

## Accurate Evaluation of MEMS Piezoelectric Sensors and Actuators Using the Agilent 4294A Precision Impedance Analyzer

### Application Note

- ▶ Excellent impedance measurement accuracy and repeatability
- ▶ Easy evaluation of resonance, anti-resonance, and mechanical characteristics using the impedance measurement method
- ▶ A wide variety of analysis functions such as equivalent circuit analysis

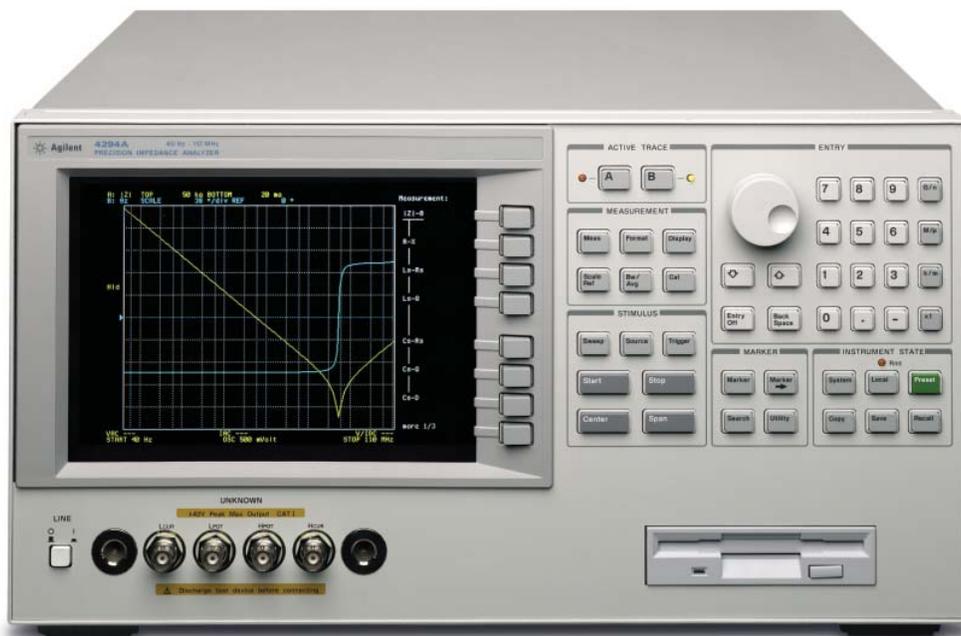


Figure 1. Agilent 4294A Precision Impedance Analyzer

## Introduction

This application brief describes the benefits of using the Agilent 4294A for device characterization of MEMS piezoelectric sensors and actuators, along with its wide variety of analysis functions and features and how it improves design efficiency.

The Agilent 4294A Precision Impedance Analyzer offers excellent impedance accuracy and is an ideal evaluation tool for design and manufacturing test.

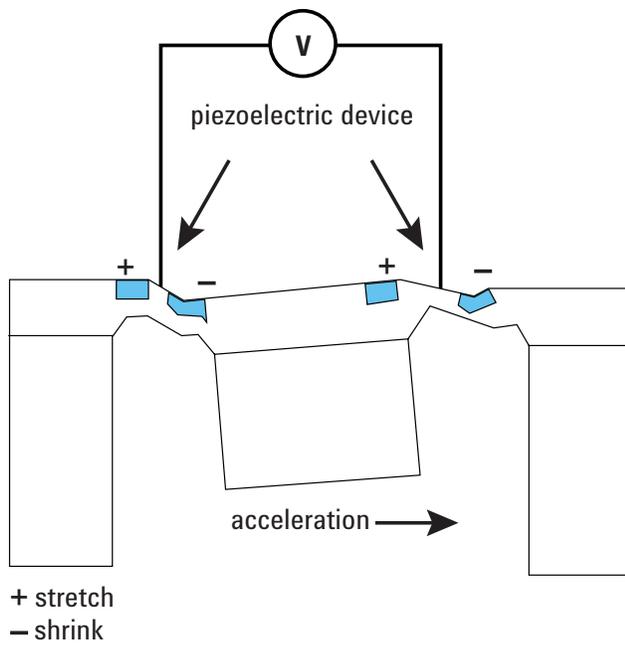


Figure 2. Mechanics of a piezoelectric sensor

## MEMS Piezoelectric Sensors and Actuators

MEMS devices such as accelerometer sensors and micro actuators are often micro-fabricated piezoelectric devices that convert a mechanical displacement to an electric signal (Figures 2 and 3). These piezoelectric devices detect mechanical displacement with the piezoelectric effect. They also transform electric signals to mechanical displacement with an inverse piezoelectric effect.

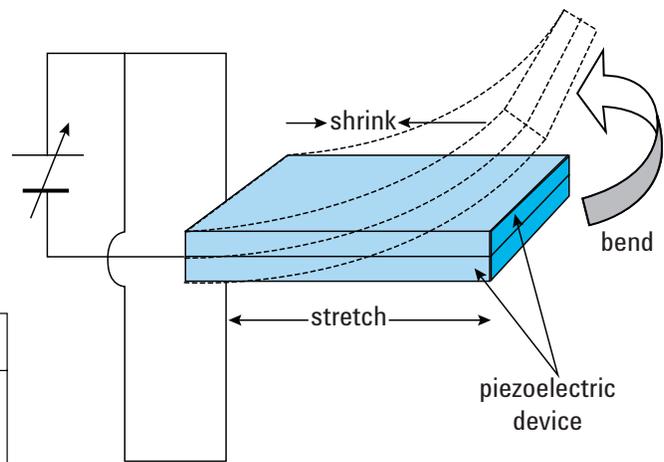


Figure 3. Mechanics of a piezoelectric actuator



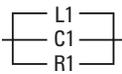
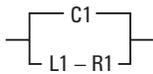
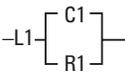
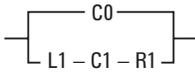
## A Wide Variety of Analysis Functions and Features

The 4294A offers a variety of analysis functions and features to help designers characterize MEMS devices quickly. The equivalent circuit function provides a basic electric circuit model of the MEMS piezoelectric device for quick oscillation mode analysis (Figure 6). Further analysis can be made using an external simulator. The 4294A outputs the measured data in a text format such as a touchstone file so that a vast majority of simulators can read them.

The 4294A can store data into memory for comparisons between memory and active traces. Marker search functions such as peak/search and max/min help users easily find targets and obtain necessary information.

Equivalent circuit model

Selected: E

A	B	C
		
D	E	
$L1 - C1 - R1$		

R1: 21.328  $\Omega$   
L1: 148.256  $\mu\text{H}$

C1: 47.5235 fF  
C0: 5.1292 pF

Figure 6. Equivalent circuit analysis function

## Summary

The Agilent 4294A Precision Impedance Analyzer offers excellent impedance measurement accuracy as well as repeatability. It is the ideal tool for the evaluation and test of the MEMS piezoelectric sensors and actuators. In addition, a wide variety of analysis functions help designers further increase their design productivity.

For more information, please refer to the following literature and websites:

- ▶ 4294A Technical Overview (P/N 5968-3808E)
- ▶ 4294A Data Sheet (P/N 5968-3809E)
- ▶ 4294A Precision Impedance Analyzer:  
[www.agilent.com/find/4294a](http://www.agilent.com/find/4294a)
- ▶ MEMS/NEMS Device Measurement Solution:  
[www.agilent.com/find/mems](http://www.agilent.com/find/mems)

## Remove all doubt

Our repair and calibration services will get your equipment back to you, performing like new, when promised. You will get full value out of your Agilent equipment throughout its lifetime. Your equipment will be serviced by Agilent-trained technicians using the latest factory calibration procedures, automated repair diagnostics and genuine parts. You will always have the utmost confidence in your measurements.

Agilent offers a wide range of additional expert test and measurement services for your equipment, including initial start-up assistance onsite education and training, as well as design, system integration, and project management.

For more information on repair and calibration services, go to

[www.agilent.com/find/removealldoubt](http://www.agilent.com/find/removealldoubt)



### Agilent Email Updates

[www.agilent.com/find/emailupdates](http://www.agilent.com/find/emailupdates)

Get the latest information on the products and applications you select.

[www.agilent.com](http://www.agilent.com)

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

[www.agilent.com/find/contactus](http://www.agilent.com/find/contactus)

### Phone or Fax

#### Americas

Canada	(877) 894-4414
Latin America	305 269 7500
United States	(800) 829-4444

#### Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	81 426 56 7832
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Thailand	1 800 226 008

#### Europe

Austria	0820 87 44 11
Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700
Germany	01805 24 6333*
	*0.14€/minute
Ireland	1890 924 204
Italy	39 02 92 60 8 484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
Switzerland (French)	44 (21) 8113811(Option 2)
Switzerland (German)	0800 80 53 53 (Option 1)
United Kingdom	44 (0) 7004 666666

Other European Countries:

[www.agilent.com/find/contactus](http://www.agilent.com/find/contactus)

Revised: March 23, 2007

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 2007  
Printed in USA, April 6, 2007  
5989-6516EN



Agilent Technologies