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Development and Measurement Technique of the Low-Passive Intermodulation Device for mobile phone

携帯電話向け Low-Passive Inter Modulation デバイスの開発と測定手法

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1. INTRODUCTION

Recently, mobile communication systems have become more multifaceted, such as GSM, CDMA, W-CDMA and LTE. Furthermore, the communication technology has been developed by the rapid growth in telecommunication data and the system diversification, such as SV-LTE system and Carrier Aggregation system. In regard to the SV-LTE system of Band13 and BC0, 3rd intermodulation distortion (IMD) occurs at Rx Band frequency. Therefore, the duplexer must meet with non-linearity performance in order to deal with high input power signal for this system.

We carried out the trial of optimized design using those simulation techniques, but, found out the gap between simulation testing result and experimental value in an extreme measurement environment. From this experiment, we confirmed that there is distortion in passive component used as matching circuit between Tx and Rx filter in duplexer. That generates IMD in the passive components, such as cable, attenuator, Isolator, connector, Inductor in the evaluation circuit are confirmed, and optimizing the measurement circuit by using the Low-PIM components. It was possible to correlate the measured value with the calculated results from simulation.

2. SIMULATION AND IMPROVEMENT

In this chapter, we discuss 3rd order IMD improvement study of BC0 and Band13 Duplexer in North American system. If the fundamental frequency is f1 and f2, the frequency of IMD products can be described by the equation (1).

$$fIMD(m+n) = m*f1 \pm n*f2 \quad (1)$$

3rd order IMD products such as 2f1-f2 or 2f2-f1 have the highest power level. In the case of BC0 and B13, 3rd order IMD is generated in the receive band of each other. This jammer signal can increase the noise level of receiver path that degrades quality of the receiver performance. Therefore, duplexer's IMD level is very important. IMD level should be below -110dBm to avoid sensitivity degradation.

It is used a technique to lower the current density in each resonator by dividing the resonator as a method for reducing the IMD level of duplexer. However, the product size grows rapidly if it has been fully divided the resonator blindly. Therefore, by identifying the resonator higher nonlinear distortion, it is possible to improve the expansion of product size to a minimum by the optimum design of the resonators.

Fig.1 schematically explains the physical images for the possible origins of nonlinearity in the SAW resonator.

A) Nonlinearity of electro-mehanical coupling cofficient (piezoelectric constant)
B) Nonlinearity of mehanical-electro coupling cofficient (piezoelectric constant)
C) Nonlinearity of Aoustic Wave (elasticity constant)
D) Nonlinearity of IDT capacitance (Dielectric constant)

We have developed a unique simulator based on this mechanism of nonlinearity and it has been used to design products.

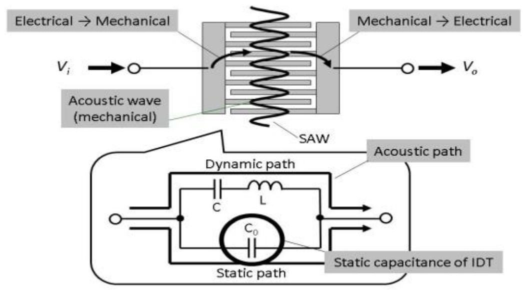

Fig.1 Possible origins of nonlinearity in SAW resonators

We simulated the IMD level of conventional duplexer. The IMD level of the resonator closer to Antenna port is higher. It is possible to lower the IMD level by optimizing the design of these resonators. By designing and utilizing the Non-linear simulation, duplexer's IMD level is improved from -80dBm to below -105dBm.

Fig.2 shows Simulation and measurement result. The improved simulation was below -105dBm but measurement result is above -90dBm. From this result, we went a review of measurement system. Base level of the measurement system is below -140dBm, but not be able to accurately measure because IMD level of test fixture (including the matching components) is not enough.

In the next chapter, we discuss improvement of the measurement system and measurement result of the duplexer after optimization of the measurement system.

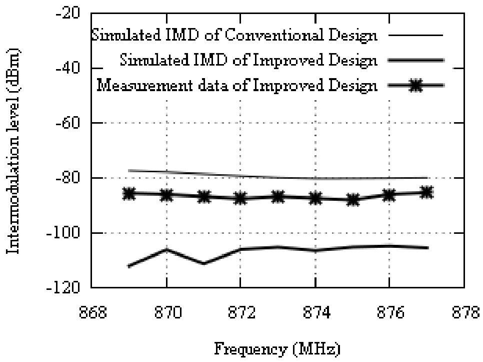

Fig.2 Simulation and measurement results

3. OPTIMIZATION OF THE MEASUREMENT SY STEM AND MESURE MENT RESULT

It is necessary to pay extra attention to IMD level of each device required for the measurement when evaluating the IMD product level of DUT. In this case, the IMD improvement simulation of duplexer is -105dBm. Therefore, over -125dBm is needed for this measurement system. We evaluated the each device used in our measurement system. We have selected cables, isolators and attenuators having the lowest PIM after evaluating Low-PIM types. We prepared Band-pass filter for the base station. Also, with regard to the SMA connector, we have chosen to use the ones which had decent IMD level after evaluating them.

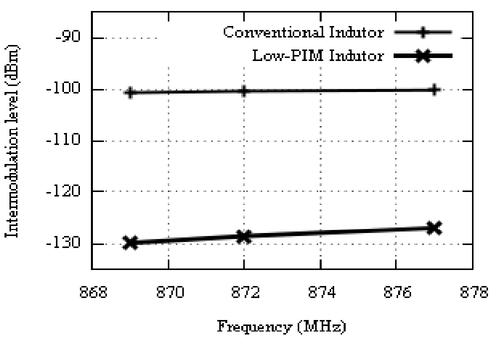

Fig.3 IMD measurement result of Inductors

Furthermore, we focus on Inductors that are used to Duplexer's matching, and evaluated its IMD level. **Fig.3** shows IMD measurement results of Inductor. The evaluation results were about -100dBm at conventional Inductor. This result is not a sufficient level for the use of Duplexer matching. Therefore, we have developed new Inductor with improved IMD level. The evaluation results were about -129dBm. Power conditions are Tx power: +24dBm and the jammer Power: +13dBm.

We measured duplexer' IMD using the above-mentioned evaluation circuit. **Fig.4** shows that the IMD measurement data after optimizing evaluation circuit.Simulation and measurement results are the same level to fit after optimization.

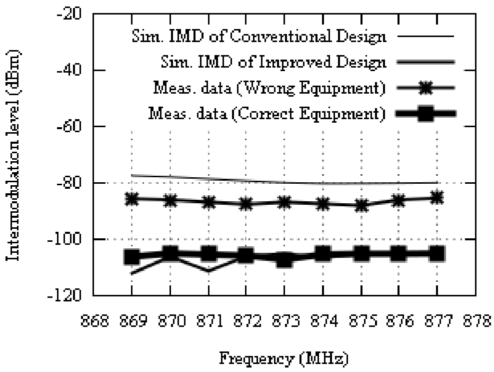

Fig.4 IMD measurement after optimization

4. CONCLUSION

According to the Non-linear simulation, IMD level of the BC0 duplexer was improved. IMD level of passive components used for the measurement must be below the IMD level of duplexer and we were able to develop Low-Passive Intermodulation Inductor.

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