

IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems

Sponsor
**Power System Relaying Committee
of the
IEEE Power Engineering Society**

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Abstract: A common format for the data files and exchange medium needed for the interchange of various types of fault, test, or simulation data is defined. Sources of transient data are described, and the case of diskettes as an exchange medium is recommended. Issues of sampling rates, filters, and sample rate conversions for transient data being exchanged are discussed. Files for data exchange are specified, as is the organization of the data. A sample file is given.

Keywords: Configuration file, data file, header file, transient data

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Foreword

[This Foreword is not a part of IEEE C37.111-1991, IEEE Standard Format for Transient Data Exchange (COMTRADE) for Power Systems.]

The increasing use of digital computer-based protection, oscillography, measurement, and control functions in electric power substations has created a potential for accumulating large quantities of digital records of power system transient events. In addition to these sources of digital data, analog and digital power-system simulators also may be used to generate transient digital records. The users of these records are faced with the problem of having to cope with different formats used by each of these systems to generate, store, and transmit these records.

COMTRADE defines a common format for storing digital records of transient events. This standard is to be used for facilitating physical exchange of data files on storage media. It is hoped that this standard will be of considerable value to the users and producers of digital data files describing transient events on electric power systems.

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1. Introduction

The rapid evolution and implementation of digital devices for fault and transient data recording and testing in the electric utility industry has generated the need for a standard format for the exchange of such data for use with various devices to enhance and automate the analysis, testing, evaluation, and simulation of the power system and related protection schemes during fault and disturbance conditions.

1.1 Purpose

This standard defines a common format for the data files and exchange medium needed for the interchange of various types of fault, test, or simulation data.

1.2 Need for a Common Format

The proliferation and implementation of digital devices for the acquisition, analysis, simulation, and testing of power-system equipment has made available a profusion and variety of data that has not been readily available in the past. Since this data may come from a variety of sources, from different manufacturers using proprietary or other standard formats, a common format standard is necessary to facilitate the exchange of such data between devices with diverse applications but that have the capability of utilizing digital data from other devices.

2. Sources of Transient Data

There are several possible sources of transient data for exchange.

2.1 Digital Fault Recorders

Digital fault recorders for monitoring power-system voltages, currents, and events are supplied by several manufacturers. These devices record analog signals by periodically sampling them and converting the measured

signals to digital values. Typical recorders monitor 16–64 analog channels and a comparable number of event (contact status) inputs. Sampling rates, analog-to-digital converter resolution, record format, and other parameters have not been standardized.

2.2 Analog Tape Recorders

Analog tape recorders record analog signals on magnetic tape, usually using frequency-modulation techniques. Recorded tapes can be played back to drive oscilloscopes or plotters for visual examination of the recorded waveforms. Typical recorders monitor up to 32 analog signals.

By employing suitable hardware and software, the signals recorded on the analog tapes can be converted to digital records in any desired format. The fidelity of the resultant output is dependent upon the limitations of both the analog recorder and the digital-conversion system. The loss in fidelity can be minimized by a proper choice of the sampling system.

2.3 Digital Protective Relays

New relay designs using microprocessors are currently being developed and marketed. Some of these relays have the ability to capture and store relay input signals in digital form and transmit this data to another device. In performing this function, they are similar to digital fault recorders, except that the nature of the recorded data may be influenced by the needs of the relaying algorithm. As with the digital fault recorders, record format and other parameters have not been standardized.

2.4 Transient Simulation Programs

Unlike the above devices that record actual power system events, transient simulation programs produce transient data by analyzing mathematical models of the power system. Because this analysis is carried out by a digital computer, the results are inherently in digital form suitable for digital data dissemination.

While originally developed for the evaluation of transient overvoltages in power systems, these programs are finding increasing usage in other types of studies, including test cases for digital relaying algorithms. Because of the ease with which the input conditions of the study can be changed, transient simulation programs can provide many different test cases for a relay.

2.5 Analog Simulators

Analog simulators model power system operations and transient phenomena, with scaled values of resistance, inductance, and capacitance, operating at greatly reduced values of voltage and current. The components usually are organized with similar line segments that can be connected together to form longer lines. The frequency response of the analog simulator primarily is limited by the equivalent length of the model segment and typically ranges from 1–5 kHz. As with the output of analog tape recorders, the analog output of the simulator could be converted to digital records with appropriate filtering and sampling.

3. Data Exchange Medium

3.1 Introduction

Electric power utilities record fault data for post-fault analysis, for determining the nature and location of the fault, and for keeping a record for future use. The data are generally stored as oscillograms on magnetic tapes and in computer

files. An oscillogram contains voltage and current waveforms that can be examined and analyzed. Digital computers cannot record voltage and current waveforms directly. The waveforms are quantized for storage in computer files. More recently, personal computers have been used to record fault data on diskettes and cassettes.

It is not convenient to transport magnetic tapes that are used with main-frame computers, in the form of reel-to-reel or cassettes, between utilities and individual users. This is especially true if the users are separated by long distances or are located in different countries. Also, the recipient of a magnetic tape must have a computer system compatible with the system on which the tape was prepared. It is more convenient to transport cassettes than to transport magnetic tapes. However, recording data to and from cassettes is a slow process.

3.2 Recommended Medium

The most commonly-used computer systems today are personal computers equipped with drives for diskettes. Double-sided, double-density, 5 1/4 in diskettes store approximately 360 Kb of text and data. Double-sided, double-density, microfloppy 3 1/2 in diskettes store approximately 720 Kb. The double-sided, high-density 1.2 Mb 5 1/4 in floppy diskettes and 1.44 Mb 3 1/2 in microfloppy diskettes are increasing in popularity. Both the 5 1/4 in diskettes and 3 1/2 in microfloppy diskettes are very well suited for the task of data exchange. They can be placed easily in padded envelopes and sent by mail from one location to another. Because of their widespread use and the convenience with which they can be sent to another location by mail, it is recommended that diskettes be used for exchanging fault data. However, individuals exchanging data may use other mutually acceptable media.

4. Data Exchange Sampling Rates

4.1 Introduction

This section is concerned with issues of sampling rates, filters, and sample rate conversions for transient data being exchanged. Of special concern is the case in which data is captured at a high sample rate but a lower sample rate is required by the device or software using the data. The simple expedient of dropping every n^{th} sample is NOT the correct way of making the conversion. This section discusses the correct way to perform this common function as well as other related topics.

Since it is difficult to anticipate all future uses of such standard test cases (e.g., future algorithms, architectures, microprocessors), it seems clear that high accuracy and high sampling rates are desirable in the test cases. That is, although many existing digital relays use 12 bit accuracy, 16 bit or higher resolution A/D converters may be used in the near future. The sampling rate issue is similar. Samples obtained at a sampling frequency of 240 Hz, for example, must be obtained using a filter with a cut-off frequency of 120 Hz to avoid aliasing. It is straightforward to convert these samples to samples at higher sampling frequencies, but the effect of the anti-aliasing filter cannot be removed. That is, it is possible to obtain samples at 960 Hz equivalent to the output of the 120 Hz anti-aliasing filter, but it is not possible to obtain samples at 960 Hz of the original (unfiltered) signal.

4.2 Sampling Process Structure

It is therefore recommended that the original samples be obtained (after a proper anti-aliasing filter, if necessary) at as high an accuracy and as high a sampling rate as possible in a given installation. However, specific choices of sampling rates (see sampling rate tables in 4.3) could make further use of the data much easier. Consider data obtained at a sampling rate of f_s Hz. It would be most convenient if there were some standard technique to convert from the data at f_s Hz to data that would have been obtained by the user's proposed system shown in Fig 1.

Developments in digital signal processing present an efficient solution to the problem if there are integers L and M such that

$$Lf_s = Mf_o = f_{LCM} \quad (1)$$

where

f_{LCM} represents the least common multiple. The solution is shown in Fig 2.

The box labeled FIR in Fig 2 is a finite impulse response equivalent of the analog filter shown in Fig 1 at a sampling rate of Lf_s Hz. Eq 1 is the key to the solution, and it limits sampling rates to some extent.

The process of converting from samples at frequency f_s to samples at frequency f_o is to determine the frequency f_{LCM} such that Eq 1 is satisfied, provide an FIR description of the desired analog filter, and implement Fig 2. The FIR description of the analog filter is a table of numbers corresponding to a digital filter description at the sampling frequency f_{LCM} . A standard technique for the FIR design might be to use an impulse equivalent filter where the n^{th} entry in the table was the impulse response of the analog filter at the n^{th} sample time. Other FIR filter design programs are available (see [B3])¹ along with a program that implements Fig 2. The transient response of the FIR filter at the beginning of the data must also be considered. If the FIR duration is one period of the nominal power system frequency, then a total of two periods of prefault data should be included in the standard cases. Artificial prefault data can be supplied if it is not present. The FORTRAN program CONVERT (see Appendix B) is an implementation of Fig 2 that is an alternative to the program in Section 8.2 of [B3]. The program is an illustration of the impulse invariant FIR filter for a second-order low-pass filter. Fig 3 shows the output samples at 720 Hz with an input sampled at 4320 Hz.

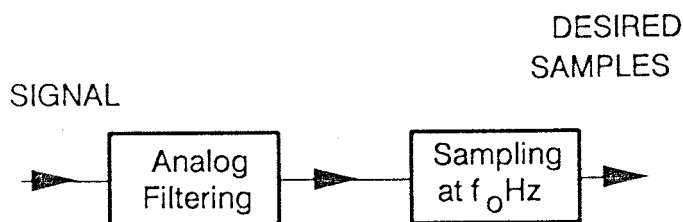


Figure 1— Typical Signal Processing

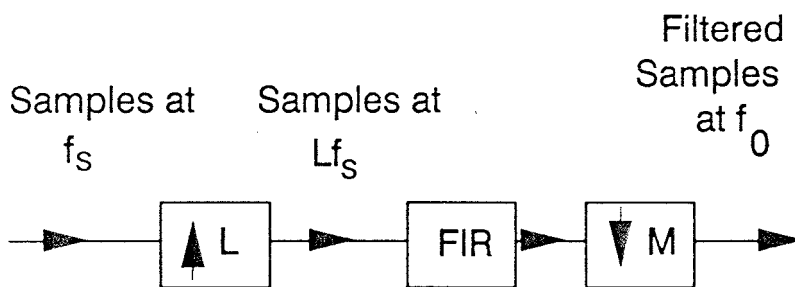


Figure 2— DSP Solution

¹The numbers in brackets, when preceded by the letter “B,” correspond to the Bibliography in Appendix A.