A Study on High-Isolation SAW Duplexer with On-Chip Compensation Circuit

オンチップ補償回路による SAW デュープレクサの高アイソレーション化の検討

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1. Introduction

High-isolation is a stringent demand for surface acoustic wave/bulk acoustic wave (SAW/BAW) duplexers that are used in wireless communication systems to keep the communication quality high [1].

The most common approach to improve the isolation of a SAW/BAW duplexer is to increase the attenuation level by changing the filter configuration. However, there is generally a tradeoff between improving attenuation and increasing insertion loss.

Thus, we reported another method that improves the isolation of the duplexer by using an additional compensation circuit [2]-[5]. The same as the conventional method, this method increases the attenuation level of a filter. However, it has the benefit of no- trade-off between attenuation level and insertion loss. The additional circuit is designed to keep high impedance in the pass band, so it does not increase the insertion loss of the duplexer.

In this study, we propose an advanced configuration of a compensation circuit for on-chip implementation. It uses the SAW resonator as circuit components the same as the filter itself. Therefore, a small-size and high-isolation duplexer is expected to be achieved.

2. Concept

The function of the compensation circuit is to adjust the magnitude and phase of the leakage signal as shown in **Fig. 1**.

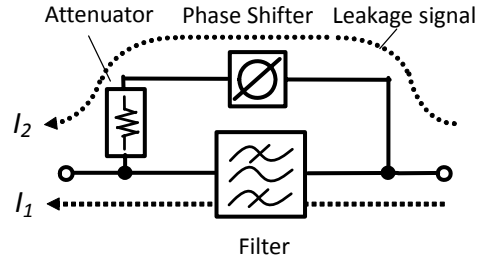

Fig. 1 Basic configuration of compensation circuit.

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In previous work, we implemented these functions into the multilayer laminate substrate as an external circuit of a discrete duplexer [5]. This configuration has the advantage that the compensation circuit can be added to an existing duplexer. However, this makes the duplexer bigger than the original duplexer. In this work, we aimed to implement these functions into a filter chip itself as mentioned above.

Figure 2 shows the configuration of the on-chip compensation circuit. As shown in the figure, the phase-shifter is achieved by using a longitudinally coupled double-mode SAW resonator. The attenuator is achieved by using an interdigital capacitor. These two components can be used at the same time to fabricate SAW filters.

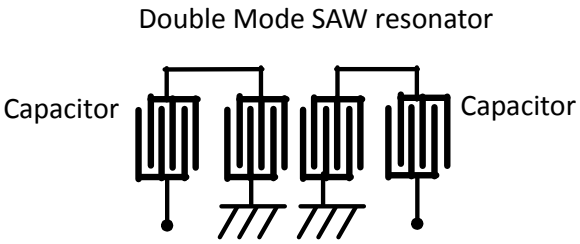

Fig. 2 Configuration of compensation circuit for on-chip implementation.

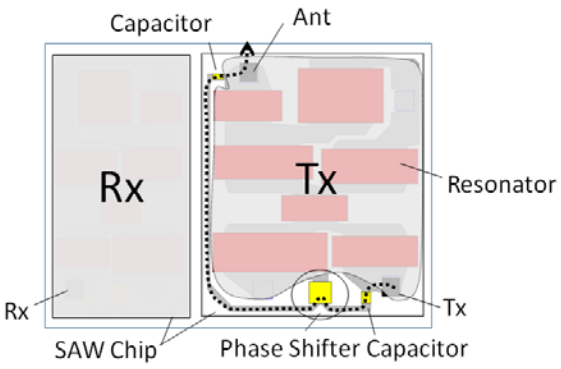

Fig. 3 Chip design of LTE-Band VIII duplexer

3. Verification & Result

To verify the effectiveness of a proposed circuit, we fabricated a prototype SAW duplexer utilizing Shear horizontal (SH)-SAW on a $LiTaO_3$ substrate for LTE Band-VIII (**Fig. 3.**).

As shown in Figure. 3, the compensation circuit is implemented on the Tx ladder filter chip along with SAW resonators containing the main filter. We designed this circuit utilizing the coupling of modes theory to achieve high-isolation and low loss [6].

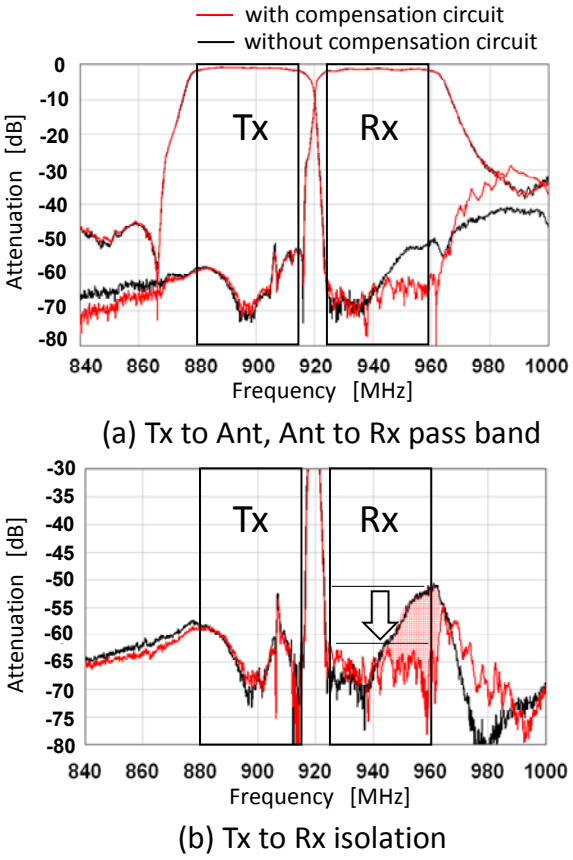

Fig. 4 Characteristics of LTE Band-VIII SAW duplexer with and without compensation circuit

Figures 4 (a) and (b) show the performance of the fabricated duplexer. As shown in the figure, the insertion loss was the same before and after addition of the compensation circuit. On the other hands, the isolation level in Rx band was improved from Typ. 52 dB to 62 dB as intended.

4. Conclusions

We proposed a method for improving isolation characteristics of a SAW duplexer with an on-chip compensation circuit.

The concept of this technology was examined through an actual duplexer. The proposed method was proved to improve isolation in the RX band of LTE Band-VIII SAW duplexer by about 10 dB.

This method is expected to be applied to various types of discrete filters and duplexers to enhance their attenuation and isolation.

References

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