Non-Invasive Human Body Electrophysiological Measurements using Displacement Current Sensors

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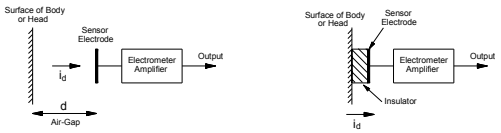
- Applications to Body Electrophysiology
- Examples of ECG, EEG and EOG
- High resolution ambulatory ECG

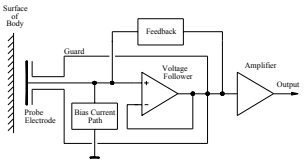
The Electric Potential Sensor



Remote Mode Contact Mode

(i_d = displacement current)

The Electric Potential Sensor



The Electric Potential Sensor

Features

- A 'perfect' voltmeter
- Measures spatial electric potential or field
- No electrical contact - no charge current
- Non-invasive and biocompatible
- Room temperature operation
- Scalable

The Electric Potential Sensor

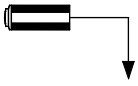
Applications

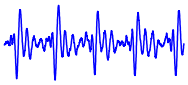
- Geographic surveying
- Materials and device testing
- Electric potential microscopy
- Security
- Electrophysiology – ECG, EEG, EOG…

Electrophysiological Applications

Remote (off-body) mode

Electric Potential Sensor

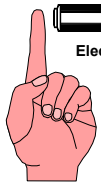




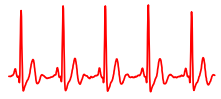
e.g. Remote Monitoring of Heartbeat

Electrophysiological Applications

Contact mode (electrically isolated)

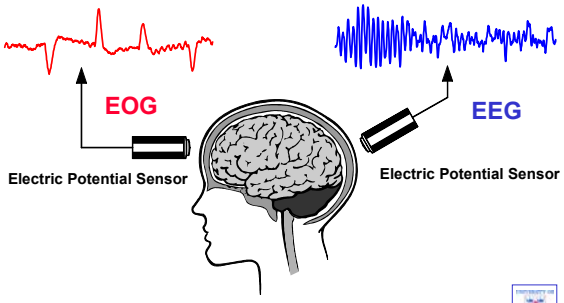


Electric Potential Sensor



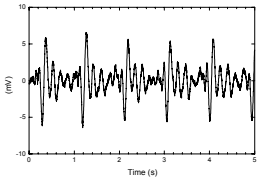
e.g. High Resolution I-lead ECG
from the fingertips

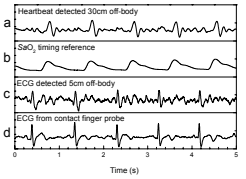
Electrophysiological Applications



Remote (off-body) mode

Monitoring heartbeat at distances up to 1m

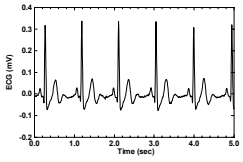




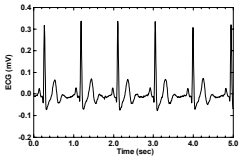
Heartbeat at 0.5m

Surface contact mode

High resolution ECG



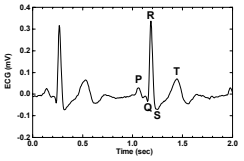
I-lead ECG from fingertips



V4-lead ECG from chest

Surface contact mode

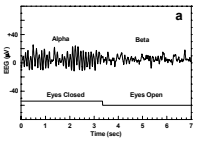
High resolution ECG



Surface His Identification

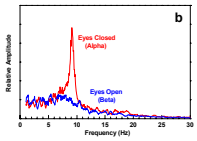
High resolution EEG

EEG through the hair with no scalp preparation



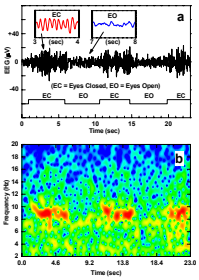
Time domain

EEG from occipital region of brain showing α-blocking



Frequency domain

High resolution EEG

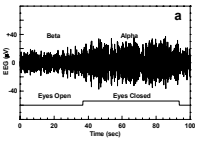


EEG from occipital region of brain showing α-blocking

Joint time-frequency spectrogram (red regions show α rhythm)

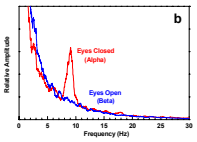
High resolution EEG

Remote mode (hair to sensor air gap)



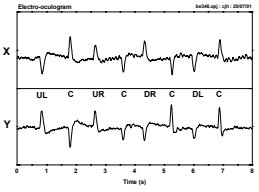
Time domain

EEG from occipital region of brain showing α-blocking



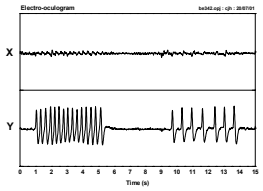
Frequency domain

Electro-oculography (EOG)



Eyeball movement

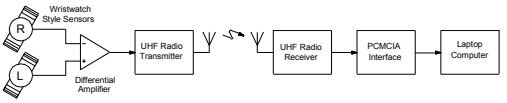
Electro-oculography (EOG)



Eyelid movement

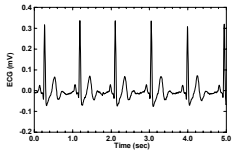
Ambulatory ECG

Wrist mounted sensors



Wireless ECG monitor

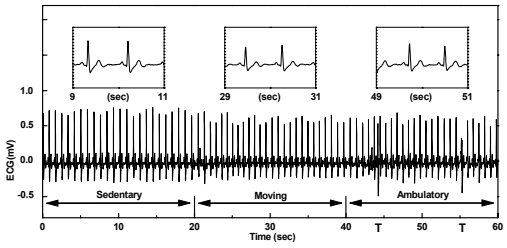
Ambulatory ECG



I-lead ECG

Ambulatory ECG

using wrist mounted sensors in wireless configuration



Summary

- a new sensor for human body electrophysiology
- non-invasive, electrically isolated, biocompatible
- remote and contact modes
- has been applied to ECG, EEG, EOG

Current and future work

- sensor miniaturisation
- new sensor array configurations
- investigation of 'new' signals
- commercialisation

References

1) *Electric potential probes - new directions in the remote sensing of the human body*.
C. J. Harland, T. D. Clark and R. J. Prance. Meas. Sci. Technol. 13 (2002) 163.

2) *Remote detection of human electroencephalograms using ultrahigh input impedance electric potential sensors.*
C. J. Harland, T. D. Clark and R. J. Prance. Applied Physics Letters 81 (2002) 3284.

3) *High resolution ambulatory electrocardiographic monitoring using wrist mounted electric potential sensors.*
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