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National Instrument List Mode Data Acquisition (NILA) System

USER'S MANUAL

E. Trujillo
NEN-1

August, 2013

Revision Sheet

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USER'S MANUAL

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1.0 GENERAL INFORMATION

1.0 GENERAL INFORMATION

The purpose of this user manual is to provide directions, logic, and user support when operating the National Instrument list mode data acquisition system alternative (NILA) used to detect and record neutron pulses. It also describes the methods and logic implemented to use the data for further analysis. With this manual, the user should be able to properly operate the data acquisition system with ease and swiftness as well as handle common errors and problems encountered throughout the acquisition and data analysis process. Points of contact, frequently asked questions, and caveats for each major phase during acquisition and data conversion are provided in the hopes of answering questions and reducing errors the user may typically encounter during operation. Diagrams and explanations of each procedure are also provided to remind the user of the rationality behind each method in the case of a long time span between uses of the system.

1.1 System Overview

The data acquisition system is designed to detect neutron pulses and record the pulses in counts per second (cps) at a set frequency. The pulses may be artificially simulated from neutron simulators or may actually occur during a neutron pulse experiment. Data is then stored to the system and can later be converted (using additional software programs) to be plotted and analyzed using a graphing program.

The data acquisition setup consists of neutron pulse detectors or pulse simulators generating neutron pulses as the input to the system. Data rates are streams into a configurable connector enclosure to be inputted to the acquisition system's data card, where data is then stored to the acquisition system's memory as data files. Using the system's program, the data can be converted and compressed into proper file formats to be outputted and analyzed on a typical graphing program.

The acquisition is operated using LabVIEW as the graphical user interface. With this user program, controls to begin data collection, change the settings in which data is collected, and abort the data acquisition are conveniently located on one screen for the user to operate.

1.2 Project References

Steve Tobin, tobin@lanl.gov, Work: 505-667-3315, virtual instruments to measure spent fuel and differential die-away: NEN-1

Martyn Swinhoe, swinhoe@lanl.gov, Work: 505-665-7577, project coordinator and systems developer: NEN-1

Alison Goodsell, alisong@lanl.gov, Work: 505-667-5834, MCNP modeling: NEN-1

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NEN-2

1.3 Organization of the Manual

- 1.0 General Information – Conveys a general look at the system as well as a general purpose for what the system is used for.
- 2.0 System Summary - Provides an all-purpose overview of the system and outlines the uses of the system in supporting the activities of the user.
- 3.0 Getting Started – Outlines a general walkthrough of the system from initiation through exit. The logical arrangement of the information shall enable the functional personnel to understand the sequence and flow of the system.
- 4.0 Using the “Slow” Acquisition Version – Provides the user with the logic behind using NILA’s “slow” system as well as the necessary steps to execute use the program from open to exit.
- 5.0 Using the “Fast” Acquisition Version – Provides the user with the logic behind using NILA’s “fast” option as well as the necessary steps needed to execute the program from open to exit.
- 6.0 Using the Conversion/Compression Tool – Provides the user with the necessary steps needed to execute the conversion tool to convert data files outputted from the “fast version” to files similar to the “slow” version for analysis and graphing.
- 7.0 Consolidating Data for Plotting Graphs – Affords the user one option to convert data acquired from acquisition system to files that can be easily read by common graphing programs.
- 8.0 Frequently Asked Questions – Lists the most commonly asked questions that the user may encounter while operating the system and any one of the acquisition tools.
- 9.0 Appendix – Provides additional information about device hardware and logic behind each operation that the user may find useful when conducting acquisition tests.
- 10.0 Index – Provides a list of key words and page numbers to refer to.

1.4 Acronyms and Abbreviations

National Instruments LMM Data Acquisition Alternative (NILA) – the hardware and software afforded to the user to collect, store, and manipulate data pertaining to a neutron pulse experiment.

Laboratory Virtual Instrument Engineering Workbench (LabVIEW) – Graphically programmed computer language for real-time instrumentation

Data acquisition (DAQ) – the process of sampling signals (in this case neutron impulses) that measure real world phenomena and converts the resulting samples into digital numeric values that can then be analyzed and manipulated by a computer.

Virtual Instruments (VIs) – LabVIEW programs that operate by imitating physical instruments, such as oscilloscopes and multi-meters. These programs allow the user to acquire, analyze, display, store, and troubleshoot data. All controls are displayed on a user interface that accommodates to the user and provides ease of access in controlling the data.

Data (DAT) file – a file in the format X.dat contains some type of computer data. The original program where the file was created is an indicator on how to decipher the file.

Technical Data Management (TDMS) file – a type of file produced by LabVIEW that securely saves well-documented measurement data. This is one type of LabVIEW's default file saving formats that prevents file roadblocks that can impede the optimal exchange of technical information.

Comma Separated Values (CSV) file – a file format that is used to store data in a structure table of lists. Many spreadsheet program, such as Microsoft Excel, allow the user to open and save in such file formats.

Ticks (TKS) file – contains the time at which neutron pulses are detected, typically in the format of a 32-bit 1-D array of data.

2.0 SYSTEM SUMMARY

2.0 SYSTEM SUMMARY

Pulses produced from a pulsed neutron experiment must be detected, recorded, and analyzed to gain an understanding of nuclear response in neutron detectors for nuclear research. An example of a neutron detector is ^3He . Nuclear pulses are produced during a reaction of this element. An isotope of Helium, ^3He provides for an effective neutron detector material because ^3He reacts by absorbing thermal neutrons, producing a ^1H and ^3H . Its sensitivity to gamma rays is negligible, providing a very useful neutron detector.

The NILA data acquisition software is used to detect, record, and store neutron pulses, either artificially simulated or produced in laboratory conditions. Data taken over a specified amount of time may then be plotted using a graphing program, such as Microsoft Excel, to analyze graphs and recorded data. With this program, the user may record and store data from “slow” streams of pulses (log and read) or from “high” streams of data (known as multi-card data). The LabVIEW software also gives the user the option to convert and compress recorded data taken from higher data streams to files that match the slow data stream files.

Another tool afforded to the user during this process is a program titled List Mode Data Analysis, which allows the user to convert the data produced from the NILA visual instrument and converts it to a text file format easily read by common graphing programs. Data may finally be graphed and analyzed.

2.1 System Configuration

Shown in Figure 2-1 is sample setup the user might encounter when collecting data from a neutron pulse experiment. This shows data being collected in parallel with NILA, a JSR15 and the PTR list mode system.

Figure 2-1: Sample system setup when conducting a neutron pulse experiment.

Neutron Pulse Simulators

Neutron simulators are compact and portable for element analysis. Neutron pulses may be simulated through various types of impulses (such as random, periodic, and correlated pulses) and are the input data to the DAQ system.

Figure 2-2: Neutron pulse simulator used to simulate neutron pulses, whose results may then be compared to neutron generated pulses in laboratory.

The user must connect the NPS unit to a 5V power source. The unit requires the user to connect an external PC workstation/laptop using a serial communication line, and to a pulse counting device using a coaxial cable. The user will then control the NPS unit by running the NPS program on the external PC workstation using the NPS software.

NI HDD-8265 External Hard Drive

Redundant Array of inexpensive disks (RAID) enclosures expand high-speed data streaming by offering higher data streaming rates and storage capacities. This system is configured with a number of 2 TB SATA hard drives offering a total storage capacity up to 24 TB.

Figure 2-3: External harddrive RAID disks allow large files to be stored and easily accessed without filling up the DAQ system's memory.

CA-1000 Configurable Connector Accessory Enclosure

A multipurpose data acquisition accessory enclosure designed to optimize user-defined input/output connectivity and flexibility. Impulse detectors may be connected as inputs to the enclosure and outputted data may then be read by the acquisition control unit in the form of 32-bit data.

Figure 2-4: Configurable accessory enclosure allows multiple generators/simulators to be connected to DAQ system (up to 32 channels of input).

Data Acquisition System

This system acquires analog data inputted from the pulse detectors or simulators and converts it into digital data. Thus, real-world physical conditions are converted into digital, numerical values that are then manipulated by the DAQ processing unit.

2.2 Data Flows

The main inputs to the data acquisition system include the impulse detectors/simulators that will flow into the system using a CA-1000 connector board. The impulses generated into the board are read as 32-bit signals, where up to 32 inputs may be analyzed at a single time. Data is then outputted from the connector board to the data acquisition system as 32-bit data to be read by up to three 32-bit PCI cards. Finally, the data is then read and stored by the acquisition system and

outputted as data files to be plotted and analyzed by the user as need be. Shown in Figure 2-5 is a representation of data flow during this acquisition process from the neutron generators/simulators to the data acquisition system.

Figure 2-5: Data flow from neutron simulators/generators to DAQ storage cards during the data acquisition process

2.3 Contingencies and Alternate Modes of Operation

The DAQ system has a built in memory of 500 GB to store and manipulate the data. Additional data storage systems, such as the RAID disks, may be added to the system to store faster streams of data at higher storage rates. In the event that these additional storage units are not available for use, the user should be aware of the file sizes associated with each acquisition and carry out testing accordingly.

3.0 GETTING STARTED

3.0 GETTING STARTED

This section provides a general walkthrough of the system from initiation through exit. For acquisition purposes, the system allows two different modes of acquisition to collect data. The first mode, the single-card “slow” acquisition version, is used primarily for count rates less than 500,000 cps at a sample frequency of 50MHz, or count rates less than 1,000,000 cps at a sample frequency of 25MHz. The second mode, a multi-card “fast” acquisition version, is used for count rates greater than 500,000 cps or 1,000,000 cps at sampling frequencies of 50MHz and 25 MHz, respectively. Also, the “fast” acquisition version utilizes up to 3 cards (96 channels) of input, where the “slow” version permits only 1 card (32 channels) of input.

3.1 Logging On

When first logging onto the system, the user simply needs to navigate to the file menu and open and run the program. Written as executable programs, the NILA acquisition software and compression/conversion software will immediately open to the system window and reveal multiple options for the user.

3.2 System Menu

For the purposes of detecting neutron pulses, only two executable programs will be utilized. The “NILA” executable will be used to collect, record, and store neutron pulses, while the “TDMS Compress” program will convert large data files into reduced, more efficient files.

3.2.1 Nila Acquisition

Figure 3-1: Sample Log and Read software screen when first opened

3.2.2 Convert and compress data

Figure 3-2: Sample Compression and Conversion software screen when first opened

3.3 Exit System

Once data has been collected, the system may be exited by closing the window. By doing so, the NILA program will close, thus exiting the system's program.

4.0 USING THE SYSTEM (Log and Read 2-D)

4.1 Logic When Reading Input

All digital data is then saved to one file by the DAQ processing unit, where the system counts the number of entries (0's and 1's) stored in the file. The 1's in the file correspond to a pulse generated at a given time. Time is set to '0' before the first digit is initialized, and then the total amount of time recorded from the file is dependent on the frequency assigned during the test. Shown in Figure 4-1 below is a representation of data read and stored by the system.

To calculate the amount of time elapsed from start to finish of collecting data, simply reciprocate the frequency to find the time elapsed per data entry. Thus, $50\text{MHz}^{-1}=20\text{ns}$. The total amount of time is then $20\text{ns}/\text{entry} * 100 \text{ entries} = 2 \mu\text{s}$ in this particular example.

4.2 User Options and Functions

Figure 4-2: Acquisition Screen with accompanied functions and options

1. **Start Button** – Commences data acquisition after the user has configured settings using the **Configure Data Logging** and **Configure Hardware** toggles. Turns into a red stop button when in use. See Section 4.4.1 for more information.
2. **Status window**– Notifies the user the progress during the data acquisition process. Displays “waiting” to signify that acquisition has not yet begun or “acquiring” when data is being collected and restored.
3. **Configure Data Logging toggle** – Affords the user the option to change the number of channels (cards) using during acquisition. The data rate (fast or slow), acquisition duration, and file log path can also be changed to reflect the test the user is performing.
4. **Configure Hardware toggle** – Affords the user the option to change the number of channels (cards) as well as to change which cards (1, 2, or 3) will be active or inactive. The clock rate may also be changed to accommodate to the number of cards that are being utilized to match the number of cards sent in the Data Logging toggle
5. **Data Display** – Displays the approximated count rate (cps) at each channel to give an indication of the data acquisition rates. Also distinguishes different channels on multiple cards using color coding. The elapsed time is also displayed, showing the processing time to collect and store data.

4.3 Input Procedure for Collecting Data

1. Locate the NILA executable from the computer's list of programs.

The acquisition screen, shown in Figure 4-2 will then pop up.

2. Select the **Configure Data Logging** toggle.

Figure 4-3

A window titled “Data Log Settings” will then appear.

Figure 4-4

3. Change the number of channels to 32 channels (1 card) for the slow - version.

Figure 4-5

4. Toggle the data rate to “Low (<1,000,000 cps)”.

Figure 4-6

5. Change the acquisition duration window to the desired time to acquire data. The arrow buttons may be toggled or the time may be manually inputted into the acquisition duration window.

Figure 4-7

6. Under the “Log file path” window, change the name of the file to the appropriate test performed (i.e. 40k for 40,000cps). Then, change the file extension to x.DAT, where x is the file name of the test being performed.

Figure 4-8

Also change the file location to the desired directory where the data files will be saved. Select the folder icon to the right of the window to change the directory.

7. Once all settings have been set, select the “Ok” button located at the bottom of the window. If the “Cancel” button is pressed, then all entered settings will revert back to the settings from the previous test performed.

Note: If not using Neutron Pulse Generators, skip ahead to Step 9 to begin acquiring data.

8. If using Neutron Pulse Simulators, open the “Neutron Pulser” executable program. Once opened, several options may be chosen to simulate a type of neutron impulse to be recorded by the DAQ system. Select which option is necessary as well as the pulse rate in which the neutron pulses will be simulated and press “Start” to begin pulse simulation.

For a list of the neutron pulse simulation options available, see Section 9.1, neutron pulse simulator system configurations of this manual.

Figure 4-9:

9. Run the program by selecting the “Start” button in the NILA executable. The “Start” button will then change to a red “stop” button where data acquisition may then be stopped if need be.

Shown in Figure 4-10 is a screen shot of the data acquisition system taking data

Figure 4-10

Note: Data collected after this point is automatically saved to the file directory specified in the Log File path edited in Step 3. No further action is necessary to save files

10. Once acquisition has been completed, close executable's window using the red close button at the top right of the window.

4.4 Special Instructions for Error Correction

4.4.1 Stopping Data Acquisition

By utilizing the **STOP** button located above the graph screen, data acquisition will stop and end up to the point that the **STOP** button was pressed. If the user closes the program using the red close button on the top right hand side of the window, the program will close and all data collected will be discarded. Thus, it is recommended that the user only utilize the close button when closing the program as data collected will not be saved once the close button is pressed.

4.5 Expected Output

This method records and analyzes the pulsed data in real time (during the interval between pulses) and combines: 1) the numbers of pulses in a DAT file, and 2) the time that the pulses occurred into a TKS file.

Several files are expected to be produced from using this method. Files should be produced in the format of: X.dat and X.tks, where X is the file name specified in step 6 above. All files should be stored together in a common folder for further data analysis.

Figure 4-11: Digitized Data processed by the DAQ unit will be process and outputted as a DAT file containing the channel data and a TKS file containing the time that each pulse occurred.

4.6 Caveats and Exceptions

In the event that the data is not recorded or stored properly, the program may be rerun by simply closing and reopening the executable program. Follow steps 1 through 9 to reacquire data.

This “slow” version of data acquisition works only with 1 card (i.e. 32 channels). Additional cards will not currently work with the slow version and the fast version of the data acquisition program needs to be used.

5.0 USING THE SYSTEM (MULTICARD)

Data collected for higher stream rates are similar to the slower stream rates method. Data is converted to digitized signals of 0's and 1's when inputted to the DAQ system's card. Each '1' represents a pulse detected at a specific time. However, unlike the slow acquisition method, the DAQ system is not able to read and analyze incoming data quickly enough before another pulse is detected. Therefore, every bit from this sampling process is stored into a TDMS format file and needs to be post-processed for further use.

5.2 User Options and Functions

User's Manual

Figure 5-2: Acquisition Screen with accompanied functions and options

5.1 Logic When Reading Input

1. **Start Button** – Commences data acquisition after the user has configured settings using the **Configure Data Logging** and **Configure Hardware** toggles. Turns into a red stop button when in use. See Section 4.4.1 for more information.
2. **Status window**– Notifies the user the progress during the data acquisition process. Displays “waiting” to signify that acquisition has not yet begun or “acquiring” when data is being collected and restored.
3. **Configure Data Logging toggle** – Affords the user the option to change the number of channels (cards) using during acquisition. The data rate (fast or slow), acquisition duration, and file log path can also be changed to reflect the test the user is performing.
4. **Configure Hardware toggle** – Affords the user the option to change the number of channels (cards) as well as to change which cards (1, 2, or 3) will be active or inactive. The clock rate may also be changed to accommodate to the number of cards that are being utilized.
5. **Data Display** – Displays the approximated count rate (cps) at each channel to give an indication of the data acquisition rates. Also distinguishes different channels on multiple cards using color coding. The elapsed time is also displayed, showing the processing time to collect and store data.

5.3 Collecting Data

1. Locate the NILA executable from the computer's list of programs.

The acquisition screen, shown in Figure 5-2 will then pop up.

2. Select the **Configure Data Logging** toggle.

Figure 5-3

A window titled “Data Log Settings” will then appear.

Figure 5-4

3. Change the number of channels to reflect the number of cards necessary for the “fast” acquisition version.

Figure 5-5

4. Toggle the data rate to “High (>1,000,000 cps)”.

Figure 5-6

5. Change the acquisition duration window to the desired time to acquire data. The arrow buttons may be toggled or the time may be manually inputted into the acquisition duration window.

Figure 5-7

6. Under the “Log file path” window, change the name of the file to the appropriate test performed (i.e. 40k for 40,000cps). **Note: with this test version, the file extension does not need to be named to a TDMS file as it is automatically done by the program.**

Figure 5-8

Also change the file location to the desired directory where the data files will be saved. Select the folder icon to the right of the window to change the directory.

7. Once all settings have been set, select the “Ok” button located at the bottom of the window. If the “Cancel” button is pressed, then all entered settings will revert back to the settings from the previous test performed.
8. Select the **Configure Hardware** toggle.

Figure 5-9

A window titled **Aquisition Settings** will then appear.

Figure 5-10

9. Verify that the “Trigger line (source)” slot # corresponds with the Channel 1-32 (card 1) slot #. This function allows the first channel to be triggered and will result in no acquisition if not triggered. Set the Trigger line to the same slot # as the channel 1-32 card port.

Figure 5-11

10. Toggle the Clock Rate to the desired level for test performed. This will set the time interval that pulses are detected and recorded. If the clock rate is set too high, an error message will then be produced and will automatically be set to a value dependent on the number of cards utilized per test. Shown in is the error message produced and shown in are the maximum frequencies allowed per card utilized.

Figure 5-12

Test Frequency Limits	
Number of Cards	Maximum Frequency
1	50 MHz
2	25 MHz
3	16.667 MHz

Table 5-1

11. Once all settings have been set, select the “Ok” button located at the bottom of the window set the entered settings as default for consequent tests. If the “Cancel” button is pressed, then all entered settings will revert back to the settings from the previous test performed.

Note: If not using Neutron Pulse Generators, skip ahead to Step 12 to begin acquiring data.

11. If using Neutron Pulse Simulators, open the “Neutron Pulser” executable program. Once opened, several options may be chosen to simulate a type of neutron impulse to be recorded by the DAQ system. Select which option is necessary as well as the pulse rate in which the neutron pulses will be simulated and press “Start” to begin pulse simulation.

For a list of the neutron pulse simulation options available, see Section 9.1, neutron pulse simulator system configurations of this manual.

Figure 5-13

12. Run the program by selecting the “Start” button in the NILA executable.

The “Start” button will then change to a red “stop” button where data acquisition may then be stopped if need be.

Shown in is a screen shot of the data acquisition system taking data. Channel data from multiple cards will be colored corresponding to card that the channel is located.

Figure 5-14

Note: Data collected after this point is automatically saved to the file directory specified in the Log File path edited in Step 6. No further action is necessary to save files.

13. Once acquisition has been completed, close the program's window using the red close button at the top right of the window.

5.4 Special Instructions for Error Correction

5.4.1 Stopping Data Acquisition

By utilizing the **STOP** button located above the graph screen, data acquisition will stop and end up to the point that the **STOP** button was pressed. If the user closes the program using the red close button on the top right hand side of the window, the program will close and all data collected will be discarded. Thus, it is recommended that the user only utilize the close button when closing the program as data collected will not be saved once the close button is pressed.

5.5 Expected Output

Files produced using these “fast” methods of acquisition are in TDMS format. Index files corresponding to each TDMS file also result from the use of this “high” stream method. For the reason that higher data streams are produced with this method, the outputted TDMS files are much larger than the DAT files produced with the slower method. In fact, the files are so large

the NILA executable will break up the output into several smaller files depending on the extremity of data collected.

Further conversion is necessary to extract both the pulses and the time each pulse is recorded at into two separate files (a channel file and a tick file). **Section 6.0** will instruct the user how to convert and compress TDMS outputs to files that are easily read as those produced with the “slower” method.

5.6 Caveats for Handling Outputs

In order to insure that the outputted TDMS files are properly converted to a DAT file, the user should save all outputted files in one directory per acquisition performed. If any of the files are missing, graphs produced will not contain whole data and may only be partially graphed.

As shown in Table 5-1, the maximum frequency is limited by the number of cards being used. A 25MHz frequency is sufficient to detect and record pulses, however using three cards will result in a frequency of 16.667MHz being utilized. At this rate, such a low frequency may cause discrepancies in the accuracy of data, thus it is not recommended to use three cards unless absolutely necessary. Further tests are necessary to confirm the precision of the different sampling frequencies. After this an optimum frequency choice will be established.

In the event that the data is not recorded or stored properly, the program may be rerun by simply closing and reopening the NILA software program. Follow steps 1 through 9 to reacquire data.

6.0 USING THE SYSTEM (COMPRESSION AND CONVERSION)

6.0 USING THE SYSTEM (COMPRESSION AND CONVERSION)

This program will convert the TDMS files to 1-D U32 binary files – DAT (Count Data Per Channel) file format and TKS (clock tick data corresponding to the count data) file format.

6.1 Logic When Reading Input

TDMS files produced using the faster data acquisition method contain information about the pulses identified and the time that these pulses are detected. Since both data sets are stored onto one file (which is typically broken up into several files due to its size), it is advantageous to the user to compress this file into a smaller version for an analysis program to read. Also, TDMS files are typically not a universal file type that is easily read by common graphing programs, thus the files must be converted from TDMS format to a simpler, universal format.

Using the Compression and Conversion software program, the user is thus able to convert the TDMS file into a DAT file and a TKS file. The DAT file, similar to the one produced using the slower method, contains channel information pertaining to the pulses detected (i.e. where the pulses occur in the sequence of digital data). Storing the time that these pulses are detected, the TKS file contains an array of information that corresponds to the time that each pulse was detected. Figure 6-1 below conveys the types of data stored in each type of file.

Note: Converting the TDMS files is very time-consuming and takes significantly more time than the original acquisition of the data.

Figure 6-1: TDMS files produced from faster data stream are converted and compressed into a DAT file and a TKS file.

6.2 User Options and Functions

Figure 6-2

1. **Log file path and target directories** – Allows the user to select the file directory of the TDMS file. Also changes the directory that the compressed file will be placed.
2. **Start/Stop at file #** – Gives the user the option of converting specified files produced when collecting data using the Multicard acquisition option.
3. **Compress Button** – Begin the compression and conversion process.
4. **Read Until** – Gives the user the option to read, convert, and compress a segment of a TDMS file or the entire file.
5. **Edge Detection** – Detects only the rising edges of the binary data acquired when converting the file (i.e. only 1s). However, the conversion/compression time is doubled if this feature is used. This feature is automatically set to “on” by default.
6. **Channel Correction** – Changes the order in which the sequence of bytes are stored in computer memory, where the most significant value in the 32-bit sequence is stored first. Use depends on the computer systems used to analyze data.
7. **Clock Rate** - Changes the frequency in which data is collected.
8. **Intensity Graph screen** – Displays the neutron counts (cps) versus the channel in which DAQ system read the input.

9. **#Samples/Segment** – Changes the number of samples that are read and converted by the **Read Until** feature.
10. **# Channels** – Refers to the number of channels that the test was conducted before conversion.

6.3 Input Procedures to Convert File Type

1. Locate the TDMS Compress executable from the computer's program list and select to open.

The “Convert and compress TDMS data” screen will pop up as shown in Figure 6-2

2. At the **Log File path** window, select the folder button to the right screen to locate the files to be converted and select the appropriate files. When the screen to open the files pops up, select the options to look at “all files” as the TDMS files will only show if this option is selected. The file directory may also be manually entered but must match the exact same directory used for the multicard data acquisition. Once the file has been chosen, select the folder button to the right of the **Target Directory** to choose a directory to save the converted and compressed files. The name may also be changed to reflect the type of test that was performed.

Figure 6-3

3. Under the **Start at file #** toggle, change the start at file number to the file that will be read first. Since files will be converted from the Multicard option, various files with associated numbers will be listed. Under the **Stop at file #** toggle, select the file number in which the converter will stop converting.

Figure 6-4

4. **Edge Detection** is automatically enabled to remove multiple counting of events, where only the “high” values (i.e. 1’s) of a data set are detected, resulting in twice the amount of time to compress/convert. Subsequent 1’s in a sequence are converted to 0’s (i.e. 0101111 becomes 0101000).

5. **Channel Correction** is also automatically enabled to account for the type of computer system that will analyze the compressed data. If enabled, the data will appear with the most significant value in the 32-bit sequence stored first when analyzed.

Figure 6-5

6. Toggle the clock rate to reflect the frequency that was used when collecting data using the “fast” version.

Figure 6-6

7. If need be, toggle the **Read Until** button to read a “Single segment” to verify that the data collected is accurate (doing so will only result in a small portion of the file being converted to be analyzed).
8. If reading only a single segment of the file from the previous step, toggle the **#Samples/Segment** to increase or decrease the samples being converted and compressed of a file.
9. Toggle the **#channels** to match the number of cards used for data collected from the “fast” version of acquisition.

Figure 6-7

10. Press the **Compress** button to begin compressing and converting the TDMS files to appropriate DAT and TKS files. The “Current log file being processed” screen will display the file currently being compressed and converted. The green button to the right of the file will blink to orange a file is being successfully compressed/converted.

Figure 6-8

If, for some reason, the compression must be stopped, press the **Stop** button

and let the executable complete its conversion of its current file processing. Note: avoid exiting the program using the red close button at the top as this will completely close the program and all data will be lost.

11. Once conversion has been completed, exit the program by pressing the red “close” button at the top right of the executable’s screen. Files are automatically converted, compressed, and saved to the file location specified by the user in Step 2 of this procedure.

6.4 Expected Outputs

After compression/conversion has been completed, the higher rate TDMS file is expected to be converted into a U32 Compressed DAT File. An accompanying TKS file of the same file size should also be produced from this option as both files are necessary in consolidating the files into one file format convenient for graphing. See **Section 7.0: Organizing Data for Plotting Graphs** for an understanding and outline of steps on converting/consolidating data for a graphing program.

Figure 6-9: TDMS file is compressed and converted to a DAT file and TKS file, where the original TDMS file is automatically deleted. Files will later be consolidated to one file to graph results.

6.5 Caveats to Handling Outputs

Both the outputted DAT and TKS file must be saved under the same directory in the same file path. Both files will then be needed simultaneously when consolidating to one graphing file. See **Section 7.0: Organizing Data for Plotting Graphs** on how to compress data into one file to be read on common graphing programs.

7.0 Organizing Data for Plotting Graphs

7.0 ORGANIZING DATA USING LIST MODE (LM) DATA ANALYSIS

This section describes the method used to convert the DAT and TKS outputted from both the slow stream method as well as the converted/compressed files into CVS files to plot easily using a graphing program such as Microsoft Excel.

7.1 LM Data Analysis Capabilities

CSV files are text files that may be easily read by a graphing program to be plotted, analyzed, manipulated, and solved from the data points collected from the DAQ system. LM Data Analysis is a program that will further convert the DAT files generated by the NILA executable to CSV files for the ease of plotting using a program of the user's choice. The user will also be able to view sample graphs and choose which data points will be converted as a CSV file.

7.2 Using LM Data Analysis

By searching for an appropriate TDMS file, LM Analysis will find the file, convey a plot of the data, and convert the file to a CSV file. Other options include grouping data points at single, double, and triple bunches of pulses in a system. Reading a file from the file system enters it into the datastore from which it can be subsequently used rather quickly.

Figure 7-1: LM Data Analysis screen when first opening program.

7.3 User Options and Functions

1. **Data Source Buttons** – Allows the user to search for TDMS files in the File System (in a directory located in the user documents) or in the Datastore (a file created that compiles all data after searched through with the File System).
2. **Data Analysis Buttons** – Gives the user the option to display and analyzed data as Pulsed Data, Multiplicity (bunches of pulses), or at Time Interval.
3. **File Directory** – Shows the file path that of the file currently being analyzed.
4. **Count Rates** – Displays the count rate (counts/sec) at each channel used when dated was acquired.
5. **Graphing Options** – sets the trigger, scales, and limits of integration of a graph data set, then outputs the file as a CSV file.

7.4 Browsing for a Data Set in the File System

In order to select a DAT file to be analyzed and converted, the user must browse the system to first locate the file. The files to be converted will be under the same directory and folder as chosen when saving the files using the Log and Read program or converting to a TDMS file using the Convert and Compress software.

1. Locate the List Mode Analysis program in the program directory and run the program.
2. Under the **Data Source** options, select the option “File System” followed by selecting the “Browse...” button.

Figure 7-2

3. Locate and select the DAT file with the ticks extension to be analyzed and converted.
Note: other associated files may be selected (such as the DAT file and the channel reference files) but the program will automatically search the file directory for the ticks file extension. Thus, select the ticks extension file to save the computer some processing time.

Figure 7-3

7.5 Browsing for a Data Set in the Datastore

Once selected and chosen when browsing the file system, data files are created and saved under the “Datastore” in the LMA Program and are compressed into one DTS file that can be easily accessed in the program’s database. Once in the database, there is no need to search for a file in the File System if it has already been searched for at least once. Shown in Figure 7-4 is a representation of related DAT files being consolidated into a DTS file to create ease of access.

Figure 7-4: Multiple DAT files are stored in a DTS file for accessibility once they have been located in the file system

Note: If files are searched again that were once searched through in the file system, copies of the same file will be added to the DTS file, thus creating a larger DTS file. It is advised that the user should browse the file system only once to locate the files and then utilize the datastore to locate files that have already been located. The datastore can be managed with the “remove datastore” option under datastore browse and the “remove file” option within each datastore.

1. Locate and run the LMA program.
2. Under the **Data Source** options, select the option “Datastore” followed by selecting the “Browse...” button.

Figure 7-5

3. Select the directory from the list of options in the new window. Double click on the directory desired, then select the data store file (.dts) file with the directory that has already once been selected. The user may then use a DTS file already created and avoid adding more data to the DTS file.

Figure 7-6

7.6 Viewing/Analyzing Data

After selecting data from the file system or datastore, the user may then view the data that has been collected and make a plot of the data. It is generally advantageous to the user to view the data and graphs before converting the data to an easily plotted file type.

1. Upon selecting data from the file system, the file will automatically open to the LMA screen and display the channel number and rate (counts per second) taken from the test. Typically, the test will have a rate shown for channels 1 and 2, while the rest of the channels will have a value of '0.'

Figure 7-7

Note: Several options may be selected to interpret and plot data based on the type of test performed. See the table below to select an analysis option based on the several types of acquisition tests performed.

Analysis Option	Acquisition Test	Step
Pulsed Data	Pulse Pair	2
	Burst Pulse	
Multiplicity	Random	3
	Correlated	
Time Interval	Periodic	4

Table 7-1: Acquisition test and corresponding referenced step.

2. Select the “pulsed data” option from the **analyses options** to the right.

Figure 7-8

Once selected, several **graphing options** will appear on the analysis software to the right of the window. These options allow the user to set various limits, triggers, and scales for the plot produced. A plot of the data will then be produced from the software.

Figure 7-9: Sample graph produced from pulsed data

Figure 7-10

- a. Using the **graphing options**, select the scales for the x- and y-axis. In a data set similar to the one above (where the first two channels are the only ones containing non-zero data), the second channel is typically selected as the trigger (see Figure 7-10). Various histograms may be viewed by setting different channels as the trigger. The trigger channel refers to the pulses from, for example, a neutron generator. The actual channel number depends on the experimental setup.

Note: A histogram cannot be made from the same channel used as a trigger. If set on the trigger channel, the histogram will not produce a graph.

- b. Once the plot has been viewed and properly adjusted to display data, select the “Save Plot CSV” option at the bottom right of the **graphing options** to save the file in CSV format. The directory may then be selected to save the outputted file.

7.7 Expected Output

When using the option to output a file in CSV format, a U32 compressed DAT file is inputted to the program. The converter then outputs the data in CSV format, where the pulses and the corresponding time that each pulse occurred are separated by commas, where all records have an identical sequence of fields. Thus, the outputted data is in a very simple text file format where the data is separated with commas.

Figure 7-11: Using LM Data Analysis software, data outputted from acquisition tests will be converted to data compatible for plotting/analyzing using common plotting programs of the user's choice.

8.0 Frequently Asked Questions

8.0 MOST COMMONLY ASKED QUESTIONS

This section describes and depicts all standard reports that can be generated by the system or internal to the user.

8.1 DAQ Setup

1. **Q:** What is the basic setup of the Neutron Pulse Experiment? What are the inputs, outputs, bit rates, etc?

A: Typically, the inputs of a pulsed neutron experiment include the neutron pulsers as the input. The $^3\text{He}(n,p)$ reaction produces pulses that are detected by the neutron detectors. The signals then travels to a pre-amplifier that will convert the signal into a 32-bit rate signal that is read by the acquisition system. Data may then be manipulated, based on the type of test performed, to convert the data into a readable text file (typically a CSV file) that can then be analyzed and plotted to analyze graphs.

2. **Q:** Are there any plans of having a “log-in” when the final version is implemented?

A: A log-in into the system may be implemented if necessary. As of now, this feature is optional and not included in any of the executable.

8.2 “Slow” Rate DAQ (Read and Log)

1. **Q:** What is the OnboardClock? How does this sample clock relate to how fast the data is read?

A: Two software configurations inter-reliant on each other during acquisition process are: how fast the pulsing signal is digitized, and how much data is acquired by the NI software from the hardware buffer at a specified time interval (i.e. how fast vs. how much).

The DAQmx Timing VI (used in both the “slow” and “fast” VIs) controls the rate of data flow from the pulse generators/simulators to the hardware buffer on the data acquisition board. Conversely, the DAQmx Read VI determines the transfer of data from the hardware buffer into the LabVIEW software.

Figure 8-1: Data flow as read by the PCI board and then sent to the VI to be viewed.

Now, the Number of Samples Per Channel determines how many samples are acquired from the hardware buffer to the software buffer.

“It is recommended that the number of samples be 1/10th the rate specified on the DAQmx Timing VI. For example, if the rate input on the DAQmx is 1000 (Hz), then the number of samples per channel should be no more than 100 to ensure there are not buffer overwrite or underwrite errors.”

When determining the how fast the data will be acquired, keep in mind that both steps in the acquisition must agree. The rate at which the data is transferred from the hardware buffer to the software buffer must not be too fast or too slow compared to the rate at which the data is being loaded into the hardware buffer. If it is too fast or too slow, a buffer error will be thrown.

8.3 “Fast” Rate DAQ (Multicard)

1. **Q:** Is it recommended that additional hard drives/disks be used when using the Multicard (fast) acquisition software?

A: Yes. Saving files produced from this version will not only slow down the computer (as each file is approx. 200 MB in size), but multiple acquisition files will also fill up the computer’s memory and freeze or crash the operating system. Thus, using an external hard drive will prevent the computer’s memory from filling up when using the “fast” executable.

8.4 Conversion and Compression

1. **Q:** The conversion tool takes quite a while to compress/convert. What are some general tips in order ensure a relatively moderate time to convert a file? What options should the user take to do so?

A: When operating the conversion/compression tool, the user should take caution in using the tools

2. **Q:** When should Channel Correction be applied?

A: Channel correction should be applied after edge detection. Channel correction will eliminate the ‘0’ values from the data files, thus compressing the converting files. If done before edge detection is applied, ‘0’ values will remain as the edge detection converts subsequent ‘1’ values to 0 values.

3. **Q:** Why is it not safe to simply exit the program if the conversion process is taking too long? Why use the stop button and close the program?

A: The exit button is a last resort in exiting a compression/conversion that is being executed. If it is necessary to terminate the action, the user is always advised to press the

programmed Stop Button rather than using the exit button as the Stop Button affords the option of resuming acquisition/conversion after it is pressed. Thus, the exit option may be utilized at the cost of losing previous data collected as the user cannot resume from whence the program was stopped.

8.5 LM Analysis

1. Q: What DAT (source) files need to be selected in order to convert the DAT files to CSV files?

A: The files titled X.dat (where x is the name of the test performed) must be selected in order to convert in CSV files. If the TKS file is selected, the program will automatically search the directory for the DAT file, created more overhead and thus slow down the program.

8.6 Plotting

1. Q: What type of scale should be used (log or regular) when plotting data?

A: Typically, a log scale used on both the x- and y-axis is utilized when plotting data. However, a regular scale may be necessary to view the initial slope of the graphs as this will convey data about the pulse behavior.

2. Q: Are TDMS files easily imported into Microsoft Excel?

A: NI Instruments currently has an extension to Excel that allows the program to import a TDMS file directly into Excel. With the type of data produced from the NILA software, excel will only read '0' values. Thus, only plots containing 0's will be produced.

9.0 Appendix

9.0 APPENDIX

This section gives additional information to system hardware, data input/output, and device logistics that the user may find helpful when operating the system.

9.1 System Configuration

9.1.1 Neutron Pulse Simulator

NPS Program Operating Modes		
Operating Mode Name	Description	Corollary
Burst Mode	Generates a pulse burst at a specified pulse rate for a specified number of pulses	---
Periodic Mode	Generates a continuous periodic pulse stream at a specified pulse rate	Does not support frequencies that require a period resolution of 500ns.
Random Mode	Generates a continuous random pulse stream of a specified average pulse rate	---
Sample Mode	Generates a correlated pulse stream	Supports user options such as: effective ^{240}Pu mass, neutron multiplication, alpha value, absolute efficiency, die-away time, predelay, and gate width
Correlated Mode	Generates pulse stream based on user defined parameters	Supports a measured rates (S, D, T, die-away time, predelay, and gate width) and raw rates (only die-away time)
Student Mode	Generates a correlated pulse based on a set of user defined parameters	Provided solely to support IAEA inspector training

Table 9-1: NPS modes of simulation along with descriptions and warnings for each test.

9.1.1.1 Burst Mode

Burst mode generates a pulse burst at a specified pulse rate for a specified number of pulses. A burst is produced each time the user clicks on the “Start” button.

Figure 9-1: Burst Mode

User specified parameters are shown in Table 9-2. The program will inform the user if the parameters selected are out of range.

Parameter	Range	Resolution
Pulse Rate	100 to 1,000,000 cps	1 cps
Pulse Count	1 to 20 cnts	1 cnt

Table 9-2: Burst Mode Parameters

9.1.1.2 Periodic Mode

Periodic mode generates a continuous periodic pulse stream at a specified pulse rate determined by the minimum period resolution (500ns). If a frequency is selected that is not allowed (such as 800kHz, or 1.25us period), the program will indicate the actual frequency produced. The software selects the next higher realizable frequency. The pulse stream begins when the “Start” button is clicked and will continue until the “Stop” button is clicked. (See Figure 9-2.) User specified parameters are shown in Table 9-3.

Figure 9-2: Periodic Mode

Parameter	Range	Resolution
Pulse Rate	100 to 1,000,000 cps	1/ 500ns

Table 9-3: Periodic Mode Parameters

9.1.1.3 Random Mode

Random mode generates a continuous random pulse stream of a specified average pulse rate. The software will once again indicate an unachievable rate error. The pulse stream begins when the “Start” button is clicked and will continue until the “Stop” button is clicked. (See Figure 9-3.) Shown in Table 9-4: Random Mode Parameters are the user specified parameters.

Figure 9-3: Random Mode

Parameter	Range	Resolution
Pulse Rate	1 to 750,000 cps	1 cps

Table 9-4: Random Mode Parameters

9.1.1.4 Sample Mode

Sample mode generates a correlated pulse stream, where the parameters of both the plutonium sample (effective ^{240}Pu mass, alpha value, and neutron multiplication) and the detection system (consisting of efficiency and die-away time, predelay, and gate width) to be simulated are specified by the user. (See Figure 9-4.) The user may toggle the duration (in seconds) for the pulse stream, where an infinite duration can be set by toggling the duration parameter to zero. User specified parameters are shown in Table 9-5: Sample Mode Parameters. The program will inform the user if the parameters selected are out of range.

Figure 9-4: Sample Mode

By selecting the “Check Rates” button, the user may then check the rates that the NPS unit will produce based on the entered parameters. (See Figure 9-5.)

Figure 9-5: Check Generated Rates

Parameter	Range	Resolution
Effective ^{240}Pu Mass	0.01 to 10,000 g	0.01 g
Neutron Multiplication	1 to 10	0.01
Alpha Value	0 to 100	0.01
Absolute Efficiency	0 to 100 %	0.01%
Die-away Time	1 to 300 us	1 us
Predelay	0 to 1023.5 us	0.1 us

Gate Width	0.5 to 1024 us	0.1 us
-------------------	----------------	--------

Table 9-5: Sample Mode Parameters

9.1.1.5 Correlated Mode

Correlated mode generates a correlated pulse stream based on user defined parameters, where the user may produce correlated rates based on either raw rates only or measured rates and measurement system parameters.

Measured Rates Method

In this mode, the user specifies both the parameters of the detection system (i.e. the die-away time for the detector and the predelay and gate width for the electronics) to be simulated and the rate (singles, doubles, triples) to be measured. If the requested rate cannot be simulated, an error will be generated by the software. (See 9-6.) User specified parameters are shown in Figure 9-6.

The screenshot shows the 'Neutron Pulse Simulator' window. The 'Correlated' tab is selected. Under 'Correlated', the 'Sample' sub-tab is active. The 'Correlated Pulse Generation' section includes the following parameters and values:

- Effective Pu240 Mass (g): 1
- Neutron Multiplication: 1
- Alpha Value: 0
- Absolute Efficiency (%): 50
- Die-away Time (us): 50
- Predelay (us): 4.5
- Gate Width (us): 64

A 'Check Rates' button is located below these parameters. At the bottom of the window, there are fields for 'Duration (s): 0' and 'Elapsed Time (s): 0', with a 'Start' button below them.

Figure 9-6: Correlated (Measured) Mode

Parameter	Range	Resolution
Measured Singles Rate	0 to 750,000 cps	1 cps
Measured Doubles Rate	0 to 250,000 cps	1 cps
Measured Triples Rate	0 to 166,000 cps	1cps
Die-away Time	1 to 300 us	1 us
Predelay	0 to 1023.5 us	0.01 us
Gate Width	0.5 to 1024 us	0.01 us

Table 9-6: Correlated (Measured) Mode Parameters

Note: Range parameters are allowed entries only. Some combinations within the allowed ranges will not work

Raw Rates Method

In this mode, the user specifies the raw pulser rates (singles, doubles, and triples) along with the die-away time. This option is used primarily to enable analyzing pulse generator behavior. (See Figure 9-7.) User specified parameters are shown in Table 9-7.

Figure 9-7: Correlated (Raw) Mode

Parameter	Range	Resolution
Raw Singles Rate	0 to 750,000 cps	1 cps
Raw Doubles Rate	0 to 250,000 cps	1 cps
Raw Triples Rate	0 to 166,000 cps	1cps
Die-away Time	1 to 300 us	1 us

Table 9-7: Correlated (Raw) Mode Parameters

9.1.1.6 Student Mode

Using a set of user defined parameters, such as a simulated detector type, the measurement type to be performed (using INCC), the simulated material type, and the mass of the simulated material type, student mode generates a correlated pulse stream. From these parameters, a set of count rates (singles, doubles, and triples) are calculated and sent to the NPS unit for generation. The program determines these rates using lookup tables and by making calculations based on actual measurement data on real samples. Note this operation is provided to support IAEA inspector training. (See Figure 9-8.)

Figure 9-8: Student Mode

The user selects the detector to be simulated from the following list: HLNC, Multiplicity Counter, AWCC, UNCL.

Depending on the detector selected, measurement types with accompanying material type choices include:

Measurement Types	Material Type Choices
Background	None
Initial Source	Check source (AmLi or Cf-252)
Normalization	
Verification	---
Calibration	---

Table 9-8: Material type choices depend on the measurement type selected, which in turn are dependent on the detector selected.

The following table lists the basic material type choices for each of the detector, depended on the measurement type selected (see Table 9-9.)

Detector	Material Types
HLNC	Pure PuO ₂ , Impure PuO ₂ , MOX
Multiplicity Counter	Pure PuO ₂ , Impure PuO ₂ , MOX
AWCC	U Metal, Bulk UO ₂ , MTR Fuel
UNCL	LWR Fuel (BWR, PWR, WWER)

Table 9-9: Student Mode Material Types

The user selects the material mass to be simulated from either a list of choices or a range of values.

User specified mass ranges are shown in Table 9-10. The program will inform the user if the parameters selected are out of range.

Material Type	Range	Resolution	Additional Options
Pure PuO₂	50 to 900 grams	1 gram	Declaration date field activated*
U Metal	200 to 3500 grams	1 gram	Active/Passive choice for sample
Bulk UO₂	50 to 1000 grams	1 gram	-----

Table 9-10: Student Mode Mass Parameters

*Note: this date is to back-decay the material simulated to agree with the forward-decay performed later with INCC. Date must be no earlier than five year prior to the current date of measurement, or in the future of date of measurement.

The “Detector Parameters” button allows the user to display the parameters to be entered into INCC prior to starting a measurement. (See Figure 9-9.)

Measurement Parameters Setup for Detector HLNC

Detector Parameters

Predelay (microseconds)	4.50	Multiplicity deadtime (1e-9)	0.0000
Gate length (microseconds)	64.00	Deadtime coefficient A (1e-6)	0.6000
Die away time (microseconds)	42.00	Deadtime coefficient B (1e-12)	0.2000
Efficiency	0.0000	Deadtime coefficient C (1e-032)	0.0000
		Doubles gate fraction	0.0000
		Triples gate fraction	0.0000

Known Alpha Analysis

Alpha weight	1.000000E+000
Rho zero	1.030000E-001

OK

Figure 9-9: Measurement Parameters

The “Check Rates” button allows the user to check the rates that the NPS unit will produce based on the entered parameters. Pulse generation is started by the user clicking the “Start” button and is terminated when the user clicks the “Stop” button.

Figure 9-10: Powered by a 5V power supply, the NPS unit is controlled by a computing unit running the operating software. The NPS unit generates pulses of the user's choice (S,D,T; random, etc.). Data is then outputted and a signal will be produced if error occurs.

Figure 9-11: The NPS internal computer generates simulated neutron pulses that are streamed into memory banks as 32 bit data. The memory banks then stream data to FPGA cards that produced digitized signals that emulate a neutron pulse.

9.2 Acquisition System Physical Features

The NILA Acquisition System's physical unit consists of the system's hard drive, laptop screen and keyboard, the 24TB system, and various racks and fans all located inside a shock mounted rack case. Shown in

Figure 9-12: The 24TB NILA transportable unit

For transport purposes and ease of accessibility, the unit's castors, located at the bottom of the rack case, can become detached if need be for maneuvering up stairs or through areas in which the wheels are not necessary.

Figure 9-13: Castors (wheels) are detachable from unit for ease of access.

Finally, the rack case comes equipped with front and rear removable lids to protect hardware during transport. As shown in Figure 9-14, the front lid must be placed upside down (with the bottom sections facing upwards) in order to fit the lid onto the front side of the case.

Figure 9-14: The two metal bolts must be facing upwards when attaching the front lid, thus the lid is placed upside down into the unit.

An extra compartment is afforded in the front lid for extra storage space of tools or cables used during transport as shown in Figure 9-15.

Figure 9-15: Extra compartment in upper portion of front case allows the user to store necessities during transportation.

10.0 INDEX

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