YD

COMMUNICATION INDUSTRY STANDARD

OF THE PEOPLE'S REPUBLIC OF CHINA

ICS 33.040.20

M33

YD/T 2375-2019

Replacing YD/T 2375-2011

Technical requirements for high accuracy time synchronization

高精度时间同步技术要求

Issued on: November 11, 2019 **Implemented on: January 01, 2020**

Issued by: Ministry of Industry and Information Technology of PRC

Table of Contents

Technical requirements for high accuracy time synchronization

1 Scope

This standard specifies the networking requirements for high-precision time synchronization, the performance index requirements for high-precision time synchronization, the reliability requirements for high-precision time synchronization networks, the basic requirements for equipment related to high-precision time synchronization.

This standard applies to high-precision time synchronization networks, based on ground transmission using PTP technology.

2 Normative references

The following documents are essential to the application of this document. For the dated documents, only the versions with the dates indicated are applicable to this document; for the undated documents, only the latest version (including all the amendments) is applicable to this standard.

YD/T 900-1997 Technical requirement for SDH equipment - Clock

YD/T 1012-1999 Node clock set of digital synchronization network and its timing feature

YD/T 1479-2006 Technical requirements and testing methods of primary reference clock equipment

YD/T 2879-2015 (OAM) technical requirements based on the synchronous network operation management and maintenance of a packet network

ITU-T G.8262 Timing characteristics of synchronous Ethernet equipment slave clock

ITU-T G.8275.1 Precision time protocol telecom profile for phase/time synchronization with full timing support from the network

IEEE 1588-2008 Standard for a precision clock synchronization protocol for networked measurement and control systems

3GPP TR 25.836 Node B synchronization of time division duplex (TDD)

Figure 1 -- Hierarchical structure of time synchronization network

5.2 Composition and basic functions of time synchronization device

The level-1 time synchronization device shall be composed of two cesium clocks and two satellite timing receivers, etc., which can be traced to a higher-level domestic time-keeping reference (for example, the National Time Service Center), through a dedicated comparison method.

The level-2 time synchronization device shall be equipped with at least rubidium clocks. The device consists of two rubidium clocks and two satellite timing receivers. It shall support the traceability of time to the level-1 time synchronization device, through ground means; support the punctuality function of ground frequency signals. It shall be able to be reliably traced to China's frequency synchronization network.

The level-3 time synchronization device shall be equipped with at least a high-stable crystal oscillator. The device consists of two high-stable crystal oscillators and at least one satellite timing receiver. It shall support time traceability to the level-2 time synchronization device or the level-1 time synchronization device, through ground means; support the punctuality function of ground frequency signals. It shall be able to be reliably traced to China's frequency synchronization network.

See Appendix B, for the location and quantity of time synchronization devices, at all levels.

5.3 Principles of time synchronization networking

5.3.1 General principles of time synchronization networking

Under normal circumstances, the time synchronization device shall prefer the signal of the satellite timing receiver. When the satellite signal is unavailable, the low-level time synchronization device shall trace to the high-level time synchronization device, through the ground time link. In the case where both the satellite signal and the ground time link are unavailable, the low-level time synchronization device shall be able to use the signal from the frequency synchronization network, to keep time. If conditions permit, the time synchronization network shall be traced to the national time-frequency standard system.

When building a time synchronization network, according to the actual network conditions, flexible networking structures (for example, level-2 or level-3 networking) and setting methods (for example, a level-3 time synchronization device with a rubidium clock) can be used.

5.3.2 Relationship between time synchronization network and frequency

the best network element of frequency time keeping as the reference. See 8.3.4, for the specific mapping mechanism of scheme 1 and scheme 2. See 9.4.2, for the source selection processing mechanism.

5.3.3 Principles of reference source setting

5.3.3.1 The principle of setting the timing reference of the level-1 time synchronization

The principle of setting the timing reference of level-1 time synchronization is as follows:

a) Under normal circumstances, the level-1 time synchronization device shall track the signal of the satellite timing receiver;

b) When the satellite timing receiver fails, the level-1 time synchronization device shall be able to keep time, based on the cesium clock;

c) If the relevant technical conditions are available, the level-1 time synchronization device can be traced to the national time-frequency system, as the fundamental guarantee for the entire time synchronization network.

5.3.3.2 The principle of setting the timing reference of the level-2 time synchronization

The principle of setting the level-2 time synchronization timing reference is as follows:

a) Under normal circumstances, the level-2 time synchronization device shall track the signal of the satellite timing receiver;

b) The level-2 time synchronization device shall be equipped with at least two ground time input reference signals, which are respectively connected to the level-1 time synchronization device, from different physical routes. When the satellite signal is unavailable, the level-2 time synchronization device shall be able to track the ground time input reference signal;

c) The level-2 time synchronization device shall be equipped with at least one ground frequency input reference signal, which shall be traceable to the frequency synchronization network. In the event that satellite signals are not available, the level-2 time synchronization device shall be able to track the ground frequency input reference signal. In the event that both satellite signals and ground time input reference signals are unavailable, the level-2 time synchronization device shall be able to use the signal, which is from the frequency synchronous network, to keep time.

5.3.3.3 The principle of setting the timing reference of the level-3 time synchronization

The principle of setting the timing reference of the level-3 time synchronization are as follows:

a) Under normal circumstances, the level-3 time synchronization device shall track the signal of satellite timing receiver;

b) The level-3 time synchronization device shall be equipped with two ground time input reference signals, which are respectively connected to the level-1 or level-2 time synchronization device, from different physical routes. When the satellite signal is unavailable, the level-3 time synchronization device shall be able to track the ground time input reference signal;

c) The level-3 time synchronization device shall be equipped with a ground frequency input reference signal, which shall be traceable to the frequency synchronization network. When the satellite signal is unavailable, the level-3 time synchronization device shall be able to track the ground frequency input reference signal. When both the satellite signal and the ground time input reference signal are unavailable, the level-3 time synchronization device shall be able to use the signal, which is from the frequency synchronous network, to keep time.

5.3.4 Principles for organizing time synchronization path

In order to ensure the reliability of the time synchronization network and the precision of time allocation, the organization of time synchronization paths shall follow the following principles:

a) Ground time transmission shall follow the principle of one-way layer-by-layer downward (applicable to scheme 1 only);

b) Ground time signal transmission is only allowed from high-level time synchronization device to low-level time synchronization device; it is not allowed for the low-level time synchronization device to transmit timing to high-level or same-level time synchronization device (only applicable to scheme 1);

c) The time transfer between the ground offices, between the time synchronization device and the synchronized device (such as base station), shall use PTP technology; the time transfer, between the ground offices between time synchronization devices, can use PTP technology or other technologies;

d) Level 2 and Level 3 time synchronization device shall be able to obtain time synchronization, from at least two different physical routing ground timing links; the ground timing physical links are preferably buried optical cables;

e) The number of time synchronization devices, which are connected in series to the time synchronization path, shall not exceed 3, of which there are at most one level-1 time synchronization device, one level-2 time synchronization device, one level-3 time synchronization device;

f) The number of bearer device network elements, which are connected in series in the time synchronization path, from the time synchronization device to the synchronized device, should not exceed 30. The number of bearer device network elements, which are connected in series between any two adjacent levels of time synchronization devices (including the OA station, which supports the PTP function) should not exceed 20. Refer to clause 10.2 for the time synchronization function and performance requirements of the bearer device;

g) For bearer device, the frequency reference shall be taken from the frequency synchronization network;

h) For the level-2/level-3 time synchronization device, when the satellite timing receiver is unavailable, the frequency reference shall preferably come from the intra-office frequency synchronization device, OR trace to the frequency synchronization network, through the shortest path.

6 Requirements for high-precision time synchronization performance indicators

6.1 Overview

The working state of the satellite timing receiver will cause changes in the time transmission link of the time synchronization network. When the satellite signal is available, the time synchronization network forms a single-level structure, that is, there is only one time synchronization device, in the time path, as the time source, as shown in Figure 3. When the satellite timing is unavailable, it may connect, in series, multiple time synchronization devices, into the time synchronization network, to form a multi-level structure, that is, a maximum of three time synchronization devices may be connected in series in the time path, as the time source, as shown in Figure 4.

For the above two cases, the end-to-end time performance indicator consists of three parts: The time source part, the bearer network part, the end distribution part. Considering that the time deviation, which is introduced by the line asymmetry and compensation error, that may exist in the engineering construction, will adversely affect the end-to-end indicator allocation, the delay asymmetry shall be accurately compensated, in the actual engineering construction. For specific requirements, see Appendix C.

the PTP technology to track the time signal from the level-1 time synchronization device. The time output performance Δt1' of the last-level time synchronization device is composed of two parts: one is the fixed time deviation introduced by the punctuality of the cesium clock; the other is the time deviation introduced by the inter-office allocation, in the inner-province backbone and inter-province backbone. In this case, the specific indicators of the time allocation of the time source part are to be studied. For reference estimates, see Appendix D.

2) For the case where the satellite timing receiver of the level-1 time synchronization device is normal, whilst the satellite timing receiver of the level-2/level-3 time synchronization device is faulty, the time output performance of the last-level time synchronization device mainly includes the time output performance of the level-1 time synchronization device, when normally tracking the satellite timing receiver (better than ±150ns), AND the time deviation introduced by the inter-office distribution of the time signal in the inner-provincial backbone and the inter-provincial backbone; its time output performance Δt1' shall be better than ±250ns (relative to UTC). The transmission method of the time signal, from the level-1 time synchronization device to the level-2/level-3 time synchronization device, is to be studied;

3) When all satellite timing receivers fail, if conditions permit, the time synchronization network can be traced to the national time-frequency standard system by other means; the time output performance Δt1' of the final time synchronization device shall be better than ±250ns (relative to at UTC). The specific traceability and transmission methods are to be studied.

b) Bearer network part: The time performance indicator Δt2 is the same as that in clause 6.2 b).

c) End allocation part: The time performance index Δt3 is the same as that in clause 6.2 c).

7 High-precision time synchronization transmission technology

7.1 High-precision time synchronization technology

The realization technology of high-precision time synchronization involves inter-office transmission technology and intra-office distribution technology. Among them, the inter-office transmission technology refers to the realization of time synchronization, between different computer rooms, which can be realized by using PTP technology, based on different transmission platforms; the intra-office distribution technology is

mainly to realize the time synchronization, between different devices in the computer room, the most commonly used implementation technology includes 1PPS+ToD interface technology and PTP interface technology. See Appendix E, for an introduction to the key factors affecting the accuracy of inter-office transmissions.

7.2 Inter-office transmission technology

Interoffice transmission technology includes the following two categories.

a) The PTP mode is supported point by point: The bearer network element device, which is involved in the time synchronization path, shall support the PTP function.

b) Transparent transmission mode: For the transparent transmission of high-precision time synchronization based on TDM mode, the intermediate node does not need to support the PTP function, whilst the end-to-end time synchronization is realized, through the exchange of PTP protocol, between the master and slave devices at both ends. The way of realizing high-precision time synchronization and transparent transmission, based on the grouping method, needs to be studied.

See Appendix F, for the requirements of the PTP protocol and its BMC algorithm.

7.3 Intra-office distribution technology

Intra-office distribution techniques include the following two categories.

a) Technologies that support intra-office two-way message exchange to achieve high-precision time transmission, mainly including PTP, general timing interface, improved NTP, etc. Among them, PTP technology is relatively mature at present, whilst other technologies need to be further studied. When using the PTP interface or the general timing interface for intra-office distribution, the downstream synchronized devices can simultaneously obtain time and frequency reference signals, through this interface.

b) Technologies that support intra-office one-way signals to achieve high-precision time transmission, mainly including 1PPS+ToD. The frequency synchronization, which is required by the downstream synchronized devices, shall be obtained, preferentially through the intra-office frequency synchronization node.

8 Requirements for high-precision time synchronization

9.3 Redundant configuration requirements of time synchronization device

The redundant configuration requirements of the time synchronization device are as follows:

a) The important card boards, such as the clock card and power supply card of the time synchronization device, shall be redundantly configured;

b) The time synchronization device shall be equipped with dual-mode satellite receivers (for example: GPS + Beidou) or two single-mode satellite receivers;

c) Support simultaneous reception of various satellite signals and ground signals; realize automatic switching of various time reference source signals;

d) After all time reference sources fail, the ground frequency input signal or internal clock can be used to keep time;

e) The mean time between failure (MTBF) of the device shall not be less than 20 years. The device card board shall be pluggable, during operation.

9.4 Selection requirements for time reference source

9.4.1 Overview

The requirements in this chapter are mainly applicable to the selection of the time reference source in the BC mode; the OC mode may use it as a reference; the TC mode is to be studied.

9.4.2 Switching conditions for time reference source

The high-precision time synchronization network shall support automatic failover, so that when the synchronization link fails, it can automatically switch to the backup reference source or link, to realize the self-healing of the synchronization link and performance, thereby meeting the synchronization requirements of the service.

The automatic switching conditions for reference source include:

a) The clock class (clockClass) is lowered or the pulse-per-second state class of 1PPS+ToD interface is lowered;

b) The clock accuracy (clockAccuracy) is lowered;

c) The Priority 1 (Priority1) and priority (Priority2) are lowered;

d) Packet message timing failure PTSF;

e) PTP link LOS;

f) PTP link failure (linkdown);

g) 1PPS or ToD interface's input signal is lost.

9.4.3 Selection mechanism of time reference source

The selection mechanism of time reference source is as follows:

a) The PTP port's source selection algorithm shall follow the BMC algorithm, which is defined in IEEE 1588-2008 (hereinafter referred to as 1588v2), which mainly includes two parts: The data set comparison algorithm and the state decision algorithm. Please refer to Appendix F.3, for the specific implementation process.

b) Principle of 1PPS+ToD source selection algorithm.

1) Scheme 1

- The source selection of the time source device shall follow the following principles:

  ● When tracking GPS normally, the output code of pulse-per-second state is 0x00;

  ● After the satellite timing receiver fails, when the time synchronization device uses the cesium atomic clock, to maintain or trace the frequency synchronization signal to the PRC, to keep time, THEN, the output code of pulse-per-second state is 0x01;

  ● After the satellite timing receiver fails, the time synchronization device uses the tungsten atomic clock, to keep the output code of pulse-per-second state as 0x05;

  ● After the satellite timing receiver fails, the time synchronization device uses the crystal clock, to maintain the output code of pulse-per-second state as 0x03;

  ● When the time source device fails, the output code of pulse-per-second state is 0x02;

  ● The output clockClass code and the pulse-per-second state code of the time source device shall maintain a consistent corresponding relationship.

- The source selection principle of bearer device shall follow the following principles:

This is an excerpt of the PDF (Some pages are marked off intentionally)

Full-copy PDF can be purchased from 1 of 3 websites:

1. https://www.ChineseStandard.us

- SEARCH the standard ID, such as GB 4943.1-2022.
- Select your country (currency), for example: USA (USD); Germany (Euro).
- Full-copy of PDF (text-editable, true-PDF) can be downloaded in 9 seconds.
- Tax invoice can be downloaded in 9 seconds.
- Receiving emails in 9 seconds (with download links).

2. https://www.ChineseStandard.net

- SEARCH the standard ID, such as GB 4943.1-2022.
- Add to cart. Only accept USD (other currencies - https://www.ChineseStandard.us).
- Full-copy of PDF (text-editable, true-PDF) can be downloaded in 9 seconds.
- Receiving emails in 9 seconds (with PDFs attached, invoice and download links).

3. https://www.google.com/search?tbm=bks&q=ChineseStandard.net

- SEARCH the standard ID, such as GB 4943.1-2022.
- Google Books -- Select your currency.
- Processed by Google (delivery, tax invoice etc.). Delivered in 9 seconds by Google.
- Tips: Download an unprotected True-PDF (text-editable) from Google-Books:
  1. https://play.google.com/books → 2. Sign in → Google account
  3. Find the BOOK you bought → 4. Click "3-dots" → Export
  5. Save as "*.pdf" (Save True-PDF to your local computer for offline reading/printing)

Translated by: Field Test Asia Pte. Ltd. (Incorporated & taxed in Singapore. Tax ID: 201302277C)

Accountable person and shareholder: Wayne Zheng

About Us (Goodwill, Policies, Fair Trading…): https://www.chinesestandard.net/AboutUs.aspx

Contact: Wayne Zheng, Sales@ChineseStandard.net

Linkin: https://www.linkedin.com/in/waynezhengwenrui/

------ The End ------