M-16

CMOS IC Design of Pulse-Type Inhibitory Neural Networks for Micro Robot

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Abstract: This paper proposed the 2.5 mm square size CMOS IC chip design of the pulse-type hardware inhibitory neural networks (P-HINN) which was a locomotion generator of the micro robot. P-HINN could control the locomotion of the micro robot without using computer programs. The locomotion control of the P-HINN was realized by oscillatory patterns of electrical activity such as biological brain. The P-HINN consisted by a pulse-type inhibitory neuron models which has a characteristics of threshold, refractory period and spatio-temporal summation characteristics. As a result, we clarified that the pulse-type hardware inhibitory neural networks can generate the waveform to actuate the micro robot in simulation level.

1. Introduction

Previously, programmed control by a microcontroller has been the dominant system among the robot controls even a micro robot. To realize the active motion such as a living body, the advantage robot controlling system using artificial intelligence were reported. The typical robot controlling system by using artificial intelligence was computer programming or using neural networks witch imitate the biological information processing.

On the other hand, insects realize the excellent functions by compact system. Robot control using programmed control by a microcontroller is difficult to realize the flexible and excellent control such as living body. In contrast, artificial neural networks control is advantageous than programmed control because artificial neural networks implements the excellent functions of living body.

We are studying about active hardware neural networks system by analog circuits which have an excellent information processing functions such as biological neural networks.

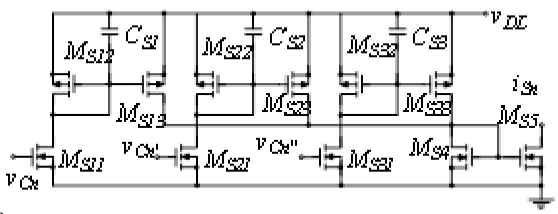
In this paper, we will propose the 2.5 mm square size CMOS IC chip design of the pulse-type hardware inhibitory neural networks (P-HINN) which is a locomotion generator of the micro robot.

2. Pulse-type hardware inhibitory neural networks

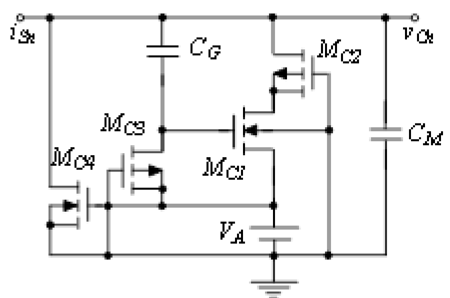
Figure 1 shows the circuit diagram of the pulse-type inhibitory neuron model (P-HINM) by CMOS. P-HINM consists of an inhibitory synaptic model and a cell body model. The circuit diagram of inhibitory synaptic model was shown in figure 1 (a). Inhibitory synaptic model has the spatio-temporal summation characteristics similar to those of living organisms, spatio-temporal summate the outputs of 3 cell body models. The circuit parameters of inhibitory synaptic model were as follows: $C_{CS1}=C_{CS2}=C_{CS3}=1$ pF, $M_{S11\text{-}13}$, $M_{S21\text{-}23}$, $M_{S21\text{-}23}$: $W/L=1$, $M_{S4,5}$: $W/L=1$. The voltage source $V_{DD}=5$ V.

The circuit diagram of the cell body model was shown in figure 1 (b). Cell body model has the same basic features of biological neurons such as threshold, refractory period, and enables the generation of continuous action potentials. The circuit parameters of the cell body model were as follows: $C_G=20$ pF, $C_M=10$ pF, M_{C1}, M_{C2}: $W/L=10$, M_{C3}: $W/L=0.1$, M_{C4}: $W/L=0.3$. The voltage source $V_A=3.3$ V.

Figure 2 shows the schematic diagram of the P-HINN. C_1, C_2, C_3 and C_4 indicates the cell body model. Solid line with solid circle indicates the inhibitory synaptic model. 4 cell body models are totally mutual coupled by the



(a) The circuit diagram of inhibitory synaptic model



(b) The circuit diagram of the cell body model

Figure 1. the circuit diagram of the pulse-type inhibitory neuron model (P-HINM) by CMOS

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inhibitory synaptic models. P-HINN is a coupled neural networks system which can generate the locomotion rhythms such as living organisms.

Figure 3 shows the example of output waveform of the P-HINN. The output waveform A, B, C and D indicates the output waveform of cell body model C_1, C_2, C_3 and C_4, respectively. It is shown that P-HINN can output the waveform of locomotion of the micro robot. The waveform was generated by using OrCAD (circuit simulation software).

Figure 4 shows the example of layout pattern of the P-HINN. This IC chip was made by On-Semiconductor, SANYO Corporation double metal double poly CMOS 0.8 μm rule. The layput size of each enhanse mode MOSFETs were as follows: $M_{S11\text{-}13}$, $M_{S21\text{-}23}$, $M_{S21\text{-}23}$: W/L=10 μm/10 μm, $M_{S4,5}$: W/L= 10 μm/10 μm. M_{C1}, M_{C2}: W/L= 20 μm/2 μm, M_{C3}: W/L= 20 μm/2 μm, M_{C4}: W/L= 6 μm/20 μm. The layout size of each capacitors were as follows: C_{CS1}=C_{CS2}=C_{CS3}=39 μm width, 39 μm length. C_G=78 μm width, 78 μm length. C_M=10 pF 39 μm width, 78 μm length. The layout size of each enhanse mode MOSFETs and capacitors satisfies the design rule.

3. Conclusions

In this paper, we proposed the CMOS IC design of the pulse-type hardware inhibitory neural networks which was a locomotion generator of the micro robot. As a result, we clarified that the pulse-type hardware inhibitory neural networks can generate the waveform to actuate the micro robot in simulation level.

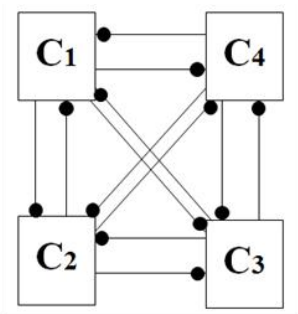

Figure 2. Schematic diagram of the P-HINN.

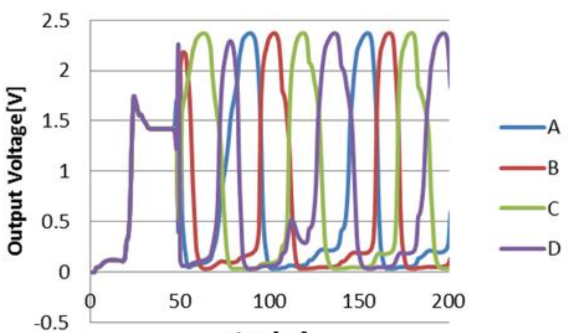

Figure 3. Example of output waveform of the P-HINN.

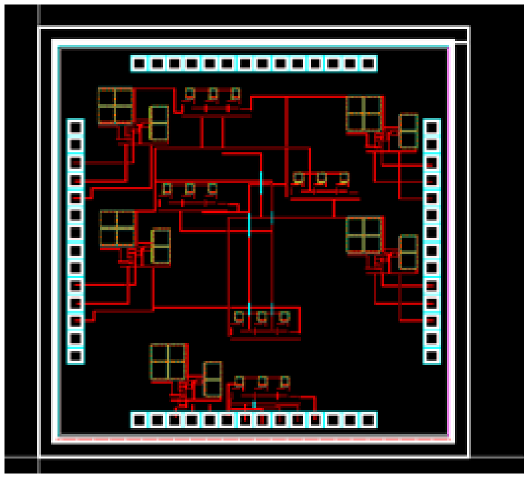

Figure 4. Example of layout pattern of the P-HINN.

4. Acknowledgments

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5. References

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