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**Technical Specifications for Ferroelectric Characterization Unit**

**Detailed specification of the equipment:**

- 1) The output of the test system must be an arbitrary waveform generator in order to produce any waveform for hysteresis, pulse, leakage, and CV tests *without a hardware configuration change*. **i.e. all measurements should be carried out without changing the electrodes or sample orientation.**
- 2) **For best resolution and flat frequency response, the charge measurement input should operate as an electrometer over the entire test frequency from 2 MHz to 1/30th Hz.**
- 3) The voltage ramp rate of the output must be controlled such that the current capacity of the measurement input is not exceeded during a test.
- 4) The test frequency must extend from a test period of 30 seconds for accurate measurement of large area bulk ceramic capacitors down to 30 seconds in Hysteresis for characterizing small-scale but leaky thin-film multi-ferroic capacitors.
- 5) Pulse measurements should be as narrow as 0.5 $\mu$ s
- 6) The minimum required leakage resolution is 1pA with evidences on company website about the accuracy.

- 7) For accuracy on small area capacitors, the parasitic input capacitance must be less than 10 femtofarads/volt.
- 8) The software operating the tester must be programmable and capable of executing all measurement types in an arbitrary order *without configuration change*.
- 9) Captured data must be automatically stored and easily transferred to other testers using network protocols.
- 10) The tester software must be adaptable to future changes in the host computer operating system.**
- 11) The tester must be capable of capturing external sensor data synchronously with polarization measurements.
- 12) In particular, the tester must be compatible with non-contact optical displacement sensors and have dedicated software for capturing, correcting, and presenting displacement information.
- 13) Computer and Ferroelectric Test System should be separate and connected through USB Cable, so that in future any advanced new computer can be utilized with Ferroelectric Test System.**
- 14) System should not work with any dedicated sample holder. Any kind of sample should be connected with appropriate wirings and measured & can be connected to any available cryogenic chamber or any available furnace.**

## **BASIC FERROELECTRIC TEST SYSTEM**

### **Detailed specifications are listed below:-**

- 1) Output Range:  **$\pm 100\text{V}$**  using built-in amplifiers (No external Amplifiers allowed for better resolution)
  - 1.1) 16-bit Arbitrary Waveform Generator output
  - 1.2) 32,000 points from 16 milliseconds to 30 seconds**
  - 1.3) Pulse Widths down to  $0.5\mu\text{s}$  and up to 1s
  - 1.4) Controlled output ramp for maximum accuracy
  - 1.5) Minimum Leakage Current = 1pA**
  - 1.6) Minimum Charge Measurement Using Electrometer = 0.8fC**
- 2) Polarization Measurement
  - 2.1) **18 bit analog to digital converters –  $76\mu\text{V}$  sensitivity on 10 pF Csense**
  - 2.2)  $0.5\mu\text{s}$  capture rate with 100ns interlace facility
  - 2.3) Polarization, output voltage, and SENSOR inputs captured simultaneously with no more than 10ns skew between channels.
  - 2.4) Minimum charge sensitivity – **0.8fC**
  - 2.5) Maximum PUND/Hysteresis Frequency – **2MHz**
  - 2.6) Minimum area resolution - **0.080u2**

- 2.7) Maximum charge resolution - **5.26mC**
- 2.8) Maximum area resolution >- **52.6 cm<sup>2</sup>**
- 2.9) Maximum hysteresis loop frequency - **250 KHz @ +/-10V Built-in**
- 2.10) Minimum hysteresis loop frequency - **0.0333 Hz (30 second period)**
- 2.11) Hysteresis Waveforms - **Mono/Arb/Sine/Tri/Double bipolar/10% Pulse/Monopolar sine/Zero/inverse cosine/Custom/Continuous Sine.**
- 2.12) Input Capacitance- **6Ff**
- 2.13) Electrometer Input at all test frequencies.**

**3) System is independent from Computer, so that in the future any available advance computer can be interface with System.**

4) 4 communication methods with accessories, USB, GPIB, RS232, or I2C.

5) 2 external 18-bit,  $\pm 10V$  high-impedance voltage inputs for interfacing with external displacement, temperature, current, or magnetic sensors.

6) Executes hysteresis, remanent hysteresis, small signal CV, IV, fatigue, imprint, PUND, retention, pyroelectric, static and dynamic magneto-electric, and piezoelectric displacement from one hardware configuration. **Without changing the probes or electrodes connected to the sample.**

7) Software should allow user to create any custom test profile, execute that profile, store the results in a permanent but unalterable database assigned to the experiment, and recall that data at any time in the future to plot or export it as commanded by the user.

8) Must correct displacement measurements for test fixture drift and offset.

**9) Compatible with Quantum Design PPMS, Dynacool and Lakeshore cryogenic chambers.**

**10) Test System should be independent from dedicated Test Fixture (Sample Holder) and has facilities to connect any available sample holders for thin film / bulk ceramic samples. This makes hooking up external equipment to the test system simple to use.**