Biologists' Voltmeter

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Abstract

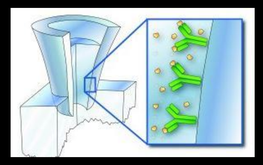
Targeting early cancer and pathogen detection, the Bio-Nano-Tech Laboratory invented a biosensor the STING biosensor.

The Biologists' Voltmeter is intended to be an inexpensive handheld portable package, consisting of the STING biosensors and the amplifier units that communicates with an iPhone application for transmitting and displaying the data.

This biosensor technology can be utilized to detect proteins, DNA, and water and blood contamination, making it an ultimate handheld device for researchers, scientists, and medical care providers.

STING Biosensor

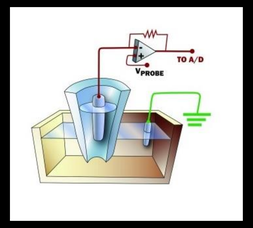
Signal **T**ransduction by **I**on **N**ano **G**ating (**STING**) is a developed sensing technology using a functionalized quartz nanopore at the tip of a nanopipette. One of the key features of this technology is that STING sensors can be easily, inexpensively and reproducibly tailored at the bench by laser-pulling a quartz capillary into a nanopipette. [1]



STING technology relies on a simple electrochemical readout that transduces, in a label-free manner, binding events at the tip of a functionalized nanopipette. Antibodies, DNA and aptamers have been used as recognition elements demonstrating the versatility of this platform for biorecognition. [1]

The high impedance of the nanopipette tip confines the sensitivity of the device, making the dimension and geometry of the tip orifice crucial for the sensor performance. STING technology can be easily integrated with piezoactuators to generate a sensor with high spatial resolution. [1]

An amplifier unit conditions the signal by amplifying it and allowing scientists to apply different types of waveforms. The output signal is digitized and ported to a computer so the gain response can be investigated by the biologists.

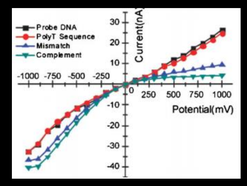


Amplifier Unit

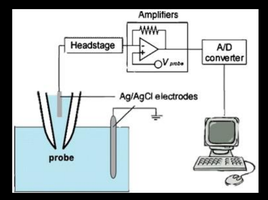
An input voltage is needed for sensing and detection. Symmetric waveforms, such as sine waves or linear sweeps, are useful for investigating the binding of charged molecules (such as DNA) and binding kinetics can be monitored by following the variation of the rectification coefficient over time. [2]

A constant voltage is used for discriminating binding events of neutral or slightly charged molecules. [2]

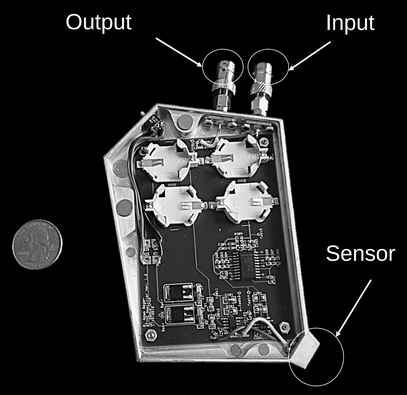
The current prototype version of the Biologists' Voltmeter communicates via coaxial cables with a computer, plotting the output signal in LabVIEW.



Linear voltage sweep changes the resistance sensed by the probe [2]



Prototype Version (Coax communication) [2]



Amplifier unit

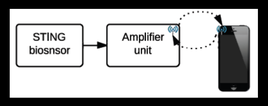
Since the corded connection of the amplifier unit hindered the mobility nature of the biosensor unit, the transmission medium was changed to a wireless device.

The underdevelopment version of the amplifier unit uses a *WiFly RN-171 802.11b/g Serial Module*, depicted below, for Wi-Fi communication.

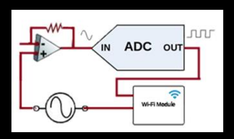
Wi-Fi Module

The amplifier unit depicted above, contains a signal amplifier, a signal generator, and an analog to digital convertor.

The picture on the right demonstrates the schematic block diagram of the current version of the amplifier which replaces the coaxial cable communication with Wi-Fi.



System block diagram



Amplifier unit block diagram

iPhone App

Users can connect to the amplifier unit using an ad-hoc network that they establish with their iPhone to transmit the type and frequency of the waveform they want and receive the amplified response. The iPhone app draws an amplitude versus time scatter graph to represent the data. The transmission is done by TCP-IP to insure data integrity.

Establishing connection

The graphs are made using core-plot, a cocoa plotting platform for iOS devices. The plot shows the input and output waveforms, representing the amplitude voltage behavior in real-time.

The iPhone app is optimized for iOS 7 and is backward compatible with the previous versions of iOS. The code has been written with iPad compatibility in mind.

Future Plans

- The amplifier module can be miniaturized and planted in a body so it can sample blood and analyze diagnosis data.
- The sensor can be mounted on robotic systems, sampling water containers and transmitting it to the user, using Wi-Fi Direct.
- The vision of this project is for every household to have a biologist' Voltmeter for routine medical check-ups and diagnosis. By processing the output signal, the computer will display the result of the diagnosis to the users, notifying them whether they are diagnosed with a disease or not.
- Adding Android compatibility.

References

[1]. Actis,Paolo. Rogersa, Adam, et al. Reversible thrombin detection by aptamer functionalized STING sensors. Biosensors and Bioelectronics. Vol 26. Issue 11. P4503

[2]. Actis, Paolo. Mak, Andy. Pourmand, Nader. Functionalized nanopipettes: toward label-free, single cell biosensors. Analytical and Bioanalytical Chemistry (rev) 2010. P 180-181.