

# Agilent Measurement of Capacitance Characteristics of Liquid Crystal Cell

Application Note 369-7

Agilent 4284A Precision LCR Meter



Agilent Technologies

## 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 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 4284A

Using the Agilent 4284A precision LCR meter with option 001 provides a test signal level of 20 Vrms, making it 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 the 4284A's test frequency range of 20 Hz to 1 MHz, its basic measurement accuracy of 0.05%, and its 6-digit measurement resolution contribute strongly to your ability to perform highly accurate measurements under diverse measurement conditions. The voltage applied to the material being tested device can be measured using the 4284A's monitoring function to meet accurate measurement requirements.

This application note will guide you in using the 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)

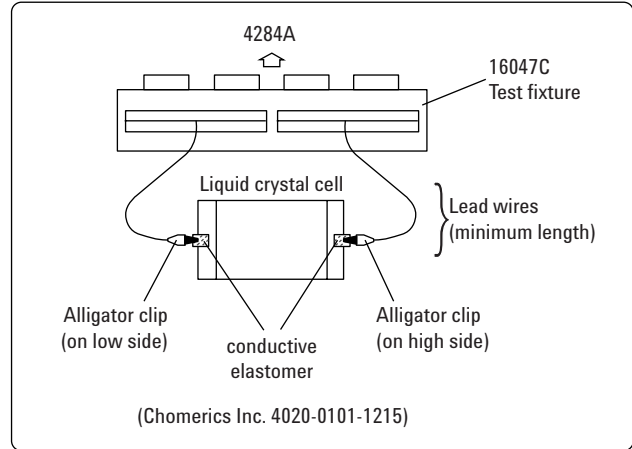
## • Connections

Figure 1 shows the connections between a liquid crystal cell and the 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).

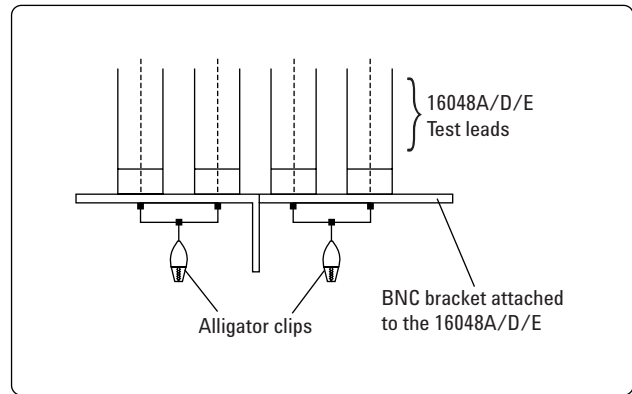
The open/short compensation function is used to eliminate the effects of the lead wires and alligator clips connected to the test fixture, but it is best to keep the length of the lead wires to a minimum for stable and repeatable measurements. If the 4284A must be located some distance from the sample 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 4284A provides 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.)

## • Measurement example

Figure 2 shows voltage-capacitance characteristics of liquid crystal cells measured using an 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 reveals 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. A single cell can be used to determine the dielectric constant when the liquid crystals are oriented vertically to the detector ( $\epsilon_{\perp}$ ) and when they are oriented parallel to the detector ( $\epsilon_{//}$ ), the splay elastic constant  $K_{11}$ , and the bend elastic constant  $K_{33}$  respectively.



(a) When using the 16047C



(b) When cable is extended

Figure 1. Connection diagrams

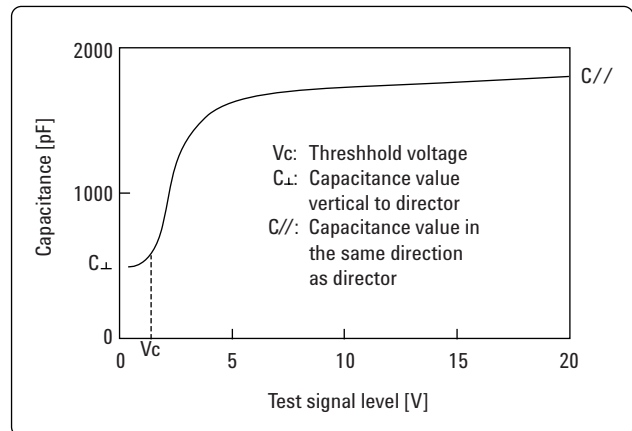


Figure 2. Voltage-capacitance characteristics measurement results

## Conclusion

The Agilent 4284A's wide test signal voltage range outperforms conventional LCR meters, and therefore contributes to easier measurement to determine 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, or the bottom line is, the 4284A is a powerful tool with which you will decrease your time to market.

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

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