

Multi-Sensor Data Acquisition System for Process Monitoring

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ANS Winter Conference. Phoenix, AZ November 13-17, 2022

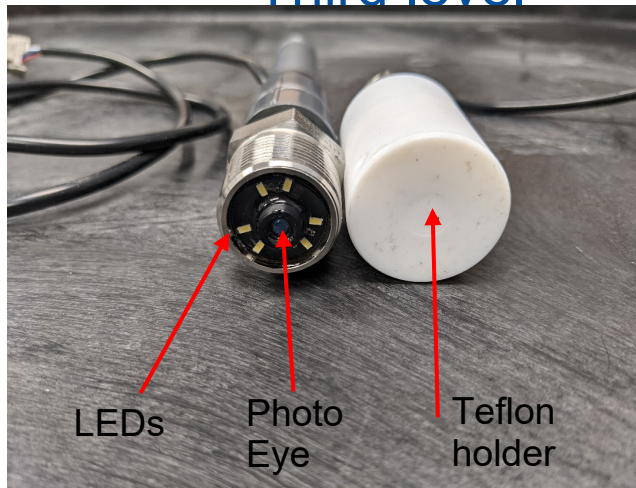
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Monitoring System for Process

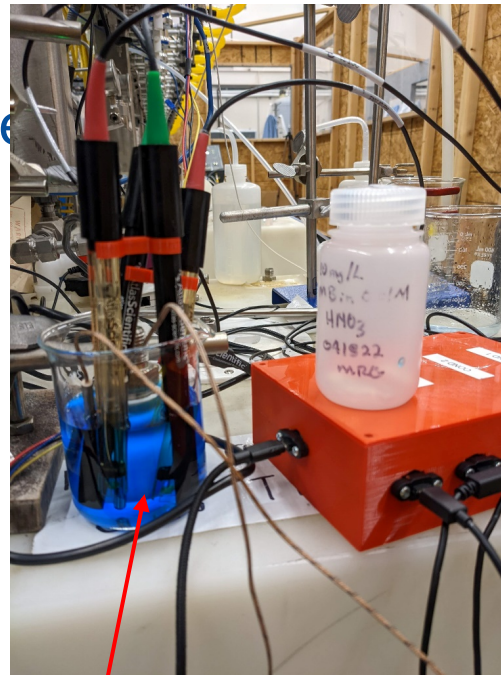
- Idaho National Laboratory (INL) is building a research test bed called Beartooth to help advance research in nuclear fuel cycle reprocessing.
 - Second level
 - Third level
- Beartooth will give researchers the ability to study the solvent extraction process and deploy several innovative technologies.
 - Fourth level
 - Fifth level
- Beartooth will use centrifugal contactors designed for the recovery and purification of special nuclear material.
- As a part of the initiative, this project will integrate non-traditional sensors into the systems which have the potential to enhance nuclear safeguarding efforts and other process activities.

ClickSense - Distributed Master-Replica System for Process Monitoring

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 - **Third level**
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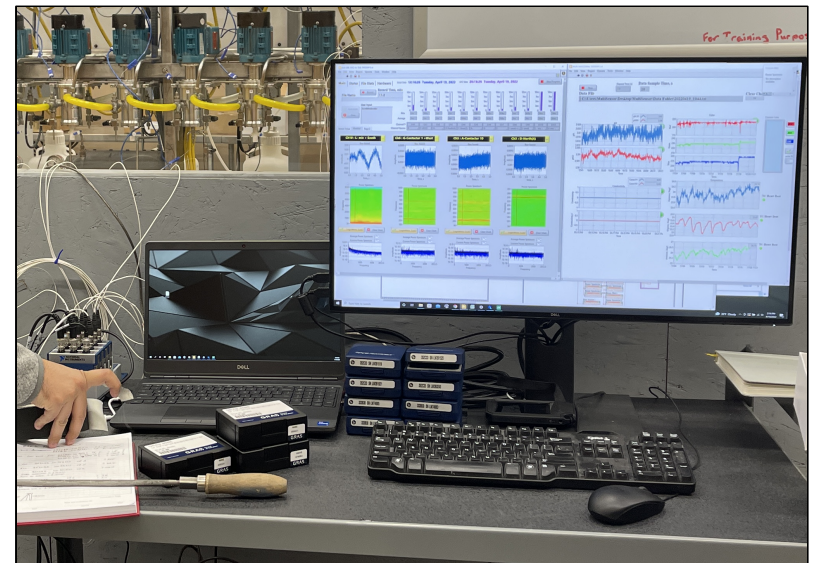
Acoustic Microphone



Accelerometer

Multi-Sensor Data Acquisition System for Process Monitoring

- One of the challenges behind deploying all the sensors is the need for a fast and reliable data collection process.
- The data acquisition system (DAQ) needs to be capable of recording multi-sensors simultaneously at rates up to 12.8kS/s/ch.



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Monitoring System for Process

- Click to edit text. The monitored system employs National Instruments (NI) hardware to digitize the signals.

| Hardware | Item Number | Sample Rate |
|-----------------------------|-------------|-------------|
| Compact DAQ Chassis | CDAQ-9174 | 0-10Mhz |
| C-Series Acquisition module | NI-9230 | 12.8kS/s/ch |

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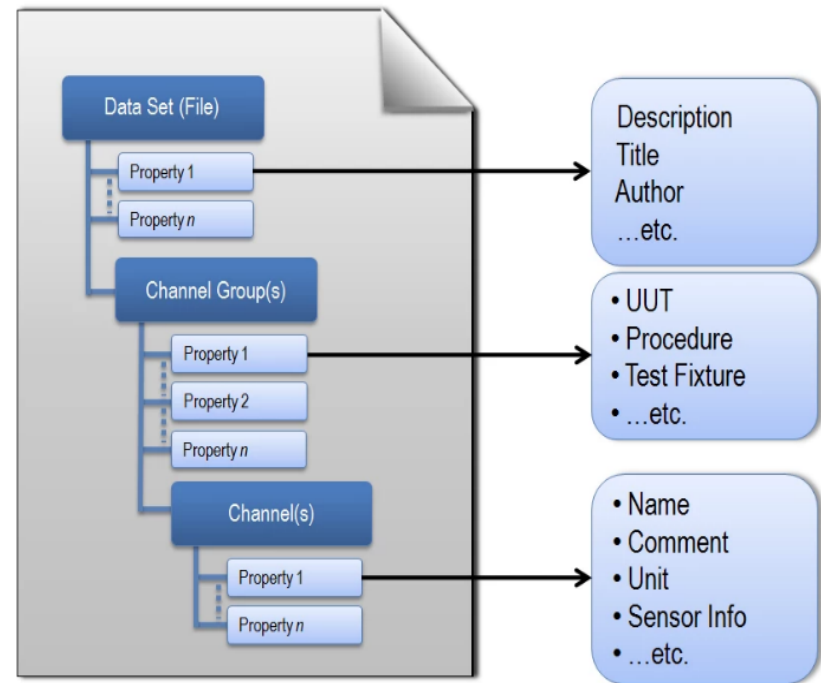
Monitoring System for Process

- Click to edit text
LabVIEW
Second level
- LabVIEW was used to control and record sensor data.
- The Technical Data Management Solutions (TDMS) function inside LabVIEW was utilized to stream the data to disk, without any loss or dropout of information.
- TDMS is a binary file structure.

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Monitoring System for Process

- The data file structure consists of three levels of architectural hierarchy.
 - Second level
 - Third level
- File, Group and Channel
- The file level can contain an infinite number of groups, with each group being able to store an unlimited number of channels.



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Monitoring

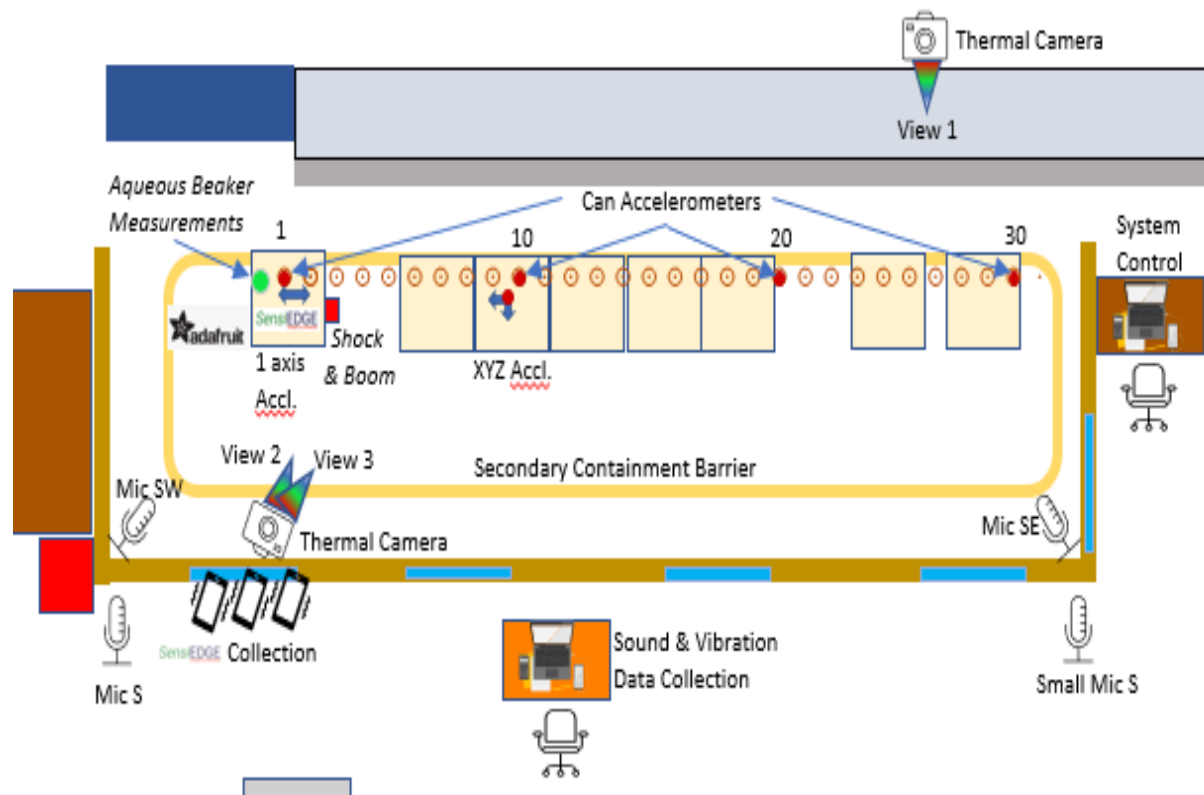
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| Measurement | Sensor | Sensing Range |
|------------------|--|---|
| Vibration | PCB Piezotronics high sensitivity accelerometer | 0.5 Hz-10 kHz |
| Vibration | PCB Piezotronics modal array accelerometer | 0.5-3 kHz |
| Acoustics | GRAS Sound & Vibration ½" Rugged Free-Field microphone | 3.15-20 kHz @ 2dB |
| Acoustics | GRAS Sound & Vibration ¼" Free-Field microphone | 4-80 kHz @ 2dB |
| Acoustics | GEM Infrasound logger | 0.05-25 Hz |
| Seismic-acoustic | Raspberry Shake and Boom | Infrasound 1-44 Hz
Seismic 0.7-44 Hz |
| Color | Atlas Scientific EZO-RGB Embedded Color Sensor | ~425- ~750 nm wavelength |
| pH | Atlas Scientific pH 101P | 0-14 |
| Conductivity | Atlas Scientific Conductivity K 10 | 10 µS/cm-1 S/cm |

Click Sensor Data Acquisition System for Process Monitoring

- During the testing and evaluation, there were 12 inputs to the program.
 - 8 accelerometers
 - 4 microphones
- The limits of the hardware was pushed by setting the upper bound to the max sampling rate of 12.8kS/s/ch.
 - Tested data throughput
 - Tested data dropout
- This sample rate also gives the highest possible measurement fidelity.

Multi-Sensor Data Acquisition System for Process Monitoring



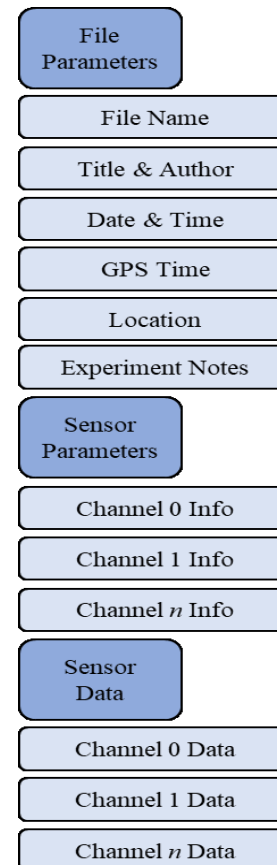
Testing and Evaluation set up

ClickSense - Distributed Master-Replica System for Process Monitoring

- This allowed the data to be buffered then saved to memory without any signal drops or loss of data.
- This was determined by confirming the delta between saved points which was 78.125us or 12.8S/s/ch.
- This sampling rate matched the vendors max sampling rate of the NI-9230 module.

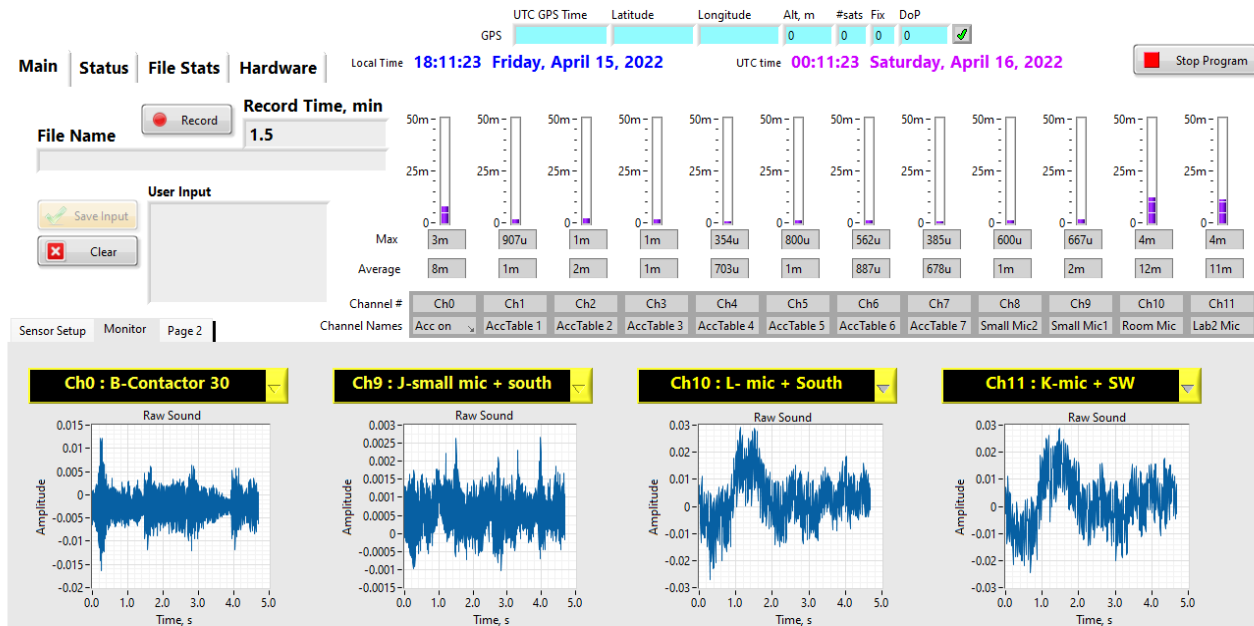
Click-to-Edit Data Acquisition System for Process Monitoring

- This software has also been written to be modular for allowing the addition or removal of sensors depending on experimental needs.
 - Second level
 - Third level
 - Fourth level
 - Fifth level
- The sampling rates can also be changed as needed.
- The picture to the right demonstrated how the TDMS filer was configured in this project.



Click-Read-Data Acquisition System for Process Monitoring

Click-Read-Data



- The GUI was also built to be user friendly.
- The GUI includes multiple tabs that show controls and indicators.
- This provides the operator with real time measurement data.

Click-Seed Data Acquisition System for Process Monitoring

- As part of the fuel reprocessing test bed, this project is exploring the use of non-traditional sensors to monitor the solvent extraction process.
 - Second level
 - Third level
- A robust DAQ system is necessary to allow for the collection and storage of large data sets.
 - Fourth level
 - Fifth level
- The robust DAQ system is essential, not only due to the multiple sensor types, but also for the high sampling rates of each sensor.



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