

An Experimental Chip for Bio-Inspired Locomotion Controller based on the Wilson-Cowan Neural Oscillator

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Introduction

We propose an analog CMOS circuit that implements a biologically-inspired locomotion controller for quadruped walking robots. The circuit is designed for emulating a central pattern generator (CPG), which is a biological neural network that can generate rhythmic movements for locomotion of animals [1]. We have fabricated a prototype chip using standard CMOS technology. From the experimental results on the prototype chip, we have confirmed desired performances of the proposed circuit.

CPG Circuit

The proposed circuit is based on a CPG model constructed from the Wilson-Cowan (WC) neural oscillator that can be easily implemented on a silicon chip [2]. **Figure 1** shows the schematic of the WC neural oscillator circuit that consists of excitatory and inhibitory neuron circuits, both of which interact with each other via capacitive couplings. We constructed a network circuit (hereafter call the CPG circuit) from the WC neural oscillator circuits. Depending on coupling configurations (**Fig. 2**), a CPG circuit can produce various rhythmic patterns that correspond to the typical locomotion patterns of animals, such as walk, trot, and gallop. We have applied such rhythmic patterns to locomotion control in quadruped walking robots.

Experimental results

The CPG circuit was fabricated on a prototype chip using standard CMOS process (MOSIS AMIS 1.5-um). By changing circuit configurations, we measured voltages on the fabricated chip. **Figures 3(a)-(b)** show waveforms of the voltages that correspond to the locomotion patterns, such as trot and walk. The results show that the CPG circuit can produce stable rhythmic patterns under noisy environment (SNR:30dB).

Conclusions

An analog CMOS circuit was proposed for locomotion control in quadruped walking robots. By experiments on a fabricated chip, we have confirmed that the CPG circuit has capability of producing stable rhythmic patterns under an actual (noisy) environment. Such characteristics of the CPG circuit are suitable for robot locomotion control in real situations. In future work, we are going to incorporate our chip into a quadruped walking robot.

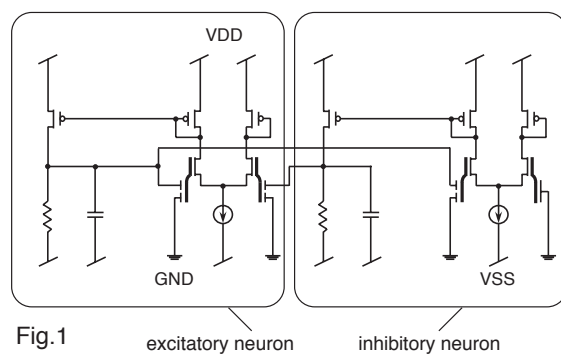


Fig.1

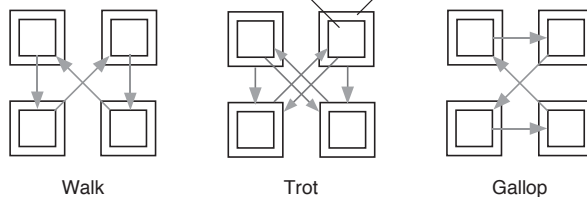


Fig.2

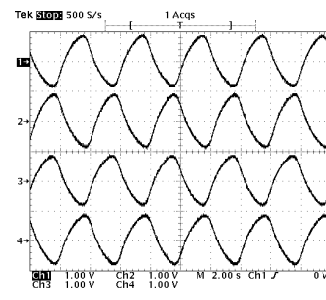


Fig. 3(a)

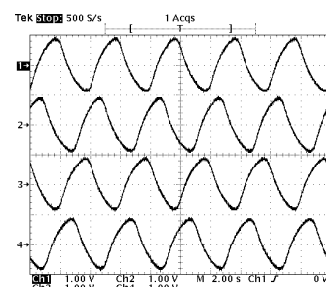


Fig. 3(b)

References

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- [2] H. Kato et al., Reaction-Diffusion Neuro chips: Analog CMOS Implementation of Locally Coupled Wilson-Cowan Oscillators, In proc. the 5th International Conference on Cognitive and Neural systems (IJCNN'2001), 2001.