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Considerations on nonlinearity measurement with high signal-to-noise ratio for RF SAW/BAW devices

高周波 SAW/BAW デバイスにおける高い信号雑音比での非線形性測定

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1. Introduction

Introduction of new communication standards makes specifications given to RF surface and bulk acoustic wave (SAW/BAW) devices tougher and tougher. For example, futher improvement of the device linearity is demanded without increasing the device size. Nevertheless, it is still unclear where and how the non-linearity occurs.

For finding origin(s) of the very weak non-linearity, its measurement system must possess excellent linearity, large signal-to-noise ratio (SNR) and low feedthrough level.

This paper discusses the setup of the non-linear measurement system for RF SAW/BAW devices.

2. Nonlinearity measurement system

Fig. 1 shows the system setup for the harmonics measurement. A sinusoidal signal (f_1) generated by a signal generator (SG) is amplified by a power apmplifier (PA), and is applied to the device under test (DUT) mounted on a printed circuited board (PCB). Non-linear signals genarated by the DUT are detected by the spectrum analyzer (SA).

Low- and high-pass filters (LPF/BPF) are inserted to minimize influence of nolinearities in SG, PA and SA. Muliple filters are cascaded to make the filter out-ouf-band rejection better than 100 dB.

All these instruments are inter-connected by cables with SMA connectors. The DUT is placed in a shield box to avoid detection of very weak non-linear signals from ambient.

Sharing the reference clock between SG and SA is quite effective to reduce the frequency offset and fluctuation of the SA read, and enables us to reduce the resolution bandwidth (RB) of SA. This reduction improves the thermal noise level by 10log(RB) [dB]. Since the SA settling time is given by RB^{-1}, RB was set at 1 [Hz] in the following experiments.

All instruments are powered on 30 min. before the measurement to avoid variation during worming up.

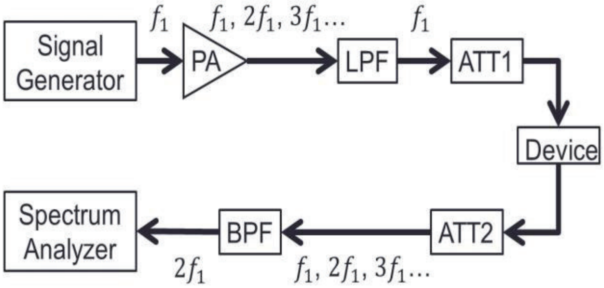

Fig. 1 Setup for nonlinearity measurement.

3. Setting of attenuator levels

In Fig. 1, two attenuators (ATT1 and ATT2) are inserted so as to set the circuit impedance for the DUT close to 50 Ω not only at the fundamental frequency f_1 but also harmonics ($2f_1$, $3f_1$, etc.). This is because the nominal impedance of LPF and BPFs is 50 Ω only for the passband and that in the rejection band is not defined.

Although large attenuation is preferable for the purpose, it also causes reduction of the signal level, which results in SNR deterioration and requests increase of the PA output. Thus, optimization of attenation levels is necessary.

In the following experiments, a single-stage ladder-type SAW filter on 42^oYX-$LiTaO_3$ was chosen as the DUT, and the incident power level was fixed at (+15) dBm.

First, ATT2 is considered. Fig. 2 shows how the second harmonic (H2) level change with ATT2. In this experiment, ATT1 was set at 10 dB. It is seen that the f_1 dependence changes dramatically with ATT2. Especially, the variation is large at frequencies where the H2 level is high.

Fig. 3 shows the difference between the H2 levels measured at ATT2 of 6 dB and 8 dB. It is seen that the differece is almost independent of f_1. The value of 2 dB coincides to the change in ATT2. The difference becomes larges at a few frequencies. This is due to very weak H2 level. ATT2 was set at 6 dB for the following experiment.

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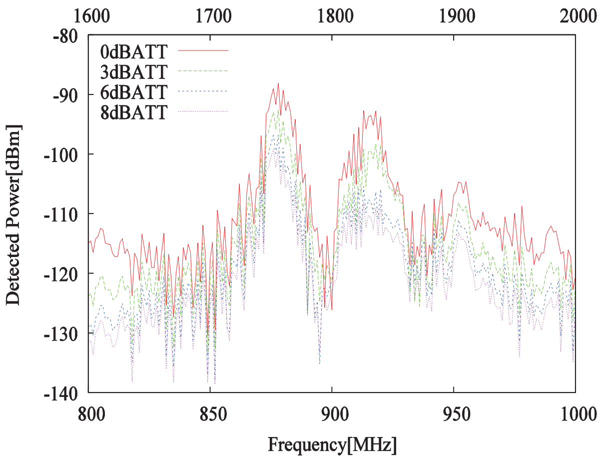

Fig. 2 Variation of H2 level with ATT2 (ATT1=10 dB)

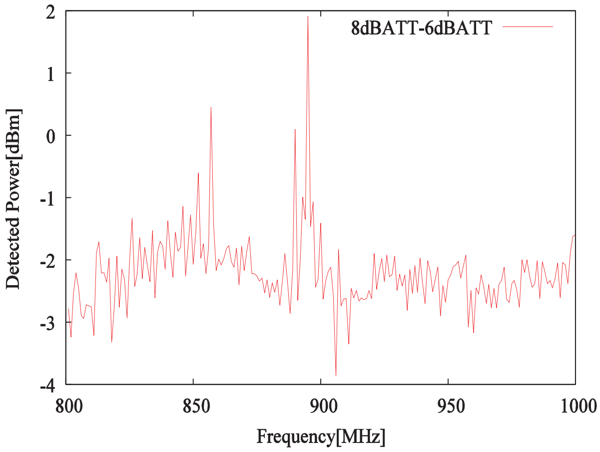

Fig. 3 Difference of H2 levels at ATT2 of 6 dB and 8 dB.

Next, ATT1 is considered. Fig. 4 shows how the H2 level change with ATT1. It is seen that the f_1 dependence changes dramatically with ATT1. The variation is large at frequencies where the H2 level is high also for this case.

Fig. 5 shows the difference between the H2 levels measured at ATT1 of 3 dB and 6 dB. It is seen that the differece is almost independent of f_1. The value of 6 dB corresponds to twice of the change in ATT2. This reflects the fact that the H2 level is proportional to square of the input signal level. From this discussion, ATT1 was fixed at 3 dB.

4. Conclusion

This paper discussed the setup of the non-linearity measurement for RF SAW/BAW devices.

In the above mentioned condition, the background H2 level estimated by directly cascading ATT1 with ATT2 is below -140 dBm for the whole frequency range. Since the thermal noise level is circa -160 dBm, further enhancement might be possible for the background level.

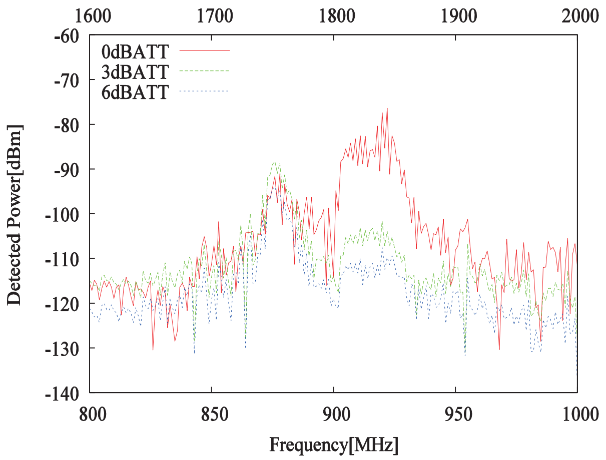

Fig. 4 Variation of H2 level with ATT1 (ATT2=6 dB)

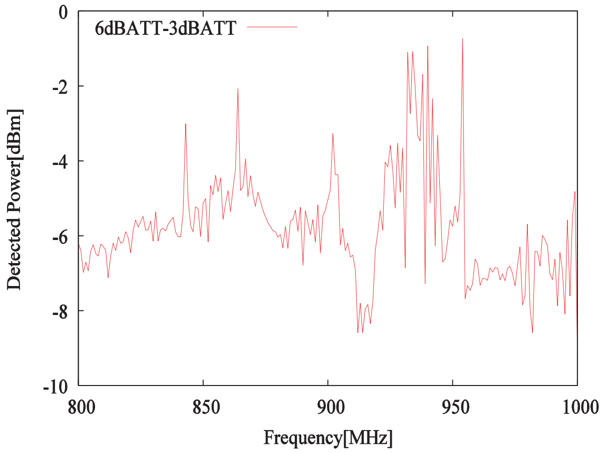

Fig. 5 Difference of H2 levels at ATT1 of 3 dB and 6 dB.

Anyway, since even very weak H2 signals (-130 to -120 dBm) in Figs. 2 to 5 is much higher than the background level, they are considered to be caused by the non-linearity of DUT.

The next step is to enhance the setup to be able to measure not only the amplitude but also the phase of the non-linear signals.

Acknowledgements

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References

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