

Appendix A: Data File Format

UTAcquisition records data in an extended binary format originally designed to capture Full Matrix Capture data. The data is split in the raw A-scan data and a file containing the gate values. The A-scan data and gate data are read/written using the classes DAQDataFile.cs and DAQGateFiles.cs respectively in the Neovision/ANDEBaseLib project. Note that the gate file can be recalculated and recreated by the UTAAnalysis program. Table 10 gives a general description of the header for the *.daq file. The header is written by BaseScanDataFile.WriteHeader() which can be overridden by derived classes.

Table 10: DAQ Data File Header Format

| Property | Data Type | Description |
|----------------|------------------|---|
| Prefix | char[] | Used to verify the type of file when reading the file. For ANDE, the prefix is 'ANDEDAQ'. |
| VerMajor | Int16 | Major version number of file format. Currently 6. |
| VerMinor | Int16 | Minor version number of file format. Currently 5. |
| Operator | String | User name of acquisition operator. Received from SCADA in header message. |
| ToolDesc | String | Tool ID received from SCADA in header message. E.g. TM12/A125. |
| SerialNo | String | Serial number of UT instruments (MPLT's). |
| ScanDate | Int32*6 | Date/time of acquisition stored as year, month, day, hour, minute and second |
| SampleFreq | Int32 | Sample frequency in MHz. Converted to ESampleFrequency enum (Neovision/BaseInterfaces/InstrumentHeader.cs) |
| SampleReq | Int32 | Sample resolution in bits. Converted to ESampleResolution enum (Neovision/BaseInterfaces/InstrumentHeader.cs) |
| FrameCount | Int32 | Number of frames in the file |
| FooterOffset | Int64 | Offset of the footer data in bytes from the beginning of the file. Set to -1 if there is not a footer. |
| NumChannels | Int32 | Number of channels to be listed below |
| Channels | Channel[] | Array of channel objects (described below). There will be NumChannels objects. |
| NumAxes | Int32 | Number of axes provided by tool. For ANDE, this should be 1 (axial). |
| AxisLabels | String[] | Name of each axis. There will be NumAxes strings. |
| NumMeta | Int32 | Number of meta-data values provided by tool. This is not used for ANDE and will be 0. |
| MetaLabels | String[] | Name of each meta-data value. There will be NumMeta strings. |
| HasPrimaryAxis | Boolean | True if PrimaryAxis object is defined. For ANDE, this will be true. |
| PrimaryAxis | AxisInfo | Primary axis information – the primary axis for ANDE is the axial axis. |
| HasFrameAxis | Boolean | True if FrameAxis object is defined. For ANDE, this will be true. |
| FrameAxis | AxisInfo | Frame axis information – the frame axis for ANDE is the rotary axis. |
| HasProbe | Boolean | True if the following Probe information is present. |
| Probe | ProbeSettings | Probe information as described in tables below. |
| ScanInfo | BaseScanSettings | Scan configuration settings such as scan direction, pitch, inspection information. |
| DataOffset | Int64 | File offset where frame data starts |
| FrameCache | Int64[] | FrameCache is file offset for first frame of each slice. |
| PosCache | float[] | PosCache is axial position for the slice. |

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Channel Class Format

| Property | Data Type | Description |
|-------------------|-----------|---|
| Name | String | Channel name |
| Calibrated | Boolean | Flag to indicate if the channel is a calibrated channel |
| Mode | Int32 | Inspection mode (e.g. PulseEcho). Converted to EInspectionMode enum (Neovision/BaseInterfaces/InstrumentHeader.cs) |
| RxElems | Int32 | Number of receive elements. For ANDE, this is set to 3600. (Normally this property is used for Full Matrix Capture type data) |
| TxElems | Int32 | Number of transmit elements. For ANDE, this is set to 1. (Normally this property is used for Full Matrix Capture type data) |
| SampleFreq | Int32 | Sample frequency in MHz used to specify gate values. (i.e. gate values are recorded in digitization points at a particular frequency) |
| Filter | String | Analog filter used for the receiver (e.g. "0.75-25 MHz Bandpass") |
| ZeroOffset | Int32 | Offset time reference point applied to A-scan to account for propagation delay. For ANDE, this is set to 0. |
| AcqDelay | Int32 | Starting time for A-scan data capture in digitization points after the acquisition trigger. |
| InspDelay | Int32 | Starting time for A-scan data capture in digitization points after the interface signal is found (only applicable in Echo Trigger Mode). This is not used in ANDE. |
| Range | Int32 | Acquisition window length of A-scan data capture in digitization points. |
| Gain | Decimal | Receiver gain in dB. |
| Voltage | UInt16 | Pulser voltage in V. |
| Width | UInt16 | Pulse width in ns. |
| TxElem | UInt16 | Transmit UT channel |
| RxElem | UInt16 | Receive UT channel |
| EchoTriggerMode | Boolean | If true, the start of the acquisition window shifts depending on where the interface signal is. This is not used in ANDE and should be false. |
| Rectified | Boolean | True if the signal is rectified. This is always false for ANDE data acquired with UTAcquisition. |
| Aperture | UInt16 | Aperture size in elements for Full Matrix Capture channels. Not used in ANDE. |
| Averaging | UInt16 | A-scan averaging. For ANDE, this is always 1. |
| HalfMatrixCapture | Boolean | If true, only half the aperture is captured for a Full Matrix Capture channel. Does not apply for ANDE. |
| CircularAperture | Boolean | If true, the probes elements are arranged in a circle and therefore a Full Matrix Capture channel will wrap the aperture around the ends of the probe. Does not apply for ANDE. |
| EchoTriggerGate | Gate | Echo trigger gate (interface gate) |
| NumGates | Int32 | Number of additional gates to read |
| Gate | Gate[] | Gate definitions for additional gates. There will be NumGates definitions. |
| HasPrimaryDAC | Boolean | If true, read the next DACCurve object, otherwise skip to the next property (PrimaryDAC is null) |
| PrimaryDAC | DACCurve | Primary depth amplitude correction curve which is applied from the beginning of the acquisition |
| HasSecondaryDAC | Boolean | If true, read the next DACCurve object, otherwise skip to the next property (SecondaryDAC is null) |
| SecondaryDAC | DACCurve | Secondary depth amplitude correction curve which is applied from the beginning of the interface signal |

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| Gate Class Format | | |
|-------------------|-----------|---|
| Property | Data Type | Description |
| Label | String | Label or name of gate |
| Offset | Int16 | Starting offset of gate in digitization points |
| Length | UInt16 | Length of gate in digitization points |
| Thresold | Int16 | Threshold of gate in tenths of percent. (e.g. 1000 is 100%) |
| Params | UInt16 | Gate flags. Converted to EGateParams enum (Neovision/BaseLib/Channels.cs) |

| DACCurve Class Format | | |
|-----------------------------|---------------|---|
| Property | Data Type | Description |
| Name | String | Label or name of DAC |
| Coeff_A | float | Best-fit coefficient A of the DAC curve as defined by $Y=A*X^2 + B*X + C$ |
| Coeff_B | float | Best-fit coefficient B of the DAC curve as defined by $Y=A*X^2 + B*X + C$ |
| Coeff_C | float | Best-fit coefficient C of the DAC curve as defined by $Y=A*X^2 + B*X + C$ |
| fMinTime_us | float | Start time of the DAC corresponding to the earliest raw data point |
| fMaxGain_dB | float | End time of the DAC corresponding to the latest raw data point |
| fDeadTime_us | float | Dead-band (gain is 0 dB) time at the beginning of the DAC |
| fOffsetGain_dB | float | Constant gain added to the DAC (except during the dead-band time) |
| NumPoints | Int32 | Number of raw data points for the DAC |
| DACDataPoint | SDataPoints[] | Raw points used to generate best-fit coefficients as defined below. |
| SDataPoint Structure Format | | |
| Property | Data Type | Description |
| fTime_us | float | Time in μ s at which the data point was recorded |
| fGain_dB | float | Gain in dB of the receive channel for the datapoint |
| nAmplitude | Int32 | Amplitude of the signal for the data point |
| fCorrected_dB | float | Normalized gain in dB of the datapoint (i.e. the gain required to change all the data points to have equal amplitude) |

| ProbeSettings Class Format | | |
|--------------------------------|---------------------|---|
| Property | Data Type | Description |
| Desc | String | Label or description of the probe. Can be used as serial number for transducer. |
| NumElements | UInt16 | Number of probe elements or transducers |
| ProbeType | Int32 | Type of probe converted to EProbeType (Neovision/BaseInterfaces.InstrumentHeader.cs) enumeration. Can be either <i>Phased Array</i> or <i>Conventional</i> . For ANDE, ProbeType is <i>Conventional</i> . |
| Probe | ConventionalProbe[] | Conventional probe definition as described below. There will be NumElements ConventionalProbe objects. |
| ConventionalProbe Class Format | | |
| Property | Data Type | Description |
| Desc | String | Label for probe |

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| | | |
|-----------|--------|--|
| Frequency | Single | Nominal centre frequency of probe/transducer in MHz |
| Angle | Single | Angle of probe in degrees. For ANDE, this is the angle of the probe relative to the normal radial direction. |
| Position | Single | Position of probe. For ANDE, this is the rotary position of the probe relative to top dead centre (TDC). |

The B-scan data is organized into *frames* where a frame is the A-scans from a single UT channel for a full rotation. Given that data is acquired every 0.1° , a B-scan frame has 3600 A-scans. The ANDE system nominally has 12 UT channels so each *slice* of data is 12 frames corresponding to a single axial position. The frames of data for a slice are written in the same order as the UT channels are defined. Table 11 below describes the structure of a *frame* of data. Note that this structure was designed for Full Matrix Capture (FMC) style data which includes every permutation of transmit/receive element pairs and supports null waveforms (where data was not acquired).

Table 11: Frame data structure

| ScanFrame Format | | |
|------------------|-----------|--|
| Property | Data Type | Description |
| FrameIndex | Int32 | Index of frame |
| TxElems | Int16 | Number of transmit elements. This is 1 for conventional UT channels. |
| RxElems | Int16 | Number of receive elements. This is 3600 for ANDE-UT. |
| NumAxes | Int16 | Number of axes. This is 1 for ANDE-UT |
| NumOtherValues | Int16 | Number of meta-data values. This is 0 for ANDE-UT. |
| AxisValues | float[] | Axis values. AxisValues[0] corresponds to the axial position. |
| OtherValues | float[] | Meta-data values. Not used in ANDE-UT. |
| Size | Int32 | Length of A-scan waveforms (i.e. number of points in the digitized waveform) |
| Data | Ascan[] | A-scan waveforms. |

| A-scan Format | | |
|---------------|-----------|--|
| Property | Data Type | Description |
| Len | UInt16 | Length of waveform |
| TxElem | UInt16 | Transmit UT channel number. |
| RxElem | UInt16 | Receive UT channel number. |
| Delay | float | Delay in digitization points. Note that this value does not need to be an integer as the program does support non-integral offsets for data. |
| Interface | Int32 | Interface time-of-flight (ToF) in digitization points |
| GateVals | Int32[] | Gate values |
| Data | UInt16 | Waveform data |

The footer for a DAQ data file contains information to be passed to FLAW C-scan files such as they change records and software gains. Table 12 shows the format for the footer of the *.daq file. The footer is written by the `BaseScanDataFile.WriteFooter()` function which is overridden by the `DAQDataFile` class.

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Table 12: Footer Format

| Footer Format | | |
|------------------|----------------|---|
| Property | Data Type | Description |
| NumChangeRecords | Int32 | Number of change records present |
| ChangeRecords | ChangeRecord[] | Length of waveform |
| NumSoftwareGains | Int32 | Number of software gain values recorded |
| SoftwareGains | float[] | Software gains in dB. |

| ChangeRecord Class Format | | |
|---------------------------|-----------|--|
| Property | Data Type | Description |
| Axial | float | Axial position in mm where the change occurred |
| Timestamp | String | Time when change occurred |
| ParamName | String | Name of parameter which was changed |
| PreValue | decimal | Original value of the parameter |
| NewValue | decimal | New value of the parameter |