M-7

Development of Driver Circuit with Mounted CMOS IC Bare Chip for MEMS Micro-Robot.

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Abstract: This paper suggests downsizing of a driver circuit mounted CMOS IC bare chip for MEMS micro-robot. In the control system, the digital electronic circuit is usually used, although it cannot respond to unexpected situation. Therefore, the neural network that mimics a brain of living organisms is desirable. Moreover, the discrete circuit is too large to mount the micro-robot. Therefore, the miniaturization of the circuit is required. The downsizing was realized by using a bare chip IC in this study. The wire bonding technology is used for connection of peripheral circuits and bare chip, and space-wiring of the circuit were used. The drive circuit including a bare chip can realize in 9.4mm × 7.5mm by using the two-stage structure.

1. Introduction

Recently, some robots are expected to work at small space such as the field of the precision machinery engineering and medical assistance in the blood vessels. Activities in the small space are required small mechanisms and flexible controls. In the mechanism of the micro-robot, miniaturization of parts is realized by using micro electro mechanical system technology (MEMS).[2] In the control system, the study of the neural networks is active. The artificial neural networks (ANN) is the systems that simulated the output waveform of the neurons in living organisms by software or the analog electronic circuit.[1] Therefore, the neural networks is expected flexible controls like living organisms. Moreover, mounting all control system on the micro-robot is desirable. A purpose of this study is constructing a micro-robot of insect form, and miniaturization of the driver circuit to mount on the robot by using a IC bare chip and the two-stage structure.

2. Micro-Robot

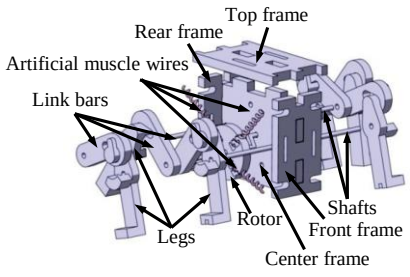

Figure.1 The diagram of the micro-robot.

Figure 1 is a diagram of the micro-robot. The micro-robot components are fabricated by MEMS technology. This robot is driven by artificial muscle wires that shows extpanshion and shrink by an electric current. 6 legs of the micro-robot are connected by a link mechanism.

3.Control System

3-1.Driver Circuit

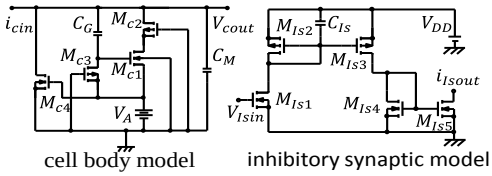

Figure 2. Circuit diagram of ANN

The neural networks is composed of cell body model and inhibitory synaptic model. Figure 2 is the basic circuit diagram of the cell body model and inhibitory synaptic model. The synaptic model has temporal summation characteristics like the living organisms. And the cell body model oscillate by control the value of V_A. Driving waveforms for the micro-robot required 4 input waveforms. In this study, each of 4 cell body models and 4 synapse models are connected. Therefore, the waveforms are obtained for walk pattern of the micro-robot. We correct output value by adjusting operational amplifiers and capacitors, transistors. Because input value of the voltage and periodicity for the micro-robot is determined about 2V, 0.417Hz, the voltage, the periodicity, respectively.

3-2. Peripheral circuit

Figure 3 is layout diagrams of the developed circuit. The size of the circuit board is 7.5mm × 9.4mm × 0.8mm. And it is used the frame retardant type 4 (FR4) circuit board. A cavity and pad pattern is formed in the circuit for a bare chip mount. Connection of the circuit and the bare chip is used the wire bonding technology. In order to downsizing of the circuit, the two-stage structure and point-to-point construction are used. There are through-holes in each board and the upper and lower board are continuity by conducting wires.

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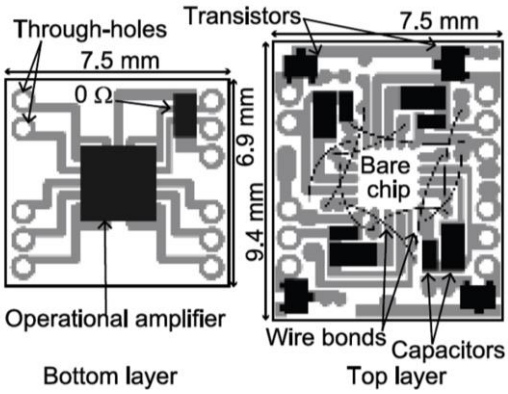

Figure 3. Layout diagrams of the circuit

4.Result and discussion

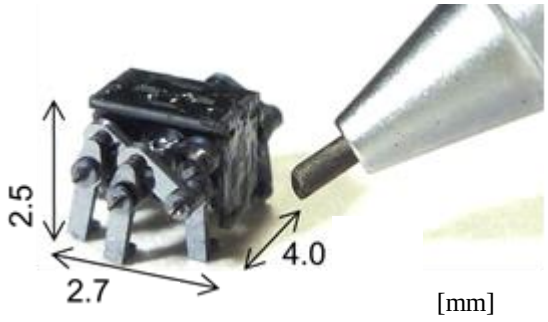

Figure 4. Fabricated the micro-robot

Figure 4 shows the fabricated micro-robot without the circuit. The size of the micro-robot was 4.0mm × 2.7mm × 2.5mm.

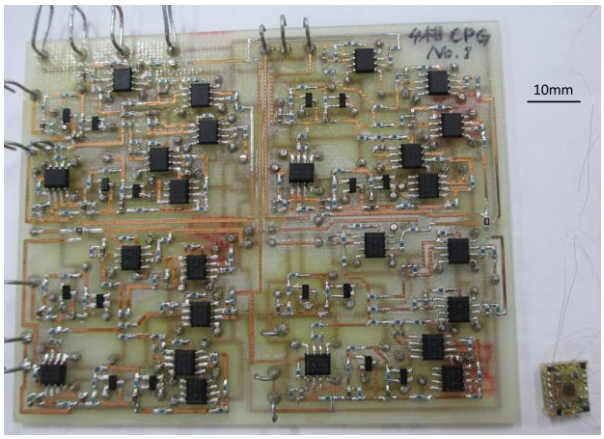

Figure 5. Discrete circuit and fabricated circuit

Figure 5 shows the comparison of the fabricated discreat circuit of ANN and the circuit with ANN CMOS IC barechip. In this study, the bare chip sizes 1.93mm × 1.93mm was used. The size of the discrete circuit was 80mm × 100mm.

Figure 6 shows the output waveform. The result of output voltage is 2V and the periodicity is 0.417Hz. Those are enough value for micro-robot to walk.

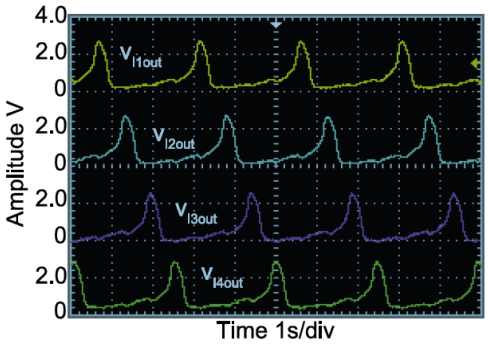

Figure 6. Driving waveform generated

In the result, the ANN system size could downsize below 1% of the discrete circuit, and we could mount on the micro-robot.

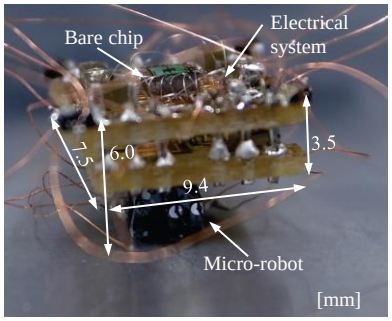

Figure 7. Micro-robot mounted the circuit

5. Conclusion

We constructed a micro-robot of insect form that mounted the driver circuit of the ANN systems on the robot. The weight was 0.33g. And the size was 7.5mm × 9.4mm × 6.0mm.

6. References

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[2] Romanos Piperakis, Saito Suguru, Takahashi Hiroki, Nakajima Masayuki: Virtual World Modeling for Software Robot using Neural Networks, ITE Technical Report, Vol.25, No.32, pp.15-20, 2001

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