Improving the Test Efficiency of MEMS Capacitive Sensors Using the Agilent E4980A Precision LCR Meter

Application Note

- Exceptional accuracy and repeatability
- DC bias function up to 40 V (Option 001)
- High-speed measurement, scanner interface (Option 301)

Figure 1. Agilent E4980A Precision LCR Meter

Agilent Technologies

Introduction

This application brief describes the features of the Agilent E4980A and how it can dramatically improve the test efficiency of MEMS capacitive sensors.

Agilent E4980A Precision LCR Meter

The Agilent E4980A Precision LCR Meter with extremely high accuracy and speed is an ideal tool for research and development, as well as manufacturing test.

MEMS Capacitive Sensor

For a MEMS sensor such as a pressure sensor or accelerometer sensor, one of the major methods to detect mechanical displacement is one that detects the capacitance change caused by mechanical displacement (Figure 2). A capacitor is micro-fabricated on the substrate and displacement of the capacitor electrodes is detected as capacitance change.

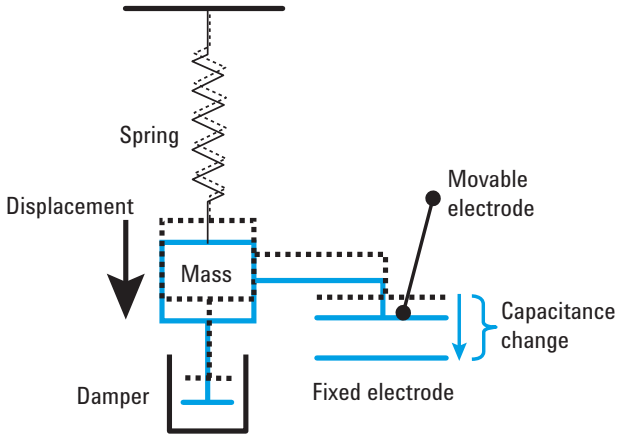

Figure 2. Principle operation of a MEMS capacitive sensor

High-Accuracy Measurement of Sensor Capacitance

The capacitance of a MEMS capacitive sensor needs to be measured in precise sub-femto farad resolution because the capacitance change of the actuator is very small as its position changes very slightly. Therefore, capacitance measurement requires an instrument with very high measurement accuracy and repeatability.

The Agilent E4980A Precision LCR Meter has the ability to measure capacitance with atto-farad order repeatability (σ<1 fF). This instrument is the ideal tool for testing MEMS capacitive sensors. Also the E4980A can test the capacitance without being affected by any resonances of the MEMS structures, as the frequency range up to 2 MHz is far enough away from the resonant frequency (generally up to 10s of kHz) of the mechanical structure such as a movable electrode (see Figure 3).

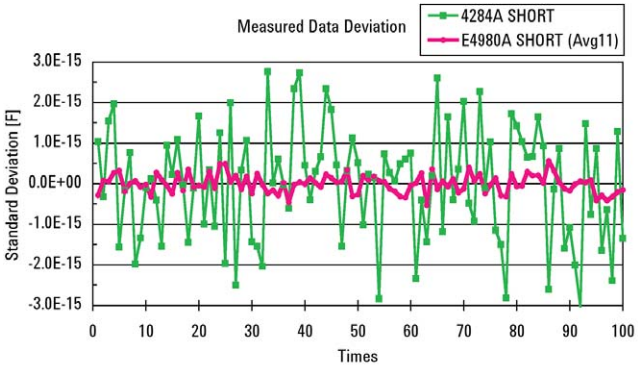

Figure 3. Superb repeatability of the E4980A

Efficient Evaluation Method Without Physical Stimulus Test

MEMS capacitive sensors detect physical quantities such as pressure and acceleration. Generally, testing MEMS sensors by inducing physical stimulus such as pressure is ideal but leads to test efficiencies. Replacing physical stimulus test with electrical test in the manufacturing process can improve the test throughput.

For a capacitive sensor, applying DC voltage to the capacitor generates an electrostatic force between the electrodes, which changes the distance between the electrodes (capacitance). Measuring capacitance with the DC voltge sweep is faster than the physical stimulus test. This can improve the manufacturing test efficiency once the relationship between physical quantities such as pressure and acceleration and the DC voltage applied are known in advance by:

- modeling the device
- sampling devices and evaluating capacitance versus physical quantity and capacitance versus applied voltage for the same device (See Figure 4)

Figure 5 shows an example of capacitive sensor characteristics.

NOTE: This method is available for displacement of up to approximately 1/3 of the distance between electrodes when no signal is input.

The Agilent E4980A Precision LCR Meter (with Option 001) applies up to 40-V DC bias voltage with high accuracy and performs DC sweep measurement up to 201 points, which is very effective for improving throughput.

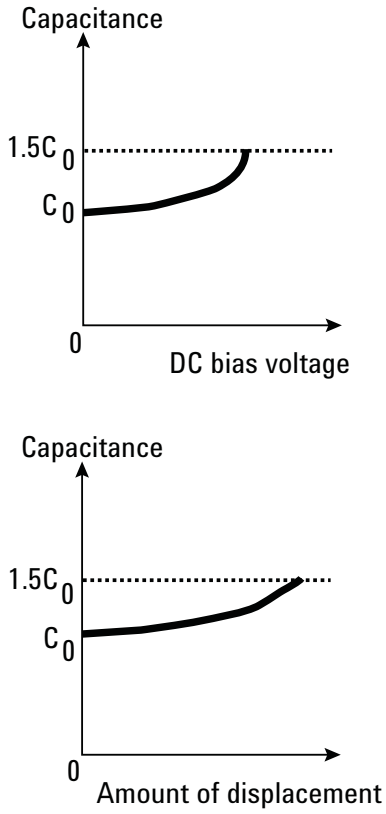

Figure 4. DC bias characteristic test for faster test throughput of capacitive sensors

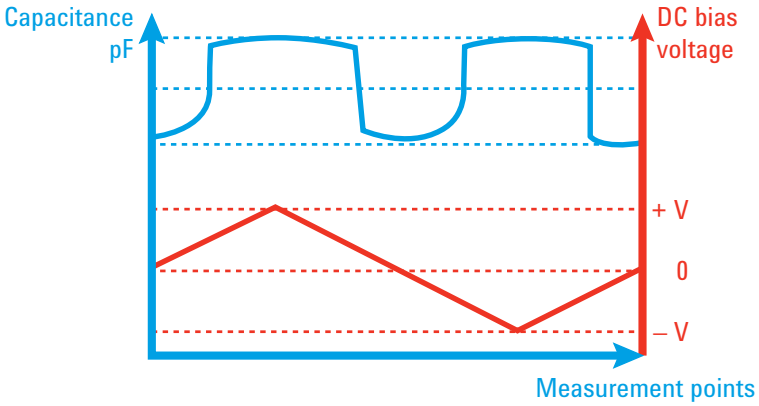

Figure 5. Example of capacitive sensor profile

High-Speed Measurement Maximizes Manufacturing Test Throughput

Throughput is always a major issue in the manufacturing test process. The Agilent E4980A Precision LCR Meter achieves a measurement speed that is five times as fast as the legacy Agilent 4284A, which improves test productivity in both design and manufacturing. In addition, the 128-channel scanner interface option (Figure 6) maximizes the test throughput without sacrificing the measurement accuracy. The instrument has all compensated data up to 128 channels so it can quickly get the corrected measured data inside the instrument. This also dramatically improves the total throughput because users do not need to take the extra time of transferring measured data and corrected data back and forth between an external controller and the instrument.

Summary

The Agilent E4980A Precision LCR Meter, which provides high accuracy and repeatability as well as high-speed measurements, is the ideal measurement instrument for testing and evaluating MEMS capacitive sensors. With up to 40-V DC bias (Option 001) and the 128-channel scanner interface (Option 301), test productivity in design and manufacturing can be improved.

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

- Agilent E4980A Brochure (P/N 5989-4235EN)
- Agilent E4980A Data Sheet (P/N 5989-4435EN)
- Agilent Technologies Impedance Measurement Handbook (P/N 5950-3000)
- MEMS/NEMS Device Measurement Solution: **www.agilent.com/find/mems**
- Agilent E4980A Precision LCR Meter: **www.agilent.com/find/e4980a**

Figure 6. Agilent E4980A scanner interface

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

Agilent Email Updates

www.agilent.com/find/emailupdates
Get the latest information on the products and applications you select.

Agilent Direct

www.agilent.com/find/agilentdirect
Quickly choose and use your test equipment solutions with confidence.

Agilent Open

www.agilent.com/find/open
Agilent Open simplifies the process of connecting and programming test systems to help engineers design, validate and manufacture electronic products. Agilent offers open connectivity for a broad range of system-ready instruments, open industry software, PC-standard I/O and global support, which are combined to more easily integrate test system development.

LXI

www.lxistandard.org
LXI is the LAN-based successor to GPIB, providing faster, more efficient connectivity. Agilent is a founding member of the LXI consortium.

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

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

Revised: March 23, 2007

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

Printed in USA, April 13, 2007
5989-6518EN

Agilent Technologies