

Woods Hole Oceanographic Institution



OBSAPS Data Acquisition System: Operator's Manual and System Overview

by

McPeak, S.P., D'Spain, G.L., and Stephen, R.A.

Woods Hole Oceanographic Institution
Woods Hole, MA 02543

May 2011

Technical Report

Funding was provided by the Office of Naval Research under Contract Nos. N00014-10-1-0994
and N00014-10-1-0987.

Approved for public release; distribution unlimited.

WHOI-2011-05

**OBSAPS Data Acquisition System:
Operator's Manual and System Overview**

by

McPeak, S.P., D'Spain, G.L., and Stephen, R.A.

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

May 2011

Technical Report

Funding was provided by the Office of Naval Research under Contract Nos. N00014-10-1-0994
and N00014-10-1-0987.

Reproduction in whole or in part is permitted for any purpose of the United States
Government. This report should be cited as Woods Hole Oceanographic Institution
Technical Report, WHOI-2011-05.

Approved for public release; distribution unlimited.

Approved for Distribution:


Maurice Tivey, Chair

Department of Geology and Geophysics

**OBSAPS Data Acquisition System:
Operator's Manual and System Overview**

McPeak, S.P. *, D'Spain, G.L., and Stephen, R.A.*****

May 15, 2011

Technical Report

***Applied Physics Laboratory
University of Washington
Seattle, WA 98105**

**** Marine Physical Laboratory
Scripps Institution of Oceanography
San Diego, CA 92152**

*****Woods Hole Oceanographic Institution
Woods Hole, MA 02543**

WHOI-2011-05
OBSAPS Data Acquisition System: Operator's Manual and System Overview

Table of Contents

Table of Contents	2
Abstract	3
Description	3
System Hardware	4
<i>System A/D Performance</i>	<i>4</i>
<i>System D/A Performance</i>	<i>4</i>
<i>System Timing with GPS Antenna Connected to PXI-6682</i>	<i>4</i>
<i>PXI-6682 (Dev3 in Software) Connection Description/Summary</i>	<i>5</i>
<i>PXI-6251 (Dev1 in Software) Connection Description/Summary</i>	<i>5</i>
<i>BNC 2090 Front Panel Connections</i>	<i>5</i>
<i>FTE – Future Time Event</i>	<i>5</i>
Introduction	6
Software Overview and Functionality	6
<i>Display features</i>	<i>9</i>
<i>Audible Alarms</i>	<i>9</i>
Software Operation Procedure	10
<i>Description of program tabs on the front panel</i>	<i>18</i>
‘Critical Info’	18
‘Read .sio file’	18
‘SET FTE’	18
‘Time Domain’	18
‘H-91 Spectral’	18
‘Additional Spectral Plots’	19
‘GPS NMEA String’	19
‘Gyro NMEA String’	19
‘NMEA File Log’	19
‘DAQ Out’	19
‘DAQ In’	19
‘Misc.’	19
Known Issues	20
Tips for successful operation of software	22
Future features to implement	22
NMEA Log File Description – OBSAPS Expedition	23
Explanation of Druck Voltage to Depth Conversion used during OBSAPS (April-May’11)	25
<i>Druck Pressure sensor conversion from volts to depth</i>	<i>25</i>

Abstract

On the Ocean Bottom Seismometer Augmentation to the Philippine Sea Experiment (OBSAPS, April-May, 2011, R/V Revelle), a VLA and six OBSs were deployed to listen to an active acoustic source, a J15-3. This report describes the hardware and software used to control and record the acoustic transmissions from the source. Some significant features of the system are: 1) The system transmits general user-defined source functions, such as M-sequences (.SIO files). 2) In addition to controlling the source waveform, the system also records six real-time channels in binary files with user-selectable lengths: the monitor hydrophone mounted near the source, the power amplifier voltage and current, the depth of the source, sonobuoy data (when deployed) and an IRIG-B time reference. Files are output in .AUV format with a precision GPS-based time stamp in the file name. 3) The transmission start time along with ADC and DAC sample rates are disciplined to GPS time. 4) A convenient, Labview based, user interface provides real-time source control and monitoring. 5) The software provides parsing and logging of gyro and GPS NMEA sentences. The system, which was based on an earlier system from Scripps MPL, worked well on OBSAPS and is available for future projects.

Description

The data acquisition software is written in Labview 9.0. The program provides the following features:

1. Data acquisition of 6 analog channels at 8kHz sample rate each with an analog range of (+/-5V). Timing and sample clock are determined by a GPS time reference disciplined clock source.
2. 1 channel of DAC output with adjustable gain setting (+/-5V). The sample rate is also user adjustable (4kHz or 8kHz). The DAC output sample clock is disciplined to the GPS time reference.
3. Ability to read .SIO files for playback using the DAC output channel.
4. Time Domain Displays for all 6 channels of ADC.
5. Frequency Domain Displays for H-91, PA Voltage, PA Current and Sonobuoy and Druck pressure sensor analog inputs.
6. Software settable thresholds for H-91, PA Voltage, PA Current and Depth peak values.
7. SPL determination for J15-3 based on source RMS current and H-91 RMS voltage levels.
8. Provide the ability to start recording at user defined precise time.
9. Generate AUV files of recorded 6 ADC channels.
10. Parse and log 2 NMEA Strings (GPS 'GGA' and Gyro 'HDT').

System Hardware

1. Dell 470 Precision PC (2.80 GHZ, 1G Ram)
2. NI PXI-6251 multi-function DAQ
3. NI PXI-6682 timing and synchronization board
4. NI BNC-2090 breakout box
5. SBS Technologies 210-2 (PC side) and SBS 212-2 (CompactPCI chassis side) communication cards
6. OneStop System CompactPCI chassis S/N 3836
7. Stanford Research System SR650 (HP and LP filters)
8. Stanford Research System SR640 (dual LP filters)
9. Tektronix TDS2004C Oscilloscope
10. Dual Chroma 61502 power amps (PA)
11. H-91 fish, modulator and demodulator hydrophone system
12. J15-3 acoustic source and tow body
13. Arbiter 1084C Station Clock
14. Analogic 2020 Waveform Generator
15. Custom box for isolation and scaling of PA output voltage
16. Custom 6dB gain (+/-10V max output) signal amplifier
17. Custom dry side box for Druck Pressure Sensor supply voltage and dropping resistor.
18. Battery 9-30VDC for supplying Druck power
19. Druck PTX 1830 Pressure Sensor
20. Fluke Digital Volt Meter
21. Extech magnetic pickup current meter

System A/D Performance

16 bit resolution
6 single ended channels
8kHz sample rate
Input range = +/- 5V

System D/A Performance

16 bit resolution
8kHz or 4kHz user selectable sample rate
1 single ended output
Output range = +/-5V

System Timing with GPS Antenna Connected to PXI-6682

GPS Synchronization Accuracy: +/- 100nS <13 nS standard deviation
GPS PPS accuracy: within 15nS to GPS/UTC
Internal Time base synchronization to GPS with 10nS resolution
AIS timescale is used on ALL PXI-6682 internal time stamps and converted to

WHOI-2011-05
OBSAPS Data Acquisition System: Operator's Manual and System Overview

UTC in software. UTC offset from GPS time is received from GPS signal

PXI-6682 (Dev3 in Software) Connection Description/Summary

Dev3/PFI1 = 8kHz clock out (A/D and D/A clock source)

Dev3/PFI2 = Pulse Output (used to trigger ADC and DAC start at user defined FTE)

PXI-6251 (Dev1 in Software) Connection Description/Summary

Dev1/PFI0 = A/D clock source

Dev1/PFI1 = FTE Pulse (1us) input – this triggers both A/D and D/A tasks

Dev1/ai0:5 = ADC channels

Dev1/ao0 = DAC output

BNC 2090 Front Panel Connections

ACH0 = H-91 demodulated (LP and HP filtered) signal

ACH1 = PA Voltage

ACH2 = PA Current

ACH3 = Druck Pressure signal (voltage developed across 118 ohm resistor from 4-20mA sensor output)

ACH4 = Sonobuoy (LP filtered) signal

ACH5 = IRIG-B modulated signal

PFI0/TRIG1 = 8kHz Clock pulse from PXI-6682 (Dev3/PFI1)

USER1 = Pulse signal from PXI-6682 (Dev3/PFI2)

FTE – Future Time Event

The FTE is the time for when the operator wants the ADC, DAC and logging functions to begin. The following events occur at the FTE:

- Pulse (1uS) out from the PXI-6682
- 8kHz clock begins - sourced from the PXI-6682
- PXI-6682 begins to buffer time stamps on rising edges of the clock
- PXI-6251 begins both A/D and D/A tasks on rising edges of clock pulse
-

WHOI-2011-05
OBSAPS Data Acquisition System: Operator's Manual and System Overview

Introduction

On the Ocean Bottom Seismometer Augmentation to the Philippine Sea Experiment (OBSAPS, April-May, 2011, R/V Revelle), a vertical line array (VLA) of hydrophones and six OBSs were deployed to listen to an active acoustic source, a J15-3 from NUWC (Naval Underwater Weapons Center, Newport). This report describes the hardware and software used to control and record the acoustic transmissions from the source.

Some significant features of the system are:

- 1) The system enables general user defined source functions, such as M-sequences. It is not restricted to CW (continuous wave) or LFM (linear frequency modulated) waveforms. It reads the source function from .sio files and outputs a mono signal suitable for input to the power amplifier.
- 2) The transmission start time and the ADC and DAC sample rates are all disciplined to GPS time.
- 3) In addition to controlling the source waveform, the system also records six real-time channels: the monitor hydrophone mounted near the source, the power amplifier voltage, the power amplifier current, the depth of the source, sonobuoy data (when deployed) and an IRIG-B time reference. Files are output in .auv binary format, in user-selectable file lengths, with a precision GPS-based time stamp in the file name.
- 4) The system has a convenient, Labview based, user interface for real-time source control and monitoring. Software provides automatic selection of source functions and the corresponding setting of playback (record start/stop) times. This is a feature implemented for ease of operator use.
- 5) The software provides parsing and logging of gyro and GPS NMEA sentences.

The system, which was based on an earlier system from Scripps MPL, worked well on OBSAPS and is available for future projects.

Software Overview and Functionality

This software was developed to provide 6 channels of ADC recording and 1 channel of DAC output. The software was developed to be used for data acquisition and transmission playback for an acoustic source. The software drives the acoustic source with pre-loaded SIO files and monitors/records 6 analog channels (H-91 monitor hydrophone, PA voltage, PA current, depth, sonobuoy and IRIG-B). Both the ADC and DAC sample rates are driven from a disciplined 8kHz clock source which is sync'd to the GPS time reference. The ADC sample rate is fixed at 8kHz. The DAC output can be set to either 4kHz or 8kHz by the user.

The software interacts with two National Instruments pieces of hardware. The NI PXI-6251 is a multi-function data acquisition board used for ADC conversions and analog output. The NI PXI-6682 is used for GPS timing and synchronization and generation of the disciplined clock signal used for ADC and DAC functionality. The PXI-6682 also provides the ability to set the preprogrammed start time (FTE). The PXI-6251 buffers the ADC samples and this data is then read and queued by the software. Likewise, the PXI-6682 buffers the associated

WHOI-2011-05
OBSAPS Data Acquisition System: Operator's Manual and System Overview

time stamps for each sample and these buffered time stamps are read and queued by software. The software then de-queues the ADC and time stamp data and aligns them for file writing and file naming purposes. The queue'ing and de-queue'ing of the ADC samples and timestamps is done in asynchronous tasks. This 'producer/consumer' architecture allows for the data file writing process to be fairly immune to OS timing issues. The PXI-6682 is responsible for generating the GPS disciplined 8kHz sample clock which is used by the PXI-6251 for both ADC and DAC sample clocks. The PXI-6682 is also responsible for providing the start pulse to initiate logging and transmission at user defined times.

The program opens and reads SIO files. Once read these files are converted to Labview waveforms and output on the DAC channel specified. Due to RAM limitations of the DAQ system PC, the largest SIO file which can be read was experimentally found to be 17.4 MB. The operator can control the gain applied to the SIO file at the time when the file is loaded. The user can also choose between 'Sun' or 'Linux' SIO files to specify the byte order used in reading the file as well. The byte order of the SIO files is determined by the system which generates them.

The software provides the user the ability to set a 'Future Time Event' (FTE) for the desired start time for both ADC and DAC functionality as well as logging. It should be noted that both the ADC and DAC functionality will both begin at the pre-programmed 'FTE' time. If no DAC output is desired (such as for an ambient noise measurement), the user can achieve this in one of the following three ways...

- a. do not load an SIO file prior to setting the FTE
- b. disconnect the DAC output manually from the BNC-2090.
- c. disable the PA output

The program generates two types of files as output. These file type are 'AUV' and 'CSV' files. The AUV format stores the 6 channels of ADC data in binary format. The 'CSV' files store the NMEA data in comma separated ascii readable text. The NMEA data includes both GPS and Gyro strings. These data streams are input to the software via two comports. A detailed description of this file structure is contained at the end of this document. Both the GPS and Gyro NMEA data streams are parsed in real time and displayed to the user as well.

The user can select the file size in seconds for the AUV files. This value is defaulted to 60 second files. When the program is stopped, the software will pad the most recent AUV file with 0's so all files will be the same size. It should be noted that in order to stop logging the user must stop the program. It is then necessary to restart the program for the next transmission and data logging session.

As the data is acquired the software will close and open new files as they are filled to continuously log the 6 channels of ADC data in a time series. The logged ADC data should be continuous from one file to the next.

WHOI-2011-05
OBSAPS Data Acquisition System: Operator’s Manual and System Overview

The AUV filename format implemented in software corresponds to the time stamp associated with the very first sample in each file. This time stamp is received from the PXI-6682 and is determined at the hardware level of the board. The time stamps from the PXI-6682 are accurate to within +/- 100nS <13 nS standard deviation. The AUV filename format is

“%y%j%H%M%S%4u.auv”
 11127100400.0000.auv

Data symbol	Data type	Example
y	year within century (00-99)	11
j	day number of the year (001-366)	127
H	hour (00-23)	10
M	minutes (00-59)	04
S	seconds (00-59)	00
4u	4 decimal points of fractional seconds	0000

The software also logs the GPS and Gyro NMEA data strings. The filename format corresponds to when NMEA file logging was initiated. That format is

“NMEA_Data_%y%j%H%M%S.csv”
 NMEA_Data_11127095235.csv

The user can set the desired file size in seconds for the NMEA logs. The user can also select the desired sample rate for the NMEA file logs. The default values are 3600 seconds/file and 1 sample per second. So with these default parameters the software generates 1 hour NMEA files containing a NMEA GPS and Gyro string every second. There are time stamps in the NMEA file logs themselves for each new line of data. It should be noted that these time stamps are generated by Labview functions which read the PC clock. So there is some amount of latency due to the OS and the function call itself. The raw logged GPS and Hydro NMEA strings themselves also contain timestamps.

The logging of AUV files begins when the ‘FTE’ occurs. This is when the software will begin writing ADC data to file as well as outputting the waveform contained in the SIO file to the DAC. The NMEA data log begins as soon as the ‘FTE’ is set.

The software provides time series displays of all 6 ADC channels. These six time series graphs are updated at a 0.75 second rate. This rate is possible to adjust, but nominally fixed in software. The rate is determined by the number of ‘samples read per channel’ from the multi-function DAQ board and the sample frequency rate. The frequency rate and ‘samples read per channel’ are fixed in software. The sample rate is set to 8kHz and the ‘samples read per channel’ is defaulted to 6000. The ‘number of samples read per channel’ corresponds to the number of ADC and time stamp samples buffered and read from the PXI-6251 and PXI-6682 devices each time their respective function’s are called. It should be noted that successful operation of the code during OBSAPS was with the sample rate settings

WHOI-2011-05
OBSAPS Data Acquisition System: Operator's Manual and System Overview

mentioned above. Adjusting these rates could impact the codes functionality and should be thoroughly tested.

The software also provides a decimated time series display of the depth information with adjustable history length. This provides the user the ability to monitor a certain length of depth history on the front panel.

The software also provides a spectral display of the H-91 monitor hydrophone scaled for db SPL re $1\mu\text{PA}^2$. There is also a selectable spectral display generated for PA Voltage, PA Current, Sonobuoy or depth.

Display features

1. Time series displays for monitor hydrophone, PA voltage, PA current, depth, Sonobuoy and IRIG-B.
2. Decimated depth display with adjustable history length and averaging.
3. Peak and hold indicators for monitor hydrophone levels, PA voltage and PA current.
4. Spectral plots for monitor hydrophone, PA voltage, PA current, sonobuoy and depth.
5. Unwound GPS and Gyro NMEA strings.

Audible Alarms

1. H-91 Peak Volts > Threshold (150mS beeps @ 250 Hz)
2. PA Peak Volts > Threshold (150mS beeps @ 300Hz)
3. PA Peak Current > Threshold (150mS beeps @ 350Hz)
4. Druck Depth > Threshold (150mS beeps @ 400Hz)
5. The software produces a 440 Hz 5 second tone when stopped by the user OR automatic shut off.

Software Operation Procedure

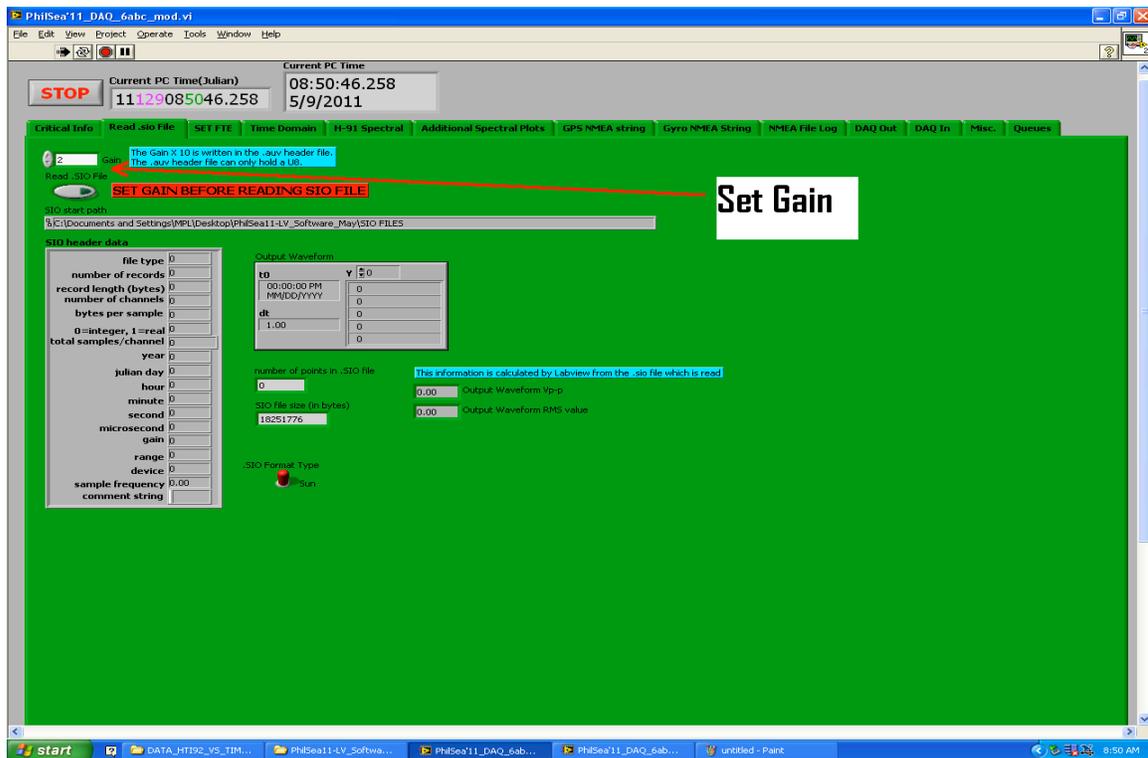
1. Start the program which should be ran in Labview 9.0
2. Verify that the following drivers are the following or more recent
 - a. NIDAQ9231f1 (DAQmx driver for PXI-6251 multifunction DAQ card)
 - b. Sync3.2.2 (PXI-6682 Timing and Synchronization)
3. Run the program which is done when running Labview by pressing the 'Play' button in the far upper left hand corner of the screen.

*****Note: the VERY first time that the software is run it is necessary to immediately press the 'STOP' button and restart the software. This is only necessary on the very first attempt to run the program.**
4. Check the 'Critical Info' tab. All indicators should be GREEN.
5. Set the software thresholds for PA peak current, PA peak voltage, H-91 peak voltage and Druck depth.
6. Set the proper PA Voltage, PA Current, H-91, Druck scaling and offset factors. These default to the following values:
 - a. H-91 scale factor = 1
 - b. PA Voltage scale factor = 200
 - c. PA Current scale factor = 50
 - d. Druck Scale factor = 53.6122
 - e. Druck offset of 0.6399

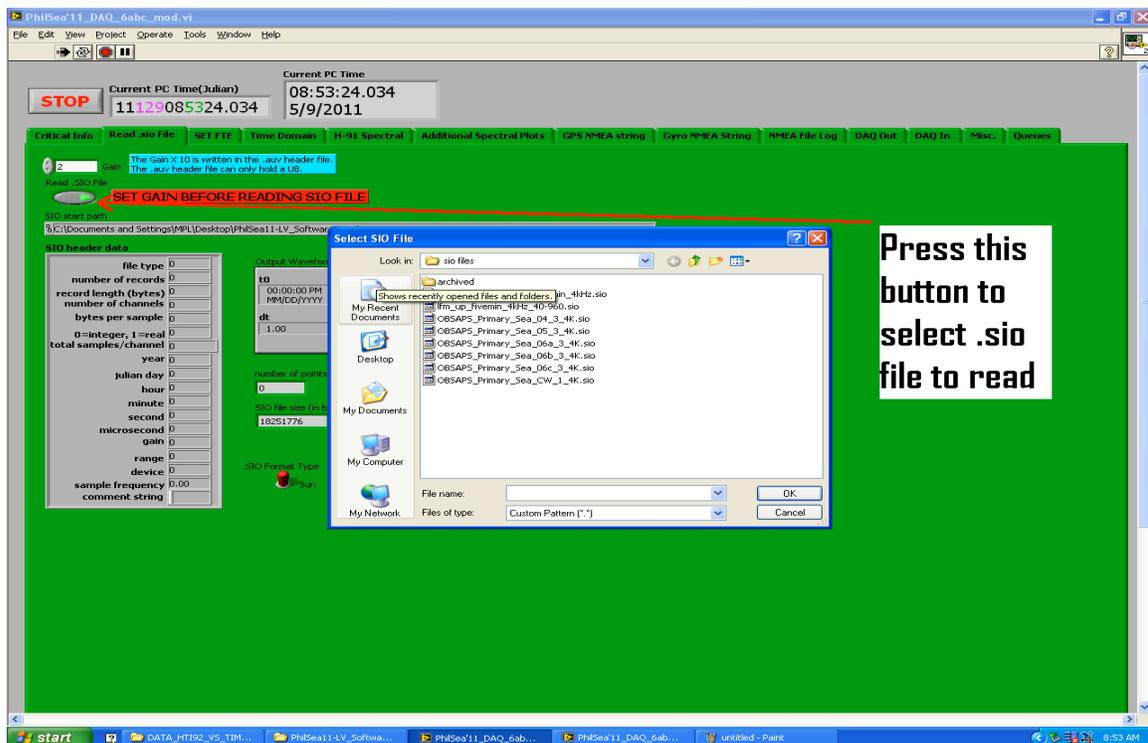
***** A detailed description of the Druck Offset can be found at the bottom of this document *****
7. Set the desired DAC output gain. This control can be found on the "Read sio file" tab.

*****Note: it is very important to set the DAC gain BEFORE reading the sio file. Once the sio file is read, the DAC gain can not be adjusted without stopping the program and restarting this procedure.**

WHOI-2011-05 OBSAPS Data Acquisition System: Operator's Manual and System Overview



8. Read the desired SIO file. This can be done on the “Read sio file” tab.



OBSAPS Data Acquisition System: Operator's Manual and System Overview

9. Check to make sure that all wiring and hardware are properly set up and configured. Verify that the DAC output of the Labview system is at 0V and then enable the PA amplifiers. If dual Chroma amplifiers are used it is important to make sure that both amplifiers are enabled and properly synced for master/slave series operation. It is also important to verify that any other necessary signal processing/conditioning hardware is enabled at this point such as:
 - a. PA Vref input 6dB scaling amp (if Chroma amps are used)
 - b. H-91 demodulator deck box
 - c. LP and HP filters used for signal conditioning
 - d. Tektronix AM503 current amp w/50 ohm load
 - e. Druck deck box connected to 9-30VDC battery supply
 - f. Oscilloscope for monitoring signals.
 - g. Extech magnetic current probe connected to PA output
 - h. Fluke DMM connected to PA output.
 - i. Connection of the tow cable to the winch on deck

10. Set the 'FTE' (Future Time Event). The FTE is the time at which the program will begin transmission and logging of the 6 ADC channels. Setting the FTE is accomplished in the 'Set FTE' tab.
 - a. Select the 'FTE set method'. There are 4 main choices in the drop down menu:
 - Primary 6a
 - Primary 6b
 - Primary 6c
 - Manual

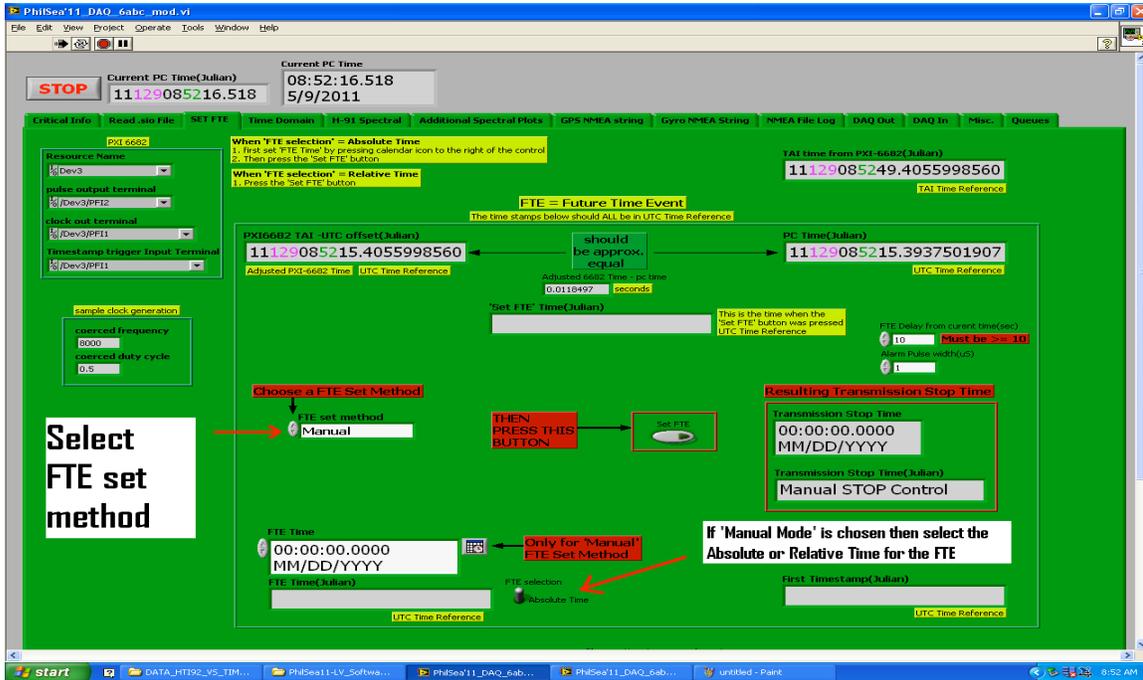
For the Primary 6a, 6b and 6c selections the program will automatically set the desired start and stop times based on the current time. These start and stop times are defaulted for the "OBSAPS_Primary_Sea_6a.sio", "OBSAPS_Primary_Sea_6b.sio" and "OBSAPS_Primary_Sea_6c.sio" files. In any of these three modes the software will automatically start and stop logging once the FTE is set. The start and stop times are based on the parameters found in the Misc. tab. The ability to quickly set the start and stop times for various SIO files to be transmitted is a convenient tool when a user is cycling through a transmission list and start/stop schedule.

When in Manual mode the user has two further options for setting the FTE. This selection is chosen by the "FTE Selection" toggle switch. The two different settings are:

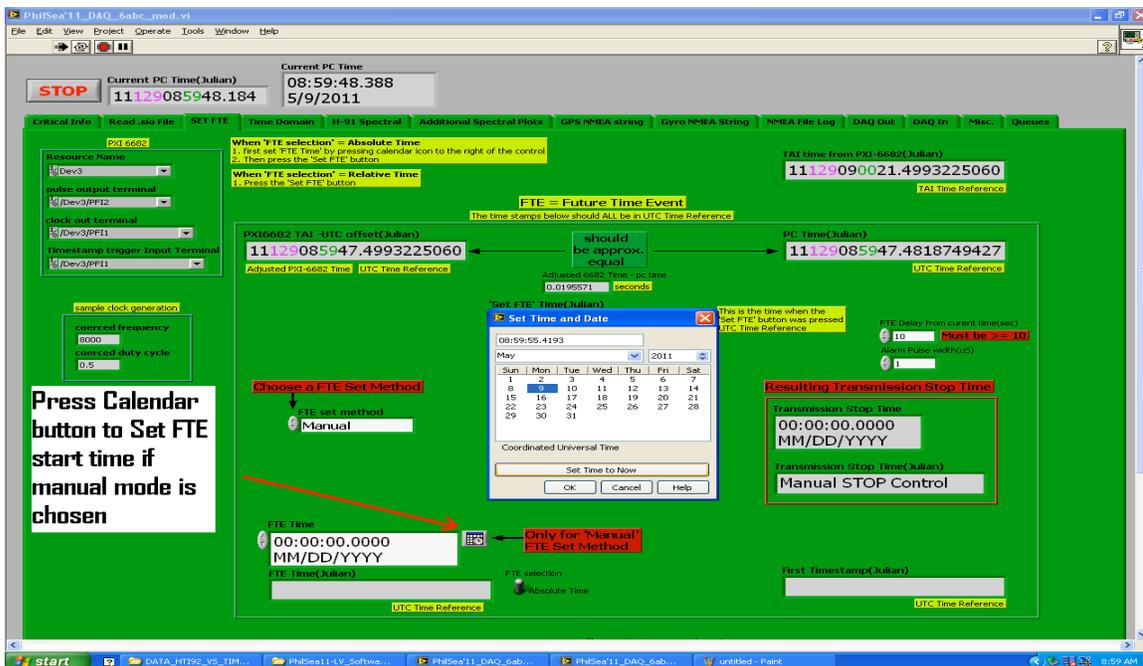
- Absolute – when in this mode the user must select the desired start time by using the Calendar button shown below.
- Relative – when in this mode the FTE will occur a set amount of time from whenever the 'Set FTE' button is pressed. The amount of time is determined by the 'FTE Delay from current time(sec)' control which can be found on the

WHOI-2011-05 OBSAPS Data Acquisition System: Operator's Manual and System Overview

“SET FTE” tab. This is a convenient way to set an FTE if the user does not require any specific time.

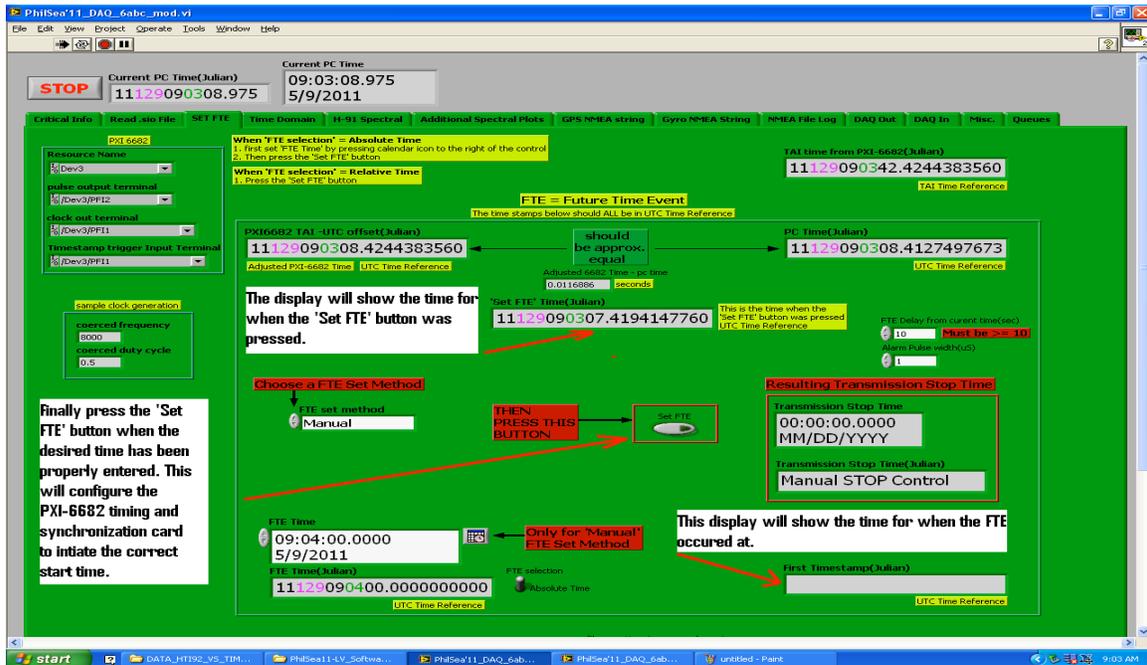


If ‘absolute’ is chosen, then press the small calendar button to the upper right of the ‘FTE Time’ indicator. Press the ‘Set Time to Now’ to update to the current time. Then, type in the desired time for the FTE to occur at.



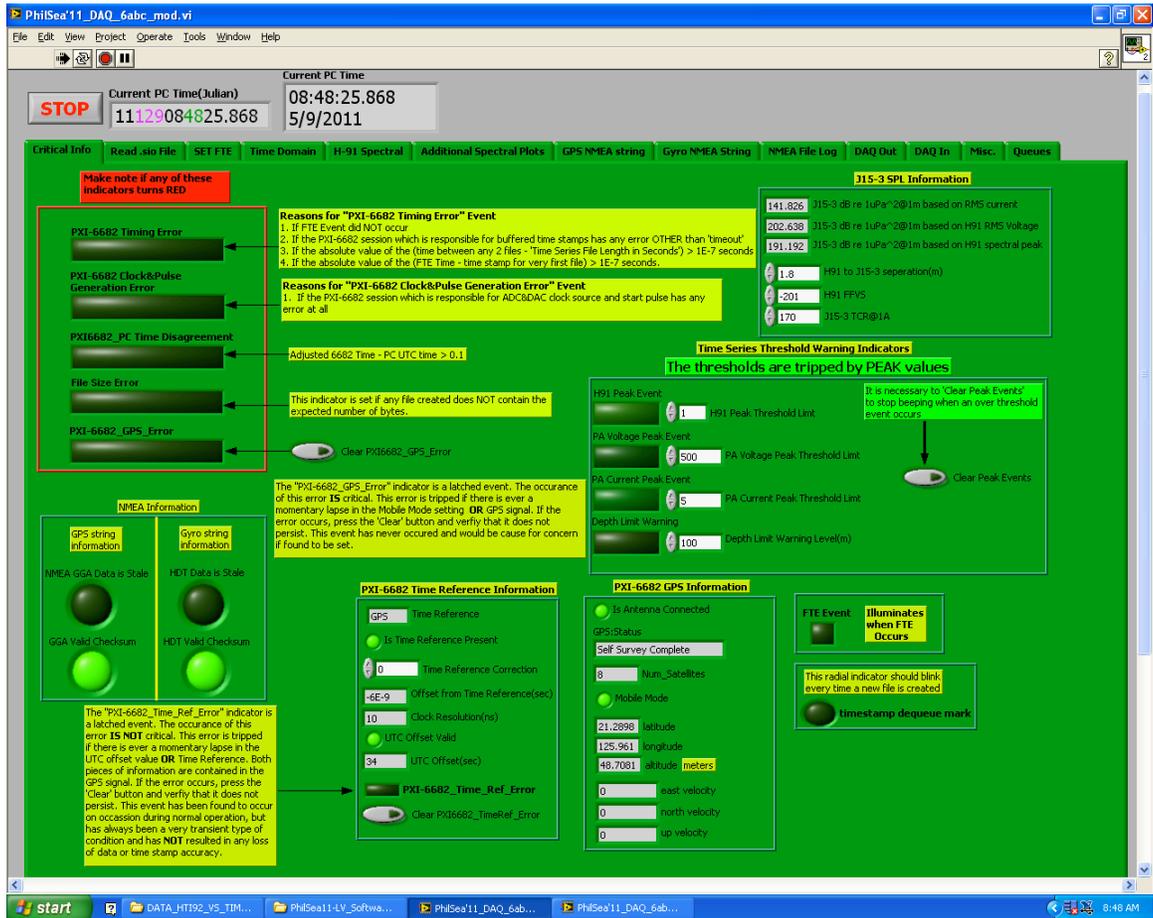
WHOI-2011-05
OBSAPS Data Acquisition System: Operator's Manual and System Overview

- b. Press the 'Set FTE' button which is in the middle of the same page.
***Note: to avoid 'FileSize Errors' be sure to press the 'Set FTE' button on 5,15,25,35,45,55 second intervals.



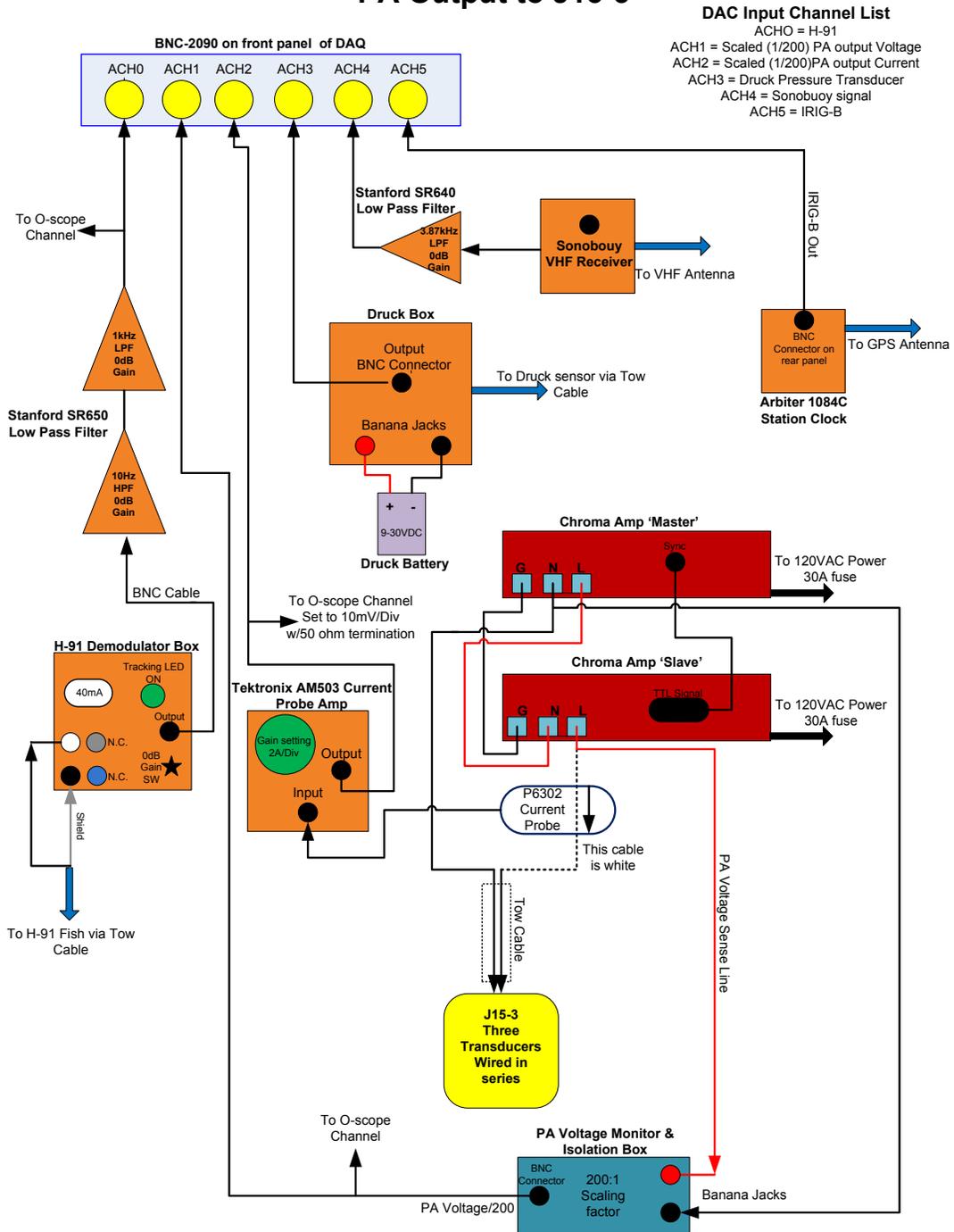
11. Wait for the FTE to occur. The playback and recording of the 6 channels will begin when the FTE occurs. The ADC data read by the software can be displayed in either the Time Domain or spectral plot tabs.
12. Immediately after the FTE occurs verify that the 'Critical Info' tab is ALL green. This indicates that the FTE event occurred successfully without any errors.

WHOI-2011-05 OBSAPS Data Acquisition System: Operator's Manual and System Overview

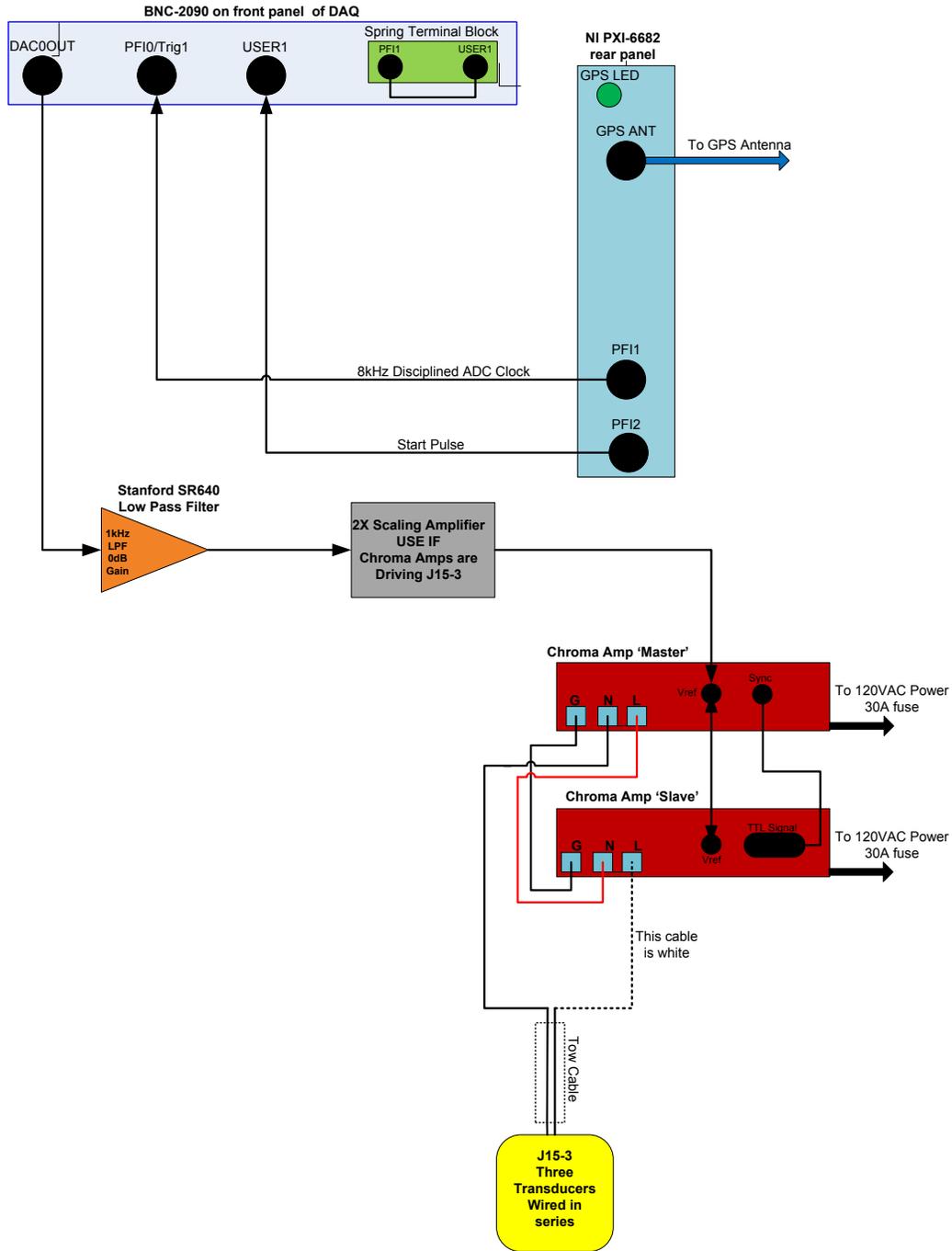


13. If the 'FTE set method' was chosen to be 'manual' then press the large rectangular 'STOP' button in the upper left hand corner of the screen. The program will take 15 seconds to completely shut down. The user will know when the software is no longer running because a 5 second 440Hz tone burst will occur just as the software is shutting down. If the user has selected 'Primary 6A', 'Primary 6B' or 'Primary 6C' as the 'FTE set method' then the program will shut down automatically. The 5 second 440Hz tone will still occur at the end.

**OBSAPS
 DAQ System ADC Inputs &
 PA Output to J15-3**



OBSAPS DAQ System DAC Output & Connection to NI PXI-6682 Timing & Synchronization



Description of program tabs on the front panel

'Critical Info'

This tab is the best place to get a quick synopsis of the overall condition of the DAQ system.

- a. Time Reference and Synchronization information from the PXI-6682 board
- b. GPS and Gyro NMEA string information
- c. Threshold events, limits and reset control
- d. GPS data from the PXI-6682 device
- e. Future Time Event status
- f. Indication of new 'AUV' file creation – this will occur at a regular interval defined by the desired file length size.

'Read .sio file'

- a. set gain for 'SIO' file
- b. selection of 'SIO' file for the software to read
- c. selection of 'Sun' or 'Linux' byte order
- d. display for number of points in the .sio file, file size and output waveform Vp-p and RMS values

'SET FTE'

- a. control for setting the Future Time Event
- b. Julian day time stamp updates from PXI-6682
- c. Configuration information for PXI-6682
- d. PXI-6682 sample clock generation information

'Time Domain'

- a. Time domain graphs for all six channels of ADC
- b. Peak and Hold displays for H-91, PA Voltage and PA Current
- c. Decimated Depth display

'H-91 Spectral'

Spectral display for H-91 output scaled to db SPL re 1uPa²

'Additional Spectral Plots'

Spectral Displays for PA Current, PA Voltage, Sonobuoy and Druck Pressure sensor voltage

'GPS NMEA String'

Display and parsing of the incoming GPS 'GGA' NMEA string

'Gyro NMEA String'

Display and parsing of the incoming Gyro 'HDT' NMEA string

'NMEA File Log'

NMEA file log controls, "File Length", "Sample Rate".

'DAQ Out'

DAC output sample rate settings

'DAQ In'

DAC input sample rate setting and number of samples read from hardware per pass in software.

Time Series File size information

PXI 6251 multi-function DAQ trigger setup information

File path for most recent .auv file created

'Misc.'

Display of 6 channel acquired data (signed 16 bit integer array)

H-91, PA Peak Voltage, PA Peak Current Peak and Hold variables

Various PXI-6682 Time Stamp controls

Three Booleans indicators for trouble debugging purposes specific to the PXI-6682 device.

Known Issues

1. There have been instances of 'File Size Errors' occurring during the OBSAPS expedition (April-May'11). The error occurs when a file is created which is greater than the expected file size. The 'File Size Error' was found to occasionally occur during testing at WHOI and APL, however it was non-repeatable and there was not enough time with the hardware and software to thoroughly debug the issue. Knowing this, prior to arriving in Kaohsiung the software was designed to alert the user to the 'File Size Error' event as soon as a file grew beyond its expected size. The idea was that the user could then stop the logging and transmission process and restart to avoid the File Size error issue.

During the OBSAPS expedition the root cause of the 'File Size Error' was discovered. The error was found to occur when the software function which reads ADC data from the PXI-6251 hardware times out during operation. The occurrence of this timeout prevents the software from reading all the samples available at that time. The function which reads ADC samples is configured to nominally read a set number of samples per channel. This number was defined as 6000 during OBSAPS (April-May'11). The expected number of samples read by the function per call is:

Expected Samples Read per call = Channel Count * 6000 = 36,000

The file sizes during OBSAPS were set to 60 seconds. With 6 channels of ADC data being sampled at 8kHz this equated to each file containing $6*8000*60 = 2,880,000$ samples when full.

In software, files are filled with ADC data each time the function returns values. Under normal operation this occurs every 0.75 seconds ($6000 * 1/8\text{kHz}$). So under normal operation, every 0.75 seconds the file should increase by 36,000 samples. This process repeats until the file contains 2880000 samples. At this point the file is closed, a new file is opened and the process repeats.

When the FTE is set by the user this initiates the function calls which query the ADC hardware for any available samples. Prior to the FTE occurring there will be no ADC samples available, so the function calls will time out. For the OBSAPS expedition the time out for the function which queries the ADC for data was set to 10 seconds. Once the FTE has occurred the ADC will be sampling and the function query will return 36,000 samples every 0.75 seconds. So for normal operation the 10 second timeout is more than adequate. However the problem occurs if the function which queries for ADC data times out just as the FTE has occurred. When this event occurs the very first ADC data query after the FTE has occurred will NOT return the full 36,000 samples as expected. Instead the function will return some sample count 'X' which is $< 36,000$ because it timed out during the middle of the function's operation. All future ADC queries will result in the expected 36,000 samples returned. Since the file will grow at 36,000 samples per call of the function, this causes the file to contain $2880000 + X$ samples when it is closed and a new file opened. All future files will

OBSAPS Data Acquisition System: Operator's Manual and System Overview

contain 2,8800,000 samples, however it is just the first file which is too large. In the event of a 'File Size Error' occurring no data is lost, however it is important to realize that the timestamp contained in the filename is not accurate for all files past the very first file where the error first occurred until when the program was stopped. Therefore it is necessary to look at the IRIG-B channel for correct ADC time stamp information when a 'File Size Error' event occurs. It would also be acceptable to count samples from the timestamp contained in the filename of the first file.

We were able to work around this issue at sea by proper timing of when the 'Set FTE' button was pressed. During OBSAPS all FTE's were set to occur on the even minute. When the 'Set FTE' button is pressed the ADC query function is initiated. This function had a 10 second timeout for the DAQ code used during OBSAPS. Prior to the FTE's occurrence the function would timeout every 10 seconds because NO samples would be ready. So if the 'Set FTE' button is pressed at 5, 15, 25, 35, 45 or 55 seconds past the even minute, this will cause the ADC read function to time out approximately 5 seconds BEFORE the FTE occurs. This guarantees that the ADC read function DOES NOT timeout just as the FTE occurs. Thus the function will be able to read the full 36,000 samples each time it is called as expected and NO File Size Errors will occur. This technique was proven to work for several days at the end of the OBSAPS expedition.

During OBSAPS there were several attempts made at solving the 'File Size Error' issue programmatically. These attempts involved adjusting the ADC read function's timeout programmatically as well as holding off the start of ADC reads until AFTER the FTE occurs. These experiments were successful in preventing the 'File Size Error' event, however they also occasionally caused the FTE to NOT occur at all. These changes were not robust enough to be used for gathering data, so we decided to use the method mentioned above to prevent the 'File Size Error' issue from occurring. More development time is necessary to solve this issue in software.

2. When Labview is started for the first time it is necessary to cycle the DAQ program Start/Stop/Start. The first time that the DAQ software runs after Labview has opened there will be an error with the PXI-6682 communication. Simply stopping the DAQ program and restarting will get rid of this error for future Start/Stop sequences of the software. The nature of this problem is NOT fully understood, but it is possible that it is caused by the fact that the system is NOT being used with an NI PXI chassis. Instead the hardware is installed in a OneStop system compactPCI chassis. There are also two SBS Technologies boards which provide the communication link between the chassis and the computer's PCI bus. The software needs to be tested with a PXI chassis to confirm if the chassis is the root of the problem. NI apps engineers have been involved in attempting to solve this issue.
3. If SIO files are opened which are too great in size the program will have one of the following two errors:

WHOI-2011-05
OBSAPS Data Acquisition System: Operator's Manual and System Overview

- a. Memory Overflow error
- b. DAQ write error

The largest SIO files to have been found to reliably work are 17.4MB in size which equate to just under 20 minutes of audio at 4K samples/sec.

- 4. The NMEA file logging is not always producing files, which are roughly the same size, when the program is allowed to run for long periods. For some reason the logging is stopping and restarting during operation.
- 5. If the program is stopped prior to the FTE's occurrence an invalid AUV file will be created. This should not be happen and would be a simple matter to resolve. The invalid AUV file name is always "04001000000.0000.auv"

Tips for successful operation of software

- 1. When opening large SIO files it's a good idea to test run a practice FTE before the actual desire FTE. For large SIO files Labview can give 'Memory Overflow Errors' or 'DAQ write errors' for the first attempted FTE after the large SIO file is read. Simply stopping the software and re-running can often times result in successful loading of the SIO file and setting of the FTE. The reason behind why this seems to work are probably related to how Labview allocates RAM to store the SIO file which is read as well as the process by which the DAQmx drivers write the resulting waveform to the PXI-6251 board.
- 2. Its good practice to restart the PC after every long duration acquisition.

Future features to implement

- 1. The depth time display should have numbers which go negative from 0 being at the surface. This would be more intuitive for the user.
- 2. It would be nice to be able to start acquisitions without logging data so operators can tell depth of the J15-3 prior to the actual start of logging.
- 3. It would be nice to have a 'playlist' of SIO files with corresponding start and stop times. The program could then cycle through this list without the operator's involvement.
- 4. The NMEA data logging should begin when the FTE event occurs. This corresponds to when the ADC/DAC functionality start. Currently the NMEA data logging starts when the 'SET FTE' button is pressed.

NMEA Log File Description – OBSAPS Expedition

The NMEA files contain the gyro and GPS NMEA strings that the Revelle was outputting at approximately a 1 second rate. The GPS NMEA data was generated by the GP150 gps unit and the Gyro NMEA data was generated by the PHINS device. These two RS232 strings were received on 2 separate com ports with the DAQ System PC.

The NMEA file name contains the time stamp for when the file was created. The operator could define a "NMEA File Length (sec)" which would control how many seconds of data each file would contain. At these regular intervals the software would close the existing file and open a new one. The timestamp in the file name is of the following format:

NMEA_Data_%y%j%H%M%S.csv
 NMEA_Data_11127095235.csv

Data symbol	Data type	Example
y	year within century (00-99)	11
j	day number of the year (001-366)	127
H	hour (00-23)	09
M	minutes (00-59)	52
S	seconds (00-59)	35

At a user defined interval the software will take a 'snapshot' of the current NMEA (GPS and Gyro) strings that had been received on the com ports and write these strings to the NMEA file. A timestamp will also be pre-pended to each new line which is written to file. This time stamp will follow the format stated below:

%y%j%H%M%S%4u
 11127095236

Data symbol	Data type	Example
y	year within century (00-99)	11
j	day number of the year (001-366)	127
H	hour (00-23)	09
M	minutes (00-59)	52
S	seconds (00-59)	36
4U	4 decimal places of precision for the seconds	

The first 5 lines of each NMEA file are filled with a header. Below is an example of that header:

Data Format:
 TimeStamp,X,NMEA GGA string,X,NMEA HDT string<cr><lf>
 X=Data Valid?

WHOI-2011-05
OBSAPS Data Acquisition System: Operator's Manual and System Overview

if X=0 : Valid Data
if X=1 : Stale Data

The file's 'Valid Data' or 'Stale Data' (X) indicator was determined by the software depending on the rate at which NMEA strings were received. If the PC does not detect a valid GPS or Gyro NMEA string within the last 2 seconds, the software will set the value 'X' to 1 for the appropriate NMEA string to indicate that the data has gone stale. Otherwise the NMEA string will be considered valid and 'X' will be set to 0. This valid or stale data check also drives an indicator on the Labview program front panel. This is an indicator to the operator to alert them if a problem occurred with either of the NMEA strings such as an unplugged RS232 cable or some other interruption in the RS232 data.

The following is a breakdown of the GPS or (GPGGA string) received from the Revelle and logged to the NMEA files.

\$GPGGA, %f,%f,%1s,%f,%1s,%d,%d,%f,%f,%1s,%1s,*%s
\$GPGGA,094502,2132.8597,N,12606.1389,E,2,7,1.4,25,M,,M,,*4F

UTC Time
Latitude
Latitude Sector
Longitude
Longitude Sector
GPS Quality
Number of Satellites
HDOP
Altitude above mean sea level
Altitude unit of measure
Geoidal speration unit of measure
Checksum

The following is a breakdown of the Gyro or (HEHDT string) received from the Melville and logged to the NMEA files.

\$HEHDT,%f,%1s*%s
\$HEHDT,164.984,T*29

Heading
True or Magnetic
Checksum

Explanation of Druck Voltage to Depth Conversion used during OBSAPS (April-May'11)

The Labview code does the following calculations with the signed 16 bit integers representing Druck voltage which are produced by the ADC.

1. Multiply by 10V / 65536 to convert to volts. This is a common step for all ADC measurements. The ADC has a 10V range and there are $2^{16} = 65536$ counts in that range.
2. Apply a 30Hz 1st order LP filter to the 6000 point array of Druck data. This removes HF noise due to the lack of capacitance across the 118 ohm resistor which the Druck current develops a voltage across and the DAQ system measures.
3. Multiply by 1.013559 -> this scale factor compensates for the fact that there is a 118 ohm resistor in the OBSAPS expedition's Druck deck box instead of a 119.6 ohm resistor as what the '09 Cal Data used.
4. Then subtract a constant 0.6399613 -> this is a scaled voltage measurement taken from while in Kaohsiung (April 28,11) when the J15-3 was on deck.
5. Multiply by 53.612226 to get depth in meters.

Below is a more detailed description of this procedure which is placed in the LV code where this measurement is taken.

Druck Pressure sensor conversion from volts to depth

The value 1.013559 is derived from the fact that PhilSea'11 uses a 118 ohm resistor where the calibration data was recorded using a 119.6 ohm resistor. The Druck voltage on the deck of the ship in Kaohsiung on April28,11 was measured as 0.6314V by the DAQ. This measurement scaled by 1.013559 converts to 0.639961V for use with the '09 calibration data. The "Depth Scale Factor" was determined by using 1 point from the '09 cal data for SN:2700602 as well as the scaled on deck '0 meter' reading taken in Kaohsiung. The cal data point was taken from the 'Druck measured with DAQ(scaled)' column in the data set. The cal data point used is: 2.27V across 119.6 ohms @87.39m. The second data point was chosen from the measurement taken on the deck of the Revelle. That data point was 0.6314V across the 118ohm resistor in the Druck deck box. That value scaled for the '09 calibration data gives 0.639961V across 119.6 ohms @ 0 meters. This gives a slope of $(87.39-0)/2.27-0.639961 = 53.612226$

REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-2011-05	2.	3. Recipient's Accession No.
4. Title and Subtitle OBSAPS Data Acquisition System: Operator's Manual and System Overview		5. Report Date May 2011	
7. Author(s) McPeak, S.P., D'Spain, G.L., and Stephen, R.A.		6.	
9. Performing Organization Name and Address Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543		8. Performing Organization Rept. No.	
12. Sponsoring Organization Name and Address Office of Naval Research		10. Project/Task/Work Unit No.	
		11. Contract(C) or Grant(G) No. (C)N00014-10-1-0994 (G)N00014-10-1-0987	
		13. Type of Report & Period Covered Technical Report	
		14.	
15. Supplementary Notes This report should be cited as: Woods Hole Oceanographic Institution Technical Report, WHOI-2011-05.			
16. Abstract (Limit: 200 words) On the Ocean Bottom Seismometer Augmentation to the Philippine Sea Experiment (OBSAPS, April-May, 2011, R/V Revelle), a VLA and six OBSs were deployed to listen to an active acoustic source, a J15-3. This report describes the hardware and software used to control and record the acoustic transmissions from the source. Some significant features of the system are: 1) The system transmits general user-defined source functions, such as M-sequences (.SIO files). 2) In addition to controlling the source waveform, the system also records six real-time channels in binary files with user-selectable lengths: the monitor hydrophone mounted near the source, the power amplifier voltage and current, the depth of the source, sonobuoy data (when deployed) and an IRIG-B time reference. Files are output in .AUV format with a precision GPS-based time stamp in the file name. 3) The transmission start time along with ADC and DAC sample rates are disciplined to GPS time. 4) A convenient, Labview based, user interface provides real-time source control and monitoring. 5) The software provides parsing and logging of gyro and GPS NMEA sentences. The system, which was based on an earlier system from Scripps MPL, worked well on OBSAPS and is available for future projects.			
17. Document Analysis a. Descriptors Acoustic Source Ocean Acoustics Marine Seismology b. Identifiers/Open-Ended Terms c. COSATI Field/Group			
18. Availability Statement Approved for public release; distribution unlimited.		19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 22
		20. Security Class (This Page)	22. Price