

Specifications: Impedance Analyzer System

1) The Impedance Analyzer System shall consist of the following either integrated or in modular form:

- a. A base Impedance Analyzer
- b. An interface to support 2 and 4 probe dielectric/impedance measurements.
- c. An Interface to support high current electrochemical measurements
- d. An interface to support high voltage measurements.
- e. A sample cell to support the high voltage measurements
- f. A shield for the high voltage measurement sample cell
- g. Computer to control the equipment via IEEE, Ethernet, USB or other instrument bus capable of supporting the Analyzer and associated equipment.
- h. Computer-Instrument Interface
- i. Software to control the Impedance and Electrochemical measurements as well as associated temperature control hardware.

2) The impedance Analyzer System for investigating the properties of highly insulating and more conductive polymers and polymer-composites as a function of frequency, temperature, dc-bias, AC signal amplitude, time, shall have the following attributes and capabilities:

- a. The base Impedance Analyzer in the system shall be able to measure impedances in the range 0.001 to $10^{15} \Omega$ (18 orders or magnitude).
- b. The Impedance Analyzer shall be able support measurements in the frequency range 3 μHz up to at least 20 MHz.
- c. The Impedance Analyzer shall be able to support capacitance measurements in that cover the range 1 fF up to 1 F.
- d. The Impedance Analyzer shall have a phase resolution of less than 0.001° ($\tan \delta \sim 10^{-5}$) to enable measurements on low loss materials.
- e. The Impedance Analyzer system shall support 2 and 4 wire measurements with standard (manufacturer specified and furnished) and custom (user designed and built) sample cells.
- f. The measurements allowed by the system are to included dielectric sample and well as interdigitating electrodes based measurements.
- g. The Impedance Analyzer in the system and relevant control software shall be able to carry out harmonics analysis for non-linear dielectric spectroscopy.
- h. The Impedance Analyzer in the system shall be able to offer an unlimited number of frequency points per sweep, within the range specified.
- i. The Impedance Analyzer shall be able to apply a DC Bias of up to 40 V and at least 50 mA.
- j. The Impedance Analyzer System shall be able to make measurements at high AC and DC voltages ($|V| \geq 500 \text{ V}$) and frequency range 10 μHz up to at least 10 kHz.

This capability includes a relevant measurement module, sample cell and shield from electromagnetic interference.

- k. The high voltage unit shall be able to support impedance measurements in the range that includes 100Ω up to $10^{15} \Omega$.
 - l. The impedance analyzer system, and associated software shall be compatible with existing temperature control hardware (or provide matching capability at no additional cost). The currently installed temperature control system (valued at \$80K) consists of the following:
 - i. NOVOCOOL Temperature Unit (-100 to 250 °C) which includes controller, cryostat, LN2 dewar, evaporator and gas heater (Novocontrol Technologies)
 - ii. NOVOTRONIC Temperature Unit (20 C to 400 °C) controller and air stream heater (Novocontrol Technologies)
 - iii. 2 x BDS 1200 Sample cells for 2 and 4 probe measurements (Novocontrol Technologies)
 - iv. PC-Controlled through WinDETA software (Novocontrol Technologies)
 - m. The impedance analyzer system shall be able to support electrochemical and impedance measurements with currents of up to 2 A (and up to 20 V or more).
 - n. The impedance analyzer system shall include software for analyzing electrochemical responses.
 - o. All the measurements, including temperature control shall be computer controlled from a single interface enabling automated measurements to be made with the variables temperature, frequency, AC signal amplitude, DC Bias, Time (for repeat tests) all automatically controlled and run without user intervention.
- 3) The Impedance Analyzer system shall be backed by:
- a. A user manual
 - b. Installation/Installation instructions
 - c. Any necessary user training or training materials