	REV C	Removed 3.5, 7 and 7.1, Updated 4.3.3 and 4.4.6, Added 4.3.14, 4.4.6	Added description for Trigger Fault (Status Word error detection) and Error Message. Added detail on Raw Data file Save/Load. Added description of Data View file. Added description of Header Decode tab features.	J. Alexander
10/29/2008	Rev D	Section 3 and 4 updated	Added source selection and new sync connector description.	D. Cole
11/04/2008	Rev E	Section 4.3.12	Added 4.3.12 to show new Image Tab	D. Cole

1 Scope

This document describes the following:

- Using Gravity 64-bit Analyzer card with GRAVity FCAV Analyzer Application Software

This document provides a high level description of the hardware, but does not include register definitions and details for controlling the card.

1.1 Customer Specific Firmware

It is intended that the Gravity FCAV card support customer specific FC-AV and ARINC818 implementations. These implementations may cover less common image sizes, pixel packing methods, header definitions, and/or compression methods. For customers using special firmware loads, Great River will assign a unique, customer specific part number. Additional details for a customer specific FC-AV and ARINC818 protocol will be covered in a customer specific ICD.

1.2 Reference Documents

ANSI X3.230-1994	Fibre Channel - Physical and Signaling Interface (FC-PH)
ANSI X3.297-1997	Fibre Channel – Physical and Signaling Interface – 2 (FC-PH-2)
ANSI X3.303-1998	Fibre Channel - Physical and Signaling Interface - 3 (FC-PH-3)
ANSI INCITS 356-2002	Fibre Channel – Audio Video (FC-AV), 25 November 2002
ARINC 818 Draft 1	Avionics Digital Video Interface, High Data Rate, Dec. 24, 2005

2 Overview of Gravity FCAV Analyzer

2.1 Product Description

The Gravity FCAV Analyzer product is intended to support implementations of ANSI INCITS 356-2002 Fibre Channel – Audio Video (FC-AV) for transporting digital video, in particular, the ARINC818 implementations.

The FCAV Analyzer captures 16Mbytes of raw data from the FC link, including all special characters and idles. For an XGA signal at 60 Hz, this represents approximately 3.5 FC containers of video frames. The analyzer provides a byte-by-byte look at each FC frame. The software facilitates data capture by providing a variety of trigging options. Once data is captured, it is color coded and labeled according to FC Frame numbers. A search feature facilitates finding errors, ordered sets, or strings of data. Timing information is provided for FCAV containers, FC Frames, video lines and frames

Fibre Channel provides a reliable, high bandwidth video link for video networks, point-to-point video connections (up to 500 meters using multi mode fiber and up to 10km using single mode fiber).

Each Gravity FC-AV card is Fibre Channel compliant at the FC-0, FC-1, and FC-2 layers. The cards use Frame Header Control Protocol (FHCP) and described in Clause 7 of the FCAV standard. FHCP is an easy to implement, low overhead, protocol based on the FC-AV container system. FC-AV containers are described in Clause 5 of the FC-AV standard.

The cards are currently available at 2.125Gbps link speed. Customers can special order other link speeds between 1 and 3.1875 Gbps.

Gravity64 FC-AV is a 64/66 PCI card that can achieve 160Mbytes/sec transfer rates.

The following sections describe the cards compatibility with Fibre Channel Standards when using the standard firmware load.

2.2 Fibre Channel Compatibility

The Gravity FC-AV cards are Fibre Channel compatible at the FC-0, FC-1, and FC-2 as described below.

2.2.1 Compatibility with FC-0, FC-1, FC-2

2.2.1.1 Physical

Gravity FC-AV card can be configured with either optical or copper interfaces (or both).

All cards can be factory loaded with SFF Transceivers that operate at 850 nm or 1310 nm. These transceivers are compatible with standard LC multimode or single mode fiber cable.

Lower baud rate`(<1.5Gbps) cards can also be factory loaded with high-speed transformer coupled electrical interfaces. The copper interfaces uses two "differential 1x3" shrouded connectors compatible with 150-Ohm FCN1010 type cable.

See the Product Specification sheet for ordering options.

2.2.1.2 Signaling/Encoding

All cards use 8B/10B Encoding (per ANSI X3.230-1994 -FC-PH) for all signaling transmission.

2.2.1.3 Signaling Speed

Standard signaling speed is 2.125 Gbps.   Non-standard baud rates can also be achieved through special factory loaded oscillators.

2.2.1.4 Fibre Channel Frames and Ordered sets

All cards use Fibre Channel Frames and Ordered sets as defined in ANSI X3.230-1994 (FC-PH)

2.2.2 Compatibility with the FC-AV Standard

When using Great River's standard firmware along with the EFC_FCAV application software, the Gravity FC-AV cards transport digital video using Frame Header Control Protocol (FHCP) as described in the FC-AV Standard Clause 7.

More specifically, Gravity FC-AV cards use FHCP to transport FC-AV Containers (FC-AV Standard Clause 5), where a single Video frame is loaded into a single simple mode container.

2.2.3 Compatibility with other FC equipment

Gravity FC-AV cards use FC frames as the basic unit of transport for video and header data. FC frames are further discussed in the referenced FC-PH specification.   As such, the digital video link will be compatible with commercial off-the-shelf Fibre Channel development tools. FC-AV is not compatible with other data oriented protocols used with Fibre Channel such as SCSI or RDMA.

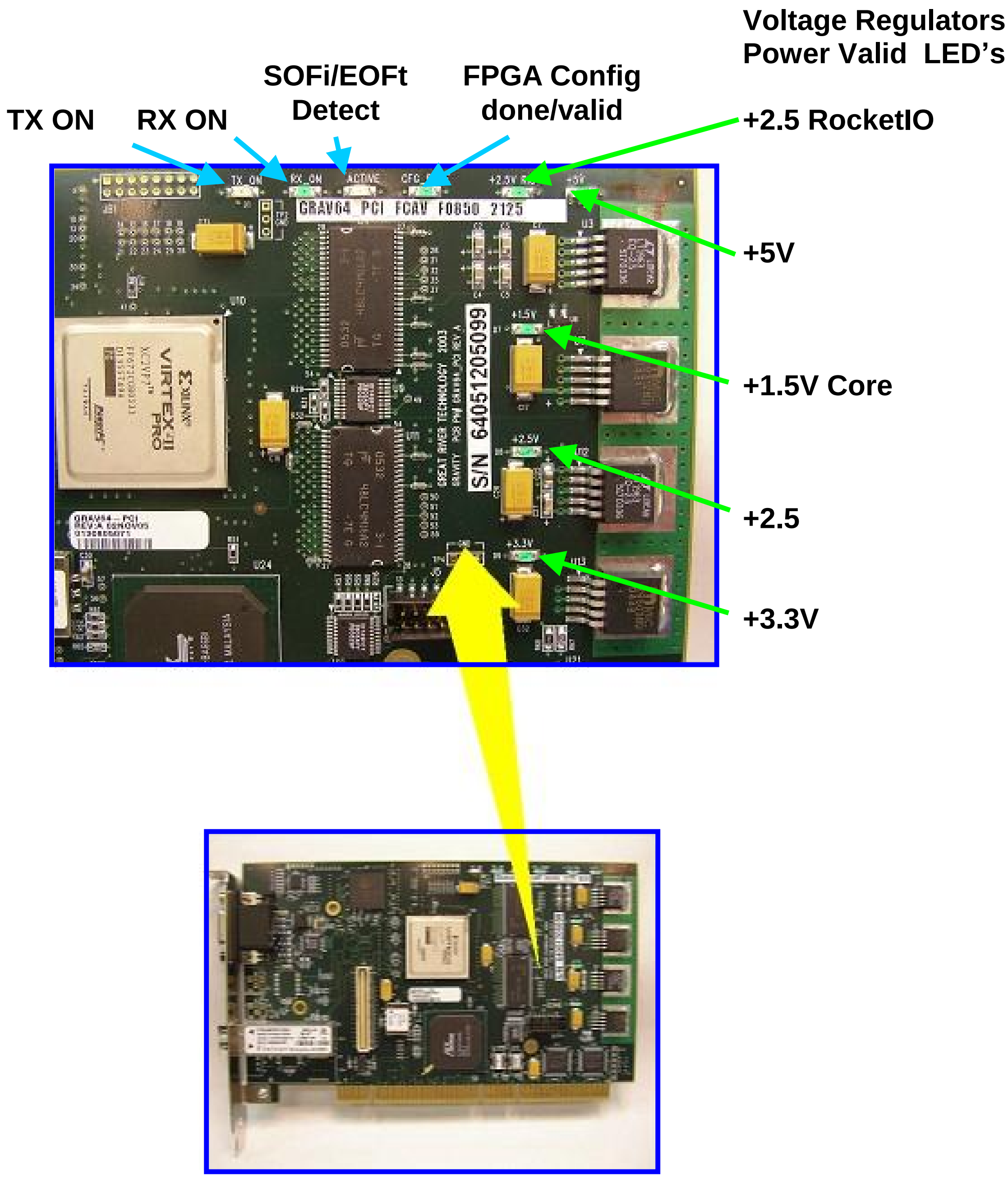
2.2.4 Non-standard implementations

Gravity FCAV cards supports customer specific FC-AV implementations through special firmware loads. These implementations may cover less common image sizes, pixel packing methods, header definitions, and/or compression methods. These implementations may deviate from FC standards in order to meet the need of proprietary video interfaces.

2.3 ARINC 818 Compatibility

The GRAVity FCAV Analyzer was designed with ARINC 818 compatibility in mind, and the ARINC 818 Draft 1 *Avionics Digital Video Interface, High Data Rate*, Dec. 24, 2005, was consulted. However, since ARINC 818 is still in draft form, the GRAVity FCAV analyzer is not guaranteed to be compatible with the emerging standard. Once the standard is finalized, a GRAVity ARINC 818 Analyzer will be developed for specific implementations of ARINC 818.

3 Gravity FC-AV Hardware Operation



3.0.2 Circuit Card LED Indicators

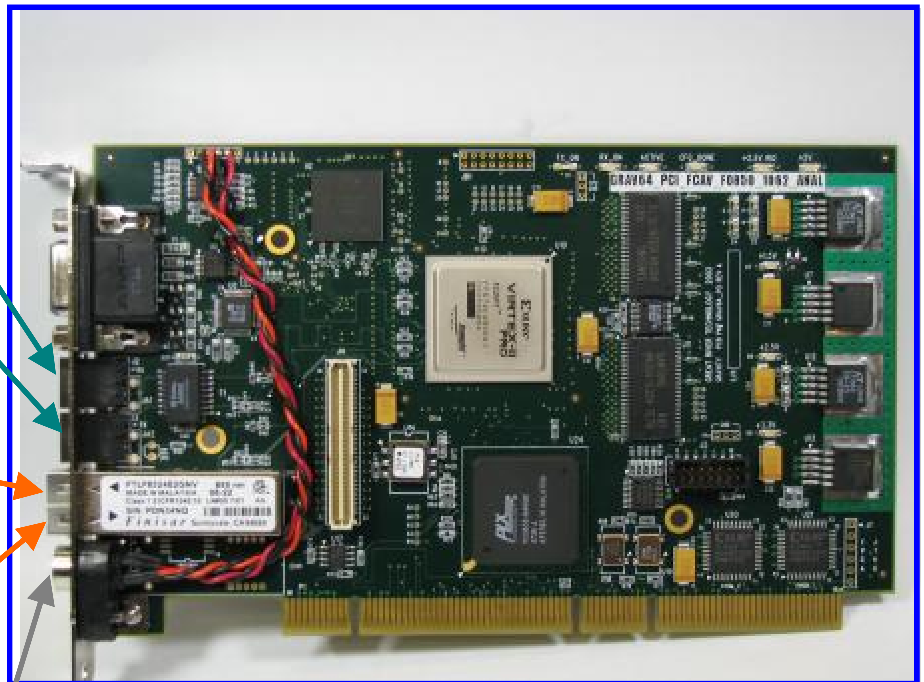
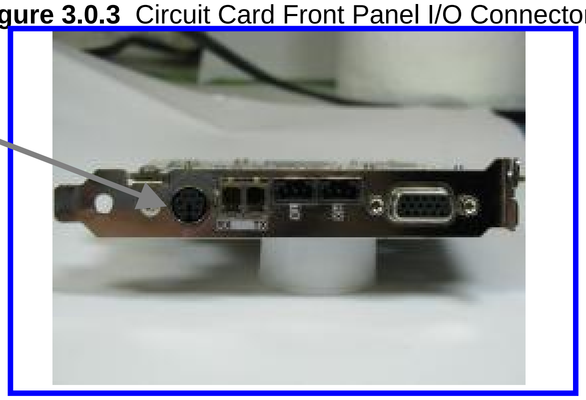


Figure 3.0.3 Circuit Card Front Panel I/O Connectors



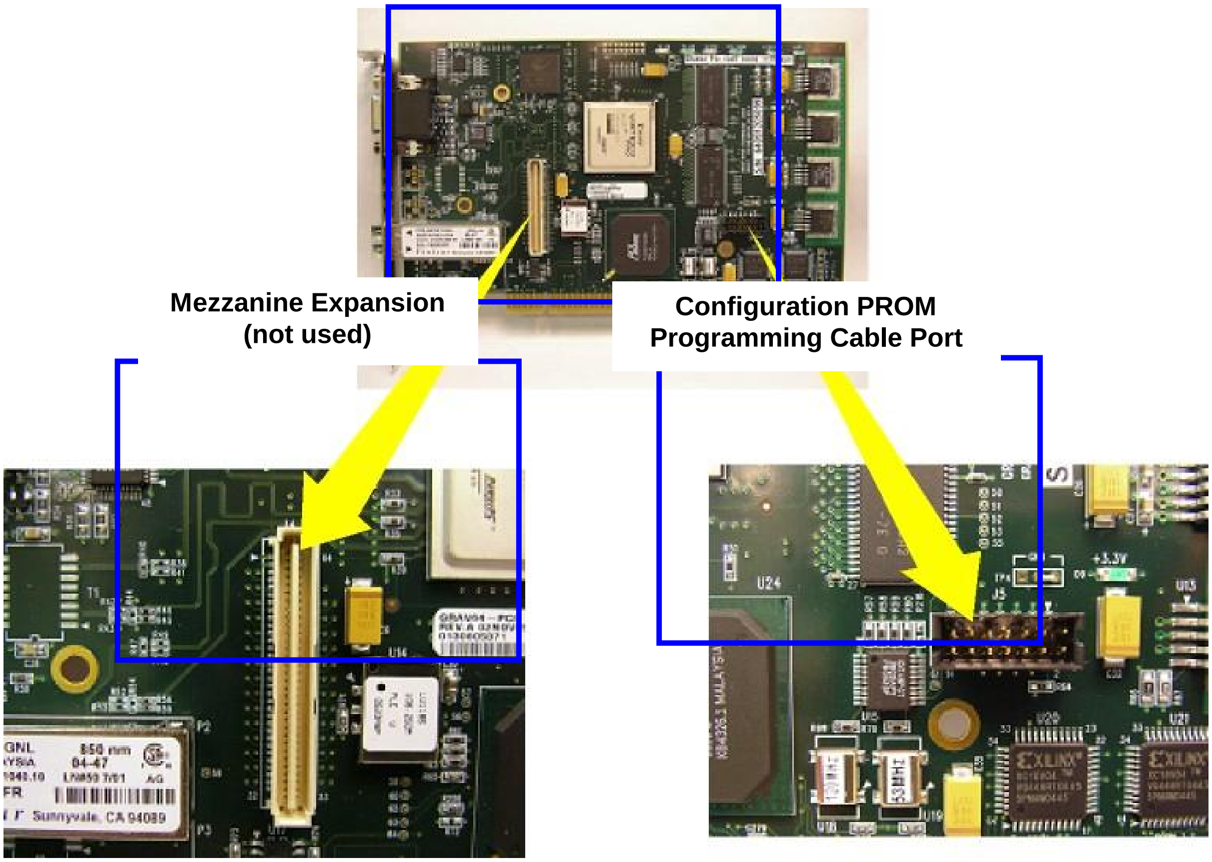


Figure 3.0.4 Circuit Card I/O Connectors

3.1 Recommended System Configuration

The FCAV hardware manages the majority of the tasks needed to receive and analyze FCAV signals.

Minimum System Requirements:
Processor: PIII 733MHz
Memory: 128MB
BUS: 533MHz FSB w/ (1) PCI slot or (1) PCI-X slot
Video Card: 64 MB (capable of 1280x1024 resolution)

Recommended System Requirements:
Processor: P4 3.0GHz
Memory: 512MB
BUS: 800MHz FSB w/ (1) PCI slot and (1) PCI-X slot
Video Card: ATI or NVIDIA w/ 256 MB

Data capture is accomplished by the FCAV hardware. FCAV hardware will process video images from FC link. System performance will impact the response time of the application, and time to transfer images from hardware memory to PC memory. The maximum bandwidth for the PCI 64bit/66Mhz bus is 528MBps. The maximum bandwidth for the PCI 32bit/33Mhz bus is 132MBps. The FCAV hardware typically achieves a bandwidth of 160MBps in a PCI 64bit/66Mhz. This is sufficient to support FCAV applications from 1.0625Gbps or 2.125Gbps link speeds. Operating the FCAV Analyzer card in a 32-bit slot will not impact the analyzer capture performance, but may slow down the transfer of data from the hardware to the software.

3.2 Memory Operation

The hardware has two 2MB by 32-bit memory spaces referred to as Ping and Pong memory. The memory is single port SDRAM. These memory spaces are used for several tasks. The memory is used to store trace data from the FC link and move data from PC memory via the PCI bus.

3.3 PCI Interface

The Gravity64 FC-AV cards have 64-bit PCI interfaces that run at 66 MHz which drive +3.3 volt logic levels on outputs and have +5 volt tolerant inputs.

3.4 Fiber and Copper Interface

When a data capture is triggered, the GRAVITY FC-AV Analyzer card captures raw FC data via a FO850 link or a standard FCN copper interface and stores the data in on-board memory, and then transfers the data via a DMA transfer over the PCI bus as depicted in Figure 3.4 below.

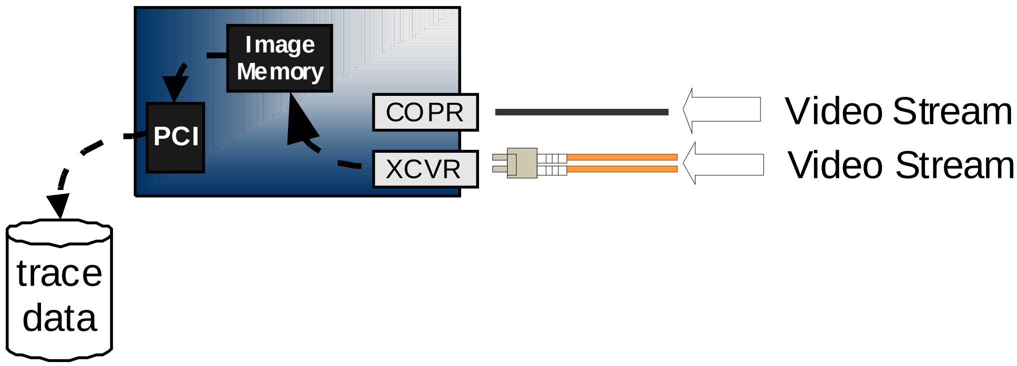


Figure 3.4 Data Capture

4 Using the GRAVity FC-AV / ARINC818 Analyzer

4.1 Hardware and Software Installation

First, follow the instructions in the Quick Start Guide for GRAVity FCAV. This covers board installation and loading the driver.

Once the board and driver are installed, insert the GRAVity FCAV Analyzer set-up disk. The disk should auto launch and guide you through the installation steps, click next at each dialog box. If the disk does not auto launch, then using Windows Explorer, find the setup.exe file on the CD, and double click it to launch the installation.

4.2 System Memory Allocation

The FCAV Analyzer software allocates buffers in system memory to store data. The application uses approx 60 Mbytes.

4.3 Capturing and Analyzing Data

4.3.1 Quick Start

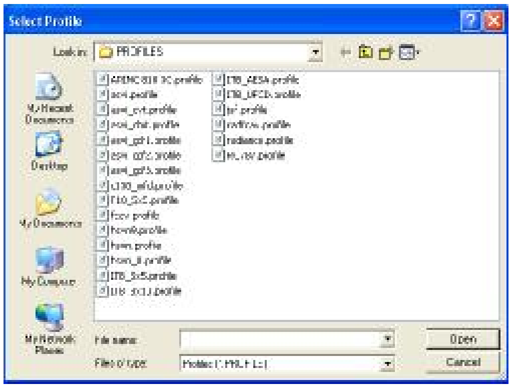
The fastest way to capture data is to :

1. **Hook your Optic or Copper cable to the analyzer ports. Select either Optic (default) or copper in the Source selection**

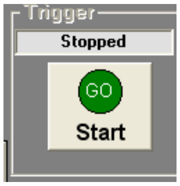
2. **Load a Profile for your FCAV or ARINC818 format.**

Select the Load Profile menu item from the File menu.

Select your Profile



3. **Click start to trigger for a capture**



4.3.2 Graphical User Interface Overview

The ARINC818/FCAV Analyzer Application is shown below with each of the major sections labeled.

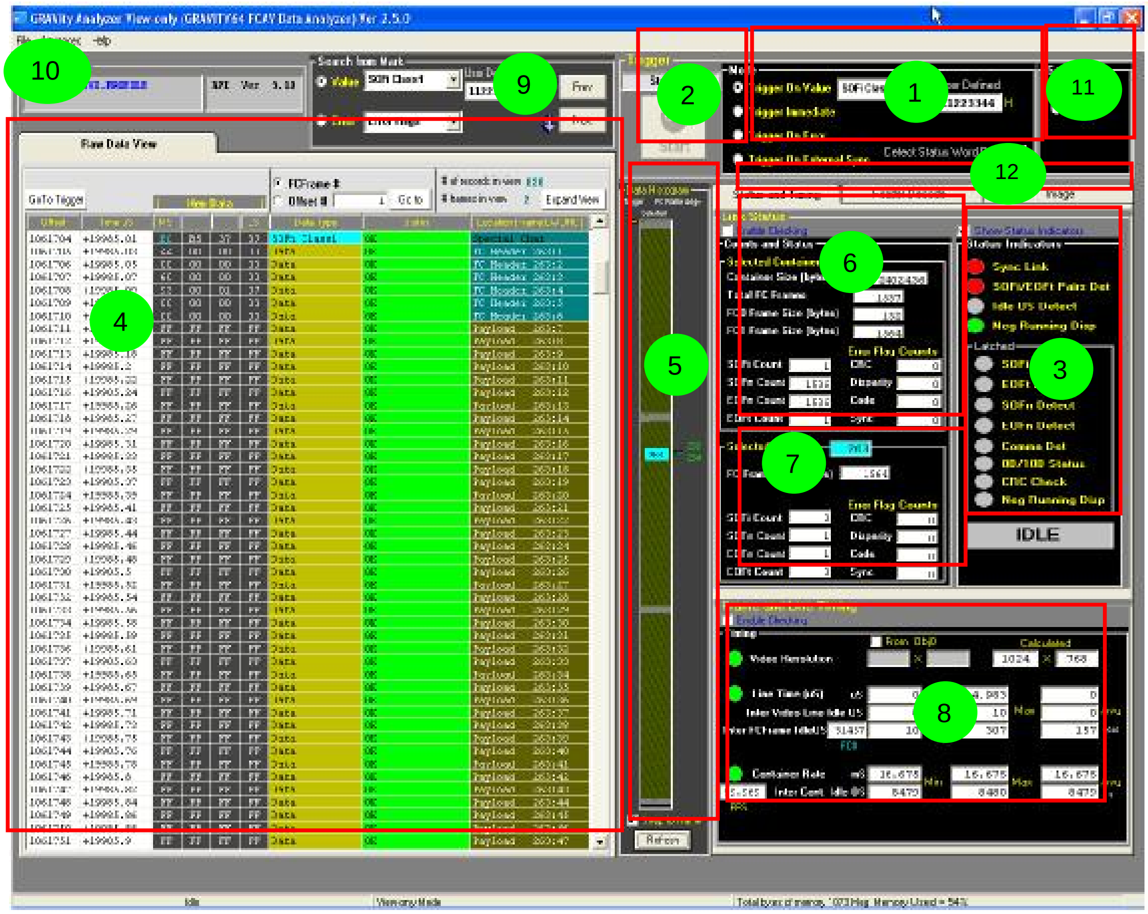
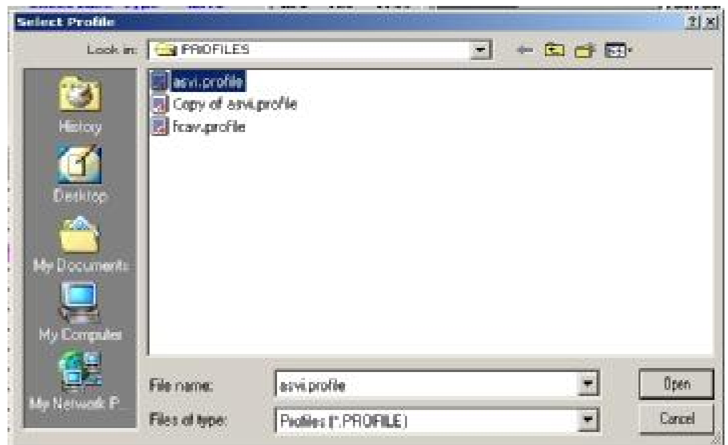


Figure 4.3.1 GRAVity FCAV Analyzer Graphical User Interface (GUI)

1. Area for setting data capture triggers: predefined or user defined.
2. Data capture button to initiate a new data trace.
3. Link Status indicates the health of the FC link.
4. Raw Data window, displays captured data with time stamp and colored decoding.
5. Histogram – graphically represents total data size and current frame being viewed.
6. FCAV container related information and statistics.
7. FC Frame related information and statistics.
8. Video frame and line timing information and statistics.
9. Search feature with predefined and user defined options.
10. Configuration information indicates FCAV profile loaded, API version, and FPGA version.
11. Input Source, either Optic or Copper.
12. Container Tabs, Header and Image can be viewed.

4.3.3 Loading a Profile

A default profile will be loaded automatically. To select a different profile, in the File menu, select *Load Profile*. The profile will not need to be changed once it has been set-up for the proper frame size and frame rate. Tolerance values may need to be adjusted if receiving variable frame rates since the min and max values may be exceeded causing status flags to indicate RED meaning out of range, the line and container min/max values are highlighted in the example of a profile shown below.




```
#RATE
DATARATE,2.125
#VALUES
LINETIMEMINMAX,20.45,20.9
CONTAINERRATEMINMAX,16.6,16.7
VIDEORESOLUTION,1024,768
BYTESPERPIXEL,3
FRAMESPERLINE,2
#SIZES
CONTINERSIZE,2402436
FCFRAMECOUNT,1537
FC1FRAMESIZE,1564
FC0SIZE,132
CONTAINERHEADERSIZE,88
FCFRAMEHEADERSIZE,24
#LOCATION
FCHeader,00FFFFFF,00808000
CONTHeader,00FFFFFF,00004080
OBJ0,00FFFFFF,000040C0
CRC,00FFFFFF,00800080
PAYLOAD,00FFFFFF,00006060
#DEFINITIONS
1,BCB55757,SOFi Class1,00FFFFFF,00FF7F00
1,BCB53737,SOFn Class1,00,00FFFF00
1,BC95D5D5,EOFn,00,007F7F00
1,BCB5D5D5,EOFnp,00,00FFFF00
1,BC957575,EOFt,00,007FFF00
1,BCB57575,EOFtp,00,007FFF00
```

4.3.4 Saving and Loading Raw Data

Raw Data can be saved to a binary file or loaded from a previously-saved file. This allows viewing and analysis of previously-captured data. Saving Raw Data saves the entire capture buffer (16Meg bytes) to disk file. This is often desirable when there is a particular feature or problem in the captured data that the user wishes to save and then retrieve for analysis at a later time. Since the entire capture buffer is saved, when this data is retrieved it is identical to the original captured data.

To save Raw Data, in the File menu, select "Save", then "Save RAW Buffer". The data is saved as binary data values. To Load Raw Data, in the File menu, select "Load", then "Load RAW Buffer".

4.3.5 Selection of Trigger

Three options are provided for triggering: Trigger on Value, Trigger Immediate, and Trigger on Error. These trigger options are described in the next three sections.

Note : Upon trigger a trigger out pulse will be sent out of the front panel Sync connector via the differential Sync Out + and Sync Out – signals. This pulse is at the start of the captured data and is approx. 1 uS in duration.

4.3.5.1 Trigger On Value

Figure 4.3.3 shows the predefined choices for Trigger on Value. Typically a SOFi would be used to initiate data capture at the beginning of a new video frame.

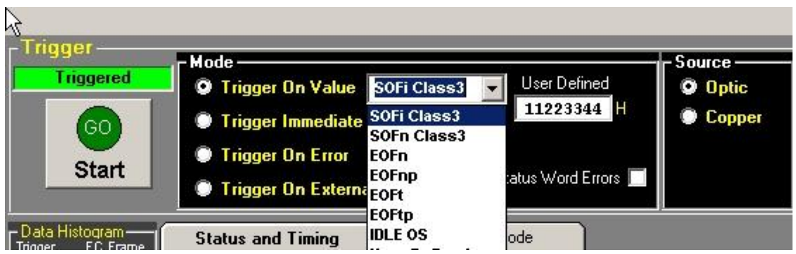
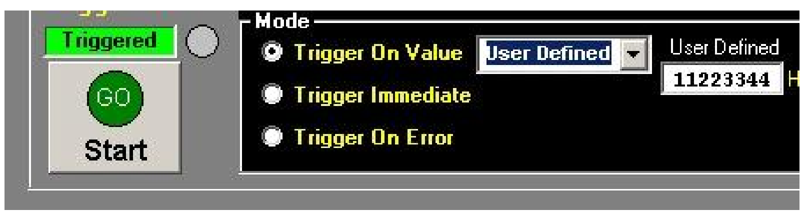


Figure 4.3.3 Trigger Options

To trigger on a data string, select User Defined in the drop down menu, and type in an 8 digit HEX number.



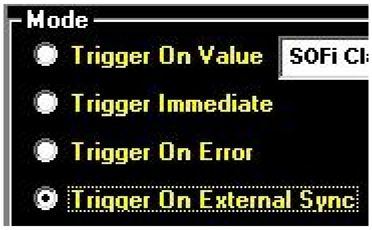
4.3.5.2 Trigger Immediate

This type of trigger will not wait for any predefined vale and instead will capture data immediately. This feature is useful when it is unknown what is on the link.

4.3.5.3 Trigger On Error

This type of trigger will on trigger the analyzer if an error is flagged. The four types of errors that will cause this trigger are CRC, Disparity, Code Violation or Link sync.
Once the start button is pressed with this type of trigger, the analyzer will wait until an error occurs before it triggers. This time frame could be indefinite and if the trigger never occurs because of no errors, the Stop button must be pressed to stop the analyzer.

4.3.5.4 Trigger on External



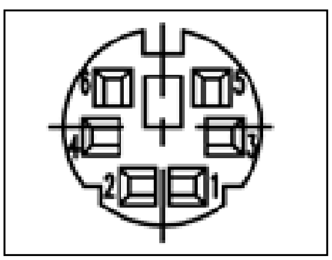
This type of trigger allows the analyzer to be triggered from an external source.
This external source is fed to the card via the Sync connector on the front panel. See the pin descriptions for this connector below.
The analyzer is looking for a LO to HI transition and once it sees this signal, that trigger will be initialized and data captured.

Note the electrical characteristics of this trigger signal. This is a differential input.

4.3.5.4.1 Sync Pulse Connector details

Pin Number	Description
1	Sync Out Shield
2	Sync In Shield
3	Sync Out - (negative side of input sync pulse)
4	Sync In - (negative side of output pulse from trigger, approx 1uS long)
5	Sync Out + (positive side of input sync pulse)
6	Sync In + (positive side of output pulse from trigger, approx 1uS long)

Pin definitions viewed from back panel of EFC PCI card

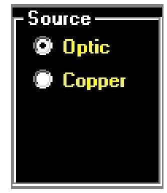


Mating Connector

In Line Plug
Manufacturer “Singatron”
Manufacturer P/N 62000-6P
Digikey P/N 275-1031-ND

4.3.6 Selecting the Data Source

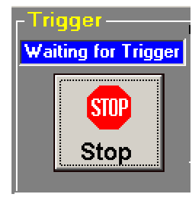
The FC-AV Analyzer card captures raw FC data via a FO850 link or a standard FCN copper interface.



Note: This data input is always a flow through to the TX port. Therefore the analyzer can be inserted inline and will allow the flow of data without interruption.

The selection of this port is made with the radio buttons as shown below

4.3.7 Initiating a Data Capture



Once a trigger is selected, click once on the Start button. The gray button will turn green, and the word Acquiring will be displayed. Typically, a data capture will last less than 10 seconds. If a Trigger on Error is selected, the FCAV Analyzer will wait indefinitely for an error. Pressing the Stop button will stop a data capture. Stopping before the capture is completed can prevent a full data trace from being captured

4.3.8 Link Status Check

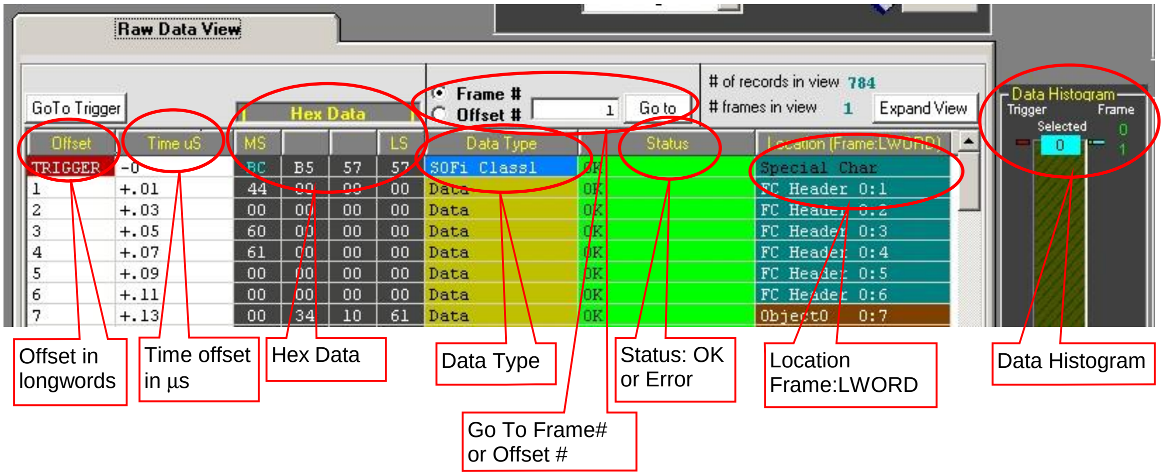
After initiating a data capture, and before the data is captured, the FCAV Analyzer checks the status of the fiber channel link. The check is done once, **preceding** the capture of data. The definition of the link status bits are shown in Table 4.3.5 below.

Sync Link	Green indicates that the serializer/encoder is able to recognize (and synchronize on) 8b/10b codes.
SOFi/EOFt Pairs Detect	Indicates that a Start of Frame and End of Frame has been detected
IDLE OS DET	Green indicates that idle ordered sets have been detected.
SOFi DETECT	Green indicates that a series of SOFi ordered sets have been detected.
EOFt DETECT	Green indicates that a series of EOFt ordered sets have been detected.
SOFn DETECT	Green indicates that a series of SOFn ordered sets have been detected.
EOFn DETECT	Green indicates that a series of EOFn ordered sets have been detected.
COMMA DET	Green indicates that K28.5 characters have been detected. Red indicates that no valid K28.5 characters have been detected.
8b10b CODE	Red indicates the detection of invalid 8B/10B codes.
CRC Check	Red indicates a FC Frame CRC error
Neg Running Disparity	Red indicates a negative running disparity error

Table 4.3.5 Link Status

4.3.9 Captured Data Grid Format

The Raw Data headings are shown below with a small portion of the captured data. Each of the headings are described below.



Offset – indicates the offset in long words from the beginning of the data trace

Time – indicates time relative to the beginning of the data trace, or, relative to any point that the user manually sets it to by clicking in the grid location.

Hex Data – Shown in 4-byte groups, with the least significant on the right hand side.

Data Type – indicates whether the Hex Data is data or a FCAV Ordered Set.

Status – Indicates if the data is OK or an error was detected.

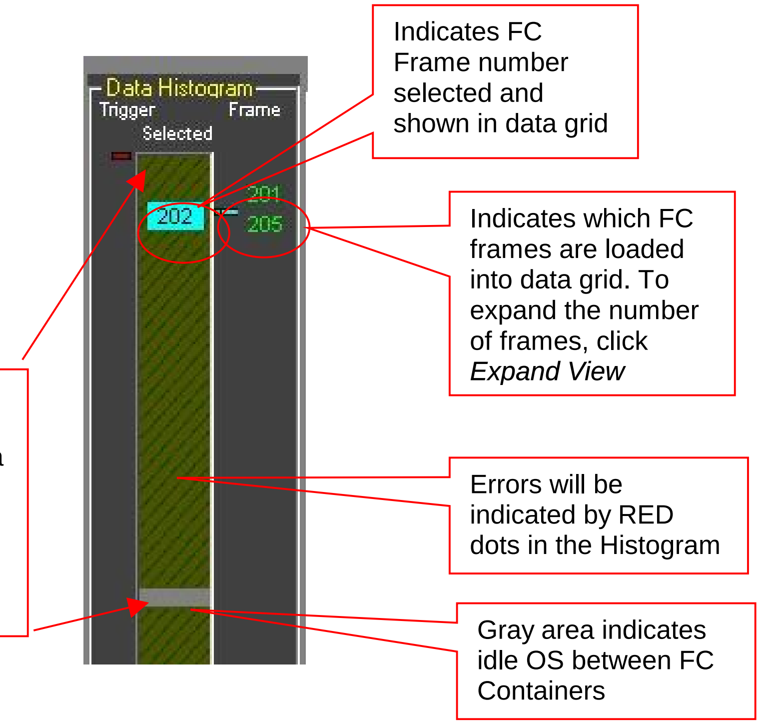
Location – indicates location & function within a FC frame, such as a header, CRC…

Histogram – Shows relative position of a FC frame in the Grid, indicates the frame number, and shows which frames are loaded into the grid. The default range of data is to load a frame above and below the current frame. The amount of data in the grid can be expanded by clicking the *Expand View* button.

Go To – Allows jumping to either a particular FC frame #, or an Offset number. Select Frame # or Offset #, enter a number, and click Go To. The grid will then be populated with the desired data

4.3.10 Histogram

The Histogram is a graphical representation of the all the data captured. Since the data grid displays less than a single FC frame, the histogram indicate the relative position of the data being viewed in relation to the entire data trace. In this example, a SOFi was used as a trigger.

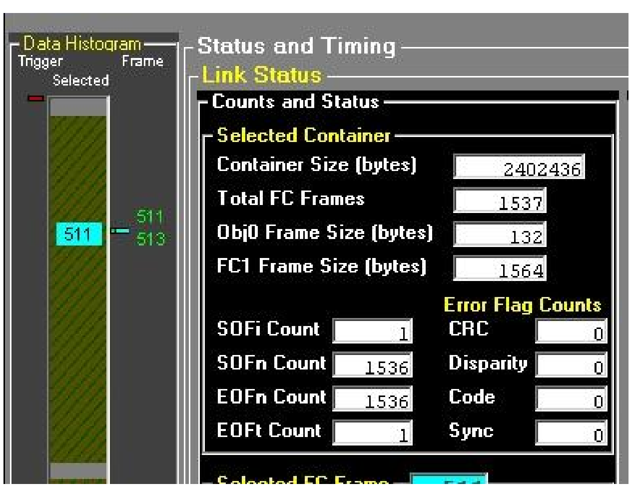


4.3.11 Container Statistics and Status

Once a container is selected by clicking in the Histogram, the container statistics will be updated. The container size is all the data between the SOFi and the EOFt, and should be a fixed number from container to container. The following is reported:

- Container Size in bytes
- Total FC Frames
- FC Frame 0 Size in bytes
- FC Frame 1 - N size in bytes

- SOFi Count - FC Frame CRC errors
- SOFn Count - 8B/10B disparity errors
- EOFn Count - Code errors
- EOFt Count - Synchronization errors

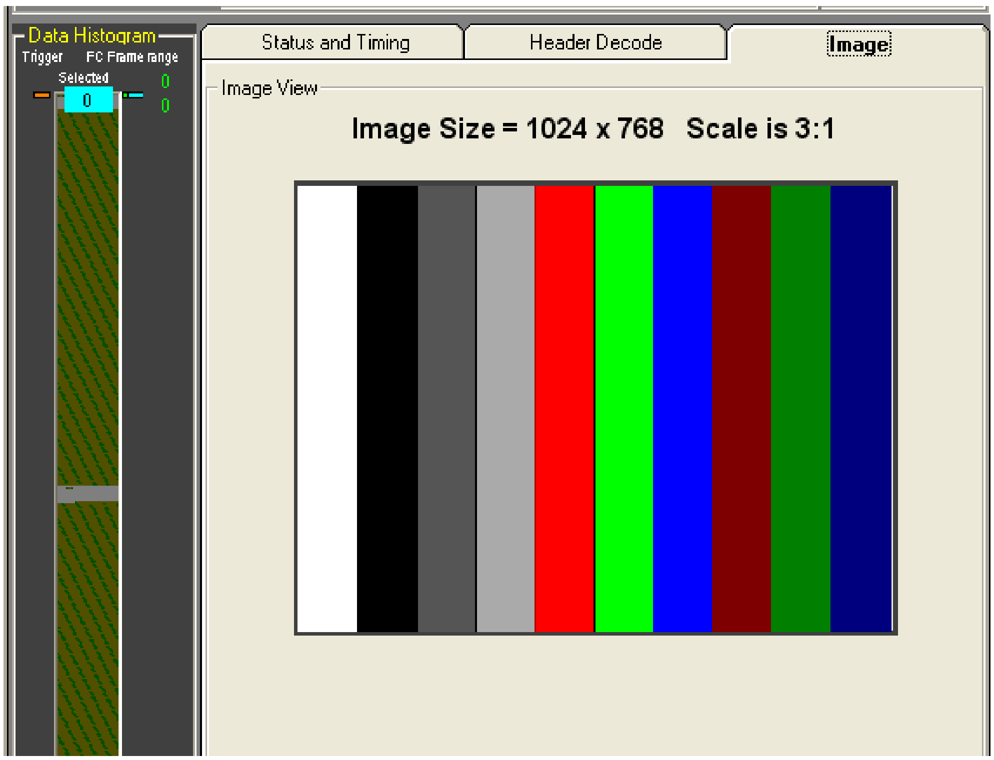


4.3.12 Container Image View Tab

The actual thumbnail of an image for the currently selected container can be viewed by clicking on the “Image” Tab

This image is compressed to fit and is only for reference purposes only.
This image is actually decoded from the information in the PROFILE that is loaded so this information must be correct for pixel packing and decoding.

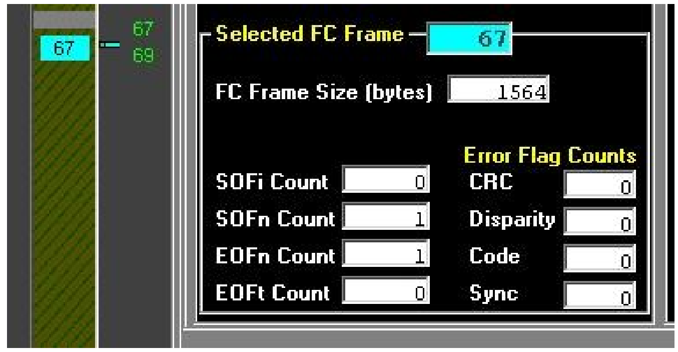
As each container is selected from the Histogram, this image view will be updated.



4.3.13 FC Frame Statistics and Status

The data in this section refer to the FC frame indicated in the blue rectangle in the Histogram, and again in the Selected FC Frame box. This section reports the size of the selected frame, as well as:

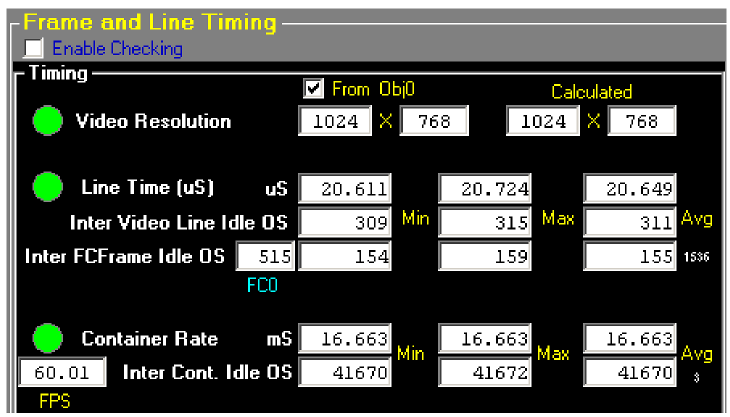
- SOFi Count - FC Frame CRC errors
- SOFn Count - 8B/10B disparity errors
- EOFn Count - Code errors
- EOFt Count - Synchronization errors



4.3.14 Video Frame Resolution and Timing

The Timing section calculates the video resolution, the line timing, and the container (video frame) rate.

Video Resolution
The video resolution is provided in a .profile file. The resolution from the profile is compared against the calculated resolution only if the "Enable Checking" is on. The resolution is also derived from the Container header if the "Obj0" check box is on.

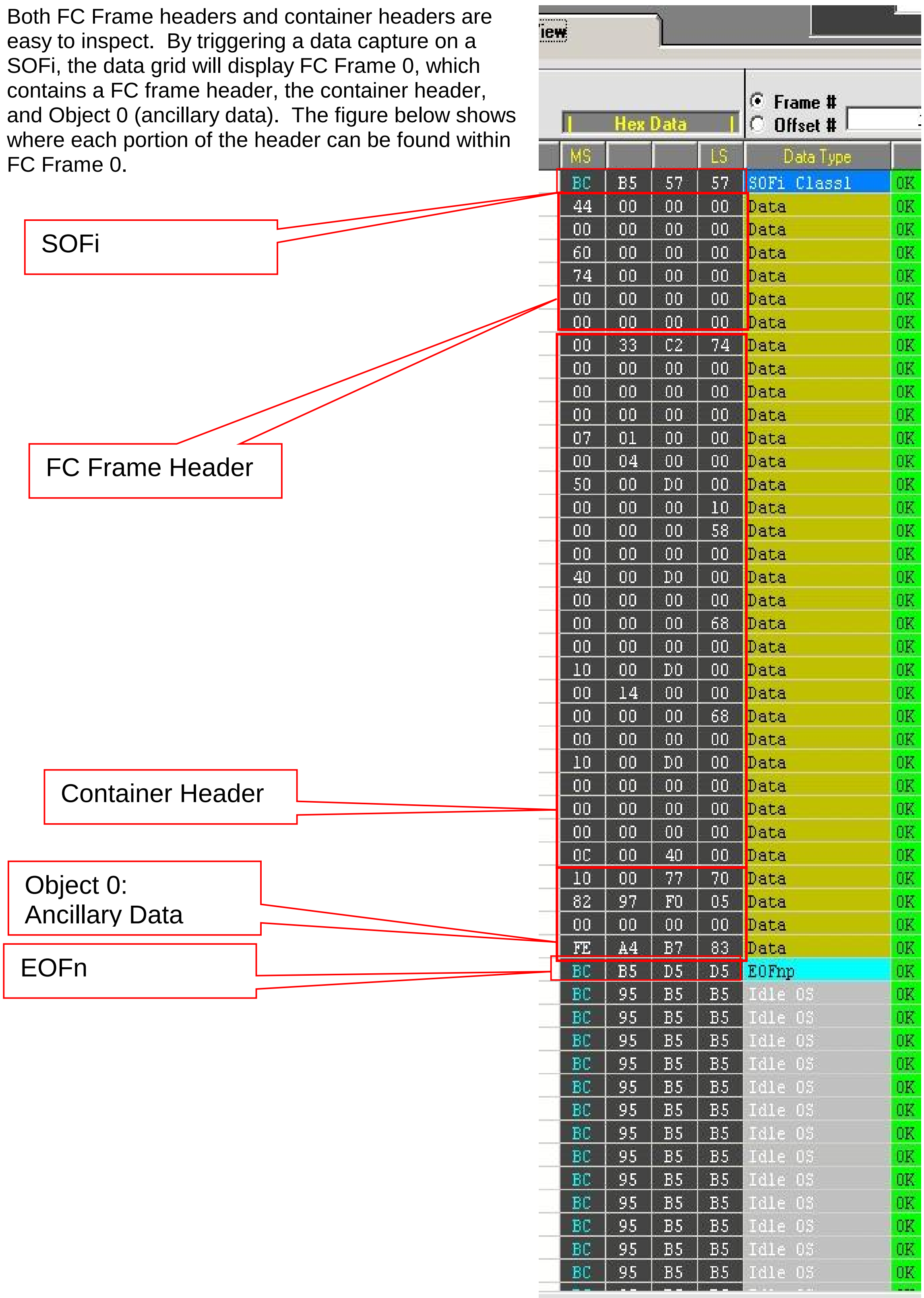


Line Timing
The line timing is provided both in terms of microseconds, and idle counts between lines. The line time in microseconds is determined by calculating the SOFn to EOFn time, and then adding the min, max, and average times of the interline idle ordered sets. The second method of determining line timing provides the count of idle ordered sets between lines since each FC frame should be identical in length (except the first frame with the container header. The first FC Frame is broken out, indicated by Obj0, in the example, 0 idle ordered sets were counted because the data capture began in the middle of a container. The min, max, and average number of idle ordered sets are given, and the number of lines used in the average is shown in the lower right. A red oval shows that in this example, 1536 lines were averaged.

Container Rate
The container rate is also provided in terms of time and number Idle OS. The time is based on SOFi to SOFi time, and the Idle OS number is a count. The FPS value is based on the average frame rate. The number of containers used in the average in this example is 4, as shown in the red oval.

4.3.15 Header Inspection

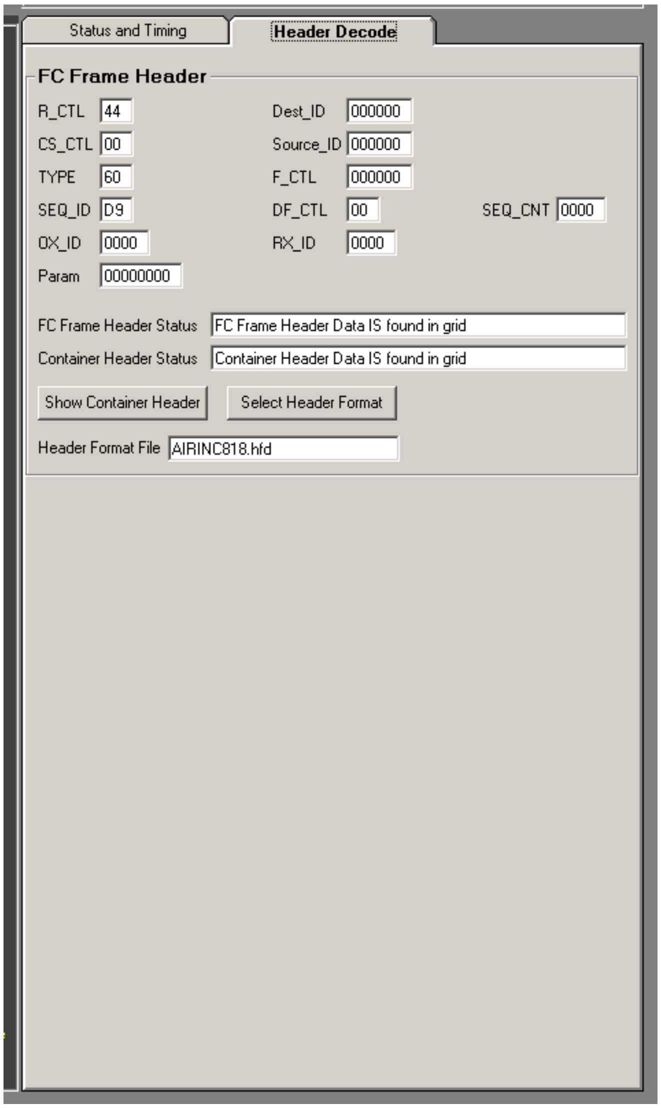
Both FC Frame headers and container headers are easy to inspect. By triggering a data capture on a SOFi, the data grid will display FC Frame 0, which contains a FC frame header, the container header, and Object 0 (ancillary data). The figure below shows where each portion of the header can be found within FC Frame 0.



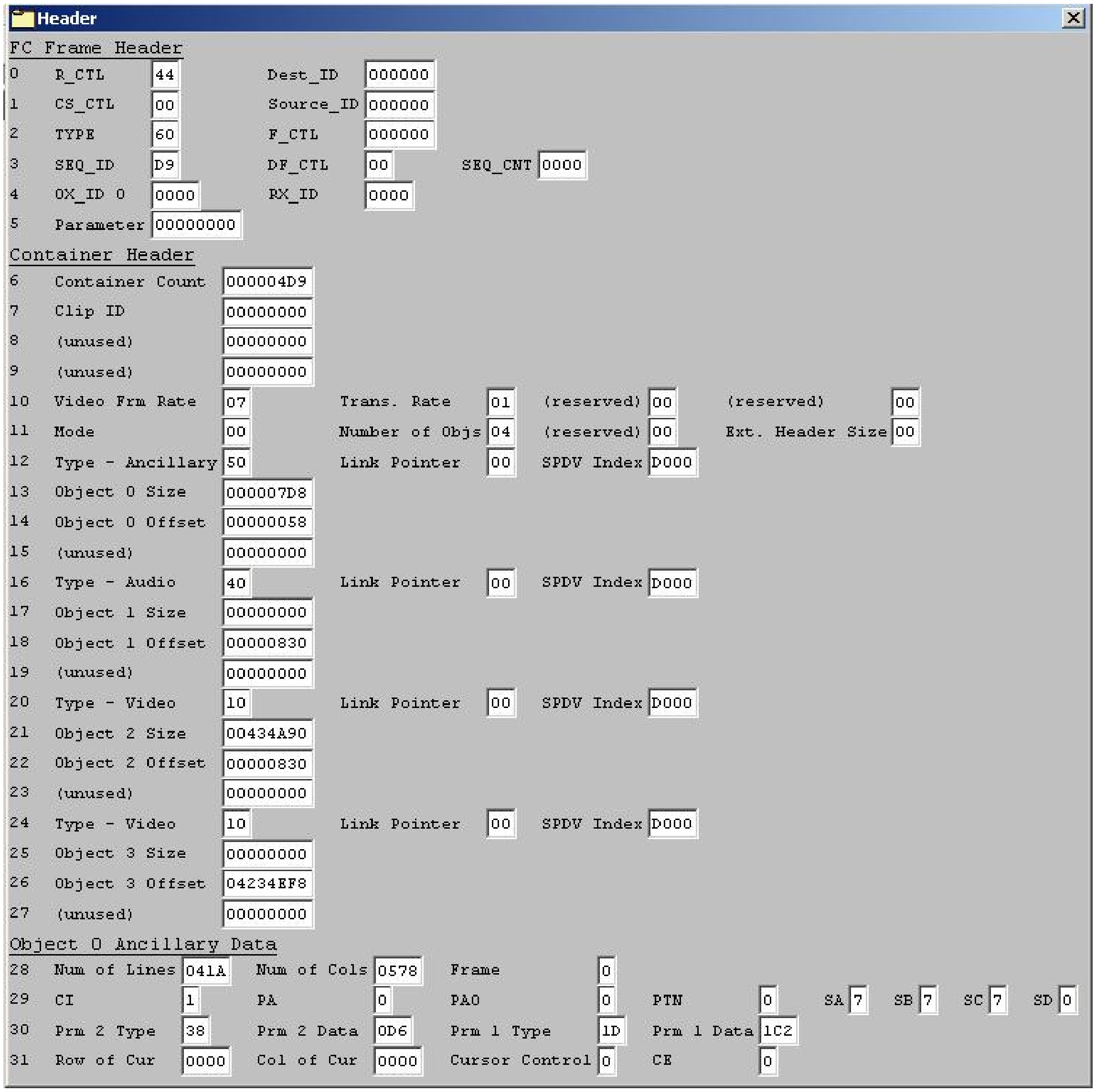
4.3.16 Header Decode Tab

Selecting the Header Decode tab will display the Header for the current frame. On this tab, only the FC Frame Header data is displayed. This view also shows a status message for the FC Frame Header and Container Header as found in the current frame. The Container Header data can also be displayed by pressing the “Show Container header” button. The format for the Container Header data display can be changed by pressing the “Select Header Format” button and selecting the desired format file. This selection is saved in the program initialization file.

A Header Decode Tab view is shown in the image below:



The Container Header data can also be displayed by pressing the “Show Container header” button. This will display the FC Frame Header, Container Header, and Object 0 Ancillary data for the current frame, as the image below illustrates:

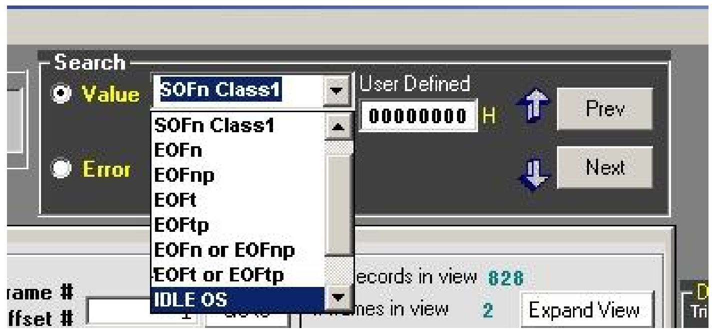


4.3.17 Searching Data

Once data has been captured, is easily examined using the two search methods, *Search for VALUE*, or *Search for ERROR.* Once a search parameter is selected, clicking the next or previous button will jump the data grid to where the parameter is, and reload the grid if needed. If a search is initiated and the parameter does not exist in the data trace, a dialog box will open and indicate that the parameter doesn't exist.

Search on Value
A drop down menu provides an extensive list of search options that are optimized for evaluating FCAV containers and FC frames.
The search options include:

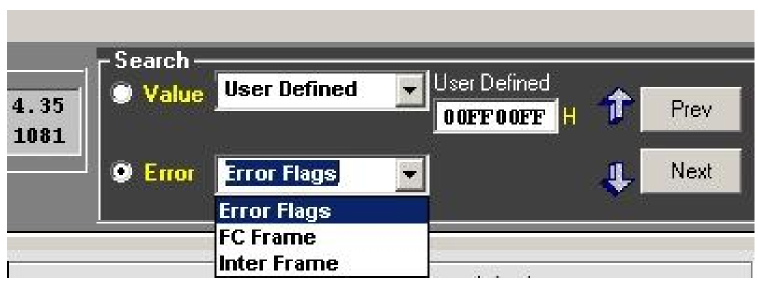
- SOFi Class 1
- SOFn Class 1
- EOFn
- EOFnp
- EOFt
- EOFtp
- EOFn or EOFnp
- EOFt or EOFtp
- IDLE OS
- OS Unknown
- User Defined



If *User Defined* is selected, then an 8 digit value is entered, in HEX, into the the input field. A search is initiated by indicating Prev (for previous), or Next.

Search on Error
Three options are provided for finding errors within a data trace

- Error Flags
- FC Frames
- Inter Frame

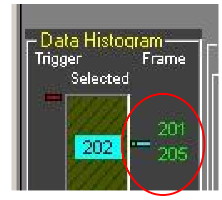


Searching for an Error Flag will find an occurrence of any of the 4 types of error flags:
FC Frame CRC, 8B/10B Disparity, 8B/10B Code, and Receiver Synchronization. These errors are discussed in section 4.4.4.

FC Frame error indicates erroneous ordered sets between a SOFn/EOFn pair, which should contain only data.

An Inter Frame error indicates that something other than an idle OS occurs between an EOFt and the next SOFi.

4.3.18 Saving Data View to File



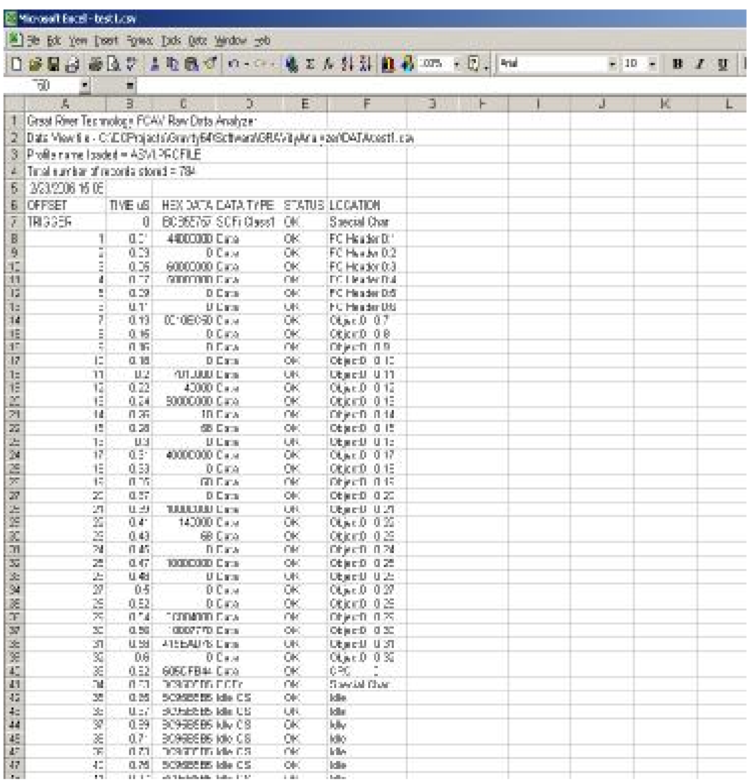
Data in the grid can be saved as a comma delimited file. The entire data buffer isn't saved, just the frames indicated by the green numbers on the Histogram. The data is saved by selecting the *File* drop down menu, selecting *Save Data View,* and then entering a file name. The data will be saved as a .CSV (comma separated values) type file and can be imported into Excel for viewing and formatting.

All of the data can be saved to a .DAT file for later loading.
Select the File menu and Under Save, choose "Save Raw Buffer".
To later reload any save .DAT file, first make sure you have the correct PROFILE loaded the under File menu choose Load "Load Raw Buffer"

4.3.19 Data View File Description

The Data View file is a CSV (comma separated value) file containing the frames saved in the Data View. The file has a 5 line header containing the location of the file, the Profile, the number of records, and a date/time stamp. After the header there are 6 columns for OFFSET, TIME (in microseconds), the HEX DATA, DATA TYPE, STATUS and LOCATION. The data in these columns is the same content as in the GRAVity Analyzer GUI Data View.

The image below shows part of a Data View file:



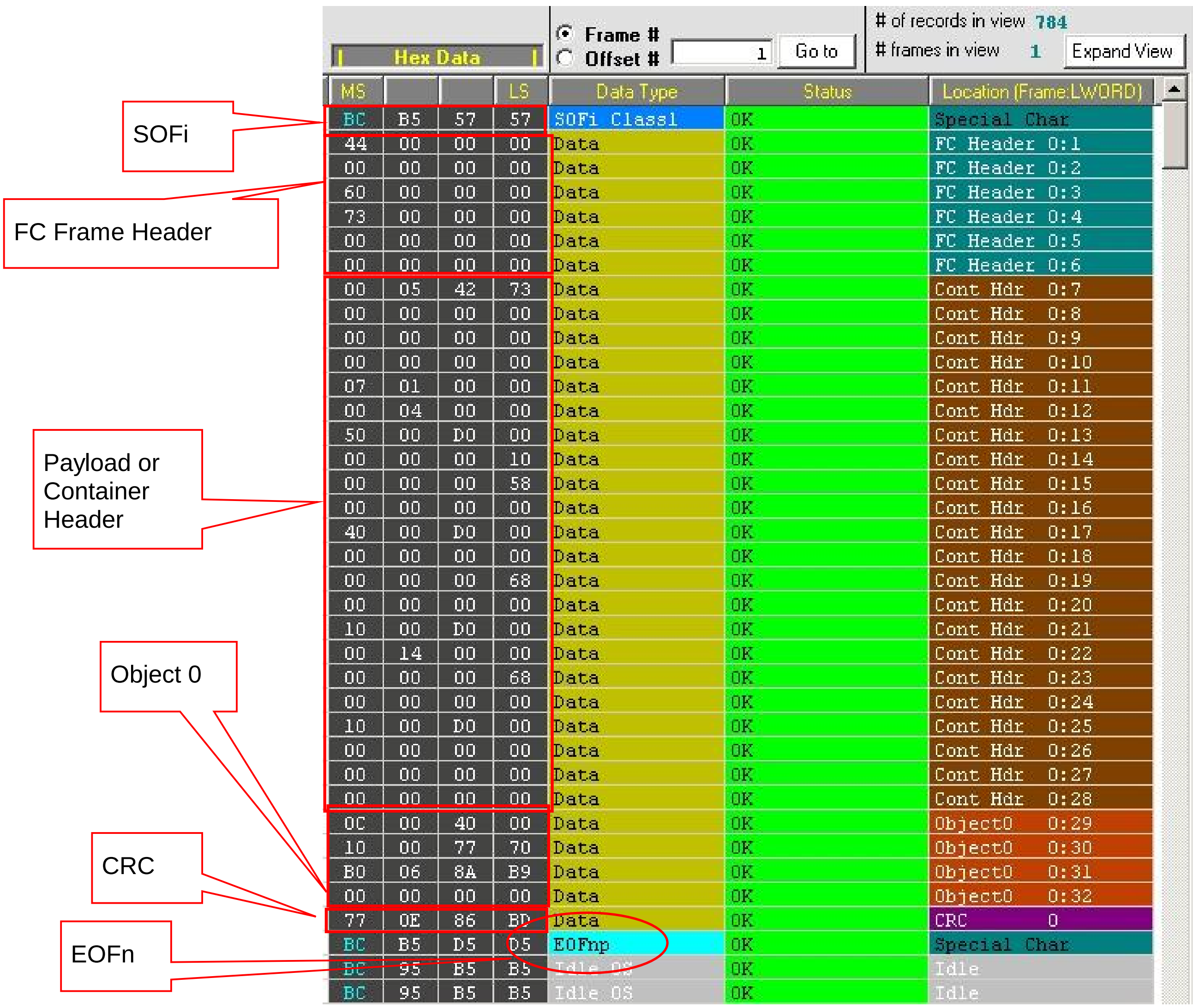
4.4 Using the GRAVity FCAV Analyzer for Troubleshooting

The GRAVity FCAV Analyzer can help find and diagnose a number of common errors that occur during the development phase of FCAV systems.

4.4.1 FC Frame and FCAV Container Structure

A Fiber Channel frame has the following elements: a SOFi or SOFn, a FC Header, the Payload or Container Header and Ancillary Data, a CRC, and an EOFn or EOFt. Figure 4.4.1 (below) shows how these elements are easily identified with the GRAVity FCAV Analyzer.

A data trace that was captured with a SOFi trigger as shown below.

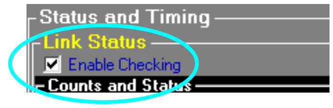


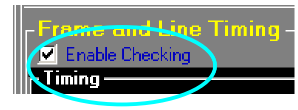
MS			LS	Data Type	Status	Location (Frame:LWORD)
BC	B5	57	57	SOFi Class1	OK	Special Char
44	00	00	00	Data	OK	FC Header 0:1
00	00	00	00	Data	OK	FC Header 0:2
60	00	00	00	Data	OK	FC Header 0:3
73	00	00	00	Data	OK	FC Header 0:4
00	00	00	00	Data	OK	FC Header 0:5
00	00	00	00	Data	OK	FC Header 0:6
00	05	42	73	Data	OK	Cont Hdr 0:7
00	00	00	00	Data	OK	Cont Hdr 0:8
00	00	00	00	Data	OK	Cont Hdr 0:9
00	00	00	00	Data	OK	Cont Hdr 0:10
07	01	00	00	Data	OK	Cont Hdr 0:11
00	04	00	00	Data	OK	Cont Hdr 0:12
50	00	D0	00	Data	OK	Cont Hdr 0:13
00	00	00	10	Data	OK	Cont Hdr 0:14
00	00	00	58	Data	OK	Cont Hdr 0:15
00	00	00	00	Data	OK	Cont Hdr 0:16
40	00	D0	00	Data	OK	Cont Hdr 0:17
00	00	00	00	Data	OK	Cont Hdr 0:18
00	00	00	68	Data	OK	Cont Hdr 0:19
00	00	00	00	Data	OK	Cont Hdr 0:20
10	00	D0	00	Data	OK	Cont Hdr 0:21
00	14	00	00	Data	OK	Cont Hdr 0:22
00	00	00	68	Data	OK	Cont Hdr 0:23
00	00	00	00	Data	OK	Cont Hdr 0:24
10	00	D0	00	Data	OK	Cont Hdr 0:25
00	00	00	00	Data	OK	Cont Hdr 0:26
00	00	00	00	Data	OK	Cont Hdr 0:27
00	00	00	00	Data	OK	Cont Hdr 0:28
0C	00	40	00	Data	OK	Object0 0:29
10	00	77	70	Data	OK	Object0 0:30
B0	06	8A	B9	Data	OK	Object0 0:31
00	00	00	00	Data	OK	Object0 0:32
77	0E	86	BD	Data	OK	CRC 0
BC	B5	D5	D5	EOFnp	OK	Special Char
BC	95	B5	B5	Idle OS	OK	Idle
BC	95	B5	B5	Idle OS	OK	Idle

Figure 4.4.1 Data Trace Showing Container and Frame Structure

Complete containers should also have a matched SOFi/EOFt pair (one per container), as well as SOFn/EOFn matched pairs (one per FC Frame). The example shown in Figure 4.4.2 gives insight into how the FCAV Analyzer helps to easily determine frame and container structure issues. The Histogram indicates that FC Frame 139 is being evaluated, and by inspection, it is clear that a full container is not present because the length of the data before the gray area indicating interframe idle OS isn't the same length as the full containers below. Inspecting the status shows the wrong number of bytes in the container, wrong number of frames, a SOFi/EOFt mismatch, wrong video resolution, but correct frame structure, line timing, and container timing in the balance of the data trace. **Conclusion:** The FC Frame and Container structures are fine, as well as the line and container timing, but a full container wasn't received.

The Following Errors will only show up if the “Enable Checking” check boxes are checked for both the Timing and the Counts and Stats areas





Histogram shows full container not present due length of data

Container Size Low

Incorrect number of frames

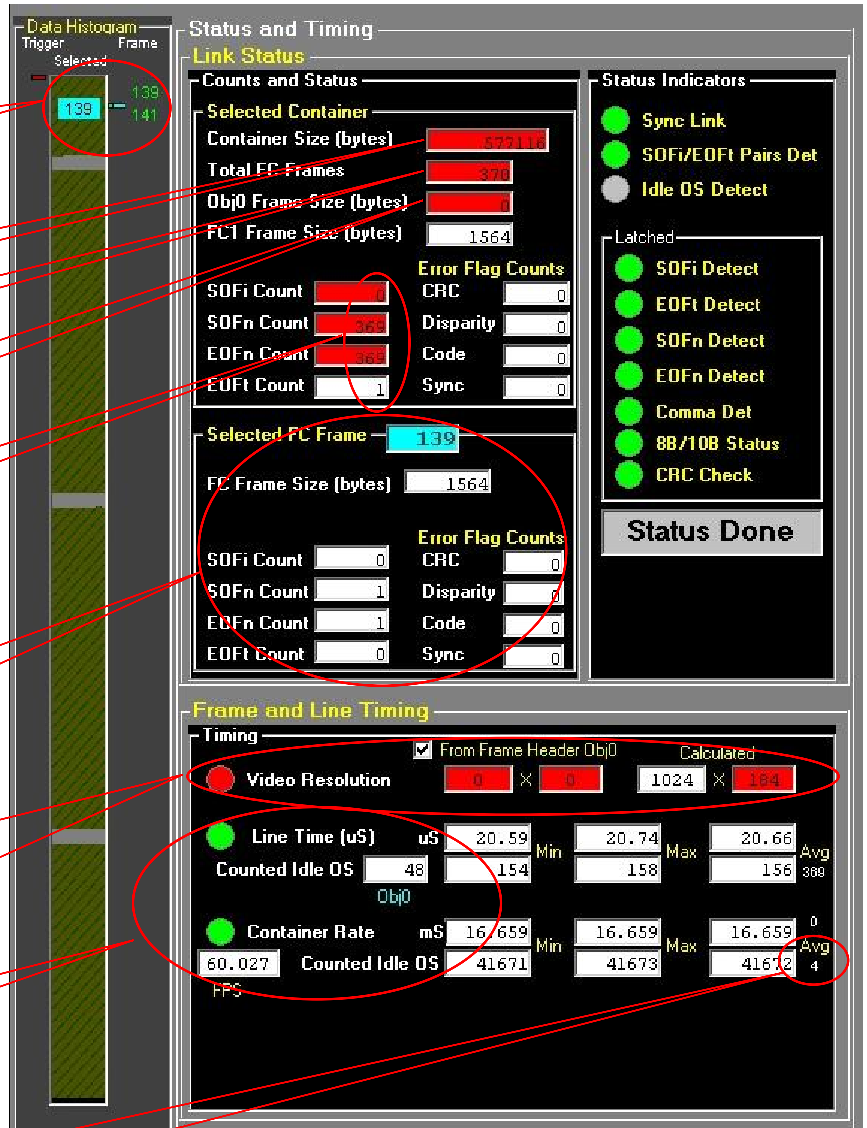
No Container Header

SOFi/EOFt pair mismatch indicates a complete container wasn’t received

Frame 139 is proper size, framed by an SOFn/EOFn pair, with no Error flags set

Video Resolution wrong – no data from container header, but calculated resolution at 1024 x 184 shows that complete video lines are being received, but the full container wasn’t received

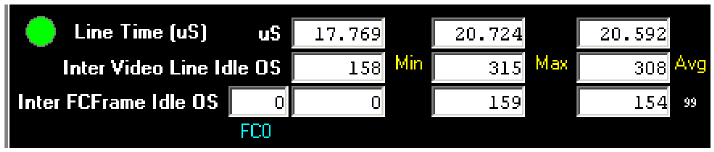
Line timing and container rate are correct.



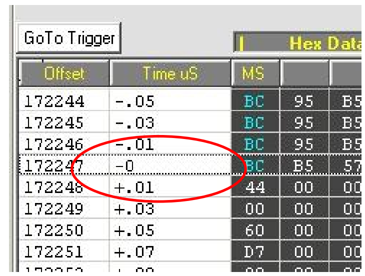
Despite an incomplete container at the beginning, four complete containers were received

4.4.2 Video Line Timing

Precise video line timing can be important for maintaining synchronization with a display, or preventing video receiver FIFO problems. The FCAV Analyzer captures and calculates the minimum, maximum, and average line times over the selected FCAV container. A container is selected by clicking in the histogram.



An individual line time can be determined by searching for an SOFn, clicking in the time stamp (leftmost column) to set the time to 0 relative to the SOFn, then searching for the next EOFn and looking at the time code. For formats that use two FC frames per video line, it is necessary to go to the second EOFn. The time of the line can be read directly from the time code of the second EOFn.



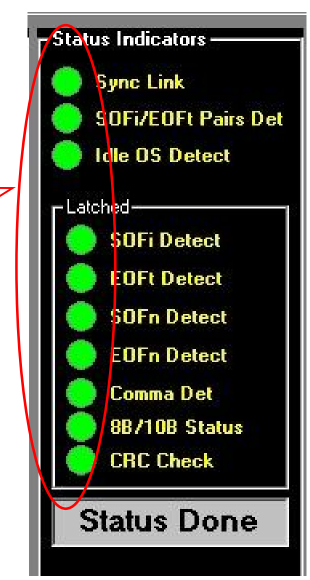
4.4.3 Video Frame Timing

The timing of a video frame is easily verified by checking the container rate in FPS or ms.

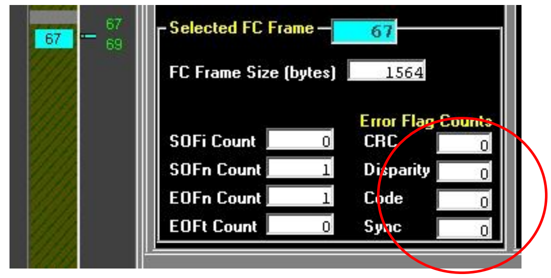
4.4.4 Link Synchronization and Errors

When a data capture is initiated by selecting a trigger and clicking the start button, the fiber channel serial link is checked ***prior to*** capturing data. The 10 Status Indicator lights display the results of the status check. These lights indicate the status of the link BEFORE the data is captured, and provide a valuable snapshot of the link.

10 Status Indicators

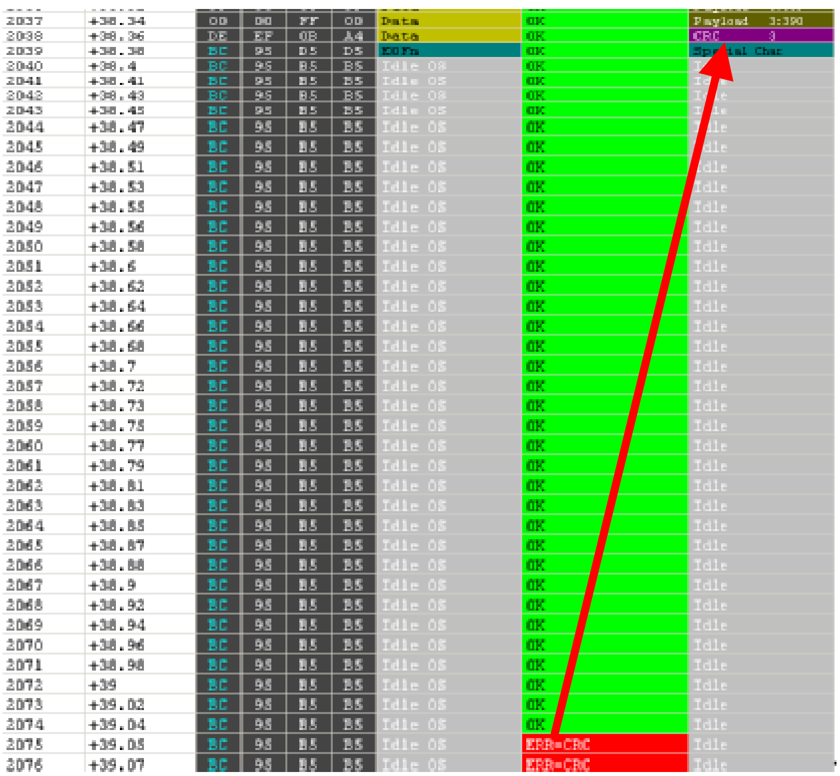


Four error indicators are captured as part of the data trace. The four error flags indicate the health of each FC Frame, and a receiver's ability to capture the incoming data. The four error flags are: Sync, Code, Disparity, and CRC. They are described below.



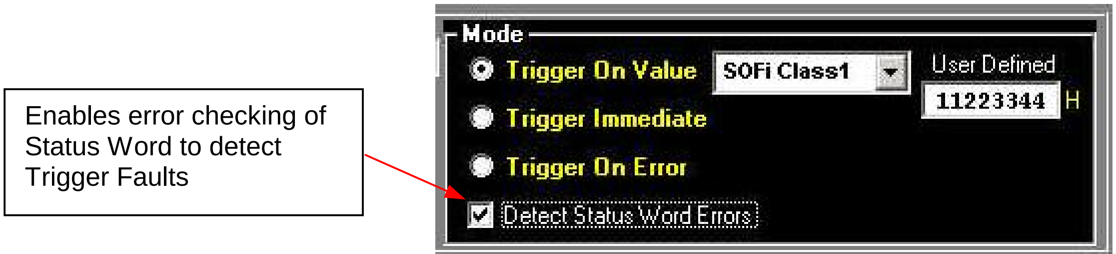
- § **Sync** – indicates the receiver can't distinguish and capture the incoming bit stream, indicating a mismatched frequency or that 8B/10B packets aren't present. This is the lowest level link check.
- § **Code** – indicates that an invalid 8B/10B code has been received.
- § **Disparity** – indicates the incorrect disparity of a 10B code.
- § **CRC** – indicates that the CRC embedded at the end of a FC frame does not match the CRC calculated by the analyzer over the FC Frame. A CRC error can indicate bit errors during transmission or reception. A CRC error always refers to the CRC in the FCFrame above the CRC errors in the Raw data.

As shown below, the CRC errors corresponds with the CRC in the previous FCFrame



4.4.5 Trigger Faults

This application has features to check the integrity of the RAW data. Specifically, the program can check the unused bits b0, b1, and b2 in the Status Word. When these bits are found to be set, this usually indicates a Trigger Fault in the RAW data. To enable detection of this error, check the checkbox labeled “Detect Status Word Errors” in the Trigger area of the main screen. If this checkbox is selected and such an error is detected, the user should re-trigger and capture new data.

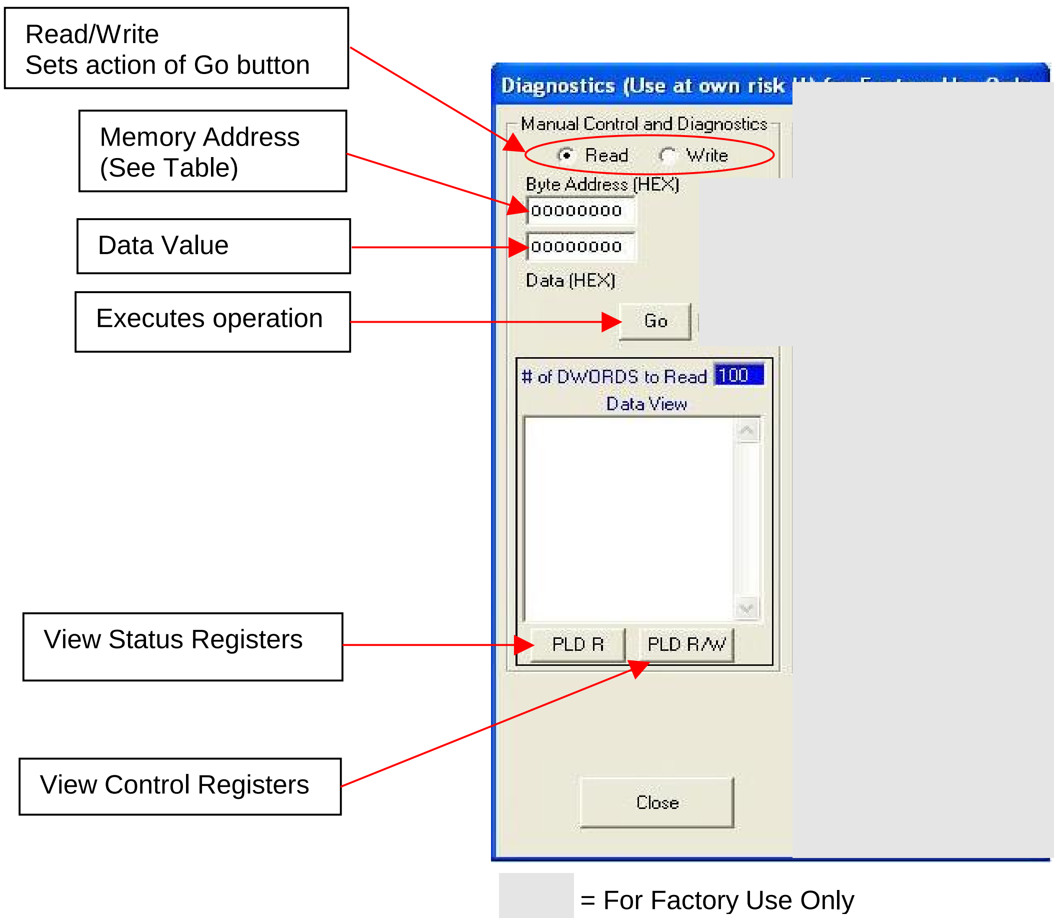


If a Status Word Trigger Fault error is detected, the following error message will be displayed:

4.5 Advanced Diagnostics

Disclaimer: The diagnostic functions are provided for factory test, and verification. Advanced users may find some of the functions helpful for system verification, but it is possible to override safety features of the application that can result in corrupted data, and system lock up. The grayed out section of the menu box should not be accessed unless specifically instructed by a factory representative.

To open the Advanced Diagnostics dialog box, got to the *Advanced* drop down menu, and select H/W Viewer



The diagnostics menu can be used to view the contents of the PLD status registers and to view the content of the Ping and Pong image stores or to change pixel values in memory.

The **PLD R** button is used to retrieve the contents of status registers in the PLD and the **PLD R/W** is used to retrieve content of the PLD control registers.

Ping and Pong memory contents can be observed using the following steps:

1. Enter the base address (In hex) in the top most entry box
2. Check the **Read** radio button
3. Enter the number of Double Words to read
4. Click the **GO** button

The memory contents will be displayed in the view port.

Ping and Pong memory, header and pixel data, can be modified using the following steps:

5. Enter the base address (In hex) in the top most entry box
6. Check the **Write** radio button
7. Enter the new value (In hex) in the bottom most entry box
8. Click the **GO** button

The memory contents will be displayed in the view port. Note that when a write command is executed the number of displayed **DWORDS** is automatically set to 1.

4.6 Loop Through (Line Spy)

The GRAVity FCAV Analyzer has a loop through feature. The incoming data stream will be transmitted out exactly as received, with the exception of CRC errors. If a FC Frame is received with a CRC error, a correct CRC will be inserted in the transmitted frame. This feature is always active when the analyzer is running and when the analyzer triggers, the last container is sent through the line spy. Therefore a receiving card will on the line spy will always capture the last container.

This is applicable to both the Optic and Copper connectors.

5 Fibre Channel Frame Format and Ordered Sets

The Fibre Channel transport layer is comprised of frames as defined below.

The basic unit of transport for video and header data will be FC frame. Each FC frame has the structure shown below (and as described in the referenced FC-PH specification).

Word	Identifier	Byte 0	Byte 1	Byte 2	Byte 3
XX	Idle word	K28.5	D21.4	D21.5	D21.5
XX	Idle word	K28.5	D21.4	D21.5	D21.5
0	**$SOF_{i/n}$**	**K28.5**	**D21.5**	**D23.x**	**D23.x**
1	Frame Header R_CTL D_ID	FC Frame Header byte	FC Frame Header byte	FC Frame Header byte	FC Frame Header byte
2	Frame Header CS_CTL S_ID	FC Frame Header byte	FC Frame Header byte	FC Frame Header byte	FC Frame Header byte
3	Frame Header Type F_CTL	FC Frame Header byte	0000 **x**000 **(Bit 19)**	FC Frame Header byte	FC Frame Header byte
4	Frame Header	FC Frame Header byte	FC Frame Header byte	**0000 0000 (SEQ_CNT)**	**0000 0000 (SEQ_CNT)**
5	Frame Header	FC Frame Header byte	FC Frame Header byte	FC Frame Header byte	FC Frame Header byte
6	Frame Header	FC Frame Header byte	FC Frame Header byte	FC Frame Header byte	FC Frame Header byte
7 to N*	Payload	Data	Data	Data	Data
N+1	CRC	Data	Data	Data	Data
N+2	**$EOF_{n/t}$**	**K28.5**	**D21.x**	**D21.x**	**D21.x**
XX	Idle word	K28.5	D21.4	D21.5	D21.5

Table 5.0a Fibre Channel Frame Definition

The 24 FC Frame header bytes originate from header files loaded via GRAV_FCAV. All fields can be set by the user and may be defined differently than described in FC-PH. However, Gravity FC-AV will automatically update the sequence count and the end sequence bit as described below.

SEQ_CNT	The *Sequence Count* is used as defined in FC-PH and is incremented by one LSB for each consecutive FC frame of the FC-AV data sequence.
END_SEQ	The *End Sequence* bit (Word 3, bit 19) is set to logic 1 for the last FC frame of a data sequence (FC-AV container), and set to logic 0 for all other frames of the sequence.

Table 5.0b Fields updated by hardware

5.1 Idle Words

Idle ordered sets, K28.5, D21.4, D21.5, D21.5, are transmitted between FC frames and their number can be adjusted to change the overall timing of the video field rate (or FC-AV container rate).

When receiving, the Gravity FC-AV requires a minimum of six Idle ordered sets between each Fibre Channel frame.

When transmitting, the number of Idle ordered sets between FC frames can be varied to adjust the video frame time.

The Gravity FC-AV automatically pads the Idle OS after the last FC frame in a sequence, such that the required video frame rate (required by the profile) is achieved. Users may set the minimum number of Idle OS between all other frames by writing to a PLD control register. (See EFC API User's Manual)

5.2 Start of Frame

The first frame of an FC-AV container transfer sequence uses the Start of Frame Initiate Class 1 SOF_{i1} ordered set (K28.5, D21.5, D23.2, D23.2). Subsequent frames of the FC-AV container sequence use the Start of Frame Normal Class 1 SOF_{n1} ordered set (K28.5, D21.5, D23.1, D23.1).

5.3 Data Payloads

The first frame of an FC-AV container data sequence contains the container header and Object 0 ancillary data as its data payload.

Subsequent frames of the FC-AV container sequence contain the Object 2 video pixel data.

5.4 Cyclic Redundancy Check (CRC)

All data frames include a 4 byte CRC using the following 32-bit polynomial:

$$X^{32} + X^{26} + X^{23} + X^{22} + X^{16} + X^{12} + X^{11} + X^{10} + X^{8} + X^{7} + X^{5} + X^{4} + X^{2} + X + 1$$

5.5 End of Frame

All frames except the last frame of an FC-AV container data transfer sequence use the End of Frame Normal EOF_n ordered set (beginning RD Negative - K28.5, D21.4, D21.6, D21.6 or beginning RD Positive - K28.5, D21.5, D21.6, D21.6).

The last frame of an FC-AV container data transfer sequence uses the End of Frame Terminate EOF_t ordered set (beginning RD Negative - K28.5, D21.4, D21.3, D21.3 or beginning RD Positive - K28.5, D21.5, D21.3, D21.3).

6 Fibre Channel Containers

Gravity FC-AV cards adhere to the FC-AV container system of transport as described in Clause 5 of the standard.

A container is simply the set of Fibre Channel frames used to transport a single video frame. For uncompressed progressive scanned video, only two objects are required: Object 0, which contains ancillary data, and Object 2 that carries the video payload. Object 1, by definition, is restricted to Audio and is not typically used.

6.1 FC frame 0

In all video profiles, the container header and Object 0 are in a single Fibre Channel frame. This frame is the first frame of the sequence and begins with an SOFi (rather than SOFn). All subsequent frames (Object 2) carry video payload.

The Fibre Channel frame 0 is comprised of 32 long words (128 bytes) as follows:

FC Frame header	6 Lwords	(24 bytes)
FC-AV Container Header	22 Lwords	(88 Bytes)
Object 0: Ancillary Data	4 Lwords	(16 bytes)
Total	32 Lwords	(128 bytes)

The FC frame header is that same as that defined in section 5. The container header and ancillary data are described in the “FC-AV Container Header” section below.

6.2 *FC-AV Container Header*

Gravity FC-AV cards allow users to adhere to the standard definition of the Container Header (as shown in table 6.2) or, since Gravity cards use text based header files, part or all of these fields may be user defined.

Word	Identifier	Byte 0	Byte 1	Byte 2	Byte 3
0	Container Count	(MSB)			(LSB)
1	Clip ID	(MSB)			(LSB)
2	Container Time Stamp	(MSB)			
3	Container Time Stamp				(LSB)
4	Transmission Type	(Video Frame Rate)	(Transmission Rate)	(Reserved)	(Reserved)
5	Container Type	(Mode)	(Number of Objects)	(Reserved)	(Size of Ext. Header)
6	Object 0 Class	(Type)	(Link Pointer)	(SPDV Index)	(SPDV Index)
7	Object 0 Size	(MSB)			(LSB)
8	Object 0 Offset	(MSB)			(LSB)
9	Object 0 Object Type Defined	Type Defined	Type Defined	Type Defined	Type Defined
10	Object 1 Class	(Type)	(Link Pointer)	(SPDV Index)	(SPDV Index)
11	Object 1 Size	(MSB)			(LSB)
12	Object 1 Offset	(MSB)			(LSB)
13	Object 1 Object Type Defined	(Type)	(Link Pointer)	(SPDV Index)	(SPDV Index)
14	Object 2 Class	(Type)	(Link Pointer)	(SPDV Index)	(SPDV Index)
15	Object 2 Size	(MSB)			(LSB)
16	Object 2 Offset	(MSB)			(LSB)
17	Object 2 Object Type Defined	Type Defined	Type Defined	Type Defined	Type Defined
18	Object 3 Class	(Type)	(Link Pointer)	(SPDV Index)	(SPDV Index)
19	Object 3 Size	(MSB)			(LSB)
20	Object 3 Offset	(MSB)			(LSB)
21	Object 3 Object Type Defined	Type Defined	Type Defined	Type Defined	Type Defined

Table 6.2 Object 0 Container Header

6.3 FC-AV Object 0: Ancillary Data

Also included in the Object 0 FC frame are 24 bytes of Ancillary Data (as shown in table 6.3). Since the Gravity card uses text based header files, part or all of these fields may be user defined.

Word	Identifier
0	Ancillary Data
1	Ancillary Data
2	User Defined Data
3	User Defined Data

Table 6.3 Object 0 Ancillary data

6.4 FC-AV Object 2 Video Data

In all video profiles, container Object 2 is comprised of a set of Fibre Channel frames. These frames begin with SOFn and can carry up to 2112 bytes video of video payload per FC frame. The exact number of bytes per FC frame and the total number of FC frames, depends on the video profiles.

Gravity FC-AV cards, using the standard firmware, support video profiles as described in Section 7. Supported video profiles insert one half of a video line using three bytes per pixel in each FC payload frame.