

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

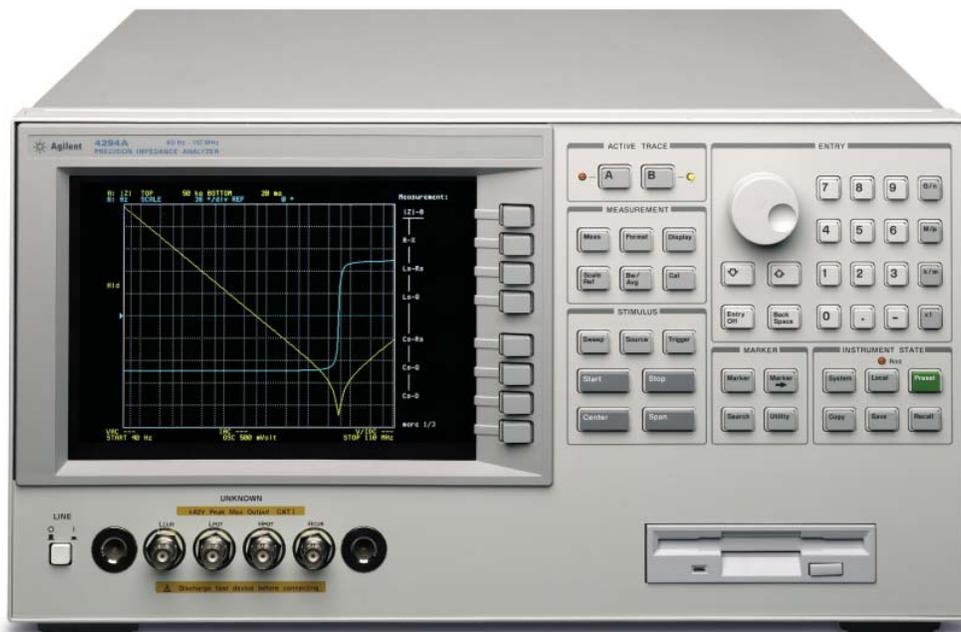


Figure 1. Agilent 4294A Precision Impedance Analyzer



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.

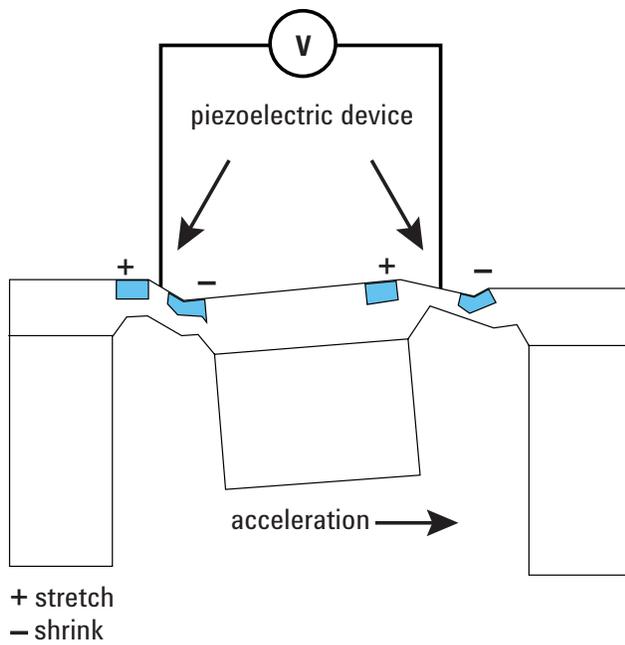


Figure 2. Mechanics of a piezoelectric sensor

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.

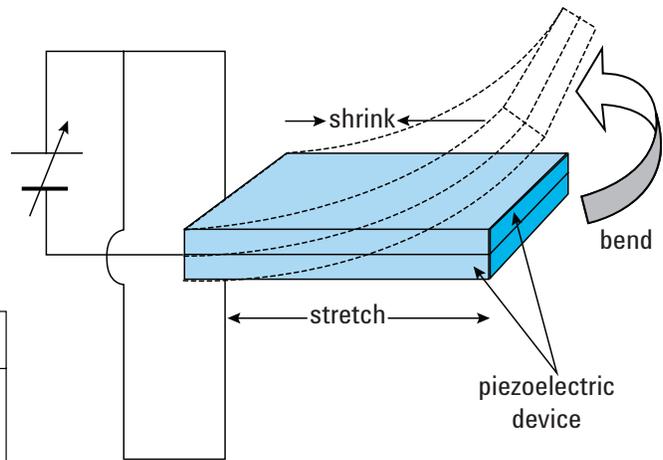


Figure 3. Mechanics of a piezoelectric actuator

Highly Accurate Impedance Measurements of Piezoelectric Devices

The mechanical characteristics of a piezoelectric device are determined by its structure and can be evaluated electrically by measuring its oscillation mode such as resonance and anti-resonance frequencies. The impedance measurement method is the most accurate method to evaluate the oscillation mode of a piezoelectric device. (Refer to application note "New Technologies for Accurate Impedance Measurement," 5968-4506E, for more information about 4294A measurement theory)

The 4294A, with a basic impedance accuracy of 0.08%, produces very precise measurements (Figure 4). An impedance versus frequency chart is shown on the 4294A display to identify resonant and anti-resonant frequencies that represent the mechanical characteristics of a piezoelectric sensor and/or actuator (Figure 5).

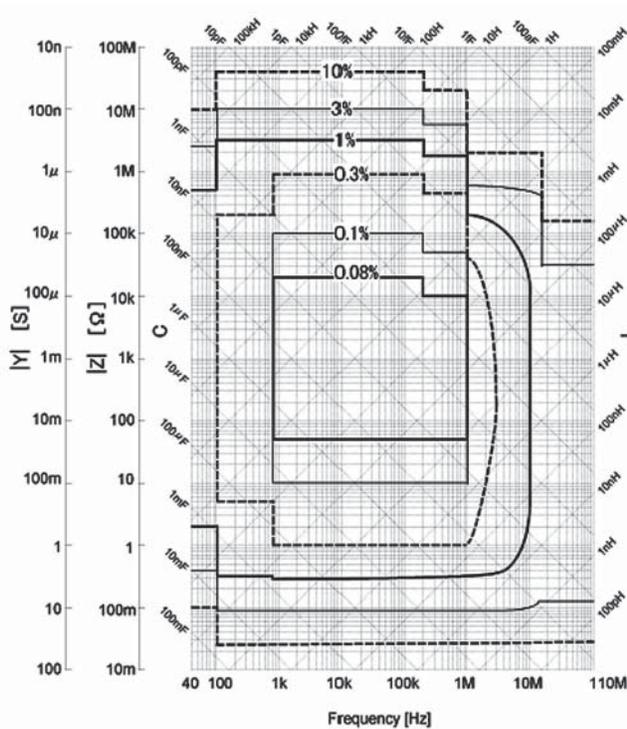


Figure 4. 4294A impedance measurement accuracy chart

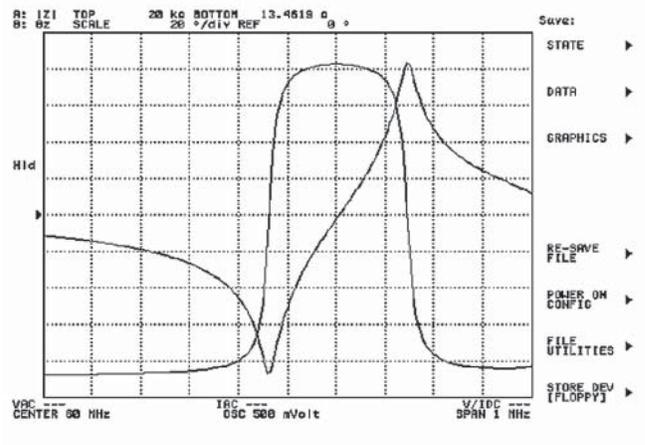


Figure 5. Measurement example of a resonator

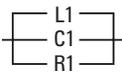
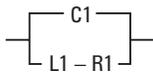
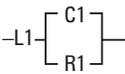
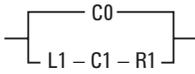
A Wide Variety of Analysis Functions and Features

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 Ω
L1: 148.256 μH

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
- ▶ MEMS/NEMS Device Measurement Solution:
www.agilent.com/find/mems

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