



WEARABLE EEG SOLUTIONS

Monitoring someone's brain state can reveal essential information that may be used e.g. in medical diagnosis. But until recently, this required wiring users or patients to a big machine to monitor their EEG (electroencephalogram). Together with their partners, imec & Holst Centre have now developed a high-quality ambulatory monitoring solution, allowing to do brain monitoring in uncontrolled environments (e.g., at home, in a classroom), even with the user moving.

The new EEG technology combines dry electrodes with active sensor nodes and miniaturized electronics. It provides continuous skin-to-electrode impedance monitoring, adding information about the contact quality throughout the recording. The electronic solution is integrated in ergonomic headsets, designed with a variety of applications in mind. It includes a unique signal processing capability that assesses the quality of the signal and cancels out motion artefacts. The system can be connected to desktops, portables, tablets and smartphones through Bluetooth.

Imec's wearable EEG platform is a complete solution with an EEG Headset Platform and BCI Data Analytics Platform that can be customized for research purposes aiming at different applications.

EEG HEADSET PLATFORM

The EEG Headset Platform consists of an easy-to-use, convenient, wearable, wireless EEG headset prototype. The headset prototypes are made in various sizes and with different electrode configurations. They enable 8-channel EEG recording using comfortable, dry, polymer-based electrodes. Next to the EEG, they can monitor electrode-tissue impedance (ETI) at each electrode, as well as headset acceleration and orientation. A number of options related to EEG and ETI signal acquisition and transmission are configurable in the firmware. The EEG Headset Platform has an unmatched low-power performance providing autonomies of more than 5 hours while streaming data from all sensors in real-time using standard Bluetooth® profile. The autonomy is further increased if the data is not transmitted but stored locally on an SD-card. For autonomous headset operation applications, several embedded algorithms are available, running on the integrated Cortex-M4 microcontroller.

EEG DATA ANALYTICS PLATFORM

The BCI Data Analytics Platform includes software aimed at research and clinical studies. The software offers an easy-to-use graphical user interface capable of acquiring and visualizing raw EEG data and EEG spectra in real-time, as well as recording data using the HDF5 file format. The BCI Data Analytics platform also includes real-time and offline signal quality assessment and (motion) artifact handling methods as well as state-of-the-art EEG feature extraction tools and data analytics methods required for various brain monitoring applications. The software can communicate with external applications using a TCP/IP link, transmitting the data at different levels of abstraction, from raw data and spectral EEG content to application specific command and control information. The software architecture is flexible and can be adapted for various research and clinical applications.

APPLICATION AREAS

This new wearable EEG solution supports EEG applications in environments that do not require specialized technical assistance, such as at family doctors, psychiatrists, paramedic care, ICU. Besides, it also enables home or clinical applications that are based on:

- Estimation of user's cognitive state in terms of vigilance and focus levels
- Identification of user's mood and emotions in terms of valence and arousal
- Detection of users intentions in term of imagining movements of body parts

KEY FEATURES OF THE EEG HEADSET PLATFORM

- Convenient and comfortable EEG headset
- Available in three sizes (S/M/L)
- Available with different electrode configurations
- Dry and flexible conductive polymer electrodes
- Active dry sensors with high input impedance (1.3G μ @ 10Hz)
- 8-channel EEG captured at 256Hz
- Continuous 8-channel ETI monitoring
- Monitoring headset acceleration and orientation
- Bluetooth-enabled (cellphone communication)
- Data can be stored on an integrated SD card
- Embedded algorithms on Cortex-M4 μ Processor
- Long autonomy: 5+ hours
- USB rechargeable battery
- Safety circuit ensures a single fault condition results in current limited to 50 μ A
- Made with hypoallergenic materials
- Contains disposable inserts for easy maintenance
- Polymer electrodes can be cleaned using alcohol

KEY FEATURES OF THE EEG DATA ANALYTICS PLATFORM

- Software available for visualization and storage on a PC or a tablet
- Storage of signals in HDF5 format
- Real-time and offline signal quality assessment
- Real-time and offline artifact handling methods
- State-of-the-art feature extraction tools
- State-of-the-art EEG data analytics
- Flexible software suitable for research application development
- Real-time monitoring on a handheld device (i.e., tablet)

Description	Min	Typical	Max	Units	
Headset form factor	Headset				
Headset weight		200		grams	
Headset communication	Bluetooth 2.1 + EDR (SPP)				
Software GUI	Qt-based, MS & Android				
Basic software functionality	Data acquisition & visualization: EEG, ETI, acceleration, orientation				
Data analysis algorithms	Signal quality, artifact handling, feature extraction, data analytics				
Data storage	SD card and in software (HDF5)				
Application interface	Raw data, features				
Device user interface	Multi-color LEDs				
Battery	Charging interface		Micro USB		
	Battery life		8	hours	
	Charging time		2	hours	
Electrode locations	Configuration 1	Measurement electrodes: F3, F4, F7, F8, Fz, P3, P4, A1 Reference: right mastoid (A2), Patient bias: Pz			
	Configuration 2	Measurement electrodes: F7, F8, T3, T4, C3, C4, P3, P4 Reference: Cz, Patient bias: Fpz			
	Configuration 3	Measurement electrodes: F3, F4, F7, F8, Fz, C3, C4, Cz Reference: right mastoid (A2), Patient bias: left mastoid (A1)			
EEG	Range		1.5	mV	
	Resolution		0.36	μ V	
	Available sampling frequencies	128	256	1024	Hz
	Bit depth	12		bits	
ETI	Range	90	900	1800	k Ω
	Resolution	22	220	4 395	Ω
	Available sampling frequencies	128	256	256	Hz
	Bit depth	12		bits	
Acceleration	Range (X,Y,Z)	ff12	ff12	ff16	g
	Sensitivity	ff1200		LSB/g	
	Available sampling frequencies	32	32	256	Hz
	Bit depth	16		bits	
Orientation (gyroscope)	Range	ff1250	ff1250	ff12000	$^{\circ}$ /sec
	Available sampling frequencies	32	32	256	Hz
	Bit depth	16		C	

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