

Recommendation

ITU-T G.8272.1 (01/2024)

SERIES G: Transmission systems and media, digital systems and networks

Packet over Transport aspects – Synchronization, quality and availability targets

Timing characteristics of enhanced primary reference time clocks

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Recommendation ITU-T G.8272.1

Timing characteristics of enhanced primary reference time clocks

Summary

Recommendation ITU-T G.8272.1 specifies the requirements for enhanced primary reference time clocks (ePRTC) suitable for time and phase synchronization in packet networks. It defines the error allowed at the time output of the ePRTC. These requirements apply under the normal environmental conditions specified for the equipment.

History *

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Enhanced primary reference time clock, ePRTC, primary reference time clock, PRTC, synchronization, time error, wander.

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Recommendation ITU-T G.8272.1

Timing characteristics of enhanced primary reference time clocks

1 Scope

This Recommendation specifies the requirements for enhanced primary reference time clocks (ePRTC) suitable for time, phase and frequency synchronization in packet networks. These requirements apply under the normal environmental conditions specified for the equipment.

The ePRTC provides a reference time signal traceable to a recognized time standard (e.g., coordinated universal time (UTC)) and also a frequency reference. Compared with the primary reference time clock (PRTC) as defined in [ITU-T G.8272], the ePRTC is subject to more stringent output performance requirements and includes a frequency input directly from an autonomous primary reference clock. The performance of the autonomous primary reference clock for this particular application is specified in Annex A.

An ePRTC provides the reference signal for time, phase and frequency synchronization for clocks within a network or section of a network. In particular, the ePRTC can also provide the reference signal to the telecom grand master (T-GM) within the network node where the ePRTC is located.

This Recommendation defines the ePRTC output requirements, including for an ePRTC integrated with a T-GM clock.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T G.703] Recommendation ITU-T G.703 (2016), *Physical/electrical characteristics of hierarchical digital interfaces*.
- [ITU-T G.810] Recommendation ITU-T G.810 (1996), *Definitions and terminology for synchronization networks*.
- [ITU-T G.811] Recommendation ITU-T G.811 (1997), *Timing characteristics of primary reference clocks*.
- [ITU-T G.811.1] Recommendation ITU-T G.811.1 (2017), *Timing characteristics of enhanced primary reference clocks*.
- [ITU-T G.8260] Recommendation ITU-T G.8260 (2022), *Definitions and terminology for synchronization in packet networks*.
- [ITU-T G.8271] Recommendation ITU-T G.8271/Y.1366 (2020), *Time and phase synchronization aspects of packet networks*.
- [ITU-T G.8272] Recommendation ITU-T G.8272/Y.1367 (2018), *Timing characteristics of primary reference time clocks*.

3 Definitions

Definitions related to synchronization are contained in [ITU-T G.810] and [ITU-T G.8260].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ePRTC	enhanced Primary Reference Time Clock
FM	Frequency Modulation
GNSS	Global Navigation Satellite System
MTIE	Maximum Time Interval Error
NE	Network Equipment
PPS	Pulse Per Second
PRC	Primary Reference Clock
PRTC	Primary Reference Time Clock
PTP	Precision Time Protocol
TDEV	Time Deviation
T-GM	Telecom Grand Master
UTC	Coordinated Universal Time

5 Conventions

None.

6 Time error, wander and jitter in locked mode

The time error noise generation of an ePRTC is characterized by two main aspects:

- 1) the constant time error (time offset) at its output compared with the applicable primary time standard (e.g., UTC);
- 2) the amount of phase error (wander and jitter) produced at its output.

For the characterization of the second aspect described above (phase error), the calculation of the maximum time interval error (MTIE) and the time deviation (TDEV) is useful.

Clause 6.1 defines the time error requirements applicable at the output of the ePRTC, which correspond to the combination of the two aspects described above (constant time error and phase error). No requirement is defined for the constant time error component taken alone, only when it is combined with the phase error.

Clauses 6.2 and 6.3 define the wander and jitter requirements applicable at the output of the ePRTC, which correspond to the second aspect described above (phase error).

The performance specified in clauses 6.1 and 6.2 also applies to the output of the combined ePRTC and T-GM function when integrated into a single piece of equipment. Therefore, there is no additional allowance for the inclusion of the T-GM function.

NOTE – Optimization of the noise inside the equipment is possible by combining the two functions. Therefore, the total noise of equipment that integrates the ePRTC and T-GM can be the same as equipment that only contains the ePRTC.

6.1 Time error in locked mode

Under normal, locked operating conditions, the time output of the ePRTC, or the combined ePRTC and T-GM function, should be accurate to within 30 ns or better when verified against the applicable primary time standard (e.g., UTC). For the ePRTC this value includes all the noise components, i.e., the constant time error (time offset) and the phase error (wander and jitter) of the ePRTC.

For the combined ePRTC and T-GM function, the time error samples are measured through a moving-average low-pass filter of at least 100 consecutive time error samples. This filter is applied by the test equipment to remove errors caused by timestamp quantization, or any quantization of packet position in the test equipment, before calculating the maximum time error. Normal, locked operating conditions mean that:

- The ePRTC is fully locked to the incoming reference time signal, and is not operating in warm-up;
- There are no failures or facility errors in the reference path, including but not limited to antenna failures;
- The environmental conditions are within the operating limits specified for the equipment;
- The equipment is properly commissioned and calibrated for fixed offsets such as antenna cable length, cable amplifiers and receiver delays;
- The reference time signal (e.g., global navigation satellite system (GNSS) signal) is operating within limits, as determined by the relevant operating authorities;
- If the reference time signal is operated over a radio system such as GNSS, multipath reflections and interference from other local transmissions, such as jamming, must be minimized to an acceptable level;
- There are no extreme propagation anomalies, such as severe thunderstorms or solar flares.

6.2 Wander in locked mode

The wander requirements apply to all the interfaces listed in clause 9.2.2.

When the ePRTC is in the normal, locked mode of operation, the wander, expressed in MTIE, measured using a similar configuration as the synchronized clock configuration defined in Figure 1a of [ITU-T G.810] (with the use of a time standard instead of a frequency standard), should have the limits shown in Table 1.

Table 1 – Wander generation (MTIE)

MTIE limit (ns)	Observation interval τ (s)
4	$0.1 < \tau \leq 1$
$0.11114 \times \tau + 3.89$	$1 < \tau \leq 100$
$0.0375 \times 10^{-3} \tau + 15$	$100 < \tau \leq 400\,000$
30	$\tau > 400\,000$

The resultant requirements are shown in Figure 1.

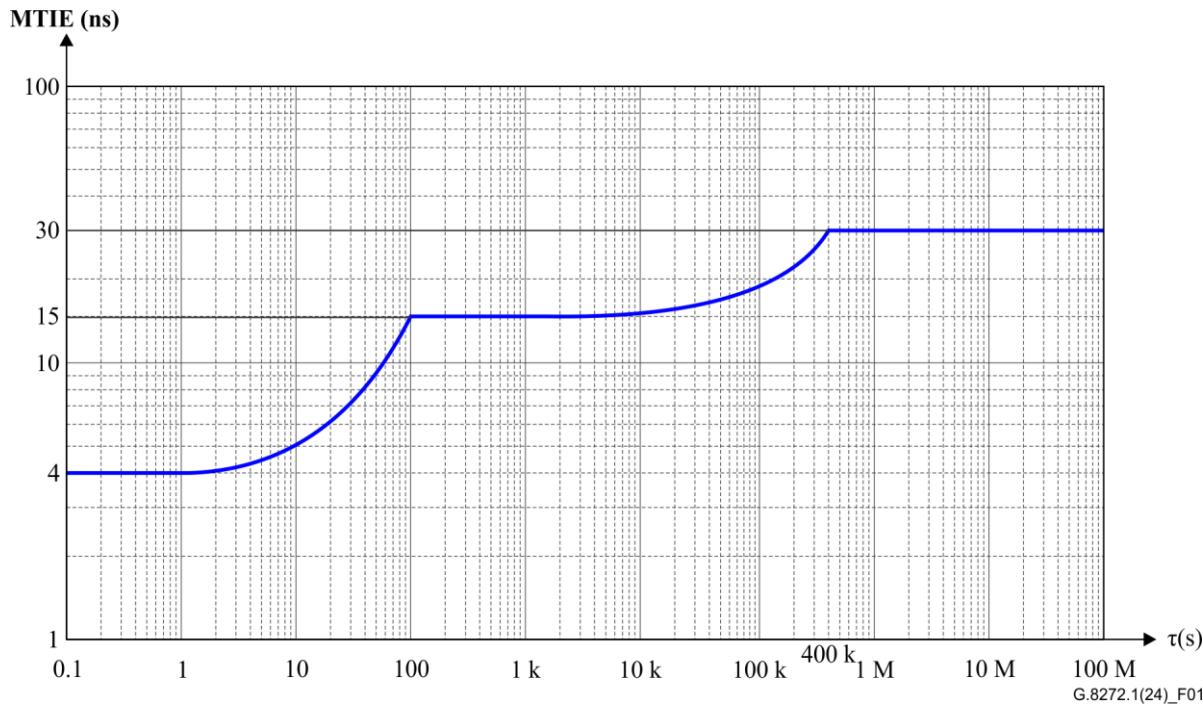


Figure 1 – MTIE as a function of an observation (integration) interval τ

NOTE 1 – For the 1 pulse per second (PPS) output interface, the MTIE mask is applicable for observation intervals greater than or equal to 1 second.

When the ePRTC is in the normal, locked mode of operation, the wander, expressed in TDEV, measured using a similar configuration as the synchronized clock configuration defined in Figure 1a of [ITU-T G.810] (with the use of a time standard instead of a frequency standard), should have the limits shown in Table 2.

Table 2 – Wander generation (TDEV)

TDEV limit (ns)	Observation interval τ (s)
1	$0.1 < \tau \leq 30\,000$
$3.33333 \times 10^{-5} \tau$	$30\,000 < \tau \leq 300\,000$
10	$300\,000 < \tau < 1\,000\,000$