Sound Creation Based on Nonlinear Cell Circuits

Naruno Fujii and Hiroshi Yamamoto
Faculty of Science and Technology, Sophia University
7–1, Kioi-cho, Chiyoda-ku, Tokyo 102–8554, Japan
Email: nanno0917@sophia.ac.jp

Yoshifumi Nishio
Faculty of Electrical and Electronic Engineering, Tokushima University
2–1, Minami-Josanjima, Tokushima 770–8506, Japan
Email: nishio@ee.tokushima-u.ac.jp

Masaki Bandai and Mamoru Tanaka
Faculty of Science and Technology, Sophia University
7–1, Kioi-cho, Chiyoda-ku, Tokyo 102–8554, Japan
Email: mamoru.tanaka@gmail.com

I. Abstract

The sound has three elements. They are "Sound volume", "Musical pitch", and "Tone color". First, "Sound volume" changes by the amplitude of the waveform. When the amplitude is large, the sound will be also large. And the other hand, when the amplitude will be small, the sound will be also small. Next, about "Musical pitch", It changes depend on its frequency. The sounds with high frequencies become high-pitched sounds, and the sounds with low frequencies become low-pitched sounds. The last, "Tone color" can be decided by its waveforms.Sound is classified into three kinds by the waveform. They are "Pure tone", "Musical tone", and "Unpitched sound". "Pure tone" is a sound that has only one sine wave. And, "Musical tone" is the lasting sounds that have regular vibrations except for the pure tone. Then, "Unpitched sound" is a sound that has almost no regular vibrations. In this research, we focused on the musical tone waveform. Now, the signal processing is mainly used in order to generate the musical tone waveform. Then, we propose the method for generating the musical tone waveform from the state equation as a new method. We calculate the state equation from the nonlinear circuit that is modified Nishio circuit. In this method, the frequency and the musical tone waveform can be changed easily by changing the value of capacitance of the nonlinear circuit.

II. Simulation Results

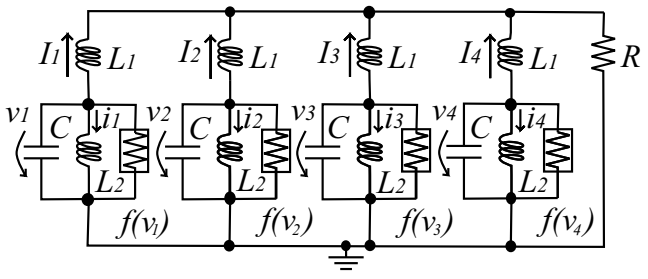

Fig. 1. Circuit model. $L_1 = 100.7[mH]$, $L_2 = 10.31[mH]$, $C = 12.69[\mu F]$,and $R = 26.72[\Omega]$.

The nonlinear circuit which used this research is shown in Figure 1. The state equation obtained from this circuit is shown in (1). In this research, we calculated the voltage waveform of the capacitor from each node electrical potential. We considered as the waveform to be a musical tone waveform, and generated the musical tone. Thus, we showed to be able to generate the musical tone from the state equation.

$$\begin{cases} L_1 \dfrac{dI_k}{dt} = v_k - R\displaystyle\sum_{j=1}^{4} I_j \\ L_2 \dfrac{di_k}{dt} = v_k \\ C \dfrac{dv_k}{dt} = -I_k - i_k - f(v_k) \\ f(v_k) = -\alpha \dfrac{|v_k+1|-|v_k-1|}{2} \\ \alpha = 0.012 \end{cases} \tag{1}$$

The information of music is usually written in its score. In this research, MIDI information plays the role of score. MIDI information shows the property of each music such as length and pitch of each note. In this MIDI information, quarter note are defined as one second. Actually to play the musics by using this method, it is necessary to combine such data into this system. To keep the "Sustain" of each notes which is decided by MIDI information, and to realize the smooth "Release" , changing the volume of resistance α is needed. It can be expected that resistance α works as like a inclination when sound is releasing. Then it leads smoothly shift to the next note.

III. Conclusion

In this paper, we showed that the musical tone can be generated by using the state equation that had been obtained from the nonlinear circuit that the Nishio circuit had been modified. And to realize not only generate the musical tone but also generate the comfortable musical tone from state equations, what we focused on was "Enverope". "Enverope" are consisted of four elements as follows, "Attack", "Decay", "Sustain" and "Release". In order to improve the quality of sound, "Release" can be the very important element in particular. Smooth "Release" makes the sounds more artistic and natural. Resistance α works as like a inclination of "Release". Then, it can be expected that resistance α is the key point of "Release".

References

[1] Y.Nishio and A.Ushida, "Chaotic Wandering and its Analysis in Simple Coupled Chaotic Circuits ", IEICE Transactions on Fundamentals, vol.E85-A,no.1,pp.248-255,Jan.2002.