IEC 60255-24

Edition 2.0 2013-04

INTERNATIONAL STANDARD

IEEE Std C37.111™

NORME INTERNATIONALE

colour inside

Measuring relays and protection equipment –
Part 24: Common format for transient data exchange (COMTRADE) for power systems

Relais de mesure et dispositifs de protection –
Partie 24: Format commun pour l'échange de données transitoires (COMTRADE) dans les réseaux électriques

IEC 60255-24:2013 IEEE Std. C37.111-2013

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MEASURING RELAYS AND PROTECTION EQUIPMENT –

Part 24: Common format for transient data exchange (COMTRADE) for power systems

FOREWORD

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International Standard IEC 60255-24/IEEE Std C37.111 has been jointly revised by the Power System Relaying Committee of the IEEE Power and Energy Society[1] in cooperation with IEC Technical Committee 95: Measuring relays and protection equipment, under the IEC/IEEE Dual Logo Agreement.

This second edition cancels and replaces the first edition published in 2001 and constitutes a technical revision. The main changes with respect to the previous edition are as follows:

a) The new edition allows single file format (with extension .CFF) in lieu of four separate files.

b) The single file with .CFF extension contains four sections of information corresponding to .CFG, .INF, .HDR, and .DAT. The DAT section is either in ASCII or Binary.

c) The following additional data file types are also supported: binary32 (using 4 bytes to represent integer numbers) and float32 (using 4 bytes to represent real numbers).

d) The configuration (.CFG) file/section has been modified. Four new fields have been added at the end of the .CFG file/section in two separate lines. Two fields represent the time information and the time difference between local and UTC time, and these two fields comprise one line. Another two fields represent the time quality of samples and comprise the last line of the file/section.

e) Some of the fields in the Configuration (.CFG) file/section have been designated critical instead of non-critical.

f) The use of Unicode UTF-8 characters has been added. However and because of the extensive use of the terms ASCII and Text throughout this document, any occurrence of these terms also inherently implies Unicode UTF-8.

The text of this standard is based on the following IEC documents:

FDIS	Report on voting
95/308/FDIS	95/311/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

International standards are drafted in accordance with the ISO/IEC Directives, Part 2.

The IEC Technical Committee and IEEE Technical Committee have decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

[1] A list of IEEE participants can be found at the following URL:
http://standards.ieee.org/downloads/C37/C37.111-2013/C37.111-2013_wg-participants.pdf

INTRODUCTION

The increasing use of digital technology in devices such as protection, oscillograph, measurement, and control apparatus in electric power substations has created the potential for accumulating large numbers of digital records of power system transient events. In addition to these sources of digital data, analog and digital power-system simulators may be used to generate digital records. The users of these records are faced with the problem of having to cope with different formats used by each system to generate, store, and transmit records.

MEASURING RELAYS AND PROTECTION EQUIPMENT –

Part 24: Common format for transient data exchange (COMTRADE) for power systems

1 Scope

This International Standard defines a format for files containing transient waveform and event data collected from power systems or power system models. The format is intended to provide an easily interpretable form for use in exchanging data. The standard is for files stored on currently used physical media such as portable external hard drives, USB drives, flash drives, CD, and DVD. It is not a standard for transferring data files over communication networks.

This standard defines a common format for the data files and exchange medium needed for the interchange of various types of fault, test, and simulation data. The rapid evolution and implementation of digital devices for fault and transient data recording and testing in the electric utility industry have generated the need for a standard format for the exchange of time sequence data. These data are being used with various devices to enhance and automate the analysis, testing, evaluation, and simulation of power systems and related protection schemes during fault and disturbance conditions. Since each source of data may use a different proprietary format, a common data format is necessary to facilitate the exchange of such data between applications. This will facilitate the use of proprietary data in diverse applications and allow users of one proprietary system to use digital data from other systems.

2 Normative references

IEEE Std C37.118 ™ -2005, *IEEE Standard for Synchrophasors for Power Systems*

IEEE Std C37.232 ™ -2007, *IEEE Recommended Practice for Naming Time Sequence Data Files*

IEEE Std 260.1 ™ -1993, *IEEE Standard Letter Symbols For Units of Measurement (SI Units, Customary Inch-Pound Units)*

IEEE Std 280 ™ -1985 (R1996), *IEEE Standard Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering (DOD)*

IEEE Std 754 ™ -2008, *IEEE Standard for Floating Point Arithmetic*

ISO 80000-1, *Quantities and units – Part 1: General*

3 Terms and definitions

For the purpose of this document the following terms and definitions apply:

3.1
critical data
any data that are necessary for reproduction of the sample data

3.2
non-critical data
any data in the COMTRADE configuration file which are not absolutely necessary for reproduction of the sample data, and some variables provided in the configuration file that may not be relevant to a particular application

3.3
COMTRADE
Common Format for Transient Data Exchange
format of time sequence data generated by various sources for exchange purpose

Note 1 to entry: This note applies to the French language only.

3.4
electro-magnetic transient program
EMTP
programs that produce time sequence data by analyzing mathematical models of the power system, unlike the devices that record actual power system events

Note 1 to entry: Electromagnetic transient simulation programs can provide many different test cases for a relay, because of the use of the case with which the input conditions of the study can be changed.

Note 2 to entry: This note applies to the French language only.

3.5
skew
time difference between sampling of channels within the sample period of a record for an analog-to-digital converter

EXAMPLE: In an eight-channel device with one analog-to-digital (A/D) converter without synchronized sample and held running at a 1 ms sample rate, the first sample will be at the time represented by the **timestamp**; the sample times for successive channels within each sample period could be up to 125 µs behind each other. In such cases the skew for successive channels will be 0; 125; 250; 375 µs…; etc.

3.6
time sequence data
TSD
type of electronic data file where each data item in the file corresponds to an instant of time that is identified by an explicit or implicit time tag, such as transient data records, event sequences, and periodic data logs

Note 1 to entry: This note applies to the French language only.

4 File and data storage

4.1 Categories of files

4.1.1 General

Files stored on digital devices and media consist of bytes representing a combination of alphabetic, numeric, symbol, punctuation, and other formatting characters. Depending on the format, a byte, part of a byte, or more than one byte, may be represented by a letter, number, or symbol (e.g., “A,” “3,” or “+”). There are three general classes of files used on computer systems: executable files, text files, and data files. The use of the file determines the category.

4.1.2 Executable files

Executable files contain a sequence of instructions suitable for processing by a computer. Computer programs are stored as executable files (.EXE). COMTRADE does not define executable files.

4.1.3 Text files

Text files imply data in human-readable form. A text file may be used for control of a computer program if the format is rigidly specified. COMTRADE text files use the character representation specified in ANSI X3.4-1986 [B1][2].This is often called “ASCII format” or “text (.TXT) format” by word processor programs. Characters from the Unicode UTF-8 Standard are also allowed. Any occurrence of the terms ASCII or text in this document also inherently implies Unicode UTF-8.

COMTRADE defines one freeform ASCII text file intended for strictly human interpretation, the header file. COMTRADE also defines three files in which the format is rigidly controlled and which are both human- and computer-readable—the configuration file, the information file, and the ASCII form of the data file.

Most word processors can save text files in two or more formats. The text format contains only the characters actually typed, including punctuation and standard formatting characters such as carriage return/line feed. Other formats contain special characters, specific to the particular word processor being used. The text format shall be used for the text files in a COMTRADE record to eliminate word processor-specific characters or codes. Programs intended to read COMTRADE files only require use of the typed characters that most word processor programs can read or print.

If no command exists in the word processor to save the file in this format, an alternative method is to use the print functions to print the text to disk to create the file.

4.1.4 Data files

Data files may contain numeric data, text data, or both. The data may be stored in either binary or ASCII format. Fields within ASCII format data files use defined text separated by commas, or some other common delimiter. As such, they are both human- and machine-readable. Most word processors cannot format, read, or write data files in binary form. However, many spreadsheet and data processing programs can read binary data files, if the format is known. Binary numbers must be processed by application-specific software to be easily interpreted by humans. COMTRADE defines one binary file, the binary form of the data file. Binary data are generally used when large amounts of data are to be stored because this uses less storage space (e.g., three bytes of binary data can represent numbers from 0 to 16 777 215 whereas three bytes of ASCII data can only represent numbers from 0 to 999). ASCII numbers have the advantage of being interpreted by humans and by standard computer hardware and software.

4.2 Critical/non-critical data

Some of the data in the configuration file are not absolutely necessary for reproduction of the sample data, and some variables provided in the configuration file may not be relevant to a particular application. Such data is described as non-critical and may be omitted. However, the position normally occupied by such variables shall be maintained in order to maintain the integrity of the file. If data are described as non-critical in any clause of this standard, the position may be left empty and the corresponding data separator retained following the

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2 This is a reference to the Bibliography.

preceding data separator with no intervening characters or spaces. Any data that are necessary for reproduction of the sample data are termed critical. If such data are missing, the file may be unusable.

4.3 Data representation

4.3.1 General

Data are stored in files as series of binary digits or bits. Each bit can be either a 1 or a 0. The bits are organized in groups of eight bits called bytes. When a computer reads the data in a file, it reads the data as a series of bytes.

4.3.2 Binary data

The eight bits in a byte can be organized in 256 different combinations. They can be used, therefore, to represent the numbers from 0 to 255. If larger numbers are needed, several bytes can be used to represent a single number. For example, 2 bytes (16 bits) can represent the numbers from 0 to 65 535. When the bytes are interpreted in this fashion, they are known as binary data. Several different formats are in common use for storage of numeric data in binary form. This standard supports three of these formats. The supported formats are 16 and 32 bit integer numbers defined according to the two’s complement system (hereinafter, referred to as “binary” and “binary32” data respectively), and 32 bit real numbers defined according to the IEEE Std 754™-2008 (hereinafter, referred to as float32 data). The float32 data type format is intentionally listed in this binary data subclause for convenience even though the format is not a straight binary count.

4.3.3 ASCII data

As an alternative to a byte representing the numbers 0 to 255, a byte can be used to represent 256 different symbols. ASCII is a standard code of symbols that match 128 of the combinations of eight binary bits. For example, the byte 01000001 represents an uppercase “A” while 01100001 represents a lowercase “a.” With 128 different combinations, it is possible to represent all of the keys on the keyboard plus many other special symbols. The remainder of the 256 combinations available from an eight-bit format are used for drawing and other special characters. To represent a number in ASCII format requires one byte for each digit of the number. For example, 4 bytes are needed to represent the number 9 999 in ASCII format. When the bytes are interpreted in this fashion, they are known as ASCII data.

4.4 Data field delimiters and lengths

4.4.1 General

Data fields within a file or within a subset of data in a file shall be separated from the other data fields so that they may be extracted for reading or manipulation. For instance, written text uses a space as a word delimiter. Computer files use a variety of delimiters. In the binary form of COMTRADE data files, the only delimiter is a strict definition of the length and position of each data variable, and a byte count of the position within the file is necessary to determine the limit of any data entry. On the other hand, the ASCII files defined by COMTRADE use the comma and the carriage return/line feed as data separators. This permits the use of variable field lengths, but means that these characters cannot be used within any data entry. Leading spaces or zeroes are allowed in ASCII numeric fields provided the permitted maximum character count is not exceeded.

4.4.2 Carriage return/line feed delimiter <CR/LF>

COMTRADE uses the symbol <CR/LF> to represent a data separator terminating a set of data. The delimiter is the combination of two ASCII formatting characters:

CR = carriage return takes the cursor or insertion point back to the beginning of the current line and is identified by the hexadecimal value 0D.

LF = line feed moves the cursor or insertion point to a new line below the current line and is identified by the hexadecimal value 0A.

The symbols “<” and “>” surrounding the CR/LF are used to delineate the delimiter from the neighbouring text within this standard and are not part of the delimiter.

Historically, operating systems use LF to indicate a new line but not all of them do. Others may use a variety of other characters for indicating new lines. It is important to note that in COMTRADE <CR/LF> is defined as a separator and not as a new line indicator because the main intent is to exchange transient data between users and across operating systems.

4.4.3 Comma delimiter

The comma is used as a delimiter for data entries within the COMTRADE configuration (.CFG), information (.INF), ASCII format data (.DAT), and combined format data (.CFF) files.

4.4.4 Field lengths

Field lengths are specified for many alphabetic or numeric variables in the COMTRADE standard. These limitations were specified to simplify reading lines of data containing many variables. For integer numeric variables, the maximum field length is one character longer than required to hold the maximum value for that field. This extra character space is allowed for a leading minus for signed numbers and to allow the application of simple programming techniques that automatically print the leading space, even for unsigned numbers.

4.5 Floating point notation for ASCII data

Real numbers may be stored in several ways. Numbers of limited range can be entered as a numeric string of ASCII characters with a decimal point. For larger or smaller numbers, any reasonable limit on string length leads to a loss of resolution. In such cases, it is desirable to store the number in a format allowing use of a representation of the significant digits (mantissa) and a multiplier (exponent) format. Spreadsheets and other mathematical programs often use floating point notation to represent such numbers. COMTRADE allows the use of floating point notation (Kreyszig [B6]) to represent real numbers in the .CFG and .DAT files. The terms exponential notation or scientific notation are sometimes used for this form and interpretations of the form vary. Since programs designed to read COMTRADE files must be able to recognize and interpret numbers represented in this format, one single format is defined here. The numbers shall be interpreted and displayed as follows.

A signed floating point value consists of an optional sign (+ or –) and a series of decimal digits containing an optional decimal point, followed by an optional exponent field that contains the character “e” or “E” followed by an optionally signed (+ or –) integer exponent. The exponent is a factor of base 10, so 3E2 means 3 multiplied by 100 (10^2) or 300. Correct interpretation of negative numbers and negative exponents requires the inclusion of the negative sign. For positive numbers or exponents the sign is optional and is assumed positive if absent.

The format shall be written as:

[±]d[d][.]d[d][d][d][E[±]d[d][d]]

where

– Square brackets surround any optional item.

– “d” represents any numeral between 0 and 9.
– At least one numeral must appear in the field.
– If the decimal point appears, at least one numeral shall appear to the left and right.
– The character “e” or “E” represents “exponential” with base 10.
  • If the exponential sign appears, it must be followed by at least one numeral
  • The intervening plus/ minus sign is optional if positive, but must be “+” or “–” not “±.”
– The numeric value following “E” must be an integer.

Examples:

Acceptable

1E2 (= 100)

1.23E4 (= 12 300)

0.12345E-5 (= 0.0000012345)

–1.2345E2 (= –123.45)

Unacceptable

.123 (one numeral must precede decimal)

123E (at least one numeral must follow “E”)

±0.123E±4 (plus/minus signs make the value indeterminate)

0.123 E4 (space before “E” not allowed)

4.6 Methods of accessing data in files

4.6.1 General

The two different methods used to access text and data files are sequential or random access. In general, text files are sequential access and data files are either sequential or random access.

4.6.2 Random access files

Data within random access files can be retrieved or stored in any random sequence. The access time for each record is independent of the location of the data. Each data field has a specific address that can be used for reading or writing. COMTRADE does not recommend the use of random access files.

4.6.3 Sequential files

Sequential files are accessed by reading or writing each data field in sequence. Individual data fields have no specific address and their position in the file is relative to the other variables. The exact byte-count position in the file is dependent on the length of the preceding variables. COMTRADE uses sequential files.