Precision Non-Linear Materials Testers

Since its inception in 1988, Radiant Technologies, Inc. has been dedicated to innovating characterization equipment for non-volatile memory technologies, non-linear electromechanical materials, MEMS, and actuators/sensors. Radiant pioneered and developed the first ferroelectric test system which quickly became the world-wide industry standard for characterizing non-linear materials. Precision and accuracy have been the driving force behind the engineering of our test equipment and thin ferroelectric film components.

New Precision PiezoMEMS Analyzer

Radiant Technologies' Precision PiezoMEMS Analyzer integrates digital, analog, and communications circuit functions with the existing non-linear materials measurement capabilities of the Precision Multiferroic Non-linear Materials Tester, all supervised by Radiant's Vision programmable test environment. The PiezoMEMS Analyzer not only measures piezoelectric properties of actuator and sensor elements of a commercial product, it will communicate with the product's electronic logic, talk to embedded microprocessors, supply asynchronous voltages and pulses, and measure sensor frequencies. The PiezoMEMS Analyzer combines the following capabilities:

The Precision PiezoMEMS Analyzer is driven by Vision Software. Vision has four interconnected units:

- **A Library** of 155 measurement, analysis, plotting, program control, and documentation tasks.

- Radiant Testers are **ten times cheaper to operate** for simple measurements than are testers operated manually or with scripts.

- **Radiant's PiezoMEMS Analyzer** running under the Vision Materials RDP Operating System reduces Cost of Test by a factor greater than 10 over any other ferroelectric tester.

- **An Editor** to arrange multiple tasks together from the Library into a Test Definition.

- **An Execution Engine** to read and execute the Test Definition.

- **An amorphous database engine** to Archive everything that happens in every Test Definition.

New Precision PiezoMEMS Analyzer

Applications:

All hardware functions of the PiezoMEMS Analyzer are available as independent tasks in Vision's Library. By constructing complex test definitions using combination of tasks in the library, an engineer can

1. Independently test specialized non-linear components using non-linear materials.

2. Design build, and communicate with digital, analog, and microprocessor circuits surrounding the non- linear component.

3. Portals in the circuit to allow direct electrical, piezoelectric, pyroelectric, or magnetoelectric analysis of the non-linear component while it remains embedded in the circuitry. This single capability is the absolute necessity to understand and predict the reliability of the embedded component and its surrounding circuit.

4. Characterize the performance of the combined circuit/non-linear component system.

5. Control the thermal, atmospheric, magnetic environment around the system from within a test definition using ovens, cryogenic chambers, vibrating sample magnetometers, or magnetic coils.

6. Qualify the short-term performance limits and long- term reliability of the sample under test.

Radiant offers a wide range of Precision Test Systems (PiezoMEMS Analyzer, Multiferroic II, Premier II, LCII and RT66C) for material research, development, and device qualification. Vision Data Management Software drives Radiant's test systems. Vision Software allows researchers the simplicity, power, and flexibility to take experiments to the next level. Vision dramatically reduces previously time intensive processes by offering automatic data acquisition, storage, plotting and data export. Complete accessory packages for High Voltage Testing to 10kV, Thermal Testing, Piezoelectric, Magnetoelectric, Transistor, and Reliability Testing are provided for each Precision Test System.

Precision PiezoMEMS Analyzer

All existing Precision Multiferroic II Hardware and Software functions with the addition of the following features:

» Impedance measurement with built-in LCR.
» Asynchronous pulse generator with programmable delay triggered by the tester's already existing SYNC pulse.
» Independent DC Bias voltage source.
» Asynchronous 16-bit voltage measurement.
» Frequency counter up to 60 MHz

» Parallel Digital I/O port to control pMEMS circuitry while providing power/ground connections from the tester power supply.
» I^{2}C Communications Port also supplying remote power.
» Temperature chamber with internal user prototyping space and connections to pMEMS tester signals.
» ±100V or 200V Built-in Internal Amplifier

Precision Multiferroic II

The Precision Multiferroic II Test System is one of Radiant's most advanced systems. The Multiferroic II unique frequency rating is 270KHz@+/-100V, 100KHz. 5KHz@500V using the built-in internal amplifier. The Multiferroic is ideal for magnetoelectric testing.

Multiferroic II specifications include:

» 18 ADC Bits
» 16-bit Arbitrary Waveform Generator output
» ±10V output (100V, 200V and 500V built-in drive voltage options) expandable to 10kV
» Minimum Hysteresis Frequency 0.03Hz
» Maximum Hysteresis Frequency 270KHz at 9.9V to ±100V
» Maximum Small Signal Cap Frequency 1MHz
» Maximum Pulse Width 1s/Minimum Pulse Width 0.5µs
» 2 external 18-bit, ±10V SENSOR voltage inputs

Precision LCII

The Precision LCII is an ideal general-purpose tester for Universities and Research Laboratories.

LCII specifications include:

» 18 ADC Bits - 16-bit Arbitrary Waveform Generator output ±10V output (100V, 200V and 500V built in drive voltage options)
» Expandable to 10kV
» Minimum Hysteresis Frequency 0.03Hz
» Maximum Hysteresis Frequency 5KHz at 9.9V to ±200V
» Maximum Small Signal Cap Frequency 20KHz
» Maximum Pulse Width 1s/Minimum Pulse Width 50µs
» 2 external 18-bit, ±10V SENSOR voltage inputs

Precision Premier II

The Precision Premier II is an advanced tester that has a large test envelope in terms of frequency response, voltage range and accuracy.

Premier II specifications include:

» 18 ADC Bits
» 16-bit Arbitrary Waveform Generator output ±10V output (100V, 200V and 500V built-in drive voltage options) expandable to 10kV
» Minimum Hysteresis Frequency 0.03Hz
» Maximum Hysteresis Frequency 250KHz at 9.9V
» Maximum Small Signal Cap Frequency 1MHz
» Maximum Pulse Width 1s/Minimum Pulse Width 0.5µs
» 2 external 18-bit, ±10V SENSOR voltage inputs

Precision RT66C

Radiant's RT66C test is perfect for the researcher looking for a flexible unit at an affordable price.

Precision RT66C specifications include:

» 14 ADC Bits
» 12-bit Arbitrary Waveform Generator output
» +/-200V output (expandable to 10kV)
» Minimum Hysteresis Frequency 1/8thHz
» Maximum Hysteresis Frequency 1Hz
» Maximum Small Signal Cap Frequency 2KHz
» Maximum Pulse Width 100ms/Minimum Pulse Width 500µs
» 1 external ±10V SENSOR voltage inputs, 12C COMM channel

Vision Data Acquisition Software
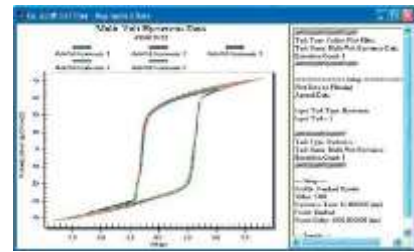
The Power of Vision Test Definitions and Datasets

Radiant's Precision Line of Test Systems are driven by Vision Software. Vision Software is a framework that loads a variable series of independent agents known as Tasks. Tasks are configurable objects that perform the procedures of an experiment and collect and analyze any measured data. Such an experiment is called a Test Definition.

The true power of Vision is in grouping Tasks together in Test Definitions to form custom experiments (Datasets), so the user is not tied to running one specific task at a time. The Test Definition may consist of any number of Measurement Tasks. Researchers can create a dataset to hold any number of arbitrary Test Definitions that are executed from inside the dataset to save and document the data forever. Vision's "Innovative Test Editor" let's researchers create and document complex Test Definitions using computer icons to represent Tasks.

Vision offers 115 Tasks in Total. Vision is the only software package available for ferroelectric testers that provides exceptional freedom to design, conduct and review all procedures associated with any material experiment. Vision dramatically increases the productivity of the researcher, reducing the time required to acquire data in an experiment. Vision's enhanced productivity directly reduces cost of test. Vision dramatically increases the complexity of the research that may be accomplished by allowing researchers to combine different measurement tasks with environmental controls into an automated test procedure managed by programmable logic embedded with automated data collection, analysis and plotting tools.

■ HARDWARE TASKS

These are Tasks that send signals to a tester through the driver. These also may communicate with other instruments attached to the tester or to the host computer. Hardware Tasks normally apply a voltage profile to the sample. Hardware Tasks include.

Waveform	Applies a sine, square, triangle or user-defined voltage waveform to stress the sample. The waveform is of user-defined voltage, frequency, and duration.
DC Bias	Applies a constant user-defined voltage to the sample for a user-defined duration

Measurement Tasks

These are Hardware Tasks that receive data from the tester. Measurement Tasks include, but are not limited to:

Hysteresis	This Task measures sample polarization (µC/cm2) response to a Task-applied voltage profile.
Small Signal Capacitance	This measurement captures the samples capacitance as a function of voltage.
PUND	A standard five-pulse ferroelectric sample characterization measurement that captures both switching (remnant + non remanent) and non-switching (non-remanent) polarization (µC/cm2). Pulse width and voltage are under user control.
Leakage	Captures the current through a sample induced by a steady-state, DC Bias voltage. Voltage and measurement duration are user-defined.
Fatigue	Performs a series of stress/measure sequences. In the stress sequence, the sample is submitted to a switching waveform.
General Monopolar	The General Monopolar Task allows up to five independently configured monopolar Hysteresis measurements to be made in sequence to execute a PUND measurement using continuous waveforms. Each measurement may be preceded by an unmeasured presetting pulse or poling DC Bias period.
Curve Energy	Determines the energy returned and the energy lost from a charged capacitor. It is useful for measuring power capacitors for new energy generating systems.
Piezo-Electric	Captures a sample's displacement as a function of voltage profile along with the sample's polarization response. An external displacement measurement instrument must be attached to the tester to make this measurement.
Pyro-Electric	Sets the sample to a series of temperature by performing GPIB control of an external thermal device. At each temperature, it captures the sample's polarization response and/or small-signal capacitance.

Magneto-electric	Radiant's Magneto-electric Response Task allows the user to measure the magnetoelectric coupling coefficient in multiferroic materials and composite magneto piezoelectric devices.
Transistor	Radiant has introduced an I^2C digital-to-analog converter product that can be attached to the Precision Premier II or Multiferroic Test System and is controlled from Vision. The addition of this extra voltage source makes it possible for the testers to measure the performance of thin-ferroelectric-film gate transistors (TFFTs and MFSFETs).
DLTS	Deep Level Trap Spectroscopy Task allows the user to measure the population of traps filled during a voltage pulse of a non-linear material and measure the decay rate of the trapped population as a function of temperature.
PAINT	PAINT originally was designed to capture the mechanical and acoustic vibrations induced in an ink jet chamber by the pulsing of the piezoelectric element to fire an ink droplet. In reality, the PAINT task in Vision can be used to capture the acoustic response of any activity, including SONAR type measurements in a water tank.

■ EXTERNAL INSTRUMENT CONTROL

These are Hardware Tasks that communicate with remote instruments through a GPIB bus.

LCR Meter	This Task allows the user to query an external LCR meter for its measurements including capacitance, loss, and Tan Delta. LCR Meter is built-in the PiezoMEMS Analyzer.
Set Field	This Task allows the user to specify a setting for the superconducting magnet connected to a Quantum Design 6000 controller.
Temperature	This Task sets the sample to a series of temperature by performing GPIB control of an external thermal device. At each temperature, it captures the sample's polarization response and/or small-signal capacitance. These are combined to calculate the pyroelectric coefficient.

■ FILTERS

These are Tasks that collect, operate on, store and plot data from one or more Measurement Tasks or other Filters.
Filter categories include:

Collect/Plot	Simple data collection and plotting.
Mathematical Analysis	Combine two measured data vectors into one through addition, subtraction, multiplication, or division or perform single vector manipulation on one or more input data vectors.
Averaging	Average multiple data vectors together to form a single vector, average one or more single vectors with itself over multiple iterations in a Branch Loop or perform statistical analysis on one or more single vectors.
Data Mining	Invoking the data mining wizard allows the user to sort through all the Datasets on the computer to pull out and plot together any tests.

■ EXTERNAL SENSOR CONTROL

These are Tasks that document and/or control the progress of an experiment.

SENSOR 2 Collect/ Plot Filter	Now, the user can separately plot the measurements on SENSOR 2 of the PiezoMEMS Analyzer, Multiferroic II, Premier II and LCII testers. and apply all the math filters to process the results.
Read Sensor Tasks	These Tasks allow the user to directly take a reading of the voltage on SENSOR or SENSOR2 without having to execute a subsidiary task like Hysteresis.
Sensor Oscilloscope	The oscilloscope task presents a real-time display of the voltage on one of the sensor ports of the PiezoMEMS Analyzer, Multiferroic II, Premier II and LCII testers.

Radiant Offers a Wide Variety of Tester Accessories

Tester Accessories Include:	Test Stations, 10kV High Voltage, Thermal, Piezoelectric, Magnetoelectric, Transistor, Multiplexer and Reliability Testing.

High Voltage Testing

Radiant's Test Systems have a built in ±10V drive voltage. The PiezoMEMS Analyzer, Multiferroic II, Premier II, and Precision LCII have optional ±30V, ±100V, ±200V and ±500V stand-alone configurations. These units can be expanded to 4kV and 10kV with the addition of a High Voltage Interface (HVI) and High Voltage Amplifier. The Rt66C comes with a built-in ±200V drive voltage. The RT66C can be expanded to 10kV with the addition of a High Voltage Interface and 10kV amplifier.

AutoCal 230°C Piezoelectric (Converse D33) Thermal Test Chamber

AutoCal230C Piezoelectric (Converse D33) Thermal Test Chamber

The AutoCal 230°C Piezoelectric Thermal Test Chamber Includes - Displacement Sensor, Heated Piezoelectric/ Pyroelectric Measurement Test Fixture, Pyroelectric/ Chamber and Advanced Piezoelectric Software. The Self-calibration will allow fully automatic temperature (to be internally heated to 230°C) profiles for both electrical and piezoelectric tests. The heating unit is built-in to the self-contained fixture, so no additional temperature chamber is necessary. The bundle's simple user interface is controlled by Radiant's fully automated Vision Data Acquisition Software. Converse D33 Measurements can be extracted using Vision Software

The heated test fixture provides a safe operating environment for testing at high voltages (10kV) and is rated to 230°C. The fiber optic sensor detects the amplitude of non-coherent light reflected from the sample surface to determine the distance from the sensor wand to the sample surface. The AutoCal 230°C Piezoelectric Chamber is a cost-effective option for researchers measuring piezoelectric displacements on the order of one micron or larger using Radiant testers.

Non Heated Piezoelectric (Converse D33) Test Bundle for Bulk Ceramics

The Bulk Ceramic Piezoelectric Test Bundle is rated to 10kV. Allows piezoelectric displacements (converse d33 measurement) on the order of one micron or larger using Radiant Testers. Includes a Piezoelectric Displacement Sensor, Piezoelectric Measurement Test Fixture, and Advanced Piezoelectric Software. The Sample Chamber is rated to 10,000 Volts. The bundle's simple user interface is controlled by Radiant's fully automated Vision Data Acquisition Software. Converse D33 Measurements can be extracted using Vision Software.

Non Heated Piezoelectric (Converse D33) Test Bundle for Bulk Ceramics

High Voltage Cryogenic Probe (HVCP) For Quantum Chambers

The (HVCP) fixture is compatible with Quantum Design Chambers and connects to a Radiant Technologies Precision Non-linear Materials Tester to allow electrical testing of single crystal or bulk ceramic capacitors in the temperature and magnetic field environments created by the chamber. Electrical measurements up to 1,200 volts can be executed at stable temperatures down to 10 Kelvin with DC magnetic fields up to 9 Tesla without electrical breakdown of the internal helium atmosphere that cools the chamber.

Measurements above 1,200 volts up to 4,000 volts may be executed without breakdown if the chamber is placed in High Vacuum mode.

High Voltage Cryogenic Probe (HVCP) compatible with Quantum Design PPMS

Bulk Ceramic High Temperature/Voltage Test Fixtures

Radiant offers several test fixtures that range from 230°C to 650°C rated to 10kV. These test fixtures can be used at room temperature, with silicon oil, or in a chamber or furnace.

High Voltage High Temperature Test Fixture

Multiplexer –A two, 1x8 Channel MUX

(MUX 2018) The Multiplexer 2018 provides an interface between Radiant' s Testers to test multiple capacitors at one time. The MUX 2018 is a two 1x8 Channels with separate replays on each channel. The MUX 2018, signal input and output connections are rated to 500V.

The MUX 2018 is its own stand-alone USB controlled instrument and can test hot or cold temperatures.

Precision Radiant Tester with Multiplexer

Magnetoelectric Bundles for Thin Films and Bulk Ceramics (MER)

Radiant' s Magneto-electric Test Bundle allows users to set DC Magnetic Fields across a sample using any coil and adjust those fields while a test progresses under Vision Software.

Radiant Tester with Magneto Test Bundle

The (MER) Task allows a researcher to construct and execute custom measurement tasks while controlling temperature and plotting data in real time to explore Multiferroic Materials across a Magnetic, Electric and Thermal Envelopes.

The MER Bundle can be used with any DC Magnet or a VSM.

Thermal Testing

Radiant' s Chamber Task automatically measures the Pulse Polarization response and Small Signal Capacitance of a Pyroelectric material that is being heated and/or cooled. Radiant' s Chamber Task controls Linkam Stages (-196C to 600C) Chambers, Hot Chucks and Furnaces. The Chamber Task is included with Radiant's Heated Piezoelectric/ Pyroelectric Test Bundle to 230C. Thermal Test Bundles with Linkam Stages, Chambers and Furnaces quoted upon request.

Piezoelectric Test Bundles for Thin Films

Radiant Technologies offers three tools that enable the characterization and control of piezoelectric films during product development and manufacturing.

• High Resolution Angstrom-Level Measurement Platform – VibroONE Laser interferometry to measure d33 and evaluate piezoMEMS, bulk devices as well as the surface of clamped thin films. 0.2 Angstrom Resolution, 2µm spot size and 2MHz band width. Thermal Stage can be added to measure at temperatures from -196C to 600C.

• NanoMeter Measurement Platform-IVS500 – Resolution above the noise floor with averaging = ~1 nanometer, 300µm spot size, 100kHz band width. This platform is intended for use with packaged parts.

•e31 characterization to track film piezoelectric coefficients.

High Resolution Thermal- Angstrom-Level Measurement Platform-VibroOne & Thermal Stage

Piezoelectric Nano Displacement Sensor - PNDS

(PNDS/AFM) Radiant's PNDS is a fully functional table-top Atomic Force Microscope especially modified by Radiant to capture the absolute displacement of piezoelectric butterfly loops from piezoelectric and ferroelectric materials as well as fully integrated PiezoMEMs devices such as membranes and cantilevers.

Probe Stations and Simple Test Station

RTI-30 Fully Integrated Probe station with optics for the research of advanced active and passive components. Binocular and Trinocular stereo zoom microscope with 20X magnification (Included wide field eyepieces), LED ring Illuminator, precision x-y stage with isolated and shielded chuck, vacuum hold down and Z-lift. Hot Chucks quoted upon request.

Simple Test Station is a small yet reliable and stable test station for laboratories. The Simples Test Station does not have optics.

RTI-30 Fully Integrated Probe Station

Transistor Testing

Measures the performance of thin-ferroelectric-film gate transistors (TFFTs and MFSFETs).