Medical waveform description Format Encoding Rules

MFER Part I

Version 1.01 – 2003

Introduction

Medical waveforms such as electrocardiogram and electroencephalogram are widely utilized in physiological examination, healthcare information and other areas in the clinical field. Signal processing technology has extended the utilization of waveform data to various fields including research and investigation. However, there is no commonly used standard format for wafeform data, only proprietary standards. HL7 and DICOM formats enable description of medical waveforms but the scope of application is limited. IEEE 1073 provides some stipulations but it is specialized at the medical device level, and is not always easy to apply. To make physiological information easy to handle, medical waveform data should be described separately from other information and thus it is desirable to have a universal standard description format for medical waveforms. If such a standard format is popularly used, physiological information could be utilized more efficiently and the effective use of waveform data can be expected for healthcare information such as electronic health records and physiological research.

The Medical waveform description Format Encoding Rules(MFER) has the following aims

- Simple and easy installation

  MFER is aiming at utmost simplification; for example, MFER enables simple encoding of standard 12-lead ECG. Simplification facilitates understanding, installation, trouble shooting, and decreases implementation cost.

  - Harmonization with other standards

  MFER is specialized in medical waveforms. For encoding information other than medical waveforms, it is recommended to use the HL7, DICOM or IEEE 1073 format, whichever has its forte for the specific non-waveform information. In principle, therefore, it is considered more effective to encode information such as patient information and examination information, excluding medical waveforms, using a format which has the strong point for such information rather than using MFER for both wavforms and patient information. It is also considered that for message exchange and database management, general computer technology should be easily utilized in addition to standards in the medical field. Medical specifications will be developed independently by specialists in individual fields. That is, the rules will be specified by referring specifications for ECG to cardiologists and specifications for EEG to neurologists.

- Separation of application and provider

  With MFER, providers of medical waveforms concentrate on description of waveforms as accurately as possible using the entire rules. Application are not obliged to wholly install the specifications but might understand and utilize only the necessary information for each individual purpose. Depending on the system design, unnecessary tips in the information supplied by providers may be ignored or regarded as errors to suspend processing. However, MFER can sufficiently be used since it enables encoding of the minimum necessary information on medical waveforms.

- Human interface specification

  Medical waveform information must be encoded in such a manner to enablie users to cope with diversified purposes and differences among patients. MFER not only encodes data in a definite form but also has a structure to enable transmission of important information with messages to users. It is expected that MFER will be used with the following basic policy. MFER must not impede features of each individual system and must not prevent technological development. MFER aims at enabling easy conversion of past database of medical waveforms, accurate encoding of present waveform information, and sufficient description of possible new medical waveforms in the future. It is also important that MFER does not exclude other rules.

MFER is composed of three standards. Part I is basic standards, Part IIs are application standard and Part IIIs are specializations.

Health informatics — Medical waveform description Format Encoding Rules : MFER — Part 1: Basic standard

1. Scope

The aim of MFER is to encode medical waveforms such as ECG, EEG, respiration curve and various data, which are sampled at a certain frequency, interval or distance. The scope of application is not a specified place such as homecare, telemedicine, outside hospitals, outpatients, laboratories, wards and operating rooms, but all cases where medical waveforms are used. However, applications for special purposes such as monitoring waveforms strictly in real time are beyond the scope of MFER. Real-time waveform monitoring is not an issue of MFER. For real-time waveform monitoring, environments including a lower layer standard are important and MFER is not intended to impede the convenience of real time communications medical waveforms. MFER is applicable for encoding medical waveforms of all types of instruments including electrocardiographs, electroencephalographs, patient monitors and so on. The encoded medical waveform data can be utilized for information systems including hospital information systems, laboratory information systems and clinical information systems. Furthermore, use of the data for basic, clinical and epidemiological research is expected to improve the usefulness of medical waveforms and to contribute to healthcare and medicine.

- Interchange of waveform information

  Medical waveforms are encoded using MFER and interchanged between instruments and instruments, instruments and computers and computers and computers through physical media or network. In principle, information other than medical waveforms is interchanged using higher standards like HL7 or DICOM which is used in the systems. Namely, patient information data are encoded with a basic protocol such as HL7 and only medical waveforms are encoded with MFER.

  - Waveform database

  MFER aims at providing the method to efficiently encode only medical waveforms so that the encoded data may be collected in a database to be used for clinical and research purposes, independent of a specific data storage or network. Accordingly, it is desirable to use MFER for encoding medical waveforms only, while patient information or observation data are managed by the database management system.

  - Electronic Healthcare Records

  With a viewer, to be developed through sufficient examination by specialists in concerned fields, users of MFER can easily refer to waveforms together with information in electronic medical records.

  - Synchronization of waveforms

  Generally, if individual systems are under independent environments, data of different systems can be synchronized on the time axis by utilizing synchronization of the clock of SNTP, etc. MFER enables synchronization between medical waveforms, for example, between an ultrasonic image and ECG or between CT and EEG. This does not require providers of medical waveforms to make SNTP-applied processing for real-time online display.

  - Research, investigation, and signal processing

  To utilize MFER medical waveforms for the purpose of performance evaluation of an analysis algorithm or research, the functions of the provider (e.g. data acquisition system) should be designed to match the purpose. If supplementary description of conditions for utilization is required, information relating to the research purpose can be encoded using levels 2 and 3 of MFER.

- Compatibility

  MFER medical waveforms are configured and processed to ensure compatibility between old and new versions. When the new version is applied to waveform data encoded with the old version, the system of the new version follows the specifications of the old version and then uses the new specifications. The system of the current version (which will be old in the future) ignores specifications which are not stipulated at the present, so that such blank specifications do not disable further processing due to error. It is important to observe this condition not only for version information but also for interpretation of encoding rules.

2. Normative references

IEEE 1073-1996IEEE Standard for Medical Device Communications—Overview and
Framework

IEEE P1073.1IEEE Standard – Medical Device Data Language (MDDL) – Framework and Overview

IEEE P1073.2.0 IEEE Standard – Medical Device Application Profiles (MDAP) – Base Standard

ENV 13734 Health informatics – Vital signs information representation

ENV 13735 Health informatics –Interoperability of patient connected medical
devices

CEN/TC251/PT-40File Exchange Format for Vital Signs

ENV 1064 Standard communications protocol – computer assisted electrocardiography (SCP-ECG)

HL7 V2.4Chapter 7 Observation Reporting

DICOM 3.3-2003

DICOM 3.5-2003

DICOM Supplement 30 Annex A Composite information object definistions

ISO/IEC 8824-1(1998) Information technology — Abstract Syntax Notation One (ASN.1):
Specification of basic notation

ISO/IEC 8825-1(1998) Information technology — ASN.1 encoding rules:
Specification of Basic Encoding Rules (BER),
Canonical Encoding Rules (CER) and
Distinguished Encoding Rules (DER)

ASTM E1238 Standard Specification for Transferring Clinical Observations Between Independent Computer Systems

ASTM E1467 Standard Specification for Transferring Digital Neurophysiological Data Between Independent Computer Systems

RFC2030 SNTP: Simple network time protocol

3. Term(s) and definition(s)

4. Symbols (and abbreviated terms)

5. Overview

MFER documents consist of three parts. Part 1 is the present document describing the basic principle; Part 2 provides rules for installation and message interchange; and Part 3 provides details of waveforms.

5.1. General description

Waveform information model

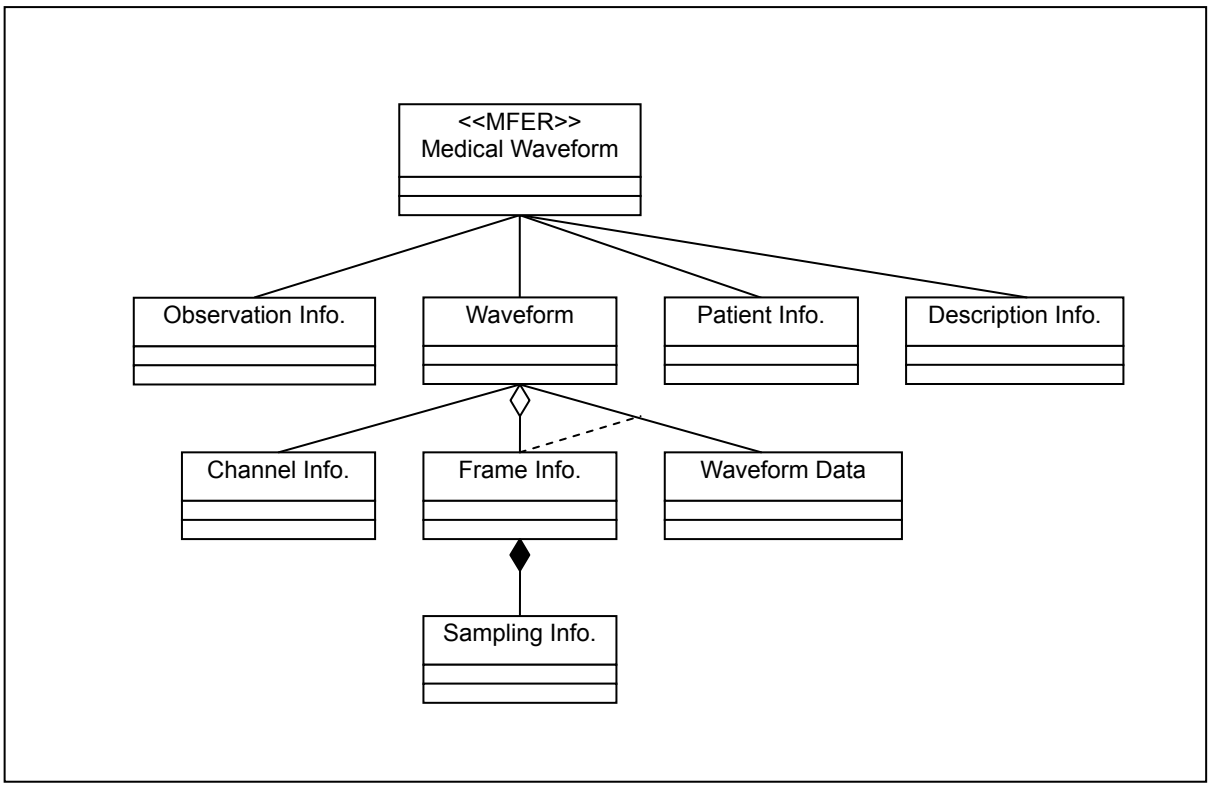


Figure 1. Waveform information model

5.1.1. Encoding waveform data

The main part of MFER encodes medical waveforms with the sampling attributes (Figure 2.) and the frame attributes (Figure 3.). As defined for the sampling attributes, sampled (time) sequential data values are encoded with the sampling resolution and sampling rate which is the sampling interval or sampling frequency. The sampled data are written in blocks which are described with block length for each channel. These data blocks are repeated according to sequential attributes.

5.1.1.1 Sampling attributes

(1). Sampling rate

The sampling rate is described with sampling interval or sampling frequency. The sampling interval stands for the time interval or distance a waveform data value is sampled.

(2). Sampling resolution

Sampling resolution represents a minimum sampling value per least significant bit.

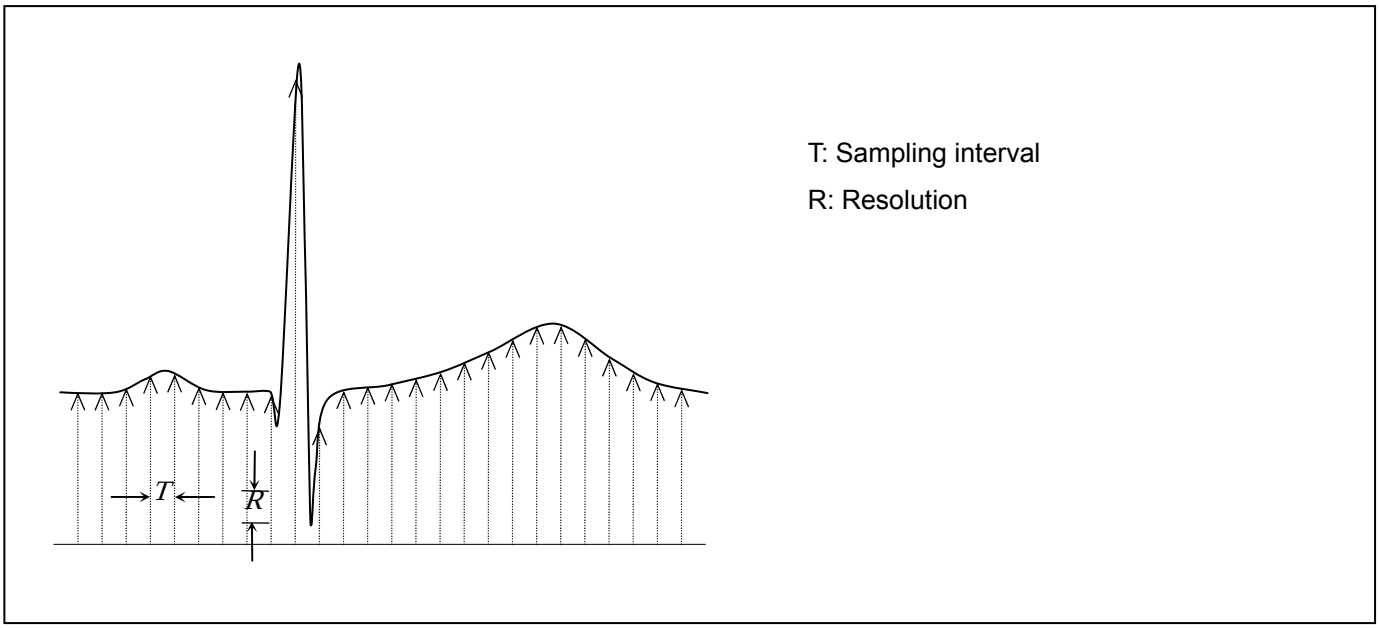


Figure 2. Sampling attributes

5.1.1.2 Frame attributes

The frame is a waveform encoding unit consisting of data blocks, channels and sequences. A configuration example of a frame is shown below.

(1). Data block

The data block is the minimum waveform data array for each channel.

(2). Channels

The channels indicate different waveform groups; e.g. if three waveform groups exist, the number of channels is 3.

(3). Sequence

The sequence represents the repetition of the group with the data block and channel.

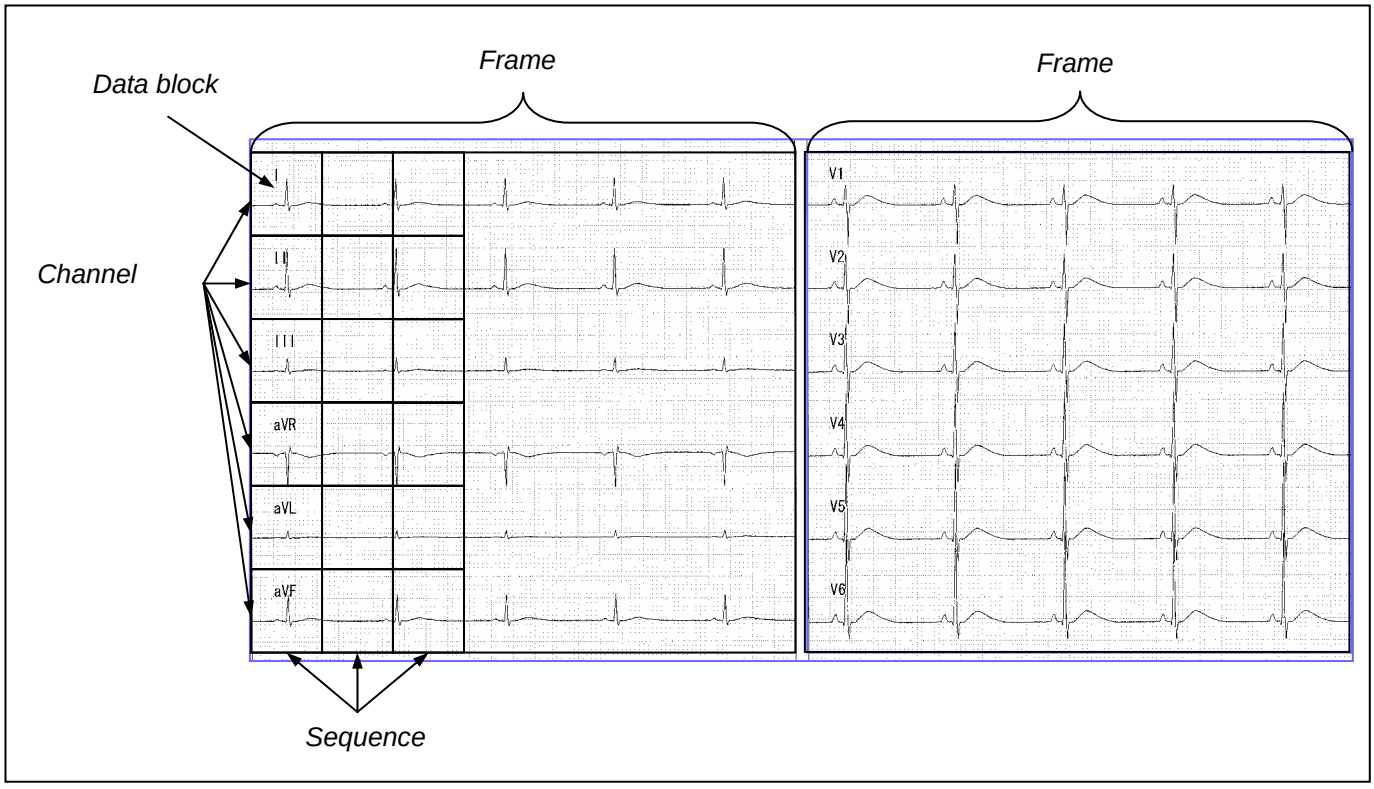
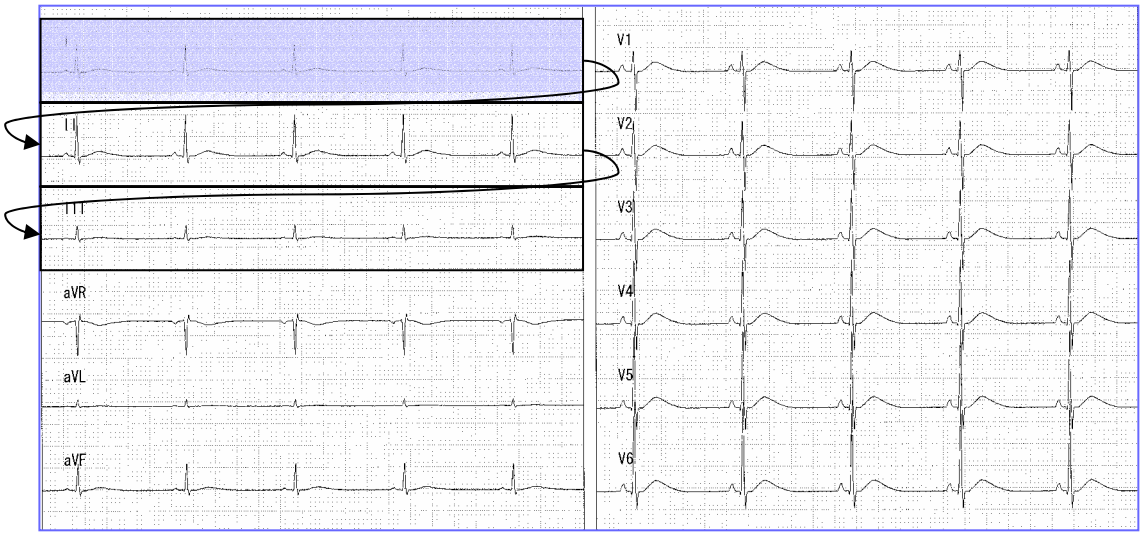


Figure 3. Frame attributes

Example 1. Alternate mode format

The frame is composed of a single sequence of consecutive data blocks where all data values of a channel (lead) are encoded in a single.

With this example, the entire lead I ECG is assigned to one data block and leads II to aVF are sequentially assigned to subsequent data blocks to form the first frame. In the same way, leads V1 to V6 are assigned to sequentual data blocks to form the second frame.

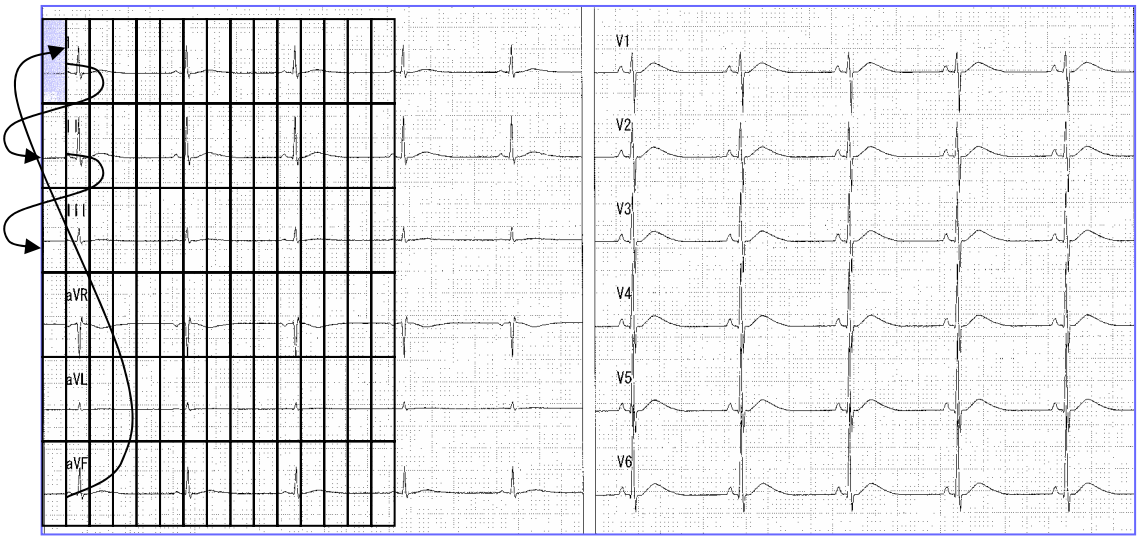


- Data block length: All data values of one lead; e.g. 5 seconds
- Number of channels: 6
- Number of sequences: 1
- Number of frames: 2

Figure 4. Alternate mode

Example 2. Multiplex mode format

The frame is composed of a number of sequences where each sequence consists of a short data block for each consecutive channel. The data block contains the data values for a short segment of the waveform of a channel.



- Data block length: one sampled data
- Number of channels: 6
- Number of sequences: Number of data blocks in one channel; e.g. 5-second ECG per lead
- Number of frames: 2

Figure 5. Multiplex mode

5.1.2. Description format

MFER encodes waveform data values in frames which include a header to identify the contents. The header describes sampling conditions, frame alignment and other related information. The information for the header shall be encoded with the TLV (type, length and value) conforming to the encoding rules. Descriptors include the root definition which covers all encodings and channel definitions which cover encodings for relevant channels.

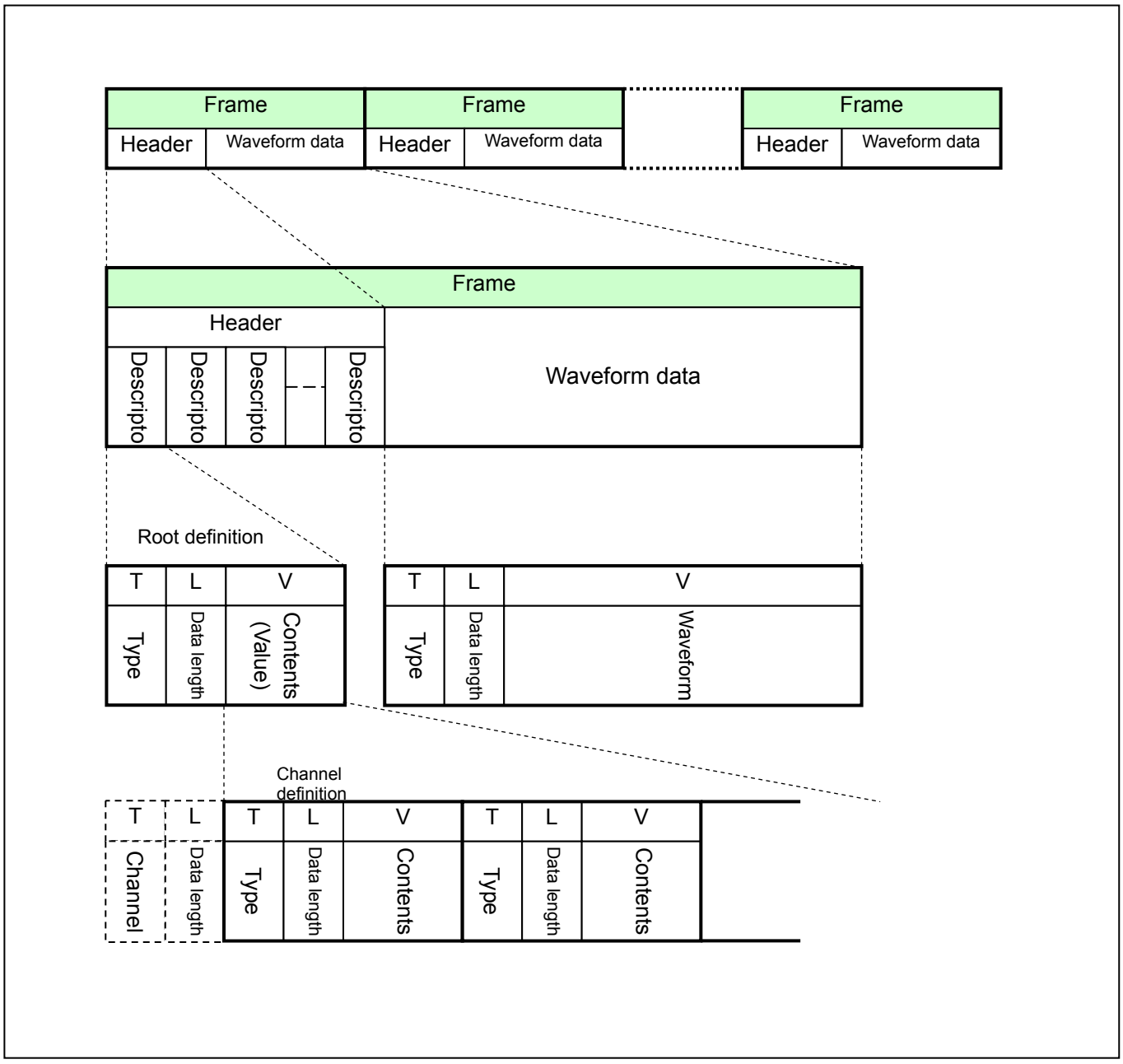


Figure 6. Encoding format

Example 3. Alignment of waveform data values

Figure 7. shows an alignment of data values in a frame. One data block consists of five sampled data. If each value is encoded with a 16-bit integer, one data block is formed with 10 octets. As the number of channels is 3, three data blocks, each consisting of five sampled data, are encoded in one data group through one sequence. The sequence is repeated four times in this example.

If sampling is made at 4 ms intervals, that is, at a frequency of 250 Hz, 20 ms data (4 ms x 5 sampled data = 20 ms) are stored in one block. As the number of sequences is 4, the waveform data per each channel is 80 ms (20 ms x 4) in length.

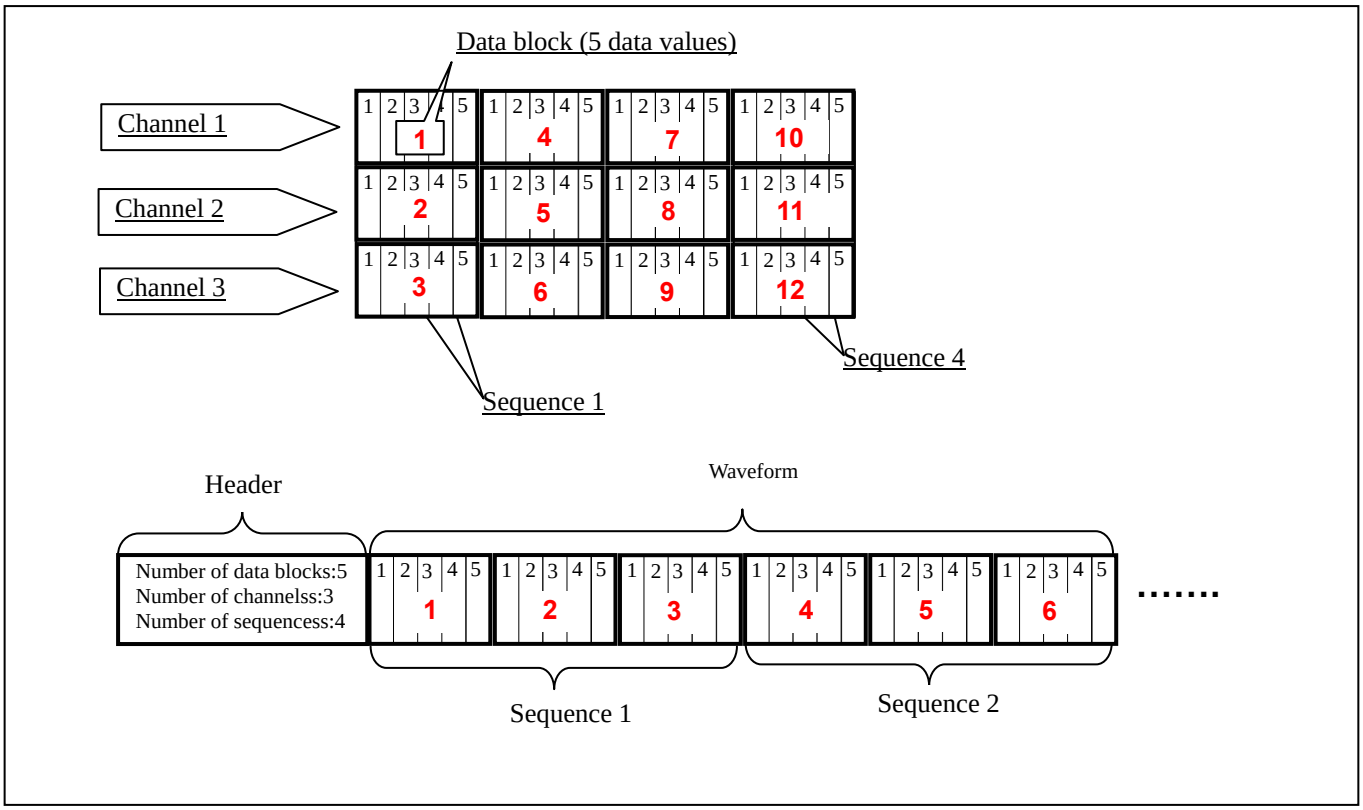


Figure 7. Waveform data alignment

5.1.3. Encoding rules

The header and waveform data shall be encoded based on the encoding rules and shall be composed of the type, length and value (TLV). The type, hereinafter called tag, indicates the attributes of the data. Although MFER resembles BER (basic encoding rules) in this point, it should be noted that the tag in MFER is completely different from the tag in BER.

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

Figure 8. Data unit

- The tag (T) consists of one or more octets and indicates the attributes of the data value.
- The data length (L) is the length of data values indicated in one to four octets (the number of octets used for the data length section is up to five).

Note: If the value section uses 128 or more octets, the first octet of the data length section indicates the number of octets (0x80 + length octets) used for the data length and the subsequent octets indicate the data length.

- The value (V) is the contents, waveform data or the like, of the attribute identified by the tag.

5.1.3.1 Type (Tag)

The tag is composed of a class, primitive/context (P/C) and tag number. The tag is sorted into four classes. Class 0 is MFER level 1, class 1 is MFER level 2, class 2 is MFER level 3 and class 3 is for private use. The private level is intended for special research purposes but future updates are expected to make it compatible with common use.

8	7	6	5 4 3 2 1
Class		P/C	Tag Number
0	0	0	Level 1
		1	
0	1	Level 2	
1	0	Level 3	
1	1	Private	

Figure 9. Type(tag)

A channel definition for each channel is encoded with a special context tag of P/C = 1 and tag number of 1F (31). That is, the type number is P/C + tag number encoded with 3F (63) and identifies the attribute of the relevant channel. The channel number is identified with 7 bits in the octet with bit 8 = 0 for up to 127th channel and with bit 8 = 1 for 128th or higher channel. Thus, channel numbers are successively identified by every 7 bits of subsequent octets.

8	7	6	5 4 3 2 1	8		8		8	
0	0	1	31(1FH)	1	Channel Number1	1	····	0	Channel Number N

Figure 10. Channel definition tag

5.1.3.2 Data length

The data length indicates the number of octets used for data values in the value (V) section (that is, the length excluding octets used for tag and data length sections). The data length encoding method differs depending on whether the number of octets used for data is less than 127 or more than 128 octets,.

(1). In case the data value section uses 127 octets or less

The data length is encoded in one octet.

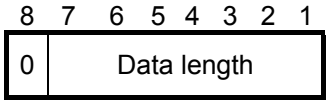


Figure 11. Data length (<=127 octets)

(2). In case the data value section uses 128 octets or more

The total data length is encoded using multiple octets. The first octet identifies the number of octets used to indicate the total data length. For example, two subsequent octets are used to indicate the number of octets from 128 to 65535 and thus three octets are used to encode the data length. However, MFER allows representation of a data length using multiple octets even if the value section uses 127 octets or less. Also, users' systems may designate a maximum data length.

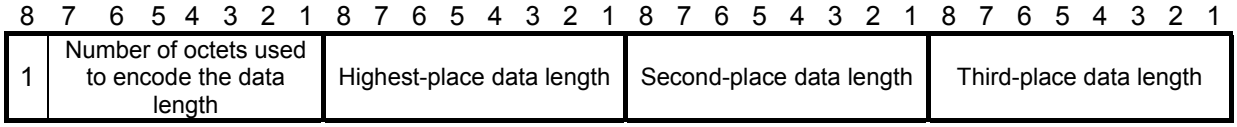


Figure 12. Data length (<16777216 octets)

(3). Designation of infinite data length

MFER allows designation of an infinite data length by encoding 0x80 for the data length. This infinite length designation is terminated by encoding the end-of-contents (tag = 00, data length = 00). In MFER, the infinite length designation is available only with the tag number 0x3F (definition of the channel attribute).

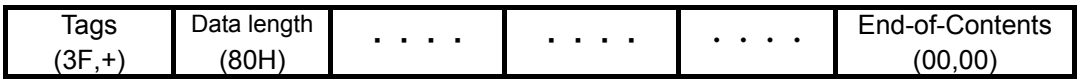


Figure 13. Infinite length designation and end-of-contents designation

(4). In case the data length is 0

This indicates that the data section is blank. In MFER, this resets concerned items in the root definition to default values and places the channel definition in the condition that the root definition designates.

5.1.3.3 Value (V)

The header or waveform data values are encoded in the value section according to descriptors specified by the tag.

5.1.4. Utilization and definition

5.1.4.1 General principles for encoding and utilization

In MFER, providers and users of medical waveform data are separately considered. To encode medical waveforms (e.g. ECGs), providers are not concerned about how the waveforms will be displayed or recorded but make maximum considerations about how accurately they should represent the waveforms. Users interpret, display or record necessary information in the provided waveforms according to the in own purposes.

5.1.4.2 Encoding principle

All definitions in MFER are optional and not mandatory. That is, all tags have default values defined and as far as a tag uses the default value, the item need not be defined. Accordingly, it is expected that minimum definitions may suffice for ordinary uses.

5.1.4.3 Definition levels

(1). Level 1

Definitions at level 1 are basic definitions, which are divided into ordinary rules (marked with an asterisk) and rules for precise encoding.

(2). Level 2

Definitions at level 2 are supplementary definitions. They may be used as required but it is desirable to make the supplementary definitions with a host protocol if they can be defined with the host protocol.

(3). Level 3

Definitions at level 3 are extended definitions, which are desired to be used as limitedly as possible. Items of these extended definitions may considerably affect the system with regard to privacy, security, etc. Thus, sufficient considerations should be taken in designing them.

5.1.5. General principles in interpretation, scope and priority of definitions

(1). Initial values (default values)

All definitions in MFER have initial values that are applied until defined anew.

(2). Multiple definitions

Multiple definitions can be made for any item. Depending on items, a new definition overrides an old definition or all definitions, such as for events, are used in multiple times. e.g. Setting the sampling frequency to 250 Hz overrides the initial value of 1 kHz. If multiple events occur, they are interpreted in definition order.

(3). Later definition priority

Each definition is interpreted in definition order. If an item has related definitions, definition shall be made in due order. e.g. Before defining each channel, the number of channels shall be defined. The default is big-endian, so to use little-endian, little-endian must be designated.

(4). Channel attribute definition order

Before defining the attributes of a channel, the number of channels shall be defined. If the number of channels is defined later, previous channel definitions are reset to the root definition including default values.

(5). Root definition (general definition) and channel definition (definition per channel)

The root definition is effective for all channels. The channel definition is effective only for the relevant channel and overrides the root definition. However, caution should be taken that if the root definition is made later, it overrides the content of the relevant channel. e.g. If EEG is designated in the root definition, ECG designated for a channel in the channel definition is overriding EEG.

(6). Definition reset

If the data length is defined as zero (no data) in the definition of an item, the content in the definition is reset to default. If the data length is designated as zero in a channel definition, the definition follows the root definition including default. If the number of channels is defined, contents defined for the channel attribute are all reset to the root definition including default.

(7). Incomplete definition ignored

If a definition is made without the necessary preceding definition, the definition is ignored. e.g. A channel definition made with the number of channels undefined is ignored.

(8). Succession of definitions

Unless redefined, each definition applies to all succeeding frames, in the effective range, except for the data pointer which is succeeding renewed. e.g. To use little-endian for all encodings with MFER, define little-endian once, then it is effective over the whole region irrespective of frames. Contents defined in the root definition are applies to all frames unless overridden by channel definition. Thus, it suffices to define common items in the root definition.

(9). Definition and efficacy of data

It depends on the functions of the user whether data defined by the provider can be used by the user or not. If some content cannot be processed, users may discard all the data or use the processible range of data.

5.1.6. Waveform time and synchronization

The acquisition time of the waveform is not available unless it is specified by a supplementary definition. The time, if defined with MFER, is indicated by an offset time (MWF_PNT) from an external reference clock. Thus, the time depends on the system clock. If the system manages the clock as an absolute clock, the time of waveform is an absolute time. If the time is uniformly managed with a clock within the system, the time of the waveform follows the system clock. If the time is managed within an instrument such as an electrocardiograph, the time of the waveform depends on the instrument.

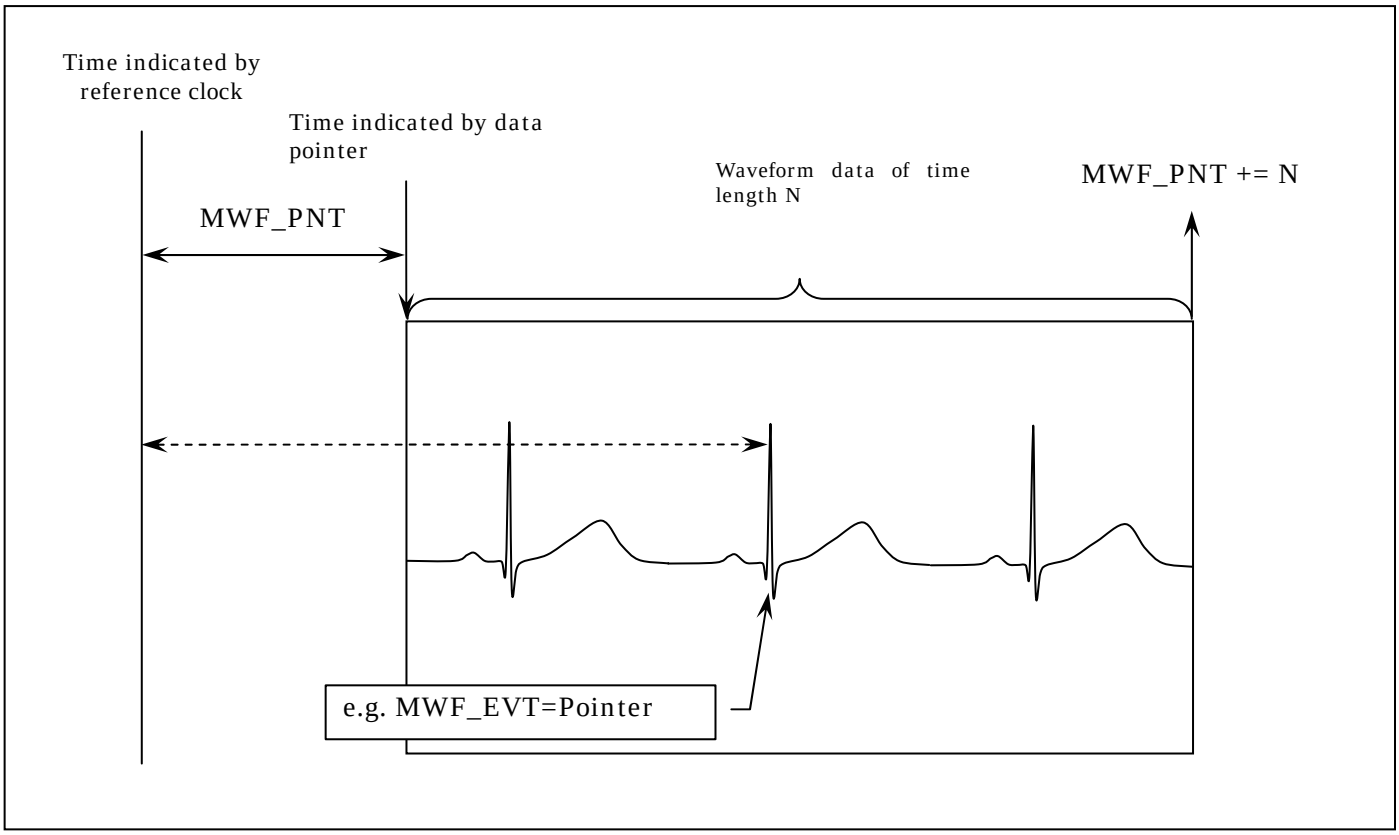


Figure 14. Clock and pointer

(1). Reference clock

If the reference clock is managed under the absolute time of GPS or the like, MFER describes the time of the waveform with an absolute time. Accordingly, synchronized processing is possible between different systems if they are managed under an absolute clock. If a reference clock is managed within a system, synchronized processing is possible within the system. If a clock is managed within an instrument, synchronized processing is possible within the instrument.

(2). Pointer

A pointer value is managed by the sampling time interval defined in the root definition. If a sampling interval is different between frames, the reference differs frame by frame. As the root sampling interval is 1 ms and a pointer is represented in signed 32 bits, it can represent up to 24.8 days as a time offset.

(3). Synchronization

The value of an event such as beat annotation is represented with the time (number of sampling times) indicated by the sampling interval defined in the root or channel definition.

(4). Renewal of pointer

If two or more frames are used, the pointer advances by the number of data values at the end of each frame. If the pointer for a subsequent frame is set to default, the frame succeeds to the pointer of the previous frame. For example, if the pointer is zero at the start of the previous frame and 5-second data (5000 data values with a sampling interval of 1 ms) are encoded in the frame, the pointer is renewed to 5000 at the end of the frame and the subsequent frame uses the pointer set at 5000. Accordingly, if the pointer is not controlled at the each frame, these waveform data are encoded as continuous frames.

(5). Pointer management

- For a long time data acquisition system such as a patient monitoring system, the A/D converter clock may differ from the master clock. In such case, the pointer of subsequent frames can manage skipped (leap data) or defective data.
- In stored data or received data, the pointers indicate whether each frame is continuous or not.

5.2. Rules

5.2.1. Sampling attributes

Sampling attributes include major sampling parameters such as sampling interval (or sampling frequency) and resolution (sensitivity), and supplementary information of the type of data, an offset value and a null value.

(1). MWF_IVL (0V): Sampling rate

This tag indicates the frequency or interval the medical waveform is sampled.

MWF_IVL *			Data length	Default	Encoding range/remarks	Duplicated definitions
11	0Bh	Unit	1	1000Hz		Override
		Exponent (10th power)	1		$10^{-128\sim+127}$	
		Integer	≤4		e.g. signed 16-bit integer	

Table 2. Sampling rate

The unit may be frequency (Hz), time (s) or distance (m).

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

Table 3. Sampling rate unit

(2). MWF_SEN (0C): Sampling resolution

This tag indicates the resolution, minimum bits, the medical waveform is sampled (generally, digitized).

MWF_SEN *			Data length	Default	Encoding range/remarks	Duplicated definitions
12	0Ch	Unit	1	Unfixed		Override
		Exponent (10th power)	1		$10^{-128\sim+127}$	
		Integer	≤4		e.g. signed 16-bit integer	

Table 4. Sampling resolution

As an exciter or amplifier affects A-D conversion, the minimum number of bits allowed for the waveform shall be specified to make the influence as little as possible.

Unit		Value	Remarks
Potential	Volt	0	
Pressure	mmHg (torr)	1	
	Pa	2	
	cmH2O	3	

	mmHg/S	4	
Force	dyne	5	
	N	6	
Ratio	%	7	Same code is used for Vol%
Temperature	℃	8	
Heart rate	/m	9	
	/s	10	
Resistance	Ω	11	
Current	A	12	
Number of revolutions	r.p.m.	13	
Power	W	14	
	DB	15	
Weight	Kg	16	
Work volume	J	17	
Vascular resistance	dyne s m-2 cm-5	18	
Flow rate, flow volume	L	19	
	L/s	20	
	L/m	21	
Candela	cd	22	

Table 5. Sampling units

(3). MWF_DTP (01): Data type (type of encoding)

This tag indicates the type of waveform data. While medical waveforms are usually sampled with a precision of 12 bits, they are all interpreted and encoded as 16-bit data.

MWF_DTP		Data length	Default	Remarks	Duplicated definitions
10	0Ah	1	signed 16-bit integer		Override

Table 6. Data type

Value	Type of data
0	16-bit signed integer, –32768～32767
1	16-bit unsigned integer, 0～65535
2	32-bit signed integer
3	8-bit unsigned integer
4	16-bit status
5	8-bit signed integer
6	32-bit unsigned integer
7	32-bit single-precision floating decimal number (IEEE754)
8	64-bit double-precision floating decimal number (IEEE754)
9	8-bit AHA compression method

Table 7. Data type code

(4). MWF_OFF (0D): Offset value

This tag indicates an offset value of sampling data. Encoding of an offset value depends on the type of encoding data.

MWF_OFF		Data length	Default	Remarks	Duplicated definitions
13	0Dh	≤8 (depends on types of encoding data values)	0		Override

Table 8. Offset value

(5). MWF_NUL(12) : NULL value

This tag indicatse null data so that existing data is ignored as no data. As null data uses the same encoding space as waveform data, the tag should be used carefully. For example, a minimum negative value 8000h is occasionally used for a null value. Encoding of a null value depends on the type of encoding data.

MWF_NUL		Data length	Default	Remarks	Duplicated definitions
18	12h	≤8 (depends on types of encoding data values)	Unused		Override

Table 9. Null value

5.2.2. Definition of frame attributes (data alignment)

As described in 5.1.1.2, a frame is composed of data blocks, channels and sequences.

(1). MWF_BLK(04) : Data block length (number of data values)

This tag indicates the number of data values sampled in a block. The number of octets used for real data values depends on the type of data. If 10 data values are encoded in the block and the type of data is signed 16-bit integer, the number of octets for the real data is 20 octets (10 x 2).

MWF_BLK*		Data length	Default	Remarks	Duplicated definitions
04	04h	≤4	1		Override

Table 10. Data block length

(2). MWF_CHN(05) : Number of channels

This tag indicates the number of channels. As the previously specified channel attribute is reset to the root definition including default, the number of channels shall be specified before defining the channel attribute. The number of channels cannot be specified with a channel definition of channel attribute.

MWF_CHN*		Data length	Default	Remarks	Duplicated definitions
05	05h	≤4	1		Override

Table 11. Number of channels

(3). MWF_SEQ(06) : Number of sequences

This tag indicates the number of sequences. If the number of sequences is not designated, it depends on the data block length, the number of channels and the number of waveform data values, which are defined for the concerned frame.

MWF_SEQ*		Data length	Default	Remarks	Duplicated definitions
06	06h	≤4	Depends on waveform data length		Override

Table 12. Number of sequences

(4). MWF_PNT(07) : Pointer

This tag indicates the heading pointer for the waveform data in the frame. If no pointer is designated, the heading of the waveform is processed as zero. The pointer for the next frame is deemed to be a value adding the number of data values in the previous frame.

For example, if no pointer is specified for the first frame with the sampling interval set at 2 ms and the number of data values set at 1000 and the number of sequences set at 1 in the root definition, the pointer for the second frame advances by 2 seconds (1000 data values x 1 sequence of 2 ms).

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

Table 13. Pointer

(5). Frame encoding examples

a. In case the number of data values is less than designated for the frame

Suppose block length is 5, the number of channels is 3 and the number of sequences is 4. If the total number of real data values is (5 x 3 x 3 +8), seven remaining data value fields are processed as no data. Here, it depends on the processing system whether the memory area is secured or not. If the number of sequences is not specified and the default is used, no memory area is secured.

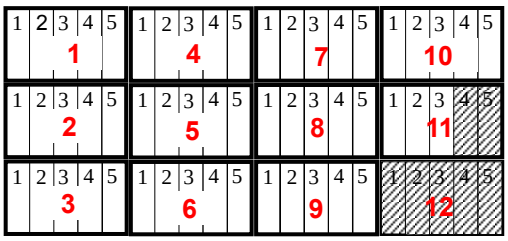


Figure 15. Example of a frame with blank data field

b. In case the number of data values is more than specified for the frame

Suppose the data length is 5, the number of channels is 3 and the number of sequences is 4. If the number of data values is (5 x 3 x 4 + 8), eight data values flowing over the frame are skipped.

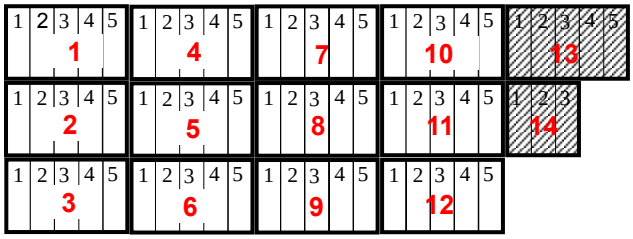


Figure 16. Example of a frame with some data values overflowed

c. In case a different number of data values in a block is specified by a definition of channel attributes

Suppose the root definition specifies that the data block length is 2, the number of channels is 3 and the number of sequences is 4. If a definition of channel attributes (channel definition) overrides the number of data values in a block 2 with 5 for the channel, the result is as follows:

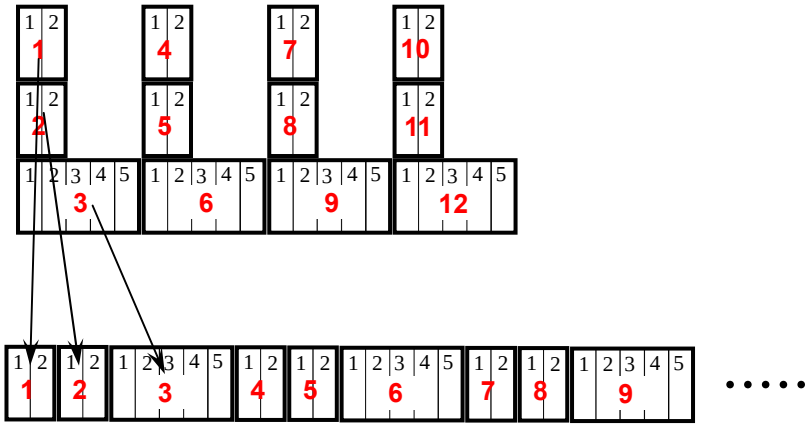


Figure 17. Definition of channel attributes overriding the number of data values in a

d. In case a different number of sequences is specified by a definition of channel attributes

Suppose the root definition specifies that the data block length is 5, the number of channels is 3 and the number of sequences is 4. If a definition of channel attributes (channel definition) overrides the number of sequences 4 with 2, the result is as follows

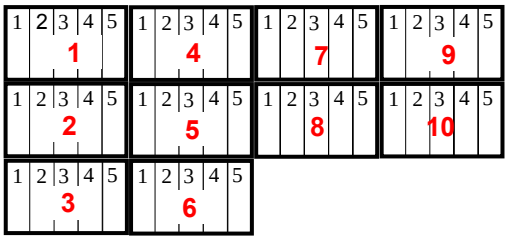


Figure 18. Definition of channel attribute overriding the number of

5.2.3. Waveform Encoding

The waveform type, waveform attributes and waveform data are encoded as follows.

(1). MWF_WFM(08) : Type of waveform

Types of waveforms such as standard 12-lead ECG and monitoring ECG are grouped based on instruments and purposes.

MWF_WFM*		Data length	Default	Remarks	Duplicated definitions
08	08h	≤2	Unidentified		Override

Table 14. Classification of waveforms

As a rule, standardization will be made by types of waveforms. However, since encoded waveforms such as ECG and EEG are used in monitors, common specifications are applied as much as possible to these waveforms. For details, refer to the specification for each individual waveform.

Classification	Type	Value	Description	Reference	Remarks
		0	Unidentified		
Electrocardiogram	ECG_STD12	1	Standard 12 lead ECG	Part3-1	Different kinds of 12 lead ECGs including general ECGs can be encoded.
	ECG_LTERM	2	Long-term ECG	Part3-2	Holter ECG, monitoring ECG
	ECG_VECTR	3	Vectorcardiogram	Part3-5	
	ECG_EXCER	4	Stress ECG	Part3-3	
	ECG_INTR	5	Intracardiac ECG	Part3-4	His bundle ECG, intracardiac ECG, intravascular ECG, cardiac surface ECG
	ECG_SURF	6	Body surface ECG	Part3-5	Body surface potential map Body surface His bundle ECG
	ECG_ILATE	7	Ventricular late potential	Part3-5	
	ECG_LATE	8	Body surface late potential	Part3-5	
Sound	SOUND	30	PCG, etc.	Part3-13	8 kHz,11 kHz,22 kHz etc.
Pulse	PULSE	31	Fingertip pulse, carotid pulse	Part3-14	
Monitoring	MON_LTRM	20	Long-term waveform	Part3-10	
	MON_SPL	21	Sampled waveform	Part3-10	
	MON_PWR	25	Power spectrum	Part3-9	Some part is EEG_CSA.
	MON_TRD	26	Trendgram	Part3-11	
Magnetocardiogram		100	MCG	Part3-12	
Electroencephalogram	EEG_REST	40	Resting EEG	Part3-6	Includes surgical monitoring EEG.
	EEG_EP	41	Evoked EEG	Part3-7	ABR SEP
	EEG_CSA	42	Frequency analysis	Part3-8	
	EEG_LTRM	43	Long-term EEG	Part3-6	Sleeping EEG
Private	49152～65535				

Table 15. Classification of waveforms

For types of waveforms, numbers 1 to 49151 (BFFFh) are already taken. Numbers 49152 to 65535 may be used privately but shall be used for new types of waveforms by upgrading MFER as quickly as possible.

(2). MWF_ATT(3F) : Channel attributes (channel definition)

This tag enables definition of the attributes of each individual channel. Before defining, it is required to specify the channel number with MWF_CHN (05): number of channels.

The method to encode a channel number differs depending on whether it is ≤127 or ≥ 128. Refer to Figure 19. for ≤127 and Figure 20. for ≥128.

MWF_ATT*		Data length	Default	Remarks	Duplicated definitions
63	3Fh	Depends on definition.			Override

Table 16. Channel attributes

For the tag of the channel attribute definition, context mode is selected with P/C (bit 6 = 1).

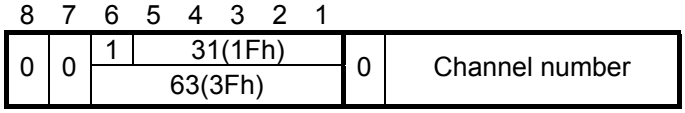


Figure 19. Number of channel ≤ 127

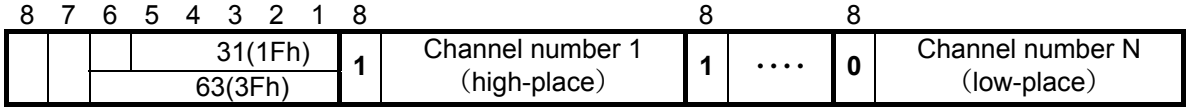


Figure 20. Number of channel ≥ 128

The data length involves all the range of the channel attribute definition.

Tag		Data length	Group of definition									
3Fh	Channel number	Whole definition	Channel attribute definition			Channel attribute definition			·····	Channel attribute definition		
			T	L	V	T	L	V		T	L	V

Figure 21. Definition of channel attributes

The infinite length described in 5.1.3.2(3). can be used for the channel attribute definition.

Tag		Data length	Group of definition								
3Fh	Channel number	80h	Channel attribute definition			Channel attribute definition			·····	End-of-contents	
			T	L	V	T	L	V		00	00

Figure 22. Definition of channel attributes with infinite length

(3). MWF_LDN(09) : Attributes of waveform (lead name, etc.)

Code and information can be added to the type of waveform. If a waveform is required to be reconfigured as in the case of deriving leads III and aVF from leads I and II, the codes shall always be specified. The codes should be taken into special consideration as they have a function to specify some processing as in the case of deriving other limb leads from leads I and II or deriving a waveform based on the lead name.

As the lead names are defined depending on the type of waveform, they are not consolidated throughout each type of waveform in MFER. Thus, caution should be taken in encoding lead names.

For waveform codes, numbers 1 to 49151 (BFFFh) are already taken. Numbers 49152 to 65535 may be used privately but shall be used for new types of waveforms by upgrading the MFER as soon as possible.

MWF_LDN *			Data length	Default	Data range , remarks	Duplicated definitions
09	09h	Waveform code	≤2	Unidentified	Data length = 2, if waveform information is encoded	Override
		Waveform information	Str≤32			

Table 17. Definition of waveform attribute

Example 4. Standard 12 leads ECG leads code

Standard 12 leads are encoded according to the SCP-ECG coding system. (If no waveform information is encoded, a lead name may be encoded in one octet.)

Code	Lead	Code	Lead
1	I	61	III
2	II	62	aVR
3	V1	63	aVL
4	V2	64	aVF
5	V3	66	V8
6	V4	67	V9
7	V5	68	V8R
8	V6	69	V9R
9	V7		
11	V3R		
12	V4R		
13	V5R		
14	V6R		
15	V7R		

Table 18. Codes of standard 12 leads

Example 5. Monitoring waveform

Encoding monitoring waveform information

Waveform Code	Waveform information	
128		Encoded aortic pressure codes
129	“Aorta”	Encoded with arterial pressure and aorta
143	“Aorta”	Encoded with pressure and aortic pressure

Table 19. Blood pressure waveform (aortic blood pressure waveform)

Example 6. Electroencephalogram waveform

Generation of waveform codes by combination of electrodes

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

Figure 23. Generation of waveform code by combination of electrodes

Waveform codes can be generated by combination of electrode codes.

Name	Abbr.	Electrode code
Left Front polar	FP1	12
Right Front polar	FP2	13
Left Ear	A1	74
Right Ear	A2	75

Table 20. Electrode codes (refer to Part 3-6 for full details)

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

Table 21. Example of waveform code generation

(4). MWF_INF(15) : Waveform information

This tag enables encoding of incidental information for waveforms.

MWF_INF			Data length	Default	Data range , remarks	Duplicated definitions
21	15 h	information code	2			Multiple definitions are possible
		Starting time (point)	4		Point number based on the sampling interval specified in the root definition	
		Duration	4			
		Waveform information	Str≤256			

Table 22. Waveform information

Encoding contents of incidental information are as follows:

a. Information related to waveform generation

Information directly related to the generation on waveforms, such as wavelengths of infrared light and red light for SpO2 measurement or catheterization coefficient, injection temperature, injection quantity and blood temperature for thermodilution cardiac output measurement. Calibration waveform and the flush of blood pressure sensor may also be described in the waveform information.

b. Information indirectly affecting waveforms

Information indirectly affecting the generation of waveforms, such as photic stimulation and hyperventilation for EEG measurement.

c. Recording conditions

Recording conditions such as failure to balance the zero of blood pressure sensor and lead-off.

The following models are available for waveform information:

Waveform information	Code only	Code + starting time	Code + starting time + duration	Presence of waveform information
Information code	Applied to the whole waveform	Concerned event at concerned time	Concerned event during the duration from the starting time	Indicates whether descriptive information supplementing the information code is encoded.
Starting time				
Duration				
Supplementation				

Table 23. Encoding of waveform information (with code)

Incidental information	Waveform information only	Waveform information + starting time	Waveform information + starting time + duration
Information code	Designation of no code; e.g. 0 or -1		
Starting time	0	Starting time	Starting time
Duration	0	0	Duration
Supplementation	Supplementary information (encoded with character strings)		

Table 24. Encoding of waveform information (with no code)

d. Supplementary explanation

The information can be utilized by vendors and researchers as a character string. It is recommended to use a format involving the vendor's name, code classification and diagnosis name. It is also recommended to encode description in such a manner as description coding system (vendor's name) code or an abbreviated name.

(5). MWF_FLT(11) : Filter

This tag describes the filter name which is used during MFER waveform data recording.

Note: MFER recommends to store original waveforms if possible. If display or recording during measurement uses a filter, MFER describes the filter with waveform information data unit.

MWF_FLT		Data length	Default	remarks	Duplicated definitions
17	11h	Str≤32	unused		Possible

Table 25. Filter

Example 7. Filter name

As shown below, a filter or the characteristic is encoded as a character string. It is desirable to define the details through negotiation with users.

Hum filter ON

Secondary Butterworth

Chebycheff

Elliptic

(6). MWF_IPD(0F) : Interpolation or decimation

When encoding the waveform through interpolation or thinning-out, the fact is encoded with this tag.

MWF_IPD			Data length	Default	Remarks	Duplicated definitions
15	0Fh	Code	1	unused		
		Supplementary information	2			

Table 26. Interpolation or decimation

Name	code	Supplementary description
Unconditional decimation	1	
Unconditional interpolation	2	
Lagrange ｌs interpolation	3	Order
Spline interpolation	4	Order
Linear interpolation	5	
Addition	6	Number of adding times

Table 27. Interpolation/decimation codes

(7). MWF_WAV(1E) : Waveform data

The entity of waveform data shall strictly be encoded following the waveform encoding method. If the waveform is compressed, the encoding method depends on the compression method. But the waveform decompressed shall be processed according to the encoding method.

If waveform data are different from what are defined in frame information, it is recommended to discard data exceeding the defined data length and to process blank data fields as no data. However, such processing depends on users and is not guaranteed.

MWF_WAV			Data length	Default	Remarks	Duplicated definitions
30	1Eh	Data	Waveform length			

Table 28. Waveform data

5.2.4. Encoding of control parameters

(1). MWF_BLE(01) : Endianity

This tag enables designation of the octet alignment in the data section (TLV values only). The big-endian is the octet alignment where octets are aligned from most significant to least significant. This is used by Sun Microsystems and Macintosh CPU. The little-endian is the octet arrangement where octets are aligned from least significant to most significant. This is used by Intel CPU.

MWF_BLE		Data length	Default	Remarks	Duplicated definitions
01	01h	1	Big-endian		Override

Table 29. Endianity

Endianity	
0	Big-endian
1	Little-endian

Table 30. Big/little endian

However, irrespective of the specification by this tag, the tag and data length are processed in the network alignment (big-endian).

(2). MWF_VER(02) : Version

A version is composed of three parts (three octets).

Precaution: Versions should be managed by taking into sufficient consideration the compatibility between old and new versions.

In referring to the database of an old version with a new version, the old specification is assured securely. In referring to the database of a new version with an old version, the specification of the old version is assured.

MWF_VER		Data length	Default	Remarks	Duplicated definitions
02	02h	1	0	Main version	Override
		1	0	Sub version	
		1	0	Revision history	

Table 31. Version

(3). MWF_TXC(03) : Character code

This tag enables designation of the character code used for the text (e.g. ISO 2022 for Japanese text). If text is written with no character code specified, it is not assured whether users can process the text or not.

MWF_TXC		Data length	Default	Remarks	Duplicated definitions
03	03h	Str≤16	ASCII		Override

Table 32. Character code system

For the structure and meaning of each coding system, refer to the proper specification.

Character code	Note	Description
JIS X 0201	Japanese katakana	Code for Information Exchange (ISO-IR 13) -1976
	Japanese romaji	Code for Information Exchange (ISO-IR 14) -1976
JIS X 0208	Japanese kanji, hiragana, katakana	Code for the Japanese Graphic Character set for information interchange (ISO-IR 87) -1990
JIS X 0212	Japanese kanji	Code of the supplementary Japanese Graphic Character set for information interchange (ISO-IR 159) -1990
RFC 1468	Japanese characters for internet	Japanese Character Encoding for Internet Messages
ISO 2022		Information Technology - Character code structure and extension techniques ISO/IEC 2022-1994
ISO 8859		Information Processing - 8-bit single-byte coded graphic character sets - parts 1-9 for ISO-IR 100, 101, 109, 110, 144,127, 126, 138 and 148.
ANSI X3.4		1986 ASCII character set
ISO 646		1990 Information Processing - ISO 7-bit coded character set for information interchange
ISO 2375		1986 Data Processing - Procedure for the registration of escape sequences
ISO 6429		1990 Information Processing - Control functions for 7-bit and 8-bit coded character sets
ENV 41 503		1990 Information systems interconnection - European graphic character sets and their coding
ENV 41 508		1990 Information systems interconnection - East European graphic character sets and their coding
UNICODE	UTF-8	The world wide character standard from ISO/IEC 10646-1-19933

Table 33. Character codes

(4). MWF_ZRO(00) : Blank/end-of-contents

Usually, a blank tag is not analyzed. This tag also indicates the end of the infinite length if designated, together with data length = 0.

MWF_ZRO		Data length	Default	Remarks	Duplicated definitions
00	00h	1			Multiple use possible

Table 34. Blank or end-of-contents

(5). MWF_NTE(16) : Comment

This tag encodes a memo or comment it does not directly affect encoding of waveforms.

Note: Information affecting waveforms is encoded using the MWF_INF tag (waveform information).

MWF_NTE		Data length	Default	Remarks	Duplicated definitions
22	16h	Str≤256			Multiple use possible

Table 35. Comment

A comment shall be encoded within 256 characters but multiple comments may be written as required. It depends on the user's system whether a comment has the meaning or not. A long comment can be written by using this tag in required number of times.

By using a special control code, the content of a comment can be given a specific meaning to indicate details to computers.

a. Control characters

Control characters are used to specify special processing. They are not case sensitive.

Control character	Meaning	Remarks
<	Indicates the start of control sentence structure.	Control sentence continues until closed with the control character (>).
>	Indicates the end of control sentence structure.	
C	Indicates a channel.	Indicates the channel number.
L	Indicates a lead.	Indicates a lead of ECG, EEG, etc. Depends on lead composition.
P	Pointer	Indicates a position (pointer) of waveform.
F	Filter	Applied filter
S	Sensitivity	Recording sensitivity
¥	Backslash "¥"	A character following ¥ is not recognized as a control character.

Table 36. Control characters

The control sentence structure is <control character = control information>.

Example 8. Comment with control

<C=2><P=100> abnormal waveform observed is a comment indicating that an abnormal waveform is observed at the pointer position of 100 in the second channel of the concerned frame.

<L=1 FP1-A1> indicates that a lead between FP1 and A1 was recorded in the EEG lead channel 1.

<F LP=50> indicates that the waveform was recorded with the low-pass filter set at a cutoff frequency of 50Hz.

(6). MWF_MAN(17) : Information on waveform generating machine

This tag encodes the information on the manufacturer, model and version number of the medical waveform generating machine with a component separator in between.

MWF_MAN		Data length	Default	Remarks	Duplicated definitions
23	17h	Str≤128	none		Override

Table 37. Information of waveform generating machine

Example 9. Manufacturer information

Manufacturer^model^version number^serial number

a. MWF_CMP(0E) : Compression

This tag is to compress the encoding waveform.

MWF_CMP			Data length	Default	Remarks	Duplicated definitions
14	0Eh	compression code	2			
		Data length	4		Data before compression	
		Compressed data	Data length after compression		Compressed data	

Table 38. Compression

MFER enables encoding of waveforms by compressing. This improves the efficiency of encoding capacity but makes the processing speed lower. So, sufficient consideration should be made when compressing. If compression is specified with this tag (MWF_CMP), data in the header section or waveforms in the data section are all compressed thereafter. Compressed data block length and channels in sequences may not be available depending on compression methods but the encoded frame information returns after decompression.

Compression ID	Compression method	Description
0	No compression	No compression applied to data encoding (default)
2	MFER	Compression applied to header section
3		Compression applied to waveform data section

Table 39. Compression method

Compressed data

Tag	0Eh
Data length	Length of whole data section
Compression code	2
Data before compression	Length of data before compression
Compressed data (header)	Compressed data (data of header)

Table 40. Compression applied to header section

Tag	0Eh
Data length	Length of whole data section
Compression code	3
Data before compression	Length of data before compression
Compressed data (waveform data)	Compressed data waveform data

Table 41. Compression applied to waveform data

5.3. Supplementary tag

Supplementary tags are level 2 and are used for encoding of events and measurement information. It is recommended to commit encoding of such information to the HL7 or DBMS if possible.

(1). MWF_PRE(40) : Preamble

This tag for a special purpose is encoded at the heading of a file or other plcase to indicate the attributes of the entire MFER waveform file and data. The MWF_PRE is fixed in length. The classification is in four characters (MFR + space) and description is in a fixed number of 28 characters. Blank fields, if any, are to be filled with 00h or space (20h).

MWF_PRE		Data length	Default	Remarks	Duplicated definitions
64	40h	4		"MFR "	To be encoded at the head
		28		28 chars.	

Table 42. Preamble

Example 10. Preamble information

"MWF_PRE 0x20 MFR Standard 12 leads ECG" is equal to "@MFR Standard12 leads ECG"

(2). MWF_EVT(41) : Event

This tag is to encode supplementary waveform information such as events.

MWF_EVT			Data length	Default	Encoding range/remarks	Duplicated definitions
65	41h	event code	2	None		Multiple use possible
		Starting time (point)	4		Number of data values acquired at the sampling interval defined in the root definition	
		Duration	4			
		Event information	Str≤256			

Table 43. Event

- Beat annotation: For classification of waveforms, etc.
- Interpretation: For interpretation of relevant waveform

The following models are available for the event encoding structure:

a. Event code only

If the starting time (point) and duration (points) are not specified, the event applies to the whole entire waveform.

b. Event code and starting time (point)

If the event code and starting time are specified, the concerned event exists only at the starting time.

c. Event code, starting time (point) and duration (number of points)

The event exists for the duration from the starting time.

Event	Code only	Code + starting time	Code + starting time + duration	Presence of event information
Event code	Event is applied to entire waveform	Event is at specified time	Event is during the duration from the starting time	Indicates whether descriptive information is encoded to supplement the event code.
Starting time				
duration				
Event information				

Table 44. Event (with event code)

Incidental information	Event information only	Presence of starting time	Presence of starting time and duration
Event code	Designation of no code; e.g. 0 or -1		
Starting time	0	Starting time	Starting time
duration	0	0	duration
Event information	Event information is encoded with character strings.		

Table 45. Event (with no code)

d. Event information

A character string of event information can be encoded for any event other than specified by a common event code or to add a comment or to be used for a special purpose by vendors and researchers.

It is recommended to use a format such as vendor, code classification and diagnosis. It is also recommended to encode description in such a manner as description^coding system (vendor)^code or abbreviation.

Example 11. Event

Ventricular Premature Contraction (in case no vendor is specified)

Ventricular premature beat^Nihon manufacture co. (in the case no code is used)

PREMATURE VENTRICULAR CONTRACTIONS^ LOINC^8646-5

ventricular premature complex ^SCP-ECG^VPC

Premature ventricular contraction ^VSIR^3204

(3). MWF_VAL(42) : Value (measurements, etc.)

This tag is to encode waveform-related information such as measurements.

MWF_VAL			Data length	Default	Encoding range/remarks	Duplicated definitions
66	42h	Value code	2	None		Multiple definitions available
		Time point	4		Number of data values sampled is encoded.	
		value	Str≤32		Value is encoded with a character string with unit (“^”)	

Table 46. Value

Example 12. Measurement value

If heart beat is found at the concerned time,

MWF_VAL heart rate code (provided in the specification for each waveform)

Point = -1

"80^/min" ‥‥‥‥‥Heart rate is 80 bpm.

"120^mmHg" ‥‥‥Blood pressure is 120 mmHg.

(4). MWF_CND(44) : Acquisition or processing information

This tag represents the acquisition condition or processing information during the waveform acquisition processing. For example, if the EEG waveforms are stored in original form but displayed with a montage during examination, the montage is represented with this tag to reproduce the integrity with combination electrodes.

MWF_CND			Data length	Default	Remarks	Duplicated definitions
68	44h	Acquisition condition	2		Recording/Montioring	
		Description code 1	2			
		Description code 2	2			
		Starting point	4			
		Duration	4			
		Descriptive information	Str≤256			

Table 47. Recording/display condition

MFER requires faithful reproduction form. For example, the waveform was displayed during measurement using some filter, but the waveform in MFER coding is stored in unprocessed form as far as possible and filter or montage information are described in this tag, The contents for expected faithful reproduction are encoded with description codes 1 and 2. The conditions are provided in the waveform specifications (Part 3).

(5). MWF_SKW(43) : Sampling skew

This tag represents the time skew between channels by A-D conversion. Though the most recent devices may not require the designation of such a time skew, it may be designated as required, using this tag.

MWF_SKW		Data length	Default	Remarks	Duplicated definitions
67	43h	2	0	Time skew between channels is encoded in ns.	Override

Table 48. Sampling skew

5.4. Extension tag

The extension tags are for the extended supplemented information with MFER. These information should be represented with system standard such as HL7,DICOM, and so on. The patient demographic information should take into consideration a privacy and security.

(1). MWF_PNM(81) : Patient name

This tag represents a patient name. It is recommended to encode a patient name as follows:

Family name^^first name^^middle name

Note(Japanese):family name^family name (furigana)^first name^first name(furigana)^middle name^middle name(furigana)

MWF_PNM		Data length	Default	Remarks	Duplicated definitions
129	81h	Str≤128	None		Override

Table 49. Patient name

(2). MWF_PID(82) : Patient ID

This tag identifies a patient identification number. The way of using and managing patient ID numbers is beyond the scope of MFER. It is recommended to encode a patient identification number as follows:

Patient ID^Local ID^Temporary ID

If no separator("^") is used, patient ID data is processed as a unique ID in the system.

MWF_PID		Data length	Default	Remarks	Duplicated definitions
130	82h	Str≤64	None		Override

Table 50. Patient ID

(3). MWF_AGE(83) : Date of birth, age

This tag is to encode the date of birth and age. The age is based on the date of examination or measurement.

MWF_AGE				Data length	Default	Remarks	Duplicated definitions
131	83h	Age	Years	1	None		override
			Days	2			
		date of birth	Year	2			
			Month	1			
			Day	1			

Table 51. Age

(4). MWF_SEX(84) : Sex

This tag is to encode the sex of the patient.

MWF_SEX		Data length	Default	Remarks	Duplicated definitions
132	84h	1	Unclear		override

Table 52. Sex

Sex	Value
Unidentified	0
Male	1
Female	2
Unfixed	3

Table 53. Sex

(5). MWF_TIM(85) : Measurement date/time

This tag is to encode the examination/measurement date/time or the data acquisition date/time. The date/time has an important meaning in encoding storage objects with MFER but it should be used carefully.

MWF_TIM			Data length	Default	Remarks	Duplicated definitions
133	85h	Year	2	None	1900 - 2100	Override
		Month	1		1 - 12	
		Day	1		1-31(1-30、1-28,29)	
		Hour	1		0 - 23	
		Minute	1		0 - 59	
		Second	1		0 - 59	
		Millisecond	2		0 - 999	
		Microsecond	2		0 - 999	

Table 54. Measurement time

(6). MWF_MSS(86) : Message

This tag is to encode a character string of an interchangeable message between systems.

MWF_MSS		Data length	Default	Remarks	Duplicated definitions
134	86h	Str≤1024	none	Message will be defined for each purpose.	Duplicated definition possible

Table 55. Message

5.5. List of tags

Name of tag	Code		Description	Referrence
*MWF_IVL	11	0B	Sampling interval	エラー！参照元が見つかりません。
*MWF_SEN	12	0C	Sampling resolution	エラー！参照元が見つかりません。
*MWF_BLK	04	04	Data block length	エラー！参照元が見つかりません。
*MWF_CHN	05	05	Number of channels	エラー！参照元が見つかりません。

*MWF_SEQ	06	06	Number of sequences	エラー！参照元が見つかりません。
*MWF_WFM	08	08	Type of waveform	エラー！参照元が見つかりません。
*MWF_ATT	63	3F	Channel attribute definition	エラー！参照元が見つかりません。
*MWF_LDN	09	09	Waveform attribute	エラー！参照元が見つかりません。
*MWF_WAV	30	1E	Waveform data	エラー！参照元が見つかりません。
MWF_DTP	10	0A	Type of data	エラー！参照元が見つかりません。
MWF_OFF	13	0D	Offset	エラー！参照元が見つかりません。
MWF_NUL	18	12	NULL value	エラー！参照元が見つかりません。
MWF_PNT	07	07	Pointer	エラー！参照元が見つかりません。
MWF_INF	21	15	Incidental information	エラー！参照元が見つかりません。
MWF_FLT	17	11	Filter information	エラー！参照元が見つかりません。
MWF_IPD	15	0F	Interporation/deficit	エラー！参照元が見つかりません。
MWF_BLE	01	01	Byte arrangement	エラー！参照元が見つかりません。
MWF_VER	02	02	Version number	エラー！参照元が見つかりません。
MWF_TXC	03	03	Character code	エラー！参照元が見つかりません。
MWF_ZRO	00	00	Blank/end-of-contents	エラー！参照元が見つかりません。
MWF_NTE	22	16	Comment	エラー！参照元が見つかりません。
MWF_MAN	23	17	Device information	エラー！参

				照元が見つかりません。
MWF_CMP	14	0E	Compression	エラー！参照元が見つかりません。
MWF_PRE	64	40	Preamble	エラー！参照元が見つかりません。
MWF_EVT	65	41	Event	エラー！参照元が見つかりません。
MWF_VAL	66	42	Value	エラー！参照元が見つかりません。
MWF_CND	68	44	Recording/monitoring condition	5.3(4).
MWF_SKW	67	43	Waveform conversion error	エラー！参照元が見つかりません。
MWF_PNM	129	81	Patient name	エラー！参照元が見つかりません。
MWF_PID	130	82	Patient ID	エラー！参照元が見つかりません。
MWF_AGE	131	83	Date of birth, age	エラー！参照元が見つかりません。
MWF_SEX	132	84	Sex	エラー！参照元が見つかりません。
MWF_TIM	133	85	Measurement time	エラー！参照元が見つかりません。
MWF_MSS	134	86	Message	エラー！参照元が見つかりません。

Table 56. List of tags

Use of asterisked tags enables encoding of basic waveforms such as standard 12-lead ECG. Items in yellow fields are what are ハ used ハ frequently. They may be used according to each application purpose.

Annex A. Standard encoding (Informative)

MFER does not impose any restriction on the encoding order. But it should be taken into consideration as interpretation is made in the order of definitions including default definitions. This annex is intended to aid MFER users in understanding the standard encoding including the encoding order.

Examples shown here are to aid MFER users in understanding the encoding with the rules. However, it is not assured that the encoded data are fully decoded by users. That is, it is not assured that a certain waveform encoded with MFER is displayed on a viewer with the specifications fully satisfied. Though it depends on the specifications of the viewer whether a viewer satisfactorily displays a waveform or not, it is expected that a viewer can fully exhibit the functions by faithfully interpreting the header described with MFER.

(1). Waveform encoding example: Standard 12-lead ECG

The following is an example a standard 12-lead ECG is encoded with MFER.

Tag		Code					Description
		Tag	Length	Data			
1	MWF_PRE	40	20	4D 46 52 20			@ MFR
				53 74 61 6E 64 61 72 64 20 31 32 20 6C 65 61 64 73 20 45 43 47 20 20 20 20 20 20 20			Standard 12 leads ECG
2	MWF_MAN	17	26	4E 69 68 6F 6E 20 4D 61 6E 75 66 61 63 74 75 72 65 20 63 6F 2E 5E 45 43 47 2D 32 30 30 33 5E 31 2E 30 32 2E 33 33			Nihon Manufacture co.^ECG-2003 ^1.02.33
3	MWF_BLE	01	01	00			Big endian
4	MWF_WFM	08	01	01			Classification of waveform = Standard 12-lead ECG
5	MWF_IVL	0B	04	01	Interval		Sampling interval = 1 x 10 ⁻³ s =10 ms
				FD	-3		
				00 01	1		
6	MWF_SEN	0C	04	00	Volt		Sampling resolution = 1000 x 10 ⁻⁹ V = 1 mV
				F7	-9		
				03 E8	1000		
7	MWF_BLK	04	04	00 00 00 01			Data block length = 1
8	MWF_CHN	05	04	00 00 00 08			Number of channels = 8
9	MWF_SEQ	06	04	00 00 27 10			Number of sequences = 10000 ms = 10 s
10	MWF_ATT	3F 00	03	MWF_LDN	09		Channel definition specifies that channel 1 is lead I.
				Length	01		
				Data	01	Lead I	
11	MWF_ATT	3F 01	03	MWF_LDN	09		Channel definition specifies that channel 2 is lead II.
				Length	01		
				Data	02	Lead II	
12	MWF_ATT	3F 02	03	MWF_LDN	09		Channel definition specifies that channel 3 is lead V1.
				Length	01		
				Data	02	Lead V1	

17	MWF_ATT	3F 07	03	MWF_LDN	09		Channel definition specifies that channel 8 is lead V6.
				Length	01		
				data	08	Lead V6	
18	MWF_WAV	1E	84	Data length is designated with four octets.			Waveform data values use 1600000 octets.
			00 02 71 00	Data length is four octets.			

Table 57. Example of MFER-applied encodings of standard 12-lead ECG

(2). MWF_PRE(64) : Preamble

It is recommended to use a preamble as a human interface. Though a preamble may be encoded in any position, considering the purpose, it is to be encoded at the heading of a file or the like. The example below is a preamble summarizing a standard 12-lead ECG.

Preamble tag（MWF_PRE）

Data length（32：fixed length）

Classification “MFR”

Description (28 octets) “Standard 12 leads ECG” which can be reviewed as “@ MFR Standard12 leads ECG.”

(3). Pre-definition

Pre-definition affects the whole encoding with MFER.

a. MWF_BLE (01) : Big-endian or little-endian

Once the octet alignment, big-endian or little-endian, is defined (default: big-endian), it is effective over all encoding thereafter. Usually, data are encoded in the same octet alignment, so it is anticipated to be specified in the forefront. However, caution should be taken that data may be transferred between different systems with different octet alignments.

b. MWF_CMP (0E) : Compression

With MFER, once compression is specified, it affects all the contents thereafter. Thus, it should be pre-defined if required.

c. MWF_VER (02) : Version

Interchangeability of data is assured by designating the version.

d. MWF_TXC (03) : Character code

The character code defined with this tag affects the encoding system. If it is not defined, the ASCII or the code settled in the user ｓ system is used.

e. MWF_MAN (17) : Vendor, model number, version number and serial number

Users are recommended to identify such particulars, especially if devices of different vendors are used.

(4). Definition of waveform information

Definition of waveform information

a. MWF_WFM (08) : Classification of waveform

The classification of all concerned waveforms is defined with this tag. It is an important definition as the waveform code differs depending on the classification of waveforms.

b. MWF_INF(15): Incidental waveform information

Incidental waveform information is encoded with this tag if incidental information such as measurement, recording and waveform generating conditions should be encoded.

c. MWF_DTP (0A) : Data encoding type

The data encoding type is designated if data values are encoded with other than signed 16-bit integers (default).

d. MWF_FLT (11) :Filter

This tag is intended to briefly inform the user of the types or characteristics of filters such as low-pass, high-pass and band-pass.

e. MWF_IPD (0F) : Interpolation, thinning-out, etc.

If the waveform is interpolated or thinned out, this tag is to inform the user of the effect.

(5). Extended Definition

Event information MWF_EVT (41), measurements MWF_VAL (41) and recording and measurement conditions MWF_CND (44) are encoded in the extended definition.

(6). Supplementary Definitions

As a rule, supplementary information is the information which should be committed to a commonly used processing system such as the HL7. However, it may be encoded with MFER for extremely limited applications.

a. MWF_TIM (85) : Date/time of measurement or data acquisition

Usually, the measurement date/time is encoded here so that it shows the data pointer with offset 0. Caution should be taken that the date/time depends on the system and may not be absolutely reliable.

b. MWF_PNM (81) : Patient name

It is expected that the patient name is entered with the host protocol and encoding it with MFER is strictly defined.

c. MWF_PID (82) : Patient ID

It is expected that the patient ID is entered with the host protocol and encoding it with MFER is strictly defined.

d. MWF_AGE (83) :Patient age

It is expected that the patient age is entered with the host protocol and encoding it the MFER is strictly defined.

e. MWF_SEX (84) :Patient sex

It is expected that the sex is entered with the host protocol and encoding it with MFER is strictly defined.

f. MWF_MSS (86) : Message field

Messages can be used for multiple purposes. But it is expected that such information is entered with the host protocol and encoding it with MFER is strictly defined.

(7). Definition of frame structure

One or more frames are used to encode waveforms.

a. MWF_PNT (07) : Data pointer

A data pointer indicates the heading position of the frame. It is a heading value of the frame, based on the sampling interval encoded in the root definition or the default time (1 ms) if no sampling interval is encoded in the root definition. It has meaning when the waveform frame appears.

b. MWF_BLK (04) : Data block length

This tag is to indicate the data block length in a frame.

c. MWF_CHN (05) : Number of channels

This tag is to indicate the number of channels in a frame.

d. MWF_SEQ (06) : Number of sequences

This tag is to indicate the number of repetitions waveforms are encoded in the designated number of blocks and the designated number of channels. There is no problem in the number of waveform data blocks if the definition is encoded formally (the value encoded based on the type of data, block length, number of channels and number of sequences is equal to the waveform data length). But if the definition is not encoded formally, the number of waveform data blocks is deemed to be based on the number of sequences.

(8). Definition of sampling attribute

Sampling attribute is designated with the following tags.

a. MWF_IVL (0B) : Sampling interval or frequency

This tag is provided to indicate the sampling interval or frequency.

b. MWF_SEN (0C) : Sensitivity (resolution)

This tag is provided to indicate the digitizing resolution.

c. MWF_OFF (0D) : Offset

This tag is provided to indicate an offset value for digitizing.

d. MWF_NUL (12) NULLvalue

This tag is provided to indicate no data (null value) with a special value. Caution should be taken that if a null value is specified, it applies throughout the definition and cannot be placed in unused condition in the file.

e. MWF_LDN (09) : Waveform attribute (lead name, etc.)

This tag is provided to indicate the name of waveform in the root definition region. Use of the definition is limited to channel 1 only.

(9). Definition of channel attribute

Usually, the number of channels is more than one and channel definition is made for each channel. Channel definition includes designations which are overriden and designations which are not overrided.

a. MWF_WFM (08) : Classification of waveform

This tag is to specify the classification of the waveform of the concerned channel. The content encoded in the root definition is overidden. Definition of the classification of the waveform cancels the previous content encoded in the channel definition by resetting it to the content of the root definition or the default.

b. MWF_LDN (09) : Waveform attribute (lead name, etc.)

This tag is to indicate the name of the waveform of the concerned channel.

c. MWF_IVL (0B) : Sampling interval or frequency

This tag is to indicate the sampling interval or frequency of the concerned channel. Unless designated, the sampling interval or frequency encoded in the root definition is taken over.

d. MWF_SEN (0C) : Sensitivity (resolution)

This tag is to indicate the sensitivity (resolution) of the concerned channel. Unless designated, the sensitivity (resolution) encoded in the root definition is taken over.

e. MWF_BLK (04) : Data block length

This tag is to indicate the number of data values in a block for the concerned channel. Unless designated, what is encoded in the root definition is taken over.

f. MWF_SEQ (06) : Number of sequences

This tag is to indicate the number of sequences. Unless specified, what is encoded in the root definition is taken over.

g. MWF_NUL (12) NULLvalue

This tag is to indicate no data (null value) with a special value (e.g. 800016).

(10). Waveform data

Contents in the waveform data section are interpreted and used on the supposition that data values are stored under the previously defined conditions .

(11). Priority in data encoding

a. Priority to later definition or channel definition

Priority is given to the most resent definition before use. Conditions encoded in the channel definition override those of the root definition.

b. Relations between waveform data length and other definitions (number of data blocks, number of channels, etc.)

To properly represent waveforms, usually the waveform data length should correspond to the data length defined by the number of data values in a block, the number of channels, the number of sequences and the type of data.

However, waveforms may be encoded with a data length different from what is defined by the number of data values in a block, etc. In such a case,

- if the waveform data length is shorter than defined by the number of data values in a block, etc., it is interpreted that there are no data values in blank fields,
- if the waveform data length is longer than defined by the number of data values in a block, etc., data values beyond the defined length are ignored, or
- if a channel definition for a channel defines a different condition from the root definition, the channel definition overrides the root definition. For example, if the number of data values in a block is specified as 2 with a channel definition for a channel with the number of data values in a block specified as 1 in the root definition, the number of data values in a block is 1 in the scope of the root definition and the number of data values in a block = 2 is effective only for the channel.