

tDCS Stimulator (1ch)

RESEARCH ADDENDUM



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CAUTION

As a user of this device you have the responsibility to understand its proper function and operational characteristics. This manual should be thoroughly read before attempting to use or placing this device into service. This device should only be used for its intended application.

WARNING

Do not use this device if you have any metal implants in the head, or implanted devices such as cochlea implants or cardiac pacemakers.

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1 Scope and Research Parameters

Scope

This manual covers software version 1.03d

Parameters List

Research mode parameters	Min	Max	Default
Sham operation	OFF	ON	OFF
Sham stimulation	0 sec	60 sec	30 sec
Sham current	0.50 mA	4.50 mA	1.00 mA
R skin min	1k Ω	5k Ω	2k Ω
R skin max	10k Ω	20k Ω	15k Ω
R divergence	10%	200%	50%
Lock current	OFF	ON	OFF
Max stimulation current	1.00 mA	4.50 mA	2.00 mA
Set password	-	xxxx	0000
R sim start	10k Ω	25k Ω	20k Ω
R sim end	1k Ω	10k Ω	5k Ω

*Ramp up time is set through the normal configuration menu

Accessing the Research Parameters

Research parameters can be accessed through the configuration menu. Scroll down until the **Research Mode** menu item and press **Select**.

The research menu can be password protected. The password only needs to be entered once to access the research parameters and access remains valid until the device is shut down.

The password consists of 4 digits, ranging from 0000 to 9999.

When changing batteries, the stored password and all other parameters are still retained.

Recovering a Lost Password

In case a device password is lost, the device can be restored to its factory defaults.

All data will be reset to their initial values. No password will be needed to access the Research Configuration pages.

Go to **Configuration** and press **Select**.

Scroll down until the **Factory reset** menu item and press **Select**.

Press the **Right button** to restore the default settings.

When restoring to factory defaults, all configuration data, including stimulation settings, and research parameters are reset to their default values. Last session data is also cleared from memory.

3 SHAM Parameters

Introduction

SHAM operation is virtually indistinguishable from normal operation through the display of pseudo random parameters that are approximated to a normal stimulation curve.

However, during SHAM operation, none of the error checks are active since there is no current to measure. This means, that if the electrodes are disconnected, no error condition will be triggered.

The following parameters are used for SHAM operation:

SHAM operation parameters	Min	Max	Default
Sham operation	OFF	ON	OFF
Sham stimulation	0 sec	60 sec	30 sec
Sham current	0.50 mA	4.50 mA	1.00 mA
R sim start	10kΩ	25kΩ	20kΩ
R sim end	1kΩ	10kΩ	5kΩ

SHAM Operation

SHAM operation can be set to **ON** or **OFF**.

The default value is **OFF**.

When **SHAM Operation** is set to **ON**, no stimulation current will be flowing through the electrodes. Optionally, when **SHAM Stimulation** (below) is bigger than **0** (not OFF) a brief current will flow to make the SHAM stimulation feel real. During a stimulation session, the display will show pseudo random values to simulate a realistic stimulation.

SHAM Stimulation

SHAM stimulation can be set to a value of **OFF** (0 sec) and up to **60 sec**.

The default value is **30 sec**.

When **SHAM Stimulation** is set to **OFF**, no stimulation current will be flowing through the electrodes. To make a SHAM stimulation feel more realistic, a short stimulation of 30 seconds is usually preferred to trick the subject. See Annex A.

SHAM Current

SHAM current can be set to a value of **0.50 mA** and up to **4.50 mA**.

The default value is **1.00 mA**.

When **SHAM Stimulation** is set to a value bigger than 0 sec (not OFF), a current will be flowing through the electrodes for a short period of time to trick the subject. This current can be set independently and is hidden to the user.

The **SHAM Current** can be set to a value lower than the normal stimulation current, since its purpose is only to generate the feeling of stimulation.

The maximum value that can be set depends on **Max Stimulation Current**, covered in chapter 5.

R Sim Start

R Sim Start can be set to a value of **10kΩ** and up to **25kΩ**.

The default value is **20kΩ**.

When **SHAM stimulation** is set to **ON**, the display will show pseudo random simulated numbers. During a stimulation session, the skin resistance drops over time. To tailor the simulation to specific electrodes, the start value of R can be customized. This value will also be randomized within an upper and lower limit. This value represents the lower limit.

R Sim End

R Sim End can be set to a value of **1kΩ** and up to **10kΩ**.

The default value is **5kΩ**.

When **SHAM Stimulation** is set to **ON**, the display will show pseudo random simulated numbers. During a stimulation session, the skin resistance drops over time. To tailor the simulation to specific electrodes, the end value of R can be customized. This value will also be randomized within an upper and lower limit. This value represents the lower limit.

4 Resistance Alert Triggers

R Skin Min

R Skin Min can be set to a value of **1kΩ** and up to **5kΩ**.

The default value is **2kΩ**.

During a stimulation session, the skin resistance is monitored. This sets the lower limit for the skin resistance. When this level is reached, an error will be triggered and the stimulation will be terminated to prevent injury.

R Skin Max

R Skin Max can be set to a value of **5kΩ** and up to **20kΩ**.

The default value is **15kΩ**.

This sets the upper limit for the skin resistance. When this level is reached, an error will be triggered and the stimulation will be terminated to prevent injury. This value is only monitored after the ramp up transition. Be aware of the following formula for the maximum possible current that the device can deliver when setting R Skin Max:

$$I_{max} = 28V / R_{skin}$$

R Divergence

R Divergence can be set to a value of **10%** and up to **200%**.

The default value is **50%**.

Skin resistance should drop over time. The lowest value of a moving average of R is constantly checked against the actual current R.

If the current R diverges too much upwards, this could indicate dry electrodes. A warning will be triggered every 30 seconds at 75% of R Divergence to moisten the electrodes.

If the current R crosses the upper limit of divergence, the stimulation will be terminated.

5 Current Settings

Lock Current

Lock Current can be set to **ON** or **OFF**.

The default value is **OFF**.

To prevent the subject from lowering the target current during a stimulation session, set this value to **ON**.

Maximum Current

The device Maximum Current can be set to a value of **0.50 mA** and up to **4.50 mA**.

The default value is **2.00 mA**.

The maximum **Stimulation Target Current** setting can be configured to an upper limit. When a user accesses the stimulation parameters, the device will apply this value as the upper limit.

6 Password Protection

Set Password

Password can be set ranging from **0000** to **9999**.

The default value is **0000**.

To prevent unauthorized access to the research parameters, a password can be set. Setting the password to 0000, disables the password protection.

7 Miscellaneous Menu's

Introduction

Two default menu items in the **Configuration Menu** are also useful in a research setting: Ramp-up Time and Last Session. These two menu's are part of the normal manual but again explained here in more detail.

Ramp-up Time

Ramp-up Time can be set to a value of **10 sec** to **120 sec**.

The default value is **30 sec**.

During a stimulation session, the current is not increased to the maximum value immediately to allow the subject to accommodate comfortably to the current levels. This **Configuration Menu** option sets the time it takes to reach the configured target current. See Annex A.

Last Session

Last session displays the end status of the last stimulation session.

The following values are shown:

- I avg : the average current of the stimulation session
- Time : the time in minutes of actual stimulation
- Cause : how the stimulation session was terminated

Possible values for Cause are:

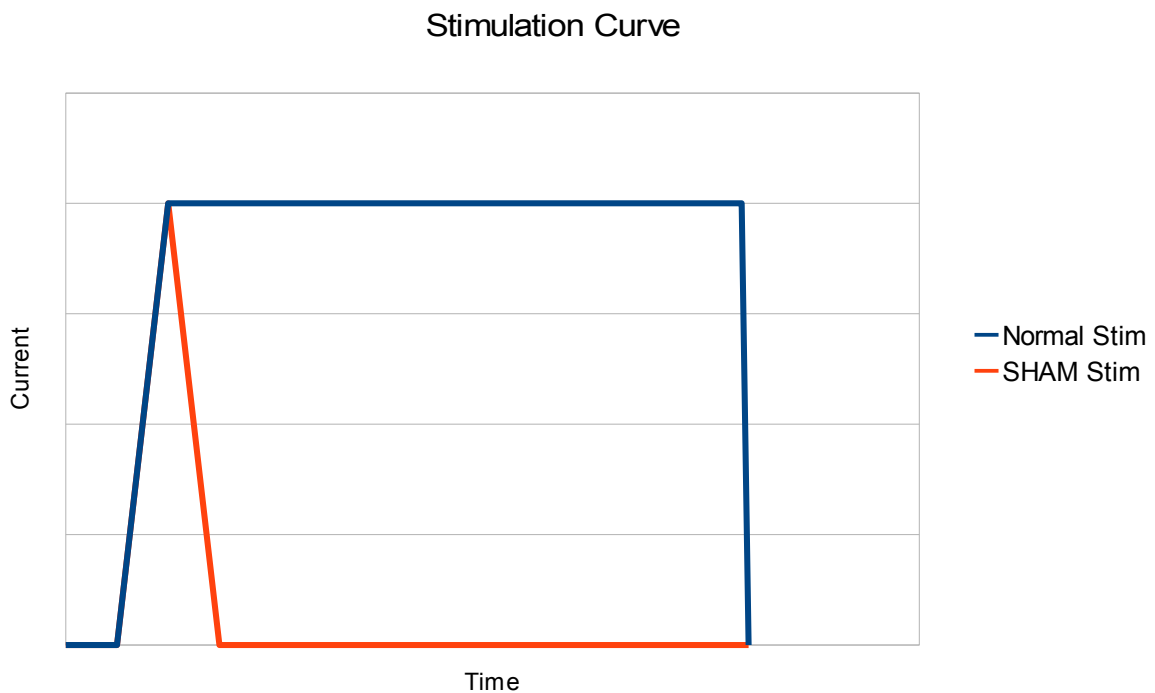
- Normal : normal termination at the end of the preset time
- User abort : stimulation was aborted by the user
- R too low : R reached the lower limit of R Skin Min
- R too high : R reached the upper limit of R Skin Max
- No contact : the circuit was interrupted or no electrodes are connected
- Shortcircuit : the electrodes caused a short circuit
- Pads too dry: R crossed the upper limit of R divergence

Annex A

Stimulation Curve

Stimulation curve, with the following actions:

- Ramp up
- Ramp up transition (at target current)
- Normal and SHAM Stimulation
- Ramp down



SHAM Stimulation ramps up and down according to the following formula's:

$$\text{SHAM_RAMP_UP_START} = \text{RAMP_UP_TRANSITION} - \text{SHAM_STIMULATION}/2$$

$$\text{SHAM_RAMP_DOWN_END} = \text{RAMP_UP_TRANSITION} + \text{SHAM_STIMULATION}/2$$

Annex B

Technical Specifications

Size and Weight

Parameter	Typical
Length	135mm
Width	115mm
Height	35mm
Weight	280gr

Power

Parameter	Typical
Power	2 x 9V
Battery life	10hrs

Alkaline batteries, continuous operation at 50% display brightness and 2mA stimulation current.

Connections

Connector type	jack	3.5mm
	tip	anode(+)
	ring	cathode(-)

Operations and Storage Limits

Operating limits	Min	Max
Temperature	14 °C	28 °C
Humidity (non-condensing)	-	70%
Atmospheric pressure	700 hPa	1060 hPa

Storage limits	Min	Max
Temperature	0 °C	60 °C
Humidity (non-condensing)	-	70%
Atmospheric pressure	700 hPa	1060 hPa

tDCS Specifications (electrical)

Stimulation specifications	Min	Max
Output current	0.50 mA	4.50 mA
Output current precision (better than)	-	<0.005 mA
Current correction time		45 ms
Maximum output voltage	-	28V
Allowed electrode resistance	1k Ω	20k Ω