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Device for measuring the plant electrophysiology

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The system for measuring the electrophysiology of phyto-objects is based on CYBRES EIS spectrometer and intended for analysis and monitoring electric responses of plants to external stimuli. The system measures biopotentials, tissue conductivity at different frequencies and allow investigating the effects of frequency shift in tissue response. In addition to measurements, the device can also perform an electrical or light stimulation of plants. All modules have two channels, which enable two-channel or differential measurement. Real-time data (with time stamps) can be recorded into the internal flash memory, transmitted to a computer, or written as html-pages for the online data plot in internet. To improve the accuracy of measurements, the system is thermally stabilized at the PCB level. The needle- or surface- electrodes are used to receive signals from plants. The RGB LED is provided for displaying working modes of the device or for the blue/red light stimulation. The system is fully autonomous and can operate without user intervention.

In addition to electrophysiological sensors, the system is equipped with 3D accelerometer/magnetometer, real time clock, EM power meter (optional), temperature/humidity/pressure/light/CO_2 (optional) and voltage sensors for monitoring environmental conditions during long-term experiments. USB interface is used for data transmission and for powering the device. Digital lines are galvanically isolated. This electrophysiological module is a part of phyto-monitoring and phyto-sensing system with various sensors that measure the plant physiology (such as sap/water flow, leaves transpiration or level of photosynthesis) and various environmental parameters[1].

Resolution of biopotentials (input current)	±64nV (±70pA)
The potential for electrical stimulation and measurement of tissue conductivity	±10mV – ±1B
The frequencies of electrical stimulation and measurement of tissue conductivity	8Hz – 0.3MHz (max. 0.65MHz)
Intervals between measurements	0.1sec – 100 seconds
Internal flash memory	512MB
Analysis of the frequency shift	FFT, FRA
Power supply	USB, 5V

[1]see www.youtube.com/watch?v=_xfKOYOpNU4.

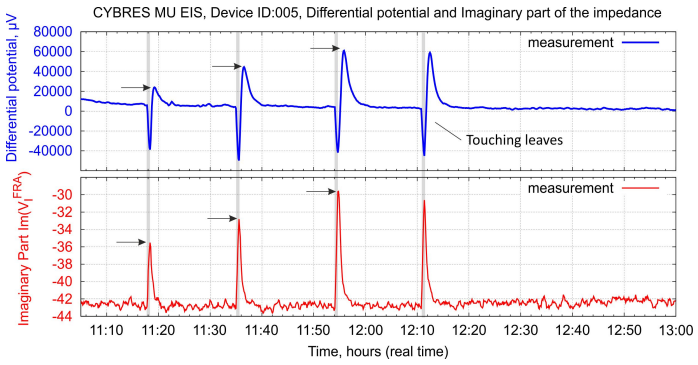

Рис. 1. Example of electrophysiological responses of a plant on touch: (above) electric potential; (below) the imaginary part of tissue impedance at the frequency of 500 Hz.

Applications. This system is designed for professional and amateur purposes, as a tool for biological laboratories, and for plant enthusiasts. In the professional use this system can be employed to study the electrical reaction of plants, as phyto- or bio-sensors, in the bio-hybrid and robotic systems, for biotechnological processes based on phyto-objects. The embedded algorithms support methods developed by S.N.Maslobrod with biopotentials and by V.A.Sokolova with the tissue conductivity, as well as the methodology from the *PLEASED* (PLants Employed As Sensing Devices) and *Flora Robotica* projects. Additional algorithms for data analysis can be easily implemented with the provided script language. In amateur applications the system has a variety of potential usages, for example, in school or university courses on biology, for studying 'the electrical language of plants', or to carry out experiments in the context of Cleve Backster and Peter Tompkins works with the 'Secret life of plants'.