HDice NMR Synchronization Status

Detector Support Group

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Synchronization Topics

- Goals of synchronization.
- Functionality of existing NMR.
- Planned features of synchronized NMR.
- Limitations of Lock-in Amplifier.
- Synchronization test programs.
- Project schedule.
- Status summary.

Goals of NMR Synchronization

- Provide an independent and accurate magnet current measurement.
- Current measurements to be synchronized with the lock-in amplifier measurements.
- Maximize the number of acquisition points for variable NRM sweep lengths (20-600 sec.)
- Store measurements in NMR data files.

Existing NMR Program

- Uses internal lock-in amplifier triggering.
- Current/field is read back from power supply.
- Asynchronous lock-in amplifier and current measurements.
- Different acquisition rates for current/field measurements and stored lock-in amplifier data.
- Current measurements are not stored in NMR data files.

NMR Synchronization Features

- Use external lock-in amplifier triggering.
- Current measured by shunt instrumentation.
- Current and lock-in amplifier measurements synchronized.
- Variable acquisition rates to maximize number of data points.
- Synchronized current & lock-in amplifier measurements stored in NMR data files.

Comparison of Features

Feature	Existing NMR	Synchronized NMR
Triggering	Asynchronous lock-in trigger.	Synchronized by external lock-in trigger.
Current Measurement Instrumentation	Oxford Power Supply.	CT-Box current shunt.
Data Stream	Asynchronous lock-in amplifier and current measurements.	Synchronized lock-in amplifier and current measurements
Data Acquisition Rates	Different DAq rates for lock-in buffer data & current measurements.	Same DAq rate for instrumentation. Variable rate to maximize data points.
Data Files	Current measurements not stored in NMR data files.	Current and lock-in amplifier measurements are stored in NMR data files.

CAENels CT-Box Current Shunt

Synchronization based on a new product by CAENels:

- Summary of Specifications:
  - +/- 150 Amp range
  - 24 bit ADC current resolution
  - < 0.005% current accuracy
  - 1Hz – 100 KHz sampling frequency in 10µs steps (Oscilloscope mode)
  - Output TTL triggering
  - Local current monitoring and status
- New product Issues:
  - Firmware errors requiring updates.
  - Hardware issues.
  - Lack of documentation on software protocols, etc.
  - Not shipped with software we could use.
  - Required extensive development of a library of LabVIEW instrument device drivers.
  - Developed LabVIEW DAq code using DSG device driver library to test the CT-box.
  - **All Issues resolved.**

Lock-in Amplifier

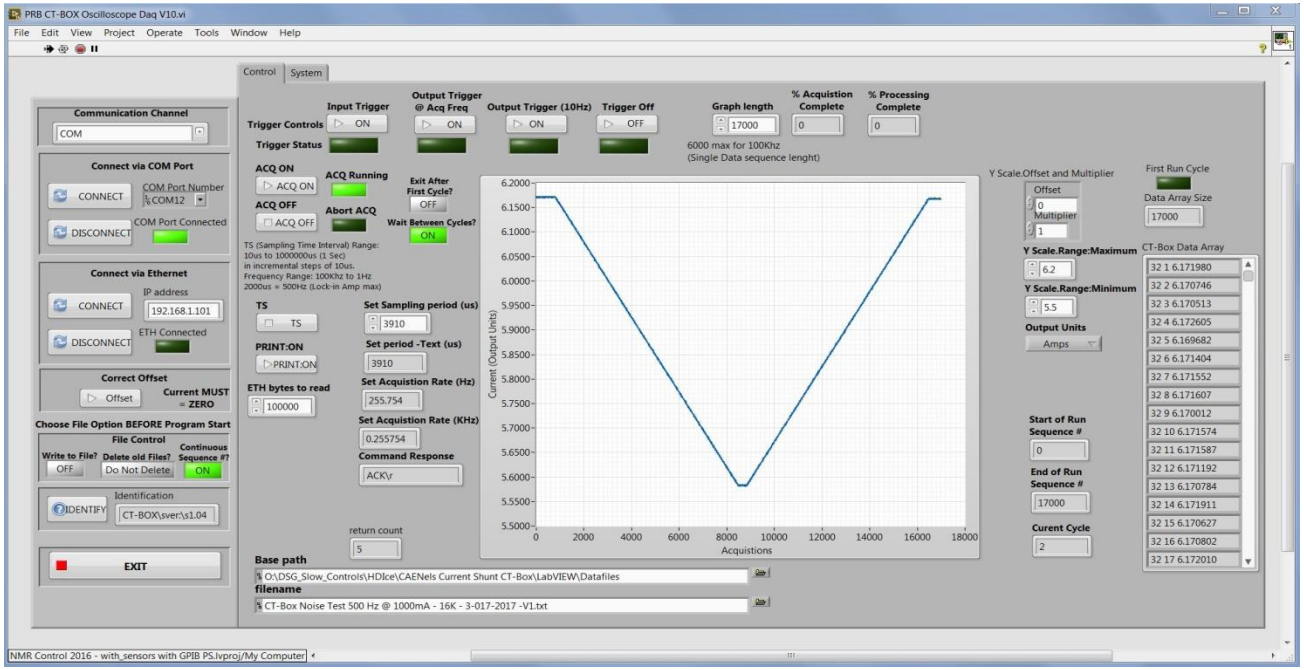
- Stanford SR844 Lock-in Amplifier Limitations:
  - Internal buffer depth only 16.3K:
    - Limits number of data points on NMR sweeps.
    - Must lower acquisition frequency on longer sweeps.
  - No output trigger available.
  - Slow acquisition rate – 512Hz maximum (internal trigger)
  - Slow buffer data readout speed (~70 Sec. for 16K)
  - Input (external) triggering issues:
    - Specifications: *Up to 512 Hz external triggering.*
    - DSG testing shows at acquisition frequency ~>300Hz, trigger efficiency is less than 100%
    - Trigger efficiency needs to be 100% for synchronization.

Synchronization Test Programs

- CT-Box data acquisition program.
- Lock-in amplifier test program.
- Triggering efficiency program.
- NMR development test program.

Synchronization Test Programs

- CT-Box data acquisition program.
  - Tests CT-Box data acquisition and triggering.
  - Uses queued data (FIFO)
    - Acquisition & data decode are independent processes.

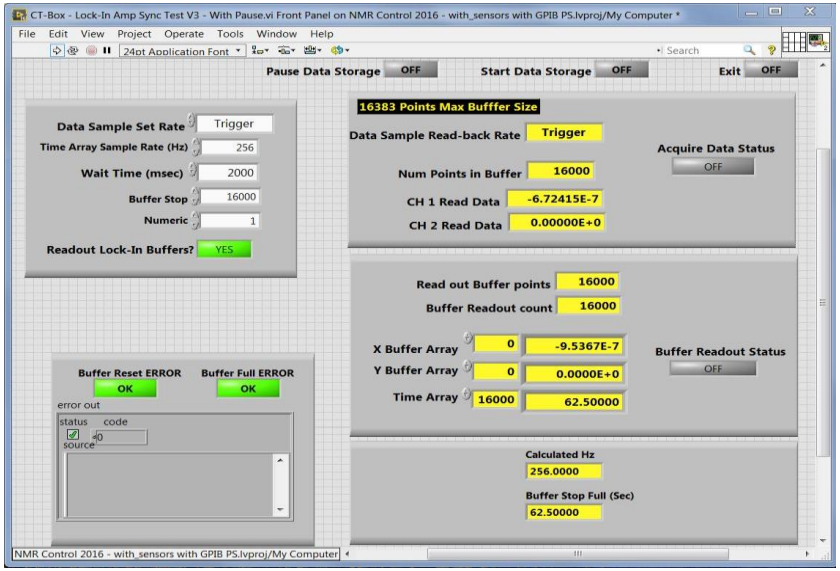


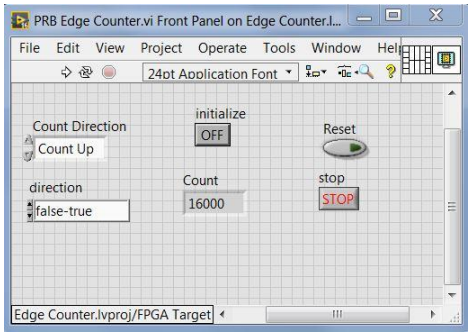
Synchronization Test Programs

- Lock-in amplifier test program.
- Triggering efficiency program.

Programs used together to test:

- Lock-in amplifier data acquisition.
- Data buffer storage and read out.
- Lock-in amplifier dual data stream.
- Lock-in amplifier external triggering capabilities and limitations.





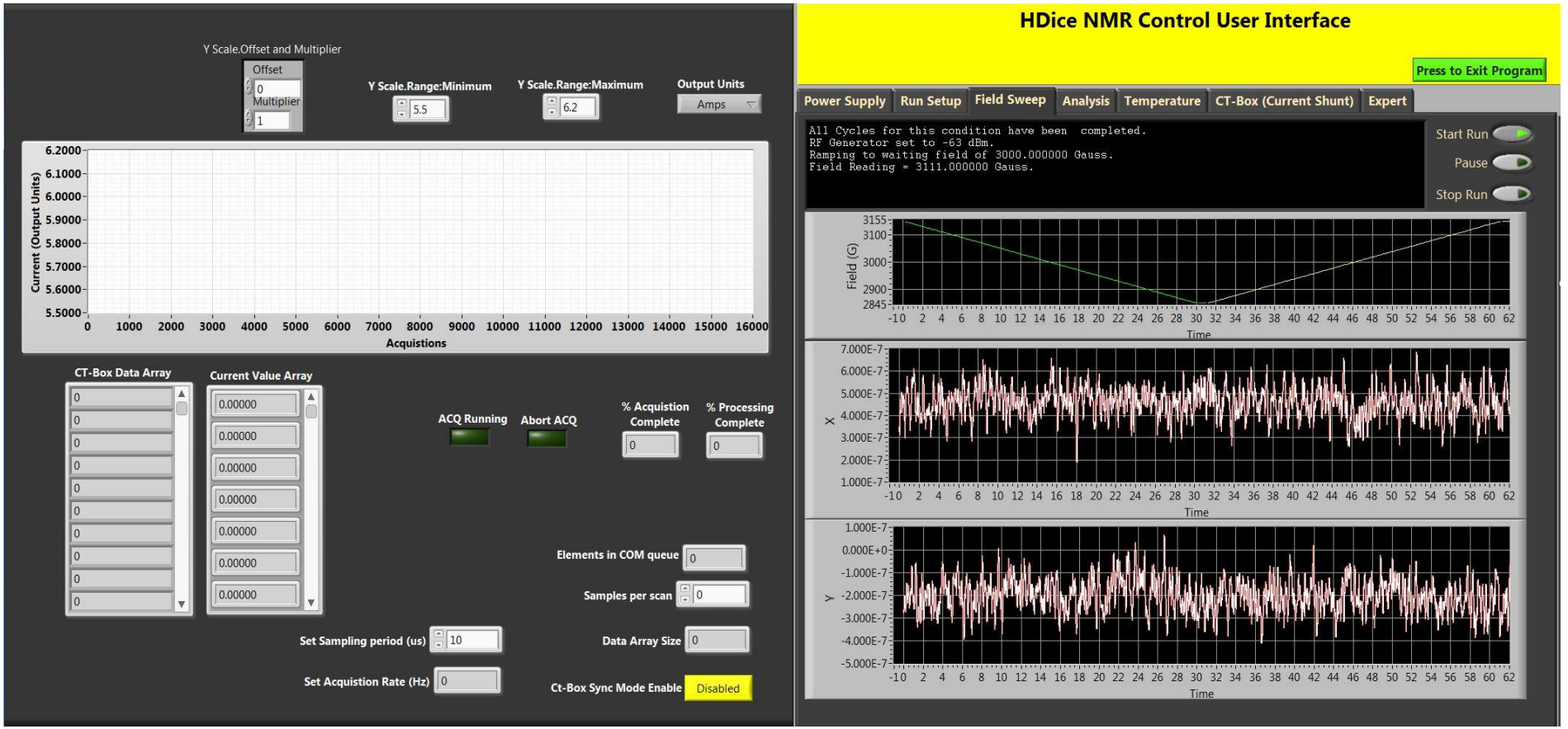
NMR Development Test Program

- **Instrumentation used in NMR**
  - RF Signal Generator.
  - RF Switching/Attenuator Box.
  - Magnet Power Supply
  - Helium temperature & level.
  - **Lock-in Amplifier.**
  - **Current Shunt**

NMR Development Test Program

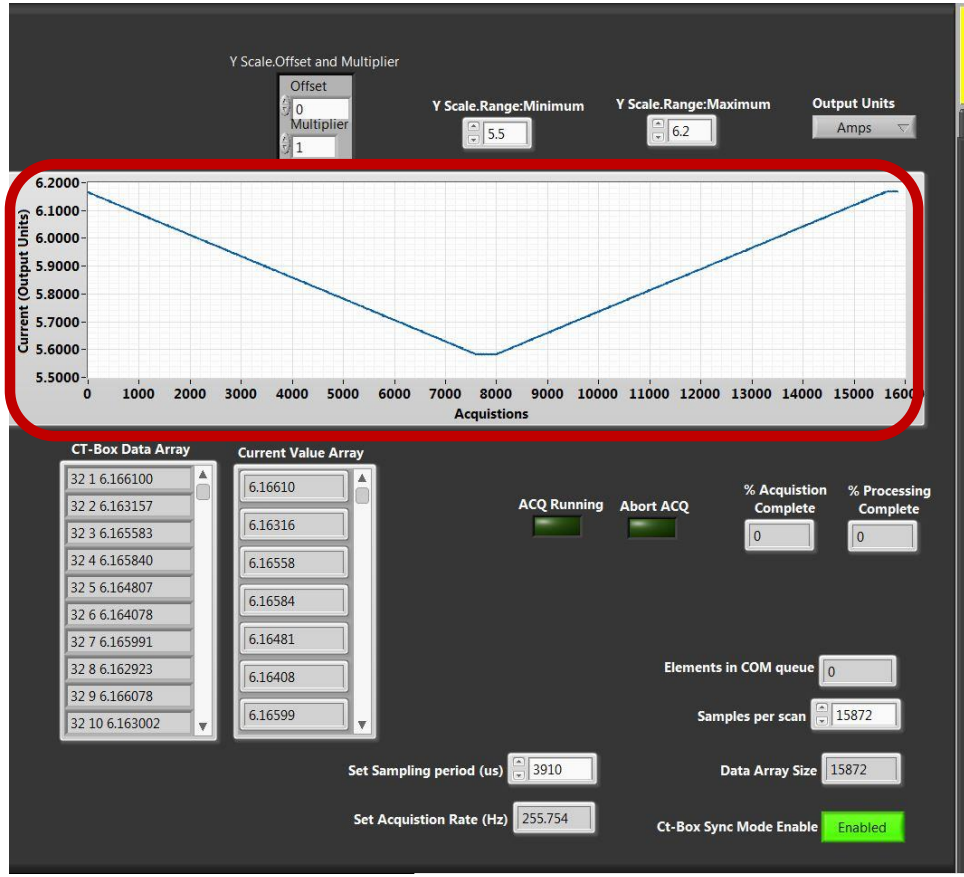
- Tests the communication and timing between NMR Instrumentation.
  - CT-Box does not have an internal buffer memory.
  - Computer must accept CT-Box serial communication stream at data acquisition rate.
  - Program must communicate with all instrumentation used in NMR without dropping CT-Box events.

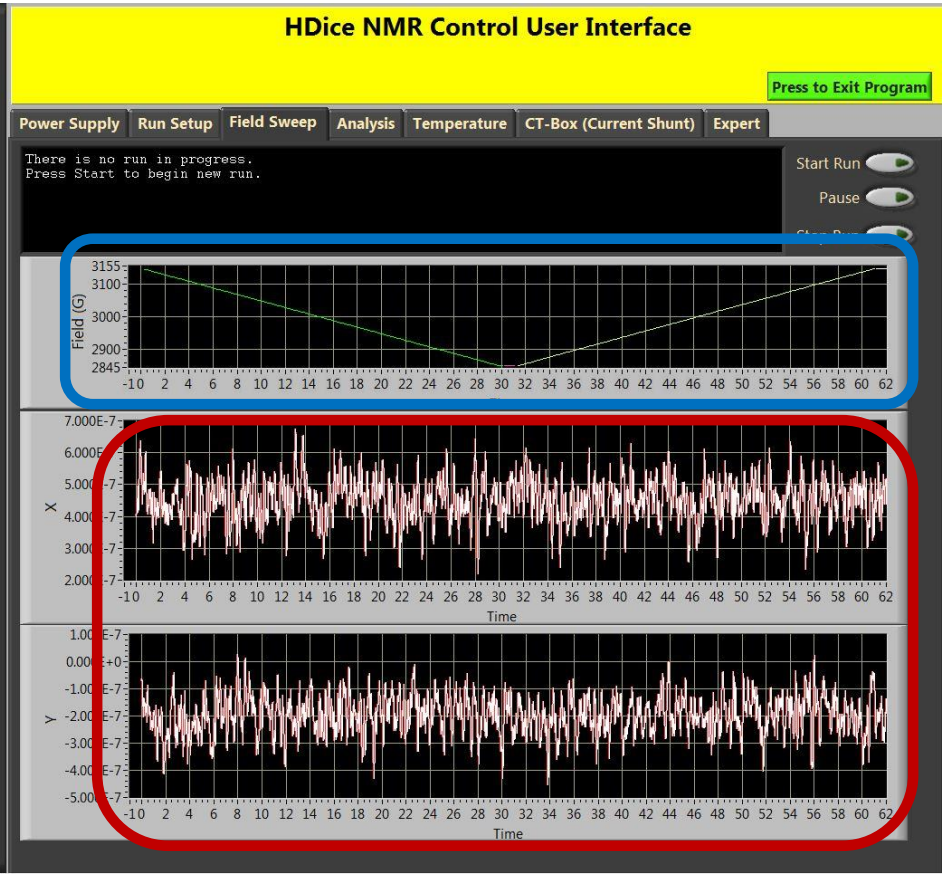
NMR Development Test Program



Asynchronous Test Sweep

NMR Development Test Program





Synchronous Test Sweep

Synced CT-Box & Lock-in Data

Async Power Supply Data

Synchronization Schedule

DSG HDIce Schedule 2/22/2018		Feb		March				April					May				June				July					August				September				October				
		19	26	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10	17	24	1	8	15	22	29
Upgrade of RF Rack #1	Upgrade of RF Box # 1 and # 2:																																					
	Upgrade electronics for readback of terminator and cable types & interlock status																																					
	Debug and test																																					
	Isolate rack mounting on RF generator, RF amplifier, RF box, signal generator																																					
	Configure new PC and instrumentation interface hardware for NMR rack 1 upgrade																																					
	Debug and test NMR, RTP, and FRS programs with upgraded instrumentation																																					
	Rack 1 instrumentation used to develop synchronization hardware and software																																					
	Install & debug instrumentation, computer, power supply, and hardware interfaces in HDIce lab																																					
Synchronization for Lock-in Amplifier Data	Develop, debug, and test hardware trigger interface for CT-box to lock-in amp																																					
	Develop code interface between lock-in amp triggers with current measurement device drivers																																					
	Develop test program to test triggering rate efficiency and timing																																					
	Develop, debug, and test synchronization library sub-routines into lock-in amp DAQ code																																					
	Modify, debug, and test NMR subroutines to write synchronized measurements to data file																																					
	Integrate, debug, and test synchronization code package into main NMR program																																					
Debug Gauss offset issue in NMR scans																																						
Modify, debug, and test NMR code to write gauss/current measurements to data file																																						
Revise RF Splitter/Attenuation boxes to add local instrumentation status readback capabilities																																						
Consolidate RF Splitter/Attenuation box communication interfaces into a single communication interface																																						
Debug VISA device base drivers for Oxford Mercury iPS power supplies																																						
Revise, debug, and test RTP and NMR programs for Oxford Mercury iPS power supplies																																						
Update all NMR LabVIEW instrumentation drivers to VISA.																																						
Rewrite, reorganize, and document NMR main program and subroutine libraries																																						

Status Summary

The present work being done has to address the following questions:

1. **Is the CT-Box current shunt going to work in synchronization?**
2. **What instrumentation will be the trigger for synchronization and will the instrumentation work?**
3. **What are the limitations to the synchronization plan?**
4. **Will the two independent (but triggered by the CT box) data streams from the lock-in amplifier & CT-Box align and have 100% trigger efficiency?**
5. **Can all of the instrumentation used in the NMR program communicate at the same time without losing CT-Box events?**

Code development is underway and more testing is definitely needed, but so far all the answers look encouraging:

1. **Yes.**
2. **CT-Box will trigger the lock-in amplifier and it will work.**
3. **The lock-in amplifier is the limiting factor in the system.**
4. **Yes, the two data streams will align and have 100% trigger efficiency.**
5. **Yes, all instruments can work together at speed without losing CT-Box events.**