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Simulation of Temperature Compensation for SC-cut Oscillators using B-mode

B モードを利用した SC カット発振器の温度補償シミュレーション

Ryo Haga[†], Rifwa Hayashi, Yosuke Hanada, Takayuki Sato, Yasuaki Watanabe
(Tokyo Metropolitan Univ.)
芳賀　良，花田洋輔，林　里花，佐藤隆幸，渡部泰明（首都大学東京）

1. Introduction

The SC (Stress compensated) cut is a generic name for a family of bulk wave cuts that are compensated by higher order elastic effects to minimize problems that exist in more common crystal cuts[1,2,3].

The experimentally determined orientation is (θ, ϕ) = (21.93° , 33.93°) , as shown in Fig. 1[4]. And θ direction reduces it or, as for the rotation to the other direction, it can remove stress seen with AT cut resonator because the quartz crystal has anisotropy.

The SC cut provides compensation for thermal transient, planar stress effects and improved phase noise performance that is used as super high - stable crystal oscillators (Oven Controlled Xtal Oscillators) including the portable base station.

On the other hand, spurious frequency called steep B mode of the temperature characteristic is on the SC cut. The resonance resistance of B mode is approximately equal to the main resonance, and it is a well-known fact that there is in a resonance frequency in approximately 1.1 times of the main vibration [4].

At first it enforced whether it could be used for temperature sensor about B mode by the simulation. If TCXO (Temperature Controlled Xtal Oscillators) that uses the SC cut becomes a mainstream, the current consumption is minute, and the negative environmental impact becomes few oscillators on the world scale. The frequency stability of C mode aims at ±1ppb.

2. Temperature Characteristics of the SC cut Resonators

Figure 2 and Figure 3 show the frequency characteristics of the SC cut resonators and the temperature characteristics.

In Fig. 3, it has a gradual characteristics in the C mode and has extreme slope in the B mode.

In other times, NL cut (what's called New Linear) [5] had already existed, but because near-by spurious resonances were existed. The Lagrange interpolation was used here to be similar at temperature - frequencies of C and B modes in the SC cut.

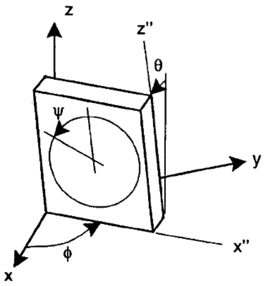


Fig. 1 Azimuth of the SC cut resonator [4]

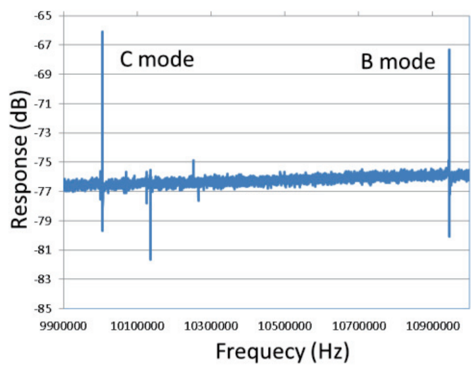


Fig. 2 Frequency characteristics of the SC cut resonators

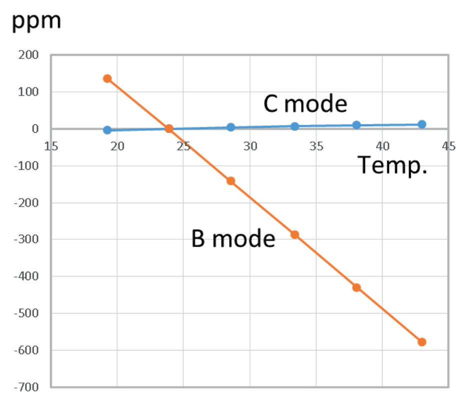


Fig. 3 Temperature characteristics of the SC cut resonators

E-mail address: ryohaga0821@gmail.com

3. Block Diagram using SC-cut

Figure 4 made the circuit schematic which was finally targeted block diagram, and it used Matlab Simulink / LTspice simulations. It is assumed that C mode frequency is 10MHz, and B mode is 11MHz, respectively. Each mode is separated by a filter and is formed a standard of in B/C. The C mode is designed as a frequency standard, and therefore B mode will have temperature information. At first block diagram shown in Fig. 5 was analyzed, and it confirmed whether a circuit worked tightly.

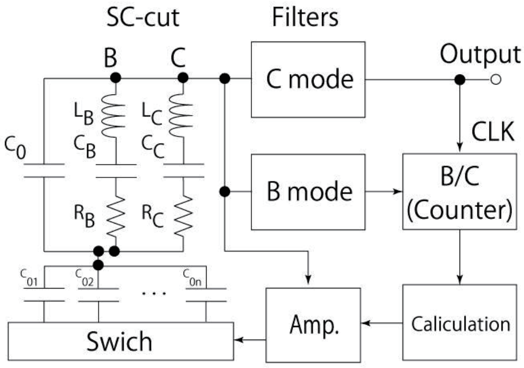


Fig. 4 Block diagram using the SC cut resonator

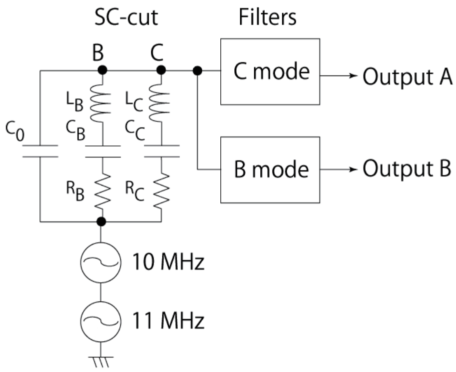


Fig. 5 Circuit element which becomes most basic.

4. Simulation

Figure 6 described the simulation frequency characteristic by C mode and the B mode, and understands that it is correct in comparison with Fig. 2.

Figure 7 (a), (b) is the result that FFT (First Fourier transform) performed of the output of each filter. From these, it understands that each filter processes it appropriately.

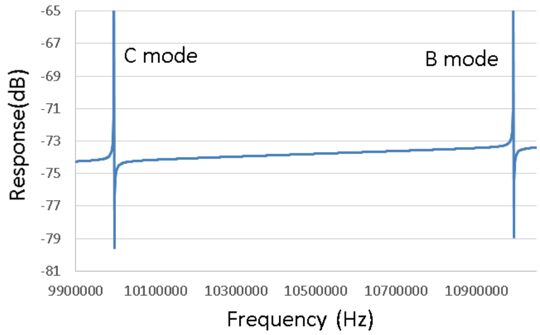
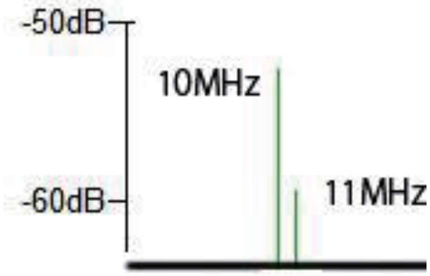
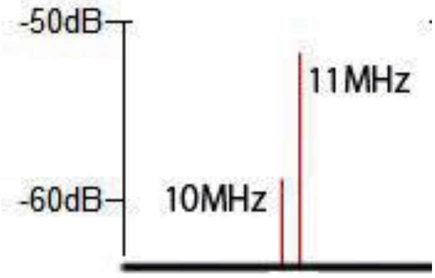


Fig. 6 The SC cut resonator by the simulation



(a)



(b)

Fig. 7 Simulation results. (a) 10MHz. (b) 11MHz.

5. Conclusions

The simulation of temperature compensation for the SC-cut oscillators have been developed. We need to advance research related to Fig. 5 on “Calculation”, “Amplifier” and “Switches”.

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