V-3

MINIATURE SAW ANTENNA DUPLEXER FOR PORTABLE TELEPHONE

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Summary

A new low loss and high power SAW filter for an antenna duplexer used in a portable telephone transceiver was developed. Loss as low as 1.0 ~ 1.2 dB and output power as high as 2 watts at 800 MHz were achieved. Experimental results of a miniature duplexer employing this filter were also presented.

Introduction

A portable telephone (cellular radio) requires not only high performance but also miniature devices.[1] SAW technologies are worth noticing due to its small device size compared with conventional technologies.[2]

As shown in Fig. 1, an antenna duplexer consists of transmitter and receiver filters connected in parallel via appropriate transmission lines. Low loss and high power characteristics are required for the transmitter filter, while low loss and high sidelobe suppression for receiver filters. In a conventional duplexer, each filter is constructed with 4 ~ 7 cascade-connected semi-coaxial resonators containing high dielectric ceramics.

In this paper, a new low loss and high power SAW filter at 800 MHz was described. Experimental results of a miniature duplexer employing the new filter as for a trasmitter filter and the previously published high performance SAW filters as for receiver filters were also presented.

Such duplexer contained the low noise amplifier as well as receiver second filter within it. The transmitter second filter which was also constructed with SAW filter mounted on TO-18 miniature package was introduced in high power amplifier (HPA), as is shown in Fig. 1. The required frequency responses for the transmitter circuit were achieved by the new SAW filter combined with transmitter second filter.

The characteristics of a miniature high power amplifier which was constructed with power MOS FETs and SAW filter will be published in near future.

New Configuration for Low Loss and High Power SAW Filter

Maximum input power is limited to 10 ~ 15 dBm in 800 MHz conventional transversal SAW filters. This is because

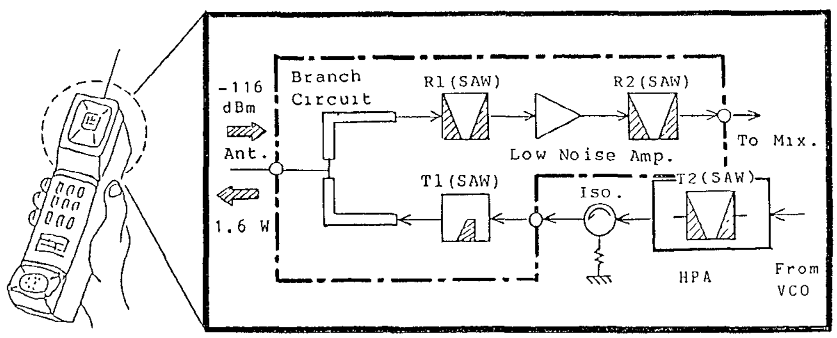


Fig. 1. Block diagram for SAW antenna duplexer

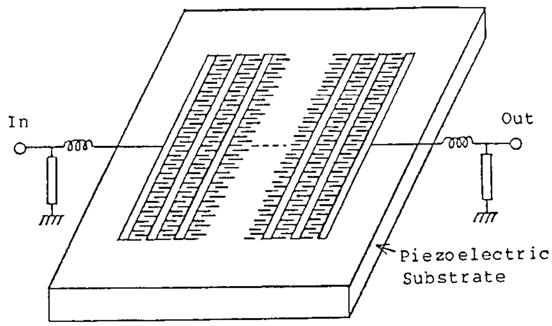
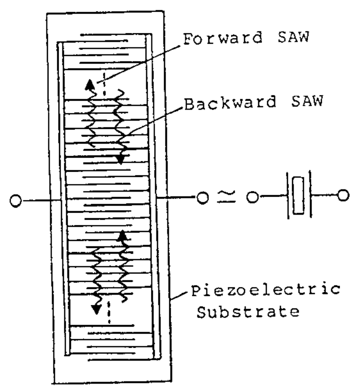
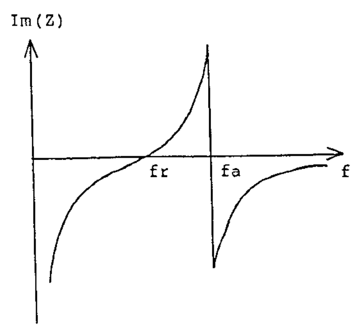


Fig. 2. High power SAW filter



(a) Unit resonator



(b) Frequency characteristics

Fig. 3. Wideband SAW resonator

1.1~1.2 μm finger electrodes are used in IDT at 800 MHz SAW filters and degradation in IDT electrodes occurs due to the electromechanical migration caused by large vibration amplitude of SAW. From our fundamental experiments, aluminum electrodes doped with 1.5 ~ 2.5 % copper ensure about 5 dB improvement for input power.[4]

However, according to EIA standards, the radiation power from class II portable telephone is defined 1.6 watts. The duplexer must endure about 35 dBm input power. To achieve more than 15 dB improvement, a new filter configuration was developed.

As shown in Fig. 2, the new configuration is constructed with electrically cascade-connected SAW multi-resonators formed on a piezoelectric crystal substrate. Simple matching circuits are also introduced to input and output terminals. As shown in Fig. 3(a), within each resonator, which is constructed with many finger pairs, the interaction between forward and backward travelling SAWs occurs due to the internal reflections.

As is different from the conventional SAW resonator (reflector type), this configuration provides a very wide band resonator, of which phenominon is very similar to that of DFB (Distributed Feedback Laser). The example of the impedance characteristics for SAW resonator is shown in Fig. 3(b).

The transmitter filter was designed to reduce the receiver band noise generated from high power amplifier. So, the ladder type SAW resonator filter shown in Fig. 4, where the antiresonant frequency of each resonator was assigned within the receiver band, was fit for the purposes. This configuration also offers high power characteristics. This is because, within the passband most of the input energy is transfered electrically through the cascade-connected resonators, and the degradation of IDT electrodes is very small due to the negrigible influence of SAW vibrations.

Fig. 2's configuration was one chip realization of Fig. 4's ladder type filter, where the Ci's (i=0,1,···,n) were equivalent to the sum of the capacitance between earth and finger electrodes and the capacitance between earth and uniform electrodes.

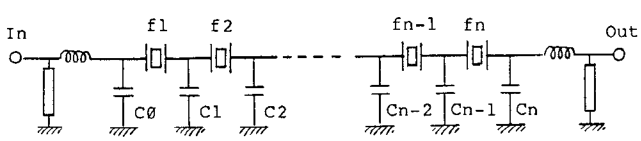
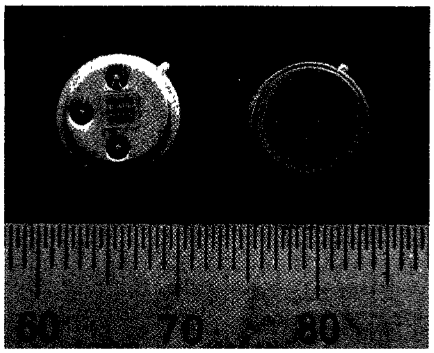


Fig. 4. Ladder type SAW filter

Experiment

A photograph of the filter mounted on TO-5 package used in the experiment is shown in Fig. 5. The filter which was formed with 18 electrically connected SAW resonators was designed using 36° rotated



1 mm/div

Fig. 5. Photograph for high power SAW filter

Y cut X propagation $LiTaO_3$ as a substrate[3] 1.1 ~ 1.2 μm aluminum finger electrodes doped with 1.5 ~ 2.5 % copper were used.

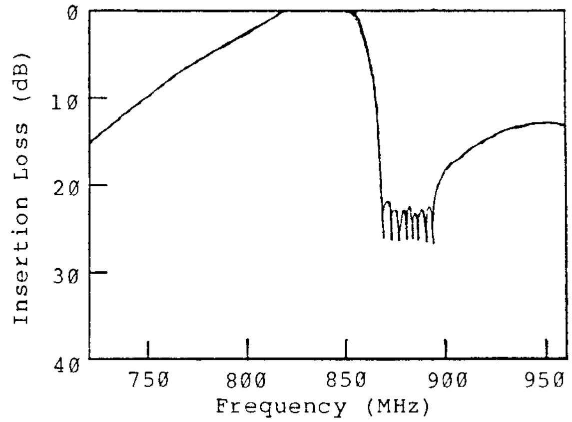
Computer simulation and experimental results are shown in Fig. 6(a) and (b). Insertion loss was as low as 1.0 ~ 1.2 dB, while the rejection level at receiver band is over 20 dB. Results of the fundamental experiment for a SAW duplexer is shown in Fig. 7. As for receiver filters (R1 and R2), we employed the previously published high performance SAW filters.[1]

As is shown in the figure, frequency characteristics required for an antenna duplexer of a portable telephone transceiver were satisfied over a wide temerature range. The size of the duplexer which included a low noise amplifier and receiver second filter within it was less than 10 ml. Photograph of the SAW duplexer is shown in Fig. 8.

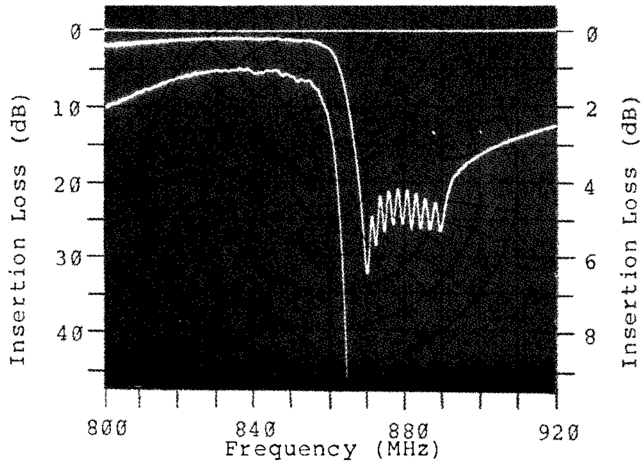
The system specifications require 2000 hour heat run test with 2 watt output power. Considering the margin, we did aging test with three power levels, that is 2, 3, and 4 watt output power. As is shown in Table 1, no degradation in IDT electrodes was observed after the aging test of 3000 hours even with 4 watt output power. The photographs of the comparision between pure aluminum electrodes and aluminum-copper electrodes after the test are shown in Fig. 9. From these results, we got the feasibility of a miniature SAW antenna duplexer as for the class II portable telephone transceiver.

Conclusion

A new developed ladder type SAW filter which was achieved by SAW multi-resonators and capacitors between earth and electrodes provides not only low insertion loss but also high power



(a) Computer simulation results



(b) Experimental results

Fig. 6. Frequency characteristics of high power SAW filter

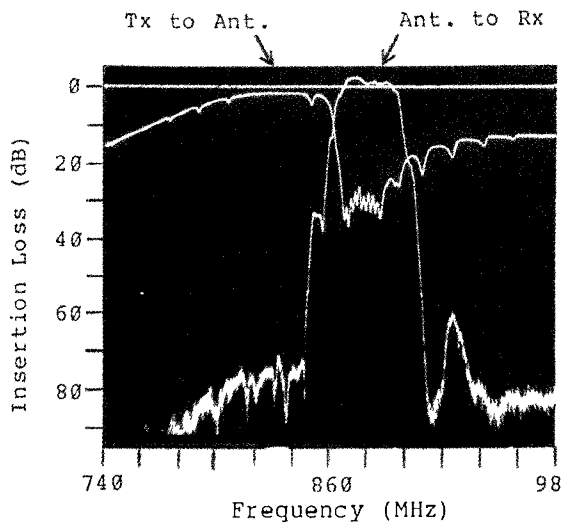


Fig. 7. Experimental results of SAW antenna duplexer

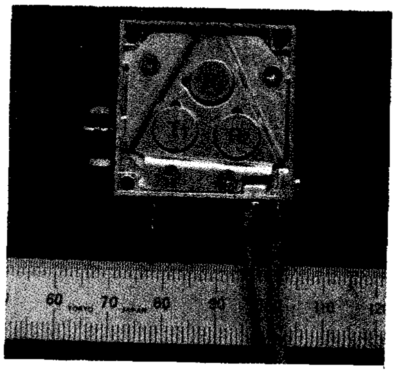
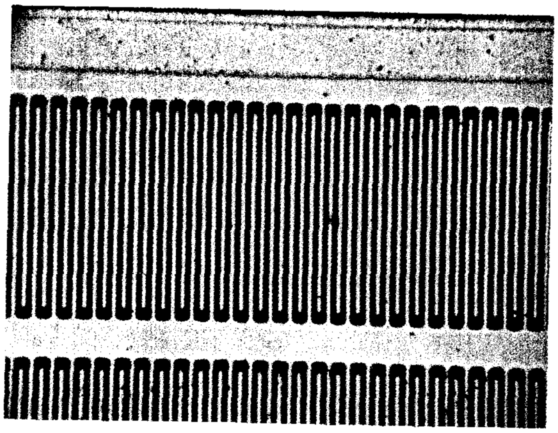


Fig. 8. Photograph for miniature SAW antenna duplexer

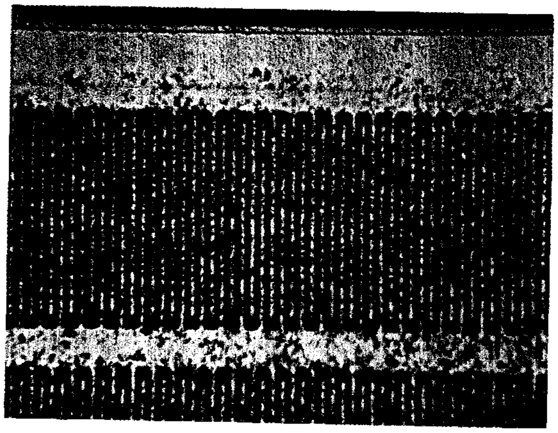
Table 1. Aging test for high power SAW filter

Output Power	Pure Al Electrodes (1.1~1.2 μm)	Al-Cu Electrodes (1.1~1.2 μm)
2 W	610 hours	no degradation (3000 hours)
3 W	246 hours	no degradation (3000 hours)
4 W	100 hours	no degradation (3000 hours)

characteristics. Fundamental experiments for a SAW antenna duplexer including three SAW filters (T1, R1 and R2) and low noise amplifier offer the feasibility of a miniature duplexer for portable telephone transceiver, as well as increase the possibility of new SAW functional devices combined with other active and passive elements.



(a) Al-Cu electrodes
(4 W output after 3000 hours)



(b) Pure Al electrodes
(2 W output after 610 hours)

Fig. 9. Photographs of IDT electrodes after aging tests

References

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