FURUNO ELECTRIC GNSS Receiver for Time Synchronization

Supporting nanosecond-precise infrastructure with GNSS technology cultivated from marine business

Although we are rarely aware of it, the mobile base stations that support our daily lives are precisely controlled using nanosecond time synchronization technology to achieve stable communication services. FURUNO ELECTRIC CO., LTD. provides high performance and reliable GNSS products for time synchronization.

When arranging to meet someone, it's enough to specify the time in minutes. The operations of Japan's railroads, which run at the highest density in the world, are managed in seconds. And a typical IT system is controlled in milliseconds.

However, there are applications where time precision is required on the order of nanoseconds (ns), which is even more precise than microseconds (μs). One such example is the mobile communications infrastructure.

Radio waves are subject to interference. Communication quality may deteriorate due to the influence of radio waves emitted by neighboring base stations.

To avoid this, 5G base stations use nanosecond time synchronization technology to match the timing of upstream and downstream signals, to avoid interference with base stations of either the same or other carriers. Since 5G frequencies are allocated without a buffer, called a guard band, it is necessary to prevent interference between carriers using adjacent frequency bands.

Providing high-precision receivers for time synchronization by using GNSS technology cultivated from marine business

The standard for time synchronization is UTC (Universal Time Coordinated). Standard radio waves (radio-controlled clocks) and NTP servers are used to deliver the time, but their performance is insufficient to prevent interference in telecommunications. Therefore, GNSS receivers for time synchronization have been used to output the time data, which is converted into a one-second pulse signal (1PPS) synchronized with UTC.

The GNSS receiver is either directly mounted on the base station, or the time is distributed from the GNSS receiver mounted on the "Grand Master Clock" to the base station by PTP. The standard specification of 5G stipulates that the time synchronization for base stations needs to be within ±1.5μs of UTC time. Considering the delay in delivering the time via PTP, the GNSS receiver, which is the main source of time, is required to have extremely high accuracy on the nanosecond order.

In addition, GNSS time synchronization is used as infrastructure to support financial transactions, broadcasting, and power systems.

FURUNO ELECTRIC provides time synchronization products for such applications.

The company originally developed and marketed marine electronic equipment, such as fish finders and sonars, and is one of the world's leading manufacturers in this field. Since the 1980s, GPS/GNSS receivers have also been developed to provide the position of ships over the ocean.

The technology and know-how accumulated have been applied to land-based applications, and the company has developed a wide range of products, including GNSS receivers for automobiles, ETC, Wi-Fi, and handy terminals for business use. Time synchronization products are another example of such products.

Specifically, the lineup includes the GT series, a GNSS receiver that generates simple 1PPS time signals, the GF series, which also provides an accurate reference frequency (10 MHz) in combination with an oscillator, and the TB-1 for high-precision measurements at locations such as mobile base stations. They provide the high-performance time output required in

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Figure 1: World's Top Class Time Performance in a Single Band Positioning System with Excellent Cost Performance (Furuno Research)

Manufacturer	Furuno	Company A	Company B	
Positioning method	Single Band Positioning	Single Band Positioning	Single Band Positioning	Dual Band Positioning
1PPS accuracy	< ±40ns	Not published	Not published	Not published
1PPS stability	< 4.5ns (1σ)	< 15ns (1σ)	< 20ns (1σ)	<5 ns (absolute mode) <2.5 ns (differential mode)
Price	Same price level			High cost
Antenna	Reasonable single band antenna			Costly dual-frequency antenna

the telecommunications, broadcasting and other social infrastructures.

Kunihiko Hashimoto, an engineer from FURUNO ELECTRIC's System Products Division says, "Since they are used in critical infrastructures such as mobile communications, broadcasting, and electric power, they must be highly accurate and reliable."

Minimizing precision degradation even in poor environments such as urban zones

This high level performance is the most important feature of Furuno products.

The company pursues both superior performance in terms of accuracy, which indicates the time difference from UTC, and stability, which indicates the variation. The accuracy is ±40ns, and the stability is 4.5ns, while other companies are all in the double-digit range (Figure 1).

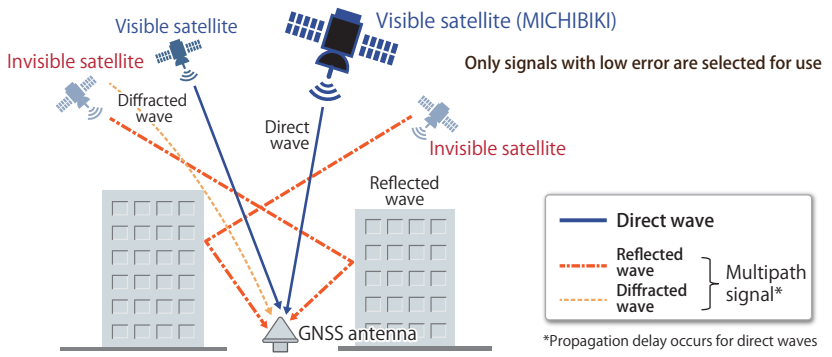
"There are two types of GNSS receivers for time synchronization: single band receivers and dual band receivers, the latter being very costly. We have achieved world class time performance while adopting a single band system with excellent cost performance," says Mr. Hashimoto.

This is possible because the company has developed everything from chips to software in-house, specifically for the purpose of time synchronization.

Furthermore, these products are designed to achieve high performance not only in ideal environments with open skies, but also in poor and realistic environments.

Because of the short range of 5G, many base stations have been placed in urban areas. They may operate in areas where the satellite cannot be seen or where many reflected waves are generated, such as in a building valley. In such environments, the time performance calculated by GNSS receivers deteriorates. It is possible to deliver the time via PTP from a Grand Master Clock installed in a place with good visibility, but it is not realistic to cover all urban areas because the PTP performance deteriorates with the number of relay hops. Therefore, by utilizing Dynamic Satellite Selection™ (Figure 2), a countermeasure algorithm for reflected waves developed by FURUNO ELECTRIC, it is possible to reduce errors even in urban reception environments by efficiently using only direct waves or reflected waves with good quality, and by selectively using only signals with low errors.

Figure 2: Dynamic Satellite Selection™ Minimizes Degradation of Time Precision even in Urban Areas



Mr. Hashimoto says, "Our receivers for timing achieve the world's highest performance in ideal environments with open skies, as well as the lowest performance degradation in environments such as urban zones."

Maintaining high precision for 24 hours even in the event of antenna failure

There is one more point that should not be overlooked as a way to achieve highly precise time synchronization.

The GF series, one of the Furuno flagship products, combines GNSS reception with an oven-controlled crystal oscillator (OCXO) to reduce errors within 1.5μs for 24 hours even if satellite signals are lost, thus satisfying the standards required for mobile communications. This is called holdover.

"While receiving satellite signals, the GF module monitors the status of the OCXO and learns when and how it tends to deviate, including temperature changes. Even if the antenna fails, it will minimize the error based on what it has learned in addition to the original performance of the OCXO," says Mr. Hashimoto.

The base stations are always time synchronized with each other with high precision to maintain high quality communication service until the failure is detected and maintenance personnel arrive at the site.

The GF series with OCXO and holdover functions also reflects Furuno's experience and know-how in dealing with problems in the field over many years, and has been well-received in the field of professional mobile radio and other applications because it helps to reduce the design cycle.

On the other hand, the GT series, which provides basic time synchronization functions at a reasonable cost, can be used by users as components to be integrated into their own systems.

Another product for measurement reference, TB-1, also combines a GNSS receiver and OCXO to generate highly precise time signals in a very compact size. In general, rubidium atomic oscillators have been used for measurements during the installation of mobile base stations and field testing of in-vehicle devices, but they are usually expensive and difficult to transport. This palm-sized TB-1 is able to provide a signal with accuracy equivalent to that of a rubidium oscillator at a fraction of the cost, and is highly praised by users.

FURUNO ELECTRIC is also working on countermeasures against the problems of GNSS jamming and spoofing that have become a reality in disputed waters overseas, and has published several white papers on such issues.

Although we are not usually aware of it, it is Furuno's technology that actually supports our daily lives and has achieved world-class performance and reliability in the world of time synchronization.

Inquiry

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