FURUNO

FURUNO Timing Multi-GNSS Receiver

Model GT-100

Function Specifications

(Document No. SE22-600-013-02)

FURUNO ELECTRIC CO., LTD.

www.furuno.com

IMPORTANT NOTICE

The following satellite systems are operated and controlled by the authorities of each government.
- GPS, SBAS(WAAS) : USA
- GLONASS :Russia
- Galileo, SBAS(EGNOS) :Europe
- QZSS, SBAS(MSAS) :Japan
- NavIC, SBAS(GAGAN) : India
- BeiDou: China

Since this product receives satellite signals to operate, its performance may deteriorate significantly depending on the operational status and broadcast contents of each satellite. The items described in the various specifications of this product are not guaranteed, including the above cases. When using each satellite, it is necessary to fully understand the characteristics of the system and utilize its benefits at the user's responsibility.

This document is the specifications for the following products. If the target products are different or the associated software is different, please refer to the corresponding specifications separately.
・GT-100

The software of this product has been designed and verified with the utmost care, but if you find any problems during use, please contact us. We may check and provide the correction software. In addition, if we find a problem, we may contact you and provide correction software.

When we provide a modified software, we may ask you to update the software. Therefore, we strongly recommend that the serial port of this product be accessible from outside your product so that you can easily update the software. We also strongly recommend that the serial port of this product be connected to a network, etc., so that software can be updated by remote download. If you need more information on how to update the software, please contact us.

FURUNO ELECTRIC CO., LTD. reserves the right to make changes to its products and specifications without notice.

Revision History

Version	Change contents	Date
0	Initial release	2022.04.12
1	Change tracking sensitivity (Table 3-3, Table 3-4, Table 3-5, Table 3-9, Table 3-10, Table 3-11, Table 3-12 and Table 3-13) Change acquisition sensitivity (COLD) (Table 3-7)	2023.02.07
2	Update in chapter 1 Tables 3-3 to 3-13 are summarized in Table 3-3. Change tracking sensitivity (section 3) Change in table 6.1-1 Change in table 6.1-2	2023.06.05

Table of Contents

1 Outline

This document is the functional specifications of the multi-band GNSS receiver GT-100.
The software version covered by this manual is 4850-569-015.

2 Terms

The following is a detailed description of the terms used in this document.
It contains a lot of important information about the behavior of this product, so we strongly recommend that you read it carefully.

Table 2-1. Terms related to this document

<table>
<tr><th>Term</th><th>Description</th></tr>
<tr><td>GPS</td><td>GPS (Global Positioning System) is a GNSS owned and operated by the United States of America.</td></tr>
<tr><td>GLONASS</td><td>GLONASS (Global Navigation Satellite System) is a GNSS owned and operated by the Russian Federation.</td></tr>
<tr><td>Galileo</td><td>Galileo is a GNSS owned by the European Union and operated by the European GNSS Agency (GSA)</td></tr>
<tr><td>BeiDou</td><td>BeiDou Navigation Satellite System (BDS) is a GNSS owned and operated by the People's Republic of China.</td></tr>
<tr><td>NavIC</td><td>NavIC (Navigation Indian Constellation) is a GNSS owned and operated by India.</td></tr>
<tr><td>QZSS</td><td>QZSS (Quasi-Zenith Satellite System) is a GNSS owned and operated by Japan.</td></tr>
<tr><td>SBAS</td><td>A general term for satellite systems that broadcast GNSS augmentation information.</td></tr>
<tr><td>GNSS (GNSS Satellite)</td><td>Abbreviation for Global Navigation Satellite System. It is used as a general term for satellite constellation such as GPS, GLONASS, Galileo, BeiDou, NavIC, QZSS, and SBAS.</td></tr>
<tr><td>Frequency band (L1band/L5 band)</td><td>In recent years, some GNSS broadcasts are also being broadcast in the frequency band called the L5 band centered on 1176.45 MHz, in addition to the conventional frequency band called the L1 band centered on 1575.42 MHz. The frequency bands for each satellite / signal name are as follows.
To receive the L5 band, an antenna compatible with the L5 band is required.
<table>
<tr><th>Satellite/signal name</th><th>Frequency band</th><th>Satellite/signal name</th><th>Frequency band</th></tr>
<tr><td>GPS L1 C/A</td><td>L1</td><td>GPS L5</td><td>L5</td></tr>
<tr><td>GLONASS L1OF</td><td>L1</td><td>Galileo E1</td><td>L1</td></tr>
<tr><td>Galileo E5a</td><td>L5</td><td>BeiDou B1I</td><td>L1</td></tr>
<tr><td>BeiDou B1C</td><td>L1</td><td>BeiDou B2a</td><td>L5</td></tr>
<tr><td>NavIC L5</td><td>L5</td><td>QZSS L1 C/A</td><td>L1</td></tr>
<tr><td>QZSS L5</td><td>L5</td><td>SBAS L1</td><td>L1</td></tr>
</table>
</td></tr>
</table>

Term	Description
Ephemeris	An ephemeris is one of the information that each GNSS satellite broadcasts. It shows the time and the detailed orbital information of the broadcasting satellite. This information is necessary for positioning, and it is repeatedly broadcasted in short cycles. In the case of GPS, it is broadcast every 30 seconds. Starting with the ephemeris remaining in the receiver is called HOT START in this product. Although it depends on the type of satellite, the expiration date of the ephemeris possessed by this product is 1 to 4 hours after the last ephemeris was received.
Almanac	An almanac is one of the information that GNSS satellites broadcast. It contains various correction information, UTC parameters, and rough orbital information for all the satellites of a constellation. In the case of GPS, Almanac is broadcast every 750 seconds. In this product, starting with the almanac information remaining in the receiver is called WARM START. If neither ephemeris nor almanac remains in the receiver, it will be a COLD START.
Jamming signal	Jamming signals are electrical noises generated in or around the GNSS signal bands by other equipment or radios. Jamming signals are often intentionally broadcasted by malicious actors with the intend to affect the performance of near-by GNSS receivers. Jamming signals will interfere with the reception of genuine GNSS satellite signals, which may result in poor or failed positioning. This product has a function to detect and mitigate jamming signal.
Spoofing signal	Spoofing signals are signals generated by malicious actors that mimic the broadcast contents of the GNSS satellite using something similar to a simulator. Receiving such signals may affect position and time. This product has a function to detect and eliminate spoofing signals.
DSS (Dynamic Satellite Selection)	DSS is a unique multipath countermeasure by Furuno that automatically detects satellites that may cause accuracy deterioration and excludes them from positioning calculations. It greatly reduces the effect of multipath and contributes to improved accuracy. This function is ON by default.
T-RAIM	Abbreviation for Time Receiver Autonomous Integrity Monitoring It is a mechanism to identify and eliminate satellites that may adversely affect the positioning calculation. It is based on the principle of combination and majority voting when the number of GNSS satellites is larger than the minimum number of satellites required for the positioning calculation. This function works automatically in this product.

Term	Description
Time to First Fix (HOT)	The GNSS simulator inputs a signal of -130dBm to the end of the antenna. At this time, the time from when the HOT RESTART command is input to the receiver with the ephemeris until the initial positioning is performed, is defined as the initial positioning time (HOT). This value is the result when multiple GNSS systems are used.
Time to First Fix (COLD)	The GNSS simulator inputs a signal of -130dBm to the end of the antenna. At this time, the time from when the COLD RESTART command is input to the receiver until the initial positioning is performed, is defined as the initial positioning time (COLD). This value is the result when multiple GNSS systems are used.
Acquisition sensitivity (HOT)	This is the sensitivity that enables initial positioning after entering HOT RESTART command to the receiver with the ephemeris and transferred to Time Only mode.
Acquisition sensitivity (COLD)	This is the sensitivity that enables initial positioning after the receiver is powered on with no backup.
Tracking sensitivity	This is the sensitivity that allows a receiver to continue receiving that signal after the initial reception.
Re-acquisition time	In Time Only mode, the satellite signal is received at -130dBm and positioned. After confirming the positioning, leave the antenna disconnected for 10 seconds. After that, when the antenna is reconnected, the time required to resume signal reception is defined as the re-acquisition time.
Re-acquisition sensitivity	In Time Only mode, the satellite signal is received at -130dBm and positioned. After confirming the positioning, leave the antenna disconnected for 10 seconds. Decrease the signal sensitivity while the antenna is not connected, and then reconnect the antenna. At this time, the sensitivity at which re-positioning is possible is defined as the Re-acquisition sensitivity.
MAX|TE|	MAX|TE| means absolute value of maximum time error and indicates the maximum deviation (absolute value) from UTC time of 1PPS. See Figure 2.1 for an image.
MTIE	MTIE means maximum time interval error and shows the relative MIN-MAX value of 1PPS. See Figure 2.1 for an image.
SDEV	SDEV means standard deviation and means the variance value of 1PPS.
TDEV	TDEV means time deviation and indicates the degree of fluctuation of 1PPS.
PRTC	PRTC is one of the international standards established by ITU-T (International Telecommunication Union Telecommunication Standardization Sector), which is a United Nations organization that creates and recommends global standards for communication standards and is a performance standard defined by G.8272. The target is 1PPS output from the product, and if MTIE and TDEV meet the specified threshold value, it is considered to be PRTC compliant.

<table>
<tr><th>Term</th><th>Description</th></tr>
<tr><td>PRTC-A</td><td>PRTC-A is one of the PRTC standards, and MTIE & TDEV meet the following conditions.
[TDEV]
<table>
<tr><th>Time deviation limit [nsec]</th><th>Observation interval τ [sec]</th></tr>
<tr><td>3</td><td>1<τ<100</td></tr>
<tr><td>0.03τ</td><td>100<τ<1000</td></tr>
<tr><td>30</td><td>1000<τ<10000</td></tr>
</table>
[MTIE]
<table>
<tr><th>MTIE limit [nsec]</th><th>Observation interval τ [sec]</th></tr>
<tr><td>0.275τ+ 25</td><td>1<τ<273</td></tr>
<tr><td>100</td><td>273<τ</td></tr>
</table></td></tr>
<tr><td>PRTC-B</td><td>PRTC-B is one of the PRTC standard, and MTIE & TDEV meet the following conditions.
[TDEV]
<table>
<tr><th>Time deviation limit [nsec]</th><th>Observation interval τ [sec]</th></tr>
<tr><td>1</td><td>1<τ<100</td></tr>
<tr><td>0.01τ</td><td>100<τ<500</td></tr>
<tr><td>5</td><td>500<τ<10000</td></tr>
</table>
[MTIE]
<table>
<tr><th>MTIE limit [nsec]</th><th>Observation interval τ [sec]</th></tr>
<tr><td>0.275τ+ 25</td><td>1<τ<55</td></tr>
<tr><td>40</td><td>55<τ</td></tr>
</table></td></tr>
</table>

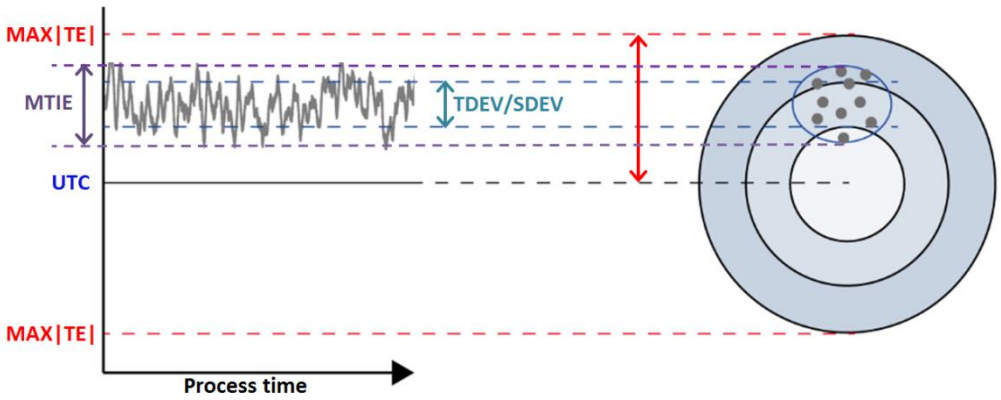

Figure 2-1. Image of MAX|TE| and MTIE

3 GNSS Receiver Performance

This chapter describes the specifications for GNSS reception. The performance described in this chapter was evaluated in the measurement environment shown in Figure 3.1 below. In addition, the conditions at the time of measurement are the default setting, 25 degree C constant (no airflow). If a signal reception mask is set with a command, that mask may limit the performance.

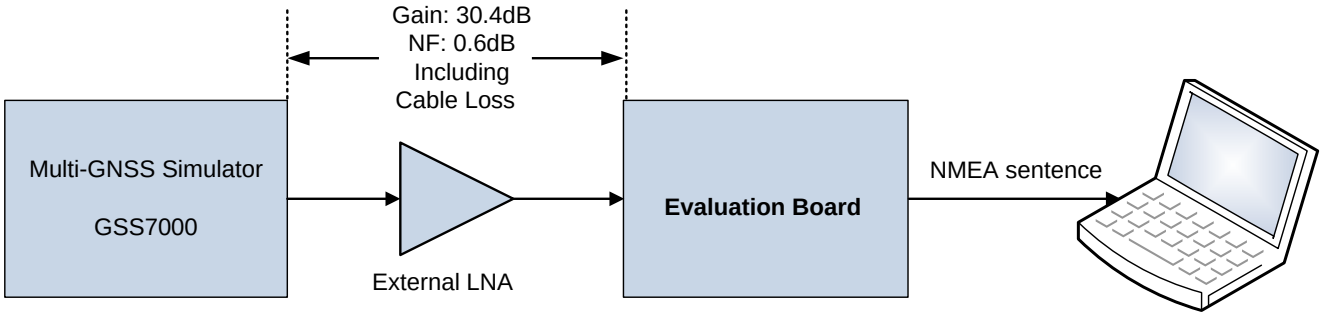

Figure 3-1. Measurement environment

The following are specifications related to the receiving channels. They are divided into two groups according to satellite constellation signals, and each group has a channel availability limit. Group A contains L1 band signals and NavIC, and Group B is L5 band signals excluding NavIC.

Table 3-1. Received channel specifications

Item	Specification	Note
Group A	32 channels	The following satellite constellations are targeted. ・GPS L1 C/A ・GLONASS L1OF ・Galileo E1 ・BeiDou B1I ・BeiDou B1C ・QZSS L1 C/A ・SBAS L1 ・NavIC L5
Group B	30 channels	The following satellite constellations are targeted. ・GPS L5 ・Galileo E5a ・BeiDou B2a ・QZSS L5
Total	62 channels	

The following are the specifications for the initial positioning time and re-acquisition time. See Chapter 2 for definitions of each item.

Table 3-2. TTFF / Re-acquisition time specification

Item	Specification	Item	Specification
TTFF (COLD)	35 seconds (TYP)	TTFF (HOT)	2 seconds (TYP)
Re-acquisition time	1 second (TYP)		

The following are the Sensitivity specifications for each satellite constellation.

Table 3-3. Sensitivity specifications for each satellite signal

satellite signal	Acquisition sensitivity (COLD)	Acquisition sensitivity (HOT)	Re-acquisition sensitivity	Tracking sensitivity
GPS L1C/A	-148 dBm	-162 dBm	-157 dBm	-163 dBm
GLONASS L1OF	-146 dBm	-156 dBm	-153 dBm	-162 dBm
Galileo E1	-140 dBm	-156 dBm	-156 dBm	-162 dBm
BeiDou B1I [*1]	-144 dBm	-156 dBm	-153 dBm	-162 dBm
BeiDou B1C	-140 dBm	-155 dBm	-148 dBm	-162 dBm
QZSS L1C/A	-146 dBm	-158 dBm	-155 dBm	-162 dBm
GPS L5	-136 dBm	-156 dBm	-151 dBm	-159 dBm
Galileo E5a	-136 dBm	-156 dBm	-152 dBm	-159 dBm
BeiDou B2a	-136 dBm	-156 dBm	-149 dBm	-156 dBm
QZSS L5	-133 dBm	-156 dBm	-149 dBm	-159 dBm
NavIC L5	-146 dBm	-156 dBm	-154 dBm	-163 dBm

[*1] Values are for BDS B1I stand-alone positioning.

4 Environment Robustness Specifications

The environmental robustness specifications for the GNSS receiver are described below.

Table 4-1. Environment Robustness Specifications

Item	Specification	Note
Anti-Jamming	Available	It has 8 channels of anti-jamming function against carrier waves. In addition, jamming can be detected and notified by a sentence.
Anti-Spoofing	Available	It has a spoofing signal detection function which generates an alarm and eliminates the demodulation of spoofing signals. Please refer to the Protocol Specifications for more details.
Multipath mitigation	Available	It has the Dynamic Satellite Selection (DSS), a Furuno unique multipath countermeasure.
T-RAIM	Available	It is a function to eliminate anomalous satellites.
Antenna current detection	Available	By connecting an antenna detection circuit to this receiver, the antenna connection status (open, short) can be detected. Please refer to the hardware specifications for more details on recommended antenna detection circuits.

5 Operation restrictions

Based on the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies and Japanese export regulations, the operation of this product is limited to the following conditions. Please note.

Table 5-1. Operation restrictions

Item	Specification	Note
Altitude	< 18300 meters	
Velocity	< 515 m/s	

6 1PPS / Clock Output specifications

This chapter describes the specifications for the 1PPS and clock output signal. Please refer to the Protocol Specifications for the 1PPS signal settings. The performance described in this chapter was measured and evaluated in the environment shown in Figure 6.1 and Figure 6.2 below. Unless otherwise noted, the measurement conditions are the default settings, in open sky, and at constant 25 degree C (no airflow).

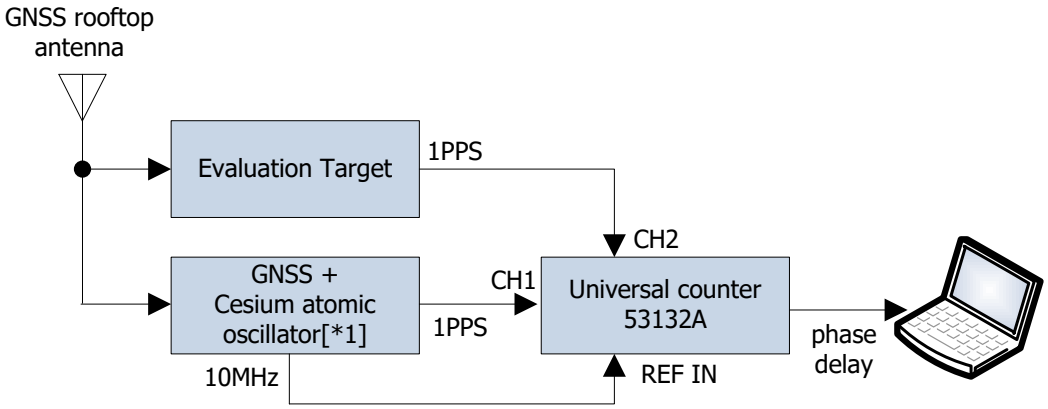

Figure 6-1. 1PPS measurement environment

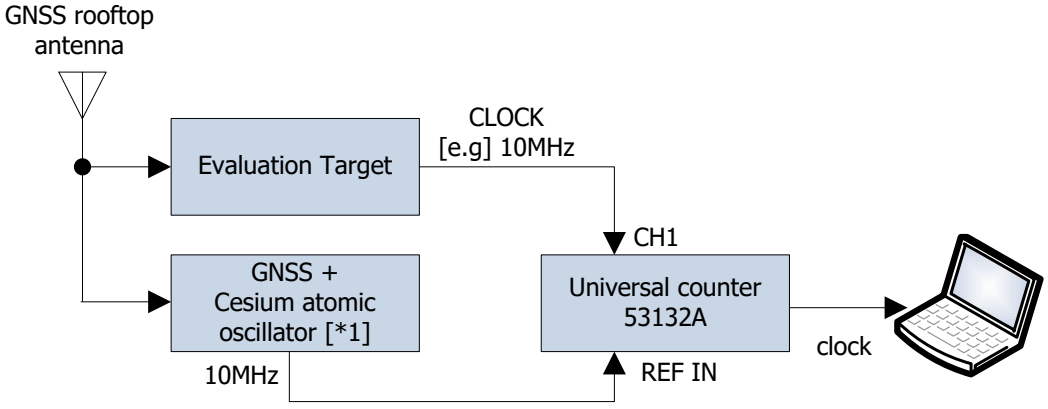

Figure 6-2. clock measurement environment

[* 1]
A cesium atomic oscillator that is corrected the aging characteristics by using the reference time of the GNSS receiver.

6.1 1PPS

Table 6.1-1. 1PPS basic specifications

Item	Specification	Note
1PPS output resolution (Time pulse jitter)	< ± 0.2 nsec	This is the hardware output resolution of this product related to the 1PPS output. The smaller it is, the more stabilize 1PPS output can be.
Synchronization target	GPS, UTC	1PPS output can be synchronized with GPS time or UTC time. Please refer to the Protocol Specifications for more details.
Setting time	< 60 sec	This is the time required for transition into the FINE LOCK state.
1PPS accuracy (Time deviation)	G.8272 PRTC-A compliant G.8272 PRTC-B compliant	@ 1sigma / [*1] This does not require an external oscillator, etc.
1PPS stability (MTIE)	G.8272 PRTC-A compliant G.8272 PRTC-B compliant	Relative MIN-MAX value / [*1] This does not require an external oscillator, etc.

Table 6.1-2. 1PPS output specifications

Item	Specification	Note
1PPS accuracy (MAX|TE|)	< 40 nsec	MIN-MAX value from UTC time / [*1][*2]
1PPS stability (Standard deviation)	< 4.5 nsec	Standard deviation @ 1sigma / [*3]

[* 1]
The conditions are the default setting, open skies, and a constant 25 degree C environment (no airflow). In addition, it must be in the FINE LOCK state and must be in Self Survey mode for at least 3 hours or have already transitioned in Time Only mode.

[* 2]
It is necessary to adjust the cable delay in advance. In addition, it may be necessary to adjust the hardware offset of the entire system in which this product is installed.

[* 3]
The conditions are the default setting, open skies, and a constant 25 degree C environment (no airflow). In addition, it must be in the FINE LOCK state and must be in Self Survey mode for at least 24 hours or have already transitioned in Time Only mode.

6.2 Clock

Table 6.2-1. Clock basic specifications

Item	Specification	Note
Clock configurable value	10MHz, 2.048MHz, 30.72MHz etc.	Any frequency can be output. Please refer to the protocol specifications for how to change the output frequency.
Short-term stability (Root Allan variance τ = 1 second))	< 5E-10	[*1]
Clock accuracy	< 0.5 ppb	@ 1sigma / [*1]
Long-term stability (24-hour average)	< ± 1E-12	[*1]
Relationship between 1PPS and clock	Coherent	The clock and the pulse edge of the PPS are in sync.

[* 1]
The conditions are the default setting, open skies, and a constant 25 degree C environment (no airflow). In addition, it must be in the FINE LOCK state and must be in Self Survey mode for at least 3 hours or have already transitioned in Time Only mode.

7 Holdover specifications

Describes the holdover specifications for 1PPS and clock signals. By inputting external PPS or external clock from the ICLK, this product can holdover depending on its accuracy. and on the other hand, it also supports holdover as a free-run internal oscillator without inputting anything to the ICLK.

The holdover specifications for each are as follows. The holdover possible time can be set with the HOLDOVER command. By default, it is set to 1 second, so if user wants to use holdover, please set an arbitrary holdover time with the HOLDOVER command in advance. Please refer to the protocol specification for more details.

Table 7-1. Holdover specifications when using the ICLK

Item	Specification	Note
1PPS accuracy	-	Depends on the PPS and clock input to the ICLK
Clock accuracy	-	Depends on the PPS and clock input to the ICLK

Table 7-2. Holdover specification when free-run without using the ICLK

Item	Specification	Note
1PPS accuracy	Less than the value calculated by the following formula <± 100 [nsec] * Elapsed time [sec] The 1PPS accuracy specification for the holdover time is, for example, as follows from the above formula. <± 6us / 1min <± 30us / 5min <± 360us / 1Hour <± 8.6ms / 24Hour	[*1]
Clock accuracy	< 100ppb	[*2]

[*1]
This is the maximum time deviation that fluctuates after transition to HOLDOVER state via FINE LOCK state. In addition, the condition is that the temperature is constant at 25 degree C (no airflow).

[*2]
After transitioning to HOLDOVER state via FINE LOCK state, the range shown on the upper is maintained for up to 24 hours. In addition, the condition is that the temperature is constant at 25 degree C (no airflow).