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Avatar EEG Recorder User Guide
3000 Series

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Hardware Configuration

- Eight biopotential measurement channels with 500Hz storage, 500Hz Bluetooth transmission
- Some units optionally support up to 4000Hz storage, Bluetooth transmission up to 1000Hz
- One optional optically isolated, wired digital channel
- EMI filter and anti-alias low-pass sinc filter and no DC filter
- 24 bit sample size, gain 12, range 750mVpp
- Bluetooth v2.1 EDR wireless communications, serial port profile
- Removable microSDHC card with FAT file system

User Settings

A file called config.txt can be found on the microSDHC card. This file is read by the device upon power up and it determines the operational configuration. Generally, setting a parameter to 1 will enable that feature while setting a parameter to 0 will disable that feature. If the microSDHC card is not present the following defaults are used:

```
WRITE_TO_SD             = 0
BLUETOOTH_ON            = 1
BLUETOOTH_DISCOVER      = 1
DEMO_MODE               = 0
SINGLE_ENDED            = 0
ENABLE_TRIGGER_CHANNEL  = 0
NUMBER_OF_CHANNELS      = 8
STORAGE_RATE            = 500
BLUETOOTH_TX_RATE       = 500
```

Use a text editor such as Notepad++ to adjust runtime settings for the device. (Using the stock Notepad program in Windows may not display the file nicely as the line endings in the file are a single line feed character, 0x0A.)

- **`BLUETOOTH_ON`**: When set to 0 the Bluetooth hardware is powered off
- **`BLUETOOTH_DISCOVER`**: When set to 0, unit will not respond to inquiries from other Bluetooth devices. However the device will still be connectible.
- **`DEMO_MODE`**: Can be useful for testing. Sets channel two to be shorted internally and channel three to have a 1Hz, +/-1.875mV square wave. All other channels will operate normally.
- **`SINGLE_ENDED`**: When set to 1, all input channels will share a common reference, on pin 6. When set to 0, unit operates in fully differential mode with each input channel having its own reference.
- **`NUMBER_OF_CHANNELS`**: If not using all eight channels, this number can be reduced to save power, Bluetooth transmission bandwidth and disk space.
- **`STORAGE_RATE`**: Samples per second to be stored to the microSDHC card - assuming `WRITE_TO_SD` is set to 1. Valid values are 500, 1000 and 4000.
- **`BLUETOOTH_TX_RATE`**: Samples per second to be transmitted via Bluetooth - assuming BLUETOOTH_ON is set to 1. Valid values are 250, 500 and 1000.

Advanced Settings

The amplifier's gain setting can be set to 1, 2, 4, 6, 8, 12, or 24 by modifying the config.txt file. Default gain setting is 12. e.g. To use a gain of 6:

```
GAIN = 6
```

Note that changing the gain affects the calculation from raw counts to volts (see “Converting Counts to Volts” section). The table below shows the range, in volts, and the approximate input referred noise, in µVpp, for each gain setting. The reported values pertain to a 500Hz storage rate and will increase if higher storage rates are used.

Gain	Range (V)	Input Referred Noise (µVpp)
1	9.000	10.9
2	4.500	5.8
4	2.250	3.2
6	1.500	2.5
8	1.125	2.2
12	0.750	2.0
24	0.375	1.6

Power Supply

WARNING: Use special caution when working with lithium-ion cells, they are very sensitive to charging characteristics and may explode or burn if mishandled. Always charge on a fire-proof surface. Never leave charging batteries unattended. Do not make any modification of the batteries or chargers in any form or shape (including pack making). Only use the provided charger to charge the supplied lithium ion batteries. The supplied lithium ion batteries operate at more than twice the voltage of an alkaline battery and should only be used to power the Avatar EEG recorder.

The Avatar EEG recorder will run on only one battery. Use two batteries for 24+ hours recording. Battery life (and thus viable recording time) will vary depending on config.txt settings and battery charge. Ensure correct polarity of batteries. Negative side of both batteries must touch the spring contact.

To turn unit on and begin recording press the keypad button. To turn unit off and stop recording hold the keypad button down for more than two seconds.

Keypad Status Lights

Red: Turns on and stays on if there is a problem. Problems include, but are not limited to, an invalid entry on the microSDHC card, a corrupt or full microSDHC card, or a low battery. To clear the red light, batteries must be removed and reinserted after the problem has been solved.
Blue: Turns on briefly when inserting the first battery. Also turns on for about a second during power up initialization.
Green: Turns on after successful power up. Stays on unless writing to the microSDHC card. If writing to the microSDHC card it will blink during each write. The blinking rate depends on the number of channels enabled and the rate of storage.

Recording to microSDHC

Place one or two batteries in unit and press the keypad button to turn on. If a microSDHC card is present and `write_to_sd = 1`, then recording begins approximately two seconds after the device is powered on. Each file name has the format of `yyyy_mm_dd_hh_mm_ss.rec` corresponding to the start time of the recording. Periodically a new file is started to keep file size manageable. **To avoid possible file corruption, press and hold the keypad button for more than two seconds to close file before removing the microSDHC card or taking batteries out.** Wireless (Bluetooth) communications will not interrupt recording.

Removing and Inserting the microSDHC

The microSDHC can be removed from the Avatar EEG recorder by gently pushing it (further) into the slot on the side of the device and allowing it to release out. You can push on the card with a fingernail, tweezers or other small object. Once it is released, the card can be removed by pulling on it. In the event that it is hard to reach, tweezers may be helpful. Once the card is removed it can be placed into the provided SD adapter for reading on a computer. If your computer does not have an SD card slot, USB adapters are readily available. The Avatar EEG microSDHC card is formatted with a FAT file system that can be read by most computers. When inserting the card back into the Avatar EEG recorder, exercise caution while guiding the card back into the microSDHC socket. Push gently until the card is locked into place.

Converting Counts to Volts

The values recorded are the raw counts from the 24-bit ADC. For a gain of 12 the range of each channel is 750mVpp. Thus to convert counts to volts multiply by 0.750 and then divide by 2^24.

Wireless Functionality

Upon power up, and depending on the config.txt settings, the recorder is made discoverable via Bluetooth. When a client connects via Bluetooth, it begins wireless transmission. If not using the wireless communications you may set `BLUETOOTH_ON = 0` to save power.

Real-Time Clock (RTC)

RTC settings will last for a couple of hours between battery changes. If batteries are kept in the unit, the RTC settings will be retained as long as the batteries have power. The time can be set via wireless communications by using the Avatar EEG desktop or Android software.

Optically Isolated Digital Input Channel

For units with a BNC connector, to enable the digital input storage or transmission, ensure the following line exists in the config.txt file on the microSDHC card.

```
ENABLE_TRIGGER_CHANNEL = 1
```

The input will read a 1 when no current is applied to the BNC connector. The input will read 0 when a current is applied. A current can be applied by supplying a 3V to 5V source to the positive (middle) pin on the BNC connector. The supply must be able to drive a 12mA current. There is a small bit of latency for the detection. This is because the infrared emitter needs to illuminate/de-illuminate and the optical transistor needs to detect this change. In our engineering tests, the latency detecting a high (to illuminate) transition is around 50us and the latency detecting a low transition is around 10us.

The digital channel is sampled simultaneously with the EEG channels. It is also sampled at the same rate.

Bias Electrode

The Bias electrode is required for proper operation and is derived from each channel. Thus, at a minimum, the system setup must use one input electrode, a reference electrode and the bias electrode. The bias electrode is used as a means to counter the common-mode interference in a EEG system as a result of power lines and other sources, including fluorescent lights. Other names for bias are 'RLD', 'DRL', 'active ground' and 'DC bias'. The name 'RLD - right leg drive' comes from historical reasons and often this electrode is not attached to a leg. It can be attached on the skin to an arm, earlobe or scalp.
Important: BIAS setting are derived from all of the **enabled** channels. Thus is it important to only enable that channels that are connected. Otherwise common mode rejection may be compromised. If you wish to override the default BIAS derivation please contact customer support.

Tips for Acquiring a Clean Signal

Testing set-up and environment are extremely important for preventing artifacts in biological signals. To acquire the cleanest signal possible:

- Ensure the recorder's bias settings are properly set (see above)
- Minimize electrode-skin impedances by abrading the skin, making sure the area is free of hair, and using a conductive paste at the electrode-skin interface (<5kΩ is ideal)
- Reduce tension and/or pressure on the electrodes and (ideally) fix the electrodes directly to the skin
- Choose a recording environment free from strong sources of 60Hz electromagnetic noise (e.g. power lines, some computer monitors and fluorescent lights)
- If it is impossible to eliminate sources of 60Hz noise in the testing environment, care should be taken to use a testing set-up that, itself, minimizes 60Hz noise, since filtering can also introduce artifacts. We have observed that the following set-ups (in order of decreasing efficacy) are effective and easy to implement:

    - Tin/copper shielding sleeve encasing the entire length of electrode cables (recorder grounded to shielding through pin1)
    - Braiding of electrode cables.

Electrode Connections and Configuration

For single ended configurations the shared common references are electrically connected through pin 6. This configuration still requires a Bias connection (see above). In the single ended configuration all counts from the Avatar EEG recorder are inverted.

Fully differential configuration:

	2	**1**	
BIAS	**4**	**3**	
	6	**5**	
Channel 8 Input	**8**	**7**	Channel 8 Reference
Channel 7 Input	**10**	**9**	Channel 7 Reference
Channel 6 Input	**12**	**11**	Channel 6 Reference
Channel 5 Input	**14**	**13**	Channel 5 Reference
Channel 4 Input	**16**	**15**	Channel 4 Reference
Channel 3 Input	**18**	**17**	Channel 3 Reference
Channel 2 Input	**20**	**19**	Channel 2 Reference
Channel 1 Input	**22**	**21**	Channel 1 Reference

Single ended configuration:

	2	**1**	
BIAS	**4**	**3**	
	6	**5**	Single Ended Reference
	8	**7**	Channel 8 Input
	10	**9**	Channel 7 Input
	12	**11**	Channel 6 Input
	14	**13**	Channel 5 Input
	16	**15**	Channel 4 Input
	18	**17**	Channel 3 Input
	20	**19**	Channel 2 Input
	22	**21**	Channel 1 Input