Extended Abstracts of the 2017 International Conference on Solid State Devices and Materials, Sendai, 2017, pp341-342

G-7-01 (Invited)

QZSS Short Message Synchronized SS-CDMA Communication

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Abstract

As a safety confirmation system, we propose synchronized spread-spectrum code-division multiple-access (SS-CDMA) communication for short message communication system using Quasi-Zenith Satellite System (QZSS). In the proposed system, the satellite reception timings of all uplink signals are synchronized using transmission timing control method in order to realize high-density multiple access. In this paper, we measure the terminal time deviation and the propagation delay calculation error for evaluating the satellite reception timing error.

1. Introduction

At the Great East Japan Earthquake occurred in March 2011, many terrestrial communication infrastructures were lost due to the earthquake and the tsunami mainly in coastal areas. A safety confirmation system that can operate without a terrestrial mobile network is needed. To realize quick safety confirmation, we have proposed synchronized spread-spectrum code-division multiple-access (SS-CDMA) method [1]-[6] for the Quasi-Zenith Satellite System (QZSS) short message communication system [7]. Fig. 1 shows the concept of the proposed system. QZSS is composed of one or some geostationary satellites and multiple Quasi-Zenith Satellites (QZS) [7]. In this system, highly accurate location information, identification (ID) and simple message are transmitted from the mobile terminals (MT, *e.g.* smart phone) to the HUB station via the geostationary satellite. In addition, the system needs to accommodate more than 3 million users per hour without congestion, because many users try to communicate with others in times of big disaster. In the proposed system, the satellite reception timings of all uplink signals are synchronized using transmission timing control method in order to realize high-density multiple access.

In this paper, for realizing high-density user multiple access, we measure the terminal time deviation and the propagation delay calculation error at the same time and evaluate the satellite reception timing error of the uplink signal.

2. QZSS Short Message Synchronized SS-CDMA Communication

In the proposed synchronized SS-CDMA communication, long orthogonal spreading code with high spreading gain is used in order to realize the direct communication between MT and the satellite. Furthermore, it is possible to accommodate messages from the many MTs at high density by utilizing the code for multiple access in uplink.

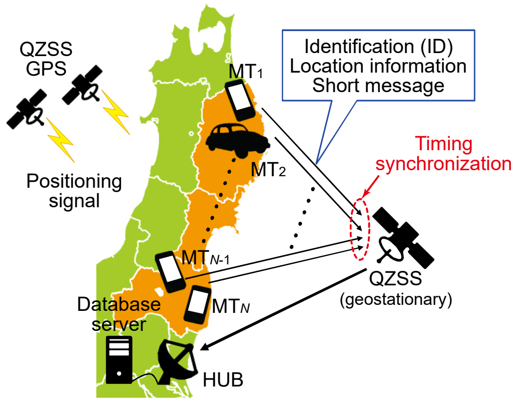


Fig. 1 Concept of QZSS short message synchronized SS-CDMA communication.

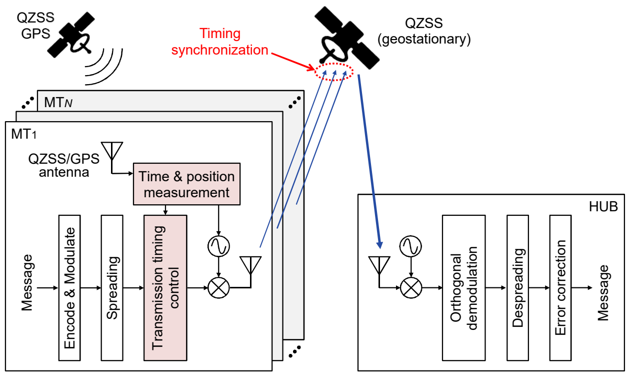
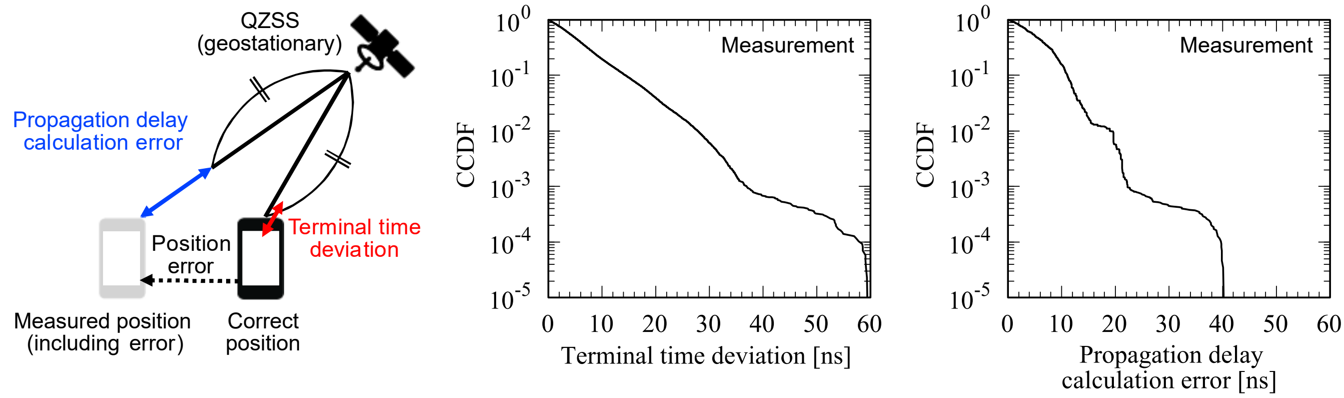


Fig. 2 Block diagram of synchronized SS-CDMA.

In order to realize high-density user multiple access, ensuring the code orthogonality in uplink by timing and frequency synchronization is the most important issue. Fig. 2 shows the block diagram of system of synchronized SS-CDMA. In the synchronized SS-CDMA communication, positioning signals from QZSS and Global Positioning System (GPS) are used for timing and frequency synchronization. In the synchronized SS-CDMA communication, each MT controls the timing of transmission and frequency using the highly accurate time, position and frequency information and synchronizes the timing that the satellite receives uplink signals. Transmission timing of the signal encoded, modulated and spread in each terminal is controlled using the position of its own terminal and the current time calculated from the positioning signal. The transmission carrier frequency is controlled using reference frequency information. In synchronized SS-CDMA communication, code orthogonality between uplink signals is ensured by transmission timing control method and transmission carrier frequency control



(a) Factors of satellite reception timing error (b) Terminal time deviation (c) Propagation delay calculation error

Fig. 4 Measurement results of satellite reception timing error.

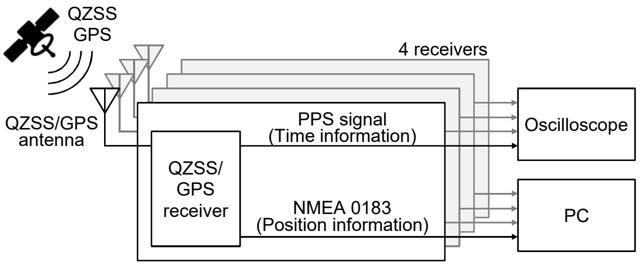


Fig. 3 Block diagram of measurement system with 4 receivers.

method at all terminals that transmit simultaneously. The received signal is demodulated, despread and error corrected at the HUB station.

For realizing this system, the satellite reception timing error needs to be within about 50 ns in order to suppress the degradation of capacity [2], [4]. The high-density user multiple access is possible if accurate time, position and frequency can be obtained from the satellite positioning signals.

3. Evaluation of Satellite Reception Timing Error

For evaluating the satellite reception timing error, we measure terminal time deviation and propagation delay calculation error. Fig. 3 shows the measurement system block diagram. The pulse per second (PPS) signal output from the QZSS/GPS receiver is input to the oscilloscope. The position information (NMEA) is input to personal computer (PC).

Fig. 4(a) shows the factors of the satellite reception timing error. The satellite reception timing error is composed of the terminal time deviation and the propagation delay calculation error. The terminal time deviation is the deviation of the current time calculated by each MT from the satellite positioning signals. Since the terminal time deviation causes a difference in the satellite reception timing of the uplink signals, the transmission characteristics are deteriorated. The propagation delay calculation error is an error generated in the calculation of the propagation distance to the satellite due to the position error. Since the propagation delay calculation error causes an error in the transmission timing of each MT according to the direction and magnitude of the position error, the transmission characteristic deteriorates due to difference among the satellite reception timings. From the above, it is necessary to simultaneously measure the terminal time deviation and the propagation delay calculation error in order to evaluate the satellite reception timing error.

Figs. 4(b) and (c) show the complementary cumulative distribution functions (CCDF) of the absolute value of the terminal time deviation and the propagation delay calculation error, respectively. At the required terminal time deviation and the propagation delay calculation error of 50 ns for high-density multiple access, the CCDFs have achieved 0.03 % and less than 0.001 %, respectively. Therefore, high-density multiple access can be realized by the transmission timing control method using satellite positioning signals.

4. Conclusions

In this paper, we proposed synchronized SS-CDMA communication for short message communication system using QZSS. As a result of evaluation, high-density multiple access can be realized by transmission timing control using satellite positioning signals. Currently, we are considering field-programmable gate array (FPGA) implementation of the proposed transmission timing control method.

Acknowledgements

A part of this work is supported by JSPS KAKENHI Grant Number JP16H04361.

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