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Summary Paper of IEEE PSRC Working Group H5-c
Report on a Common Data Format for IED Sampled Data

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Abstract: This IEEE PSRC Working Group report presents an investigation of "sampled data" utilized in modern IEDs. It summarizes the definitions of "sampled data" pertaining to IED's and relevant new international standards that have been introduced since the IEEE Std C37.111-1999 COMTRADE. The information will be useful to anyone needing to exchange data between the referenced standards outside of the IED or as design considerations for a new IED. Specific recommendations have been made in regards to a future revision of COMTRADE to facilitate the data exchange process.

Introduction:

There are new requirements that need to be defined for universal exchange and interlocking of sampled data and other related IED data. Three standards were identified as being critical for IED sampled data, these standards are: COMTRADE - IEEE Std C57.111-1999, PQDIF - IEEE Std 1159.3-2002, and IEC-61850.

Creating a synergy of sampled data among these standards would benefit the industry as a whole and resolve future IED compatibility issues. Both PQDIF and IEC61850 have a XML-based data file structure, it was determined that a possible mapping of the existing COMTRADE file structures into the IEC-61850 SCL and XML data modeling could resolve missing logical node definitions, data values, and matching data types. Making COMTRADE a subset of the PQDIF data superset could harmonize many issues including the issue of variable sample rates and how to handle them within COMTRADE. These efforts could result in lossless data conversion between these standards. This report defines the possibilities for data exchange under the present versions and will recommend future beneficial changes as appropriate.

EXISTING SAMPLED DATA STANDARDS

COMTRADE – IEEE Std C37.111-1999 : The Common Format for Transient Data Exchange (COMTRADE) was first published in 1991 as C37.111. It was later revised in 1999 to expand and clarify the definitions of the data exchange format. The standard specifies four files of which one contains the actual sampled data. The data file has the extension (.DAT) and the data can be in either ASCII or binary format. In order to extract the sampled data into meaningful information, it is necessary to use the accompanying configuration file (.CFG) that specifies the sample rate, type of data, number of channels and scaling factors along with other key information.

The data file structure consists of rows and columns, the first column is the sample sequence number, and the second column is the time stamp for that sample number. Beginning with the third column is the analog input(s) and following all analog channels are the columns of the status inputs. In each row (or scan) a comma separates the data and the last value must end with a carriage return/line feed (<CR/LF>) indicating the end of the data row.

From the standard, "Each data sample record shall consist of integers arranged as follows:

n, timestamp, A_1, A_2, …A_k, D_1, D_2, …D_m where,

n is the sample number. Critical, integer, numeric, minimum length = 1 character, maximum length = 10 characters, minimum value = 1, maximum value = 9999999999.

Timestamp is the time stamp. Non-critical if **nrates** and **samp** variables in .CFG file are nonzero, critical if **nrates** and **samp** variables in .CFG file are zero. Integer, numeric, minimum length =1 character, maximum length = 10 characters. Base unit of time is microseconds (μs).

A_1, ….. A_k are the analog channel data values separated by commas until data for all analog channels are displayed. Non-critical, integer, numeric, minimum length = 1 character, maximum length = 6 characters, minimum value = Ð99999, maximum value = 99998. Missing analog values must be represented by placing the value 99999 in the field.

D_1,…… D_m are the status channel data values separated by commas until data for all status channels are displayed. Non-critical, integer, numeric, minimum length = 1 character, maximum length = 1 character. The only valid values are 0 or 1. No provision is made for tagging missing status data and in such cases the field must be set to 1 or to 0. The last data value in a sample shall be terminated with carriage return/line feed.

An example of ASCII sampled data containing six analog values and six status values could be represented as:

5, 667, -760, 1274, 72, 61, -140, -502, 0,0,0,0,1,1 <CR/LF>

Binary data files have the same basic structure except status channel data are compacted. No data separators are used and no carriage return/line feed terminates the data row. Data translation is made by sequential position within the file. The data is stored in LSB/MSB format and must be converted accordingly.

A binary example of the equivalent ASCII record above would be:

05 00 00 00 9B 02 00 00 08 FD FA 04 48 00 3D 00 74 FF 0A FE 30 00

PQDIF – IEEE Std 1159.3-2002

IEEE Standard 1159.3 (commonly known as the Power Quality Data Interchange Format – PQDIF), is a file or stream based mechanism of transferring power quality and related measurement or simulation data from a data source to a data sink in a compact, unambiguous, and deterministic way.

PQDIF was developed by the power quality community to address deficiencies in the use of COMTRADE for power quality purposes. The result of the design effort was a file format that is made up of records which are logically related. There are four types of records:

- Container (start of stream or file identifier, global options)
- Data Source (channel and series definitions generally representing an instrument or simulation program)
- Monitor Settings (optional – PT/CT ratio's, frequency response characteristics, calibration, etc.)
- Observations (e.g. waveforms, RMS traces, events, trends, statistics, etc.)

These records are organized in a hierarchical structure based on the record type as shown in Figure 1. The "high-level" record structure is completely separated from the "low-level" element structure.

Physically, the file is made up of a series of linked records of the various types defined in the figure. Each record is made up of a "header" and a "body." The header provides the high-level information. The body contains the low-level information. The contents of the header allow for a parser to determine the record type by the tag field. If the parser doesn't know about that tag type, it can ignore it by using the size and link information to find the next record in the file. A signature is also provided to further validate the record as a valid PQDIF record.

The body of each record is made up of a set of "elements" which contain data. There are three element types:

- Scalar - represents a single data value
- Vector - represents an array of data values
- Collection - contains other elements

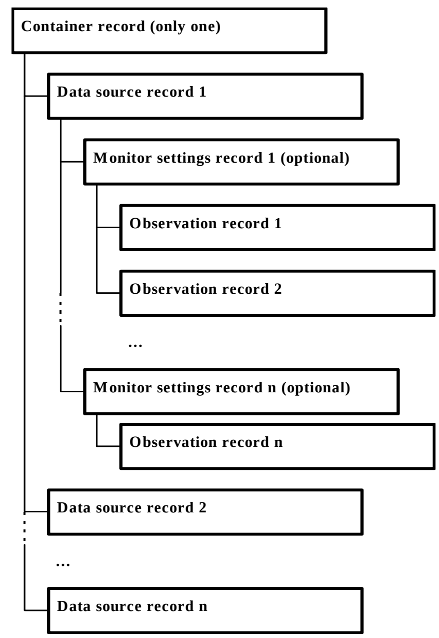

Figure 1 – Hierarchical Structure of PQDIF

In order to be able to identify a specific record or element, each one is given a "tag." This tag is actually a GUID, which makes extending the list of tags straightforward and does not require a central registration authority.

Because each element is tagged, there is a separation between the "physical" and "logical" structure. This allows the logical structure to be defined separately from the physical structure. The low-level physical format allows each element to have a tag. The logical format defines what the tags are, and what element type and primitive data type(s) are expected for each. Since collections can contain other collections, the logical format also specifies this hierarchy.

This structure can be thought of in terms of a file system. With this analogy, a tag can be thought of as a file name that inherently indicates what the contents to follow are used for. A collection would be a subdirectory, a scalar is a file with one value (number, string, GUID, timestamp) in it and a vector is a file with a series of values in it. A collection can contain other collections which creates a hierarchy just like a file system.

Probably the most important logical construct of a PQDIF file is the Observation Record. Observations are time stamped and contain the actual measured or simulated data from one or more logical channels. The type, format, units and other attributes of a channel are defined once in the Data Source Record (channel and series definitions). Observation Records instantiate instances of one or more of those channels and within a channel, one or more data series that are necessary to represent the data associated with that channel.

A channel of an observation can represent power quality event summaries, waveform or phasor domain traces, period recording (time trends) of any quantity, sequence of event logs, and statistical data of any quantity that can be represented in standard SI units.

High end power quality monitors typically have data sources defining 200 or more channels. Most of these channels represent steady state ID_QT_VALUELOG type data. Other channels represent transient, rms variation, harmonic, lightning, and event statistical information. Typically an instrument or gateway produces a single PQDIF file per day containing all event and trend observations for that day. When compressed, a typical daily PQDIF file of this sort may be around 1 MB in size.

Since the release of IEEE 1159.3, implementers have identified a few additions to the standard they would like to make. The use of GUID's for extensibility has allowed them to make those changes themselves without breaking existing reader/analysis programs or colliding with other implementer changes. The changes can then be implemented in the formal standard definition during the next maintenance release.

IEC 61850

IEC 61850 is a series of standards that consists of 14 parts. The title of IEC 61850 is "Communication Networks and Systems in Substations". However, IEC 61850 specifies more than the communication interfaces. It includes information models of the substation equipment, the specification of a configuration language used to exchange configuration information between tools from different manufacturers of substation automation equipment and specification of conformance testing of the communication interfaces.

The core element of the information model is the logical node. A logical node can be considered as a basic container of related functional data of any definable element. Logical nodes represent a function's information as defined by its data and data attributes.

The logical nodes involved in the acquisition of measured information are shown in Figure 2. TCTR is the logical node for a current transformer, TVTR the one for a voltage transformer. (Note that the logical nodes representing primary equipment are typically single phase.) Therefore we need three instances of a logical node TCTR or TVTR to represent a three-phase device. In the example of Figure 2, the instance name includes the phase identification as a prefix (e.g. A for phase A). The output of the logical nodes TCTR and TVTR is representing the waveform on the power line. Several logical nodes representing substation automation functions are using that waveform. The examples shown in Figure 2 are MMXU – Measurement unit (the function to calculate e.g. rms values), MHAI – harmonic calculation, MSQI – sequence calculation, Pxxx – any kind of protection functions, RSYN – synchrocheck and RADR – waveform recording, analog channel.

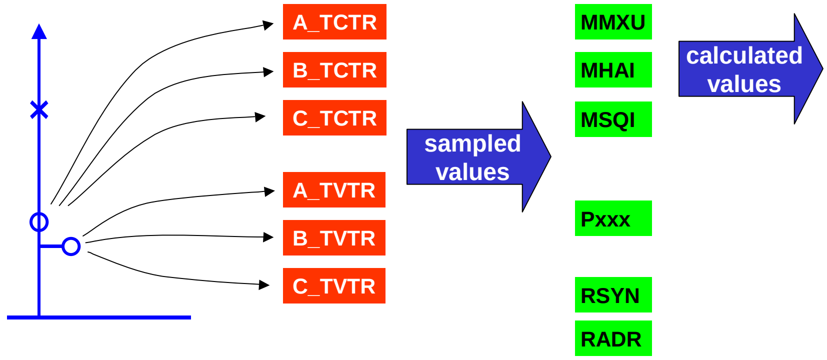

Figure 2 - Acquisition of measured information

Sampled data in IEC 61850

IEC 61850 has two areas where it deals with sampled data. The first is the modeling of the acquisition of sampled data from current and voltage measurement as shown already in Figure-2 above. The data object A of the LN TCTR is representing a sample of the current waveform (similar for V of TVTR). The communication services defined in IEC 61850-7-2 and IEC 61850-9-2 describe how a series of samples is transmitted over the communication network. While the main purpose of these communication services is for the online transmission of sampled values between e.g. a CT or VT and the protection relay, it would be possible to use these communication services to replay a recorded sequence of sampled data.

The second area is the description concerning the recording of a series of sampled data. Here, IEC 61850 does not describe a new format for the file, where the sampled data are stored. Instead, IEC 61850 refers to COMTRADE. Using file transfer, a COMTRADE file can be retrieved from the device. However, what IEC 61850 defines, is the structure to configure the recording of sampled data.

For that purpose, IEC 61850 introduces three logical nodes:

RDRE: Disturbance recorder function
RADR: Disturbance recorder channel analog
RBDR: Disturbance recorder channel binary

With these logical nodes, a disturbance recorder can be modeled as shown in Figure 3. For each channel, an instance of the logical node RADR or RBDR is required. These logical nodes contain all channel specific settings and information if that specific channel has triggered. The logical node RDRE is required once. This logical node contains the global settings and information concerning the status of the recorder and the required control, e.g. to clear the memory of the recorder.

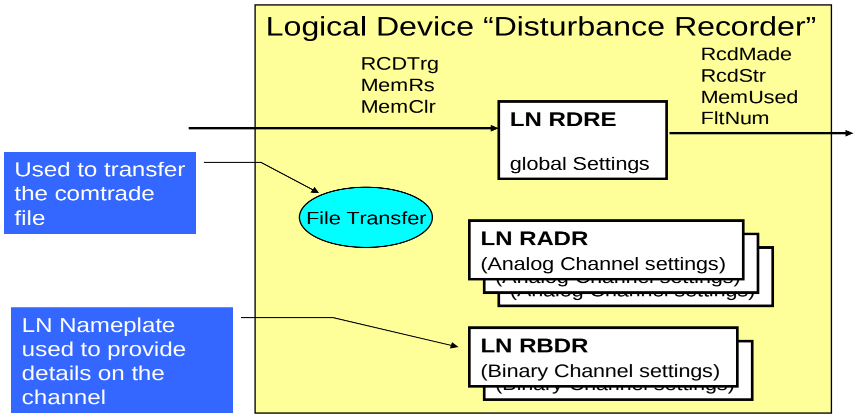

Figure 3 – principles of modeling a disturbance recorder in IEC 61850

Using the logical nodes with the setting attributes, the behavior of the disturbance recorder can be configured online with the required communication services. It is also possible to read out the current settings from the device by reading the data of these logical nodes. The information contained in these logical nodes is similar to the information of the COMTRADE configuration file.

Assuming that the values are preconfigured in the IED, they are also described in the SCL file of the IED implementing the disturbance recorder function. The extract of the SCL file with the data model of the disturbance recorder including its preconfigured settings is therefore similar in content to the COMTRADE configuration file. Details of the mapping of IEC 61850 LN data on the elements of the COMTRADE configuration file are described in the report.

CONVERSION OF SAMPLED DATA BETWEEN STANDARDS

Conversion considerations of PQDIF-2002 and COMTRADE-1999

This section describes how to map power system waveform and event data stored in the IEEE Std 1159.3-2002 PQDIF to the IEEE Std C37.111-1999 COMTRADE and vice versa. In specifying this mapping, there are many instances where arbitrary conventions must be adopted to facilitate the mapping. In general, the conventions suggested are those that are in common practice in at least one or more software implementations of COMTRADE and/or PQDIF.

High Level Issues

There are a few key differences between the COMTRADE and PQDIF standards that merit attention and our first set of arbitrary mapping conventions. PQDIF permits (and encourages) storing multiple "Observations" in a single PQDIF file. An observation in PQDIF is an event such as a multi-channel recording of voltage, current, and binary status variables during a fault. COMTRADE easily represents such data in a single .CFG/.DAT file pair. PQDIF however, can represent multiple such recordings (observations) in a single file. Note that the PQDIF equivalent of a .CFG file is the Data Source Record.

When converting a PQDIF file (e.g. rootname.pqd) containing multiple observations to COMTRADE format, multiple .CFG/.DAT file pairs result. Arbitrary conventions must be adopted to name and optionally archive these files.

COMTRADE-1999 to PQDIF-2002

When converting from COMTRADE to PQDIF, some information for the channel definitions may be developed from the COMTRADE .CFG files *but because of the nature of "non-critical" data items in COMTRADE* it is usually necessary to separately map most of these fields manually. Also, much latitude has been taken over the years in *how the COMTRADE standard has been implemented by various vendors, which leads to certain ambiguities*.

A software implementation for partially automating the configuration to channel definitions process can read the configuration file and attempt to infer quantity measured, SI units, and scale information. Typically, the software would have difficulty determining the remaining information including characteristic, quantity type, value type and location or phase.

Possible automated mappings could be as follows:

Phase could be derived from *ch_id* and/or *ph* fields in the analog channel definition information records if well defined rules are used to assign this field. However, this is a non-critical field and for general-purpose translators this will have to be manually overridden.

Units can be derived from the *uu* field of the analog channel definition information records if strict rules are used to create this field. If this is possible, the PQDIF quantity measured can be inferred directly.

Scale and offset information can be derived directly from the *'a'* and '*b'* fields. These are critical data and so should always be present. However, PQDIF requires that the scale be a base SI unit. If the units of the scaled values are not base SI, i.e. kilo volts, the scales provided must be adjusted.

In practice, existing implementations of COMTRADE to PQDIF converters require an external mapping file due to the ambiguities mentioned above

PQDIF-2002 to COMTRADE-1999

Conversion from PQDIF to COMTRADE can be accomplished without any loss of data and without the need for a configuration file for a subset of the PQDIF quantity types. The PQDIF quantity types easily converted to COMTRADE are:

- WAVEFORM – any instantaneous waveform data
- PHASOR – any instantaneous RMS variation trace with, or without phase information
- VALUELOG – any trend of any steady state parameter over time

Notable quantities that do not have a clear mapping include the following PQDIF quantity types:

- RESPONSE – arbitrary spectra and frequency domain measurements
- FLASH – Lightning strike events
- HISTOGRAM – PQ event statistics
- CPF – PQ event cumulative probability functions
- MAGDUR, MAGDURCOUNT, MAGDURTIME – PQ event summary tables

During the conversion process from PQDIF to COMTRADE, some naming conventions are required to identify the multiple “views” of individual channels that may be present in a PQDIF file. For example, most power quality measurement devices record instantaneous, maximum, minimum, and average traces on a single channel (phase) for RMS Variations depending on the length of the recording as shown in Figure 4.

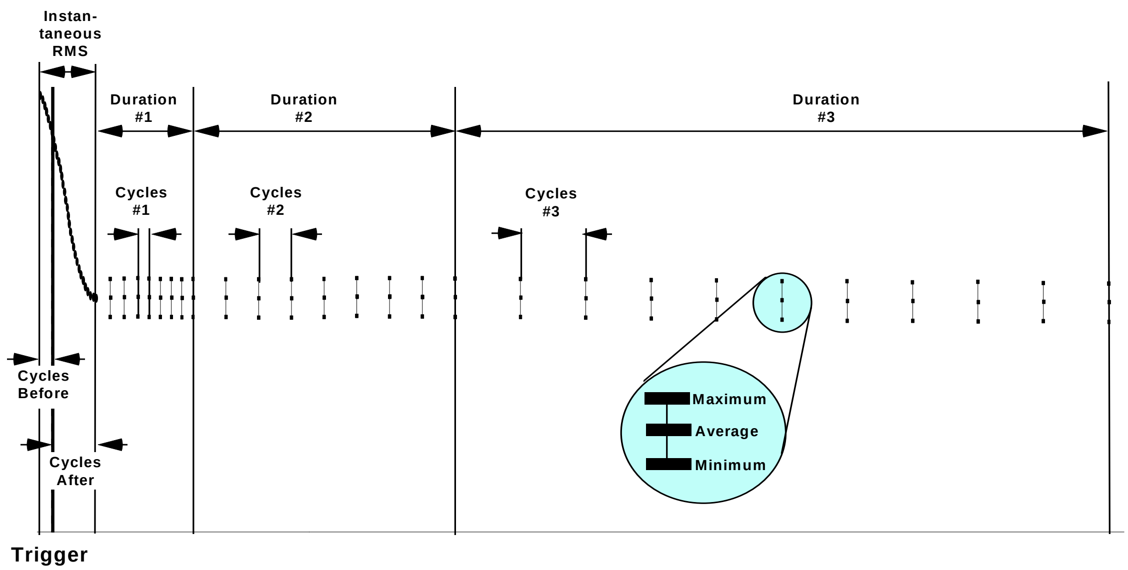

Figure 4 – Instantaneous, Min, Max, and Average Traces in a Long RMS Variation

The following conventions have been used to facilitate identifying each of the channels associated with an RMS Variation such as this.

IEC61850 to/from COMTRADE-1999

When IEC 61850 disturbance recorder models were created, COMTRADE was the basis for the modelling. However, the focus was to supply all required configuration attributes. It was not intended to map descriptive information from the COMTRADE configuration file into the logical nodes (LN’s). That’s why some information that is part of the COMTRADE configuration file is not available as data directly in IEC 61850. However, it is easy to add this information to the LNs of IEC 61850 so that at the end the IEC 61850 data model would contain the complete content of a COMTRADE configuration file.

The following table provides an overview on the information in the COMTRADE configuration file and the place where that information can be found in IEC 61850. There are two different ways to have the information in IEC 61850 available:

(1) The information is contained in an attribute of the data model. In that case, the information can be read and optionally be written while the device is in operation using the communication services of IEC 61850-7-2.
(2) The information is available in the SCL file of the substation. Note that information available in the data model can also be represented in the SCL file.

In order to have all information from the COMTRADE configuration file available in IEC 61850, the following extensions to the logical nodes currently defined have been proposed:

RDRE class				
Attribute Name	**Attr. Type**	**Explanation**		
Settings				
SmpRte	ASG	Sample Rate in Hertz. (If zero, time stamp of ChTrg is used for COMTRADE conversion.)		O
EndSmp	ING	Last sample number at SmpRte.		O
Ft	ING	Indication of the File type. (binary, ASCII, B64,...)		O
TmMult	ASG	Time multiplication factor		O
RevYr	ING	COMTRADE Revision Year (1991, 1999, etc.)		O

RADR class				
Attribute Name	**Attr. Type**	**Explanation**		**M/O**
Measured values				
AnVal	SAV	Analogue input channel		M
AnSkew	ASG	Analog channel skew due to anything. (Time skew in COMTRADE in microseconds.)		O
Ref				

RBDR class				
Attribute Name	**Attr. Type**	**Explanation**		
Settings				
ActSt	ING	Active state (0, 1)		O
Ref				

Table 1 – LN definitions of Disturbance Recorder function

With these extensions, an extract of the data model for a disturbance recorder could be the following:

Logical Device **Logical Node** **Data.DataAttribute**	**Comtrade Configuration file**
Atlanta_110kV_Line1_DR/	
RDRE	
FltNum.stVal	
PreTmms.setVal	Used together with ChTrg.t to calculate time stamp of first value
PstTmms.setVal	
SmpRte.setVal	Sample rate
FtBin.setVal	File type
TmMult.setMag	Time stamp multiplication factor
RADR1	
AnVal.units	Units
AnVal.sVC	Scaling
AnVal.min	Min value
AnVal.max	Max Value
ChTrg.stVal	
ChTrg.t	Time stamp of trigger point
ChNum.setVal	Channel number
RADR2	
....	
RBDR1	
ChNum.setVal	Channel number
ActSt.setVal	Normal state of channel

Table 2 – Disturbance Recorder Data Model

With these extensions to the data model, a XML file based on the SCL file can be created that can replace the COMTRADE configuration file. That SCL file would contain the following sections:

- an extract of the substation section that contains the switchgear equipment representing the recorded information (i.e. the current and voltage transformers measuring the recorded waveforms or circuit breaker and switches, when position indications are also recorded)
- The relevant part of the data model from the IED sections of the disturbance recorder itself and the IED where the LNs TCTR and TVTR are implemented
- The relevant section of the data template section.

COMTRADE configuration file	**IEC 61850 data model**
Station name	The information can currently not be directly found in the data model. However, it can be retrieved from the substation section of the SCL file.
Identification of device	The information can currently not be directly found in the data model. However, it can be retrieved from the IED section of the SCL file.

Revision	A new attribute in the RDRE logical node is proposed to handle the year of COMTRADE standard used. E.g. 1991, 1999, etc.
Number and type of channels	Indirectly through the number of instances of LNs RADR and RBDR.
Line frequency	From one of the related LN TCTR/TVTR. The related LN TCTR/TVTR can be found through the substation section of SCL.
Sampling rate	Sample Rate in Hertz. (If zero, time stamp of ChTrg is used for COMTRADE conversion.)
Time stamp of first data value and trigger point	Use time stamp of ChTrg of the individual channel LN that triggered together with PreTmms of that channel; if no individual PreTmms per channel, use PreTmms of LN RDRE
Data file type	New data is Ft in RDRE LN
Time stamp multiplication factor for data file	New data is TmMult in RDRE LN
For each analogue channel	
Channel no	RADR.ChNum.setVal
Phase	The information can currently not be directly found in the data model. However, in the substation section of the SCL file, the association between a logical node instance (i.e. the channel) and the single line diagram can be made.
Circuit component	Same as phase
Units and scaling	New data AnVal in RADR LN
Skew	New data AnSkew in RADR LN.
Min / max values	In the data type of RADR LN
Primary / secondary ratio	DO Rat and VRtg/ARtg of related LN TCTR/TVTR. The related LN TCTR/TVTR can be found through the substation section of SCL.
Indication if value is primary	IEC 61850 assumes that values are always primary values
For each binary channel	
Channel no	RBDR.ChNum.setVal
Phase	See above for analogue channel
Circuit component	Same as phase
Normal state of channel	New data ActSt in RBDR LN

Table 3 – Mapping of COMTRADE to IEC 61850

IEC61850 to/from PQDIF-2002
IEC 61850 is currently being amended to represent power quality data. The current Committee Draft (CD) adds new logical nodes to represent RMS Variation and Transient events. The logical nodes are primarily focused on containing summary representations of the underlying detailed time series data. This summary information includes the magnitude and duration of an RMS variation event for example. An optional element under consideration by the PQ task force in the 61850 power quality logical node definitions is to specify the name of a PQDIF, COMTRADE, or other formatted file that contains the original time series data. Conversion to/from PQDIF would therefore not really be a conversion – it is simply a matter of configuring the logical device to produce the desired COMTRADE / PQDIF event detail files and then retrieve those files using 61850 file transfers.

DATA FORMATS / DATA TYPES / ATTRIBUTES IN USE / Future Considerations
Any new IED should support the current standard applicable to its designed application. As such, a protection IED should support the IEC-61850 data types and a power quality IED should support the PQDIF data types. As noted in Table 5-1 this would mean both could have a seamless exchange of sampled data if a conversion path is provided.

Revision of the COMTRADE 1999 standard is ongoing; the investigation of the aforementioned standards clearly illustrates the need to harmonize the data formats to simplify data exchange for industry users. Eliminating the need for conversions of the raw data formats reduces data loss and handling of the configuration information requires much less effort. Being documented in the full report, the effort to implement such conversion programs are a minimum.

Both ASCII and Binary data should be supported as the norm as this is common to all three standards. Table 4 shows the extension of the data types and possible harmonized mapping:

C37.111 (COMTRADE)		IEEE 1159.3 (PQDIF)		IEC-61850
Signed Integer 1,2 or 4 bytes		Signed Integer 1,2 or 4 bytes		Signed Integer 1,2 or 4 bytes
Unsigned Integer 1,2 or 4 bytes		Unsigned Integer 1,2 or 4 bytes		Unsigned Integer 1,2 or4 bytes
Boolean 1,2 or 4 bytes		Boolean 1,2 or 4 bytes		Boolean 1,2, or 4 bytes
Real 4-byte single or 8-byte DP		Real 4-byte single or 8-byte DP		Real 4-byte single or 8-byte DP
Complex 8-byte single or 16-byte DP		Complex 8-byte single or 16-byte DP		Complex 8-byte single or 16-byte DP
Character 1-byte ASCII or 2-byte Unicode		Character 1-byte ASCII or 2-byte Unicode		Character 1-byte ASCII or 2-byte Unicode
Date Stamp 12-bytes		Date Stamp 12-bytes		Date Stamp 12-bytes
		GUID 16-bytes		

Table 4 – Comparison of data types and possible additions for COMTRADE.
(Shaded attributes of column one are recommended additions.)

Those listed in Italic text and shaded box are the data types being recommended for addition to the COMTRADE standard revision. Support of these additional data types will reflect present practice in the industry and allow loss less data conversion when required.

It is recommended that an expansion of supported and defined channel attributes be adopted along with these new data types to complete the support for the industry's present practice and reflect the way in which COMTRADE is already being used. The following additional Sampled Data Attributes are proposed for a future revision to COMTRADE in Table 5:

Attribute	**Proposed Additions**
Quantity Type	Phasor, value log, flash
Quantity Measured	Power, energy, temp
Quantity Characteristic	Rms, thd, tif, TPF
Series Quantity Units	watts, vars
Series Value Type	min, max, avg
Channel ID	Phase

Table 5 – Proposed new attributes for COMTRADE

Advantages of Expanded Formats

One of the main goals of the industry today is the seamless exchange of data and information between multifunctional IEDs and different analysis or configuration applications related to various types of power system events. It is driven by the requirement for the development of analysis tools that can process the data from multiple sources that record such power system events.

The use of XML as a data format that allows the clear identification of each data object in a human readable and easily parsed format will help in the creation of tools that ensure interoperability between the devices and tools that produce COMTRADE (and other data) files and the applications that use them.

The object oriented models defined in IEC 61850 support the representation of waveform and disturbance recording functions, as well as the time-stamped sampled analog or binary values. An expanded COMTRADE file should be able to support the data objects and their attributes supported by IEC 61850 in order to allow their analysis and visualization.

Use of an XML schema to validate the COMTRADE Configuration file portion will help to achieve the interoperability goal and support the introduction of Conformance Testing procedures.

Considering the fact that power system events are detected and recorded by different types of devices that produce different types of records, it makes logical sense to harmonize the data types and data models in order to be able to convert between the different types of record formats. This will allow the creation of analysis tools that can perform their tasks based on the different types of records available for the same event(s).

The expanded COMTRADE format will also support its use for both legacy and IEC 61850 based devices or distributed recording systems using the IEC 61850 Process bus or GOOSE messages.

It helps to also distinguish between physical and virtual analog and binary inputs into the device performing the recording functions.

The use of the standard data object names in IEC 61850, as well as the object hierarchy and substation configuration language (SCL) will support the self configuration of the analysis or visualization tools that could be based on future COMTRADE files.

SUMMARY / CONCLUSIONS

This report presented different methods of sampling data in modern IED's. Three standards were identified and reviewed, COMTRADE - IEEE Std C37.111-1999, PQDIF - IEEE Std 1159.3-2002 and IEC-61850. The different data formats, types and attributes to the corresponding standards were compared. Different possible conversions of sampled data between the different standard formats were presented for consideration. Recommended changes to the COMTRADE standard were made in order to harmonize these data between the three standard formats. It is a recommendation of this working group that consideration be given to formally harmonize these standards in the next revision of COMTRADE and also to adopt the XML format for self-description of data and file verification. Finally, after that revision is prepared have a new working group provide a guide for loss less conversion between these standards for the industry at large.

REFERENCES

[R1] IEEE Std C37.111-1999; "**IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems**". [1]

[R2] IEEE Std 1159.3 - 2003; "**IEEE Recommended Practice for the Transfer of Power Quality Data**". [1]

[R3] IEC TS 61850, "**Communication Networks and Systems in Substations**".

[R4} ANSI X3.4-1986 (R1997), "**Information Systems Coded Character SetÑ7-Bit American National Standard Code for Information Interchange**" (7-bit ASCII).[2]

[R5] IEEE Std 260.1-1993, "**American National Standard Letter Symbols For Units of Measurement**" (SI Units, Customary Inch-Pound Units).

[R6] IEEE Std 280-1985 (R1996), "**IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering**" (DoD).

[1]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).

[2]ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (http://www.ansi.org/).

BIOGRAPHY: (Presenting on behalf of the H5-c WG)

Benton Vandiver III, P.E. received BSEE from the University of Houston in 1979, beginning his career with the Substation Division of Houston Lighting & Power the year before. He developed extensive knowledge in the application, setting, testing, modeling, and design of traditional and digital relaying systems used in all types of power system protection, control, and monitoring. He is currently Technical Director for OMICRON Electronics Corp. USA in Houston, TX. He is a long time member of IEEE and is Chairman of Working Group H5-C Common Data Format for IED Sampled Data. He holds a US Patent and has authored or co-authored numerous technical papers for conferences in North America.