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Clinical Application Driven Physiology in Biomedical Engineering Laboratory Course Education

By
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CleveLabs
Biomedical Engineering Course
Biomedical basics through clinical applications

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Background

- Need for biomedical engineers in research and industry has increased dramatically in recent years
- BME students should be prepared with an appropriate skill set for real-world problems.
- This requires novel strategies for training BME students in both engineering principles and clinical applications.
- BME education requires hands on learning with cutting edge technology to produce students ready to solve clinical problems in both research and industry.

Background -continued

- These clinical application interfaces are critical for students to understand how physiological signals may be manipulated to extract meaningful benefits for various medical disorders and rehabilitation needs.
- The biomedical engineering laboratory course presented in this paper was implemented and evaluated at a number of universities.
- Utilizing a virtual environment for practical applications bridges the gap between fundamentals and real world designs.
- An innovative biomedical engineering (BME) laboratory course that integrates wireless electrophysiology devices with a hands on learning approach has been developed.

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BioRadio Model 150 Wireless Monitoring System

- Lightweight, programmable, wireless physiological monitor
- Viewing and recording
  - •EEG,
  - •ECG,
  - •EMG,
  - •EOG, and
  - •PSG signals.
- Labs Designed to be used by freshmen to grad students
- Eliminates the restrictions encountered with traditional tethered equipment
- Opens up a whole new realm of monitoring opportunities.
- Affordable

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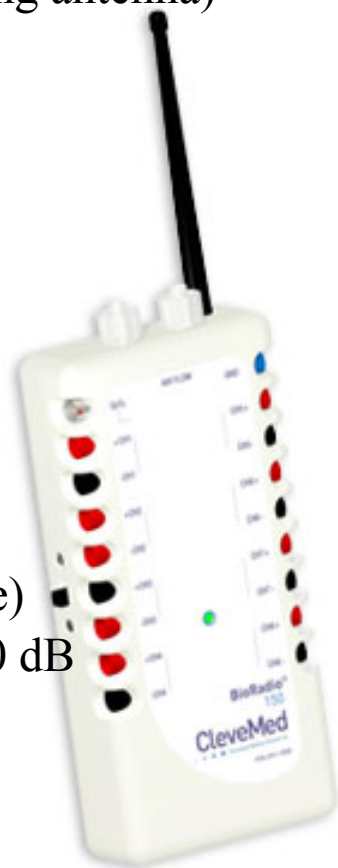
BioRadio 150 Specifications

- Dimensions: 135 mm x 63 mm x 25 mm (5.3” x 2.5” x 1”) (not including antenna)
- Weight: 210 grams (6.4 oz.) with batteries
- Antenna: 76 mm (3.0“) flexible
- Number of Input Channels:
  - 8 configurable channels (external sensors) plus:
  - 1 internal position sensor,
  - 1 pulse oximeter,
  - 1 airflow sensor,
  - 1 DC channel Input Range ± 750µV to ± 2V (configurable)
- Resolution 8, 12, 16 bits, configurable
- Sampling Rate 128 - 960 Samples per second per channel (configurable)
- Filter Input bandwidth 0.5 Hz - 250 Hz (-3dB attenuation); CMRR 100 dB
- Noise < 2 µV peak-to-peak (0.5 Hz – 100 Hz)
- Input Impedance > 20 MΩ @ 10 Hz
- Input Interface Standard no-touch 1.5 mm connectors
- Power Supply 2 AA alkaline batteries, Battery Life 12 hours continuous use



Wireless Frequencies

- Current System, 900 MHz., ISM Band
  - United States and all of North and South America
  - Australia and New Zealand
  - China, incl. Hong Kong and Taiwan
  - Indonesia, Malaysia, Philippines, Singapore, and Thailand
  - South Africa
- Coming in the Near Future, 2.4 GHz, ISM Band
  - Worldwide

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CleveLabs BME Course User Interface Software

- Interfaces to National Instrument's LabVIEW™
  - BioRadio LabVIEW driver.
  - Dynamically linked library to stream data from the computer serial port directly into LabVIEW
- LabVIEW programming language is a
  - Popular tool in BME education, research, and industry
  - Familiar environment for users to intuitively operate the course application software and also for designing their own laboratories
  - Virtual instruments (VI's) facilitate problem solving and decision making
  - Sub VI's were designed for starting, reading data, and stopping and to support student designed software.
- Separate driver libraries were also created in MATLAB®
- Data can be exported to ASCII format and printed

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CleveLabs BME topics

Selectable BME Laboratory Course Sessions

Engineering Basics
- BioRadio Introduction
- Data Acquisition Basics
- Digital Signal Processing
- Statistical Analysis
- Image Processing
- Post-Processing Toolbox

Basic Physiology
- Biopotential Basics
- Electrocardiography I
- Electroencephalography I
- Electromyography
- Electro-Oculography
- Respiration

Advanced Physiology
- Speech Recognition
- Polysomnography
- Electrocardiography II
- Electroencephalography II

Clinical Applications
- Biofeedback
- Gait Pattern Recognition
- Environmental Controls
- Heart Rate Detection
- Alertness Detection
- Motor Control
- Student Designed Lab

CleveLabs BME Labs Contain

- A wide range of laboratory topics
  - –The course can be approached in a sequential manner or
  - –Select and implement based on research focus
- Background and discussion text on each lab (incl. Anatomy)
- Clinical setup movies were integrated into each lab to illustrate electrode or sensor setup,
- Real-time displays of raw and processed signals in the time and frequency domains
- Signal processing toolbox
- Practical applications for each lab
- Examples of abnormal clinical phenomena
- User-friendly student database for saving and reporting results.

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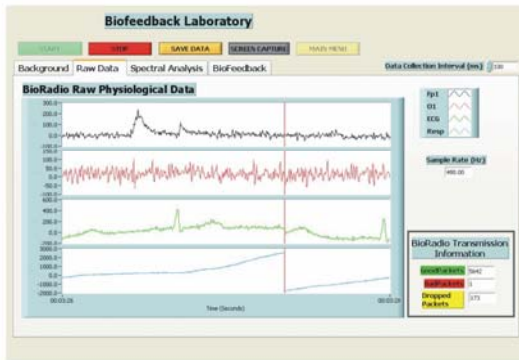
Hands on lab
Designed for 2 students to work together

- Students instrument each other
- Students view and process their own waveforms
- Wireless systems lets them evaluate affects of motion and exercise
- Untethered system allows students to move around the lab, interact with other students, ask questions of the instructor, and take breaks
- Software allows students to prepare for labs, process their data, and complete homework assignments outside of the lab



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Laboratory Course Materials

- Wireless BioRadio 150 physiological signal acquisition system
  - Student Worn Transceiver Unit
  - Computer Transceiver Unit
  - USB Cable
- Software, student and teacher laboratory editions
- Transducers
- Disposables,
  - Gold cup electrodes
  - Snap leads
  - Snap electrodes
  - Cotton swabs
  - Skin prep

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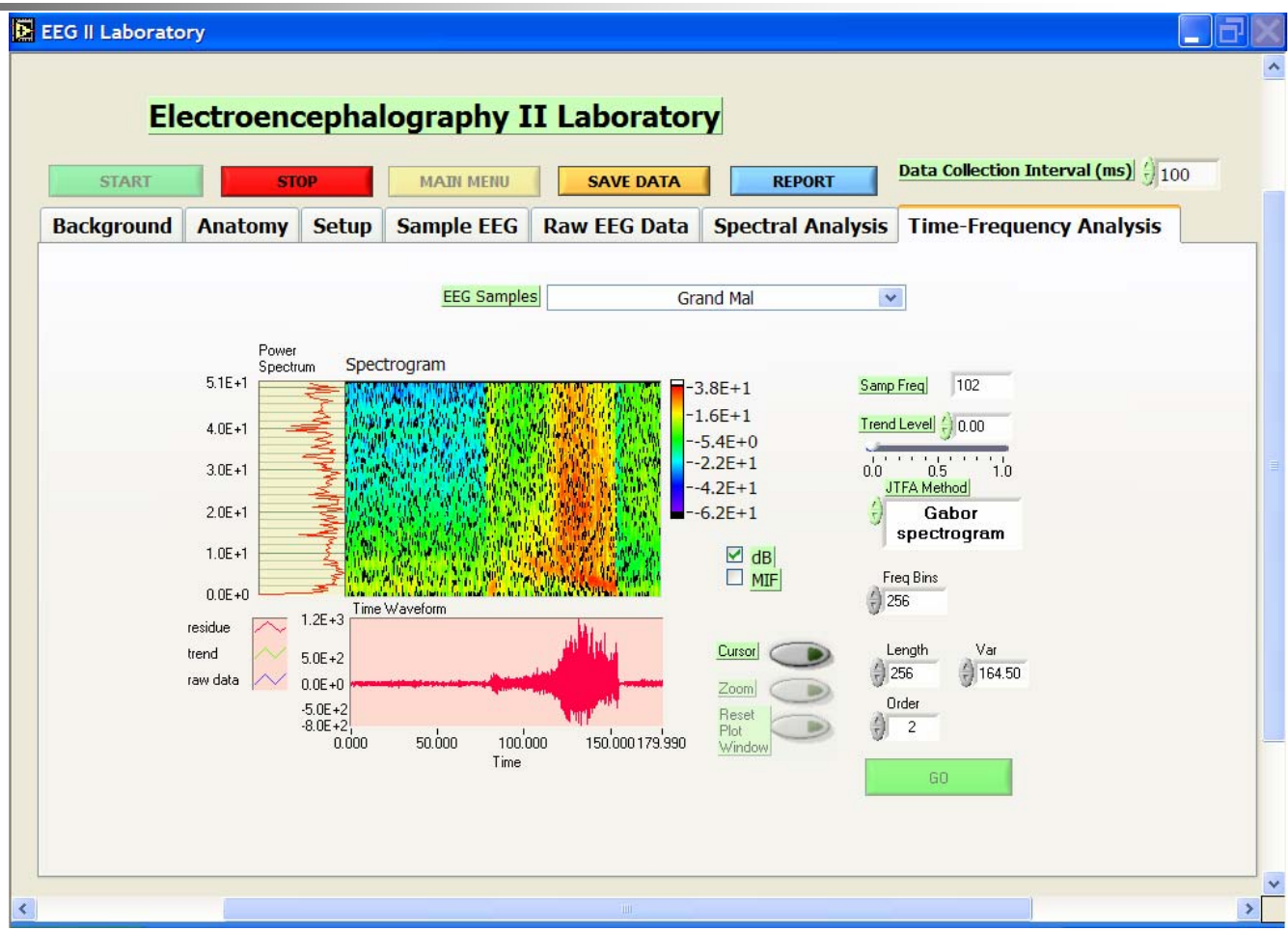
Electroencephalography II Lab

- Evaluate abnormal brain waves
- Joint Time-Frequency analysis shows how frequency content varies over time
- Explore Clinical Data Base and look for seizures



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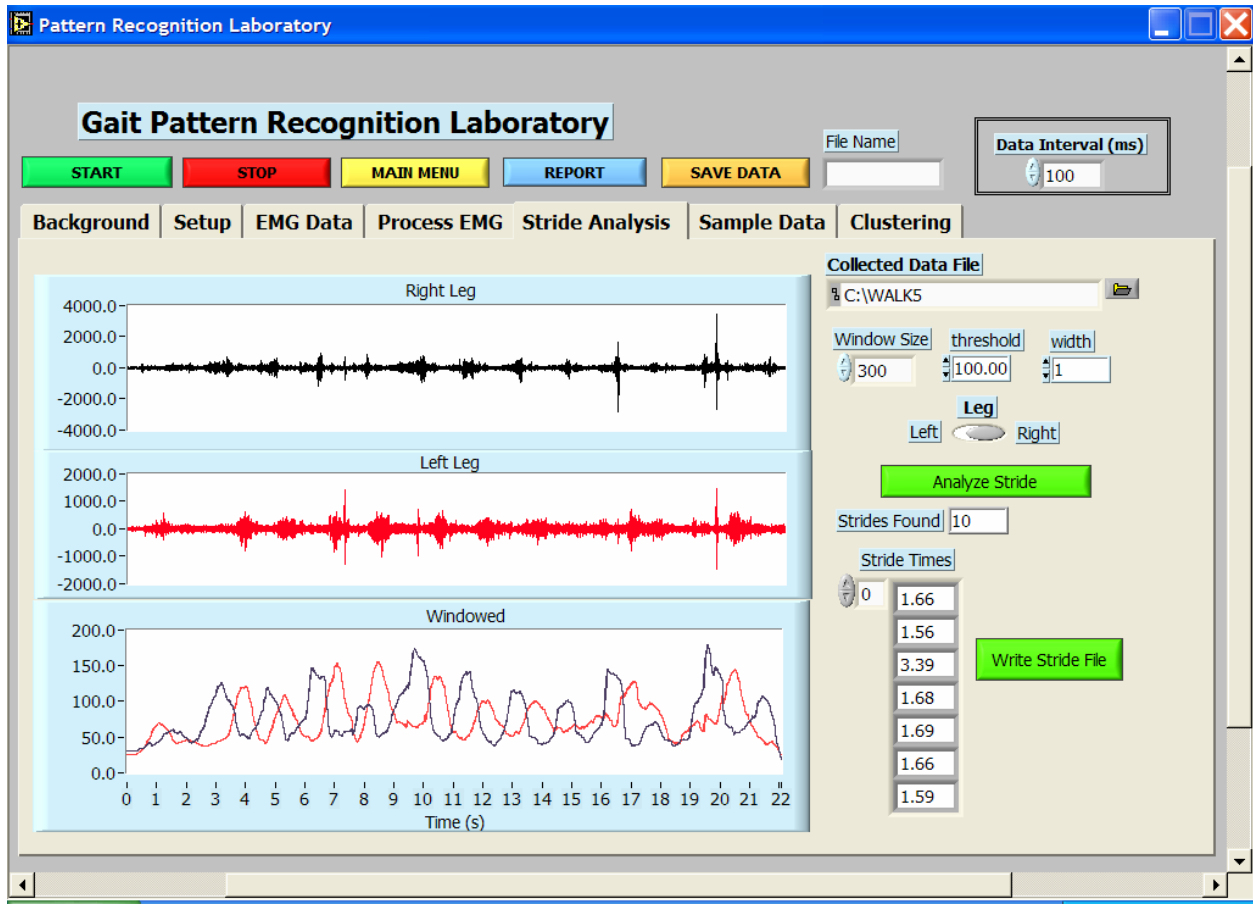
Gait Pattern Recognition Lab

- Record surface EMG from Leg Muscles
- Learn basics of gait cycle
- Calculate stride times
- Compare stride times with abnormal data such as Parkinson's, ALS, and Huntington's
- Learn how to use data for diagnosis



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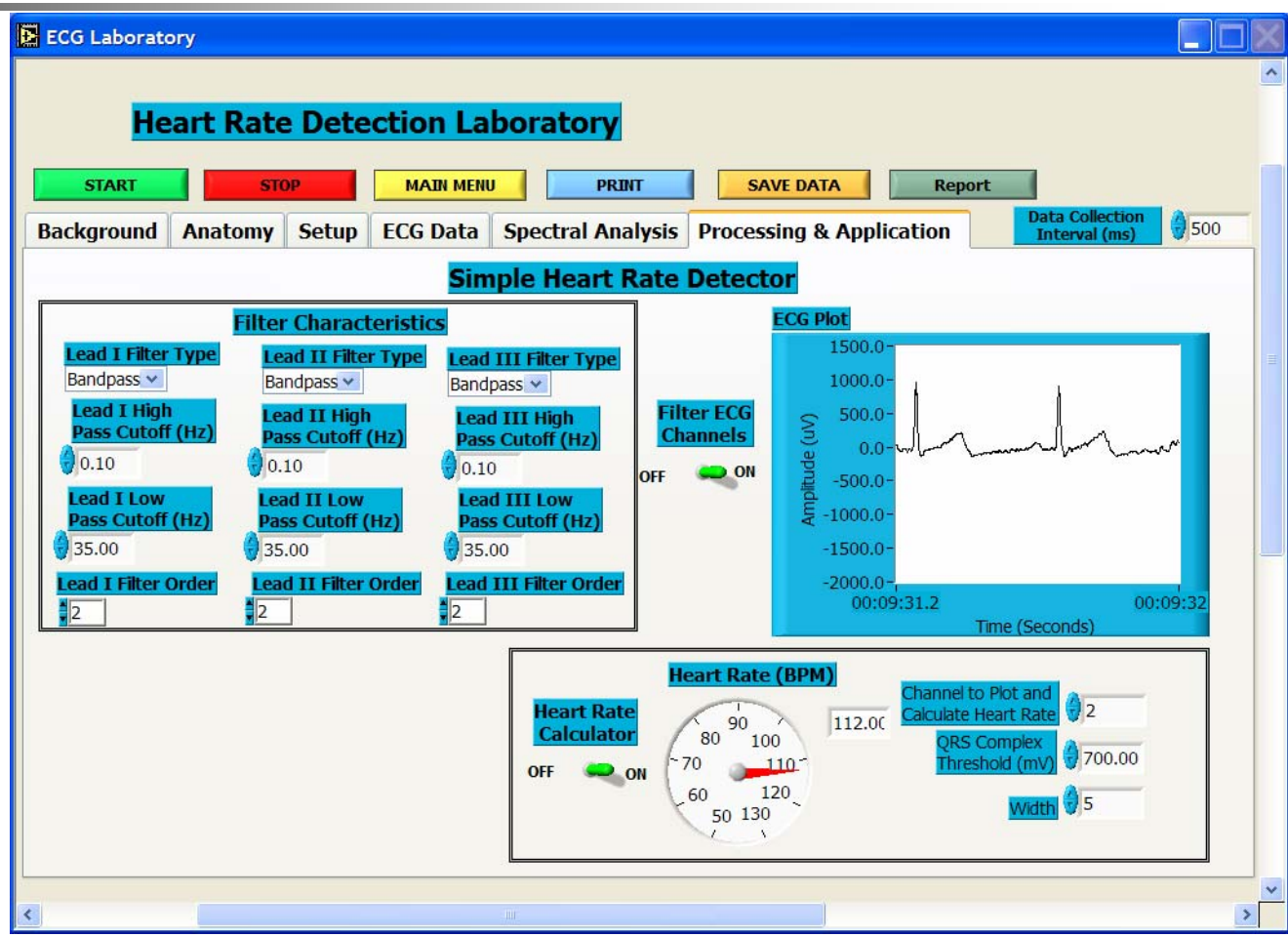
Heart Rate Detection Lab

- Students monitor their own ECG
- Develop a threshold detection for QRS complex
- Develop real-time heart rate detection algorithms
- Test algorithm to failure using arrhythmia data base
- Design more robust heart rate detector



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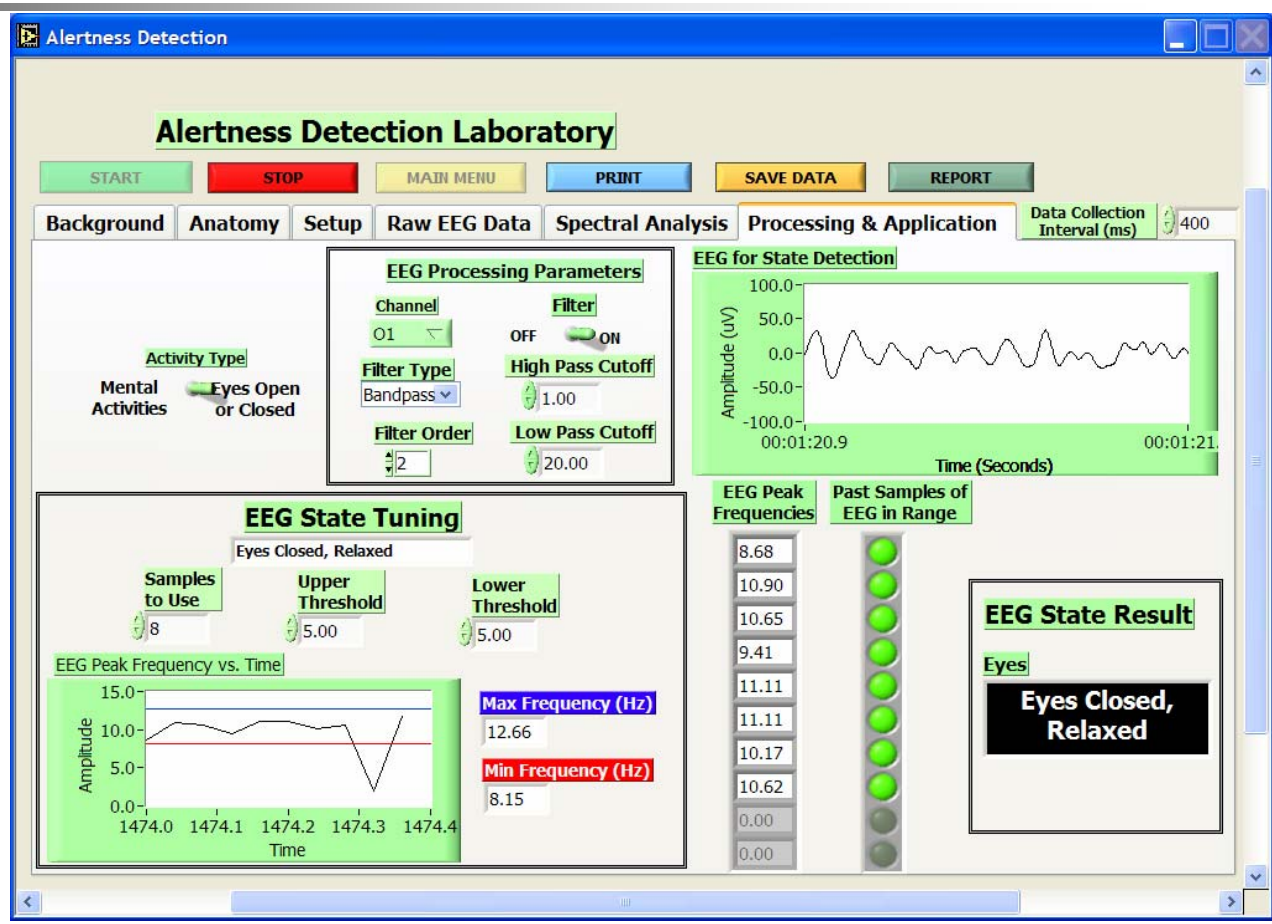
Alertness Detection Lab

- Students monitor their own EEG
- Evaluate alertness using EEG
- Detect state difference when eyes are open and closed, and when mental state is relaxed or active
- Evaluate technique and potential applications



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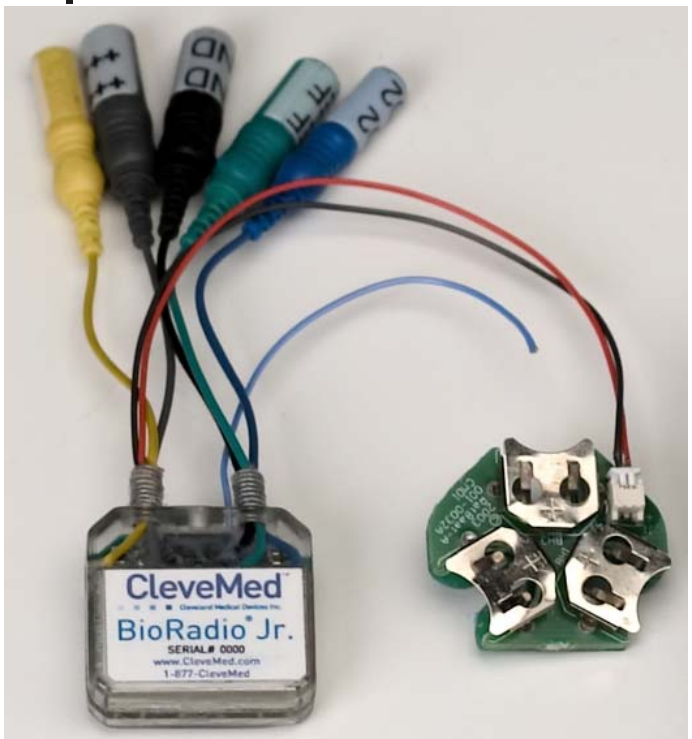
Smaller Hardware



BioRadio Jr.

- Non-Programmable (factory settings)
  - 2 channels
  - 960 sps
  - Up to 12 bits
- Input Selections
  - EEG +/- 1 mV, 0.1-70 Hz.
  - EKG +/- 5 mV, 0.1-150 Hz.
  - EMG +/- 50 mV, 0.1-500 Hz.
- Range, 50 ft.
- Low Noise , < 1 uV RMS
- Low weight, 191 grams (0.42 oz.)
- Battery options, 14 hrs to days

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