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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital networks – Design objectives for digital networks

Timing characteristics of enhanced primary reference clocks

Recommendation ITU-T G.811.1

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Recommendation ITU-T G.811.1

Timing characteristics of enhanced primary reference clocks

Summary

Recommendation ITU-T G.811.1 outlines the requirements for enhanced primary reference clocks (ePRCs) suitable for frequency synchronization. These requirements apply under normal environmental conditions specified for the equipment.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.811.1	2017-08-13	15	11.1002/1000/13301

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ePRC, ePRTC, frequency synchronization.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Recommendation ITU-T G.811.1

Timing characteristics of enhanced primary reference clocks

1 Scope

This Recommendation outlines the requirements for enhanced primary reference clocks (ePRCs) suitable for frequency synchronization. These requirements apply under normal environmental conditions specified for the equipment.

The ePRC provides the reference signal for the timing or synchronization of other clocks within a network or section of a network. In particular, the ePRC in its autonomous form can provide a frequency input to an enhanced primary reference time clock (ePRTC). This Recommendation defines the ePRC output, but it does not apply to the output of a slave clock directly fed by an ePRC. The long-term accuracy of the ePRC should be maintained at 1 part in 10^{12} or better, with verification to coordinated universal time (UTC). An ePRC may be realized as an autonomous clock, operating independently of other sources. Alternatively, the ePRC may be realized as a non-autonomous clock which is disciplined by UTC-derived precision signals received from a radio or satellite system. In either case, the requirements for long-term accuracy and short-term stability, as specified in this Recommendation, apply.

Several classes of ePRCs are being considered. This version specifies ePRC class A. Other classes are for further study.

The long-term accuracy specified in this Recommendation is adequate when a single ePRC provides the reference synchronization signal to all other clocks within a network (synchronous mode of operation). In the pseudo-synchronous mode, i.e., not all clocks in the network have timing traceable to the same ePRC, the long-term accuracy is dependent on the number of ePRCs in that network.

When more than one ePRC is used in a network, a statistical approach is needed to determine the long-term accuracy of each ePRC in that network.

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.8260] Recommendation ITU-T G.8260 (2015), *Definitions and terminology for synchronization in packet networks.*

3 Definitions

3.1 Terms defined elsewhere

The terms and definitions used in this Recommendation are contained in [ITU-T G.810] and [ITU-T G.8260].

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CMI Coded Mark Inversion

ePRC enhanced Primary Reference Clock

ePRTC enhanced Primary Reference Time Clock

FPM Flicker Phase Modulation

MTIE Maximum Time Interval Error

NE Network Element

OAM Operations and Maintenance

PLL Phase Locked Loop

PRC Primary Reference Clock

PRTC Primary Reference Time Clock

SDH Synchronous Digital Hierarchy

SEC SDH Equipment Clock

SSMB Synchronization Status Message Byte

STM Synchronous Transport Module

TDEV Time Deviation

UI Unit Interval

UTC Coordinated Universal Time

WFM White Frequency Modulation

5 Conventions

None.

6 Frequency accuracy

The maximum allowable fractional frequency offset for observation times greater than one week is 1 part in 10^{12}, over all applicable operational conditions.

7 Noise generation

The noise generation of an ePRC represents the amount of phase noise produced at its output. A suitable reference, for practical testing purposes, implies a performance level that is more stable than the output requirements. The ability of the clock to limit this noise is described by its frequency stability. The measures, maximum time interval error (MTIE) and time deviation (TDEV) are useful for characterization of noise generation performance.

Both MTIE and TDEV are measured through an equivalent 10 Hz, first-order, low-pass measurement filter, at a maximum sampling time, τ_0, of 1/30 seconds. The minimum measurement period, *T*, for

TDEV is twelve times the integration period, τ ($T = 12\tau$). For measurements over longer observation periods, alternative filter bandwidth and sampling time may be required for practical considerations.

7.1 Wander

The wander, expressed in MTIE and measured using the independent clock configuration defined in Figure 2a of [ITU-T G.810], should have the limits as shown in Table 1 and Figure 1:

Table 1 – Wander generation (MTIE)

MTIE limit [µs]	Observation interval τ [s]
.004	$0.1 < \tau \leq 1$
$0.11114 \times 10^{-3}\tau + 0.00389$	$1 < \tau \leq 100$
$0.0375 \times 10^{-6}\tau + 0.015$	$100 < \tau \leq 1000$
$10^{-6}\tau + 0.0140375$	$\tau > 1000$

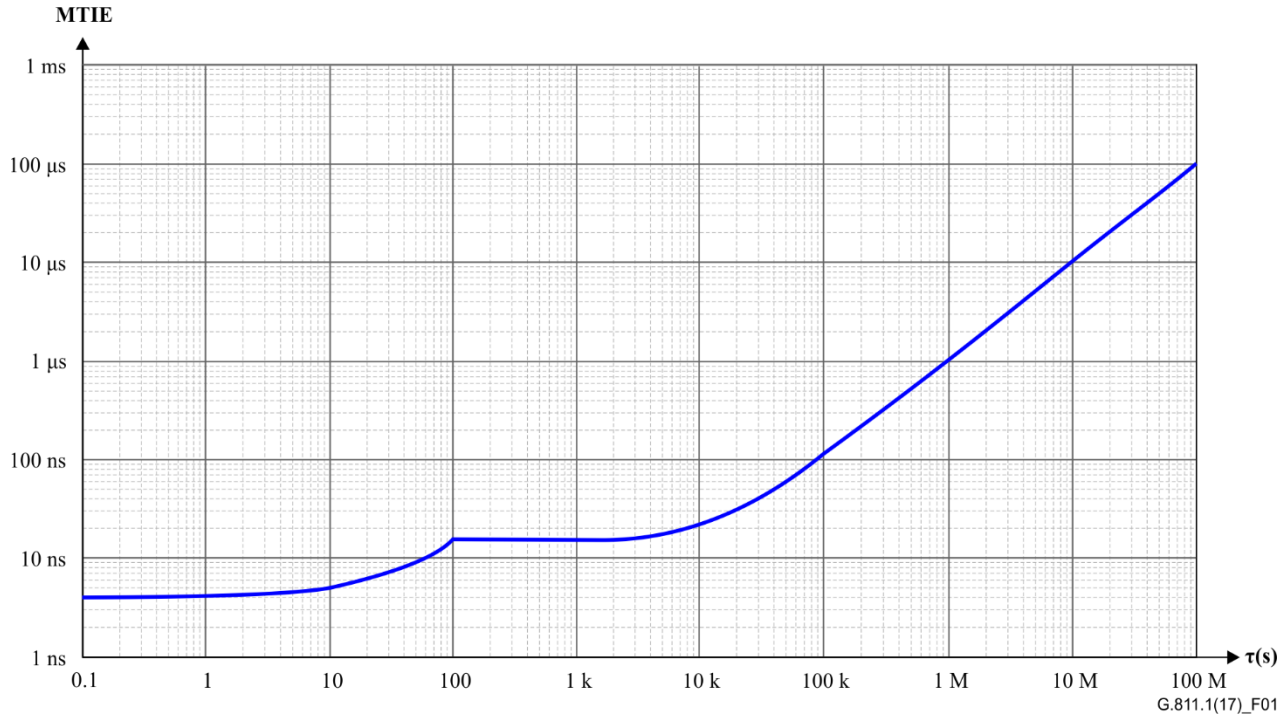

Figure 1 – MTIE as a function of an observation (integration) period τ

The wander, expressed in TDEV and measured using the independent clock configuration defined in Figure 2a of [ITU-T G.810], should have the limits as shown in Table 2 and shown in Figure 2:

Table 2 – Wander generation (TDEV)

TDEV limit [ns]	Observation interval τ [s]
1	$0.1 < \tau \leq 10000$

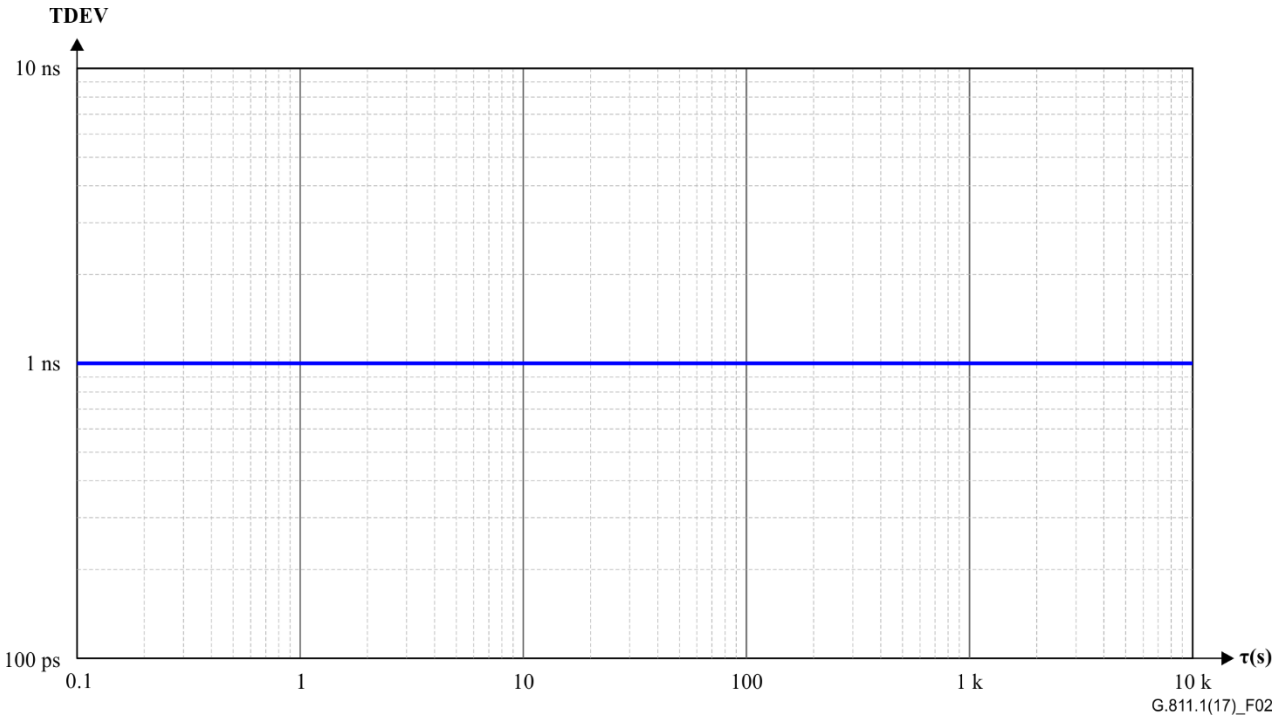

Figure 2 – TDEV as a function of an observation (integration) period τ

NOTE – Longer observation time and corresponding TDEV mask is for further study.

7.2 Jitter

While most specifications in this Recommendation are independent of the output interface at which they are measured, this is not the case for jitter production; jitter generation specifications must utilize existing specifications that are currently specified differently for different interface rates. These requirements are stated separately for the interfaces identified in clause 8. To be consistent with other jitter requirements, the specifications are in UIpp, where the unit interval (UI) corresponds to the reciprocal of the bit rate of the interface.

The intrinsic jitter at 2048 kHz and 2048 kbit/s output interfaces as measured over a 60-second interval shall not exceed 0.05 UIpp when measured through a single pole band-pass filter with corner frequencies at 20 Hz and 100 kHz.

The intrinsic jitter at 1544 kbit/s output interfaces as measured over a 60-second interval shall not exceed 0.015 UIpp when measured through a single pole band-pass filter with corner frequencies at 10 Hz and 40 kHz.

The intrinsic jitter at 10 MHz output interfaces as measured over a 60-second interval shall not exceed 0.01 UIpp when measured through a single pole band-pass filter with corner frequencies at 20 Hz and 100 kHz.

8 Phase discontinuity

Primary reference clocks need a very high level of reliability and are likely to include replication of the equipment to ensure the continuity of the output. However, any phase discontinuity, due to internal operations within the clock, should only result in a lengthening or shortening of the timing signal interval and must not, at the clock output, cause a phase discontinuity in excess of 1/8 UI over a period of time up to 60 seconds (this refers to output signals at 1544 kbit/s, 2048 kbit/s, 2048 kHz, or 10 MHz).

9 Degradation of the performance of an ePRC

If redundancy is applied and a clock frequency departs significantly from its nominal value, this should be detected and switching to an undegraded oscillator should then be effected. This switching should be accomplished before the MTIE or TDEV specification is exceeded.

10 Interfaces

The requirements in this Recommendation are related to reference points, which may be internal to the equipment or network element (NE) in which the ePRC is embedded and are, therefore, not necessarily available for measurement or analysis by the user. Consequently, the performance of the ePRC is not specified at these internal reference points, but rather at the external interfaces of the equipment. The output interfaces specified for the equipment in which the ePRC clock may be contained are:

– 2048 kHz interfaces according to clause 15 of [ITU-T G.703] with additional jitter and wander requirements as specified herein;

– 1544 kbit/s interfaces according to clause 7 of [ITU-T G.703] with additional jitter and wander requirements as specified herein;

– 2048 kbit/s interfaces according to clause 11 of [ITU-T G.703] with additional jitter and wander requirements as specified herein;

– 10 MHz interfaces according to [ITU-T G.703];

NOTE – 10 MHz interfaces may be available on autonomous ePRCs. 10 MHz interfaces may be required in the future when evolving an existing autonomous ePRC into an ePRTC. Such interfaces may provide an improvement in phase noise performance.

– other interfaces (such as sine wave 8 kHz to 5 MHz) are for further study.

All of the above interfaces may be implemented on all equipment.

Bibliography

[b-ITU-T G.783] Recommendation ITU-T G.783 (1997), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*.

[b-ITU-T G.811] Recommendation ITU-T G.811 (1997), *Timing characteristics of primary reference clocks*.

[b-ITU-T G.812] Recommendation ITU-T G.812 (1988), *Timing requirements at the outputs of slave clocks suitable for plesiochronous operation of international digital links*.

[b-ITU-T G.822] Recommendation ITU-T G.822 (1988), *Controlled slip rate objectives on an international digital connection*.

[b-ITU-T G.823] Recommendation ITU-T G.823 (1993), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy*.

[b-ITU-T G.824] Recommendation ITU-T G.824 (1993), *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy*.

[b-ITU-T G.825] Recommendation ITU-T G.825 (1993), *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)*.

[b-ITU-T G.8272.1] Recommendation ITU-T G.8272.1/Y.1367.1 (2016), *Timing characteristics of enhanced primary reference time clocks*.

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