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Research Report

Development of a Synthesizer System Using a 32-Channel Speaker

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Abstract

This study developed an experimental sound system that combines a synthesizer outputs with 3D audio. To confirm the operation of this system, on November 23, 2025, the track “War Between Good And Evil” from the album “Antidote Action” by Dissecting Table (UPD Organization 2026) was played (Dissecting Table 2025). The developed system comprises a computer, a universal serial bus (USB) audio interface, a USB device, a line selector, a buffer, a filter, a mixer, and a speaker. The USB audio interface uses TASCAM US-2x2HR (TASCAM 2026) to input the signal from a computer sequencer (Tsuji 2015) playing Waveform Audio File Format (WAV) files into the mixer. The WAV files are created using MixPad, a multitrack recording software program (NCH Software 2026). The USB device outputs pulse-width modulation (PWM) signals and control signals using Km2Net USB-FSIO30 (Komatsu 2011). The line selector changes the connection between the PWM signal and the filter in four ways via the buffer (Tsuji 2018a). The buffer inputs four PWM signals. Due to its ability to output three identical PWM signals, the buffer can output a total of 12 PWM signals. The filters include a whitening filter, biquad circuit (Tow 1968), and state variable filter (SVF) (Imada & Fukaya 1989). The whitening filter is a digital circuit. The biquad circuit and SVF are formed by cascading two filters. The mixer system uses 2 mixers with 2 inputs and 8 outputs each, and 1 mixer with 2 inputs and 16 outputs. The mixer inputs control signals to move the sound source among the speakers. The speaker unit uses Fostex’s 16-cm full-range FE166NV2 (Fostex 2026). The filter and mixer use the FX-AUDIO- [ACCESSORY SERIES 005] Petit Susie (North Flat Japan 2021) power supply noise filter. Furthermore, after listening to the system in an actual setting, dummy head microphones were positioned at the center of gravity of the rectangle formed by the 32 speakers to record the system’s performance. Finally, the binaural recording was listened to with headphones to confirm sound localization.

1. Introduction

Sound Particles’ SkyDust 3D (Sound Particles 2026) is a synthesizer plugin with eight oscillators, 256-note polyphony, various waveforms and envelope generators, a sequencer, filters, effects, and more. Sky Dust 3D’s output supports Dolby Atmos (Dolby 2025), binaural (Namba et al. 1989), and Ambisonics (Genelec Japan Inc. 2025) audio. This system cannot create complex timbres such as Sky Dust 3D; however, it can generate noisy timbres by inputting pulse-width modulation (PWM) signal outputs from universal serial bus (USB) device into an analog filter. By using the 32 speakers connected to the mixer, sound source movement can be performed to create a unique three-dimensional audio effect. Furthermore, Waveform Audio File Format (WAV) files can be played from a computer to move the sound source using up to 16 speakers; similarly, it can produce unique three-dimensional sound effects. Synthesizer outputs can be recorded binaurally using the developed dummy head microphones.

2. Basic Structure of the System

Figure 1 presents the basic structure of the system. The yellow dashed lines in the figure represent the control signals. The computer and USB device are connected via a USB interface to form a computer synthesizer. USB device outputs PWM signals from PWM 0 to PWM 4, with a maximum frequency of approximately 14,963 Hz. Control signals Control 0 to Control 9 are output, and the maximum frequency that can be set using the computer is 500 Hz. The output signals of the line selector are defined as Line 0 to Line 3. Filter 1 is a whitening filter, Filter 2 is a biquad circuit, and Filter 3 is a state variable filter (SVF). Mixer 1 and Mixer 2 are 2-input, 8-output mixers. Mixer 3 is a 2-input, 16-output mixer. Speakers are defined as Speaker 1 to Speaker 32. PWM 0, PWM 1, PWM 2, and PWM 4 are input to the line selector. The input and output connections of the line selector can be changed in four ways using Control 6 to Control 9. Line 0 to Line 3 are input to the buffer. Line 0 to Line 3 output three identical signals each, resulting in a total of 12 output signals. Line 0 is input to Filter 1 and Mixer 1. Line 0 of Filter 1 is used for the input signal, while Line 0 of Mixer 1 is used for the control signal. In this configuration, instead of using Line 1 for system connection, the signal is output from a USB audio interface. Line 2 is input to Filter 2 and Mixer 2. Line 2 of Filter 2 is used for the input signal and control signal. Line 2 of Mixer 2 is used for the control signal. Line 3 is input to Filter 3 and used as the input signal. Control 0 is input to Mixer

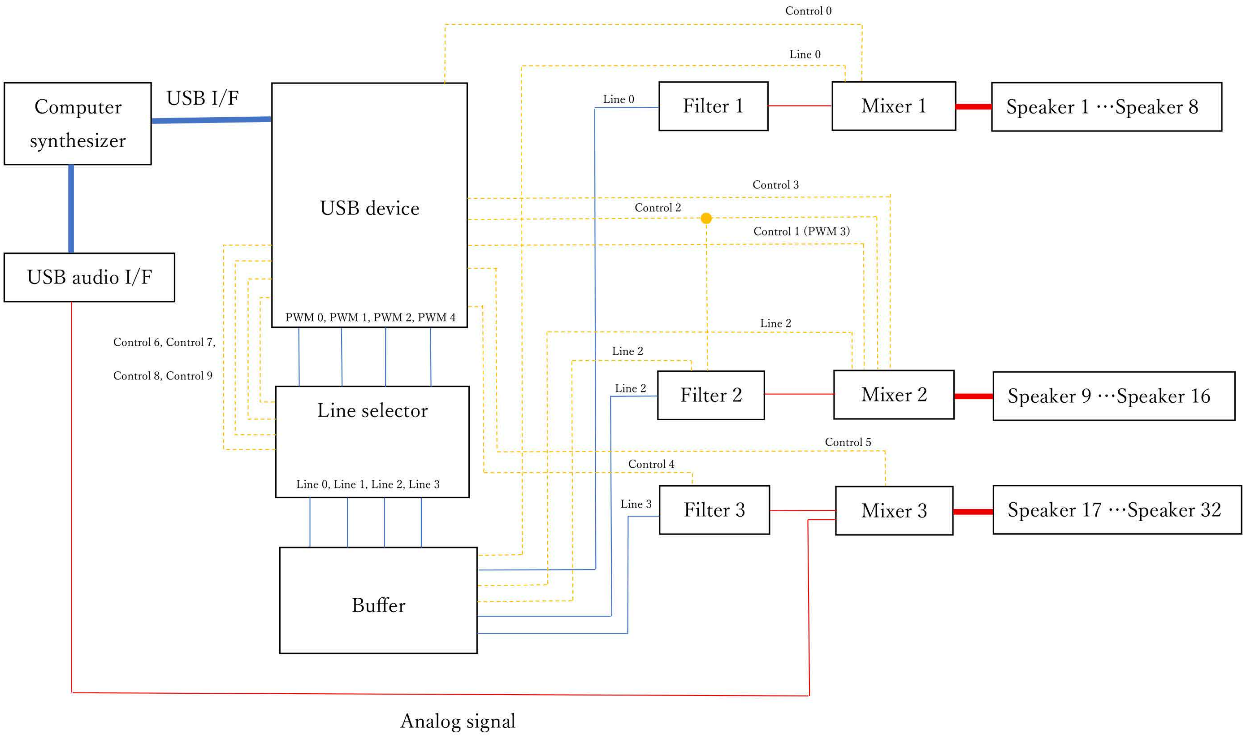


Figure 1. Basic structure of the system

1. Control 1 to Control 3 are input to Mixer 2. Control 1 is PWM 3; no signal is output during this performance. Control 4 is input to Filter 3. Control 5 is input to Mixer 3. The output signal from Filter 1 is input to Mixer 1. The output signal from Filter 2 is input to Mixer 2. The output signals from Filter 3 and the USB audio interface are input to Mixer 3. The output signals from Mixer 1 are input to Speaker 1 to Speaker 8. The output signals from Mixer 2 are input to Speaker 9 to Speaker 16. The output signals from Mixer 3 are input to Speaker 17 to Speaker 32. The speaker placement is shown in Figure 2. The sound source for the front speakers moves from Speaker 1 to Speaker 8 and then from Speaker 8 back to Speaker 1. The speakers are arranged as shown in Figure 2 to facilitate the Doppler effect. The rear speaker audio source moves in the following sequence: Speaker 1, Speaker 8, Speaker 2, Speaker 7, Speaker 3, Speaker 6, Speaker 4, and Speaker 5. It then moves in the reverse sequence: Speaker 4, Speaker 5, Speaker 3, Speaker 6, Speaker 2, Speaker 7, Speaker 1, and Speaker 8. The rear speakers are positioned in the same manner as the front speakers. Furthermore, the heights of the front and rear speakers are changed to make the sound source more audible. To achieve discrete sound source movement, speakers are stacked on top of each other and arranged at eight locations as shown in the figure. One sound source moves from Speaker 17 to Speaker 24. The other sound source moves from Speaker 25 to Speaker 32.

3. Filter Design

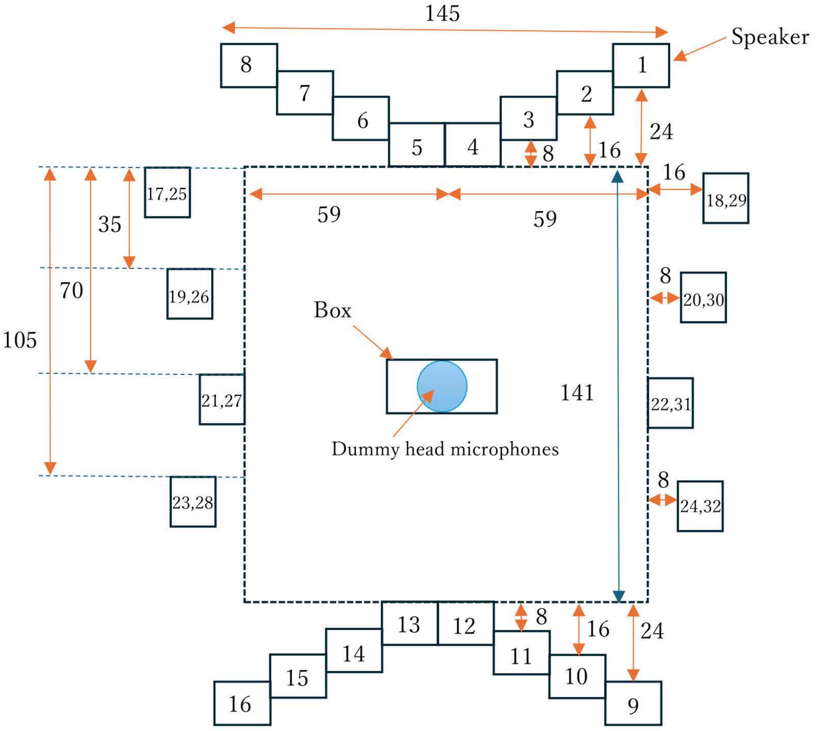
3.1. Design of Filter 1

The signal output by the pseudo-random signal generator circuit (Okawa et al. 2012), which uses a fourth-order primitive polynomial (Imai 1990) was XORed with the input signal on line 0 and output as a random signal. The fourth-order primitive polynomial is given by Equation 1, and the circuit diagram is shown in Figure 3. The terms of the fourth-order polynomial in Equation 1 correspond to the D flip-flop TC74HC74AP (Toshiba Corporation. 2014a), while the adder corresponds to the exclusive-OR circuit TC4030BP (Toshiba Corporation. 2014a). A CD74HC4050 buffer is used (Texas Instruments Inc. 2005).

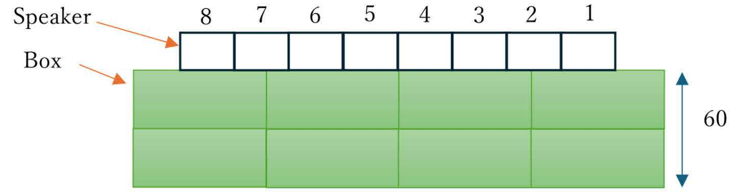
$$x^4 + x + 1 \tag{1}$$

3.2. Design of Filter 2

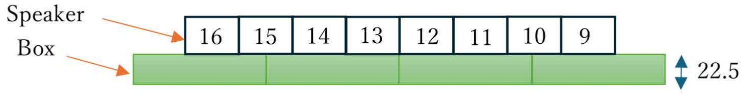
The basic configuration of this filter is shown in Figure 4, and the circuit diagram is shown in Figure 5. The buffer in Figure 5 and inverter are implemented using CD74HC4050 and SN74HCU04 (Texas Instruments Inc.



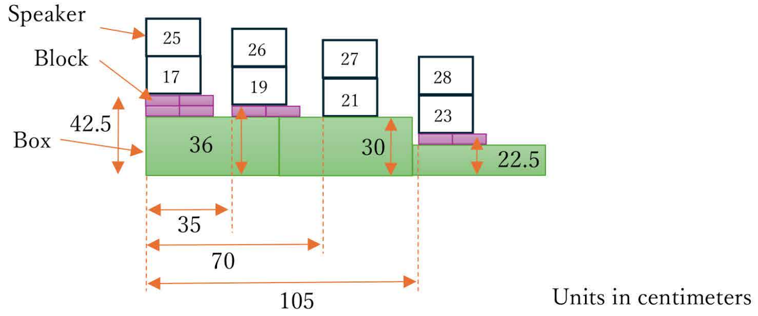
Upper side



Front side



Rear side



Left side

Figure 2. Speaker placement

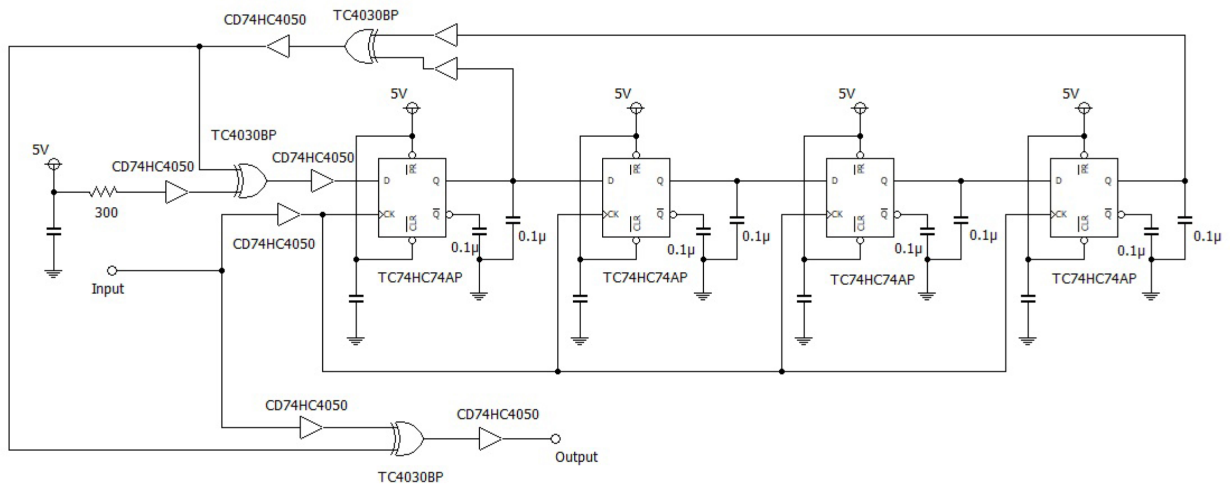


Figure 3. The circuit for Filter 1

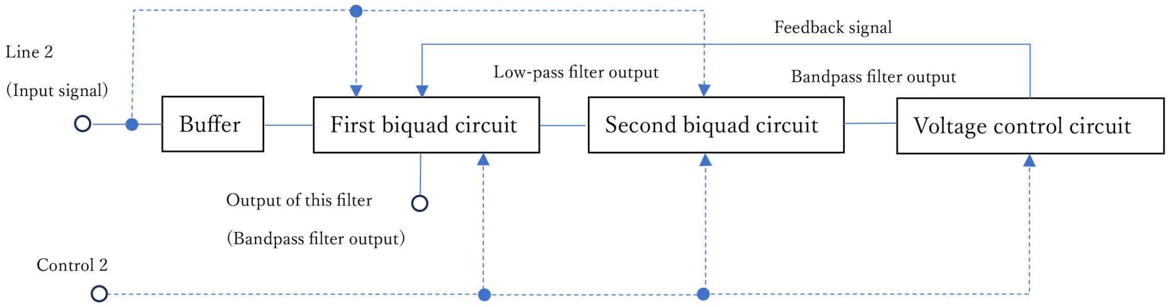


Figure 4. Basic structure of Filter 2

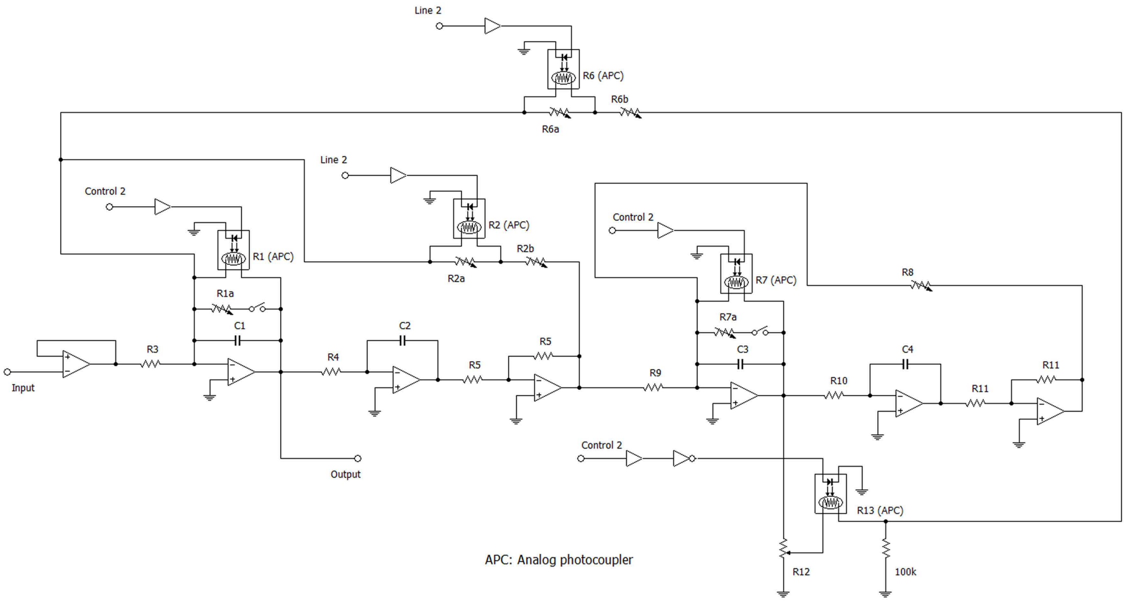


Figure 5. The circuit for Filter 2

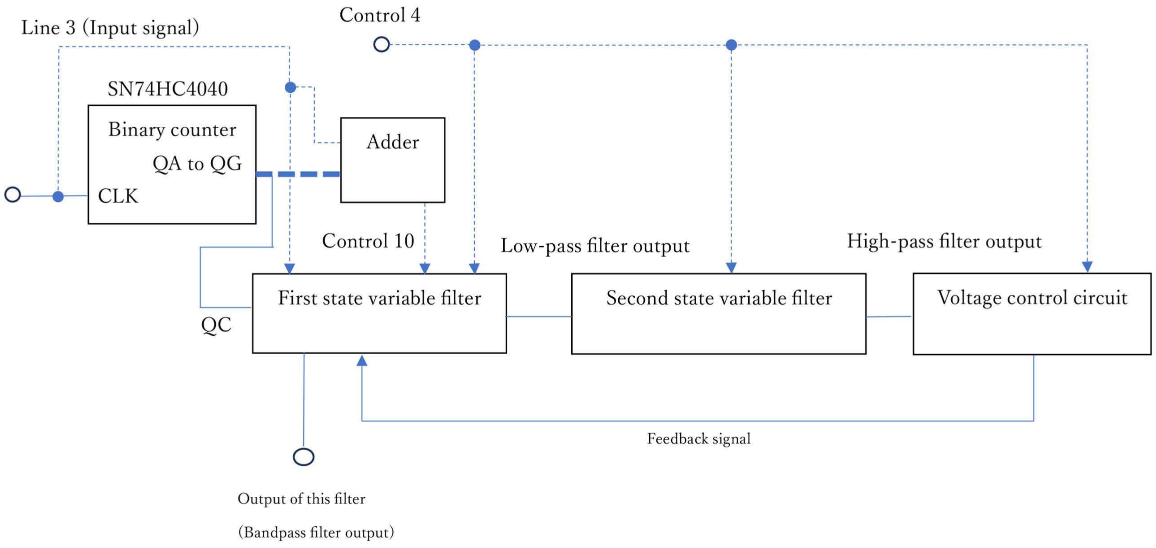


Figure 6. Basic structure of Filter 3

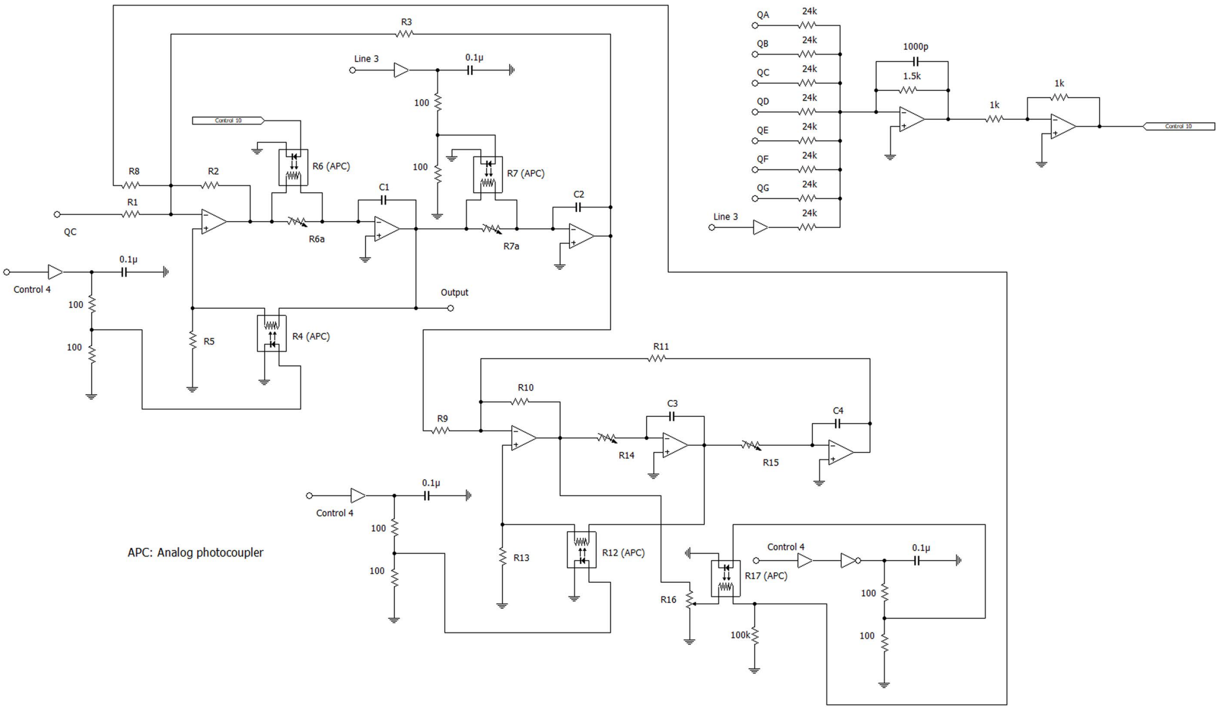


Figure 7. The circuit for Filter 3

2004), respectively. As shown in Figure 4, the output of the low-pass filter in the first biquad circuit (Van Valkenburg 1982) is input to the second biquad circuit. The output of the bandpass filter in the second biquad circuit is input to the voltage control circuit (Tsuji 2016). The output of the voltage control circuit is input to the first biquad circuit. The output of this filter is the output of the bandpass filter of the first biquad circuit. The control signal Control 2 is input to this filter to control sensitivity and the feedback signal. When the input signal Line 2 is not output by the computer synthesizer, Control 2 becomes 5 V (High), reducing the sensitivity and the voltage of the feedback signal. The input signal Line 2 controls the center frequency. As shown in Figure 5, the sensitivity, feedback signal, and center frequency are controlled by inputting the control signal to the analog photocoupler. Sensitivity is controlled by R1 and R7 of the analog photocoupler. The feedback signal is controlled by R13 of the analog photocoupler. The center frequency is controlled by R2 and R6 of the analog optocoupler and the variable resistor R8. Impedances Z1, Z2, Z6, and Z7 are expressed in Equation 2. Because Z2 and Z6 must have equal values, R2a and R6a, as well as R2b and R6b, use dual variable resistors. R4 and R10 use fixed resistors. R1a and R7a control the maximum resistance value of the analog photocoupler. The switch can also be used to isolate or bypass the resistance value of the analog photocoupler. R2a and R6a also control the maximum resistance value of the analog photocoupler. R2b and R6b control the minimum resistance value of the analog photocoupler. The transfer function of the filter is given by Equation 3. T_{BP} represents the general form of a second-order response characteristic, T_0 represents the transfer function of this filter, T_1 represents the transfer function of the second biquad circuit, and T_2 represents the transfer function of the voltage control circuit.

$$
\begin{aligned}
Z1 &= \frac{R1R1a}{R1+R1a} \\
Z2 &= \frac{R2R2a}{R2+R2a} + R2b \\
Z6 &= \frac{R6R6a}{R6+R6a} + R6b \\
Z7 &= \frac{R7R7a}{R7+R7a}
\end{aligned} \tag{2}
$$

$$
\begin{aligned}
T_{BP} &= \frac{\dfrac{\omega_0}{Q}s}{s^2 + \dfrac{\omega_0}{Q}s + \omega_0^2} \\[2ex]
T_0 &= \frac{-\dfrac{Z1}{R3}\dfrac{1}{C1Z1}s}{s^2 + \dfrac{1}{C1Z1}s + \dfrac{1}{C1C2Z6R4}(1 + T_1T_2)} \\[1ex]
\omega_0 &= \sqrt{\frac{1}{C1C2Z6R4}(1 + T_1T_2)} \\[1ex]
Q_0 &= C1Z1\sqrt{\frac{1}{C1C2Z6R4}(1 + T_1T_2)} \\[1ex]
Z2 &\approx Z6 \\[2ex]
T_1 &= \frac{-\dfrac{Z7}{R9}\dfrac{1}{C3Z7}s}{s^2 + \dfrac{1}{C3Z7}s + \dfrac{1}{C3C4R8R10}} \\[1ex]
\omega_1 &= \sqrt{\frac{1}{C3C4R8R10}} \\[1ex]
Q_1 &= C3Z7\sqrt{\frac{1}{C3C4R8R10}} \\[1ex]
T_2 &= \frac{R12b}{R12a + R12b} \times \frac{10^5}{R13 + 10^5} \\[1ex]
R12 &\approx R12a + R13b
\end{aligned} \tag{3}
$$

3.3. Design of Filter 3

The basic configuration of this filter is shown in Figure 6, and the circuit diagram is shown in Figure 7. The buffer and inverter in Figure 7 use the same ICs as those used in Filter 2. This filter was designed without using the all-pass filter of the conventional SVF (Tsuji 2019). As shown in Figure 6, an SN74HC4040 binary counter (Texas Instruments Inc. 2003) is used. The input signal Line 3 is input to the CLK terminal of the binary counter. The frequency division signal output from the QC terminal of the binary counter is input to the first SVF. The output signal from the low-pass filter of the first SVF is input to the second SVF. The output signal from the high-pass filter of the second SVF is input to the voltage control circuit. The output signal from the voltage control circuit is input to the first SVF. The output of this filter is the output of the bandpass filter in the first SVF. The input signal from Line 3 and the division signals output from the seven terminals QA to QG of the binary counter are input to the adder. The input signal Line 3 and control signal Control 10 output from the adder are input to the first SVF to control the center frequency. The control signal Control 4 is input to this filter to control sensitivity and feedback signals. When the input signal Line 3 is not output by the computer synthesizer, the control signal Control 4 goes High, decreasing the sensitivity and voltage of the feedback signal. As shown in Figure 7, the sensitivity, feedback signal, center frequency, and cutoff frequency are controlled by inputting the control signal to the analog photocoupler. Sensitivity is controlled by R4 and R12 of the analog photocoupler. The feedback signal is controlled by $R17$ of the analog photocoupler. The center frequency is controlled by R6 and R7 in the analog photocoupler. The cutoff frequency is controlled by the dual variable resistors R14 and R15. The analog photocoupler is LCR0202 (Eagle Power International Holding LTD); therefore, the 5 V voltage for control signals Line 3 and Control 4 was halved before input. Impedances Z6 and Z7 are expressed in Equation 4. R6a and R7a control the maximum resistance value of the analog photocoupler. The transfer function of this filter is given by Equation 5. T_{BP} and T_{HP} represent the general form of a second-order response characteristic, T_0 represents the transfer function of this filter, T_1 represents the transfer function of the second SVF, and T_2 represents the transfer function of the voltage control circuit.

$$
\begin{aligned}
Z6 &= \frac{R6R6a}{R6+R6a} \\
Z7 &= \frac{R7R7a}{R7+R7a}
\end{aligned}
\tag{4}
$$

$$T_{BP} = \frac{\frac{\omega_0}{Q}s}{s^2 + \frac{\omega_0}{Q}s + \omega_0^2}$$

$$T_{HP} = \frac{s^2}{s^2 + \frac{\omega_0}{Q}s + \omega_0^2}$$

$$T_0 = \frac{\frac{R2}{C1R1Z6}s}{s^2 + \frac{R2}{C1Z6}(\frac{R5}{R4+R5})(\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R8})s + \frac{R2}{C1C2Z6Z7}(\frac{1}{R3} + \frac{T_1T_2}{R8})}$$

$$\omega_0 = \sqrt{\frac{R2}{C1C2Z6Z7}(\frac{1}{R3} + \frac{T_1T_2}{R8})}$$

$$Q_0 = \frac{\sqrt{\frac{R2}{C1C2Z6Z7}(\frac{1}{R3} + \frac{T_1T_2}{R8})}}{\frac{R2}{C1Z6}(\frac{R5}{R4+R5})(\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R8})}$$

$$R1 \approx R2 \approx R3 \approx R8$$

$$C1 \approx C2$$

$$T_1 = \frac{-\frac{R10}{R9}s^2}{s^2 + \frac{R10}{C3R14}(\frac{R13}{R12+R13})(\frac{1}{R9} + \frac{1}{R10} + \frac{1}{R11})s + \frac{R10}{C3C4R11R14R15}}$$

$$\omega_1 = \sqrt{\frac{R10}{C3C4R11R14R15}}$$

$$Q_1 = \frac{\sqrt{\frac{R10}{C3C4R11R14R15}}}{\frac{R10}{C3R14}(\frac{R13}{R12+R13})(\frac{1}{R9} + \frac{1}{R10} + \frac{1}{R11})}$$

$$R9 \approx R10 \approx R11$$

$$C3 \approx C4$$

$$T_2 = \frac{R16b}{R16a + R16b} \times \frac{10^5}{R17 + 10^5}$$

$$R16 \approx R16a + R16b \tag{5}$$

4. Mixer Functions

4.1. Functions of Mixer 1

Mixer 1 has 2 inputs, 8 outputs, and a built-in amplifier. By inputting the control signal on Line 0, the sound source can be moved to the front eight speakers. When Line 0 is not output by the computer synthesizer, the Control 0 signal becomes High, stopping the mixer output. The mixer inputs are Input 1 and Input 2, and mixer outputs are from channel 1 to channel 8. The output signal from Filter 1 was input to Input 1. The signal input to Input 1 switches in order from channel 1 to channel 8 and then switches in order from channel 8 to channel 1, repeating this cycle. The signal input to Input 2 switches in the reverse order of the signal input to Input 1, repeating this cycle. An analog multiplexer IC, TC4051BP (Toshiba Corp. 2006), is used to switch the input signal to eight outputs. The power amplifier IC used is NJM2073D (New Japan Radio 2004). TC4051BP outputs a signal that switches between 0 and 7 at the output terminal when control signals are input to terminals A, B, and C. Logical operations are performed using the divided signal output from the QB to QE terminals of the SN74HC4040 binary counter. The control signals input to terminals A, B, and C are defined as A1, B1, and C1. These logic expressions are shown in Equation 6, the circuit diagram and measured control signal are shown in Figures 8 and 9, respectively, and the truth table for the TC4051BP is given in Table 1. From Table 1, the control signal changes, and the output terminal is altered. The buffer, inverter, AND gate, and OR gate are implemented using CD74HC4050, SN74HCU04, TC74HC08AP (Toshiba Corp. 2014c), and TC74HC32AP (Toshiba Corp. 2014d), respectively. To stop the output of TC4051BP, a High signal is applied to the INH terminal using the Control 0 signal. Two TC4051BP devices are used to control the signals from Input 1 and Input 2.

$$A1 = (QB \wedge \neg QE) \vee (\neg QB \wedge QE)$$

$$B1 = (QC \wedge \neg QE) \vee (\neg QC \wedge QE)$$

$$C1 = (QD \wedge \neg QE) \vee (\neg QD \wedge QE) \tag{6}$$

Table 1. Truth Table for TC4051BP

C1	B1	A1	Output terminal
L	L	L	0
L	L	H	1
L	H	L	2
L	H	H	3
H	L	L	4
H	L	H	5
H	H	L	6
H	H	H	7

4.2. Functions of Mixer 2

Mixer 2 also has 2 inputs, 8 outputs, and a built-in amplifier. Inputting the control signals Line 2 and Control 1 moves the sound source for the rear eight speakers. However, Control 1 is PWM 3; therefore, no signal is output during this performance. When Line 2 is not output by the computer synthesizer, the Control 2 signal becomes High, stopping the output signal of Filter 2 from being input to Mixer 2. In this case, PWM3 is not output; therefore, the control signal Control 3 is High. The mixer inputs are Input 1 and Input 2. The mixer outputs are channels 1 to 8. The output signal from Filter 2 was input to Input 1. The signal input to Input 1 switches in the following order: 1ch, 8ch, 2ch, 7ch, 3ch, 6ch, 4ch, and 5ch. It then switches in the reverse order: 4ch, 5ch, 3ch, 6ch, 2ch, 7ch, 1ch, and 8ch. This sequence repeats. The signal input to Input 2 switches in the following order: 4ch, 5ch, 3ch, 6ch, 2ch, 7ch, 1ch, and 8ch. It then switches in the reverse order: 1ch, 8ch, 2ch, 7ch, 3ch, 6ch, 4ch, and 5ch. This sequence repeats. The analog multiplexer IC, power amplifier IC, binary counter IC, and OR gate IC were the same as those for Mixer 1. A logical OR operation is performed on the control signals Line 2 and Control 1, and the result is input to the CLK terminal of the binary counter to generate the divided signals. The divided signals output from the QD, QE, and QF terminals of the binary counter are input to terminals A, B, and C of TC4051BP. The signal from Input 1 is output from the mixer using two TC4051BP devices. The control signal is input to the INH terminal of TC4051BP to facilitate alternation of the two TC4051BP outputs. The signal output from the QG terminal of the binary counter was logically operated with the control signal Control 2 and input to the terminal INH. The control signals input to the INH terminals of the two TC4051BP devices are referred to as INH 1 and INH 2. The logic expression is represented by Equation 7.

$$INH\ 1 = Control\ 2 \vee QG$$

$$INH\ 2 = Control\ 2 \vee \neg QG \tag{7}$$

The signal from Input 2 is also output from the mixer using two TC4051BP devices in the same method as that of the signal from Input 1. The signal output from the QG terminal of the binary counter performs a logical operation with the control signal Control 3. The control signals input to the INH terminals of the two TC4051BP devices are referred to as INH 3 and INH 4. The logic expression is represented by Equation 8.

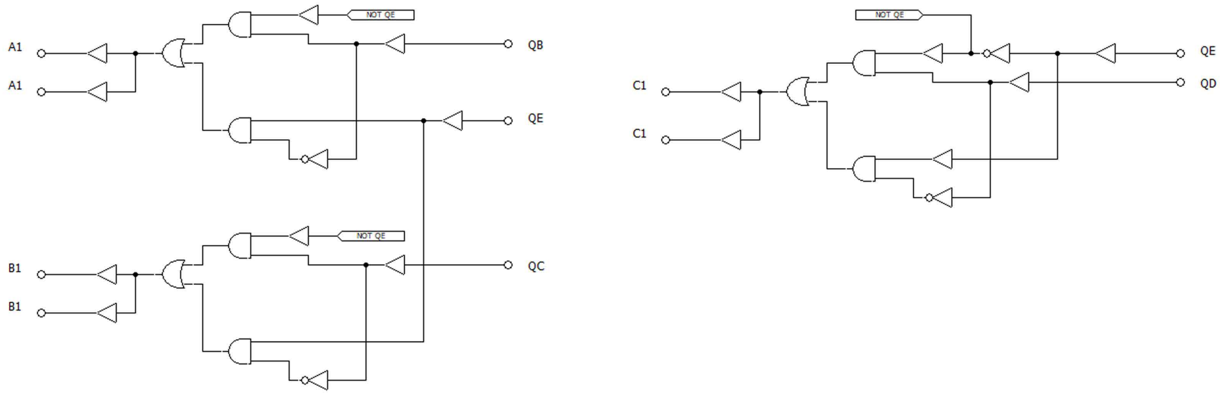
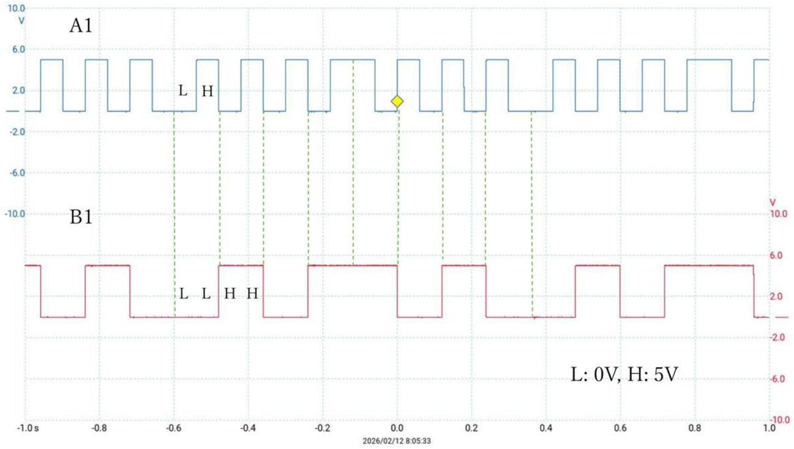
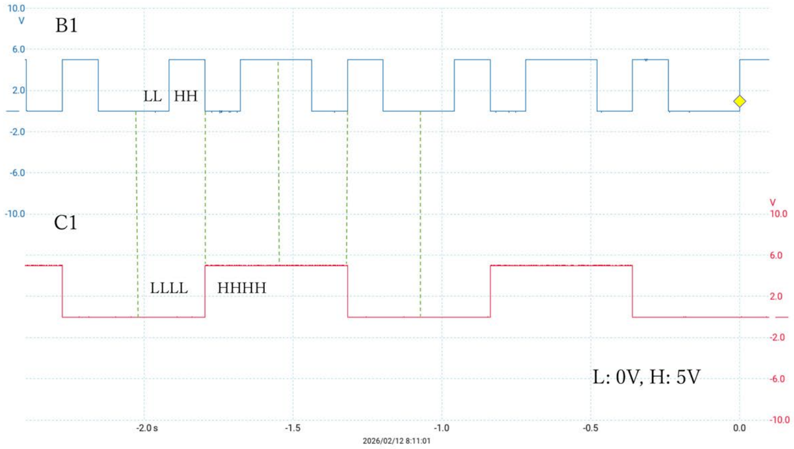


Figure 8. Control signals for TC4051BP



(a) A1 and B1



(b) B1 and C1

Figure 9. Measured control signals for TC4051BP

Table 2. Correspondence of Each Output

Input 1 signal								Input 2 signal							
Output terminal for AM 1 (INH 1: Low, INH 2: High)								Output terminal for AM 3 (INH 3:Low, INH 4: High)							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
Mixer output								Mixer output							
1	8	2	7	3	6	4	5	4	5	3	6	2	7	1	8
Output terminal for AM 2 (INH 1: High, INH 2: Low)								Output terminal for AM 4 (INH 3:High, INH 4: Low)							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
Mixer output								Mixer output							
4	5	3	6	2	7	1	8	1	8	2	7	3	6	4	5

Figure 10. Violin bow and metal sheet

$$INH\ 3 = Control\ 3 \vee QG$$

$$INH\ 4 = Control\ 3 \vee \neg QG \tag{8}$$

Table 2 presents the correspondence between the analog multiplexer's output terminals and the mixer's outputs. The analog multiplexers used for the signal at the mixer's Input 1 are referred to as AM 1 and AM 2, while those used for the signal at Input 2 are referred to as AM 3 and AM 4. Low represents 0 V.

4.3. Functions of Mixer 3

Mixer 3 has 2 inputs, 16 outputs, and a built-in amplifier. Inputting the control signal Control 5 moves the sound source for the 16 speakers on the left and right sides, as shown in Figure 2. This mixer does not have a function to stop output. The mixer inputs are Input 1 and Input 2, while the mixer outputs are channels 1 to 16. The output signal from the USB audio interface was input to Input 1, and the output signal from Filter 3 was input to Input 2. The signal input to Input 1 cycles through channels 1 to 8 in sequence and repeats this cycle. The signal input to Input 2 cycles through channels 9 through 16 in sequence and repeats this cycle. The analog multiplexer IC, power amplifier IC, and binary counter IC are the same as those in Mixer 1. Control 5 from the control signal output by the USB device is input to the CLK terminal of the binary counter to output a divided signal. The divided signals output from the QB, QC, and QD terminals of the binary counter are input to terminals A, B, and C of TC4051BP. The voltage input to the INH terminal of the TC4051BP is low. Two TC4051BP devices are used to control the signals from Input 1 and Input 2.

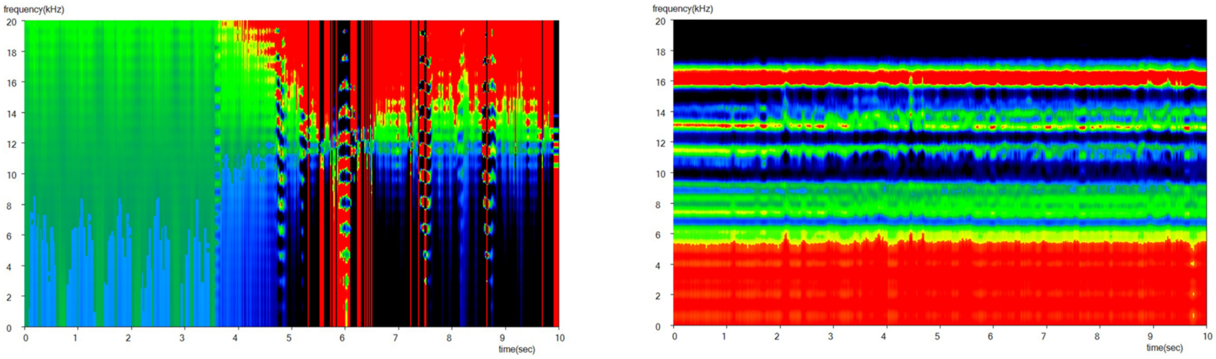
5. Creation of WAV Files

A WAV file was created for playback on a computer synthesizer. Friction noise was generated using the violin bow and metal sheet shown in Figure 10. The signal captured by the condenser microphone was recorded using multitrack recording software via the Metal Zone MT-2 effects pedal (Roland Corp. 2026) and a USB audio interface. The WAV files extracted from the multitrack recording software were mastered on a computer and used in the computer's sequencer. The WAV format used a sampling frequency of 44.1 kHz and linear quantization with 16 bits.

6. Frequency Analysis

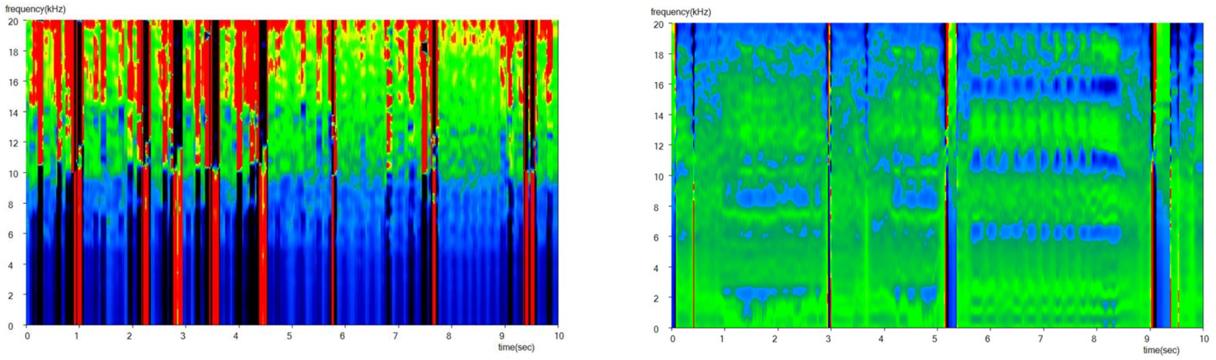
Frequency analysis was conducted on the signal output from Filter 1, Filter 2, Filter 3, and the USB audio interface. Figure 11 presents the frequency analysis of each signal. The output signals were digitized at a sampling frequency of 44.1 kHz with 16-bit linear quantization. The power spectrum was calculated using the Burg method with 48-order autoregressive coefficients (Ehara 1991). Frequency analysis was performed at 100 ms per frame (4410 samples). Next, the sample number per frame was shifted by 20 ms (882 samples), and new 20 ms audio data were input. This operation was repeated to conduct a frequency analysis for 10 s. The audio data x(n) are represented by Equation 9, where N is the number of samples, e is the frame number, and s is the shift number. The frequency components were normalized to allow each signal to be compared (Tsuji 2018b).

$$x(n)\ (n = e \cdot s, e \cdot s + 1, e \cdot s + 2, ..., e \cdot s + (N-1), \\ e = 0, 1, 2, ..., 495, s = 882, N = 4410) \tag{9}$$



(a) Output signal from Filter 1

(b) Output signal from Filter 2



(c) Output signal from Filter 3

(d) Output signal from USB audio interface

Figure 11. Frequency analysis each signals

Figure 12. Actual synthesizer system

7. Actual Performance

On November 23, 2025, the performance of a synthesizer system using 32-channel speakers was demonstrated at the UPD studio. The performance was auditioned directly within the system and was also recorded using dummy head microphones for binaural playback. Dissecting Table's "War Between Good And Evil" was played. A photograph of the actual system is shown in Figure 12. The synthesizer system consists of a computer, a USB audio interface, a USB device, a line selector, a buffer, a filter, a mixer, and speakers. As shown in Figure 2, the 32 speakers were arranged to form a rectangle measuring 118 cm in width and 141 cm in height, with the speaker units facing inward. The dummy head microphones were placed on a box positioned at the center of gravity of the rectangle formed by the speakers. The box measures 21 cm in height, 36 cm in width, and 29 cm in depth. The front speakers played back the output signal from Filter 1 via Mixer 1. The rear speakers played back the output signal from Filter 2 via Mixer 2. The left and right speakers played back the output signals from the USB audio interface and Filter 3 via Mixer 3. Mixer 1 and Mixer 2 moved the speaker's sound source to the left and right. The left and right speakers moved the sound source between front and back and left and right. When listening within the system, the sound source movement between the front and rear speakers was continuous, while the movement between the left and right speakers was discrete, making the sound more audible. When listening to binaural recordings, the left − right sound localization of the front and rear speakers was easy to perceive; however, determining the sound localization of the rear speakers was difficult. Sound localization from the left and right speakers shifted the sound image to the left and right as well as front and back, creating a three-dimensional effect.

8. Conclusion

This study attempted to combine synthesizer output with 3D audio. The synthesizer output was played from 24 speakers positioned around the listener, while the computer's WAV file was played from 8 speakers positioned on the left and right. Using a mixer, the speaker's sound source could be moved, allowing for three-dimensional playback. When listening to this system's output through headphones after binaural recording, the sound image moved to the front, back, left, and right, creating a three-dimensional acoustic experience. Furthermore, improvements to the mixer's sound quality and the development of analog filters to further enhance system performance should be considered.

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9. Author’s Profile

Ichiro TSUJI

Ichiro Tsuji, born in 1966, graduated from the Department of Electrical Faculty of Technology of Kokushikan University in 1991. He joined the NEC home Electronics Corp the same year. At the Development Research Laboratory, he was engaged in researching a three-dimensional playback system for a two-channel speaker. He then moved to NEC Corp and was engaged in the research and development of a multimedia-related project. He retired in 1998. He is currently a regular member of the Acoustical Society of Japan. Regarding his musical activities, in Tokyo in 1986, he started working on noise/industrial music for his band, “Dissecting Table.” He returned to his hometown of Hiroshima in 1998 and has been pursuing musical activities ever since. His records and compact disks have been released under the independent label of the UPD Organization and under labels in Europe and the United States. Since 2011, the works have been produced by controlling PWM signals output from a USB device on a computer.
