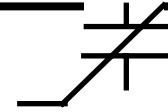


Measuring Direct d_{33} and d_{31} with Piezotest Instruments

Radiant Technologies, Inc.

July 26, 2010

Summary



- The growing research focusing on piezoelectric materials increases the demand for the full range of measurements from Radiant's test equipment.
- The Radiant testers can already execute small and large signal piezoelectric measurements on bulk and thin film devices.
- Using the versatility of Vision, Radiant has now created a task for the Vision Library that will control a Piezotest PM100, PM200, or PM300 system for measuring the direct d_{33} coefficient for bulk ceramic materials.

The Piezotest PM300 System



The Piezotest meters determine the direct piezoelectric constant of the samples under test using the acoustic stimulus method.

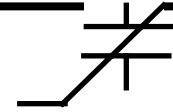
For more information on the PM300, go to www.piezotest.com.

Photograph of the Piezotest PM300 system courtesy of Piezotest.

The Piezotest PM300 System

- The Piezotest PM300 system will measure
 - d_{33}
 - d_{31} and d_{15} using adaptors
 - Capacitance and $\tan \delta$ @ 1 kHz
- The acoustic frequency range for d_{33} is 30 Hz to 300 Hz.
- The static load is fixed at 10 Newtons
- The oscillatory force range is 0.05 N to 0.5 N.
- The acoustic frequency and acoustic force are programmable remotely.

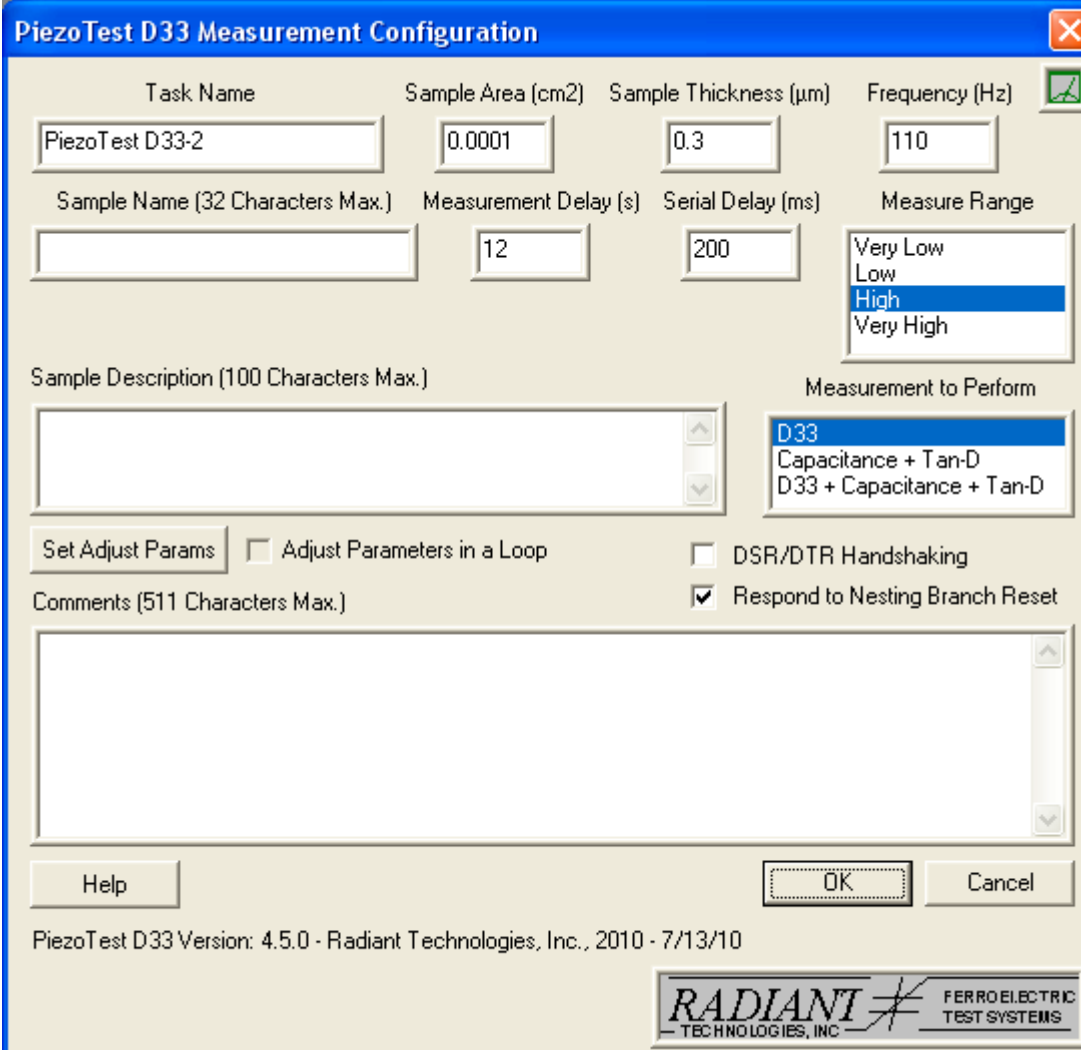
The PM100 and PM200 do not measure the capacitance or $\tan \delta$ parameters.



Vision Control

- The Piezotest systems are controlled via RS232 communications.
- With a Piezotest system connected to the host computer, Vision will automatically open and program the RS232 channel to communicate with the Piezotest instrument remotely.
- The user simply selects the Piezotest task from QuikLook for immediate execution or from the Vision Library to embed the measurement in a test definition for automated data acquisition.

The Piezotest Task



The image shows a software dialog box titled "PiezoTest D33 Measurement Configuration". It contains several input fields and controls for configuring a measurement task. The fields are arranged in a grid-like fashion. At the top, there are four input boxes for "Task Name", "Sample Area (cm2)", "Sample Thickness (µm)", and "Frequency (Hz)". Below these are four more input boxes for "Sample Name (32 Characters Max.)", "Measurement Delay (s)", "Serial Delay (ms)", and a "Measure Range" dropdown menu. The "Measure Range" dropdown is currently open, showing options: "Very Low", "Low", "High" (which is selected), and "Very High". Below the "Sample Name" field is a "Sample Description (100 Characters Max.)" text area. To the right of this is a "Measurement to Perform" dropdown menu, which is also open, showing options: "D33" (selected), "Capacitance + Tan-D", and "D33 + Capacitance + Tan-D". Below the "Sample Description" field is a "Set Adjust Params" button and a checkbox for "Adjust Parameters in a Loop". To the right of this is another checkbox for "DSR/DTR Handshaking". Below the "Set Adjust Params" button is a "Comments (511 Characters Max.)" text area. To the right of this is a checked checkbox for "Respond to Nesting Branch Reset". At the bottom of the dialog are three buttons: "Help", "OK", and "Cancel". Below the buttons is the version information: "PiezoTest D33 Version: 4.5.0 - Radiant Technologies, Inc., 2010 - 7/13/10". At the very bottom right is the Radiant Technologies logo, which includes the text "RADIANT TECHNOLOGIES, INC." and "FERROELECTRIC TEST SYSTEMS" next to a stylized symbol.

Task Name	Sample Area (cm2)	Sample Thickness (µm)	Frequency (Hz)
PiezoTest D33-2	0.0001	0.3	110

Sample Name (32 Characters Max.)	Measurement Delay (s)	Serial Delay (ms)	Measure Range
	12	200	High

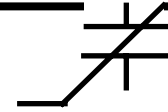
Sample Description (100 Characters Max.)	Measurement to Perform
	D33

Set Adjust Params Adjust Parameters in a Loop DSR/DTR Handshaking
Comments (511 Characters Max.) Respond to Nesting Branch Reset

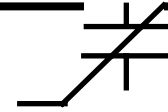
PiezoTest D33 Version: 4.5.0 - Radiant Technologies, Inc., 2010 - 7/13/10

RADIANT TECHNOLOGIES, INC. FERROELECTRIC TEST SYSTEMS

Measurement Options

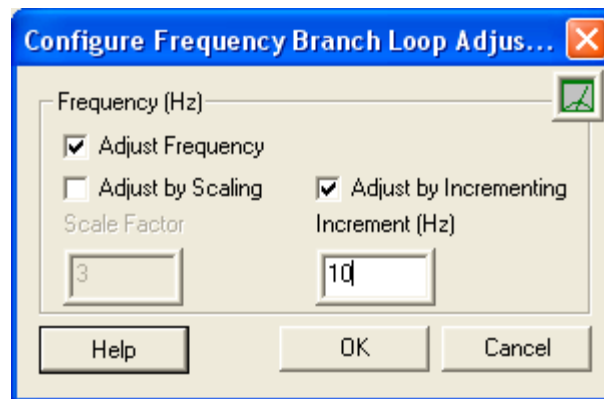


- The user may select to capture only d_{33} , only capacitance/ $\tan \delta$, or all three together in a single access to the instrument.
- The task allows the user to step the test frequency inside Branch loop of a test definition.
- The data filters in the Vision Library recognize the Piezotest task so the user can create data plots of multiple measurements real time during the execution of a test definition.

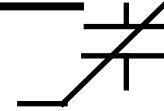


Branch Loop

- The task allows the user to step the test frequency inside Branch loop of a test definition.



- The setting shown above will increase the measurement frequency of the Piezotest PM300 unit by 10 Hz on every loop.



Results Panel

- The panel below displays the test settings and the result of a single inquiry to the Piezotest instrument.

The screenshot shows a software window titled "PiezoTest D33 Data". The interface includes several input fields and buttons. The results are displayed in a table-like format:

Sample Name	D33 (pC/N)	Capacitance (pF)	Tan-Delta
	398.0	124.0	0.0

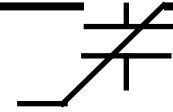
Below the table, there are fields for "Sample Description", "Sample Area (cm2)", "Sample Thickness (µm)", and "Frequency (Hz)".

Sample Area (cm2)	Sample Thickness (µm)	Frequency (Hz)
4.52e+000	6.01e+003	110

Further down, there are fields for "Measurement Range", "Measurement Delay (s)", and "Serial Delay (ms)".

Measurement Range	Measurement Delay (s)	Serial Delay (ms)
High	12	50

The "Selected Measurement" field contains "D33". There is a "Comments" text area at the bottom. At the very bottom, there are buttons for "Admin Info", "Export", "Help", "Create a DataSet", and "OK". The footer text reads: "PiezoTest D33 Version: 4.5.0 · Radiant Technologies, Inc., 2010 · 7/13/10". The Radiant Technologies logo is also present.

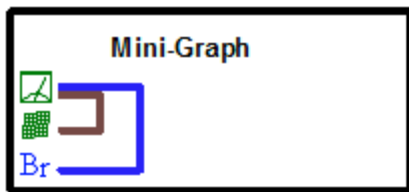


Demonstration

- Demonstrations of the use of the Piezotest Task in Vision follows.
- The next slide is the graphical depiction of a Vision program for sequential measurements of the d_{33} value of the same sample.
 - In the first test, the sample is left in place between tests.
 - In the second test, the sample is removed and remounted before each measurement.
- The feature in Vision to export graphical representations of test definitions can be found at

www.ferrodevices.com/Data%20Mining.html

Sequential Test Program



Task V:4.5.0 7/13/10 Measurement Task

Task Type: PiezoTest D33
Task Name: PiezoTest Sample
Frequency (Hz): 110
Measurement Range: High
Measurement: D33
Measurement Delay (s): 12
Serial Delay (ms): 50

Branch Target

Filter Target

Task V:4.5.1 6/30/10 Filter Task

Task Type: Single-Point Filter
Task Name: Plot d33 vs Measurement
Input Task Type: PiezoTest D33 Task
X-Axis: Loop Coun
Captured Parameters: 1
Measured Parameter 1: D33 (pC/N)
Number of Associated Tasks: 0
Input Task Names...

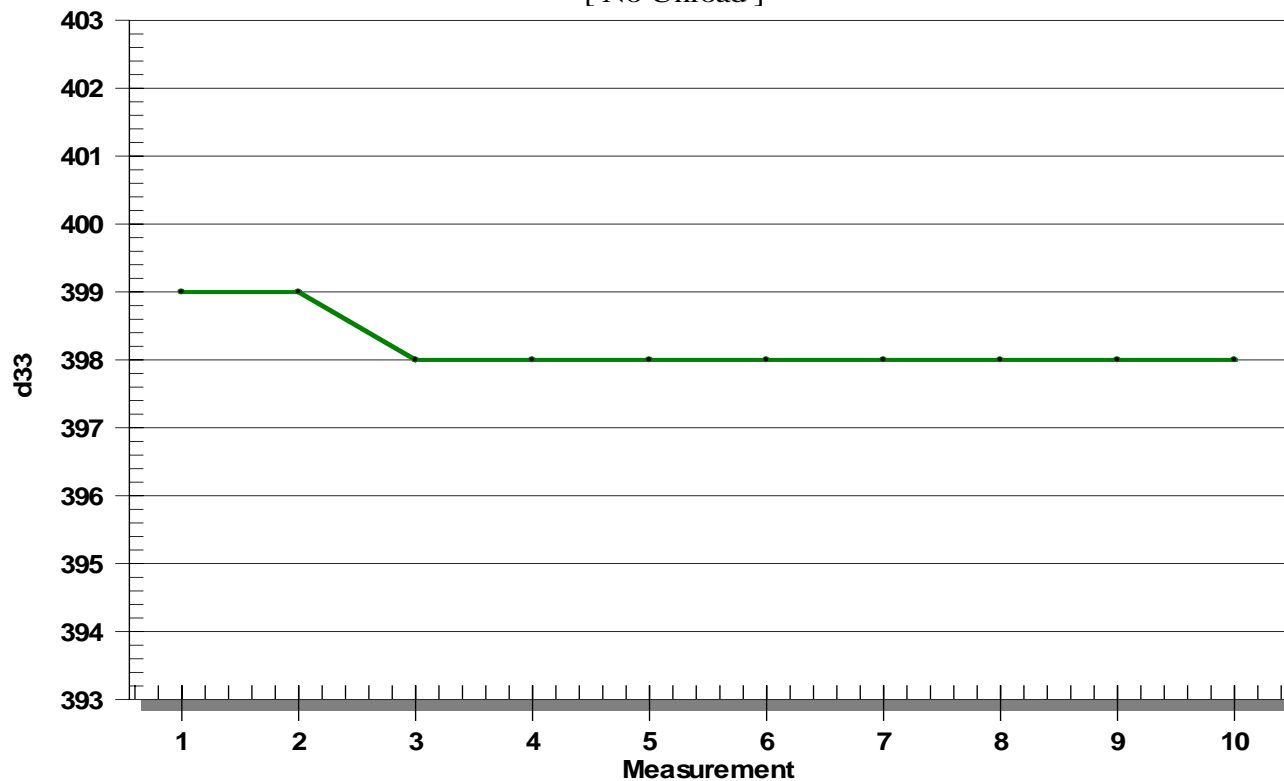
Task V:4.5.0 6/08/10 Branch Task Br

Task Type: Branch Task
Task Name: Loop to 10
Logic: if Loop Counter < 10, then Branch
Target Task: PiezoTest Sample

Sequential Tests

- The data below are ten sequential measurements made *without* removing the sample from the test fixture between measurements. The sample has a known d_{33} of 399. The instrument was a PM300.

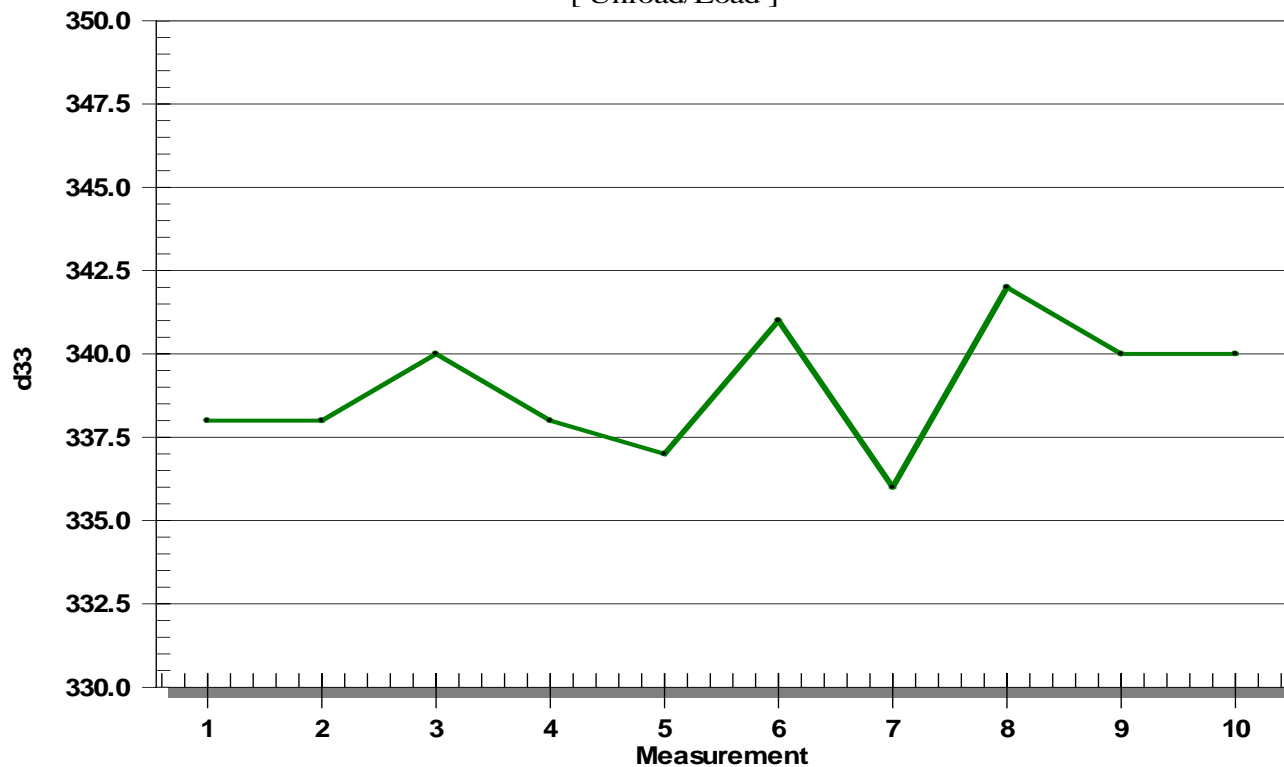
Sample 399 d_{33} on Contiguous Measurements
[No Unload]

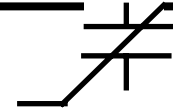


Sequential Tests

- The data below are ten sequential measurements made on a different sample removing it and re-loading it from/to the test fixture before each test. The sample had a known d_{33} of 343.

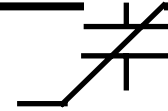
Sample 343 Sequential Measurements
[Unload/Load]





Analysis

- The Piezotest PM300 proved to be very quiet and reproducible as determined by the sequential measurements made without unloading the sample.
- Unloading the sample and then loading it again between each test increased the variance of the ten sequential measurements but this variance was dramatically lower than the $\pm 25\%$ measurement variance typically allowed in industry.



Conclusion

- Vision now includes a task to control the Piezotest PM100, PM200, and PM300 acoustic-based direct piezoelectric constant measurement instruments.
- As part of the Vision Library, the Piezotest Direct d_{33} Task may be incorporated into automated test definitions for the measurement and analysis of multiple samples.
- With the collected d_{33} data safely stored in Vision's database architecture, the measurements may be recalled, plotted, or exported at any time after testing.
- Please contact Radiant Technologies with any inquiries.