3 * ACQ2106 + 4xACQ424 + AO424 + DIO432 in low latency control mode to a single host.

This factory acceptance test outlines the procedures undertaken to demonstrate that the equipment is functioning as intended.

Minimum required release:
acq400-131-20191107115916

Recommended:
RELEASE acq400-132-20191119141501

Revision of document.

Date	Change
22.11.2019	Added more detailed information on plotting data
25.11.2019	Added numbers to the plots and their corresponding descriptions.
26.11.2019	Added some information on debug.
20.12.2019	Added sample construction information.
23.01.2020	Fixed sample construction diagram.
27.01.2020	Added a section on working with a BOLO8 system.
29.01.2020	Added CS Studio information and improved BOLO8 data explanation.
10.02.2020	Added section on isolating CPUs.

Load driver for low latency control.

To configure the host computer for low latency control mode there is a script that must be run in order to load the driver for the module. The script can be found in the D-TACQ AFHBA404 github repo here:

https://github.com/D-TACQ/AFHBA404

To load please run the following commands inside the AFHBA404 directory after cloning (or updating) the repository:

```
sudo make

sudo ./scripts/install-hotplug

sudo ./scripts/loadNIRQ
```

N.B. Make sure that you use at least:
https://github.com/D-TACQ/AFHBA404/releases/tag/1.4.1

Or higher.

Installing acq400_hapi

The user will need to clone acq400_hapi from GitHub and install it on PIP. The repository can be found here:

https://github.com/D-TACQ/acq400_hapi

The repository should be cloned to the following location on the host computer:

/home/$USER/PROJECTS/

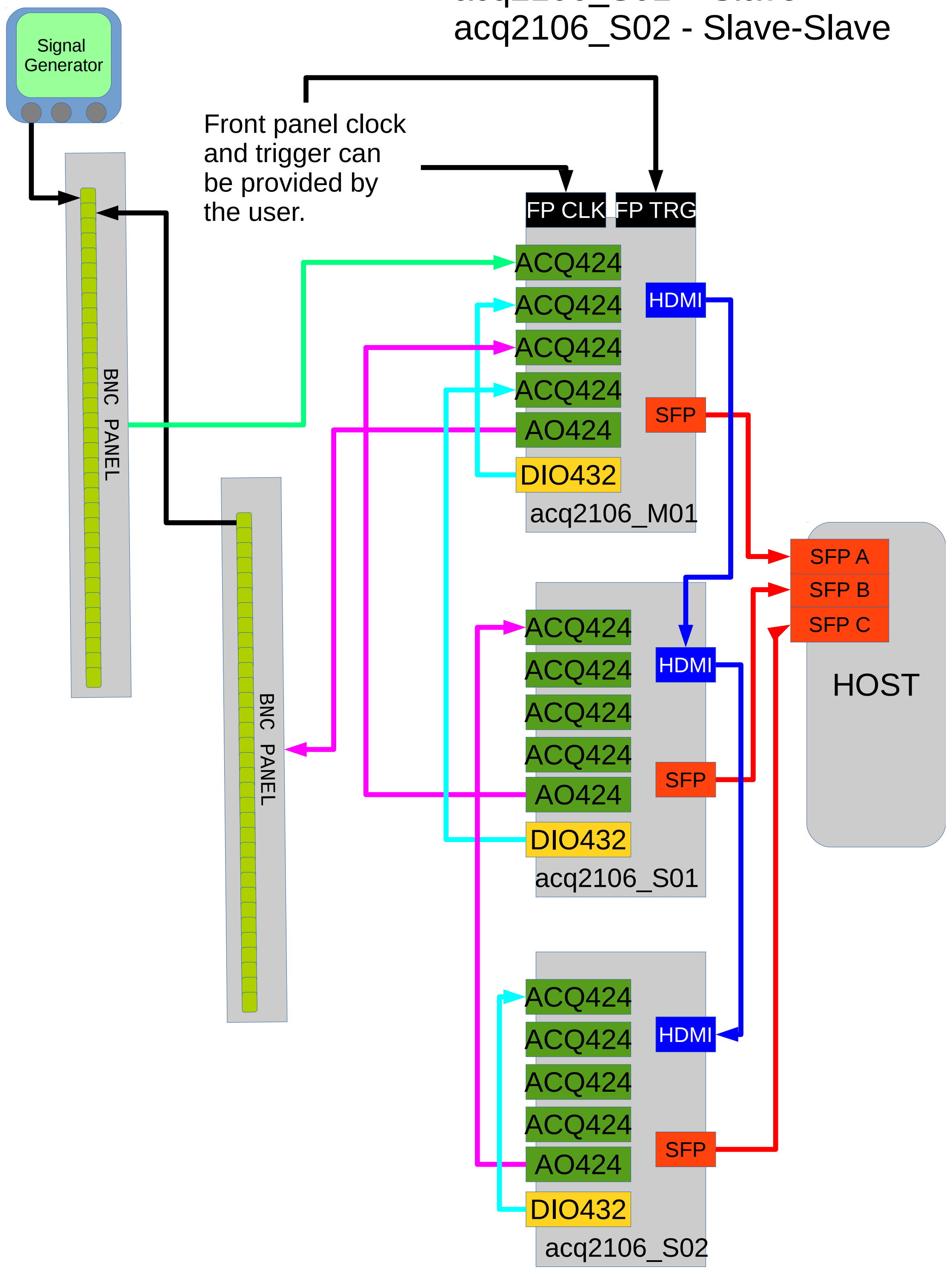
It can be cloned using the following command:

```
git clone https://github.com/D-TACQ/acq400_hapi.git
```

Once this repository has been cloned, acq400_hapi can be installed by running:

```
sudo pip3 install acq400_hapi
```

acq2106_M01 – Master
acq2106_S01 – Slave
acq2106_S02 - Slave-Slave



Set up CS Studio

Configure CS Studio to monitor the UUTs. It is best to use the STREAMVIEW4.opi. Configure a CS Studio workspace as such:

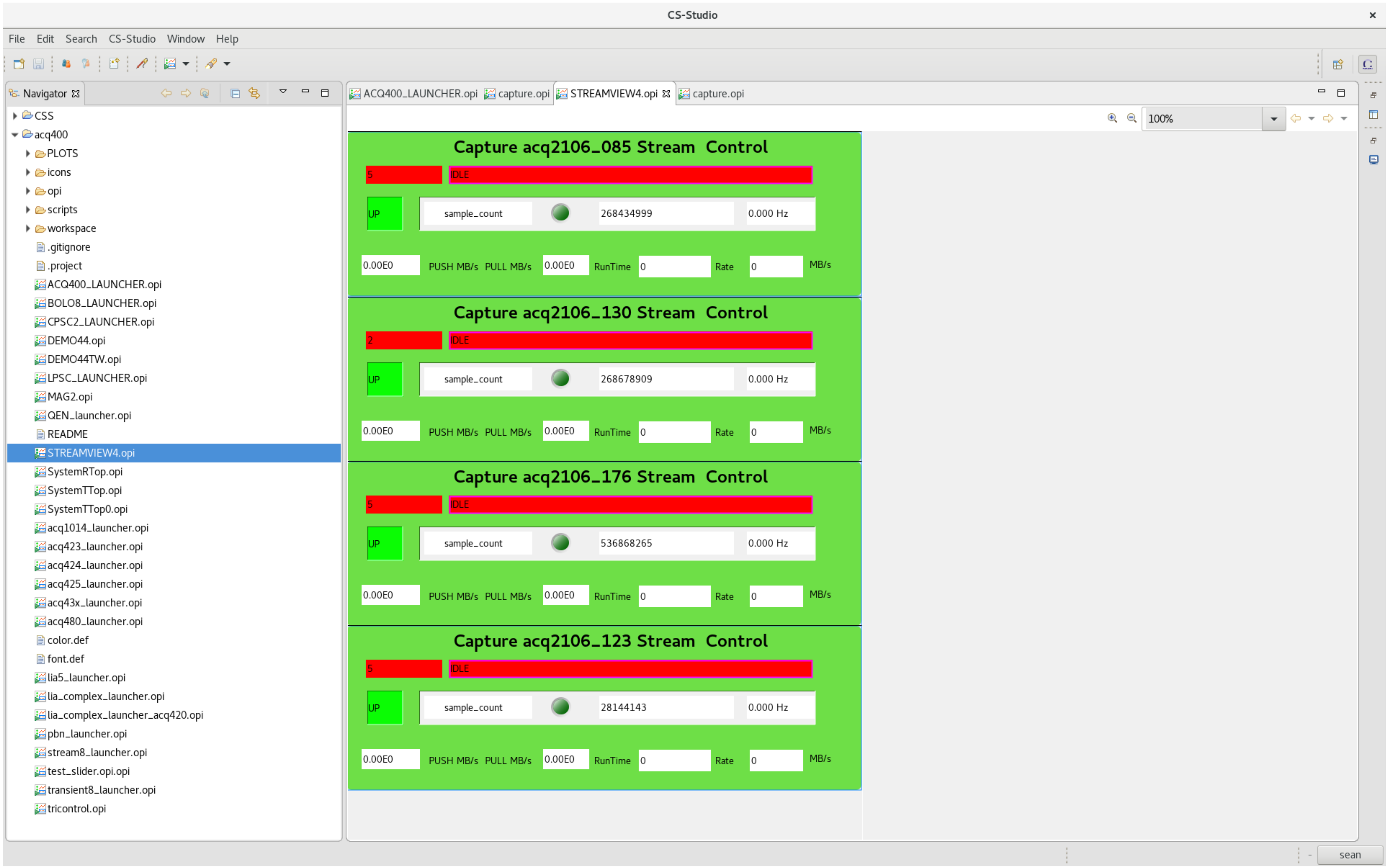
Set macros UUT1 UUT2 UUT3 UUT4 from

Edit|Preferences|CSS Applications->Display->BOY|OPI Runtime

Run STREAMVIEW4.opi direct from Navigator

```
    new file:   ACQ400/STREAMVIEW4.opi
    new file:   ACQ400/opi/stream_view.opi
```

An image showing what the CS Studio OPI looks like is included in the following slide.



CSS
acq400
PLOTS
icons
opi
scripts
workspace
.gitignore
.project
ACQ400_LAUNCHER.opi
BOLO8_LAUNCHER.opi
CPSC2_LAUNCHER.opi
DEMO44.opi
DEMO44TW.opi
LPSC_LAUNCHER.opi
MAG2.opi
QEN_launcher.opi
README
STREAMVIEW4.opi
SystemRTop.opi
SystemTTop.opi
SystemTTop0.opi
acq1014_launcher.opi
acq423_launcher.opi
acq424_launcher.opi
acq425_launcher.opi
acq43x_launcher.opi
acq480_launcher.opi
color.def
font.def
lia5_launcher.opi
lia_complex_launcher.opi
lia_complex_launcher_acq420.opi
pbn_launcher.opi
stream8_launcher.opi
test_slider.opi.opi
transient8_launcher.opi
tricontrol.opi

Capture acq2106_085 Stream Control

5 IDLE

UP sample_count 268434999 0.000 Hz

0.00E0 PUSH MB/s PULL MB/s 0.00E0 RunTime 0 Rate 0 MB/s

Capture acq2106_130 Stream Control

2 IDLE

UP sample_count 268678909 0.000 Hz

0.00E0 PUSH MB/s PULL MB/s 0.00E0 RunTime 0 Rate 0 MB/s

Capture acq2106_176 Stream Control

5 IDLE

UP sample_count 536868265 0.000 Hz

0.00E0 PUSH MB/s PULL MB/s 0.00E0 RunTime 0 Rate 0 MB/s

Capture acq2106_123 Stream Control

5 IDLE

UP sample_count 28144143 0.000 Hz

0.00E0 PUSH MB/s PULL MB/s 0.00E0 RunTime 0 Rate 0 MB/s

Isolating CPUs

For performance reasons it makes sense to isolate a CPU (or more than one) to handle the control program. This means that the linux scheduler will not be allowed to allocate any other processes to the CPUs that have been isolated. To get a task to run on the isolated CPUs the user must explicitly specify which CPUs the program is allowed to run on either using taskset or sched_set_affinity.

To isolate CPUs the user should edit the grub file. An example grub file is provided on the following slide. Once the file has been edited the user should make a new grub config like so:

```
grub-mkconfg -o /boot/grub/grub.cfg
```

Once this has been done a reboot is required for the changes to be implemented. To check the changes were successful the user can use:

```
[dt100@seil ~]$ cat /sys/devices/system/cpu/isolated

0-1
```

New grub file with CPUs isolated.

```
[dt100@seil ~]$ cat /etc/default/grub
GRUB_SAVEDEFAULT=true
GRUB_DEFAULT=0
GRUB_TIMEOUT=5
GRUB_DISTRIBUTOR="$(sed 's, release .*$,,g' /etc/system-release)"
#GRUB_CMDLINE_LINUX_DEFAULT=""
GRUB_CMDLINE_LINUX="console=ttyS1,115200 console=tty0"
GRUB_CMDLINE_LINUX_DEFAULT="isolcpus=0,1"
isolcpus="0,1"
GRUB_TERMINAL="serial"
GRUB_SERIAL_COMMAND="serial --speed=115200 --unit=0 --word=8 --parity=no --stop=1"

GRUB_INIT_TUNE="480 440 1"
```

Control script

A control script has been created to automate the LLC capture. It is contained in the scripts directory of the AFHBA404 GitHub repository referenced in the previous slide.

To run the script “cd” into the AFHBA404 directory and run the following command:

```
./scripts/acqproc_multi.sh
```

There are a few parameters which can be configured inside the script. These include whether or not to use **MDSplus** (entirely optional) and which UUTs are currently being used. If the user wishes to use MDSplus the local MDSplus server must also be specified.

The control script will configure the system **clocks** using the sync_role script. This can also be changed. By default it is set to configure the first system as a “**master**” and all subsequent systems as slaves over HDMI. This setting can be changed to “**fpmaster**” if the user wishes to use a front panel clock and trigger. The default clock speed is **20kHz** although this can also be changed. The slaves always share the same clock as the master system.

Once the system is configured for capture the control program is started. After the control program has been started the system is armed and triggered. The default capture length is **400k samples** and this is also configurable.

Explanation of the control scripts

There are two control scripts that are used to configure the systems for LLC capture. The first is llc-config-utility.py which configures the aggregator and distributor onboard the FPGA on all of the systems.

Then the clocks are set by sync_role.py. The clocks can be configured by the user (the clocks should not be set faster than ~500kHz).

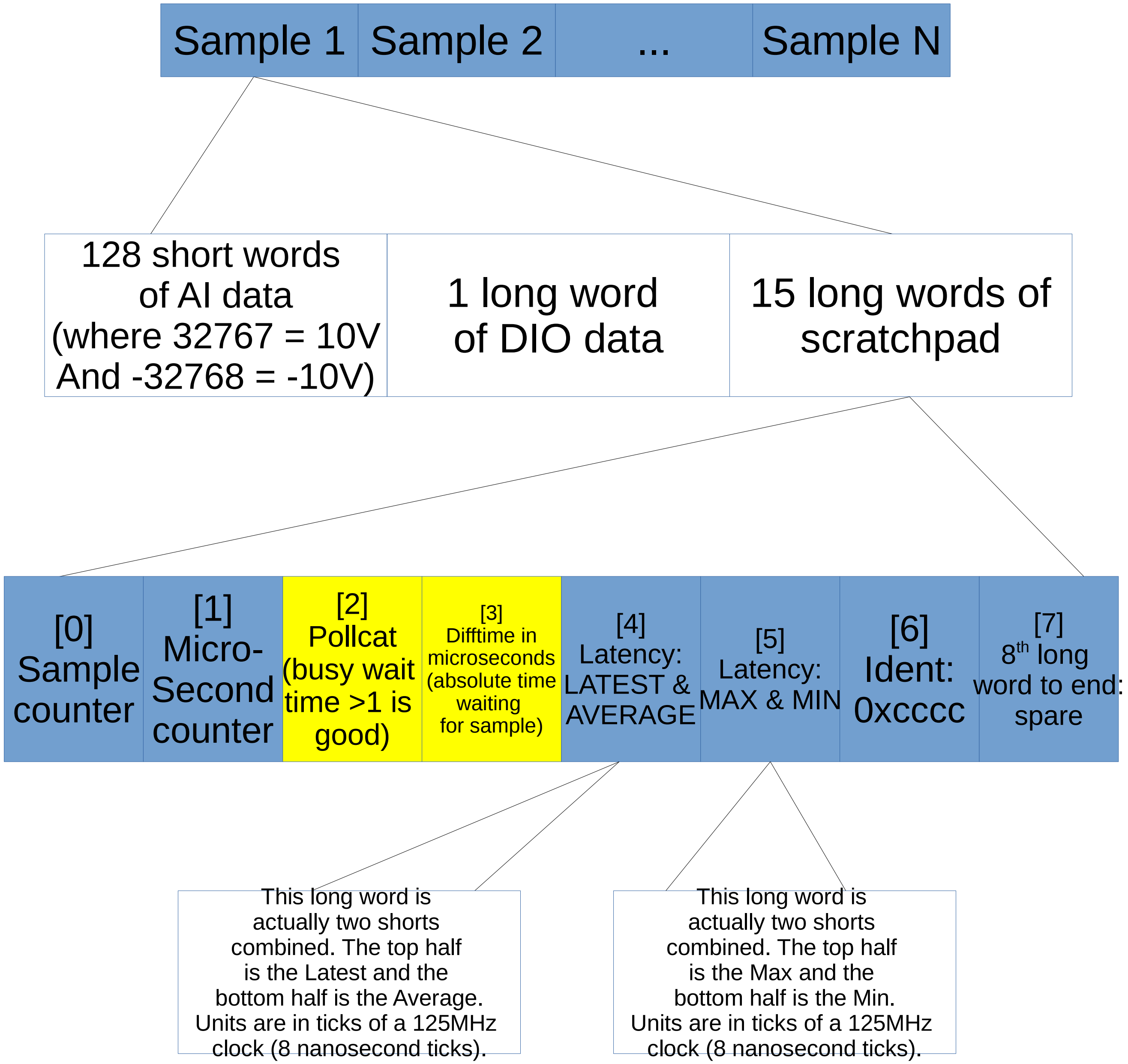
Output of the control script

The control script will display a histogram of the T_LATCH values, showing how many samples were missed by the host computer (the T_LATCH is the sample counter, so the difference between any two consecutive samples should be one). Ideally there should be no samples missed. There is also some textual output of the T_LATCH histogram data.

The control script will also automatically configure the UUT to calculate some latencies. These latencies are encoded in the scratchpad and will be shown in a histogram, along with some relevant statistics. Please note that the latency registers will not be enabled unless the UUT is running the firmware “RELEASE acq400-125-20190930193608” or above. If your system is not running this release then you can upgrade according to section 29.3 of the the 4GUG available here: http://www.d-tacq.com/resources/d-tacq-4G-acq4xx-UserGuide-r28.pdf

Example histograms are are shown in the following pages. Since there are three UUTs in the loop for this test, there will be six histograms shown in total. Once the FAT has been completed these can be turned off inside the script by disabling the analysis.

Sample construction

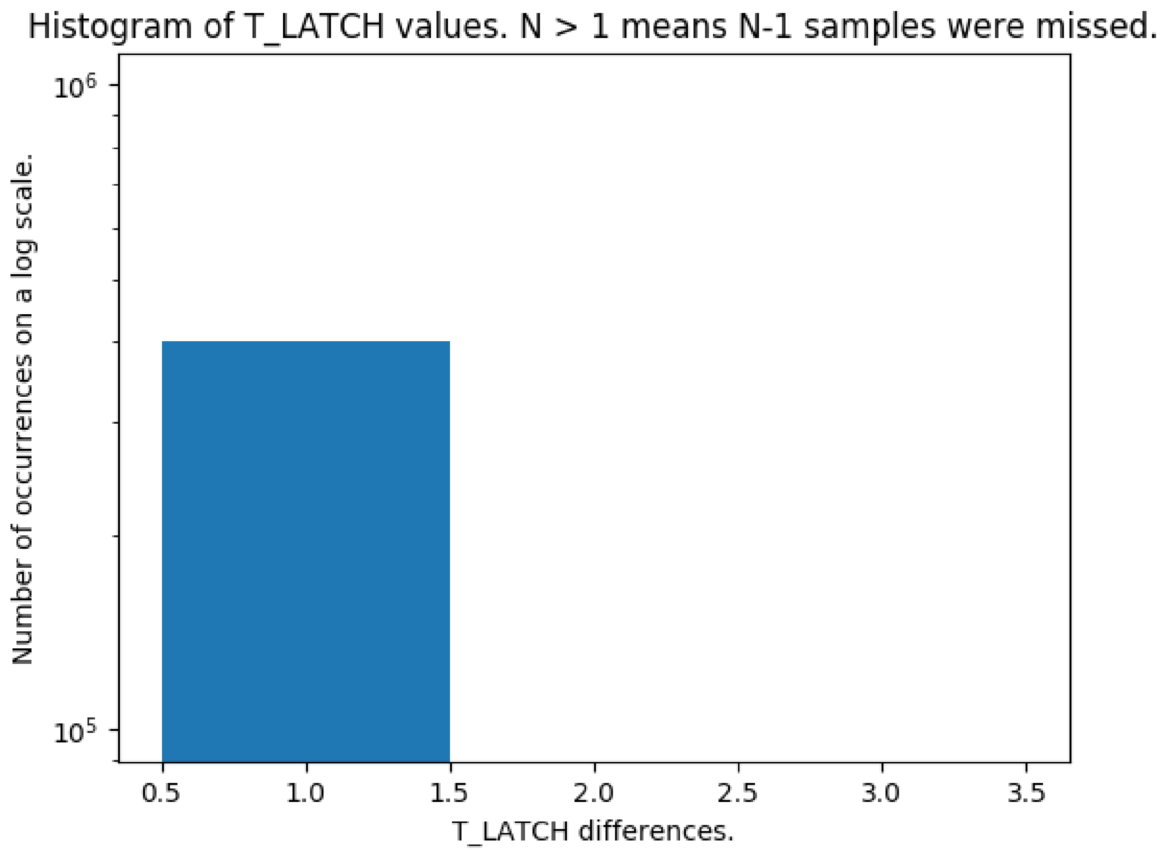

Sample 1
Sample 2
...
Sample N
128 short words of AI data (where 32767 = 10V And -32768 = -10V)
1 long word of DIO data
15 long words of scratchpad
[0] Sample counter
[1] Micro-Second counter
[2] Pollcat (busy wait time >1 is good)
[3] Difftime in microseconds (absolute time waiting for sample)
[4] Latency: LATEST & AVERAGE
[5] Latency: MAX & MIN
[6] Ident: 0xcccc
[7] 8th long word to end: spare

This long word is actually two shorts combined. The top half is the Latest and the bottom half is the Average. Units are in ticks of a 125MHz clock (8 nanosecond ticks).

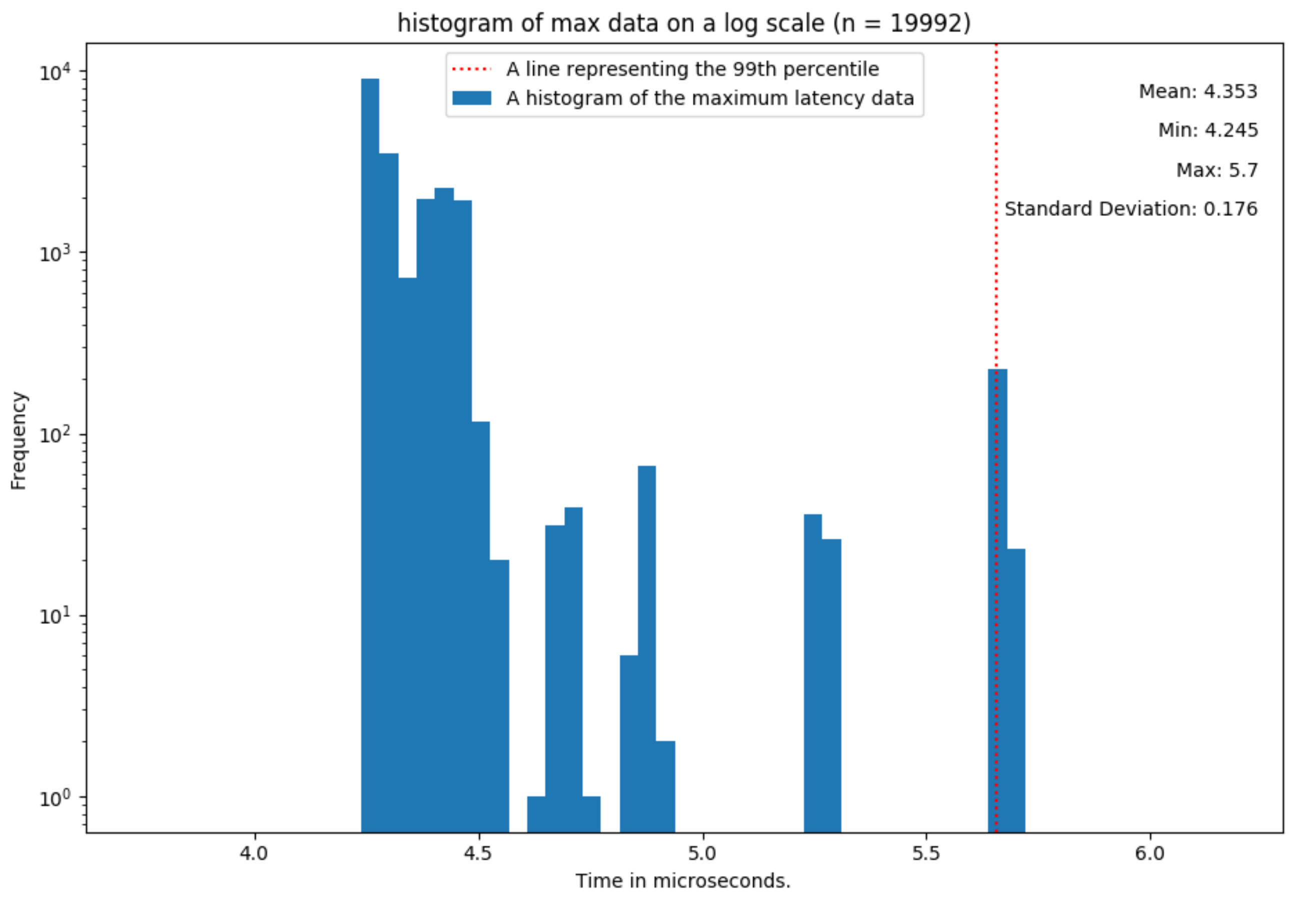
This long word is actually two shorts combined. The top half is the Max and the bottom half is the Min. Units are in ticks of a 125MHz clock (8 nanosecond ticks).

Note: In the scratchpad blue fields are generated on the acq2106 and yellow fields are inserted by the control program

Histogram of the sample counter (T_LATCH) on an ideal run.



Histogram of the FPGA maximum latency register



Plotting data from the first UUT

Due to the number of channels and number of cards, there are three separate example commands to plot data (one command for each UUT).

The commands use a python script called host_demux.py which can be found in the user_apps/analysis/ directory of acq400_hapi. The first command is as such:

```
python3 ./host_demux.py --src=/home/dt100/PROJECTS/AFHBA404/uut0_data.dat \
--nchan=160 --pchan=1,2,45,80,109 --data_type=16 --plot_mpl=1 \ --mpl_subrate=1
acq2106_085
```

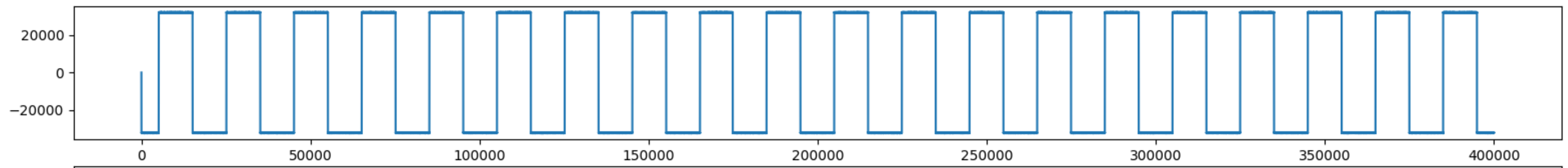
Provided the system has been connected according to the setup diagram on page 4, this will plot:

1. The input channel (CH001),
2. The first AO loopback (CH002),
3. The first DO loopback (any from CH033:CH064, with CH045 chosen for readability),
4. The AO from UUT2 (CH080),
5. The DO from UUT2 (any from CH097:CH128, with CH109 chosen for readability).

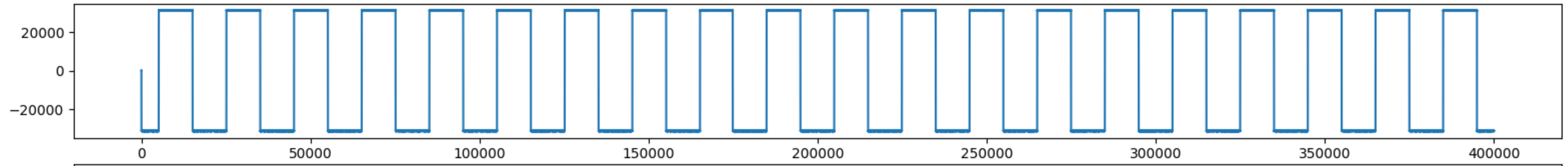
The resultant plot is shown on the next slide.

Data plotted from the first (master) UUT

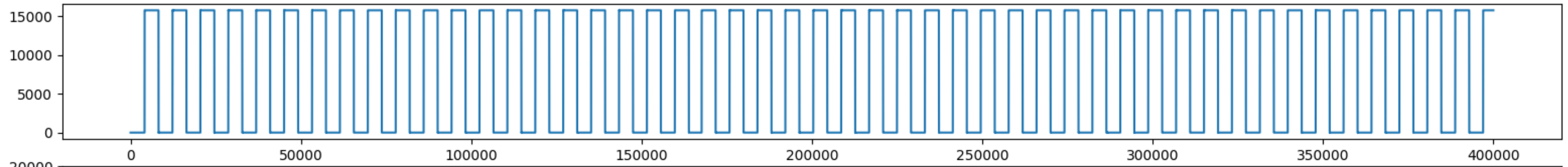
1. Sig gen wave



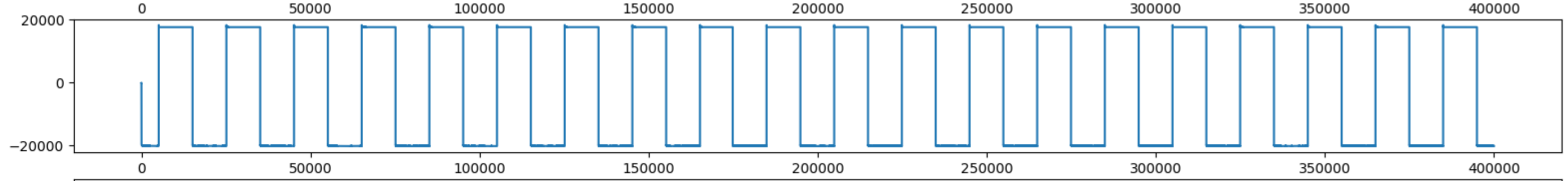
2. AO1



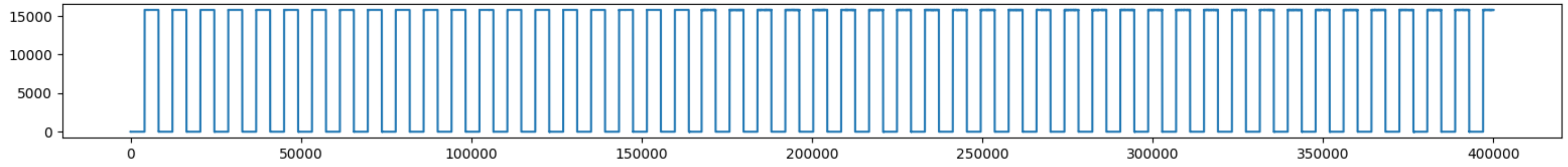
3. DO1



4. AO2



5. DO2



Plotting data from the second UUT

The command to plot data from the second UUT is as follows:

```
python3 ./host_demux.py \
--src=/home/dt100/PROJECTS/AFHBA404/uut1_data.dat \

--nchan=160 --pchan=1:2 --data_type=16 --plot_mpl=1 \ --mpl_subrate=1
acq2106_085
```

This will plot:

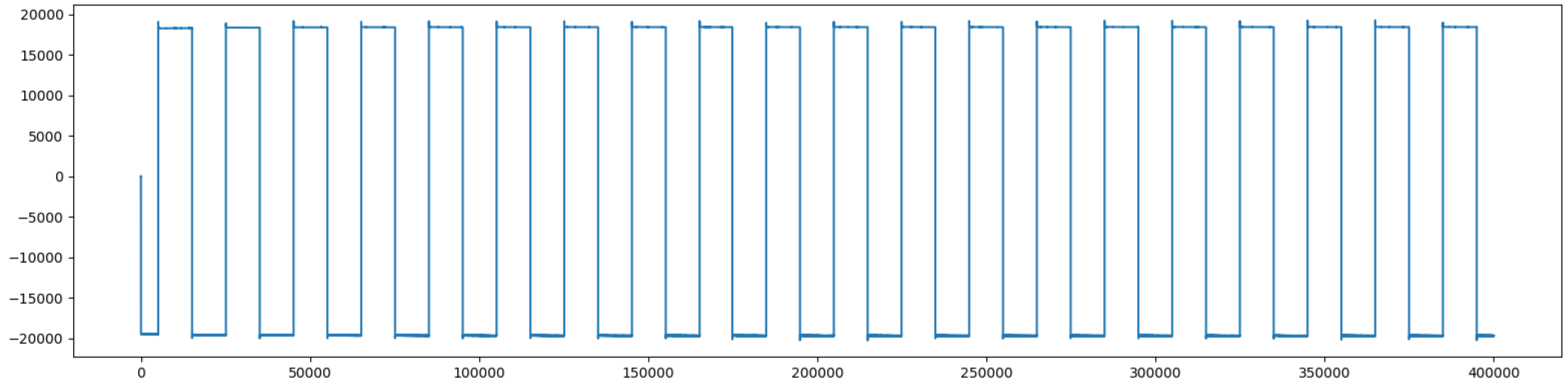
1. The first input channel (a copy of CH01 from UUT1),

2. The second channel (looped back from UUT3 AO),

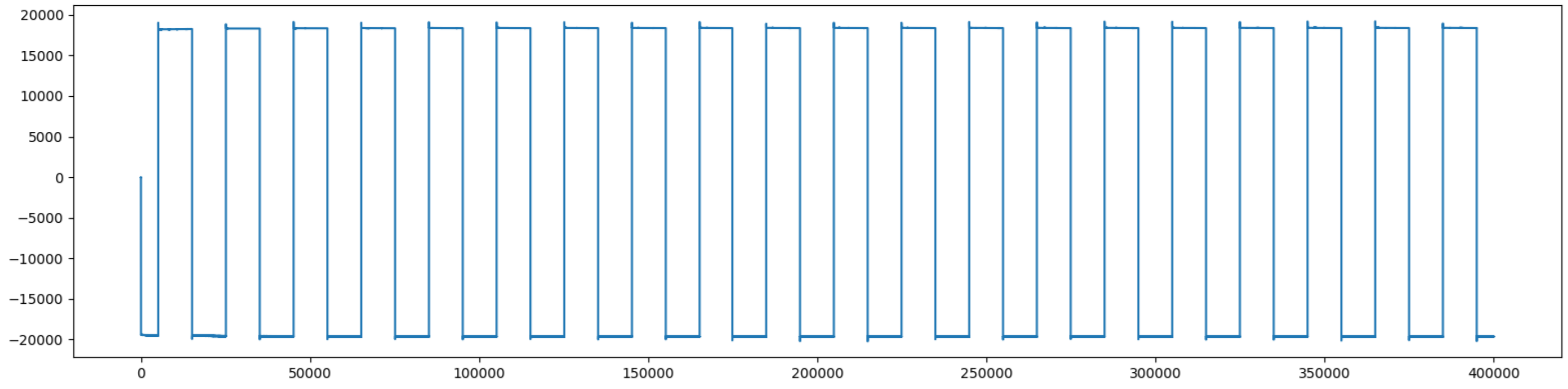
The plot for this command is shown on the following page.

Data plotted from the second (slave) UUT

1. Sig gen signal copied to AI 1 in software.



2. AO 3.



Plotting data from the third UUT

The command to plot data from the third UUT is as follows:

```
python3 ./host_demux.py \ --src=/home/dt100/PROJECTS/AFHBA404/uut2_data.dat
--nchan=160 \ --pchan=13,14,15 --data_type=16 \ --plot_mpl=1
--mpl_subrate=1 \ acq2106_085
```

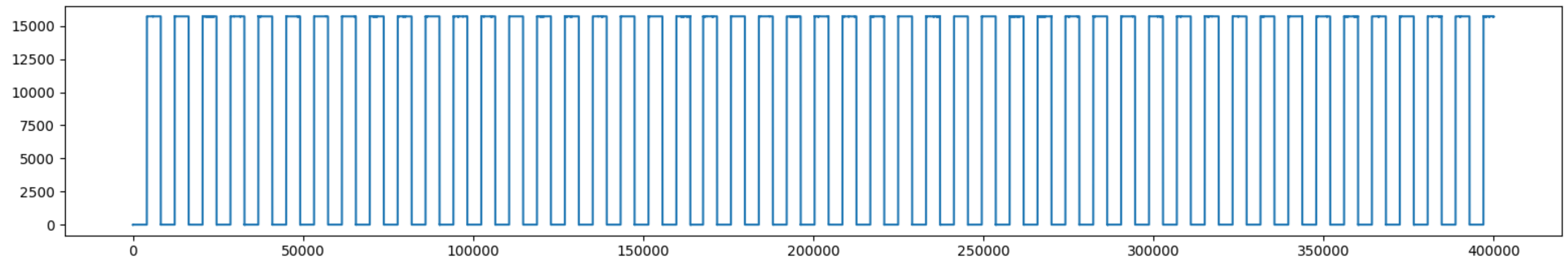
This plots:

1. Channel 13 on UUT3’s DO.
2. Channel 14 on UUT3’s DO.
3. Channel 15 on UUT3’s DO.

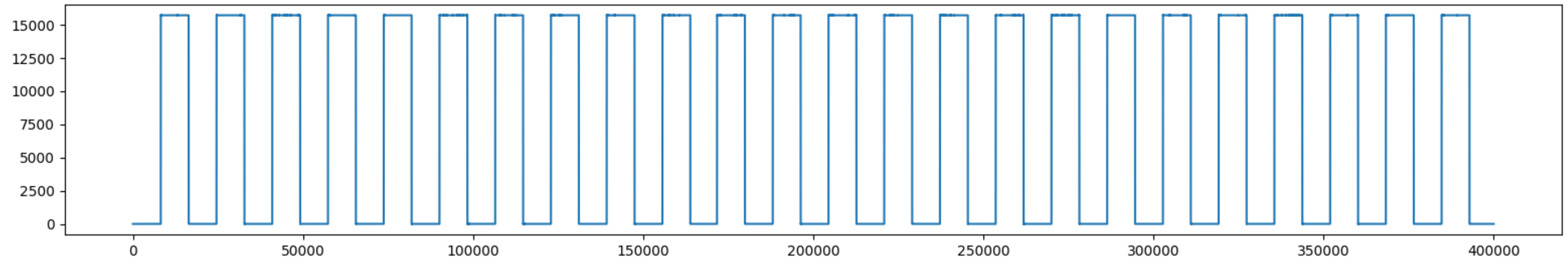
The corresponding plot is on the following page.

Data plotted from the third (slave-slave) UUT

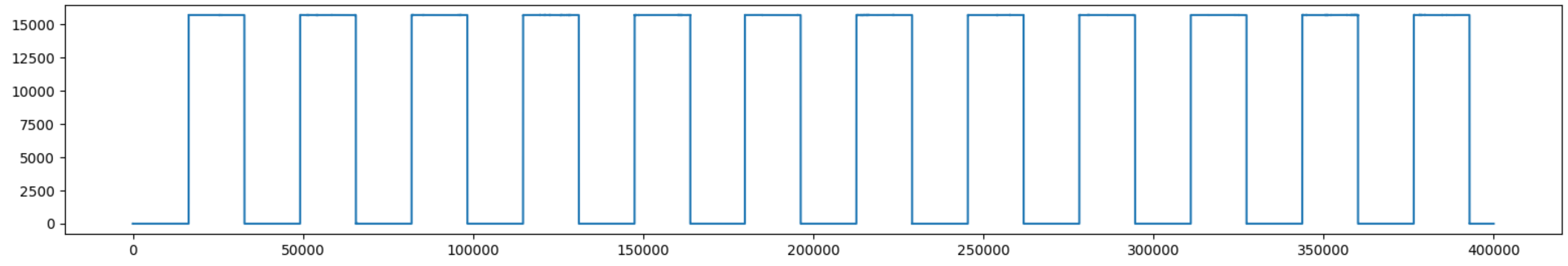
1. DIO3 (bit 13)



2. DIO3 (bit 14)



3. DIO3 (bit 15)

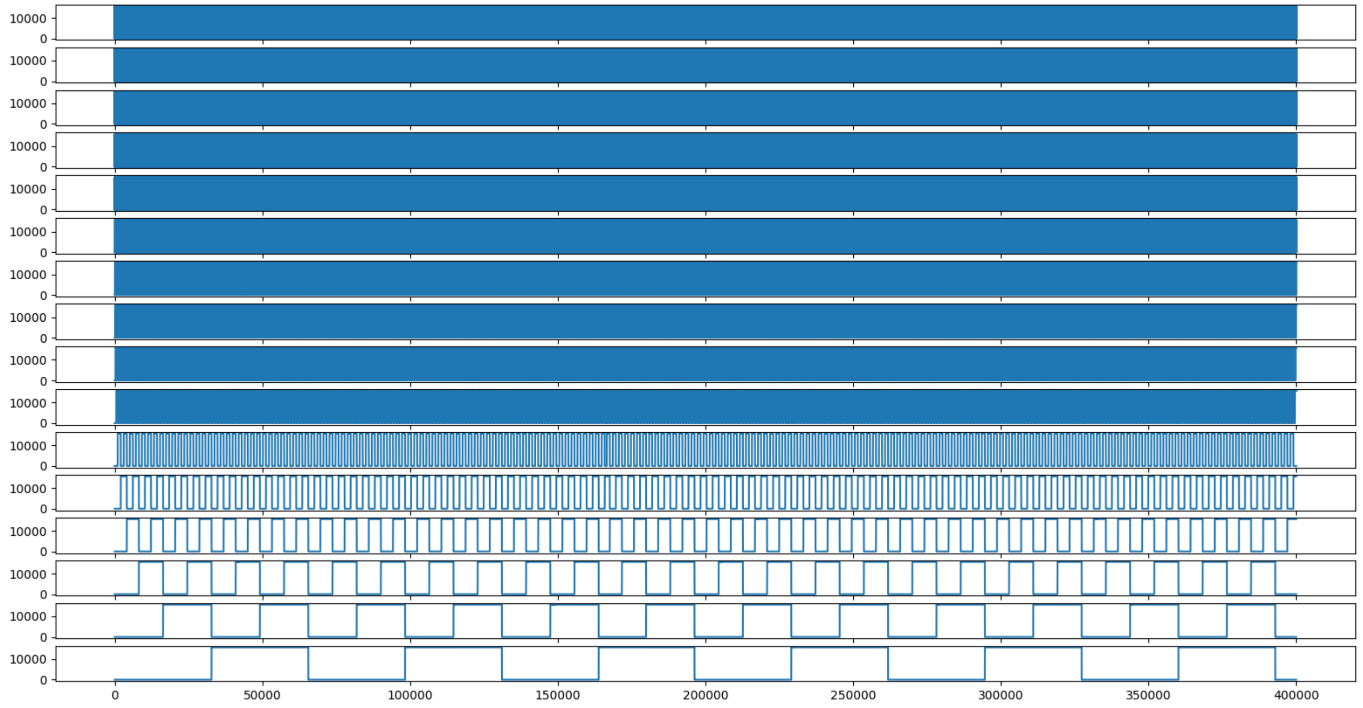


Demonstration of 16 bits of digital output looped back to an AI module

Here is an example of showing all 16 digital outputs on a DIO432 looped back to 16 channels on an AI module.

The command to do this was:

```
python3 ./host_demux.py --src=/home/dt100/PROJECTS/AFHBA404/uut2_data.dat \
--nchan=160 --pchan=1:16 --data_type=16 --plot_mpl=1 --mpl_subrate=1 acq2106_085
```



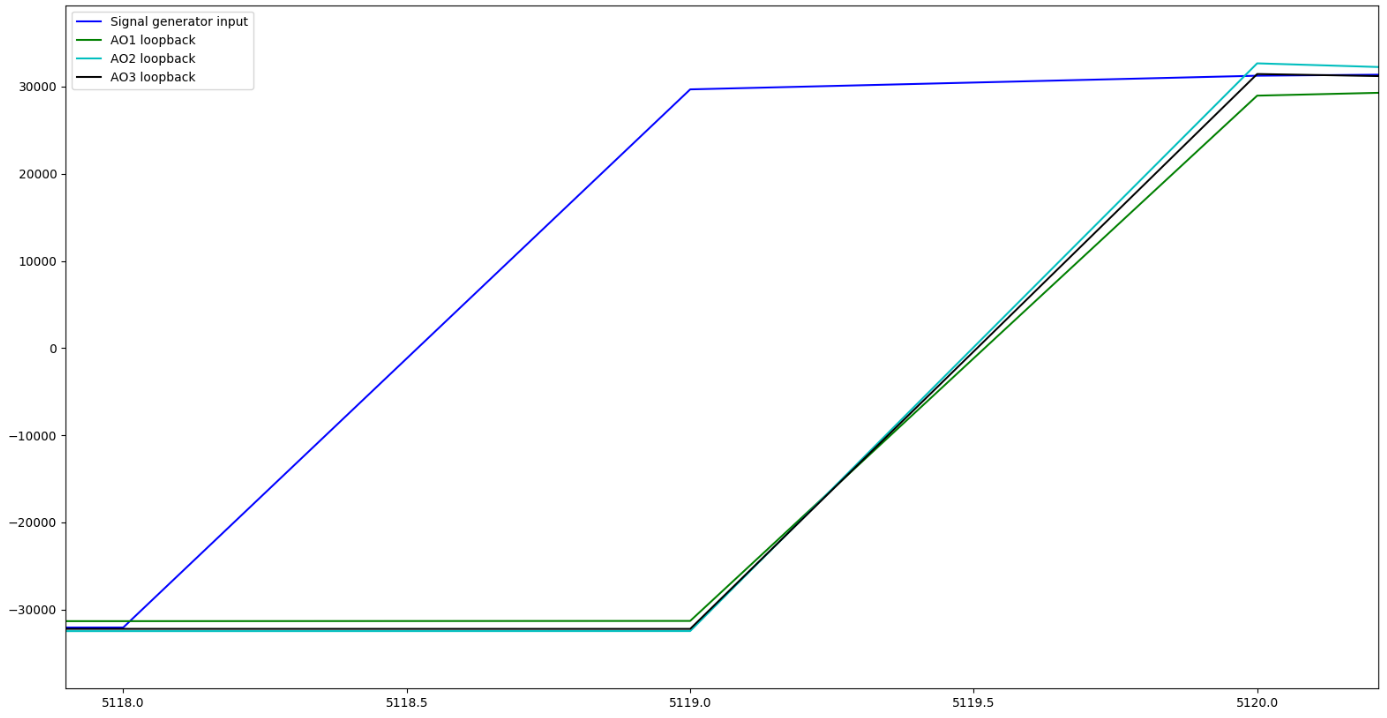
Comparison of AO channels to signal generator.

Here the AO channels are compared to the signal generator. At 20kHz there should be a single sample difference.

As can be seen from the plot there is a single sample (at 20kHz) difference between the signal generator and the re-sampled AO waves.

The command to plot is as so:

```
python3 ./scripts/llc_multi_wave_comparison.py
```



Analysing the latency of the data

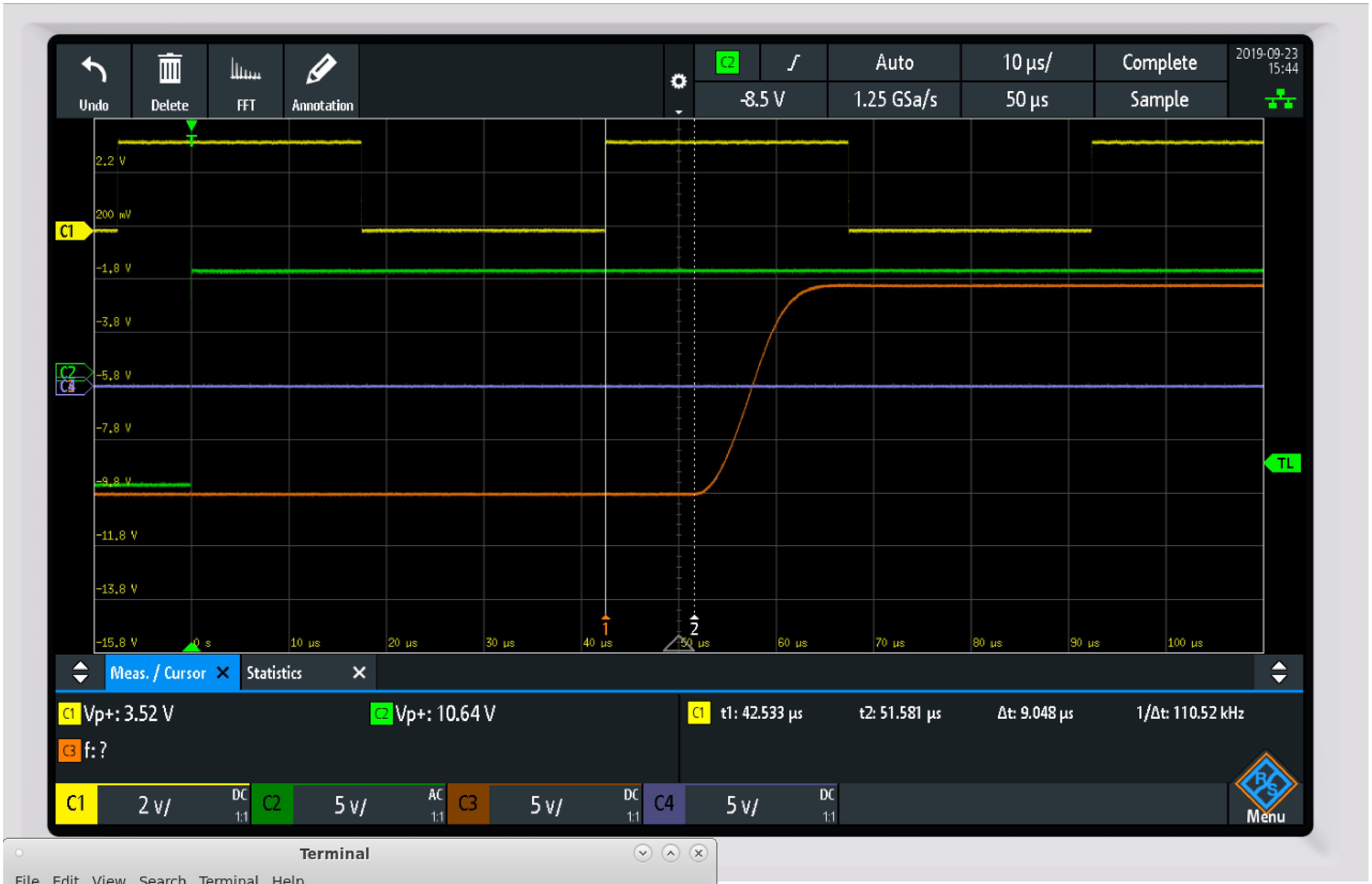
The control script analyses the FPGA latency registers and plots the histogram of that data, but the latency can also be seen on a scope for an independent verification of the latency. There are already guides written by D-TACQ that explain how to measure the latency of the system. The D-TACQ low latency white paper is available here:

http://www.d-tacq.com/resources/LLC_White_Paper.pdf

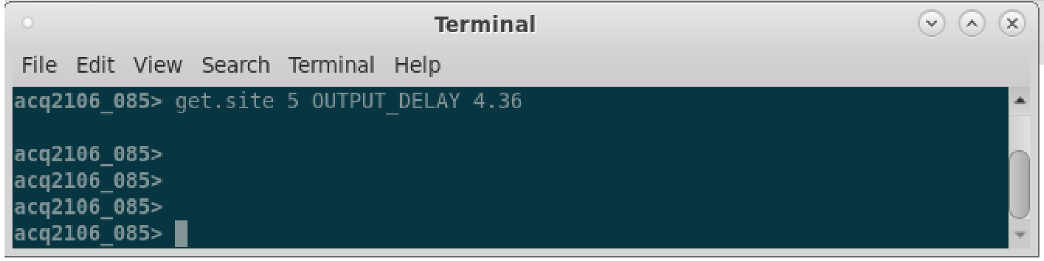
And the D-TACQ LLC system latency measurement guide, available here:

LLC-system-latency-measurement-guide.pdf

The following page contains a scope trace showing the latency of the system.



C1 Vp+: 3.52 V
C2 Vp+: 10.64 V
C3 f: ?
C1 t1: 42.533 µs t2: 51.581 µs Δt: 9.048 µs 1/Δt: 110.52 kHz



```
acq2106_085> get.site 5 OUTPUT_DELAY 4.36

acq2106_085>
acq2106_085>
acq2106_085>
acq2106_085>
```

Appendix: Including a BOLO8 mezzanine in the system.

If the user wishes to include a 4th acq2106 with BOLO8 mezzanines then there is another control script to control this type of operation. The script is included in the following directory in the AFHBA404 repo:

scripts/acqproc_multi_bolo.sh

This will configure capture for the the systems as in the previous section, PLUS configure the BOLO acq2106.

Information on BOLO LLC

There is a full FAT on BOLO LLC operation that should be considered before attempting to configure a BOLO UUT within the UUT stack. This FAT can be found here:

http://www.d-tacq.com/details_page.php?prod_id=contact&page_id=2

Under BOLO8 LLC FAT.

New control program

Along with the new control script there is also a new control program that handles the BOLO alongside the original 3 UUTs. This new program can be found in the following location in the AFHBA404 repo:

LLCONTROL/afhba-llcontrol-multiuut-4AI1AO1DX.c

Using hexdump to view the data

It can be useful to hexdump the data to check the composition of the data. The following command may be changed to check different columns of long word data (scratchpad or BOLO8 data for instance).

```
hexdump -e '80/4 "%08x," "\n"' uut3_data.dat | cut -d, -f1,4,8,49-55 | head
```

The following command will work for viewing short word data (acq424 channels for instance).

```
hexdump -e '160/2 "%04x," "\n"' uut0_data.dat | cut -d, -f1-10 | more
```

Parsing the BOLO8 data

The standard 128AI, Dx, 32AO box has a sample size 320 bytes

2 site BOLO test unit has a sample size 256bytes.

However, the llcontrol program continues to store 320bytes from each UUT in its output data file regardless of actual content, and so uut3_data.dat therefore contains data at 320bytes per sample.

When viewing BOLO data, extract the data from the file at 320 bytes per sample, and ignore anything beyond 256 bytes.

eg this is all the valid data:

```
hexdump -e '80/4 "%08x," "\n' | cut -d, -f1-64
```

```
hexdump -e '128/2 "%04x," 1/4 "%08x," 1/4 "%10d," 14/4 "%08x," "\n"' uut3_data.dat |
cut -d, -f1,2,17,129,130 | more
```

From that, remember the BOLO data is grouped in 3's, MAG, PHASE, POWER, so you probably only want to see every 3rd channel, and the after the TLATCH, the rest of the SPAD isn't interesting. So, to dump data from 4 channels in site 1 + TLATCH:

```
hexdump -e '80/4 "%08x," "\n' | cut -d, -f1,4,7,10,49
```

Debug

If something doesn’t work in acqproc_multi.sh then there are a few steps to take to make sure things are configured correctly. The acqproc_multi script assumes that the system configuration is identical to that in the diagram on page 5. It is worth checking that this is the case. HDMI connections and SFP connections are crucial to have wired correctly.

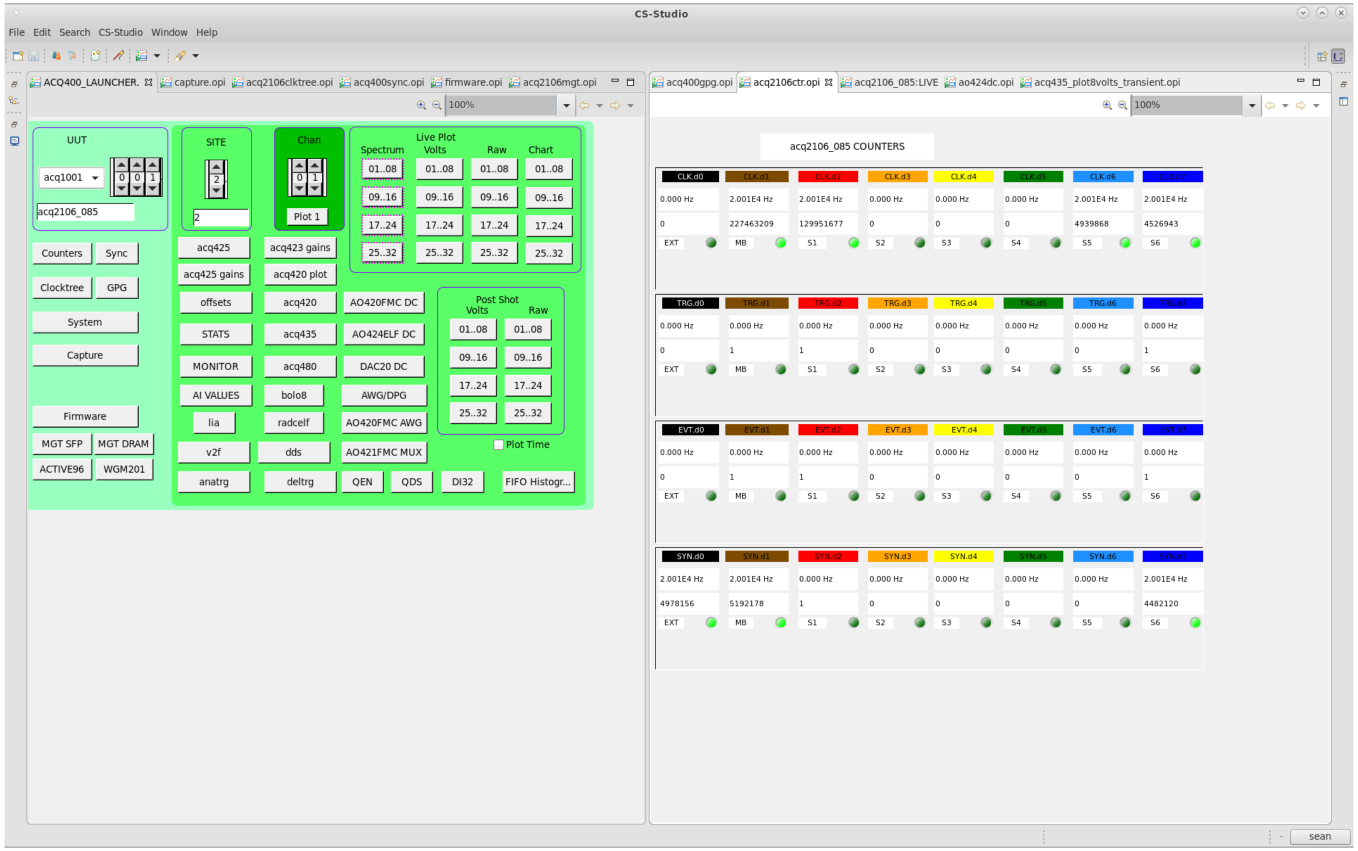
If the system is configured exactly as shown on page 5, then the user should check the clocks and triggers on each UUT individually. The best method of doing this is using CS Studio. Instructions for installing and using CS Studio can be found here:

https://github.com/D-TACQ/ACQ400CSS

Once CS Studio is installed the user should check for each UUT that the clocks and triggers are accounted for.

CS Studio counters page

The CS Studio counters page should look very similar to the image below after running a capture using acqproc_multi.sh. It contains the information for the clocks on each site and information about the triggers. In this case the trigger is set to soft, so we get 1 soft trigger in the d1 trigger counter box, and a corresponding trigger in the d2 trigger box. The user should check this information for each UUT.



acq2106_085 COUNTERS

CLK.d0	CLK.d1	CLK.d2	CLK.d3	CLK.d4	CLK.d5	CLK.d6	CLK.d7
0.000 Hz	2.001E4 Hz	2.001E4 Hz	0.000 Hz	0.000 Hz	0.000 Hz	2.001E4 Hz	2.001E4 Hz
0	227463209	129951677	0	0	0	4939868	4526943
EXT ⚫	MB 🟢	S1 🟢	S2 ⚫	S3 ⚫	S4 ⚫	S5 🟢	S6 🟢

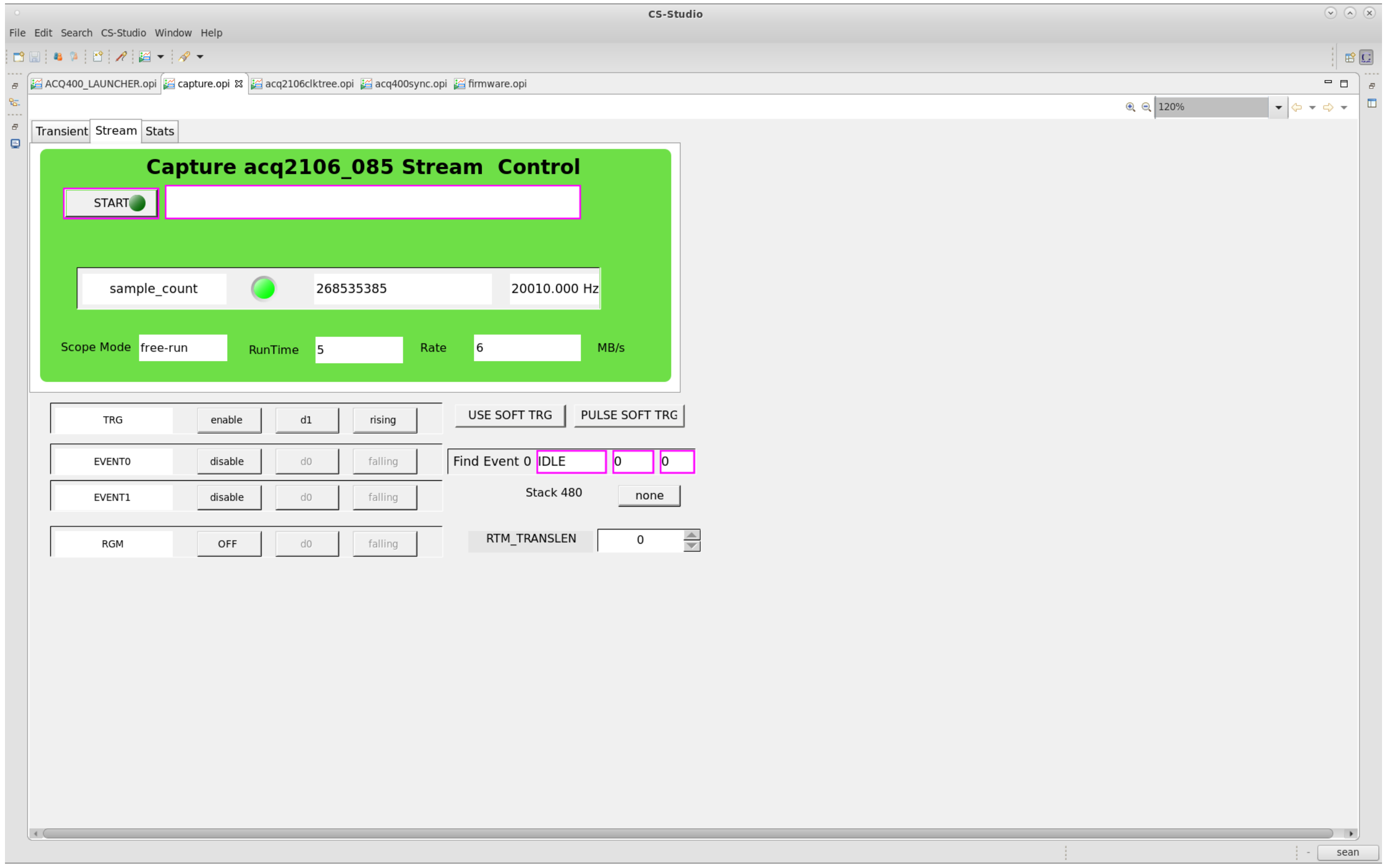
TRG.d0	TRG.d1	TRG.d2	TRG.d3	TRG.d4	TRG.d5	TRG.d6	TRG.d7
0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz
0	1	1	0	0	0	0	1
EXT ⚫	MB ⚫	S1 ⚫	S2 ⚫	S3 ⚫	S4 ⚫	S5 ⚫	S6 ⚫

EVT.d0	EVT.d1	EVT.d2	EVT.d3	EVT.d4	EVT.d5	EVT.d6	EVT.d7
0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz
0	1	1	0	0	0	0	1
EXT ⚫	MB ⚫	S1 ⚫	S2 ⚫	S3 ⚫	S4 ⚫	S5 ⚫	S6 ⚫

SYN.d0	SYN.d1	SYN.d2	SYN.d3	SYN.d4	SYN.d5	SYN.d6	SYN.d7
2.001E4 Hz	2.001E4 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	0.000 Hz	2.001E4 Hz
4978156	5192178	1	0	0	0	0	4482120
EXT 🟢	MB 🟢	S1 ⚫	S2 ⚫	S3 ⚫	S4 ⚫	S5 ⚫	S6 🟢

Check UUTs are streaming

To check that the UUTs are streaming data the user should observe the stream tab of the capture OPI as shown below. During a capture the sample count should be ticking up. The clock speed should also be visible in the box next to it. The rate will also be visible in the rate box. Again, this should be verified for all UUTs.



Capture acq2106_085 Stream Control

sample_count 268535385 20010.000 Hz

Scope Mode free-run RunTime 5 Rate 6 MB/s

TRG	enable	d1	rising
EVENT0	disable	d0	falling
EVENT1	disable	d0	falling
RGM	OFF	d0	falling

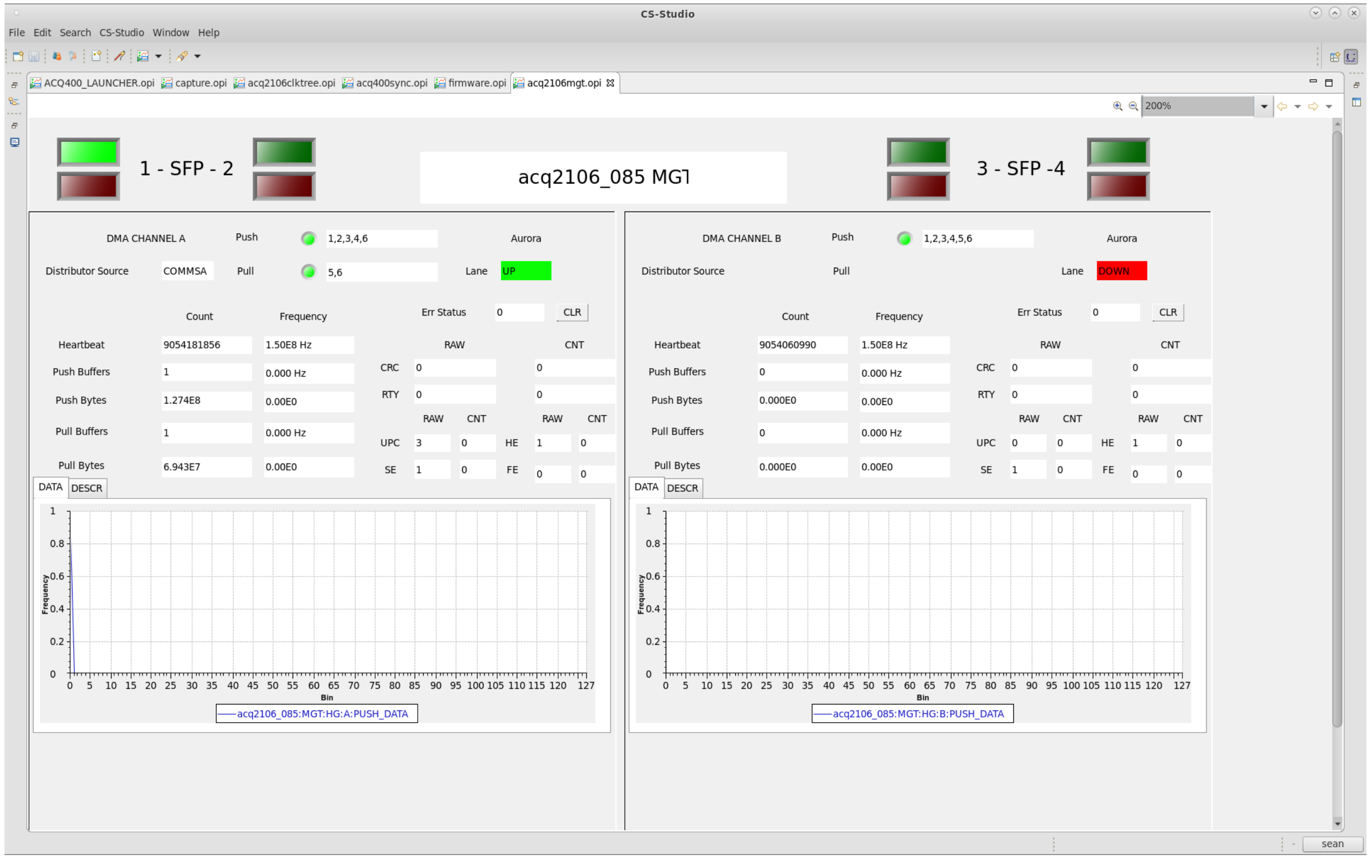
Find Event 0 IDLE 0 0

Stack 480 none

RTM_TRANSLEN 0

Check CS Studio MGT-SFP page

The MGT-SFP page is useful for checking whether data has been sent to the host and if data has been returned from the host. After running one capture the page should look similar to the image below. There should be 1 push buffer and 1 pull buffer with a non zero value in each (how large depends on how much data has been streamed). Check all the UUTs are the same after rebooting and running a single capture.


CS-Studio
File Edit Search CS-Studio Window Help
ACQ400_LAUNCHER.opi capture.opi acq2106clktree.opi acq400sync.opi firmware.opi acq2106mgt.opi
200%
1 - SFP - 2
acq2106_085 MGT
3 - SFP -4
DATA DESCR
Frequency
Bin
acq2106_085:MGT:HG:A:PUSH_DATA
acq2106_085:MGT:HG:B:PUSH_DATA
sean

DMA CHANNEL A

Push	1,2,3,4,6	Aurora	
Distributor Source	COMMSA	Lane	UP
Pull	5,6	Err Status	0

	Count	Frequency
Heartbeat	9054181856	1.50E8 Hz
Push Buffers	1	0.000 Hz
Push Bytes	1.274E8	0.00E0
Pull Buffers	1	0.000 Hz
Pull Bytes	6.943E7	0.00E0

	RAW	CNT
CRC	0	0
RTY	0	0

	RAW	CNT		RAW	CNT
UPC	3	0	HE	1	0
SE	1	0	FE	0	0

DMA CHANNEL B

Push	1,2,3,4,5,6	Aurora	
Distributor Source		Lane	DOWN
Pull		Err Status	0

	Count	Frequency
Heartbeat	9054060990	1.50E8 Hz
Push Buffers	0	0.000 Hz
Push Bytes	0.000E0	0.00E0
Pull Buffers	0	0.000 Hz
Pull Bytes	0.000E0	0.00E0

	RAW	CNT
CRC	0	0
RTY	0	0

	RAW	CNT		RAW	CNT
UPC	0	0	HE	1	0
SE	1	0	FE	0	0

Checking which sites are enabled

If there is data going to the host (as shown in the previous page), but the system still isn’t working, then check that the correct sites are included in the aggregator. This can also be seen in the image in the previous slide in the ‘push’ and ‘pull’ boxes in the MGT-SFP OPI. The sites included in the ‘push’ box should be AI and DI, and the sites included in the ‘pull’ box should be AO and DO. Note that DO and DI will likely be the same site (site 6).

Checking the DI

The user can verify the Digital Input by attaching a square wave signal to the DIO432 mezzanine and an AI channel. By default the lower DIO432 will be configured half as DO and half as DI. Connecting channel 17 will toggle the 17th bit of the DIO data. An example of this is shown on the following slide.

17th bit toggling

```
[dt100@seil AFHBA404]$ hexdump -e '80/4 "%08x " "\n"' uut0_data.dat | awk '{ print $65" "$66 }' | more
00000000 00000001
00000000 00000002
00010001 00000003
...
0001000e 00000011
...
0001000f 00000012
00000011 00000013
...
00000023 00000026
00010026 00000029
00010026 0000002a
```

Hexdump DI vs AI

The following command will show the sampled AI data against the DI data, with the sample counter included. Please note that due to the way the DIO samples it will always lag one sample behind the AI.

```
[dt100@seil AFHBA404]$ hexdump -e '128/2 "%04x," 1/4 "%08x," 1/4 "%10d," 14/4 "%08x," "\n"' uut2_data.dat | cut -d, -f1-4,129,130 | more
005e,3e46,0038,000f,00000000,         1
0042,3e5d,0031,000a,00000000,         2
002c,3e50,0028,0008,00000000,         3
001f,3e53,0020,0005,00010001,         4
0015,3e57,0018,0003,00010002,         5
ffad,0013,ffd4,fff0,00010003,         6
ffc2,0001,ffd4,fff2,00000004,         7
ffd4,0003,ffd7,fff5,00000005,         8
ffe0,0006,ffdc,fff7,00000006,         9
ffe7,0005,ffe2,fff9,00000007,        10
004c,3e47,0026,000c,00000008,        11
0036,3e5a,0023,000a,00010009,        12
0024,3e54,001e,0006,0001000a,        13
0019,3e55,0017,0003,0001000b,        14
0011,3e3d,0011,0002,0001000c,        15
ffaa,0011,ffcf,fff0,0001000d,        16
ffc2,fffe,ffd0,fff2,0000000e,        17
ffd2,0001,ffd6,fff4,0000000f,        18
ffdf,0006,ffdb,fff7,00000010,        19
ffe6,0008,ffe2,fff8,00000011,        20
004e,3e46,0022,000b,00000012,        21
0036,3e5a,0023,0008,00010013,        22
0025,3e54,001e,0005,00010014,        23
001a,3e56,0018,0004,00010015,        24
0011,3e58,0010,0000,00010016,        25
ffab,0010,ffcf,ffef,00010017,        26
ffc1,fffc,ffcf,fff3,00000018,        27
```

Hexdump DI vs AI with acq196 emulation

The following command is the same as the previous command, except with acq196 emulation enabled (so real CH02 appears demuxed on CH17):

```
[dt100@seil_AFHBA404]$ hexdump -e '128/2 "%04x," 1/4 "%08x," 1/4 "%10d," 14/4 "%08x," "\n"' uut2_data.dat | cut -d, -f1,2,17,129,130 | more
004b,0043,3e4d,00000000,         1
0035,002e,3e46,00000000,         2
0025,001e,3e4a,00000000,         3
0017,0014,3e45,00010000,         4
0013,000c,3e46,00010003,         5
ffbd,ffb9,ffef,00010003,         6
ffcc,ffc9,0009,00000004,         7
ffda,ffd6,fff9,00000004,         8
ffe3,ffdf,fffa,00000006,         9
ffeb,ffe3,fffb,00000007,        10
003c,0035,3e4c,00000008,        11
002c,0025,3e42,00010009,        12
001f,0018,3e43,0001000a,        13
0012,000e,3e47,0001000b,        14
0008,0005,3e4b,0001000c,        15
ffb4,ffb3,ffef,0001000d,        16
ffc6,ffc2,fff0,0000000e,        17
ffd3,ffd0,fffd,0000000e,        18
ffdd,ffd6,fff9,00000010,        19
ffe4,ffdf,fffb,00000010,        20
0038,0030,3e4d,00000012,        21
0023,0021,3e45,00010013,        22
0018,0013,3e41,00010015,        23
0010,000b,3e45,00010015,        24
0008,0003,3e4e,00010017,        25
ffb5,ffaf,fff7,00010017,        26
ffc5,ffc3,fff6,00000018,        27
```