

# COVERING NOTE

GENERAL SECRETARIAT INTERNATIONAL TELECOMMUNICATION UNION

Geneva, 30 March 2005

ITU – TELECOMMUNICATION  
STANDARDIZATION SECTOR

**Subject: Erratum 1 (03/2005) to**

ITU-T Recommendation G.812 (06/2004), *Timing requirements of slave clocks suitable for use as node clocks in synchronization networks*

*Modify Table 17 as follows:*

**Table 17/G.812 – Noise transfer requirements**

|                         | Type I | Type II | Type III |
|-------------------------|--------|---------|----------|
| Maximum bandwidth (MHz) | 3      | 1       | 1        |
| Maximum gain (dB)       | 0.2    | 0.2     | 0.2      |



INTERNATIONAL TELECOMMUNICATION UNION

# ITU-T

TELECOMMUNICATION  
STANDARDIZATION SECTOR  
OF ITU

# G.812

(06/2004)

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

Digital networks – Design objectives for digital networks

---

## **Timing requirements of slave clocks suitable for use as node clocks in synchronization networks**

ITU-T Recommendation G.812

ITU-T G-SERIES RECOMMENDATIONS  
TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

|                                                                                                                                              |                    |
|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS                                                                                             | G.100–G.199        |
| GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS                                                                  | G.200–G.299        |
| INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES                                                      | G.300–G.399        |
| GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES | G.400–G.449        |
| COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY                                                                                            | G.450–G.499        |
| TESTING EQUIPMENTS                                                                                                                           | G.500–G.599        |
| TRANSMISSION MEDIA CHARACTERISTICS                                                                                                           | G.600–G.699        |
| DIGITAL TERMINAL EQUIPMENTS                                                                                                                  | G.700–G.799        |
| DIGITAL NETWORKS                                                                                                                             | G.800–G.899        |
| General aspects                                                                                                                              | G.800–G.809        |
| <b>Design objectives for digital networks</b>                                                                                                | <b>G.810–G.819</b> |
| Quality and availability targets                                                                                                             | G.820–G.829        |
| Network capabilities and functions                                                                                                           | G.830–G.839        |
| SDH network characteristics                                                                                                                  | G.840–G.849        |
| Management of transport network                                                                                                              | G.850–G.859        |
| SDH radio and satellite systems integration                                                                                                  | G.860–G.869        |
| Optical transport networks                                                                                                                   | G.870–G.879        |
| DIGITAL SECTIONS AND DIGITAL LINE SYSTEM                                                                                                     | G.900–G.999        |
| QUALITY OF SERVICE AND PERFORMANCE - GENERIC AND USER-RELATED ASPECTS                                                                        | G.1000–G.1999      |
| TRANSMISSION MEDIA CHARACTERISTICS                                                                                                           | G.6000–G.6999      |
| DIGITAL TERMINAL EQUIPMENTS                                                                                                                  | G.7000–G.7999      |
| DIGITAL NETWORKS                                                                                                                             | G.8000–G.8999      |

*For further details, please refer to the list of ITU-T Recommendations.*

# ITU-T Recommendation G.812

## Timing requirements of slave clocks suitable for use as node clocks in synchronization networks

### Summary

This Recommendation outlines minimum requirements for timing devices used as node clocks in synchronization networks. The requirements relate to frequency deviation; pull-in, hold-in and pull-out range; noise generation, tolerance and transfer; transient response and holdover performances. The node clocks are suitable for use in SDH and PSTN network applications.

This Recommendation includes specifications for three types of clocks. The Type I clock is primarily intended for use in networks optimized for the 2048 kbit/s hierarchy. The Types II and III clocks are primarily intended for use in networks optimized for the particular 1544 kbit/s hierarchy that includes the rates 1544 kbit/s, 6312 kbit/s and 44 736 kbit/s.

Additionally, this Recommendation includes specifications for three other clocks in Annex A. Type IV is typically deployed in existing networks that support the 1544 kbit/s. The Types V and VI clocks were defined for transit and local node applications in the 1988 version of this Recommendation.

### Source

ITU-T Recommendation G.812 was approved on 13 June 2004 by ITU-T Study Group 15 (2001-2004) under the ITU-T Recommendation A.8 procedure.

### Keywords

Clock performance objectives, clock performance parameters, jitter performance, node clock, wander performance.

## FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

## INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

© ITU 2004

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

# CONTENTS

|                                                                        | Page |
|------------------------------------------------------------------------|------|
| 1 Scope .....                                                          | 1    |
| 2 Node clock types and applications .....                              | 1    |
| 2.1 Synchronization network considerations.....                        | 1    |
| 2.2 Node clock types and applications .....                            | 2    |
| 3 References.....                                                      | 3    |
| 4 Definitions .....                                                    | 3    |
| 5 Abbreviations.....                                                   | 3    |
| 6 Frequency accuracy .....                                             | 4    |
| 7 Pull-in, hold-in, and pull-out ranges .....                          | 4    |
| 8 Noise generation .....                                               | 4    |
| 8.1 Wander in locked mode.....                                         | 5    |
| 8.2 Non-locked wander .....                                            | 7    |
| 8.3 Jitter .....                                                       | 7    |
| 9 Noise tolerance .....                                                | 8    |
| 9.1 Wander tolerance.....                                              | 9    |
| 9.2 Jitter tolerance .....                                             | 12   |
| 10 Noise transfer.....                                                 | 14   |
| 11 Transient response and hold-over performance.....                   | 16   |
| 11.1 Short-term phase transient response .....                         | 16   |
| 11.2 Long-term phase transient response (hold-over).....               | 17   |
| 11.3 Phase response to input signal interruptions .....                | 19   |
| 11.4 Phase discontinuity .....                                         | 20   |
| 12 Interfaces.....                                                     | 21   |
| Annex A – Specifications for Types IV, V and VI clocks.....            | 21   |
| A.1 Frequency accuracy .....                                           | 21   |
| A.2 Pull-in, hold-in and pull-out ranges.....                          | 21   |
| A.3 Noise generation.....                                              | 22   |
| A.4 Noise tolerance .....                                              | 25   |
| A.5 Noise transfer.....                                                | 29   |
| A.6 Transient response and hold-over performance .....                 | 30   |
| A.7 Interfaces .....                                                   | 34   |
| Appendix I – Relationship between TDEV and power spectral density..... | 35   |
| Appendix II – Measurement method for noise transfer .....              | 37   |
| II.1 Measurement set-up.....                                           | 37   |
| II.2 Functional model of TDEV noise generator .....                    | 38   |

Document ID: 123456789

# ITU-T Recommendation G.812

## Timing requirements of slave clocks suitable for use as node clocks in synchronization networks

### 1 Scope

This Recommendation outlines minimum requirements for timing devices used as node clocks in synchronization networks. The function of a node clock is to select one of the external synchronization links coming into a telecommunication station as the active synchronization reference, to attenuate its jitter and wander and subsequently to distribute the reference to the telecommunication equipment in the station. The requirements in this Recommendation apply under the normal environmental conditions specified for telecommunications equipment.

This Recommendation specifies node clocks suitable for use in SDH and PSTN network applications. They may provide acceptable performance for other applications, but that has to be investigated for each case individually.

In normal operation, a node clock is operating as a slave clock, traceable to a primary reference clock. For purposes of redundancy, a node clock will in general have multiple reference inputs. In the event that all links between the master(s) and the node clock fail, the node clock should be capable of maintaining operation within prescribed performance limits (the hold-over mode of operation).

A node clock can be a separate piece of equipment called a Stand Alone Synchronization Equipment (SASE) or it can be a part of another equipment such as a telephony exchange or an SDH cross-connect.

This Recommendation defines six Types of clocks. Applications for each clock Type are described in clause 2.

### 2 Node clock types and applications

#### 2.1 Synchronization network considerations

Design of synchronization networks in general is not standardized. Principles for synchronization of SDH networks are outlined in ITU-T Rec. G.803. Some of these principles can be taken as general design rules for synchronization networks.

Synchronization requirements for node clocks in a PSTN environment can in principle be derived from the controlled slip rate objectives in ITU-T Rec. G.822. There are three elements that determine whether G.822 objectives can be achieved:

- the hold-over stability of the clocks;
- the network topology (i.e., length, routing and redundancy of the references); and
- the operational practices of the operator (i.e., mean time to repair).

Only the first element is covered in this Recommendation. Network providers can choose to use particular clock Types in their synchronization planning in order to match their network topology and operational practices.

Synchronization requirements for node clocks in an SDH environment are mainly driven by the jitter and wander specifications in ITU-T Recs G.823, G.824 and G.825. Given that SDH equipment clocks (as specified in ITU-T Rec. G.813) have only limited filtering capabilities and at the same time need to maintain their STM-N and PDH outputs in conformance with ITU-T Recs G.823,

G.824 and G.825, the phase transients at the output of node clocks must meet specifications that are more stringent than what is strictly needed for pure PDH transport equipment.

NOTE – Since the bandwidths of SDH equipment clocks are wider in networks based on the 2048 kbit/s hierarchy compared to those based on the 1544 kbit/s hierarchy (as described in ITU-T Rec. G.813 option 1 and option 2, respectively), the output phase transient requirements are correspondingly more stringent for node clocks deployed in 2048 kbit/s hierarchy environments.

## 2.2 Node clock types and applications

This Recommendation includes specifications for three clocks. The Type I clock is primarily intended for use in networks optimized for the 2048 kbit/s hierarchy. The Types II and III clocks are primarily intended for use in 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 Type I clock can be used at all levels of the synchronization hierarchy in 2048 kbit/s based networks. The wander generation and bandwidth of Type I clocks are limited to values that allow the deployment of the maximum number of node clocks according to the synchronization network reference chain as defined in ITU-T Rec. G.803. Although a Type I clock is primarily intended for use in networks supporting the 2048 kbit/s hierarchy, a Type I clock can also be deployed in 1544 kbit/s based networks as long as at least its pull-in range, noise generation and noise tolerance (see clauses 7, 8 and 9) comply with the more stringent requirements that apply to Types II and III clocks in order to be compatible with SDH equipment clocks built according to ITU-T Rec. G.813 option 2.

The Type II clock has a more stringent hold-over stability specification than a Type I clock. It is typically deployed at distribution hubs in networks that support the 1544 kbit/s hierarchy mentioned above. Type II clocks have a hold-over stability specification sufficient to operate with a single reference at the highest levels of the synchronization hierarchy. Although a Type II clock is primarily intended for use in networks supporting the 1544 kbit/s hierarchy, a clock with Type II hold-over specifications can also be deployed in 2048 kbit/s based networks as long as at least its noise generation, noise tolerance and transient behaviour (see clauses 8, 9, 11.1 and 11.4) comply with the more stringent requirements that apply to Type I clocks in order to be compatible with SDH equipment clocks built according to ITU-T Rec. G.813 option 1.

The Type III clock has a less stringent hold-over stability requirement than Type I and Type II. It is typically deployed in end offices in networks that support the 1544 kbit/s hierarchy mentioned above. Like a Type II clock, a clock with Type III hold-over stability may also be deployed in 2048 kbit/s based networks as long as at least its noise generation, noise tolerance and transient behaviour (see clauses 8, 9, 11.1 and 11.4) comply to the more stringent requirements that apply to Type I when it is used to synchronize SDH equipment.

Additionally, this Recommendation includes specifications for three clocks in Annex A.

The Type IV clock is typically deployed in existing networks that support the 1544 kbit/s hierarchy mentioned above. If clocks with Type IV hold-over performance are embedded in SDH equipment in this hierarchy, the requirements in ITU-T Rec. G.813 option 2 should be met as well.

The Type V clock is typically deployed in existing transit nodes of networks based on both 1544 kbit/s and 2048 kbit/s hierarchies according to the specifications of the 1988 version of this Recommendation. It should be noted that these clocks are perfectly suitable for the synchronization of 2048 kbit/s based SDH networks provided they conform at least to the noise generation and short-term stability requirements (clauses 8, 11.1 and 11.4) of Type I clocks.

The Type VI clock is typically deployed in existing local nodes of networks based on the 2048 kbit/s hierarchy according to the specifications of the 1988 version of this Recommendation. Like Type V, clocks with Type VI hold-over stability characteristics may be used for the

synchronization of SDH networks as long as the clock at least meets the noise generation and short-term stability requirements (clauses 8, 11.1 and 11.4) of the Type I clock.

### 3 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 (2004), *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.813 (2003), *Timing requirements of SDH equipment slave clocks (SEC)*.
- [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*.

### 4 Definitions

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

### 5 Abbreviations

This Recommendation uses the following abbreviations.

|      |                                  |
|------|----------------------------------|
| CMI  | Coded Mark Inversion             |
| MTIE | Maximum Time Interval Error      |
| NE   | Network Element                  |
| PDH  | Plesiochronous Digital Hierarchy |
| ppm  | parts per million                |

|      |                                       |
|------|---------------------------------------|
| PRBS | Pseudo Random Binary Sequence         |
| PRC  | Primary Reference Clock               |
| PSD  | Power Spectral Density                |
| PSTN | Public Switched Telephone Network     |
| SASE | Stand Alone Synchronization Equipment |
| SDH  | Synchronous Digital Hierarchy         |
| SEC  | SDH Equipment Clock                   |
| SSU  | Synchronization Supply Unit           |
| STM  | Synchronous Transport Module          |
| TDEV | Time Deviation                        |
| UI   | Unit Interval                         |

## 6 Frequency accuracy

Under prolonged hold-over conditions, the output frequency accuracy of the different Types of node clocks should not exceed the values in Table 1 with regard to a reference traceable to a primary reference clock, over a time period T as reported in the same Table.

**Table 1/G.812 – Output frequency accuracy requirements**

|                                                                                      | Type I | Type II              | Type III             |
|--------------------------------------------------------------------------------------|--------|----------------------|----------------------|
| Accuracy                                                                             | NA     | $1.6 \times 10^{-8}$ | $4.6 \times 10^{-6}$ |
| Period T                                                                             | NA     | 1 year               | 1 year               |
| NA Not applicable                                                                    |        |                      |                      |
| NOTE – The time period T applies after 30 days of continuous synchronized operation. |        |                      |                      |

## 7 Pull-in, hold-in, and pull-out ranges

The minimum pull-in, hold-in and pull-out ranges for the different Types of node clocks should be according to Table 2, whatever the internal oscillator frequency offset may be.

**Table 2/G.812 – Pull-in, hold-in, and pull-out requirements**

|                   | Type I             | Type II              | Type III             |
|-------------------|--------------------|----------------------|----------------------|
| Pull-in           | $1 \times 10^{-8}$ | $1.6 \times 10^{-8}$ | $4.6 \times 10^{-6}$ |
| Hold-in           | NA                 | $1.6 \times 10^{-8}$ | $4.6 \times 10^{-6}$ |
| Pull-out          | TBD                | NA                   | NA                   |
| NA Not applicable |                    |                      |                      |
| TBD To be defined |                    |                      |                      |

## 8 Noise generation

The noise generation of a slave clock represents the amount of phase noise produced at the output when there is an ideal input reference signal or the clock is in hold-over state (see 11.2). 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 characterization 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  $\tau_0$  of 1/30 second. The minimum measurement period for TDEV is twelve times the integration period ( $T = 12 \tau$ ).

### 8.1 Wander in locked mode

When the slave clock is in the locked mode of operation, the MTIE at constant temperature (within  $\pm 1$  K) measured using the synchronized clock configuration defined in Figure 1-a/G.810 should have the limits in Tables 3 and 4 for the different Types of node clocks.

**Table 3/G.812 – Wander generation (MTIE) for Type I node clock at constant temperature (within  $\pm 1$  K)**

| MTIE limit (ns)       | Observation interval $\tau$ (s) |
|-----------------------|---------------------------------|
| 24                    | $0.1 < \tau \leq 9$             |
| $8 \times \tau^{0.5}$ | $9 < \tau \leq 400$             |
| 160                   | $400 < \tau \leq 10\,000$       |

**Table 4/G.812 – Wander generation (MTIE) for Types II and III node clocks at constant temperature (within  $\pm 1$  K)**

| MTIE limit (ns)        | Observation interval $\tau$ (s) |
|------------------------|---------------------------------|
| 40                     | $0.1 < \tau \leq 1$             |
| $40 \times \tau^{0.4}$ | $1 < \tau \leq 10$              |
| 100                    | $\tau > 10$                     |

When temperature effects are included of which the limits and rate of change are to be defined, the allowance for the total MTIE contribution of a single Type I node clock is given by the values in Table 5.

**Table 5/G.812 – Total wander generation (MTIE) for Type I node clock for variable temperature**

| MTIE limit (ns)  | Observation interval $\tau$ (s) |
|------------------|---------------------------------|
| $3.2 \tau^{0.5}$ | $2500 < \tau \leq 10\,000$      |

NOTE – For observation periods greater than 10 000 s, the MTIE is expected not to exceed 1  $\mu$ s.

The resultant requirements are shown in Figure 1.

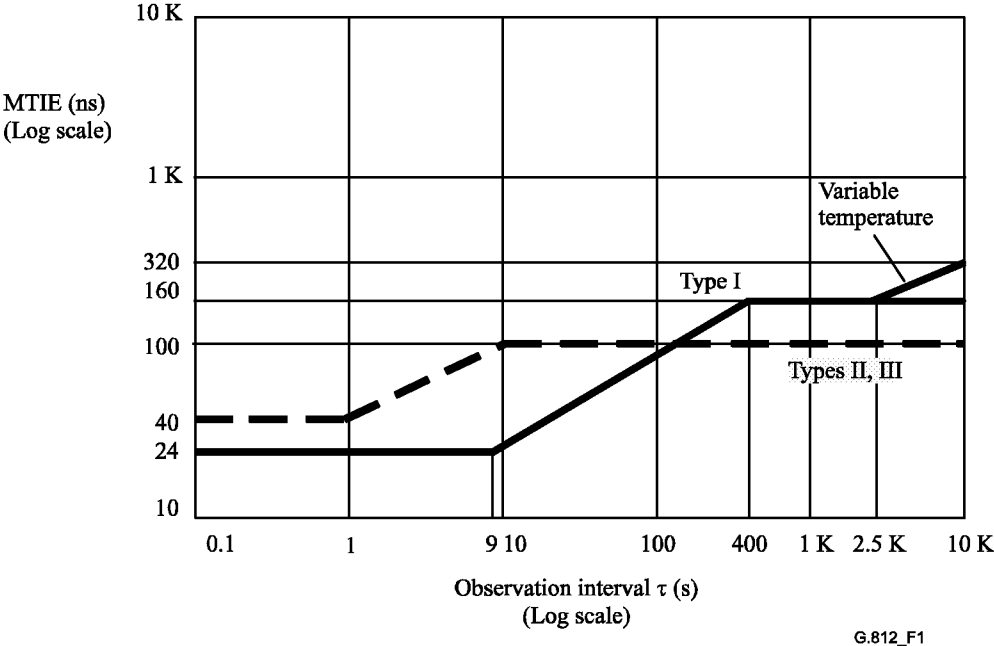


Figure 1/G.812 – Wander generation (MTIE)

When the node clock is in the locked mode of operation, the TDEV at constant temperature (within  $\pm 1$  K) measured using the synchronized clock configuration defined in Figure 1-a/G.810 should have the limits in Tables 6 and 7 for the different Types of node clock.

Table 6/G.812 – Wander generation (TDEV) for Type I node clock at constant temperature (within  $\pm 1$  K)

| TDEV limit (ns) | Observation interval $\tau$ (s) |
|-----------------|---------------------------------|
| 3               | $0.1 < \tau \leq 25$            |
| $0.12 \tau$     | $25 < \tau \leq 100$            |
| 12              | $100 < \tau \leq 10\,000$       |

Table 7/G.812 – Wander generation (TDEV) for Types II and III node clocks at constant temperature (within  $\pm 1$  K)

| TDEV limit (ns)          | Observation interval $\tau$ (s) |
|--------------------------|---------------------------------|
| $3.2 \times \tau^{-0.5}$ | $0.1 < \tau \leq 2.5$           |
| 2                        | $2.5 < \tau \leq 40$            |
| $0.32 \times \tau^{0.5}$ | $40 < \tau \leq 1000$           |
| 10                       | $\tau > 1000$                   |

The resultant requirements are shown in Figure 2.

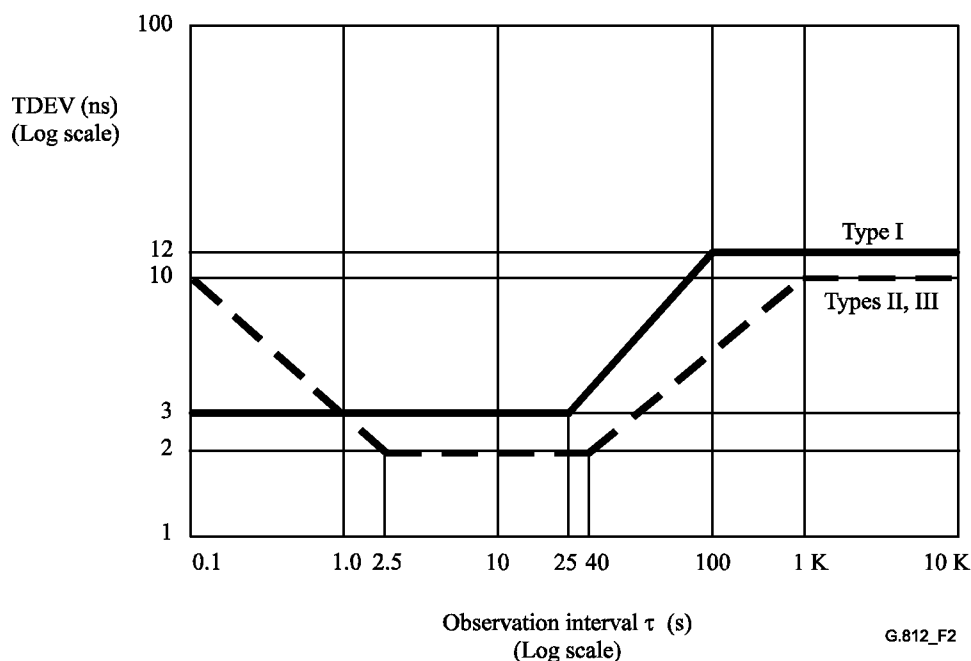


**Figure 2/G.812 – Wander generation (TDEV) for constant temperature**

## 8.2 Non-locked wander

When a clock is not locked to a synchronization reference, the random noise components are negligible compared to deterministic effects like initial frequency offset. Consequently, the non-locked wander effects are included in 11.2.

## 8.3 Jitter

While most requirements in this Recommendation are independent of the output interface at which they are measured, this is not the case for jitter production; jitter generation requirements utilize existing Recommendations that have different limits for different interface rates. These requirements are stated separately for the interfaces identified in clause 12. To be consistent with other jitter requirements, the values are in UI peak-peak, where the UI corresponds to the reciprocal of the bit rate of the interface.

Note that all filter values for STM-N interfaces specified in this clause have been harmonized with the filter values for the network limit as specified in ITU-T Rec. G.825.

NOTE – Due to the stochastic nature of jitter, the peak-peak values given in this clause eventually are exceeded. The requirements should therefore be fulfilled in at least 99% of all measurements made.

### 8.3.1 Output jitter at 2048 kHz and 2048 kbit/s interfaces

In the absence of input jitter, the intrinsic jitter at 2048 kHz and 2048 kbit/s output interfaces as measured over a 60-second interval should not exceed 0.05 UI peak-peak when measured through a single pole band-pass filter with corner frequencies at 20 Hz and 100 kHz.

### 8.3.2 Output jitter at a 1544 kbit/s interface

In the absence of input jitter, the intrinsic jitter at a 1544 kbit/s output interface should not exceed 0.05 UI peak-peak when measured through a single pole band-pass filter with corner frequencies at 10 Hz and 40 kHz. The measurement interval is for further study.

### 8.3.3 Output jitter at an STM-N interface

In the absence of input jitter at the synchronization interface, the intrinsic jitter at optical STM-N output interfaces as measured over a 60-second interval should not exceed the limits given in Table 8 below. The allowed jitter on an STM-1 electrical (CMI) interface is also given in Table 8 below.

The measurement filter roll-off at the lower cut-off frequency shall be 20 dB/decade and the roll-off at the upper cut-off frequency shall be 60 dB/decade. The characteristic of the upper cut-off filter roll-off is for further study.

**Table 8/G.812 – STM-N jitter generation**

| Interface                                                                               | Measuring filter<br>(–3 dB frequencies) | Peak-peak amplitude<br>(UI) |
|-----------------------------------------------------------------------------------------|-----------------------------------------|-----------------------------|
| STM-1<br>electrical                                                                     | 500 Hz to 1.3 MHz                       | 0.50                        |
|                                                                                         | 65 kHz to 1.3 MHz                       | 0.075                       |
| STM-1<br>optical                                                                        | 500 Hz to 1.3 MHz                       | 0.50                        |
|                                                                                         | 65 kHz to 1.3 MHz                       | 0.10                        |
| STM-4                                                                                   | 1000 Hz to 5 MHz                        | 0.50                        |
|                                                                                         | 250 kHz to 5 MHz                        | 0.10                        |
| STM-16                                                                                  | 5000 Hz to 20 MHz                       | 0.50                        |
|                                                                                         | 1 MHz to 20 MHz                         | 0.10                        |
| For STM-1: 1 UI = 6.43 ns.<br>For STM-4: 1 UI = 1.61 ns.<br>For STM-16: 1 UI = 0.40 ns. |                                         |                             |

## 9 Noise tolerance

The noise tolerance of a G.812 clock indicates the lower limit of the maximum phase noise level at the input of the clock that should be accommodated while:

- Maintaining the clock within prescribed performance limits. The exact performance limits are for further study.
- Not causing any alarms.
- Not causing the clock to switch reference.
- Not causing the clock to go into hold-over.

In general, the noise tolerance of a G.812 clock is the same as the network limit for the synchronization interface in order to maintain acceptable performance. However, the synchronization interface network limit may be different according to the application. Therefore, in order to determine the slave clock noise tolerance, the worst-case network limit should be used. An explanation of the different network limits for acceptable payload performance is given in Appendix I/G.813 for information.

The wander and jitter tolerances given in 9.1 and 9.2 represent the worst levels that a synchronization carrying interface should exhibit. The TDEV signal used for a conformance test should be generated by adding white, gaussian noise sources, each of which has been filtered to obtain the proper type of noise process with the proper amplitude. Guidance is provided in Appendix II.