

An Introduction to Using IGOR in the Quantum Devices Group

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13th December 2021

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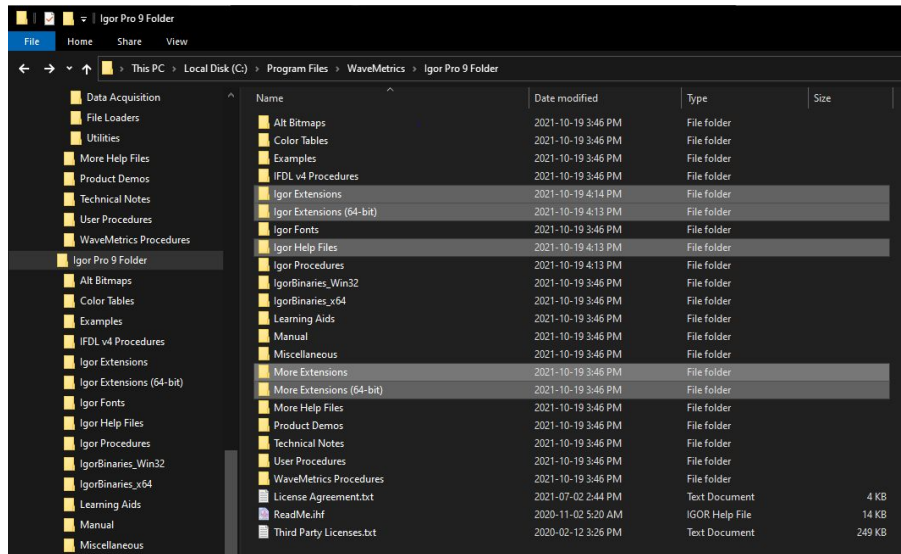
XOPs

On GitHub, go to 'IgorAcq/XOP/'

Here you will see a list of XOP's

- JSON-XOP-latest
- SOCKIT
- SQL
- VISA-ASYNC_7

Also need to copy into IGOR procedures.



Adding .ipf files

Open up IGOR and go File/New Experiment

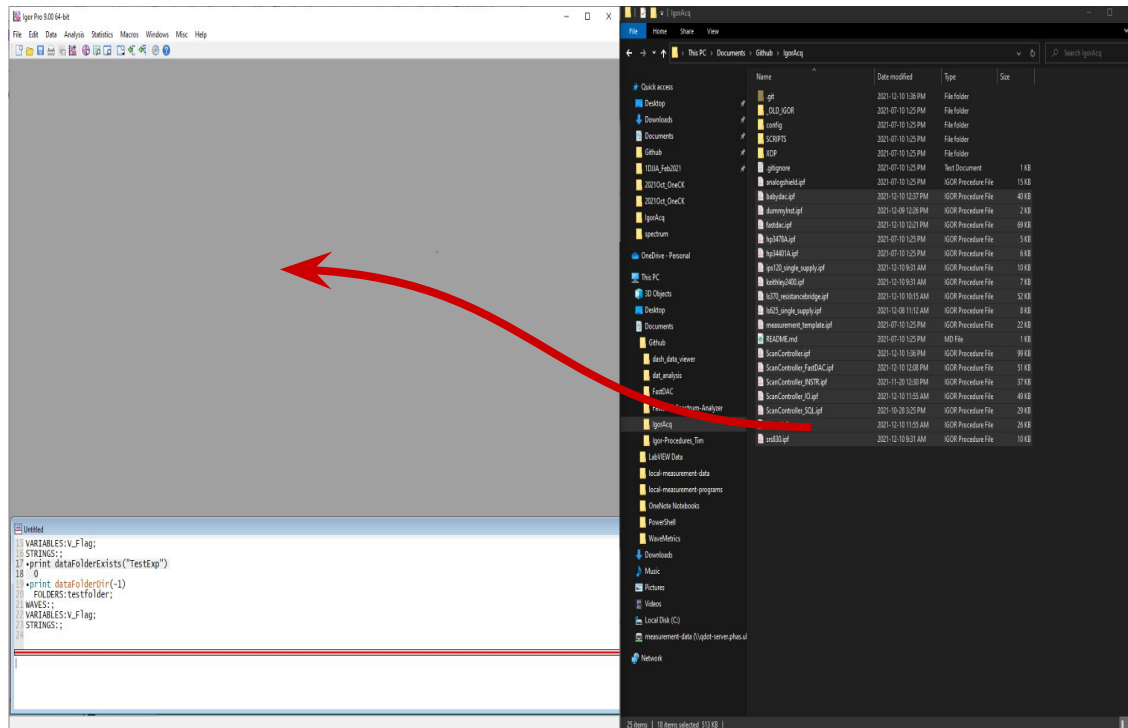
From

C:\Users\folklab\Documents\Github\IgorAcq

Add the following .ipf files by drag and drop

- babydac.ipf
- fastdac.ipf
- ls370_resistancebridge.ipf
- ls625_single_supply.ipf
- ScanController.ipf
- ScanController_FastDAC.ipf
- ScanController_INSTR.ipf
- ScanController_IO.ipf
- ScanController_SQL.ipf
- Scans.ipf
- srs830.ipf
- keithley2400.ipf

Or manually add in IGOR: File/Open
File/Procedure...



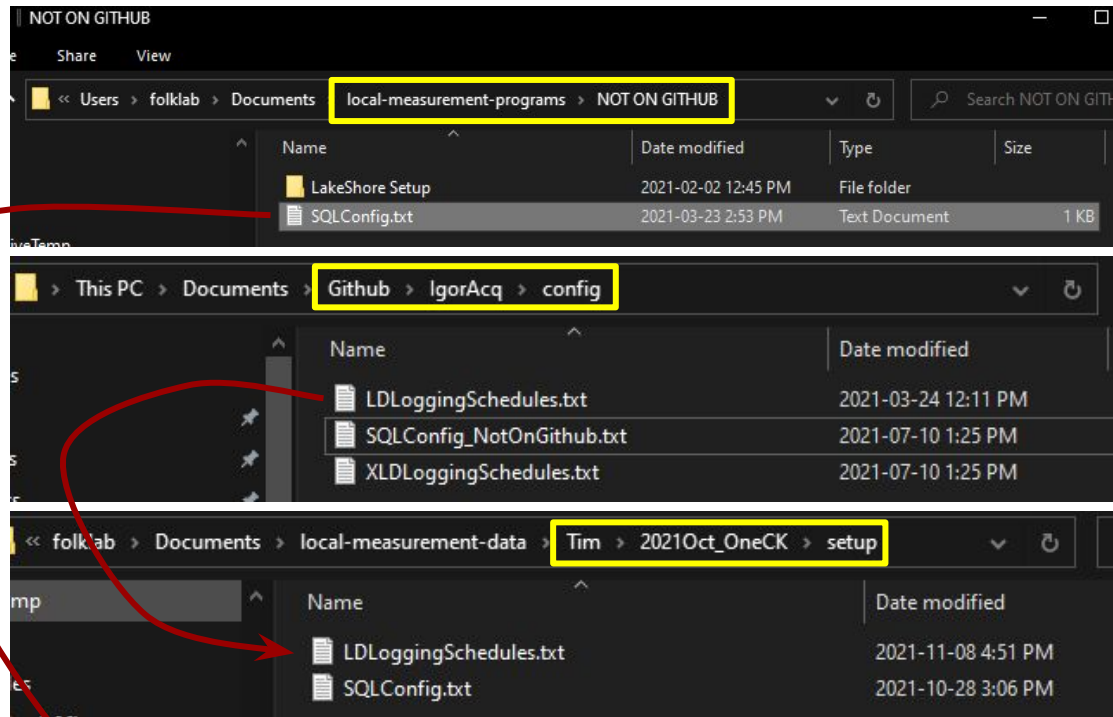
Adding .txt files

We also need to add some text files to a 'setup' folder in the experiment.

Two files to move:

- C:\Users\folklab\Documents\local-measurement-programs\SQL Config.txt
- C:\Users\folklab\Documents\Github\IgorAcq\config\LDLoggingSchedules.txt

Add to experiment subfolder names 'setup'



Defining File Paths

Local file path

C:\Users\folklab\Documents\local-measurement-data
 \<your name>\<experiment>

Where:

<your name> is your name

<experiment> is the specific experiment name

Set paths in IGOR

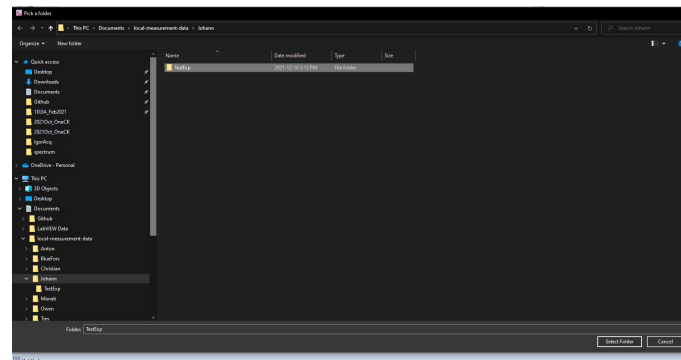
newpath data (Then select Local file path)

newpath server (Then select server drive e.g. Z:)

Check if folder exists

print dataFolderExists(data)

prints 1 if path exists



```

10  testFolder: testFolder;
11  NAME: testFolder;
12  TYPE: testFolder;
13  *print dataFolderExists(testFolder);
14  testFolder: testFolder;
15  NAME: testFolder;
16  TYPE: testFolder;
17  STRING: testFolder;
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```

ASRL number

Open application NI MAX

Connect instrument and use 'F5' to refresh
(note "Refresh" does not refresh the device list)

Or

`listSerialports()`
`listGPIBinstr()`

The screenshot displays the NI MAX 'My System' window. The left-hand tree view shows the 'My System' node expanded, revealing 'Devices and Interfaces'. Under this category, there is a list of ASRL (ASRL1 through ASRL19) and two GPIB devices (NI USB-6008 and NI GPIB-USB-HS). Below the device list are 'Network Devices', 'Software', and 'Remote Systems'. The right-hand pane is divided into three sections: 'System Settings' (showing Hostname, DNS Name, Vendor, Model, Serial Number, Firmware Version, Hardware Revision, Operating System, System Start Time, and Description), 'System Resources' (showing memory and disk usage statistics), and 'PXI System Settings' (showing Resource Manager, Active Resource Manager, Trigger Manager, and Default Trigger Manager settings).

Instrument specific connections

Useful to set verbose = 1

FastDAC:

`openFastDACconnection(instrID, visa_address, [verbose,numDACCh,numADCCh,master, optical])`

E.g. `openFastDACconnection("fd", "ASRL18::INSTR", numDACCh=8, numADCCh=4, master=1, verbose=1)`

BabyDAC: Detailed BabyDAC information already on Discourse <https://qdev-forum.phas.ubc.ca/t/babydac-wiki/102>

`openBabyDACconnection(instrID, visa_address, [verbose])`

E.g. `openBabyDACconnection("bd", "ASRL10::INSTR", verbose=1)`

`InitBabyDACs(instrID, boards, ranges, [custom])`

E.g. `InitBabyDACs(bd, "5,4", "55,55")`

Magnet: (magnet values can be found in the comments in `openLS625connection()` for LD nad XLD)

`openLS625connection(instrVarName, visa_address, amps_per_tesla, max_field, max_ramprate, [verbose, hold])`

E.g. `openLS625connection("magy", "ASRL15::INSTR", 55.2181, 1000, 155.058, verbose=1)`

Remotely Controlling Fridge:

`openLS370connection(instrID, http_address, system, [verbose])`

E.g. `openLS370connection("ls370", "10.18.101.12:49301/api/v1/", "bfsmall", verbose=1)`

Checking Instrument Connections

FastDAC:

```
print getFDACStatus(instrID)
rampMultipleFdac(instrID,channels,setpoint)
print getFDACStatus(instrID)
```

BabyDAC: <https://qdev-forum.phas.ubc.ca/t/babydac-wiki/102>

Magnet:

```
print getls625status(magy)
setLS625rate(magy,50)
print getls625status(magy)
```

Status Output: We will address how to make use of this logging in post analysis.

```
{"LS625 Magnet Supply":{"variable name":"magy", "field mT":-0.03079, "rate mT/min":49.984}}
```

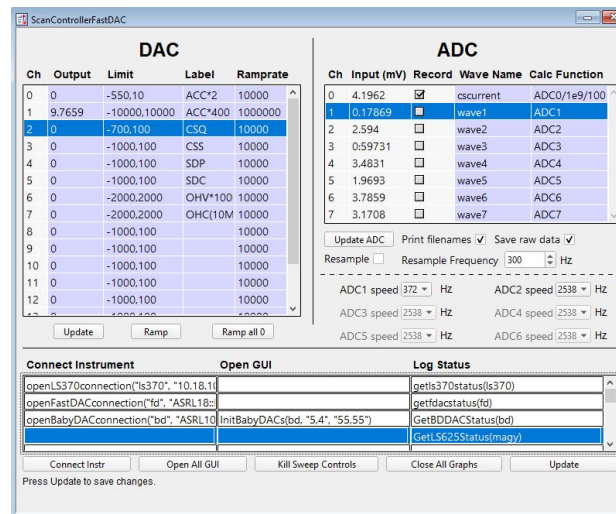
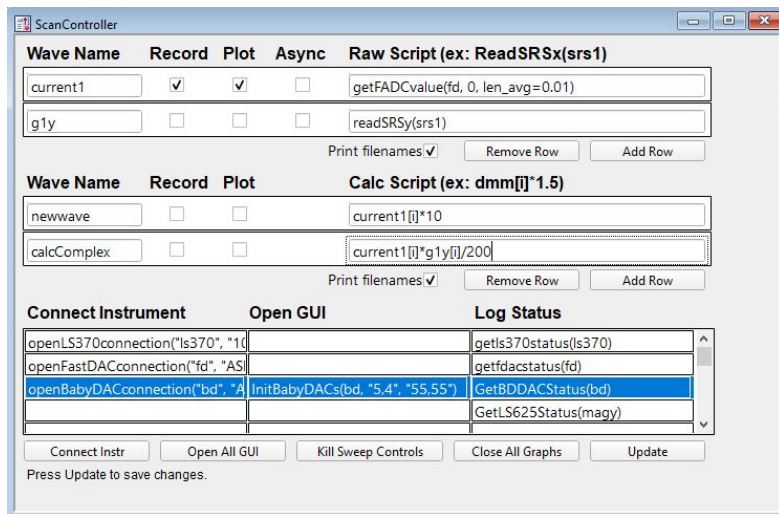
Types of ScanControllers

ScanController

- Original controller for Slow scans

ScanControllerFastDAC

- Equivalent of ScanController for FastDAC scans



ScanController

Open up the window: `InitScanController()`

Raw Script

FastDAC: `getFADCvalue(fdid, channel, [len_avg])`

BabyDAC: `ReadBDadc(instrID, channel, board_number)`

Lockin: `readSRS(srs1)`

etc

Calc Script

This will perform the mathematical operation specified.

"[i]" is used to update the corresponding index of calc wave

Connect Instrument

Copy + Paste the function for connecting to an instrument

Change to verbose = 0

Log Status (makes SweepLogs)

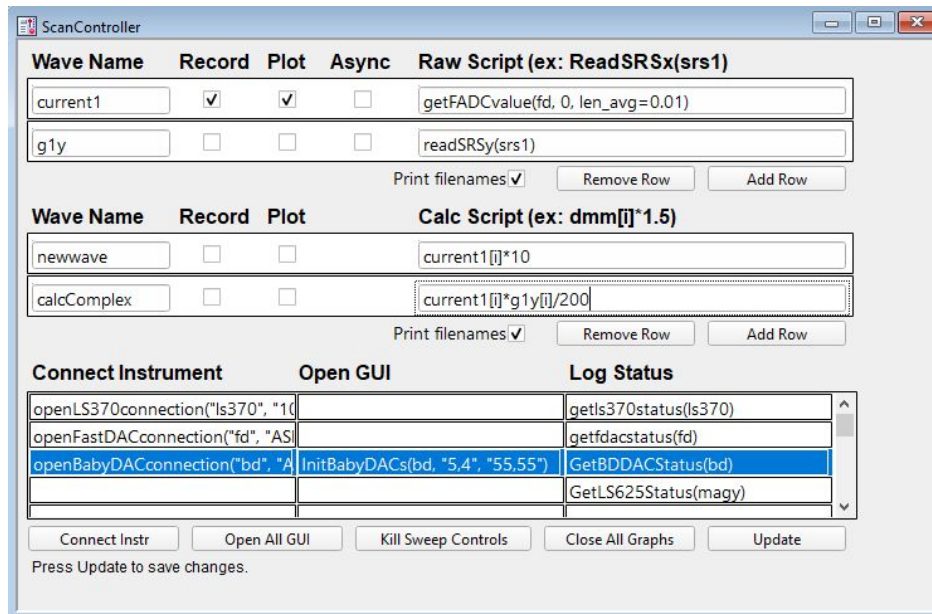
Logging functions collect meta data about each scan.

FastDAC: `getFDACStatus(instrID)`

BabyDAC: `GetBDDACStatus(instrID)`

370: `getLS370Status(instrID)`

625: `GetLS625Status(instrID)`



ScanControllerFastDAC - DAC

Open up the window: `InitScanController()`

Ch

This corresponds to the number on the FastDAC DAC labels

Output

The voltage output in mV on this FastDAC channel

Limit

The voltage limits on DAC channel.

Scan will abort if FastDAC tries to ramp outside these limits.

Label

When running FastDAC scans, you can refer to the channel by its number or by the label you define. This is useful if you have many different gates.

Ramprate

Sets Ramprate in mV/s for each channel (for everything except scanning)

Update

Clicking Update will ask each of the channels what they are at and will update the output.

Ramp

This will ramp each of the channels to the values specified in Output

Ramp all 0

This ramps every channel down to zero

The screenshot displays the ScanControllerFastDAC GUI. The DAC table lists channels 0-12 with their respective outputs, limits, labels, and ramp rates. The ADC table lists channels 0-7 with their inputs, record status, wave names, and calculation functions. Below these tables are buttons for 'Update', 'Ramp', and 'Ramp all 0'. The right side of the GUI features an 'ADC' section with a table of ADC inputs, record status, wave names, and calculation functions. Below this are buttons for 'Update ADC', 'Print filenames', and 'Save raw data'. The bottom section contains a 'Connect Instrument' table with columns for 'Open GUI' and 'Log Status', and buttons for 'Connect Instr', 'Open All GUI', 'Kill Sweep Controls', 'Close All Graphs', and 'Update'.

Ch	Output	Limit	Label	Ramprate
0	0	-550,10	ACC*2	10000
1	9.7659	-10000,10000	ACC*400	1000000
2	0	-700,100	CSQ	10000
3	0	-1000,100	CSS	10000
4	0	-1000,100	SDP	10000
5	0	-1000,100	SDC	10000
6	0	-2000,2000	OHV*100	10000
7	0	-2000,2000	OHC(10M	10000
8	0	-1000,100		10000
9	0	-1000,100		10000
10	0	-1000,100		10000
11	0	-1000,100		10000
12	0	-1000,100		10000

Ch	Input (mV)	Record	Wave Name	Calc Function
0	4.1962	<input checked="" type="checkbox"/>	cscurrent	ADC0/1e9/100
1	0.17869	<input type="checkbox"/>	wave1	ADC1
2	2.594	<input type="checkbox"/>	wave2	ADC2
3	0.59731	<input type="checkbox"/>	wave3	ADC3
4	3.4831	<input type="checkbox"/>	wave4	ADC4
5	1.9693	<input type="checkbox"/>	wave5	ADC5
6	3.7859	<input type="checkbox"/>	wave6	ADC6
7	3.1708	<input type="checkbox"/>	wave7	ADC7

Connect Instrument	Open GUI	Log Status
openLS370connection("ls370", "10.18.1		getls370status(ls370)
openFastDACconnection("fd", "ASRL18::		getfdacstatus(fd)
openBabyDACconnection("bd", "ASRL10	InitBabyDACs(bd, "5,4", "55,55")	GetBDDACStatus(bd)
		GetLS625Status(magy)

ScanControllerFastDAC - ADC

Input

The voltage INPUT in mV on this FastDAC channel

Record

Checking record will record the inputs and save them under the variable Wave Name

Wave Name

The name of variable to refer to the specific input values

Calc Function

This will perform the mathematical operation specified.

ADC0/1000 this function:

- Takes voltage readings from raw wave ADC0
- Convert mV to V by dividing by 1000
- Current amplifier is set at 1e9 amplification so V => nA in this case (but may need to do further calculation to convert to nA)

Update ADC

Clicking Update ADC will read the current value from the ADC channels

Save Raw Data

Checking Save Raw Data will save the raw data. We recommend to keep this checked (HD space is a negligible cost).

Resample (Resample Frequency)

Checking Resample will resample the raw data to the requested frequency.

I.e. Lowpass filters then downsamples to reduce datapoints significantly while maintaining info below resample frequency.

ADC Speed

This is the frequency that ScanControllerFastDAC will read values from the FastDAC ADC

DAC

Ch	Output	Limit	Label	Ramprate
0	0	-550,10	ACC*2	10000
1	9.7659	-10000,10000	ACC*400	1000000
2	0	-700,100	CSQ	10000
3	0	-1000,100	CSS	10000
4	0	-1000,100	SDP	10000
5	0	-1000,100	SDC	10000
6	0	-2000,2000	OHV*100	10000
7	0	-2000,2000	OHC(10M	10000
8	0	-1000,100		10000
9	0	-1000,100		10000
10	0	-1000,100		10000
11	0	-1000,100		10000
12	0	-1000,100		10000

ADC

Ch	Input (mV)	Record	Wave Name	Calc Function
0	4.1962	<input checked="" type="checkbox"/>	cscurrent	ADC0/1e9/100
1	0.17869	<input type="checkbox"/>	wave1	ADC1
2	2.594	<input type="checkbox"/>	wave2	ADC2
3	0.59731	<input type="checkbox"/>	wave3	ADC3
4	3.4831	<input type="checkbox"/>	wave4	ADC4
5	1.9693	<input type="checkbox"/>	wave5	ADC5
6	3.7859	<input type="checkbox"/>	wave6	ADC6
7	3.1708	<input type="checkbox"/>	wave7	ADC7

Update ADC Print filenames ☒ Save raw data ☒

Resample ☐ Resample Frequency 300 Hz

ADC1 speed 372 Hz ADC2 speed 2538 Hz

ADC3 speed 2538 Hz ADC4 speed 2538 Hz

ADC5 speed 2538 Hz ADC6 speed 2538 Hz

Update Ramp Ramp all 0

Connect Instrument

openLS370connection("ls370", "10.18.1	
openFastDACconnection("fd", "ASRL18::	
openBabyDACconnection("bd", "ASRL10	InitBabyDACs(bd, "5.4", "55.55")

Open GUI

Log Status

getls370status(ls370)
getfdacstatus(fd)
GetBDDACStatus(bd)
GetLS625Status(magy)

Connect Instr Open All GUI Kill Sweep Controls Close All Graphs Update

Press Update to save changes.

ScanControllerFastDAC - Connecting and Logging

Connect Instrument

Copy + Paste the function for connecting to an instrument
Change to verbose = 0

Open GUI

This will bring up the GUI interface with an instrument if it has been written.

Mainly used for the BabyDACs

InitBabyDACs(bd, "5,4", "55,55")

Log Status

Logging functions collect meta data about each scan.

FastDAC: getFDACStatus(fd)

BabyDAC: GetBDDACStatus(bd)

LS370: getLS370Status(ls370) ← Fridge Temps

LS625: GetLS625Status(magy) ← Mag Field

DAC

Ch	Output	Limit	Label	Ramprate
0	0	-550,10	ACC*2	10000
1	9.7659	-10000,10000	ACC*400	1000000
2	0	-700,100	CSQ	10000
3	0	-1000,100	CSS	10000
4	0	-1000,100	SDP	10000
5	0	-1000,100	SDC	10000
6	0	-2000,2000	OHV*100	10000
7	0	-2000,2000	OHC(10M	10000
8	0	-1000,100		10000
9	0	-1000,100		10000
10	0	-1000,100		10000
11	0	-1000,100		10000
12	0	-1000,100		10000

ADC

Ch	Input (mV)	Record	Wave Name	Calc Function
0	4.1962	<input checked="" type="checkbox"/>	cscurrent	ADC0/1e9/100
1	0.17869	<input type="checkbox"/>	wave1	ADC1
2	2.594	<input type="checkbox"/>	wave2	ADC2
3	0.59731	<input type="checkbox"/>	wave3	ADC3
4	3.4831	<input type="checkbox"/>	wave4	ADC4
5	1.9693	<input type="checkbox"/>	wave5	ADC5
6	3.7859	<input type="checkbox"/>	wave6	ADC6
7	3.1708	<input type="checkbox"/>	wave7	ADC7

Update ADC Print filenames ☒ Save raw data ☒

Resample ☐ Resample Frequency 300 Hz

ADC1 speed 372 Hz ADC2 speed 2538 Hz
 ADC3 speed 2538 Hz ADC4 speed 2538 Hz
 ADC5 speed 2538 Hz ADC6 speed 2538 Hz

Connect Instrument **Open GUI** **Log Status**

openLS370connection("ls370", "10.18.1		getls370status(ls370)
openFastDACconnection("fd", "ASRL18::		getfdacstatus(fd)
openBabyDACconnection("bd", "ASRL10	InitBabyDACs(bd, "5,4", "55,55")	GetBDDACStatus(bd)
		GetLS625Status(magy)

Connect Instr Open All GUI Kill Sweep Controls Close All Graphs Update

Press Update to save changes.

Calibrating the FastDAC

1. `CalibrateFDAC`(instrID) e.g. `CalibrateFDAC(fd)`
2. Using a BNC, connect:
 - ADC 0 to DAC 0
 - ADC 1 to DAC 1
 - ADC 2 to DAC 2
 - ADC 3 to DAC 3
3. `CalibrateFADC`(instrID) e.g. `CalibrateFADC(fd)`

BabyDAC Basic Scan (found in 'scans.ipf')

`ScanBabyDAC`(instrID, start, fin, channels, numpts, delay, ramprate, [y_label, comments, nosave])

instrID: Name of the instrument when you open a connection

start: Starting voltage in mV

fin: Finishing voltage in mV

channels: Channels to sweep with these setting.

The channel can be specified by providing the channel number or label set in ScanController BabyDAC Window E.g. "0" or "ACC*2"

numpts: Number of points in scan. This is historic from the BabyDAC scans.

delay: This is the delay between finishing the ramp to the starting voltage and taking the first data point. This can normally be set to be quite short e.g. 1s

ramprate: This is the rate to ramp to the starting voltage. This can normally be set quite high e.g. 10000

Optional

y_label: The y label on the plotted graph.

comments: These comments are saved in the hdf file and can be useful during analysis

nosave: The output will be saved as default under a new dat. However specifying nosave=1 will not save the scan

EXAMPLES

`ScanBabyDAC`(bd, -10, 10, "OCSB*1000", 10, 0.001, 1000, y_label="current", comments="testing", nosave=1)

FastDAC Basic Scan (found in 'scans.ipf')

ScanFastDAC(instrID, start, fin, channels, [numpts, sweeprate, ramprate, delay, starts, fins, x_label, y_label, comments, use_AWG, nosave])

sweeprate: This is the rate at which the FastDAC will sweep from the starting voltage to the finishing voltage. In units of mV/s

The time taken for a scan can be calculated by: $\text{Time of Scan} = (\text{fin} - \text{start}) / \text{sweeprate}$

delay: This is the delay between finishing the ramp to the starting voltage and taking the first data point. This can normally be set to be quite short e.g. 1s

starts: This is used if you want to ramp multiple channels at the same time.

This can be done with the syntax "<channel1-start-mV>, <channel2-start-mV>" where <channel1-start-mV> is the starting voltage for channel 1.

fins: Similar to starts

Fins is the ending voltage of multiple channels "<channel1-end-mV>, <channel2-end-mV>" where <channel1-end-mV> is the ending voltage for channel 1.

x_label: The x label on the plotted graph should be set to the channel that is being ramped but this argument provides control if necessary

y_label: The y label on the plotted graph.

FastDAC Basic Scan (found in 'scans.ipf')

Sweeping One Channel

`ScanFastDAC`(fd, -10, 10, "ACC*400", sweeprate=20, ramprate=10000, delay=0, comments="testing", nosave=1)

We will scan FastDAC labelled as fd

- On channel "ACC*400"
- From -10mV to 10mV
- A sweeprate of 20 in this instance will be a 1 second scan. $(10 - (-10))/20 = 1$
- Ramprate specifies how fast to ramp to starting voltage -10mV
- Once we reach -10mV the FastDAC will not delay and it will start sweeping immediately

Sweeping Multiple Channels

`ScanFastDAC`(fd, -100, 100, "OHV*1000, OHC(10M)", sweeprate=10, starts="-100, 70", fins="100, -70", comments="Checking ratio for 0 bias", nosave=1)

We will scan FastDAC labelled as fd

- We will be ramping channels "OHV*1000, OHC(10M)"
- "OHV*1000" from -100mV to 100mV
- "OHC(10M)" from 70mV to -70mV
- A sweeprate of 10 in this instance will be a 20 second scan. $(100 - (-100))/10 = 20$

List of scan template names (found in 'scans.ipf')

BabyDAC scans

ReadVsTime
ReadVsTimeUntil
ScanBabyDACUntil
ScanBabyDAC2D
ScanBabyDACRepeat
ScanBabyDAC_SRSAmplitude

FastDAC scans

ReadVsTimeFastdac
ScanFastDAC
ScanFastDacSlow
ScanFastDAC2D
ScanFastDACRepeat
FDacSpectrumAnalyzer

ScanBabyDAC_SRSAmplitude is just an example function to show how you can change some other instrument in the y-axis

'Pseudo code' edit of ScanBabyDAC to also ramp lock-in

```
function ScanBabyDAC_SRSAmplitude(babydacID, srsID, startx, finx, channelsx,  
numptsx, delayx, rampratex, starty, finy, numpty, delayy, [comments, nosave])
```

```
    // Reconnect instruments  
    sc_openinstrconnections(0)
```

```
    // Initialize ScanVars  
    InitBDscanVars()
```

```
    // Check software limits and ramprate limits  
    SFbd_pre_checks()
```

```
    // Ramp to start without checks because checked above  
    SFbd_ramp_start()
```

```
    // Let gates settle  
    sc_sleep()
```

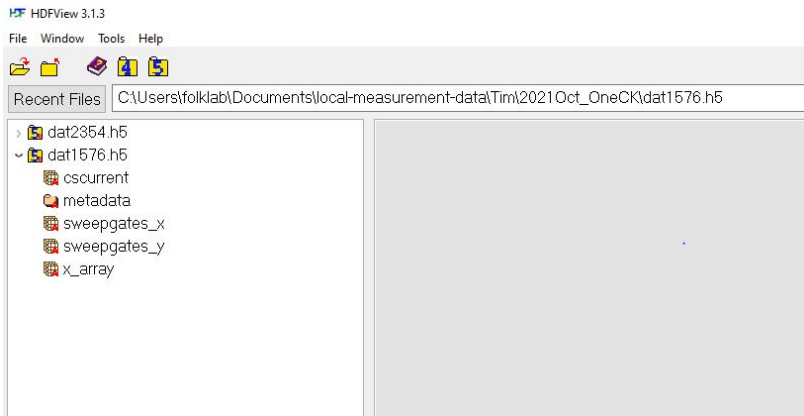
```
    // Make waves and graphs etc  
    initializeScan()
```

```
    // main loop  
    variable i=0, j=0, setpointx, setpointy  
    do  
        setpointx = S.startx  
        setpointy = starty + (i*(finy-starty))/(S.numpty-1)  
        RampMultipleBD(S.instrID, S.channelsx, setpointx, ramprate=S.rampratex, ignore_lims=1)  
        SetSRSAmplitude(srsID, setpointy)  
        sc_sleep(S.delayy)  
        j=0  
        do  
            setpointx = S.startx + (j*(S.finx-S.startx))/(S.numptsx-1)  
            RampMultipleBD(S.instrID, S.channelsx, setpointx, ramprate=S.rampratex, ignore_lims=1)  
            sc_sleep(S.delayx)  
            New_RecordValues(S, i, j)  
            j+=1  
        while (j<S.numptsx)  
        i+=1  
    while (i<S.numpty)  
  
    // Save by default  
    if (nosave == 0)  
        EndScan(S=S)  
    else  
        ddownwindow /k SweepControl  
    endif  
end
```

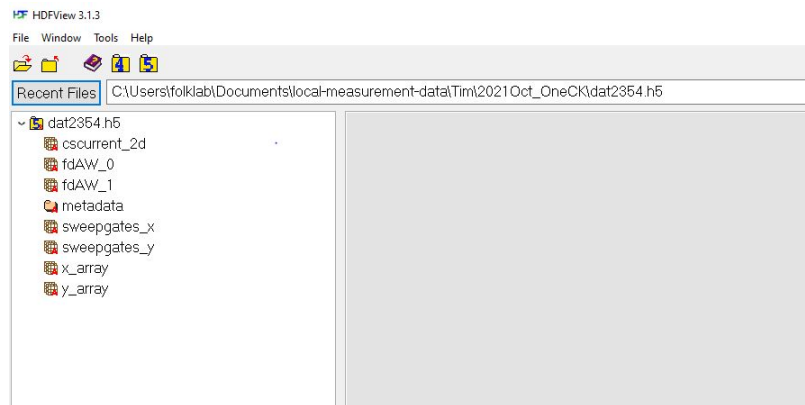
Manual inspection of hdf file

- Click on file in C:\Users\folklab\Documents\local-measurement-data\<your name>\<experiment>
- Or open application 'HDFViewer' and 'open file'

1D Scan



2D Scan



Manual inspection of sweeplogs

1. Click on 'metadata'
2. Click on 'sweeplogs'
3. Copy (ctrl-c) the cell

4. Go to a json viewer website
5. <https://codebeautify.org/jsonviewer>
6. Paste (ctrl-v) and click 'beautify'

The image is a composite of three screenshots illustrating the process of inspecting sweeplogs:

- Top Left:** A screenshot of the HSPView 3.3.3 application. The 'Recent Files' list shows 'dat1576 h5'. The left sidebar has 'metadata' selected. The main window displays 'Object Attribute Info' for 'sc_config' and 'sweep_logs'. A small 'sc_config' window is open in the foreground, showing 'O-based' settings.
- Top Right:** A screenshot of the 'Code Beautify' JSON Viewer website. The JSON data is pasted and displayed in a formatted, color-coded view. The 'Beautify' button is visible.
- Bottom:** A screenshot of the 'JSON to CSV' converter website, showing the same JSON data being converted into a CSV format.

Using Python to parse hdf files

```
import h5py
import json

with h5py.File(<path-to-file>) as f:
    cscurrent = f['cscurrent '][:]
    config = f['metadata'].attrs['sc_config ']
    sweeplogs = f['metadata'].attrs['sweep_logs']
    sweepgates_x= f['sweepgates_x'][:]
    x_array= f['x_array'][:]

d = json.loads(sweeplogs)

fdac1f = d['FastDAC 1']['MeasureFreq']
```

1. We open the file with the path name, this can be relative or absolute
2. We ask for an attribute of 'metadata' in this case we want 'sweep_logs'
3. Turn the sweep_logs into json format
4. Pull the 'MeasureFreq' from 'FastDAC 1'

Using Regex to find hdf file path from datnum

```
import re

import os

datnum = 42

regex = re.compile(r'.*dat' + str(datnum) + '.h5$')

path = <path-to-folder>

filename = []

for root, dirs, files in os.walk(path):

    for file in files:

        if regex.match(file):

            if full_path == 1:

                filename.append(path + '/' + file)

            else:

                filename.append(file)
```

1. Set a regex expression that will check if the string contains 'dat<dat-num>.h5'
2. Look at all the files in the folder that is provided in path
3. If the filename matches the regex expression, append to filename list

Generally filename should only be 1 element long, but sometimes you may find that you have multiple files with the same dat number. So checking all the files which match the regex is good practice to test for duplicates.

Instrument not responding correctly

```
print fd, bd, magy, bd_window_resource  
1 2 2 1
```

Here we see that bd and magy are equal to the same variable and IGOR is getting confused.

Possible solution

- `killvariables` fd, bd, magy, bd_window_resource
- `killvisa()`
- Click 'Connect Instr' in the ScanController or ScanControllerFastDAC window

Check if each variable is now equal to a unique integer

```
print fd, bd, magy  
1 2 3
```

Bytes left in FastDAC buffer

Sometimes if bytes are 'left'/'stuck' in the FastDAC buffer, a function will abort with the error

[ERROR] "getFDACOutput": Bad response:

Possible solution

- `clearfdacBuffer(fd)`