Degradation of sound quality caused by jitter of digital sound system

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Abstract:
We have found that a jitter found in RF signal correlates strongly the deterioration of sound quality. Even a jitter of peak-to-peak several nano-seconds, the assessed degradation at sound quality caused by a given jitter on the bit stream was "-3" in the seven-grade scale, where error rate is C1．1 in both the reference and assessed cases. The jitter will be generated in a digital signal processing at the series-parallel transform and sampling and re-sampling by a clock of PLL etc. Then, any dubbing process will seriously deteriorate the sound quality. We have made experimental experience that the reduction of jitter is more important than to reduce the quantization error and merely increasing the sampling frequency.

Introduction:

Through many experiments [1] - [7], we have convinced that a jitter found in bit stream lastly deteriorates the sound quality seriously. The measurements are by the Time Interval Analyzer: "TA520 by YOKOGAWA Ltd, and Audio Analyzer: "SYSTEM TWO CASCADE" by AUDIO PRECISION.

Measurement Equipment:

The block diagram of a measurement is shown in Figure 1, constructed by a CD transporter, a DAC, a power amplifier, and loudspeakers. Their DC power supply circuits are improved by paralleling good capacitors considering the step-response of signals, and the other parts are adjusted carefully.

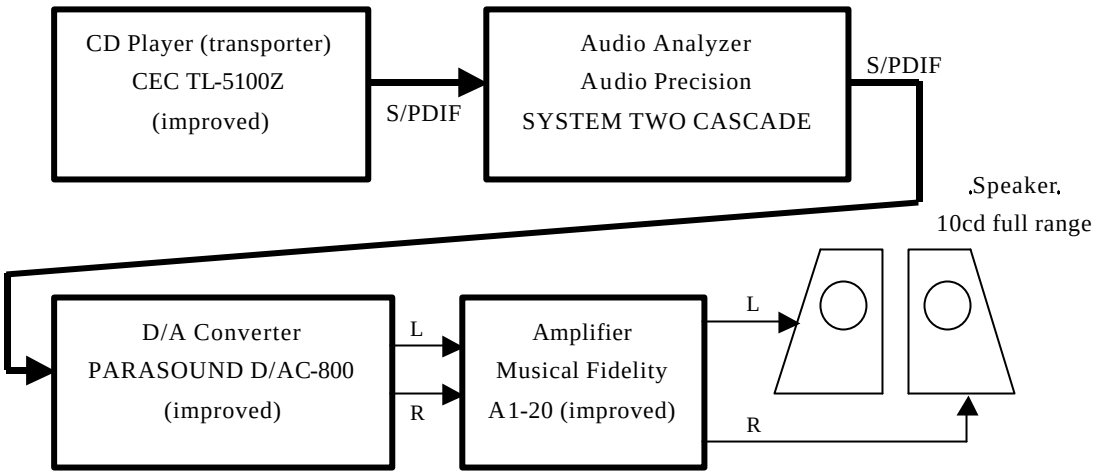

Figure 1: Block diagram of the experiment

Measurements and The Results:
The result between the sound quality and the jitter of RF signal is shown in Figure 2.

Another experiment is as follows. Using the Audio Analyzer: "SYSTEM TWO CASCADE", though its purpose is to measure the stability of a CD player giving a jitter to a bit stream of the output of a CD transporter, we have utilized it to obtain a relationship between a jitter of a bit stream and the sound quality.

We have intentionally given a jitter to a bit stream. A jitter amplitude characteristic of the bit stream of an output of a CD transporter is shown in Figure 3. Figure 4 shows the jitter amplitude characteristics when the bit stream is phase-modulated by 2Hz sinusoidal waveform and nominal ±88.6 pico-second peak-to-peak amplitude. The degradation of sound quality caused by a given jitter was assessed by ten experts in the seven-grade scale (Table 1). In the case of the three musical resources, the Mean Opinion Score (MOS) was "-1.875 " and the standard deviation was "0.375". The result shows that large deterioration of sound quality was brought by the given jitter of at most peak-to-peak 35 ns. And C1 both in the original and the measured cases are less than 1.

Detailed observation is that sound quality, the basic elements of music such as the rhythm, melody and harmony are not destroyed, however, playing nuances are seriously, deteriorated.

The comments from subjects are follows;
1. Lingering sound of a piano is lost.
2. The depth of sound space is lost.
3. A sorrowful cello sound change to a cheap cheerful one.
4. Agreeable beat sound sensation from the bass is lost.

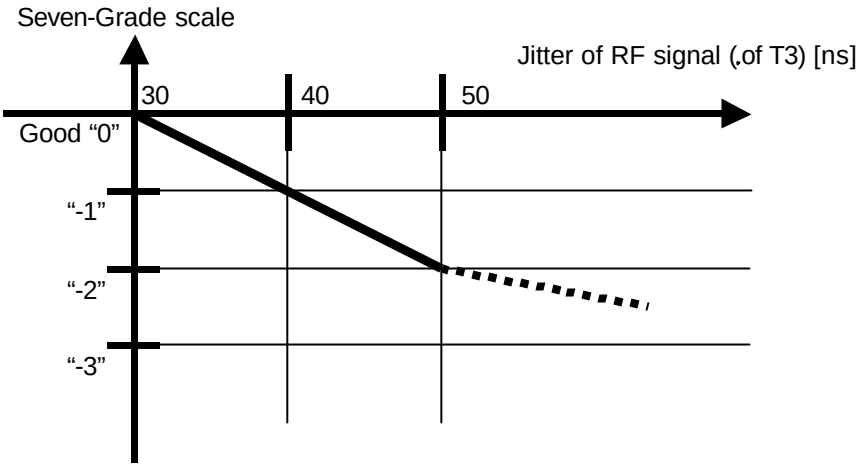

Figure 2: Sound quality vs. jitter of RF signal (.of T3)

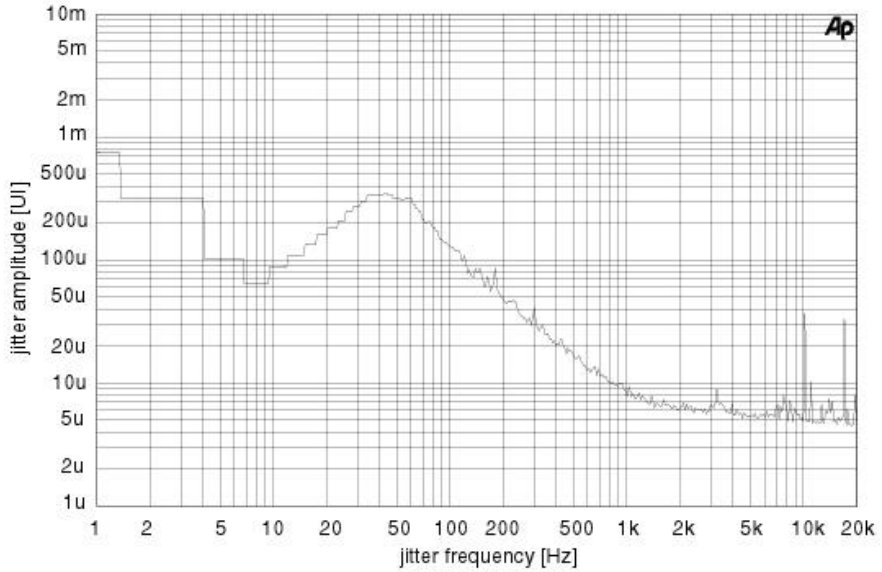

Figure 3: Jitter amplitude characteristics of the output of CD transport in Fig.1

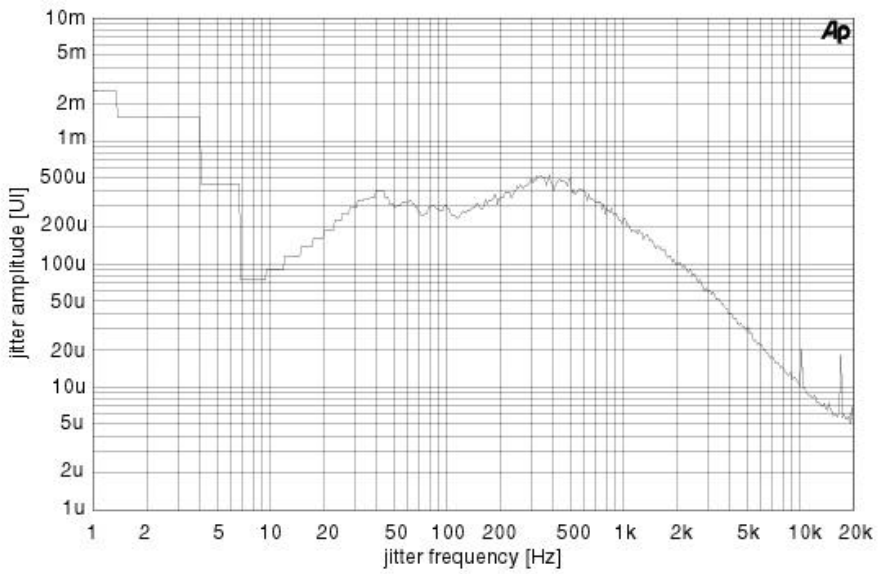

Figure 4: Jitter amplitude characteristics with added jitter 2Hz sinusoidal waveform and ±88.6ps

Table 1: Seven-Grade scale (comparison scale) [anchor: jitter is not added]

+3: Much worse
+2: Worse
+1: Slightly worse
0: The same
-1: Slightly better
-2: Better
-3: Much better

Conclusion:

It is clarified that a very small magnitude of jitter of several 10 ns jitter in RF signal deteriorates seriously the sound quality. ñ88.6 pico-second /2Hz in a bit stream given by SYSTEM TWO CASCADE; at most peak-to-peak 35 ns jitter of digital audio signal seriously deteriorates the sound quality.

Discussion:

1. At first, we have measured code error in a two second. The result is that error is zero! Then we have measured jitter in analogue out put signal. The result is that "700 ns" when the sound quality is very bad, and "less than 140 ns" when the sound quality is good [2].
2. We have found two measurement tool of jitter as described. The measured jitter is as described in this

paper.

3. If the code error is zero, the deterioration of sound quality might be caused in the process of sampling and re-sampling. Then we have measured jitter of PLL in the both case of a sound quality is good and a sound quality is bad. However, the jitter of PLL in the both case are almost the same; 2.3 ns. Our consideration have stopped.

   If we return to the fact that the jitter of RF signal is strongly correlate with sound quality, some kinds of error might be concurred in the case the sound quality is bad. We have already obtained the fact that the difference of analogue signal between the reference analogue out put signal and the measured analogue out put signal is large when the sound quality of the measured signal is bad in the discussion of 1.

   It is said concerning the . of jitter of RF signal that 20 ns: very good, 30 ns: fair, and 50 ns: very bad.

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