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Digital networks – Design objectives for digital networks

Timing characteristics of SDH equipment slave clocks (SEC)

ITU-T Recommendation G.813

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ITU-T Recommendation G.813

Timing characteristics of SDH equipment slave clocks (SEC)

Summary

This Recommendation outlines minimum requirements for timing devices used in synchronizing network equipment that operate according to the principles governed by the Synchronous Digital Hierarchy (SDH).

This 2003 revision of ITU-T Rec. G.813 includes, in addition to a few editorial points, two technical points:

- An update in 8.2 b) of the jitter tolerance for Option 2 that has already been published in ITU-T Rec. G.813 Corrigendum 1 in 2001.
- The introduction of STM-64 jitter generation values for Options 1 and 2 in clause 7.3.

Source

ITU-T Recommendation G.813 was revised by ITU-T Study Group 15 (2001-2004) and approved under the WTSA Resolution 1 procedure on 16 March 2003.

Keywords

Clock performance objectives, Clock performance parameters, Jitter performance, SDH equipment clock, Wander performance.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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ITU-T Recommendation G.813

Timing characteristics of SDH equipment slave clocks (SEC)

1 Scope

This Recommendation outlines requirements for timing devices used in synchronizing network equipment that operate according to the principles governed by the Synchronous Digital Hierarchy (SDH). These requirements apply under the normal environmental conditions specified for the SDH equipment. In normal operation, SDH equipment contains a slave clock traceable to a primary reference clock. In general, the SDH equipment clock (SEC) will have multiple reference inputs. In the event that all links between the master and the slave clock fail, the equipment should be capable of maintaining operation (holdover) within prescribed performance limits.

The SEC is part of the SDH equipment, the functions of which are specified in ITU-T Rec. G.783 as the Synchronous Equipment Timing Source (SETS). Slave clocks used in SDH equipment must meet specific requirements in order to comply with network jitter requirements for plesiochronous tributaries.

This Recommendation contains two options for the SEC. The first option, referred to as "Option 1," applies to SDH networks optimized for the 2048 kbit/s hierarchy. These networks allow the worst-case synchronization reference chain as specified in Figure 8-5/G.803. The second option, referred to as "Option 2," applies to SDH networks optimized for the particular 1544 kbit/s hierarchy that includes the rates 1544 kbit/s, 6312 kbit/s, and 44 736 kbit/s. The synchronization reference chain for these networks is defined in Appendix II.

An SDH equipment slave clock should comply with all of the requirements specific to one option and should not mix requirements between Options 1 and 2. In the clauses where one requirement is specified, the requirements are common to both options. It is the intention that Options 1 and 2 should be harmonized in the future.

Careful consideration should be taken when interworking between networks with SECs based on Option 1 and networks with SECs based on Option 2.

This Recommendation defines the minimum requirements for clocks in SDH NEs. However, some SDH NEs may have a higher quality clock. This Recommendation allows for proper network operation when a SEC (Option 1 or 2) is timed from another SEC (like option), or a higher quality clock. Hierarchical timing distribution is recommended for SDH networks. Timing should not be passed from a SEC in free-run/holdover mode to a higher quality clock since the higher quality clock should not follow the SEC signal during fault conditions.

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.

- [1] ITU-T Recommendation G.703 (2001), *Physical/electrical characteristics of hierarchical digital interfaces*.
- [2] ITU-T Recommendation G.783 (2000), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*.

- [3] ITU-T Recommendation G.801 (1988), *Digital transmission models*.
- [4] ITU-T Recommendation G.803 (2000), *Architecture of transport networks based on the synchronous digital hierarchy (SDH)*.
- [5] ITU-T Recommendation G.810 (1996), *Definitions and terminology for synchronization networks*.
- [6] ITU-T Recommendation G.811 (1997), *Timing requirements of primary reference clocks*.
- [7] ITU-T Recommendation G.812 (1998), *Timing requirements of slave clocks suitable for use as node clocks in synchronization networks*.
- [8] ITU-T Recommendation G.822 (1988), *Controlled slip rate objectives on an international digital connection*.
- [9] ITU-T Recommendation G.823 (2000), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy*.
- [10] ITU-T Recommendation G.824 (2000), *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy*.
- [11] ITU-T Recommendation G.825 (2000), *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)*.
- [12] ITU-T Recommendation Q.551 (2002), *Transmission characteristics of digital exchanges*.

3 Definitions

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

4 Abbreviations

This Recommendation uses the following abbreviations:

CMI	Coded Mark Inversion
FPM	Flicker Phase Modulation
MTIE	Maximum Time Interval Error
NE	Network Element
OAM	Operation And Maintenance
PLL	Phase Locked Loop
PRC	Primary Reference 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 Frequency accuracy

a) Option 1

Under free-running conditions, the SEC output frequency accuracy should not be greater than 4.6 ppm with regard to a reference traceable to a G.811 clock.

NOTE – The time interval for this accuracy is for further study. Values of 1 month and 1 year have been proposed.

b) Option 2

Under free-running conditions, the SEC output frequency accuracy should not be greater than 20 ppm. Note that payload performance is not guaranteed for a fractional frequency deviation with a magnitude greater than 4.6 ppm. However, Operations and Maintenance (OAM) functionality shall be supported when a SEC is performing at the minimum accuracy.

6 Pull-in, hold-in, and pull-out ranges

6.1 Pull-in range

a) Option 1

The minimum pull-in range should be ± 4.6 ppm, whatever the internal oscillator frequency offset may be.

b) Option 2

The minimum pull-in range shall be ± 20 ppm, whatever the internal oscillator frequency offset may be.

6.2 Hold-in range

a) Option 1

The hold-in range for Option 1 is not required.

b) Option 2

The minimum hold-in range shall be ± 20 ppm, whatever the internal oscillator frequency offset may be.

6.3 Pull-out range

a) Option 1

The pull-out range is for further study. A minimum value of ± 4.6 ppm has been proposed.

b) Option 2

The pull-out range is not specified.

7 Noise generation

The noise generation of a SEC represents the amount of phase noise produced at the output when there is an ideal input reference signal or the clock is in holdover state. A suitable reference, for practical testing purposes, implies a performance level at least 10 times more stable than the output requirements. The ability of the clock to limit this noise is described by its frequency stability. The measures MTIE and Time Deviation (TDEV) are useful for characterisation of noise generation performance.

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 for TDEV is twelve times the integration period ($T = 12\tau$).



7.1 Wander in locked mode

a) Option 1

When the SEC is in the locked mode of operation, the MTIE measured using the synchronized clock configuration defined in Figure 1a/G.810 should have the limits in Table 1, if the temperature is constant (within $\pm 1^\circ\text{K}$):

**Table 1/G.813 – Wander generation (MTIE)
for Option 1 with constant temperature**

MTIE limit	Observation interval τ
40 ns	$0.1 < \tau \leq 1 \text{ s}$
$40\tau^{0.1} \text{ ns}$	$1 < \tau \leq 100 \text{ s}$
$25.25\tau^{0.2} \text{ ns}$	$100 < \tau \leq 1000 \text{ s}$

The resultant requirement is shown by the thick solid line in Figure 1.

When temperature effects are included, the allowance for the total MTIE contribution of a single SEC increases by the values in Table 2.

**Table 2/G.813 – Additional wander generation (MTIE)
for Option 1 with temperature effects**

Additional MTIE allowance	Observation interval τ
$0.5 \tau \text{ ns}$	$\tau \leq 100 \text{ s}$
50 ns	$\tau > 100 \text{ s}$

The resultant requirements are shown by the thin solid line in Figure 1.

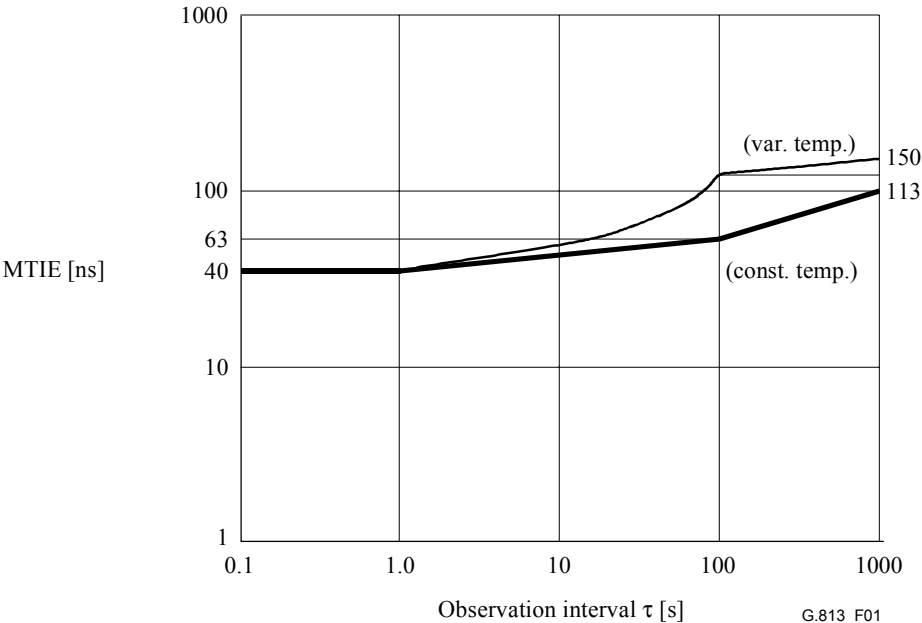


Figure 1/G.813 – Wander generation (MTIE) for Option 1

When the SEC is in the locked mode of operation, the TDEV measured using the synchronized clock configuration defined in Figure 1a/G.810 should have the limits in Table 3, if the temperature is constant (within $\pm 1^\circ\text{K}$):

**Table 3/G.813 – Wander generation (TDEV)
for Option 1 with constant temperature**

TDEV limit	Observation interval τ
3.2 ns	$0.1 < \tau \leq 25$ s
$0.64 \tau^{0.5}$ ns	$25 < \tau \leq 100$ s
6.4 ns	$100 < \tau \leq 1000$ s

The resultant requirements are shown in Figure 2.

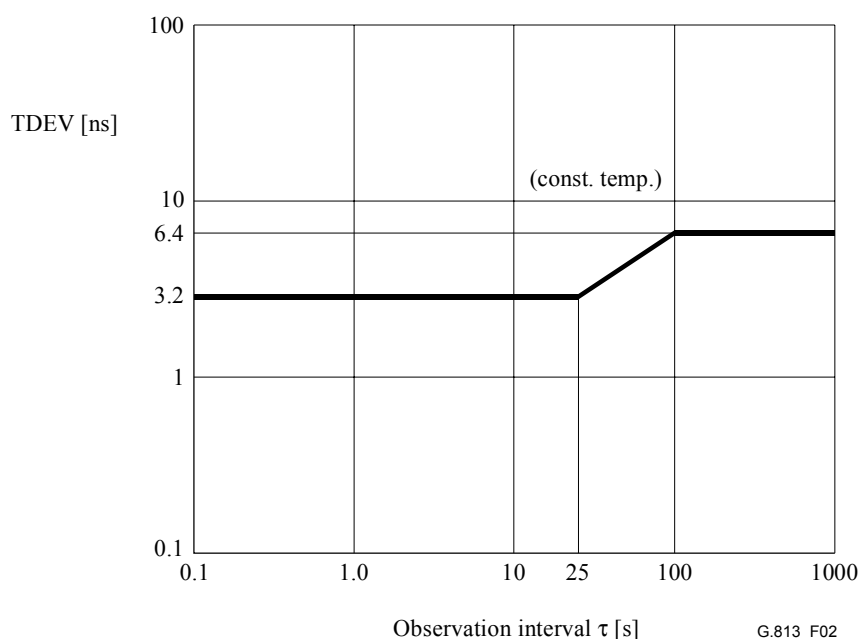


**Figure 2/G.813 – Wander generation (TDEV)
for Option 1 with constant temperature**

b) *Option 2*

When the SEC clock is in the locked mode of operation synchronized to a wander free reference, the MTIE and TDEV measured at the output under constant temperature (within $\pm 1^\circ\text{K}$) shall be below the limits in Tables 4 and 5.

**Table 4/G.813 – Wander generation (MTIE)
for Option 2 with constant temperature**

MTIE limit	Observation interval τ
20 ns	$0.1 < \tau \leq 1$ s
$20 \tau^{0.48}$ ns	$1 < \tau \leq 10$ s
60 ns	$10 < \tau \leq 1000$ s