PQDIF Guidelines for PQVIEW® Applications Characterization

Power Quality Data Interchange Format Guidelines

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REPORT SUMMARY

Background

The need for a common power quality data interchange format has recently become increasingly important. Many utilities are monitoring the quality of the power they deliver to their customers, while some customers are installing their own instruments to measure the utility supply or to monitor their sensitive processes. Power quality software applications have been developed to provide database management and analysis of the data collected. Multiple vendors, each with their own proprietary formats for data storage, produce such PQ monitoring systems and associated software applications. In order to maximize benefits that can be realized by integrating all of these systems, EPRI initiated the development of a common format for power quality measurement data formally known as the Power Quality Data Interchange Format (PQDIF).

One of the primary third-party applications for the storage and analysis of power quality information is PQView® developed by EPRI and Electrotek Concepts, Inc. A major goal of the PQView system is to accept and catalogue data from many sources of power quality data. To fulfill this goal, a mechanism for importing PQDIF data from a standard file into PQView was developed.

Objectives

The objective of this document is set out specific guidelines for forming PQDIF representations by vendors so that the data from their instruments can be included in PQView databases. This can be done following the rules for creating PQDIF given by the proposed IEEE P1159.3 Draft and the guidelines for data representation proposed in this document.

ABSTRACT

The Power Quality Data Interchange Format (PQDIF) provides a standard way of representing a large variety of power quality data, allowing exchange of the data between instruments and software from different vendors. One important application is the transfer of power quality data into the PQView program. This document if focused on that application.

IEEE P1193.3 Draft Recommended Practice explains in detail the formation of the physical implementation of PQDIF and goes into great detail on the logical implementation. However, because of the flexibility of the format there are often multiple ways to represent the same data. The guidelines contained in this document will allow information to be interpreted by the PQDIF translator for PQView.

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1 INTRODUCTION

Overview

The need for a common power quality data interchange format has recently become increasingly important. Many utilities are monitoring the quality of the power they deliver to their customers, while some customers are installing their own instruments to measure the utility supply or to monitor their sensitive processes. Power quality software applications have been developed to provide database management and analysis, to run harmonic and transient simulations, to perform economic assessments, and to identify measurements using rules-based expert systems or artificial neural networks. Multiple vendors, each of which has traditionally employed proprietary formats for data storage, produce such PQ monitoring systems and associated software applications. In order to maximize benefits that can be realized by integrating all of these systems, EPRI initiated the development of a common format for power quality measurement data formally known as the Power Quality Data Interchange Format (PQDIF). PQDIF provides a common format to which all vendors can export and import allowing the end user maximum flexibility in choice of tool and vendor.

Power quality data is a broad category that includes many forms of data that are collected, processed and stored. This can include basic information like raw voltage waveform data to highly processed statistical information on derived quantities such as THD. Because of the wide range of data that may be measured or calculated, a highly flexible, but standard, method of exchanging the data is required. Because PQDIF was developed to allow for the transfer of *most* power quality data – measurements, simulation results, calculated index values, etc. – in a high fidelity form in a predicable and standard way the file structure is very open and flexible. There are several side effects of this level of flexibility. The most obvious is the complexity. It is indeed a fairly complex format when compared to the simple ASCII files of COMTRADE or other proprietary formats. Also, the flexibility leads to occasional ambiguities in the ways to model a particular type of data. Without the proper guidance, this flexibility can be confusing and might result in vendors developing PQDIF files that appear to be structurally accurate with regard to allowable PQDIF element tags but are not structured such that the PQView IEEE P1159.3 DRAFT 4 importer expects the data. Many of the instrument manufacturers that have begun to implement a PQDIF export function to allow integration of their instruments with the PQView system have realized this possible confusion and have requested a test tool to verify the validity of their export functions. In general, transients, rms variations, and steady-state measurement trends can be represented with little or no ambiguity into PQDIF for import by the PQView PQDIF characterizer.

This guide is intended to give specific guidance in applying PQDIF for use with PQView®. PQView is the Measurement Module of the EPRI Power Quality Diagnostic System (PQDS). PQView was designed so that measurement data from various proprietary instrument formats could be stored in a common database format allowing system analyses based on data from various instrument sources. The PQView PQDIF characterizer allows PQView users to import measurement data from any source or format that is exported as a PQDIF file. A brief introduction to PQDIF is provided but the full description of PQDIF, its structure and the tools for creating PQDIF objects is detailed in the proposed IEEE Recommended Practice P1159.3, "Recommended Practice for a Power Quality Data Interchange Format - An Extensible File Format for the Exchange of Power Quality Measurement and Simulation Data." A software development tool kit (PQDIF SDK) is also available from the web site of IEEE TF P1159.3, http://grouper.ieee.org/groups/1159/3/index.html.

PQDIF Structure

There are two "layers" to the PQDIF format: the *physical* layer and the *logical* layer. The physical layer describes the physical structure of the file without regard to what will actually be stored in it. It uses tags to identify particular elements of the file. This is similar in concept to TIFF (Tagged Image File Format), used for storing images.

The logical layer uses the structure defined by the physical layer and specifies tags to use when building up elements in the file.

The physical layer is based on

- Specific "physical" data types (e.g. INT1, INT2, INT4, REAL4, REAL8, etc.) for portability and a specific list of IDs for physical representation (e.g. ID_SERIES_PHYS_TYPE_INTEGER1, etc.)
- 4-byte alignment for efficient processing
- *Tags*—using GUID's (Globally Unique Identifiers)—for unique identification of elements (hereafter called "tags")

The logical layer is based on

- Specific lists of tags to identify elements of a file
- A hierarchy of tags and expected physical types
- Extensibility using user-defined tags for private data
- Extensibility of the standard format using tags defined in the future

To keep things simple, many elements in the logical layer are based on an explicit list of enumerated IDs such as

- Phase (ID_PHASE_AN, ID_PHASE_BN, etc.)
- IEEE 1159 disturbance category (ID_1159_TRANSIENT, ID_1159_SHORTDUR, etc.)
- High-level quantity type (ID_QT_WAVEFORM, ID_QT_RMS, etc.)
- Series quantity units (ID_QU_TIMESTAMP, ID_QU_VOLTS, ID_QU_AMPS, etc.)
- Series value type (ID_SERIES_VALUE_TYPE_MIN, ID_SERIES_VALUE_TYPE_MAX, etc.)

Other Recommended Reading

This guideline does not address the basics of PQDIF. That information is included as part of the IEEE P1159.3 draft standard, which is available at http://grouper.ieee.org/groups/1159/3/index.html. The material in this document assumes a basic understanding of the structure of PQDIF, the tools used to create PQDIF files or objects, and PQDIF examples included in the development kit.

2 OVERVIEW OF PQVIEW DATA REQUIREMENTS

Data Types Characterized and Included in PQView Database

PQView is designed to hold and analyze a broad range of power quality data. The data model for PQView is event centric for disturbance information. Steady-state information is stored as highly compressed trend data.

Data Processed by the PQDIF Characterizer (Version 2.1.1)

Triggered Data or Events

Triggered or event data is any data gathered as the result of a trigger condition and is meant to be a disturbance or event. The event is *usually* triggered by channel data from the instrument and is marked as ID_TRIGGER_METH_CHANNEL. An external trigger may also be indicated. Full analysis by the PQView characterizer requires a trigger channel to be specified. As a result, not all characteristics would be available for externally triggered data.

The two types of data processed by the PQDIF characterizer are RMS and Waveform. The triggered data analysis portion of the characterizer analyses only voltage triggered information and processes up to 3 phases of voltage and current. Also, the neutral voltage and neutral current are passed through to the database.

RMS or waveform data for an event must be represented in a single observation. For example, all of the individual channels recorded for a single event – Van, Ia, Vbn, Ib, etc. – should be included in a single observation. Additionally, all of the data for each individual channel must be stored in a single channel instance of the overall observation. If the data for one of the channels is stored as multiple channel instances within the one event observation, each instance will be processed as though they were separate events. This is already a recommendation in the IEEE 1159.3 draft standard, but a requirement for most viewers and analysis programs, including PQView.

As of this writing, harmonic triggered events are not supported by the PQView PQDIF Characterizer. The proposed format for representing that data, however, is presented in this document as support for this data type within the characterizer is expected to be implemented soon.

Steady-State Data

Non-triggered information like steady-state voltage, current and power information is handled in a different manner in the characterizer. This information is tagged with the ID_TRIGGER_METH_PERIODIC for the trigger method. Again there are two types of data that fall into the steady-state category, trend data and periodically sampled waveform information.

Trend data is a time trend of any value supported by PQView. Any values that are not represented in the PQView Channel table is disregarded. A listing of the current contents of the channel table is included in Appendix A of this document. Additional channels are periodically added to this table so you should consult Electrotek for updated listings if you do not find a channel definition meeting a particular need.

Periodic waveforms are analyzed to provide as much information as possible. Fourier transforms are performed on all data that has at least one full cycle of information that has been sampled at a power of 2 points per cycle. There must be at least 32 points per cycle for full analysis. If Fourier analysis is performed the following characteristics are extracted.

Voltage/Current Waveforms:

- RMS
- HARMONIC RMS
- PEAK
- CREST FACTOR
- FORM FACTOR
- ARITHMETIC SUM
- TIF
- ODD THD
- EVEN THD
- TOTAL THD
- HARMONIC SPECTRA
- POSITIVE SEQUENCE
- NEGATIVE SEQUENCE
- ZERO SEQUENCE

If three phases of voltage and current are present power calculations are performed and the following additional characteristics are added to the database:

- ACTIVE POWER
- REACTIVE POWER
- APPARENT POWER
- TRUE POWER FACTOR
- DISPLACEMENT FACTOR
- ACTIVE POWER HARMONIC SPECTRA
- REACTIVE POWER HARMONIC SPECTRA

PQDIF Optional Tags Required or Recommended for the Characterizer

A number of tags are listed as optional in the generic PQDIF specification from IEEE. They are either required or recommended for processing of data by the PQView PQDIF characterizer.

Required for Full Characterization

Data Source Record Tags:

> **TagNameDS –** This tag must be at the top level of the Data Source Definition. This entry will be used to automatically create the sites information in PQView.
>
> **TagSeriesNominalQuantity –** In order to completely characterize event records, the voltage channels defined for the event records must inform the characterizer of the base voltage.

Observation Record Tags:

> **TagChannelTriggerIdx –** This tag indicates the channel or channels that caused the event to be triggered. The value of this tag is the the channel definition indices referencing the data source.

Highly Recommended

Monitor Settings Record Tags:

> **TagNominalFrequency –** This specifies nominal system frequency. If not specified, 60 Hz is assumed.

TagTriggerHigh – On voltage channel settings, specify the trigger level for swells. This is used to program the RMS variation event characterizer and 1.1 pu will be used if not supplied.

TagTriggerLow– On voltage channel settings, specify the trigger level for sags. This is used to program the RMS variation event characterizer and .9 pu will be used if not supplied. These trigger values are used to re-characterize the rms variation data including determination of IEEE 1159 characterizations.

Data Types Ignored

The PQView PQDIF characterizer continues to evolve as Electrotek evaluates the benefits of importing various data types which can be specified by PQDIF but that are not yet compatible with the PQDIF characterizer. There are some data types already identified for inclusions in the characterizer, but that are not yet implemented. This section lists several types of data supported in PQDIF that are not carried through to PQView. Some of these types have no PQView equivalent and others have yet to be implemented.

- All statistical data except quantity characteristics that reflect a statistical basis such as flicker PST Statistical information such as PDF data types are not included.
- All harmonic information from sources other than waveform snapshots (i.e., periodically triggered waveform records).
- Some combinations of characteristics and phase are ignored such as power quantities in the neutral-to-ground circuit.
- All channels with the following Quantity Types (PQDIF tag ID_QT_???????) are currently not supported:
  - ID_QT_RESPONSE
  - ID_QT_FLASH
  - ID_QT_HISTOGRAM
  - ID_QT_HISTOGRAM3D
  - ID_QT_CPF
  - ID_QT_XY
  - ID_QT_MAGDUR
  - ID_QT_XYZ
  - ID_QT_MAGDURTIME
  - ID_QT_MAGDURCOUNT

3 DATA SPECIFICATIONS

RMS Triggered Events Records

This section describes how to define a channel to hold standard RMS information that is part of a triggered RMS type event. The PQView model of an RMS variation event is fully documented in PQView 2.0 Design Documentation, available from EPRI. Briefly, RMS variation event information is stored as a set of magnitude and duration characteristics that are derived by the characterizer from voltage RMS trends. The original triggered trend data can optionally be imported to the database as well. Triggered rms variations are expected to be captured according to IEC, UNIPEDE, and other standards, which specify that rms variation recording begins when any one of the enabled phases exceeds thresholds, and ends when all enabled phase returns back within thresholds or when an instrument specific time-out occurs.

Some instruments can capture corresponding waveform information along with the RMS trace of a triggered RMS variation event. The characterizer will maintain the relationship between the RMS and waveform data provided all of the data is included in a single observation record. The waveform data will be characterized for transient characteristics as well and stored as shown below in the Transient Events section.

Data Source Definition

For each channel of data, there must be a Data Source definition record to define the data type, including its characteristics and the format in which it is stored. The following PQDIF Data Source record definition shows all of the fields either required or recommended for a triggered RMS voltage channel, Vab. The remaining voltage channels (Vbc, Vca) would be identical with the exception of the tagPhaseID value. These channel definitions may optionally be followed by definitions for the current channels.

This definition includes minimum, maximum and average series definitions for each channel. This allows for envelope-based measurements. If only instantaneous values of the RMS value is available (and it is not an average over an interval longer than 1 cycle) only the ID_SERIES_VAL_TYPE_VALUE should be used. If you have just a series of average values over an interval, omit the ID_SERIES_VALUE_TYPE_MIN and ID_SERIES_VALUE_TYPE_MAX series definitions.

All RMS variation event data must be reported using the ID_QT_PHASOR quantity type whether phase angle information is available or not. This can be considered an implementation restriction.

All other tags in Figure 3-1are required in order create valid triggered RMS variation event PQDIF channel so that the PQView characterizer adequately processes the event. The following example data source segment illustrates the hierarchical structure of the required data source elements and is created with the PQDIFR tool available from the IEEE 1159.3 web site.

```
-tag: tagRecDataSource (level 0)
   +-tag: tagEffective value: 9/3/1999 15:2:42.000000000
   +-tag: tagDataSourceTypeID  value: ID_DS_TYPE_MEASURE
   +-tag: tagNameDS  value: 'Standby'
   +- tag: tagChannelDefns (level 1)
    |   +- tag: tagOneChannelDefn (level 2)
    |   |   +-tag: tagChannelName  value: 'Voltage A'
    |   |   +-tag: tagPhaseID value: 5 (ID_PHASE_AB)
    |   |   +-tag: tagQuantityTypeID value: ID_QT_PHASOR
    |   |   +-tag: tagQuantityMeasuredID  value: ID_QM_VOLTAGE
    |   |   +- -- tag: tagSeriesDefns (level 3)
    |   |   |   +- tag: tagOneSeriesDefn (level 4)
    |   |   |   |   +- tag: tagQuantityUnitsID value: ID_QU_SECONDS
    |   |   |   |   +- tag: tagQuantityCharacteristicID value: ID_QC_RMS
    |   |   |   |   +- tag: tagValueTypeID  value: ID_SERIES_VALUE_TYPE_TIME
    |   |   |   |   +- tag: tagStorageMethodID  value: 6
    |   |   |   |   +-(End of collection)
    |   |   |   +- tag: tagOneSeriesDefn (level 4)
    |   |   |   |   +- tag: tagQuantityUnitsID value: ID_QU_VOLTS
    |   |   |   |   +- tag: tagQuantityCharacteristicID value: ID_QC_RMS
    |   |   |   |   +- tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_MIN
    |   |   |   |   +- tag: tagSeriesNominalQuantity value: 480.000000
    |   |   |   |   +-(End of collection)
    |   |   |   +-tag: tagOneSeriesDefn (level 4)
    |   |   |   |   +-tag: tagQuantityUnitsID value: ID_QU_VOLTS
    |   |   |   |   +-tag: tagQuantityCharacteristicID  value: ID_QC_RMS
    |   |   |   |   +-tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_MAX
    |   |   |   |   +-tag: tagStorageMethodID value: 3
    |   |   |   |   +-tag: tagSeriesNominalQuantity value: 480.000000
    |   |   |   |   +-(End of collection)
    |   |   |   +-tag: tagOneSeriesDefn (level 4)
    |   |   |   |   +- tag: tagQuantityUnitsID value: ID_QU_VOLTS
    |   |   |   |   +- tag: tagQuantityCharacteristicID value: ID_QC_RMS
    |   |   |   |   +-tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_AVG
    |   |   |   |   +-tag: tagStorageMethodID value: 3
    |   |   |   |   +-tag: tagSeriesNominalQuantity  value: 480.000000
    |   |   |   |   +-(End of collection)
    |   |   |   +-(End of collection)
    |   |   +-(End of collection)
… The channel definitions repeat to include all recorded phases.
```

Figure 3-1
Required Tags for Triggered RMS Variation Event

Monitor Settings Record

The Monitor Settings records are normally optional in PQDIF. They are not required for the PQDIF characterizer but several of the tags in the Monitor Settings record are highly recommended. Figure 3-2 shows the minimum tags that are highly recommended as part of the Monitor Settings record.

The Threshold information is used to program the RMS variation event characterizer. If these tags are not present, the characterizer will assume defaults of 0.90 pu and 1.10 pu for sags and swells. These may not be appropriate for your instrument and application and completing these tags gives you an opportunity to override these defaults.

The base system frequency is required for a number of calculations with the characterizer. This is specified as a tag in the monitor settings record. While not absolutely required, the characterizer will assume 60 Hz if this tag is not present.

```
-tag: tagRecMonitorSettings (level 0)
   +-tag: tagEffective value: 9/3/1999 15:2:42.000000000
   +-tag: tagNominalFrequency (value: 60.000000
   +-tag: tagChannelSettingsArray (level 1)
   |   +- tag: tagOneChannelSetting (level 2)
   |   |   +-tag: tagChannelDefnIdx value: 0
   |   |   +-tag: tagTriggerTypeID value: 3 (ID_TRIG_LOW | ID_TRIG_HI)
   |   |   +-tag: tagTriggerHigh  value: 528.000000
   |   |   +-tag: tagTriggerLow  value: 432.000000
   |   |   +-(End of collection)
…  Repeated for all channels
```

Figure 3-2
Minimum Recommended Tags for Monitor Settings Record

Observation Record

Observation records carry the actual data for an event or trend of steady-state data. For RMS variation event data, the observation needs certain time stamp information for the record including the start time for the record and the trigger time that usually is some time after the beginning of the record. For event records, the trigger information is very important and is required for full characterization of the data.

Figure 3-3 is a sample observation record for an RMS variation event. This event was triggered on voltage phase a-n as the rms voltage violated the ID_TRIGGER_METH_LOW trigger value specified in the Monitor Settings record. The software creating this record had elected to name the record 'RMS Variation (Sag)'. This name is arbitrary and you can choose a title that suits your naming conventions.

As discussed in the Data Source section above, the quantity type for RMS records must be ID_QT_PHASOR. The time series must be the first series instance in the channel. If the event is triggered on a base voltage other than the TagSeriesNominalQuantity specified in the channel definition, the tagSeriesBaseQuantity of the observation record is used to override the channel definition base value.

```
- tag: tagRecObservation (level 0)
   +- tag: tagObservationName  value: 'RMS Variation (Sag)'
   +-tag: tagTimeCreate  value: 9/15/1999 20:32:50.000000000
   +-tag: tagTriggerMethodID value: ID_TRIGGER_METH_LOW
   +-tag: tagTimeTriggered  value: 9/15/1999 10:11:16.630000000
   +-tag: tagTimeStart value: 9/15/1999 10:11:16.630000000
   +-tag: tagChannelTriggerIdx values: ID_PHASE_AN
   +-tag: tagChannelInstances (level 1)
   |   +-tag: tagOneChannelInst (level 2)
   |   |   +-tag: tagChannelDefnIdx value: 0  References the channel defn. in data source
   |   |   +-tag: tagSeriesInstances (level 3)
   |   |   |   +-tag: tagOneSeriesInstance (level 4)  Series 0, Time
   |   |   |   |   +-tag: tagSeriesScale value: 1.000000
   |   |   |   |   +-tag: tagSeriesOffset  value: 0.000000
   |   |   |   |   +-tag: tagSeriesValues (Vector of time data)
   |   |   |   |   +-(End of collection)
   |   |   |   +-tag: tagOneSeriesInstance (level 4)  Series 1, Average
   |   |   |   |   +-tag: tagSeriesBaseQuantity value: 480.000000
   |   |   |   |   +-tag: tagSeriesScale value: 0.100000
   |   |   |   |   +-tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +-tag: tagSeriesValues (Vector of average data)
   |   |   |   |   +-(End of collection)
   |   |   |   +-tag: tagOneSeriesInstance (level 4)  Series 2, Minimum
   |   |   |   |   +-tag: tagSeriesBaseQuantity value: 480.000000
   |   |   |   |   +-tag: tagSeriesScale value: 0.100000
   |   |   |   |   +-tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +-tag: tagSeriesValues (Vector of minimum data)
   |   |   |   |   +-(End of collection)
   |   |   |   +-tag: tagOneSeriesInstance (level 4)  Series 3, Maximum
   |   |   |   |   +-tag: tagSeriesBaseQuantity value: 480.000000
   |   |   |   |   +-tag: tagSeriesScale value: 0.100000
   |   |   |   |   +-tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +-tag: tagSeriesValues (Vector of maximum data)
   |   |   |   |   +-(End of collection)
   |   |   |   +-(End of collection)
   |   |   +-(End of collection)
```

|…for all channels

Figure 3-3
Sample Observation Record for RMS Variation Event

Waveform Channels with RMS Triggered Data

Some instruments are capable of capturing waveform information at the trigger time of an RMS based event. Some also can capture significant waveform based data during the RMS variation event. This data can be included with RMS variation event insuring that the relationship is maintained or it can be saved as separate transient event records.

To include waveform information with RMS variation events, follow the recommendations given in the following Transient Records section. You may include non-contiguous (time-wise) sections of waveform data by adding multiple instances of each channel of waveform data. There is no hard limit to the number of “segments” or instances of each channel but it is best not to exceed four or five segments from a data management and record size perspective. The additional waveform segments’ time series must be relative to the observation time stamp to ensure that a viewer or analysis program can show the waveforms in proper time sequence.

Transient Records

Transient event records in the context of the PQDIF characterizer are those triggered events that are composed of waveform data as opposed to RMS trend data. This section describes how to define a channel to hold transient event information that is part of a triggered waveform event type. The PQView model of transient events is fully documented in the PQView 2.0 Design Documentation, available from EPRI. Briefly, transient records are processed for a number of characteristics including magnitude, duration, and principle frequency among others. The original triggered raw waveform data can optionally be imported to the database as well.

The PQView PQDIF characterizer will process up to 4 voltage and 4 current waveforms in each observation. For complete characterization, the waveforms must be sampled at a power of 2 points per cycle between 32 points per cycle and 4096 points per cycle. Trigger information from the instrument is important for accurate and complete characterization.

Data Source Definition

The following PQDIF Data Source record definitions show all of the fields either required or recommended for a triggered transient voltage channel, Va. The remaining voltage channels (Vb, Vc) would be identical with the exception of the tagPhaseID value. These channel definition may optionally be followed by definitions for the current channels.

This channel definition in Figure 3-4 includes a value series for the waveform itself and Min and Max series with tagValueType of ID_SERIES_VALUE_TYPE_PEAK for passing along the instantaneous maximum and minimum values of the event. The value series is used to hold the waveform data. The time series should contain (or expand to) exactly the same number of points as the waveform series. Note that the tagSeriesBaseQuantity value for the VAL, MIN and MAX series is set to the “peak” base voltage for a 480 volt system, 678 Volts. For waveform information, 100% or 1 pu should correspond the peak value of the normal waveform (sqrt(2) * Vbase RMS).

The peak channels are completely optional and are used to hold peak values of the signal between the individual samples of the waveform. By our convention, these values include low frequency information. The max series hold the positive going peak value and the min series hold the negative going peak.

All transient event data must be reported using the ID_QT_WAVEFORM quantity type. All other tags in the fragment are required in order create valid PQDIF and to adequately process the event.

```
|   +-tag: tagOneChannelDefn (level 2)
|   |   +-tag: tagChannelName value: 'Voltage A'
|   |   +-tag: tagPhaseID value: ID_PHASE_AN
|   |   +-tag: tagQuantityTypeID value: ID_QT_WAVEFORM
|   |   +-tag: tagQuantityMeasuredID ID_QM_VOLTAGE
|   |   +-tag: tagSeriesDefns (level 3)
|   |   |   +-tag: tagOneSeriesDefn (level 4)
|   |   |   |   +-tag: tagQuantityUnitsID value: ID_QU_SECONDS
|   |   |   |   +-tag: tagQuantityCharacteristicID value: ID_QC_INSTANTANEOUS
|   |   |   |   +-tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_TIME
|   |   |   |   +-tag: tagStorageMethodID  value: 6
|   |   |   |   +-(End of collection)
|   |   |   +-tag: tagOneSeriesDefn (level 4)
|   |   |   |   +-tag: tagQuantityUnitsID value: ID_QU_VOLTS
|   |   |   |   +-tag: tagQuantityCharacteristicID value: ID_QC_INSTANTANEOUS
|   |   |   |   +-tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_VAL
|   |   |   |   +-tag: tagStorageMethodID value: 3
|   |   |   |   +-tag: tagSeriesNominalQuantity value: 678.822510
|   |   |   |   +-(End of collection)
|   |   |   +-tag: tagOneSeriesDefn (level 4)
|   |   |   |   +-tag: tagQuantityUnitsID value: ID_QU_VOLTS
|   |   |   |   +-tag: tagQuantityCharacteristicID value: ID_QC_PEAK
|   |   |   |   +-tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_MAX
|   |   |   |   +-tag: tagStorageMethodID value: 3
|   |   |   |   +-tag: tagSeriesNominalQuantity value: 678.822510
|   |   |   |   +-(End of collection)
|   |   |   +-Collection -- tag: tagOneSeriesDefn (level 4)
|   |   |   |   +-tag: tagQuantityUnitsID value: ID_QU_VOLTS
|   |   |   |   +-tag: tagQuantityCharacteristicID value: ID_QC_PEAK
|   |   |   |   +-tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_MIN
|   |   |   |   +-tag: tagStorageMethodID value: 3
|   |   |   |   +-tag: tagSeriesNominalQuantity value: 678.822510
|   |   |   |   +-(End of collection)
|   |   |   +-(End of collection)
```

Figure 3-4
Required Fields for a Triggered Transient Voltage Channel (V_a)

Monitor Settings Record

There are no special requirements for characterization of transient events in the monitor settings beyond tagNominalFrequency giving the base frequency for the system monitored.

Observation Record

Observation records carry the actual data for an event or trend of steady state data. For transient event data, the observation needs certain time stamp information for the record including the start time for the record and the trigger time that usually is some time after the beginning of the record. For event records, the trigger information is very important and is required for full characterization of the data.

The peak channels are completely optional and are used to hold peak values of the signal between the individual samples of the waveform. By our convention, these values include low frequency information. The max series hold the positive going peak value and the min series hold the negative going peak. The values in the peak series are interpreted as follows. If full series of values (one peak value for each entry in the waveform value series) are present then the peak data is analyzed as each point being the peak in the previous time interval. If only one point is present in each of the peak series, those values are assumed to be at the trigger time indicated by the tagTimeTriggered tag. The peak characteristics for the transient are determined by these peak channels, if they are present.

Figure 3-5 is a sample transient data observation record. Trigger information is extremely important for complete characterization of the data. Note that the tagSeriesBaseQuantity tags are not really needed as the tagSeriesNominalQuantity from the data source record provides the correct value.

```
-tag: tagRecObservation (level 0)
   +- tag: tagTimeCreate value: 9/15/1999 20:31:33.000000000
   +- tag: tagTimeStart value: 9/15/1999 20:28:15.537302083
   +- tag: tagTimeTriggered value: 9/15/1999 20:28:15.561000000
   +- tag: tagTriggerMethodID value: ID_TRIGGER_METH_CHANNEL
   +- tag: tagChannelTriggerIdx values: 4  Trigger was on channel defn. 4 in data source
   +- tag: tagChannelInstances (level 1)
   |   +- tag: tagOneChannelInst (level 2)
   |   |   +- tag: tagChannelDefnIdx value: 4  References the channel defn. in data source
   |   |   +- tag: tagChannelFrequency value: 60.000000
   |   |   +- tag: tagSeriesInstances (level 3)
   |   |   |   +- tag: tagOneSeriesInstance (level 4) Series 0, Time
   |   |   |   |   +- tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +- tag: tagSeriesScale: 0.000130
   |   |   |   |   +- tag: tagSeriesValues (type: INTEGER2) [ 3 ]
   |   |   |   |   +-(End of collection)
   |   |   |   +- tag: tagOneSeriesInstance (level 4) Series 1, Voltage waveform
   |   |   |   |   +- tag: tagSeriesBaseQuantity value: 678.822510
   |   |   |   |   +- tag: tagSeriesScale value: 0.100000
   |   |   |   |   +- tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +- tag: tagSeriesValues (type: INTEGER2) [ 384 ]
   |   |   |   |   +-(End of collection)
   |   |   |   +- tag: tagOneSeriesInstance (level 4)  Series 2, Positive Peaks
   |   |   |   |   +- tag: tagSeriesBaseQuantity value: 678.822510
   |   |   |   |   +- tag: tagSeriesScale value: 1.000000
   |   |   |   |   +- tag: tagSeriesOffset: 0.000000
   |   |   |   |   +- tag: tagSeriesValues (type: INTEGER2) [ 1 ]
   |   |   |   |   +-(End of collection)
   |   |   |   +- tag: tagOneSeriesInstance (level 4)  Series 3, Negative Peaks
   |   |   |   |   +- tag: tagSeriesBaseQuantity value: 678.822510
   |   |   |   |   +- tag: tagSeriesScale value: 1.000000
   |   |   |   |   +- tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +- tag: tagSeriesValues (type: INTEGER2) [ 1 ]
   |   |   |   |   +-(End of collection)
   |   |   |   +-(End of collection)
   |   |   +-(End of collection)
```

Figure 3-5
Sample Transient Data Observation Record

Trend Data

Trend data records give long-term steady-state trends of any quantity that PQView recognizes. The table of channels accepted by PQView is given in Appendix A.

In general, trend data is indicated by specifying a trigger method of ID_TRIGGER_METH_PERIODIC in the observation record and specifying a quantity type of ID_QT_VALUELOG in the data source definition for the channel.

Trend data can be stored in several ways. The simplest of these would have just a series of instantaneous values collected over time. These values could be the average value of the variable over the time interval. Also, the minimum and maximum values over the interval can be captured.

Data Source Definition

The data source definitions for trend data are fairly similar to the previous types discussed thus far. Typically, there is a time series definition followed by one or more series to hold the data for the channel.

Figure 3-6 shows a record fragment that displays the definition for phase A RMS voltage trend with minimum, maximum and average value series. As with all data source Voltage based channels definitions, it is recommended to include the base voltage for the record. While the characterizer does not currently use that information, it is passed on to PQView for steady state analysis such as voltage regulation.

```
|   +- tag: tagOneChannelDefn (level 2)
|   |   +- tag: tagChannelName value: 'SS RMS VAN'
|   |   +- tag: tagPhaseID value: ID_PHASE_AN
|   |   +- tag: tagQuantityMeasuredID value: ID_QM_VOLTAGE
|   |   +- tag: tagQuantityTypeID value: ID_QT_VALUELOG
|   |   +- tag: tagSeriesDefns (level 3)
|   |   |   +- tag: tagOneSeriesDefn (level 4)
|   |   |   |   +- tag: tagQuantityUnitsID value: ID_QU_SECONDS
|   |   |   |   +- tag: tagQuantityCharacteristicID value: ID_QC_RMS
|   |   |   |   +- tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_TIME
|   |   |   |   +- tag: tagStorageMethodID value: 1
|   |   |   |   +-(End of collection)
|   |   |   +- tag: tagOneSeriesDefn (level 4)
|   |   |   |   +- tag: tagQuantityUnitsID value: ID_QU_VOLTS
|   |   |   |   +- tag: tagQuantityCharacteristicID value: ID_QC_RMS
|   |   |   |   +- tag: tagValueTypeID valueID_SERIES_VALUE_TYPE_MIN
|   |   |   |   +- tag: tagStorageMethodID value: 3
|   |   |   |   +- tag: tagSeriesNominalQuantity value: 7448.000000
|   |   |   |   +-(End of collection)
|   |   |   +- tag: tagOneSeriesDefn (level 4)
|   |   |   |   +- tag: tagQuantityUnitsID value: ID_QU_VOLTS
|   |   |   |   +- tag: tagQuantityCharacteristicID value: ID_QC_RMS
|   |   |   |   +- tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_MAX
|   |   |   |   +- tag: tagStorageMethodID value: 3
|   |   |   |   +- tag: tagSeriesNominalQuantity value: 7448.000000
|   |   |   |   +-(End of collection)
|   |   |   +-Collection -- tag: tagOneSeriesDefn (level 4)
|   |   |   |   +- tag: tagQuantityUnitsID value: ID_QU_VOLTS
|   |   |   |   +- tag: tagQuantityCharacteristicID value: ID_QC_RMS
|   |   |   |   +- tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_AVG
|   |   |   |   +- tag: tagStorageMethodID value: 3
|   |   |   |   +- tag: tagSeriesNominalQuantity value: 7448.000000
|   |   |   |   +-(End of collection)
|   |   |   +-(End of collection)
|   |   +-(End of collection)
```

Figure 3-6
PQDIF Data Source Record Fragment – Definition for Phase A RMS Voltage Trend

Monitor Settings Record

There are no special requirements for characterization of trend data in the monitor settings beyond tagNominalFrequency giving the base frequency for the system monitored.

Observation Record

Observation records carry the actual data for an event or trend of steady state data. For waveform snapshot data, the observation needs certain time stamp information for the record and the ID_TRIGGER_METHOD_PERIODIC tag.

Figure 3-7 is a fragment of a sample periodic triggered waveform data observation record. Note that the tagSeriesBaseQuantity tags, if specified, supercede the value specified by tagSeriesNominalQuantity in the data source record. The tagSeriesNominalQuantity represents the declared nominal for the measurement location, whereas the tagSeriesBaseQuantity represents the actual base value existing at the time of the observation measurement. These can be different for instruments that support features such as floating base voltages for triggering purposes.

```
- tag: tagRecObservation (level 0)
   +- tag: tagObservationName value: 'Steady-state trend'
   +- tag: tagTimeCreate value: 11/8/2000 13:44:16.000000192
   +- tag: tagTimeStart value: 5/6/1995 0:2:15.000000126
   +- tag: tagTriggerMethodID value: ID_TRIGGER_METH_PERIODIC
   +- tag: tagChannelInstances (level 1)
   |   +- tag: tagOneChannelInst (level 2)
   |   |   +- tag: tagChannelDefnIdx value: 26
   |   |   +- tag: tagSeriesInstances (level 3)
   |   |   |   +- tag: tagOneSeriesInstance (level 4)
   |   |   |   |   +- tag: tagSeriesValues (type: REAL4) [ 96 ]
   |   |   |   |   +- tag: tagSeriesBaseQuantity value: 1.000000
   |   |   |   |   +-(End of collection)
   |   |   |   +-Collection -- tag: tagOneSeriesInstance (level 4)
   |   |   |   |   +- tag: tagSeriesValues (type: INTEGER2) [ 96 ]
   |   |   |   |   +- tag: tagSeriesBaseQuantity value: 7448.000000
   |   |   |   |   +- tag: tagSeriesScale value: 0.232897
   |   |   |   |   +- tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +-(End of collection)
   |   |   |   +- tag: tagOneSeriesInstance (level 4)
   |   |   |   |   +- tag: tagSeriesValues (type: INTEGER2) [ 96 ]
   |   |   |   |   +- tag: tagSeriesBaseQuantity value: 7448.000000
   |   |   |   |   +- tag: tagSeriesScale value: 0.232897
   |   |   |   |   +- tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +-(End of collection)
   |   |   |   +- tag: tagOneSeriesInstance (level 4)
   |   |   |   |   +- tag: tagSeriesValues (type: INTEGER2) [ 96 ]
   |   |   |   |   +- tag: tagSeriesBaseQuantity value: 7448.000000
   |   |   |   |   +- tag: tagSeriesScale value: 0.232897
   |   |   |   |   +- tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +-(End of collection)
   |   |   |   +-(End of collection)
```

Figure 3-7
Sample Fragment of Periodic Triggered Waveform Data Observation Record

Waveform Snapshots

Steady-state data can also be derived from periodic snapshots of voltage and current waveforms. The PQView PQDIF characterizer can process these waveforms to give a full set of steady-state quantities and pass them through to the database. Note that as of version 2.1.1 of the characterizer, only one cycle of data is analyzed and that for full processing the number of points per cycle must be a power of 2 between 32 and 4096 points.

Waveform snapshot records are indicated to the PQDIF characterizer by the use of the ID_TRIGGER_METH_PERIODIC tag in the observation record and the ID_QT_WAVEFORM tag in the definition.

Data Source Definition

The Data Source definition for waveform snapshots includes a time and a value series for each channel.

The data source record fragment below shows the definition for phase A voltage waveform snapshot with time and value series. As with all the data source recordVoltage based channel definitions, it is recommended to include the base voltage for the record. While the characterizer does not currently use that information, it is passed on to PQView for steady state analysis such as voltage regulation.

```
|   +- tag: tagOneChannelDefn (level 2)
|   |   +- tag: tagChannelName (value: 'Waveform VA'
|   |   +- tag: tagPhaseID value: ID_PHASE_AN
|   |   +- tag: tagQuantityMeasuredID value: ID_QM_VOLTAGE
|   |   +- tag: tagQuantityTypeID value: ID_QT_WAVEFORM
|   |   +- tag: tagSeriesDefns (level 3)
|   |   |   +- tag: tagOneSeriesDefn (level 4)
|   |   |   |   +- tag: tagQuantityUnitsID value: ID_QU_SECONDS
|   |   |   |   +- tag: tagQuantityCharacteristicID value: ID_QC_ INSTANTANEOUS
|   |   |   |   +- tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_TIME
|   |   |   |   +- tag: tagStorageMethodID value: 4
|   |   |   |   +-(End of collection)
|   |   |   +- tag: tagOneSeriesDefn (level 4)
|   |   |   |   +- tag: tagQuantityUnitsID value: ID_QU_VOLTS
|   |   |   |   +- tag: tagQuantityCharacteristicID value: ID_QC_INSTANTANEOUS
|   |   |   |   +- tag: tagValueTypeID value: ID_SERIES_VALUE_TYPE_VAL
|   |   |   |   +- tag: tagStorageMethodID value: 3
|   |   |   |   +- tag: tagSeriesNominalQuantity value: 678.822510
|   |   |   |   +-(End of collection)
|   |   |   +-(End of collection)
|   |   +-(End of collection)
```

Figure 3-8
Record Fragment of Definition for Phase A Voltage Waveform Snapshot with Time and Value Series

Monitor Settings Record

There are no special requirements for characterization of snapshot waveform data in the monitor settings beyond tagNominalFrequency giving the base frequency for the system monitored.

Observation Record

A sample observation record for a waveform snapshot is shown in Figure 3-9.

```
- tag: tagRecObservation (level 0)
   +- tag: tagTimeCreate value: 9/16/1999 7:18:52.000000000
   +- tag: tagTimeStart value: 9/16/1999 7:18:16.620000000
   +- tag: tagObservationName value: 'Snapshot'
   +- tag: tagTriggerMethodID value: 2
   +- tag: tagChannelInstances (level 1)
   |   +- tag: tagOneChannelInst (level 2)
   |   |   +- tag: tagChannelDefnIdx value: 2
   |   |   +- tag: tagSeriesBaseQuantity value: 678.822510
   |   |   +- tag: tagChannelFrequency value: 60.000000
   |   |   +- tag: tagSeriesInstances (level 3)
   |   |   |   +- tag: tagOneSeriesInstance (level 4)
   |   |   |   |   +- tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +- tag: tagSeriesScale value: 0.000130
   |   |   |   |   +- tag: tagSeriesValues (type: INTEGER2) [ 3 ]
   |   |   |   |   +-(End of collection)
   |   |   |   +- tag: tagOneSeriesInstance (level 4)
   |   |   |   |   +- tag: tagSeriesBaseQuantity value: 480.000000
   |   |   |   |   +- tag: tagSeriesScale value: 0.100000
   |   |   |   |   +- tag: tagSeriesOffset value: 0.000000
   |   |   |   |   +- tag: tagSeriesValues (type: INTEGER2) [ 128 ]
   |   |   |   |   +-(End of collection)
   |   |   |   +-(End of collection)
   |   |   +-(End of collection)
```

Figure 3-9
Sample Record of a Waveform Snapshot

4 RECOMMENDATIONS FOR OTHER SITUATIONS

No RMS Data —Waveforms Only (DFT's and Other Waveform Based Devices)

With version 2.1.1 of the PQDIF characterizer, it is the responsibility of the instrument or instrument support software to process the waveform information, to identify trigger information from the raw data, and to process the waveform information to create RMS data that can be processed as RMS variation events.

A good approach is to create a virtual instrument to process the waveforms for both transient and RMS variation events. Many trigger algorithms can be applied to the raw waveform information to identify trigger points -- waveshape fault, rate change, deviation from base, etc. RMS processing also can be done in a straightforward manner by applying a sliding one-cycle rms calculation to the waveform data and checking against specified sag and swell thresholds. Once the trigger point has been determined, the data can be completely processed by the PQDIF characterizer to find a full range of characteristics.

Threshold Crossings without Detailed RMS Data (Basic Outage and Sag Detection Equipment)

There are a number of instruments on the market that capture only basic sag or outage information. At this time, PQView will not accept this kind of data through the PQDIF characterizer unless the data can be made to emulate the RMS triggered event records in section 3.1. In the future, the characterizer will process the ID_QT_MAGDUR and ID_QT_MAGDURTIME quantity types.

A APPENDIX

This appendix shows a list of all channels available for import into PQView. This list does change over time as new requirements are added. Contact Electrotek Concepts for the most up-to-date list if a required channel is not found.

The channel ID's are show for information only. The PQDIF characterizer maps phase, quantity measured and characteristics into the PQView channel number automatically.

PQView Channel Table Summary

Quantity	Characteristic	ChannelID	Name	Description	rank
V	v(t)	4113	v(t) A	Phase A Instantaneous Voltage	1
		4114	v(t) B	Phase B Instantaneous Voltage	2
		4115	v(t) C	Phase C Instantaneous Voltage	3
		4116	v(t) AB	Phase AB Instantaneous Voltage	4
		4117	v(t) BC	Phase BC Instantaneous Voltage	5
		4118	v(t) CA	Phase CA Instantaneous Voltage	6
		4119	v(t) N	Neutral Instantaneous Voltage	7
		4120	v(t) R	Residual Instantaneous Voltage	8
		4121	v(t) Net	Net Instantaneous Voltage	9
		4123	v(t) Avg LN	Avg LN Instantaneous Voltage	11
		4124	v(t) Avg LL	Avg LL Instantaneous Voltage	12
	V(F)	4129	V(F) A	Phase A Voltage Spectrum	1
		4130	V(F) B	Phase B Voltage Spectrum	2
		4131	V(F) C	Phase C Voltage Spectrum	3
		4132	V(F) AB	Phase AB Voltage Spectrum	4
		4133	V(F) BC	Phase BC Voltage Spectrum	5
		4134	V(F) CA	Phase CA Voltage Spectrum	6
		4135	V(F) N	Neutral Voltage Spectrum	7
		4136	V(F) R	Residual Voltage Spectrum	8
		4137	V(F) Net	Net Voltage Spectrum	9
		4139	V(F) Avg LN	Avg LN Voltage Spectrum	11
		4140	V(F) Avg LL	Avg LL Voltage Spectrum	12
	V Peak	4145	V Peak A	Phase A Peak Voltage	1
		4146	V Peak B	Phase B Peak Voltage	2
		4147	V Peak C	Phase C Peak Voltage	3
		4148	V Peak AB	Phase AB Peak Voltage	4
		4149	V Peak BC	Phase BC Peak Voltage	5
		4150	V Peak CA	Phase CA Peak Voltage	6
		4151	V Peak N	Neutral Peak Voltage	7
		4152	V Peak R	Residual Peak Voltage	8
		4153	V Peak Net	Net Peak Voltage	9
		4155	V Peak Avg LN	Avg LN Peak Voltage	11
		4156	V Peak Avg LL	Avg LL Peak Voltage	12

Quantity	Characteristic	ChannelID	Name	Description	rank
V	V RMS	4161	V RMS A	Phase A RMS Voltage	1
		4162	V RMS B	Phase B RMS Voltage	2
		4163	V RMS C	Phase C RMS Voltage	3
		4164	V RMS AB	Phase AB RMS Voltage	4
		4165	V RMS BC	Phase BC RMS Voltage	5
		4166	V RMS CA	Phase CA RMS Voltage	6
		4167	V RMS N	Neutral RMS Voltage	7
		4168	V RMS R	Residual RMS Voltage	8
		4169	V RMS Net	Net RMS Voltage	9
		4171	V RMS Avg LN	Avg LN RMS Voltage	11
		4172	V RMS Avg LL	Avg LL RMS Voltage	12
	V HRMS	4177	V HRMS A	Phase A Harmonic RMS Voltage	1
		4178	V HRMS B	Phase B Harmonic RMS Voltage	2
		4179	V HRMS C	Phase C Harmonic RMS Voltage	3
		4180	V HRMS AB	Phase AB Harmonic RMS Voltage	4
		4181	V HRMS BC	Phase BC Harmonic RMS Voltage	5
		4182	V HRMS CA	Phase CA Harmonic RMS Voltage	6
		4183	V HRMS N	Neutral Harmonic RMS Voltage	7
		4184	V HRMS R	Residual Harmonic RMS Voltage	8
		4185	V HRMS Net	Net Harmonic RMS Voltage	9
		4187	V HRMS Avg	Avg LN Harmonic RMS Voltage	11
		4188	V HRMS Avg	Avg LL Harmonic RMS Voltage	12
	V THD	4193	V THD A	Phase A Voltage Total Harmonic Distortion	1
		4194	V THD B	Phase B Voltage Total Harmonic Distortion	2
		4195	V THD C	Phase C Voltage Total Harmonic Distortion	3
		4196	V THD AB	Phase AB Voltage Total Harmonic Distortion	4
		4197	V THD BC	Phase BC Voltage Total Harmonic Distortion	5
		4198	V THD CA	Phase CA Voltage Total Harmonic Distortion	6
		4199	V THD N	Neutral Voltage Total Harmonic Distortion	7
		4200	V THD R	Residual Voltage Total Harmonic Distortion	8
		4201	V THD Net	Net Voltage Total Harmonic Distortion	9
		4203	V THD Avg LN	Avg LN Voltage Total Harmonic Distortion	11
		4204	V THD Avg LL	Avg LL Voltage Total Harmonic Distortion	12
	V ETHD	4209	V ETHD A	Phase A Voltage Even Harmonic Distortion	1
		4210	V ETHD B	Phase B Voltage Even Harmonic Distortion	2
		4211	V ETHD C	Phase C Voltage Even Harmonic Distortion	3
		4212	V ETHD AB	Phase AB Voltage Even Harmonic Distortion	4

Quantity	Characteristic	ChannelD	Name	Description	rank
V	V ETHD	4213	V ETHD BC	Phase BC Voltage Even Harmonic Distortion	5
		4214	V ETHD CA	Phase CA Voltage Even Harmonic Distortion	6
		4215	V ETHD N	Neutral Voltage Even Harmonic Distortion	7
		4216	V ETHD R	Residual Voltage Even Harmonic Distortion	8
		4217	V ETHD Net	Net Voltage Even Harmonic Distortion	9
		4219	V ETHD Avg	Avg LN Voltage Even Harmonic Distortion	11
		4220	V ETHD Avg LL	Avg LL Voltage Even Harmonic Distortion	12
	V OTHD	4225	V OTHD A	Phase A Voltage Odd Harmonic Distortion	1
		4226	V OTHD B	Phase B Voltage Odd Harmonic Distortion	2
		4227	V OTHD C	Phase C Voltage Odd Harmonic Distortion	3
		4228	V OTHD AB	Phase AB Voltage Odd Harmonic Distortion	4
		4229	V OTHD BC	Phase BC Voltage Odd Harmonic Distortion	5
		4230	V OTHD CA	Phase CA Voltage Odd Harmonic Distortion	6
		4231	V OTHD N	Neutral Voltage Odd Harmonic Distortion	7
		4232	V OTHD R	Residual Voltage Odd Harmonic Distortion	8
		4233	V OTHD Net	Net Voltage Odd Harmonic Distortion	9
		4235	V OTHD Avg	Avg LN Voltage Odd Harmonic Distortion	11
		4236	V OTHD Avg	Avg LL Voltage Odd Harmonic Distortion	12
	V CF	4257	V CF A	Phase A Voltage Crest Factor	1
		4258	V CF B	Phase B Voltage Crest Factor	2
		4259	V CF C	Phase C Voltage Crest Factor	3
		4260	V CF AB	Phase AB Voltage Crest Factor	4
		4261	V CF BC	Phase BC Voltage Crest Factor	5
		4262	V CF CA	Phase CA Voltage Crest Factor	6
		4263	V CF N	Neutral Voltage Crest Factor	7
		4264	V CF R	Residual Voltage Crest Factor	8
		4265	V CF Net	Net Voltage Crest Factor	9
		4267	V CF Avg LN	Avg LN Voltage Crest Factor	11
		4268	V CF Avg LL	Avg LL Voltage Crest Factor	12
	V FF	4273	V FF A	Phase A Voltage Form Factor	1
		4274	V FF B	Phase B Voltage Form Factor	2
		4275	V FF C	Phase C Voltage Form Factor	3
		4276	V FF AB	Phase AB Voltage Form Factor	4
		4277	V FF BC	Phase BC Voltage Form Factor	5
		4278	V FF CA	Phase CA Voltage Form Factor	6
		4279	V FF N	Neutral Voltage Form Factor	7
		4280	V FF R	Residual Voltage Form Factor	8

Quantity	Characteristic	ChannelID	Name	Description	rank
V	V FF	4281	V FF Net	Net Voltage Form Factor	9
		4283	V FF Avg LN	Avg LN Voltage Form Factor	11
		4284	V FF Avg LL	Avg LL Voltage Form Factor	12
	V AS	4289	V AS A	Phase A Voltage Arithmetic Sum	1
		4290	V AS B	Phase B Voltage Arithmetic Sum	2
		4291	V AS C	Phase C Voltage Arithmetic Sum	3
		4292	V AS AB	Phase AB Voltage Arithmetic Sum	4
		4293	V AS BC	Phase BC Voltage Arithmetic Sum	5
		4294	V AS CA	Phase CA Voltage Arithmetic Sum	6
		4295	V AS N	Neutral Voltage Arithmetic Sum	7
		4296	V AS R	Residual Voltage Arithmetic Sum	8
		4297	V AS Net	Net Voltage Arithmetic Sum	9
		4299	V AS Avg LN	Avg LN Voltage Arithmetic Sum	11
		4300	V AS Avg LL	Avg LL Voltage Arithmetic Sum	12
	V TIF	4353	V TIF A	Phase A Voltage Telephone Influence Factor	1
		4354	V TIF B	Phase B Voltage Telephone Influence Factor	2
		4355	V TIF C	Phase C Voltage Telephone Influence Factor	3
		4356	V TIF AB	Phase AB Voltage Telephone Influence Factor	4
		4357	V TIF BC	Phase BC Voltage Telephone Influence Factor	5
		4358	V TIF CA	Phase CA Voltage Telephone Influence Factor	6
		4359	V TIF N	Neutral Voltage Telephone Influence Factor	7
		4360	V TIF R	Residual Voltage Telephone Influence Factor	8
		4361	V TIF Net	Net Voltage Telephone Influence Factor	9
		4363	V TIF Avg LN	Avg LN Voltage Telephone Influence Factor	11
		4364	V TIF Avg LL	Avg LL Voltage Telephone Influence Factor	12
	V Flicker RMS	4369	V Flicker RMS	Phase A Flicker RMS Value	1
		4370	V Flicker RMS	Phase B Flicker RMS Value	2
		4371	V Flicker RMS	Phase C Flicker RMS Value	3
		4372	V Flicker RMS	Phase AB Flicker RMS Value	4
		4373	V Flicker RMS	Phase BC Flicker RMS Value	5
		4374	V Flicker RMS	Phase CA Flicker RMS Value	6
		4375	V Flicker RMS	Neutral Flicker RMS Value	7
	V Flicker dV/V	4385	V Flicker dV/V	Phase A Flicker dV/V Base	1
		4386	V Flicker dV/V	Phase B Flicker dV/V Base	2
		4387	V Flicker dV/V	Phase C Flicker dV/V Base	3
		4388	V Flicker dV/V	Phase AB Flicker dV/V Base	4
		4389	V Flicker dV/V	Phase BC Flicker dV/V Base	5

Quantity	Characteristic	ChannelID	Name	Description	rank
V	V Flicker dV/V	4390	V Flicker dV/V	Phase CA Flicker dV/V Base	6
		4391	V Flicker dV/V	Neutral Flicker dV/V Base	7
	V Flicker	4401	V Flicker	Phase A Frequency of Maximum Flicker Harmonic	1
		4402	V Flicker	Phase B Frequency of Maximum Flicker Harmonic	2
		4403	V Flicker	Phase C Frequency of Maximum Flicker Harmonic	3
		4404	V Flicker	Phase AB Frequency of Maximum Flicker Harmonic	4
		4405	V Flicker	Phase BC Frequency of Maximum Flicker Harmonic	5
		4406	V Flicker	Phase CA Frequency of Maximum Flicker Harmonic	6
		4407	V Flicker	Neutral Frequency of Maximum Flicker Harmonic	7
	V Flicker	4417	V Flicker	Phase A Magnitude of Maximum Flicker Harmonic	1
		4418	V Flicker	Phase B Magnitude of Maximum Flicker Harmonic	2
		4419	V Flicker	Phase C Magnitude of Maximum Flicker Harmonic	3
		4420	V Flicker	Phase AB Magnitude of Maximum Flicker Harmonic	4
		4421	V Flicker	Phase BC Magnitude of Maximum Flicker Harmonic	5
		4422	V Flicker	Phase CA Magnitude of Maximum Flicker Harmonic	6
		4423	V Flicker	Neutral Magnitude of Maximum Flicker Harmonic	7
	V Flicker SWA	4433	V Flicker SWA	Phase A Flicker Spectrum Weighted Average	1
		4434	V Flicker SWA	Phase B Flicker Spectrum Weighted Average	2
		4435	V Flicker SWA	Phase C Flicker Spectrum Weighted Average	3
		4436	V Flicker SWA	Phase AB Flicker Spectrum Weighted Average	4
		4437	V Flicker SWA	Phase BC Flicker Spectrum Weighted Average	5
		4438	V Flicker SWA	Phase CA Flicker Spectrum Weighted Average	6
		4439	V Flicker SWA	Neutral Flicker Spectrum Weighted Average	7
	V Flicker(f)	4449	V Flicker(f) A	Phase A Flicker Spectrum	1
		4450	V Flicker(f) B	Phase B Flicker Spectrum	2
		4451	V Flicker(f) C	Phase C Flicker Spectrum	3
		4452	V Flicker(f) AB	Phase AB Flicker Spectrum	4
		4453	V Flicker(f) BC	Phase BC Flicker Spectrum	5
		4454	V Flicker(f) CA	Phase CA Flicker Spectrum	6
		4455	V Flicker(f) N	Neutral Flicker Spectrum	7
	V Flicker Pst	4497	V Flicker Pst A	Phase A Short Term Severity Value (Pst)	1
		4498	V Flicker Pst B	Phase B Short Term Severity Value (Pst)	2
		4499	V Flicker Pst C	Phase C Short Term Severity Value (Pst)	3
		4500	V Flicker Pst	Phase AB Short Term Severity Value (Pst)	4
		4501	V Flicker Pst	Phase BC Short Term Severity Value (Pst)	5
		4502	V Flicker Pst	Phase CA Short Term Severity Value (Pst)	6
		4503	V Flicker Pst	Neutral Short Term Severity Value (Pst)	7

Quantity	Characteristic	ChannelID	Name	Description	rank
V	V Flicker Plt	4513	V Flicker Plt A	Phase A Long Term Severity Value (Plt)	1
		4514	V Flicker Plt B	Phase B Long Term Severity Value (Plt)	2
		4515	V Flicker Plt C	Phase C Long Term Severity Value (Plt)	3
		4516	V Flicker Plt AB	Phase AB Long Term Severity Value (Plt)	4
		4517	V Flicker Plt	Phase BC Long Term Severity Value (Plt)	5
		4518	V Flicker Plt CA	Phase CA Long Term Severity Value (Plt)	6
		4519	V Flicker Plt	Neutral Long Term Severity Value (Plt)	7
I	i(t)	8209	i(t) A	Phase A Instantaneous Current	1
		8210	i(t) B	Phase B Instantaneous Current	2
		8211	i(t) C	Phase C Instantaneous Current	3
		8215	i(t) N	Neutral Instantaneous Current	7
		8216	i(t) R	Residual Instantaneous Current	8
		8217	i(t) Net	Net Instantaneous Current	9
		8218	i(t) All	All Phase Instantaneous Current	10
	I(F)	8225	I(F) A	Phase A Current Spectrum	1
		8226	I(F) B	Phase B Current Spectrum	2
		8227	I(F) C	Phase C Current Spectrum	3
		8231	I(F) N	Neutral Current Spectrum	7
		8232	I(F) R	Residual Current Spectrum	8
		8233	I(F) Net	Net Current Spectrum	9
		8234	I(F) All	All Phase Current Spectrum	10
	I Peak	8241	I Peak A	Phase A Peak Current	1
		8242	I Peak B	Phase B Peak Current	2
		8243	I Peak C	Phase C Peak Current	3
		8247	I Peak N	Neutral Peak Current	7
		8248	I Peak R	Residual Peak Current	8
		8249	I Peak Net	Net Peak Current	9
		8250	I Peak All	All Phase Peak Current	10
	I RMS	8257	I RMS A	Phase A RMS Current	1
		8258	I RMS B	Phase B RMS Current	2
		8259	I RMS C	Phase C RMS Current	3
		8263	I RMS N	Neutral RMS Current	7
		8264	I RMS R	Residual RMS Current	8
		8265	I RMS Net	Net RMS Current	9
		8266	I RMS All	All Phase RMS Current	10
	I HRMS	8273	I HRMS A	Phase A Harmonic RMS Current	1
		8274	I HRMS B	Phase B Harmonic RMS Current	2

Quantity	Characteristic	ChannelID	Name	Description	rank
I	I HRMS	8275	I HRMS C	Phase C Harmonic RMS Current	3
		8279	I HRMS N	Neutral Harmonic RMS Current	7
		8280	I HRMS R	Residual Harmonic RMS Current	8
		8281	I HRMS Net	Net Harmonic RMS Current	9
		8282	I HRMS All	All Phase Harmonic RMS Current	10
	I THD	8289	I THD A	Phase A Current Total Harmonic Distortion	1
		8290	I THD B	Phase B Current Total Harmonic Distortion	2
		8291	I THD C	Phase C Current Total Harmonic Distortion	3
		8295	I THD N	Neutral Current Total Harmonic Distortion	7
		8296	I THD R	Residual Current Total Harmonic Distortion	8
		8297	I THD Net	Net Current Total Harmonic Distortion	9
		8298	I THD All	All Phase Current Total Harmonic Distortion	10
	I ETHD	8305	I ETHD A	Phase A Current Even Harmonic Distortion	1
		8306	I ETHD B	Phase B Current Even Harmonic Distortion	2
		8307	I ETHD C	Phase C Current Even Harmonic Distortion	3
		8311	I ETHD N	Neutral Current Even Harmonic Distortion	7
		8312	I ETHD R	Residual Current Even Harmonic Distortion	8
		8313	I ETHD Net	Net Current Even Harmonic Distortion	9
		8314	I ETHD All	All Phase Current Even Harmonic Distortion	10
	I OTHD	8321	I OTHD A	Phase A Current Odd Harmonic Distortion	1
		8322	I OTHD B	Phase B Current Odd Harmonic Distortion	2
		8323	I OTHD C	Phase C Current Odd Harmonic Distortion	3
		8327	I OTHD N	Neutral Current Odd Harmonic Distortion	7
		8328	I OTHD R	Residual Current Odd Harmonic Distortion	8
		8329	I OTHD Net	Net Current Odd Harmonic Distortion	9
		8330	I OTHD All	All Phase Current Odd Harmonic Distortion	10
	I CF	8353	I CF A	Phase A Current Crest Factor	1
		8354	I CF B	Phase B Current Crest Factor	2
		8355	I CF C	Phase C Current Crest Factor	3
		8359	I CF N	Neutral Current Crest Factor	7
		8360	I CF R	Residual Current Crest Factor	8
		8361	I CF Net	Net Current Crest Factor	9
		8362	I CF All	All Phase Current Crest Factor	10
	I FF	8369	I FF A	Phase A Current Form Factor	1
		8370	I FF B	Phase B Current Form Factor	2
		8371	I FF C	Phase C Current Form Factor	3
		8375	I FF N	Neutral Current Form Factor	7

Quantity	Characteristic	ChannelID	Name	Description	rank
I	I FF	8376	I FF R	Residual Current Form Factor	8
		8377	I FF Net	Net Current Form Factor	9
		8378	I FF All	All Phase Current Form Factor	10
	I AS	8385	I AS A	Phase A Current Arithmetic Sum	1
		8386	I AS B	Phase B Current Arithmetic Sum	2
		8387	I AS C	Phase C Current Arithmetic Sum	3
		8391	I AS N	Neutral Current Arithmetic Sum	7
		8392	I AS R	Residual Current Arithmetic Sum	8
		8393	I AS Net	Net Current Arithmetic Sum	9
		8394	I AS All	All Phase Current Arithmetic Sum	10
	IT	8705	IT A	Phase A Current/Time Weighted Product	1
		8706	IT B	Phase B Current/Time Weighted Product	2
		8707	IT C	Phase C Current/Time Weighted Product	3
		8711	IT N	Neutral Current/Time Weighted Product	7
		8712	IT R	Residual Current/Time Weighted Product	8
		8713	IT Net	Net Current/Time Weighted Product	9
		8714	IT All	All Phase Current/Time Weighted Product	10
	I Demand	8721	I Demand A	Phase A Demand Interval RMS Current	1
		8722	I Demand B	Phase B Demand Interval RMS Current	2
		8723	I Demand C	Phase C Demand Interval RMS Current	3
		8727	I Demand N	Neutral Current/Demand Interval RMS Current	7
		8728	I Demand R	Residual Current/I Demand	8
		8729	I Demand Net	Net Current/Demand Interval RMS Current	9
		8730	I Demand All	All Phase Current/Demand Interval RMS Current	10
Power	P(F)	12321	P(F) A	Phase A Power Spectrum	1
		12322	P(F) B	Phase B Power Spectrum	2
		12323	P(F) C	Phase C Power Spectrum	3
		12330	P(F) All	All Phase Power Spectrum	10
	P	13057	P A	Phase A Real power	1
		13058	P B	Phase B Real power	2
		13059	P C	Phase C Real power	3
		13066	P All	All Phase Real power	10
	Q	13073	Q A	Phase A Reactive Power	1
		13074	Q B	Phase B Reactive Power	2
		13075	Q C	Phase C Reactive Power	3
		13082	Q All	All Phase Reactive Power	10
	S	13089	S A	Phase A Apparent Power	1

Quantity	Characteristic	ChannelD	Name	Description	rank
Power	S	13090	S B	Phase B Apparent Power	2
		13091	S C	Phase C Apparent Power	3
		13098	S All	All Phase Apparent Power	10
	PF	13105	PF A	Phase A Power factor	1
		13106	PF B	Phase B Power factor	2
		13107	PF C	Phase C Power factor	3
		13114	PF All	All Phase Power factor	10
	DF	13121	DF A	Phase A Displacement Factor	1
		13122	DF B	Phase B Displacement Factor	2
		13123	DF C	Phase C Displacement Factor	3
		13130	DF All	All Phase Displacement Factor	10
	P Demand	13137	P Demand A	Phase A Demand Interval Real Power	1
		13138	P Demand B	Phase B Demand Interval Real Power	2
		13139	P Demand C	Phase C Demand Interval Real Power	3
		13146	P Demand All	All Phase Demand Interval Real Power	10
	Q Demand	13153	Q Demand A	Phase A Demand Interval Reactive Power	1
		13154	Q Demand B	Phase B Demand Interval Reactive Power	2
		13155	Q Demand C	Phase C Demand Interval Reactive Power	3
		13162	Q Demand All	All Phase Demand Interval Reactive Power	10
	S Demand	13169	S Demand A	Phase A Demand Interval Apparent Power	1
		13170	S Demand B	Phase B Demand Interval Apparent Power	2
		13171	S Demand C	Phase C Demand Interval Apparent Power	3
		13178	S Demand All	All Phase Demand Interval Apparent Power	10
	DF Demand	13185	DF Demand A	Phase A Demand Interval Distortion Factor	1
		13186	DF Demand B	Phase B Demand Interval Distortion Factor	2
		13187	DF Demand C	Phase C Demand Interval Distortion Factor	3
		13194	DF Demand	All Phase Demand Interval Distortion Factor	10
	PF Demand	13201	PF Demand A	Phase A Demand Interval Power Factor	1
		13202	PF Demand B	Phase B Demand Interval Power Factor	2
		13203	PF Demand C	Phase C Demand Interval Power Factor	3
		13210	PF Demand All	All Phase Demand Interval Power Factor	10
	DFCoS	13217	DFCoS A	Phase A Distortion Factor Coincident with S demand	1
		13218	DFCoS B	Phase B Distortion Factor Coincident with S demand	2
		13219	DFCoS C	Phase C Distortion Factor Coincident with S demand	3
		13226	DFCoS All	All Phase Distortion Factor Coincident with S demand	10
	PFCoS	13233	PFCoS A	Phase A Power Factor Coincident with S demand	1
		13234	PFCoS B	Phase B Power Factor Coincident with S demand	2

Quantity	Characteristic	ChannelD	Name	Description	rank
Power	PFCoS	13235	PFCoS C	Phase C Power Factor Coincident with S demand	3
		13242	PFCoS All	All Phase Power Factor Coincident with S demand	10
Energy	PIntg	21521	PIntg A	Phase A Real Power Integrated, Net	1
		21522	PIntg B	Phase B Real Power Integrated, Net	2
		21523	PIntg C	Phase C Real Power Integrated, Net	3
		21530	PIntg All	All Phase Real Power Integrated, Net	10
	PIntgPos	21537	PIntgPos A	Phase A Real Power Integrated, Into Load	1
		21538	PIntgPos B	Phase B Real Power Integrated, Into Load	2
		21539	PIntgPos C	Phase C Real Power Integrated, Into Load	3
		21546	PIntgPos All	All Phase Real Power Integrated, Into Load	10
	PIntgNeg	21553	PIntgNeg A	Phase A Real Power Integrated, Out of Load	1
		21554	PIntgNeg B	Phase B Real Power Integrated, Out of Load	2
		21555	PIntgNeg C	Phase C Real Power Integrated, Out of Load	3
		21562	PIntgNeg All	All Phase Real Power Integrated, Out of Load	10
	QIntg	21569	QIntg A	Phase A Reactive Power Integrated, Net	1
		21570	QIntg B	Phase B Reactive Power Integrated, Net	2
		21571	QIntg C	Phase C Reactive Power Integrated, Net	3
		21578	QIntg All	All Phase Reactive Power Integrated, Net	10
	QIntgPos	21585	QIntgPos A	Phase A Reactive Power Integrated, Into Load	1
		21586	QIntgPos B	Phase B Reactive Power Integrated, Into Load	2
		21587	QIntgPos C	Phase C Reactive Power Integrated, Into Load	3
		21594	QIntgPos All	All Phase Reactive Power Integrated, Into Load	10
	QIntgNeg	21601	QIntgNeg A	Phase A Reactive Power Integrated, Out of Load	1
		21602	QIntgNeg B	Phase B Reactive Power Integrated, Out of Load	2
		21603	QIntgNeg C	Phase C Reactive Power Integrated, Out of Load	3
		21610	QIntgNeg All	All Phase Reactive Power Integrated, Out of Load	10
	SIntg	21617	SIntg A	Phase A Apparent Power Integrated, Net	1
		21618	SIntg B	Phase B Apparent Power Integrated, Net	2
		21619	SIntg C	Phase C Apparent Power Integrated, Net	3
		21626	SIntg All	All Phase Apparent Power Integrated, Net	10

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