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Proceedings of Symposium on Ultrasonic Electronics, Vol. 34 (2013) pp. 257-258
20-22 November, 2013

"1612" Precision Test Fixture for Measuring Equivalent Circuit Parameters of Quartz Crystal Units

高精度 1612 フィクスチャによる水晶の等価パラメータ解析

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1. Introduction

We describes improvements in deveped a 1612-type (1.6 x 1.2 mm) precision test fixture for measuring equivalent parameters of quartz crystal units.

Previously, the equivalent constants of miniature quartz resonators were measured using methods such as π-network and crystal impedance (CI) meter methods.[1] In these two types of methods, "equivalent constants" may be equivalent parameters of resonance frequency and the Butterworth–Van Dyke model constants.[2] In fact, since commercial production of quartz resonators began, their size has been decreasing yearly.[3] Compared with the 1612-type fixture, a 3225-type one seems very large[4,5]; therefore, detailed design phase is needed.

2. Measurement System

1. Previous systems:

Figures 1(a) and **(b)** show a 3225-type quartz crystal unit (3.2 x 2.5 mm) and a 2016-type one (2.0 x 1.6 mm), respectively.

The circuit is a coaxial network with a 65-GHz bandwidth, 1.85-mm diameter, and ϕ 0.803-mm pin. The electrical length (connector end to device) is 0.3 mm.[5,6]

2. New system:

Figures 2(a) and (b) show a schematic of a 1612-type device mount adapter and its dimensions. In the case of this Fig. 2(a), the 3225-type of the areas is added. The center of the electrode at the bottom of the (DUT) comes into contact with the coaxial center pin. It is understood that the previous width of the pin and diameter was extremely thick. Therefore, a special feature of the circuit is a coaxial network with a 110-GHz bandwidth and 1.00mm diameter, ϕ 0.434-mm pin and 0.28-mm electrical length.

3. Experimental Results

The experimental setup is shown in **Fig. 3**. The DUT is located at the standing wave ratio (SWR) bridge. This setup is used for conventional zero-phase measurement of most resonator devices.

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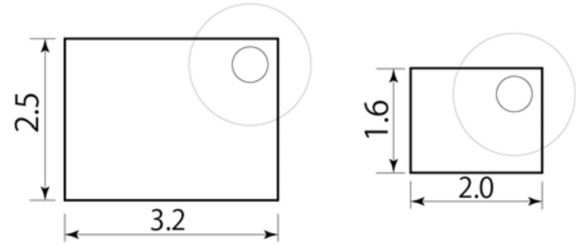
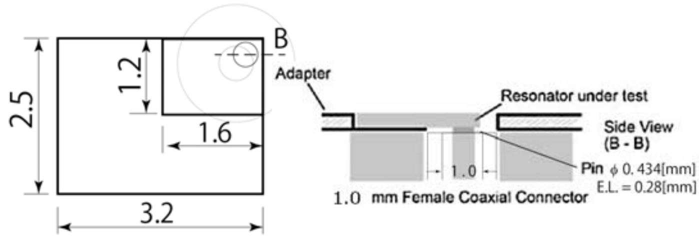


(a) 3225-type (b) 2016-type

Fig. 1 Previous 3225- and 2016-types units



(a) 1612-type (b) 1.0 mm coaxial connector

Fig. 2 New 1612-type quartz crystal unit and 1.0-mm coaxial connector

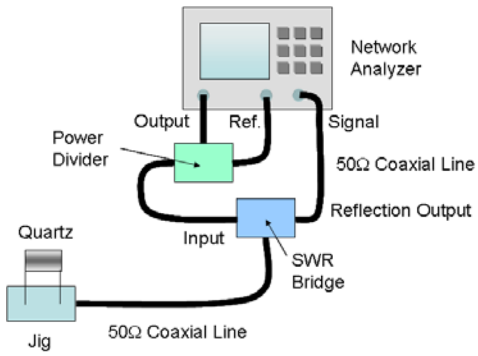


Fig. 3 Experimental setup

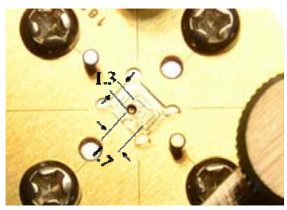


Fig. 4 Schematic of proposed test fixture

A cesium beam frequency standard (5 x 10^{-13}) was used to stabilize the frequency. **Figure 4** shows a schematic of the 1612-type device mount adapter.

Figure 5 shows the experimental frequency temperature characteristics from 23 May 2012 to 8 June 2012. The resonant frequency was about 48 MHz. The results in Fig. 5 indicate that long-term stability can be suppressed in an ignorable range. This frequency is correct in which the electrical length is 0.28 mm at 48 MHz[4].

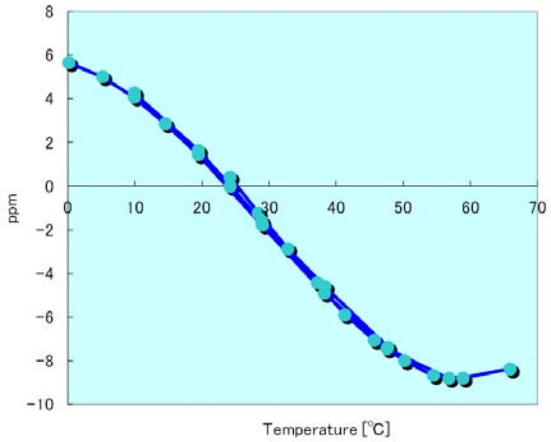


Fig. 5 Frequency temperature characteristics (f_s = 48MHz, From 2012/5/23 to 2012/6/8.)

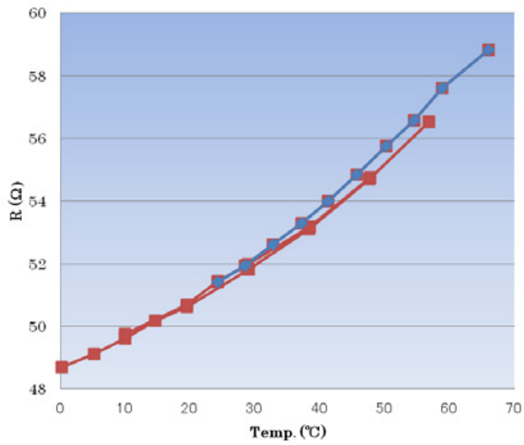


Fig. 6 Equivalent series resistance vs. temperature (f_s = 48MHz, From 2012/5/23 to 2012/6/8.)

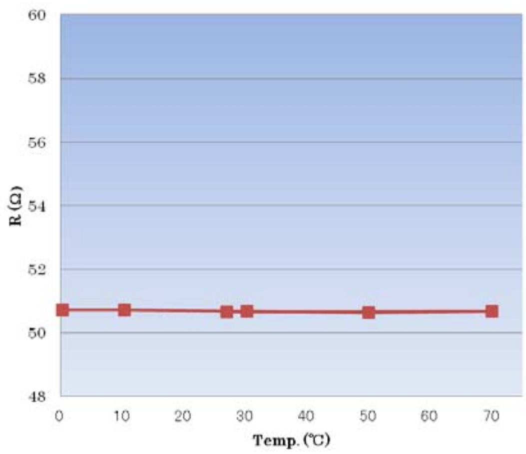


Fig. 7 Fixed resistor

Figure 6 shows the equivalent series resistance vs. temperature characteristics. The equivalent resistance gradually increase in temperature by 48.7 Ω/0°C from 58.7 Ω/66°C. This will limit piezoelectric performance, i.e., series resistance or measurement error.

Figure 7 shows the resistance vs. temperature characteristics with a fixed resistor of 50 Ω which is equal to the series resistance of the crystal unit. We found only 50.68 Ω ±0.02 Ω in this figure. Therefore, it can be said that measurement error is impossible.

4. Conclusion

We developed the 1612-type precision test fixture for measuring equivalent parameters of quartz crystal units. The frequency temperature characteristics are correct, but the equivalent resistance gradually increases in temperature. This will limit piezoelectric resistance/performance. In the near future we will be able to put an end to piezoelectric resistance/performance.

Acknowledgment

This work was partially supported by the 2012 Industry Supporting Program of Ministry of Economy, Trade and Industry (MITI), New Energy and Industrial Technology Development Organization (NEDO), and IEC TC49 Japan National Committee.

The authors also thank K. Kato of Kawashima Manufacturing Inc. for providing the test fixture. The authors thank M. Wada from NDK Inc., M. Hattori from EPSON Inc., Y. Sakuta from the Nihon University and O. Takahashi from Showa Shinku Inc. for their valuable feedback on this work.

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