TECHNICAL SPECIFICATION

**ISO/TS 22077-3**

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# Health informatics — Medical waveform format —

## Part 3: Long term electrocardiography

*Informatique de santé — Forme d'onde médicale —*

*Partie 3: Électrocardiographie de longue durée*

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# Contents

Page



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# Foreword

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

ISO/TS 22077 consists of the following parts, under the general title *Health informatics — Medical waveform format*:

— *Part 1: Encoding rules*

— *Part 2: Electrocardiography*

— *Part 3: Long term electrocardiography*

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# Introduction

The ambulatory ECG examination is widely utilized in the clinical field. This rule applies for long-term waveform description such as ambulatory ECG, monitoring waveforms, etc. Recently, EMR, or Electronic Medical Records, becomes commonly used and it strongly requires Ambulatory ECG examination for the therapeutic purpose. However, new digitalized data of Ambulatory ECG recorder cannot be used among different manufacturers scanner. This Technical Specification intends that MFER encoded data for ambulatory ECG is analysed by other scanner and these are also interoperable on EMRs.

This Technical Specification defines the detailed rules for electrocardiogram waveform format that is encoded according to the medical waveform format encoding rules (MFER). In addition to electrocardiogram waveform format encoding, there are rules for other waveforms such as long-term ECG (Holter ECG), stress ECG, etc. that are contained in other MFER Technical Specifications. Please refer to those specifications for additional information.

**About MFER**

Medical waveforms such as electrocardiogram, electroencephalogram, and blood pressure waveforms are widely utilized in clinical areas such as physiological examinations, electronic medical records, medical investigations, research, education, etc. Medical waveforms are used in various combinations and document types according to the intended diagnostic purpose. For example, ECG waveforms are utilized extensively in the clinical arena, with resting 12-lead ECG being used the most. A cardiologist makes diagnoses using 10 s to 15 s ECG waveform measurements; however, longer periods are sometimes required to recognize patient heart conditions such as arrhythmia. Also, there are many other methods using ECG such as Holter ECG, physiologic monitoring ECG, stress ECG, intracardiac ECG, VCG, EEG with ECG, blood pressure with ECG, PSG, etc. MFER can describe not only ECG for physiological examinations conducted in ICU and operating room acute care contexts, but also EEG, respiration waveform, and pulse.

**Simple and easy**

MFER is a specialized representation for medical waveforms that removes unnecessary coded elements ("tags") for waveform description. For example, a standard 12-lead ECG can be described simply only using a common sampling condition and the lead condition, making waveform synchronization and correct lead calculation much easier.

**Using with other appropriate standards**

It is recommended that MFER only describes medical waveforms. Other information can be described using appropriate standards such as HL7, DICOM, IEEE, etc. For example, clinical reports that include patient demographics, order information, medication, etc. are supported in other standards such as HL7 Clinical Document Architecture (CDA); by including references to MFER information in these documents, implementation for message exchange, networking, database management that includes waveform information becomes simple and easy.

**Separation between supplier and consumer of medical waveforms**

The MFER specification concentrates on data format instead of paper-based recording. For example, recorded ECG is processed by filter, data alignment, and other parameters, so that the ECG waveform can be easily displayed using an application viewer. However, it is not as useful for other purposes such as data processing for research investigations. A design goal of MFER is that a waveform is described in raw format with as complete as possible recording detail. When the waveform is used, appropriate processing of the data are supported like filtering, view alignment, and so on. In this way, the medical waveform described in MFER can be used for multiple purposes.

**Product capabilities are not limited**

Standards often support only a minimum set of requirements, so the expansion of product features can be greatly limited. MFER can describe medical waveform information without constraining the potential features of a product. Also, medical waveform display must be very flexible, and thus MFER

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has mechanisms supporting not only a machine-readable coded system for abstract data, but also human-readable representation.

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

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# Health informatics — Medical waveform format —

# Part 3:
# Long term electrocardiography

## 1 Scope

This Technical Specification defines the application of medical waveform format encoding rules (MFER) to describe long-term electrocardiogram waveforms measured in physiological laboratories and health care clinics. It covers electrocardiograms such as bipolar 2, 3-lead, 12-lead that are measured by medical equipment such as Holter electrocardiograph and patient physiological monitors that are compatible with the medical waveform format Encoding rules (MFER) Technical Specification (ISO 22077-1).

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

## 3 Terms and definitions

**3.1**
**recorder**
recording equipment worn or carried by the patient including associated electrodes and cables for recording or recording and analysing heart action potentials

Note 1 to entry: Some recorders can record not only ECG but also non-invasive blood pressure measured automatically, SpO2, and respiratory waveform.

**3.2**
**scanner**
equipment that retrieves ECG waveforms from the recorder and analyses and edits ECG waveforms provided by the recorder to determine the presence of abnormal heart rhythms such as arrhythmia

**3.3**
**patient event**
information or event for analysing the ECG.

EXAMPLE For example, they may have chest pain, dizziness, or palpitatins, etc. Pushing a “patient event” switch located on the recorder allows for recording ECG waveforms with the time of occurrence.

**3.4**
**heart beat**
ECG cycle, comprising the P,QRS and the ST-T wave

**3.5**
**dominant beat**
typical heart beat used for measurement and analysis

Note 1 to entry: In general, it is decided for heart beat excepting extrasystole or drifts of baseline.

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**3.6**
**average beat**
typical heart beat used for measurement and analysis

Note 1 to entry: This is averaged for waveforms excluding abnormal beats for each lead.

**3.7**
**abstract waveform**
one heartbeat of P-QRS-T, extracted by each lead for analyzing and editing

**3.8**
**low battery**
<information>battery voltage is low and exchange of battery is required

**3.9**
**leads off**
<information> electrodes are disconnected

**3.10**
**out of range**
<information in patient monitoring system>poor condition on the radio field

**3.11**
**pacing pulse**
pulsed waveform from artificial pacemaker

## 4 Symbols and abbreviated terms

| | |
|---|---|
| CEN | Comité Européen de Normalization/European Committee for Standardization |
| DBMS | Data Base Management system |
| DICOM | Digital Imaging and Communications in Medicine |
| ECG | Electrocardiogram |
| EEG | Electroencephalogram |
| EHR | Electronic Health Record |
| GPS | Global Positioning System |
| HL7 | Health Level Seven |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronic Engineers |
| JIS | Japanese Industrial Standard |
| LSB | Least significant bit |
| MFER | Medical waveform Format Encoding Rules |
| MSB | Most significant bit |
| OID | Reference to the ISO standard |
| SAS | Sleep Apnea Syndrome |

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SCP-ECG Standard Communications Protocol for Computerized Electrocardiography (ISO IS 11073-91064)

SpO2 Saturation of Peripheral Oxygen

UID Reference to the ISO standard

UUID Reference to the ISO standard

VCG Vectorcardiogram

XML Extensible Markup Language

# 5 Encoding format

## 5.1 Primary description

MFER provides encoding of Long-term ECG waveforms but since MFER is used mutatis mutandis for encoding of ECG waveforms such as ambulatory ECG, patient monitor system, etc., In addition, together with encoding of ECG waveforms, encoding of information of recognition for waveform, measurement information, interpretation information, etc. is provided, but these are all optional functions and are dependent on each implementation concept. For instance, interpretation code or measurement value might be described by other standard such as HL7, XML, DBMS, etc. with waveforms decoding MFER. However, in all instances, when implementing a device, apply the requirements as listed in ISO 22077-1.

### 5.1.1 Sampling attributes

Sampling attributes including sampling rate and resolution are given in Tables 1 to 4.

#### 5.1.1.1 MWF_IVL (0Bh): Sampling rate

This tag indicates the frequency or sampling interval for the medical waveform is sampled (Table 1).

**Table 1 — Sampling rate**

| MWF_IVL | | | Data length | Default | Encoding range/remarks | Duplicated definitions |
|---|---|---|---|---|---|---|
| 11 | 0Bh | Sampling rate unit | 1 | 1 000 Hz | | Override |
| | | Exponent (10th power) | 1 | | $10^{-128 \sim +127}$ | |
| | | Mantissa | ≤4 | | e.g. unsigned 16-bit integer | |

The unit may be frequency in hertz, time in seconds or distance in meters (Table 2).

**Table 2 — Sampling rate unit**

| Unit | | Value | Remarks |
|---|---|---|---|
| Frequency | Hz | 0 | Including power |
| Time interval | s | 1 | — |

#### 5.1.1.2 MWF_SEN (0Ch): Sampling resolution

This tag indicates the resolution of least significant bit for ECG waveform sampled (generally, digitized) (Table 3).

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**Table 3 — Sampling resolution**

| MWF_SEN | | | Data length | Default | Encoding range/remarks | Duplicated definitions |
|---|---|---|---|---|---|---|
| 12 | 0Ch | Sampling resolution unit | 1 | See Table 6 | — | Override |
| | | Exponent (10th power) | 1 | | $10^{-128 \sim +127}$ | |
| | | Mantissa | ≤4 | | e.g. unsigned 16-bit integer | |

**Table 4 — Sampling units**

| Unit | | Value | Default | Remarks |
|---|---|---|---|---|
| Voltage | Volt | 0 | 0,000 001 V | |

### 5.1.2 Frame attributes

A frame is composed of data blocks, channels, and sequences.

#### 5.1.2.1 MWF_BLK (04h): Data block length

This tag indicates the number of data sampled in a block (Table 5).

**Table 5 — Data block length**

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

#### 5.1.2.2 MWF_CHN (05h): Number of channels

This tag indicates the number of ECG channels (Table 6). If a previously specified channel attributes 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 within the definition of a channel attribute

**Table 6 — Number of channels**

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

#### 5.1.2.3 MWF_SEQ (06h): Number of sequences

This tag indicates the number of sequences (Table 7). 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 that are defined for the specified frame.

**Table 7 — Number if sequences**

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

### 5.1.3 Waveform class

Long-term ECG waveform is grouped based on instruments and purpose, as shown in Table 8.

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**Table 8 — Waveform class**

| MWF_WFM | | Date length | Remarks | Duplicated definitions |
|---|---|---|---|---|
| 08 | 08h | 2 | | Override |
| | | Str ≤ 32 | Waveform encoding | |

As a general rule, each type of waveform is described in a separate specification.

For types of waveforms (Tables 9 to 10), numbers 1 to 49151 (BFFFh) are reserved. Numbers 49152 to 65535 can be used privately, but it is recommended to add these to the MFER specification rather than rely on private extensions.

**Table 9 — Long-term ECG waveform-1**

| Major classification | Type | Value | Waveform descriptions | Remarks |
|---|---|---|---|---|
| Electrocardiogram | ECG_LTERM | 2 | Long-term ECG | Ambulatory ECG<br>Patient monitoring system ECG |

a) It is recommended that ECG classified into the type ECG_LTERM is used when it takes over 30 min for measurement, because application system such as viewer may have different display format for each waveform type. However, this recommendation is not a requirement.

b) In addition, extracted waveforms which are used in the long-term ECG are shown in Table 10. These waveforms shall be extracted after being analysed and edited, and then shall be used for scanning.

**Table 10 — Long-term ECG waveform-2**

| Major classification | Type | Value | Waveform descriptions | Remarks |
|---|---|---|---|---|
| Electrocardiogram | ECG_BEAT | 9 | Dominant beat extracted waveform | Extracted waveform for one beat by ambulatory ECG<br>Write comment<br>Average, Median, Dominant |

## 5.2 Data alignment

Data alignment recommended by ambulatory ECG standard shall be prescribed. Data alignment should be simple as much as possible in order to prevent troubles caused by the complication which may result in some limitation of interoperability by using complicated format.

### 5.2.1 Data encoding

In long-term ECGs, the recorder for recording ECG waveforms, the scanner for analysing and editing ECG waveforms, and the electronic medical record for referring waveforms shall be encoded in the most appropriate format respectively in accordance with MFER.

— Recorder encoding: The recorder encodes ECG waveforms on the assumption that it processes the data in real time. The data encoded by the recorder shall be regarded as the original data (original ECG). This encoding format is defined in view of the risk of sudden disconnection of battery or other record media in patient's daily life. Furthermore, encoding of information including pacemaker spike and patient event shall be also prescribed.

— Scanner encoding: In the scanner encoding, information derived from analysing and editing the long-term ECG data recorded by the recorder shall be added to the original data. This encoding format is defined in view of reading MFER file with the scanner, and the secondary information, including heart beat code or event strip created by the scanner, shall be encoded in this format. This format also shall be used to output data from the scanner to the host system such as electronic medical record in accordance with MFER.

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### 5.2.2 Recorder encoding

In recorder encoding, the following points should be noted:

— In view of sudden disconnection of battery or other record media, the data recorded by the time of the disconnection should be kept to allow for reading data in a proper format.

— Information on patient event or body movement should be in the same way as ECG and respiratory waveforms, so that every user can read data without any difficulty.

#### 5.2.2.1 Encoding of waveforms

In recorder encoding, waveforms shall be encoded according to MWF_WAV (1Eh), and shall consist of lead, status and stopper. Figure 1 shows one minute waveform data, and it is an example of waveform data recorded using leads called CM5 and NASA.

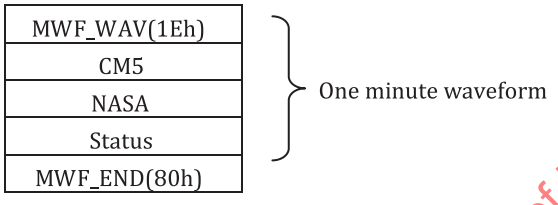


**Figure 1 — Encoding of waveform**

MWF_END (80h) tag shall be encoded at the end of the file as a stopper.

In encoding waveforms, it is practical to use a multiple frame.

It is practical to use multiple frames to encode waveforms. Frames are usually created in the order that waveforms are generated, and then the frames shall be aligned to create waveforms.

| Frame 1 | | Frame 2 | | Frame 3 |
|---|---|---|---|---|
| Header -1 | Wave body | Header -2 | Wave body | Header-3 |

**Figure 2 — Multiple frame configurations**

In encoding successive waveforms with the multiple frames, waveforms encoded with frames later than Frame 2 are usually the same with pre-encoded condition or status in Frame 1. For example, the sampling frequency and waveform code are usually the same. In such case, according to MFER, the header is frequently omissible.

#### 5.2.2.2 Encoding format for pacemaker spike and patient event

Pacemaker spike and patient event shall be encoded by data type MWF_DTP (0Ah) “16-bit status”.

**Table 11 — Waveform information (status)**

| MWF_DTP | | Data length | Default | Remarks | Duplicated definitions |
|---|---|---|---|---|---|
| 10 | 0Ah | 1 | N.A. | | Override |

**Table 12 — Definition of data type**

| Value | Data type |
|---|---|
| 4 | 16-bit status |

Pacemaker information shall be encoded with 16-bit status.

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**Table 13 — Definition of status**

| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | |

| Bit | Information | Value |
|---|---|---|
| 0 | Pacing | 0: none 1: Pacing |
| 1 | Reserved | |
| 2 | Ventricular pacing | 0: none 1: Ventricular pacing |
| 3 | Atrial pacing | 0: none 1: Atrial pacing |
| 4 | Reserved | |
| 5 | Low battery | 0: none 1:Battery changing |
| 6 | Leads off | 0: none 1:Electrode disconnection |
| 7 | Radio field strength | 0: none 1:Out of range |
| 8 | Patient event 1 | 0: none 1: patient event 1 |
| 9 | Patient event 2 | 0: none1: patient event 2 |
| 10 - 12 | Body position | 000: none<br>001: Standing/Seating<br>010: Supine<br>011: Right lateral decubitus<br>100: Left lateral decubitus<br>101: Prone<br>110: Reserved<br>111: Reserved |
| 13 | Reserved | |
| 14 | Reserved | |
| 15 | Reserved | |

Patient event 1 is defined on the assumption that the recorder event key is held down in ambulatory ECGs. In the patient monitoring system, this corresponds with the “nurse call” in the transmitter. Patient event 2 can be used as medical information. It is recommended that its practical use is defined by each user.

#### 5.2.2.3 Encoding of event information

Said “event information” includes every information except waveform information. Patient event is defined as “Status” in 5.2.2.2 of this rule. Value of body movement, blood pressure, and SpO2 shall be encoded as patient event.

**Table 14 — Reference pointer**

| MWF_RPT | | | Data length | Default | Remarks | Duplicated definitions |
|---|---|---|---|---|---|---|
| 69 | 45h | Data type | 1 | | | Possible |
| | | Reference pointer | Str < 256 | | URL | |

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**Table 15 — Data type**

| Data type | Value |
|---|---|
| External data | 0 |
| MFER data | 1 |

Event information shall be encoded using the reference pointer MWF_RPT (45) in a number of formats. Some examples are shown below:

a) **MWF_EVT (41h)**

Figure 3 illustrates the encoding of patient event in event information by using the reference pointer MWF_RPT (45h). It is recommended that MWF_END (80h) is used to encode not only waveforms but also event information.

Using MWF_EVT (41h), patient event shall be defined as character string.

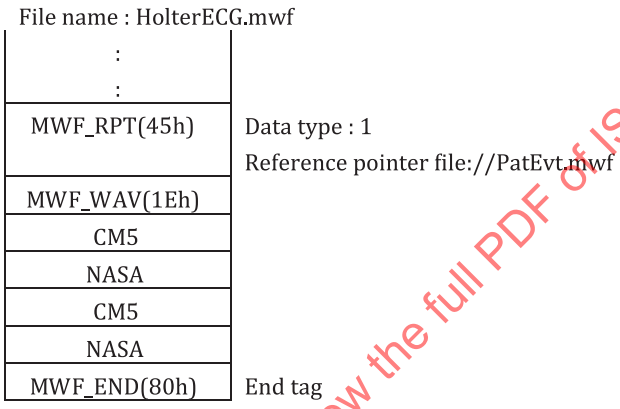


**Figure 3 — Definition of event**

**Table 16 — Event**

| MWF_EVT | | | Data length | Encoding range / remarks | Duplicated definitions |
|---|---|---|---|---|---|
| 65 | 41h | Waveform recognition pointcode | 2 | | Multiple definitions available |
| | | Starting time (point) | 4 | Number of data values acquired at the sampling interval defined in the root definition | |
| | | Duration | 4 | | |
| | | Event information | Str < 256 | | |

b) **MWF_VAL (42h)**

Figure 4 illustrates the encoding of patient event in event information by using the reference pointer MWF_RPT (45). It is recommended that MWF_END (80h) is used to encode not only waveforms but also event information.

This rule only applies to irregular measurements such as non-invasive blood pressure (NIBP). By using MWF_VAL (42h), NIBP shall be defined as measurement value.

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File name : HolterECG.mwf

| | |
|---|---|
| : | |
| : | |
| MWF_RPT(45h) | Data type : 1<br>Reference pointer file://NIBP_data.mwf |
| MWF_WAV(1Eh) | |
| CM5 | |
| NASA | |
| CM5 | |
| NASA | |
| MWF_END(80h) | End tag |

File name : NiBP_data.mwf

| | |
|---|---|
| : | |
| : | |
| MWF_VAL(42h) | Encoding N IBP as MWF_VAL |
| Encoding of measurement value | Encoding of time point and measurement value |
| MWF_END(80h) | End tag |

**Figure 4 — Definition of measurement value**

**Table 17 — Measurement value**

| MWF_VAL | | | Data length | Encoding range/remarks | Duplicated definition |
|---|---|---|---|---|---|
| 66 | 42h | Value code | 2 | | 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 ("^") | |

### 5.2.3 Scanner encoding

The scanner encoding format after analysing and editing shall be prescribed.

#### 5.2.3.1 Encoding of MFER interpretation code and beat annotation

Interpretation code and beat annotation shall be encoded with the event tag.

**Table 18 — Encoding of interpretations**

| MWF_EVT | | | Data length | Encoding range•remarks | Duplicated definition |
|---|---|---|---|---|---|
| 65 | 41h | Interpretation code | 2 | | Multiple definitions available |
| | | Starting time (point) | 4 | Number of data values acquired at the sampling interval defined in the root definition. | |
| | | Duration time | 4 | | |
| | | Interpretation information | Str < 256 | | |

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Interpretation code format shall be defined as follows:

**Table 19 — Interpretation code format**

| 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | Interpretation code | | | | | | | | | | | Possiblity | |

Interpretation code shall consist of number starts with 4244. See Table 20.

Each possibility bit code means as follows:

0: Undesignated (No need to be defined or specified)

1: In case the possibility of the applicable finding is unlikely

2: Suspicious

3: Strongly suspicious

#### 5.2.3.2 Interpretation

When the applicable interpretation is encoded throughout the whole frame, the definition shall be made in the root definition region. Both starting time and duration shall not be used when the event information is not used. In the case that event information is used, “0 (zero)” shall be used for both starting time and duration.

#### 5.2.3.3 Beat-to-beat waveform classification

The time when the relevant heart beat is observed shall be designated as starting time, and the duration shall not be used. In the case that event information is used, “0 (zero)” shall be used for the duration.

#### 5.2.3.4 Waveform classification in the given period

Relevant regional time shall be designated by using the starting time and duration in order to encode abnormal waveforms, for example, atrial fibrillation.

#### 5.2.3.5 Simultaneous encoding of event code and event information

Event code and event information shall be used simultaneously. Alternatively, event code = 0 and event information shall be encoded. See the example below.

E.g. Event information shall be encoded with “interpretation text^code system (manufacturer name)^abbreviation or code” (in case of encoding plurality of event information, use “&”). In encoding with MFER code MWF_ECGL_VE_ISO(4496) and adding event information defined in SCP-ECG, the event information shall be encoded as follows:

ventricular premature complex^SCP-ECG^VPC

**Table 20 — Interpretation code**

| Reference ID | CODE | | Interpretation (English) |
|---|---|---|---|
| | DEC | HEX | |
| MWF_ECG_UNDFD | 4224 | 1080 | Unclassified |
| MWF_ECGL_NOR_BEAT | 4228 | 1084 | Normal beat |
| MWF_ ECGL_WPW _BEAT | 4232 | 1088 | Wolff-Parkinson-White syndrome type beat |

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**Table 20** *(continued)*

| Reference ID | CODE | | Interpretation (English) |
|---|---|---|---|
| | DEC | HEX | |
| MWF_ECGL_BBB_BEAT | 4236 | 108C | Bundle branch block beat |
| MWF_ECGL_JUC_BEAT | 4240 | 1090 | Junctional beat |
| MWF_ECGL_SUP_BEAT | 4244 | 1094 | Supraventricular beat |
| MWF_ECGL_SBBB_BEAT | 4248 | 1098 | Supraventricular beat with Bundle branch Block |
| MWF_ECGL_SWPW_BEAT | 4252 | 109C | Supraventricular beat with WPW |
| MWF_ECGL_AVC_BEAT | 4256 | 10A0 | Aberrant Ventricular Conduction |
| MWF_ECGL_VENT_BEAT | 4260 | 10A4 | Ventricular beat |
| MWF_ECGL_FUS_BEAT | 4264 | 10A8 | Fusion beat |
| MWF_ECGL_VENTESP_BEAT | 4268 | 10AC | Ventricular escape beat |
| MWF_ECGL_IDORHM_BEAT | 4272 | 10B0 | Idioventricular rhythm |
| MWF_ECGL_UNDFD_BEAT | 4276 | 10B4 | Undefined beat |
| MWF_ECGL_UNDFD_L_BEAT | 4280 | 10B8 | Learning beat |
| MWF_ECGL_UNDFD_C_BEAT | 4284 | 10BC | Calibration beat |
| MWF_ECGL_A_PACE_BEAT | 4288 | 10C0 | Atrial paced beat |
| MWF_ECGL_V_PACE_BEAT | 4292 | 10C4 | Ventricular paced beat |
| MWF_ECGL_D_PACE_BEAT | 4296 | 10C8 | Dual paced beat |
| MWF_ECGLPAC_F_BEAT | 4300 | 10CC | Paced fusion beat |
| MWF_ECGL_ART_1_BEAT | 4304 | 10D0 | Artefact |
| MWF_ECGL_ART_2_BEAT | 4308 | 10D4 | Artefact |
| MWF_ECGL_BRADY | 4480 | 1180 | Bradycardia |
| MWF_ECGL_TACHY | 4484 | 1184 | Tachycardia |
| MWF_ECGL_PAUSE | 4488 | 1188 | Pause |
| MWF_ECGL_PROLONG | 4492 | 118C | Prolong |
| MWF_ECGL_VE_ISO | 4496 | 1190 | VE Isolated |
| MWF_ECGL_VE_COU | 4500 | 1194 | VE Couplet |
| MWF_ECGL_VE_RUN | 4504 | 1198 | VE Run |
| MWF_ECGL_VT | 4508 | 119C | Ventricular Tachycardia |
| MWF_ECGL_RONT | 4512 | 11A0 | R on T |
| MWF_ECGL_VENT_BIGE | 4516 | 11A4 | Ventricular Bigeminy |
| MWF_ECGL_VENT_TRI | 4520 | 11A8 | Ventricular Trigeminy |
| MWF_ECGL_SVE_ISO | 4524 | 11AC | SVE Isolated |
| MWF_ECGL_SVE_COU | 4528 | 11B0 | SVE Couplet |
| MWF_ECGL_SVE_RUN | 4532 | 11B4 | SVE Run |
| MWF_ECGL_PARO_S_TACHY | 4536 | 11B8 | Paroxysmal Supraventricular Tachycardia |
| MWF_ECGL_SUP_BIGE | 4540 | 11BC | Supraventricular Bigeminy |
| MWF_ECGL_SUP_TRI | 4544 | 11C0 | Supraventricular Trigeminy |
| MWF_ECGL__A_FIB | 4548 | 11C4 | Atrial Fibrillation |
| MWF_ECGL_A_FLUTTER | 4552 | 11C8 | Atrial Flutter |
| MWF_ECGL_A_F_F | 4556 | 11CC | Atrial Flutter/Fibrillation |
| MWF_ECGL_ST_ELE | 4560 | 11D0 | ST Elevation |

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**Table 20** *(continued)*

| Reference ID | CODE | | Interpretation (English) |
|---|---|---|---|
| | DEC | HEX | |
| MWF_ECGL_ST_DEP | 4564 | 11D4 | ST Depression |
| MWF_ECGL_CAP_FAIL | 4568 | 11D8 | Capture Failure |
| MWF_ECGL_UNDER_SENS | 4572 | 11DC | Under Sensing |
| MWF_ECGL_OVER_SENS | 4576 | 11E0 | Over Sensing |

## 5.3 Lead name

Lead name means the waveform code used in long-term ECGs. This code shall be used in 12-lead ECG and/or Vector lead ECG. As the lead code is encoded by the number 0-127, extra attention would be required in the case of complying with other rules such as SCP-ECG. Lead code later than 4160 is defined in the long-term ECG standard. For more detailed lead name other than the definition in the long-term ECG standard, see Annex D.

**Table 21 — Lead name-1**

| Code | Lead | Code | Lead |
|---|---|---|---|
| 1 | I | — | — |
| 2 | II | — | — |
| 3 | V1 | — | — |
| 4 | V2 | — | — |
| 5 | V3 | — | — |
| 6 | V4 | — | — |
| 7 | V5 | — | — |
| 8 | V6 | — | — |
| 9 | V7 | — | — |
| 10 | [b] | — | — |
| 11 | V3R | 61 | III |
| 12 | V4R | 62 | aVR |
| 13 | V5R | 63 | aVL |
| 14 | V6R | 64 | aVF |
| 15 | V7R | 65 | -aVR[a] |
| 16 | X | 66 | V8 |
| 17 | Y | 67 | V9 |
| 18 | Z | 68 | V8R |
| 19 | CC5 | 69 | V9R |
| 20 | CM5 | 70 | D(Nehb Dosal) |
| — | — | 71 | A(Nehb Anterior) |
| 31 | NASA | 72 | J(Nehb Inferior) |
| 32 | CB4 | — | — |

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

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

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**Table 21** *(continued)*

| Code | Lead | Code | Lead |
|---|---|---|---|
| 33 | CB5 | — | — |
| 34 | CB6 | — | — |

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

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

**Table 22 — Lead name-2**

| Code | Lead | Remarks |
|---|---|---|
| 4160 | Status | In case status including body position is encoded |
| 4161 | Body position | In case body position is encoded as successive waveforms |
| 4162 | Body movement | |
| 4163 | Respiratory | In case method for respiratory measurement is not specified (including snoring) |
| 160 | Impedance respiratory waveform | |
| 143 | Blood pressure | In case method for NiBP measurement is not specified |
| 175 | SPO2 | |
| 4166 | ECG1 | These shall be used in case lead name is not definite |
| 4167 | ECG2 | |
| 4168 | ECG3 | |
| 4169 | ECG4 | |

## 5.4 Lead calculation

Recent electrocardiographs frequently adopt systems to record limb leads by Leads I and II only. In such event, Leads III, aVR, aVL, and aVF shall be found by calculation. Derivation shall be performed by the following operation:

In implementing lead calculation, thorough consideration shall be given to aspects such as A/D conversion method, phase deviation or electrode disconnection, and care should be practiced to prevent occurrence of arithmetic waveform distortion.

**Table 23 — Lead calculation operation table (derivation from leads I and II)**

| Lead name | Arithmetic operation | Computation (right hand potential R; left hand potential L; and left foot potential F) |
|---|---|---|
| III | II – I | III = F–L = (F–R)– (L–R), where II = F–R, I = L–R |
| aVR | – (I + II)/2 | aVR = R–(L+F)/2 = {(R–L)+(R–F)}/2 |
| aVL | I – II/2 | aVL = L–(R+F)/2 = {(L–R)+(L–F)}/2 = (I–III)/2 = I–II/2 |
| aVF | II – I/2 | aVL = F–(R+L)/2 = {(F–R)+(F–L)}/2 = (II+III)/2 = II–I/2 |
| -aVR | Negative number of aVR | |

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**Table 24 — Lead calculation operation table (derivation from leads I and III)**

| Lead name | Calculation formula | Calculation (right hand potential R; left hand potential L; and left foot potential F) |
|---|---|---|
| II | III+ I | II = F–R = (F–L)+ (L–R), where III = F–L, I = L–R |
| aVR | – I – III/2 | aVR = R–(L+F)/2 = {(R–L)+(R–F)}/2 = {–I–(III+I)}/2 = –I–III/2 |
| aVL | (I – III)/2 | aVL = L–(R+F)/2 = {(L–R)+(L–F)}/2 = (I–III)/2 |
| aVF | III + I/2 | aVL = F–(R+L)/2 = {(F–R)+(F–L)}/2 = {(III+I)+III}/2 = III+I/2 |
| -aVR | Negative number of aVR | |

**Table 25 — Lead calculation operation table (derivation from leads II and III)**

| Lead name | Calculation formula | Calculation (right hand potential R; left hand potential L; and left foot potential F) |
|---|---|---|
| I | II – III | I = L–R = (F–R)– (F–L), where II = F–R, III = F–L |
| aVR | – II + III/2 | aVR = R–(L+F)/2 = {(R–L)+(R–F)}/2 = {– (II–III) –II }/2 = –II+III/2 |
| aVL | –III + II/2 | aVL = L–(R+F)/2 = {(L–R)+(L–F)}/2 = {(II–III) –III}/2 = –III+II/2 |
| aVF | (II +III)/2 | aVL = F–(R+L)/2 = {(F–R)+(F–L)}/2 = (II+III)/2 |
| -aVR | Negative number of aVR | |

Sampled ECG data for all leads shall be completely synchronized.

## 5.5 Filter information

When filter information is described in MFER, it is classified in two cases: filter-processed data and non-filtered use information.

### 5.5.1 Description of filter-processed data

Description is made on the filter information processed for the data described by MFER.

**Table 26 — Filter information**

| MWF_FLT | | Data length | Duplicated definitions |
|---|---|---|---|
| 17 | 11h | Str < 256 | Possible |

**Table 27 — Filter description example**

| Filter function | Abbreviation | Example | Meaning |
|---|---|---|---|
| Filter information only | None | Hum filter ON | Ham filter (not specified) is used. More specific information shall be provided by adding power supply frequency information. |
| High pass filter | HPF | HPF = 0.05 | Characteristics unspecified 0.05 Hz low frequency cutoff (high-pass) filter is used. |
| Low pass filter | LPF | LPF = 150^second order Butterworth filter | Butterworth second characteristics150 Hz high frequency cutoff (low-pass) filter is used. |
| Band elimination filter | BEF | BEF = 50^Hum filter | 50 Hz ham filter is used. Cutoff characteristics uncertain. |

In ECG, high-pass (low frequency cutoff) filter is frequently described by the time constant, but in MFER, it is recommended to describe it by frequency. For example, the low frequency cutoff filter, which has the primary Butterworth characteristics shown by frequently used CR, is described by the following:

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By High-pass Filter = 1/ωT, the lower cutoff frequency of time constant of 3 s is described by 1/(2π × 3 s) approximately 0,05 Hz.

### 5.5.2 Description of filter use information

In this case, MFER ECG data has not been subject to filter processing, and the fact that a specific filter is used is stipulated only. For example, this information may be used to indicate that the ECG was measured by an electrocardiograph, printed on recording paper underwent the relevant filter processing, and may be utilized for diagnosis.

## 5.6 Unique identifier

This tag indicates UID (Unique Identifier).

**Table 28 — Unique identifier**

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

Definition of the Object Identifier is not in the scope of MFER. This is designated with OID, UUID.

# 6 Measurement information

Of information generated during measuring ECG, information that would exert effect on the authenticity of ECG and validity of waveforms is encoded. For example, it is possible to encode waveform display information and power supply frequency that do not exert effect on generation of ECG waveform measurement but that are required to reproduce the condition at the time of measurement. The descriptions in this chapter are recommended to be implemented in accordance to local conventions whenever possible.

## 6.1 Measurement date/time

This tag encodes the examination/measurement date/time or the data acquisition date/time (Table 29).

The date/time is an important object stored using MFER. Care should be taken to ensure it is accurate.

**Table 29 — Measurement time**

| 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 | |
| | | Milli-sec | 2 | | 0 – 999 | |
| | | Micro-sec | 2 | | 0 – 999 | |

## 6.2 Patient information

### 6.2.1 Patient name

Patient name should be encoded as follows.

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Family name^first name^middle name

**Table 30 — Patient name**

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

### 6.2.2 Patient ID

The patient identifier may be encoded. Management of patient identifiers is outside the scope of the MFER specification. It is recommended to encode a patient ID as follows:

Patient ID^Local ID^Temporary ID.

If the above format is not provided, then the available identifier shall be used for all applications.

**Table 31 — Patient ID**

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

### 6.2.3 Age and date of birth

Age of the patient and date of birth may be encoded. The patient age is based on the date of examination or waveform acquisition.

**Table 32 — Age and date of birth**

| MWF_AGE | | | | Data length | Default | Remarks | Duplicated definitions |
|---|---|---|---|---|---|---|---|
| 131 | 83h | Age | Years | 1 | None | | Override |
| | | | Days | 2 | | | |
| | | Birth date | Year | 2 | | | |
| | | | Month | 1 | | | |
| | | | Day | 1 | | | |

### 6.2.4 Gender

Patient gender may be encoded.

**Table 33 — Gender**

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

**Table 34 — Gender code**

| Gender | Value |
|---|---|
| Unclear | 0 |
| Male | 1 |
| Female | 2 |
| Unspecified | 3 |

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### 6.2.5 Comment

Memos and comments may be encoded. Information that does not exert a direct effect on waveform may be encoded (e.g. patient movement).

[Reference] Information that exerts effect on waveform may be encoded by ancillary information (MWF_INF).

**Table 35 — Comment**

| MWF_NTE | | Data length | Default | Remarks | Duplicated definitions |
|---|---|---|---|---|---|
| 22 | 16h | Str<256 | | | Available |

Only one comment shall be encoded within 255 characters; however, multiple comments may be included as required. Each comment may be read by a viewer, whether or not the comment has any user specified meaning. By using multiple instances of comments, longer comments may be accommodated.

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# Annex A
(informative)

# MFER Conformance statement

## A.1 Conformance statement

Each implementer should provide a specification sheet of their MFER waveform format using the conformance statement below (Table A.1). Use of non-default values should be identified clearly. If the extension capabilities of the MFER description are used, an additional sheet with these 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** |
|---|---|---|---|
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| Note | | | |
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# Annex B
(informative)

# Waveform encoding

## B.1 Recording example

With ambulatory ECG recorder, it is impossible to know exactly when the measurement is finished. Therefore, when encoding waveforms, the waveform information shall be encoded regularly (e.g. every 1 min) to prevent users from reading data improperly by MWF_END (80h) when they add information. As MWF_END (80h) indicates that there is no other MFER encoding after MWR_END (80h), this tag should written at the end of the file.

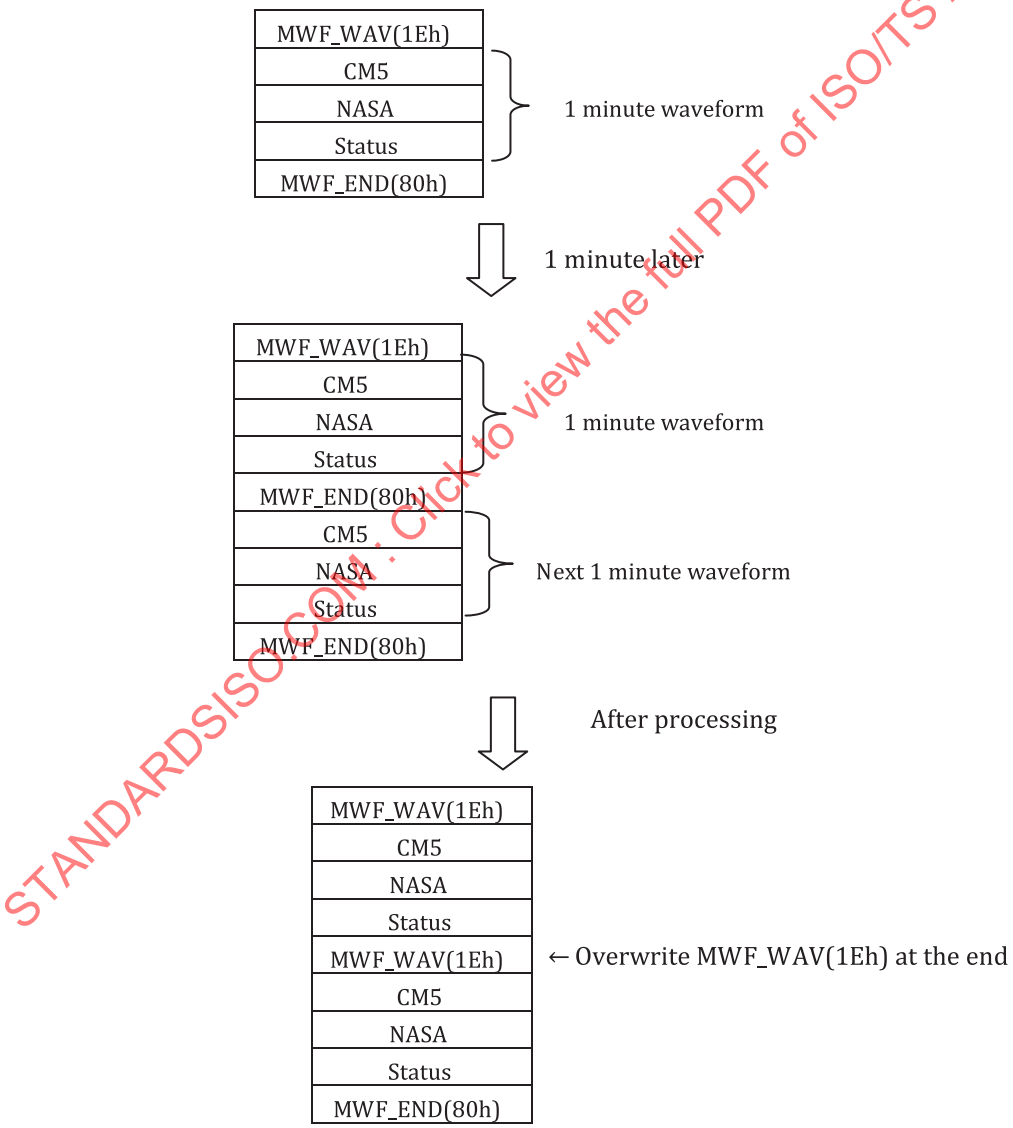


**Figure B.1 — Encoding of waveform**

The data updating shall be made in the order shown below in encoding by the recorder:

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1. Additionally encode waveform data
2. Encode MWF_END(80h)
3. Encode new waveform data to MWF_END(80h) which indicates an ending point of the last data

MWF_WAVE(1Eh) shall be written for every predetermined time. In such event, as data such as sampling or sequence encoded in the first place shall remain, the ECG data are recognized as a successive waveform.

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# Annex C
(informative)

# Example of waveform coding

## C.1 Example of waveform coding

The table below shows examples of the encoding of teo-channel ambulatory ECG with status information (pacemaker spike, patient event, etc.) and body movement. The waveform should be divided into several blocks (1 block is 30 s), and sampling frequency is 125 Hz. The body movement should be encoded for every second.

According to the example of waveform coding, tags should be outputed in the following order:

**Table C.1 — Example of waveform coding**

| Tag name | | Code | | | | Descriptions |
|---|---|---|---|---|---|---|
| | | Tag No (HEX) | Length (DEC) | Data (HEX) | | |
| 1 | MWF_PRE | 40 | 32 | 4d 46 52 20 | | MFR |
| | | | | 4c 6f 6e 67 20 54 65 72 6d 20 45 43 47 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 | | Long-term ECG |
| 2 | MWF_BLE | 01 | 1 | 01 | | Little endian |
| 3 | MWF_TXC | 03 | 6 | 55 54 46 2d 38 00 | | Character encoding scheme is UTF-8 |
| 4 | MWF_MAN | 17 | 53 | 4e 69 68 6f 6e 4b 6f 68 64 65 6e 5e 52 41 43 2d 33 31 30 33 5e 56 65 72 20 30 31 2d 30 36 20 50 5e 33 31 30 33 30 30 30 30 30 32 30 30 35 30 37 31 35 30 32 00 | | Information on manufacturer or model name |
| 5 | MWF_WFM | 08 | 1 | 02 | | Waveform type = Long-term ECG |
| 6 | MWF_TIM | 85 | 11 | Year | d7 07 | 2007/01/23 13:31:00, 0, 0 |
| | | | | Month | 01 | |
| | | | | Day | 17 | |
| | | | | Hour | 0d | |
| | | | | Minute | 1f | |
| | | | | Second | 00 | |
| | | | | Milli-second | 00 00 | |
| | | | | Micro-second | 00 00 | |
| 7 | MWF_AGE | 83 | 7 | Years | 16 | Age = 22 years old |
| | | | | Days | fe 1f | Age by day = 8 190 days old |
| | | | | Birth date [y] | c0 07 | Birth date = 1984/11/23 |
| | | | | Birth date [M] | 0b | |
| | | | | Birth date [D] | 17 | |

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**Table C.1** *(continued)*

| Tag name | | Code | | | | Descriptions |
|---|---|---|---|---|---|---|
| | | Tag No (HEX) | Length (DEC) | Data (HEX) | | |
| 8 | MWF_PNM | 81 | 42 | 4d 61 72 6b 20 53 6d 69 74 68 00 | | Mark Smith |
| 9 | MWF_PID | 82 | 11 | 31 31 32 33 37 30 30 30 35 31 00 | | ID = 1123700051 |
| 10 | MWF_SEX | 84 | 1 | 01 | | Gender = Male |
| 11 | MWF_SEN | 0c | 4 | Measure | 00 | Electrical potential = 5 micro V<br>5 × $10^{-6}$ V |
| | | | | Exponent part | fa | |
| | | | | Data | 05 00 | |
| 12 | MWF_IVL | 0b | 4 | Measure | 01 | Interval = 8 milli-second<br>8 × $10^{-3}$ sec. |
| | | | | Exponent part | fd | |
| | | | | Data | 08 00 | |
| 13 | MWF_BLK | 04 | 4 | a6 0e 00 00 | | Block length = 30 s<br>3 750 samples<br>Sampling interval × Recording time |
| 14 | MWF_DTP | 0a | 1 | 00 | | Data type<br>16 bit signed integer |
| 15 | MWF_CHN | 05 | 1 | 04 | | The number of channel = 4<br>• ECG1<br>• ECG2<br>• Status information<br>• Body movement information |
| 16 | MWF_SEQ | 06 | 4 | 01 00 00 00 | | The number of sequence = 1 |
| 17 | MWF_ATT | 3f 00 | 4 | MWF_LDN | 09 | Waveform type = ECG1 |
| | | | | Length | 02 | |
| | | | | Data | 46 10 | |
| 18 | MWF_ATT | 3f 01 | 4 | MWF_LDN | 09 | Waveform type = ECG2 |
| | | | | Length | 02 | |
| | | | | Data | 47 10 | |
| 19 | MWF_ATT | 3f 02 | 7 | MWF_LDN | 09 | Waveform type = status |
| | | | | Length | 02 | |
| | | | | Data | 40 10 | |
| | | | | MWF_DTP | 0a | Data type = 16 bit status |
| | | | | Length | 01 | |
| | | | | Data | 04 | |

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