SPEAKER SYSTEM
BASED ON TIMEDOMAIN THEORY

INTRODUCTION

50 years has passed since “Acoustics (Beranek)” issued, and 35years has passed since “Music, Physics and Engineering (Olson)” issued.
Many acoustic components were produced with electric sound reproduction technology, and countless numbers of components were popularized.
But basic quality, such as “Good sound”, or “High Fidelity” has progressed very slowly. We cannot say the up-to-date speaker system or amplifier is better than the system 20 or 30 years before.
This typical phenomenon is applied only in audio engineering area, not in another engineering area such as computer engineering or Car technology engineering.
It is doubtful that the harmonic distortion or frequency response is proportional to “Sound goodness”; in spite of the harmonic distortion or frequency response is the basics of sound technology.

We cannot tell which is better the vintage 0.1%-distortion amplifier and up-to-date 0.001%-distortion amplifier. (There used be a amplifier company called “Point-One”, titled by the amplifier’s distortion) In fact, we can tell which is better only after listening.
In electric-acoustic-reproduction world, audio R&D has been done based on the distortion as a key parameter, which results almost no difference in listening (in spite of 100 times difference in distortion).
On the other hand, in car engineering, it is no doubt that the acceleration and speed will change dramatically if the engine output changes 100 times.
As the same, we have many doubtful points in frequency response. But here we focus on distortion, and we will discuss about frequency response another chance.

BACKGROUND

In 1980, I was much moved and inspired I had never experienced when I listened to the music in the famous hall in Europe. (Picture.1) I found many people also affected who were not interested in music itself.
I found “Sound goodness” is important factor, i.e., necessary condition
for musical emotion. Besides music piece or performance.
After I had experienced this ultimate emotion, I was inspired to deliver this kind of musical emotion to many people using electric-acoustic reproduction system. So I started researching and developing this kind of reproduction system.

In conventional audio, audio system was evaluated in frequency domain (F-domain). Sound wave is expressed by the collection of sine waves; reproduction system should express all of the sine waves exactly.
Mathematics taught us the sound wave is expressed by the collection of the sine waves, and using the analysis-measurement tool, we can see the collection of the sine waves for the sound, so we were apt to think “Sound” = “collection of the sine waves”. But there is difference between “sound wave is expressed by the collection of the sine waves” and “sound wave is made of the collection of the sine waves”.
Fig.2 top is the tone-burst. This signal is Fourier transformed to Fig.2 center signal (collection of sine waves). Fig.2 bottom signal is the summation of Fig.2 center signals. We can see the difference between Fig.2 top signal and Fig.2 bottom signal. But if we sum up to infinity frequency sine waves, Fig.2 top should be the same as Fig.2 bottom.
If we sum up left half parts, it should be the mute sound. Also if we sum up the right half parts, it should be the 8 sine waves.
In other words, “Mute” is “8 sine waves”!! It seems to be very strange.

In Timedomain audio, sound wave is treated in time domain. Sound is the pressure change

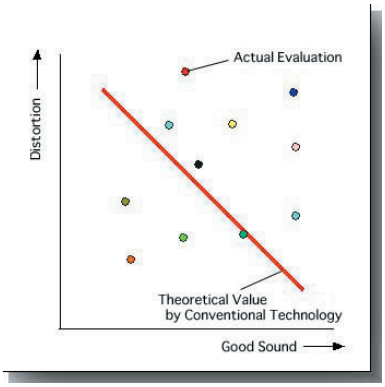


Fig.1
Distortion vs. Sound goodness relationship

Picture.1
Staatsoper(Wien)

in time domain, which is sensed by the ear.
The faithful reproduction means, “Faithful sound-pressure wave reproduction” in Timedomain audio.
Let’s discuss about the tone-burst wave as mentioned before. The left half is mute part, which lead to no reproduction(no sine wave). Only we have to reproduce the right half 8-cycle sine waves faithfully.
In short, high fidelity means faithful frequency reproduction in conventional F-domain way of thinking, on the other hand in Timedomain way of thinking, high fidelity means faithful sound-shape reproduction.
We can apply Timedomain theory to anything about sound. So we will apply Timedomain theory to all audio components. Now we have released the amplifier and speaker system. So next we explain about speaker system.

CONVENTIONAL SPEAKER CONSTRUCTION

Typical conventional speaker system is made by the rectangular wood box, woofer, squawker, tweeter, and dividing network which divide the amplifier output to Low range, Mid-range, and High-range.
But in principle, it is impossible to reproduce the original sound using this kind of system. Of course, it is possible to reproduce original signal synthesizing each signal part mathematically or electrically. But acoustically it is impossible.
One example, if you input the same level of sound in reverse phase, output should be zero mathematically or electrically. But in reality, we can hear reverse phase sound from 2-speaker unit acoustically.
Also in F-domain way of thinking, basic idea is sine wave, which is the fundamental element of F-domain sound.
In natural world, simply repeated, continuous sound like sine wave does not exist. We are apt to mislead the result in F-domain way of thinking.
Fig.3 indicates the concept of the conventional speaker system, which is inputted sine wave. If its frequency is 1kHz, 1kHz sine wave is radiated from tweeter, and woofer, even though the level or phase is different. The enclosure box is vibrated at 1kHz, 1kHz signal is radiated from the panel of the enclosure box, and even some amount of harmonic distortion is increased.
It should be pure 1kHz signal both by measurement and by listening. Also theoretically, it should be 1kHz even added different level of sine waves or different phase of sine waves.

Fig 4 is the concept schematic of impulse signal input to the system.
Impulse signal has the same nature as the natural sound. Impulse signal is radiated from both tweeter and woofer. But their addition is not the same as the original impulse signal. The result is different from the case of sine wave. The more number of speaker units, the result will be much more different from the original impulse signal.
The enclosure box is vibrated by the impulse signal. But its vibration will remain after the input signal disappeared. This remaining vibration sound has no relation to the original signal. If we call this remaining sound “distortion”, the distortion ratio is infinity. (Because the original signal is zero)

SPEAKER SYSTEM BASED ON TIMEDOMAIN THEORY

We will show the basics of the dynamic speaker in Fig.5. Voice coil current in the magnetic field generates the sound force. This force vibrates the cone diaphragm, so this vibration according to the sound signal shape generates the sound, and then the sound transmits to the space.

<VIRTUAL GROUND>
For the accurate cone diaphragm movement, the basic still-ground point, magnetic circuit must not be moved. Thinking about conventional speaker system, the magnetic circuit is fixed by the frame at the enclosure

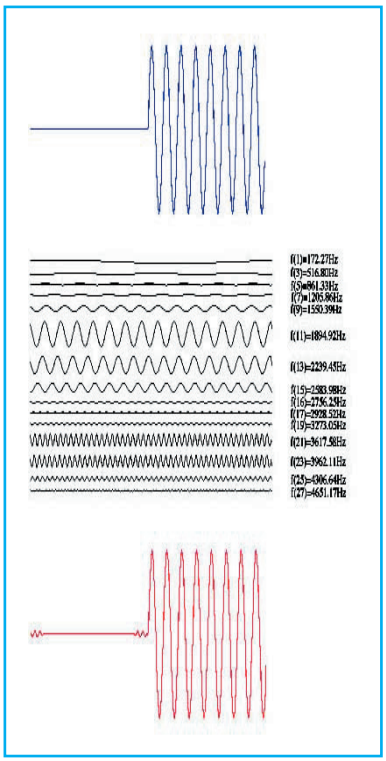


Fig.2
Tone burst signal and Fourier transformation

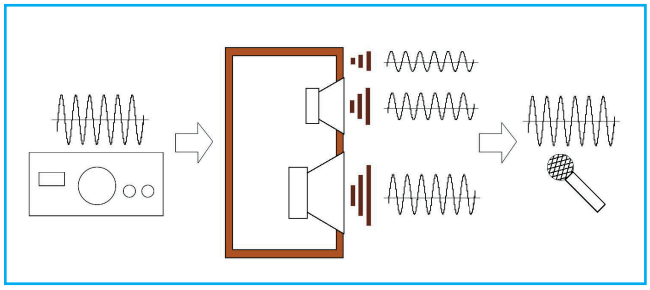


Fig.3
Sine wave reproduction model
: Sine wave is sine wave even if any same frequency sine wave synthesized

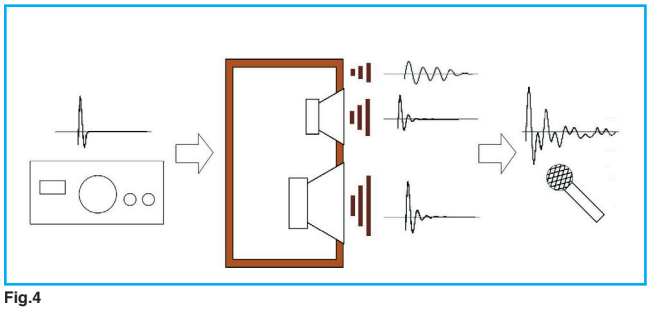


Fig.4
Impulse response reproduction model
: Music signal is similar to impulse signal. Synthesized music signal is different from original.

box panel. The voice coil current vibrates the speaker box and flame. In this case, the box and flame are not the still point. The sound from the cone diaphragm is not pure original signal in this case. (Fig.6)

Ideally speaking, the magnetic circuit should be fixed at the ground. But in real case, the voice coil current induces the vibration to the ground and the con-rod, which connect between unit and ground, so the ideal case will not come true.

In our Timedomain way, the magnetic circuit is fixed at the virtual ground (Fig.7) Virtual ground is the metal shaft, which mass is 1000 times heavy as the diaphragm mass. This virtual ground is supported by the GEL material, which does not transmit the vibration. So this virtual ground is the ideal ground: basic still point.

<SMALL DIAMETER, SINGLE UNIT>

For accurate reproduction of the sound pressure waveform, speaker unit should be the small diameter, single unit. The original waveform is not reproduced by the synthesis from the conventional multi-way units. The large diaphragm will induce the divided vibration; also induce the inaccurate movement because of the heavy mass.

Our pipe type "Yoshii9" adopted the 5.5cm-diameter diaphragm, which mass is only 1.4g. This mass (1.4g) is less than 1/10 of the 20cm units. It is the same case such that the car weight is 10 times heavier, quick start and stop will be difficult even how this car has strong engine and brakes.

<PIPE TYPE>

The conventional enclosure is composed of the panel, so the enclosure box has its own rigid body vibration. This vibration cannot be stopped how it is reinforced. As we mentioned before, this kind of vibration generates the disturbing sound. On the other hand our enclosure is "EGG-SHAPE" or "PIPE TYPE" using our Timedomain method. These shapes seems to be unique, also they are so rigid as you know. Even if the disturbing sound generates from these enclosure, only little part of the sound reaches to the listener.

Here we explain our PIPE-TYPE SPEAKER called "Yoshii9" as a typical example of our Timedomain method.

Pipe has the similar nature to the exhaust pipe of the automobile, we prefer to call it "Flow-Pipe" rather than enclosure.

This pipe supports the speaker unit with the virtual ground. The speaker unit is separated by the GEL material from the pipe, so the vibration does not transmit to the pipe.

The pipe is made of the aluminum. The aluminum surface is the hard almite layer after honing treatment. Pipe shape is originally rigid, so it does not vibrate by the inner sound pressure.

The sound pressure wave from the backside of the speaker unit transmits through pipe decreasingly, and then goes out from the bottom.

Inside the conventional enclosure box, there is full of dirty sound such as standing wave sound, diffraction sound, reflection sound, and the sound through absorbing materials. You can recognize this dirty sound if you hear the microphone sound or stethoscope sound set inside the box. This undesirable sound transmits through the speaker diaphragm and reaches to listeners. You can hear this sound if you put the sound-making substance inside the speaker box. You can recognize that the speaker diaphragm has almost no sound-shield performance.

Yoshii9, which flame construction and pipe coupling is well considered that the backside sound pressure wave from the unit transmits quite smoothly. So the backside sound itself is good enough, and never goes back to the front side.

As a result, the sound becomes quite real, so we can hear the very small sound that is never heard from the conventional system. Also we can hear the delicate sound expression.

If the speaker unit is mounted to the conventional enclosure box, F_0 goes up because of the box-air spring addition to the original F_0 value.

Using the Timedomain pipe, air volume moves in pistonicly as the speaker diaphragm moves. So the air mass in the pipe is added to

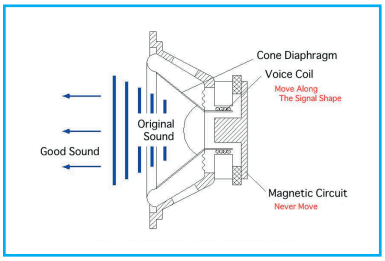


Fig.5
Concept schematic of dynamic speaker

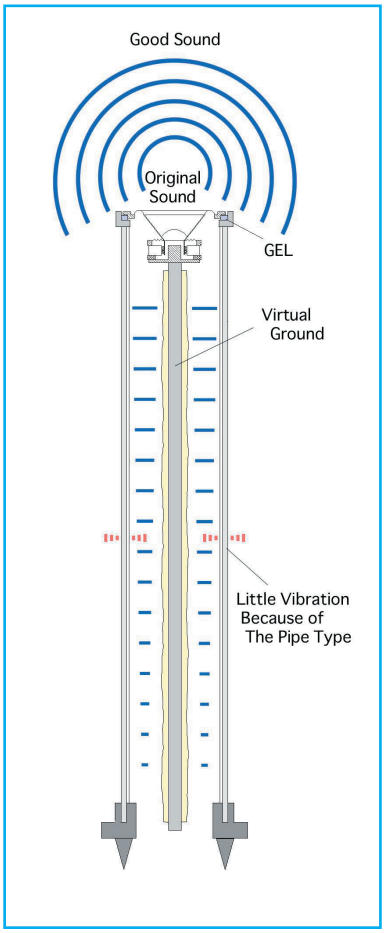


Fig.7
Concept schematic of Timedomain Speaker system

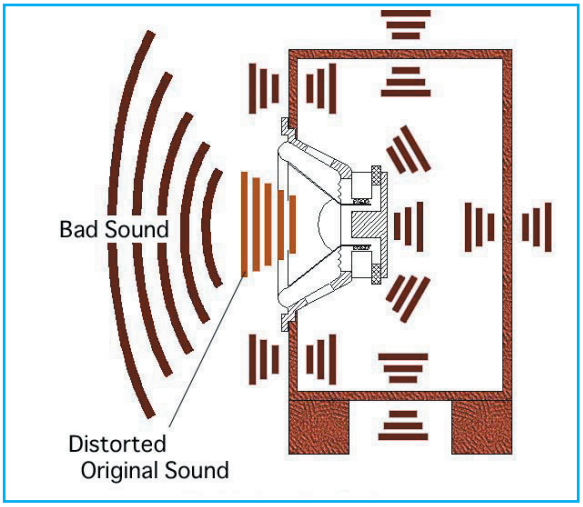


Fig.6
Concept schematic of conventional speaker system

the F_0, F_0 value goes down from the original F_0 value. And the pipe controls the airflow, so Yoshii9 has superior bass expression that never heard from the conventional speaker system.

<TIME-AXIS DISTORTION; COLLUPTION>

Thus speaker system's reproduction capability and expression capability are increased, the same level quality is necessary for driving amplifier.

Conventional F-domain way-distortion, i.e. linear distortion (Frequency response) and non-linear distortion (harmonic distortion) is compensatable, but time-based distortion, which Timedomain proposed, is impossible to equalize or compensate.

As this type of distortion is impossible to recover, it is better to call it "diffusion", "collapse", or "loss", than "distortion". So to speak, it is increase of entropy.

Entropy increase occurs anywhere in the amplifier. Most of the increasing point in electric-mechanical part than the electric circuit.

We notice much of the sound part is lost when we hear the sound using conventional amplifier. And we have impression that all the sound is dull.

The amplifier of Yoshii9 is designed not to increase entropy as possible.

We will describe about this amplifier another chance.

SYSTEM SOUND BY TIMEDOMAIN THEORY

Speaker system designed by Timedomain theory is all horn type; GS-1 (Picture.2) by ONKYO Corporation, egg type system bundled with FUJITSU-PC, egg type system by FUJITSU TEN Limited. egg type; "TIMEDOMAIN mini(Picture.3)" and "TIMEDOMAIN light" by our company, pipe type system by UCHIDA YOKO Co., Ltd., pipe type system by M.E.T. Japan Co., Ltd., pipe type system by SANYO Electric Co., Ltd. and pipe type; "Yoshii9" (Picture.4) also by our company. Their outlooks are quite different, but their sounds are commonly quite natural.

They will reproduce real sound image and real sound stage. So they will even reproduce atmosphere.

Furthermore they will reproduce the figure of the sound, the sound is hard to collapse, and so it is easy to find out one instrument sound in the noise. And their reproduced sound reaches far away.

We come to notice that the recorded sound has full of information even in old time recording, or any media, just we could not reproduce it as if we thought it was the limitation of the recording, limitation of the media, or reproduction tool.

We summarize the sound feature in Table.1

FUTURE PRODUCT STRATEGY

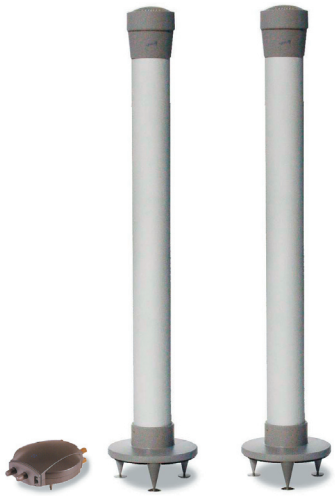
Our Timedomain sound is admired, of course by musician, and also by the people who are not interested in audio or music. "Reproduced music emotion for all the people" is our desire. Timedomain Theory is applicable to all things about sound; we would like to deliver reproduced good sound and reproduced emotion for all over the world.

(TIMEDOMAIN CORPORATION)

TIMEDOMAIN
Timedomain Corporation

Picture.3
Amplifier installed, egg-type, Timedomain Speaker: "TIMEDOMAIN mini" by Timedomain Corporation (May/2001 released)

Picture.2
The first product based on Timedomain Theory: "GS-1" by Onkyo Corporation (1983 released)



Picture.4
Yoshii9 (Tube-type Timedomain Speaker system and Timedomain Amplifier) by Timedomain Corporation (July/2000 released)

I feel so natural. I never feel tired even after long time listening.	I feel quite real about the background noise. The acoustic instrument sound is quite real. So I can feel delicate expression of the music.
Sound image is real. It seems to be actual musician existence. Time Domain system describes sound distance, sound width, and even sound height.	I can hear the conversation so clearly. I can hear English pronunciation clearly. I can recognize the lip shape, tongue movement, even teeth movement.
Deep sound stage. I can feel the recording atmosphere.	No exaggeration of the consonant sound, also no booming sound.
Sound image is completely separated from the speaker system. I do not feel the sound is generated from the speaker system. I feel like that the sound is generated from the space.	I can hear semitone of the bass instrument so clearly. Also I can recognize the variation of the various touches or bowing of the bass instruments, and variation of the music tone.
The sound does not collapse even at the long-distance from the speakers. The sound reaches long distance as if sound pressure does not decrease.	I can easily hear the small background noise of the music performance reproduction such as audience whispering.
I can hear without collapse even in small sound. I can hear the sound clearly separated from the noise.	I was very surprised at the real, high fidelity sound from the old recording, LP, compact cassette, and TV sound.
Sound separation between sound-images is good. I can hear various sounds in the orchestra.	The fundamental tone starts just from the sound or voice beginning, so the sound is very natural.

TABLE-1 Timedomain system's sound feature (impression by listeners)