

Recommendation

ITU-T G.8262.1/Y.1362.1 (11/2022)

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

Packet over Transport aspects – Synchronization, quality and availability targets

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Internet protocol aspects – Transport

Timing characteristics of enhanced synchronous equipment slave clock

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
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
Ethernet over Transport aspects	G.8000–G.8099
MPLS over Transport aspects	G.8100–G.8199
Synchronization, quality and availability targets	G.8200–G.8299
Mobile network transport aspects	G.8300–G.8399
Service Management	G.8600–G.8699
ACCESS NETWORKS	G.9000–G.9999

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

Recommendation ITU-T G.8262.1/Y.1362.1

Timing characteristics of enhanced synchronous equipment slave clock

Summary

Recommendation ITU-T G.8262.1/Y.1362.1 outlines requirements for timing devices used in synchronizing network equipment that uses the physical layer to deliver frequency synchronization. This Recommendation defines the requirements for clocks, e.g., bandwidth, frequency accuracy, holdover and noise generation.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.8262.1/Y.1362.1	2019-01-12	15	11.1002/1000/13850
1.1	ITU-T G.8262.1/Y.1362.1 (2019) Amd. 1	2019-08-29	15	11.1002/1000/14011
2.0	ITU-T G.8262.1/Y.1362.1	2022-11-13	15	11.1002/1000/15128

Keywords

eEEC, eOEC, jitter, synchronization, wander.

* 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>.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). 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/software copyrights, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the appropriate ITU-T databases available via the ITU-T website at <http://www.itu.int/ITU-T/ipr/>.

© ITU 2023

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

Table of Contents

		Page
1	Scope	1
2	References.....	1
3	Definitions	2
4	Abbreviations and acronyms	2
5	Conventions	3
6	Frequency accuracy	3
7	Pull-in, hold-in and pull-out ranges	3
	7.1 Pull-in range	3
	7.2 Hold-in range.....	3
	7.3 Pull-out range	3
8	Noise generation	3
	8.1 Wander in locked mode.....	3
	8.2 Non-locked wander	5
	8.3 Jitter.....	5
9	Noise tolerance	6
	9.1 Wander tolerance level 1	6
	9.2 Wander tolerance level 2	7
	9.3 Jitter tolerance	9
10	Noise transfer.....	9
11	Transient response and holdover performance	9
	11.1 Short-term phase transient response	10
	11.2 Long-term phase transient response (holdover)	11
12	Interfaces.....	12
	Appendix I – Relationship between requirements contained in this Recommendation and other key synchronization-related Recommendations.....	13
	Appendix II – List of Ethernet interfaces applicable to synchronous Ethernet	14
	Appendix III – Considerations related to synchronous Ethernet over 1000BASE-T and 10GBASE-T	15
	Appendix IV – Performance estimation for cascaded media converters acting as enhanced synchronous equipment clocks.....	16
	IV.1 Noise generation.....	16
	IV.2 Noise tolerance	16
	IV.3 Noise transfer.....	16
	IV.4 Transient response and holdover performance.....	17
	Appendix V – Example for short-term phase transient response.....	18
	Bibliography.....	19

Introduction

The synchronization method refers to the primary reference clock (PRC) distributed method (for instance, based on the global navigation satellite system (GNSS)), or the master-slave method using a synchronous physical layer (e.g., Ethernet PHY layer network (ETY), STM-N). These methods are widely implemented to synchronize the TDM networks.

Recommendation ITU-T G.8262.1/Y.1362.1

Timing characteristics of enhanced synchronous equipment slave clock

1 Scope

This Recommendation outlines new requirements for timing devices used in synchronizing network equipment that supports synchronous clocks, involved in time and phase transport. It supports clock distribution based on network-synchronous line-code methods (e.g., synchronous Ethernet, synchronous optical transport network (OTN) to deliver frequency synchronization).

This Recommendation focuses on the requirements for the enhanced synchronous Ethernet equipment clock (eEEEC) and the enhanced synchronous OTN equipment clock (eOEC).

This Recommendation allows for proper network operation when this clock is timed from another network equipment clock or a higher-quality clock.

Included in this Recommendation are requirements for clock accuracy, noise transfer, holdover performance, noise tolerance and noise generation. These requirements apply under the normal environmental conditions specified for the equipment.

This Recommendation contains a single option for enhanced synchronous equipment clock. The networks containing enhanced synchronous equipment clock allow the worst-case synchronization reference chain as specified in Figure 8-5 of [ITU-T G.803].

Careful consideration should be taken when using both ITU-T G.8262.1 and ITU-T G.8262 clocks in the same chain as this may lead to not meeting the performance required by the relevant time and phase synchronization application. The highest performance can be achieved in networks where only enhanced synchronous equipment clocks or better clocks are implemented, see [ITU-T G.8261] for the applicable network limits.

OTN 3R regenerators, as specified in [ITU-T G.8251], provide through-timing capability and can transmit timing via synchronous OTN.

More information on synchronous Ethernet can be found in [ITU-T G.781], [ITU-T G.8261] and [ITU-T G.8264], and for synchronous OTN can be found in [ITU-T G.709] and [ITU-T G.7041].

NOTE – The clock specified in this Recommendation is compatible with the Option 1 clock specified in [ITU-T G.8262].

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.709] Recommendation ITU-T G.709/Y.1331 (2020), *Interfaces for the optical transport network*.
- [ITU-T G.781] Recommendation ITU-T G.781 (2020), *Synchronization layer functions for frequency synchronization based on the physical layer*.

- [ITU-T G.803] Recommendation ITU-T G.803 (2000), *Architecture of transport networks based on the synchronous digital hierarchy (SDH)*.
- [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.813] Recommendation ITU-T G.813 (2003), *Timing characteristics of SDH equipment slave clocks (SEC)*.
- [ITU-T G.825] Recommendation ITU-T G.825 (2000), *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)*.
- [ITU-T G.7041] Recommendation ITU-T G.7041/Y.1303 (2016), *Generic framing procedure*.
- [ITU-T G.8251] Recommendation ITU-T G.8251 (2022), *The control of jitter and wander within the optical transport network (OTN)*.
- [ITU-T G.8261] Recommendation ITU-T G.8261/Y.1361 (2019), *Timing and synchronization aspects in packet networks*.
- [ITU-T G.8262] Recommendation ITU-T G.8262/Y.1362 (2018), *Timing characteristics of synchronous Ethernet equipment slave clock*.
- [ITU-T G.8264] Recommendation ITU-T G.8264/Y.1364 (2017), *Distribution of timing information through packet networks*.
- [ITU-T G.8272] Recommendation ITU-T G.8272 (2018), *Timing characteristics of primary reference time clocks*.
- [IEEE 802.3] IEEE Standard 802.3-2022, *IEEE Standard for Ethernet*.

3 Definitions

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

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

eEEC	enhanced synchronous Ethernet Equipment Clock
ePRTC	enhanced Primary Reference Time Clock
ETY	Ethernet PHY layer network
GNSS	Global Navigation Satellite System
MTIE	Maximum Time Interval Error
NE	Network Element
eOEC	enhanced OTN Equipment Clock
eSEC	enhanced Synchronous Equipment Clock
OTN	Optical Transport Network
PAM4	4-level Pulse Amplitude Modulation
PRC	Primary Reference Clock
SDH	Synchronous Digital Hierarchy

SSM	Synchronization Message Channel
STM	Synchronous Transport Module
TDEV	Time Deviation
UI	Unit Interval

5 Conventions

eSEC: enhanced synchronous equipment clock is a generic term used for clocks defined in this Recommendation.

6 Frequency accuracy

Under free-running conditions, the enhanced equipment clock output frequency accuracy should not be greater than 4.6 ppm with regard to a reference traceable to an ITU-T G.811 or ITU-T G.8272 clock.

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

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

7.1 Pull-in range

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

7.2 Hold-in range

The hold-in range for enhanced equipment clock is not required.

7.3 Pull-out range

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

8 Noise generation

The noise generation of an enhanced equipment clock 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 maximum time interval error (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 τ_0 of 1/30 seconds. The minimum measurement period for TDEV is twelve times the integration period ($T = 12\tau$).

8.1 Wander in locked mode

When the enhanced equipment clock is in the locked mode of operation synchronized to a wander-free reference, the MTIE measured using the synchronized clock configuration defined in Figure 1a of [ITU-T G.810] should have the limits in Table 1, if the temperature is constant (within $\pm 1^\circ\text{K}$):