

# ANSI/CTA Standard

**Standard for Consumer EEG File Format  
(Attuned Container Format)**

**ANSI/CTA-2060**

**November 2017**



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## FOREWORD

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## CONTENTS

|                                                                                                    |           |
|----------------------------------------------------------------------------------------------------|-----------|
| <b>1 Scope.....</b>                                                                                | <b>1</b>  |
| <b>2 References.....</b>                                                                           | <b>1</b>  |
| <b>2.1 Normative References.....</b>                                                               | <b>1</b>  |
| 2.1.1 Normative Reference List .....                                                               | 1         |
| 2.1.2 Normative Reference Acquisition .....                                                        | 1         |
| <b>2.2 Informative References .....</b>                                                            | <b>1</b>  |
| 2.2.1 Informative Reference List.....                                                              | 2         |
| 2.2.2 Informative Reference Acquisition .....                                                      | 2         |
| <b>2.3 Compliance Notation.....</b>                                                                | <b>2</b>  |
| <b>2.4 Definitions .....</b>                                                                       | <b>2</b>  |
| <b>2.5 Symbols and Abbreviations .....</b>                                                         | <b>2</b>  |
| <b>3 Extended Data Format (Attuned Container Format) for EEG and multi-modal data storage.....</b> | <b>2</b>  |
| 3.1 Introduction.....                                                                              | 2         |
| 3.2 Notation .....                                                                                 | 4         |
| 3.3 Basic Concepts.....                                                                            | 4         |
| <b>4 Basic Structure of an Attuned file .....</b>                                                  | <b>5</b>  |
| 4.1 Chunk.....                                                                                     | 5         |
| 4.2 FileHeader Chunk .....                                                                         | 6         |
| 4.3 StreamHeader Chunk .....                                                                       | 7         |
| 4.4 Samples Chunk.....                                                                             | 7         |
| 4.4.1 Structure of Sample.....                                                                     | 8         |
| 4.4.2 Structure of Value .....                                                                     | 8         |
| 4.5 ClockOffset Chunk .....                                                                        | 9         |
| 4.6 Boundary Chunk.....                                                                            | 9         |
| 4.7 StreamFooter Chunk .....                                                                       | 10        |
| <b>Annex A Meta Data Specification .....</b>                                                       | <b>11</b> |
| <b>A.1 EEG and EXG Meta Data .....</b>                                                             | <b>11</b> |
| <b>A.2 Event Marker Meta Data .....</b>                                                            | <b>13</b> |
| <b>A.3 Experiment Meta Data .....</b>                                                              | <b>13</b> |
| <b>A.4 Human Subject Meta Data .....</b>                                                           | <b>14</b> |
| <b>A.5 Recording Environment Meta Data .....</b>                                                   | <b>15</b> |
| <b>A.6 Synchronization Meta Data .....</b>                                                         | <b>15</b> |
| <b>A.7 Audio Meta Data .....</b>                                                                   | <b>16</b> |
| <b>A.7 Gaze Meta Data .....</b>                                                                    | <b>16</b> |
| <b>Annex B Meta Data Specification .....</b>                                                       | <b>18</b> |
| <b>B.1 MoCap (Motion Capture) Meta Data .....</b>                                                  | <b>18</b> |
| <b>B.2 Video Raw Meta Data.....</b>                                                                | <b>20</b> |
| <b>B.3 Video Compressed Meta Data .....</b>                                                        | <b>21</b> |

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## Standard for Consumer EEG File Format (Attuned Container Format)

### 1 Scope

This standard describes an extensible container file format for time-synchronized multi-channel time-series data of various types, with a focus on biosignal data such as EEG, EMG, EOG, ECG, GSR, MEG, nNIRS, fMRI, and event markers. Other data types are addressed by vendor-specific or general-interest extensions (e.g., accelerometer, gyroscope, PCM/MP3 audio, raw/H.264 video).

### 2 References

#### 2.1 Normative References

The following standards contain provisions that, through reference in this text, constitute normative provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed here.

##### 2.1.1 Normative Reference List

1. IEEE Std 754-2008 – IEEE Standard for Floating-Point Arithmetic, August, 2008
2. The Unicode Standard, Version 8.0.0
3. Extensible Markup Language (XML) 1.0 (Fifth Edition)
4. ISO 8601, Date and Time Format

##### 2.1.2 Normative Reference Acquisition

1. IEEE 445 Hoes Lane, Piscataway, NJ 08854-4141 USA; Tel: +1 732 981 0060; Internet: <http://dx.doi.org/10.1109/IEEESTD.2008.4610935>, [standards.ieee.org](http://standards.ieee.org)
2. The Unicode Consortium, Mountain View, CA; ISBN 978-1-936213-10-8; Internet: <http://www.unicode.org/versions/Unicode8.0.0>
3. The World Wide Web Consortium (W3C); Internet: [www.w3.org](http://www.w3.org)
4. [International Organization for Standardization www.iso.org](http://www.iso.org)

#### 2.2 Informative References

The following references contain provisions that, through reference in this text, constitute informative provisions of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below.

### 2.2.1 Informative Reference List

1. The XDF (Extensible Data Format) Project

### 2.2.2 Informative Reference Acquisition

1. Swartz Center for Computational Neuroscience, 9500 Gilman Dr. #0559, La Jolla CA 92093-0559; Internet: <http://sccn.ucsd.edu/people/#> and <https://github.com/sccn/xdx>

## 2.3 Compliance Notation

As used in this document “shall” and “must” denote mandatory provisions of the standard. “Should” denotes a provision that is recommended but not mandatory. “May” denotes a feature whose presence does not preclude compliance, and implementation of which is optional. “Optional” denotes items that may or may not be present in a compliant device.

## 2.4 Definitions

|         |                          |
|---------|--------------------------|
| Attuned | Attuned Container Format |
|---------|--------------------------|

## 2.5 Symbols and Abbreviations

|       |                                                                            |
|-------|----------------------------------------------------------------------------|
| ADC   | Attuned Container Format                                                   |
| BCI   | Brain-Computer Interface                                                   |
| ECG   | Electrocardiography                                                        |
| EEG   | Electroencephalography                                                     |
| EMG   | Electromyography                                                           |
| EOG   | Electroculography                                                          |
| fMRI  | functional Magnetic Resonance Imaging                                      |
| HED   | Hierarchical Event Descriptor                                              |
| GSR   | Galvanic Skin Response                                                     |
| MCN   | Modified Combinatorial Nomenclature for electrode placements in the brain. |
| MEG   | Magnetoencephalography                                                     |
| MoCap | Motion Capture                                                             |
| nNIRS | near-Infrared Spectrography                                                |
| XDF   | Extensible Data Format                                                     |
| XML   | Extended Markup Language                                                   |

## 3 Extended Data Format (Attuned Container Format) for EEG and multi-modal data storage

### 3.1 Introduction

Attuned (Attuned Container Format) is an extensible storage format for time series data and associated metadata. Attuned was created to address the need for a true multi-modal time-series file format that can hold simultaneously multiple diverse time-series data streams.

A key requirement for Attuned was to be able to store essentially any kind of time series data streams with few or no limitations on the number of channels, sampling rates, value formats, and amount or type of associated meta-data. A core use case for the format, is to store data from multiple sensors, which measure diverse physiological data (e.g., EEG and other brain signals, heart rate, motion capture, eye tracking, video, audio, and human interface device inputs), but also any other kind of states that relates to such measurements (e.g., simultaneous application state and events). Attuned was designed with the additional requirements in mind that the file contents shall be streamable (e.g., at the time of recording or playback), the contained streams can be time-synchronized, the file format is efficient in terms of storage space, and that the specification should be simple and compact.

Based on these criteria, Attuned was designed as a chunk-based format. In a chunk-based format the entire file is a sequence of chunks, where multiple streams are stored in an interleaved, and therefore streamable fashion. This also enables forward compatibility, where implementations can skip over unknown chunk types (e.g., introduced in a future version of the standard) to allow for space-efficient storage of high-volume multi-channel time-series data. Attuned defines a chunk type that can store such data in a simple generic binary array format. These chunks also allow for storage of variable-length binary data, such as video frames, and therefore can hold virtually any kind of streamable data in a storage-efficient manner.

To satisfy the requirement for arbitrary extensible meta-data for each data stream, Attuned provides a flexible text-based chunk type that can hold any kind of structured metadata using XML as the encoding. While it is possible to store arbitrary content in these chunks, to enable a maximum degree of compatibility Attuned recognizes several predefined types of stream content ("content-types"), such as EEG, Video, Audio, MoCap, Markers, etc., and for each content-type, a set of predefined metadata fields, such as channel labels, color space, units, etc., that are found in the appendix of this document. These fields were chosen based on the meta-data present in domain-specific "gold standard" file formats (e.g., traditional video, EEG, or audio file formats). This appendix is expected to be amended in future revisions of the standard to add support for additional content-types or to augment the set of standardized meta-data fields. It shall be emphasized however, that implementers (vendors) are free to add their own custom metadata fields or content-types to satisfy their storage needs. It is encouraged that such extensions to be provided to a public Attuned extension registry. Unless indicated otherwise, registered extensions will automatically be considered for integration into subsequent Attuned revisions. Since fields are easy to add in future extensions, but hard to remove, the initial set of meta-data fields tends to be conservative and covers primarily the essential and widely agreed-upon fields.

To address the requirement for time synchronization in a fully general way, each sample has a timestamp, which is stored with an efficient compression scheme to minimize storage overhead. These time stamps may even be read off of different clocks which are allowed to drift relative to each other. For such cases, the format may contain periodic clock offset measurements for each stream held in special type of chunk, which determine how these different clocks relate to each other at any given time and allow for synchronization. While all time stamps could as well be stored in an already synchronized form, Attuned gives users the option to store the ground truth measurements, in order to not alter or falsify the raw data.

An Attuned file can contain any number of (multi-channel) streams, each of which comprises an XML-based header that specifies both format and meta-data of the stream, as well as a sequence of multi-channel data *samples* in a compact binary representation, which may also be empty if no sample data is present.