Faithful Reproduction of Deep Sensation in Digital Audio System Focused on Socialization in SECI Model

- Discovery of Important Physical Factors Concerned with Sound Deteriorations in Digital Audio System with CD Players -

Minoru MITSUI† Tomoharu ISHIKAWA† Makoto MIYAHARA‡

†School of Information Science, Japan Advanced Institute of Science and Technology
{mminoru, ishikawa}@jaist.ac.jp
‡Department of science and engineering, Chuo University
miya-hm@tamacc.chuo-u.ac.jp

Abstract

Fundamentally speaking, audio system should be faithfully reproduced deep sensations of human that evoke deep musical emotions such as "atmospherics", "feel of tension" and "texture of sound", etc. It is possible to construe faithful reproduction of deep sensations in audio system as an example of process to translation from tacit knowledge into the other tacit knowledge. Therefore, development of audio systems which can faithfully reproduce deep emotions is possible to say the same as "Socialization" in SECI model. However, most of existing audio system can not reproduce such as deep musical emotion. For this purpose, we have been developed such as audio systems focused on the deep musical sensations. In our researches, we found jitter in digital audio systems deteriorate sound quality seriously.
In this paper, at first, we investigate the relation between sound quality concerned with deep sensations and jitter in digital audio systems. Accordingly, we speculated that the influence of jitter was transformed to other shapes before or within the D/A converter block. One of the possibilities is that the influence of the jitter affects the sound quality, indirectly, via the power supply line.
Secondarily, we attempted to clarify the relation of sound quality and an ideal power supply of audio systems. The measurement result showed the proposed power supply can suppress the turbulence comparing with conventional ones. The assessment result showed that the MOS value of sound quality of the proposed power supply was higher than conventional ones.

Keywords: Socialization in SECI model, Deep sensations, "atmospherics", jitter in digital audio systems, Ideal power supply

1 Analysis of effects of jitters

In our researches, we clarified jitter which is fluctuation of clock in digital signal deteriorates sound quality seriously [2]-[5]. Especially, in addition, "atmospherics" of sound was deteriorated [2]-[5]. Fig.1 shows a brief paradigm of these research used in our investigation on an audio system. Results showed that RF jitter (part 1 in Fig.1) deteriorates sound quality at output (part 4) but no any specific jitters were observed in D/AC clock (part 3) which has constant fluctuation less than 300ps no matter with the RF jitter. Secondarily, Bit Stream jitter (part 2) also deteriorates sound quality. The same as the case of RF jitter, no special jitter were observed in the D/AC clock (part 3).

When tracing the stream of the jitter in the audio system for several jitter sources, we found that the jitter was suppressed by the PLL circuit (part 3). Therefore, the jitter almost was not observed in the D/A converter block. Accordingly, we speculated that the influence of jitter was transformed to other shapes before or within the D/A converter block. One most plausible possibility is that the influence of the jitter affects the sound quality, indirectly, via the route of power supply line since the conventional power supply is not ideal one. We confirmed our speculation with psychophysical-method.

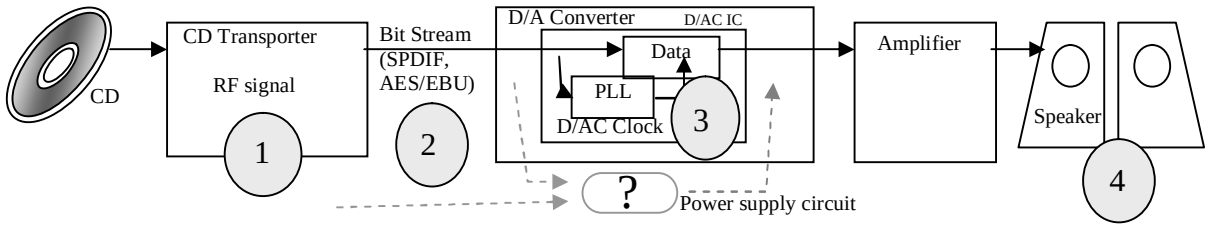

Fig.1: Overview of digital audio system

2 Set up of equipment for experiment

According to result of our researches concerned about jitter within digital audio systems, we speculated that the influence of jitter might be transformed via the power supply line.
Consequently, digital audio systems need ideal power supply witch can suppress influences of jitter.
In this research, "Series-Shunt parallel power supply" was devised to approach below two ideal conditions for an ideal power supply.
(1) Supplying a necessary electric current immediately when loading becomes heavy suddenly.
(2) Absorbing excess an electrical charge quickly when loading reduces suddenly.
Furthermore, we used the audio system with the proposed power supply for psychological assessment experiments and compare with conventional ones.

2.1 Design of ideal power supply

The series regulator is popularly used the most conventional power supply in audio systems because of its cost and simple structure. It can supply a necessary electric current (condition (1)), but is not good for condition (2). On the other hand, shunt regulator can absorb the excess electrical charge quickly when loading reduces suddenly (for condition (2)). To satisfy both of the conditions, we used these electric power circuits in parallel to construct an ideal power supply. Therefore, we devised "Series− Shunt parallel power supply"[5][6] as an ideal power supply, referred to as "proposed power supply".

2.2 Conversion of power supply circuit of D/A Converter equipment

A power supply circuit of D/AC equipment was replaced with the proposed power supply, and then compare its performance with that of conventional series power supply, where D/AC equipment was LHH1002 (Philips). The circuit was designed easily to switch between the replaced power supply circuit and the original one. Fig.2 shows the circuit with proposed power supply.

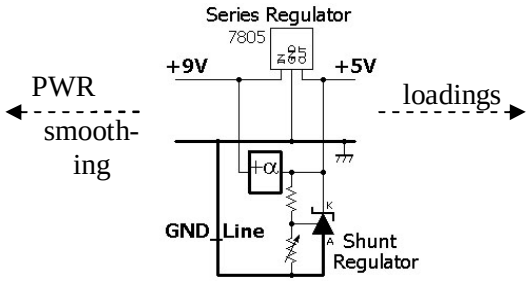

Fig.2: The circuit of proposed power supply

3 Assessment experiment

We conducted assessment experiments to compare the conventional series power supply with proposed power supply. Fig.3 shows the setup used in this assessment experiments. The series power supply is used as the base line of assessment. Experimental conditions are showed in Table1. Assessment words are extracted from assessment word concerned with deep sensations [7]. Assessment sessions repeated until when subjects were fully understood.

Table1: Experimental conditions

Musical resources	1. Hooked on DIXIE, K-TEL, 6782, Track No.1, content of jazz, drums, trumpet, saxophone, etc. 2. Enya, WEAMUSIC, 25P2-2465, Track No.12, content of voice, synthesizer.
Number of subjects	5
Assessment scale	7 grades scale (-3: Much worse, -2: Worse, -1: Slightly worse, 0: The same, +1: Slightly better, +2: Better, +3: Much better) Base on ITU-R BS.562-3[8]
Assessment items	Over all quality, "Atmospherics", "Holographic", "Lowness centroid of sound", "Tautness", "Powerful" [7].

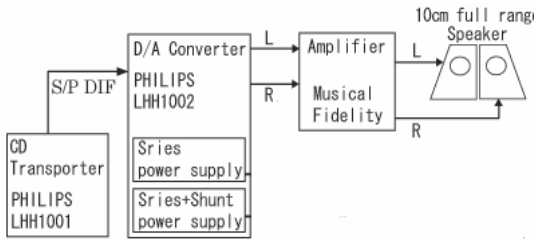

Fig.3: Equipments for this research

3.2 Result of assessment experiment

Table 2 shows the result of assessment experiment. The scores of assessment are average score of 5 subjects, and parenthetical numbers are Standard Deviation (SD) of scores.

In Table 2, score of the all assessment words were obtained positive score. The average score were over "+2". This means that the proposed power supply improved sound quality a lot compare with the base line system, and the outperforms than conventional ones. Especially, "Atmospherics", "Holographic", and "Tautness" were larger than "+2".

Table 2: The results of assessment experiment

Assessment words	Resources 1 Average (SD)	Resources 2 Average (SD)
Over all quality	**+2.4 (0.89)**	**+2.2 (0.45)**
"Atmospherics"	+2.2 (0.84)	+2.0 (0.71)
"Holographic"	+2.2 (0.45)	+2.2 (0.84)
"Lowness centroid of sound"	+1.6 (1.14)	+2.2 (0.84)
"Tautness"	+2.4 (1.10)	+2.4 (1.12)
"Powerful"	+1.8 (0.89)	+2.0 (0.89)

4 Evaluation of anti-turbulence properties

4.1 Measurement method

It is believed that the outstanding perform of the proposed power supply was obtained in assessment experiment. However, we could not find any concrete evidence in analogue output signal under the normal condition to give a physical support. This is because we had not clear idea how to detect the difference in a complex audio system. For this reason, we simplified the system by removing unnecessary parts in the measurement. The measurements were carried out only on the division of power supplies.
In the experiment, voltage turbulence was added to both power supplies respectively. Fig.4 shows measurement equipments. Turbulence signal was set to rectangular wave (peak to peak amplitude: 2V, Frequency: 200Hz).

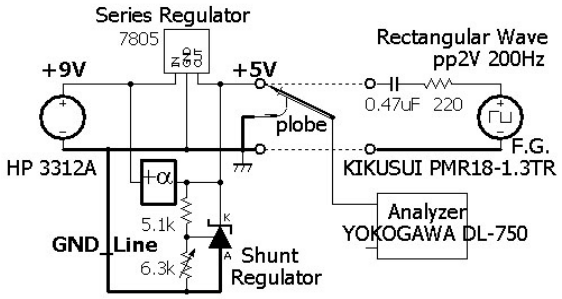

Fig.4: Measurement equipment of voltage turbulence

4.2 Result of measurement

Fig.5 and Fig.6 shows result of measurement of voltage turbulence in 5 ms period of inputted rectangular signal and response of voltage turbulence at time waveform. Horizontal axis is time. Left vertical axis and solid line are response of voltage turbulence. Right vertical axis and broken line show input voltage.

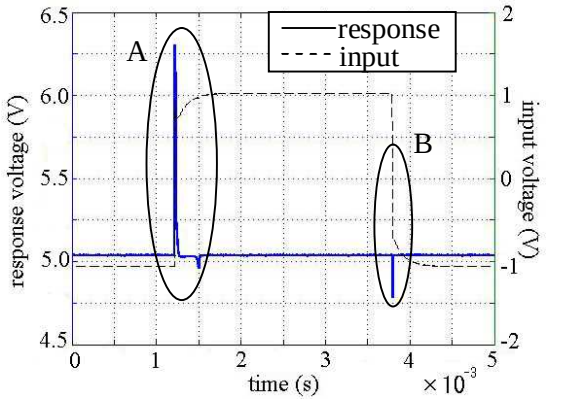

Fig.5: Turbulence of series power supply

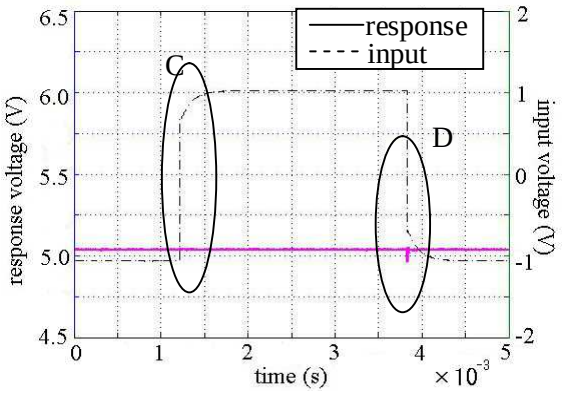

Fig.6: Turbulence of proposed power supply

In the rising transient of signal, the part A in Fig.5, the response voltage of conventional power supply was an impulse with amplitude of 1.26V. In contrast, response voltage of proposed power supply (see the part C in Fig.6) was greatly reduced. The amplitude was only 0.01V, less than one-hundredth. This difference clearly shows that the proposed power supply was mush more robust than the conventional one. In the dropping transient of signal, conventional power supply suppress the turbulence to 0.25V (part B in Fig.5) because of its ability of supplying. Moreover, proposed power supply suppressed the turbulence to 0.07V (part D in Fig.6).

The measurement results show that the proposed power supply has excellent anti-turbulence property. This is why the audio system with the proposed power supply outperforms that the conventional ones.

4.3 Discussion

As the result of assessment and experiment, the proposed power supply improved “Atmospherics” especially. On the other hand, our researches concerned with digital signal jitter showed that jitter deteriorate “Atmospherics” seriously [2]-[5]. According to the result of these researches noted above, from the psychophysical standpoint, the proposed power supply might suppress influence of jitter. That is to say the anti-turbulence property is helpful in suppressing the effects caused by jitters. Therefore, we confirmed our speculation. However, we should need much more experiments to clarify the complex structures between sound deterioration, jitter and power supply.

5 Conclusions

In this study, as an example of “Socialization”, aspiring faithful reproduction of deep sensations of human, we clarify the relation of sound quality and the power supply. “Series–Shunt parallel power supply” was devised to approach the ideal conditions, and implement in an audio system. The assessments result showed that the proposed

power supply can faithfully reproduce the sound and can evoke the deep emotion. To find the physical evidence we conducted a voltage turbulence experiment. It showed that the proposed power supply can suppress the turbulence to 1% comparing with conventional ones. The anti-turbulence property is helpful in suppressing the effects caused by jitters.

References

[1] Makoto Miyahara, "New Generation Audio: New Perception Model for the High Order Sensation -Distortion of the Expansion and Contraction of Time and Digital Sound-", 13-6, pp.39-46, 1996. (in Japanese)

[2] Shingo Fuyuki, Tomoharu Ishikawa, Yukio Kobayashi, Makoto Miyahara, "The Deterioration of High Order Sensations in Digital Audio Signal caused by Jitter - A Sharp Loss of "Atmospheric" and (Deepness) - ", Technical report of IEICE, EA97-104, pp.9-16, 1998. (in Japanese)

[3] Makoto Miyahara, Yukio Kobayashi, Tomoharu Ishikawa, Minoru Mitsui, Teppei Koga, "Degradation of sound quality caused by jitter of digital sound system", FORUM ACUSTICUM SEVILLA, MUS-05-001-IP, 2002.

[4] Minoru MITSUI, Tomoharu ISHIKAWA, Yukio KOBAYASHI, Makoto MIYAHARA, "The Relationship between Degradation of the Sound Quality and Digital Signal Jitter", 1029D, WESPAC8, 7.2003.

[5] Minoru MITSUI, Kouta Yoneyama, Tomoharu ISHIKAWA, Makoto MIYAHARA, "Considerations of Relationships between Deterioration of Sound Quality and Physical Factors on the Digital Audio Systems", ITE report, Vol.30, No.68, pp67-79, 2006.12. (in Japanese)

[6] H.L Jou, J.C Wu, etal, "A new control algorithm of active power line conditioner for improving power quality", Electric Power Systems Research, Volume 70, Issue 1, June 2004, pp.1-6, Elsevier.

[7] Tomoharu Ishikawa, Makoto Miyahara, "Hierarchical Structure of Assessment Words for the Evaluation of Information of High Order Sensations", KANSEI2001, 2001.10.

[8] Subjective assessment of sound quality, ITU-R BS.562-3, 1978