

Precision Test Fixture for Measuring Equivalent Circuit Parameters of GHz Surface-Mounted Quartz Crystal Units

GHz 帯表面実装共振デバイス電気等価定数評価のための高精度測定用具

Yasuaki Watanabe^{1†}, Manabu Wada², Yukinori Sakuta³, Masashi Hattori⁴, Osamu Takahashi⁵ (¹T.M.U.; ²NDK; ³Nihon Univ.; ⁴Epson; ⁵Showa Shinku)
渡部 泰明^{1†}, 和田 学², 作田 幸憲³, 服部 雅史⁴, 高橋 理⁵
(¹首都大, ²日本電波, ³日大, ⁴エプソン, ⁵昭和真空)

1. Introduction

A coaxial type fixture for precisely measuring the impedance characteristics of small size surface-mounted quartz crystal units has been developed¹⁻³⁾. This fixture is compliant with one-port S-parameter reflection method in IEC60444-5²⁾, and measures the frequency impedance characteristics of a device under test from its reflection coefficients.

This measurement fixture uses a 65 GHz coaxial connector and calibrators with 1.85mm inside diameter. Using a “zero-length” coaxial center pin method, this fixture can apply up to 10 GHz devices without the electrical length compensation.

2. Experimental Setup

Figure 1 shows a schematic of the device-mount-adapter (SMD) and is a 3225 type. The center of electrode on the bottom side of device under test contacts the coaxial center pin.

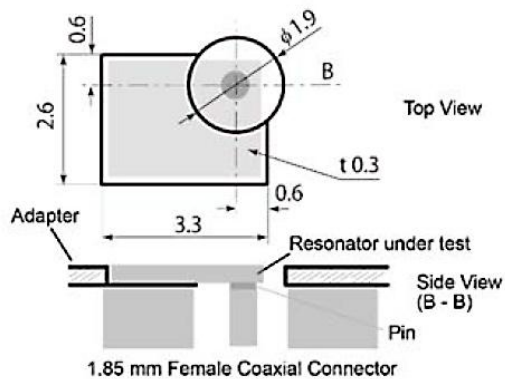


Fig. 1: Schematic of proposed test fixture.

y.watanabe@iecc.org

Since the length of the pin to the electrode is less than 0.3 mm, the parasitic inductance of the pin can be ignored up to 10 GHz.

The experimental setup is depicted in Fig. 2. The device under test (DUT) located the standing wave ratio (SWR) bridge. This setup is the conventional a zero phase measurement setup used to measure the zero phases of most resonator devices.

If the matched impedance is connecting terminal, the output power is adjusted to coincide with -20 dBm for the maximum power. In this method, coaxial open-circuit, short-circuit, and resistive terminations designed for 50 Ω system are prepared for detecting zero-phase at the end of the adapter.

A Cesium beam frequency standard (5×10^{-13}) used to stabilize the frequency. The temperature is controlled $23 \pm 1^\circ\text{C}$.

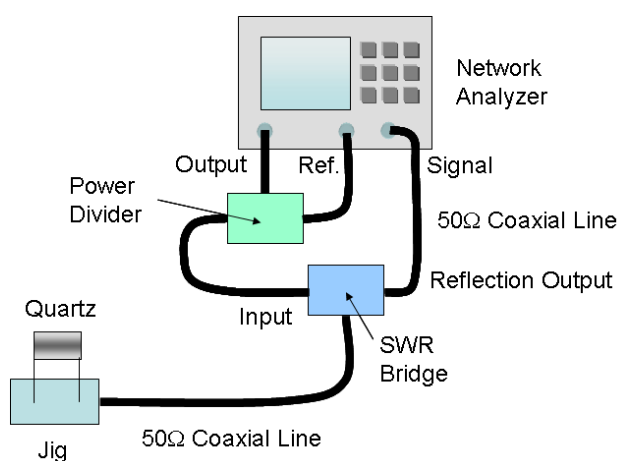


Fig. 2: Experimental setup.

3. Result

Table I shows the equivalent zero-frequencies and zero-impedances (Agilent

E4991A 1 MHz ~ 3 GHz, RF impedance / Material analyzer, Agilent 16092A Spring clip fixture; Electrical length = 3.4 [mm]), and are 10 MHz, 155 MHz and 670 MHz AT-cut resonators. This is considered the most reliable to date.

TABLE I

Zero Frequencies and Zero Impedances.

F_s [MHz]	9.999 053(7)	154.782 119	669.607 057
R_s [Ω]	64.20	11.90	22.65

Figure 3 shows an experimental result of the reflection signal when a standard termination was connected to the fixture head.

The reflection level was under -40 dB in the range from 40 MHz to 10 GHz. This result indicates that the proposed fixture has a remarkable potential in the wideband.

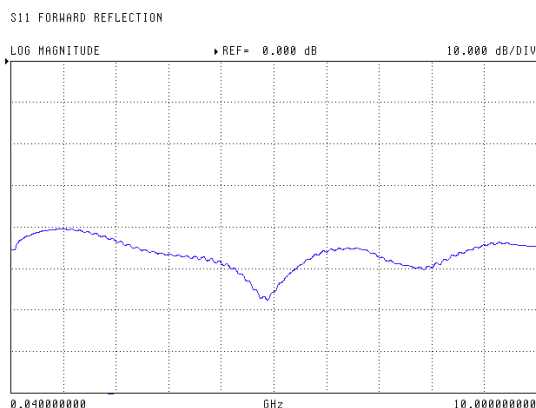


Fig. 3: Reflection characteristics of termination.

Table II shows the equivalent zero-frequencies and zero-impedances of the proposed fixture. For each device, the test fixture is accurately-calibrated (open-circuit, short-circuit and 50Ω), and measures in three times.

An important point here, the impedance of the 10 MHz has deviations of 12 %. This is an error because the band width (sweep bands) is 1 MHz of TABLE I at the 10 MHz.

On the 10 MHz quartz resonator and the

RF impedance / material analyzer were -0.3 ppm of the frequency deviation and $+12$ % of the impedance. In a similar way, 155 MHz quartz resonators were $+0.076$ ppm and -1.1 %, and 670 MHz were -0.98 ppm and -1.2 %.

On the contrary, the proposed test fixtures were ± 0.54 ppm of the frequency deviation and ± 0.06 % of the impedance, respectively. These values endure evaluating¹⁾.

TABLE II

Zero Frequencies and Zero Impedances.
Each measurement in three times.

F_s [MHz]	9.999 0567	154.782 154	669.606 208
δ/f_0 [ppm]	0.019	0.083	0.54
R_s [Ω]	52.26	10.77	21.46
$\delta R_s/R_s$ [%]	0.05	0.06	0.05

4. Conclusions

The proposed test fixture and existing impedance analyzer have been compared with the quartz crystals of 10 MHz, 155 MHz and 670 MHz. They are close to match excluding the impedance of 10 MHz.

In the future, we expect to converge this fixture to 0.1 ppm of the frequency deviation, and to 1 % of the impedance of the errors.

Acknowledgment

This work was partially supported by the 2010 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.

References

- IEC60444-1, Measurement of quartz crystal unit parameters by zero phase technique in a π -network (1986).
- IEC60444-8, Test fixture for surface mounted quartz units (2003).
- IEC60444-5, Methods for the determination of equivalent electrical parameters using automatic network analyzer techniques and error correction (1995).