GLONASS TIMESCALE DESCRIPTION

Definition of System

1. System timescale: GLONASS Time.

2. Generation of system timescale: on the basis of time scales of GLONASS Central Synchronizers (CS).

3. Is the timescale steered to a reference UTC timescale?

Yes.

a. To which reference timescale: UTC(SU), generated by State Time and Frequency Reference (STFR).

b. Whole second offset from reference timescale:

10800 s (03hrs 00min 00s):

$$t_{GLONASS} = UTC(SU) + 03hrs00\,\text{min}$$

c. Maximum offset (modulo 1s) from reference timescale:

1 ms.

4. Corrections to convert from satellite to system timescale:

- SVs broadcast corrections $\tau_n(t_b)$ and $\gamma_n(t_b)$ in navigation signals with frequency division multiple access (FDMA) in L1, L2 frequency bands for 30-minute segments of prediction interval;

- SVs broadcast corrections $\tau^j(t_b)$, $\gamma^j(t_b)$ and $\beta^j(t_b)$ in navigation signals with code division multiple access (CDMA) in L1, L3 frequency bands for the segments of prediction intervals divisible by 90 seconds.

a. Type of corrections given; include statement on relativistic corrections:

- L1, L2 FDMA signals - linear coefficients broadcast in operative part of navigation message for each SV;

- L1, L3 CDMA signals - quadratic coefficients broadcast in operative part of navigation message for each SV.

Periodic part of relativistic corrections taking into account the deviation of individual SVs orbits from GLONASS nominal orbits is incorporated in calculation of broadcast corrections to convert from satellite timescale to GLONASS Time.

b. Specified accuracy of corrections to system timescale.

The accuracy of calculated offset between SV timescale and GLONASS Time – 5,6 ns (rms).

c. Location of corrections in broadcast messages:

- L1, L2 FDMA signals:

  - $\tau_n(t_b)$ – line 4, bits 59 – 80 of navigation frame;

  - $\gamma_n(t_b)$ - line 3, bits 69 – 79 of navigation frame;

- L1 CDMA signals:

  – $\tau^j(t_b)$ - line of 10th type digital information, bits 116 – 147;

  - $\gamma^j(t_b)$ - line of 10th type digital information, bits 148 – 166;

  - $\beta^j(t_b)$ - line of 10th type digital information, bits 167 – 181;

- L3 CDMA signals:

  – $\tau^j(t_b)$ - line of 10th type digital information, bits 123 – 154;

  - $\gamma^j(t_b)$ - line of 10th type digital information, bits 155 – 173;

  - $\beta^j(t_b)$ - line of 10th type digital information, bits 174 – 188.

d. Equation to correct satellite timescale to system timescale:

- L1, L2 FDMA signals:

$$t_{GLONASS} = t + \tau_n(t_b) - \gamma_n(t_b)(t - t_b)$$

where t - satellite time;

$\tau_n(t_b)$ - offset of the nth SV timescale relative to GLONASS Time at t_b;

$\gamma_n(t_b)$ - relative offset of the nth SV carrier frequency from the nominal value at t_b;

t_b - the number of the time interval to the middle of which the operational information of the navigation frame is referenced;

- L1, L3 CDMA signals:

$$t_{ГЛОНАСС} = \mathrm{mod}_{86400}[t^j + \tau^j(t_b) - \gamma^j(t_b)\cdot(t^j - t_b) - \beta^j(t_b)\cdot(t^j - t_b)^2]$$

where t^j - time of broadcasting signal in SV timescale;

$\tau^j(t_b)$ - offset of the jth SV timescale relative to GLONASS Time at t_b;

$\gamma^j(t_b)$ - relative offset of the jth SV carrier frequency from the nominal value at t_b;

$\beta^j(t_b)$ - half drift of the offset of the jth SV carrier frequency from the nominal value at t_b.

5. Corrections to convert from GLONASS system time to reference UTC(SU) time.

- L1, L2 FDMA signals - τ_c;

- L1, L3 CDMA signals - $\tau_c(t_b)$, $\dot{\tau}_c(t_b)$ for the segments of prediction interval divisible by 90 s.

a. Type of corrections given:

- L1, L2 FDMA signals – constant;

- L1, L3 CDMA signals – linear coefficients.

b. Specified accuracy of corrections to reference timescale:

The accuracy of calculating GLONASS Time – UTC offset is below 1 μs.

c. Location of corrections in broadcast messages:

- L1, L2 FDMA signals:

  - τ_c - line 5, bits 38 – 69 of navigation frame;

- L1 CDMA signals:

  - $\tau_c(t_b)$ - line of 10th type digital information, bits 182 – 221;

  - $\dot{\tau}_c(t_b)$ - line of 10th type digital information, bits 222 – 234;

- L3 CDMA signals:

  - $\tau_c(t_b)$ - line of 10th type digital information, bits 189 – 228;

  - $\dot{\tau}_c(t_b)$ - line of 10th type digital information, bits 229 – 241.

d. Equations to correct system timescale to reference timescale:

- L1, L2 FDMA signals:

$$t_{UTC(SU)} + 03hrs00\min = t_{GLONASS} + \tau_c$$

where τ_c - correction to convert from GLONASS Time to UTC(SU);

- L1, L3 CDMA signals:

$$t_{UTC(SU)} = \mathrm{mod}_{86400}[t_{GLONASS} + \tau_c(t_b) + \dot{\tau}_c(t_b)\cdot(t - t_b) - 10800s]$$

where τ_c - correction to convert from GLONASS system time to UTC(SU) at t_b;

$\dot{\tau}_c(t_b)$ - rate of changing the correction to convert from GLONASS system time to UTC(SU) at t_b;

6. Specified stability of system timescale:

Depends on CS characteristics.

7. Specified stability of reference timescale:

Depends on State Time and Frequency Reference (STFR) characteristics.

8. Specified stability of satellite clocks:

- $1\cdot10^{-13}$ (τ = 1 day).

9. Availability of System to GNSS Time Offset (GGTO):

a. Systems for which corrections are given:

GPS - correction τ_{GPS} broadcast by SVs.

b. Type of GGTO corrections given:

τ_{GPS} – fractional part of GPS-GLONASS Time offset (integer part is determined by user from GPS navigation message).

c. Stated accuracy of GGTO corrections given:

not worse than 30 ns (rms).

d. Location of corrections in broadcast messages:

- L1, L2 FDMA signals:
  - τ_{GPS} - line 5, bits 10 – 31 of navigation frame;
- L1 CDMA signals:
  - τ_{GPS} - line of 12th type digital information, bits 197-226;
- L3 CDMA signals:
  - τ_{GPS} - line of 12th type digital information, bits 195-224.

e. Equation used for GGTO message:

$$T_{GPS} - T_{GL} = \Delta T + \tau_{GPS}$$

where ΔT - integer part of GPS-GLONASS Time offset;

τ_{GPS} - fractional part of the offsets.

Describe the details of the system, i.e. locations of system and reference timescale clocks, generation of timescales, and other details.

GLONASS Central Synchronizers are located at two sites of GLONASS Control Segment and include an ensemble of hydrogen frequency standards with daily frequency instability less than $2 \cdot 10^{-15}$. One of them is the Main CS, the other is Reserved CS.

GLONASS Time is generated on the basis of the Main CS timescale. The offset of Reserved CS timescale relative to the Main CS timescale is calculated by “all-in-view” method with using SV signals.

GLONASS reference timescale UTC(SU) is generated by STFR which includes cesium frequency standards, a group of hydrogen frequency standards, TWSTFT and CGGTTS links for synchronization to UTC.

Describe how the timescale transfers from the reference timescale to the system timescale and finally to the satellites. Include the nominal rate of SV updates.

The offsets of GLONASS Central Synchronizers timescales relative to UTC(SU) are controlled by “all-in-view” method with using SV signals. The data are transferred to GLONASS System Control Center where GLONASS Time is generated and corrections for GLONASS Time–UTC(SU) offset are calculated. The corrections are calculated and uploaded once per day.

If any other pertinent details exist concerning the generation and realization of system and/or reference time, include them as well.

GLONASS Time is corrected simultaneously with corrections of UTC in accordance with Bulletin C IERS and, as a result, the offset between GLONASS Time and UTC(SU) is constant and equals 10800 s.