Quadra Impedance Spectroscopy

Quadra provides real-time impedance spectroscopy in a compact form, well suited for embedding or autonomous field applications.

Impedance spectroscopy is a widely recognized method for examining the properties of different materials and objects in engineering and biomedicine. In most applications, the impedance data is used for mapping and correlation with a phenomenon of interest. The measurement is relative by nature, focusing on a change or comparison with a baseline, rather than determining the value of impedance on an absolute scale.

Quadra has been designed to perform impedance spectroscopy in real time – the novel technology (Figure 1) allows it to acquire a spectrogram of 15 frequencies during a short time frame of 1ms. Therefore, it is best suited for applications where the measurement time is limited or the phenomenon of interest is changing rapidly. High repeatability of the measurement and sufficient number of frequency points on the spectrogram facilitate accurate characterization of objects or systems under investigation.

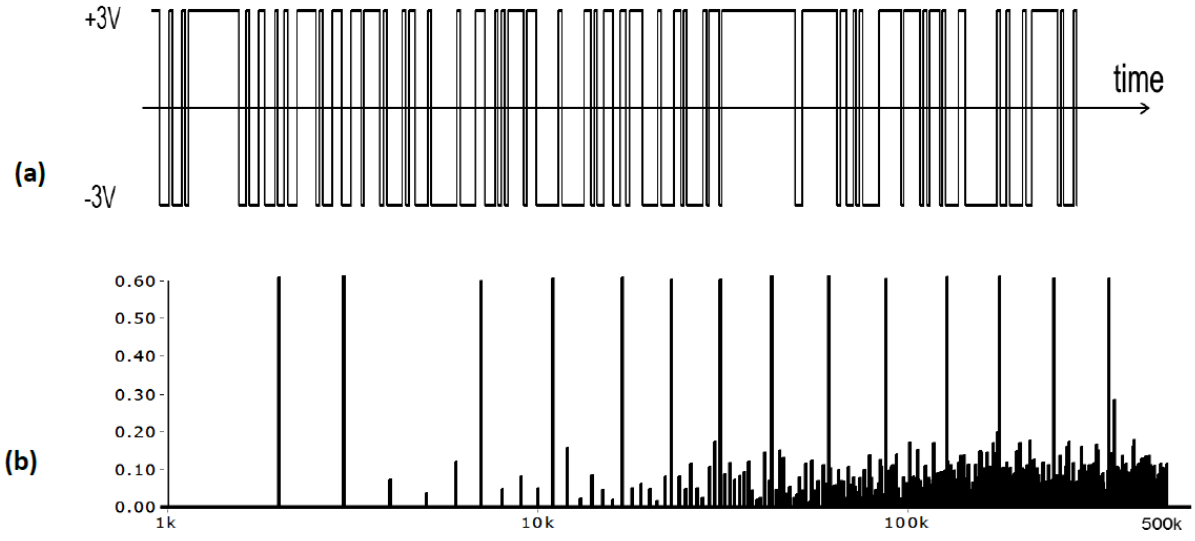

Figure 1 Example of a spectrally sparse multi-frequency binary waveform (a) with known spectral content (b), which is used as excitation signal.

Elements of the QUADRA platform

Quadra impedance spectroscopy platform consists of an application-specific front-end and the DSP (Digital Signal Processing) module, which streams measured data to the host system for further processing. The platform can be implemented as modules – in separate enclosure(s) or integrated into host system enclosure. The front-end and DSP circuits can also be embedded in a custom PCB design.

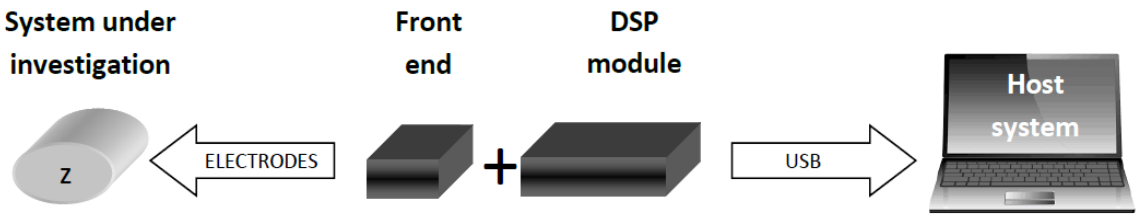

Figure 2 Quadra platform implementation with stand-alone modules and host PC.

Application specific front end

Each application requires specific electrode arrangement for excitation and response measurement. The front end connects to the electrodes and provides signal conditioning for DSP module. In stand-alone applications, standardised D-sub connector on the DSP module allows to prepare different setups and quickly switch from one measurement to another.

All applicable combinations of voltage and current for excitation/monitoring in 2- or 4-wire configuration can be implemented by appropriate front end design. Customised designs are available on request.

DSP module

The DSP provides generation of binary waveform and real-time calculation of impedance or admittance. Different sets of 15 frequencies can be selected. The highest set, 1 kHz…349 kHz, enables 1 ms acquisition time and covers a wide range of applications from tissue and material structure mapping to detection of cells and coatings. The lowest set extends down to frequencies used for e.g. electrochemical applications (0.5 Hz...195 Hz).

Real-time calculation includes preprocessing of the streamed data: compensation of distortions induced by the electrode interface, noise and interference reduction - enhancements facilitated by the DSP.

The DSP module can be powered by an internal battery, e.g. in biomedical applications where a mains power supply cannot be used due to safety reasons. The battery in the stand-alone enclosure can be charged via USB, which also serves as the standard communication interface.

Data processing in the host system

Data processing includes visualisation, extracting useful information, modelling, classification. Quadra can be controlled directly from the data acquisition and analysis software such as LabView or MatLab. Control and data processing support is available as optional services.

Quadra standard evaluation kit

- Battery-powered DSP module in an enclosure (USB connection to the host PC).
- Front end with voltage excitation and 1 kΩ current measurement shunt.
- Screw terminal breakout box for experimenting and provisional front-end set-up.
- Windows utility (GUI) for rapid setup with data recording and LabView program code.

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Technical Parameters of the DSP Module

Parameter	Value
Impedance	Relative value of impedance (Module in Ohms and phase in degrees)
Measurement repeatability	0.1 %
Spectrogram Acquisition Period	1 ms
Number of Frequencies in Spectrogram	15
Spectrogram Frequency range	1 kHz … 349 kHz (highest set of frequencies), sets of lower frequencies down to 0.5 Hz … 195 Hz range available
Excitation waveform	spectrally sparse signal, contains set of 15 predetermined frequency components
Excitation channel	1 differential output (50 Ω), bipolar output voltage range 0.4 Vpp … 7.5 Vpp (selectable in 255 steps, DC offset 0 V)
Measurement channel	2 differential channels (input resistance >10 MΩ), bipolar input voltage range 3Vpp at preamplifier gain 1x (selectable gain values 1x, 2x, 4x, 8x)
Host interface	12 Mbps, Full Speed, USB 1.0, USB 2.0, USB 3.0, (PC computer with Microsoft Windows 7 and above)
Power	USB bus: 500 mA (2.5 VA), or internal battery (8h autonomous operation)
Module dimensions	110 x 60 x 20 mm
Space required for DSP embedding	less than 30 x 30 mm of PCB area

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