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# Data Processor 3 QASPR Project

Steven Adriel Ruiz
Charles W. Morrow

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 871850-1136

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# Data Processor 3
# QASPR Project

Steven Adriel Ruiz

Advanced Nuclear Fuel Cycle Technologies
Sandia National Laboratories
PO Box 5800
Albuquerque, New Mexico 87185-MS1136

Abstract

The following discussion contains a high-level description of methods used to implement software for data processing. It describes the required directory structures and file handling required to use Excel's Visual Basic for Applications programming language and how to identify shot, test and capture types to appropriately process data. It also describes how to interface with the software.

# ACKNOWLEDGMENTS

The content of this document was supported by the Data Reduction Team. I would like to thank my colleagues from the Data Reduction Team who provided insight and expertise that greatly assisted the on the progress of this paper.

I would like to thank Charles Morrow for assistance with entire scope of this document. He has been a great mentor and has provided me with the all the knowledge necessary to compose a competent document. I would also like to show our gratitude to Jan Erickson (Retired) and Amanda Barela for sharing their wisdom on how QDRT operates and the necessary rigmarole to be successful within DRT.

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# NOMENCLATURE

| | |
|---|---|
| ACRR | Annular Core Research Reactor |
| DOE | Department of Energy |
| DP3 | Data Processor 3 |
| DRT | Data Reduction Team |
| FWHM | full width at half maximum |
| pcd | photo-conducting device |
| QASPR | Qualification Alternative to Sandia Pulsed Reactor |
| SNL | Sandia National Laboratories |
| SPR | Sandia Pulsed Reactor |
| VBA | Visual Basic for Applications, a Microsoft™ computer language |
| WSMR | White Sands Missile Range |

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# 1 INTRODUCTION

The reason for Data Processor 3's (DP3's) emergence was to have a more modern/updated version of data processor that could read and manipulate data from various file formats. The Yokogawa DL850 can produce multiple file formats most notably single and dual capture. All previous versions of data processor were limited to single capture file formats. DP3 can process data with single and dual capture file formats.

The migration to dual capture files was inevitable simply because the Yokogawa DL850 had the capability and to help with experiment efficiency. There was room to improve with experiments in terms of recording data and the amount of equipment used in the experiment. Before dual capture capabilities experimenters would use two different oscilloscopes to record two different horizontal resolutions separately but the Yokogawa DL850 offers the ability to simultaneously record two different resolutions on one oscilloscope which is dual capture. All data is recorded and embedded into one file produced by the DL850. Consequently, experimenters can consolidate the number of files produced and the number of scopes used.

Currently, DP3 only processes/calibrates experimental transistor data with no intention of further development in Visual Basic for Applications, a Microsoft™ computer language (VBA). Data Processor 3 will eventually migrate to a more advanced high-level language.

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# 2 HIGH-LEVEL DESCRIPTION

Data Processor 3 processes experimental transistor data generated by the experimenters, specifically data generated with Piece Part Circuits (Figure 2-1). Processing includes reducing and averaging/splining data sets. Data sets can reach anywhere up to 30 million recorded values so reducing the data is important to give the modelers a reasonable size data set to analyze. From a down-selected number of points, the set is splined in high transient periods and averaged in all other periods (Morrow 2017, in progress). In general, averaging is done by selecting a point from the full set and averaging it with a selected number of neighboring data points, while splining consists of curve fitting within bracketed time frame (Figure 2-2) both of which DP3 implements. Applying reducing and splining methods preserves the integrity from the full data set and significantly reduces the uncertainty for the reduced data. From the reduced and averaged/splined data sets DP3 produces an output with post processing calculations or the data is output as is.

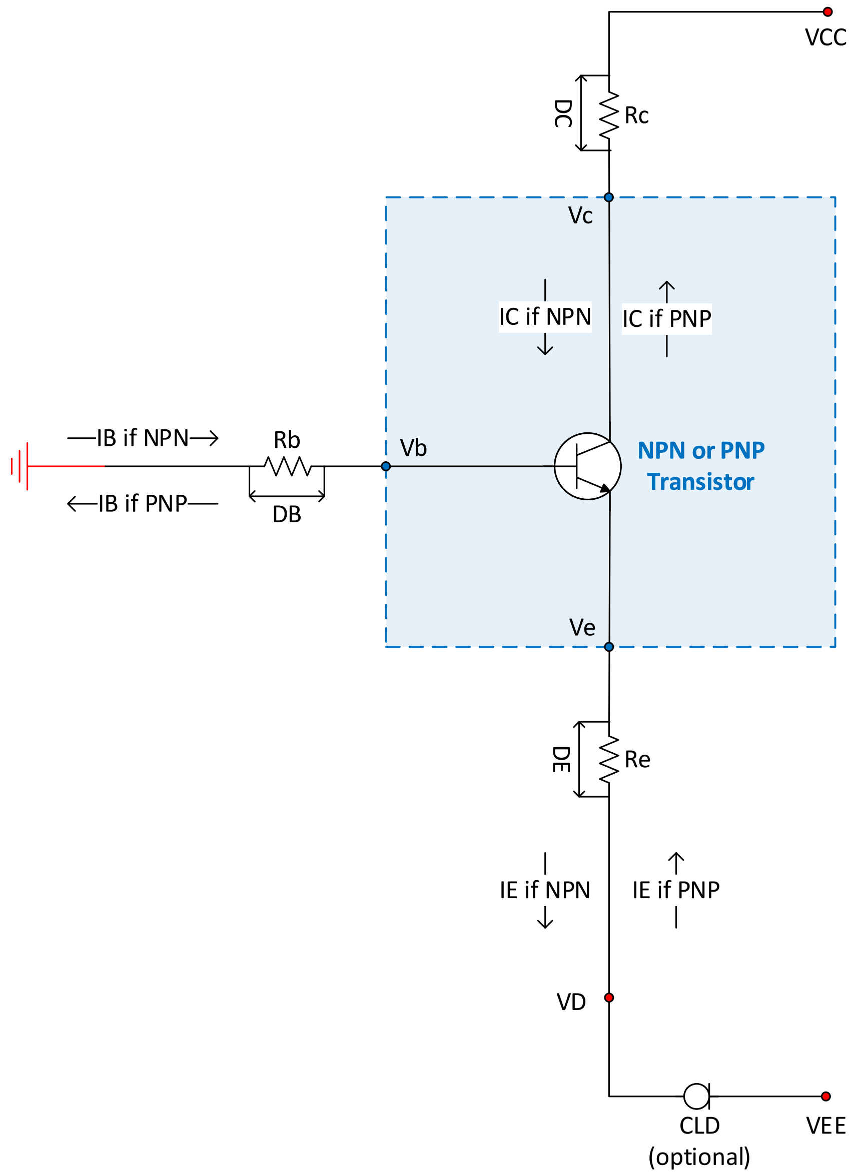


**Figure 2-1: Piece Parts Circuit.**

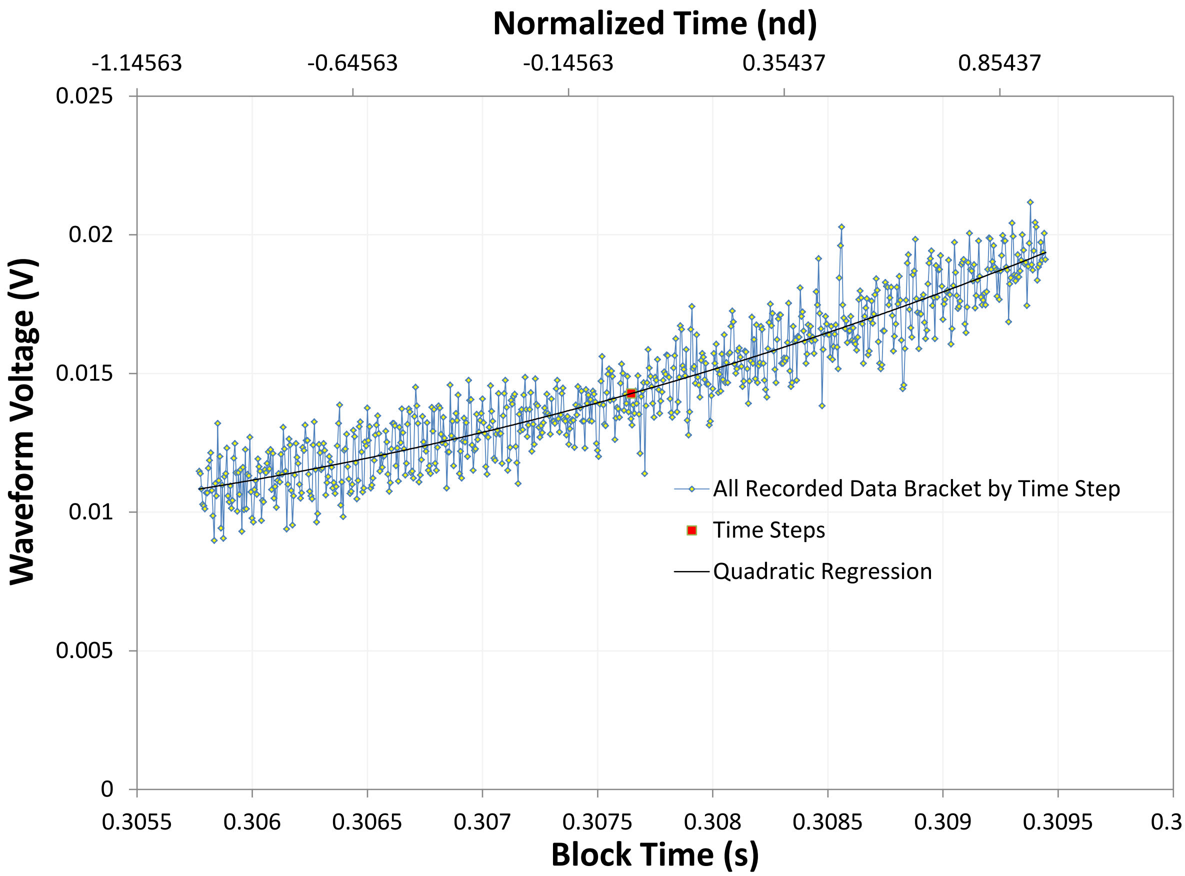


**Figure 2-2: Splining.**

## 2.1 Files and Directory Structures

The output DP3 produces contains a specific directory structure along with files. **Note: The NeuCal Directory and corresponding files are only created if post processing is done otherwise the output.zip file is the only output DP3 generates.**

### *2.1.1 Directory Structures*

#### 2.1.1.1 Temporary Work Directory

Before any processing takes place DP3 creates a temporary work folder on the user's desktop. This is where all the work is done creating, editing and copying directories and files. The main directory created inside the temporary work folder is the "output" directory, described in Section 2.1.1.3. This is a copy of the work directory found on the Qualification Alternative to Sandia Pulsed Reactor (QASPR) server with various directories and files added to it. If no post processing is done, then DP3 excludes the NeuCal file structure from the output directory and final output directory. Once the output directory is created DP3 processes data and stores generated files in the appropriate directories found inside the output directory.

DP3 then checks for a final output folder, described in Section 2.1.1.4, on the output destination, described in Section 3.1.2. If no final output directory is present, then it is created inside the temporary work folder. A copy of the NeuCal file structure along with its files is stored on the top level of the final output folder. The output directory gets compressed to a zip file called "output.zip," described in Section 2.1.1.3 and is copied to the final output directory. The final output directory is then copied to the output destination.

If a final output directory is present on the output destination, DP3 reaches into the final output directory, unzips the output.zip file and stores the contents in a temporary holding folder inside the temporary work folder. DP3 then copies newly created files from the output directory to the NeuCal file structure found in the final output directory and temporary holding folder. This overwrites any preexisting files residing in the final output directory and temporary holding folder. The temporary holding folder is then compressed back into the output.zip file and then copied to the final output directory which will overwrite any preexisting output.zip files (Figure 2-3 and Figure 2-5). The method of unzipping the output.zip and then writing the files was adopted because of the limitations VBA has adding/copying a file to a compressed folder.

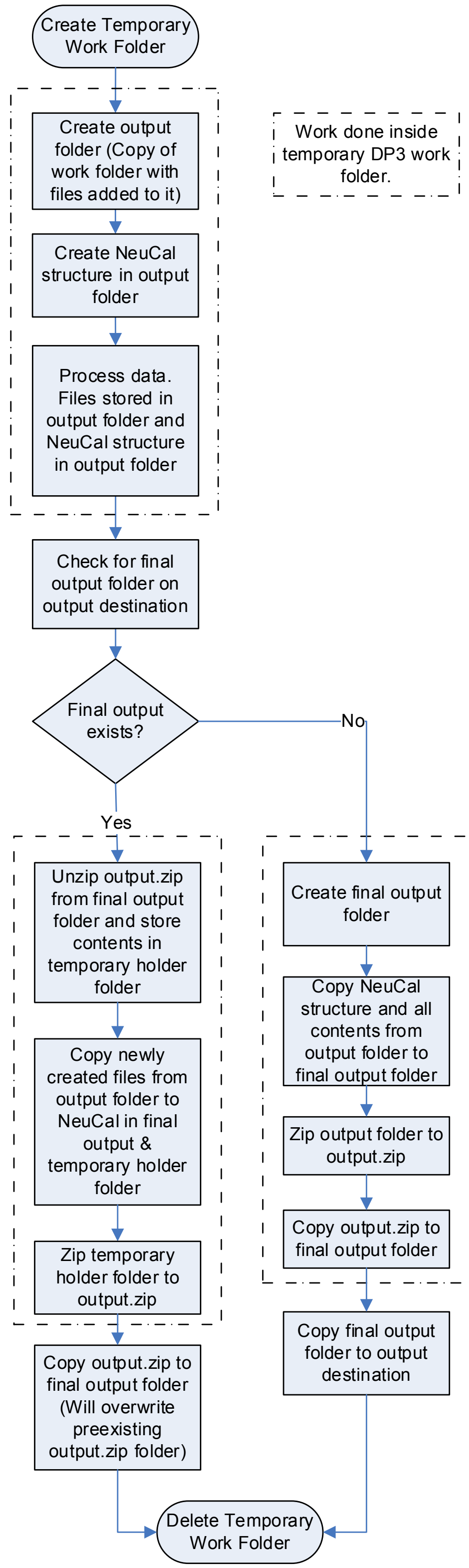


**Figure 2-3: Post Processing Temporary Work Folder Flowchart.**

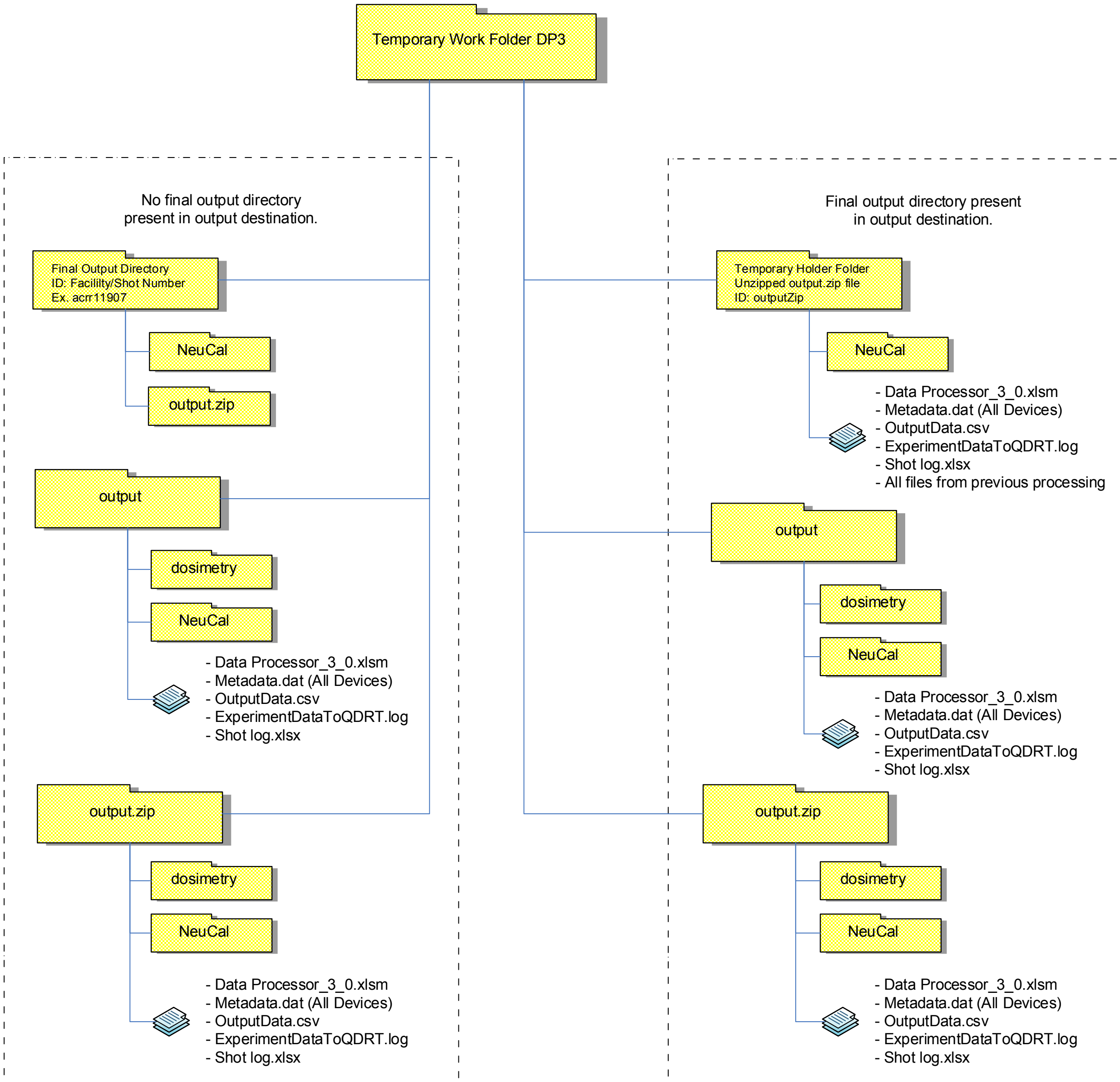


**Figure 2-4: Temporary Work Folder Structure.**

### 2.1.1.2 NeuCal File Structure

The NeuCal directory contains a directory for each test type, Active, Candy Bag and Delayed On (Erickson, 2017) and formatted FPcols.txt files, described in Section 2.1.2.5. Inside the test type directories contains individual device directories, identified by device serial number. Test type directories are populated with the device directories depending on the test type being processed. Each device directory contains three files: a device response prn file, a completed neutron_cal.in template file and device specific metadata.dat file, all described in Section 2.1.2 (Figure 2-5). The NeuCal Directory is created in the output directory and copied to the final output directory (Figure 2-6). **Note: The NeuCal directory is only created if post processing is done.**

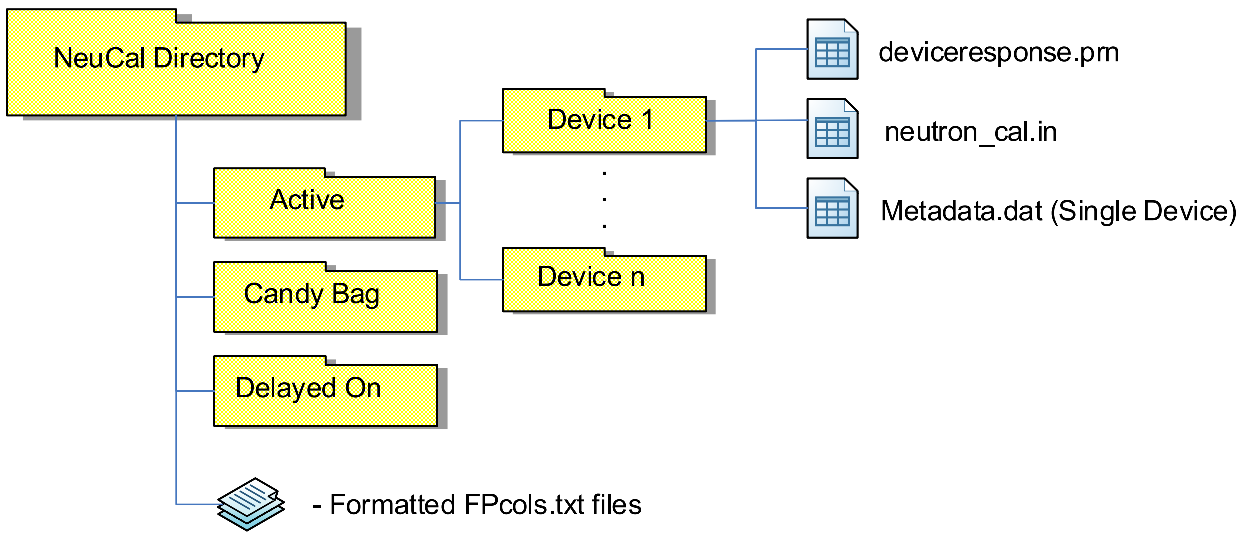


**Figure 2-5: NeuCal File Structure.**

### 2.1.1.3 Output Directory and Output.zip File

The output directory is the directory that contains all information regarding post processing calculations and dosimetry or just processed data in the case where no post processing is needed. To start, DP3 generates a copy of the work directory found on the QASPR server (Ex. \\snl\css\QASPR_DRT_serve\GeneralWork\ACRR\11909) and is used as a base for the output directory. Note: DP3 only copies non-empty directories and files from the work directory. This is done to avoid error using VBA's built-in copy functions. Typically, the output directory starts out with a dosimetry directory and a corresponding shot log. Before processing happens, various content is added to the directory such as the NeuCal file structure, FPcols.txt files and ExperimentDataToQDRT.log file. During processing DP3 populates the NeuCal file structure with device specific files and creates a Metadata.dat and a OutputData.csv containing information about all the devices included in the shot. Once processing is complete the output directory is compressed into a zip file called output.zip. The zip file contains the same information and is the same exact structure as the output directory. For now, compressed files are the most efficient way of moving and storing processed data.

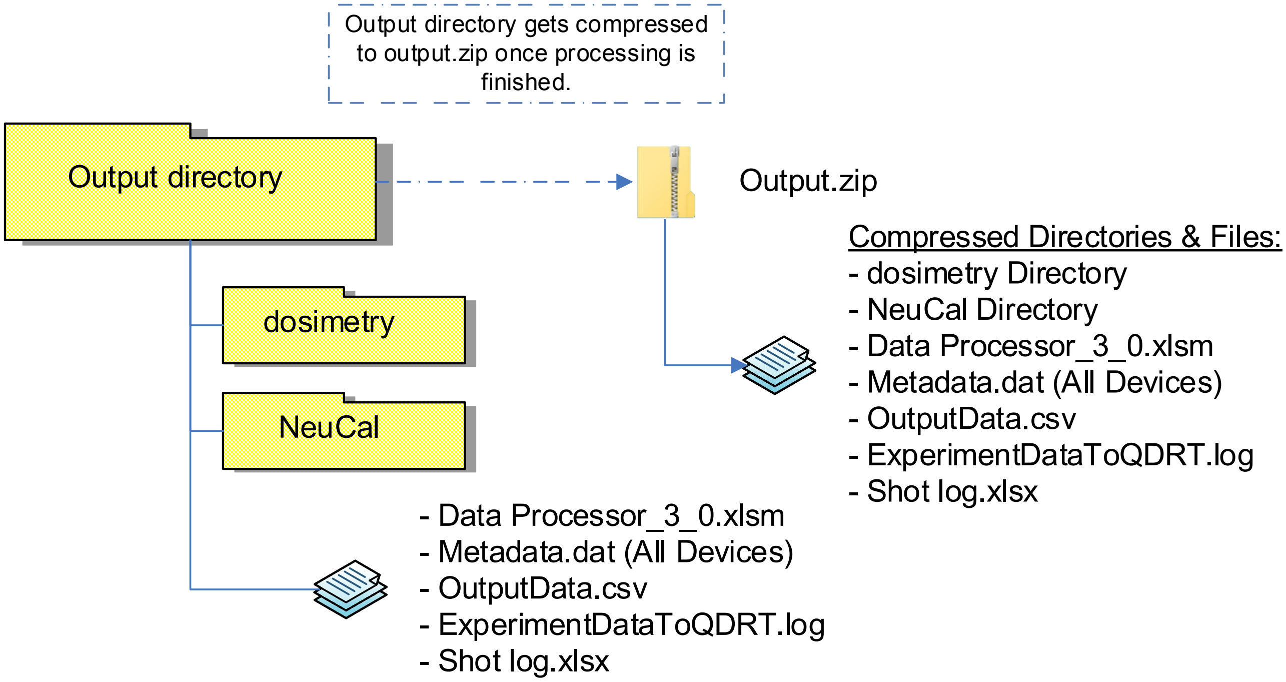


**Figure 2-6: Output Directory.**

#### 2.1.1.4 Final Output Directory

The final output directory is the directory that is stored on the output destination of the user's choice, described in Section 3.1.2. The final output directory is identified by the experiment facility and shot number concatenated together and contains the NeuCal file structure, Section 2.1.1.2 and the output.zip, Section 2.1.1.3 which is the output directory compressed, described in Section 2.1.1.3. After processing is complete a copy of the NeuCal file structure from the output directory and a copy of the output.zip is copied from the temporary work directory, described in Section 2.1.1.1, are stored on the top level of the final output directory (Figure 2-7). The folder structure of the final output directory is in the format most useful for the modelers and may be subject to change in the future.

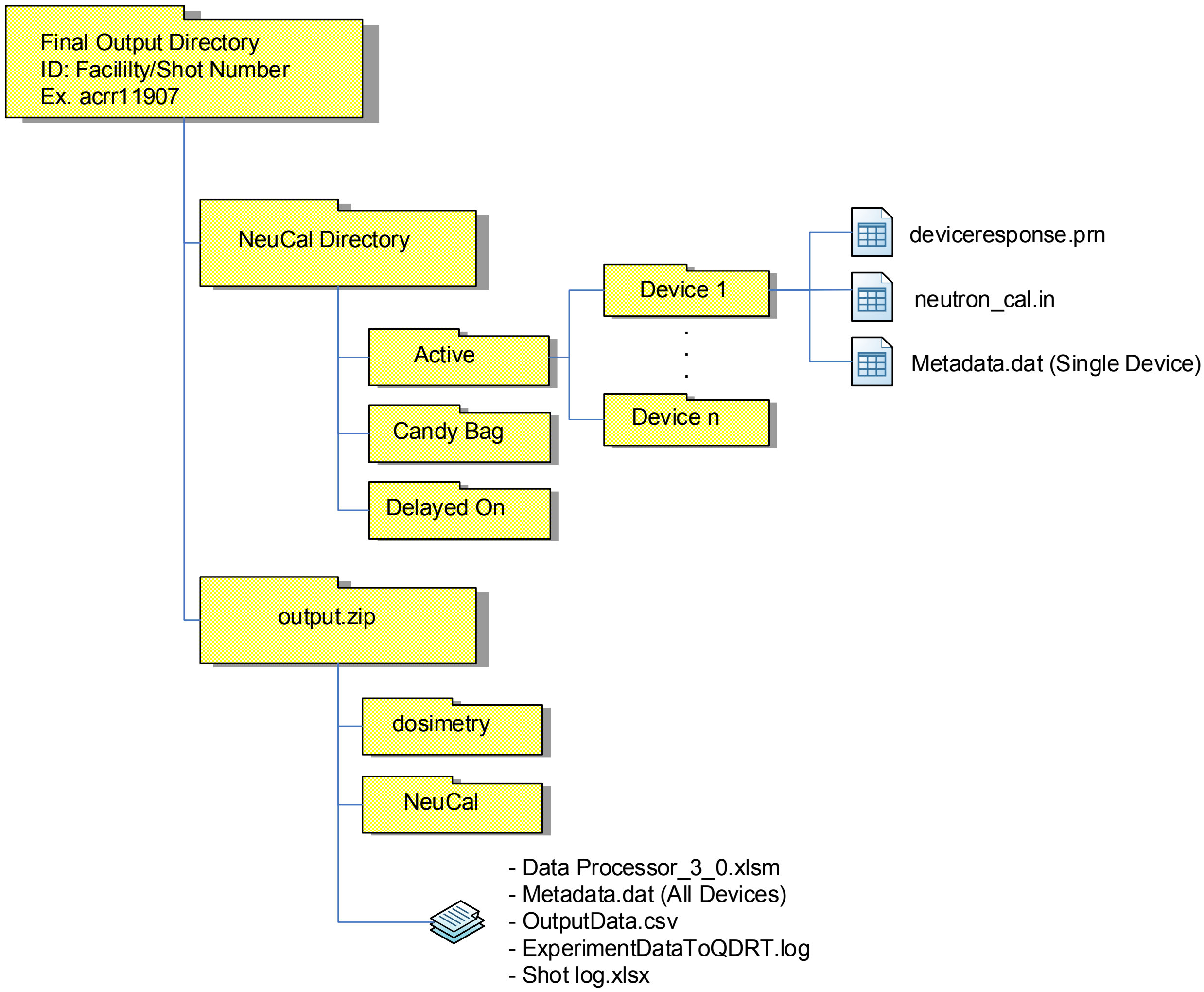


**Figure 2-7: Final Output Directory.**

### 2.1.1.5 Candy Bag Directory

DP3 requires a specific folder structure to process candy bag test type (Figure 2-8). The directories under the candy bag folder, Device Type, post, pre, etc., are not created automatically by the ExperimentDataToQDRT software script (Erickson, 2016) the user must create all directories under the candy bag folder manually. The Device Type directory naming convention is determined by the device name prefix typically found in the shot log under the "Device" column. The number of candy bags attached with a shot determines how many Device Type directories will created in the candy bag directory. If multiple candy bags attached with a shot have the same device prefix append sequential numbers to the end of each prefix. Under each Device Type directory, the user must create a pre and post directory. These directories hold the measured candy bag data in WDF/WVF format for pre and post shot.

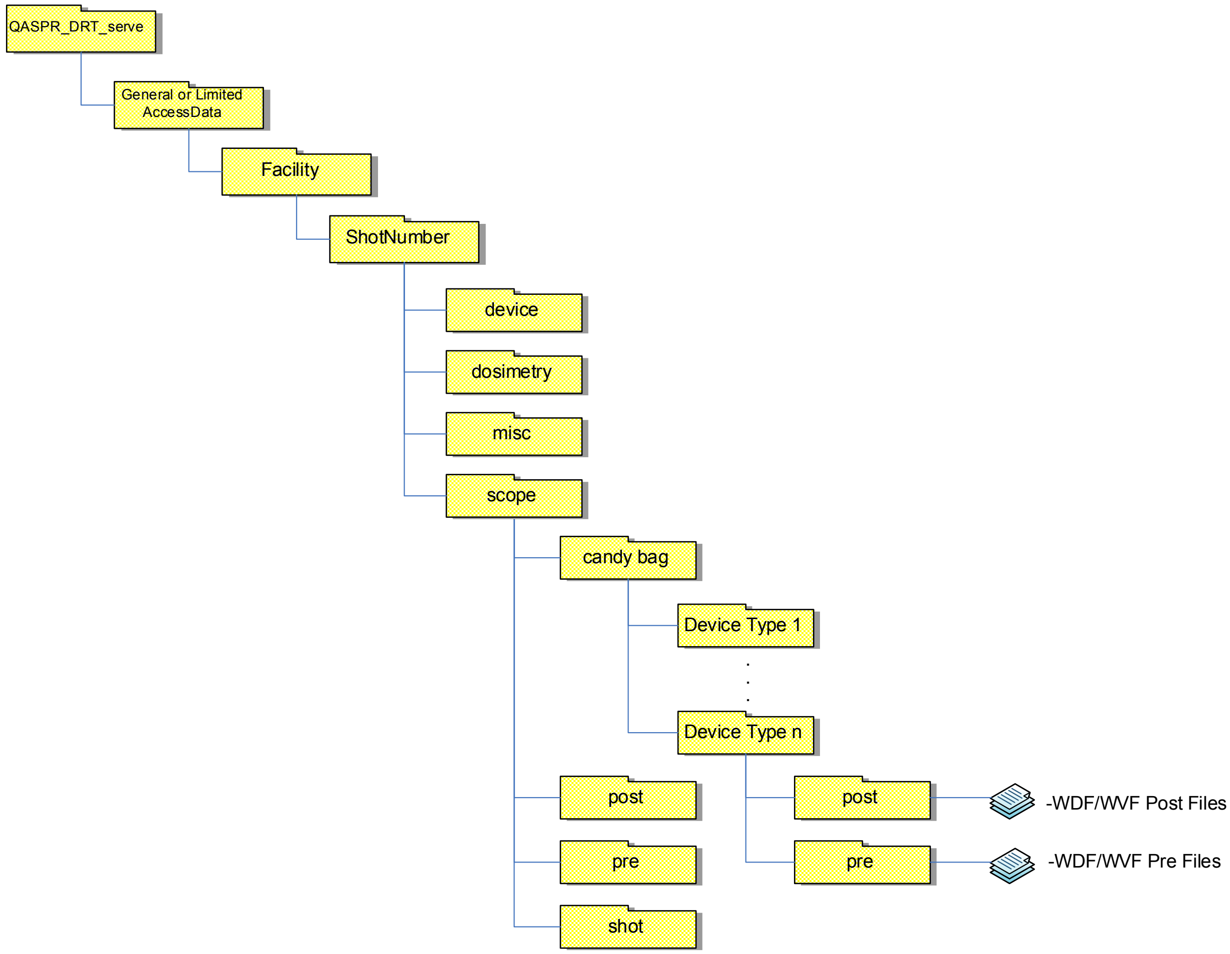


**Figure 2-8: Required Candy Bag Directory Structure.**

### *2.1.2 Files*

#### 2.1.2.1 Device Response PRN File

The prn file is used as an input to Xyce software. The general format is two column wise vectors of data, the first column being a calculated time vector dependent on the shot and test type and the second column being a data vector containing a calculated inverse gain. As of now, DP3 formats the prn file specific to what Xyce needs which is the absence of column headers. The format may change in the future with further development of Xyce. The prn file is generated for each device and is stored in device specific directory under the NeuCal file structure (Figure 2-5). **Note: Device response prn file is only created when post processing is done.**

#### 2.1.2.2 Metadata.dat Files

There are two types of metadata.dat files that are generated, a device specific metadata.dat file containing information relative a specific device stored in device specific directory under the NeuCal file structure and an all device metadata.dat file containing information for all devices stored on the top level of the output directory (Figure 2-6). The metadata files include initial condition values, described in Section 2.2.2.1, for Base, Emitter, Collector voltages and currents, calculated inverse gain and information on the device such as serial number, turn on time, test type, etc. **Note: Metadata.dat files are only created when post processing is done.**

#### 2.1.2.3 Neutron_cal.in File

The neutron_cal.in file is a template provided by modelers. The template contains various information on a device and has value place holders which DP3 replaces with resistor values, voltages, etc. when the file is generated. The template starts out as a cir file and then saved as a .in file. The templates are found in the molder's directory on the QASPR server (\\snl\css\QASPR_DRT_serve\ModelerData). **Note: Neutron_cal.in file is only created when post processing is done.**

#### 2.1.2.4 OutputData.csv File

The last file DP3 generates is the OutputData.csv file. It contains vectors of data and information including shot dates, device serial numbers, shot number, facility, date of creation, time, delta inverse gain, inverse gain, voltages and currents for each transistor leg. The OutputData.csv has specific formatting described in Section 2.1.2.4.1. The OutputData.csv file is saved as a comma delimited file which is useful for the modelers.

##### *2.1.2.4.1 Formats*

All shot data is calculated, stored in memory and written to the OutputData.csv file. The user can choose either one of two formatting options, described in Section 3.1.4, Stacked or Columns. The Columns format presents the shot data in columns side by side in horizontal fashion. This format makes it easier for the data analyst to read and plot data and is recommended for verifying (Figure 2-9). The Stacked format is used by the modelers. It is shot data for each device stacked on top of each other (Figure 2-9). The modelers use this format for their software scripts which extracts the data and analyzes it. **Note: The user must select the Column format type if no post processing is done**.

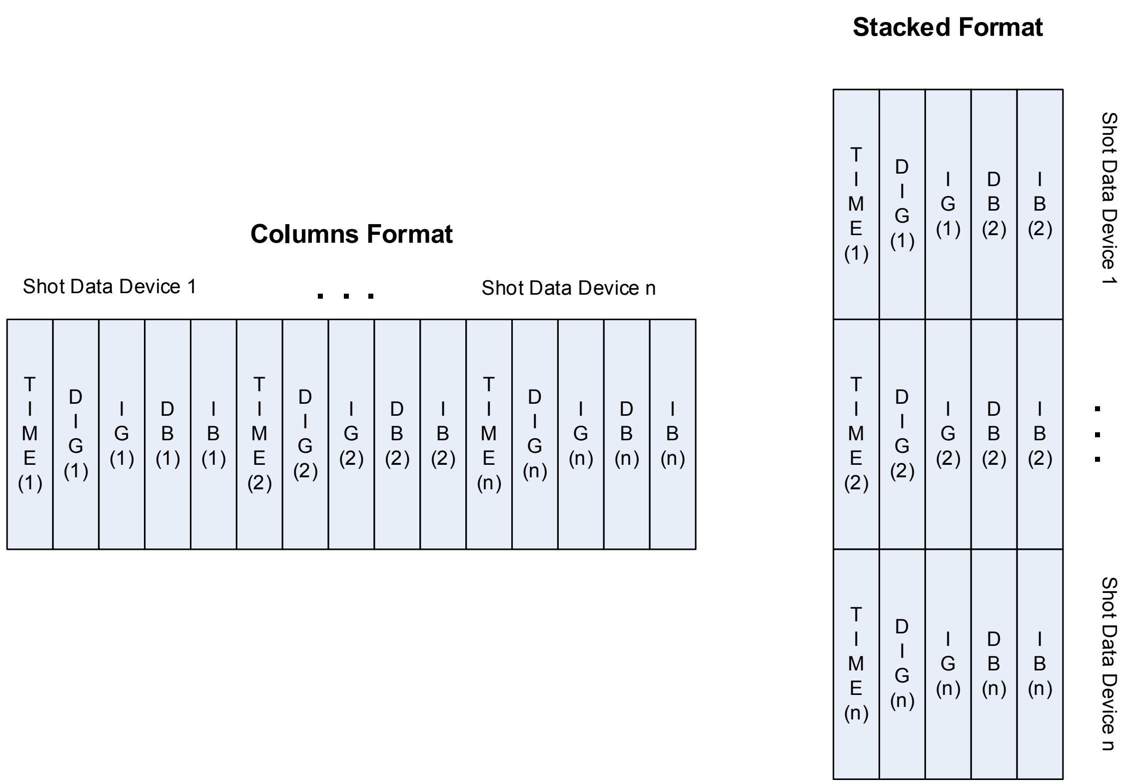


**Figure 2-9: OutputData.csv Formats.**

#### 2.1.2.5 Frenkel Pair File Formatting

As of September 2017, the modelers have requested specific formatting for the generated Frenkel Pairs files which is to remove column headers, negative times with its associated data and replacing the first and last values with zero in the data column. This formatting may be subject to change in the future depending on the modeler's needs.

#### 2.1.2.6 Miscellaneous

DP3 copies the "summary" worksheet from the shot log for a given shot to the DP3 workbook. Information about the shot is extracted from the summary sheet such as device names, date, resistor values, etc. In more recent shots experimenters have automated their recording process by including a setup file where trace names and other information are entered. This file is used as a reference for the data analyst and is copied to the DP3 workbook if present for a given shot.

## 2.2 Processing

### *2.2.1 Shot Types, Test Types and File Types*

Described below is the shot, test and capture types of a shot and how the combinations of these types effect processing.

#### 2.2.1.1 Shot Type

There are two shot types that are defined, Steady State and Pulsed. A Steady State shot type is a steady dose of energy from a reactor radiating devices over a long period and a Pulsed shot type is a pulse of energy from a reactor radiating devices over a short period. The Steady State shot type is denoted by the "SS" marking in the shot log under the Peak MW column. If not noted in the shot log the user can assume the shot type is Pulsed.

#### 2.2.1.2 Test Type

There are three types of tests experimenters conduct which are Active, Candy Bag and Delayed On. An Active test type is implemented by powering on all devices and taking measurements for the duration of the experiment. A Candy Bag test type is implemented by radiating standalone devices in a "candy bag" earlier in time, then powering on and measuring the devices 1 to 2 days later. A Delayed On test type implements the same procedure as the candy bag test but devices are typically powered on and measured around 100 seconds later. The test type is typically denoted in the shot log. If the shot is Delayed On test type it is denoted by the marking "Parts delayed on at t0+100sec" in some variation under the Comments column. This is the indication that the test type is Delayed On. Candy bag test type it is denoted by either the "CB" or "Candy Bag" marking under the Op or MJ Columns. If neither of these indicators are found for Candy Bag and Delayed On in the shot log, then the user can assume that the shot is of Active test type.

#### 2.2.1.3 Capture Type

The Yokogawa DL850 produces two file formats, single capture and dual capture both of which is processed by DP3. A single capture file contains only one sampling frequency for a recorded signal and dual capture contains multiple sampling frequencies for the same recorded signal (Morrow, 2017, in progress). DP3 determines the capture type.

#### 2.2.1.4 Combinations

Shots are broken up into a number of categories and are defined by the combinations of shot type, test type and capture type. For a given combination, specific processing is required. For instance, a Steady State Active Dual Capture shot requires dual capture data extraction methods and time vectors generated with evenly spaced points to capture the entirety of the shot versus Pulsed Active Single Capture which requires single capture data extraction methods and logarithmically spaced time vectors with most of the points centered around the transient. The shot type and test type are entered by the user, described in Section 3.1.3, and the capture type is determined by DP3. Once the combination of shot type, test type and capture type are identified, the appropriate processing and subroutines are implemented (Figure 2-10).

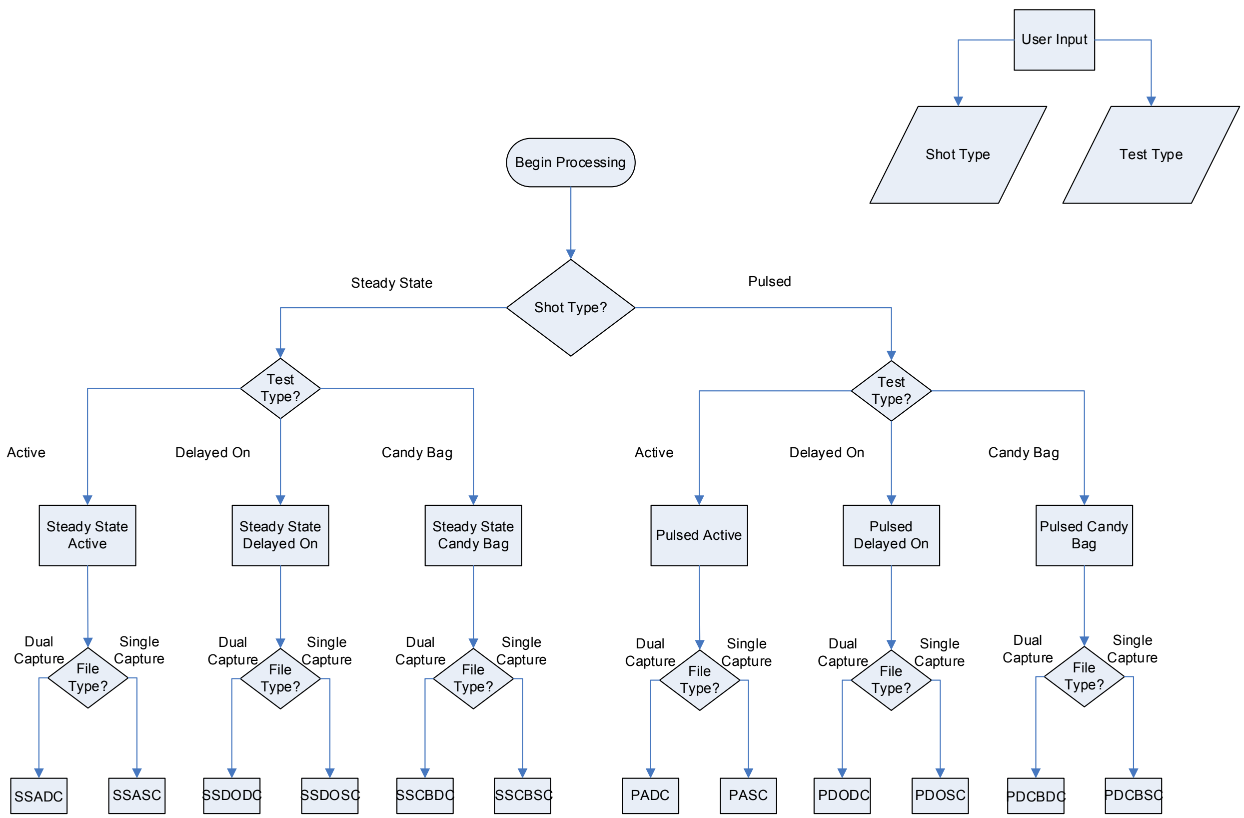


**Figure 2-10: Shot, Test & Capture Type Combinations.**

### *2.2.2 Post Processing*

Only post processing calculations for Piece Parts circuits is included and is enabled by checkmark box in the user interface described in Section 3.1.4.

#### 2.2.2.1 Initial Conditions

Before an experiment is conducted each device must be characterized. In general, this is done by powering on each device and taking measurements pre-experiment. Using the measured voltages, currents, gains, etc. are calculated (Table 2-1) and then averaged. These are called initial conditions. Either one of two methods are implemented when calculating the initial conditions.

**Table 2-1: Post Processing Calculations**

| Name | Acronym | Calculation | Comments |
|---|---|---|---|
| Base Differential Voltage | DB | Measured Values | Not calculated measured with Yokogawa oscilloscope. |
| Collector Differential Voltage | DC | Measured Values | Not calculated measured with Yokogawa oscilloscope. |
| Emitter Differential Voltage | DE | Measured Values | Not calculated measured with Yokogawa oscilloscope. |
| Resistance on Base Leg | Rb | Measured Value | Measured before experiment. |
| Resistance on Collector Leg | Rc | Measured Value | Measured before experiment. |
| Resistance on Emitter Leg | Re | Measured Value | Measured before experiment. |
| Base Current | IB | $IB = \frac{DB}{Rb}$ | Post processing calculation. |
| Collector Current | IC | $IC = \frac{DC}{Rc}$ | Post processing calculation. |
| Emitter Current | IE | $IE = \frac{DE}{Re}$ | Post processing calculation. |
| Inverse Gain | IG | $IG = \frac{IB}{IC}$ | Post processing calculation. |
| Delta Inverse Gain | DIG | $DIG = IG - IGic$ | IGic is inverse gain initial condition. |

##### *1.1.1.1.1 Method #1*

The first method is done by extracting measured data from pre files generated by the experimenters “pre-experiment.” DP3 determines the method by the presence of pre files. If the pre files are included with the shot then the pre files are used to calculated the initial conditions otherwise shot files are used. Prior to early 2017, pre files were only generated for Candy Bag and Delayed On test types but will be standard procedure for all test types moving forward. When using pre files DP3 finds the interval when the device is powered on and generates a linear time vector in that time frame. The generated linear time vector is then used to load waveform data from corresponding pre files. Once all waveform data is processed, voltages, currents and gains are calculated, averaged and then stored. Extracting measured data from the pre files is the simpler of the two methods and gives a better estimate of device characteristics pre-radiation.

##### *1.1.1.1.2 Method #2*

The second method is extracting measured data from shots files generated by the experimenters during the experiment. When using the shot files two separate linear time vectors are generated. The first is in the pre-pulse time frame and is determined by the Full Width Half Max (FWHM) (Morrow 2017, in progress) of the reference photo-conducting device (pcd). From the calculated FWHM, DP3 generates a linear time vector is from $-12 * FWHM \ to -2 * FWHM$ defined as pre-pulse. The second linear time vector is generated from the horizontal offset to a point right before radiation is detected (point of inflection). The second generated linear time vector gives a better estimate of the device characteristics because the time frame is considered pre-radiation as opposed to the pre-pulse where some damage has occurred to the device from radiation. Once both time vectors are generated and waveform data is processed, voltages, currents and gains are calculated, averaged and stored for each time vector (Figure 2-11). **Note: Generally, Method #2 is only used for Pulsed Active shots with no pre files.**

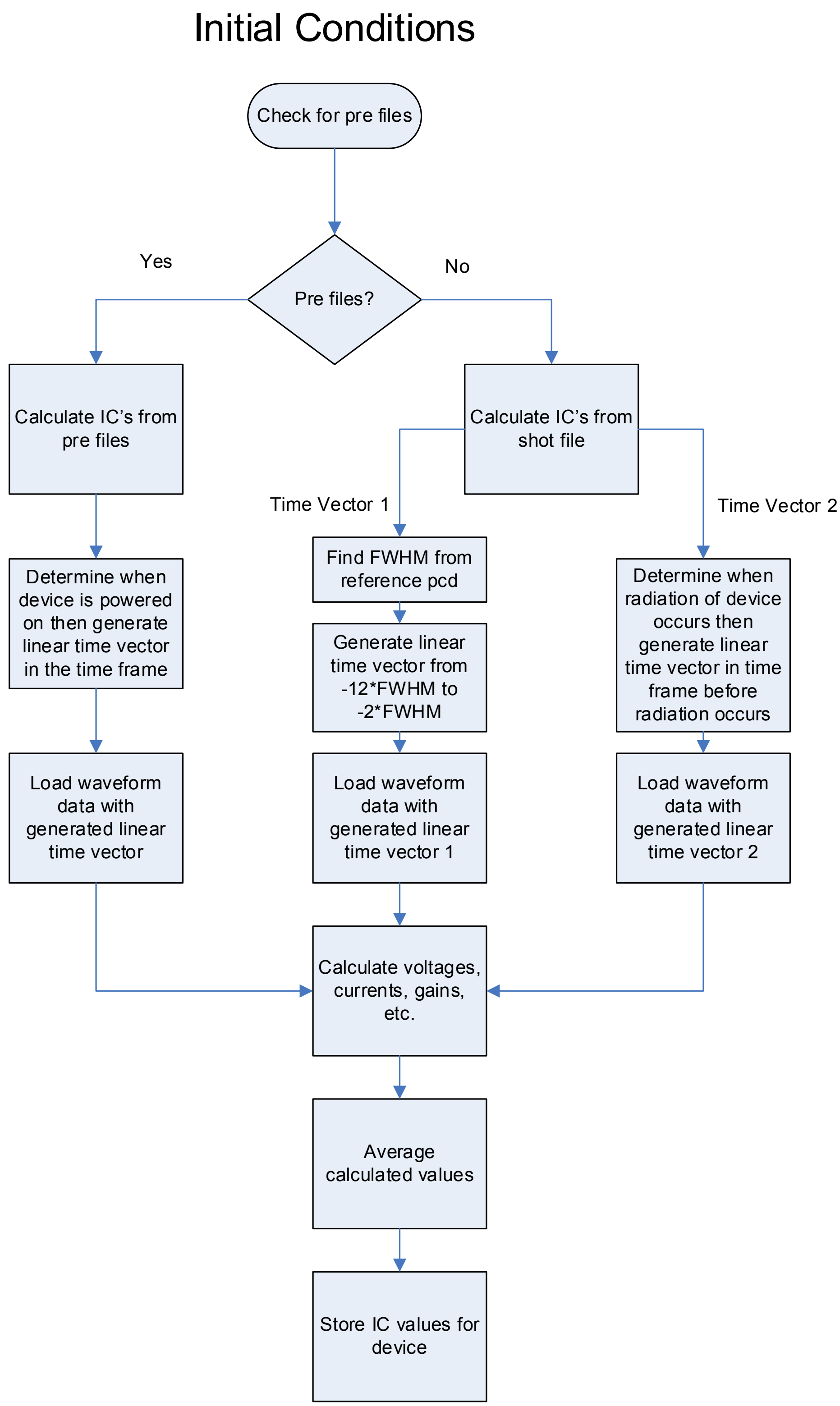


**Figure 2-11: Calculation of Initial Conditions Flowchart.**

### 2.2.2.2 Shot Data

Shot data is calculated voltages, currents, and gains from measured data extracted from shot files generated by the experimenters. All devices in a given experiment are powered on and measured while being radiated with either a pulse of energy of a short period or a steady amount of energy over a long period. The shot data is analyzed to give an indication of the characteristics and performance of each device before and after the radiation period.

#### *2.2.2.2.1 Time Vectors*

To get the most out of the measured data embedded in the shot files, correct time vectors must be generated for processing.

##### 2.2.2.2.1.1 Candy Bag and Delayed On Time Vector Generation

Candy Bag and Delayed On test types generate time vectors using the same method regardless of the shot type. A logarithmically spaced time vector should be considered for these two test types with the origin point placed at the turn on time of the device. The turn on time is indicated by the falling edge of a trigger signal embedded with each shot file which DP3 finds and uses for the point of origin (Figure 2-12). Most of the points should be place at the turn on time. This captures the behavior of the device immediately after it is powered on.

##### 2.2.2.2.1.2 Steady State Active Time Vector Generation

A Steady State Active shot requires a linear time vector (Figure 2-12). The device is powered on and radiated for the entirety of the experiment. For the data to be analyzed correctly, it must be extracted with evenly spaced time steps.

##### 2.2.2.2.1.3 Pulsed Active Time Vector Generation

A Pulsed Active shot requires a logarithmically spaced time vector with the origin point place at peak of the transient. This is indicated by the peak value of the reference pcd embedded in the shot files. DP3 finds the time at which the peak occurs and uses that time as the point of origin for Pulsed Active (Figure 2-12).

The waveform data is processed with the generated time vectors and the voltages, currents and gains are then calculated, averaged and stored (Table 2-1).

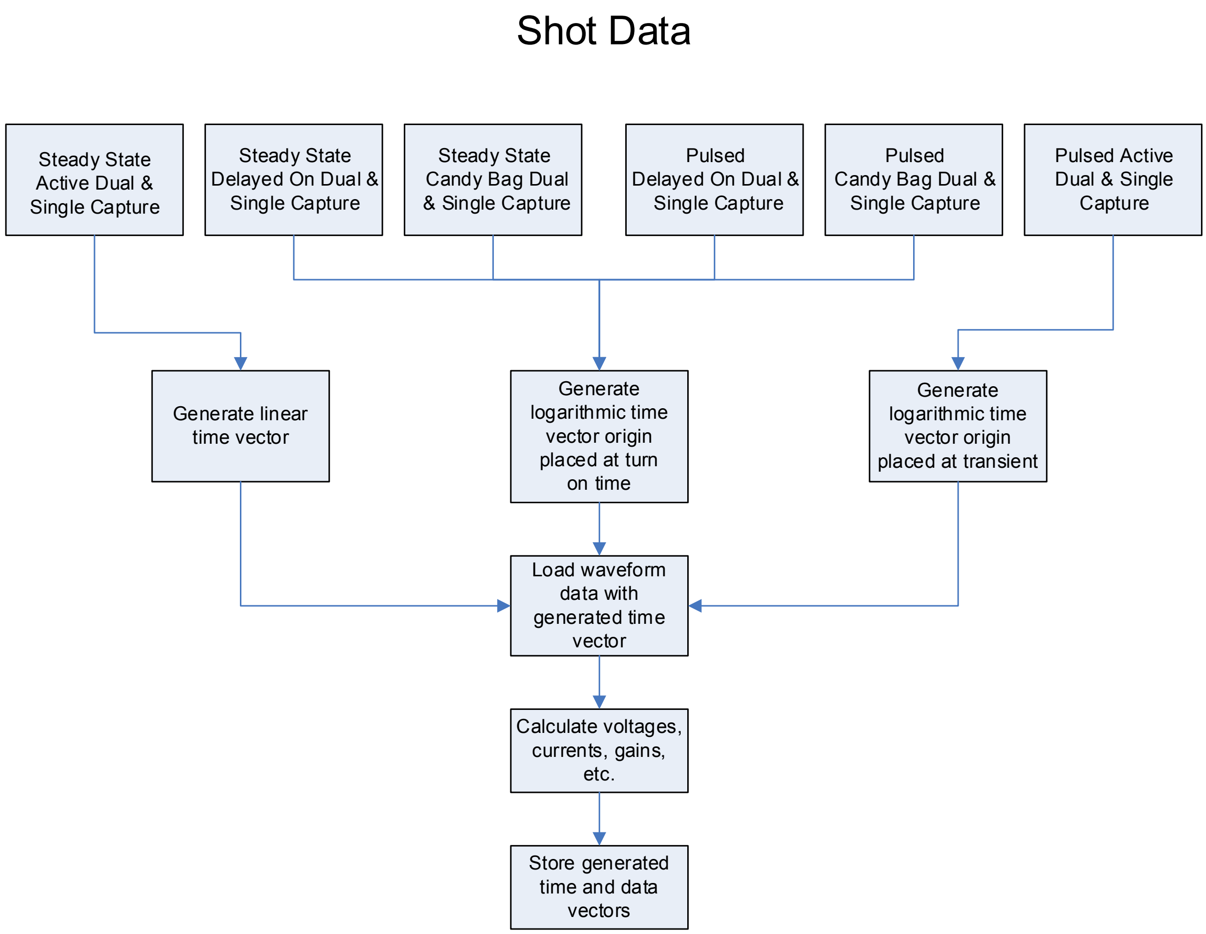


**Figure 2-12: Calculation of Shot Data Flowchart.**

# 3 USER INTERFACE

Inputs to Data Processor 3 are entered through an Excel custom ribbon. The ribbon is under the custom created tab labeled "Data Processor" (Figure 3-1).

## 3.1 Ribbon Inputs

Only the inputs shown below are required for DP3 to process data and is described in greater detail.

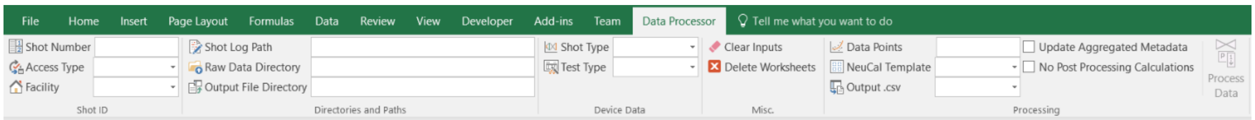

**Figure 3-1: Data Process Custom Excel Ribbon.**

### *3.1.1 Shot ID*

Shot Number – Number used to identify shot. Typically listed in the shot log.

Access type – Experimenters determine the access level of all generated experiment data on the QASPR server. Ask experimenter if access type is unknown. Options:

- General – Data available to any of the QASPR users.
- Limited – Data available to limited number of QASPR users.

Facility – facility where experiment was conducted. Typically found on shot log, ask experimenters if facility is unknown. Options:

- ACRR - Annular Core Research Reactor
- WSMR - White Sands Missile Range
- SPR - Sandia Pulse Reactor
- Other – Other Reactors

### *3.1.2 Directories and Paths*

Shot log path – File path of the shot log of shot being processed.

Raw Data Directory – Folder path of raw directory for specific shot being processed. The raw data directory can be found on QASPR server.

(Ex. \\snl\css\QASPR_DRT_serve\GeneralAccessData\Raw\ACRR\11907)

Output File Directory – Output destination of the user's choice. This must be folder path string

(Ex. \\snl\css\QASPR_DRT_serve\GeneralAccessData\Processed\ACRR). If analyzing a shot, it is recommended to use the user's desktop as the output destination.

### *3.1.3 Device Data*

Shot type – Type of experiment conducted via release of energy from the reactor. Typically listed in shot log. Options:

- Steady State – Steady does of energy radiating devices over long period.
- Pulsed – Pulse of energy radiating devices over short period.

Test Type – Type of test conducted. Typically listed in the shot log. Options:

- Active – Devices are powered on and measured for duration of experiment.
- Candy Bag – Device are radiated earlier in time then powered on and measured 1 to 2 days later.
- Delayed On – Device are radiated earlier in time then powered on and measured approximately 100 seconds later.

### *3.1.4 Processing*

Data Points - Number of output points. Data is reduced to this number of data points.

NeuCal Template – Neutron calibration template. Subject to change templates are altered semi-frequently. Options:

- neutron_cal_TEMPLATE.cir – Most recent template file updated by modelers.
- neutron_cal_TEMPLATE_AG.cir – Older template may still be used.

Output .csv – format of OutputData.csv file. Options

- Columns – Data arranged in column vectors placed next to each other for each device, described in Section 2.1.2.4.1.
- Stacked – Data arranged in stacked form for each device, described in Section 2.1.2.4.1.

Clear Inputs – Button to clear inputs on Data processor worksheet.

Delete Worksheets – Button to delete all worksheets in DP3 workbook except for "Data Processor" worksheet.

Update Aggregated Metadata – Check to write to aggregated metadata file with various shot information. The file is named AggregatedMetaDataAW.csv and can be found in: \\snl\css\QASPR_DRT_serve\GeneralAccessData\Processed_ShotLogs

No Post Processing Calculations – Check to omit post processing calculations (Only for Piece Parts circuits). If box is checked then processed data is output as is with no post processing calculations.

Process Data – Button to start processing. **Note: Process Data button will remain grayed out until user enters all inputs on ribbon and "Data Processor" worksheet inputs are populated.**

## 3.2 Errors

To ensure that no errors occur the user must wait until processing is finish. This is indicated by a pop up prompt when complete. In the event of an error the user must be able to debug various issues that could arise some of these errors could be due to format of input file, memory, etc. If an error occurs the Visual Basic developer platform will become active and the user will be prompted. DP3 returns the line in which the error occurred and a description of the error (Figure

3-2). To debug it is suggested to step through the code line by line. This can be done in VBA developer interface by reproducing the error and placing breakpoint before the line where the error occurrs and then using F8 to step through the code. To avoid error a few things can be done: close all file explorer windows that are open and any files that may be used by DP3 such as the shot log.

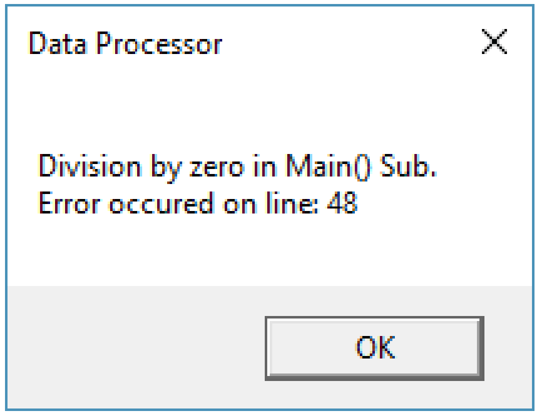


**Figure 3-2: Error Prompt.**

## 3.3 Use

If the user is processing a shot for the first time it is recommended to place DP3's produced output to your desktop and use the Columns formatting. This allows you to easily plot shot data and check the work of DP3 before placing on QASPR Server.

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# 4 DP3 SUBROUTINES

Listed are the modules and subroutines specifically written for Data Processor 3 with a brief description of each subroutine.

## 4.1 Module_DP3_DualCapture

Contains subroutines used for dual capture file format.

### *4.1.1 Subroutines*

calcInitCondFromPreDC - Calculates initial conditions using pre files.

calcInitCondFromShotDC - Calculates initial conditions using shot files.

calcShotDataPADC - Calculates shot data for Pulsed Active Dual Capture shot.

calcShotDataPCBDC - Calculates shot data for Pulsed Candy Bag Dual Capture shot.

calcShotDataPDODC - Calculates shot data for Pulsed Delayed On Dual Capture shot.

calcShotDataSSADC - Calculates shot data for Steady State Active Dual Capture shot.

calcShotDataSSCBDC - Calculates shot data for Steady State Candy Bag Dual Capture shot.

calcShotDataSSDODC - Calculates shot data for Steady State Delayed On Dual Capture shot.

findFallingEdgeDC - Returns falling edge of trigger signal. Used for Delayed On and Candy Bag shots.

findPeakReferencePcdDC - Finds time of peak value for pcd reference.

getInitCondTimeVectorsDC - Returns two time vectors used for calculating initial conditions. Time vector 1 is time before any damage occurs to device(PreRad) and time vector 2 is time right before the pulse occurs(PrePulse).

getSupplyVoltagesDC - Stores power supply voltages.

getTurnOnTimeDC - Returns device turn on time.

pulsedActiveDC – Processes data for pulsed active shot dual capture.

pulsedCandyBagDC - Processes data for pulsed candy bag shot dual capture.

pulsedDelayedOnDC – Processes data for pulsed delayed on shot dual capture.

steadyStateActiveDC – Processes data for steady state active shot dual capture.

steadyStateCandyBagDC - Processes data for steady state candy bag shot dual capture.

steadyStateDelayedOnDC – Processes data for steady state delayed on shot dual capture.

## 4.2 Module_DP3_GlobalVariables

Contains all declared global variable for Data Processor 3.

### *4.2.1 Subroutines*

resetGlobalVariables – Resets all global variables from shot to shot.

## 4.3 Module_DP3_Main

Main module.

### *4.3.1 Subroutines*

Main – Main subroutine.

processData – Choose correct processing for shot type.

pulsedActiveTest - Processes data for pulsed active shot.

pulsedCandyBagTest - Processes data for pulsed candy bag shot(s).

pulsedDelayedOnTest - Processes data for pulsed delayed on shot.

pulsedOtherTest - Processes data for pulsed other shot.

pulsedShot - Chooses appropriate processing for pulsed test type either active, delayed on, candybag or other.

refreshInputs - Executes callback functions used by custom ribbon to refresh global variables.

steadyStateActiveTest - Processes data for steady state active shot.

steadyStateCandyBagTest - Processes data for steady state candy bag shot(s).

steadyStateDelayedOnTest - Processes data for steady state delayed on shot.

steadyStateOtherTest - Processes data for steady state other shot.

steadyStateShot - Chooses appropriate processing for steady state test type either active, delayed on, candybag or other.

## 4.4 Module_DP3_Ribbon

Contains callback functions used by Excel custom ribbon under tab “Data Processor”.

### 4.4.1 Subroutines

clearData – Callback function used to clear contents of input field on ribbon.

clearInputsRibbon – Callback function to clear “Data Processor” worksheet contents.

deleteAllSheetsClick – Callback function to delete all worksheets in DP3 workbook.

doPostProcessing – Callback function to enable post processing calculations.

getAccessType – Callback function to get access type then stored into global variable.

getDataPoints – Callback function to get number of data points then stored into global variable.

getEnabledProcessData – Callback function to enables ‘Process Data’ button.

getFacilityID – Callback function to get facility then stored into global variable.

getNeuCalCount – Callback function to get the number of cir file in modelers directory.

getNeuCalLabel – Callback function to get the string name of each cir file found.

getNeuCalTemplate – Callback function to populate drop down menu with present cir files (NeuCal Templates).

getOutput – Callback function to get output format of csv file then store into global variable.

getOutputDirectory – Callback function to get output destination then store into global variable.

getRawDataDirectory – Callback function to get raw data directory then store into global variable.

GetRibbon – Callback function creates pointer object to store memory address of custom created ribbon. Used with RefreshRibbon to update custom ribbon when execution is stopped.

getShotLogPath – Callback function to get file path of shot log then store into global variable.

getShotNumber – Callback function to get shot number and then store into global variable.

getShotType – Callback function to get shot type then store into global variable.

getTestType – Callback function to get test type then store into global variable.

initializeMyRibbon– Callback function initializes custom ribbon when DP3 workbook is opened.

inputsCheck – Callback function to get access type then stored into global variable.

RefreshRibbon – Callback function to refresh ribbon once execution has stopped.

updateAggregatedMetadata – Callback function to enable writing to aggregated metadata file.

## 4.5 Module_DP3_SingleCapture

Contains subroutines used for single capture file format.

### 4.5.1 Subroutines

calcInitCondFromPreSC - Calculates initial conditions using pre files.

calcInitCondFromShotSC - Calculates initial conditions using shot files.

calcShotDataPASC - Calculates shot data for Pulsed Active Single Capture shot.

calcShotDataPCBSC - Calculates shot data for Pulsed Candy Bag Single Capture shot.

calcShotDataPDOSC - Calculates shot data for Pulsed Delayed On Single Capture shot.

calcShotDataSSASC - Calculates shot data for Steady State Active Single Capture shot.

calcShotDataSSCBSC - Calculates shot data for Steady State Candy Bag Single Capture shot.

calcShotDataSSDOSC - Calculates shot data for Steady State Delayed On Single Capture shot.

findFallingEdgeSC - Returns falling edge of trigger signal. Used for Delayed On and Candy Bag shots.

findPeakReferencePcdSC - Finds time of peak value for reference pcd.

getInitCondTimeVectorsSC - Returns two time vectors used for calculating initial conditions. vTimesIC1 is a time before any damage occurs to device(PreRad) and vTimesIC2 is a time right before the pulse occurs(PrePulse).

getSupplyVoltagesSC - Stores power supply voltages.

getTurnOnTimeSC - Returns device turn on time.

pulseActiveSC – Processes data for pulsed active shot single capture.

pulsedCandyBagSC – Processes data for pulsed candy bag shot single capture.

pulsedDelayedOnSC – Processes data for pulsed delayed on shot single capture.

steadyStateActiveSC – Processes data for steady state active shot single capture.

steadyStateCandyBagSC – Processes data for steady state candy bag shot single capture.

steadyStateDelayedOnSC – Processes data for steady state delayed on shot single capture.

## 4.6 Module_DP3_Utilites

Contains all subroutines used as utilities for Data Processor 3.

### 4.6.1 Subroutines

addSheets - Adds worksheet to current workbook.

calcCurrent - Calculates current of specified leg. Emitter, Base or Collector.

calcDIG - Calculates Delta Inverse Gain using equation DIG = IG - IGic.

calcIG - Calculates Inverse Gain.

calcIGIncludeInitCond - Replaces Inverse Gain data with initial condition values before turn on time.

checkFinalOutputDirectory - Checks for final output directory in output destination.

clearContents - Clears contents of specified worksheet.

clearInputs - Clears contents of Data Processor worksheet.

copyAllFiles - Copies NeuCal, Metadata.data, OutputData.csv files to final NeuCal and output.zip directories.

copyDataProcessorToWork - Saves a copy of DP3 to output folder.

copyFilesToWork - Copies necessary files to DP3 work folder.

createFinalOutputDirectory – Creates final output directory in DP3 work folder.

copyNeuCalDirectory - Copies NeuCal directory from DP3 output folder to final output folder.

copyOutputZip - Copies zip file into final output folder.

copySetupFile - Copies scope worksheets from setup file of current shot to workbook.

copyShotLog - Copies 'summary' worksheet from shot log of current shot to DP3.

copyWorkToDesktop – Copies shot's work folder from QASPR server to DP3 folder on user's desktop.

createCsv - Creates and saves .csv file containing shot data.

createDeviceDirectories - Creates device directories in DP3 NeuCal folder.

createFinalOutputDirectory - Creates final output directory in DP3 work folder.

createMetadataAllDevice - Creates metadata.dat file with information from all devices.

createMetadataDevice - Create metadata.dat file containing only information specific to device.

createNeuCalDirectories - Create NeuCal directories in DP3 output folder.

createNeuCalTemplates - Creates neutron_cal.cir file under NeuCal directory.

createNewZip - Creates empty zip file.

createOutputZip - Creates zip file and copies contents of DP3 output folder into zip file.

createPrn - Creates and saves deviceresponse.prn file.

createTempWorkFolder - Creates temporary DP3 work folder on user's desktop.

deleteSheets - Deletes specified worksheet in current workbook.

deleteTempWorkFolder - Deletes DP3 temp work folder.

dimensionArrays - Dimensions global arrays.

fillData - Stores data item in column vector in repeating fashion.

fillDataDeviceNames - Stores all device names in one array for formatting purposes.

fillShotDataArrays - Fills global shot data arrays.

findClosest - Returns closest number and index to target number in a given array.

findMax - Returns largest value and index in a given array.

findMin - Returns smallest value and index in a given array.

getActiveDosimetry - Returns file path name for .wvf/.wdf containing active dosimetry for single capture file.

getCandyBagPath - Returns folder paths for devices in candy bag folder.

getDesktop - Returns path of user's desktop.

getDeviceNames - Retrieves devices names from shot log information.

getDeviceNumber - Parses device number of waveform name.

getFiles - Returns file path names for .wvf/.wdf files for shot being processed.

getResistorValues - Retrieves resistor values from shot log information.

getSetupFile – Returns file path name to setup file.

getShotDate - Retrieves date of shot from shot log information.

getShotLog - Returns file path name to shot log.

getTraceNames – Returns trace names as they were entered into scope through setup file.

getValidDataIndex - Returns indices of valid data(when device is powered on).

getWaveFormCount - Returns a count of specified waveform name from header file.

getWaveFormNames – Returns a string array of specified waveform names.

isHighFrequencyData - Identifies high or low frequency data. Used for single capture files.

logAmpTransferFunction - Applies lop amp transfer function to data.

logBase - Returns log base.

logInputs - Logs various inputs to Metadata worksheet for current run.

numberOfDimensions - Returns number of dimensions for given array.

returnNeuCalCirFileList- Returns names for each cir file located in the Modelers directory.

saveCsv - Saves 'Results' worksheet as .csv file.

storeCsvFormat - Places column or stacked formatted array on output data worksheet.

storeVector - Stores single column of multidimensional array into single row or column vector.

timeShift - Shifts time vector of device relative to reference pcd using clock time.

writeMetadata - Writes String message to Metadata worksheet.

# 5 CONCLUSIONS

This discussion described the directory structure required to use Visual Basic for Applications, a Microsoft™ computer language, a temporary work folder on the user's desktop, an output folder containing post processing calculations and dosimetry and a final output folder stored on the output destination containing a NeuCal file structure and output.zip. It described the files that are created from the post processing calculations along with their respective formats. The combination of shot type, test type and capture type and how it effects the creation of time vectors used to process data is described and lastly how to use Data Processor 3 by describing the input values in detail and what to do when errors occur.

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