
**Health informatics — Medical
waveform format —**

**Part 5:
Neurophysiological signals**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 215, *Health informatics*.

A list of all parts in the ISO 22077 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Neurophysiological signals are used to monitor and assess an individual's brain activity for a wide array of clinical examinations including sleep polysomnography (PSG), determination of brain death, evoked potentials (EP), and electromyography (EMG).

Electroencephalography (EEG) is an electrophysiological monitoring method to record electrical activity of the brain. It is typically non-invasive, with multiple electrodes placed along the scalp (see [Figures B.1](#) and [B.2](#)). Diagnostic applications generally focus on the spectral content of EEG, that is, the type of neural oscillations (popularly called "brain waves") that can be observed in EEG signals. EEG is most often used to diagnose epilepsy, which causes abnormalities in EEG readings. It is also used to diagnose sleep disorders, coma, encephalopathies, and brain death.

PSG examinations include monitoring the condition of the body during sleep at night. Confirmed diagnosis of sleeping disorders and sleeping respiratory disorders is supported by recording neurophysiological signals through electrodes. By measuring brain waves, eye movements, electromyogram movements, etc., the depth of sleep (sleep stage), quality, presence or absence of midwake arousal, respiration by breathing, snoring, oxygen saturation, etc., can be assessed.

To correctly interpret neurophysiological changes, medical device systems need to capture these data, along with additional waveforms such as the respiration, SpO₂, EOG (eye movement). Healthcare providers and clinical specialists who perform these examinations greatly benefit from interoperability – having all the examination data recorded in a single standardized package or file that can be safely and securely managed and exchanged.

The purpose of this document is to describe the heterogeneous neurophysiological waveforms and related data that can be normalized to a standard semantic representation and format and persisted in a single package. The specification also supports the time synchronization of these waveforms and related parametric data so that the clinician receiving the data package is able to better assess the patient's condition throughout the examination period.

About Medical waveform Format Encoding Rules (MFER)

The MFER standards address several challenges that are not limited to either EEG waveforms or the neurophysiological assessments that are the main subject of this document:

- **Simple and easy implementation:** application of MFER is very simple and is designed to facilitate understanding, easy installation, trouble-shooting, and low implementation cost.
- **Using with other appropriate standards:** it is recommended that MFER only describes medical waveforms. Other information can be described using appropriate standards such as HL7®¹⁾, DICOM®²⁾, IEEE®³⁾, etc. For example, clinical reports that include patient demographics, order information, medication, etc. are supported in other standards such as HL7® Clinical Document Architecture (CDA). By including references to MFER information in these documents, implementation for message exchange, networking, database management that includes waveform information becomes simple and easy.
- **Separation between supplier and consumer of medical waveforms:** the MFER specification concentrates on data format instead of paper-based recording. For example, recorded ECG/EEG are processed by filter, data alignment, and other parameters, so that the ECG waveform can be easily displayed using an application viewer. However, it is not as useful for other purposes such as data

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processing for research investigations. A design goal of MFER is that a waveform is described in raw format with as complete as possible recording detail. When the waveform is used, appropriate processing of the data are supported like filtering, view alignment and so on. In this way, the medical waveform described in MFER can be used for multiple purposes.

- **Product capabilities are not limited:** standards often support only a minimum set of requirements, so the expansion of product features can be greatly limited. MFER can describe medical waveform information without constraining the potential features of a product. Also, medical waveform display must be very flexible, and thus MFER has mechanisms supporting not only a machine-readable coded system for abstract data, but also human-readable representation.

The MFER specification supports both present and future product implementations. MFER supports the translation of stored waveform data that was encoded using other standards, enabling harmonization and interoperability. This capability supports not only existing waveform format standards but can be extended to support future formats as well.

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Health informatics — Medical waveform format —

Part 5: Neurophysiological signals

1 Scope

This document specifies a heterogeneous format of neurophysiological waveform signals to support recording in a single persistent record package as well as interoperable exchange. The document focuses on electroencephalography (EEG) waveforms created during EEG examinations. Specific provision is made for sleep polysomnography examinations (PSG), brain death determination, evoked potentials (EP), and electromyography (EMG) studies.

This document is intended for neurophysiology.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 22077-1:2015, *Health informatics — Medical waveform format — Part 1: Encoding rules*

ISO/TS 22077-3:2015, *Health informatics — Medical waveform format — Part 3: Long term electrocardiography*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22077-1:2015 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

4 Symbols and abbreviated terms

CO ₂	Carbon dioxide
DC	Direct Current
DICOM	Digital Imaging and Communication in Medicine
ECG	Electrocardiography
EEG	Electroencephalography
EMG	Electromyography
EOG	Electrooculography

EP	Evoked potentials
HPF	High-frequency pass filter
IEEE	Institute of Electrical and Electronic Engineers
LOINC ⁴⁾	Logical Observation Identifiers Names and Codes
LPF	Low-frequency pass filter
MFER	Medical waveform Format Encoding Rules
PSG	Polysomnography
SEP	Somatosensory evoked potential
SNOMED-CT ⁵⁾	Systematized Nomenclature of Medicine-Clinical Terms
SpO2	Saturation of peripheral oxygen

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5 General

5.1 Overview of the rules

All MFER content (see ISO 22077-1:2015, 4.2.2), including the file header and waveform data, should be encoded based on the encoding rules that are composed of the tag, length and value (TLV), 3-tuple as shown in [Figure 1](#).

Tag (T)	Data length (L)	Value (V)
---------	-----------------	-----------

Figure 1 — Data unit

- The tag (T) consists of one or more octets and indicates the attribute of the data value.
- The data length (L) is the length of data values indicated in one or more octets.
- The value (V) is contents which are indicated by tag (T); e.g. attribute definition, waveform data, etc.

In order to make effective use of this document, a MFER conformance statement is provided in [Annex A](#) and sample waveform description are provided in [Annex C](#).

5.2 Configuration of waveform data

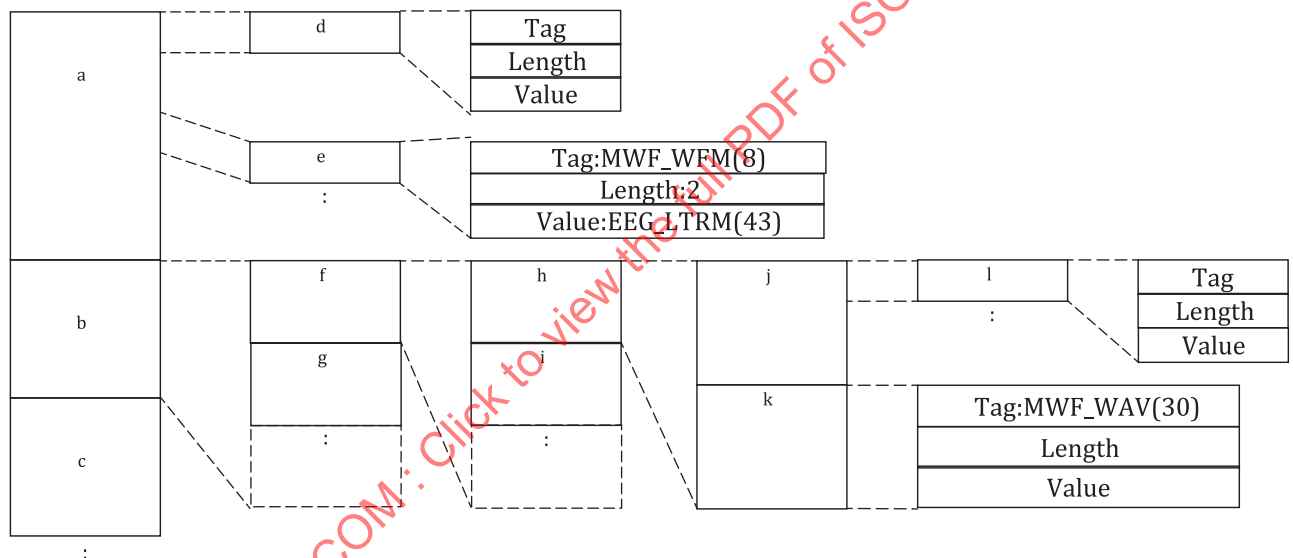
Medical waveform data described in accordance with the MFER is an aggregate of waveform frame data that consists of a header section (encoding detailed information about the waveform) and a waveform data section (main data of waveform). See [Figure 2](#). The header and waveform data are encoded based on the encoding rules that are composed of TLV (Tag - Data length - Value). One MFER waveform file can include several waveforms. The content of an MFER waveform file is sequentially interpreted from the beginning of the file, and a single file can contain multiple waveform definitions. Given the sequential

precedence processing for an MFER file, a waveform definition applies until another definition with the same tag is encountered. In this case, the subsequent definition replaces the preceding definition for the same waveform.

Additionally, the definition for one waveform can be used, by reference, to define additional waveforms in the MFER file. For example, a 60 channel EEG might only require four core waveform specifications, with the other channels referring to the same definition, providing simplification of the overall file complexity.

When there are several waveforms in a MFER waveform file, each waveform can be located anywhere in the file; however, in the specification of data generated during EEG and other examinations, waveform frames should be located as shown in [Figure 2](#) to enhance usability and avoid erroneous interpretation:

- The information about EEG examination and others should be described before description of waveform [i.e. in (a) and (d) content should be included before (e)]. For this document, the waveform class definition(s) (MWF_WFM) are for neurophysiological signals and should be set to one of the appropriate values defined in [Table 2](#).
- The same type waveforms should be described in a sequential, contiguous manner, and located chronologically in the file.



Key

- | | | | |
|---|--|---|-------------------------|
| a | EEG examination | h | frame #1 of waveform #1 |
| b | waveform (type #1) | i | frame #2 of waveform #1 |
| c | waveform (type #2) | j | header |
| d | Explanation about neurophysiological signals | k | waveform data |
| e | explanation (waveform class) | l | explanation about frame |
| f | waveform #1 of type #1 | | |
| g | waveform #2 of type #1 | | |

Figure 2 — Waveform data configuration

5.3 Time synchronization

In EEG examination data, several types of neurophysiological signals and biomedical data, such as SpO2 or respiration may be described together in the same MFER file, requiring support for time

synchronization between the waveform streams and these parametric observations. In addition, it is necessary to capture the state of the photic stimulator at the time the data was acquired.

NOTE For EEG examinations, photic stimulators are used to investigate anomalous brain activity triggered by specific visual stimuli, such as flashing lights or other patterns.

The reference time used for synchronization starts counting from the beginning of the examination period. The data recording system shall establish the reference time for each data point using the recorded examination time. The reading system can then establish synchronization between data points by correlating the acquisition time for each data point.

The reference time of waveforms such as EEGs are described using the pointer tag (MWF_PNT). The reference time of events such as photic stimulator information (stimulator period, frequency, mode, duration, etc.) is described using "starting time" item of the event tag (MWF_EVT). The reference time of measurements such as heart rate and respiration rate are described using the "time point" item of the value tag (MWF_VAL). Reference time is indicated as a data pointer that depends on the sampling rate of the waveform frame. The waveform reader system may also achieve data synchronization using pointers of different sampling rate.

For example, in [Figure 3](#), if the sampling interval of a photic stimulator event is 1 second and the sampling interval of EEG waveform is 1 ms, then the point of photic stimulator event becomes 60 s and the point of EEG waveform becomes 60 000 samples at the time of the start of the photic stimulator.

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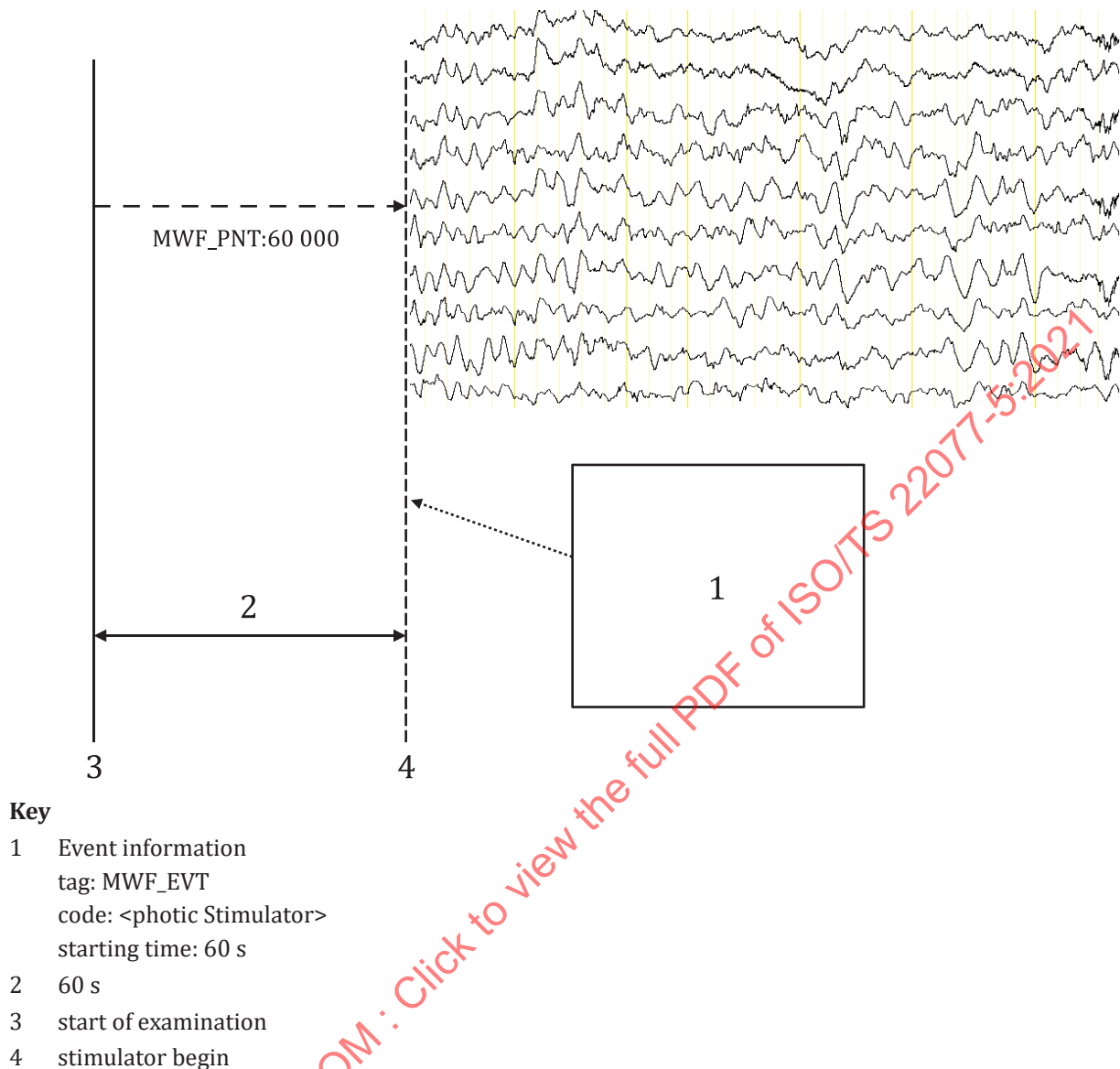


Figure 3 — Time synchronization

6 Waveform encoding

6.1 General

6.1.1 Application of EEG studies

This set of medical waveform format encoding rules (MFER) is aimed at ensuring that the waveforms collected during EEG studies, including PSG examinations, are encoded together with the needed contextual and descriptive information of the EEG examination. The waveforms recorded during EEG studies include “full disclosure waveform” (i.e. comprehensive continuous waveform data covering the entire period of the exam), and “intermittent record waveform” (i.e. waveform records in short segments of particular interest during the exam). Intermittent waveforms are also commonly described as, e.g. “one shot”, “window”, “snapshot”, “snippet”.

6.1.2 Full disclosure waveforms

This form is used when encoding all EEG waveforms during examinations, including the resting period, and the loading period such as photic stimulation. This not only includes encoding of waveform signals from all leads used in the examination but also encoding of a subset of waveforms selected from multiple leads. Note that for full disclosure waveform recording, encoding waveforms for the entire period of the examination within one frame (see [Figure 2](#)) significantly reduces the MFER file complexity and simplifies reading of the EEG content.

Encoding of full disclosure waveform shall be done in accordance with ISO 22077-1. The waveform class of these waveforms include EEG_REST (40), EEG_EP (41), EEG_LTRM (43) and others.

6.1.3 Intermittent record waveforms

Intermittent recording of waveforms is used when encoding the waveforms of EEG, etc., using interval records to capture shorter periods of interest during the examination such as resting, photic stimulation, hyperventilation periods or one-shot records taken at random during the examination.

The point of time when the record concerned was taken during the test shall be encoded with using the pointer tag (MWF_PNT).

For example, in [Figure 4](#), if the sampling interval is 1 ms, then the point of information event (point #1) becomes 600 s and the point of EEG waveform becomes 600 000 samples at the time of the start of the examination.

Using the same sampling interval, the point of information event (point #2) becomes 900 s and the point of EEG waveform becomes 9 000 000 samples at the time of the start of the examination.

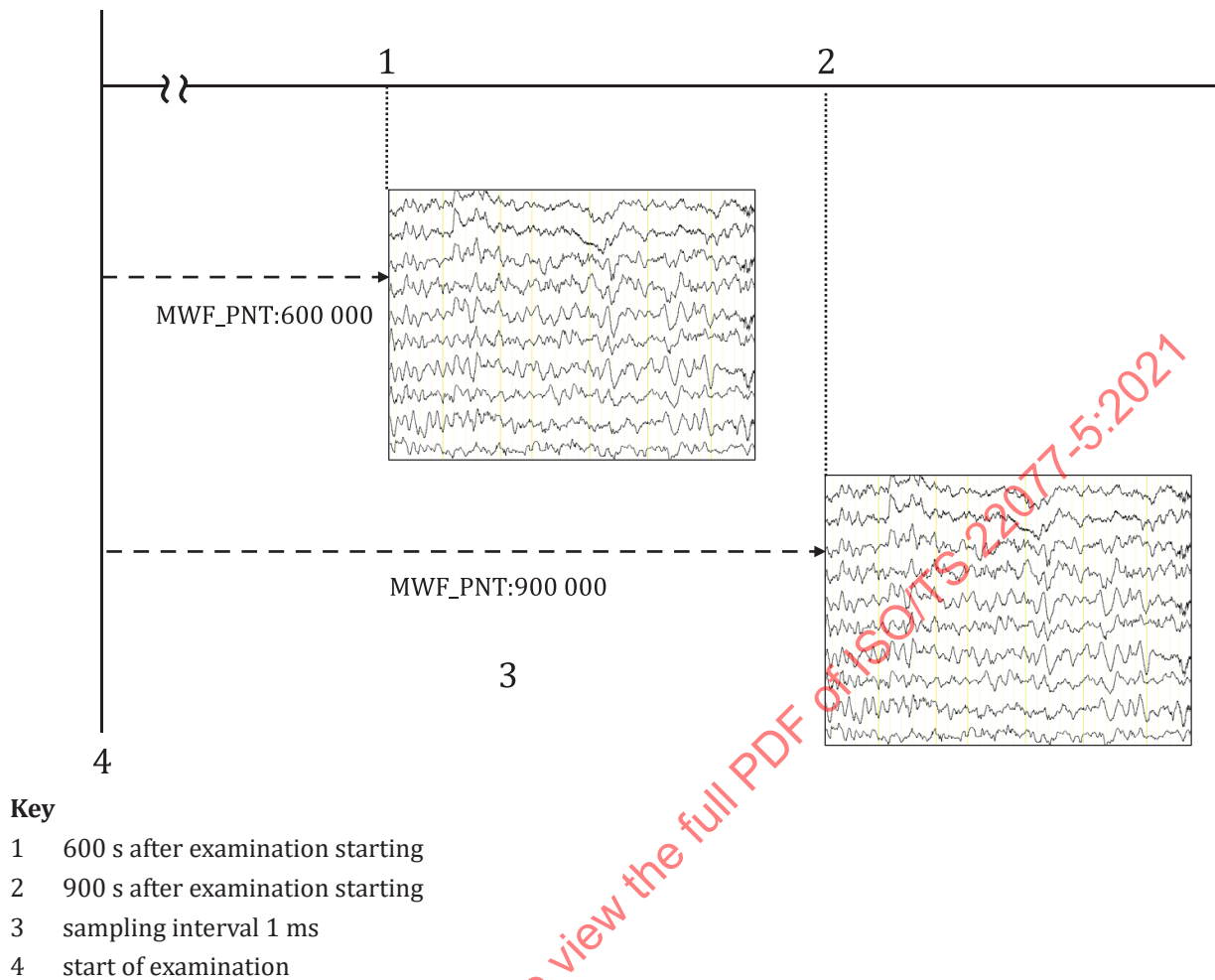


Figure 4 — Intermittent record waveform

6.2 Waveform class

6.2.1 General

The waveform class indicates that this waveform data represents a neurophysiological signal. Furthermore, the waveform class indicates the kind of waveform that is included in the MFER data. The format is given in [Table 1](#).

Table 1 — Waveform class

MWF_WFM		Data length	Default	Remarks	Duplicated definitions
08	08h	2	Non-specific waveform	—	Override
		Str ≤ 32	Waveform description	—	Override
NOTE 1 See ISO 22077-1:2015, 5.1.3.					
NOTE 2 See ISO 22077-1:2015, 4.3.3.2 and 4.3.3.3.					

6.2.2 Waveform Class for EEG, PSG, EP, EMG

6.2.2.1 General

Each waveform class shall identify its Type based on [Table 2](#) below.

Table 2 — Classification of waveforms

Classification	Type	Value	Description	Remarks
Electrocardiography	ECG_LTERM	2	Long-term ECG	Holter ECG, monitoring ECG
Electroencephalography (Neurophysiological signal)	EEG_REST	40	Resting EEG	Includes surgical monitoring EEG
	EEG_EP	41	Evoked EEG	ABR SEP
	EEG_CSA	42	Frequency analysis	Reserved for future use.
	EEG_LTRM	43	Long-term EEG	Sleeping EEG
	EMG	44	Electromyography	—
	EOG	45	Electrooculography	—
Respiratory	RESP	46	Respiratory	Impedance resitatory, air-flow, Snore asnd others
NOTE 1 See ISO 22077-1:2015, section 5.1.3 [Waveform for general waveform type definitions (40) through (43)].				
NOTE 2 EMG, EOG and RESP are uniquely defined in this document.				

The following subsections provide additional detail for each of the waveforms identified in [Table 2](#), except those reserved for future use, such as EEG_CSA.

6.2.2.2 EEG_REST, EEG_LTRM

Electroencephalography (EEG) is a diagnostic technique recording the electrical activity of the brain. Usually the electrodes are placed on the surface of the skull; special techniques use implanted electrodes as well (see [Annex B](#)).

EEG data are used to diagnose epilepsy, to monitor encephalopathy, for anaesthesia and coma state determination, and within sleep studies.

In clinical procedures, an EEG is typically is recorded for 20 minutes to 60 minutes using electrodes placed on the patient's scalp. Long term monitoring (e.g. to monitor epilepsy) may last from 6 hours to several days. In both cases, video and audio recordings are often made as well.

Electrical potentials are in the range of 1 μ V to 500 μ V.

In sleep medicine, polysomnography (PSG), also called a “sleep study”, is an examination for diagnosing sleep disorders. EEG data captured during PSG examinations are used as the primary indicator for sleep stages, arousal, and wakefulness, but it is also used to aid in the diagnosis of parasomnia and nocturnal epilepsy. Additional physiological parameters are recorded during sleep in order to identify sleep stages, measure brain function, monitor respiratory control, and monitor patient movement and body position.

A polysomnography consists of several measured quantities, with the most relevant for this document:

- brain activity (EEG);
- eye movements (EOG);
- activity of skeletal muscles (EMG).

Additionally, some of the following parameters are recorded:

- electrical activity of the heart (ECG);
- changes in blood oxygen levels (pulse oximetry);
- respiratory parameters like nasal and oral airflow via pressure transducers in front of nostrils and mouth or chest and abdominal expansion during breathing (via belts);

— sound recordings to measure snoring.

Data acquisition is done via a multichannel recording unit which samples sensors attached to different parts of the patient's body. Study duration is typically up to 8 hours. Channel selection varies somewhat between labs.

In many cases a video is taken to show the person's movements during sleep, as well as audio recordings.

6.2.2.3 EMG, EEG_EP

Electromyography (EMG) is a diagnostic technique recording the electrical activity of skeletal muscles. The electrical potential of the muscle cells changes on activation, due to a patient's movement or triggered by external stimulation. The data are used to detect neuromuscular abnormalities or to monitor muscular activity. In polysomnography, electromyography is used to measure the muscle tension and movement.

Two different techniques are used. Surface EMG assesses muscle function by recording electrical potentials from muscle at the skin surface. Intramuscular EMG uses needle electrodes inserted through the skin into the muscle, often in combination with surface electrodes as reference.

Within polysomnography, only surface EMG is used.

Measured values are in the range of 50 μ V to 30 mV.

6.2.2.4 EOG

Electrooculography (EOG) is a diagnostic technique to record eye movement, which is an important measure for classification of the sleep stage, for example slow-rolling eye movements in less deep sleep stages and rapid, irregular eye movements indicating the REM phase.

Typically, two electrodes are used to measure the eye movement. They are placed above or below the outer canthus of the eyes.

Measured values and sampling rates are approximately in the same range as EEG.

6.2.2.5 RESP

Respiratory are parameters like nasal and oral airflow via pressure transducers in front of nostrils and mouth or chest and abdominal expansion during breathing (via belts).

6.3 Waveform attributes (lead names)

6.3.1 Waveform code

Lead name means the waveform code that is one of waveform attributes. The format is as in [Table 3](#).

Table 3 — Definition of waveform attributes

MWF_LDN			Data length	Default	Remarks	Duplicated definitions
09	09h	Waveform code	2	undefined	Data length = 2, if waveform information is encoded	Override
		Waveform information	Str $\leq$ 32		—	Override

NOTE 1 See ISO 22077-1:2015, Table 11 for general specifications.

6.3.2 EEG

Since the EEG becomes bipolar, it is described as follows.

Generation of waveform codes by combination of electrodes (see [Figure 5](#)).

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
0	1	– negative electrode (G1)								+ positive electrode (G2)					

NOTE See ISO 22077-1:2015, Figure 8 for additional specifications.

Figure 5 — Generation of waveform code by combination of electrodes

Waveform codes can be generated by combination of electrode codes, as shown in [Table 4](#) and [Table 5](#). The electrode code is given in [Annex B](#) (additional specifications are in ISO 22077-1:2015, Table 14).

Table 4 — Electrode code

Name	Abbreviation	Electrode code
Left front polar	FP1	12
Right front polar	FP2	13
Left ear	A1	74
Right ear	A2	75

Table 5 — Example of waveform code generation

Lead	– electrode	+ electrode	Waveform code
FP1 - A1	12	74	17994(464A)
FP2 - A2	13	75	18123(46CB)

6.3.3 PSG, EOG, EMG, EP, RESP

Waveform codes can be generated by parameters of PSG, EOG, EMG, EP, RESP as shown in [Table 6](#).

Table 6 — Waveform code

Code	Lead	Remarks
31	Pulse	—
175	SpO ₂	—
4161	Body position	—
4162	Body movement	—
4180	Impedance respiratory	—
4181	Airflow	Nostril and Mouth Respiration
4182	Snore	—
4183	Rib Cage movement	—
4184	Abdominal movement	—
4185	Leg movement(Left)	—
4186	Leg movement(Right)	—

NOTE 1 See ISO 22077-1:2015, Tables 10 and 22 for additional electrode code specifications.

NOTE 2 Leads (4180) and following are newly defined in this document.

Table 6 (continued)

Code	Lead	Remarks
4187	EMG1	—
4188	EMG2	—
4189	EMG3	—
4190	EMG4	—
4191	EOG(Left eye movement)	—
4192	EOG(Right eye movement)	—
4193	EOG3	—
4194	EOG4	—
4195	CO2	—
4196	DC1	DC input channel 1
4197	DC2	DC input channel 2
4198	DC3	DC input channel 3
4199	DC4	DC input channel 4
NOTE 1 See ISO 22077-1:2015, Tables 10 and 22 for additional electrode code specifications.		
NOTE 2 Leads (4180) and following are newly defined in this document.		

6.3.4 ECG

Encoding of ECG waveform attribute is done in accordance with the long-term ECG specification, ISO/TS 22077-3:2015, Annex D. Lead name means the waveform code used in long-term ECGs. This code shall be used in 12-lead ECG and/or Vector lead ECG. The lead code is encoded by the number 0 to 127 in [Table 7](#).

Lead code later than 4160 is defined in the long-term ECG standard such as [Table 8](#). For more detailed lead name other than the definition in the long-term ECG standard, see ISO/TS 22077-3.

Table 7 — Lead name-1

Code	lead	Code	Lead
1	I	—	—
2	II	—	—
3	V1	—	—
4	V2	—	—
5	V3	—	—
6	V4	—	—
7	V5	—	—
8	V6	—	—
9	V7	—	—
10	(V2R) ^a	—	—
11	V3R	61	III
12	V4R	62	aVR
13	V5R	63	aVL
14	V6R	64	aVF

^a Although V2R (10) is defined in other rules such as SCP-ECG, the definition shall not be used in MFER.

^b -aVR lead shall not be encoded according to MFER. The users (viewer) should make a calculation to derive -aVR when required.

NOTE 1 See ISO/TS 22077-3:2015, Table 21.

Table 7 (continued)

Code	lead	Code	Lead
15	V7R	65	-aVR ^b
16	X	66	V8
17	Y	67	V9
18	Z	68	V8R
19	CC5	69	V9R
20	CM5	70	D(Nehb Dosai)
—	—	71	A(Nehb Anterior)
31	NASA	72	J(Nehb Inferior)
32	CB4	—	—
33	CB5	—	—
34	CB6	91	MCL

^a Although V2R (10) is defined in other rules such as SCP-ECG, the definition shall not be used in MFER.

^b -aVR lead shall not be encoded according to MFER. The users (viewer) should make a calculation to derive -aVR when required.

NOTE 1 See ISO/TS 22077-3:2015, Table 21.

Table 8 — Lead name-2

Code	Lead	Remarks
4166	ECG1	These shall be used in case lead name is not defined.
4167	ECG2	
4168	ECG3	
4169	ECG4	

NOTE 1 See ISO/TS 22077-3:2015, Table 22 for additional specifications.

6.4 Sampling attributes

6.4.1 General

"Sampling interval (MWF_IVL)" and "Sampling resolution (MWF_SEN)" should be described in accordance with ISO 22077-1. If multiple types of waveform are present, the sampling attributes described immediately before description of their waveform data are used. See 5.3 for additional use information.

6.4.2 MWF_IVL (0Bh): Sampling rate

This tag indicates the frequency or interval the medical waveform is sampled (see Table 9).

Table 9 — Sampling rate

MWF_IVL		Data length	Default	Encoding range/re-marks	Duplicated definitions
11	0Bh	Sampling rate unit	1 000 Hz	-	Override
		Exponent(10 th power)		10 ^{-128~+127}	
		Mantissa		e.g. signed 16-bit integer	

The unit can be frequency in Hertz, time in seconds or distance metres (see Table 10).

Table 10 — Sampling rate unit

Unit		Value	Remarks
Frequency	Hz	0	Including power
Time interval	s	1	—
Distance	m	2	—

6.4.3 MWF_SEN (0Ch): Sampling resolution

This tag indicates the resolution of least significant bit, medical waveform sampled (generally, digitized) (see [Table 11](#)).

Table 11 — Sampling resolution

MWF_SEN			Data length	Default	Encoding range/remarks	Duplicated definitions
12	0Ch	Sampling resolution unit	1	See Table 12	10 ⁻¹²⁸ ~+127 e.g. signed 16-bit integer	Override
		Exponent(10 th power)	1			
		Mantissa	≤4			

Table 12 — Sampling units

Unit		Value	Default	Remarks
Voltage	V	0	0,000 001 V	—
Pressure	mm Hg(Torr)	1	—	—
	Pa	2	—	—
	cm H ₂ O	3	—	—
	mm Hg/s	4	—	—
Ratio	%	7	—	Include volume fraction (%)
Flow rate, flow, volume	l	19	—	—
	l/s	20	—	—
	l/min	21	—	—

Sampling attributes shall conform to ISO 22077-1:2015, Tables 2, 3, 4 and 5.

6.5 Frame attributes

"Data block length (MWF_BLK)", "Number of channels (MWF_CHN)" and "Number of sequences (MWF_SEQ)" should be described in accordance with ISO 22077-1. If multiple types of waveform are present, the frame attributes described immediately before description of their waveform data are used.

Frame attributes shall conform to ISO 22077-1:2015, Table 6.

6.6 Pointer

This tag indicates the waveform data pointer, which is represented by the sampling rate of the root level, in the frame. If no pointer is designated, the pointer of the first frame is initialized as zero. The pointer for the next frame is deemed to be a value adding the number of data length of the virtual root level channel in the previous frame.

Pointer references shall conform to ISO 22077-1:2015, Table 28.

In electrocardiogram test, the pointer can be used to indicate the position of waveform in the examination.

The format is provided in [Table 13](#).

Table 13 — Pointer

MWF_PNT		Data length	Default	Remarks	Duplicated definitions
07	07h	≤4	Zero or pointer of previous frame	—	Override

6.7 Filter

"Filter information (MWF_FLT)" should be described in accordance with ISO 22077-1. [Table 14](#) and [Table 15](#) provide the format and some examples.

Filters shall conform to ISO/TS 22077-3:2015, Tables 26 and 27.

Neurophysiological signal often uses special filters to eliminate the influence of various artefacts during examination. Because some filters cause distortion or delay of neurophysiological signal waveform, a clear description of attenuation rate, delayed time, etc. is recommended if care is deemed necessary.

In electroencephalography, HPF and LPF have the following settings.

HPF: 0.001, 0.003, 0.03, 0.1, 0.3, 0.6, 1.0, 2.0, 5.0, 10 s

LPF: 15, 30, 35, 60, 70, 120, 300, 600, 1 200, 3 000 Hz

Table 14 — Filter information

MWF_FLT		Data length	Default	Remarks	Duplicated definitions
17	11h	Str ≤ 128	unused	—	Possible

Table 15 — Filter description example

Filter function	Abbreviation	Example	Meaning
Filter information only	None	Hum filter ON	Hum filter (characteristics, etc. not specified). Combining line frequency information can provide specific filter information.
High-frequency pass filter	HPF	HPF=0,5^delay time=1 023 ms	Indefinite characteristics 0,5 Hz low frequency cut-off (high-pass) filter used. Delay time is 1 023 ms.
Low-frequency pass filter	LPF	LPF=150^secondary Butterworth filter	Butterworth secondary characteristics 150 Hz high frequency cut-off (low-pass) filter used.
Band elimination filter	BEF	BEF=50^Hum filter	50 Hz Hum filter used. Cut-off characteristics not known.

7 Event information

7.1 General

The event information as EEG, PSG, EOG, EMG and EP should be described using with "Event (MWF_EVT)" and "Value (MWF_VAL)".

Event information shall conform to ISO 22077-1:2015, Table 32.

7.2 Measurement status – related events

Measurement status-related events such as photic stimulation and hyperventilation, etc. is described as event. The format is [Table 16](#). Events include those listed in [Table 17](#).

Table 16 — Measurement-related events

MWF_EVT			Data length	Encoding range/Remarks	Duplicated definitions
65	41h	Event code	2	See Table 17	Multiple definitions available
		Starting time (point)	4	Number of samples acquired at the sampling interval defined in the root definition.	
		Duration	4		
		Event information	Str ≤ 256	See Table 17	
NOTE 1 See ISO 22077-1:2015, 4.3.3.2.					

Table 17 — Measurement-related event code

Reference ID	CODE		Event	Explanation/ Event information
	DEC	HEX		
MWF_CAL	4701	125D	Calibration	—
MWF_EVENT1	4702	125E	Event1	—
MWF_EVENT2	4703	125F	Event2	—
MWF_PHOTO_STIM	4704	1260	Photic stimulation	—
MWF_HYPERVENT	4705	1261	Hyperventilation	—
MWF_IMP_CHECK	4706	1262	Skin Electrode Impedance Check	—
MWF_RESET	4707	1263	Reset	—
MWF_EYES_OPEN	4708	1264	Eye open	—
MWF_EYES_CLOSED	4709	1265	Eye closed	—
MWF_EYE_MOVEMENT	4710	1266	Eye movement	—
MWF_BODY_MOVMENT	4711	1267	Body movement	—
MWF_EMG	4712	1268	EMG	—
MWF_ARTTIFACT	4713	1269	Artifact	—
MWF_NOISE	4714	126A	Noise	—
MWV_WAKING	4715	126B	Waking	—
MWF_APNEA	4716	126C	Apnea	—
MWF_HYPOPNEA	4717	126D	Hypopnea	—
MWF_NREM1	4718	126E	Stage1 Non-REM	See Reference [5]
MWF_NREM2	4719	126F	Stage2 Non-REM	
MWF_NREM3	4720	1270	Stage3 Non-REM	
MWF_REM	4721	1271	Stage REM	
MWF_LIGHTS_ON	4722	1272	Turn on the lights in the room	—
MWF_LIGHTS_OFF	4723	1273	Turn off the lights in the room	—

NOTE 1 See ISO 22077-1:2015, Table 32 for additional specifications.

Annex A

(informative)

MFER conformance statement

Each implementer should provide a specification sheet of their specific MFER waveform format as a conformance statement ([Table A.1](#)). Use of non-default values should be identified clearly. If the extension part of the MFER description is used, an additional sheet with other optional extensions should also be provided.

Table A.1 — Conformance statement template

[illegible]

Annex B (informative)

EEG electrode code

B.1 Electrode positioning

Small metal discs or electrodes that are placed on the scalp in specific positions in accordance to established positioning schemes. The manner in which pairs of electrodes are connected to each amplifier of the EEG machine is called a montage. Each montage will use one of three standard recording derivations:

common reference	Each amplifier records the difference between a scalp electrode and a reference electrode. The same reference electrode is used for all channels. Electrodes frequently used as the reference electrode are A1, A2, the ear electrodes, or A1 and A2 linked together.
average reference	Activity from all the electrodes are measured, summed together and averaged before being passed through a high value resistor. The resulting signal is then used as a reference electrode and connected to input 2 of each amplifier and is essentially inactive. All EEG systems will allow the user to choose which electrodes are to be included in this calculation.
bipolar	These sequentially link electrodes together usually in straight lines from the front to the back of the head or transversely across the head. For example, the first amplifier can have electrodes FP1 and F3 connected to it and the second amplifier F3 and C3 connected to it.

The 10–20 system or International 10–20 system is an internationally recognized method to describe and apply the location of scalp electrodes in the context of an EEG examination, e.g. polysomnography (see [Figure B.1](#)). These positions are identified by the recordist who measures the head using the International 10/20 System. Electrode positioning relies on taking measurements between certain fixed points on the head. The electrodes are then placed at points that are 10 % and 20 % of these distances.

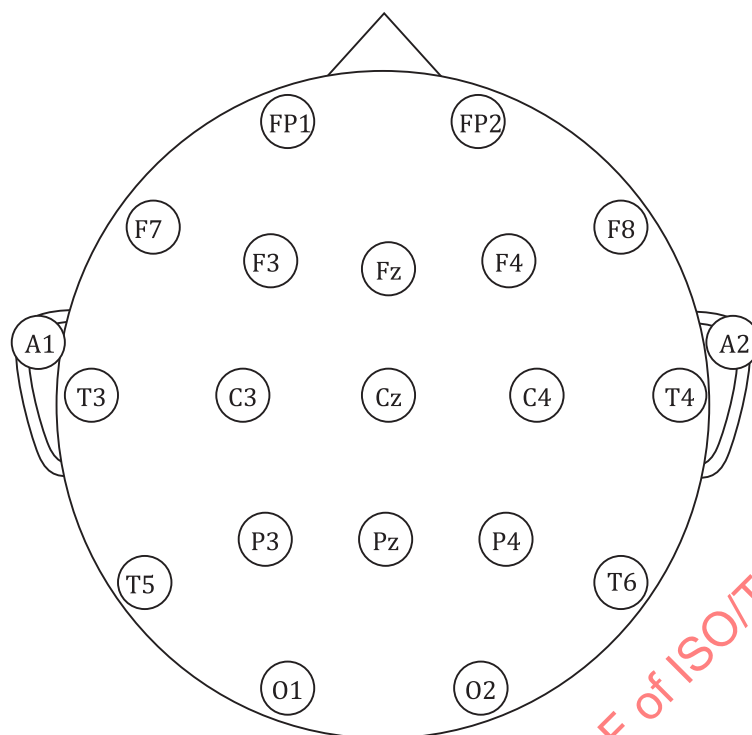


Figure B.1 — The 10-20 system

When recording a more detailed EEG with more electrodes, extra electrodes are added using the 10 % division, which fills in intermediate sites halfway between those of the existing 10-20 system (see [Figure B.2](#)).

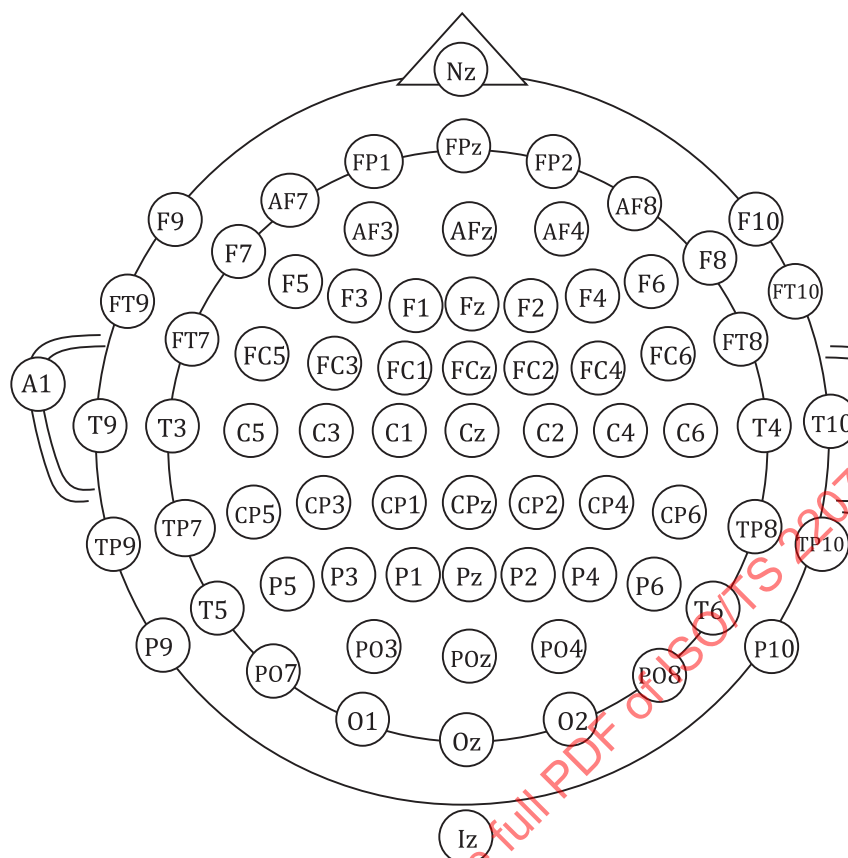


Figure B.2 — Higher-resolution systems

B.2 Electrode code

The electrode code is given as [Table B.1](#).

Table B.1 — EEG electrode code names

Name	Abbreviation	Electrode code	IEEE 11073-10101 Part::Code
Undefined	U	0	
Nasion	Nz	1	7::996
Front polar	Fpz	2	7::1000
Anterior frontal	AFz	3	7::1004
Frontal	Fz	4	7::1008
Front central	FCz	5	7::1012
Central	Cz	6	7::1016
Centro parietal	CPz	7	7::1020
Parietal	Pz	8	7::1024

NOTE 1 See Reference [4] for the related DICOM waveform specification.

NOTE 2 IEEE 11073-10101 is the most suitable mapping, while LOINC® or SNOMED-CT® can be added in the future as needed.

NOTE 3 According to ACNS (American Clinical Neurophysiology Society) Guideline 2, ACNS 2016 prefers T7 to T3, T8 to T4, P7 to T5, and P8 to T6. IEEE 11073-10101 is described as T3, T4, T5, and T6, the same as this standard. See Reference [6].

Table B.1 (continued)

Name		Abbreviation	Electrode code	IEEE 11073-10101 Part::Code
Parieto-occipital		POz	9	7::1028
Occipital		Oz	10	7::1032
Inion		Iz	11	7::1036
Front polar	Left	FP1	12	7::1041
	Right	FP2	13	7::1042
Frontal	Left	F1	14	7::1049
	Right	F2	15	7::1054
Front central	Left	FC1	16	7::1089
	Right	FC2	17	7::1094
Central	Left	C1	18	7::1129
	Right	C2	19	7::1134
Centro parietal	Left	CP1	20	7::1153
	Right	CP2	21	7::1158
Parietal	Left	P1	22	7::1177
	Right	P2	23	7::1182
Occipital	Left	O1	24	7::1209
	Right	O2	25	7::1214
Anterior frontal	Left	AF3	26	7::1217
	Right	AF4	27	7::1222
Frontal	Left	F3	28	7::1057
	Right	F4	29	7::1062
Front central	Left	FC3	30	7::1097
	Right	FC4	31	7::1102
Central	Left	C3	32	7::1137
	Right	C4	33	7::1142
Centro parietal	Left	CP3	34	7::1161
	Right	CP4	35	7::1166
Parietal	Left	P3	36	7::1185
	Right	P4	37	7::1190
Parieto-occipital	Left	PO3	38	7::1233
	Right	PO4	39	7::1238
Frontal	Left	F5	40	7::1065
	Right	F6	41	7::1070
Front central	Left	FC5	42	7::1105
	Right	FC6	43	7::1110
Central	Left	C5	44	7::1145
	Right	C6	45	7::1150

NOTE 1 See Reference [4] for the related DICOM waveform specification.

NOTE 2 IEEE 11073-10101 is the most suitable mapping, while LOINC® or SNOMED-CT® can be added in the future as needed.

NOTE 3 According to ACNS (American Clinical Neurophysiology Society) Guideline 2, ACNS 2016 prefers T7 to T3, T8 to T4, P7 to T5, and P8 to T6. IEEE 11073-10101 is described as T3, T4, T5, and T6, the same as this standard. See Reference [6].

Table B.1 (continued)

Name		Abbreviation	Electrode code	IEEE 11073-10101 Part::Code
Centro parietal	Left	CP5	46	7::1169
	Right	CP6	47	7::1174
Parietal	Left	P5	48	7::1193
	Right	P6	49	7::1198
Anterior frontal	Left	AF7	50	7::1225
	Right	AF8	51	7::1230
Frontal	Left	F7	52	7::1073
	Right	F8	53	7::1078
Front temporal	Left	FT7	54	7::1113
	Right	FT8	55	7::1118
Temporal	Left	T3	56	7::1249
	Right	T4	57	7::1254
Temporo parietal	Left	TP7	58	7::1273
	Right	TP8	59	7::1278
Post temporal	Left	T5	60	7::1257
	Right	T6	61	7::1262
Parieto occipital	Left	PO7	62	7::1241
	Right	PO8	63	7::1246
Frontal	Left	F9	64	7::1081
	Right	F10	65	7::1086
Front temporal	Left	FT9	66	7::1121
	Right	FT10	67	7::1126
Temporal	Left	T9	68	7::1265
	Right	T10	69	7::1270
Temporo parietal	Left	TP9	70	7::1281
	Right	TP10	71	7::1286
Parietal	Left	P9	72	7::1201
	Right	P10	73	7::1206
Ear	Left	A1	74	7::1289
	Right	A2	75	7::1290
Anterior temporal	Left	T1	76	7::1297
	Right	T2	77	7::1298
Pharyngeal	Left	Pg1	78	7::1305
	Right	Pg2	79	7::1306
Sphenoidal	Left	Sp1	80	7::1313
	Right	Sp2	81	7::1314
Reference		Ref	100	
Reference 2		Ref2	101	

NOTE 1 See Reference [4] for the related DICOM waveform specification.

NOTE 2 IEEE 11073-10101 is the most suitable mapping, while LOINC® or SNOMED-CT® can be added in the future as needed.

NOTE 3 According to ACNS (American Clinical Neurophysiology Society) Guideline 2, ACNS 2016 prefers T7 to T3, T8 to T4, P7 to T5, and P8 to T6. IEEE 11073-10101 is described as T3, T4, T5, and T6, the same as this standard. See Reference [6].

Table B.1 (continued)

Name	Abbreviation	Electrode code	IEEE 11073-10101 Part::Code
Non Specific Electrode	EEG	127	
NOTE 1 See Reference [4] for the related DICOM waveform specification.			
NOTE 2 IEEE 11073-10101 is the most suitable mapping, while LOINC® or SNOMED-CT® can be added in the future as needed.			
NOTE 3 According to ACNS (American Clinical Neurophysiology Society) Guideline 2, ACNS 2016 prefers T7 to T3, T8 to T4, P7 to T5, and P8 to T6. IEEE 11073-10101 is described as T3, T4, T5, and T6, the same as this standard. See Reference [6].			

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Annex C (informative)

Example of waveform encoding

C.1 Electroencephalography (EEG)

[Table C.1](#) is a sample describing the EEG. The sampled EEG waveform is for 30 minutes and it has 12ch EEG waveforms and 1ch ECG waveform. Photoc stimulator for 15 seconds is given 10 minutes and 20 minutes after the start of the examination.

Table C.1 — Example of encoding electroencephalography

Tag name		Code			Descriptions
		Tag No (HEX)	Length (DEC)	Data (HEX)	
1	MWF_PRE	40	32	4d 46 52 20	MFR
				50 6f 6c 79 73 6f 6d 6e 6f 67 72 61 70 68 79 20 20 20 20 20 20 20 20 20 20 20 20 20	Polysomnography
2	MWF_BLE	01	1	00	Big endian
3	MWF_TIM	85	11	Year 07 e4	The examination date and time: 2020/02/05 13:31:20, 0, 0
				Month 02	
				Day 05	
				Hour 0d	
				Minute 1f	
				Second 14	
				Milli-second 00 00	
				Micro-second 00 00	
4	MWF_AGE	83	7	Years 23	Age: 35 years old
				Days 33 07	Age in days: 13 063 days old
				Birth date [Y] 07 c0	Date of birth: 1984/05/01
				Birth date[M] 05	
				Birth date[D] 01	
5	MWF_SEX	84	1	01	Male
6	MWF_WFM	08	2	00 2b	Long-term EEG (EEG_LTRM)
7	MWF_DTP	0a	1	00	Data type: Signed 16 bits integer
8	MWF_IVL	0b	4	Unit 01	Sampling interval: 1 s
				Exponent 00	
				Mantissa 00 01	
9	MWF_PNT	07	4	00 00 00 00	Pointer: 0 s

Table C.1 (continued)

Tag name		Code				Descriptions
		Tag No (HEX)	Length (DEC)	Data (HEX)		
10	MWF_EVT	41	24	Event code	12 60	Event: Photic stimulator (4704)
				Starting time	00 00 02 58	Starting time: 600 s
				Duration	00 00 00 0f	Duration: 15 s
				Event information	46 72 65 71 75 65 6e 63 79 3d 38 5e 48 7a	Information: Frequency=8^Hz
11	MWF_EVT	41	24	Event code	12 60	Event: Photic stimulator (4704)
				Starting time	00 00 04 b0	Starting time: 1 200 s
				Duration	00 00 00 0f	Duration: 15 s
				Event information	46 72 65 71 75 65 6e 63 79 3d 38 5e 48 7a	Information: Frequency=8^Hz
12	MWF_IVL	0b	4	Unit	01	Sampling interval: 1 × 10 ⁻³ s = 1 ms
				Exponent	fd	
				Mantissa	00 01	
13	MWF_SEN	0c	4	Unit	00	Sampling resolution: 10 × 10 ⁻⁶ volt = 10 micro volt
				Exponent	fa	
				Mantissa	00 0a	
14	MWF_BLK	04	4	00 1b 77 40		Data block length: 1 800 000 samples
15	MWF_CHN	05	1	0c		Number of channels: 12
16	MWF_SEQ	06	4	00 00 00 01		Number of sequences: 1
17	MWF_ATT	3f 00	4	MWF_LDN	09	Channel 1 attribute
				Length	02	negative electrode: FP1(12)
				Data	46 4a	positive electrode: A1(74)
18	MWF_ATT	3f 01	4	MWF_LDN	09	Channel 2 attribute
				Length	02	negative electrode: FP2(13)
				Data	46 cb	positive electrode: A2(75)
19	MWF_ATT	3f 02	4	MWF_LDN	09	Channel 3 attribute
				Length	02	negative electrode: F3(28)
				Data	4e 4a	positive electrode: A1(74)
20	MWF_ATT	3f 03	4	MWF_LDN	09	Channel 4 attribute
				Length	02	negative electrode: F4(29)
				Data	4e cb	positive electrode: A2(75)
21	MWF_ATT	3f 04	4	MWF_LDN	09	Channel 5 attribute
				Length	02	negative electrode: C3(32)
				Data	50 4a	positive electrode: A1(74)
22	MWF_ATT	3f 05	4	MWF_LDN	09	Channel 6 attribute
				Length	02	negative electrode: C4(33)
				Data	50 cb	positive electrode: A2(75)
23	MWF_ATT	3f 06	4	MWF_LDN	09	Channel 7 attribute
				Length	02	negative electrode: P3(36)
				Data	52 4a	positive electrode: A1(74)

Table C.1 (continued)

Tag name		Code				Descriptions
		Tag No (HEX)	Length (DEC)	Data (HEX)		
24	MWF_ATT	3f 07	4	MWF_LDN	09	Channel 8 attribute
				Length	02	negative electrode: P4(37)
				Data	52 cb	positive electrode: A2(75)
25	MWF_ATT	3f 08	4	MWF_LDN	09	Channel 9 attribute
				Length	02	negative electrode: O1(24)
				Data	4c 4a	positive electrode: A1(74)
26	MWF_ATT	3f 09	4	MWF_LDN	09	Channel 10 attribute
				Length	02	negative electrode: O2(25)
				Data	4c cb	positive electrode: A2(75)
27	MWF_ATT	3f 0a	4	MWF_LDN	09	Channel 11 attribute
				Length	02	negative electrode: T3(56)
				Data	5c 4a	positive electrode: A1(74)
28	MWF_ATT	3f 0b	4	MWF_LDN	09	Channel 12 attribute
				Length	02	negative electrode: T4(57)
				Data	5c cb	positive electrode: A2(75)
29	MWF_FLT	11	11	48 50 46 3d 30 2e 35 33 5e 48 7a		Filter: HPF=0,53^Hz
30	MWF_FLT	11	10	4c 50 46 3d 31 32 30 5e 48 7a		Filter: LPF=120^Hz
31	MWF_PNT	07	4	00 00 00 00		Pointer: 0 ms
32	MWF_WAV	1e	84 (hex)	02 93 2e 00		Data length is designated as 4 bytes.
						Data length: 43 200 000 bytes
			Wave-form information			In this case, the data value section uses 128 octets or more, the most significant bit is set.
				ch.1: FP1-A1	xx xx xx xx	1 800 000 samples × 2(byte)
				ch.2: FP2-A2	xx xx xx xx	1 800 000 samples × 2(byte)
				ch.3: F3-A1	xx xx xx xx	1 800 000 samples × 2(byte)
				ch.4: F4-A2	xx xx xx xx	1 800 000 samples × 2(byte)
				ch.5: C3-A1	xx xx xx xx	1 800 000 samples × 2(byte)
				ch.6: C4-A2	xx xx xx xx	1 800 000 samples × 2(byte)
				ch.7: P3-A1	xx xx xx xx	1 800 000 samples × 2(byte)
				ch.8: P4-A2	xx xx xx xx	1 800 000 samples × 2(byte)
				ch.9: O1-A1	xx xx xx xx	1 800 000 samples × 2(byte)
				ch.10: O2-A2	xx xx xx xx	1 800 000 samples × 2(byte)
ch.11: T3-A1	xx xx xx xx	1 800 000 samples × 2(byte)				
ch.12: T4-A2	xx xx xx xx	1 800 000 samples × 2(byte)				
33	MWF_WFM	08	2	00 02		Long-term ECG (ECG_LTERM)
34	MWF_DTP	0a	1	00		Data type: Signed 16 bits integer
35	MWF_IVL	0b	4	Unit	01	Sampling interval: 1 × 10 ⁻³ s = 1 ms
				Exponent	fd	
				Mantissa	00 01	

Table C.1 (continued)

Tag name		Code			Descriptions
		Tag No (HEX)	Length (DEC)	Data (HEX)	
36	MWF_SEN	0c	4	Unit	Sampling resolution: 10×10^{-6} volt = 10 micro volt
				Exponent	
				Mantissa	
37	MWF_BLK	04	4	00 1b 77 40	Data block length: 1 800 000 samples
38	MWF_CHN	05	1	01	Number of channels: 1
39	MWF_SEQ	06	4	00 00 00 01	Number of sequences: 1
40	MWF_ATT	3f 00	4	MWF_LDN	Channel 1 attribute ECG1(4166)
				Length	
				Data	
41	MWF_FLT	11	10	48 50 46 3d 30 2e 35 5e 48 7a	Filter: HPF=0,5^Hz
42	MWF_FLT	11	9	4c 50 46 3d 33 35 5e 48 7a	Filter: LPF=35^Hz
43	MWF_PNT	07	4	00 00 00 00	Pointer: 0 ms
44	MWF_WAV	1e	84 (hex)	00 36 ee 80	Data length is designated as 4 bytes. Data length: 3 600 000 bytes In this case, the data value section uses 128 octets or more, the most significant bit is set.
			Wave- form informa- tion	ch.1: ECG1 xx xx xx xx	1 800 000 samples $\times$ 2(byte)
45	MWF_END	80			

C.2 Polysomnography (PSG)

Table C.2 is a sample describing the PSG. The sampled PSG waveform is for 8 hours. It has EEG, EOG, EMG, ECG, respiration and others. The sampling frequency of the EEG, EOG, EMG and ECG waveforms is 1 000 Hz, and that of respiration and other waveforms is 250 Hz.

Table C.2 — Example of encoding polysomnography

Tag name		Code			Descriptions
		Tag No (HEX)	Length (DEC)	Data (HEX)	
1	MWF_PRE	40	32	4d 46 52 20	MFR
				50 6f 6c 79 73 6f 6d 6e 6f 67 72 61 70 68 79 20 20 20 20 20 20 20 20 20 20 20 20 20	Polysomnography
2	MWF_BLE	01	1	00	Big endian

Table C.2 (continued)

Tag name		Code				Descriptions
		Tag No (HEX)	Length (DEC)	Data (HEX)		
3	MWF_TIM	85	11	Year	07 e4	The examination date and time: 2020/02/05 13:31:20, 0, 0
				Month	02	
				Day	05	
				Hour	0d	
				Minute	1f	
				Second	14	
				Milli-second	00 00	
				Micro-second	00 00	
4	MWF_AGE	83	7	Years	23	Age: 35 years old
				Days	33 07	Age by day: 13 063 days old
				Birth date [Y]	07 c0	Date of birth: 1984/05/01
				Birth date[M]	05	
				Birth date[D]	01	
5	MWF_SEX	84	1	01	Male	
6	MWF_WFM	08	2	00 2b	Long-term EEG (EEG_LTRM)	
7	MWF_DTP	0a	1	00	Data type: Signed 16 bits integer	
8	MWF_IVL	0b	4	Unit	01	Sampling interval: 1 × 10 ⁻³ s = 1 ms
				Exponent	FD	
				Mantissa	00 01	
9	MWF_SEN	0c	4	Unit	00	Sampling resolution: 10 × 10 ⁻⁶ volt = 10 micro volt
				Exponent	Fa	
				Mantissa	00 0a	
10	MWF_BLK	04	4	01 b7 74 00		Data block length: 28 800 000 samples
11	MWF_CHN	05	1	03		Number of channels: 3
12	MWF_SEQ	06	4	00 00 00 01		Number of sequences: 1
13	MWF_ATT	3f 00	4	MWF_LDN	09	Channel 1 attribute
				Length	02	negative electrode: F3(28)
				Data	4e 4b	positive electrode: A2(75)
14	MWF_ATT	3f 01	4	MWF_LDN	09	Channel 2 attribute
				Length	02	negative electrode: C3(32)
				Data	50 4b	positive electrode: A2(75)
15	MWF_ATT	3f 02	4	MWF_LDN	09	Channel 3 attribute
				Length	02	negative electrode: O1(24)
				Data	4c 4b	positive electrode: A2(75)
16	MWF_FLT	11	11	48 50 46 3d 30 2e 35 33 5e 48 7a		Filter: HPF=0,53^Hz
17	MWF_FLT	11	10	4c 50 46 3d 31 32 30 5e 48 7a		Filter: LPF=120^Hz
18	MWF_PNT	07	4	00 00 00 00		Pointer: 0 ms