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APPLICATION NOTE

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Application Note 277: Transcranial Current Stimulation with STMISOLA

Transcranial Current Stimulation is an electrical stimulation methods, which employ a direct current of value typically between 1 and 2 milliamps (ma). This method is typically oriented to neuronal stimulation in the brain. Depending on the type of electrodes used for stimulation, and their associated placement on the scalp and body, Transcranial Direct/Alternating Current Stimulation (tDCS/tACS) may also be referred to as High Definition Transcranial Direct Current Stimulation (HD-tDCS) or High Definition Transcranial Alternating Current Stimulation (HD-tACS). Note that tDCS signals are unipolar (direct current) while tACS signals are bipolar (alternating current).

Please see this paper as reference:

> Electrodes for high-definition transcranial DC stimulation for applications in drug delivery and electrotherapy, including tDCS, P. Minhas et al. / Journal of Neuroscience Methods *190 (2010) 188–197*

Upon first introduction tDCS employed the use of large surface area electrodes (25 cm2 – 64 cm2), and electrodes – either carbon composition or metal – were isolated from the skin surface with conductive gel soaked sponges, to help reduce ion transfer from electrodes into the skin and to reduce current density at the electrode sites. tDCS/tACS can also be employed with Ag/AgCl electrode arrays

- Total arbitrary control of current wave shape is possible (DC or AC stimulation).
- Multiple STMISOLA units can be applied to the same subject.
- Electrode configurations are highly mutable.
- Exact output current applied can be sampled.
- Other physiological signals can be sampled simultaneously to look for tDCS/tACS impact on hemodynamics, sympathetic or parasympathetic nervous system.

tDCS/tACS can also be employed with Ag/AgCl electrode arrays. This application note illustrates how a HD-tDCS/HT-tACS setup can be constructed using the following BIOPAC equipment:

1 x MP160WS or MP160WSW (Data acquisition system)
OR
1 x MP150WS or MP160WSW (Data acquisition system)
1 x STMISOLA (Isolated linear stimulator)
1 x CBLLIMIT2 (Unipolar Current Limiter 2 ma)
1 x CBLCFMA (Current Feedback Monitor)
3 x CBL204 (Y–electrode lead coupler)
5 x LEAD110 (Electrode lead, unshielded)
1 pk. EL502 or EL504 (Solid gel electrodes)

In this particular setup, the configuration will be an extension of what is shown in the above referenced paper. Four electrodes (EL502 or EL504) will be connected to the positive or negative output of the STMISOLA stimulator (see Figure 2). The remaining (sole) electrode (EL502 or EL504) will be connected to the opposing output of the stimulator. For scalp attachment, the sole electrode is surrounded by the four connected electrodes. This type of electrode setup is known as a “Laplacian” setup.

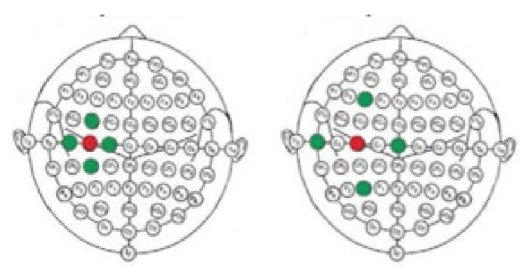


Figure 1: Setup examples: smaller Laplacian array (L) and larger Laplacian array (R)

By switching electrode connections to the stimulator outputs, current can be directed either into, or out of, the center (sole) electrode in the Laplacian setup. Figure 1 illustrates example electrode configurations. The electrodes in green are all connected, employing three CBL204 to link four LEAD110 leads together, where each LEAD110 is connected to a green electrode. All four, circumferential, green electrodes are then tied to a stimulator output (ANODE) and the remaining (sole) electrode, shown in red, is connected to the opposing stimulator output (CATHODE).

To be additionally specific, all electrode connections are placed in series with two other elements: a) Current limiting cable CBLLIMIT2/CBLLIMIT2AC and b) Current feedback monitor CBLCFMA; see figure 4 for setup diagram.

Figure 2: BIOPAC – STMISOLA Figure 3: BIOPAC – CBL204

Plug four of the LEAD110 electrode leads into two of the CBL204 adapters (see Figure 2), use the remaining CBL204 adapter to link the two previous adapters together to create four linked LEAD110 electrode leads. Plug the assembly into the desired output of the STMISOLA. Plug the remaining LEAD110 into the opposing polarity output on the STMISOLA. See Figure 4 for sample setup diagram.

IF the setup is expanded to include biopotential signal(s) recording, isolation should be added:

- MP160 setup: add INISO
- MP150 Setup: add HLT100C or AMI100D + INISO(A)

Connect INISO between CBLCFMA and HLT100C/AMI100D.

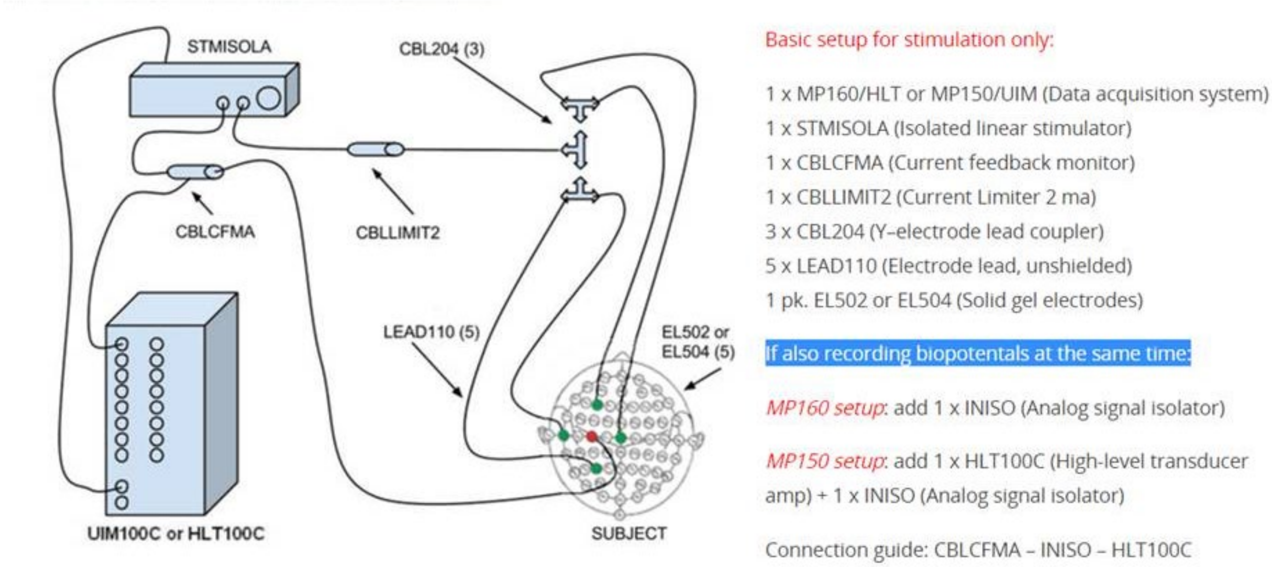
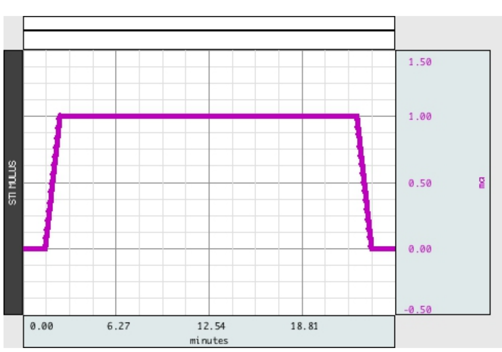


Figure 4: tDCS Sample Setup

Use Acq*Knowledge* Stimulator Setup the set the MP160/150 to output the desired tDCS/tACS waveform. Typically, the waveform will be 20 minutes long (1200 seconds), with a 60 second positive and negative ramp. The ramps permit increasing current excitation to the maximum desired current, then decreasing back to zero at the end of the procedure, as per Figure 5. Set the waveform graph sample rate to 10 Hz.

1 V control output = 1 ma tDCS current
with STMISOLA in 1 ma/V setting



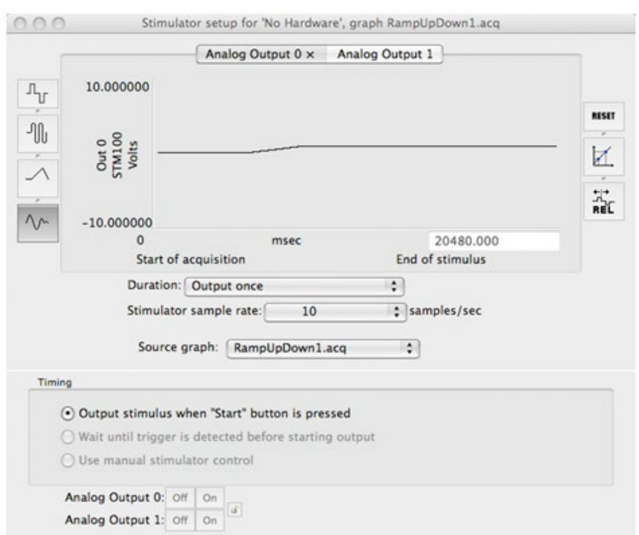


Figure 5: Stimulator waveform setup

Figure 6: Acq*Knowledge* Stimulator Setup Window (10 Hz output rate)

Connect the STMISOLA to the DA0 or DA1 output on the UIM100C (MP150) or HLT100C/AMI100D (MP160). Direct the arbitrary wave created (Figure 5) to the Stimulator Setup Window in Acq*Knowledge*, as shown in Figure 6.

The Stimulator Setup Window will only show the beginning of the electrical stimulus as the computer will continue to feed the MP160/150 the proper stimulus waveform during the entire recording. When ready, press the “Start” button in Acq*Knowledge*. The stimulus will be output to the STMISOLA. In this case, the output will start at 0 ma, wait for roughly 60 seconds, then ramp up over 60 seconds to 1ma output current, hold the output current for 20 minutes, then ramp back down to 0 ma.

IMPORTANT SAFETY NOTE

The STMISOLA should be placed on the 1 ma/volt setting (Zout = 1 kohm). This will translate a 1 volt control signal (from Acq*Knowledge* and the MP160/150) to 1 ma output current via the STMISOLA. If the setting is 10 ma/volt (Zout = 100 ohms) then the output current will be 10 ma. Please verify all settings and check operational currents prior to tDCS/tACS tDCS procedures.

With this setup it’s also possible to perform AC current stimulation as opposed to simply DC current stimulation. Total waveshape control is afforded by the Stimulator window in Acq*Knowledge*. Any arbitrary waveshape can be constructed to be output as the desired DC or AC current signal. For example, an arbitrary wave could start with a slow ramp, stabilize at a consistent current, oscillate around a given level and then return to zero. Arbitrary waves of any specific shape or duration are possible.

To monitor the exact output current, a standard Volt-Ohmeter can be used when placed in series with either the positive or negative stimulator output leads. The Volt-Ohmeter should be placed on the current monitoring setting. Alternatively, the CBLCFMA current sensing feedback monitor cable can be placed in series between the negative stimulator output and the associated electrode lead. The cable’s voltage report signal (1 V = 10 ma) is directed to an analog input channel on the MP160/150, for monitoring during stimulus output.

Electrode Placement, Current Magnitude and Polarity

tDCS/tACS is an investigative protocol. Please consult the available literature to determine appropriate electrode placement, current magnitudes and appropriate polarity.

NOTES REGARDING USE OF ELECTRODES

For electrical stimulation, generally, the lower the electrode salt content, the less skin irritation will be experienced by subject. This is because fewer salt ions are driven into skin during stimulation. This strategy puts more demand on the stimulator, because skin impedances are higher with low salt electrodes. There is no one size fits all requirement. For example, it's possible to help mitigate the undesirable effects of higher salt content electrodes by stimulating the subject with bipolar pulses, instead of unipolar pulses.

Click here for more details about using BIOPAC electrodes and gels.