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Evaluation of frequency divider characteristics using QCM oscillator with IoT

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1. Introduction

QCM (quartz crystal microbalance) has an advantage in that it can be used to easily evaluate on various objects. QCMs used in vacuum evaporation system are absolutely necessary for evaporation. Recently, there have been various reports on the Q-value of QCMs, and in particular, reports on phase noise have been increasing. We previously used an IoT-based QCM [1-4]. Current tasks include both 1) reducing power consumption and 2) converting the phase noise of QCM to a Q-value, so we ended up using heterodyne detection.

Heterodyne detection is easy to use, but the discussion turned to whether there was a more simple way. In this report, we conducted an experiment to change the division ratio by using a new circuit with divider characteristics in a QCM oscillator, and we attempted to obtain the Q-value of the oscillator. As a result, it is shown that the phase noise was approximately -20 dBc/Hz compared with the normal Q-value in the oscillator with a reduced Q-value at a division ratio of 1/2.

2. Measurement systems

Fig. 1 shows the Wi-Fi module we propose, with the transmitter on the left and receiver on the right. Equivalent Wi-Fi modules are used for TX and RX. At the leftmost part, the QCM oscillator and local oscillator are also excited, and their outputs are input for heterodyne detection.

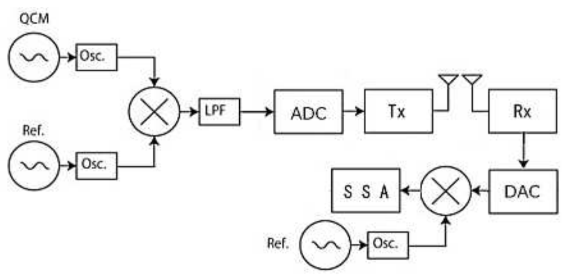

Fig. 1 IoT measurement system

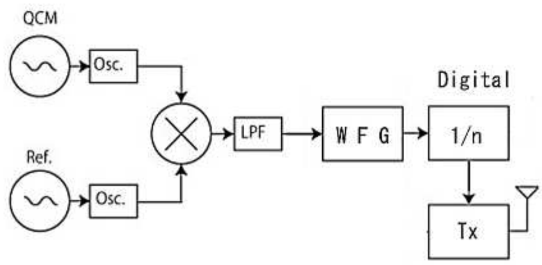

Fig. 2 Measurement system with divider circuits.

Fig. 2 shows digital modulation using a waveform forming circuit after the QCM oscillator, which is the subject of this report. After digital modulation, the components are measured for phase noise through the wave form forming circuit, which work as a parameter that directly shows the Q-value of the QCM oscillator.

For this system, we prepared an oscillator (arbitrary waveform generator) simulating phase noise and tested a digital divider ratio of 1/2. As shown in Fig. 3, a) without deposition (5 MHz: sine wave) and b) with deposition [5.4 MHz: sine wave, during deposition; PM modulation, PM frequency of 100 Hz, waveform (Shape) = noise, phase deviation = 40 degrees)] were each prepared, and their characteristics were measured through a mixer. A high-pass filter (HPF) was provided at the output of the mixer, and the difference between the cases with deposition and without deposition was input to a signal source analyzer to measure the phase noise as a reference.

Fig. 4 shows that we used an low-pass filter (LPF) at the output of the mixer in the input section, and we made it work with a waveform generator (WFG) that converted from a sine wave to a digital wave and a digital divider at a division ratio of 1/2. Naturally, the frequency of the divider is 200 kHz. The digital wave was also converted back to a sine wave using the WFG, and its phase noise characteristics were measured using a reference 10 MHz oscillator (Agilent N5181A) and a mixer.

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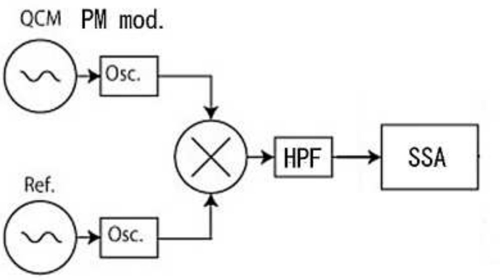

Fig. 3 Phase-noise measurement system phase-

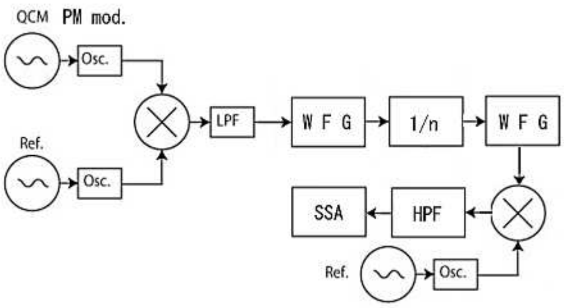

Fig. 4 Measurement system of experimental apparatus.

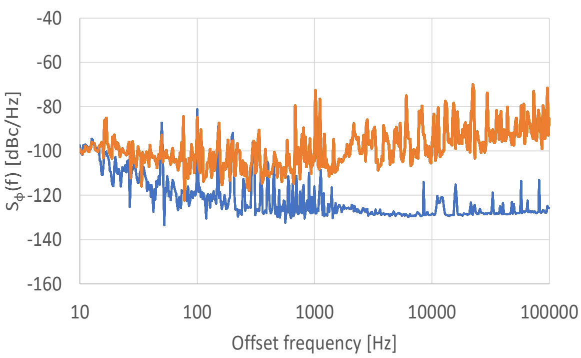

Fig. 5 Phase noise of system in Fig. 3.

The output of the mixer was measured with a signal source analyzer at 10.2MHz through an HPF.

3. Measurement results

First, Fig. 5 shows the results of obtaining the phase noise of Fig. 3 using a simulated oscillator. According to this figure, the difference in the phase noise between the cases with deposition and without deposition was approximately -20 dBc at an offset frequency of 1000 Hz.

The following shows the results (Fig. 4) with a digital divider ratio of 1/2. Fig. 6 shows the phase noise characteristics with deposition (5 MHz) and without deposition (5.4 MHz: division ratio of 1/2). According to this figure, the difference in the phase noise was approximately -20 dBc at an offset frequency of 1000 Hz; therefore, the phase noises in Figs. 3 and 4 corresponded.

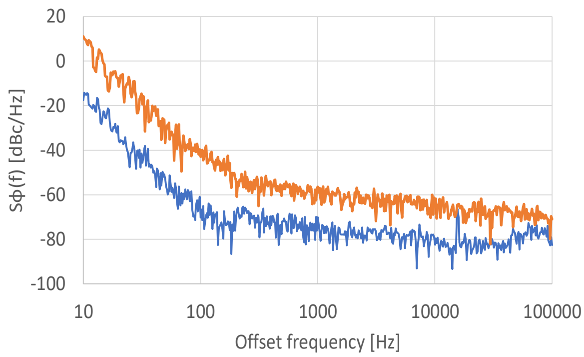

Fig. 6 Phase noise of system in Fig. 4.

4. Conclusions

It was shown that the phase noise was approximately -20 dBc/Hz at an offset frequency of 1000 Hz compared with the normal Q-value in the oscillator with a reduced Q-value at a division ratio of 1/2, and this result was almost the same as that of the heterodyne detection in Fig. 3. In the future, we plan to develop a QCM oscillator with an optimal divider ratio.

Acknowledgment

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References

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