HDice Status Meeting

Date: September 11, 2020
Time: 11:00AM – 11:40AM

Attendees: Peter Bonneau, Aaron Brown, Pablo Campero, Brian Eng, Tyler Lemon, Marc McMullen, Amrit Yegneswaran

1. Presented and discussed "fsNMR Requests Made August 20, 2020" talk
    1.1. Talk attached at end of minutes

2. VI requested and provided to remotely control Oxford IPS 120 power supply while UITF tests are occurring
    2.1. Initial VI developed by Peter Bonneau for VISA driver development
    2.2. HDice group requested addition of power supply voltage readback and heater switch control, developed by Tyler Lemon

3. Discussed findings of CSV conversion to HDF5 (Hierarchical Data Format version 5) investigation
    3.1. HDF5 files have .h5 file extension and store all data in subsets
    3.2. Tyler Lemon developed Python program to read CSV file and create HDF5 file from data
    3.3. When HDF5 file was uploaded to Zurich lock-in amplifier, instrument gave error stating to check file permissions
    3.4. Discovered that lock-in amplifier can only have files that it creates uploaded to it
        3.4.1. .h5 files it creates most likely has metadata or checksum that verifies that file has not been manipulated
    3.5. DSG will continue developing Zurich lock-in amplifier-based fsNMR program
    3.6. Tom O'Connell of HDice group will look into whether there is a paid option that would allow uploading files

fsNMR Requests Made August 20, 2020

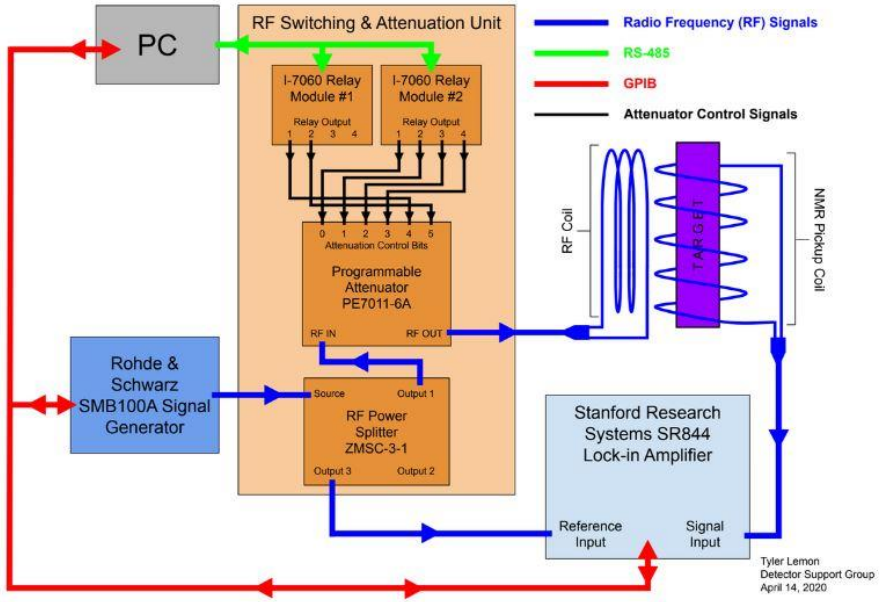
Tyler Lemon
Detector Support Group
August 25, 2020

Contents

- Overview of fsNMR
- Initial fsNMR request
- Additional fsNMR requests
- Change acquisition of lock-in amplifier *X* and *Y* to calculation
- Change *X* and *Y* scaling equations
- Implement cryogenic sensor logging
- Develop new program based on Zurich lock-in amplifier
  - Overview
  - Timeline
  - Task Breakdown
- Conclusion

fsNMR Overview

- Frequency-swept NMR (fsNMR) program sweeps lock-in amplifier's reference frequency while holding magnetic field around target constant
- Lock-in amplifier measures any NMR response induced in the target
- DSG has been developing and adding features to fsNMR program since March 2020



Initial fsNMR request (requested 3/12/2020, completed 4/20/2020)

- Modify fast resonance scanner program to sweep multiple times (aka multiple cycles)
  - Display average of previous sweeps on same plot as original data
  - Save all data from all cycles
  - Save average of all cycles
  - Save settings used in lock in amplifier on in a file
  - Add *X*, *Y* readout in addition to *R*, Phase readout
- Add ability to subtract background data from current cycle and scale new data to the background
  - Background data is any data from a previous run
  - Formula for scaling: $S = (N - B) \times \frac{M}{B}$
    - S = scaled data for frequency *f*
    - N = new data from current run at frequency *f*
    - B = background data point at frequency *f*
    - M = absolute maximum of background data

Additional fsNMR requests

#	Task	Date Requested	Status
3	Added feature to require user to set attenuation to use in cycles if no background is used	5/14/2020	Completed 6/11/2020
4	Added automatic setting of attenuator based on background settings if background is used	5/14/2020	Completed 6/11/2020
5	Add ability to log raw data in addition to scaled data to fsNMR program	5/14/2020	Completed 6/11/2020
6	Change program to log data at completion of each cycle rather than at end of program	5/14/2020	Completed 6/11/2020
7	Add delay between cycles	5/14/2020	Completed 6/11/2020
8	Add ability to manually scale y-axis on all plots	5/14/2020	Completed /6/11/2020
9	Implement cryogenic sensor logging into fsNMR program	5/14/2020	Completed 8/24/2020
10	Remove background scaling from phase	6/11/2020	Completed 6/11/2020
11	Develop new program using Zurich lock-in amplifier	6/11/2020	Not started, waiting for fsNMR program to be finalized
12	Develop data review program	7/30/2020	Completed 8/5/2020
13	Debug plot coloring and raw data logging	7/30/2020	Completed 8/5/2020
14	Debug Zurich lock-in amplifier communication	8/6/2020	Completed 8/19/2020
15	Debug NMR rack serial communication errors	8/10/2020	Completed 8/10/2020
16	Change fsNMR program scaling/acquisition method for X and Y	8/12/2020	Completed 8/25/2020
17	Add ability to save screenshot of program front panel upon completion of scans	8/25/2020	In progress, looking into how to implement screenshot funcitonality

As of 8/26/2020, only tasks #11 and #17 remains

Change Acquisition of Lock-In Amplifier *X* and *Y* to Calculation

- Previously, program directly acquired amplitude, phase, *X*, and *Y* components of NMR signal measured by lock-in amplifier
- HDice requested that acquisition be replaced with calculation based on amplitude and phase of NMR signal measured by lock-in amplifier
- Motivation:
  - Previously thought that calculation of *X* and *Y* would take too much processing power
    - With new, more powerful PC, that is not the case
  - Since lock-in amplifier calculates *X* and *Y* from amplitude and phase, results of acquiring *X* and *Y* from lock-in amplifier or calculating *X* and *Y* from *Amplitude* and *Phase* in LabVIEW should be the same
- Next steps:
  - Awaiting results of discussion and feedback

Change *X* and *Y* Scaling Equations

Old Equations

Equation applied to Amplitude, X, and Y

$$S = (N - B) \times \frac{M}{B}$$

S = resulting scaled data
N = newly acquired data for frequency *f*
B = background data at frequency *f*
M = absolute maximum of background data

New Equations

$$S_X = \frac{R - R_{0bkgd}}{R_{bkgd}} R_{0bkgd} \cos(\phi - \phi_0)$$

$$S_Y = \frac{R - R_{0bkgd}}{R_{bkgd}} R_{0bkgd} \sin(\phi - \phi_0)$$

R = Amplitude measurement at frequency f
R_{0bkgd} = Absolute maximum amplitude of background data
R_{bkgd} = Background amplitude measurement at frequency f
ϕ = Phase measurement at frequency f
ϕ_0 = Phase of background data at R_{0bkgd}

- Motivation:
  - Better scaling of *X* and *Y* components of NMR signal
- Result:
  - Resulting scaled *X* and *Y* were not as expected
  - Equations again changed to:

$$S_X = (X - X_{bkgd}) \times \frac{R_{0bkgd}}{R_{bkgd}}$$

$$S_Y = (Y - Y_{bkgd}) \times \frac{R_{0bkgd}}{R_{bkgd}}$$

- Next Steps:
  - Awaiting results of discussion and feedback

Implement Cryogenic Sensor Logging

- Add ability to read and log data for liquid helium temperature and level
  - Data read from sensors via RS-232
- Add ability to send email alerts if sensor readings go out of set bounds
- Motivation:
  - To ensure target is healthy as scans are performed by monitoring target conditions in production dewars
- Result:
  - Addition completed on August 24, 2020

Develop New fsNMR Program Based on New Zurich Lock-In Amplifier

- New Zurich lock-in amplifier has built-in signal generator
  - Removes need for external signal generator and RF Attenuation & Distribution Box
- Motivation:
  - Use new equipment that limits additional equipment needed to acquire NMR data

Zurich fsNMR Timeline

Task	Duration (Days)	Aug 31 M	Sept 1 T	2 W	3 TH	4 F	7 M	8 T	9 W	10 TH	11 F	14 M	15 T	16 W	17 TH	18 F	21 M	22 T	23 W	24 TH	25 F	28 M	29 T	30 W
Zurich research	5						Labor Day																	
LabVIEW driver development	10																							
Test program development	10																							
Base fsNMR program development	20																							
Add averaging	5																							
Add background subtraction/scaling	5																							
Add sensor monitoing	5																							
DSG test of program	5																							
HDice test of program	10																							
Develop after feedback	5																							

Some tasks may be performed in parallel.

All durations are estimated assuming only this project is worked on for 40 hours per week.

Zurich fsNMR Timeline (cont.)

Task	Duration (Days)	29	30	October 1	2	5	6	7	8	9	12	13	14	15	16	19	20	21	22	23	26	27	28	29	30	Novemb 2	3	4
		T	W	TH	F	M	T	W	TH	F	M	T	W	TH	F	M	T	W	TH	F	M	T	W	TH	F	M	T	W
Zurich research	5																											
LabVIEW driver development	10																											
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DSG test of program	5																											
HDice test of program	10																											
Develop after feedback	5																											

Some tasks may be performed in parallel.

All durations are estimated assuming only this project is worked on for 40 hours per week.

Zurich fsNMR Timeline (cont.)

Task	Duration (Days)	November																	
		2	3	4	5	6	9	10	11	12	13	16	17	18	19	20	23	24	2
		M	T	W	TH	F	M	T	W	TH	F	M	T	W	TH	F	M	T	W
Zurich research	5																		
LabVIEW driver development	10																		
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DSG test of program	5																		
HDice test of program	10																		
Develop after feedback	5																		

Some tasks may be performed in parallel.

All durations are estimated assuming only this project is worked on for 40 hours per week.

Zurich fsNMR Timeline (cont.)

Task	Duration (Days)	4	25	26	27	30	December 1	2	3	4	7	8	9	10	11	14	15	16	17
		T	W	TH	F	M	T	W	TH	F	M	T	W	TH	F	M	T	W	TH
Zurich research	5			Thanksgiving															
LabVIEW driver development	10																		
Test program development	10																		
Base fsNMR program development	20																		
Add averaging	5																		
Add background subtraction/scaling	5																		
Add sensor monitoing	5																		
DSG test of program	5																		
HDice test of program	10																		
Develop after feedback	5																		

Some tasks may be performed in parallel.

All durations are estimated assuming only this project is worked on for 40 hours per week.

Zurich fsNMR Task Breakdown

- Zurich lock-in amplifier research
  - Research how to use lock-in amplifier's built-in software
  - Research capabilities of Zurich lock-in amplifier
  - Research how to program lock-in amplifier
  - Estimated duration: 5 days
- LabVIEW driver development
  - Develop subVIs to execute functions and features of Zurich lock-in amplifier
  - Estimated duration: 10 days

Zurich fsNMR Task Breakdown (cont.)

- Test program development
  - Develop program using new LabVIEW drivers to replicate lock-in amplifier's built-in software
  - Verify that LabVIEW drivers function correctly
  - Estimated duration: 10 days
- Base fsNMR program development
  - Develop basic fsNMR program features
    - Setting parameters for fsNMR sweeps
    - Amplitude, Phase, X, and Y readout, plotting, and logging
  - Estimated duration: 20 days

Zurich fsNMR Task Breakdown (cont.)

- Add averaging to fsNMR program
  - Add ability to run multiple cycles and average cycle results
  - Log raw data and averaged data
  - Estimated duration: 5 days
- Add background subtraction and scaling
  - Add ability to read previous run as background
  - Program will subtract background from current data and scale new data to background
  - Estimated duration: 5 days

Zurich fsNMR Task Breakdown (cont.)

- Add sensor monitoring
  - Add ability to read, log, and alarm on liquid helium temperature and level
  - Estimated duration: 5 days
- DSG test of fsNMR program
  - DSG testing and debugging of program to ensure all aspects work correctly
  - Estimated duration: 5 days

Zurich fsNMR Task Breakdown (cont.)

- HDice test of fsNMR program
  - HDice group's testing of new program
  - Estimated duration: 10 days
- Additional development after feedback
  - After HDice group's testing, it is expected that there will be feedback on changes to program
  - Estimated duration: 5 days

Conclusion

- Further changes to fsNMR program requested by HDice group
  - Change acquisition of lock-in amplifier *X* and *Y* to calculation
    - Initial changes made, awaiting feedback
  - Change *X* and *Y* scaling equation
    - Initial changes made, awaiting feedback and equation discussion
  - Implement cryogenic sensor logging
    - Completed
- Development of new program based on Zurich lock-in amplifier requested
  - Development of new program to take ~4 months

Thank You