BS ISO 22077-1:2015

BSI Standards Publication

Health informatics — Medical waveform format

Part 1: Encoding rules

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee IST/35, Health informatics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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ISBN 978 0 580 78918 2

ICS 35.240.80

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2015.

Amendments issued since publication

Date	Text affected

INTERNATIONAL STANDARD

ISO 22077-1

First edition
2015-04-01

Health informatics — Medical waveform format —

Part 1: Encoding rules

Informatique de santé — Format de la forme d'onde médicale —

Partie 1: Règles d'encodage

Reference number
ISO 22077-1:2015(E)

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Foreword

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The committee responsible for this document is ISO/TC 215, *Health Informatics*.

Introduction

Medical waveform data such as an electrocardiogram (ECG) or an electroencephalogram (EEG) are widely utilized in physiological examinations, physiological research, electronic medical records, healthcare information, and other areas in the clinical field. Medical waveform data can be used for many medical and research purposes if digital signal processing technology is applied to standardize the data in a digital format. For medical waveforms, it is essential to standardize the data format to expedite the mutual application of the standard so that the data can be processed electronically and used in a variety of ways.

Simple and easy implementation: application of medical waveform format encoding rules (MFER) is very simple and is designed to facilitate understanding, easy installation, trouble-shooting, and low implementation cost.

Harmonization with other standards: MFER is specially utilized to describe the medical waveform data. Other information than waveform data, such as patient demographic data and finding information, etc. should be written using other healthcare standards, such as HL7, DICOM, ISO/IEEE 11073.

In addition, experts in each field should independently develop relevant standards for medical specifications; for example MFER for ECG is developed by cardiologists and EEG is developed by neurologists.

Combination with coded information and text information: MFER policy is that both machine and human readable manner are used. Namely coded information is for computer processable and text data are for human readable information. Arterial blood pressure (ART) is coded as 129 and information description fields indicate “Right radial artery pressure”, for example. As the description of MFER is quite flexible, MFER neither hinders the features of each system nor impedes the development of technologies.

Health informatics — Medical waveform format —

Part 1:
Encoding rules

1 Scope

This International Standard specifies how medical waveforms, such as electrocardiogram, electroencephalogram, spirometry waveform, etc., are described for interoperability among healthcare information systems.

This International Standard may be used with other relevant protocols, such as HL7, DICOM, ISO/IEEE 11073, and database management systems for each purpose.

This is a general specification, so specifications for particular waveform types and for harmonization with DICOM, SCP-ECG, X73, etc. are not given.

This International Standard does not include lower layer protocols for message exchange. For example, a critical real-time application like a patient monitoring system is out of scope and this is an implementation issue.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
frame
waveform encoding unit consisting of data blocks, channels, and sequences

2.2
medical waveform
time sequential data that are sampled by A/D converter or transmitted from medical equipment

2.3
sampling
data that are converted at a fixed time interval

2.4
channel
individual waveform data group

3 Abbreviated terms

AAMI	Association for the Advancement of Medical Instrumentation
A/D	Analog to Digital
CSE	Common Standards for Quantitative Electrocardiography
CEN	Comité Européen de Normalization/European Committee for Standardization
ECG	Electrocardiogram

EEG	Electroencephalogram
GPS	Global Positioning System
HL7	Health Level Seven
DICOM	Digital Imaging and Communications in Medicine
IEEE	Institute of Electrical and Electronic Engineers
IEC	International Electrotechnical Commission
JIS	Japanese Industrial Standard
LSB	Least significant bit
MFER	Medical waveform Format Encoding Rules
MSB	Most significant bit
OID	Reference to the ISO standard.
SCP-ECG	Standard Communications Protocol for Computerized Electrocardiography (EN 1064)
SPO_2	Saturation of Peripheral Oxygen
UID	Reference to the ISO standard
UUID	Reference to the ISO standard
VCG	Vectorcardiogram

4 Basic specifications

4.1 Basic attributes

4.1.1 General

Medical waveform data described in accordance with the MFER consists of Sampling attributes (Figure 1), Frame attributes (Figure 2) and other supplemental information.

4.1.2 Sampling attributes

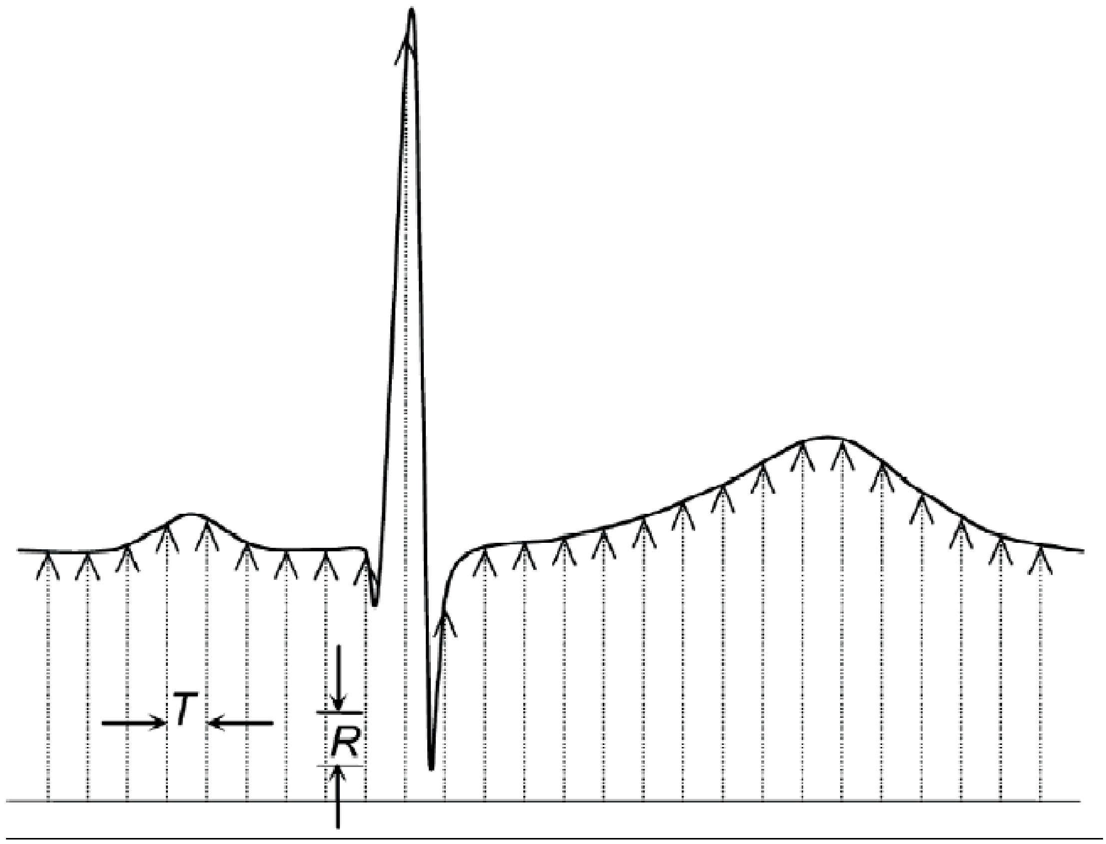
Sampling information has two attributes, sampling rate and sampling resolution.

a) sampling rate

The sampling rate is described with sampling interval or sampling frequency. The sampling interval stands for the time or distance interval of each sampled data as distributed sampled waveform data.

b) sampling resolution

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



Key

T sampling interval (or frequency)

R resolution

Figure 1 — Sampling attributes

4.1.3 Frame attributes

The frame is a waveform encoding unit consisting of data blocks, channels, and sequences. A configuration example of a frame is shown as Figure 2.

a) data block

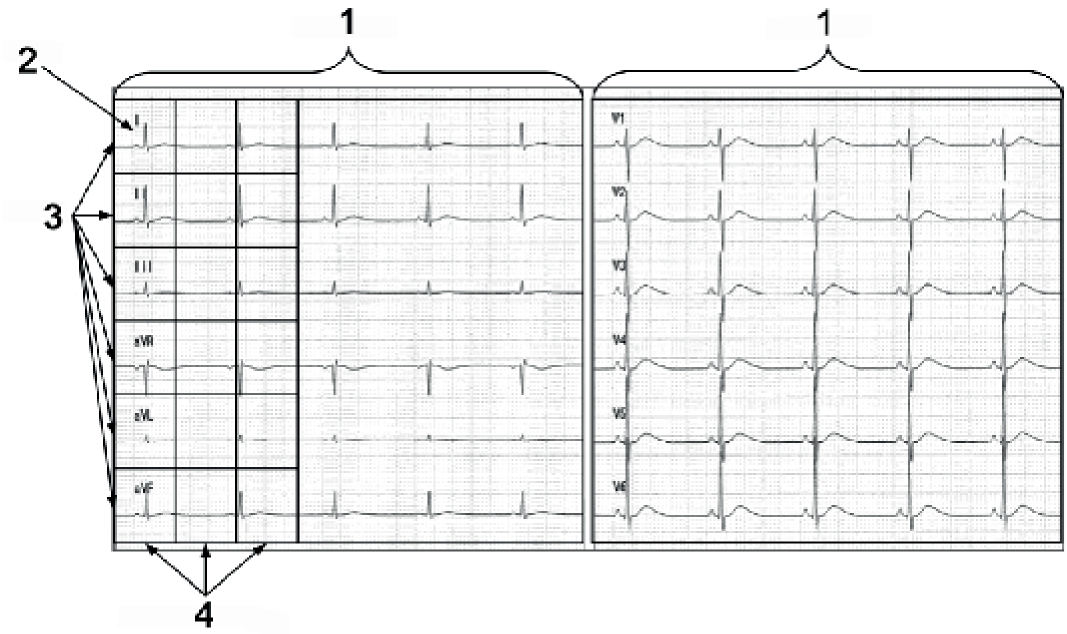
The data block is the waveform data array for each channel.

b) channels

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

c) sequence

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



Key

1 frame

2 data block

3 channel

4 sequence

Figure 2 — Frame attributes

4.2 Encoding rule

4.2.1 General

The header and waveform data should be encoded based on the encoding rules which are composed of the tag, length and value (TLV), as shown in Figure 3.

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

Figure 3 — 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) are the contents which are indicated by tag (T); e.g. attribute definition, waveform data, etc.

4.2.2 Tag (T)

The tag is composed of a class, primitive/context (P/C) and tag number. The tag is classified into four classes (Table 1). Classes 0 to 2 are MFER standard coding and class 3 is for private use. The private definition is intended for special purposes but should be included within any updated future version.

Table 1 — Tag

8	7	6	5	4	3	2	1
Class		P/C	Tag number				
0	0	0/1	MFER				
0	1						
1	0						
1	1		Private				

a) primitive type (P/C = 0).

P/C = 0 indicates a primitive description.

b) context type (P/C = 1).

This has only two tags which are group and channel definition on current MFER. Figure 4 gives an example of a group definition.

8	7	6	5	4	3	2	1
0	1	**1**	0	0	1	1	1

Figure 4 — Group definition

4.2.3 Data length (L)

The data length indicates the number of octets used for data values in the value (V) section (i.e. 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 are less than 127 or more than 128 octets.

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

The length is encoded in one octet, as shown in Figure 5.

8	7	6	5	4	3	2	1
0	Data length						

Figure 5 — Data length ≤ 127 octets

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

The long data length can be encoded using multiple octets. The first octet indicates the number of octets used to represent the total data length. For example, two subsequent octets are used to indicate the waveform data length from 128 to 65 535 and thus three octets are used to encode the data length as in Figure 6. However, MFER allows representation of a data length using multiple octets even if the length is less than 127 octets. For example, four octets can describe up to 4 294 967 295 bytes length as a data part.

8	7 6 5 4 3 2 1	8 7 6 5 4 3 2 1	8 7 6 5 4 3 2 1	8 7 6 5 4 3 2 1
1	Length number (e.g. 3 octets)	Most significant octet	The second octet	The third octet

Figure 6 — Data length

c) Designation of indefinite data length.

MFER allows designation of an indefinite data length by encoding 80 h on the top of the data length field (Figure 7). This indefinite length designation is terminated by encoding the end-of-contents (tag = 00, data length = 00).

Tag P/C=1	Length (80h)	- - - - -	- - - - -	- - - - -	End-of-Contents (00,00)

Figure 7 — Indefinite length designation and end-of-contents designation

d) In case the data length is 0.

MFER indicates that the definition indicated by tag resets to the default value. Namely, on the root definition the concerned items re-initialize to default values and in case of the channel definition, the channel definition is re-initialized to the root definition.

4.2.4 Value (V)

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

4.3 Encoding principle

4.3.1 General

All definitions in MFER have default values, so any additional or amended definitions are optional. Thus the definition corresponding to each tag has a default value, so re-definition is not necessary if the default value is retained. It is expected that default definitions will suffice for most purposes.

4.3.2 Definition levels

4.3.2.1 Level 1 — basic definitions

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

4.3.2.2 Level 2 — supplementary definitions

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

4.3.2.3 Level 3 — extended definitions

Definitions at level 3 are extended definitions, which should be used as little as possible. Items of these extended definitions may considerably affect the system with regard to security. Thus, great care should be taken in using them.

4.3.3 General principles in interpretation, scope and priority of definitions

4.3.3.1 Initial values (default value)

All definitions in MFER have initial values that are applied until redefined by any subsequent definition.

4.3.3.2 Multiple definitions

Multiple definitions may be made for any item. Depending on items, a new definition, an old definition, or all definitions (such as for events), can be used multiple times.

For example, setting the sampling frequency to 250 Hz overrides the initial value of 1 kHz.

If multiple events occur, they are interpreted in definition order.

4.3.3.3 Later definition priority

Each definition is interpreted in definition order. If an item has related definitions, definition should be made in due order. The default endianity is big-endian, so to use little-endian endianity the definition for little-endian must be designated.

For example, before defining each channel, the number of channels should be defined.

4.3.3.4 Channel attributes definition order

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

4.3.3.5 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, care should be taken because if a subsequent change to the root definition is made, it will override the default content of the relevant channel for subsequent channel definitions.

For example, if EEG is designated in the root definition, ECG designated for a channel in the channel definition overrides EEG.

4.3.3.6 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 value. If the data length is designated as zero in a channel definition, the definition follows the root definition including the default value. If the number of channels is defined, contents defined for the channel attribute are all reset to the root definition including the default value.

4.3.3.7 Incomplete definition ignored

If a definition is made without an adequate preceding definition, the definition is ignored.

In the absence of any complete definition, the default root definition will be applied.

For example, if the number of channels is undefined, any dependent channel definition is ignored.

4.3.3.8 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. Thus, contents defined in the root definition apply to all frames unless overridden by channel definition(s), so it suffices to define common items in the root definition.

For example, to use little-endian for all encodings with MFER, define little-endian once, then it is effective over the whole region irrespective of frames.

4.3.3.9 Definition and efficacy of data

It depends on the functional capability of the user application whether or not the user can use data defined by the provider. If some content cannot be processed, users may discard all the data or use only the processable range of data.

5 Basic rules (Level 1)

5.1 Primary description

5.1.1 Sampling attributes

Sampling attributes are sampling frequency or sampling interval and resolution are given in Tables 2 to 5.

a) **MWF_IVL (0Bh): Sampling rate**

This tag indicates the frequency or interval the medical waveform is sampled (Table 2).

Table 2 — Sampling rate

MWF_IVL*			Data length	Default	Encoding range/ remarks	Duplicated definitions
11	0Bh	Unit	1	1 000 Hz	—	Override
		Exponent (10^{th} power)	1		10^{-128} to 10^{+127}	
		Mantissa	≤4		e.g. unsigned 16-bit integer	

The unit may be frequency in Hertz, time in seconds or distance metres (Table 3).

Table 3 — Sampling rate unit

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

b) **MWF_SEN (0Ch): Sampling resolution**

This tag indicates the resolution, minimum bits, the medical waveform is sampled (generally, digitized) (Table 4).

Table 4 — Sampling resolution

MWF_SEN*			Data length	Default	Encoding range/ remarks	Duplicated definitions
12	0Ch	Unit	1	see Table 5	—	Override
		Exponent (10^{th} power)	1		10^{-128} to 10^{+127}	
		Mantissa	≤4		e.g. unsigned 16-bit integer	

Table 5 — Sampling resolution units

Unit		Value	Default	Remarks
Voltage	V	0	0,000 001 V	—
Pressure	mm Hg(Torr)	1	—	—
	Pa	2	—	—
	cm H_2O	3	—	—
	mm Hg/s	4	—	—
Force	dyne	5	—	—
	N	6	—	—
Ratio	%	7	—	Include volume fraction (%)
Temperature	°C	8	—	—
Heart rate	min^{-1}	9	—	—
	s^{-1}	10	—	—
Resistance	Ω	11	—	—
Current	A	12	—	—
Rotation	r/min	13	—	—
Power	W	14	—	—
	dB	15	—	—
Mass	kg	16	—	—
Work	J	17	—	—
Vascular resistance	dyne · s · $m^{-2}cm^{-5}$	18	—	—
Flow rate, flow, volume	l	19	—	—
	l/s	20	—	—
	l/min	21	—	—
Luminous intensity	cd	22	—	—

5.1.2 Frame attributes

As described in Figure 2 a frame is composed of data blocks, channels and sequences.

a) MWF_BLK (04h): Data block length

This tag indicates the number of data sampled in a block (Table 6).

Table 6 — Data block length

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

b) MWF_CHN (05h): Number of channels

This tag indicates the number of channels (Table 7). As the previously specified channel attribute is reset to the root definition including default, the number of channels should be specified before each definition of the channel attribute. The number of channels cannot be specified with a channel definition of channel attribute.

Table 7 — Number of channels

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

c) MWF_SEQ (06h): Number of sequences

This tag indicates the number of sequences (Table 8). 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.

Table 8 — Number of sequences

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

5.1.3 Waveform

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

a) MWF_WFM (08h): Waveform class

Waveforms such as standard 12-lead ECG and monitoring ECG are grouped based on instruments and purposes, as shown in Table 9.

Table 9 — Waveform class

MWF_WFM*		Data length	Default	Remarks	Duplicated definitions
08	08h	2	Non-specific waveform	—	Override
		Str ≤ 32	Waveform description	—	

As a general rule, standardization will be made by type of waveforms, each is described in a separate specification (e.g. for standard 12-lead ECG 11073-92301). However, because monitoring systems use multiple waveforms such as ECG, SpO2, EEG, etc., refer to the specification for each individual waveform standard.

For types of waveform (Table 10), numbers 1 to 49 151 (BFFFh) are already reserved. Numbers 49 152 to 65 535 can be used privately but it should be documented in the MFER specification as quickly as possible if the waveform is commonly used.

b) MWF_LDN (09h): Waveform attributes (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 should 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. See Table 11 for the definition of waveform attributes.

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

For waveform codes, numbers 1 to 49 151 (BFFFh) are already reserved. Numbers 49 152 to 65 535 can be used privately but should be used for new types of waveforms by upgrading the MFER promptly.

Table 10 — Classification of waveforms

Classification	Type	Value	Description	Remarks
—	—	0	Unidentified	—
Electrocardiogram	ECG_STD12	1	Standard 12 lead ECG	Different kinds of 12 lead ECGs including general ECGs can be encoded
	ECG_LTERM	2	Long-term ECG	Holter ECG, monitoring ECG
	ECG_VECTR	3	Vectorcardiogram	—
	ECG_EXCER	4	Stress ECG	—
	ECG_INTR	5	Intracardiac ECG	His bundle ECG, intracardiac ECG, intravascular ECG, cardiac surface ECG
	ECG_SURF	6	Body surface ECG	Body surface potential map Body surface His bundle ECG
	ECG_ILATE	7	Ventricular late potential	—
	ECG_LATE	8	Body surface late potential	—
Sound	SOUND	30	PCG, etc.	8 kHz, 11 kHz, 22 kHz, etc.
Pulse	PULSE	31	Fingertip pulse, carotid pulse	—
Monitoring	MON_LTRM	20	Long-term waveform	—
	MON_SPL	21	Sampled waveform	—
	MON_PWR	25	Power spectrum	Some part is EEG_CSA
	MON_TRD	26	Trendgram	—
Magnetocardiogram		100	MCG	—
Electroencephalogram	EEG_REST	40	Resting EEG	Includes surgical monitoring EEG
	EEG_EP	41	Evoked EEG	ABR SEP
	EEG_CSA	42	Frequency analysis	—
	EEG_LTRM	43	Long-term EEG	Sleeping EEG
Private	49 152 to 65 535		—	—

Table 11 — Definition of waveform attributes

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		—	

EXAMPLE Standard 12-lead ECG code, shown in Table 12.

Mainly, standard 12-leads are encoded according to the SCP-ECG (EN 1064) or annotated ECG coding system, but some leads are not defined the same as SCP-ECG.

Table 12 — Lead code of standard 12 lead ECG

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

EXAMPLE Monitoring aortic pressure waveform.

Encoding monitoring waveform information.

Table 13 — Blood pressure waveform (Aortic blood pressure waveform)

Waveform code	Waveform information	Remarks
128	—	Coded value indicates as “Aortic pressure”
129	“Aorta”	Coded value indicates as “Arterial pressure” and Information description part indicates “Aorta”
143	“Aorta”	Coded value only indicates as “Pressure” and Information description part indicates “Aorta”

EXAMPLE Electroencephalogram waveform.

Generation of waveform codes by combination of electrodes (see Figure 8).

<table>
<tr><td>16</td><td>15</td><td>14</td><td>13</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td colspan="7">− negative electrode (G1)</td><td colspan="7">+ positive electrode (G2)</td></tr>
</table>

Figure 8 — Generation of waveform code by combination of electrodes

Waveform codes can be generated by combination of electrode codes, as shown in Table 14 and Table 15.

Table 14 — 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 15 — Example of waveform code generation

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

c) MWF_WAV (1Eh): Waveform data

The entity of waveform data should strictly be aligned as defined in Frame attributes (4.1.3). If the waveform data are compressed, the data alignment may depend on the compression method, but the waveform data after un-compressing should be aligned according to the definition (see Table 16).

If waveform data are different from what is defined in frame information, exceeding data may be discarded. However, such processing depends on application and it is not guaranteed.

Table 16 — Waveform body

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

5.1.4 Channel

a) MWF_ATT (3Fh): Channel attributes (channel definition)

This tag defines the attributes of each channel (see Table 17). Before this definition, it should be required to specify the channel number using Table 7.

The method of encoding a channel number differs depending on whether it is ≤127 or ≥128. Refer to Figure 10 for ≤127 and to Figure 11 for ≥128.

Table 17 — Channel attributes

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

NOTE Channel definition for each channel is encoded with a special context tag of P/C = 1 and tag number of 1Fh. That is, the type number is P/C + tag number encoded with 3Fh and identifies the attribute of the relevant channel. The channel number is identified with seven bits in the octet with bit 8 = 0 for up to 127 channels and with bit 8 = 1 for 128 or higher channel number.

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

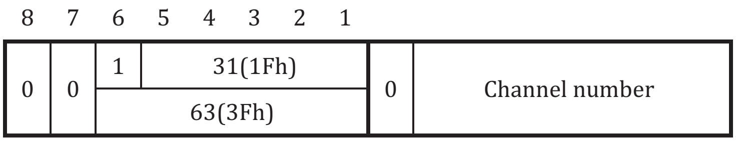


Figure 9 — Number of channel ≤127

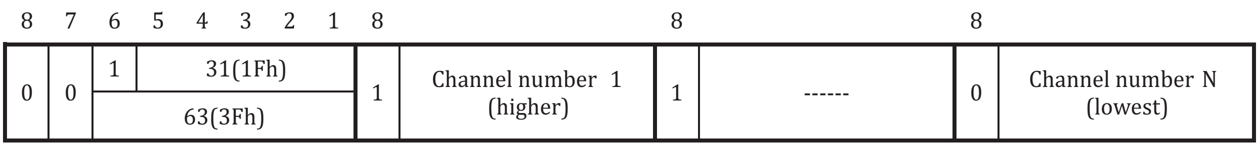


Figure 10 — Number of channel ≥128

The data length includes all the range of the channel attribute definition (Figure 11).

Tag		Data length	Group of definition									
3Fh	Channel number	All definition	Channel attribute definition			Channel attribute definition			----	Channel attribute definition		
			T	L	V	T	L	V	—	T	L	V

Figure 11 — Definition of channel attributes

The indefinite length described in Figure 7 can be used for the channel attribute definition (Figures 11 and 12).

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 12 — Definition of channel attributes with indefinite length

5.2 Auxiliary rule

5.2.1 Data description

a) MWF_DTP (01h): Data type

This tag indicates the type of waveform data (Tables 18 and 19). While medical waveforms are usually sampled with a precision of 12 bits, by default they are all interpreted and encoded as 16-bit data.

Table 18 — Data type

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

Table 19 — Data type code

Value	Type of data
0	Signed 16 bits integer, −32 768 to 32 767
1	Unsigned 16 bits integer, 0 to 65 535
2	Signed 32 bits integer
3	Unsigned 8 bits integer
4	16 bits status
5	Signed 8 bits integer
6	Unsigned 32 bits integer
7	32 bits single-precision floating (IEEE 754)
8	64 bits double-precision floating (IEEE 754)

Table 19 *(continued)*

Value	Type of data
9	8 bits AHA differential

Note “8 bit AHA differential allows large values to be expressed in just 8 bits because each succeeding value expresses the difference from the previous value.

b) MWF_OFF (0Dh): Offset value

This tag indicates an offset value (Table 20) of sampling data. Encoding of an offset value depends on the type of encoding data.

Table 20 — Offset value

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

c) MWF_NUL(12h): NULL value

This tag indicates null data. If null values (Table 21) are included in waveform data, the waveform datum is ignored even if it exists. As null data use the same encoding space as waveform data, the tag should be used carefully. For example, a minimum negative value 8 000 h is occasionally used for a null value. If the null values are encoded during a period in which the electrode is removed, ECG is not displayed. Encoding of a null value depends on the type of encoding data.

Table 21 — Null value

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

d) MWF_CMP (0Eh): Compression

This tag is to compress the encoding waveform.

Table 22 — Compression

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	

MFER enables encoding of waveforms by compressing (Table 22). This improves the efficiency of encoding capacity but makes the processing speed decrease, 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 (Table 23) but the encoded frame information returns after decompression.

Table 23 — Compression method

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

Compressed data methods for headers and waveforms are given in Tables 24 and 25 respectively.

Table 24 — Compression applied to header section

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 25 — Compression applied to waveform data

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

5.2.2 Other definition

a) MWF_BLE (01h): Endianity

This tag indicates byte alignment in the data section (TLV values only). The big-endian is aligned byte data from most significant to least significant. This is used by Sun Microsystems®[1)] and Macintosh®[1)] CPUs. The little-endian is aligned from least significant to most significant. This is used by Intel®[1)] and other 'PC' CPUs (see Tables 26 and 27).

Table 26 — Endianity

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

Table 27 — Big/Little endian

Endianity	
0	Big-endian
1	Little-endian

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

b) MWF_PNT (07h): Pointer

1) Sun Microsystems®, Macintosh®, and Intel® are examples of suitable products available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these products.

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 (Table 28). 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.

For example, if no pointer is specified for the first frame with the sampling interval set at 2 ms, and the number of waveform length for each channel set at 1 000, and the number of sequences set at 1 in the root definition, then the initial pointer of the second frame advances by 2 s (1 000 data values × 1 sequence of 2 ms).

Table 28 — Pointer

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

c) MWF_ZRO (00h): Blank/End-of-contents

Usually, a blank tag is not analysed. This tag also indicates the end of the indefinite length if designated, together with data length = 0. End-of-contents (Table 29) need succeed two zero as explained in Figure 7.

Table 29 — Blank or end-of-contents

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

5.2.3 Information description

a) MWF_PRE (40h): Preamble

This tag for a special purpose is encoded at the heading of a file 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; see Table 30).

Table 30 — Preamble

MWF_PRE		Data length	Default	Remarks	Duplicated definitions
64	40h	4	—	“MFR“	To be encoded at the head
		28		28 characters	

EXAMPLE Preamble information:

“MWF_PRE 0x20 MFR Standard 12 leads ECG” is equal to “@ MFR Standard12 leads ECG”.

b) MWF_MAN (17h): Manufacturer information of medical device

This tag indicates the information on the manufacturer, model and version number of the medical waveform generating machine with a component separator in between (see Table 31).

Table 31 — Manufacturer information

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

EXAMPLE Description sample:

Manufacturer^model^version number^serial number.

c) MWF_EVT (41): Event

This tag is to encode supplementary waveform information such as events (refer to Annex C; see Table 32).

— Beat annotation: for classification of waveforms, etc.

— Interpretation: for interpretation of relevant waveform.

Table 32 — Event

MWF_EVT			Data length	Default	Encoding range/ remarks	Duplicated definitions
65	41h	event code	2	None		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			

d) MWF_INF (15h): Waveform information

This tag indicates waveform information which is generated (refer to Annex C), for example, catheter information to measure cardiac output by dye dilution method (see Table 33).

Table 33 — Waveform information

MWF_INF			Data length	Default	Data range/remarks	Duplicated definitions
21	15h	Information code	2	—	—	Possible
		Starting time (point)	4		Point number based on the sampling interval specified in the root definition	
		Duration	4			
		Waveform information	Str < 256		—	

e) MWF_CND (44h): 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 (see Table 34).

Table 34 — Recording/Display condition

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

MFER requires faithful reproduction of waveforms. For example, the waveform was displayed during measurement using some filters, 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).

f) MWF_NTE (16h): Comment

This tag represents a memo or comment. It does not directly affect encoding of waveforms.

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

Table 35 — Comment

MWF_NTE		Data length	Default	Remarks	Duplicated definitions
22	16h	Str < 256	—	—	Possible

A comment should be encoded within 255 characters but multiple comments may be written as required. Whether a comment has meaning or not depends on the user's system. A long comment can be written by using this tag the 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, as shown in Table 36.

The control sentence structure is <control character = control information>. For example "<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 cut-off frequency of 50 Hz.

Table 36 — Control character definitions

Control character	Meaning	Remarks
<	The start of control sentence structure	Control sentence continues until closed with the control character (>)
>	The end of control sentence structure	—
C	Channel	Indicates the channel number
L	Lead	Indicates a lead of ECG, EEG, etc. Depends on lead composition
P	Pointer	Indicates a position (pointer) of waveform

Table 36 *(continued)*

Control character	Meaning	Remarks
F	Filter	Applied filter
S	Sensitivity	Recording sensitivity
\	Backslash “\”	A character following \ is not recognized as a control character

g) MWF_VER (02h): Version

This tag does not show the version of this standard. This tag is for use of the manufacturer to indicate a version. A version is composed of three parts (three octets; see Table 37).

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

In referring to the data written in an old version with a new version, the old specification is ensured securely. In referring to the database of a new version with an old version, the specification of the old version is ensured.

Table 37 — Version

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

h) MWF_TXC (03h): Character code

As shown in Table 38, this tag enables designation of the character code (Table 39) used for the text (e.g. ISO 2022 for Japanese text). If text is written with no character code specified, it is not ensured whether users can process the text or not.

Table 38 — Character code system

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

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

Table 39 — Character code

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	—	ISO/IEC 2022:1994, Information technology — Character code structure and extension techniques

Table 39 *(continued)*

Character code	Note	Description
ISO 8859	—	*Information technology — 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	—	1991 *Information technology —* ISO *7-bit coded character set for information interchange*
ISO 2375	—	2003, *Information technology — Procedure for the registration of escape sequences and coded character sets*
ISO/IEC 6429	—	1992, *Information technology — Control functions for 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 10646:2003

i) MWF_FLT (11h): Filter

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

NOTE It is recommended to store original waveforms if possible. If display or recording during measurement uses a filter, MFER describes the filter with waveform information.

Table 40 — Filter

MWF_FLT		Data length	Default	Remarks	Duplicated definitions
17	11h	Str < 256	unused	—	Possible

As shown below, a filter or the characteristic is encoded as a character string. A free text field can be used for describing the filter properties. Recently sophisticated digital filters have been developed, the characteristic of these filter cannot be represented commonly. Therefore, only information on filters used during acquisition of waveform may be represented, as shown in Table 40.

EXAMPLE Filter name

— Hum filter ON

— 30 Hz second order Butterworth low pass

— Chebycheff

— Elliptic

j) MWF_IPD (0Fh): Interpolation or decimation

When encoding the waveform through interpolation or thinning-out, the fact is designated with this tag, shown in Table 41, using the interpolation/decimation codes shown in Table 42.

Table 41 — Interpolation or decimation

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

Table 42 — Interpolation/decimation codes

Name	Code	Supplementary description
Unconditional decimation	1	—
Unconditional interpolation	2	—
Lagrange's interpolation	3	Order
Spline interpolation	4	Order
Linear interpolation	5	—
Average	6	Number of averaging times

6 Supplemental description (Level 2)

a) MWF_VAL (42h): Value (measurements, etc.)

This tag represents waveform-related information such as measurements.

Table 43 — Value

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

EXAMPLE Measurement value

If a heart beat is found at the concerned time,

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

Point = –1 indicates in the whole region of the frame.

"80^/min"··········Heart rate is 80 bpm.

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

b) MWF_SKW (43h): 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, shown in Table 44.

Table 44 — Sampling skew

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

c) MWF_SET (67h): Group definition

This tag represents a group such as one or more region of interest (ROI). For example, it clearly defines the P-QRS-T (Einthoven deflections) beat in ECG (such as pointers or measurement value), shown in Table 45.

Table 45 — Group definition

MWF_SET		Length	Default value	Remarks	Override
103	67h	Depend on definition	—	—	Not available with in same group

d) MWF_UID (87h): Unique identifier

This tag indicates unique identifier (UID), shown in Table 46.

Table 46 — Unique identifier

MWF_UID		Length	Default value	Remarks	Override
135	87h	Str ≤ 64	No	—	No

Description of the unique identifier (UID) is not be defined by the MFER. This is designated with object identifier (OID), universally unique identifier (UUID).

e) **MWF_MAP (88h): Description map**

A description map (file pointer) can improve processing efficiency by describing a large capacity file in accordance with the MFER (see Table 47). This description cannot be ensured, as it depends on the application.

Table 47 — Description map

MWF_MAP			Length	Default value	Remarks	Override
136	88h	Tag 1	1	No	Data length is used as 6 × N Tag(MWF_ZRO) is not used	Override
		Reserved 1	1			
		File pointer 1	4			
		Tag 2	1			
		Reserved 2	1			
		File pointer 2	4			
		--	—			
		--	—			
		--	—			
		Tag N	1			
		Reserved N	1			
		File pointer N	4			

The file pointer should be described by an unsigned 32-bit integer.

f) MWF_END (80h): End of description

This tag indicates an end of data description (Table 48).

Table 48 — End of description

MWF_END		Length	Default	Remarks	Override
128	80h	Undefined	—	—	

NOTE All data after this tag are ignored.

g) MWF_RPT (45h): Reference pointer

This tag indicates an external reference file pointer represented as a hyperlink (Table 49).

Table 49 — Reference pointer

MWF_SIG			Length	Default	Remarks	Override
69	45h	Data class	1	—		Possible
		Reference pointer	str < 256		Represent as URL	

Attributes of data class are shown in Table 50.

Table 50 — Attribute of data class

Data class	Value
Undetermined data format	0
MFER Data	1

h) MWF_SIG (46h): Digital signature

This tag indicates a digital signature (Table 51).

Table 51 — Digital signature

MWF_SIG			Length	Default	Remarks	Override
70	46h	Signature method	1	—	—	No
		Hash value	< 256			

7 Extended description (Level 3)

The extension tags are for the extended supplemented information with MFER. This information should preferably be represented with a system standard applicable to the most widespread convention in the useage of the particular implementation of MFER. Such local conventions may be, for example, HL7, DICOM, and so on. The handling of patient demographic information should take in other local considerations and in particular privacy and security.

a) MWF_PNM (81h): Patient name

This tag represents a patient name (Table 52). 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).

Table 52 — Patient name

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

b) MWF_PID (82h): Patient ID

This tag identifies a patient identification number (Table 53). 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 are processed as a unique ID in the system.

Table 53 — Patient ID

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

c) MWF_AGE (83h): Birth date and age

This tag is to encode the birth date and age (Table 54). The age is based on the date of examination or measurement.

Table 54 — Birth date and age

<table>
<tr><th colspan="4">MWF_AGE</th><th>Data length</th><th>Default</th><th>Remarks</th><th>Duplicated definitions</th></tr>
<tr><td rowspan="5">131</td><td rowspan="5">83h</td><td rowspan="2">Age</td><td>Years</td><td>1</td><td rowspan="5">None</td><td rowspan="5">—</td><td rowspan="5">Override</td></tr>
<tr><td>Days</td><td>2</td></tr>
<tr><td rowspan="3">Date of birth</td><td>Year</td><td>2</td></tr>
<tr><td>Month</td><td>1</td></tr>
<tr><td>Day</td><td>1</td></tr>
</table>

d) MWF_SEX (84h): Gender

This tag is to encode the sex of the patient (Table 55), using the codes shown in Table 56.

Table 55 — Gender

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

Table 56 — Gender code

Sex	Value
Unclear	0
Male	1
Female	2
Undefined	3

e) MWF_TIM (85h): Measurement date/time

This tag is to encode the examination/measurement date/time or the data acquisition date/time (Table 57). The date/time has an important meaning in encoding storage objects with MFER so it should be used carefully.

Table 57 — Measurement time

MWF_TIM			Data length	Default	Remarks	Duplicated definitions
133	85h	Year	2	None	1 900 to 2 100	Override
		Month	1		1 to12	
		Day	1		1 to 31(1 to 30, 1 to 28, 29)	
		Hour	1		0 to 23	
		Minute	1		0 to 59	
		Second	1		0 to 59	
		Millisecond	2		0 to 999	
		Microsecond	2		0 to 999	

f) MWF_MSS (86h): Message

This tag is to encode a character string of an interchangeable message between systems (Table 58).

Table 58 — Message

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

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

MFER specification			**Frame**	**/**	**Ver.**		
Producer	Manufacturer		Date		Model		
	Author		Edited date				
Waveform title			Specification				
Preamble			Endianity	•Default(big endian) •Big endian •Little endian			
Version	..	Character					
Sampling attributes	Sampling rate	Unit		Exponent		Mantissa	
	Sampling resolution	Unit		Exponent		Mantissa	
Data type	•Default •()	NULL	•Not used •()	Offset value	•Not used •()		
Frame number		Block		Channel		Sequence	
Channel No.	Lead or Waveform	Condition			Remarks		

Table A.1 *(continued)*

MFER specification				Frame	/	Ver.	
Producer	Manufacturer			Date		Model	
	Author			Edited date			
Waveform title				Specification			
Preamble				Endianity	•Default(big endian) •Big endian •Little endian		
Note							

Annex B
(informative)

Description example

B.1 Data alignment example

B.1.1 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.

With example shown in Figure B.1, 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 sequential data blocks to form the second frame.

— Data block length: All data values of one lead; e.g. 5 s

— Number of channels: 6

— Number of sequences: 1

— Number of frames: 2

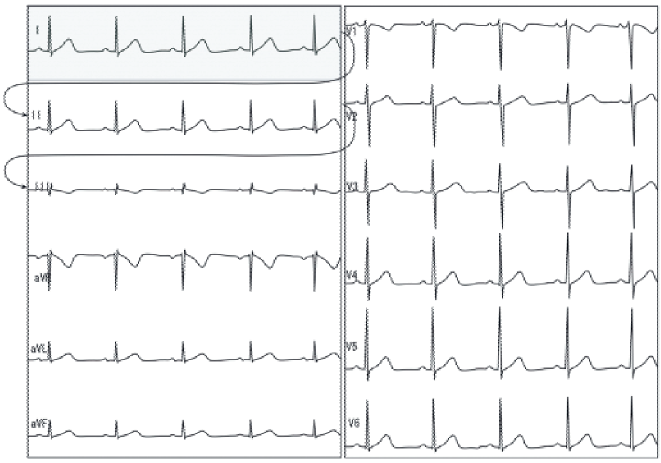


Figure B.1 — Alternate mode description

B.1.2 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 shown in Figure B.2.

— Data block length: one sampled data

— Number of channels: 6

— Number of sequences: Number of data blocks in one channel; e.g. 5-s ECG per lead

— Number of frames: 2

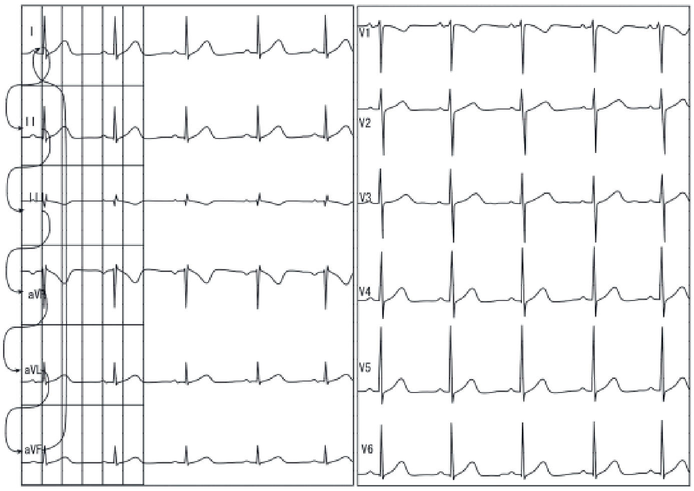


Figure B.2 — Multiplex mode

B.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 should be encoded with the TLV (tag, length, and value) conforming to the encoding rules (Figure B.3). Descriptors include the root definition which covers all encodings and channel definitions which cover encodings for relevant channels.

EXAMPLE Alignment of waveform data values.

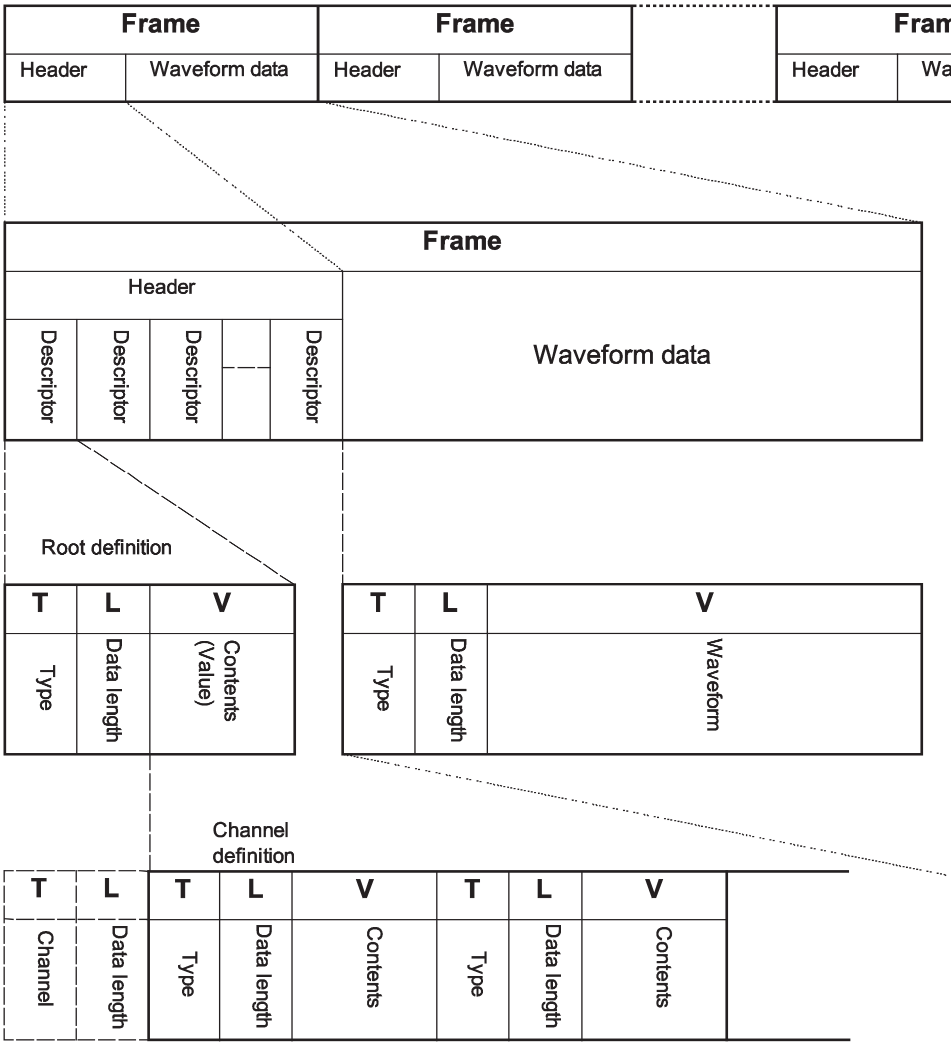


Figure B.3 — Encoding format

Figure B.4 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 three, 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 × 5 ms 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 × 4) ms in length.

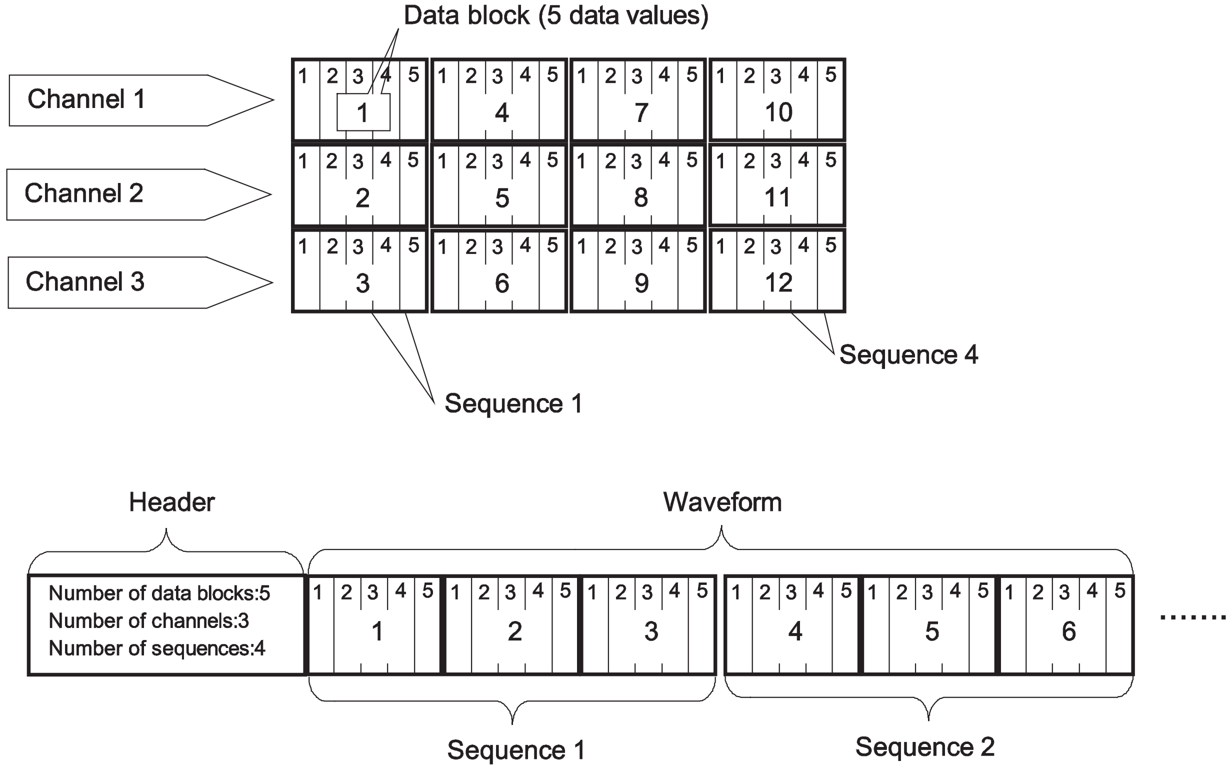


Figure B.4 — Waveform data alignment

B.3 Waveform time and synchronization

B.3.1 General

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 originating instrument.

a) 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.

b) Pointer

A pointer value (see Figure B.5) 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.

c) 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.

d) 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 s data (5 000 data values with a sampling interval of 1 ms) are encoded in the frame, the pointer is renewed to 5 000 at the end of the frame and the subsequent frame uses the pointer set at 5 000. Accordingly, if the pointer is not controlled at each frame, these waveform data are encoded as continuous frames.

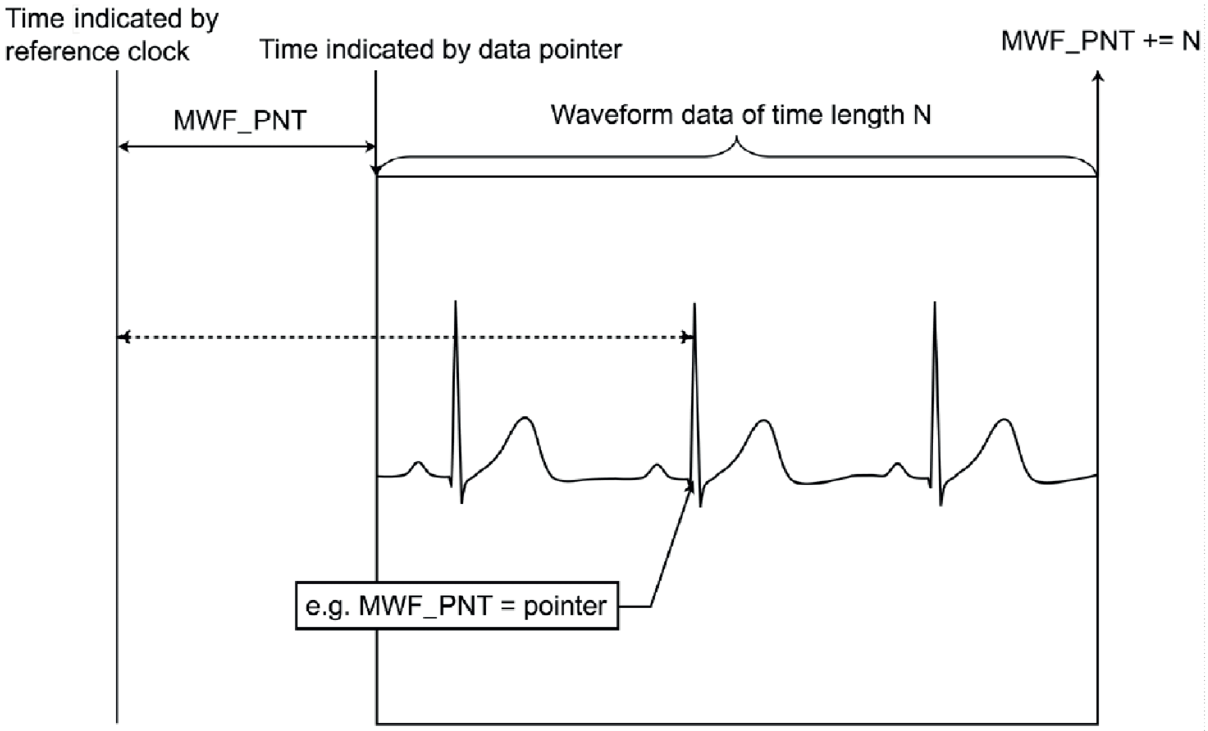


Figure B.5 — Pointer and timing

e) Pointer management

— For a long duration data acquisition system such as a patient monitoring system, the A/D converter clock may differ from the master clock. In such a 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.

B.3.2 Frame encoding examples

B.3.2.1 In case the number of data values is less than the frame encoding

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 × 3 × 3 + 8), seven remaining data value fields are processed as no data (Figure B.6).

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.

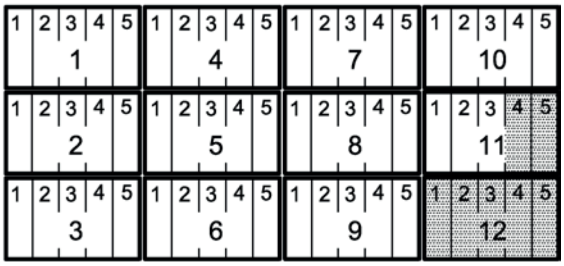


Figure B.6 — Example of a frame with blank data filed

B.3.2.2 In case the number of data values is more than the frame encoding

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 × 3 × 4 + 8), eight data values flowing over the frame are skipped, as shown in Figure B.7.

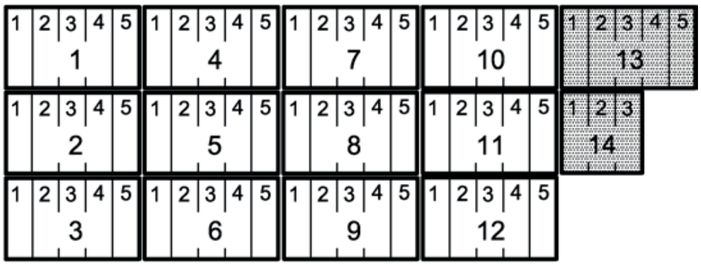


Figure B.7 — Example of a frame with some data values overflowed

B.3.2.3 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 shown in Figure B.8.

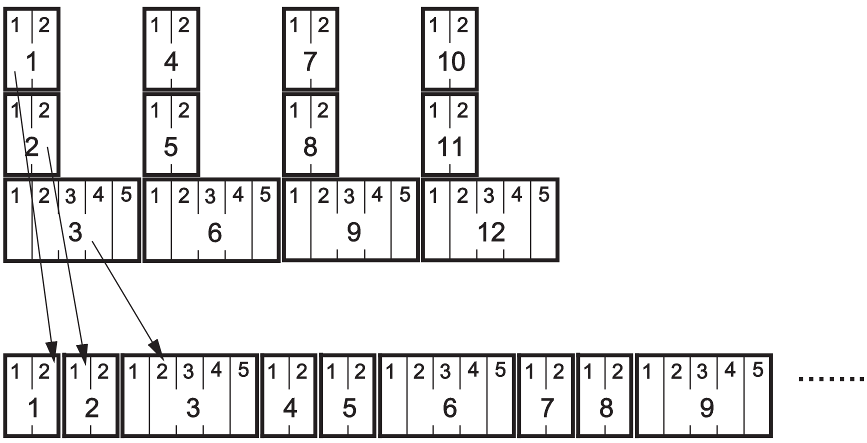


Figure B.8 — Definition of channel attributes overriding the number of data values in a block

B.3.2.4 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 shown in Figure B.9.

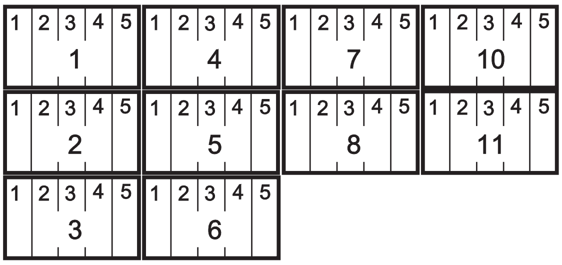


Figure B.9 — Definition of channel attribute overriding the number of data values in a sequence

Annex C
(informative)

Event information description

C.1 Information related to waveform generation

This is information directly related to the generation on waveforms, such as wavelengths of infrared light and red light for SPO_2 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.

C.2 Information indirectly affecting waveforms

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

C.3 Recording conditions

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

The models shown in Figures C.1 and C.2 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				

Figure C.1 — 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)		

Figure C.2 — Encoding of waveform information (with no code)

C.4 Supplementary explanation

The event 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.

Annex D
(informative)

Example of standard encoding

D.1 General

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 ensured that the encoded data are fully decoded by users, i.e. it is not ensured 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.

D.2 Example

D.2.1 Waveform encoding example: Standard 12-lead ECG

Figure D.1 shows an example of Standard 12-lead ECG 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			Waveform = Standard 12 -lead ECG
5	MWF_IVL	0B	04	01	Interval		Sampling interval = 1 × 10^{-3} s = 1 ms
				FD	−3		
				00 01	1		
6	MWF_SEN	0C	04	00	Volt		Sampling resolution = 1 000 × 10^{-9} V = 1 μV
				F7	− 9		
				03 E8	1 000		
7	MWF_BLK	04	04	00 00 00 01			Data block length = 1
8	MWF_CHN	05	01	08			Number of channels = 8
9	MWF_SEQ	06	04	00 00 27 10			Number of sequences = 10 000 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	03	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 160 000 octets.
			00 02 71 00	Data length is four octets			

Figure D.1 — Example of MFER applied encoding of standard 12 lead ECG

D.2.2 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 Standard 12-leads ECG.”

D.2.3 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 because the data may be transferred between different systems with different octet alignments.

b) MWF_VER (02): Version

Interchangeability of data are ensured by designating the version.

c) 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.

D.2.4 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_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.

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.

D.2.5 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.

D.2.6 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's name

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

c) MWF_PID (82): Patient's ID

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

d) MWF_AGE (83): Patient's age

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

e) MWF_SEX (84): Patient's gender

It is expected that the patient's sex be 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. However, it is expected that such information entered with the host protocol and encoding it with MFER be strictly defined.

D.2.7 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 repetition waveforms 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). However, if the definition is not encoded formally, the number of waveform data blocks is deemed to be based on the number of sequences.

D.2.8 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): Sampling 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) NULL value

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 an unused condition in the file.

D.2.9 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.

D.2.10 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 that 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.

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