Fusion of Biology, Brain Science and Information Communication Techology

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We are going to establish a method which treats severe mental disorders such as autism and Asperger's syndrome with investigation of neuron and synaptic signals in brain science. Besides, we have been developing new Brain Machine Interface (BMI), based on our method. As a part of its achievements, this paper describes development of our signal acquisition equipment to collect neuron and synaptic signals of animals with small stress during the measurement. In particular, we present its system requirements, redundant Analog-to-Digital Converter (ADC) design, and improved power supply circuits as well as design of data transmission line.

We have investigated system requirements to realize our measurement system as shown in Fig. 1, and found that some measurement conditions and abilities of the measuring instrument are needed to get beneficial information from activity change of neurons and synapses nearby a probe. We also have searched what the system needs, and decided to study two problems: ADC and power supply circuit designs.

A high-precision ADC which converts an analog signal into a digital signal is needed at the input stage of the system. However available ADCs are difficult to obtain high SNR because an input signal from neuron and synapse is too small. Thus, we propose a redundant ADC design method using Fibonacci sequence of number theory[1)]. Then we have found many interesting properties that help realization of high SNR ADC by using Fibonacci sequence and its property called Golden ratio.

As signal amplification and conversion need clean and reliable power source, high-quality power supply circuit is needed in this system. There the power circuits have to be superior in terms of efficiency, size and noise, and then we propose two techniques[2)] : single-inductor dual-output with zero voltage switching and noise spread spectrum.

Finally, we have developed a prototype of signal processing and transmission stages based on the provisional specifications, and then we have realized and evaluated a wireless system as shown in Fig. 2.

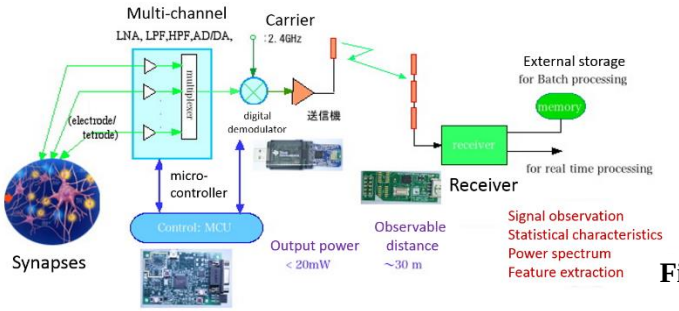

Fig. 1 Configration block of our developing system to assist the study of synapse informatics

Fig. 2 Implementation of data transmission line

[1] Y. Kobayahi, et.al., "SAR ADC Design Using Golden Ratio Weight Algorithm," Proc.ISCT, Nara (Oct. 2015). [2] Y. Kobori, N. Tsukiji, et. al., "High Efficiency ZPS-PWM Dual-Output Converters with EMI Reduction Method," Proc. ICCDS, Vancouver, Canada (Aug. 2015).