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

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Electrical relays
Part 24: Common format for transient data exchange (COMTRADE) for power systems
(IEC 60255-24:2001)

Relais électriques
Partie 24: Format commun pour l'échange de données transitoires (CONTRADE) dans les réseaux électriques
(CEI 60255-24:2001)

Elektrische Relais
Teil 24: Standardformat für den Austausch von transienten Daten elektrischer Energieversorgungsnetze (COMTRADE)
(IEC 60255-24:2001)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 95/120/FDIS, future edition 1 of IEC 60255-24, prepared by IEC TC 95, Measuring relays and protection equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60255-24 on 2001-05-01.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop) 2002-02-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow) 2002-02-01

Annexes designated "informative" are given for information only.
In this standard, annexes A to E are informative.

Endorsement notice

The text of the International Standard IEC 60255-24:2001 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60027-2	NOTE Harmonized with IEC 60027-2A and IEC 60027-2B as HD 245.2 S1:1983 (not modified).
IEC 60027-3	NOTE Harmonized as HD 245.3 S2:1991 (modified).
IEC 60027-4	NOTE Harmonized as HD 245.4 S1:1987 (modified).
IEC 60044-1	NOTE Harmonized as EN 60044-1:1999 (modified).

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INTRODUCTION

This part of IEC 60255 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 data. This data is 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 standard is necessary to facilitate the exchange of such data between applications. This facilitates the use of proprietary data in diverse applications and allows users of one proprietary system to use digital data from other systems.

ELECTRICAL RELAYS –

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

1 Scope and object

This part of IEC 60255 defines a format for files containing transient waveform and event data collected from power systems or power system models. This standard applies to files stored on physical media such as digital hard drives and diskettes. It is not a standard for transferring data files over communication networks. The format is intended to provide an easily interpretable format for use in exchanging data; as such, it does not make use of the economies available from data encoding and compression which proprietary formats depend on for competitive advantage.

2 Definitions

For the purpose of this part of IEC 60255, the following definitions apply.

2.1
data representations
data stored in files as a series of binary bits

NOTE Each bit can be either a 1 or a 0. The bits are organized in groups of 8 bits called bytes. When a computer reads the data in a file, it reads the data as a series of bytes.

2.1.1
binary data
data organized in the form of bytes

NOTE The 8 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, e.g., 2 bytes (16 bits) can represent the numbers from 0 to 65535. 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.

2.1.2
ASCII (American National Standard Code for Information Interchange) data
symbols that match 127 of the combinations of eight binary bits

NOTE As an alternative to a byte representing the numbers 0 to 255, it can be used to represent 255 different symbols. The American National Standard Code for Information Interchange (ASCII) is a standard that lists symbols that match 127 of the combinations of eight binary bits, e.g. the byte 01000001 represents an upper case "A" while 01100001 represents a lower case "a". With 127 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 8-bit format are used for drawing and other special application characters. To represent a number in ASCII format requires one byte for each digit of the number.

2.2
critical/non-critical
some of the data in the configuration file is not absolutely necessary for the reproduction of the sample data, and some variables provided for in the configuration file may not be relevant to a particular application. Such data may be described as non-critical and may be omitted. An example of such non-critical data is the recording device channel name. However, the position normally occupied by such variables must be maintained in order to maintain the integrity of the file. If data is described as non-critical in any section of the standard, the position may be left empty or filled, using the space character, and the corresponding data separator following the preceding data separator applied with no intervening characters or spaces.

Any data which is necessary for the reproduction of the sample data is termed critical. If such data is missing, the file may be unusable.

2.3
primary/secondary ratios
the devices used to measure and record events on a high voltage system are not capable of directly accepting the high voltage and high currents of the power system. These devices are built to accept inputs in more manageable and less dangerous levels, termed secondary quantities. Voltage transformers and current transformers are used to reduce the voltage and current signals on the power system to these lower values. The transformer ratios are chosen so that when the power system is running at the rated or nominal primary value, the secondary value is at the nominal secondary value. The ratio is specified in primary:secondary order, the convention being that the primary is closest to the source of power. Primary ratings are available for all common voltages and load values on the power system. Common values for the secondary values are in the region of 70 V line-to-ground, and 1 A or 5 A. An ANSI/IEEE standard [12] [1)] specifies the description and rating of these transformers.

Thus for a current transformer applied to a feeder and rated at 800:5, the secondary current will be at the nominal 5 A value only when the primary load current was 800 A. Lower load values result in correspondingly lower values of secondary current.

For three-phase applications, voltage transformers are normally rated in phase-to-phase voltage values rather than phase-to-ground. The output of a voltage transformer rated at 345 kV: 120 V will be 120 V phase-to-phase (70 V phase-to-ground) only when the primary system phase-to-phase voltage runs at 345 kV. The term "line-to-line" is used interchangeably with the term "phase-to-phase", and similarly the term "line-to-ground" is used instead of "phase-to-ground".

2.4
floating point notation
real numbers may be stored in several ways. Numbers of a limited range can be entered as a numeric string 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 a floating point notation to represent such numbers. COMTRADE allows the use of floating point [4] notation to represent real numbers for conversion factors in the .CFG file. 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 are interpreted and displayed as follows:

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1) Figures in square brackets refer to the bibliography.

A signed floating point value consisting of an optional sign (+ or –), a series of decimal digits containing an optional decimal point, followed by an optional exponent field containing 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 to the power 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 if absent.

The format is written as: [±]dd[.]dddd[E[±]ddd] where

- square brackets surround any optional item;
- d represents any numeral between 0 and 9;
- at least one numeral must appear in the field;
- the upper case "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;
- if the decimal point appears, at least one numeral must appear to the left and right.

EXAMPLES

Acceptable
1E2 (=100), 1.23E4 (=12300), 0.12345E–5 (=0.0000012345), –1.2345E2 (= –123.45)

Unacceptable
.123 (one numeral must precede the decimal point)
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)

2.5
categories of files
files stored on digital devices and media consist of bytes representing a combination of alphabetical, numerical, symbol, punctuation and other formatting characters. Depending on the format, a byte, part of a byte, or more than one byte, may represent a letter, number or symbol (e.g. A or 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

2.5.1
executable files
files containing a sequence of instructions suitable for processing by a computer. Computer programs are stored as executable files (.EXE). COMTRADE does not define executable files

2.5.2
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 the American Standard for Character Information Interchange [8] (ASCII). This is often called "ASCII format" or "Text (.TXT) format" by word processor programs.

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

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 format(s) contain special characters specific to the particular word processor being used. The text format is used for the text files in a COMTRADE record to eliminate word processor specific characters or codes. Programs intended to read COMTRADE files need only deal with the typed characters which 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.

2.5.3
data files
data files may contain numerical data, text data, or both. The data may be stored in either binary or ASCII form. Fields within ASCII format data files use defined text separated by commas, or some other common delimiter such that 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 have to be processed by application-specific software in order to be easily interpreted by humans. COMTRADE defines one binary file: the binary form of the data file. The binary form is generally used when large amounts of data are to be stored because it uses less storage space (e.g. 3 bytes of binary data can represent numbers from 0 to 16 777 215 whereas 3 bytes of ASCII data can only represent numbers from 0 to 999). ASCII numbers have the advantage that they can be interpreted by humans, and by standard computer hardware and software

2.6
methods of accessing data in files
there are two different methods used to access text and data files: random access and sequential order

2.6.1
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 use random access files

2.6.2
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

2.7
data separators, delimiters, field lengths, data minimum and maximum values
data fields within a file or within a subset of data in a file must 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. 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 and zeros are allowed in ASCII numeric fields providing the permitted maximum character count is not exceeded

2.7.1
carriage return / line feed delimiter
COMTRADE uses the symbol <CR/LF> to represent a data separator terminating the end of a line or 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.

LF = Line Feed moves the cursor or insertion point down to a new line below the current line.

The symbols "<" and ">" surrounding the CR/LF are used to delineate the delimiter from the nearby text within the standard and are not part of the delimiter.

In most present day computer programming or application environments, the two character combination is automatically generated when the RETURN or ENTER key is pressed

2.7.2
comma delimiter
the comma is used as a delimiter for data entries within a sample in COMTRADE configuration (.CFG), information (.INF), and ASCII format data (.DAT) files

2.7.3
field lengths, data maximum and minimum values
field lengths are specified for many alphabetical or numeric variables in the COMTRADE standard. These limitations were specified to simplify reading lines of data containing many variables. In integer numeric variables the field maximum 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 which automatically print that leading space even when used for unsigned numbers. The 6-character and 10-character field lengths for data, time stamps and sample numbers used in earlier revisions of COMTRADE are retained for backward compatibility

3 COMTRADE files

Each COMTRADE record has a set of up to four files associated with it (see 2.5.3 for background information on files and data storage). Each of the four files carries a different class of information. The four files are header, configuration, data and information. All files in the set shall have the same filename, differing only by the extensions that indicate the type of files.

File names are in the form xxxxxxxx.yyy. The xxxxxxxx portion is the name used to identify the record (e.g., FAULT1 or TEST_2). The .yyy portion of the file name is used to identify the type of file and is known as the extension: .HDR for the header file, .CFG for the configuration file, .DAT for data file(s), and .INF for the information file. The file names shall follow the IBM Compatible DOS [15] conventions for legal characters within the file names (e.g. periods and spaces are not allowed as part of the file name). The file names are limited to eight characters and extensions are limited to three characters.

3.1 Header file (xxxxxxxx.HDR)

The header file is an optional ASCII text file created by the originator of the COMTRADE data typically using a word processor program. The data is intended to be printed and read by the user. The creator of the header file can include any information in any order desired. Examples of such information to include are given in 4.1. The header file format is ASCII.

3.2 Configuration file (xxxxxxxx.CFG)

The configuration file is an ASCII text file intended to be read by a computer program and shall therefore be saved in a specific format. The configuration file contains information needed by a computer program in order to properly interpret the data (.DAT) file. This information includes items such as sample rates, number of channels, line frequency, channel information, etc.

One field in the first line of the configuration file identifies the year of the COMTRADE standard revision with which the file complies, e.g. 1996, 2000, etc. If this field is not present, or if it is empty, then the file is assumed to comply with the original issue of the standard (1991). The configuration file also contains a field which identifies whether the companion data file is stored in ASCII or binary format. Details of the exact content and format of the configuration file are given in clause 5.

The configuration file can be created with a word processing program or by a computer program that makes the configuration file from information available in the data that is the source of the transient record. If a word processor is used to create the configuration file, it must save the data in ASCII text file format.

3.3 Data file (xxxxxxxx.DAT)

The data file contains the value for each input channel for each sample in the record. The number stored for a sample is a scaled version of the value presented to the device that sampled the input waveform. The data file also contains a sequence number and time stamp for each set of samples.

The stored data may be either zero based or it may have a zero offset. Zero-based data spans from a negative number to a positive number (e.g., –2000 to +2000). Zero-offset numbers are all positive with a positive number chosen to represent zero (e.g., 0 to 4000, with 2000 representing zero). Conversion factors specified in the configuration file define how to convert the data values to engineering units.

In addition to data representing analog inputs, inputs that represent on/off signals are also frequently recorded. These are often referred to as digital inputs, digital channels, digital sub-channels, event inputs, logic inputs, binary inputs, contact inputs, or status inputs. In this standard, this type of input is referred to as a status input. The state of a status input is represented by a number '1' or '0' in the data file.

The data files may be in either ASCII or binary format; a field in the configuration files indicates which format is used. A detailed description of the data file format is given in clause 6.

3.4 Information file (xxxxxxxx.INF)

The information file is an optional file which contains extra information that file originators and users may wish to exchange over and above that required for minimum application of the data set. The format provides for public information which any user can read and use, and private information which may be accessible only to users of a particular class or manufacturer. A detailed description of the information file is given in clause 7.

4 Header files

The header file is an ASCII text file for the storage of supplementary narrative information provided for the user to better understand the conditions of the transient record. The header file is not intended to be manipulated by an applications program.

4.1 Content

Examples of information which may be included:

- description of the power system prior to disturbance;
- name of the station;
- identification of the line, transformer, reactor, capacitor, or circuit-breaker that experienced the transient;
- length of the faulted line;
- positive and zero-sequence resistance and reactance, capacitance;
- mutual coupling between parallel lines;
- locations and ratings of shunt reactors and series capacitors;
- nominal voltage ratings of transformer windings, especially the potential and current transformers;
- transformer power ratings and winding connections;
- parameters of the system behind the nodes where the data was recorded (equivalent positive and zero sequence impedance of the sources);