An 8-Channel Flexible Dry Active-Electrode System for Neural Monitoring and Motion Artifact Detection

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1. Motivation

- Develop a wearable brain neural monitoring system.
- The device will be used for monitoring and diagnostic applications.
- The presented device is designed to be accompanied by a module for
  - Signal processing
  - Wireless data communication

Avertus

Emotiv

Cognionics

2. Design Challenges:

Application Level	System Level	Circuit Level
• Comfortable to use	• Multiple channels	• BW: 0.1- 500 Hz
• Fast setup	• Long battery life	• EEG Amp.: 10uV to 1mV
• Light weight	• Fully wireless	• High CMRR/PSRR
• Low-cost	• Differential Recording	• Low noise(<100nV/sqrt(Hz)
• Self-contained		• Resolutions >10 bits

3. Electrode Considerations

Dry Electrodes:

☺ Do not involve using any gels → Fast setup

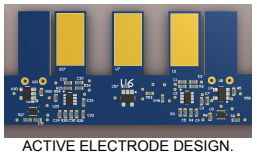
☺ Easy integration for portable designs → self-contained + low-cost

☺ More convenient and comfortable than wet electrodes.

☹ Contact not as good as wet electrodes.

Flexible Circuit:

- Adjusts to the skull curvature
- Light weight.
- Allows to improve electrode-skin contact . with spring-like mechanical design.



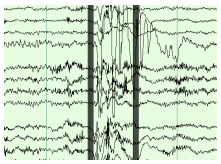
ACTIVE ELECTRODE DESIGN.

Active Electrodes:

- Remove the wire between electrode pads and amplifier inputs.
- Decreases risk of noise being coupled.
- No signal attenuation at the input
- Allows for active shielding.

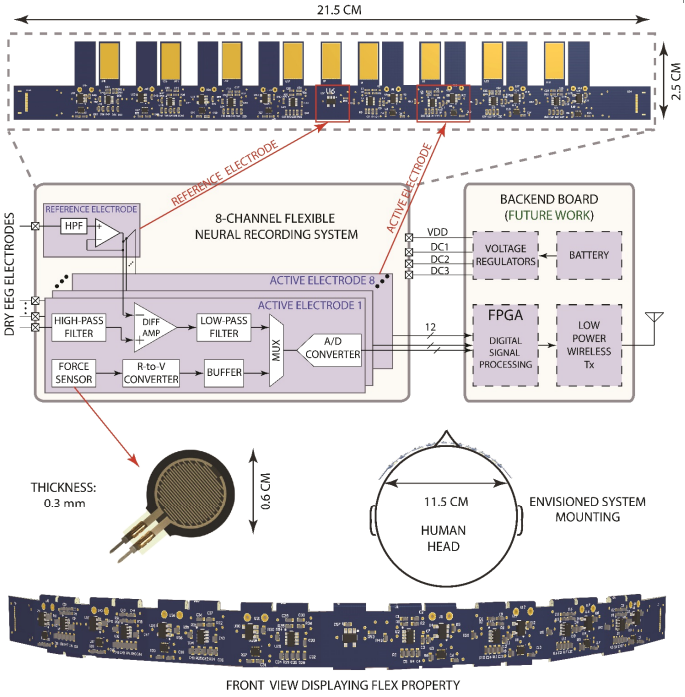
4. Motion Artifact Removal

- Large artifacts could be generated due to the poor skin contact with dry electrodes.
- The contact quality can be quantified using a force sensor between the electrode and the skin.
- This information could be used to compensate the effect of artifacts in the digital backend.



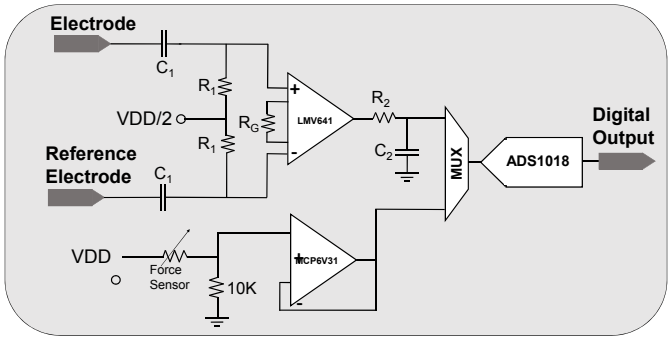
Motion artifacts have larger amplitudes and usually start and end quickly. eegatlas-online.com

5. System-Level Design



SYSTEM SPEC: SIZE: 21.5 x 2.5 CM²
WEIGHT: <50 GRAMS
4-LAYER FLEX PCB (POLYAMIDE SYBSTRATE)

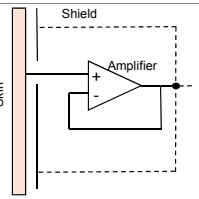
6. Circuit-Level Design



Circuit implementation for proposed active electrode.

Gain: $G = 1 + \frac{49.7k\Omega}{R_G}$ **High Pass Pole:** $f_{HP} = \frac{1}{2\pi R_1 C_1}$ **Low Pass Pole:** $f_{LP} = \frac{1}{2\pi R_2 C_2}$

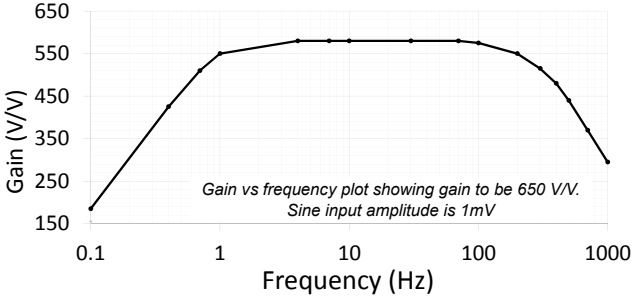
Formulas used to control gain, and bandwidth of bandpass filter.



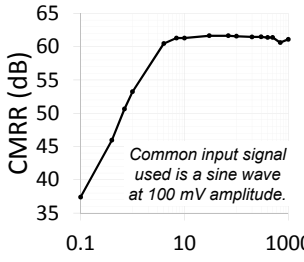
Active Shielding Module:

- Blocks capacitive coupling of analog/digital signals of active electrode to the electrode plate.
- Biased by output of amplifier to protect signal input.

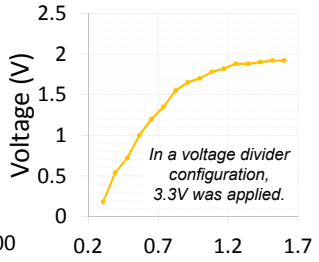
7. Results



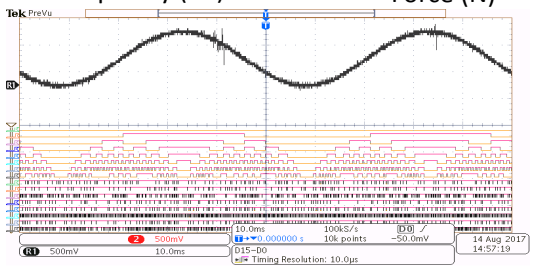
Gain vs frequency plot showing gain to be 650 V/V. Sine input amplitude is 1mV



Common input signal used is a sine wave at 100 mV amplitude.



In a voltage divider configuration, 3.3V was applied.



Sampled 20Hz signal and digital output of the ADC.

8. Impact/Contributions

- A point-of-care low-cost wearable EEG recording system can improve personalized for both **monitoring** and **diagnosis** applications.
- The device yields smallest form factor, lightest weight compared to the commercially-available products.
- Future additions to the device will include features such as fully wireless operation, and embedded signal processing for neurological event detection (e.g. epilepsy seizures).