

Keysight Technologies

Measurement of Capacitance

Characteristics of Liquid Crystal Cell

E4980A Precision LCR Meter

4284A Precision LCR Meter

Application Note





Introduction

Today liquid crystals used in LCD displays are being used in a wider range of products than ever before, prompting the need for rapid liquid crystal application research. The properties of liquid crystal materials used for LCDs are evaluated using the data gained from voltage-capacitance characteristics measurement. The measurement technique presented in this application note describes how to take best advantage of the E4980A and 4284A's powerful features, when measuring capacitance while varying an ac signal voltage applied to the liquid crystal material under test. Capacitance characteristic measurements provide the researcher with information on critical parameters, such as the elastic constants which determines the threshold voltage of the liquid crystal material and the acuteness of its threshold characteristics.

Problems

One problem encountered when using conventional instruments to measure voltage-capacitance characteristics is that the maximum test signal voltage is not high and therefore the test signal must be voltage amplified (using an external amplifier) before being applied to the liquid crystal material under test. Adding an external amplifier not only introduces additional measurement error, but also complicates the measurement procedure, because the voltage applied to the material under test must be accurately known to obtain correct and accurate measurement results.

Solutions offered by the Keysight E4980A and 4284A LCR meters

The Keysight Technologies, Inc. E4980A or Keysight 4284A precision LCR meter with Option 001 provide a test signal level of 20 Vrms, making them optimal for measuring the capacitance characteristics of liquid crystal materials. Moreover, the test signal voltage can be set with a resolution of 1%. In addition to test frequency ranges of 20 Hz to 2 MHz for the E4980A and 20 Hz to 2 MHz for the 4284A's, a basic measurement accuracy of 0.05%, and 7- or 6-digit measurement resolution respectively contribute strongly to your ability to perform highly accurate measurements under diverse measurement conditions. The voltage applied to the device or material being tested can be measured using the instruments' monitoring function to meet accurate measurement requirements.

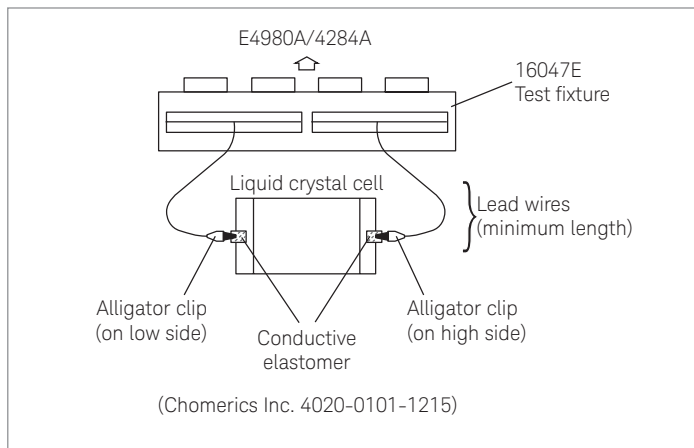
This application note will guide you in using the E4980A and 4284A to make measurements to determine the voltage-capacitance characteristics of experimental liquid crystal samples.

Measurement of Test Signal Voltage versus Capacitance Characteristic (Freedericksz Transition)

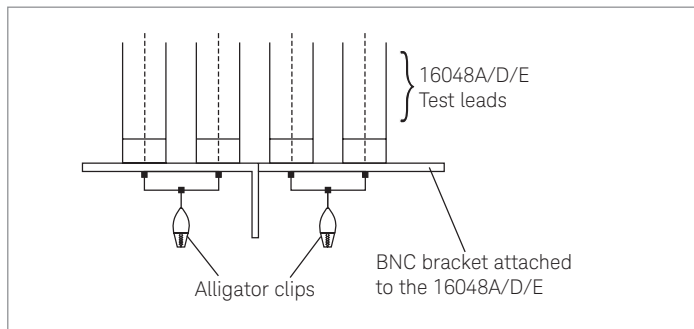
Connections

Figure 1 shows the connections between a liquid crystal cell and the E4980A or 4284A. The liquid crystal cell is in the form of liquid crystals sandwiched between two glass plates which have electrodes installed. In this experimental measurement procedure, the electrodes of the liquid crystal cell are held using alligator clips and a conductive elastomer with the lead wires connected to an 16047C test fixture. (See Figure 1a).

The open/short compensation function is used to eliminate the effects of the lead wires and alligator clips connected to the test fixture, but it is best to keep the length of the lead wires to a minimum for stable and repeatable measurements. If the E4980A or 4284A must be located some distance from the sample cell which, for example, must be placed into a thermostatic chamber, the cables can be extended by 1 m, 2 m, and 4 m respectively using the 16048A/D/E test leads. (See Figure 1b). The E4980A and 4284A provide a correction function for the 16048A/D/E, so that accurate measurement is insured with minimum effects due to extending the cable. (Note that the 16048D/E requires an 4284A Option 006.)



(a) When using the 16047C



(b) When cable is extended

Figure 1. Connection diagrams

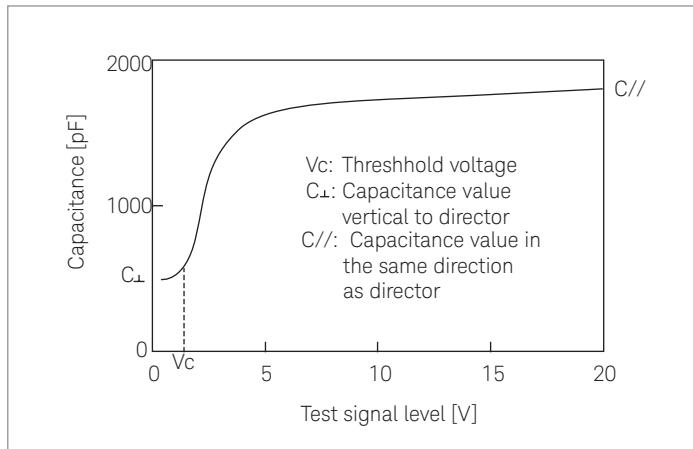


Figure 2. Voltage-capacitance characteristics measurement results

Measurement example

Figure 2 shows voltage-capacitance characteristics of a liquid crystal cell measured using a 4284A Option 001. The graph shows measurement results plotted by an HP 9000 Series 300 Technical Computer System where a 1 kHz test signal was varied from 0.1 V to 20 V in 0.1 V steps. Figure 2 exhibits that the threshold voltage V_c required for obtaining the elastic constants was accurately measured. The test signal voltage can be varied high enough for point $C_{//}$ to be measured accurately. From the measured voltage-capacitance characteristics for a single cell, the following parameters can be determined:

- Dielectric constant when the liquid crystal is oriented vertically to the director (ϵ_{\perp})
- Dielectric constant when the liquid crystal is oriented parallel to the director ($\epsilon_{//}$)
- Splay elastic constant K_{11}
- Bend elastic constant K_{33}

The E4980A with option E4980A-001 can also measure the voltage-capacitance characteristics while varying the test signal voltage from 0 to 20 V rms. A maximum of 201 test signal voltages/currents, frequencies or bias voltages/ currents can be programmed to perform a list sweep measurement. The list sweep measurement function obviates the need for programming the measurement sequence. The measurement data can be saved in removable USB memory device for data logging and for post-processing by an external computer. It is also possible to control the E4980A and extract measurement data over GPIB or LAN.

Conclusion

The wide test signal voltage ranges of the Keysight E4980A and 4284A outperform conventional LCR meters, and contribute to easier measurement for determining the voltage-capacitance characteristics of liquid crystal materials. This will pave the way for efficient evaluation of new liquid crystal materials for new product applications. The bottom line is, the Keysight E4980A and 4284A are powerful tools that will help you decrease your time to market.

Reference

Liquid crystals - Basics, Kohji Okano and Shunsuke Kobayashi, (Tokyo: Baihukan, 1985), pp. 216-220.

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