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Measurement of Load Resonance Frequency (FL) of Crystal Resonator



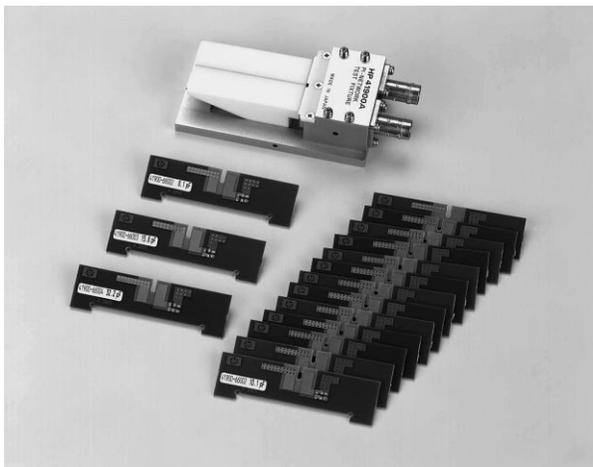
HP E4915A/E4916A Crystal Impedance Meter

HP 41900 π Network Test Fixture

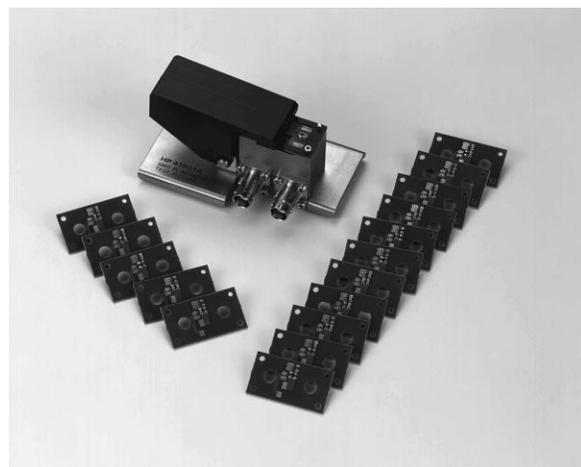
HP 41901A SMD π Network Test Fixture

Product Note E 4915/16-3

May 1998



41900A and CL Boards



41901A and CL Boards

Introduction

Crystal resonators are widely used as key devices in diverse applications such as mobile communications equipment, computers, information terminals and home appliances. Especially in data communications systems, the trend is towards more effective use of frequencies and higher frequency band, with an accompanying shift to smaller crystal resonators and surface mounting. In addition, the demand is ever increasing for lower consumption and lower costs. Several criteria are used to evaluate crystal resonators. These include resonance frequency (Fr), resonance resistance (Rr or CI : crystal impedance), equivalent circuit constants (C0/C1/R1/L1), load resonance frequency (FL), drive level dependency

characteristics (DLD) and temperature characteristics. Of these criteria, this report describes existing problems in measuring load resonance frequency (FL) and introduces a new solution to measurement problems.

What is load resonance frequency (FL)?

A crystal resonator has two frequencies with zero phase near resonance frequency. The lower one is called the resonance frequency (Fr) and the higher one anti-resonance frequency. When a crystal resonator is actually mounted on a circuit board, a load capacitance (CL) is connected in series or in parallel. There are still two frequencies with zero phase, but in general, the lower frequency will be higher compared with the

frequency when no CL is connected. The increase in frequency depends on the CL. This lower frequency when a CL is connected is called the load resonance frequency (FL). Since a crystal resonator is used in the actual circuit with a CL connected, the FL is an important parameter and thus it is specified without fail in the specifications of crystal resonators.

Meaning of terms

Fr: Resonance frequency. A crystal resonator has two frequencies with zero phase near the resonance frequency; the lower one is called the resonance frequency (Fr).

FL: Load resonance frequency. When a load capacitance is connected in parallel with a

resonator, the lower frequency in zero phase is called load resonance frequency (FL).

Rr/CI: Resonance resistance. The resistance at resonance frequency. It is also called CI (crystal impedance).

RL: Load resistance. The resistance at load frequency when a load capacitance is connected in series with a crystal resonator.

CL: Load capacitance

Problems in measuring the load resonance frequency (FL)

To measure load resonance frequency (FL), a load capacitance (CL) is required. Usually, the CL has a trimmer (to change CL values). Using a trimmer to adjust CL values entails the following problems:

- An LCR meter and other devices are required for adjusting the CL to a target value. The capacitance is measured directly by using the meter. If the accuracy of this LCR is not good enough, the measurement accuracy of this LCR value is adversely affected, consequently causing resonance frequency deviation and other problems.
- The adjustment with the trimmer is performed manually, so the CL value may change depending on the operator or each time it is adjusted.
- The CL value may fail to retain a constant value owing to mechanical vibration or loose trimmer.

Proposal from HP

If you see the HP 41900A π Network Test Fixture (lead type) or HP 41901A SMD π Network Test Fixture (SMD type) in

combination with a CL board with a fixed C, all those problems will be resolved. In other words, errors in trimmer adjustment or errors caused by stray capacitance can be reduced and load resonance frequency (FL) can be measured in a simple manner.

The CL board with a fixed C does not have a trimmer. CL boards with about twenty different values of fixed C are available.

16 types for 41900A:

32/24/20/18/16/14/13/12/11/10/9/8/
7/6/5.5/5

22 types for 41901A:

32/24/20/18/16/14/13/12/11/10/9/8/
7/6/5.5/5/4.6/4.3/4/3.6/3.3/3

(The numbers in the parentheses mean nominal CL values. The unit is [pF]).

The CL value of each board is marked on each CL board. This CL value is a value obtained by adding a stray capacitance of the fixture to the C value of the CL board measured by the HP's LCR meter (e.g. 16.4 pF). Thus, each board has its own such value. For example, individual boards of the same nominal CL value of 12 pF may have different values such as "12.2 pF" or "11.8 pF".

For the CL values that are not available (e.g. 15.0 pF, 10.0 pF), corrected values are calculated through a function built in the meter (target capacitance trimming function). A CL board having a CL value nearest the target CL value should be used. Corrective calculation gives only FL values. Since the RL correcting function is not provided, RL is not displayed when a CL value is being trimmed.

Characteristics of CL board with fixed C

(1) *Fewer error factors than with conventional ones*

- With a fixed C attached, it is free from troubles where the CL value changes during adjustment with the trimmer depending on operators or each time adjustment is made.
- Since no trimmer is attached, it is possible to avoid troubles where the C value changes owing to mechanical vibration or the CL value cannot be retained because of a loose trimmer.

(2) *Easier to use than the CL with trimmer*

- Since the CL board with a fixed C has a fixed CL value, an LCR
- Since a board with a fixed C is used, bothersome work of attaching the trimmer and C chip is eliminated.
- Adjustment with the trimmer can be omitted.
- Measurement becomes simple to do. (See "Measurement method using E4915A/E4916A".)

Measurement method using E4915A/E4916A

(1) Items to be prepared
E4915A/E4916A (FW Rev.2.10 or later), π network fixture (41900A or 41901A), CL board with fixed C.

Note: Be sure to select a CL board with a CL value nearest the target CL value. The larger the difference between the target CL value and the CL value of the CL board, the larger the error of the calculated FL value.

Example: When CL boards of 9.2 pF, 10.1 pF, 24.2 pF and 32.1 pF are available:

Ex 1: If you want 10 pF of measurement result, use the 10.1 pF CL board.

Ex 2: If you want 30 pF of

measurement result, use the 32.1 pF CL board.

(2) Measurement procedure

An example of measuring the FL value with a 12 pF load is used in this explanation. A CL board of 12.2 pF is used here.

1. Set the measurement conditions. (Type of π network fixture, nominal frequency, nominal CL, voltage application level, measurement speed, etc.)
2. Open/Short/Load corrections
3. Select the measurement parameters ("Ftrim") for activating the target capacitance trimming function.
4. Set the target CL value and the actual CL value.
Example: Set to 12 pF for the target CL value and 12.2 pF for the actual CL value.
5. Mount the CL board and the resonator on the π network fixture.

Through the above operation, the results of corrective calculation of FL value with 12 pF loading can be obtained from actual measurement value with 12.2 pF loading. (RL is not displayed.)

Ordering information

HP 41900A π Network Test

Fixture

Standard:

CL boards with fixed C (16 boards), calibration standard (50 Ω , short)

Optional:

001 Variable Load Capacitor Adapter Kit

Note: CL board with trimmer (1 board), SMD capacitor are included.

HP 41901A SMD π Network Test Fixture

Optional:

010 Attachment Kit :

QIAJ-QS06, 4 terminals

020 Attachment Kit :

QIAJ-QS06, 2 terminals

030 Attachment Kit :

QIAJ-QS07, 4 terminals

040 Attachment Kit :

QIAJ-QS07, 2 terminals

050 Attachment Kit :

QIAJ-QS08, 4 terminals

060 Attachment Kit :

QIAJ-QS08, 2 terminals

Note: The following items are included in the above options 010 through 060. CL boards with fixed C (22 boards), contact board (1 board), device positioning plate (1 plate), calibration standard (50 Ω)

If you need conventional variable load capacitance boards (CL with trimmer), you must place an order, combining the above options with the options below.

011 Variable Load Capacitor

Adapter Kit :

QIAJ-QS06, 4 terminals

021 Variable Load Capacitor

Adapter Kit :

QIAJ-QS06, 2 terminals

031 Variable Load Capacitor

Adapter Kit :

QIAJ-QS07, 4 terminals

041 Variable Load Capacitor

Adapter Kit :

QIAJ-QS07, 2 terminals

051 Variable Load Capacitor

Adapter Kit :

QIAJ-QS08, 4 terminals

061 Variable Load Capacitor

Adapter Kit :

QIAJ-QS08, 2 terminals

Note: The following items are included in the above options 011 through 061. CL board with trimmer (1 board), SMD capacitors

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