

IEEE Standard for Synchrophasor Data Transfer for Power Systems

IEEE Power and Energy Society

Developed by the
Power System Communications and Cybersecurity
Committee

IEEE Std C37.118.2™-2024
(Revision of IEEE Std C37.118.2-2011)

IEEE Standard for Synchrophasor Data Transfer for Power Systems

Developed by the

Power System Communications and Cybersecurity Committee
of the
IEEE Power and Energy Society

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Abstract: A method for the real-time exchange of synchronized phasor measurement data between power system equipment is defined within this standard. This includes the following: messaging that can be used with any suitable communication protocol for real-time communication between phasor measurement units (PMU), phasor data concentrators (PDC), and other applications; message types, contents, and their use as well as data types and format specifications; descriptions of typical measurement systems; communication options and requirements. Note that while cybersecurity is discussed, and while its importance is acknowledged in the overall system, it is considered beyond the scope of this standard.

Keywords: IEEE C37.118.2™, PDC, phasor, phasor data concentrator, phasor measurement unit, PMU, synchronized phasor, synchrophasor

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Introduction

This introduction is not part of IEEE Std C37.118.2-2024, IEEE Standard for Synchrophasor Data Transfer for Power Systems.

Digital computer-based measurement, protection, and control systems have become common features of electric power systems. These measurement, protection, and control systems use sampled data to compute various quantities such as voltage and current phasors. Phasors are used in many protection and data acquisition functions, and their utility is increased further by referencing them to a common time base. This can be accomplished by synchronizing the phasor estimate to a precise time source that is common to the various measuring sites. Phasor estimates synchronized to a common time source and referenced to a common frequency are defined as synchrophasors. Simultaneous measurement sets derived from synchronized phasors provide a vastly improved method for tracking power system dynamic phenomena for improved power system monitoring, protection, operation, and control.

The present version of the standard is the fourth revision of this standard. The original standard for synchrophasors was IEEE Std 1344™-1995 [B4], which was reaffirmed in 2001.⁶ This standard was replaced in 2005 by IEEE Std C37.118™-2005 [B5], and in 2011 by IEEE Std C37.118.1™-2011 [B6] and IEEE Std C37.118.2™-2011 [B7]. IEEE Std C37.118-2005 provided additional clarification for the phasor and synchronized phasor definitions. The concepts of total vector error and compliance tests were introduced. The message formats were updated from the original standard to improve information exchange with other systems such as a master station. Specifically, the sync, frame size, and station identification fields were added to the data frame, configuration frame, header frame, and command frame. Analog data was added to the data frame, the fraction-of-second (FRACSEC) field replaced the sample count field, and the status field was significantly modified to include time quality.

The 2005 version of IEEE Std C37.118 included both measurement requirements and real-time data transfer requirements. To simplify widespread adoption and facilitate the use of other communication protocols for phasor data transfer, IEEE Std C37.118-2005 [B5] was split into two standards: IEEE Std C37.118.1™-2011 [B6] for synchrophasor measurement requirements, and IEEE Std C37.118.2-2011 [B7] for synchrophasor data transfer requirements. The 2011 edition of C37.118.1 added definitions, tests, and error limits for measurement of dynamically changing signals. It also added evaluation of frequency and ROCOF measurement under all the test conditions. C37.118.2 retained the previous requirements for data transfer, and one new configuration frame was added.

Wide usage over several years revealed several shortcomings and ambiguities in IEEE Std C37.118.2-2011 [B7]. This revision corrects these. This will improve interoperability between devices and applications from different vendors. Significant changes in this revision include discrete event data frames, measurement-based data attributes flags, separate time quality flags, and remote configuration. Frequency and rate-of-change-of-frequency are not mandatory anymore.

Numerous devices and systems compliant with the 2011 version of the standard have been in use for several years, and will continue to be for many more. This version of the standard includes support for the 2011 version, so existing systems can remain compliant. There will be a need for the two versions to co-exist, and for systems to be able to convert and combine between the two. This release includes some guidance to help accomplish this.

⁶The numbers in brackets correspond to those of the bibliography in Annex K.

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IEEE Standard for Synchrophasor Data Transfer for Power Systems

1. Overview

1.1 Scope

This standard defines a method for the exchange of synchronized phasor measurement data between power system equipment. It specifies messaging including types, use, contents, and data formats for real-time communication between phasor measurement units (PMU), phasor data concentrators (PDC), and other applications. This revision includes the following:

- a) Communications between a single PMU and a PDC,
- b) PDC functions dealing with multiple PMUs, and
- c) Onwards communications from the PDC.

1.2 Purpose

The purpose for this standard is to facilitate data exchange among measurement, data collection, and application equipment. It provides a defined, open access method for all vendors to use to facilitate development and use of synchrophasors. It is a simple and direct method for data transmission within a phasor measurement system which may be used directly or with other communication protocols. This method was initially established by IEEE Std C37.118-2005 [B5], Standard for Synchrophasors for Power Systems, and subsequently by IEEE Std C37.118.2-2011 [B7].

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall equals is required to*).^{7,8}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should equals is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may equals is permitted to*).

⁷The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁸The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

The word “reserved” indicates:

- If used in an assignment of values to an enumeration or an attribute that the values indicated are reserved for use in future editions of this standard and shall not be used for any other purpose.
- If used in a field of a message or frame that the field is reserved for use in future editions of this standard. The field shall be present in the message or frame, with the size specified. No interpretation of reserved fields is to be made for this edition of this standard, and the fields shall not be used for any other purpose.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEC/IEEE Std 60255-118-1™, IEC/IEEE Standard, Measuring relays and protection equipment—part 118-1: Synchrophasor for power system – Measurements.^{9,10}

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this Clause.¹¹

command frame: A machine-readable message sent to a phasor measurement unit (PMU) or a phasor data concentrator (PDC) for control or configuration.

configuration frame: A machine-readable message describing the data types, calibration factors, and other meta-data for the data that a PMU or a PDC sends.

coordinated universal time (UTC): An internationally agreed upon time scale maintained by the Bureau International des Poids et Mesures (BIPM) used as the time reference by nearly all commonly available time and frequency distribution systems (e.g., WWV, WWVH, LORAN-C, Transit, Omega, and GPS).

CRC-CCITT: 16-bit cyclic redundancy check (CRC) calculated using the generating polynomial $X^{16} + X^{12} + X^5 + 1$, seed value 0xFFFF (−1), no final mask.

data frame: A set of synchrophasor, frequency, rate-of-change-of-frequency, analog, and digital measurements that corresponds to the same time stamp.

NOTE—The term “frame” is used to differentiate it from individual measured values.¹²

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¹¹The *IEEE Standards Dictionary: Glossary of Terms & Definitions* is available at: <http://dictionary.ieee.org>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

¹²Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

leap second: A positive or negative one-second adjustment to the coordinated universal time that keeps it close to mean solar time.

phasor: Complex equivalent of a sinusoidal wave quantity such that the complex modulus is the cosine wave amplitude, and the complex angle (in polar form) is the cosine wave phase angle.¹³

phasor data concentrator (PDC): A function that collects phasor data, and discrete event data from phasor measurement units and possibly from other PDCs and transmits data to other applications.

phasor measurement unit (PMU): Device or function in a multifunction device that produces synchronized phasor, frequency, and rate-of-change-of-frequency (ROCOF) estimates from voltage and/or current signals and a time synchronizing signal.¹⁴

synchronized phasor: *See: synchrophasor.*

synchrophasor (synchronized phasor): Phasor representing the fundamental of an AC signal whose magnitude is the rms value of the fundamental amplitude and angle is the difference between the signal fundamental angle and the phase angle of a cosine at the nominal signal frequency that is synchronized to coordinated universal (UTC) time.¹⁵

NOTE—In this standard, the phasors from remote sites have a defined common phase relationship.

wait time: The maximum time interval during which the phasor data concentrator collects data for a particular output from one or more inputs. It is the time interval added to a message time stamp time or message-arrival time after which no more data with that time stamp is accepted.¹⁶

3.2 Acronyms and abbreviations

CRC	cyclic redundancy check
DADFREQ	data attributes associated with rate-of-change-of-frequency measurement
DAFREQ	data attributes associated with frequency measurement
DAPHASOR	data attributes associated with phasor measurement
DFR	digital fault recorder
FRACSEC	fraction-of-second
IP	internet protocol (see IETF RFC 791 [B13])
ROCOF	rate-of-change-of-frequency
SOC	second of century
TCP	transmission control protocol (see IETF RFC 793 [B14])
UDP	user datagram protocol (see IETF RFC 768 [B12])
UTF-8	unicode character encoding scheme used to represent text in writing systems

¹³Repeated from IEC/IEEE Std 60255-118-1™.

¹⁴Repeated from IEC/IEEE Std 60255-118-1™.

¹⁵Repeated from IEC/IEEE Std 60255-118-1™.

¹⁶Repeated from IEEE Std C37.247™-2019 [B11].

4. Synchrophasor messaging

This Clause describes the format of messages to and from a PMU or PDC for use in real-time communication of phasor data. *Real-time data transmission* here is defined as taking place concurrently with the measurement process and will include measurement delays and transmission delays. This standard does not address requirements for stored phasor data. Implementation of additional protocols for phasor data communication is not restricted.

4.1 Messaging overview

Messages and formats specified in this Clause are referred to as version 3 of the standard (See [Table 1](#)). Messages and formats compliant with the 2011 version (version 2) of this standard are included in [Annex A](#). All requirements for devices and applications shall be specified by the version number. A device/application shall meet all the requirements as specified for version 2 or version 3 to be considered as compliant with this standard. Compliance specification shall include the version number. [Annex H](#) includes guidance for use of both versions in the same synchrophasor measurement system.

Any communication system or media capable of carrying the messages defined in this standard may be used for transmission of these messages. For compliance, these messages shall be transmitted in their entirety as they are specified.

A general description of synchronized measurements, measurement systems, and communications considerations is included in [Annex B](#), [Annex C](#), and [Annex D](#). An example of a simple synchrophasor measurement system is shown in [Figure 1](#).

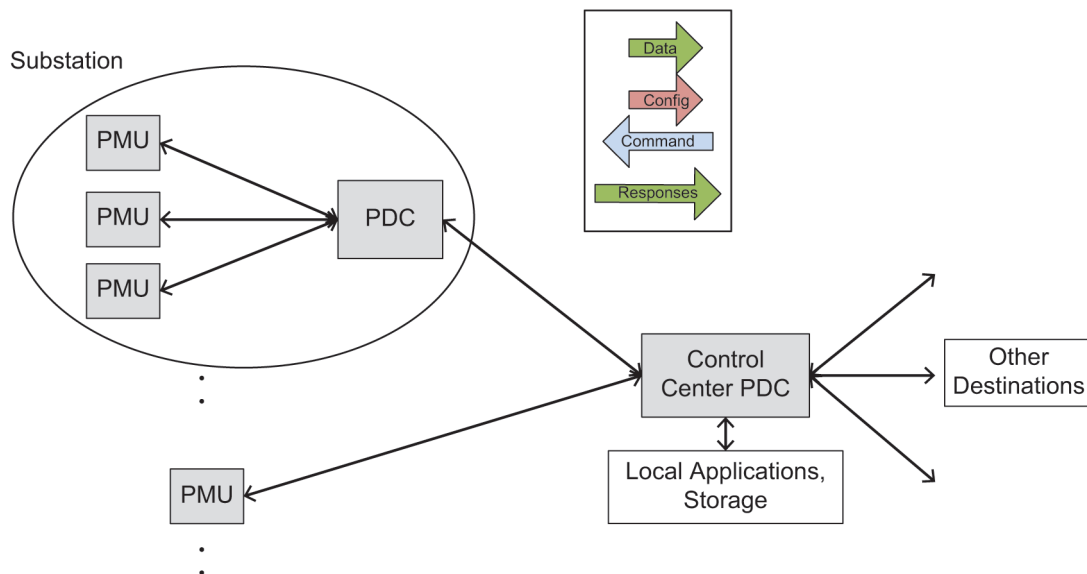


Figure 1—An example of a synchrophasor system

4.2 Types of messages

Five message types are defined: *configuration*, *periodic data*, *discrete event data*, *command*, and *error-response*.¹⁷ Each message type uses a specific machine-readable frame format. Since all messages are sent as frames, the words “message” and “frame” are used interchangeably in this standard as follows:

¹⁷The *header* message defined in previous versions of this standard is deprecated.

- Configuration messages include the data types, calibration factors, and other meta-data for the data that the PMU/PDC sends. Two configuration messages are defined in this standard: capability and stream configuration.
- Data messages include the measurements made by a PMU. Two types of data messages are defined: periodic data messages and discrete event data messages.
- Commands are messages sent to the PMU/PDC (that is the data source) for control or configuration. Two new optional configuration command messages are defined in this standard: configure stream and rename signals. A device or an application does not have to implement these commands to be considered compliant with this standard.
- Error-response messages are sent by the data source PMU/PDC in reply to commands when a command is not understood or rejected (such as for an unimplemented feature).

Periodic data messages are sent at regular time intervals determined by the data reporting rate (see 5.1.1). Discrete event data messages may be sent at any time, usually to report a discrete event such as a change in a digital signal. Signals included in discrete event data messages may also be included in periodic data messages. Data messages do not include any metadata that describe the data content. Such metadata are included in configuration messages. The match between configuration and data is achieved by a `STREAM_ID` (see 4.3.1.3). The same `STREAM_ID` is also used by command and *error*-response messages. All such messages between a data source (a PMU or a PDC) and a data receiver (usually another PDC), using the `STREAM_ID`, are identified as a data stream.

A PMU or PDC may transmit multiple data streams, each with different content, rate, format, etc. Each data stream shall have its own `STREAM_ID` so that the data, configuration, command, and *error*-response messages can be identified.

Information may be stored in any convenient form in the PMU/PDC itself, but when transmitted as messages, it shall be formatted as frames described from 4.3 to 4.7. Commands and other messages received by a connected device that are not understood may generate an *error*-response (see 4.7). This revision includes capability for retrieval of historical data.

In normal operation, the PMU sends data frames continuously. Configuration and *error*-response frames are sent on receiving the corresponding command. Configuration frames may also be sent spontaneously. This is useful in systems that do not permit commands.

4.3 Message framework

4.3.1 Overall message

All message frames consist of the following fields in sequence:

- 2-B SYNC word.
- 2-B FRAMESIZE word.
- 2-B `STREAM_ID`.
- 8-B time stamp consisting of a 4-B second-of-century (SOC), 1-B leap second information (LEAP_BYTE), and 3-B fraction of a second (FRACSEC).
- Multiple data fields. The number and format of such fields depends on the type of message sent.
- 2-B check word (CHK). This is a CRC-CCITT, 16-bit unsigned integer. It is calculated over all bytes in the frame, from SYNC, until the last data bytes inclusive.

All frames are transmitted exactly as described with no delimiters. Figure 2 illustrates the frame transmission order. The SYNC word is transmitted first and CHK word last. Two- and four-byte words including integer and floating-point numbers are transmitted most significant byte first (network or “big endian” order). All frame types use this same order and format.

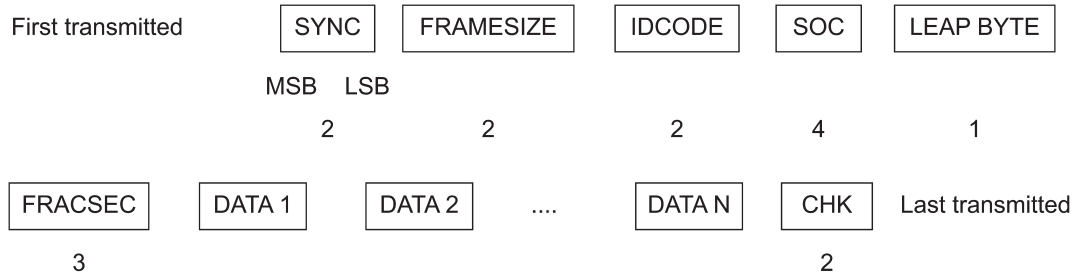


Figure 2—Example of frame transmission order

Word definitions common to all data frames are described in Table 1. Changes in this version include support for this version of the standard in the SYNC field, and separation of LEAP_BYTE field from the FRACSEC field.

Table 1—Word definitions common to all frame types

No.	Field	Size (bytes)	Comments
1	SYNC	2	Frame synchronization word. Leading byte: AA hex Second byte: Frame type and version, divided as follows:^a Bits 7 to 4: For version 3 (this version of the standard) 1000: Periodic data frame (defined in 4.5.1) 1001: Discrete event data frame (defined in 4.5.2) 1010: Capability frame (defined in 4.4.1.1) 1011: Stream configuration frame (defined in 4.4.1.2) 1100: Command frame (defined in 4.6.1) 1101: Rename signals frame (command) (defined in 4.6.2.1, optional) 1110: Configure stream frame (command) (defined in 4.6.2.2, optional) 1111: Error-response frame (defined in 4.7) Bits 3 to 0: Version number, in binary (1 to 15) Version 3 (0011) for messages defined in this revision.
2	FRAMESIZE	2	Total number of bytes in the transmitted frame, including CHK. 16-bit unsigned integer. Range = maximum 65 535.
3	STREAM_ID	2	Data stream ID number, 16-bit unsigned integer, assigned by user, 1 to 65534 (0 and 65535 are reserved). Identifies destination data stream for commands and source data stream for other messages. A stream will be hosted by a device that can be physical or virtual. If a device only hosts one data stream, the STREAM_ID identifies the device as well as the stream. If the device hosts more than one data stream, there shall be a different STREAM_ID for each stream. This may be a PMU data stream or a PDC data stream.
4	SOC	4	Time stamp, 32-bit unsigned number, SOC count starting at midnight 01-Jan-1970 (UNIX time base). Range is 136 years, rolls over 2106 AD. Leap seconds are not included in count, so each year has the same number of seconds except leap years, which have an extra day (86 400 s).

Table continues

Table 1—Word definitions common to all frame types (continued)

No.	Field	Size (bytes)	Comments
5	LEAP_BYTE	1	Leap second information. If leap seconds are eliminated from UTC, bits 4 to 6 shall be set to 0. Bit 7: Reserved. Set to 0. Bit 6: Leap second direction. 0 = add, 1 = delete. Shall be set at the same time or before the leap second pending bit is set and remains unchanged for 24 h after the leap second occurs. Bit 5: Leap second occurred. Shall be set in the first second after the leap second occurs and remains set for 24 h. Bit 4: Leap second pending. Shall be set not more than 12 h nor less than 1 s before a leap second occurs and be cleared in the second after the leap second occurs. Bits 3 to 0: Reserved. Set to 0. ^b Examples of leap second bit timing are shown in Annex F .
6	FRACSEC	3	Fraction of second time of measurement for all data frames or time of frame transmission for non-data frames. It is an unsigned 24-bit integer number. Fractional part of a second, multiplied by TIME_BASE, and rounded to the nearest integer, is equal to FRACSEC. This calculation is shown in 4.3.1.4 . Also see Annex G .
7	CHK	2	CRC-CCITT, 16-bit unsigned integer.

^aPrevious versions of this standard required bit 7 to be reserved and set to 0. This standard has set this bit to 1 to allow for backward compatibility.

^bThese bits were used as time quality indication codes in previous versions for the entire data stream. Time quality field has been added for individual PMUs in this version (see [4.5.1.2](#)).

4.3.1.1 SYNC word

The SYNC word provides synchronization and frame identification. This word is detailed in [Table 1](#). Bits 7 to 4 in the SYNC word designate the frame type. Bits 3 to 0 describe version number. Since this is the third edition of the synchrophasor standard, new messages shall be designated version 3 (binary 0011). All previously defined messages are unchanged in this standard and shall remain version 1 or 2 as applicable.

4.3.1.2 FRAMESIZE

The FRAMESIZE field shows the number of bytes in the entire frame, from the SYNC word to the CHK word, both inclusive.

4.3.1.3 STREAM_ID

The STREAM_ID identifies the source of a data, configuration, or *error*-response message, and the destination of a command message. The message STREAM_ID is associated with a data stream and ties data frames with the associated configuration information. The STREAM_ID for each output stream shall be user settable.

4.3.1.4 TIME STAMP

The time stamp consists of a 4-B second of century (SOC) field, a 1-B leap second information (LEAP_BYTE) field, and a 3-B fraction of second count (FRACSEC) field.

The FRACSEC indicates the nearest time to the actual time stamp that can be represented by an integer. For periodic data frames, it shall be interpreted as the nearest fractional second to the calculated time as determined by the reporting rate.

For calculating FRACSEC from the actual time at the PMU, and for calculating the time from the FRACSEC value received at the data destination, use the formulas shown below (also see [Annex G](#)).

$$\text{FRACSEC} = \text{ROUND}((\text{fractional second of time stamp}) \times \text{TIME_BASE})$$

$$\text{Time} = \text{SOC} + \text{FRACSEC} / \text{TIME_BASE}$$

4.3.1.5 CHK word

All frames terminate in check word (CHK). This is a CRC-CCITT. It uses the generating polynomial $X^{16} + X^{12} + X^5 + 1$ with an initial value of -1 (hex FFFF) and no final mask.

4.4 Configuration frames

A configuration frame is a data set containing information and processing parameters for a synchrophasor data stream. Configuration frame types are specified and identified by bits 7 to 4 of the SYNC word as shown in [Table 1](#). Optionally, XML formatted configuration frames may also be used. A possible format is shown in [Annex J](#).

4.4.1 Configuration frame changes in this version

Two configuration frames (capability, and stream configuration) are specified in this version of the standard (see [Table 1](#)).

4.4.1.1 Capability

This frame serves the same function as the previous CFG-1 frame. It shall include the information for all the signals available for transmission from a data source. This frame shall be transmitted from a data source (PMU or PDC) to the data destination (another PDC or an application). It is intended to provide the data destination a list of signals available to be selected for inclusion in a data stream.

4.4.1.2 Stream configuration

This frame serves the same function as the CFG-3 frame from the previous standard. It shall include the information corresponding to the signals being transmitted in a specific data stream identified by its STREAM_ID. This frame shall be transmitted from a data source (PMU or PDC) to the data destination (another PDC).

4.4.2 Device and signal names

The naming convention used for device and signal names included in configuration frames is shown in [Table 2](#). PDC_NAME, PMU_NAME and signal names¹⁸ shall be listed in name fields whose length shall be a number from 1 to 256 B. The first byte in each name field shall be the length, which is an unsigned 8-bit integer that indicates the length of the name in bytes. Subsequent number of bytes shall consist of the name.

A length of 0 indicates no further bytes (no name). In this case, the name field shall consist of a single binary 0. All name fields shall have at least one byte that is the name length. All names shall use UTF-8 coding.

¹⁸Users may wish to consult [\[B16\]](#) for selecting signal names. This standard does not place any requirements on name assignments or their interpretations. It is up to the users (senders and receivers) to assign and interpret names.

Table 2—Name field description

Byte #	Description
First byte (#0)	Name length. Unsigned 8-bit integer.
Remaining bytes (#1 to maximum 255)	Signal or device name. UTF-8 encoding. ^a

^aSome UTF-8 characters require multiple byte combinations.

4.4.3 Configuration frame description

Table 3 shows the details of all configuration frame fields. The stream configuration and capability frames shall include all the fields shown in this table.

Table 3—Configuration frame format

No.	Field	Size (bytes)	Short description
1	SYNC	2	See Table 1 .
2	FRAMESIZE	2	See Table 1 .
3	STREAM_ID	2	See Table 1 .
4	SOC	4	See Table 1 .
5	LEAP_BYTE	1	See Table 1 .
6	FRACSEC	3	See Table 1 .
7	CONT_IDX	2	Continuation index for fragmented frames. 0: Only fragment in configuration, no further fragments. 1: First fragment in series, more to follow. 2 to 65534: Number of each succeeding fragment, in order. 65535 (hex FFFF): Last fragment in series (see Annex I).
8	TIME_BASE	4	Resolution of FRACSEC time stamp. It shall be an integer multiple of the PMU data transmission rate (see Table 18). It shall also be large enough to support the time resolution required for the discrete event data frames. Bits 31 to 24: Reserved. Set to 0. Bits 23 to 0: 24-bit unsigned integer, which is the subdivision of the second that the FRACSEC is based on.
9	PDC_NAME	1 to 256	PDC name. Could be a name for the composite data stream (see Table 2).
10	NUM_PMU	2	The number of PMUs included in the data frame.
The following fields (11 to 34) are specific to each PMU. They are repeated NUM_PMU times.			
11	PMU_NAME	1 to 256	PMU name—in UTF-8 format with field index (see Table 2).
12	PMU_ID	2	PMU ID number, 16-bit unsigned integer, assigned by user, 1 to 65534 (0 and 65535 are reserved). Identifies the PMU device, which can be physical or virtual. Also see Table 1 for a description of STREAM_ID.
13	PMU_VERSION	2	Bits 15 to 4: Reserved. Set to 0. Bits 3 to 0: Version number, from the SYNC WORD (see Table 1).
14	G_PMU_ID	16	Global PMU ID. Uses RFC 4122, big-endian byte encoding. This is a large enough number to allow a unique identifier to each PMU in the world.
15	FORMAT	2	Data format within the periodic data frame (see Table 4 for details). Bits 15 to 4: Reserved. Set to 0. Bit 3: FREQ/DFREQ. 0 = 16-bit integer, 1 = floating point. Bit 2: ANALOG. 0 = 16-bit integer, 1 = floating point. Bit 1: PHASOR (format). 0 = 16-bit integer, 1 = floating point. Bit 0: PHASOR (encoding). 0 = real and imaginary (rectangular). 1 = magnitude and angle (polar).

Table continues

Table 3—Configuration frame format (*continued*)

No.	Field	Size (bytes)	Short description
16	PHNMR	2	Number of phasors—2-B unsigned integer.
17	ANNMR	2	Number of analog values—2-B unsigned integer.
18	FRNMR	2	Number of frequency signals—2-B unsigned integer.
19	DFDTNMR	2	Number of df/dt signals—2-B unsigned integer.
20	DGNMR	2	Number of digital status words—2-B unsigned integer.
21	CHNAM	1 to 256 per name	Phasor and channel names—In UTF-8 with field index (see Table 2). Minimum of 2 B for each phasor, frequency, ROCOF, analog, and digital channel. Names are in the same order as they are transmitted: all phasors, all frequencies, all ROCOFs, all analogs, and all digitals. For digital channels, the channel name order will be from the least significant to the most significant. For example: the first name is for bit 0 of the first 16-bit status word, the second is for bit 1, etc., up to bit 15. If there is more than 1 digital status, the next name will apply to bit 0 of the second word and so on.

Table continues

Table 3—Configuration frame format (continued)

No.	Field	Size (bytes)	Short description																																										
22	PHSCALE	16 × PHNMR	Conversion factor for phasor channels with flags. Magnitude and angle scaling for phasors with data flags. This factor has four 4-B long words: The first is bit-mapped flags, the second is a magnitude scale factor, the third is an angle offset, and the fourth is voltage class. First 4-B word. First 2 B: 16-bit flag that indicates the type of data modification when data is being modified by a continuous process. When no modification process is being applied, all bits shall be set to 0. (Bit 0 is the LSB, Bit 15 is the MSB) <table><tr><td>Bit #</td><td>meaning when bit set.</td></tr><tr><td>0</td><td>Not used, reserved.</td></tr><tr><td>1</td><td>Up sampled from lower rate.</td></tr><tr><td>2</td><td>Down sampled from higher rate.</td></tr><tr><td>3</td><td>Magnitude filtered.</td></tr><tr><td>4</td><td>Estimated magnitude.</td></tr><tr><td>5</td><td>Estimated angle.</td></tr><tr><td>6</td><td>Phasor magnitude adjusted for calibration.</td></tr><tr><td>7</td><td>Phasor phase adjusted for calibration.</td></tr><tr><td>8</td><td>Phasor phase adjusted for offset (± 30°, ± 120°, etc.).</td></tr><tr><td>9</td><td>Pseudo-phasor value (combined from other phasors).</td></tr><tr><td>10 to 14</td><td>Reserved for future assignment.</td></tr><tr><td>15</td><td>Modification applied. Type not defined here.</td></tr></table> Third byte: phasor type indication (bit 0 is the LSb, bit 7 is the MSb). Bits 07 to 04: Reserved for future use. Set to 0. Bit 03: 0 = voltage; 1 = current. Bits 02 to 00: Phasor component, coded as follows. <table><tr><td>111:</td><td>Reserved.</td></tr><tr><td>110:</td><td>Phase C.</td></tr><tr><td>101:</td><td>Phase B.</td></tr><tr><td>100:</td><td>Phase A.</td></tr><tr><td>011:</td><td>Reserved.</td></tr><tr><td>010:</td><td>Negative sequence.</td></tr><tr><td>001:</td><td>Positive sequence.</td></tr><tr><td>000:</td><td>Zero sequence.</td></tr></table> Fourth byte: available for user designation. Second and third 4-B words. For phasor $X = X_m e^{j\theta}$, this defines the scaling Y and angle offset θ to be applied to the phasor as follows: $X' = Y \times X_m e^{j(\theta - \theta')}$ The second 4-B word is the scale factor Y in 32-bit IEEE floating point. This scales phasor data to primary volts or amperes. If phasors are transmitted in floating-point format and scaled already, this value shall be set to 1.0. The third 4-B word is the phasor angle adjustment θ in radians represented in 32-bit IEEE floating point. If phasors are transmitted in floating-point format and scaled already, this value shall be set to 0.0. The fourth 4-B word is the voltage class for this signal, in 32-bit IEEE floating point format. voltage class shall be used as a general value which approximates the phase-to-phase rms voltage for both the phasor and analog measurements being reported by the PMU. The value is a single precision floating point number in engineering units (e.g., 500 000.0).^a Set to 0.0 if it is not available.	Bit #	meaning when bit set.	0	Not used, reserved.	1	Up sampled from lower rate.	2	Down sampled from higher rate.	3	Magnitude filtered.	4	Estimated magnitude.	5	Estimated angle.	6	Phasor magnitude adjusted for calibration.	7	Phasor phase adjusted for calibration.	8	Phasor phase adjusted for offset (± 30°, ± 120°, etc.).	9	Pseudo-phasor value (combined from other phasors).	10 to 14	Reserved for future assignment.	15	Modification applied. Type not defined here.	111:	Reserved.	110:	Phase C.	101:	Phase B.	100:	Phase A.	011:	Reserved.	010:	Negative sequence.	001:	Positive sequence.	000:	Zero sequence.
Bit #	meaning when bit set.																																												
0	Not used, reserved.																																												
1	Up sampled from lower rate.																																												
2	Down sampled from higher rate.																																												
3	Magnitude filtered.																																												
4	Estimated magnitude.																																												
5	Estimated angle.																																												
6	Phasor magnitude adjusted for calibration.																																												
7	Phasor phase adjusted for calibration.																																												
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Table continues