3P-63

Proceedings of Symposium on Ultrasonic Electronics, Vol. 31 (2010) pp. 581-582
6-8 December, 2010

Positioning of bouy for Underwater communication using RTK-GPS

RTK-GPS を用いた水中通信用ブイ位置の測位

Yoshikazu Koike[1], Hiroki Aonuma[1], Ryuta Kasumi[1], Takenori Nishino[1] and Harumasa Hojoh[2] ([1]Shibaura Inst. of Tech., [2]Tokyo Univ. of Marine Sci. and Tech.)
小池義和 [1‡], 青沼弘樹 [1], 霞竜太 [1], 西野剛典 [1], 北條晴正 [2] ([1]芝浦工大, [2]東京海洋大)

1. Introduction

Authors investigate the underwater digital communication in the depth of 10m. The image in the size of around 100kByte can be transmitted in the depth of 3m.[1-2] The transmission quality of the buoy structure with transducer is investigated, comparing with that of a transducer immersed in the sea. The deviation of the sea surface greatly affects the communication quality in the case of buoy setup. It is required that the buoy deviation due to the waves of the sea surface is observed within an accuracy of 10 centimeters. It is difficult to obtain less than 1 meter accuracy in the point positioning GPS. On the contrary, a real time kinematic GPS (RTK-GPS) gives high precise positioning within the accuracy of 10 centimeters. In the general, the cost of dual frequency RTK-GPS system is too high. Recently, the compact and low cost single frequency RTK-GPS system is provided.

In this report, the influence of sea surface deviation on the transmission quality of underwater communication is investigated, using the buoy attached with the single frequency RTK-GPS sensor.

2. Configurations of transmitter and receiver

Figure 1 shows the configuration the buoy transmitter and the receiver. The shape of transducers in the transmitter and the receiver are cylindrical with non-directivity. In most of the reports, the QPSK modulation is used to achieve a high-speed data transfer. In our system, the MSK modulation is employed for the advantage of multipath fading. The modulator and the demodulator are realized by the DSK board (TMS320C6416, Texas Instruments Incorporated.). The communication experiment was carried out at Toyosu canal. Both transmitter and receiver circuit are in the buoy which consists of plastic cylinder. The transducer is immersed at about 2m in depth. The personal computer (PC) put in the plastic case on the buoy top in order to operate the transmitter and the receiver. The receiver and the transmitter are operated by remote control using another computer in the land, which connects with the PC in the buoy through Wireless network (WiFi). Transferred data is 1000 bit of random series. Bit error rate (BER) is 0.08 at the distance of 1m in the case that the simple transducer is immersed into the sea. On the contrary, BER is 0.0 in the case that the buoy is employed. The transducer attached with the buoy will be deviated longitudinally although the simple immersed transducer will be deviated transversely. Therefore, it is considered the influence of the transducer deviation on the BER is different. In order to investigate the motion of the buoy, RTK-GPS sensor is set on the top of the buoy.

3.Principle of the single frequency RKT-GPS positioning[3]

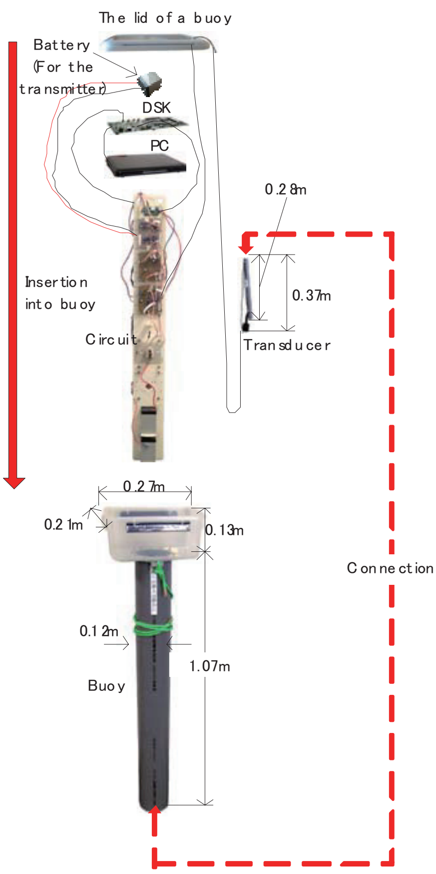

Fig.1 Composition of buoy

‡koikey@sic.shibaura-it.ac.jp

Generally, a precise positioning is obtained by the solution of the observation equation of the difference of the points.

$$\begin{aligned} \lambda\phi_{ur}^{ij} &= \rho_{ur}^{ij} - I_{ur}^{ij} + T_{ur}^{ij} + \lambda N_{ur}^{ij} + \varepsilon_{\phi} \\ P_{ur}^{ij} &= \rho_{ur}^{ij} + I_{ur}^{ij} + T_{ur}^{ij} + \varepsilon_{P} \end{aligned} \quad (1)$$

where ϕ is the phase of L1 carrier, λ is the wavelength of the carrier, r is the euclidean distance of the satellites, *P* is the observed pseudo-distance, *I* is the delay due to isosphere, *T* is the delay due to air convex, *N* is integer number of cycles, ε is an observation error. Additionally, *u* and *r* is an observation and a basement position, respectively. The sub and the super scripts of the each variable is expressed as the satellite. Double sub and super script expresses the subtraction operation between each point. The euclean distance is expressed by the following equation.

$$\rho_r^i = \sqrt{(x^i - x_r)^2 + (y^i - y_r)^2 + (z^i - z_r)^2} \quad (2)$$

where (x^i, y^i, z^i) is the satellite position and (x_r, y_r, z_r) is the receiver position. In eq.(1), the integer number of cycles *N* and the observation positions are unknown variable. On the contrary, the basement is to be a known position when the distance between the observation and the basement is enough short.

The estimated position (x_r, y_r, z_r) and the integer number of cycles *N* can be obtained by eq.(1), applying the least mean square method. More precise position can be obtained after *N* is fixed as an appropriate value.

The RTKLIB is employed in RTK-GPS positioning.[4] RTKLIB is provided by Dr.Takasu and is a general program for a single frequency RTK-GPS. The phase of L1 carrier from the basement and pseudo distance of the observation is derived by eq.(1). In RTKLIB, the decision of the integer number of cycles *N* is calculated by LASMBDA (least square ambiguity decorrelation adjustment) method, which is a kind of LMS. Using these programs, the precise position is obtained by the single frequency RTK-GPS.

RTK-GPS sensor is KGPS evk-1 (SENSORCOM corp.). The module of the KGPS evk-1 is LEA-4T, ublox AG. The single point position data is saved in flash memory storage (SD card) in the interval of 1Hz. After the several minutes data is measured, RTK-GPS position is calculated by RTKLIB program. In the GPS positioning, the role of antenna is also important. An active antenna, ANN-MS, ublox AG is employed.

4. Positioning results

Figure 2 shows the positioning results of the transmitter and the receiver buoy. As RTK-GPS enables the instant positioning, the buoy position is achieved in the interval of 1Hz. In Fig.2(a), the longitudinal difference from the sea level is indicated in 40 minutes. According to Fig.2(a), buoy position decreases gradually since the tide is receding. In Fig.2(a), the longitudinal difference from the sea level is indicated at detail in 100 seconds. The longitudinal buoy deviation appears due to the waves of the sea surface. It is found that the deviation buoy can be observed within 1cm of an accuracy using RTK-GPS. Future plan is investigated to the influence of the waves on BER.

References

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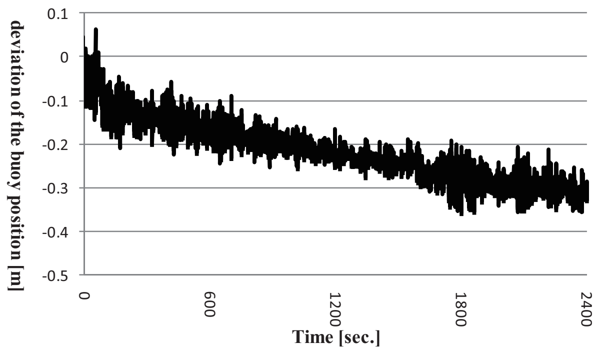
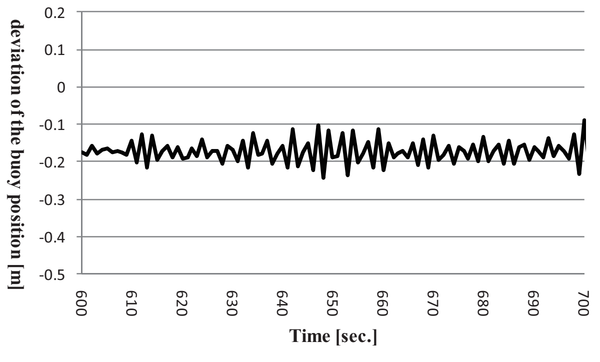
2.Y.Koike *et al*; Proc. of USE2009, 105-108 (2009).

3.Hojo *et al*; Journal of the Japan Institute of Navigation, Vol.120, pp.51-57 (2009) [in Japanese]

4. http://gpspp.sakura.ne.jp/indexe.html



(a) measurement during 40 minutes



(b) measurement between 600sec. and 700sec.

Fig.2 Positioning results of the buoy deviation.