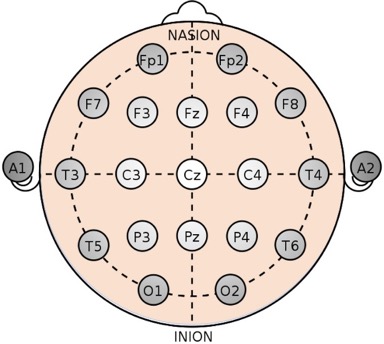
**The Temple University Hospital EEG Corpus:**

**Electrode Location and Channel Labels**

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**Abstract**

The goal of this report is to describe to users of the TUH EEG Corpus four important concepts that must be understood to correctly retrieve EEG signals from a data file (e.g., an EDF file). The four key concepts described in this document are: (1) *physical placement*: the location of the electrodes on the scalp, (2) *unipolar montage*: the differential recording process used to reduce noise, (3) *channel labels*: the system used to describe the channels, or digital signals, represented in a computer file and (4) *bipolar montages*: the differential mapping used to accentuate clinically-relevant events in the signal. This report is not intended to be a primer on the electrophysiology of an EEG, which is a subject unto itself, or a tutorial on how neurologists interpret EEGs. This report simply explains how the signal data in an EEG file must be accessed to accurately support clinical applications (e.g., manual interpretation or annotation of an EEG) and research applications (e.g., automatic interpretation using machine learning).

1. **Introduction**

An electroencephalogram (EEG) (Tong & Thakor, 2009) is a vital tool for monitoring the brain’s electrical activity and diagnosing various neural diseases. The Temple University Hospital EEG (TUEG) Corpus (Obeid & Picone, 2016) was developed to support state of the art research into automatic interpretation of EEGs using machine learning (Golmohammadi et al., 2019). The corpus consists of EEG signal data and paired EEG reports written by the attending neurologist for each patient session. The signal data is stored in an open-source European Data Format (EDF) file, (Kemp, 2013) while the reports are stored as flat text files. The header of each EDF file contains fundamental metadata information about every patient session that is evenly distributed over 24 fields that display patient information and signal condition. There are several other valuable subsets and annotations of the data (Veloso et al., 2017) that are available from our project web site (Choi et al., 2017).

This corpus consists entirely of clinical data collected from 2002 to the present at Temple University Hospital (TUH). The EEG signal data was collected using various generations of EEG equipment. Most of the data from 2002 – 2019 was collected using Natus Medical Incorporated’s (NMI) NicoletOne recording equipment (Natus, 2019). Unfortunately, this system stores the data in a proprietary format developed by Natus. The signal data was exported from the source EEG files to an open source publicly accessible format using NMI’s proprietary NicVue software tool (NicVue, 2019). The signal data that is stored represents a pruned EEG in which sections of the EEG signal marked as uninformative by the attending technician were removed. One or more EDF files are generated from a signal source file based on these pruning instructions provided by the attending technician. A direct result of this is that the Natus tool only outputs pruned data, so we had no way of releasing the entire original recording. This is still an area under research as we continue to evaluate open source tools that claim to be able to reverse engineer the Natus proprietary format.

A point we have continually emphasized throughout our long history with EEG technology development is that clinical data is messy. The data in TUEG was collected from a variety of locations in the hospital including the intensive care unit (ICU), the epilepsy monitoring unit (EMU), the emergency room (ER) and outpatient services (the 5th floor of Boyer Pavilion). Because these sessions cover the full range of EEGs conducted at TUH, there are a broad range of channel configurations and channel labels used to describe the EEG data. In fact, there are over 40 unique channel configurations contained within the entire corpus. The EDF format uses an ASCII representation for the header contained within the file while the signal data is stored as a multichannel signal in which samples are encoded as 16-bit integers. Signal channels within this file are described by labels that can be used to infer the original physical location of the electrode and the meaning of the channel.

**There is no guarantee that the channels that comprise an EEG signal appear in the file in the same order.** A common mistake made by many rudimentary software packages is that they read the data into a matrix and assume the channels are always in the same order. A key portion of an EDF file that contains the labels is shown in Figure 1. As can be seen, each channel is labeled, and each channel must be accessed via its label and/or position in this list rather than its absolute position in the file. For example, there is no constraint that the channel labeled “EEG FP1-REF” is always the first channel. This channel can appear in many positions across TUEG.

Therefore, the primary goal of this report is to document the labels that appear in this corpus and to explain how these can be mapped back to the physical locations of the sensors. We have developed a visualization tool (Capp et al., 2017) that simplifies visualizing and manipulating these channels by their labels. We provide a program, *nedc\_pystream*, that is easy to use and demonstrates how to correctly access the data. This Python code is available from our project web site (Choi et al., 2017).

Most commercial packages offer similar capabilities, since clinicians need to be able to manipulate channels symbolically. Interpreting labels can only be done through auxiliary documentation, such as that provided in this report. Channel labels, though often similar across institutions, are not guaranteed to be common across institutions (e.g., institution X might not use the label “EEG FP1-REF”). Only through documentation such as that provided in this report, can one reverse map the data in an EDF file.

When an EEG is administered, a technician wires up a patient with a specific electrode configuration. This includes deciding on the number of channels to be collected, the locations of the electrodes on the scalp, and the reference points used for the electrical signals. These “raw” signals, which are digitized versions of the electrical potential measured between an electrode and a reference point, are stored in an EEG file. We discuss the issues of electrode placement, which we refer to in this document as the *physical configuration*, in Section 2. We discuss the process of differential voltage recording, which is referred to as a *unipolar montage*, in Section 3.

nedc\_000\_[1]: more edf/01\_tcp\_ar/027/00002726/s002\_2013\_08\_23/00002726\_s002\_t000.edf

0 00002726 M 01-JAN-1943 00002726 Age:70  
Startdate 23-AUG-2013 00002726\_s002 00 X  
23.08.1308.54.407936 EDF 2140

1.00000030 EEG FP1-REF EEG FP2-REF EEG F3-REF EEG F4-REF

EEG C3-REF EEG C4-REF EEG P3-REF EEG P4-REF EEG O1-REF

EEG O2-REF EEG F7-REF EEG F8-REF EEG T3-REF EEG T4-REF

EEG T5-REF EEG T6-REF EEG A1-REF EEG A2-REF EEG FZ-REF

EEG CZ-REF EEG PZ-REF EEG ROC-REF EEG LOC-REF EEG EKG1-REF

EEG T1-REF EEG T2-REF PHOTIC-REF IBI BURSTS SUPPR ...

Figure 1. A typical set of channel labels found in the TUH EEG Corpus.

Each channel that is recorded is identified by a label (e.g., “EEG FP1-REF”) as shown in Figure 1. These labels, unfortunately, are specific to an institution, neurologist or technician. We discuss the interpretation of *channel labels* in Section 4. In Appendix B we list every channel label that appears at least once in the corpus, and the number of files in which it appears. The specific electrode location that corresponds to each of these labels is not known since most of this data was collected long before we engaged Temple Hospital, and the associated documentation has been lost over time. Nevertheless, we have attempted to provide some useful information about the origin of these labels.

In Appendix C we provide the channel labels appearing in the Duke University (DUSZ) Corpus (Swisher et al., 2015). This is a corpus similar to TUEG that used different electronic equipment to collect the EEG signal. It is valuable for testing the ability of machine learning models to assess cross-channel robustness.

It is also important to understand that when neurologists view an EEG, they impose a montage on the data. This is most often simply a list of channel pairs to be differenced and is commonly referred to as a *bipolar montage*. This type of montage is described in detail in Section 5. Note that this differencing is in addition to the differencing done to record the raw signal. A bipolar montage is imposed when the data is viewed or processed and is not actually stored in the data file. Neurologists will often view the same EEG using several different montages depending on what specific events they are looking to enhance. Software that loads an EEG and displays the results is responsible for implementing the montage view. This software must provide some way of directing which channels are to be differenced. As mentioned previously, we provide software that demonstrates how to do this in Python. Most commercial packages offer similar capabilities, since these bipolar montages are used heavily in clinical work. Although there are many popular montages used in practice (e.g., TCP), some expert clinicians prefer their own definitions. Imposing a bipolar montage is critical for machine learning researchers since they will often use the output of a bipolar montage as a starting point for their algorithm research.

1. **Physical Configuration of the Electrodes**

The most widely used arrangement of electrodes in electroencephalographic recordings is the International 10/20 system. In this system, 21 electrodes on the scalp are evenly distributed as seen in Figure 2 (López, 2017), with the distance between electrodes being either 10% or 20% of the total distance from nasion (front) to inion (back). The 10/20 system utilizes four anatomical landmarks for positioning: the point between the forehead and nose (nasion), the lowest point of the back of the skull (inion), and the preauricular areas anterior to the ears.



Figure 2. ACNS map of the International 10-20 system and its corresponding channels on an EEG.

The 10/10 and 10/5 electrode configurations are extensions of the original standard 10/20 system. The 10‑10 system derives its electrode placements from landmarks on the skull, such as the nasion (Nz), and the inion (Iz), and the left and right pre-auricular points (LPA and RPA). The 10/10 system differs from the 10/20 system in that the number of electrodes used increases from 21 to 74. In order to account for an increased number of electrodes, the number of locations have to be extended in all directions to keep an even spread of data extracted from the patient’s scalp. However, the 10/10 and 10/5 system are not as widely used as the 10/20 system, especially for clinical applications. As a result, the bulk of our data uses the 10/20 system.

1. **Unipolar Montages Used for Recording**

When recording an EEG signal and writing it to a file as a digital signal represented using 16 bits per sample, a differential voltage must be recorded. The need for this relates to the electrophysiology of an EEG, which is outside the scope of this document. Suffice it to say that for these types of low-voltage signals (typically in the microvolt range) to be useful, differential voltages must be used because the differencing process reduces noise. A unipolar montage refers to the difference between the electrical potential recorded at an electrode, which we refer to as the raw signal, and a reference node (e.g., an electrode connected to the left ear). This differential signal is what is recorded as a digital signal in a data file. All channels are collected as differential voltages, so a configuration of reference points is implied by the data written in a file.

Two general unipolar montages, which are shown in Figure 3, are used within TUEG: (1) Average Reference (AR) and (2) Linked Ears Reference (LE). The AR montage uses the average of a certain number of electrodes as the reference. The LE montage uses a lead adapter to link the left and right ears, providing a more stable reference point (Lopez et al, 2016). The LE montage is believed to reduce artifacts (Subramaniyam, 2019).

a) b) 

Figure 3. Location information of the electrodes for two montages found in TUEG: a) AR, b) LE.

The LE and AR unipolar montages are divided into four classifications in TUEG: 01\_tcp\_ar, 02\_tcp\_le, 03\_tcp\_ar\_a, and 04\_tcp\_le\_a. Each of these montages is based on the types of channels included. The montage labeled 01\_tcp\_ar uses the AR referencing method for the electrodes. The montage 02\_tcp\_le classification uses the LE montage format. The unipolar montages labeled as 03\_tcp\_ar\_a and 04\_tcp\_le\_a use AR and LE formats respectively but are collected with only 20 channels. For these last two subgroups, the auricular channels are excluded (electrodes A1 and A2).

1. **Channel Labels**

Each channel in an EDF file is labeled using a non-standard set of labels. A typical set of these labels is shown in Figure 1. As mentioned previously, a complete set of labels is listed in Appendix B. These labels unfortunately are non-standard. However, the names are often adequately descriptive so that a user can infer the nature and location of the digitized signal. It is important to understand that to access data in a correct and consistent manner, you must pay attention to the channel label. **You cannot assume that the first channel stored in an EDF file always represents the same electrode location.**

Each electrode begins with a letter corresponding to the region where the signals are read from:

• Fp: Prefrontal • P: Parietal/Parasagittal

• F: Frontal • O: Occipital

• T: Temporal • A: Mastoid Process (bone near the outer ear)

• C: Central

Even numbers (2, 4, 6, 8) are used to denote electrodes in the right hemisphere and odd numbers (1, 3, 5, 7) refer to those on the left. Each adjacent electrode represents a distance of 10% or 20% of either the total nasion-inion or right-left distance, hence the 10-20 system. “Z” refers to electrodes located on the midsagittal line. For example, Fp1-F3 refers to the signal in the segment between the left prefrontal electrode closest to the nasion and the left frontal electrode closest to the midsagittal line. The signal would represent the brain activity in the imaginary line between these two electrodes.

A complete listing of the channels associated with each of the four unipolar montages is given in Appendix A. Software is available on our project web site (Choi et al., 2017) that demonstrates one way to decode channels properly in Python. Our interface supports simple pattern matching so that channel labels can be easily identified. The software also supports a straightforward way of specifying a montage. Several of our software tools use this format, including our annotation tool (Capp et al., 2017).

Many EEG records in TUEG have at least 19 electrodes, corresponding to the aforementioned 10/20 system. Table 1 lists these electrodes with their corresponding labels. Table 1 also provides a brief description of the location of each electrode. In the AR and LE montages there are 22 signal channels that are derived from the 19 electrodes; this is due to the T3 and T4 electrodes being used twice, both longitudinally and transversely. Along the midsagittal line in the 10/20 system there are five central “Z” channels (Fpz, Fz, Cz, Pz, Oz). However, the bipolar montages applied to the data in TUEG only reference Cz, located at the apex of the scalp.

Though there are many labels listed in Appendix B, most researchers will probably not use most of these. The labels in Table 1 are most of the useful labels for machine learning research. Our software interface supports partial name matching, which makes dealing with these labels much easier.

Table 1. A listing of each of the channel labels in a 10/20 system as represented in TUEG. Channel labels described as “inner” and “outer” are defined based on the distance of that electrode from the vertex node (Cz).

|  |  |  |  |
| --- | --- | --- | --- |
| **Channel Label** | **Position on Scalp** | **Channel Label** | **Position** |
| Fp1 | left forehead | Fp2 | right forehead |
| F7 | left outer frontal | F8 | right outer frontal |
| T3 | left outer medial | T4 | right outer medial |
| T5 | left outer posterior | T6 | right outer posterior |
| O1 | left back of head | O2 | right back of head |
| F3 | left inner frontal | F4 | right inner frontal |
| C3 | left inner medial | C4 | right inner medial |
| P3 | left inner posterior | P4 | right inner posterior |
| A1 | left preauricular area | A2 | right preauricular area |
| Fpz | center forehead | Fz | center frontal |
| Cz | center top | Pz | center inner posterior |
| Oz | center back of head | EKG | electrocardiogram |

1. **Bipolar Montages Used for Viewing**

As mentioned previously, differential voltages are used to reduce noise and enhance events of interest, such as spikes. The electrical signal in the area between adjacent electrodes cancels out noise and artifacts that are due to a common reference point. This often results in a clearer and more easily interpretable signal. However, this method also makes certain electrode combinations more vulnerable to specific artifacts.

When neurologists view the data, they typically impose a bipolar montage to remove signal noise and improve spatial information interpretation of the EEG signal (Shah et al., 2017). We similarly use one of the most popular bipolar Temporal Central Parasagittal (TCP) montages for EEG interpretation and algorithm development. A TCP montage is also known as the double-banana montage. It is shown in Figure 4. This montage uses signals that correspond to the difference between two adjacent electrodes (e.g. FP1­‑F7, T3-C3), in the nasion-inion/longitudinal direction, or transverse across the scalp (left-to-right).

There are a wide range of other montages in use at the TUH. However, the TCP bipolar montage is by far the most popular among neurologists.

1. **Summary**

The goal of this report is to document how EEG signal data was collected and stored in EDF files for TUEG. We have described how channel ordering, channel labels, and the physical location of a channel can be cross‑referenced through the use of information available in this document and in the header of the EDF file. We have documented the four main montages used in TUEZ and presented an exhaustive list of channel labels. In a companion document we discuss the process of annotating EEG signals and storing these annotations in text files (Ferrell et al., 2019).

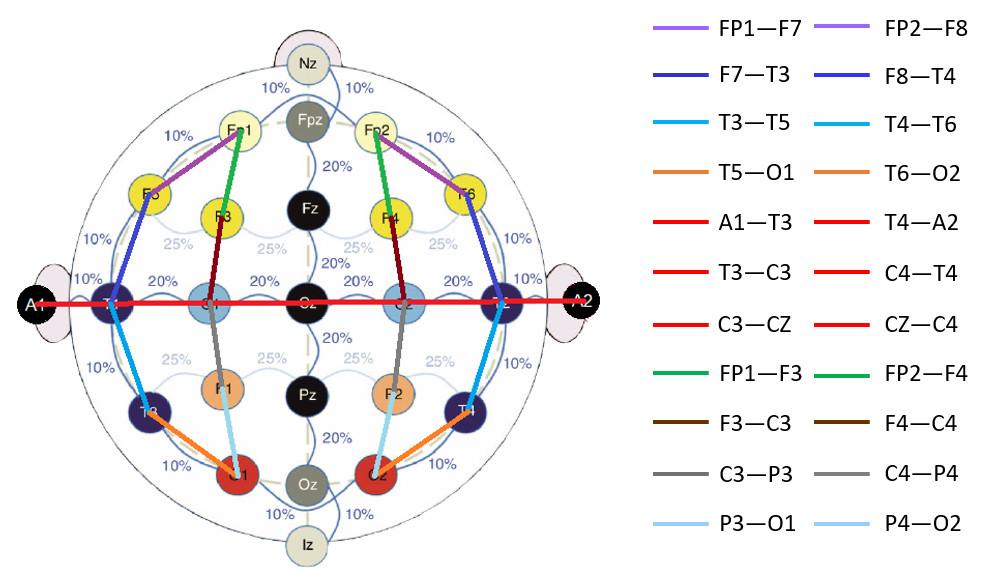


Figure 4. Electrode locations for a standard 10-20 system with a 22-channel TCP montage.

To accurately process EEG data in TUEG, you must pay attention to channel ordering and labels. We have also developed software that demonstrates how this can be done in Python. This software is available from our project web site.

To access these resources, we encourage you to register on our project web site:

*https://www.isip.piconepress.com/projects/tuh\_eeg/html/downloads.shtml*

Enrollment is quick and completely automated. You will receive a username and password that will let you access all of our online resources.

Questions about this document or our resources should be directed to *help@nedcdata.org*.

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1. **Unipolar Montages Used in TUEG**
2. **TCP\_AR**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Channel** | **Label** | **Montage Component** | **Channel** | **Label** | **Montage** |
| 0 | Fp1-F7 | EEG FP1-REF – EEG F7-REF | 11 | CZ-C4 | EEG CZ-REF – EEG C4-REF |
| 1 | F7-T3 | EEG F7-REF – EEG T3-REF | 12 | C4-T4 | EEG C4-REF – EEG T4-REF |
| 2 | T3-T5 | EEG T3-REF – EEG T5-REF | 13 | T4-A2 | EEG T4-REF – EEG A2-REF |
| 3 | T5-O1 | EEG T5-REF – EEG O1-REF | 14 | Fp1-F3 | EEG FP1-REF – EEG F3-REF |
| 4 | Fp2-F8 | EEG FP2-REF – EEG F8-REF | 15 | F3-C3 | EEG F3-REF – EEG C3-REF |
| 5 | F8-T4 | EEG F8-REF – EEG T4-REF | 16 | C3-P3 | EEG C3-REF – EEG P3-REF |
| 6 | T4-T6 | EEG T4-REF – EEG T6-REF | 17 | P3-O1 | EEG P3-REF – EEG O1-REF |
| 7 | T6-O2 | EEG T6-REF – EEG O2-REF | 18 | Fp2-F4 | EEG FP2-REF – EEG F4-REF |
| 8 | A1-T3 | EEG A1-REF – EEG T3-REF | 19 | F4-C4 | EEG F4-REF – EEG C4-REF |
| 9 | T3-C3 | EEG T3-REF – EEG C3-REF | 20 | C4-P4 | EEG C4-REF – EEG P4-REF |
| 10 | C3-CZ | EEG C3-REF – EEG CZ-REF | 21 | P4-O2 | EEG P4-REF – EEG O2-REF |

1. **TCP\_LE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Channel** | **Label** | **Montage Component** | **Channel** | **Label** | **Montage Component** |
| 0 | Fp1-F7 | EEG FP1-REF – EEG F7-REF | 11 | CZ-C4 | EEG FP1-LE – EEG F7-LE |
| 1 | F7-T3 | EEG F7-REF – EEG T3-REF | 12 | C4-T4 | EEG F7-LE – EEG T3-LE |
| 2 | T3-T5 | EEG T3-REF – EEG T5-REF | 13 | T4-A2 | EEG T3-LE – EEG T5-LE |
| 3 | T5-O1 | EEG T5-REF – EEG O1-REF | 14 | Fp1-F3 | EEG T5-LE – EEG O1-LE |
| 4 | Fp2-F8 | EEG FP2-REF – EEG F8-REF | 15 | F3-C3 | EEG FP2-LE – EEG F8-LE |
| 5 | F8-T4 | EEG F8-REF – EEG T4-REF | 16 | C3-P3 | EEG F8-LE – EEG T4-LE |
| 6 | T4-T6 | EEG T4-REF – EEG T6-REF | 17 | P3-O1 | EEG T4-LE – EEG T6-LE |
| 7 | T6-O2 | EEG T6-REF – EEG O2-REF | 18 | Fp2-F4 | EEG T6-LE – EEG O2-LE |
| 8 | A1-T3 | EEG A1-REF – EEG T3-REF | 19 | F4-C4 | EEG A1-LE – EEG T3-LE |
| 9 | T3-C3 | EEG T3-REF – EEG C3-REF | 20 | C4-P4 | EEG T3-LE – EEG C3-LE |
| 10 | C3-CZ | EEG C3-REF – EEG CZ-REF | 21 | P4-O2 | EEG C3-LE – EEG CZ-LE |

1. **TCP\_AR\_A**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Channel** | **Label** | **Montage Component** | **Channel** | **Label** | **Montage Component** |
| 0 | Fp1-F7 | EEG FP1-REF – EEG F7-REF | 10 | CZ-C4 | EEG CZ-REF – EEG C4-REF |
| 1 | F7-T3 | EEG F7-REF – EEG T3-REF | 11 | C4-T4 | EEG C4-REF – EEG T4-REF |
| 2 | T3-T5 | EEG T3-REF – EEG T5-REF | 12 | Fp1-F3 | EEG FP1-REF – EEG F3-REF |
| 3 | T5-O1 | EEG T5-REF – EEG O1-REF | 13 | F3-C3 | EEG F3-REF – EEG C3-REF |
| 4 | Fp2-F8 | EEG FP2-REF – EEG F8-REF | 14 | C3-P3 | EEG C3-REF – EEG P3-REF |
| 5 | F8-T4 | EEG F8-REF – EEG T4-REF | 15 | P3-O1 | EEG P3-REF – EEG O1-REF |
| 6 | T4-T6 | EEG T4-REF – EEG T6-REF | 16 | Fp2-F4 | EEG FP2-REF – EEG F4-REF |
| 7 | T6-O2 | EEG T6-REF – EEG O2-REF | 17 | F4-C4 | EEG F4-REF – EEG C4-REF |
| 8 | T3-C3 | EEG T3-REF – EEG C3-REF | 18 | C4-P4 | EEG C4-REF – EEG P4-REF |
| 9 | C3-CZ | EEG C3-REF – EEG CZ-REF | 19 | P4-O2 | EEG P4-REF – EEG O2-REF |

1. **TCP\_LE\_A**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Channel** | **Label** | **Montage Component** | **Channel** | **Label** | **Montage Component** |
| 0 | Fp1-F7 | EEG FP1-REF – EEG F7-REF | 10 | CZ-C4 | EEG FP1-LE – EEG F7-LE |
| 1 | F7-T3 | EEG F7-REF – EEG T3-REF | 11 | C4-T4 | EEG F7-LE – EEG T3-LE |
| 2 | T3-T5 | EEG T3-REF – EEG T5-REF | 12 | Fp1-F3 | EEG T5-LE – EEG O1-LE |
| 3 | T5-O1 | EEG T5-REF – EEG O1-REF | 13 | F3-C3 | EEG FP2-LE – EEG F8-LE |
| 4 | Fp2-F8 | EEG FP2-REF – EEG F8-REF | 14 | C3-P3 | EEG F8-LE – EEG T4-LE |
| 5 | F8-T4 | EEG F8-REF – EEG T4-REF | 15 | P3-O1 | EEG T4-LE – EEG T6-LE |
| 6 | T4-T6 | EEG T4-REF – EEG T6-REF | 16 | Fp2-F4 | EEG T6-LE – EEG O2-LE |
| 7 | T6-O2 | EEG T6-REF – EEG O2-REF | 17 | F4-C4 | EEG A1-LE – EEG T3-LE |
| 8 | T3-C3 | EEG T3-REF – EEG C3-REF | 18 | C4-P4 | EEG T3-LE – EEG C3-LE |
| 9 | C3-CZ | EEG C3-REF – EEG CZ-REF | 19 | P4-O2 | EEG C3-LE – EEG CZ-LE |

1. **Channel Labels Appearing in TUEG (v1.1.0)**

|  |  |  |  |
| --- | --- | --- | --- |
| Index | Label | Freq | Description |
| 1 | BURSTS | 37,546 | unknown |
| 2 | DC1-DC | 8,047 | DC voltage equipment |
| 3 | DC2-DC | 8,047 | DC voltage equipment |
| 4 | DC3-DC | 8,047 | DC voltage equipment |
| 5 | DC4-DC | 8,047 | DC voltage equipment |
| 6 | DC5-DC | 8,047 | DC voltage equipment |
| 7 | DC6-DC | 8,047 | DC voltage equipment |
| 8 | DC7-DC | 8,047 | DC voltage equipment |
| 9 | DC8-DC | 8,047 | DC voltage equipment |
| 10 | ECG EKG-REF | 70 | a single ECG electrode placed on the chest to monitor cardiac activity |
| 11 | EDF ANNOTATIONS | 475 | annotations created by EEG technician |
| 12 | EEG 100-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 13 | EEG 101-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 14 | EEG 102-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 15 | EEG 103-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 16 | EEG 104-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 17 | EEG 105-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 18 | EEG 106-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 19 | EEG 107-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 20 | EEG 108-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 21 | EEG 109-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 22 | EEG 110-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 23 | EEG 111-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 24 | EEG 112-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 25 | EEG 113-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 26 | EEG 114-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 27 | EEG 115-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 28 | EEG 116-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 29 | EEG 117-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 30 | EEG 118-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 31 | EEG 119-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 32 | EEG 120-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 33 | EEG 121-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 34 | EEG 122-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 35 | EEG 123-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 36 | EEG 124-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 37 | EEG 125-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 38 | EEG 126-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 39 | EEG 127-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 40 | EEG 128-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 41 | EEG 1X10\_LAT\_01- | 43 | custom electrode placement |
| 42 | EEG 1X10\_LAT\_02- | 43 | custom electrode placement |
| 43 | EEG 1X10\_LAT\_03- | 43 | custom electrode placement |
| 44 | EEG 1X10\_LAT\_04- | 43 | custom electrode placement |
| 45 | EEG 1X10\_LAT\_05- | 42 | custom electrode placement |
| 46 | EEG 20-LE | 16 | custom electrode placement |
| 47 | EEG 20-REF | 2,585 | custom electrode placement |
| 48 | EEG 21-LE | 16 | custom electrode placement |
| 49 | EEG 21-REF | 2,612 | custom electrode placement |
| 50 | EEG 22-LE | 16 | custom electrode placement |
| 51 | EEG 22-REF | 2,612 | custom electrode placement |
| 52 | EEG 23-LE | 596 | custom electrode placement |
| 53 | EEG 23-REF | 2,585 | custom electrode placement |
| 54 | EEG 24-LE | 596 | custom electrode placement |
| 55 | EEG 24-REF | 2,585 | custom electrode placement |
| 56 | EEG 25-LE | 16 | custom electrode placement |
| 57 | EEG 25-REF | 2,714 | custom electrode placement |
| 58 | EEG 26-LE | 8,897 | custom electrode placement |
| 59 | EEG 26-REF | 8,135 | custom electrode placement |
| 60 | EEG 27-LE | 8,897 | custom electrode placement |
| 61 | EEG 27-REF | 8,018 | custom electrode placement |
| 62 | EEG 28-LE | 11,197 | custom electrode placement |
| 63 | EEG 28-REF | 8,022 | custom electrode placement |
| 64 | EEG 29-LE | 11,197 | custom electrode placement |
| 65 | EEG 29-REF | 11,325 | custom electrode placement |
| 66 | EEG 30-LE | 12,818 | custom electrode placement |
| 67 | EEG 30-REF | 11,328 | custom electrode placement |
| 68 | EEG 31-LE | 8,317 | custom electrode placement |
| 69 | EEG 31-REF | 17,837 | custom electrode placement |
| 70 | EEG 32-LE | 8,317 | custom electrode placement |
| 71 | EEG 32-REF | 17,837 | custom electrode placement |
| 72 | EEG 33-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 73 | EEG 34-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 74 | EEG 35-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 75 | EEG 36-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 76 | EEG 37-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 77 | EEG 38-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 78 | EEG 39-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 79 | EEG 40-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 80 | EEG 41-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 81 | EEG 42-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 82 | EEG 43-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 83 | EEG 44-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 84 | EEG 45-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 85 | EEG 46-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 86 | EEG 47-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 87 | EEG 48-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 88 | EEG 49-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 89 | EEG 50-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 90 | EEG 51-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 91 | EEG 52-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 92 | EEG 53-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 93 | EEG 54-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 94 | EEG 55-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 95 | EEG 56-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 96 | EEG 57-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 97 | EEG 58-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 98 | EEG 59-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 99 | EEG 60-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 100 | EEG 61-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 101 | EEG 62-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 102 | EEG 63-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 103 | EEG 64-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 104 | EEG 65-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 105 | EEG 66-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 106 | EEG 67-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 107 | EEG 68-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 108 | EEG 69-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 109 | EEG 70-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 110 | EEG 71-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 111 | EEG 72-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 112 | EEG 73-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 113 | EEG 74-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 114 | EEG 75-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 115 | EEG 76-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 116 | EEG 77-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 117 | EEG 78-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 118 | EEG 79-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 119 | EEG 80-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 120 | EEG 81-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 121 | EEG 82-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 122 | EEG 83-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 123 | EEG 84-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 124 | EEG 85-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 125 | EEG 86-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 126 | EEG 87-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 127 | EEG 88-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 128 | EEG 89-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 129 | EEG 90-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 130 | EEG 91-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 131 | EEG 92-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 132 | EEG 93-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 133 | EEG 94-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 134 | EEG 95-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 135 | EEG 96-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 136 | EEG 97-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 137 | EEG 98-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 138 | EEG 99-REF | 323 | used in custom and high-resolution systems (no signal data) |
| 139 | EEG A1-LE | 12,802 | left reference electrode in an LE montage located in the left preauricular area |
| 140 | EEG A1-REF | 34,633 | left preauricular area |
| 141 | EEG A2-LE | 12,802 | right reference electrode in an LE montage located in the right preauricular area |
| 142 | EEG A2-REF | 34,633 | right preauricular area |
| 143 | EEG C3-LE | 12,818 | left inner medial |
| 144 | EEG C3-P3 | 2 | the area between the left inner medial and the left inner posterior |
| 145 | EEG C3P-REF | 13,687 | unknown |
| 146 | EEG C3-REF | 40,686 | left inner medial |
| 147 | EEG C3-T3 | 2 | the area between the left inner medial and the left outer medial |
| 148 | EEG C4-CZ | 2 | the area between the right inner medial and the center top of the scalp (the apex) |
| 149 | EEG C4-LE | 12,818 | right inner medial |
| 150 | EEG C4-P4 | 2 | the area between the right inner medial and the right inner posterior |
| 151 | EEG C4P-REF | 13,684 | unknown |
| 152 | EEG C4-REF | 40,686 | right inner medial |
| 153 | EEG CZ-C3 | 2 | the area between the center top of the scalp (apex) and the left inner medial |
| 154 | EEG CZ-LE | 12,818 | center top of the scalp (apex) |
| 155 | EEG CZ-PZ | 2 | the area between CZ and PZ |
| 156 | EEG CZ-REF | 40,685 | center top of the scalp (apex) |
| 157 | EEG EKG1-REF | 37,477 | Electrocardiogram, single electrode on chest |
| 158 | EEG EKG-LE | 12,802 | Electrocardiogram, single electrode on chest |
| 159 | EEG EKG-REF | 555 | Electrocardiogram, single electrode on chest |
| 160 | EEG F3-C3 | 2 | the area between the left inner frontal and the left inner medial |
| 161 | EEG F3-LE | 12,818 | inner frontal |
| 162 | EEG F3-REF | 40,685 | inner frontal |
| 163 | EEG F4-C4 | 2 | the area between the right inner frontal and the right inner medial |
| 164 | EEG F4-LE | 12,818 | right inner frontal |
| 165 | EEG F4-REF | 40,686 | right inner frontal |
| 166 | EEG F7-LE | 12,818 | left outer frontal |
| 167 | EEG F7-REF | 40,686 | left outer frontal |
| 168 | EEG F7-T3 | 2 | the area between the left outer frontal and the left outer medial |
| 169 | EEG F8-LE | 12,818 | right outer frontal |
| 170 | EEG F8-REF | 40,686 | right outer frontal |
| 171 | EEG F8-T4 | 2 | the area between the right outer frontal and the right outer medial |
| 172 | EEG FP1-F7 | 2 | the area between the left forehead and the left outer frontal |
| 173 | EEG FP1-LE | 12,818 | left forehead |
| 174 | EEG FP1-REF | 40,686 | left forehead |
| 175 | EEG FP2-F8 | 2 | the area between the right forehead and the right outer frontal |
| 176 | EEG FP2-LE | 12,818 | right forehead |
| 177 | EEG FP2-REF | 40,686 | right forehead |
| 178 | EEG FZ-CZ | 2 | the area between FZ and CZ |
| 179 | EEG FZ-LE | 12,818 | halfway between the apex and the forehead |
| 180 | EEG FZ-REF | 40,685 | halfway between the apex and the forehead |
| 181 | EEG LOC-REF | 17,566 | unknown |
| 182 | EEG LUC-LE | 1,621 | unknown |
| 183 | EEG LUC-REF | 523 | unknown |
| 184 | EEG O1-LE | 12,818 | left back of head |
| 185 | EEG O1-REF | 40,686 | left back of head |
| 186 | EEG O2-LE | 12,818 | right back of head |
| 187 | EEG O2-REF | 40,686 | right back of head |
| 188 | EEG OZ-LE | 12,802 | center back of head |
| 189 | EEG OZ-REF | 58 | center back of head |
| 190 | EEG P3-LE | 12,818 | left inner posterior |
| 191 | EEG P3-REF | 40,686 | left inner posterior |
| 192 | EEG P4-LE | 12,818 | right inner posterior |
| 193 | EEG P4-REF | 40,686 | right inner posterior |
| 194 | EEG PG1-LE | 12,222 | unknown |
| 195 | EEG PG1-REF | 15 | unknown |
| 196 | EEG PG2-LE | 12,222 | unknown |
| 197 | EEG PG2-REF | 15 | unknown |
| 198 | EEG PZ-LE | 12,818 | halfway between the apex and the back of the head |
| 199 | EEG PZ-REF | 40,685 | halfway between the apex and the back of the head |
| 200 | EEG RESP1-REF | 523 | on the body to record respiration |
| 201 | EEG RESP2-REF | 523 | on the body to record respiration |
| 202 | EEG RLC-LE | 1,621 | unknown |
| 203 | EEG RLC-REF | 523 | unknown |
| 204 | EEG ROC-REF | 17,567 | unknown |
| 205 | EEG SP1-LE | 3,921 | left side of the head on the sphenoid (approximately the temple) |
| 206 | EEG SP1-REF | 14,906 | left side of the head on the sphenoid (approximately the temple) |
| 207 | EEG SP2-LE | 3,921 | right side of the head on the sphenoid (approximately the temple) |
| 208 | EEG SP2-REF | 14,238 | right side of the head on the sphenoid (approximately the temple) |
| 209 | EEG T1-LE | 4,501 | left side of the head on the sphenoid (approximately the temple) |
| 210 | EEG T1-REF | 37,952 | left side of the head on the sphenoid (approximately the temple) |
| 211 | EEG T1-T2 | 2 | the area between T1 and T2 |
| 212 | EEG T2-LE | 4,501 | right side of the head on the sphenoid (approximately the temple) |
| 213 | EEG T2-REF | 37,956 | right side of the head on the sphenoid (approximately the temple) |
| 214 | EEG T2-T4 | 2 | the area between T2 and T4 |
| 215 | EEG T3-LE | 12,818 | left outer medial |
| 216 | EEG T3-REF | 40,686 | left outer medial |
| 217 | EEG T3-T1 | 2 | the area between T3 and T1 |
| 218 | EEG T3-T5 | 2 | the area between the left outer medial and the left outer posterior |
| 219 | EEG T4-C4 | 2 | the area between the right outer medial and the right inner medial |
| 220 | EEG T4-LE | 12,818 | right outer medial |
| 221 | EEG T4-REF | 40,686 | right outer medial |
| 222 | EEG T4-T6 | 2 | the area between the right outer medial and the right outer posterior |
| 223 | EEG T5-LE | 12,818 | left outer posterior |
| 224 | EEG T5-O1 | 2 | the area between the left outer posterior and the left back of head |
| 225 | EEG T5-REF | 40,686 | left outer posterior |
| 226 | EEG T6-LE | 12,818 | right outer posterior |
| 227 | EEG T6-O2 | 2 | the area between the right outer posterior and the right back of head |
| 228 | EEG T6-REF | 40,686 | right outer posterior |
| 229 | EEG X1-REF | 41 | custom electrode placement |
| 230 | EMG-REF | 17,931 | A single electrode placed on a muscle belly |
| 231 | IBI | 37,546 | interburst intervals |
| 232 | PHOTIC PH | 12,222 | photic stimulation |
| 233 | PHOTIC-REF | 14,632 | photic stimulation |
| 234 | PULSE RATE | 70 | a single ECG lead, cardiac activity |
| 235 | RESP ABDOMEN-REF | 944 | a belt placed under the arms and across the chest |
| 236 | SUPPR | 37,546 | unknown |

1. **Channel Labels in DU (v1.0)**

|  |  |  |  |
| --- | --- | --- | --- |
| Index | Label | Freq | Description |
| 1 | A1 | 43 | equivalent to EEG A1-REF |
| 2 | A2 | 43 | equivalent to EEG A2-REF |
| 3 | C3 | 43 | equivalent to EEG C3-REF |
| 4 | C4 | 43 | equivalent to EEG C4-REF |
| 5 | CO2WAVE | 43 | unknown |
| 6 | CZ | 43 | equivalent to EEG CZ-REF |
| 7 | DC01 | 2 | DC1-DC |
| 8 | DC02 | 2 | DC2-DC |
| 9 | DC03 | 45 | DC3-DC |
| 10 | DC04 | 45 | DC4-DC |
| 11 | DC05 | 45 | DC5-DC |
| 12 | DC06 | 45 | DC6-DC |
| 13 | DC07 | 2 | DC7-DC |
| 14 | DC08 | 2 | DC8-DC |
| 15 | E | 43 | ear electrode, usually on the earlobe and used for a reference |
| 16 | EDF ANNOTATIONS | 45 | annotations created by EEG technician |
| 17 | EEG A1 | 2 | equivalent to EEG A1-REF |
| 18 | EEG A2 | 2 | equivalent to EEG A2-REF |
| 19 | EEG C3 | 2 | equivalent to EEG C3-REF |
| 20 | EEG C4 | 2 | equivalent to EEG C4-REF |
| 21 | EEG CZ | 2 | equivalent to EEG CZ-REF |
| 22 | EEG E | 2 | ear electrode, usually on the earlobe and used for a reference |
| 23 | EEG F3 | 2 | equivalent to EEG F3-REF |
| 24 | EEG F4 | 2 | equivalent to EEG F4-REF |
| 25 | EEG F7 | 2 | equivalent to EEG F7-REF |
| 26 | EEG F8 | 2 | equivalent to EEG F8-REF |
| 27 | EEG FP1 | 2 | equivalent to EEG FP1-REF |
| 28 | EEG FP2 | 2 | equivalent to EEG FP2-REF |
| 29 | EEG FZ | 2 | equivalent to EEG FZ-REF |
| 30 | EEG MARK1 | 10 | unknown |
| 31 | EEG MARK2 | 10 | unknown |
| 32 | EEG O1 | 2 | equivalent to EEG O1-REF |
| 33 | EEG O2 | 2 | equivalent to EEG O2-REF |
| 34 | EEG P3 | 2 | equivalent to EEG P3-REF |
| 35 | EEG P4 | 2 | equivalent to EEG P3-REF |
| 36 | EEG PG1 | 2 | unknown |
| 37 | EEG PG2 | 2 | unknown |
| 38 | EEG PZ | 2 | equivalent to EEG PZ-REF |
| 39 | EEG T1 | 2 | equivalent to EEG T1-REF |
| 40 | EEG T2 | 2 | equivalent to EEG T2-REF |
| 41 | EEG T3 | 2 | equivalent to EEG T3-REF |
| 42 | EEG T4 | 2 | equivalent to EEG T4-REF |
| 43 | EEG T5 | 2 | equivalent to EEG T5-REF |
| 44 | EEG T6 | 2 | equivalent to EEG T6-REF |
| 45 | EEG X1 | 2 | unknown |
| 46 | EEG X2 | 2 | unknown |
| 47 | EEG X3 | 2 | unknown |
| 48 | EEG X4 | 2 | unknown |
| 49 | EEG X5 | 2 | unknown |
| 50 | EEG X6 | 2 | unknown |
| 51 | EEG X7 | 2 | unknown |
| 52 | ETCO2 | 43 | unknown |
| 53 | EVENTS/MARKERS | 45 | unknown |
| 54 | F3 | 43 | equivalent to EEG F3-REF |
| 55 | F4 | 43 | equivalent to EEG F4-REF |
| 56 | F7 | 43 | equivalent to EEG F7-REF |
| 57 | F8 | 43 | equivalent to EEG F8-REF |
| 58 | FP1 | 43 | equivalent to EEG FP1-REF |
| 59 | FP2 | 43 | equivalent to EEG FP2-REF |
| 60 | FZ | 43 | equivalent to EEG FZ-REF |
| 61 | O1 | 43 | equivalent to EEG O1-REF |
| 62 | O2 | 43 | equivalent to EEG O2-REF |
| 63 | P3 | 43 | equivalent to EEG P3-REF |
| 64 | P4 | 43 | equivalent to EEG P3-REF |
| 65 | PG1 | 43 | unknown |
| 66 | PG2 | 43 | unknown |
| 67 | PULSE | 43 | EKG-REF |
| 68 | PZ | 43 | equivalent to EEG PZ-REF |
| 69 | SPO2 | 43 | unknown |
| 70 | T1 | 43 | equivalent to EEG T1-REF |
| 71 | T2 | 43 | equivalent to EEG T2-REF |
| 72 | T3 | 43 | equivalent to EEG T3-REF |
| 73 | T4 | 43 | equivalent to EEG T4-REF |
| 74 | T5 | 43 | equivalent to EEG T5-REF |
| 75 | T6 | 43 | equivalent to EEG T6-REF |
| 76 | X1 | 43 | unknown |
| 77 | X2 | 43 | unknown |
| 78 | X3 | 43 | unknown |
| 79 | X4 | 43 | unknown |
| 80 | X5 | 43 | unknown |
| 81 | X6 | 43 | unknown |
| 81 | X7 | 43 | unknown |