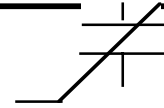


Comparison of Commercial Ferroelectric Testers

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Summary

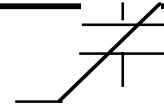
This document compares the performance of two commercially available ferroelectric testers.

- The Radiant Precision testers
- The aixACCT TF TF2000 Analyzer

The comparison is based on execution of specific research tasks.

Conclusion:

The Precision tester architecture supports the widest performance envelope and the most versatile test software of the three systems.



Architectures

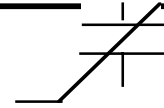
The two systems use an Arbitrary Waveform Generator (AWFG) for the output stimulus and a Virtual Ground sense circuit to measure the capacitor response. This combination was pioneered by Radiant Technologies in 1989.

The systems differ in the measurement method:

Precision	Charge sensing
aixACCT	Current sensing

NOTE: Charge sensing is more accurate over the wide frequency envelopes of the Radiant testers.

Hysteresis



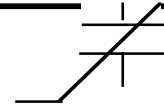
System:	Volts	Frequency
Precision Premier	$\pm 100V$	0.033Hz->200KHz
Precision Workstation	$\pm 100V$	0.033Hz->5.0KHz
Precision LC*	$\pm 10V$	0.1Hz->2KHz
aixACCT TF2000	$\pm 25V$	1Hz->10KHz

*The Precision LC has an optional internal amplifier to increase its range to $\pm 100V$.

High Voltage Ceramic Measurements

The measurement period of a hysteresis loop of a bulk ceramic capacitor must be much much slower than the frequency response of the output amplifier to ensure a distortion free measurement. Most high voltage measurements at Radiant are conducted between 2 seconds and 30 seconds to achieve sharp hysteresis loops.

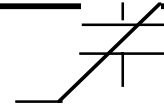
Hysteresis



Delays Between Preset and Measurement Loops

All hysteresis loops require a preset loop to ensure that the measurement loop is a complete loop. The Precision test systems allow the user to vary this delay. The Precision test systems also allow the user to turn off the preset loop to study memory effects as well as the virgin hysteresis out of the furnace.

System:	Minimum Delay	Maximum Delay
Precision Premier	200 μ s	30s
Precision Workstation	1ms	30s
Precision LC*	500ms	10s
aixACCT TF2000	-	-



PUND

System:	Minimum	Maximum
Precision Premier	1 μ s	1s
Precision Workstation	5 μ s	1s
Precision LC	50 μ s	1s
aixACCT TF2000 (standard)	N/A	N/A
aixACCT TF2000 (with external high speed oscilloscope attachment)	50ns	100 μ s

Note: The continuous frequency range of the Precision testers allows the user to construct the frequency response of the sample and predict operation outside of the measured envelope.



PUND

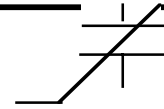
The PUND Test and Bulk Ceramic Capacitors

The PUND can be executed on bulk ceramic capacitors. Because of the fast rise time of the pulses, PUND tests tend to encourage breakdown of the ceramic capacitors. The Precision Premier and Precision Workstation have an output voltage with an adjustable ramp that takes into account the sample size. Maximum ramp time to 1KV (1V internal) would be 8ms for the Precision Premier and 20ms for the Precision Workstation.

The PUND Test and Thin Film Capacitors

The high speed PUND tests are suitable for thin film capacitors. The Precision tests systems allow the user to vary the pulse width, pulse height, and delay between pulses for the PUND test. A standard feature of the tests also allows the user to construct a custom five pulse test with any voltage, pulse width, and delay assigned to any of the five pulses.

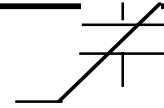
Fatigue



System:	Internal Frequency	Current	Parameter
Precision Premier*	3MHz	400mA	Any
Precision Workstation*	1MHz	400mA	Any
Precision LC*	10KHz	50mA	Any
aixACCT TF2000	20MHz	1 Amp	-

*All Precision systems have external fatigue inputs to allow unlimited fatigue frequency.

Fatigue

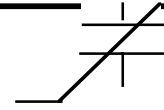


Custom Fatigue:

The programmability of the Vision operating system present on all Radiant Precision testers allows the construction of custom fatigue tests. For instance, the standard fatigue test cycles the capacitor for longer and longer periods while conducting PUND tests between each cycling period. Data is plotted as Qswitched vs Cumulative Number of Cycles. The Vision operating system allows the user to construct fatigue tests that measure the change in leakage, hysteresis, IV, or small signal capacitance as a function of the fatigue cycles. The user may select between fatigue pulses, fatigue sine wave, fatigue square wave, fatigue triangle wave, a custom file fatigue source, or an external fatigue source.

Note: Bulk ceramic capacitors must be fatigued at a low frequency to ensure that the high voltage amplifier can reach the assigned voltage during the fatigue period.

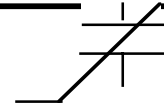
Test Ensemble



System:	Hysteresis	Pulse	Leakage & I(V)	Imprint	Fatigue	Retention	Small Sig Cap	Piezoelectric	Pyroelectric	AFM	Voltage Sources*
Precision Premier	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	3
Precision Workstation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
Precision LC	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	1
aixACCT TF2000	Y	N	N	Y	Y	Y	N	Y	Y	Y	1

*Multiple voltage sources are needed to test Ferroelectric FETs.

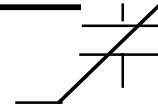
Operating System



System:	Measurement Database	Programmable Tests	Share Data and Tests on Internet	Programmable Delays between pulses and loops	Direct Graphing to Powerpoint and Word
Precision Premier	Y	Y	Y	Y	Y
Radiant Workstation	Y	Y	Y	Y	Y
Radiant LC	Y	Y	Y	Y	Y
aixACCT TF2000	N	N	N	Y	N

Note: The Vision operating system contains over 3000 pages of on-line HELP accessible from each task in Vision.

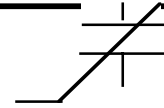
Hardware Design



System:	Built-in Self-References	High Voltage Safety Circuits	Ramped Voltage during PUND	Mux	Production Sort Equipment	Max HVA
Precision Premier	Y	Y	Y	Y	Y	10KV
Precision Workstation	Y	Y	Y	Y	Y	10KV
Precision LC	Y	Y	Y	Y	Y	10KV
aixACCT TF2000	N	?	N	Y	N	10KV

Unique Features of the Precision Tester

- The stress pulse widths and measurement pulse widths for the retention, fatigue, and imprint tests can be matched down to the minimum pulse width of the Precision tester. i.e. Fatigue and Retention can be tested with the same pulse width.
- The Precision test systems execute the Remanent Hysteresis Task, a measurement which gives the shape of the remanent polarization switching vs voltage real time.
- The Precision systems have continuous pulse and hysteresis settings over their entire range of frequencies, allowing those properties to be measured vs. frequency.
- The Precision systems have a published error specification of 0.5%.



Conclusions

- The Precision Test systems are the third generation of ferroelectric testers developed by Radiant Technologies and incorporate more advanced features than other systems.
- The Precision Test systems have the best frequency/voltage envelope across all testers.
- Only the Precision Test systems are programmable.
- Only the Precision Premier can measure ferroelectric FETs.
- The Precision test systems are designed with embedded safety systems, including a safety interlock connection, for personal protection when using high voltage amplifiers.