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Analog circuit for detecting position of smell based on pheromone source location of silkmoth

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Abstract: In this study, we proposed an analog complementary metal oxide semiconductor (CMOS) circuit based on the pheromone source location of the silkmoth. The analog circuit is achieved by the circuit for the threshold processing using the operational amplifier. Since the proposed circuit consists of the smell sensor, five metal oxide semiconductor (MOS) transistors and four resistors, the proposed circuit is simple structure. The test circuit was fabricated on the breadboard by discrete MOS transistors and resistors. The measured results of the test circuit showed that the output voltage becomes large when the smell sensor detects the smell of the target. The output voltage of the test circuit was approximately equal to the output signal of the model based on the pheromone source location of the silkmoth. The measured results showed that the proposed circuit can control the motor. In the future, the novel compact target tracking sensor can be achieved by applying the proposed circuits based on the pheromone source location of the silkmoth and the previous circuit based on the biological vision and auditory systems.

Keywords: analog circuit, pheromone source location, smell detection

1 INTRODUCTION

It is necessary for robotics system, monitoring system and other systems to process information at high speed. High speed processing is easily achieved in the biological system because the information processing is performed in massively parallel nerve networks with a hierarchical structure.

Recently, the simple complementary metal oxide semiconductor (CMOS) circuit for tracking the target [1]-[3] was proposed based on the biological vision and auditory systems. The proposed circuit can capture and track the target by processing information of the image and the sound. However, the circuit cannot track the target in the case that the information of the image and the sound is not acquired.

In such cases, the animal can track the target by using information of the smell. Recently, the model [4],[5] for detecting the position of the smell of the object was proposed based on the pheromone source location of the silkmoth.

In the case that the silkmoth detects the pheromone, the silkmoth goes straight on toward the pheromone source, the silkmoth is turned zigzag, and the silkmoth revolves around the pheromone source. The model was proposed based on such action pattern.

In this study, we proposed an analog CMOS circuit based on the pheromone source location of the silkmoth. The test circuit was fabricated on the breadboard by discrete MOS transistors and resistors. The measured results of the test circuit showed that the output voltage becomes large when the smell sensor detects the smell of the target. The output voltage of the test circuit was approximately equal to the output signal of the model based on the pheromone source location of the silkmoth.

2 MODEL

We describe in this section the pheromone source location of the silkmoth. It is considered that we can propose simple circuit by mimicking the information processing of the insect brain because the construction of the insect brain is simple.

Figure 1 shows the action pattern of the silkmoth for detecting the pheromone source. The silkmoth has the sensor which responds with the pheromone. The sensor generates the constant voltage (pulsed signal) when the pheromone is detected by the sensor.

When the silkmoth detects the pheromone, the silkmoth goes straight on toward the pheromone source until the position *a*. Other sensor responds with the pheromone when the silkmoth arrive at the position *a*.

In the case that the right sensor responds with the pheromone, the silkmoth turns toward the right. In the

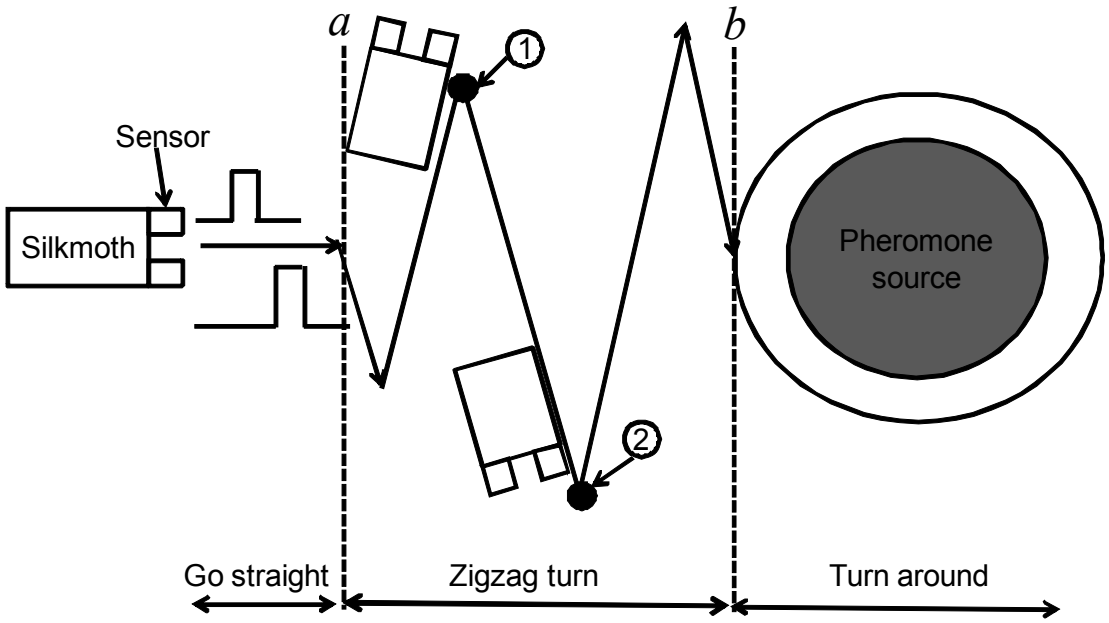

Fig. 1. The action pattern of the silkmoth for detecting the pheromone source

case that the left sensor responds with the pheromone, the silkmoth turns toward the left.

In position 1, the silkmoth turns toward the right since the right sensor responds with the pheromone. In position 2, the silkmoth turns toward the left since the left sensor responds with the pheromone. In the region from position *a* to position *b*, the silkmoth is turned zigzag.

In position *b*, both sensors respond with the pheromone, and the silkmoth detects the pheromone source. Then, the silkmoth revolves around the pheromone sources.

3 CIRCUIT

To realize the action pattern of the silkmoth, we proposed the analog CMOS circuit which outputs the constant voltage (pulsed voltage) when the smell is detected. The proposed circuit is shown in Fig. 2. The analog circuit is achieved by the circuit for the threshold processing using the operational amplifier. Since the proposed circuit consists of the smell sensor, five MOS transistors and four resistors, the proposed circuit is simple structure. The smell sensor is used as the input part. Four resistors are used to set the voltages.

The voltage V_1 is generated by the smell sensor. When the smell sensor detects the smell, V_1 becomes large. The voltage V_2 is set to the constant voltage. V_2 is the threshold voltage.

When V_1 is smaller than V_2, the output voltage V_{out} becomes 0. When V_1 is larger than V_2, V_{out} shows the constant voltage.

Thus, the proposed circuit outputs the constant voltage when the smell sensor detects the smell. By using two proposed circuit, we can develop the compact system which has the same function in Fig. 1.

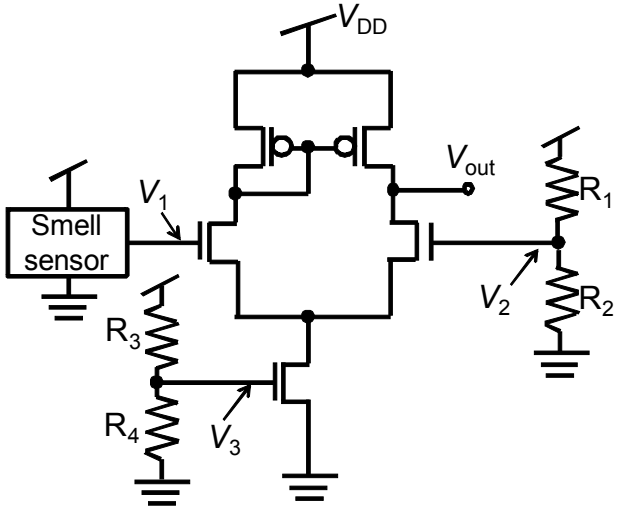

Fig. 2. The proposed circuit

4 MEASURED RESULTS

The test circuit was fabricated on the breadboard by discrete MOS transistors and resistors. Figure 3 shows the photograph of the test circuit. The supply voltage V_{DD} was set to 5 V. By setting to R_1=15 kΩ and R_2=15 kΩ, V_2 was set to 2.5 V. By setting to R_1=3 kΩ and R_2=1 kΩ, V_3 was set to 1.25 V. The ethanol was utilized as the smell source. The distance between the smell sensor and the ethanol was set to 1 m.

Figure 4 shows the output voltage V_{out} of the test circuit. V_{out} becomes the constant voltage (5 V) when the smell sensor detects the smell of the target. The output voltage of the test circuit was approximately equal to the output signal of the model based on the pheromone source location of the silkmoth. Thus, the measured results of the test circuit showed that the proposed circuit can operate normally.

Figure 5 shows the photograph of the test circuit and the motor. The motor is utilized to the system such as the target tracking, mobile robot and others. The motor rotated when the smell sensor detected the smell. It was clarified that the motor can be controlled by the output signal of the proposed circuit.

5 CONCLUSION

We proposed in this study an analog CMOS circuit based on the pheromone source location of the silkmoth. The analog circuit is achieved by the circuit for the threshold processing using the operational amplifier. Since the proposed circuit consists of the smell sensor, five MOS transistors and four resistors, the proposed circuit is simple structure. The smell sensor is input part and four resistors are used to set the voltages. The test circuit was fabricated on the breadboard by discrete MOS transistors and resistors. The measured results of the test circuit showed that the output voltage becomes large when the smell sensor detects the smell of the target. The output voltage of the test circuit was approximately equal to the output signal of the model based on the pheromone source location of the silkmoth. It was clarified from the measured results that the motor can be controlled by the proposed circuit. Thus, we can achieve the novel compact system which has the same functions of the pheromone source location of the silkmoth by using two proposed circuit. In the future, the novel compact target tracking sensor can be achieved by applying the proposed circuits based on the pheromone source location of the silkmoth and

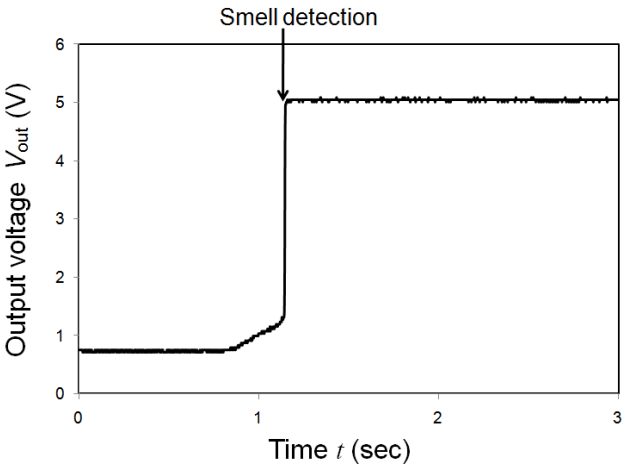

Fig. 4. Measured result of the test circuit

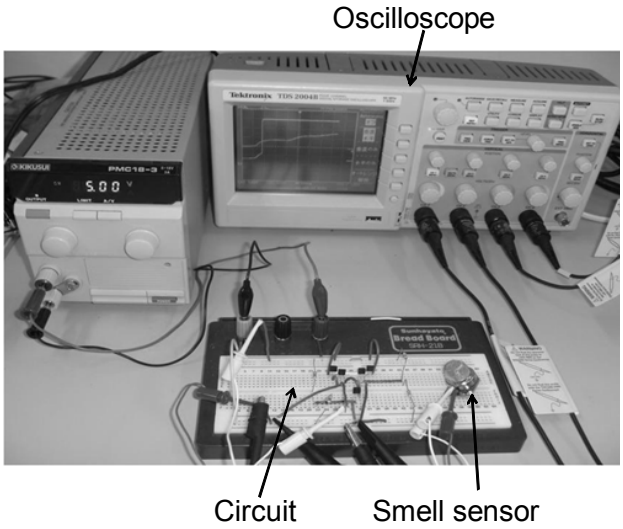

Fig. 3. The photograph of the test circuit

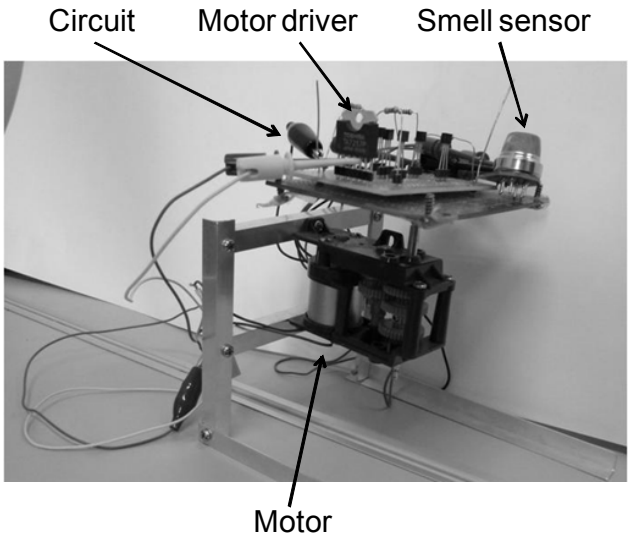

Fig. 5. The photograph of the circuit and the motor

the previous circuit based on the biological vision and auditory systems.

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