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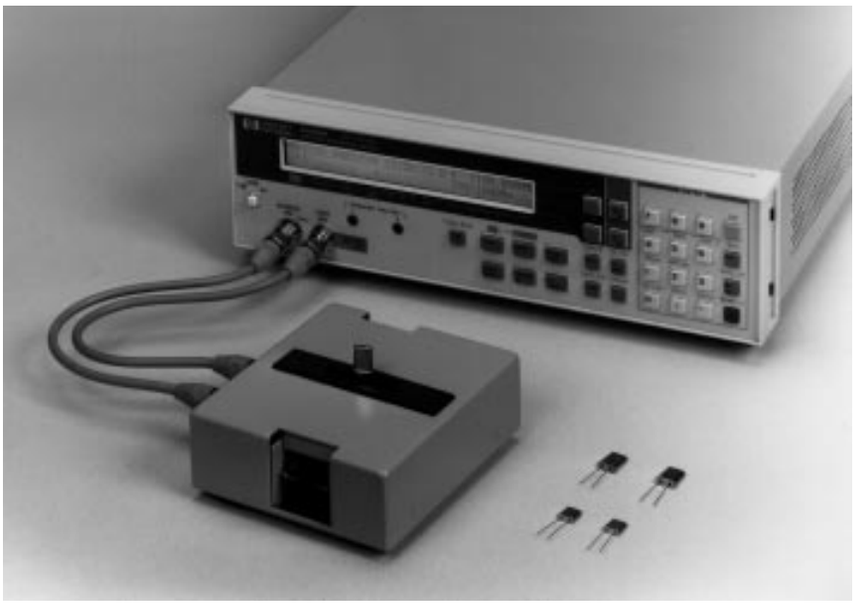
Crystal Resonator Measurements Using the HP E4915A/E4916A

Product Note E4915A/E4916A-1

HP E4915A
Crystal Impedance Meter

HP E4916A
Crystal Impedance/LCR



Introduction

End users want smaller, lighter weight, longer operating time (battery life), and lower price for mobile communication equipment, personal computers, TV games, etc. To meet these consumer demands, the equipment manufacturers place similar requirements on the component manufacturers (including crystal resonator manufacturers).

The crystal impedance (CI) meters currently used in the industry have the following disadvantages:

- They cannot be used at higher frequencies.
- The error margins increase at higher frequencies.
- They have a narrower drive level variable range (so they cannot test at the actual low-power level conditions).
- Errors increase when a smaller load capacitance (CL) is added.
- They have slow test times.

Therefore, it is difficult to satisfy today's crystal resonator measurements using these meters..

The CI meter's disadvantages come from using the oscillation method. To avoid these disadvantages, the transmission method can be used. This is typically done by using a network analyzer.

Because there are now some relatively low cost network analyzers available for crystal resonator production lines, the preferred crystal resonator measurement method is changing from the oscillation method to the transmission method. However, even a low cost network analyzer costs at least twice as much as a CI meter. Therefore, it is still expensive to use network analyzers to test low cost crystal resonators.

This product note introduces a new generation of crystal impedance meters, the HP E4915A/E4916A. These meters can use the transmission PI network method at almost the same cost as conventional CI meters. This note also describes a test solution using these new crystal impedance meters.

Comparing the Oscillation Method and Transmission Method

A conventional crystal impedance (CI) meter consists of an oscillator circuit and a frequency counter. The crystal resonator is actually stimulated by the CI meter. Before beginning measurement, you need to adjust the oscillation level and the circuit's self-oscillation frequency with a resistor that has a similar resistance to the crystal impedance. This adjustment procedure requires technical knowledge and skills. Even if the adjustment is done properly, there can be errors caused by the effect of interior wiring or other test conditions.

The transmission method that the HP E4915A/E4916A employ conforms to the IEC-444 standard. Measurements made using this method apply variable frequencies to the resonator through a PI network and measure the response. To calibrate the meter up to the point where a resonator is actually connected, you only need to connect a known impedance (open/short/load) and press buttons. By calibrating the meter, accurate measurement can be made to high frequencies. The HP E4915A/E4916A automatically searches for the resonant frequency, so you do not have to find the resonance by analyzing the frequency response trace (waveform).

HP E4915/E4916A Product Overview

- A crystal impedance meter that uses the transmission PI network method
- Easy to operate
- Wide frequency range (1 MHz – 180 MHz)
- Fast measurements (125 ms)
- Basic accuracy Fr +/-2 ppm ACI +/-5 %
- Resonant frequency measurement resolution is 0.01 ppm
- PI calibration (Open/Short/Load)
- Equivalent circuit measurements
- Spurious measurements
- Load capacitance (CL) measurements
- Monitor and set the actual power (current) applied to the resonator
- Built-in comparator

How to use the HP E4915/E4916A in crystal resonator production testing

Manual testing:

If the HP E4915/E4916A is used with an HP 41902A PI network test fixture, the following features improve your test quality and efficiency.

- Easy operation using only a few key strokes
- Error-free setting by using the save/recall function
- Easy pass/fail judgments indicated by LED lamps.
- A non-technical person can make accurate measurements
- Fast measurements of 125 ms (at the fastest setting)
- Easy to connect and disconnect the resonator under test using only one hand

Final Testing:

There are many parameters to be tested during final testing. The equivalent circuit function of the HP E4915A/E4916A measures Fr, CI, C0, C1, L1, and R1 simultaneously. The drive level dependency (DLD) function of the HP E4916A displays Fr and CI at every drive level setting. It also displays the differences from the reference level.

Intermediate Test:

Usually intermediate tests only require Fr-CI parameters (not the whole frequency response). Using a network analyzer for this purpose is not economical. By using an inexpensive E4915A/E4916A, the intermediate test can be done at a reasonable test cost. This low cost testing can help improve your resonator's quality.

Frequency adjustment evaporation (HP E4916A only):

The evaporation monitoring (EM) function of the HP E4916A can also improve the frequency adjustment accuracy by using the transmission method. The HP E4916A measures more accurately and faster (even at higher frequencies) than a CI meter using the oscillation method. In the EM function, the HP E4916A repeats measurements at a frequency point and waits until the measured value reaches a preset value. Then the HP E4916A outputs a signal (a pre-defined bit pattern) to the handler interface. You can decrease the evaporation speed or stop evaporation by using this signal.

Temperature Characteristics:

The time required for changing and stabilizing the temperature is longer than the time required to make the measurements. Therefore, it is not economical to use an expensive network analyzer for these tests. However, the inexpensive HP E4915A/ E4916A provides a reasonable test cost. Therefore, you can actually test temperature characteristics and use this information to improve your resonators' quality.

Measurement Procedure Example

Set Up

First connect an HP 41902A economy PI network test fixture to an HP E4915A/E4916A. Then press the Freq key on the HP E4915A/E4916A to enter the resonators' nominal frequency and the range of resonant frequencies to search.

Calibration

First, with nothing connected to the fixture, press the Open calibration button. Next, connect a shorting plate to the fixture and press the Short calibration button. Finally, connect a 50 ohm resistor to the fixture and press the Load calibration button. The shorting plate and the 50 ohm standard resistor are furnished with the HP PI network test fixtures.

Measurement

By connecting a crystal resonator to the fixture after the above procedure, the HP E4915A/E4916A automatically searches for and displays the resonant frequency (Fr) and the impedance at resonance -- the crystal impedance (CI). If you are measuring a device with a very slow response (high Q) resonator, select a longer measurement time setting. When you turn on the equivalent circuit function, applicable values for the C0, C1, L1, and R1 parameters are also displayed (in addition to Fr and CI).

Summary

The HP E4915A/E4916A implements the IEC standard transmission PI network method measurement, which is the same method used by network analyzers. It does this at the same low price as the conventional inexpensive CI meters. The HP E4915A/E4916A can be used in any stage of crystal resonator production, from manual test lines to fully automated lines.

For more information on Hewlett-Packard Test and Measurement products, applications, or services please call your local Hewlett-Packard sales office. A current listing is available via the Web through AccessHP at http://www.hp.com. If you do not have access to the internet, please contact one of the HP centers listed below and they will direct you to your nearest HP representative.

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Printed in U.S.A. 9/96
5965-1363E