1P3-20
Proceedings of Symposium on Ultrasonic Electronics, Vol. 34 (2013) pp. 169-170
20-22 November, 2013

Development of the Ultrasonic Waves Communication Circuit for a Wearable Device
ウェアラブルデバイスへの搭載を目的とした超音波通信回路の製作

Shin-nosuke Suzuki[1†], Kazuki Takano[1], Manabu Ishihara[1], Yukio Kobayashi[1], Nagaya Okada[2] and Kazuto Kobayashi[2] ([1]Dept. of Elec. and Comp., Oyama N. C. T; [2]Honda Electronics co., ltd.)
鈴木真ノ介 [1†]，髙野一輝 [1]，石原学 [1]，小林幸夫 [1]，岡田長也 [2]，小林和人 [2]（[1] 小山高専 電気情報; [2] (株)本多電子）

1. Introduction

Recently, computers have been evolving to be able to wear. In our team, they have been defined as "wearable device (WD)". We have proposed the novel communication method for purpose of application to WD. This communication uses a living body as a transmission path and two kinds of energy, the electric field (EF) and the ultrasonic waves (UW), are applied hybridly[1)]. Therefore, we call this method hybrid communication. To adopt the feature of those energies, this system can realize high usability and secure communication.

In this study, we focus on the UW communication in the hybrid communication. In the prior study on the UW communication, we have succeeded in the linear path communication that distanse is less than 5 cm. However, the error rate is 10~15%, and the communication accuracy should be improved. In order to improve the subject, we changed the modulation method from the conventional amplitude shift keying (ASK) to the phase shift keying (PSK), which has high noise tolerance. In this time, we designed the PSK modulation circuit for the UW communication for living bodies, and performed the experiment using the prototype.

2. System Configuration of Hybrid Communication

We use the piezoelectric oscillators which are [Pb (Zr, Ti) O_3: PZT] for construction of the hybrid communication system. PZT can output the EF and the UW, respectively or simultaneously, depending on the input signal waveform.

The UW communication is implemented in alignment path using sinusoidal signal with the resonance frequency. The UW has sharp directivity and large attenuation in the air. Therefore, the UW communication can prevent information leakage from the WD. On the UW communication, we earned the maximum transmission speed of 115.2 kbps in the experiment. The EF communication is using non-resonance signal. The EF propagates as if it covers human's surface, and this communication can realize a high data transfer rate(DTR) compared with the UW communication. The DTR of the EF communication is more than 80 times as high as that of the UW communication.

3. Design of UW Communication Circuit for Living Body

In the previous system, the ASK modulation was adopted because of easy to utilize. However, the ASK is disadvantaged at the noise tolerability and the sound reverberation effect caused the discontinuity waves. On the other hand, the PSK is communicated with sequential waveforms. Therefore, the sound reverberation does not tend to occur and the transmitted signals are strengthened against the noise. The error rate of the PSK is lower than that of the ASK[2)]. It has been evaluated by the experiment using the software "LabVIEW" (National Instruments). Accordingly, we developed the UW communication circuit which can use both the ASK and the PSK for performing evaluation and comparison about both methods on the circuit. The PSK has various systems with the amount of change of a phase. In this time, we adopted the binary phase shift keying (BPSK) . BPSK is a digital modulation method whereby the phase of carrier is shifted to represent two kind of digital state,"1" or "0".

We designed the UW communication circuit shown in **Fig. 1**. The bidirectional communication can realize by using a pair of the circuits. Both the ASK and the PSK can be used in the circuit. One of the modulation methods is chosen by the analog switch 1. The outline of communication method is as follows.

In the transmitter, the carrier from an oscillator is generated based on the control signal

E-mail: shin-s@oyama-ct.ac.jp

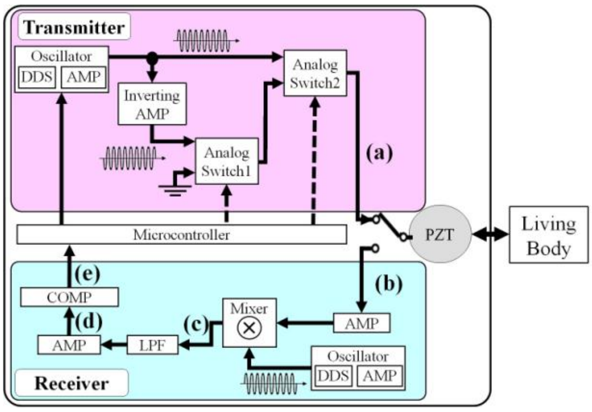


Fig. 1 Scheme of the UW Communication Circuit.

from a microcontroller. The carrier and the negative phase carrier which the phase reversed through the inverting amplifier (Inverting AMP) are input into the analog switch 2. The analog switch 2 changes based on the information signal. As a result, the modulated signal is generated and output from the PZT.

In the receiver, the demodulation is performed based on the synchronous detection. First, the received signal from the PZT is amplified, and a sinusoidal signal whose frequency is same as the carrier wave is output from the oscillator. Next, those signal are multiplied and the multiplication signal is passed a low pass filter (LPF), an amplifier (AMP), and a comparator (COMP). As a result, the original information signal can be demodulated.

4. Experiment using Prototype

We developed the prototype based on the proposed design shown in Fig. 1, and conducted the PSK communication experiment using it. As an experimental condition, the silicone bond, that thickness is about 5 mm, was used for the transmission path between the PZTs of the transmitter side and the receiver side. Because the silicone bond is similar acoustic impedance to a living body tissue. Additionally, we used the signals which generated from a function generator (FG) instead of the oscillator circuit and the microcontroller, because of simplification of the prototype. **Figure 2** shows the signals from the FG.

Figure 3 indicates the waveforms which observed as the experimental result. The additional characters of (a)-(e) in Fig. 3 correspond to the observation points in Fig. 1. In the transmitter, the PSK modulated signal which changes corresponding to the information signal was obtained. It is indicated in Fig.3 (a).

On the other hand, Fig.3 (b)-(e) show signals observed in the receiver. We obtained the demodulated information signal as shown in Fig. 3(e).


(a) Information Signal (5V/div)

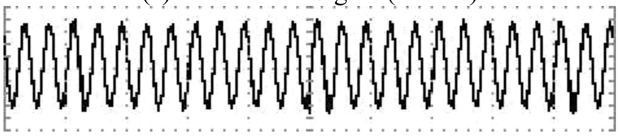
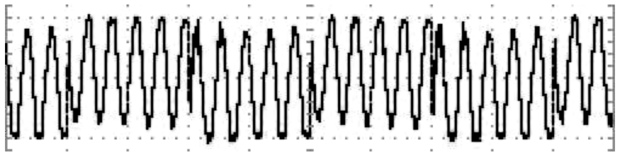
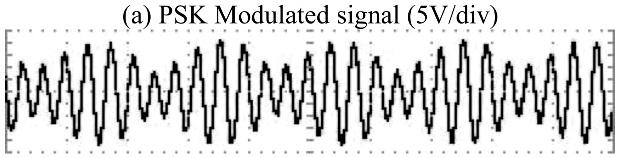
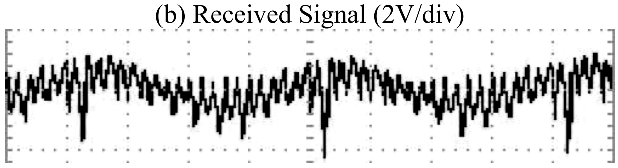
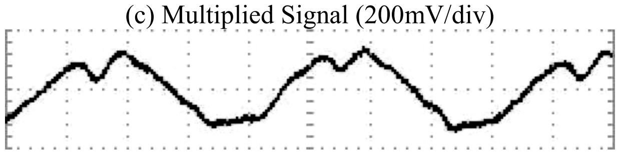

(b) Carrier (500mV/div)

Fig. 2 Output Signals from FG.


(a) PSK Modulated signal (5V/div)


(b) Received Signal (2V/div)


(c) Multiplied Signal (200mV/div)


(d) After Amplifier (5V/div)

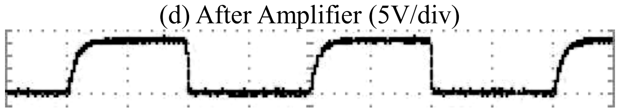

(e) After Comparator (5V/div)

Fig. 3 Observed Waveforms in Prototype.

5. Conclusion

In this paper, we designed the UW communication circuit for the accuracy improvement of the UW communication system which uses the living body as a transmission path. We developed the prototype and succeeded in the PSK communication by the experiment using it.

Next step, we are planning to install the oscillator circuit and the microcontroller to the prototype to complete the UW communication circuit. Then, we perform quantitative evaluation of the error rate between the ASK and the PSK. Additionally, in order to construct the hybrid communication system, we add the EF communication function to the circuit.

References

1. S. Suzuki, et al. : USE2010 (2010) 1Pb-28
2. S. Suzuki, et al. : USE2012 (2012) 3Pb3-1