A BLEUSTEIN-GULYAEV-SHIMIZU WAVE RESONATOR HAVING RESONANCES FOR TV AND VCR TRAPS

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ABSTRACT

A Bleustein-Gulyaev-Shimizu (BGS) wave has only a shear horizontal (SH) wave showing a complete reflection at a free edge of a substrate. In this paper, using the responses exited by a weighted interdigital transducer (IDT) and generated by the 2N±2th mode complete reflections at free edges of a ceramic substrate, we realized a new type of BGS resonator having three resonances without reflector electrodes. This resonator showed sufficient trap attenuations for practical use at both adjacent picture carrier frequency (fap) and adjacent sound carrier one (fas) in the TV・VCR VIF (video intermediate frequency) circuit.

INTRODUCTION

A Bleustein-Gulyaev-Shimizu (BGS) wave propagating on a piezoelectric ceramic substrate polarized parallel to its surface has only a shear horizontal (SH) displacement. The SH wave shows a complete reflection at a free edge of the ceramic substrate[1-2]. A Rayleigh surface acoustic wave (SAW) type resonator requires reflectors with a lot of fingers as shown in Fig.1(a). While, by utilizing this reflection of the BGS wave at the free edges, a very small resonator without reflector electrodes is realized as shown in Fig.1(b). So far, the BGS wave resonator using the ceramic substrate has not been investigated for practical applications because of the difficulty of poling the large ceramic substrate in parallel to its surface and a large deviation in the ceramic material quality.

We have succeeded in solving these problems and developing the free edge reflection type BGS wave resonator with only one resonance using ceramic substrate for the first time in the world, which was characterized by its super miniature (≦1×1×0.5mm), wide band (≧5%) and frequency-tuning-free in 20 to 160 MHz[2-3]. The BGS wave resonators in 30 to 47 MHz, at present, have been widely used as additional trap resonators in video intermediate frequency (VIF) circuits of TV and VCR (VTR) sets taking the place of LC resonators[2]. The additional trap is effective especially in the Europe sets where TV channels are so close and the US sets where have a lot of CATV channels in order to avoid the influence of adjacent picture carrier fap and adjacent sound carrier fas. Two kinds of trap resonators are required for the additional traps at fap and fas as shown in later-mentioned Fig.12. At present, these two kinds of resonators are separately designed, produced and supplied to the market.

The above-mentioned BGS resonator using the free edge reflections has only one resonance without spurious responses. In this paper, applying responses generated by a weighted interdigital transducer (IDT) and by 2N±2th mode reflections at the free edges, we propose a resonator with three resonances for both the fap and fas traps.

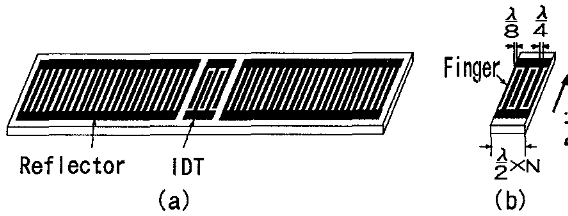

Fig.1 (a)Rayleigh SAW resonator with reflector electrodes and (b)BGS wave resonator utilizing free edge reflections.

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A BGS WAVE RESONATOR WITH ONLY ONE RESONANCE USING FREE EDGE REFLECTIONS

A BGS wave resonator with one resonance utilizing the free edge reflections has a normal IDT with fingers of width $\lambda/8$ and $\lambda/4$ (λ is a wavelength of IDT) as shown in Fig.1(b). The distance L between the two edges must be $N\times\lambda$ (N is a finger-pairs' number of IDT). Figure 2(a) shows a frequency spectrum of the resonator with N finger-pairs normal IDT. With this device, the odd modes (2N$\pm$1,3,5,••••th modes) and the even modes (2N $\pm$2,4,6,••••th modes) are not excited by the IDT because the odd modes are canceled by the IDT's symmetry and the even modes are coincident with the null response frequencies of the IDT. Therefore, the fundamental resonant frequency of the resonator is generated only the 2Nth mode as shown in Fig.2(b)[1-2]. When the distance L between the two free edges is different from $N\times\lambda$, the even mode responses are generated because their frequencies are away from the null response frequencies of the IDT spectrum as shown in Fig.3. Figure 4 shows an example of frequency characteristic which the even mode responses are

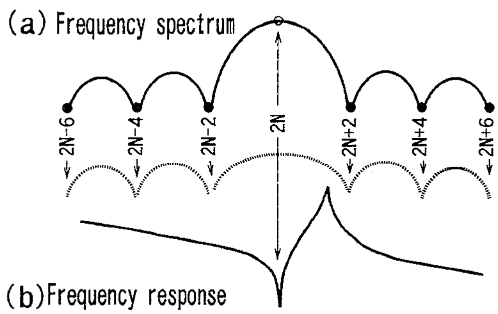


Fig.2 Frequency spectrum and characteristic of a free edge reflection BGS wave resonator with only one resonance.

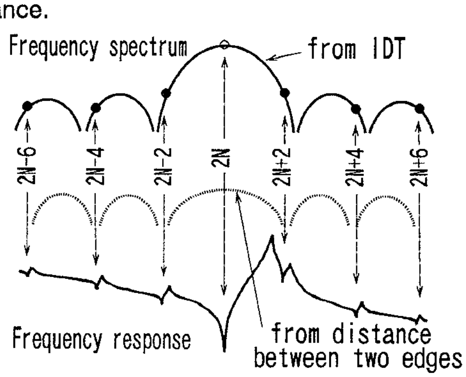


Fig.3 Principle which the even mode responses are generated because of $L\neq N\times\lambda$.

generated because of $L\neq N\times\lambda$ ($L=N\times\lambda+\lambda/10$). In this figure, the 2Nth mode of main response is 48.3 MHz, and the even mode 2N-2th and 2N-4th responses are 45.4 and 43.0 MHz, respectively.

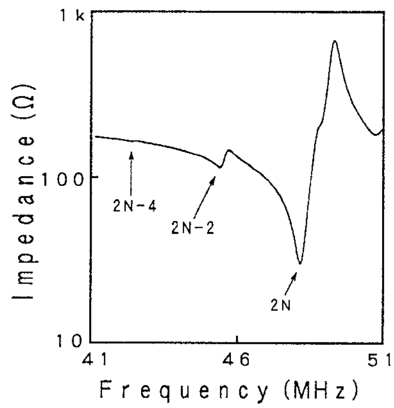


Fig.4 Example of frequency characteristic which the even mode responses are generated because of $L\neq N\times\lambda$ ($L=N\times\lambda+\lambda/10$).

ONE BGS WAVE RESONATOR WITH THREE RESONANCES

The frequencies of fap or fas in the VIF circuits are fap=31.9 and fas=40.4 MHz in the Europe PAL system, and fap=39.75 and fas=47.25 MHz in the US NTSC system. There exist a color carrier fc, a picture carrier fp and a sound carrier fs between fap and fas as shown in Fig.12. The resonator with two or three resonances for the fap and fas traps, is also required to generate no spurious responses in this range. In this paper, we investigated a new type of resonator with three resonances for both fap and fas using BGS wave.

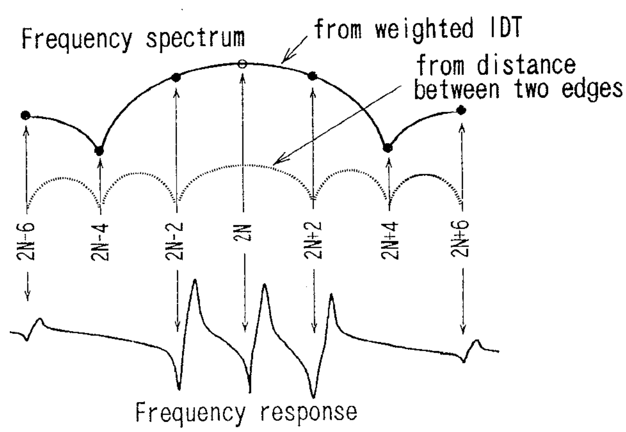
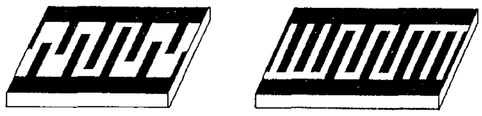


Fig.5 Principle in order to realize a resonator with three resonances using BGS wave.

Figure 5 shows a schematic illustration of the principles in order to realize a BGS wave resonator with three resonances. The solid and broken lines show frequency spectra obtained from the weighted IDT and determined from the distance L between two edges, respectively. Though the 2N±4th mode responses are canceled because they are coincident with the null responses of the IDT's spectrum shown in solid line, the 2N±2th and 2N±6th mode responses are generated because they are not coincident with the null responses. Figure 6 shows examples of an apodized and a



(a)Apodized IDT (b)Withdrawal IDT

Fig.6 Examples of (a) apodized and (b) withdrawal IDTs to realize a resonator with three resonances.

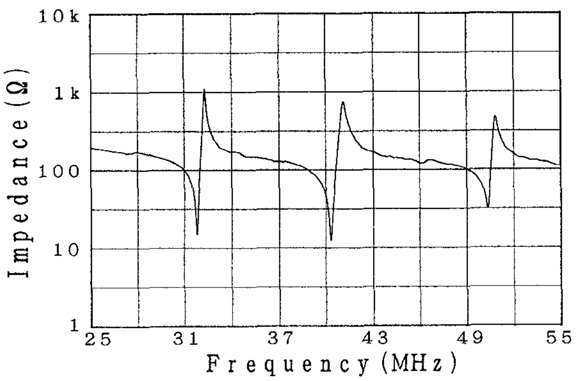


Fig.7 Frequency characteristic of the BGS resonator with three resonances fabricated by the apodized IDT.

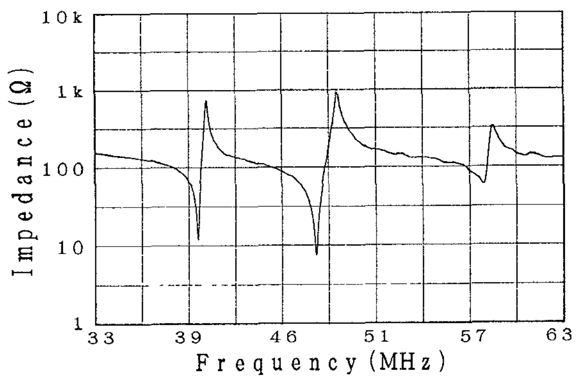


Fig.8 Frequency characteristic of the BGS resonator with three resonances fabricated by the withdrawal IDT.

withdrawal IDTs based on this principle. Figures 7 and 8 show impedance characteristics of the BGS wave resonators for the PAL system made with the apodized IDT and for the US NTSC system made with the withdrawal IDT, respectively. In both characteristics, the resonant frequency corresponding to the fas trap is the 2Nth mode's main response of the weighted IDT, and the frequencies corresponding to the fap trap and appeared above the fas trap are the 2N−2th and 2N+2th mode responses generated by the reflections at the free edges, respectively.

APPLICATION TO TRAP DEVICES

The resonators shown in Figs.7 and 8 were evaluated as the additional trap at fap and fas in the simple test circuit shown in Fig.9(a). Figures 10 and 11 show the results of the resonators for the PAL and the US NTSC systems, respectively. The trap attenuations are 18 dB at fap and 21 dB at fas for the EC PAL system, and 19 dB at fap and 24 dB at fas for the US NTSC system as shown in their figures. The attenuation values of the devices are large enough for practical use as the additional trap resonators. Figure 12 shows the test result in the TV・VCR VIF circuit for the PAL system shown in Fig.9(b). The broken and solid lines show the characteristics without and with the additional trap resonator, respectively. Comparing two lines, the trap attenuations are improved by 12 dB at fap and by 15 dB at fas simultaneously in one resonator without varies of attenuation at fc and fp.

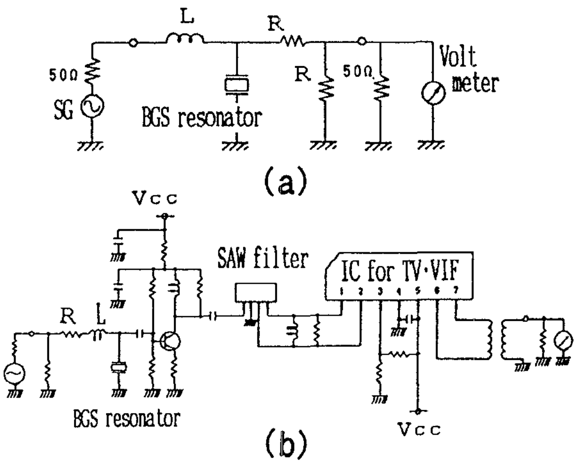


Fig.9 Test circuits of the trap resonator: (a)Simple circuit and (b) VIF test circuit.

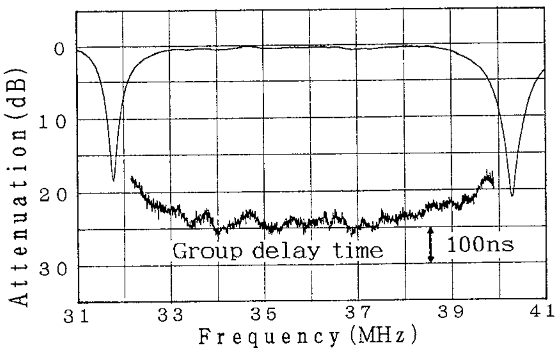


Fig.10 Frequency characteristic of the BGS resonator with resonances due to the apodized IDT in the test circuit shown in Fig.9(a).

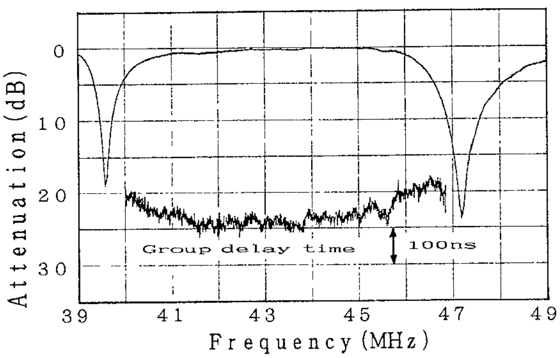


Fig.11 Frequency characteristic of the BGS resonator with resonances due to the withdrawal IDT in the test circuit shown in Fig.9(a).

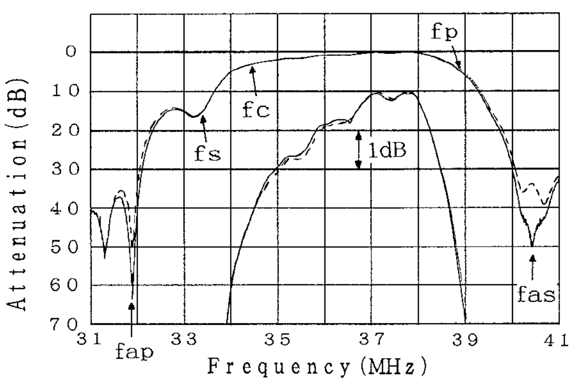


Fig.12 VIF frequency characteristics in the VIF test circuit shown in Fig.9(b).
(broken line: without the BGS wave resonator, solid line: with the BGS wave resonator)

CONCLUSION

We have developed the new BGS wave resonator with three resonances by using responses excited due to the weighted IDT and generated due to the 2N±2th mode reflection responses at free edges of substrate. For the EC PAL system the trap attenuations are 18 dB at fap and 21 dB at fas, and for the US NTSC system they are 19 dB at fap and 24 dB at fas. It is confirmed that this resonator satisfied the sufficient attenuations for practical use both at fap and fas in the TV・VCR VIF circuits.

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